Department of Agriculture and Fisheries

Sustainable Fisheries Strategy 2017–2027

Level 1 Ecological Risk Assessment
East Coast Spanish Mackerel Fishery

Queensland Government

Level 1 Ecological Risk Assessment
East Coast Spanish Mackerel Fishery

Ian Jacobsen, Amanda Dawson & Lisa Walton

Fisheries Queensland, Department of Agriculture & Fisheries

Executive Summary

The Queensland Ecological Risk Assessment Guideline (the Guideline) was released in March 2018 as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018a). 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 using a 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 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 life-history constraints of the species being assessed. In the *East Coast Spanish Mackerel Fishery* (ECSMF) the Level 1 ERA assessed fishing related risks in 15 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 (*e.g.* 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. As this approach has the potential to overestimate the level of risk, a secondary evaluation was conducted on ecological components with higher risk ratings. This evaluation examined the key drivers of risk within each profile, their relevance to the current fishing environment and the extent that a fishery contributes to this risk. The purpose of this secondary assessment was to examine the likelihood of the risk coming to fruition over the short to medium term and minimise the number of 'false positives'

In the ECSMF, the preliminary ratings indicated that at least 13 of the ecological components were at negligible or low risk of experiencing an undesirable event due to fishing activities. The two remaining ecological components, target species and ecosystem processes, were assigned a risk rating of high and intermediate/high respectively. The key drivers of risk for the target species included the ability of operators to target aggregations, latent quota in the fishery and cumulative fishing pressures *e.g.* from the recreational and charter fishing sectors. For the ecosystem processes, the majority of risks related to the removal of predators from the ecosystem and the potential for the fishery to impact on recruitment rates.

After the likelihood of the risk coming to fruition was considered, the preliminary risk ratings for three ecological components were downgraded. The most notable of these reductions were for the target species (high to intermediate/high) and ecosystem processes (intermediate/high to intermediate). The downgrading of the risk ratings were based on a number of factors including a) catch data showing that the commercial fishery is operating at well below the Total Allowable Commercial Catch (TACC)

limit, b) research demonstrating that Spanish mackerel stocks on the Queensland east coast are being sustainably fished (O'Neill *et al.*, 2018) and c) data indicating that the fishery is unlikely to deviate significantly from long-term catch and effort trends (Department of Agriculture and Fisheries, 2019b). Factors that limited the extent of the risk rating reductions included evidence that the stock is already being fished at the Maximum Sustainable Yield (MSY; O'Neill *et al.*, 2018), an increased potential for catch to increase beyond sustainability reference points and the ability of fishers (commercial, recreational and charter) to target spawning aggregations.

Based on the above results, only the target species ecological component was assigned a risk rating higher than intermediate. As these risks are confined to a single species, Spanish mackerel, they are best addressed through the harvest strategy framework. However, the Level 1 ERA also identified key knowledge gaps in a number of the risk profiles and areas where the scope of the assessment can be further refined. These information needs will be progressed through the *Fisheries Queensland Monitoring and Research Plan* for further consideration and include:

- Evaluating the effectiveness of the current TACC limit, total fishing mortality (*e.g.* retained, discarded and unreported) and how they compare to biomass reference points.
- Evaluating the economic drivers behind the Spanish mackerel retention rates and the potential for catch and effort to increase into the future;
- Improving information on finer-scale catch and effort trends for all sectors (including recreational) particularly around spawning aggregations;
- Improving the level of understanding on release fates of Spanish mackerel including shark interactions/depredation rates.

Summary of the outputs from the Level 1 (whole of fishery) Ecological Risk Assessment for the East Coast Spanish Mackerel Fishery (ECSMF).

Ecological Component	Level 1 Risk Rating	Progression
Target Species	Intermediate/High	Address through harvest strategy
Bycatch (non-SOCC)	Low	Not progressed further
Species of Conservation Concern (SOCC)		
Marine turtles	Low	Not progressed further
Sea snakes	Negligible	Not progressed further
Crocodiles	Negligible	Not progressed further
Dugongs	Negligible	Not progressed further
Cetaceans	Low	Not progressed further
Protected teleosts (SOCI only)	Low	Not progressed further
Batoids	Negligible	Not progressed further
Sharks	Low	Not progressed further
Syngnathids	Negligible	Not progressed further
Seabirds	Low	Not progressed further
Terrestrial mammal	Negligible	Not progressed further
Marine Habitats	Low	Not progressed further
Ecosystem Processes	Intermediate	Address through harvest strategy

Table of contents

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 ECSMF through the logbook reporting system irrespective of the amount of catch and effort.
Bycatch	–	The portion of the catch that is discarded / returned to sea. For the purpose of this ERA, the definition of bycatch does not include unwanted target and byproduct species.
Byproduct	–	The portion of catch retained for commercial sale that was not intentionally targeted. For the purpose of this ERA, the definition of byproduct does not include any line caught product that was retained for sale in another fishery (*i.e.* the ECIFFF or RRFFF). In this risk assessment, this portion of the catch is classified as 'bycatch'.
CRFFF	–	Coral Reef Fin Fish Fishery
DAF	–	Queensland Department of Agriculture and Fisheries
ECSMF	–	East Coast Spanish Mackerel Fishery
ECIFFF	–	East Coast Inshore Fin Fish Fishery
Ecological Component	–	Broader assessment categories that include *Target Species* (harvested), *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 defines what gear can be used *i.e.* 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.
GBR / GBRMP	–	Great Barrier Reef / Great Barrier Reef Marine Park
ITQ	–	Individual Transferable Quota
MEY	–	Maximum Economic Yield
MSY	–	Maximum Sustainable Yield
QBFP	–	Queensland Boating and Fisheries Patrol
RRFFF	–	Rocky Reef Fin Fish Fishery
SAFS	–	Status of Australian Fish Stocks
Species of Conservation Concern (SOCC)	–	Broder 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)	–	A limited number of species subject to mandatory reporting requirements as part of the Queensland logbook reporting system. Any reference to 'SOCI' refers specifically to the SOCI logbook or data compiled from the SOCI logbook.
TACC	–	Total Allowable Commercial Catch
Target	–	The primary species or species groups that have been selectively fished for and retained for commercial, recreational or Aboriginal peoples and Torres Strait Islander peoples purposes.
WTO		Wildlife Trade Operation

1 Overview

The *East Coast Spanish Mackerel Fishery* (ECSMF) is a line-only fishery that exclusively targets Spanish mackerel. While the fishery operates along the entire Queensland east coast, including within the Great Barrier Reef Marine Park (GBRMP), most of the effort is focused around the central and northern regions. The ECSMF consists of a commercial, recreational and charter fishing sector and it is managed through a mixture of input (*e.g.* gear restrictions, limited entry, spatial closures) and output controls (*e.g.* size restrictions, individual transferable quotas (ITQs)) (Department of Agriculture and Fisheries, 2019b). However, output controls are only applied to the commercial fishing sector.

The ECSMF has been the subject of a number of risk assessments and there is a reasonable level of information on the structure and health of Spanish mackerel stocks. In 2004 a whole-of-fishery Ecological Risk Assessment (ERA) was completed for the fishery (Ryan et al., 2004). This was followed by a separate assessment examining the impact of the fishery on the most vulnerable bycatch and byproduct species (Department of Primary Industries and Fisheries, 2005). Spanish mackerel stocks have also been the subject of a detailed stock assessment (O'Neill *et al.*, 2018) and have indicative sustainability assessments though the *National Status of Australian Fish Stocks* (SAFS) processes (Langstreth *et al.*, 2018).

In March 2018, Queensland released the *Ecological Risk Assessment Guideline* (the Guideline) (Department of Agriculture and Fisheries, 2018a) as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017). This Guideline provides an overview of the strategy being used to develop ERAs for Queensland's fisheries and includes a four-stage framework consisting of 1) a Scoping Study, 2) a Level 1, whole of fishery qualitative assessment, 3) a Level 2, species-specific semi-quantitative or low-data quantitative assessment, and 4) a Level 3 quantitative assessment (if applicable).

The following provides a broad, qualitative (Level 1) assessment of the risk posed by the ECSMF on a number of key ecological components. The Level 1 assessment follows-on from the completion of a scoping study that provides information on the current fishing environment, licencing trends and broad catch and effort analyses (Department of Agriculture and Fisheries, 2019d).

2 Focus/Intent

The risk profiles for Queensland's commercial fisheries vary and are highly dependent on the apparatus used. For example, the risk posed by line fishing activities will be lower when compared to a net or trawl fishery. Similarly, single-species fisheries like the ECSMF will present a lower risk when compared to multi-species or multi-apparatus fisheries. Every fishery will have elements that present a higher risk for one or more of the ecological components *i.e.* species groupings, marine habitats and ecosystem processes that interact with the fishery. These risk elements will still be present in smaller fisheries including those where there is greater capacity to target individual species.

In recognition of the above point, the primary objectives of the Level 1 assessment were to identify a) the key sources of risk within a particular fishery and b) the ecosystem components that are most likely to be affected by this risk. Used in this context, Level 1 ERAs produce outputs or risk assessments that are very fishery-specific. The inherent trade off with this approach is that risk ratings cannot be compared between fisheries as the scale, extent and impact of the risk are unlikely to be

equal. They will however provide insight into the areas or fishing activities within the ECSMF that may contribute to an undesirable event for one or more of the ecological components.

By restricting the focus of the assessment, Level 1 ERAs can be used to examine the types of risk each ecological component will be exposed to within that fishery. In doing so, the outputs of the Level 1 assessment will determine what ecological components will progress to a finer scale assessment—otherwise referred to as a Level 2 ERA. These finer scale (Level 2 ERA) assessments will focus on the species, species groupings, marine habitats or ecosystem processes (if applicable) contained within each of the ecological subcomponents.

3 Methods

The Level 1 assessment is used to assess risk at the whole of fishery level with the primary objective being to establish a broad risk profile for each fishery. Level 1 assessments will focus on a wide range of ecological components and will include detailed assessments for the *Target species* ecological component (Spanish mackerel), *Bycatch*, *Species of Conservation Concern*, *Marine Habitats* and *Ecosystem Processes*. As the ECSMF is a single species fishery, 'byproduct' will not form part of this assessment.

For the purposes of this ERA, the term '*Species of Conservation Concern'* (SOCC) was used instead of '*Species of Conservation Interes*t' as the scope of the assessment will be broader. In Queensland, the term '*Species of Conservation Interest*' or SOCI refers specifically to a limited number of non-targeted species that are subject to mandatory commercial reporting requirements. The expansion of this list allows for the inclusion of non-SOCI species including those that are afforded additional legislative protections *e.g.* the listing of hammerheads as '*Conservation Dependent*' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In the case of the SOCC, this ecological subgroup has been further divided into: marine turtles, sea snakes, crocodiles, dugongs, cetaceans, batoids, sharks, syngnathids, seabirds, protected teleosts and terrestrial mammals. The division of the SOCC ecological component recognises the variable life-history traits of this subgroup and the need to develop risk profiles for each complex.

Of the five ecological components, ecosystem processes represents the biggest challenge for management response as the viability of these processes will be influenced by factors outside of the control of fisheries management *e.g.* climate 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 an individual fishery is having 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 (Pears *et al.*, 2012; Evans *et al.*, 2016). 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 a fishery to impact on 16 categories outlined in the *Great Barrier Reef Outlook Report 2014* (Great Barrier Reef Marine Park Authority, 2014). 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 every fishery, but all processes were considered before being eliminated. A full definition of each ecosystem process has been provided in Appendix 1.

The Level 1 ERA was modelled off of an assessment method established by Astles *et al.* (2006) and incorporates five distinct steps: *Risk Context*, *Risk Identification*, *Risk Characterisation, Likelihood* and *Issues Arising*. A brief overview of each step is provided below.

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

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.

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. Used as part of a Level 1 assessment, this stage will assign each fishing activity with an indicative risk rating representing the risk posed to each ecological component. These scores will then be use to assign each ecological component with a preliminary risk rating based on the highest risk score within the profile. In the Level 1 ERA, these preliminary risk scores will be used to identify the low-risk elements in each fishery.

4. *Likelihood* – a secondary evaluation of the key factors underpinning the 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 was included in recognition of the fact that preliminary scores (see *Risk Characterisation*) may overestimate the level of risk for some ecological components.

5. *Issues Arising* – examines the assigned risk levels and the issues or characteristics that contributed to the overall classifications.

The above framework differs slightly 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 under the current management arrangements 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 to differentiate between **actual** and **potential** high risks. This aligns with the objectives of *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018a) and helps limit the extent of 'false positives' or the misclassification of low risk elements as high risk.

While viewed as a higher-level assessment, the Level 1 ERA provides important information on activities driving risk in a fishery, the ecological components at risk and areas within the fisheries management system that contribute to the risk of an undesirable event occurring. Level 1 assessments will be undertaken for all ecological components including marine habitats and ecosystem processes which have the least amount of available data. These results will be used to

inform the Level 2 assessments and refine the scope of subsequent ERAs. Level 2 assessments will focus specifically on the ecological subcomponents including key species and species groupings.

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

4 Whole of Fishery Qualitative Assessments

4.1 Risk context

As the Level 1 assessments are based at the whole of fishery level, the risk context has been purposely framed at a higher level. It also 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 Level 1 assessment has been defined as:

> *The potential for significant changes in the structural elements of the fishery or the likelihood that fishing activities in the East Coast Spanish Mackerel 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 that a fishery will deviate from these trends in the short to medium term. The reference to 'structural elements of a fishery' largely 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.

In order to frame the scope of the assessment, a 20-year period was assigned to all Level 1 assessments. That is, the likelihood that the one or more of the ecological components will experience an undesirable and unacceptable change over the next 20 years due to fishing activities in the ECSMF. In order to do this, the Level 1 assessment assumes that the management arrangements for the fishery will remain the same over this 20-year period. A 20-year timeframe has previously been used in ERAs involving the *East Coast Trawl Fishery* (Pears *et al.*, 2012; Jacobsen *et al.*, 2018) as is considered to be relatively precautionary.

While operators can access the commercial fishery using a range of line symbols (L1, L2, L3), they must hold an 'SM' symbol and Spanish mackerel quota. As SM symbol numbers are restricted, this will be the limiting factor with respect to accessing the ECSMF (Department of Agriculture and Fisheries, 2019b). These arrangements contrast with the pre-2003 or pre-quota period where anyone with an east coast line fishing symbol (*e.g.* L1, L2, L3 and L8) could target and retain Spanish mackerel for commercial sale. From an ERA perspective, this represented a far greater risk as the number of symbols able to access the fishery was much higher. Now, regardless of the number of L1, L2, L3 or L8 fishery symbols, participation rates will be limited by the number of SM symbols and

quota availability. Based on current licensing data, around 65% of the available SM symbols are operating in the ECSMF within a given season (Department of Agriculture and Fisheries, 2019b).

Outside of the commercial fishery, Spanish mackerel attracts a significant level of interest from the recreational and charter fishing sectors. These two sectors make a notable contribution to the overall rate of fishing mortality (Langstreth *et al.*, 2018) and will be a factor of significance when establishing a broader risk profile for this species (see *Fisheries Related Impacts*).

4.2 Risk Identification

Fishing activities are frequently subdivided into categories that identify the sources of risk or potential hazards (Astles *et al.*, 2009; Hobday *et al.*, 2011; Pears *et al.*, 2012). What constitutes a hazard can vary between ERAs and is often dependent on the specificity and scale of the assessment. For larger scale assessments, some of the more commonly used fishing activities 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* (Table 1). The fishing activities outlined in Table 1 will provide the foundation of the risk profiles and will be used to assign preliminary risk ratings to each ecological component (see *Risk Characterisation*).

In Queensland, 'cumulative fishing pressures' has also been identified as key source of risk (Table 1). Used as part of a Level 1 assessment, the term 'cumulative fishing pressures' will examine the risk posed by Queensland's other commercial fisheries and sectors outside of the commercial fishing industry. This parameter was included in the Level 1 assessment in recognition of the fact that a number of Queensland's fisheries have multiple fishing sectors (*e.g.* commercial, recreational, and charter). This means that the risk posed to some species may be higher than what is observed in the commercial fishing sector *e.g.* species that attract a high level of interest from the recreational fishing sector.

In addition to the cumulative fishing pressures, this section will include a secondary examination of the cumulative risks that exist outside the control of fisheries management. These factors often have a wide range of contributors, are generally more complex and at times unavoidable. As a consequence, it can be difficult to assign an accurate rating to these factors or to quantify how much of a contribution (if any) a fishery will make to this risk. The primary purpose of including these factors in the Level 1 assessment is to provide the ERA with further context on how fisheries-specific risks relate to external factors, broader risk factors that a fishery will contribute to (*e.g.* boat strike) and factors that have the potential to negatively impact on a fishery (*e.g.* climate change, the potential for urban development to affect recruitment rates).

The inclusion of cumulative impacts in the Level 1 assessment provides further context on factors that may contribute to an undesirable event. In a fisheries-based ERA it can be difficult to account for these impacts in the final risk ratings. The main reason for this is that it can be difficult to define the extent of these impacts or quantify the level of contribution they make to an overall risk; particularly in a whole-of-fishery assessment (*e.g.* the impact of recreational fishing/boating activities on SOCC subgroups). Given this, final risk ratings will concentrate on commercial fishing activities with cumulative impacts (when and where appropriate) identified as an additional source of risk *e.g.* for species targeted and retained by commercial, charter and recreational fishers. In the event that one or more of the ecological components are progressed to a Level 2 assessment than the cumulative impacts will be given additional considerations.

Unlike the fishing activities, ratings assigned to 'cumulative risks' will not be used in the determination of preliminary risk scores (see *Risk Characterisation*). The main reason for this is that the preliminary risk scores relate specifically to commercial fishing activities.

The following provides an overview of the key fishing activities / sources of risk in the ECSMF and for each of the respective ecological components. When and where appropriate the contributor of risk (*i.e.* the fishing activity) is also identified in the text.

Table 1*. Summary of the key fishing activities and their relation to risk. Table 1 is based on an extract from Pears et al. (2012). * 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 ecological subcomponents (species, habitats *etc.*) whilst deployed 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, ropes, floats *etc.*
Travel to/from fishing 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.*

4.2.1 Whole of fishery

Harvesting and **discarding** are considered the greatest contributors of risk in the commercial fishery, with **contact without capture** viewed as a secondary factor of influence. While **loss of fishing gear** has been identified as a risk in other line fisheries (Jacobsen *et al.*, 2019a; b), it is not as relevant in the ECSMF as trolling (*i.e.* towing of line closer to the water surface) is the primary method used in this fishery. Given the size of the commercial sector, there is a possibility that **travel to/from fishing grounds**, **disturbance due to presence in the area**, and **boat maintenance and emissions** will contribute to overall risk levels.

The distribution of line effort along the Queensland coastline is largely restricted through symbol boundaries. The L1 symbol restricted to water south of 24°30´S with the L2 and L3 operating in waters north of this boundary. As the majority effort is reported from northern and central Queensland, fishing activities under the L2 and L3 fishery symbols will be the biggest contributor of risk for this fishery (Department of Agriculture and Fisheries, 2019b).

4.2.2 Ecological subcomponents

Target (harvested)

Spanish mackerel are targeted by trolling or the towing of lures and baited lines behind the vessel and near the surface of the water. As it is a single species fishery, the ECSMF does not have a byproduct component, although a number of other species may be retained when targeting Spanish mackerel *e.g.* other mackerels, sharks. As these species form part of the broader *East Coast Inshore Fin Fish Fishery* (ECIFFF) they will not be assessed as part of the ECSMF Level 1 ERA.

In the commercial Spanish mackerel fishery, the risk of overexploitation is managed through a Total Allowable Commercial Catch Limit (TACC) and the use of Individual Transferable Quotas (ITQ). The TACC limit is currently set at ~578t and providing it is set at an acceptable level, provides the commercial fishery with considerable scope to management stock sustainability. With that said, the TACC limit does not take into consideration catch retained by the recreational and charter fishing sectors.

While the recreational and charter fishing sectors are not accounted for in the TACC, they have been included in the latest Spanish mackerel stock assessment (O'Neill *et al.*, 2018). Incorporating data (recreational and commercial) from New South Wales and Queensland, outputs from this assessment indicate that Spanish mackerel stocks were at 30–50 per cent of their original biomass.[1] Based on these results, it was determined that a) the east coast Spanish mackerel stock was being fished at or around the Maximum Sustainable Yield (MSY) and b) harvest levels were within sustainable limits (O'Neill *et al.*, 2018). However, the report also recognised that current rates of fishing mortality were not conducive to improving stock biomass and/or to meeting objectives outlined in the *Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; O'Neill *et al.*, 2018).

From an ERA perspective, the results of the Spanish mackerel stock assessment are important as they indicate that the risk of overfishing is currently being managed. However, quota usage data for the fishery suggests that this risk is primarily managed by economic constraints and market demand. For example, logbook data for the ECSMF indicates that the commercial sector retains around 250–300t of Spanish mackerel each season or around 50% of the prescribed 578t TACC (**harvesting**) (Department of Agriculture and Fisheries, 2019b). If market demand for Spanish mackerel were to increase, than there is considerable capacity within the current TACC for the annual catch to increase. As the east coast Spanish mackerel stock is already being fished at MSY, this is considered to be one of the more significant risks for this fishery. The greatest risk being that the rate of fishing mortality increases to a point that it exceeds that required to maintain stock biomass at an acceptable level.

[1] *Original biomass estimates refer to the start of the fishery in 1911. Additional information available from O'Neil et al (2018).*

Steps are being taken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* to improve the responsiveness of the TACC setting process and minimise the overexploitation risk for Spanish mackerel. On 1 September 2019, new fishing regulations commenced for a range of fisheries including the ECSMF. One of the more significant changes for this fishery relates to the Spanish mackerel TACC and how it is defined in the legislation. Historically, the total quota entitlement for Spanish mackerel was defined in the *Fisheries Regulation 2008*. The *Fisheries Regulations 2008* has now been replaced with the *Fisheries (Commercial Fisheries) Regulation 2019* and the *Fisheries Declaration 2019*. As part of this process, provisions setting the annual Spanish mackerel quota were moved to a third piece of legislation: *Fisheries Quota Declaration 2019*.

While above changes are largely procedural, it improves the responsiveness of the Spanish mackerel TACC setting processes. To this extent, the new arrangements provide the TACC with the flexibility needed to address changing trends and stock signals (positive or negative) or account for new information. Going forward, this will allow the fishery to develop harvest strategies that are more responsive and have greater capacity to manage stocks against key targets and biomass reference points. These initiatives though will take time to develop and implement effectively on the Queensland east coast.

Unlike the *Coral Reef Fin Fish Fishery* (CRFFF), the management regime for the ECSMF does not contain spatial or temporal closures to protect spawning aggregations. An absence of protections for spawning Spanish mackerel means that operators can increase their catch through the targeting of aggregations. This type of fishing increases the risk of an overfishing event being disguised due to catch hyperstability (Erisman *et al.*, 2011; Erisman *et al.*, 2017); something line caught Spanish mackerel are vulnerable to (Tobin *et al.*, 2013; Buckley *et al.*, 2017). Historical data show that some Spanish mackerel spawning aggregations have become extirpated and others have reduced in size and frequency (Tobin *et al.*, 2014; Buckley *et al.*, 2017). In 2016/17, around 48% of the commercial catch was taken from important spawning grounds off the coast of Townsville, during spawning season (Department of Agriculture and Fisheries, 2018c; Langstreth *et al.*, 2018). These types of fishing activities have the potential to impact on long-term recruitment rates; therefore presents as a longer-term sustainability risk.

Discarding of Spanish mackerel will be due to regulations that prohibit their retention or poor marketability/quality (*e.g.* injured or damaged fish). While evidence suggests that commercial operators can improve size selectivity through the use of alternate gear/bait types and the targeting of larger fish in key locations (Roelofs, 2004), a portion of the fish will be **discarded** due to minimum legal size limits. As pelagic schooling fin fish tend to have lower post release survival rates (Davis, 2002; Broadhurst *et al.*, 2005; Campbell *et al.*, 2010), a proportion of the **discarded** Spanish mackerel will die as a result of this interaction. These mortalities are not included in the catch data and are difficult to quantify or account for in regional stock assessments. Other factors that may contribute to the level of discards in the ECSMF include health concerns surrounding the presence of ciguatera in older/larger fish (Food and Agriculture Organization, 2004; Kohli *et al.*, 2017) and as a result of injuries sustained during the fishing event including shark depredation.

Contact without capture in the ECSMF applies to fish that have been able to free themselves before landing (*e.g.* foul-hooks, line breaks, and hook dislodgement) and those that are lost due to depredation. While difficult to quantify, it is anticipated that post interaction survival rates will be higher for fish that have escaped the hook before landing. This in part is due to the fish (theoretically)

experiencing a shorter fishing event. There may however be longer term implications for the health of the animal such as an increased risk of predation due to injury, the impacts of biofouling and infections (Borucinska *et al.*, 2002; McLeay *et al.*, 2002). On the other end of the spectrum, depredation occurs when injured and panicked fish attract the attention of larger predators (*e.g.* sharks and dolphins) who take advantage of the tethered prey (Zollett & Read, 2006; Mitchell *et al.*, 2018). Depredation compounds fishing mortality rates and presents a risk to both the fishery and to the predators that interact with the apparatus (Department of Primary Industries and Fisheries, 2005; Raby *et al.*, 2014; Mitchell *et al.*, 2018). As with post-release mortalities, fish lost to depredation are not included in the catch data and are not accounted for in stock assessments. This phenomena may also lead to **lost fishing gear** and can impact on profitability of fishing operations. For the predators, there is risk that they will also become hooked and sustain injuries or mortalities.

As with most fisheries, there is a degree of risk associated with illegal fishing, non-reporting of product (black markets), inaccurate reports of catch weights and or non-compliance with input or output controls such as minimum legal size and in-possession limits (Department of Agriculture and Fisheries, 2019b). As it is, illegal and unreported fishing activities are frequently identified as some of the biggest risks to sustainable fisheries management (Mapstone *et al.*, 1997; Williamson *et al.*, 2015). Compliance issues in this fishery include recreational fishers taking fish for commercial purposes; retaining Spanish mackerel without appropriate symbols; possessing undersized fish; inaccurate logbook records; and failing to give prior notice (Scott-Holland, 2011). These types of illegal fishing activities have the potential to mask the true extent of the fishing mortality experienced by some species (**harvesting**). In Queensland, this risk is managed through the Queensland Boating and Fisheries Patrol (QBFP) who continue to enforce the current regulations across all fishing sectors. The ability of QBFP to manage some of these risks (*e.g.* fishing in regulated waters) will improve overtime with the continued implementation of the data validation plan, the introduction of *Vessel Tracking* and recreational boat limits for priority black market species including Spanish mackerel (Department of Agriculture and Fisheries, 2018e; f; 2019c).

Outside of **harvesting** and **discarding**, few of the fishing activities will have a significant impact on the target species ecological component. As the ECSMF targets pelagic fin fish via trolling, there is a low risk of gear being lost due to snags on structural features or the substrate (**loss of fishing gear**). Accordingly, the most likely origin for gear loss will be line breakages (**contact without capture**) or poor disposal practices. **Disturbance due to presence in the area** can also be applied to trolling and the risk will be applicable to both the primary vessel and any associated tenders. While these fishing activities will create sound and surface disturbance, the extent of these risks are likely to be low, short term and localised.

Bycatch (non-SOCC)

For the purposes of this ERA, bycatch is deemed as any species landed by an operator that is returned to the water or legally retainable fish that are managed under another fishery. Traditionally, the definition of bycatch also includes target species that cannot be retained for sale and fish that have been discarded due to poor quality or health concerns. In the Level 1 ERA, the return of undersized/damaged Spanish mackerel to the water are considered under the *Target (harvested)* ecological component.

In the ECSMF, operators will catch and retain a number of incidentally caught species including shark mackerel, cobia, trevally, barracuda, mackerel tuna, spotted mackerel, school mackerel, snapper and

regulated coral reef fin fish (Department of Primary Industries and Fisheries, 2005). These species are managed as part of the *Rocky Reef Fin Fish Fishery* (RRFFF), *East Coast Inshore Fin Fish Fishery* (ECIFFF) or the *Coral Reef Fin Fish Fishery* (CRFFF). When and where appropriate fishing related risks for these species will be assessed as part of the Level 1 ERA for these fisheries.

The remainder of the non-target bycatch will mostly consist of undersized Spanish, school and spotted mackerel, undersized coral reef fin fish, mackerel tuna, trevally, barracuda, northern blue fin tuna, yellowfin tuna, marlin, wahoo, shark, leaping bonito, remora and, for operators without RQ quota, regulated coral reef fin fish (Department of Primary Industries and Fisheries, 2005).

Species of Conservation Concern

Being a largely pelagic line fishery, the ECSMF will not interact with a number of the subgroups included in the *Species of Conservation Concern* (SOCC) ecological component. As the majority of the SOCC cannot be retained for sale, **discarding** and **contact without capture** poses the most risk to these species. The risk of an interaction resulting in serious injury or death will be highly dependent on the species and the type of interaction, *i.e.* vessel strike, catching on fishing gear. This is considered to be of notable importance in the ECSMF as the SOCI logbook data does not distinguish between interactions with gear and collisions.

Marine turtles

While some marine turtle species take baited hooks (*e.g.* loggerhead turtles), their direct capture in the ECSMF is considered unlikely. Trolling offers few opportunities for marine turtles to take baited lines as lures/hooks are towed behind the vessel and near the surface of the water. This inference is supported by the SOCI and FOP data which shows that only one marine turtle interaction has been recorded form the fishery since the introduction of quota (Department of Agriculture and Fisheries, 2019b). In the unlikely event that a marine turtle was caught or foul-hooked, the operator will be on hand to release the animal and minimise the interaction period.

Indirect impacts including those associated with entanglements arguably presents as a higher risk for this subgroup. Entanglements can occur in line not associated with a fishing event (*e.g.* line that has been lost, cut off, or discarded during a previous fishing event) or resulting from capture (*e.g.* line that is still attached to a hook embedded or swallowed by the animal) (**contact without capture, loss of fishing gear**). The negative consequences of line entanglement is often long-term and can include death due to asphyxiation, increased predation risk due to impairment or loss of an appendage (Meager & Limpus, 2012). In some instances, the impacts may be more immediate and prevent the animal from reaching the surface *e.g.* if opposite end is attached caught in the substrate.

As lures and baited hooks are towed behind the vessel and nearer the surface of the water, there is a low risk that the line will become entangled to the point that it is not retrievable and/or becomes lost. In the ECSMF, the most likely source of gear loss will be due to line breakages that occur during the fish retrieval process. This is considered to be less of a risk in pelagic line fisheries as operators tend to use gear configurations with higher breaking strains. Accordingly, the ECSMF is expected to make a smaller contribution to the amount of fishing line that is lost or discarded on the Queensland east coast.

As air breathing marine animals with habitat ranges that overlap with key fishing areas (Department of Agriculture and Fisheries, 2019e), marine turtles are at risk of colliding with vessels engaged in troll

fishing activities (**disturbance due to presence in the area, contact without capture**). While trolling is carried out at low speeds, low speed (7km/h) collisions can still inflict fatal injuries (Work *et al.*, 2010). Vessel strike is one of the leading anthropogenic causes of turtle strandings according to the *Marine Wildlife Standing and Mortality Database* with as many as 126 dead or injured turtles recorded per year on Queensland's coastlines (based on 2000-2011 data; Department of Environment and Heritage Protection, 2017).

When the above factors are taken into consideration, the ECSMF is considered to be a contributor of risk to this subgroup *verse* the main driver of risk. The fishery will experience lower hooking/entanglement rates and has a lower interaction potential. Accordingly, this subgroup is expected to be at the lower end of the risk spectrum.

Crocodiles

Interactions between crocodiles and operators in the ECSMF are unlikely and the fishery does not present risk to this subgroup.

Dugongs

The risk profile for dugongs will be similar to that observed for marine turtles, with vessel activity being the primary driver of risk in this fishery. Trolling is likely to create a **disturbance due to presence in the area**, and increase the likelihood of boat strike (**contact without capture**). However, the habitat distribution of dugongs does not spatially overlap with the target fishery (*i.e.* pelagic waters close to reefs as opposed to seagrass meadows) and the likelihood of an interaction occurring is considered to be extremely low.

Cetaceans

A previous bycatch report for the ECSMF included two cetacean interactions involving a pilot whale and a dolphin. In both instances, the animal made contact with the fishing apparatus (hooked/entanglement) and was released alive (Department of Primary Industries and Fisheries, 2005). Given the nature of the gear and the relative size of dolphins/whales, the immediate consequences of this type of interaction would be limited.

The ECSMF bycatch report also recognised that vessel strike may be a factor for this subgroup (Department of Primary Industries and Fisheries, 2005). In this instance, seasonal and individual species distributions are one of the controlling factors for determining impacts of the fishery on cetacean populations. For example, baleen whales (*i.e.* humpbacks, minkes) migrate to tropical waters in the Great Barrier Reef during winter to calve and mate (Acevedo *et al.*, 2013). As air breathing mammals, cetaceans must spend a portion of their time at the surface, rendering them susceptible to boat-strike (**contact without capture**). In regards to direct fishing impacts, given the nature of the gear and the relative size of dolphins/whales, the immediate consequences would be limited.

While noting the above, this subgroup is expected to be at the lower end of the risk spectrum due to the target species and the fishing methods being employed.

Sea snakes

There are no records of sea snakes interacting with the ECSMF but the spatial distribution of operations targeting Spanish mackerel will overlap with their preferred habitats. Sea snakes will take

baited lines and their capture has been recorded in the recreational fishing survey (Webley *et al.*, 2015), but given the fishing methods used (*i.e.* trolling) the number of interactions are expected to be low to negligible.

Protected teleosts

There are four species of teleost with SOCI reporting requirements. All are no-take species in Queensland, with the humphead Maori wrasse (*Cheilinus undulatus*) listed as endangered on the IUCN redlist; potato rockcod (*Epinephelus tukula*) listed as least concern; and the Queensland groper (*Epinephelus lanceolatus*) and barramundi cod (*Chromileptes altivelis*) both listed as vulnerable.

Only three interactions with protected teleosts have been reported in this fishery. In all three instances, interactions were with fishers using handlines rather than trolling. Due to their demersal habitats and behaviours (*i.e.* ambush predators), trolling presents limited opportunities to interact with this subgroup of species. Accordingly, fishing activities in the ECSMF will pose a low risk to protected teleosts.

Sharks

A previous report on bycatch and byproduct in the ECSMF identified several species of shark that interact infrequently with the fishery including reef sharks and whalers. These interactions most commonly involved depredation of Spanish mackerel rather than direct hooking (Department of Primary Industries and Fisheries, 2005). In some instances, operators will retain sharks that are caught while in the process of targeting Spanish mackerel. The volume of shark product retained by these operators is relatively small with around 0.5t reported by dedicated Spanish mackerel fishers since 2014/15. As sharks are managed as part of the ECIFFF, the risk posed to this subgroup was assessed as part of the Level 1 ERA for this fishery (Department of Agriculture and Fisheries, 2019a; Jacobsen *et al.*, 2019c).

The ECSMF has the potential to interact with a range of shark species with **contact without capture** considered to be the primary source of risk followed by **discarding**. Anecdotal evidence suggests sharks will target Spanish mackerel operations and prey on hooked fish being angled to the surface. If handled correctly, post-release survival rates for **discarded** line-caught sharks will be high. However, mortalities may still occur in this fishery due to injuries incurred during the fishing event, due to poor handling techniques (*e.g.* use of a gaff, injuring the shark during the gear retrieval process) and long-term hook retention (Bansemer & Bennett, 2010). The extent of these mortalities or injuries (frequent/infrequent) will be difficult to quantify without additional catch validation measures and further information on the fate of line caught sharks (*e.g.* number of sharks retained, discarded: line cut, discarded: injured).

Of the shark species with additional protections, few will interact with the ECSMF. The white tip reef shark (*Triaenodon obesus*) and the short fin mako (*Isurus oxyrinchus*) may interact infrequently with the fishery *e.g.* depredation, direct capture.[2] The extent and frequency of these interactions are not expected to impact on their long-term conservation status. As trolling for Spanish mackerel is permitted in the Great Sandy Marine Park Grey Nurse Shark buffer zone, this species may also interact with this fishery. This inference is supported by regional research showing Grey Nurse Sharks

[2] The white tip reef shark (Triaenodon obesus) which, while not fully protected, are subject to an in-possession limit of one and maximum size length restrictions. The short fin mako (Isurus oxyrinchus) is classified as a migratory species; therefore is afforded full protection in the Great Barrier Reef Marine Park.

(*Carcharias taurus*) with trolling gear attached (Bansemer & Bennett, 2010; Robbins *et al.*, 2013). It is important to note though that the origin of the gear (*e.g.* commercial or recreational) and/or the legality of the operation cannot be verified without direct observation.

At a whole-of-fishery level, the ECSMF will present a lower risk to the shark subgroup. A high proportion of the observed interactions will be due to depredation and post interaction survival rates for this subgroup will be higher. There is a risk that the animal will incur injuries during the fishing event and/or due to long-term hook retention. The fishery though is not expected to be a major driver of risk for these species.

Batoids

The ECSMF has the potential to interact with a small number of batoids associated with reef systems, including those afforded additional protections under state and Commonwealth legislation; namely manta and devil rays (*Mobula* spp.).[3] These species are pelagic, spending a significant amount of time near the surface and, although migratory, are common on coral reefs (Last & Stevens, 2009; Last *et al.*, 2016). Line entanglements and foul hooking can be common for these species, particularly for *Mobula* spp., despite their pelagic habitats (Deakos *et al.*, 2011; Couturier *et al.*, 2012). The frequency of these types of interactions in the ECSMF though are expected to be low and infrequent.

Syngnathids

Interactions syngnathids and operators in the ECSMF are unlikely and the fishery does not present risk to this subgroup.

Seabirds

A report on bycatch in the ECSMF identified low interaction rates with this subgroup (Department of Primary Industries and Fisheries, 2005). These interactions mostly involved entanglements rather than hooking and the presence of the fisher helped minimise the duration of the interaction and the risk of injury.

Trolling operations have the greatest potential to interact with this subgroup as the bait/lure is towed closer to the water surface. This increases the interaction potential as sea birds can access the bait during the fishing event. While noting these risks, data from the ECSMF suggests that sea bird interactions are very low. However, it will be difficult to quantify the extent of these interactions (*i.e.* none, very rare, infrequent or frequent) and the level of risk (*i.e.* negligible, low, intermediate, high) without further validation of the SOCI data.

When compared to direct capture, entanglement in lost or discarded fishing line (**loss of fishing gear**) presents as a higher risk for this subgroup. This risk transcends the ECSMF and will be applicable to both the commercial and recreational fishing sectors. As the recreational fishery uses lighter gear and has varying levels of experience, this sector will make a significant contribution to the

[3] The Fisheries Declaration 2019 affords full protection to 'Manta ray' species. A recent review of the Family Mobulidae (devilrays) reclassified the genus 'manta' as a synonym of the genus 'Mobula' (Last et al., 2016). The intent of the legislation though still applies and affords full protection to the reef manta (Mobula alfredi, formally Manta alfredi) and the giant manta ray (Mobula birostris, formally Manta birostris).

In 2016 the Pygmy devilray (Mobula eregoodootenkee)[3], the Japanese devilray (M. japonica)[3] and the Bentfin devilray (M. thurstoni) were classified as migratory species under the EPBC Act 1999. This classification resulted in all three being afforded full protection in the GBRMP. These however are not protected under the Fisheries Declaration 2019.

amount of lost and discarded fishing line. To this extent, the risks posed by **loss of fishing gear** are anticipated to be lower in the commercial ECSMF.

Terrestrial mammals

The false water rat *Xeromys myoides* is a small native mammal that has a semi-aquatic lifestyle. Interactions between operators and this species are unlikely and the fishery does not present risk to this subgroup.

Marine Habitats

While there is potential for this fishery to have an impact on regional marine habitats, it will be small when compared to other fishing methods such as net or trawl. This is primarily due to trolling being the primary fishing method used in the ECSMF and the reduced potential for operators to interact directly with regional habitats during a fishing event. There may however be ancillary impacts relating to general boating activities such as anchoring. Despite these impacts, the marine habitat ecological component will be at the lower end of the risk spectrum for this fishery.

Ecosystem Processes

Fishing activities in the ECSMF are not expected to pose a significant risk to ecosystem processes on the east coast of Queensland. Of the ecosystem processes taken into consideration (Appendix 1), the most significant risks will be associated with the secondary impacts on key recruitment processes, the effects of depredation and facilitated foraging.

As previously stated, Spanish mackerel aggregations are targeted within this fishery and account for a significant proportion of the total catch (Tobin *et al.*, 2014; Buckley *et al.*, 2017). Spawning aggregations are productivity hotspots that support ecosystem health. Many particle feeding species utilise the temporary surplus of spawned eggs as a food source while predatory species can feed on the aggregating fish (Erisman *et al.*, 2017). At least one significant Spanish mackerel spawning aggregation has been extirpated in Queensland (Buckley *et al.*, 2017). The loss of spawning aggregations have previously resulted in declines of ecosystem health for many species worldwide (de Mitcheson, 2016).

East coast Spanish mackerel undertake predictable migrations for spawning, which allow fishers to accurately predict and target schools in transit. This targeting of aggregations and along migration routes has the potential to disrupt movement through seascapes. However, there is little information regarding the impacts of this fishing on the connectivity of this species.

No-take zones work as a connected network to replenish stocks across the ecosystem. One of the primary aims of a no-take zone is to protect a portion of the breeding stock from the effects of fishing. When functioning effectively, these zones allow individuals to mate multiple times and therefore help facilitate recruitment back into fishing regions (Harrison *et al.*, 2012). When reserves are highly fragmented or fisher non-compliance is more than minimal, their efficacy for replenishing the population through recruitment is markedly diminished (Little *et al.*, 2005). Similarly, the effectiveness of measures designed to maintain or improve recruitment rates may be undermined by the absence of measures to protect spawning aggregations (de Mitcheson, 2016; Erisman *et al.*, 2017)**.**

Spanish mackerel are a high order pelagic predator and occupy this niche with several other predators (sharks, tuna *etc.*). Theoretically, the removal of predators from an ecosystem can affect

prey abundance and induce trophic cascades. These effects have not been demonstrated for Spanish mackerel and it is unknown if Spanish mackerel removal though fishing activities could result in regional trophic shifts.

East coast Spanish mackerel operators report frequent depredation of hooked fish by sharks. A recent study suggested sharks are attracted to the sensory cues emitted by fishing activity, and that sharks may form behavioural associations with fishing vessels causing increased depredation in higher traffic fishing areas (Mitchell *et al.*, 2018). It has also been suggested that dolphins form behavioural associations with trolling activities targeting mackerel species (Zollett & Read, 2006). These interactions likely form an energetically efficient method of feeding but increase the risk of hooking or entanglement (Zollett & Read, 2006; Waples *et al.*, 2013) and may result in behavioural changes (Madigan *et al.*, 2015; Mitchell *et al.*, 2018).

Large pelagic predatory fish have a symbiotic relationship with tropical seabirds, whereby foraging activity of seabirds is greatly enhanced by the presence of sub-surface predators (Miller *et al.*, 2018). Spanish mackerel, amongst other species, contribute to this relationship (*pers. comm.* B. Congdon). Although there is little information regarding the level on interdependence within this relationship and whether large scale depletions of Spanish mackerel would result in reduced seabird foraging success.

4.3 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 (DAF). 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 secondary cumulative risks category, *External Risks*, recognises that there are factors outside the control of DAF that have the potential to contribute to an undesirable event occurring 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. Of those that are identified, fishing activities are considered to be a contributing factor but are unlikely to be the primary source of risk and/or cannot simply be resolved through a fisheries context *e.g.* climate change.

External Risks are addressed in Queensland through a wide variety of forums and by various departments. Given the wide-ranging nature of these risks, they will not be addressed directly within Queensland's ERA framework. They have however been included in the Level 1 assessment as they have the potential to either impact on fishery (*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.

4.3.1 Fisheries Related Impacts

Other Fisheries

Spanish mackerel is one of the most valued recreational fish species and attracts a significant level of effort from this sector. While recreational fishers are subject to individual limits, catch reporting is not mandatory and the level of information for this sector is fragmented. The species is included in a routine monitoring program that collects biological information (length, sex and age) from recreationally and commercially caught Spanish mackerel (Department of Agriculture and Fisheries, 2018d). However, the majority of the available information on the recreational fishing sector comes from infrequent voluntary recreational fisher surveys (Webley *et al.*, 2015).

Estimates on the recreational catch of Spanish mackerel suggest that the sector is responsible for a significant proportion of the total fishing mortality. The 2013/14 recreational fishers' survey estimates that 55,000 Spanish mackerel were caught in this sector with approximately 40% being discarded (**harvesting, discarding;** Webley *et al.*, 2009). Subsequent estimates have placed the recreational catch at 211t in Queensland waters (*vs.* 267t in the commercial ECSMF) and 26t in New South Wales (*vs.* 6t of commercial product) (Langstreth *et al.*, 2018). The popularity of the species carries over to the charter fishing sector where the reported catch regularly exceeds 20t (Department of Agriculture and Fisheries, 2019f). In both instances fishers are able to target spawning aggregations and are likely to experience shark depredation (**contact without capture**).

With high catch and discard rates for both the recreational and charter fishing sectors, the risk of overfishing due to unquantified fishing mortality is amplified. This is of particular relevance to the ECSMF where the stock assessment suggests that the fishery (commercial and recreational) is already operating at or near MSY (O'Neill *et al.*, 2018). These risks will be compounded by the existence of illegal fishing activities and the black-marketing of saleable product. While quantifying the level of non-compliance is difficult, this risk was considered sufficient enough for Spanish mackerel to be included in new regulations that impose recreational boats limits on nine priority black market species (Department of Agriculture and Fisheries, 2018e; f; 2019c).

Outside of the recreational fishing sector, the Spanish mackerel stock may incur additional mortalities resulting from interactions with other commercial fisheries. In Queensland, Spanish mackerel cannot be retained by commercial fishers unless they have an SM symbol, hold quota and are utilising a line apparatus. However, Spanish mackerel are known to be caught incidentally in nets by the ECIFFF operators when targeting grey mackerel. Net caught Spanish mackerel have poorer post release survival rates and are unlikely to survive the fishing event. The capture of Spanish mackerel in nets may also present as a compliance risk for this species *e.g.* black marketing of product. Both of these factors will contribute to fishing mortality rates on the Queensland east coast; therefore have the potential to contribute to the cumulative fishing pressures.

Spanish mackerel distributions are not restricted to Queensland governed waters and the stock extends into New South Wales. The situation in New South Wales is similar to Queensland with the Species considered to be fully fished within the State (Department of Primary Industries, 2017).

Despite this, the collective east coast Spanish mackerel stock is considered to be sustainable (Langstreth *et al.*, 2018). This situation may change if catch and effort increases across sectors, within Queensland and/or in New South Wales.

Risks relating to the harvest of Spanish mackerel by Aboriginal peoples and Torres Strait Islander peoples is more difficult to assess as there is less information on catch and effort rates. Gear restrictions for aspects of the fishery may be less stringent and take into account the importance of traditional fishing rights. Catch and effort rates for this sector have yet to be quantified and the level of overlap with the ECSMF is relatively unknown. At a whole of fishery level, catch and effort from Aboriginal peoples and Torres Strait Islander peoples will (most likely) present a lower risk for a number of the ecological components including harvest species, bycatch and marine habitats because of low numbers. This risk though will be highly dependent on the species and their significance to this sector.

4.3.2 External Impacts

Boat Strike

The effects of vessel use are generally similar regardless whether they are used for commercial or recreational fishing, or other forms of recreational use. Therefore, despite the direct impacts being relatively low for ECSMF, these impacts, when analysed in context of the all vessel activity throughout reef, may be a higher risk than initially perceived.

For most air-breathing species, the general probability of boats strikes is low, but become more likely depending on habitat use and vessel traffic. For turtles, interactions are more likely in internesting habitats and whilst travelling through shallow coastal foraging area to/from the fishery (United Nations Environment Program, 2014). Dugongs, too, are 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, 2017). Fishing activities (commercial and recreational) have the potential to contribute to this risk. With that said, the issue of boat strike mortalities is much larger than fisheries (commercial and recreational) with a wide range of recreational and commercial services contributing to this risk. It is for this reason that this risk will be difficult to assess and quantify in a fishing environment.

Marine Debris & Pollutants

Discarded and lost fishing gear from both commercial and recreational fishing is abundant in the marine environment. Nylon fishing mesh is extremely persistent in the marine environment. Plastic marine debris is a significant problem for the health of marine environments, through the degradation of habitats, ingestion by organisms and entangling marine life. In addition to fishing activities, plastic debris originates from tourism, both land and sea based, land based runoff and shipping (Bergmann *et al.*, 2015). Discarded fishing line, and other plastic debris, will degrade into microplastics, which are easily ingested by many species, including species harvested for human consumption (Kroon *et al.*, 2018). These microplastics are highly mobile and able to interact with species from all trophic levels (Bergmann *et al.*, 2015).

Discharge of garbage from a marine vessel is illegal in all Australian waters. However, boating causes the discharge of a number of pollutants. The major pollution sources associated with recreational and small to medium fishing vessels is fuel and oil. Antifouling paints, exhaust fumes including greenhouse gases and Polycyclic Aromatic Hydrocarbons (PAHs), and heavy metals are also released into the marine environment through boating activities (Burgin & Hardiman, 2011). Many of these pollutants are bioaccumulative, *i.e.* they build up in the environment due to their persistence. Discarding and loss of fishing related debris also occur in this fishery. This includes both deliberate and incidental release. Aside from lost fishing gear, the most significant sources of fishing related marine debris are bait bags, cigarette butts, and food packaging (Byrnes *et al.*, 2016).

The ECSMF is likely to represent a comparatively small, but consistent source of marine pollution. These risks are very difficult to quantify and almost impossible to assign to a particular sector or activity, due to the multifaceted sources of this risk. For example, marine pollutants can be sourced from land based runoff and boat emissions, from not only fishers but also recreational boat users and commercial shipping as well. Marine pollutants and emissions present a somewhat unique situation in that they are a risk to the fishery whilst risk is simultaneously increased by fishing activity.

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 and frequency 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 bleaching and die-offs of coral, mangroves and seagrass (Hoegh-Guldberg *et al.*, 2007; Duke *et al.*, 2017; Arias-Ortiz *et al.*, 2018), which are critical spawning (*e.g.* coral trout; Russell, 2001) and nursery grounds (*e.g.* prey; Manson *et al.*, 2005) for many species.

Changes in temperature and oceanic chemistry have been seen to affect physiology, growth and reproduction of fisheries species as well as the primary production that many of these 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 (Hoegh-Guldberg *et al.*, 2007; Godbold & Calosi; Hoegh-Guldberg *et al.*, 2017). Increased carbon dioxide in the atmosphere decreases the pH of seawater, 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. Globally fisheries are 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).

Within the GBR, this effect is already inducing large-scale coral bleaching events, with the most recent occurring in 2017. Sea level rise, increased frequency and severity of extreme weather events and changed oceanic currents also have the potential to degrade the quality and resilience of the GBR ecosystems (Great Barrier Reef Marine Park Authority, 2014).

A recent review on US fish and crustacean species examine the relationship between climate change and Atlantic Spanish mackerel (*Scomberomorus maculatus*). This species was proposed to increase in abundance and distribution under climate change scenarios due to their positive relationship with warmer sea temperatures (Hare *et al.*, 2016). The distribution of narrow barred Spanish mackerel is also closely related with temperature (Buckworth *et al.*, 2007), enhanced climate change scenarios may facilitate an expansion into higher latitudes.

4.4 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 that represents the potential (low, Intermediate or high) for it to contribute to an undesirable event for each of the ecological components and SOCC subcomponents (Table 2). In doing so, the *Risk Characterisation* stage aims to identify the key sources of risk from each fishery in order 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 the fishery that are contributing to this risk.

The scores assigned to each ecological component (excluding Ecosystem Processes) and SOCC subcomponent are based on the issues raised during the *Risk Identification* process (refer section 4.2). To this extent, they take into consideration the 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. While the majority of SOCC are classified as bycatch they have been assessed as separate entities in recognition of their complex life histories. Risk scores assigned to ecosystem processes are based on the preliminary assessment (Appendix 1) and represent the maximum score assigned to that particular fishing activity.

Outputs of the *Risk Categorisation* stage, excluding *cumulative impacts*, were used to assign each ecological component 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; Appendix 2). These preliminary risk ratings are conservative in nature and provide the first opportunity to remove low risk elements from the assessment process. Scores assigned to the cumulative risks were not considered as the preliminary risk scores are only applicable to the commercial fishery. The cumulative impacts scores though provide insight into the potential for ancillary risks to impact each of the respective ecological components.

In line with above approach, preliminary assessments for the ECSMF indicated that fishing activates presented a negligible or low risk to at least thirteen of the ecological components or subcomponents (bycatch (non-SOCC), marine turtles, dugongs, cetaceans, sea snakes, crocodiles, protected teleosts, batoids, sharks, syngnathids, seabirds, terrestrial mammals and marine habitats). Only two of the ecological components had preliminary risk assessments greater than intermediate: target species (high) and ecosystem processes (intermediate/high) (Appendix 2).

A full account of the preliminary risk ratings, key considerations and risk factors have been provided in Appendix 2. However, the following provides a general overview of the key findings of the *Risk Characterisation* stage:

- Target species received higher risk ratings due to a) the fully fished status of the stock, b) the potential for catch and effort to increase through latent licencing and quota, c) inadequate overarching protections for spawning aggregations, and d) cumulative fishing pressures.
- Ecosystem processes received a higher risk rating due to the potential for the fishery to impact recruitment processes, the removal of predators from the system and the associated impacts. These impacts/risks are intimately linked with the exploitation of Spanish mackerel.
- Data on shark depredation of Spanish mackerel is limited, thus the risk for this component, both to the target species and to the sharks themselves, may be underestimated.

***Table 2**. Summary of risk scores for the East Coast Spanish Mackerel Fishery, including the impact of the main fishing activities on key ecological components.*

Ecological Component	Line 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**	**Preliminary Risk Rating**	**Cumulative impacts Other fisheries***
Target	H	I	I	-	-	L	L	H	H[#]
Bycatch (non-SOCC)	-	L	L	-	-	L	L	L	L
SOCC									
- *Marine turtles*	-	L	L	-	L	L	L	L	L
- *Dugongs*	-	-	-	-	L	-	-	L	L
- *Cetaceans*	-	L	L	-	L	L	L	L	L
- *Crocodiles*	-	-	-	-	-	-	-	-	-
- *Sea snakes*	-	-	-	-	-	L	L	L	L
- *Protected teleosts*	-	L	-	-	-	L	L	L	L
- *Sharks*	L	L	L	-	-	L	L	L	L
- *Batoids*	-	-	L	-	-	L	L	L	L
- *Syngnathids*	-	-	-	-	-	-	-	-	-
- *Seabirds*	-	L	L	-	-	L	L	L	L
- *Terr. mammals*	-	-	-	-	-	-	-	-	-
Marine Habitats	-	-	-	L	-	L	L	L	L
Ecosystem Processes	I/H	L	I	-	-	-	-	I/H	I

**Includes recreational, charter sector; ** includes boat strike en route, [#] includes all recreational line fishing activities i.e. on water and off water activities; inshore and offshore.*

4.5 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 of a risk. 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 effectively overestimate the level of risk posed to an ecological component or subcomponent. In other words, preliminary risk ratings compiled in the *Risk Characterisation* stage may represent a potential risk—something that is discussed at length in the *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018a).

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, 2018a).

In order to address the potential overestimation of risk for some ecological components, a secondary qualitative review of the preliminary risk ratings were undertaken. This review examined factors underpinning each assessment, their relevance to the current fishing environment and areas where this 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 in itself 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, 2017) and the available resources, this was considered to be an important and necessary step.

When mitigation measures and risk likelihood are given further consideration in the ECSMF, the risk ratings of three ecological components were reduced. The most notable of these were the downgrading of the risk rating for target species from high to intermediate/high and ecosystem processes from intermediate/high to Intermediate. Sea snakes were downgraded from low to negligible as they are unlikely to interact with the fishery (Table 3; Appendix 2).

The downgrading of the risk ratings were based on a number of factors including a) annual catch levels that show the commercial fishery is operating well below the Total Allowable Commercial Catch (TACC) limit, b) research demonstrating that Spanish mackerel stocks on the Queensland east coast are sustainable (O'Neill *et al.*, 2018) and c) data indicating that the fishery is unlikely to deviate significantly from long-term catch and effort trends (Department of Agriculture and Fisheries, 2019b). The ability for these ratings to be reduced further was limited by the potential for catch to increase beyond that needed to build stock biomass and the ability of fishers (commercial, recreational and charter) to target spawning aggregations. The remaining amendments involved ecological components that were assigned low risk ratings and had minimal contact with the fishery.

A summary of the key findings of the Level 1 ERA have been provided in Table 3. Additional information on the Level 1 risk ratings including key considerations of both the preliminary risks and mitigation measures has been provided in Appendix 2.

***Table 3**. Level 1 ratings for the ecological components and subcomponents interacting with the East Coast Spanish Mackerel Fishery taking into consideration the likelihood of the risk coming to fruition in the short to medium term.*

Ecological Component	Level 1 Risk Rating	Likelihood Considerations	Level 2 Required?
Target Species	Intermediate/ High	• Key species (Spanish mackerel) managed under a TACC limit and there is some capacity for the fishery to address changing fishing patterns. • Annual catch levels have remained below the TACC limit and data suggests the fishery will not deviate significantly from long term trends. • Stock assessment and indicative sustainability assessments indicate that the stock is being fished sustainably. • While the fishery is currently operating at MSY (O'Neill *et al.*, 2018), only half of the allocated quota is being used. Further, current rates of fishing mortality are unlikely to promote biomass increases. • As the stock is already being fished at MSY, increasing catch and effort across one or more of the sectors may have long-term implications for the sustainability of the stock (*e.g.* to meet increased market demand). • Spanish mackerel are still considered to be at risk due to a) the fully fished status of the stock, b) the potential for catch and effort to increase through latent licencing and quota, c) inadequate overarching protections for spawning aggregations, and d) cumulative fishing pressures. • Recent regulatory amendments provide the TACC setting process with greater flexibility. These changes though have yet to be incorporated into a broader harvest strategy for this species. • Species attracts a considerable level of attention from recreational and charter fishing sectors. Catch levels for these sectors (combined) are lower than but comparable to the commercial fishing sectors. • The use of a *Vessel Tracking* system in this fishery helps minimise some of the risks posed by non-compliance.	No - Risks to be addressed through the Harvest Strategy Framework

Ecological Component	Level 1 Risk Rating	Likelihood Considerations	Level 2 Required?
		This information will also help refine subsequent ERAs including assessments of fine-scale effort patterns.	
Bycatch (non-SOCC)	Low	• While information on bycatch is limited, risk is expected to be low. • As trolling (the primary line method) is specifically targeted at pelagic species, the fishery will interact with a smaller number of demersal fin fish species including non-targeted bycatch. • Bycatch in the ECSMF may include species that can be retained for sale in the RRFFF or the ECIFFF. • Future risk assessments (if applicable) would benefit from additional information on the species that are discarded and the amount of catch that is retained and sold in other fisheries.	No
Species of Conservation Concern (SOCC)			
Marine turtles	Low	• While the fishery overlaps with the distribution of a number of the marine turtle species, direct capture and entanglement in fishing line will be low. • Some marine turtle species have been known to take baited hooks. This is unlikely to occur when trolling for pelagic fin fish and this risk will be more relevant to demersal line fishing operations. • This subgroup is particularly susceptible to cumulative risks including lost fishing line (particularly from the recreational fishing sector), boat strikes and customary hunting.	No
Sea snakes	Negligible	• Fishery not a risk to this subgroup of species	No
Crocodiles	Negligible	• Fishery not a risk to this subgroup of species.	No
Dugongs	Low	• Low risk to this ecological component due to the species being targeted, the areas being fished and the fishing method being used. • This subgroup afforded additional protections from regional fishing pressures *e.g.* spatial closures protecting key habitats. • Cumulative risks including boat strike, habitat loss/degradation and interactions with other fisheries considered to be more significant.	No

Ecological Component	Level 1 Risk Rating	Likelihood Considerations	Level 2 Required?
		• Further management of risk not required for this SOCC subgroup.	
Cetaceans	Low	• Low risk to this ecological component due to the species being targeted, the areas being fished and the fishing method being used. • Contact without capture interactions are possible as species may interact with the vessel and targeting bait or captured fish (*i.e.* depredation*)*. Direct risks posed by line fishing including hooking and entanglements considered to be low. • Further management of risk not required for this SOCC subgroup.	No
Protected teleosts (SOCI only)	Low	• Risks will be lower given the fishing methods used and the low likelihood of capturing demersal species. • Cumulative risks including the impact of recreational and charter fishing will be a broader risk factor for this subgroup.	No
Batoids	Low	• Low likelihood of interactions occurring in this fishery given the fishing method. Interactions, if applicable, will be more applicable to pelagic species like manta rays and devil rays (*Family Mobulidae*). • Further management of risk not considered to be warranted at this point in time. • While electronic observation being considered for some fisheries, the feasibility and applicability of this method is still being determined.	No
Sharks	Low	• Higher interaction rates occurring in this fishery with **contact without capture** identified as the most notable risk (*e.g.* depredation). • Post-release survival rates expected to be high with these types of interactions providing good handling protocols are followed. • Direct interactions (**discarding**) are also likely but post-release survival will be high if best practice handling procedures are followed. • Fishery may interact with a small number of species that are afforded additional legislative protections. The extent	No

Ecological Component	Level 1 Risk Rating	Likelihood Considerations	Level 2 Required?
		of these interactions are unlikely to pose a significant or long-term risk.	
Syngnathids	Negligible	• Fishery not a risk to this subgroup of species.	No
Seabirds	Low	• Low potential for interactions to occur as bait is towed closer to the water surface and may be more accessible for some species. • In the event that a seabird becomes hooked or entangled in the line than operators at hand to rectify the situation. • Risk is further managed through restrictions on number of lines and hooks plus guides on best management and handling. • The collective risk associated with discarded line (*e.g.* commercial, recreational and charter fishing) considered to be more significant for this subgroup and may require further investigation *e.g.* outside the ERA framework.	No
Terrestrial mammal	Negligible	• Fishery not a risk to this subgroup of species.	No
Marine Habitats	Low	• Key risks to this ecological component relate to the loss of fishing gear and regional impacts associated with general boating activities. • These risks extends beyond the commercial fishery and will be equally applicable to the recreational fishing sector. • While best practice methods of anchoring and mooring have been developed and promoted, these risks are difficult to monitor across sectors. • Given the fishing methods used in the ECSMF, impacts on marine habitats are unlikely to be significant.	No
Ecosystem Processes	Intermediate	• Assessment has a high degree of uncertainty as impacts of an individual fishery are difficult to determine. • Impacts on ecosystem processes are intimately linked with the exploitation of Spanish mackerel and the role they play in the broader ecosystem. • Spanish mackerel stocks are currently being fished sustainably / within key sustainability reference points but the potential for catch and effort to increase in the future remains a driver of risk for marine ecosystems.	No

Ecological Component	Level 1 Risk Rating	Likelihood Considerations	Level 2 Required?
		• Effective management of the targeted stock will help to minimise the risk posed to regional ecosystem processes including the potential disruption of recruitment processes, predation. • Mitigation measures to protect aggregations and latent quota reductions would reduce the impact of the fishery on ecosystem processes.	

4.6 Issues Arising

Limited Spatial Protection for Biologically Important Areas

Over the past three quota years, catch from spawning grounds has contributed around 30-45% of the total catch. With any targeted fishing of aggregations, hyperstability or the maintenance of stable catch rates despite declining populations, becomes a risk. At present, the ECSMF have no designated spatial or temporal closures to protect spawning Spanish mackerel aggregations.

Based on the available data, there are seven key spawning reefs located in the Great Barrier Reef Marine Park. Four reefs are located in Habitat Protection Zones where trolling and line fishing are permitted, two are within Marine National Parks (no fishing), and one is in a Conservation Park Zone where trolling and limited line fishing are permitted. These zones offer limited protections for spawning Spanish mackerel and may not be adequate to ensure a resilient stock. Further spatial or temporal closures may be needed to ensure the fishery remains sustainable. These recommendations were also proposed in the recent Spanish mackerel stock assessment (O'Neill *et al.*, 2018).

Increased Catch / Underutilised Quota

According to the most recent stock assessment for Spanish mackerel, the east coast population is being fished at or near the MSY (O'Neill *et al.*, 2018). Over the past three seasons, the commercial sector has caught 50% of their quota leaving a considerable level of latency in the fishery. If the remaining 50% of quota were to be utilised then the biomass of the Spanish mackerel population may decline. This problem is compounded by the fact that Spanish mackerel is retained by commercial fisheries in New South Wales and is a popular recreational species.

While the fishery is considered to be sustainable, research indicates that biomass levels are unlikely to increase under the current arrangements. This means that the fishery is unlikely to move towards a point nearer to Maximum Economic Yield (MEY) and/or meet objectives outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017). Alternatively, increasing catch and effort may have a negative impact on the long-term sustainability of the stock.

Steps are being taken to improve the responsiveness of the TACC setting process and establish a detailed harvest strategy for the fishery (Department of Agriculture and Fisheries, 2017; 2018b; 2019c). It will however take time to fully implement these measures and address the risk that total fishing mortality will exceed biomass reference points.

Limited Recreational Fishing Data

The majority of information on recreationally caught species is obtained through voluntary localised collection of data (*e.g.* the boat ramp survey program, the Fisheries Monitoring Program) and a more expansive voluntary recreational fisher surveys (Webley *et al.*, 2015). Although limited, the data do indicate that the recreational catch for some species is as high, or higher, than the commercial sector. Given these factors, the extent of fishing mortality resulting from the recreational fishing requires further investigation.

As Spanish mackerel are included in a broader monitoring program, datasets on the composition and dynamics of the commercial and recreational catch is more advanced. However, future ERAs or harvest strategies would benefit from additional information on catch and discard rates, fates and effort distributions.

Under Reporting of SOCI Species

Species of Conservation Interest or SOCI are a group of species that are afforded additional protections in Queensland waters. Often no-take species, this group includes marine turtles, whales, dolphins, crocodiles, seabirds, sawfish plus a small number of sharks, rays, teleosts and syngnathids. This group formed the basis of the broader SOCC ecological component that was assessed as part of this Level 1 ERA. In Queensland, all commercial operators are required to report interactions with these species in a dedicated SOCI logbook.

While noting that SOCI interactions will be lower in this fishery, there is limited capacity for management to verify or validate the veracity of this information. If circumstances change and one or more ecological components are progressed to a Level 2 ERA, species with low or inaccurate data sets may be assigned more conservative risk scores. The provisions of more accurate SOCI data enables risk assessments to be refined and provides managers with greater capacity to differentiate between real and potential risks (refer to the ERA Guidelines; Department of Agriculture and Fisheries, 2018a).

5 Summary & Recommendations

The final risk ratings for the ECSMF indicate that the fishery presents as a low risk to most ecological components. Based on the results obtained, only the target species ecological component was assigned a risk rating higher than intermediate. As these risks are confined to a single species, Spanish mackerel, they would be best addressed through the harvest strategy framework. However, the Level 1 ERA did identify a number of elements within the ECSMF framework that have the potential to increase the level of risk posed by fishing activities over the longer-term. Key knowledge gaps in risk profiles of some ecological components were also identified in the Level 1 assessment. Obtaining this information will help to refine risk profiles for future ERAs. Key information needs include:

- Evaluating the effectiveness of the current TACC limit, total fishing mortality (*e.g.* retained, discarded and unreported) and how they compare to biomass reference points.
- Evaluating the economic drivers behind the Spanish mackerel retention rates and the potential for catch and effort to increase into the future;

- Improving information on finer-scale catch and effort trends for all sectors (including recreational) particularly around spawning aggregations;

- Improving the level of understanding on release fates of Spanish mackerel including shark interactions/depredation rates.

6 References

Acevedo, J., Haro, D., L, D. R., Aguayo-Lobo, A., Hucke-Gaete, R., Secchi, E. & Plana, J. (2013). Evidence of spatial structuring of eastern South Pacific humpback whale feeding grounds. *Endangered Species Research* **22**, 33-38.

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., Gibbs, P. J., Steffe, A. S. & Green, M. (2009). A qualitative risk-based assessment of impacts on marine habitats and harvested species for a data deficient wild capture fishery. *Biological Conservation* **142**, 2759-2773.

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.

Bansemer, C. S. & Bennett, M. B. (2010). Retained fishing gear and associated injuries in the east Australian grey nurse sharks (*Carcharias taurus*): implications for population recovery. *Marine and Freshwater Research* **61**, 97-103.

Bergmann, M., Gutow, L. & Klages, M. (2015). *Marine anthropogenic litter*: Springer.

Borucinska, J., Kohler, N., Natanson, L. & Skomal, G. (2002). Pathology associated with retained fishing hooks in blue sharks, *Prionace glauca* (L.), with implications for their conservation. *Journal of Fish Diseases* **25**, 515-521.

Broadhurst, M. K., Gray, C. A., Reid, D. D., Wooden, M. E. L., Young, D. J., Haddy, J. A. & Damiano, C. (2005). Mortality of key fish species released by recreational anglers in an Australian estuary. *Journal of Experimental Marine Biology and Ecology* **321**, 171-179.

Buckley, S. M., Thurstan, R. H., Tobin, A. & Pandolfi, J. M. (2017). Historical spatial reconstruction of a spawning-aggregation fishery. *Conservation Biology* **31**, 1322-1332.

Buckworth, R., Newman, S., Ovenden, J., Lester, R. & McPherson, G. (2007). *The stock structure of northern and western Australian Spanish mackerel*. Fisheries Research and Development Corporation. Department of Primary Industry, Fisheries and Mines, Northern Territory Government, Australia.

Burgin, S. & Hardiman, N. (2011). The direct physical, chemical and biotic impacts on Australian coastal waters due to recreational boating. *Biodiversity and Conservation* **20**, 683-701.

Byrnes, T., Buckley, R., Howes, M. & Arthur, J. M. (2016). Environmental management of boating related impacts by commercial fishing, sailing and diving tour boat operators in Australia. *Journal of Cleaner Production* **111**, 383-398.

Campbell, M. D., Patino, R., Tolan, J., Strauss, R. & Diamond, S. L. (2010). Sublethal effects of catch-and-release fishing: measuring capture stress, fish impairment, and predation risk using a condition index. *ICES Journal of Marine Science* **67**, 513-521.

Couturier, L. I. E., Marshall, A. D., Jaine, F. R. A., Kashiwagi, T., Pierce, S. J., Townsend, K. A., Weeks, S. J., Bennett, M. B. & Richardson, A. J. (2012). Biology, ecology and conservation of the Mobulidae. *Journal of Fish Biology* **80**, 1075-1119.

Davis, M. W. (2002). Key principles for understanding fish bycatch discard mortality. *Canadian Journal of Fisheries and Aquatic Sciences* **59**, 1834-1843.

de Mitcheson, Y. S. (2016). Mainstreaming Fish Spawning Aggregations into Fishery Management Calls for a Precautionary Approach. *BioScience* **66**, 295-306.

Deakos, M. H., Baker, J. D. & Bejder, L. (2011). Characteristics of a manta ray *Manta alfredi* population off Maui, Hawaii, and implications for management. *Marine Ecology Progress Series* **429**, 245-260.

Department of Agriculture and Fisheries (2017). Queensland Sustainable Fisheries Strategy 2017–2027. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy (Accessed 11 April 2019).

Department of Agriculture and Fisheries (2018a). Ecological Risk Assessment Guidelines. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy (Accessed 11 April 2019).

Department of Agriculture and Fisheries (2018b). Queensland Fisheries Harvest Strategy. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy (Accessed 2018).

Department of Agriculture and Fisheries (2018c). Queensland stock status results. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-compliance/data/sustainability-reporting/stock-status-assessment (Accessed 22 November 2018).

Department of Agriculture and Fisheries (2018d). Monitoring our Spanish mackerel. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-compliance/monitoring-reporting/commercial-fisheries/species-specific/gulf-of-carpentaria-mackerel (Accessed 25 May 2018).

Department of Agriculture and Fisheries (2018e). Vessel Tracking. *Queensland Government*. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy (Accessed 23 May 2018).

Department of Agriculture and Fisheries (2018f). Data Validation Plan - Sustainable Fisheries. Available at https://publications.qld.gov.au/dataset/queensland-sustainable-fisheries-strategy/resource/dfbddda3-f0e4-47a2-ba25-644b999734d8 (Accessed 18 April 2019).

Department of Agriculture and Fisheries (2019a). *Scoping Study - East Coast Inshore Fin Fish Fishery (ECIFFF)*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Agriculture and Fisheries (2019b). *Scoping Study - East Coast Spanish Mackerel Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Queensland.

Department of Agriculture and Fisheries (2019c). Fisheries reform: changes to fisheries regulations, September 2019. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy/fisheries-reforms (Accessed 4 September 2019).

Department of Agriculture and Fisheries (2019d). *Scoping Study - Coral Reef Fin Fish Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Agriculture and Fisheries (2019e). *Scoping Study - Gulf of Carpentaria Line Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Agriculture and Fisheries (2019f). QFish. Available at http://qfish.fisheries.qld.gov.au/ (Accessed 7 May 2019).

Department of Environment and Heritage Protection (2017). Marine wildlife strandings annual reports. *State of Queensland*. Available at https://www.ehp.qld.gov.au/wildlife/caring-for-wildlife/strandnet-reports.html (Accessed 8 May 2018).

Department of Primary Industries (2017). *Assessment of the NSW Ocean Trap and Line Fishery - Prepared for the Department of the Environment and Energy for the purpose of assessment under Part 13 and 13(A) of the Environment Protection and Biodiversity Conservation Act 1999*. Fisheries NSW: Industries, D. o. P.

Department of Primary Industries and Fisheries (2005). *Report on the Bycatch and byproduct risk assessment for the East Coast Spanish Mackerel Fishery*. Department of Primary Industries and Fisheries, Queensland Government. Brisbane, Queensland. https://www.daf.qld.gov.au/__data/assets/pdf_file/0020/55208/EcolRiskAssess-bycatch-ECSMF.pdf

Department of the Environment and Energy (2017). *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna*. Department of the Environment and Energy, Australian Government. Canberra, ACT.

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.

Erisman, B., Heyman, W., Kobara, S., Ezer, T., Pittman, S., Aburto-Oropeza, O. & Nemeth, R. S. (2017). Fish spawning aggregations: where well-placed management actions can yield big benefits for fisheries and conservation. *Fish and Fisheries* **18**, 128-144.

Erisman, B. E., Allen, L. G., Claisse, J. T., Pondella, D. J., Miller, E. F. & Murray, J. H. (2011). The illusion of plenty: hyperstability masks collapses in two recreational fisheries that target fish spawning aggregations. *Canadian Journal of Fisheries and Aquatic Sciences* **68**, 1705-1716.

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.

Food and Agriculture Organization (2004). Ciguatera Fish Poisoning. In *Marine Biotoxins; FAO Food and Nutrition Paper 80*, pp. 185-218. Rome, Italy: Food and Agriculture Organization of the United Nation.

Godbold, J. A. & Calosi, P. (2013). Ocean acidification and climate change: advances in ecology and evolution. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* **368**, 20120448-20120448.

Great Barrier Reef Marine Park Authority (2014). *Great Barrier Reef Outlook Report 2014*. Great Barrier Reef Marine Park Authority, Australian Government. Townsville, Queensland.

Hare, J. A., Morrison, W. E., Nelson, M. W., Stachura, M. M., Teeters, E. J., Griffis, R. B., Alexander, M. A., Scott, J. D., Alade, L., Bell, R. J., Chute, A. S., Curti, K. L., Curtis, T. H., Kircheis, D., Kocik, J. F., Lucey, S. M., McCandless, C. T., Milke, L. M., Richardson, D. E., Robillard, E., Walsh, H. J., McManus, M. C., Marancik, K. E. & Griswold, C. A. (2016). A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. *PLOS ONE* **11**, e0146756.

Harrison, Hugo B., Williamson, David H., Evans, Richard D., Almany, Glenn R., Thorrold, Simon R., Russ, Garry R., Feldheim, Kevin A., van Herwerden, L., Planes, S., Srinivasan, M., Berumen, Michael L. & Jones, Geoffrey P. (2012). Larval Export from Marine Reserves and the Recruitment Benefit for Fish and Fisheries. *Current Biology* **22**, 1023-1028.

Hobday, A. J., Smith, A. D. M., Stobutzki, I. C., Bulman, C., Daley, R., Dambacher, J. M., Deng, R. A., Dowdney, J., Fuller, M., Furlani, D., Griffiths, S. P., Johnson, D., Kenyon, R., Knuckey, I. A., Ling, S. D., Pitcher, R., Sainsbury, K. J., Sporcic, M., Smith, T., Turnbull, C., Walker, T. I., Wayte, S. E., Webb, H., Williams, A., Wise, B. S. & Zhou, S. (2011). Ecological risk assessment for the effects of fishing. *Fisheries Research* **108**, 372-384.

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.

Hoegh-Guldberg, O., Poloczanska, E. S., Skirving, W. & Dove, S. (2017). Coral Reef Ecosystems under Climate Change and Ocean Acidification. *Frontiers in Marine Science* **4**.

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., Dawson, A. & Walton, L. (2019a). *Rocky Reef Fin Fish Fishery Level 1 Ecological Risk Assessment*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Jacobsen, I., Dawson, A. & Walton, L. (2019b). *Coral Reef Fin Fish Fishery Level 1 Ecological Risk Assessment*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Jacobsen, I., Walton, L. & Zeller, B. (2019c). *Level 1 Ecological Risk Assessment - East Coast Inshore Fin Fish Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Jacobsen, I., Zeller, B., Dunning, M., Garland, A., Courtney, T. & Jebreen, E. (2018). *An Ecological Risk Assessment of the Southern Queensland East Coast Otter Trawl Fishery and the River & Inshore Beam Trawl Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Queensland.

Kohli, G. S., Haslauer, K., Sarowar, C., Kretzschmar, A. L., Boulter, M., Harwood, D. T., Laczka, O. & Murray, S. A. (2017). Qualitative and quantitative assessment of the presence of ciguatoxin, P-CTX-1B, in Spanish Mackerel (*Scomberomorus commerson*) from waters in New South Wales (Australia). *Toxicology Reports* **4**, 328-334.

Kroon, F. J., Motti, C. E., Jensen, L. H. & Berry, K. L. E. (2018). Classification of marine microdebris: A review and case study on fish from the Great Barrier Reef, Australia. *Scientific Reports* **8**, 16422.

Langstreth, J., Williams, A., Stewart, J., Marton, N., Lewis, P. & Saunders, T. (2018). Status of Australian Fish Stocks: Spanish Mackerel. *Status of Australian Fish Stocks*. Fisheries Research & Development Corporation. Available at http://fish.gov.au/report/253-Spanish-Mackerel-2018 (Accessed 28 May 2019).

Last, P., White, W., Séret, B., Naylor, G., de Carvalho, M. & Stehmann, M. (2016). Rays of the World. 790.

Last, P. R. & Stevens, J. D. (2009). Sharks and rays of Australia. 645.

Little, L. R., Smith, A. D. M., McDonald, A. D., Punt, A. E., Mapstone, B. D., Pantus, F. & Davies, C. R. (2005). Effects of size and fragmentation of marine reserves and fisher infringement on the catch and biomass of coral trout, *Plectropomus leopardus*, on the Great Barrier Reef, Australia. *Fisheries Management and Ecology* **12**, 177-188.

Madigan, D. J., Brooks, E. J., Bond, M. E., Gelsleichter, J., Howey, L. A., Abercrombie, D. L., Brooks, A. & Chapman, D. D. (2015). Diet shift and site-fidelity of oceanic whitetip sharks *Carcharhinus longimanus* along the Great Bahama Bank. *Marine Ecology Progress Series* **529**, 185-197.

Manson, F. J., Loneragan, N. R., Harch, B. D., Skilleter, G. A. & Williams, L. (2005). A broad-scale analysis of links between coastal fisheries production and mangrove extent: A case-study for northeastern Australia. *Fisheries Research* **74**, 69-85.

Mapstone, B. D., Davies, C. R. & Robertson, J. W. (1997). *The effects of line fishing on the Great Barrier Reef: available evidence and future directions*. The Great Barrier Reef-Science, Use and Management. A National Conference. Proceedings. Volume 1. Invited Papers.

McLeay, L. J., Jones, G. K. & Ward, T. M. (2002). *National strategy for the survival of released line-caught fish: a review of research and fishery information*. South Australian Research and Development Institute (Aquatic Sciences), South Australian Government. Adelaide, South Australian.

Meager, J. J. & Limpus, C. J. (2012). *Marine wildlife stranding and mortality database annual report 2011. III. Marine Turtle*. Conservation Technical and Data Report 2012. Department of Environment and Heritage Protection, Queensland Government. Brisbane.

Miller, M. G. R., Carlile, N., Scutt Phillips, J., McDuie, F. & Congdon, B. C. (2018). Importance of tropical tuna for seabird foraging over a marine productivity gradient. *Marine Ecology Progress Series* **586**, 233-249.

Mitchell, J. D., McLean, D. L., Collin, S. P., Taylor, S., Jackson, G., Fisher, R. & Langlois, T. J. (2018). Quantifying shark depredation in a recreational fishery in the Ningaloo Marine Park and Exmouth Gulf, Western Australia. *Marine Ecology Progress Series* **587**, 141-157.

O'Neill, M., Langstreth, J. & Buckley, S. (2018). *Stock assessment of Australian east coast Spanish mackerel Predictions of stock status and reference points*. Department of Agriculture and Fisheries.

Pears, R. J., Morison, A. K., Jebreen, E. J., Dunning, M. C., Pitcher, C. R., Courtney, A. J., Houlden, B. & Jacobsen, I. P. (2012). Ecological Risk Assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: Technical Report.

Raby, G. D., Packer, J. R., Danylchuk, A. J. & Cooke, S. J. (2014). The understudied and underappreciated role of predation in the mortality of fish released from fishing gears. *Fish and Fisheries* **15**, 489-505.

Robbins, W. D., Peddemors, V. M., Broadhurst, M. K. & Gray, C. A. (2013). Hooked on fishing? Recreational angling interactions with the Critically Endangered grey nurse shark *Carcharias taurus* in eastern Australia. *Endangered Species Research* **21**, 161-170.

Roelofs, A. (2004). *Ecological Assessment of the Gulf of Carpentaria Line Fishery; A report to the Australian Government Department of the Environment and Heritage on the sustainable management of a multi-species tropical line fishery*. Department of Primary Industries. http://www.environment.gov.au/system/files/pages/fb5056cb-464b-41cc-8a08-d189004eccce/files/line-fishery-submission.pdf

Russell, M. (2001). *Spawning Aggregations of Reef Fishes on the Great Barrier Reef: Implications for Management*. Great Barrier Reef Marine Park Authority.

Scott-Holland, T. (2011). *Compliance Risk Assessment Queensland East Coast Spanish Mackerel Fishery*. Queensland Department of Primary Industries and Fisheries; Queensland Boating and Fisheries Patrol. Brisbane.

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.

Tobin, A., Currey, L. & Simpfendorfer, C. (2013). Informing the vulnerability of species to spawning aggregation fishing using commercial catch data. *Fisheries Research* **143**, 47-56.

Tobin, A., Heupel, M., Simpfendorfer, C., Pandolfi, J., Thurstan, R. & Buckley, S. (2014). *Utilising innovative technology to better understand Spanish mackerel spawning aggregations and the protection offered by marine protected areas*. Centre for Sustainable Tropical Fisheries and Aquaculture, James Cook University. Townsville: Corporation, F. R. a. D.

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).

Waples, D. M., Thorne, L. H., Hodge, L. E. W., Burke, E. K., Urian, K. W. & Read, A. J. (2013). A field test of acoustic deterrent devices used to reduce interactions between bottlenose dolphins and a coastal gillnet fishery. *Biological Conservation* **157**, 163-171.

Webley, J., McInnes, K., Teixeira, D., Lawson, A. & Quinn, R. (2015). *Statewide Recreational Fishing Survey 2013-14*. Queensland Government. Brisbane, Australia.

Webley, J. A. C., Connolly, R. M. & Young, R. A. (2009). Habitat selectivity of megalopae and juvenile mud crabs (*Scylla serrata*): implications for recruitment mechanism. *Marine Biology* **156**, 891.

Williamson, D. H., Ceccarelli, D. M., Evans, R. D., Hill, J. K. & Russ, G. R. (2015). Derelict Fishing Line Provides a Useful Proxy for Estimating Levels of Non-Compliance with No-Take Marine Reserves. *PLOS ONE* **9**, e114395.

Work, P. A., Sapp, A. L., Scott, D. W. & Dodd, M. G. (2010). Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology* **393**, 168-175.

Zollett, E. A. & Read, A. J. (2006). Depredation of catch by bottlenose dolphins (*Tursiops truncatus*) in the Florida king mackerel (*Scomberomorus cavalla*) troll fishery. *Fishery Bulletin* **104**, 343-349.

Appendix 1—Ecological Processes Preliminary Assessment

A1 – Ecological Processes Categories

Categories taken into consideration as part of the Level 1 preliminary assessment for the Ecological Processes ecological component. Definitions adopted from the Great Barrier Reef Outlook Report (Great Barrier Reef Marine Park Authority, 2014) and (Pears *et al.*, 2012).

CATEGORY	DESCRIPTION
SEDIMENTATION	The inflow, dispersion, resuspension and consolidation of sediments
NUTRIENT CYCLING / MICROBIAL ACTIVITY	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	The removal of mid and top order predators from the marine environment and the potential for animals to be subject to increase 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 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', than the final risk score for harvesting will be a 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 ECSMF.

Ecological Component	**Line fishing—Main activities of the Fishery**							**Other fisheries***
	Harvesting	**Discarding**	**Contact without capture**	**Loss of fishing gear***	**Travel to/from grounds**	**Disturbance due to presence in area**	**Boat maintenance & emissions**	
Sedimentation	-	-	-	-	-	-	-	-
Nutrient cycling / Microbial activity	L	-	-	-	-	-	-	L
Particle feeding	L/I	-	-	-	-	-	-	L/I
Primary production	-	-	-	-	-	-	-	-
Herbivory	-	-	-	-	-	-	-	-
Predation	I	L	I	-	-	-	-	I
Bioturbation	-	-	-	-	-	-	-	-
Detritivory	-	-	-	-	-	-	-	-
Scavenging	-	L	L	-	-	-	-	-
Symbiosis	L	-	-	-	-	-	-	L
Recruitment	I/H	-	-	-	-	-	-	I
Reef building	-	-	-	-	-	-	-	-
Competition	L	-	-	-	-	-	-	L
Connectivity	L	-	-	-	-	-	-	L
Outbreaks of disease	-	-	-	-	-	-	-	-
Species introductions	-	-	-	-	-	-	-	-
ECOSYSTEM PROCESSES (overall)	I/H	L	I	-	-	-	-	I

*Includes recreational, charter sectors

Appendix 2—Risk Ratings and Outputs

The primary objective of the Level 1 assessments were to a) identify the key sources of risk within a particular fishery and b) the ecosystem components that are most likely to be effected by this risk. Preliminary risk ratings developed as part of the *Risk Characterisation* stage take into consideration the current fishing environment (*e.g.* current catch, effort and licensing trends) and risk factors associated with 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). Depending on the fishery, broader risk factors may also contribute to an ecological component receiving a more conservative risk rating. These preliminary rates are precautionary or more conservative in nature and provide a more holistic account of a) risks posed by the fishery and b) provide the Level 1 ERA with greater capacity to address the (potential) long-term consequences of a risk. The trade-off with this approach is that the preliminary risk may overestimate the level of risk posed to an ecological component or be a reflection of the 'potential risk'. Otherwise known as a 'false positive', these values effectively overestimate the risk posed to an ecological component or subcomponent.

The potential for large-scale qualitative ERAs to produce 'false positives' places added importance on examining the likelihood of the risk coming to fruition in the short to medium term. The following provides an overview of the preliminary risk ratings and an assessment of the likelihood of it occurring in the ECSMF. Depending on the species and the current fishing pressures, preliminary risk ratings may be amended to reflect the current fishing environment.

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
Target Species	• Single species fishery with species-specific quota and recent stock assessment. • Unknown post-release mortality rates and depredation rates • Fishers known to target spawning aggregations.	High	*Likelihood* • Moderate to high *Mitigation Measures & Considerations* • Fishery is currently considered to be sustainable and is operating at or around MSY.	Intermediate / High

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
	• Species currently operating at MSY and there is significant potential for commercial effort to increase under the current TACC. • Species also attracts a significant level of interest from the recreational and charter fishing sectors.		• Fisheries data indicates that the fishery is unlikely to deviate from long-term catch and effort trends in the short term. • Risk of overfishing is currently being managed; albeit by external factors *e.g.* economic constraints and market demand. • As the stock is already being fished at MSY, increasing catch and effort across one or more of the sectors may have long-term implications for the sustainability of the stock (*e.g.* to meet increased market demand). • Spanish mackerel are still considered to be at risk due to a) the fully fished status of the stock, b) the potential for catch and effort to increase through latent licencing and quota, c) inadequate overarching protections for spawning aggregations, and d) cumulative fishing pressures. • SM monitoring program in place and Minimum legal size limit and possession limit for recreational sector.	

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• Improving data on recreational fishing through boat ramp surveys. • Recent regulatory amendments provide the TACC setting process with greater flexibility and address black-marketing .These changes have yet to be incorporated into a broader harvest strategy for this species.	
Bycatch (non-SOCC)	• Interaction rates with non-target species will be relatively low due to the fishing method	Low	*Likelihood* • Low *Mitigation Measures & Considerations* • Risks relating to the return of undersize or less-marketable Spanish mackerel are addressed as part of the target & byproduct species ecological component. • Limited information on bycatch compositions for this sector. • Bycatch in this fishery may be retained as byproduct for sale in other line fisheries.	Low
Species of Conservation Concern (SOCC)				
Marine turtles	• Few interactions recorded.	Low	*Likelihood*	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
	• High spatial overlap between key fishing grounds and preferred habitats (GBR). • Interaction rates expected to be low but limited information on interaction rates and mortalities including for boat strike. • Indirect impacts (contact without capture, lost fishing gear, boat strike) considered to be higher risk than direct impacts (discarding).		• Low *Mitigation Measures & Considerations* • While the fishery overlaps with the distribution of a number of the marine turtle species, direct capture and entanglement in fishing line will be low. • Some marine turtle species have been known to take baited hooks. This is unlikely to occur when trolling for pelagic fin fish and this risk will be more relevant to demersal line fishing operations. • This subgroup is particularly susceptible to cumulative risks including lost fishing line (particularly from the recreational fishing sector), boat strikes and customary hunting. Although interaction rates are anticipated to be low, this assessment will be difficult to quantify without additional measures to validate SOCI interactions. • Media encouraging best practice such as ensuring rubbish (fishing lines, plastic bags) are disposed of correctly.	

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• SOCI reporting. • Limits on number of lines and hooks used.	
Sea snakes	• Interactions with this subgroup highly unlikely. • High spatial overlap between key fishing grounds and preferred habitats (GBR).	Low	*Likelihood* • Negligible *Mitigation Measures & Considerations* • While research shows that sea snakes will take a baited hook, this is more likely in the demersal line fishery or in the recreational fishing sector. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	Negligible
Crocodiles	• Interactions with this subgroup highly unlikely. • Limited spatial overlap between key fishing grounds and preferred habitats.	Negligible	*Likelihood* • Negligible. *Mitigation Measures & Considerations* • Further management of risk not required for this SOCC subgroup.	Negligible

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
Dugongs	• Limited spatial overlap between key fishing grounds and preferred habitats. • Key drivers of risk do not relate to active fishing *i.e.* traveling to and from fishing grounds.	Low	*Likelihood* • Low due to the species being targeted and the fishing method used. *Mitigation Measures / FWG Discussions* • Risk largely relates to non-fishing related activities *e.g.* boat strike, contact without capture. Direct risks posed by line fishing considered to be negligible. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	Low
Cetaceans	• Interactions with this subgroup are unlikely. • Interactions and (if applicable) mortalities unlikely to have a long-term impact on regional populations.	Low	*Likelihood* • Low. *Mitigation Measures & Considerations* • Contact without capture interactions may be possible in this subgroup *e.g.* dolphins targeting bait, depredation.	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• Risk largely relates to non-fishing related activities *e.g.* boat strike, contact without capture. Direct risks posed by line fishing considered to be negligible. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	
Teleosts (protected/SOCI only)	• Interaction rates (overall) anticipated to be low. • Interactions and (if applicable) mortalities unlikely to have a long-term impact on regional populations.	Low	*Likelihood* • low *Mitigation Measures & Considerations* • Interactions with this subgroup with licence holders targeting Spanish mackerel are unlikely. The risk to this subgroup will be higher in demersal line fisheries as the species will be more inclined to take a baited hook/lure. • Information about best practice post release techniques (deflating swim bladders) and barotrauma on web page.	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• SOCI reporting. • Limits on number of lines and hooks used.	
Batoids	• Interaction rates anticipated to be low. • High spatial overlap between key fishing grounds and preferred habitats (GBR).	Low	<u>*Likelihood*</u> • low <u>*Mitigation Measures & Considerations*</u> • Low likelihood of interactions occurring in this fishery given the fishing method. Interactions, if applicable, will be more applicable to pelagic species like manta rays and devil rays (*Family Mobulidae*). • Further management of risk not considered to be warranted at this point in time. • While electronic observation being considered for some fisheries, the feasibility and applicability of this method is still being determined.	Low
Sharks	• Interaction rates (*i.e.* direct capture and predation on caught fish) will be higher.	Low	<u>*Likelihood*</u> • Low <u>*Mitigation Measures & Considerations*</u>	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
	• High post interaction/release survival rate. Most interactions will not result in the animal being landed on deck. • High spatial overlap between key fishing grounds and preferred habitats of reef species. • Indirect interactions more likely with sharks targeting fish during the retrieval process. • Interactions and (if applicable) mortalities unlikely to have a long-term impact on regional populations.		• Higher interaction rates occurring in this fishery with **contact without capture** identified as the most notable risk (*e.g.* depredation). • Post-release survival rates expected to be high with these types of interactions providing good handling protocols are followed. • Direct interactions (**discarding**) are also likely but post-release survival will be high if best practice handling procedures are followed. • Fishery may interact with a small number of species that are afforded additional legislative protections. The extent of these interactions are unlikely to pose a significant or long-term risk. • There is limited information on the frequency of shark interactions and the species compositions. These data deficiencies are partly being addressed through the expansion of the shark and ray logbook program to all commercial net and line	

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			fisheries. There is however limited capacity to validate this data (at this point in time). • Further management of risk not considered to be warranted.	
Syngnathids	• Subgroup highly unlikely to interact with the line apparatus.	Negligible	N/A	Negligible
Seabirds	• Small number reported through SOCI logbooks for other line fisheries and interaction rates anticipated to be low. • Direct interactions and (if applicable) mortalities unlikely to have a long-term impact on regional populations. • Higher risk associated with indirect impacts and cumulative fishing pressures *e.g.* discarded fishing line.	Low	*Likelihood* • Low. *Mitigation Measures & Considerations* • Risks will be most relevant to diving species that target bait/fish in the first few meters of the water column. • Risks are largely managed through restrictions on number of lines and hooks plus guides on best management and handling. • One of the few subgroups where the risk posed by trolling will be higher. However, interaction rates will be difficult to validate without additional measures.	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• The presence of the operator will help to reduce interaction times if a bird gets caught or becomes entangled in the line. • The collective risk associated with discarded line (*e.g.* commercial, recreational and charter fishing) considered to be more significant for this subgroup and may require further investigation *e.g.* outside the ERA framework. • The risk profile of this SOCC subgroup may need to be reviewed if fishing effort and/or participation rates increase in the GOCL. • Various initiatives being considered to improve catch reporting processes, including the introduction of electronic logbooks and electronic observation.	
Terrestrial mammals	• Negligible interactions or spatial overlap.	Negligible	N/A	Negligible
Marine Habitats	• Contact with marine habitat is minimal due to fishing method	Low	*Likelihood* • Low. *Mitigation Measures & Considerations*	Low

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
			• As trolling is one of the more active methods of line fishing (*e.g.* towing bait/lures behind the vessel), the fishery will have limited contact with the marine environment. Most interactions will occur during non-fishing events *e.g.* anchoring during non-fishing events. • Ecological component may experience cumulative risks or impacts *e.g.* from commercial, charter and recreational fishing. However risks will be partly mitigated by the size of the fishery, current participation rates and the accessibility of the region for non-commercial fishing sectors (*e.g.* recreational fishers). • Media encouraging best practice such as ensuring rubbish (fishing lines plastic bags are disposed of correctly. Some fishers are part of the Great Barrier Reef Marine Park Reef Guardian program that encourages best practice operation in the marine park.	
Ecosystem Processes	• Fishery targets mid-level predators.	Intermediate / High	*Likelihood* • Uncertain.	Intermediate

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
	• Fishers known to target spawning aggregations • Unknown post-release mortality rates or depredation rates for SM		*Mitigation Measures & Considerations* • Assessment has a high degree of uncertainty as impacts of an individual fishery are difficult to determine. • Impacts on ecosystem processes are intimately linked with the exploitation of Spanish mackerel and the role they play in the broader ecosystem. • Spanish mackerel stocks are currently being fished sustainably / within key sustainability reference points but the potential for catch and effort to increase in the future remains a driver of risk for marine ecosystems. • Effective management of the targeted stock will help to minimise the risk posed to regional ecosystem processes including the potential disruption of recruitment processes, predation. • Mitigation measures to protect aggregations and latent quota reductions would reduce the impact of the fishery on ecosystem processes.	