

Spanish Mackerel Fishery

Ecological Risk Assessment

2020

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Acronyms	Full form
CPUE	Catch per Unit Effort
DF	Demersal Fishery
EPBC	Environment Protection and Biodiversity Conservation (Act)
ERA	Ecological Risk Assessment
ESD	Ecologically Sustainable Development
FTO	Fishing Tour Operator
FL	Fork Length
MSY	Maximum Sustainable Yield
NT	Northern Territory
ONLF	Offshore Net and Line Fishery
SMF	Spanish Mackerel Fishery
TAC	Total Allowable Catch
TEPS	Threatened, Endangered and Protected Species

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1. Executive Summary

This report summarises the outcomes of an Ecological Risk Assessment (ERA) conducted on the Northern Territory (NT) Spanish Mackerel Fishery (SMF) in May and August 2020. The assessment was undertaken to identify the ecological risks posed by the fishery, to inform the ongoing sustainable management of the SMF resource.

The ERA followed the National Ecologically Sustainable Development reporting framework, 'How to' Guide (Fletcher *et al.* 2002).

This report provides background information on the SMF as well as information used to inform the ERA process. Risks associated with the SMF were assessed through a technical workshop attended by scientific and management experts, then circulated to external stakeholders for consideration. This report presents the outcomes of the ERA, which will be used to inform and prioritise Departmental monitoring, research and management activities for the SMF.

1.1. ERA risk rating outcomes

Table 1. ERA risk rating outcomes

Species assessed	Consequence	Likelihood	Risk rating
Spanish Mackerel	1 (minor)	3 (possible)	3 (low)
Grey Mackerel	0 (negligible)	2 (rare)	0 (negligible)
Bycatch species	0 (negligible)	1 (remote)	0 (negligible)
Protected species	0 (negligible)	1 (remote)	0 (negligible)
Boat strike	0 (negligible)	1 (remote)	0 (negligible)
Seabirds	0 (negligible)	1 (remote)	0 (negligible)
Target fishing	0 (negligible)	1 (remote)	0 (negligible)
Bait collection	0 (negligible)	1 (remote)	0 (negligible)
Ghost fishing	0 (negligible)	1 (remote)	0 (negligible)
Fishery discards	0 (negligible)	1 (remote)	0 (negligible)
Bait disposal	0 (negligible)	1 (remote)	0 (negligible)
Gear interactions	0 (negligible)	1 (remote)	0 (negligible)
Anchoring	0 (negligible)	1 (remote)	0 (negligible)
Greenhouse gases	0 (negligible)	1 (remote)	0 (negligible)
Rubbish	0 (negligible)	1 (remote)	0 (negligible)
Oil discharge	0 (negligible)	1 (remote)	0 (negligible)

2. Introduction

The Department of Industry, Tourism and Trade (DITT) utilises an Ecosystem-Based Fisheries Management (EBFM) approach which considers relevant ecological, social, economic and governance issues. ERAs are undertaken periodically to assess the impacts of a fishery's activity on all different components of the marine environments in which they operate, including the contemporary risks of harvesting activities on species by all fishery sectors, and the broader impacts of the activities on the environment (general

ecosystem). Outcomes of risk assessments are used to inform EBFM-based harvest strategies and to prioritise Departmental monitoring, research and management activities (Fletcher 2015).

The principles of Ecologically Sustainable Development (ESD) are the basis of fisheries and aquatic resource management in the NT. The *Fisheries Act 1988* (Fisheries Act) describes ESD as “the use, conservation, development and enhancement of the community’s resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased”. The Fisheries Division of DITT is responsible for fisheries management under the Fisheries Act. The outcomes from the ERA support ESD by providing a basis to address identified impacts on target species, bycatch, habitats and potential indirect impacts on the broader ecosystem (Fletcher, 2005).

This report provides background information on the SMF, including a brief summary of the management history, the risk assessment methodologies used, as well as the rationale behind the assigned risk levels in the SMF. These risk ratings will be used to inform the management of the fishery with the ultimate aim of continued ecologically sustainable utilisation and development of the resource.

3. Background

3.1. Management history of the fishery

Until the early 1970’s, the holder of a General Fishing Licence, issued under NT Fisheries Ordinance could land and sell any fish including Spanish Mackerel. Throughout the 1970’s the taking of Spanish Mackerel was restricted to Net and Line licensees.

Significant landings of Spanish Mackerel were taken by a Taiwanese gillnet fleet in waters adjacent to Northern Australia between 1974 and 1986. Recorded overall catches from the Australian Fishing Zone by the fleet peaked at 10,000 t per year with shark, tuna and mackerel being the main species. Net length restrictions were implemented in 1986 and these controls resulted in the closure of foreign fishing operations in northern Australian waters in later that year. Annual catches stabilised to between 400 t and 500 t through the early 1980’s. Concurrent reductions in Catch per Unit Effort (CPUE) and mean size were an indication that the species was overfished at that time.

The inaugural Spanish Mackerel Fishery Management Plan was introduced in 1993, introducing a possession limit of five Spanish Mackerel for recreational fishers and a licence reduction program for the commercial troll sector. On 1 January 2005 amendments were made to the Spanish Mackerel Fishery Management Plan and catch share arrangements were introduced.

A Total Allowable Catch (TAC) was established to benchmark the amount of Spanish mackerel that could be harvested without affecting the fishery. In the absence of data to support alternative assessments, the approximate equilibrium catch of the Taiwanese fleet (450 t) was taken as indicative of the annual sustainable yield. This amount was set for the TAC (this includes the recreational catch).

Table 2. Chronology of management of the Spanish Mackerel Fishery

Date	Management Arrangements
Prior 1970	Spanish Mackerel could be taken commercially on a General Fishing Licence.
1970	Through the 1970’s commercial fishing for Spanish Mackerel was restricted to Net and Line licences.
1974	A Taiwanese gillnet fleet commenced fishing for pelagic species including Spanish Mackerel in northern Australian waters. From 1974 until mid-1978, this fleet was able to fish within the 12 nautical mile (nm) limit of the NT coastline.

Date	Management Arrangements
1978	In approximately mid-1978, the foreign fishing fleet exclusion zone adjacent to Arnhem land and the Wessel Islands increased to between 40-50 nm seaward of the coastline.
1979	Foreign fishing vessels were excluded from the Gulf of Carpentaria
1980	The Fish and Fisheries Act became law, the Net and Line Licence was superseded, and commercial Spanish Mackerel fishers were granted a Reef and Mackerel licence.
1984	Management controls were altered and trolling became an authorised fishing activity in the Pelagic, Inshore Reef Fish, and Offshore Reef Fish fisheries. Licensees were encouraged to operate under a Pelagic fishery endorsement when targeting Spanish Mackerel in NT waters. Fishing was also permitted in waters external to the NT under a Commonwealth issued access entitlement.
1986	Restrictions on length of net to be used by the 30 Taiwanese gillnet vessels were introduced in response to declining shark catch rates and concerns about incidental capture of dolphins. These controls resulted in the cessation of foreign fishing operations in northern Australia later that year.
1988	The passage of the Offshore Constitutional Settlement (OCS) saw the NT assume responsibility for the management of Spanish Mackerel by troll line method from the coastline to the outer boundary of the Australian Fishing Zone.
1990	Regulatory amendments were introduced to prohibit trolling as a commercial fishing method in all NT managed fisheries other than the Pelagic Fishery. 45 licences were issued for that fishery, however Pelagic Fishery licence holders were required to catch a minimum quantity of Spanish Mackerel for their licenses to be renewed between 1990 and 1991.
1991	Prior to 1 April, holders of an offshore reef fish licence used floating handlines to land Spanish Mackerel aboard prawn trawlers in the Northern Prawn Fishery. On 1 April, a public announcement warned that the landing of Spanish Mackerel by anyone other than holder of a Pelagic licence may not be recognised in any future allocation of a fishing access entitlements, On 1 July, the SMF was declared. The SMF Management Advisory Committee was formed and in September the first draft of the initial SMF Management Plan was released for public comment.
1992	Because of some licensees failing to meet catch criteria, the number of licences fell to 34.
1993	On 27 January, the first SMF Management Plan was enacted. At the time three separate licence categories were introduced, Subsequently those categories were reduced to two: unrestricted and combined (also known as 'restricted'). At this time a "two for one" commercial licence reduction strategy was also introduced, requiring two 'restricted' licences to be traded for one 'unrestricted' licence.
1997	An additional unrestricted SMF licence was issued on recommendations from an independent review of circumstances surrounding an expired SMF licence.
2000	The ongoing "two for one" licence reduction scheme reduced licence numbers to 22.
2000-2005	The SMF Management Plan was reviewed and a new plan came into force on 1 January 2005

Date	Management Arrangements
2010	The recreational possession limit for Spanish Mackerel was reduced from five (5) to two (2), effective 1 January 2010.
2014	The most recent surrender of two restricted licences for one unrestricted licence. Numbers now stand at three restricted licences and 12 unrestricted licenses.

Description of the fishery

The NT SMF is a multi-sector fishery that extends seaward from the high water mark to the outer limit of the AFZ (Figure 1. Area of the Northern Territory Spanish Mackerel Fishery

). The fishery comprises of commercial, recreational, fishing tour operator and Aboriginal traditional sectors, with commercial operators accounting for the vast majority (i.e. around 90 per cent) of the Spanish Mackerel harvest.

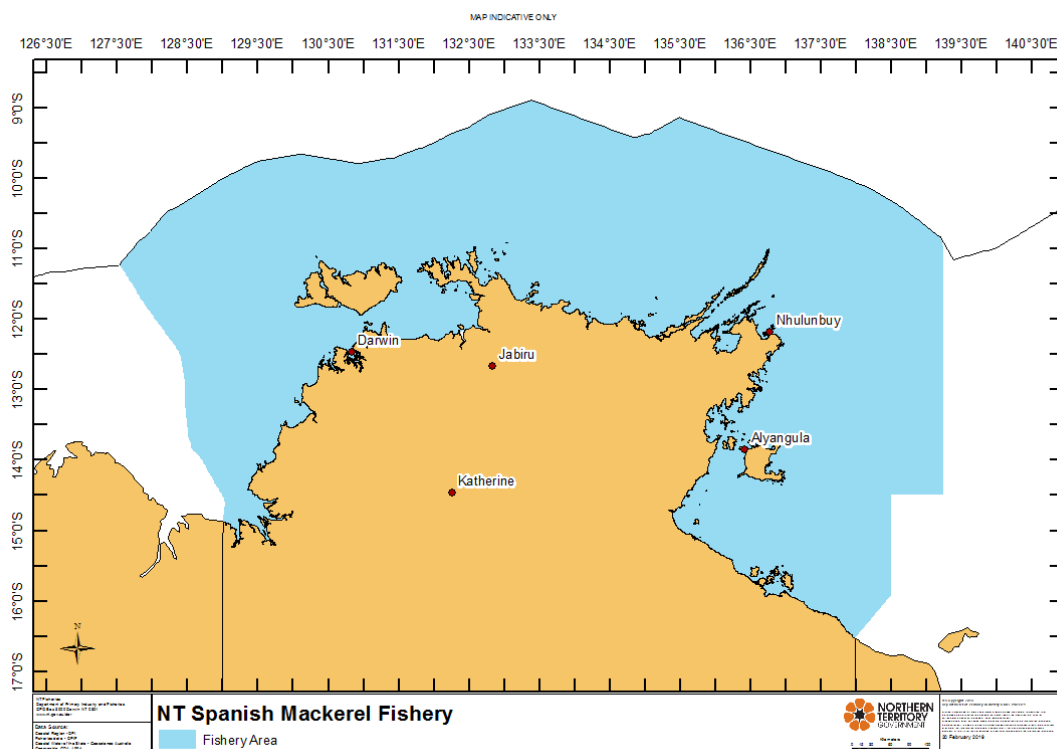


Figure 1. Area of the Northern Territory Spanish Mackerel Fishery

3.1.1. Fishing method

The SMF is a hook and line fishery. The primary fishing method used by all sectors is trolling, where baited hooks or lures are towed behind a boat moving at 3–6 knots near reefs, headlands and shoals. Recreational and FTO fishers use a single vessel and also occasionally drift or cast baited lines into mackerel schools.

Commercial operators utilise either a single, large vessel for both catching and processing at sea, while others do most of their fishing from relatively small (i.e. 4-6 metre) dories, which return to a mothership each night. There is a maximum of two dories permitted per licence. Operators generally run two to four lines behind a dory and up to eight lines behind larger vessels. Licensees in the SMF also possess a

restricted bait entitlement, which allows holders to use a restricted bait net to harvest bait for their operations. This gear is only used by a subset of fishers, as many prefer to use lures only.

3.1.2. Resource sharing

The SMF has overlapping resource access rights between the sectors of the fishery. The resources of the fishery are fished by recreational, tourism, commercial and Aboriginal sectors with a catch-sharing arrangement in place between all user groups. This arrangement aims to maintain the cumulative harvest of Spanish Mackerel within a precautionary allowable catch of 450 t per annum. The proportion of the allowable catch allocated to each user group was based on historical logbook data and catch estimates from the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003). The catch share arrangement allocated 76 per cent (342 t) to SMF licensees, three per cent (13.5 t) to Offshore Net and Line Fishery licensees, one per cent (4.5 t) to Demersal Fishery licensees, three per cent (13.5 t) to FTO licensees, 16 per cent (72 t) to recreational fishers and 1 per cent (4.5 t) for Aboriginal traditional harvest.

3.1.3. Retained species

The targeted nature of commercial Spanish Mackerel fishing ensures that this species is the significant majority of the catch. Of the 6,526 t of product harvested by the SMF over the last 20 years, 6,483 t (or 99.3 percent) of the catch was Spanish Mackerel. Grey Mackerel is the only by-product species, accounting for 0.5 per cent (or 35 t) of the cumulative catch over the same period. The remaining 0.2 per cent of the 20-year catch (or 8 t) comprises of around two dozen species (or species groups) which are not considered in more detail here because of the very minor quantities harvested.

3.1.4. Non-retained species

Logbook records suggest that the quantity of fishes discarded by the SMF is very low, in the order of two tonne over 20 years. Discarded species include Blacktip Sharks, Queenfishes, Giant Trevally, Barracuda, Bull Shark and Grey Reef Shark with most species released alive. On board fishery observers last verified the range and quantity of discard species about 10 years ago.

3.1.5. Threatened, Endangered and Protected Species (TEPS)

TEPS are a subset of the non-retained species group. There have been very few TEPS interactions reported in the SMF due to the highly targeted method of fishing. Fishers are required to report all TEPS interactions through the mandatory daily catch and effort logbook returns. The low incidence of TEPS interactions was last verified by on board fishery observers around 10 years ago.

3.2. Legislation

The Fisheries Act provides the broad statutory framework to conserve and manage the aquatic resources of the NT. In the administration of the Fisheries Act, the Minister responsible for Fisheries must pursue the following objectives, outlined in Section 2A:

- a) to manage the aquatic resources of the Territory in accordance with the principles of ecologically sustainable development, whether managing a single fish species or an ecosystem, to ensure the promotion of appropriate protection of fish and fish habitats;
- b) to protect the environment, people and economy of the Territory from the introduction and spread of aquatic pests and diseases;
- c) to maintain a stewardship of aquatic resources that promotes fairness, equity and access to aquatic resources by all stakeholder groups, including:

- (i) indigenous people
- (ii) commercial operators and aquaculture farmers; the commercial fishing, aquaculture and fishing tourism industries
- (iii) amateur fishers
- (iv) others with an interest in the aquatic resources of the Territory, and

d) to promote the optimum utilisation of aquatic resources to the benefit of the community.

The *Spanish Mackerel Fishery Management Plan 2004* is subordinate to the Act and has three primary objects (*sic*):

- a) to control the taking of Spanish Mackerel from the fishery by commercial fishing licensees, Fishing Tour Operator licensees and amateur fishers, whether taken as the principal catch or incidentally when taking fish from another fishery and whether or not the fisher releases the fish;
- b) to ensure the fishery is not endangered, detrimentally affected or overexploited, by managing the fishery in accordance with the principles of ecologically sustainable development; and
- c) to encourage fishing in the fishery by maintaining the level and quality of the yield from the fishery and ensuring Aborigines, commercial fishing licensees, Fishing Tour Operator licensees and amateur fishers have adequate access to the fishery.

3.3. Current management controls

3.3.1. Commercial

The commercial sector of the Spanish Mackerel is managed using a combination of input and output based management controls (Table 3). Two other commercial fisheries in the NT may also retain Spanish Mackerel: the Offshore Net and Line Fishery (ONLF) and the Demersal Fishery (DF). Gear and harvest controls for the ONLF and DF are contained within the *Fisheries Regulations 1992*, whereas those for the SMF are contained within the *Spanish Mackerel Fishery Management Plan 2004*.

Table 3. Summary of current management controls for Spanish Mackerel Fishery licenses

SMF Management tool	
Total Allowable Catch	374 t
Limited entry	12 unrestricted licences and three restricted licenses
Permitted gear	Troll lines, floating handlines and rods, restricted bait net
Prohibited species	Barramundi, Mud Crab, Shark, King Threadfin
Closed areas	Commonwealth and NT Marine Parks Within a 1 nm radius of four artificial reefs Tiwi Island Exclusion Zones (permit required)

3.3.2. Recreational and Fishing Tour Operator

The recreational sector and Fishing Tour Operator (FTO) sector are managed through a combination of input and output management controls (Table 4). Fishing gear and methods employed by recreational fishers (and FTO clients) are contained with the *Fisheries Regulations 1992*, and are similar to those used by commercial Fishery licensees.

FTO's are required to have a licence and are regulated through the same management methods as the recreational sector. There is no limit on the number of FTO licences that can be issued with the ability to target Spanish Mackerel.

Table 4. Summary of current management controls for the Spanish Mackerel Fishery FTO and Recreational sector.

Management tool	Recreational	FTO
Total Allowable Catch	72 t	13.5 t
Licence	NA	Yes
Permitted gear	Vertical lines (handline or rod and reel), float lines and troll lines	Vertical lines (handline or rod and reel), float lines and troll lines
Possession limit	2 per person	2 per person
Closed areas	Commonwealth and NT Marine Parks Tiwi Island Exclusion Zones (permit required) Reef fish protection areas	Commonwealth and NT Marine Parks Tiwi Island Exclusion Zones (permit required) Reef fish protection areas

3.3.3. Aboriginal Traditional

Aboriginal fishers are entitled to use the aquatic resources of an area in a traditional manner, however, this entitlement does not extend to engaging in commercial fishing activities without a licence. Commercial engagement by the Indigenous Sector is encouraged through the purchase of a commercial licence, or through the Aboriginal Coastal Licence program.

Approximately 97 per cent of Spanish Mackerel caught by Aboriginal fishers in northern Australia are taken using hook and line, with the remainder caught using other gear types.

3.3.4. Marine Protected Areas/Reef Fish Protection Areas

SMF licensees are not permitted to fish within the National Park Zone of the Oceanic Shoals Marine Park (managed by the Australian Government), northwest of Bathurst Island. Certain parts of the Cobourg Marine Park (managed by the Northern Territory Government) also contain restricted areas. Four artificial reefs were deployed near Darwin in late 2019, with licence conditions specifying that commercial SMF licensees cannot fish within a one nautical mile radius of these structures.

3.4. Monitoring

Fishing activity of the commercial and fishing tourism sectors are monitored through compulsory catch and effort logbooks. Fishers are required to record fishing details on a daily basis during fishing operations. These details include fishing hours, location, fishing method, quantity of fish and estimated weights (commercial only). Logbooks are required to be submitted no later than 28 days after the end of the month in which fishing occurred.

Location of commercial fishing effort is captured in the logbook by 60 x 60 nm reporting grid, and more recently operators who are using the electronic logbooks for all catch reporting have been reporting by GPS location. On board fishery observers document vessel and gear information, location, depth, fishing practices, catch composition (including bycatch), and where possible, measure landed species, however observer work on commercial vessel has been sporadic in the SMF, with no trips conducted in the last decade.

FTOs are also required to submit compulsory catch and effort logbooks no later than 28 days after the end of the month, recording location (to a 'sub-grid' level that is 10 x 10 nm), gear types, line hours, number of clients, origin of clients, and number of fish caught and released. FTO data is verified by fishery observers, with 30-40 observer trips conducted per year. Observers' document vessel and gear information, fishing practices, client numbers, catch composition, and numbers of retained or released species. Information gathered during observer trips is used to logbook returns, and provide biological data.

There is no formal monitoring or catch reporting system in place for recreational or Aboriginal traditional fishers, with estimates of recreational and Aboriginal traditional catch derived from the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003).

Recreational fishing surveys have been conducted at varying intervals for the past two decades and include surveys undertaken in 1995, 2001, 2009-10, 2014 and 2015. Surveys of resident anglers are ongoing within the greater Darwin area. Only the National Recreational Fishing Survey 2000/01 (Henry and Lyle 2003) provided comprehensive NT-wide data from both resident and visiting anglers. The Recreational Fishing Survey of the Northern Territory 2009/10 (West *et.al* 2012) provided comprehensive estimates of resident only catch and effort across the Territory, and both resident and visitor information over smaller spatial scales.

More recent surveys have concentrated on providing estimates of total catch and effort around the greater Darwin region. Despite the variations in survey scope, the data generated provides a good indication of the estimated catch during these periods in the Darwin region where recreational fishing effort is highest.

3.5. Sectoral catch

Commercial catches (in weight) are derived from mandatory logbooks, whereas the FTO, recreational and Aboriginal catch weights are estimated from the numeric harvest of Spanish Mackerel using a conversion ratio of 5.02 kg per fish. The harvest of Spanish Mackerel across all sectors is shown in Figure 2.

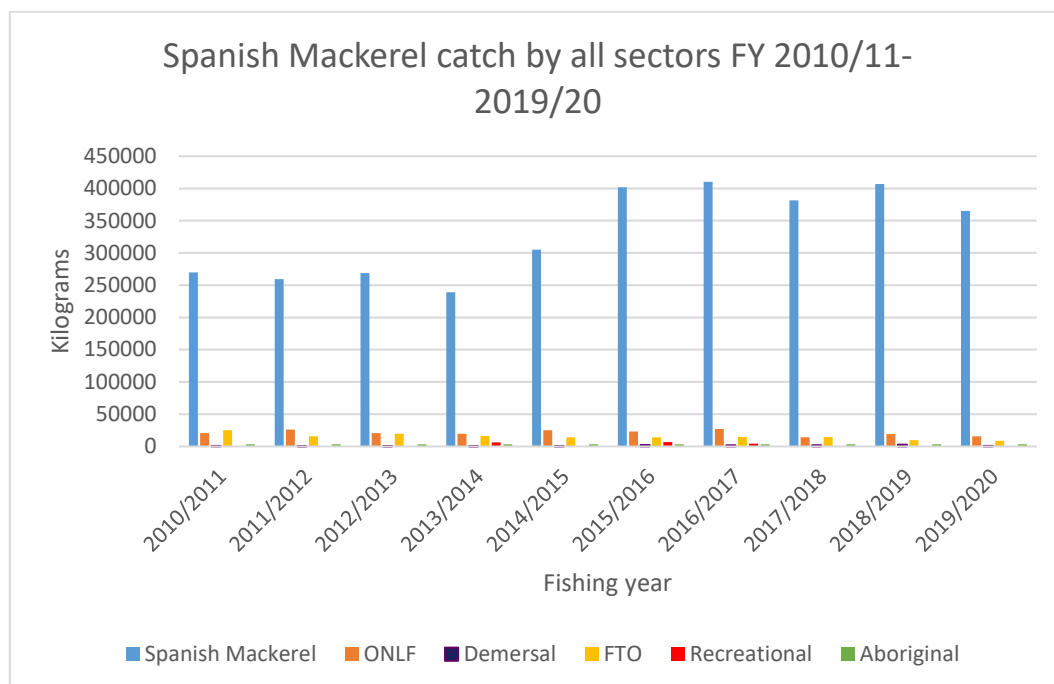


Figure 2. Overall harvest of Spanish Mackerel by sector 2010/11-2019/20. Recreational catch has been allocated a financial year based on timelines of the recreational surveys, only 3 years data are available for recreational catch. Aboriginal catch was estimated

3.5.1. Commercial

The SMF and the ONLF are responsible for the majority of the commercial harvest of Spanish Mackerel in NT waters. Spanish Mackerel are occasionally retained by the Demersal Fishery but represent a very small percentage (i.e. <one per cent) of the overall take (Figure 3).

Catch and effort data is recorded for the commercial section in 60 x 60nm reporting grids. Over the past 10 years, 25% of the cumulative catch was taken from just two 60 x 60 nm reporting grids and the top 10 most heavily fished grids account for 79% of the overall catch during this period. The remaining 21% of the cumulative catch is spread over 31 different reporting grids.

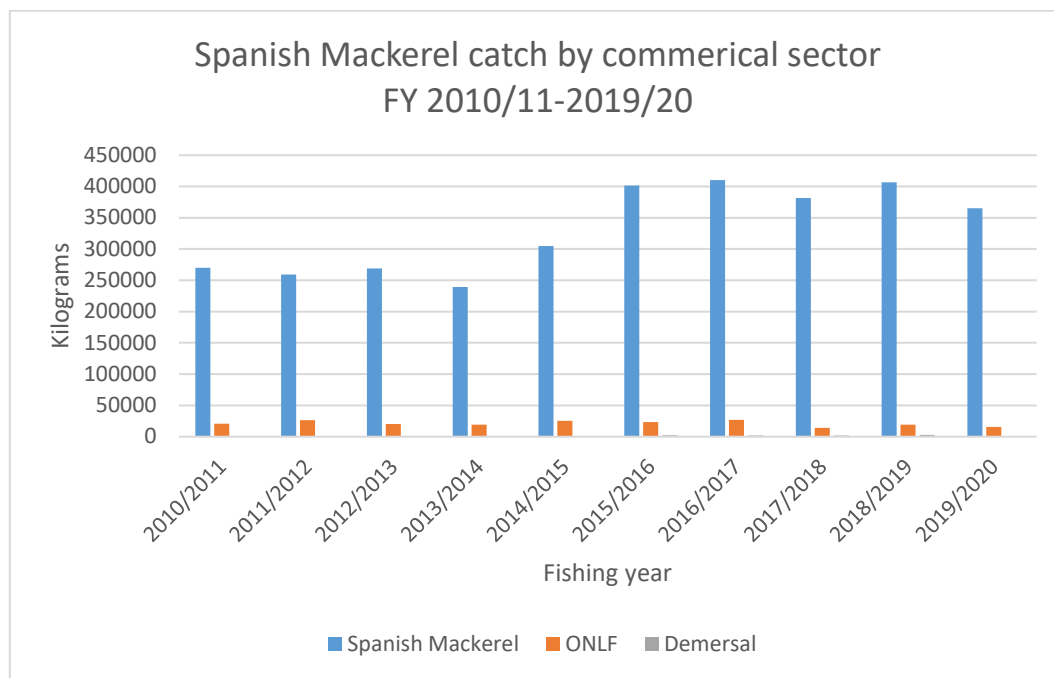


Figure 3. Harvest of Spanish Mackerel by the commercial sector 2010/11-2019/20.

3.5.2. Recreational fishers

The Survey of Recreational Fishing in the Northern Territory 2009-10 (West *et al.* 2012) was the first NT-wide survey to estimate the harvest of each local Mackerel species (Table 5); earlier surveys grouped Grey Mackerel, Spanish Mackerel and Spotted Mackerel together as "Mackerels".

Five further surveys have been undertaken in the last decade and comprise of Darwin-region surveys in 2014, 2015, 2016 and 2017 and an NT-wide survey in 2019. Provisional estimates from the 2016 survey have been made available for this ERA, but finalised results from this and later surveys are not yet publicly available.

Table 5. Numeric catch and harvest estimates for Spanish Mackerel from recent Northern Territory recreational fishing surveys (where Mackerel species were not grouped). Values in red font are used below to estimate harvest weights for this sector.

Spanish Mackerel			
Year	Catch	Retained	% of caught fish retained
2009	8287	3862	47%
2014	6273	3511	56%
2015	6899	3035	44%
2016	4551	2645	58%

3.5.3. Fishing Tour Operator

All Spanish Mackerel either retained or released are represented in Figure 4. Post release mortality for Spanish Mackerel is considered to be 100 per cent.

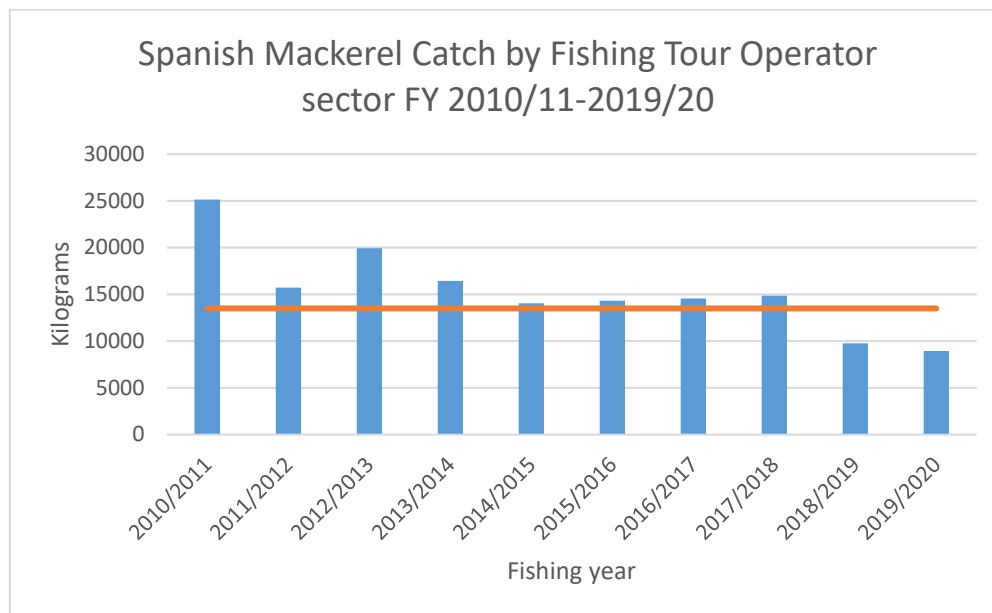


Figure 4. Harvest of Spanish Mackerel caught by Fishing Tour Operator clients 2010/11-2019/20, the orange line represents the FTO sector Spanish Mackerel allocation.

3.5.4. Aboriginal Traditional

The only estimate of the Aboriginal Traditional sector catch is from the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003). Based on the results of this survey estimated the catch of “Mackerels” (including Spanish, Grey, and Spotted) by this sector was estimated at 1,416 individuals. For the purpose of estimating the harvest of each species by Aboriginal Territorians (in terms of both number and weight), the catch was split equally between Spanish Mackerel and Grey Mackerel (i.e. 708 individuals per species) and assumed that all fish caught were harvested.

3.6. Environment

3.6.1. Climate

The climate of northern Australia is tropical monsoonal with two distinct seasons, a summer wet season which occurs broadly between October and March, and a winter dry season between April and September. The winters in northern Australia are influenced by easterly winds generated over inland Australia, resulting in dry and warm conditions with very little rainfall and low relative humidity. The high humidity and thunderstorm activity of the wet season is caused by steady west to north-west winds bringing moisture from the Timor and Arafura Sea. Cyclones may develop in the region between December and April, resulting in severe storms with gale force winds. Typically, cyclones form south of the equator in the Timor or Arafura Seas when sea temperatures are greater than 26.5°C. The monsoonal weather pattern is a major driver of important ecological processes in the marine environment and is a significant factor influencing recruitment of estuarine and coastal fishes in the Northern Territory.

3.6.2. Tides

Tidal types change across the Northern Territory between semi-diurnal (two high and two low tides per day), and diurnal (one high and one low per day) that occurs in both the north of the Arafura Sea and in the south of the Gulf (Webb 1981). Considerable variation in tidal range is experienced along the Northern Territory's coast, with ranges exceeding seven metres in the western areas during the spring tide, to less than 2 metres in areas of the Gulf of Carpentaria. The vast tidal movement combined with major inputs of fine silt sediments from numerous rivers create vast areas of high turbidity and ensures lower light penetration. With so much tidal flow, fishing in deeper water is primarily conducted during the neap tidal phase.

3.6.3. Physical Environment

The Joseph Bonaparte Gulf, west of Darwin, is an extensive, shallow basin that receives significant loads of sediment from the numerous rivers in the region (Lees 1992). It is dominated by tidal and wind-driven currents according to the season, with the area being comprised of soft substrate expanses with localised rocky outcrops, and strong tidal currents, high turbidity (particularly during the wet season), and substantial sediment mobility (Przeslawski *et al.* 2011).

The area immediately east of Darwin (Van Diemen Gulf) is a large almost fully enclosed body of water. Mainland landforms along the coast in this area are dominated by extensive low, flat, estuarine, coastal plains fringed at the coast by mud flats/banks often associated with a narrow band of mangroves. The rivers and creeks are typically tide dominated with intertidal flats, mangroves and saline flats/salt marshes with a naturally high turbidity (Roelofs *et al.* 2005).

The Arnhem Land region has a diverse coastline. The dominant landforms in western Arnhem Land are undulating sand and lateritic plains with sandy beaches and low rocky headlands with mangrove lined saline mudflats in the more protected bays and estuaries. In eastern Arnhem Land, coastal landforms are dominated by floodplains and mangroves with extensive tidal mud and sand flats (Roelofs *et al.* 2005). The major rivers of this region all have a moderate freshwater output, and wave energy is generally low except during short periods of storm and cyclonic activity in the Wet (Davies 1986). Water clarity varies within the region. The estuaries and protected bays in the west, and the near coastal waters in the east are naturally turbid, whereas the rocky platform and sandy areas in the west have low turbidity.

The Gulf of Carpentaria is a large, shallow, muddy marine bay that has marked seasonality in temperature, rainfall, salinity and wind regimes. The region has a diversity of land forms including offshore islands, fringing coral reefs, sandy, muddy and cliff-lined coastal topographies as well as extensive tidal mud/sand flats. The western Gulf of Carpentaria coast is a complex coastline with few river inputs, and is less muddy

than the southern Gulf, where extensive open coastline seagrass communities exist (Poiner *et al.* 1989). Sediments throughout the Gulf are predominantly fine muds, and these are easily resuspended due to the shallow bathymetry resulting in increased turbidity. Cyclones and storms also readily disturb and shift sediments in this shallow environment (Roelofs *et al.* 2005).

4. Methodology

4.1. Ecological Risk Assessment methodology

This ERA aims to ensure that the management of the Fishery is both effective and efficient in the context of achieving ESD outcomes. The principles of ESD form the basis of fisheries and aquatic resource management in the Northern Territory. In addition to meeting the statutory requirements of the Fisheries Act and national environmental legislation, this approach will also provide the fishing industry and key stakeholders with an ongoing opportunity to contribute to, and influence, fisheries management outcomes.

DITT will collaboratively develop more effective management arrangements under the Fisheries Act using the comprehensive issue identification, and subsequent risk assessment and priority setting process. The issue identification, risk assessment, reporting process, and final report format, is based on the National ESD Framework How To Guide (see <http://www.fisheries-esd.com.au>).

4.2. Scope

This risk assessment covers the harvest of Spanish Mackerel by all sectors within the SMF. The report is based on risk identification and assessment work undertaken by an expert panel in May 2020 and stakeholder consultation in August 2020. The identification of issues was informed by the generic ESD component tree approach, with each component tree refined specifically for the SMF. This report focuses on the Ecological Wellbeing of the fishery; the components of Human Wellbeing and Ability to Achieve will be addressed after the process to determine relevant management objectives to the benefit of the community.

Each component tree reflects the contemporary risks of harvesting activities on the retained species or non-retained species. It also included an assessment of the impacts of the activities on the broader environment. This process did not identify where additional (or reduced) management or research attention is needed; this will be done during the development of the management framework and harvest strategy, and as part of the periodic review of the fishery in accordance with the harvest strategy.

The calculation of risk in the context of a fishery is usually determined within a specified period, which for this assessment is the next five years, until 2025.

4.3. Issue Identification (component trees)

The component trees for the Fishery are refined versions of the generic trees described in the National ESD Reporting Framework. The generic trees are the results of extensive consideration and refinement during the development of the National Fisheries ESD approach. The component trees were used as the starting point to ensure thorough and consistent identification and evaluation of issues in the SMF. The component trees in this report were developed through consultation with the expert panel, and provide a realistic and practical illustration of issues facing the fishery. Each of these component trees are broken down into specific sub-components for which operational objectives can then be developed.

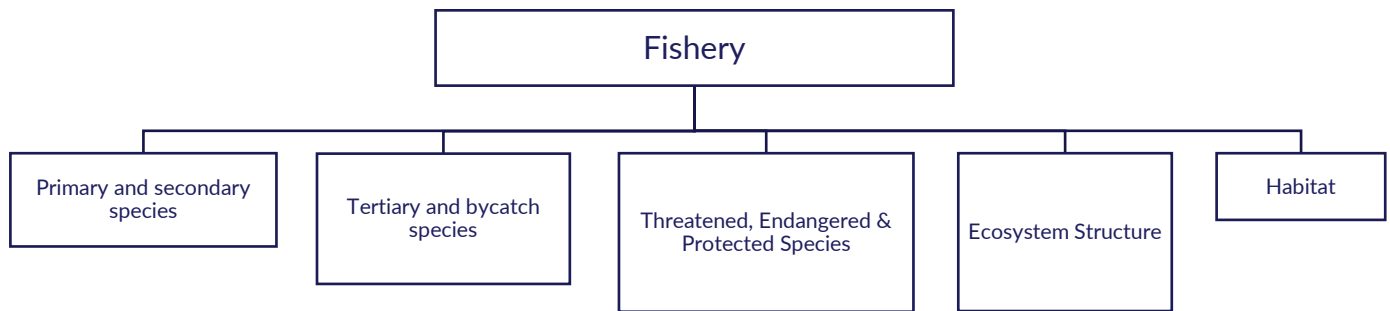


Figure 5. Fishery component tree.

4.4. Risk assessment and prioritisation of issue

After the component trees were developed by the expert panel, focus moved to the assessment and prioritisation of risks attributed to the activity of the fishery.

The risk assessments for the component trees of the SMF were based on existing management arrangements. The ESD assessment and reporting process is consistent with the Australian and New Zealand Standard AS/NZS ISO 31000 *Risk Management – Principles and Guidelines*. The expert panel and fishery stakeholders considered the potential consequences of an issue, activity or event and how likely those consequences are to occur. The estimated consequence of an event was multiplied by the likelihood of that event occurring to produce an estimated level of risk.

The expert panel worked through each element of the component tree and conducted a qualitative risk assessment of each issue. The consequence level for each issue was estimated and scored from one to four with one being minor and four being major (see Appendix 6.1). The consequence estimate was based upon the combined judgement of the expert panel. The level of consequence was estimated at the appropriate scale and context for the issue in question.

For retained species, the consequence assessment was based at the stock level (where information on structure was available). For example, killing one fish (e.g. Spanish Mackerel) is catastrophic for the individual but not for the stock. Similarly, assessments of possible ecosystem impacts were conducted at the level of the whole ecosystem, or specific habitat types, not at the level of individual patches or individual non-target species.

The likelihood of that consequence occurring was assigned one of four levels from remote (1) to likely (4). This was based on a judgement of the probability of the events or chain of events occurring that could result in a particular adverse consequence. This judgement of conditional probability was again based on the collective experience of the expert panel (see Appendix 6.1). From the consequence and likelihood scores, the overall risk value ($\text{Risk} = \text{Consequence} \times \text{Likelihood}$), was calculated (see Table 7). On the basis of this risk value each issue was assigned a Risk Rating within one of five categories Negligible, Low, Medium, High or Severe.

Table 6. Consequence x Likelihood Risk Matrix (based on AS/NZS ISO 31000; adapted from Fletcher 2015).

		Likelihood			
		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)
Consequence	Minor (1)	Negligible	Negligible	Low	Low
	Moderate (2)	Negligible	Low	Medium	Medium
	High (3)	Low	Medium	High	High
	Major (4)	Low	Medium	Severe	Severe

To ensure transparency and help stakeholders understand the basis for the risk scores received by each identified issue, the justification for each risk rating is included.

Table 7. Expected outcomes of each risk rating.

Risk Levels	Likely Management Action
Negligible	Nil
Low	None specific
Moderate	Specific management and/or monitoring required in Management Framework.
High	Increased management activities needed in Management Framework.
Severe	Increased management activities including a recovery strategy in the Management Framework. Consideration to be given to interim management arrangements to arrest the decline.

Once the expert panel had assigned risk ratings to components, the results were presented to a stakeholder workshop for consideration, in line with the Ecological Risk Assessment Guideline. The workshop provided the opportunity for stakeholders to discuss the risk ratings and provide any additional information that should be factored into the assessment. Where there was disagreement with any of the risk ratings completed by the expert group, additional information provided by the stakeholders was recorded at Appendix table 6.3.

4.5. Ecological Sustainable Development reports for higher risk issues

Central to any ESD performance report are the proposed management actions to deal with higher risk/priority issues. The higher risk/priority issues identified through this process will be addressed during the development/review of a management framework and associated harvest strategy for the SMF. This may include the establishment/review of defined operational objectives, performance indicators, reference points and decision rules.

5. Performance reports

Component trees were developed for retained and non-retained species as well as general ecosystem effects. The background colour for each component of the tree relates to the determined risk rating according to the following scheme: light blue = negligible, green = low, yellow = moderate, orange = high and red = severe. No specific management action is required where the risk is determined to be negligible or low, but risks that are rated moderate, high or severe indicates that the risk warrants a performance report and requires specific management and monitoring e.g. development/review of a management framework and/or Harvest Strategy.

5.1. Retained species

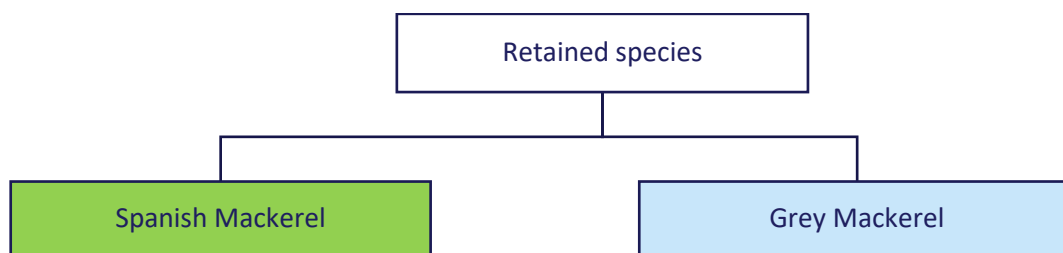


Figure 6. Component tree for retained species in the Fishery.

5.1.1. Primary species

Spanish Mackerel

Objective: To ensure that the harvest of Spanish Mackerel remain within ecologically sustainable limits.

Risk analysis: To assist with the risk analysis, information relating to individual species biology, vulnerability and stock status was considered (Appendix 6.2). The expert panel and stakeholders considered a suite of matters in determining a risk rating (Appendix 6.3).

The risk rating for the impact of the SMF on the sustainability of Spanish Mackerel was determined in accordance with tables 26 and 27 (Appendix 6.1).

Table 8. Risk rating for the impact of the Spanish Mackerel Fishery on the sustainability of Spanish Mackerel stocks.

Species	Consequence	Likelihood	Risk rating
Spanish Mackerel	(C1 - Minor)	(L3 - Possible)	(3 - Low)

Justification:

The below statements were used to justify the risk rating in Table 8:

- The majority of the Spanish Mackerel harvest (i.e. 90 per cent) is taken by the commercial sector.
- The most recent stock assessment for Spanish Mackerel (at a Territory-wide scale) indicated that the current biomass was 72 percent of the unfished (1973) biomass.
- The expert panel took a conservative approach and assumed there was 100 per cent post release mortality for fish released by the FTO and recreational sector. It was determined that this did not change the risk rating.

5.1.2. Secondary species**Grey Mackerel**

Objective: To ensure that the harvest of Grey Mackerel remain within ecologically sustainable limits.

Risk analysis: To assist with the risk analysis, information relating to individual species biology, vulnerability and stock status was considered by the Expert Panel (Appendix 6.2). The Expert Panel and stakeholders considered a suite of matters in determining a risk rating (Appendix 6.3)

Risk ratings for the impact of the SMF on the sustainability of Grey Mackerel, were determined in accordance with tables 26 and 28 (Appendix 6.1).

Table 9. Risk rating for the impact of the SMF on the viability of Grey Mackerel stocks.

Species	Consequence	Likelihood	Risk rating
Grey Mackerel	(C0 - Negligible)	(L2 - Rare)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 9:

- The majority of the Grey Mackerel harvest is taken by the commercial sector (primarily the ONLF, under a different commercial licence).
- The most recent stock assessment for the two Grey Mackerel stocks in the NT (using data to the end of 2011) indicate that current egg production is 80–90 per cent of the egg production of unfished stocks (i.e. well above accepted target reference points).

5.2. Non retained species

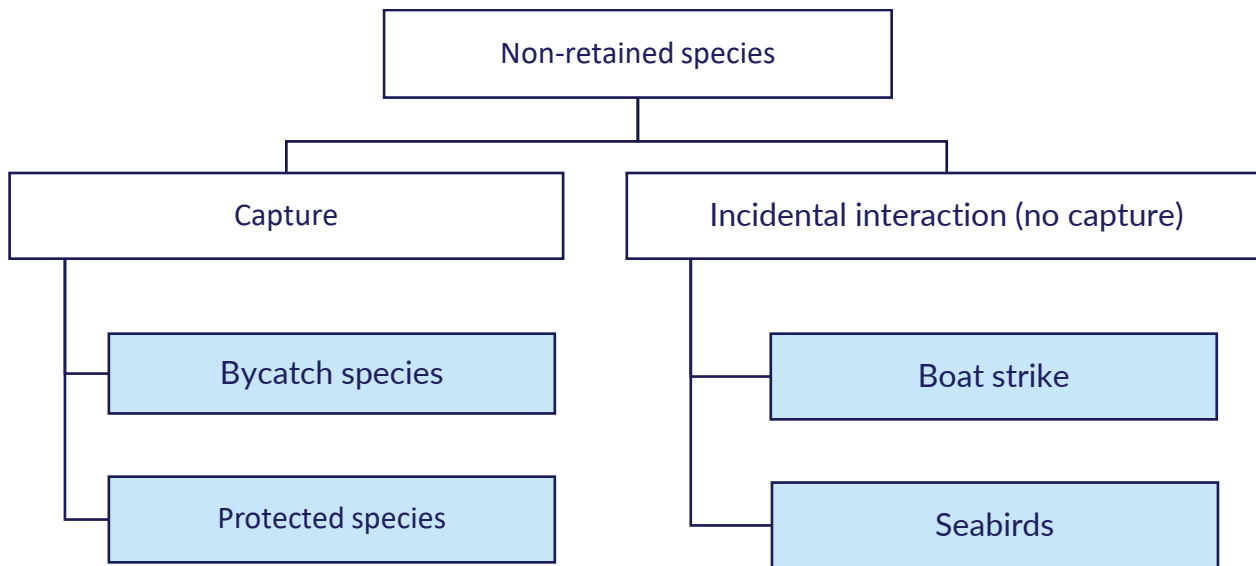


Figure 7. Component tree for non-retained species (assessed at the group level)

5.2.1. Bycatch species

Objective: To maintain the very low level of bycatch within the SMF.

Risk analysis: Risk ratings for the impact of the SMF on bycatch species were determined in accordance with tables 26 and 28.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 10. Risk rating for the impact of the SMF on the viability of bycatch species.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 10:

- Given the low bycatch rate and moderate to high survivorship of discarded animals, this assessment considered the risks to the group of bycatch species rather than each individual species.
- The total volume of bycatch reported by the SMF is very low, at approx. two tonne over the last 20 years (e.g. average 100kg/year).
- Blacktip Sharks are primarily taken by the ONLF and the harvest of this group of species (in the order of hundreds of tonnes per annum) has been assessed as sustainable, meaning any interaction the SMF has with this species would have negligible impact.
- Bull Sharks and Grey Reef Shark have not been subject to a formal assessment but are considered abundant.

5.2.2. Threatened, Endangered and Protected Species

Objective: To maintain the very low level of Protected and special species interactions.

Risk analysis: Risk ratings for the impact of the SMF on protected/ special species were determined in accordance with tables 26 and 29.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 11. Risk rating for the impact of the SMF on the viability of protected/special species.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 11:

- Due to the low encounter rate with protected/special species, the assessment considered the risks to this group of species rather than each individual species.
- Very few interactions with TEPS have occurred in the SMF logbooks over the last 20 years (i.e. one turtle and one sea snake – both released alive).
- The likelihood of recreational fishers, Aboriginal fishers or FTO clients interacting with TEPS while targeting Spanish Mackerel is considered remote.
- The expert panel considered the potential for low reporting rates, and advised that historic observer data supported the low level of interactions.

5.2.3. Boat strikes

Objective: To maintain the very low number of boat strikes within the SMF.

Risk analysis: Risk ratings for the impact of boat strike on non-retained species were determined in accordance with tables 26 and 29.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 12. Risk rating for the impact of boat strikes attributable to the Spanish Mackerel Fishery on the viability of protected/special species.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

- Boat strikes have not been observed during any SMF observer trips.
- Trolling speeds are quite slow (about six knots), so most pelagic species can swim out of the way to avoid a strike.

- Fishing primarily occurs around rocky reefs, which limits the subset of TEPS that may be encountered.

5.2.4. Seabirds

Objective: To ensure fishing in the SMF is not negatively impacting seabirds.

Risk analysis: Risk ratings for the impact of the SMF on seabird species were determined in accordance with tables 26 and 29.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 13. Risk rating for the impact of the Spanish Mackerel Fishery on the viability of seabird populations.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 13:

- A review of recreational fishing surveys, logbook records and observer data found no interactions between the SMF and seabirds.
- When targeting, Spanish Mackerel fishers (from all sectors) discard very little bait meaning few sea birds are attracted to their vessels. The fishing gear used is out of the reach of most diving seabirds for most of the time the exceptions being just after casting and during the final stages of retrieval.

5.3. General ecosystem effects

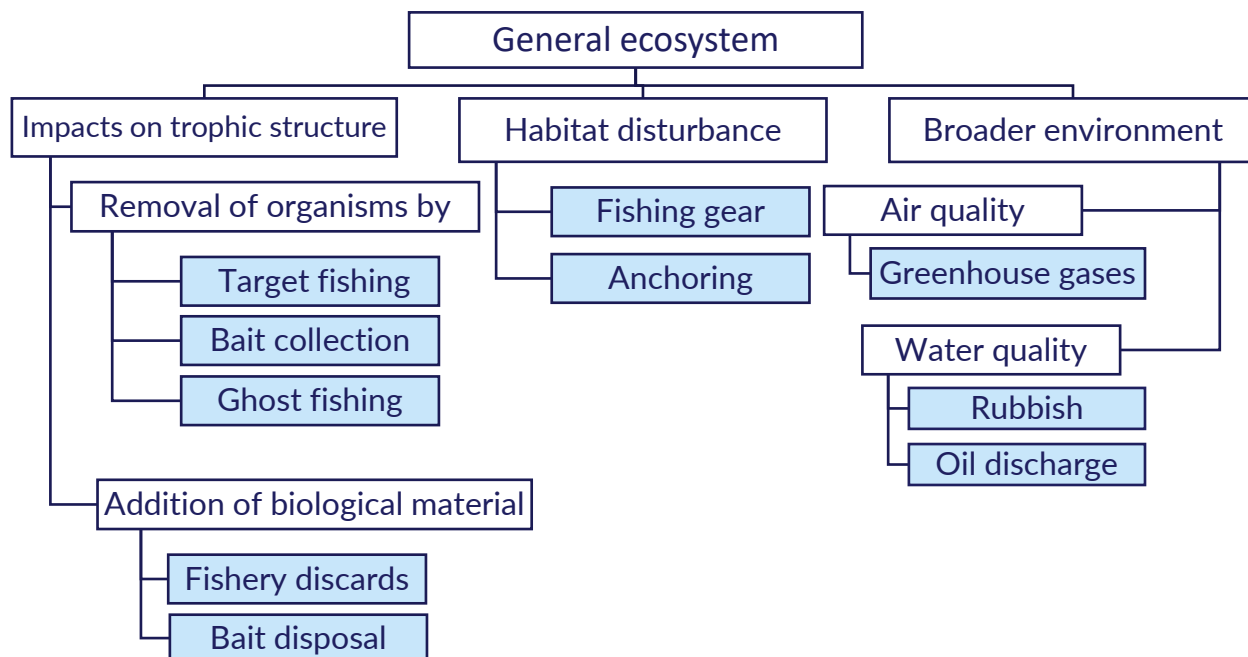


Figure 8. Component tree for the impacts of the SMF on the general ecosystem.

The highly selective nature of Spanish Mackerel fishing was a common consideration in the following assessments, particularly for commercial operations due to the relatively small size of the fishing fleet (i.e. around ten primary vessels, not all of which utilise dories).

5.3.1. Target fishing

Objective: To ensure target fishing is not negatively impacting the ecosystem.

Risk analysis: Risk ratings for the impact of the target fishing on general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 14. Risk rating for the impact of target fishing of Spanish Mackerel on trophic structure.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 14:

- Spanish Mackerel are a large, predatory fish within the Family Scombridae (Mackerels, Tunas and Bonitos) of which there are several representatives in northern Australian waters.
- All Scombrids occupy a similar ecological niche, have a broad diet, and have traits that are shared with some trevallies and sharks.
- Given the complexity of food webs in tropical marine waters and the high reproductive potential of Spanish Mackerel, the removal of this species through fishing is unlikely to have a detectable impact on food webs or ecosystem function.
- Due to the low level of exploitation, the retention of Spanish Mackerel was unlikely to pose a threat to the broader trophic structure given its current relative biomass (over 70 percent) and other fish species play a similar role to Spanish Mackerel in the trophic system.

5.3.2. Bait collection

Objective: To ensure bait collection is not impacting negatively on bait species.

Risk analysis: Risk ratings for the impact of bait collection by the SMF on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 15. Risk rating for the impact of bait collection by Spanish Mackerel fishers on trophic structure.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 15:

- Use of the restricted bait net by commercial operators is sporadic and consists of a limited number of shots per year by those fishers who use baited hooks (as opposed to lures).
- Garfish are the preferred bait, with details regarding the type and quantity of bait species recorded in compulsory logbooks.
- Bait collection is highly targeted and normally collected within 30 minutes.
- Recreational and FTOs can use cast nets and an amateur drag net, they however these methods are difficult to capture garfish, and bait for Spanish Mackerel fishing is generally purchased by these sectors
- The FTO sector also catches baitfish by line, this includes small reef fish and garfish.

5.3.3. Ghost fishing

Objective: To ensure ghost fishing is not impacting negatively on the ecosystem.

Risk rating: Risk ratings for the impact of the ghost fishing on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 16. Risk rating for the impact of ghost fishing (gear lost by Spanish Mackerel fishers) on trophic structure.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification

The below statements were used to justify the risk ratings assigned in Table 16:

- The surface and mid-water troll lines used by all sectors when Spanish Mackerel fishing are rarely lost, gear that is lost may persist in the environment for some time however the risk of ghost fishing is considered negligible.
- The likelihood of commercial restricted bait nets being lost is considered remote because this gear is rarely used, and must be monitored when in use.

5.3.4. Fishery discards

Objective: To ensure fishery discards are not impacting negatively on the ecosystem.

Risk analysis: Risk ratings for the impact of fishery discards on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3

Table 17. Risk rating for the impact of species discarded by Spanish Mackerel fishers on trophic structure.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 17:

- Discarding of bycatch by commercial operators in the SMF is very low, in the order of two tonne over the last 20 years. Bycatch species include: Blacktip Shark, Queenfish, Giant Trevally, Barracuda, Bull Shark and Grey Reef Shark.
- Many of these species are released alive by all sectors, and do not provide food for lower trophic levels (at least in the short term) when returned to the water.

5.3.5. Bait disposal

Objective: To ensure bait disposal is not impacting negatively on the ecosystem.

Risk rating: Risk ratings for the impact of bait fishing on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 18. Risk rating for the impact of bait discarded by Spanish Mackerel fishers on trophic structure.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 18:

- Recreational and FTO fishers predominantly use lures rather than bait.
- Some commercial fishers also use lures rather than bait, and there is an economic incentive to maximise the longevity of any bait that is used.
- Bait disposal is considered to be minimal, and the small amount that is discarded is consumed by other fish and marine scavengers.
- The impact of this additional food source on the marine ecosystem has not been quantified but is unlikely to be detrimental.

5.3.6. Gear interactions

Objective: To ensure gear interactions are not negatively impacting TEPS.

Risk analysis: Risk ratings for the impact gear interactions on the general ecosystem were determined in accordance with tables 26 and 29.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 19. Risk rating for the impact of Spanish Mackerel fishing gear on seafloor habitats.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 19:

- The troll lines used by all sectors when Spanish Mackerel fishing do not interact with the sea floor during fishing operations.
- The impact of gear lost by Spanish Mackerel fishers is not known, but it is assumed to be negligible.
- Restricted bait nets could potentially be lost and interact with the benthos. However, the likelihood of this occurring is considered remote because this gear is rarely used.
- The likelihood of gear interactions with seafloor habitats was considered remote due to small number of vessels that operate in the commercial fishery and the low level of fishing effort.

5.3.7. Greenhouse gas

Objective: To ensure that greenhouse gas emissions from the SMF are not impacting the environment.

Risk analysis: Risk ratings for the impact of greenhouse gases produced by the SMF on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 20. Risk rating for the impact of greenhouse gases released by vessels targeting Spanish Mackerel on the broader environment.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 20:

- Small commercial fleet, with motherships fitted with large diesel engines which are more efficient, and dories are generally fitted with modern petrol-powered four-stroke outboards resulting in the risk of greenhouse gas to be considered negligible.
- Recreational and FTO vessels are also generally fitted with modern petrol-powered four-stroke outboards.

5.3.8. Rubbish

Objective: To ensure rubbish from the SMF is not negatively impacting the environment.

Risk analysis: Risk ratings for the impact of rubbish generated by the SMF on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 21. Risk rating for the impact of rubbish from vessels targeting Spanish Mackerel on the broader environment.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 21:

- The disposal of solid, non-degradable waste in NT coastal waters is regulated through the *Marine Pollution Act 1999*.
- There are substantial penalty provisions for non-compliance with these regulations and most commercial fishers generally store rubbish on board for disposal on return to port.
- Compliance with these rules is generally considered high, but there may be instances where solid, non-degradable waste such as plastic bags, containers or cans are thrown or blown overboard.
- Recreational and FTO vessels generally undertake day trips when targeting Spanish Mackerel, and store rubbish on board for disposal (e.g. at the boat ramp or at home).
- Social pressure and stewardship also serve as effective deterrents to littering.
- The likelihood of rubbish and waste having an impact on the broader environment was considered negligible due to the small number of vessels that operate in the fishery, the level of fishing effort, and the targeted nature of Spanish Mackerel fishing by recreational and FTO fishers.

5.3.9. Oil discharge

Objective: To ensure that oil discharge from the SMF is not negatively impacting the environment.

Risk analysis: Risk ratings for the impact of oil discharge generated by the SMF on the general ecosystem were determined in accordance with tables 26 and 31.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 22. Risk rating for the impact of oil discharge by vessels targeting Spanish Mackerel on the broader environment.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 22:

- The majority of vessels in this fishery (recreational, FTO, and commercial dories) are equipped with four stroke engines that have minimal oil discharge.
- Small number of commercial motherships with diesel engines.
- The likelihood of oil discharge having an impact on the broader environment was considered negligible due to small number of vessels that operate in the fishery and the level of fishing effort.

5.3.10. Anchoring

Objective: To ensure anchoring by the SMF is not negatively impacting benthic habitat.

Risk analysis: Risk ratings for the impact of anchoring by the SMF on the general ecosystem were determined in accordance with tables 26 and 30.

In determining the likelihood and consequence, a suite of matters were considered and are outlined in Appendix 6.3.

Table 23. Risk rating for the impact of anchors used by vessels targeting Spanish Mackerel on seafloor habitats.

Consequence	Likelihood	Risk rating
(C0 - Negligible)	(L1 - Remote)	(0 - Negligible)

Justification:

The below statements were used to justify the risk ratings assigned in Table 23:

- Majority of activity by all sectors targeting Spanish Mackerel is to be continuously moving (e.g. trolling).
- Sand anchors are usually deployed on barren ground to minimise impacts on the sea floor (e.g. motherships).
- The likelihood of anchoring having an impact on seafloor habitats was considered negligible due to the nature of the recreational and FTOs sectors, and the small number of commercial vessels that operate in the fishery and the level of fishing effort.

6. Appendices

6.1. Likelihood, consequence and risk matrix tables

Table 24. Likelihood definitions

Level	Score	Definition
Remote	1	Never heard of in these circumstances but not impossible within the timeframe (<5% probability)
Unlikely	2	Not expected to occur in the timeframe but it has been known to occur elsewhere under special circumstances (5- <20% probability)
Possible	3	Clear evidence to suggest this is possible in some circumstances within the timeframe (20- <50% probability)
Likely	4	Expected to occur in the timeframe (≥50% probability)

Table 25. Consequence definitions for primary species

Level	Score	Definition
Minor	1	Measurable but minor levels of deletions of fish stock (biomass above 60% of unfished levels)
Moderate	2	Maximum acceptable level of depletion of stock (biomass 40-60% of unfished levels)

Level	Score	Definition
High	3	Level of depletion of stock unacceptable but still not affecting recruitment level of the stock (biomass 20-40% of unfished levels)
Major	4	Level of depletion of stock are already affecting (or will definitely affect) future recruitment potential of the stock (biomass <20% of unfished levels)

Table 26. Consequence definitions for secondary, tertiary and bycatch species

Level	Score	Definition
Minor	1	Measurable but minor levels of deletions of fish stock
Moderate	2	Maximum acceptable level of depletion of stock or species have high vulnerability and low resilience to harvest
High	3	Level of depletion of stock unacceptable but still not affecting recruitment level of the stock
Major	4	Level of depletion of stock are already affecting (or will definitely affect) future recruitment potential of the stock

Table 27. Consequence definitions for Threatened, Endangered and Protected Species

Level	Score	Definition
Minor	1	Few individuals directly impacted in most years, level of capture/interaction is well below that which will generate public concern
Moderate	2	Level of capture is the maximum that will not impact on recovery or cause unacceptable public concern
High	3	Recovery may be being affected and/or some clear, but short-term public concern will be generated
Major	4	Recovery times are clearly being impacted and/or public concern is widespread

Table 28. Consequence definitions of habitat impacts

Level	Score	Definition
Minor	1	There are measurable impacts in localised areas (<5% of habitat impacted)
Moderate	2	Levels of impact are measurable at larger scales (5-20% of habitat impacted)
High	3	The area impacted is sufficient that loss of habitat function is possible (20-50% of habitat impacted)
Major	4	Levels of impact are causing loss of habitat function and there is a risk of the entire habitat being impacted/ removed (>50% of habitat impacted)

Table 29. Consequence definitions for ecosystem structure and broader environment

Level	Score	Definition
Minor	1	Measurable but minor change in the environment or ecosystem structure but no measurable change to function
Moderate	2	Maximum acceptable level of change in the environment / ecosystem structure with no material change in function

Level	Score	Definition
High	3	Ecosystem function altered to an unacceptable level with some function or major components now missing and/or new species are prevalent
Major	4	Long-term, significant impact with an extreme change to both ecosystem structure and function; different dynamics now occur with different species / groups now the major targets of capture or surveys

6.2. Biological information for retained species

Spanish Mackerel

Scomberomorus commerson

Assessment information	
Distribution	Spanish Mackerel are widely distributed, found in Australian and south east Asian waters, north to China and Japan, and west to the Red Sea and South Africa. In Australian waters, Spanish Mackerel occur in WA and around northern and eastern Australia to St Helens in Tasmania but are more commonly found around the northern Australian coastline. Spanish Mackerel are an epi-pelagic, continental shelf species rarely found in waters deeper than 100 m and are commonly associated with coral reefs, rocky shoals and current lines on outer reef areas and offshore water to inshore shallow water of low salinity and high turbidity. Spanish Mackerel school mostly with fish of a similar size and of the same sex.
Growth and reproduction	Spanish Mackerel grow rapidly to a large size. Females mature at between 45 and 50 cm Fork Length (FL) and males between 40 and 45 cm FL, before two years of age. Females as small as 90 cm FL may have already spawned for two or more seasons before they are subject to commercial fishing. Spanish Mackerel are batch spawners (females spawn every few nights during a spawning run) and spawning may be repeated over a protracted season in tropical waters.
Stock structure	Genetic analyses suggest that there are three biological stocks of Spanish Mackerel across northern Australia (Moore <i>et al.</i> 2003). However, evidence from otolith microchemistry, parasite analysis and limited adult movement (at scales greater than 100 km) indicates that there are likely to be a number of smaller biological stocks with limited interaction (Buckworth <i>et al.</i> , 2007; Lester <i>et al.</i> , 2001; Moore <i>et al.</i> , 2003).
Vulnerability	Although Spanish Mackerel are a fast growing and early maturing species, they are susceptible to over-fishing (when fishing pressure is high) because of their tendency to aggregate at known locations.

Assessment information	
Stock status	Spanish Mackerel stocks have been assessed at a Territory-wide level. The most recent assessment (using data to 2015) indicated that stocks declined substantially because of high Taiwanese catches in the 1970s and 1980s but have recovered since the implementation of more stringent management in the early 1990s. Estimated biomass at the conclusion of 2015 was 72% of the unfished level (1973); this is within sustainable limits and there may be capacity for the catch to be increased (Grubert <i>et al.</i> , 2013). The stock is not considered to be recruitment impaired and the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired.
Fishing Activity	SMF licensees harvested the vast majority (90%) of the Spanish Mackerel resource in NT waters over the last decade (Figure 2). The next largest extractive user is the recreational sector (8%), followed by ONLF licensees (5%), FTO clients (3%), Aboriginal fishers (1%) and DF licensees (<1%). Note that in the absence of annual estimates of the Territory-wide harvest of Spanish Mackerel by recreational and Aboriginal fishers, harvest estimates for these sectors shown in Figure 2 are derived from the Survey of Recreational Fishing in the NT 2009/10 and the National Recreational and Indigenous Fishing Survey, respectively.

Grey Mackerel

Scomberomorus semifasciatus

Assessment information	
Distribution	Grey mackerel are found along the southern coast of eastern Indonesia, East Timor and Papua New Guinea, in parts of the Coral sea, and along the north Australian coast from the Houtman Abrolhos Islands on the west coast and to Northern NSW on the east coast (Kailola <i>et al.</i> 1993; Collette 2001). Adult Grey Mackerel are known to commonly occur in turbid tropical and sub-tropical waters at approximately 3-30m depth. This is usually in the vicinity of bottom structure in close proximity to headlands and reefs and on sandy mud and muddy sand substrates.
Growth and reproduction	Grey Mackerel grow rapidly, attaining a maximum size of 10kg and 120cm fork length (FL). Male and female fish attain sexual maturity at 55-60cm and 65-70cm FL respectively at approximately two years of age. Grey Mackerel are highly fecund (producing approximately 250,000 oocytes per spawning).
Stock structure	Two distinct populations of Grey Mackerel occur in the NT, one in the North West NT and the other in the Gulf of Carpentaria (Welch <i>et al.</i> 2009) with the Wessel Islands considered the point of separation.
Vulnerability	Although the species are fast growing and highly fecund (high production of spawn), they form aggregations which are predicated enough both spatially and temporally to be targeted. During spawning Grey Mackerel often school together which means they can be easily targeted by net fishing.

Assessment information	
Stock status	<p>North West Northern Territory</p> <p>Assessments indicate that Grey Mackerel stocks in the NT declined substantially as a result of the high Taiwanese gillnet catches in the 1970s to 1980s, but have since recovered with the cessation of foreign fishing and more stringent management of the domestic fishery. The most recent assessment estimates that in 2019 the biomass of the North West Northern Territory stock of Grey Mackerel was 71 per cent of the unfished level and that the harvest rate was 30 per cent of that required to achieve MSY (Usher and Saunders unpublished). The stock is not considered to be recruitment overfished and the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. Consequently, the North West Northern Territory biological stock is classified as a sustainable stock. Supporting this assessment is that catch per unit effort has increased over the past 10 years, while catches have remained relatively consistent.</p> <p>Gulf of Carpentaria (Goc)</p> <p>Grey Mackerel in the GoC is primarily a commercial gillnet-caught species. Queensland and the NT share the management of the GoC biological stock through the individual jurisdictions management arrangements. Queensland took most of the commercial harvest (61 per cent) in 2017.</p> <p>There has been a rising trend in the commercial catch rate since targeted fishing for Grey Mackerel began in the GoC in the late 1990s. Queensland catches and catch rates reached record levels in 2010 and 2012, respectively. Although Queensland's catch rate has fluctuated over time. The most recent assessment estimated that the GoC biomass in 2011 (896 t) was 74 per cent of the unfished biomass (Grubert <i>et al.</i> 2013) where the stock is not considered recruitment overfished. The GoC catch in 2017 (586 t) was below 2011 levels and therefore the stock is not considered recruitment overfished. Stock reduction analysis of Grey Mackerel in the GoC, using Queensland and NT catches, also concluded that the harvest rate was at 26 per cent of that required to achieve MSY (Grubert <i>et al.</i> 2013).</p> <p>Queensland introduced changes to the net fishery at the start of the 2012 season to reduce pressure on Grey Mackerel. These measures decreased the total length of available net by two-thirds, from 27km to 9km in the offshore component of the Fishery. Changes made for the Queensland inshore fishery (within 7 nautical miles of the coast) also reduced the capacity for boats to target Grey Mackerel. Commercial effort in 2017 (1,322 days fished) was above the 10-year average (1,104 days fished from 2007 to 2016).</p> <p>On the basis of the evidence provided above, the GoC biological stock is classified as a sustainable stock.</p>
Fishing activity	<p>Offshore Net and Line Fishery licensees harvested the vast majority (95%) of the Grey Mackerel resource in NT waters over the last decade. The next largest extractive user is the recreational sector (3%), with all other groups accounting for less than one percent of the overall catch.</p>

6.3. Matters considered for each component

Assessment information	
Primary Species	<ul style="list-style-type: none"> • Most recreational fishing activity in the NT is concentrated within a 250 km radius of Darwin, and it is here that the majority (i.e. around 70 per cent) of Spanish Mackerel are caught by this sector. The bulk of the remainder are caught along the Arnhem Land coast between Cobourg Peninsula and the town of Nhulunbuy. • The spread of fishing effort by the Fishing Tour Operator (FTO) sector is similar. • The catchability of Spanish Mackerel has increased over time, likely due to technological advances (e.g. side-scan sonar, differential GPS, improved weather forecasts, etc.). • Discarding and shark depredation have not been accounted for in past stock assessments (although their inclusion is unlikely to reduce the stock below the 60% biomass target level). • The average size of Spanish Mackerel near Darwin appears to be less than that in the Gulf of Carpentaria. It is not known if this is a natural or fishery-induced phenomenon. • Spanish Mackerel aggregate at known locations, which can result in hyper-stable catch rates • There are several stocks of Spanish Mackerel in NT waters, but their geographic range and connectivity is not well known • Stock assessments are conducted at a Territory-wide scale, which may overlook cases of localised depletion. • Estimates of the recreational and Indigenous harvest of Spanish Mackerel are sporadic. • Commercial fishing effort is concentrated around a few key reefs and shoals. • The fishing gear used rarely takes large (old) fish. • Harvested fish typically range from 3 to 8 years of age. • The most recent stock assessment for Spanish Mackerel (at a Territory-wide scale) indicated that the current biomass was 72% of the unfished (1973) biomass. • Spanish Mackerel in NT waters have been assessed as a “sustainable stock” in all four editions of the “Status of Australian Fish Stocks Reports”. • The expert panel considered the risk associated with 100% post release mortality of fish released by the FTO and recreational sectors (as a conservative approach).

Assessment information	
Secondary Species	<ul style="list-style-type: none"> • Grey Mackerel aggregate at known locations, which can result in hyper-stable catch rates • The harvest of Grey Mackerel by the SMF is <1% of that taken by the ONLF. • The vast majority of the Grey Mackerel harvest is taken by the commercial sector (primarily the ONLF). • The most recent stock assessment for the two Grey Mackerel stocks in the NT (using data to the end of 2011) indicate that current egg production is 80–90% of the egg production of unfished stocks (i.e. well above accepted target reference points). • Both Grey Mackerel stocks in NT waters have been assessed as a “sustainable stock” in all four editions of the “Status of Australian Fish Stocks Reports”.
Bycatch	<ul style="list-style-type: none"> • Given the low bycatch rate and moderate to high survivorship of discarded animals, this assessment considered the risks to the group of bycatch species rather than each individual species. • The total volume of bycatch reported by the SMF is very low, at around 2 t over the last 20 years. Bycatch species include: Blacktip Shark, Queenfish, Giant Trevally, Barracuda, Bull Shark and Grey Reef Shark. • Many of these species are released alive, and in good health, as the time between hooking and landing is in the order of a few minutes. • Bull Sharks and Grey Reef Shark have not been subject to a formal assessment but are considered abundant. • Bycatch caught by commercial operators was low but only sporadically recorded in the past. • The expert panel advised that historic observer data has supported low bycatch levels. • There is a need to improve bycatch reporting to inform future risk assessments. • Moving to E-logs should increase the accuracy of reporting • The total volume of bycatch reported by the SMF is very low, at around 2 t over the last 20 years. Bycatch species include: Blacktip Shark, Queenfish, Giant Trevally, Barracuda, Bull Shark and Grey Reef Shark.

Assessment information	
Threatened, Endangered and Protected Species	<ul style="list-style-type: none"> Given the low encounter rate with TEPS the assessment considered the risks to this group of species rather than each individual species. Very few interactions with TEPS have been reported in SMF logbooks over the last 20 years (i.e. one turtle and one sea snake – both released alive). The low incidence of TEPS interactions was last verified by fishery observers around 10 years ago. The likelihood of recreational fishers, Aboriginal fishers or FTO clients interacting with TEPS while targeting Spanish Mackerel is considered remote. The expert panel had considered potential low reporting rates and advised that historic observer data supported the low level of interactions.
Boat strike	<ul style="list-style-type: none"> Seagoing vessels may strike marine megafauna. The incidence and severity of these interactions will depend on the size and area of operation of the fleet, the size and speed of the vessels in the fleet, and the size, distribution and abundance of the species in question Boat strikes have not been observed during any SMF observer trips. Trolling speeds for all sectors are quite slow (about six knots) and so most pelagic species can swim out of the way to avoid a strike.
Seabirds	<ul style="list-style-type: none"> Fifty one bird species listed under the EPBC Act 1999 are known to occur in the North Marine Region (CoA, 2012). Offshore islands adjacent to the region (which overlap with the SMF) host internationally significant populations of colonially nesting terns: in particular the Crested Tern, Bridled Tern, Roseate Tern and Black-Naped Tern (Chatto 2001). A review of recreational fishing surveys, logbook records and observer data found no interactions between the SMF and seabirds. Spanish Mackerel fishers discard very little bait and so few sea birds are attracted to their vessels. The fishing gear used is out of the reach of most diving seabirds for most of the time, the exceptions being just after casting and during the final stages of retrieval.

Assessment information	
General ecosystem effects	
Target fishing	<ul style="list-style-type: none"> • Intensive fishing effort targeting keystone species has the potential to change the composition of marine ecosystems. • Spanish Mackerel are a large, predatory fish within the Family Scombridae (Mackerels, Tunas and Bonitos) of which there are several representatives in northern Australian waters. • All Scombrids occupy a similar ecological niche and have a broad diet, traits shared with some trevallies and sharks. • Given the complexity of food webs in tropical marine waters and high reproductive potential of Spanish Mackerel, the removal of this species through fishing is unlikely to have a detectable impact on food webs or ecosystem function. • Due to the low level of exploitation, the retention of Spanish Mackerel was unlikely to pose a threat to the broader trophic structure given its current relative biomass (over 70%) and that other fish species play a similar role to Spanish Mackerel in the trophic system.
Bait collection	<ul style="list-style-type: none"> • Licensees are permitted to collect bait for their operations using a restricted bait net. • Use of this gear is sporadic and consists of a couple of shots each year by those fishers who use baited hooks (as opposed to lures). • Garfish are the preferred bait, with details regarding the type and quantity of bait species recorded in compulsory logbooks. • Bait collection is highly targeted and normally collected within 30 minutes.
Ghost fishing	<ul style="list-style-type: none"> • Mackerels or sharks may bite through the terminal end of troll lines. This results in the loss of lures and short lengths of nylon and/or stainless steel leader, which fall to the seafloor. • Restricted bait nets could potentially be lost and pose a ghost fishing risk. • Lost gear may persist in the environment for some time, but is unlikely to pose a risk to marine species. • The likelihood of bait nets being lost is considered remote because this gear is rarely used and monitored when in use.

Assessment information	
Fishery discards	<ul style="list-style-type: none"> • Some incidental species may be caught and discarded, either dead or alive. • Discarding of bycatch by the SMF is very low, in the order of 2 t over the last 20 years. Bycatch species include Blacktip Shark, Queenfish, Giant Trevally, Barracuda, Bull Shark and Grey Reef Shark. • Many of these species are released alive and do not provide food for lower trophic levels (at least in the short term) when returned to the water.
Bait disposal	<ul style="list-style-type: none"> • Those fishers using baited hooks may discard ineffective or rancid bait. • Some fishers use lures rather than bait, and there is an economic incentive to maximise the longevity of any bait that is used. • Bait disposal is considered to be minimal, and the small amount that is discarded is probably consumed by other fish and marine scavengers. • The impact of this additional food source on the marine ecosystem has not been quantified but is unlikely to be detrimental.
Gear interactions	<ul style="list-style-type: none"> • Gear may be lost and accumulate on the sea floor over time. • The troll lines used by do not interact with the sea floor during fishing operations. • The impact of gear lost by Spanish Mackerel fishers (all sectors) is not known, but it is assumed to be negligible. • Restricted bait nets could potentially be lost and interact with the benthos. However, the likelihood of this occurring is considered remote because this gear is rarely used. • The likelihood of gear interactions with seafloor habitats was considered remote due to small number of vessels that operate in the fishery and the low level of fishing effort
Habitat	
Anchoring	<ul style="list-style-type: none"> • Trolling the preferred method by all sectors. • Sand anchors are usually deployed on barren ground to minimise impacts on the sea floor. • The likelihood of anchoring having an impact on seafloor habitats was considered negligible due to the small number of vessels that operate in the fishery and the level of fishing effort.

Assessment information	
Broader environment	
Greenhouse gas	<ul style="list-style-type: none"> • Spanish Mackerel fishing vessels produce exhaust emissions that may impact on the abiotic environment. • Motherships are fitted with large diesel engines whereas as dories are generally fitted with modern petrol-powered four-stroke outboards. • Majority of recreational and FTO vessels fitted with modern petrol-powered four-stroke outboards.
Rubbish	<ul style="list-style-type: none"> • Rubbish from vessels targeting Spanish Mackerel fishing vessels may enter the marine ecosystem through either accidental loss or deliberate discarding • The disposal of solid, non-degradable waste in NT coastal waters is regulated through the Marine Pollution Act 1999. • There are substantial penalty provisions for non-compliance with these regulations and most fishers generally store rubbish on board for disposal on return to port. • Compliance with these rules is generally considered high, but there may be instances where solid, non-degradable waste such a plastic bags, containers or cans are thrown or blown overboard. • Social pressure and stewardship also serve as effective deterrents to littering. • Majority of recreational and FTO vessels undertake day trips and store rubbish on board for disposal at the boat ramp or at home. • The likelihood of rubbish and waste having an impact on the broader environment was considered negligible due to nature of recreational and FTO vessels and the small number of commercial vessels that operate in the fishery and the level of fishing effort
Oil discharge	<ul style="list-style-type: none"> • Vessels targeting Spanish Mackerel produce exhaust emissions that discharge oil directly into the water column. • The majority of vessels in this fishery (commercial, recreational and FTOs) are equipped with four stroke engines that have minimal exhaust emissions. • The likelihood of oil discharge having an impact on the broader environment was considered negligible due to small number of vessels that operate in the fishery and the level of fishing effort.

6.4. List of attendees at each workshop

6.4.1. Expert Panel Workshop

	Affiliation
Mr Grant Johnson	NT Fisheries
Mr Michael Usher	NT Fisheries
Dr Thor Saunders	NT Fisheries
Dr Mark Grubert	NT Fisheries
Dr Rik Buckworth	Independent consultant

Independent scientific advice was also sought from Dr Keller Kopf from Charles Darwin University.

6.4.2. Key Stakeholder Workshop

	Affiliation
Mr Norm Hedditch	Industry
Mr Peter Manning	Industry
Mr David Ciaravolo	Amateur Fisherman's Association of NT
Mr Peter Pender	Northern Land Council
Mr Dennis Sten	NT Guided Fishing Association
Dr Mark Grubert	NT Fisheries
Dr Thor Saunders	NT Fisheries
Dr Keller Kopf	Charles Darwin University
Ms Katherine Winchester	Norther Territory Seafood Council
Mr Bruce Davey	Industry

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