Northern Territory Offshore Net and Line Fishery

Ecological Risk Assessment

2020

NORTHERN TERRITORY GOVERNMENT

Contents

1. Executive Summary **8**
1.1. ERA Risk rating outcomes 8
2. Introduction **9**
3. Background **10**
3.1. Management history of the fishery 10
3.2. Description of the fishery 10
3.3. Fishing method 11
3.4. Resource sharing 12
3.5. Retained species 12
3.6. Non retained species 12
3.7. Threatened, Endangered and Protected Species 12
4. Legislation **13**
4.1. Current management controls 14
4.1.1. Commercial 14
4.1.2. Recreational and Fishing Tourism 15
4.1.3. Aboriginal Traditional 16
4.1.4. Reef fish protection areas 16
4.2. Monitoring 16
4.3. Sectoral catch 17
4.3.1. Commercial 17
4.3.2. Fishing Tour Operator 17
4.3.3. Recreational 18
4.3.4. Aboriginal 18
4.4. Environment 19
4.4.1. Climate 19
4.4.2. Tides 19
4.4.3. Physical environment 19
5. Methodology **20**
5.1. Ecological Risk Assessment methodology 20
5.2. Scope 20
5.3. Issue identification (component trees) 20
5.4. Risk assessment and prioritisation of issues 21
5.5. Ecological risk assessment likelihood and consequence tables 22
5.6. Ecological Sustainable Development reports for higher risk issues 22
6. Performance reports **23**
6.1. Retained species 23
6.1.1. Grey Mackerel 24

6.1.1.1. Objective: 24
6.1.1.2. Risk rating 24
6.1.1.3. Sources of risk 24
6.1.1.4. Justification 24
6.1.2. Blacktip Sharks 25
6.1.2.1. Risk rating 25
6.1.2.2. Objective 25
6.1.2.3. Sources of risk 25
6.1.2.4. Justification 25
6.2. Secondary species 26
6.2.1. Spot-tail shark 26
6.2.1.1. Objective 26
6.2.1.2. Risk rating 26
6.2.1.3. Sources of risk 26
6.2.1.4. Justification 26
6.2.2. Spanish Mackerel 26
6.2.2.1. Objective 26
6.2.2.2. Risk rating 27
6.2.2.3. Sources of risk 27
6.2.2.4. Statement of considerations 27
6.2.3. Longtail Tuna 27
6.2.3.1. Objective 27
6.2.3.2. Risk rating 27
6.2.3.3. Sources of risk 28
6.2.3.4. Justification 28
6.2.4. Hammerhead Sharks 28
6.2.4.1. Objective 28
6.2.4.2. Risk rating 28
6.2.4.3. Sources of risk 29
6.2.4.4. Justification 29
6.2.5. Combined shark species 29
6.2.5.1. Objective 30
6.2.5.2. Risk rating 30
6.2.5.3. Sources of risk 30
6.2.5.4. Justification 30
6.2.6. Winghead Shark 30
6.2.6.1. Objective: 30
6.2.6.2. Risk rating 30
6.2.6.3. Sources of risk 31
6.2.6.4. Justification 31

6.2.7. Blacktip Reef Shark 31
6.2.7.1. Objective: 31
6.2.7.2. Risk rating 31
6.2.7.3. Sources of risk 31
6.2.7.4. Justification 31
6.2.8. Creek Whaler 32
6.2.8.1. Objective: 32
6.2.8.2. Risk rating 32
6.2.8.3. Sources of risk 32
6.2.8.4. Justification 32
6.2.9. Black Jewfish 32
6.2.9.1. Objective 32
6.2.9.2. Sources of risk 32
6.2.9.3. Justification 32
6.2.10. Golden Snapper 33
6.2.10.1. Objective: 33
6.2.10.2. Risk rating 33
6.2.10.3. Sources of risk 33
6.2.10.4. Justification 33
6.2.11. Combined finfish group 33
6.2.11.1. Objective: 33
6.2.11.2. Risk rating 33
6.2.11.3. Sources of risk 33
6.2.11.4. Justification 33
6.2.12. Sailfish 34
6.2.12.1. Objective: 34
6.2.12.2. Risk rating 34
6.2.12.3. Sources of risk 34
6.2.12.4. Justification 34
6.2.13. Combined other shark group 34
6.2.13.1. Objective: 34
6.2.13.2. Risk rating 34
6.2.13.3. Sources of risk 34
6.2.13.4. Justification 35
6.2.14. Tawny Shark 35
6.2.14.1. Objective 35
6.2.14.2. Risk rating 35
6.2.14.3. Sources of risk 35
6.2.14.4. Justification 35
6.2.15. Fossil Shark 35

6.2.15.1. Objective: 35
6.2.15.2. Risk rating 35
6.2.15.3. Sources of risk 35
6.2.15.4. Justification 36
6.2.16. Hardnose Sharks 36
6.2.16.1. Objective: 36
6.2.16.2. Risk rating 36
6.2.16.3. Sources of risk 36
6.2.16.4. Justification 36
6.3. Non-retained species 37
6.3.1. Bycatch 38
6.3.1.1. Objective: 38
6.3.1.2. Risk rating 38
6.3.1.3. Sources of risk 38
6.3.1.4. Justification 38
6.3.2. Threatened, Endangered and Protected Species 38
6.3.3. Sea turtles 38
6.3.3.1. Objective: 38
6.3.3.2. Risk rating 38
6.3.3.3. Sources of risk 39
6.3.3.4. Justification 39
6.3.4. Sawfish 39
6.3.4.1. Objective: 39
6.3.4.2. Risk ratings 39
6.3.4.3. Sources of risk 39
6.3.4.4. Justification 39
6.3.5. Dwarf and Largetooth Sawfish 40
6.3.5.1. Objective: 40
6.3.5.2. Risk rating 40
6.3.5.3. Sources of risk 40
6.3.5.4. Justification 40
6.3.6. Devil and Manta Rays 40
6.3.6.1. Objective: 40
6.3.6.2. Risk rating 40
6.3.6.3. Sources of risk 41
6.3.6.4. Justification 41
6.3.7. Seabird interactions 41
6.3.7.1. Objective: 41
6.3.7.2. Risk rating 41
6.3.7.3. Sources of risk 41

6.3.7.4. Justification 41
6.3.8. Dolphins 41
6.3.8.1. Objective: 41
6.3.8.2. Risk rating 42
6.3.8.3. Sources of risk 42
6.3.8.4. Justification 42
6.3.9. River sharks (*Glyphis* species) 42
6.3.9.1. Objective: 42
6.3.9.2. Risk rating 42
6.3.9.3. Sources of risk 42
6.3.9.4. Justification 42
General ecosystem effects 43
6.3.10. General ecosystem impacts 43
6.3.11. Bycatch 43
6.3.11.1. Objective: 43
6.3.11.2. Risk rating 43
6.3.11.3. Sources of risk 44
6.3.11.4. Justification 44
6.3.12. Boat strike 44
6.3.12.1. Objective: 44
6.3.12.2. Risk rating 44
6.3.12.3. Sources of risk 44
6.3.12.4. Justification 44
6.3.13. Discards 44
6.3.13.1. Objective: 44
6.3.13.2. Risk rating 44
6.3.13.3. Sources of risk 44
6.3.13.4. Justification 44
6.3.14. Bait 45
6.3.14.1. Objective: 45
6.3.14.2. Risk rating 45
6.3.14.3. Sources of risk 45
6.3.14.4. Justification 45
6.3.15. Additional biological material 45
6.3.15.1. Objective: 45
6.3.15.2. Sources of risk 45
6.3.15.3. Justification 45
6.3.16. Other environmental factors 46
6.3.16.1. Rubbish 46
6.3.16.2. Objective: 46

6.3.16.3. Risk rating 46
6.3.16.4. Sources of risk 46
6.3.16.5. Justification 46
6.3.16.6. Oil discharge 46
6.3.16.7. Objective: 46
6.3.16.8. Sources of risk 46
6.3.16.9. Justification 46
6.3.16.10. Climate Change 47
6.3.16.11. Sources of risk 47
6.3.16.12. Justification 47
6.3.17. Habitat disturbance 47
6.3.17.1. Ghost fishing 47
6.3.17.2. Objective: 47
6.3.17.3. Risk rating 47
6.3.17.4. Sources of risk 47
6.3.17.5. Justification 47
6.3.17.6. Anchoring 48
6.3.17.7. Objective: 48
6.3.17.8. Risk rating 48
6.3.17.9. Sources of risk 48
6.3.17.10. Justification 48
7. Appendices 49
7.1. Likelihood, consequence and risk matrix tables 49
7.2. Assessment information for main retained species 52
7.2.1. Grey Mackerel 52
7.2.2. Blacktip and Spot-tail Sharks 53
7.2.3. Spanish Mackerel 55
7.2.4. Longtail Tuna 57
7.2.5. Hammerhead sharks 58
7.2.6. Pigeye shark 59
7.2.7. Bull shark 60
7.2.8. Mackerel Tuna 61
7.2.9. Tiger Sharks 61
8. References 63

1. Executive Summary

This report summarises the outcomes of the Ecological Risk Assessment (ERA) conducted for the Northern Territory Offshore Net and Line Fishery (the Fishery) in June 2020. The assessment was undertaken to identify the ecological risks posed by the fishery.

This report provides background information on the Fishery as well as information used to inform the ERA process. Risks associated with the Fishery were initially assessed though a technical workshop attended by an independent panel of scientific experts. This report was presented to stakeholders of the Fishery at a workshop on 24 August 2020 for their consideration.

1.1. ERA Risk rating outcomes

Table 1: ERA risk rating outcomes.

Species assessed	Consequence	Likelihood	Risk Rating
Grey Mackerel	1 (minor)	3 (possible)	3
Blacktip Sharks (North and West coast)	1 (minor)	2 (rare)	2
Blacktip Sharks (Gulf of Carpentaria)	1(minor)	2 (rare)	2
Spot-tail Shark	1 (minor)	2 (rare)	2
Spanish Mackerel	1 (minor)	2 (rare)	2
Longtail Tuna (Indian Ocean)	3 (severe)	2 (rare)	6
Longtail Tuna (Pacific Ocean)	2 (moderate)	3 (possible)	6
Scalloped Hammerhead	2 (moderate)	3 (possible)	6
Combined shark species (Bull Shark, Tiger Shark, Lemon Shark, Pigeye Shark, Grey Reef Shark)	2 (moderate)	3 (possible)	6
Winghead Shark	4 (major)	4 (occasional)	16
Blacktip Reef Shark	1(minor)	2 (rare)	2
Creek Whaler	2 (moderate)	3 (possible)	6
Great Hammerhead	2 (moderate)	4 (occasional)	8
Black Jewfish	2 (moderate)	2 (rare)	4
Golden Snapper	3 (severe)	3 (possible)	9
Finfish combined group (Black Pomfret, Trevallies, Mackerel Tuna, Spotted Mackerel, Blue Threadfin and Batfish)	1 (minor)	2 (rare)	2
Sailfish	1 (minor)	2 (rare)	2
Milk Shark	1 (minor)	2 (rare)	2
Whitecheek Shark	1 (minor)	2(rare)	2
Tawny Shark	1 (minor)	2 (rare)	2

Species assessed	Consequence	Likelihood	Risk Rating
Fossil Shark	1 (minor)	3 (possible)	3
Hardnose Shark	1 (minor)	2 (rare)	2
Olive Ridley Turtle	3 (severe)	2 (rare)	6
Green Turtle	2 (moderate)	2 (rare)	4
Flatback Turtle	2 (moderate)	2 (rare)	4
Hawksbill Turtle	2 (moderate)	2 (rare)	4
Loggerhead Turtle	3 (severe)	2 (rare)	6
Leatherback Turtle	3 (severe)	2 (rare)	6
Green Sawfish	3 (severe)	3 (possible)	9
Narrow Sawfish	3 (sever)	3 (possible)	9
Dwarf Sawfish	4 (major)	2 (rare)	8
Largetooth Sawfish	4 (major)	2 (rare)	8
Devil and Manta Rays	4 (major)	2 (rare)	8
Seabirds	0 (negligible)	1 (remote)	0
Dolphins	1 (minor)	2 (rare)	2
River sharks (*Glyphis* species)	2 (moderate)	2 (rare)	4
Ecosystem impacts			
Boat strike	0 (negligible)	2 (rare)	0
Bycatch	1 (minor)	2 (rare)	2
Discards	1 (minor)	2 (rare)	2
Bait	1 (minor)	2 (rare)	2
Additional biological material	1 (minor)	2 (rare)	2
Other environmental factors	1 (minor)	2 (rare)	2
Habitat	1 (minor)	1 (remote)	1

2. Introduction

The principles of Ecologically Sustainable Development (ESD) are the basis of fisheries and aquatic resource management in the Northern Territory (NT). The *NT Fisheries Act 1988* (the 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 the Department of Industry, Tourism and Trade (DITT) is responsible for fisheries management under the Fisheries Act.

The current report moves a step forward in the ERA process by addressing the contemporary risks of harvesting activities on species by all fishery sectors, but also identifying the relevant issues and completing a risk assessment within the broader impacts of the activities on the environment (general ecosystem).

This report also provides background information on the Fishery, including a brief summary of the management history, and outlines the risk assessment methodologies used, as well as the rationale behind assigned risk levels in the fishery. These risk ratings will then be used to inform the review of the Fishery

management framework (including a harvest strategy), with the aim of continued ecologically sustainable development of the resource.

3. Background

3.1. Management history of the fishery

A large commercial shark fishery commenced in the waters of northern Australia in the early 1970s when a Taiwanese gillnet fleet targeted a range of pelagic shark and fish species, including various Mackerel and Tunas. Foreign fishing vessels worked within 12 nautical miles (approximately 22 km) of the coast prior to 1978. However, with the declaration of the Australian Fishing Zone (AFZ) in 1979, the foreign fishing fleet was excluded from the Gulf of Carpentaria (GoC) and waters within 50 nautical miles of Arnhem Land and the Wessel Islands.

A bilateral agreement between Australia and Taiwan permitted access for 30 gillnetters to land up to 7,000 tonnes (t) of shark from northern Australian waters. Further restrictions were introduced in 1986 as the result of declining catch rates and concerns about the incidental capture of dolphins. These restrictions limited the length of gillnets to not more than 2.5km per licence, thereby rendering the joint venture gillnetting uneconomic. Despite the permitted use of baited longlines, foreign fishing operations in Northern Australian ceased in late 1986.

In the early 1990's a series of workshops were held with stakeholders to consider the future management arrangement options for the fishery. A result of these workshops was a three to one licence reduction scheme implemented to reduce landings to ensure estimated sustainable limits were not exceeded and to ensure economic viability.

In 1995 a revised Offshore Constitutional Settlement (OCS) arrangement was finalised with the responsibility for the former Commonwealth managed offshore component and NT managed inshore fishery passed to the Northern Territory Fishery Joint Authority (NTJFA). Day to day management of the fishery is achieved under NT legislation.

Pre-existing access conditions were recognised with the passage of the OCS. At that time. Existing fishers were issued a "restricted licence" for the zone or zones which they were authorised to operate.

In 2018 the NTFJA approved the use on Total Allowable Commercial Catch (TACC) and Individual Transferrable Quota (ITQ) in the management of the ONLF, subject to satisfactory outcomes of the government regarding the cost of management, research and compliance. The Offshore Net and Line Advisory Group (ONLAG) has developed new management arrangements for the fishery that have an output (catch based) control focus.

3.2. Description of the fishery

The Fishery is a quota managed fishery, operating in the NT waters from the low water mark to the boundary of the AFZ. The area of the Fishery is approximately 542,000m² (Figure 1: Map showing the boundary of the Offshore Net and Line Fishery of the Northern Territory. The Fishery is currently managed primarily via output (catch based) but includes some input (gear based) controls.

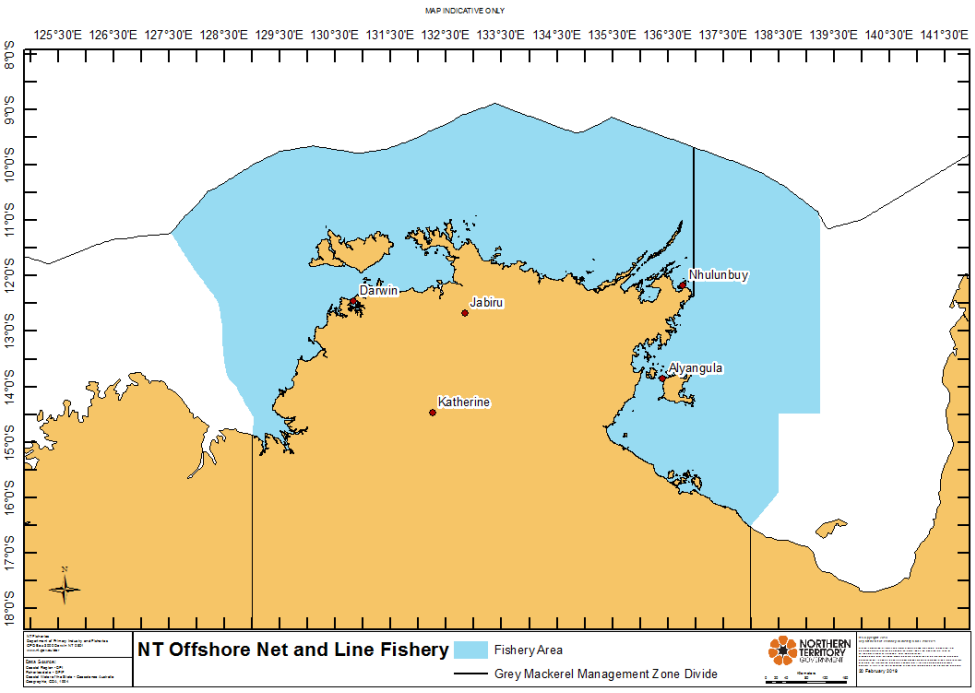

Figure 1: Map showing the boundary of the Offshore Net and Line Fishery of the Northern Territory

Within the Fishery area there are two management zones relating to Grey Mackerel, the Western Grey Mackerel Management Zone and the Eastern Grey Mackerel Management Zone that make up the waters of the fishery area.

The Western Grey Mackerel Management Zone lies west of a line commencing at the low water mark at Cape Arnhem at the point where the meridian of longitude 136 58 767 East meets the coast and extending due north until it intersects with the outer boundary of the AFZ (Figure 1).

3.3. Fishing method

Licences are entitled to use demersal or pelagic longlines or pelagic net gear. Offshore net and line licencea are endorsed to utilise longlines and pelagic net in the fishery. Bottom set gillnets are prohibited.

Pelagic nets are a near surface monofilament net that are placed vertically in the water column with the use of buoys and weight. The setting of the net is dependent on the current wind conditions and tidal flow. The net is shot from the stern of the fishing vessels either with or perpendicular to the wind and then attached to the bow of the boat, the boat and net then drift with the tide before being hauled in. The net is hauled onto a drum driven by a hydraulic winch and as the net comes over the bow the fish are removed. Gillnets can be used from two nautical miles from the low water mark to the boundary of the AFZ. Nets can be a maximum of 2000m long with a mesh size of 160mm to 185mm and a drop length of 50-100 meshes. Nets are weighted and must have a buoyed headline.

Longlines can be set for pelagic or demersal fishing. Demersal longlines may be utilised in all regions of the fishery, while pelagic longlines may only be used seaward of three nautical miles from the baseline to the outer bounds of the Fishery. Demersal longlines are main lines that are anchored and to which hooks or branch lines with hooks are attached. Demersal longlines are anchored to the seabed at both ends and at intervals along its length. A boat may use up to 15nm of longlines with a maximum of 1000 snoods. No auto baiting devices are allowed. The line can include monofilament, multi filament and synthetic material.

Structured developed of alternative or innovative gear types in the fishery is encouraged. All new gear being proposed for trial in the Fishery is subject to prior approval by Fisheries. Under the fisheries legislation there is a provision for permitting the possession of fishing gear which otherwise would not be allowed.

3.4. Resource sharing

100 percent of the fishery units for each shark species/species group and 50 percent of the Grey Mackerel fishery units were allocated to commercial licence holders based on their existing Fishery holdings. The other 50 percent of Grey Mackerel fishery units was allocated based on catch history (as recommended by industry). The period used to determine allocation to licence holders, 2007-08 to 2011-12 was the five years immediately prior to fishers being notified of the review in late 2012 and the consultation paper being released in early 2013.

3.5. Retained species

Pelagic Net

For the last ten years, pelagic net has been the predominant gear type and has been primarily used to target Grey Mackerel (*Scomberomorus semifasciatus*), Blacktip sharks (*Carcharhinus tilstoni* and *C. limbatus*) have been taken as a by-product. Additional by-product species of the pelagic net component are Spanish Mackerel (*S. commerson*), Spot-tail Sharks (*C. sorrah*) and Longtail Tuna (*Thunnus tonggol*).

Longline

Longlining operations target species from the Blacktip Shark complex (Australian and Common Blacktip). The most frequent by-product species by weight Great Hammerhead (*Sphyrna mokarran*), Pigeye Shark (*Carcharhinus amboinensis*), Tiger Shark (*Galeocerdo cuvier*) and Bull Shark (*Carcharhinus leucas*).

3.6. Non retained species

Pelagic Net

The most common pelagic net discards are Milk Sharks, Queenfishes, Hammerhead and Winghead Sharks, and Spanish Mackerel.

Longline

Longlines discards include stingrays, no take species and target species that have been damaged (by shark or lice damage).

3.7. Threatened, Endangered and Protected Species

Table 2: Threatened, Endangered and Protected Species interactions in the Offshore Net and Line Fishery 2014-15 to 2018-19.

Fishing Season	Species	Released Alive	Mortalities	Total
2014-15	Green Sawfish	25		25
	Sea Turtles	20	1	21
	Narrow Sawfish	14	2	16
	Giant Manta Ray	5	2	7
	Green Turtle	4		4

Fishing Season	Species	Released Alive	Mortalities	Total
	Glyphis spp.	3		3
	Dolphins		2	2
	Flatback Turtle	2		2
	Loggerhead Turtle	1		1
2015-16	Sea Turtles	20		20
	Green Sawfish	14		14
	Narrow Sawfish	13		13
	Dolphins	1	1	2
	Flatback Turtle	2		2
	Largetooth Sawfish	11		1
	Olive Ridley Turtle	1		1
2016-17	Narrow Sawfish	64	2	66
	Sea Turtles	37		37
	Green Sawfish	16		16
	Giant Manta Ray	12	1	13
	Loggerhead Turtle	3		3
	Dolphins		1	1
	Dwarf Sawfish	1		1
2017-18	Narrow Sawfish	21		21
	Sea Turtles	18		18
	Green Sawfish	16		16
	Dolphins	1	1	2
	Giant Manta Ray	2		2
	Largetooth Sawfish	2		2
	Green Turtle	1		1
2018-19	Sea Turtles	18		18
	Narrow Sawfish	7	7	14
	Green Sawfish	9	1	10
	Giant Manta Ray	3		3
	Dwarf Sawfish	1		1
	Green Turtle	1		1

4. Legislation

The Fisheries Act provides the broad statutory framework to provide for the conservation and management of Northern Territory's aquatic resources. In the administration of the Fisheries Act, the Minister 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;

(b) to maintain a stewardship of aquatic resources that promotes fairness, equity and access to aquatic resources by all stakeholder groups, including:

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

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

Subordinate to this is the NT *Fisheries Regulations 1992* that details amateur and commercial regulations for the fishery.

4.1. Current management controls

4.1.1. Commercial

Table 3: Current management tools used in the Offshore Net and Line Fishery.

Management tool	
Loading/ unloading	• Fish must be unloaded at Darwin or Gove • Operators can apply for exemptions to unload in other ports
Total Allowable Commercial Catch (TACC)	• Black Tip Shark - 435 t • Spot-tail Shark - 122 t • Combined shark species group (Hammerhead, Pigeye, Tiger, Bull, Sandbar, Spinner, Dusky, Winghead, Grey Reef and Lemon Sharks) – 246 t • Combined other sharks group (Whitecheek, Milk and Hardnose Sharks) - 126 t • Grey Mackerel – 535 t • Combined finfish group (including Spanish mackerel) – 60 t
Permitted gear	• Demersal longline and gaff (maximum 15nm and 1,000 hooks) • Pelagic longline (maximum 15nm and 1,000 hooks) • Pelagic net
Catch and effort data/ reporting	• Daily logbook • Observer coverage (10%) • Catch disposal records (within 1 day of unloading)
Processing at sea	• All shark must be landed with fins naturally attached • Hammerhead Shark heads must remain attached once 37 t of Scalloped Hammerhead Sharks have been taken in a licence year
Minimum trip holdings	*Demersal and pelagic longline* • Combined Australian Blacktip Shark species -5,000kg

Management tool	
	• Spot-tail shark - 1,600kg • Combined shark species - 4,700kg • Combined other shark group - 2,400kg *Pelagic net when targeting Grey Mackerel- total minimum holdings 4,500kg* • Grey Mackerel - 2,700kg • Combined Australian Blacktip Shark - 1,050kg • Spot-tail Shark - 250kg • Combined shark species - 150kg • Combined other shark - 50kg • Combined finfish - 300kg *Pelagic net when targeting shark- total minimum holdings 6,500kg* • Combined Australian Blacktip Shark - 3,700kg • Spot-tail Shark - 800kg • Combined shark species - 600kg • Combined other shark species - 150kg • Grey Mackerel - 1,100kg • Combined finfish - 150kg
Vessel Monitoring System	• Must be operating at all times
Catch restrictions	• 50kg Snapper • 5 Black Jewfish, trunked or retained as whole fish • 30 Spanish Mackerel, trunked or retained as whole fish • For each tonne of Grey Mackerel, not more than an additional 10 Spanish Mackerel, trunked or retained as whole fish
No take species	• Barramundi • King Threadfin • Mud crab
Closed Areas	• Reef Fish Protection Areas • Marine Parks

4.1.2. Recreational and Fishing Tourism

Most recreational and fishing tourism activity in the NT is concentrated within a 250km radius of Darwin. The recreational and fishing tourism sectors are managed through a combination of input and output management controls. These include spatial and temporal closures, personal and vessel possession limits and size limits. Fishing Tour Operator licence holders must also submit daily catch and effort logbook data.

4.1.3. Aboriginal Traditional

The Aboriginal traditional fishing sector is entitled to use the resources of the area of land or water in a traditional manner. Aboriginal coastal licences are a low cost, small scale fishing license available to Aboriginal people living in remote communities. Small quantities of shark may be taken if a local demand exists.

4.1.4. Reef fish protection areas

Five temporary reef fish protection areas were implemented to aid in the protection and recovery of 'at risk' reef fish. Some of the areas protect known healthy stocks of reef fish, while others will allow reefs that have been depleted by overfishing to recover. Such as by protecting spawning aggregations and removing any form of fishing related fish mortality.

Five areas are protected. They are located near Bathurst Island, Melville Island, Charles Point Wide, Lorna Shoal and Moyle/port Keats (Figure 2). These areas apply to the recreational, fishing tourism and offshore net and line commercial sector. Access to these areas is permitted to other commercial fisheries that have no impact on the mortality of reef fish. All of the areas are defined in the Fisheries Regulations 1992.

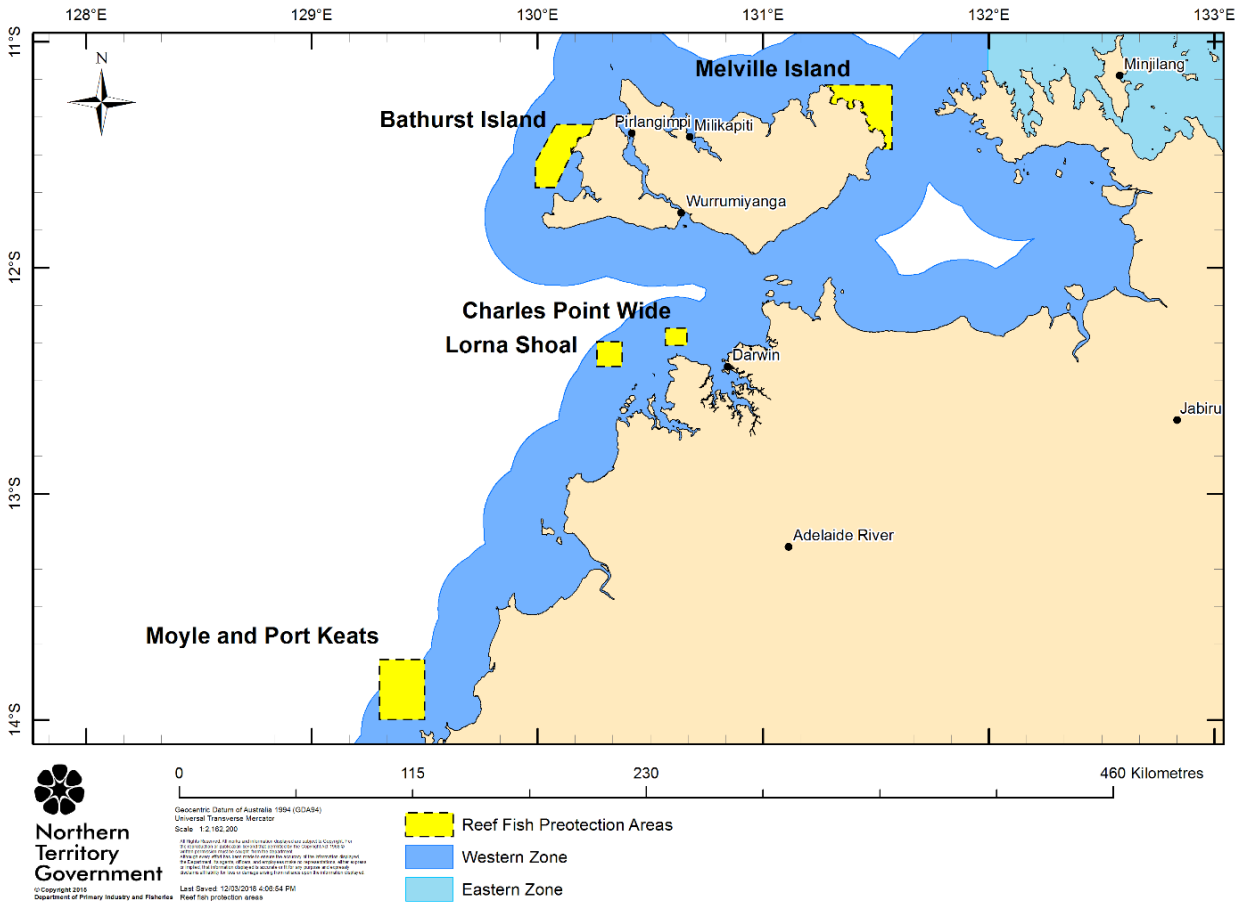

Figure 2: Map showing the location of the five temporary Reef Fish Protection Areas

4.2. Monitoring

Fishing activity of the commercial sector is 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, shot number, fishing method. Electronic monitoring is required within the longline sector of the Fishery. 100 per cent of fishing effort is recorded with an audit rate of 10 per cent.

Catch and effort logbook information is verified by on board fishery observers, who document vessel and gear information, location, depth, fishing practices, catch composition, and where possible take fish samples and biological measurements. Information gathered during observer trips is used to verify logbook returns, monitor bycatch, protected species interactions and provide biological data. Observer coverage for the fishery is currently set at 10 per cent.

4.3. Sectoral catch

4.3.1. Commercial

The commercial component of the Offshore Net and Line Fishery comprises a relatively small fleet, with an average of 10 vessels a year and a total of 600 days fished per year. Commercial vessels have primarily targeted Grey Mackerel in recent years, with the majority of shark catch primarily taken as a by-product of Grey Mackerel fishing. This is reflected in the yearly harvest figures in Table Four, where Grey Mackerel catches comprised 70-80 percent of the total harvest by the fishery in the previous five licensing years.

Table 4: Offshore Net and Line Fishery commercial catch (t).

ITQ species group*	2014-15	2015-16	2016-17	2017-18	2018-19
Grey Mackerel (west)	340.4	280.1	360.2	389.8	342.8
Grey Mackerel (east)	106.7	106.2	47.1	34.6	167.8
Combined Black Tip	67.8	31.4	67.4	28.3	29.0
Spot-tail	17.8	6.5	11.7	9.2	14.0
Combined Finfish Group	51.5	40.7	54.3	44.9	58.7
Combined Shark Species	39.7	31.3	40.0	23.8	16.5
Combined Other Shark Group	4.4	8.7	7.7	3.4	3.7
Total	**628.4**	**505.0**	**588.4**	**534.0**	**632.5**

* While figures reported to quota group for simplicity, it should be noted that the Individual Transferable Quota system was not introduced until December 2018.

4.3.2. Fishing Tour Operator

The Fishing Tour Operator (FTO) sector is required to provide log book returns for all its catch and release data, whilst sharks are not a targeted species within the sector they are caught during normal targeted fishing operations.

Sharks in the FTO sector are mostly encountered as bycatch when bait fishing for reef species and are released in most instances (Table 5). Grey Mackerel are not targeted by this sector, but is often caught while targeting Spanish Mackerel and is retained more frequently than sharks.

Table 5: Fishing Tour Operator shark catch (number of fish).

Shark	2014-15	2015-16	2016-17	2017-18	2018-19
Total catch	6,445	5,350	65,74	7,649	6,180
Percentage released	97.7%	98.2%	97.1%	96.3%	97.3%

Table 6: Fishing Tour Operator Grey Mackerel catch (number of fish).

Grey Mackerel	2014-15	2015-16	2016-17	2017-18	2018-19
Total catch	301	339	413	289	289
Percentage released	48.1%	61.1%	67.8%	55.0%	45.0%

4.3.3. Recreational

Recreational shark catch is generally not well understood. This is largely the result of inherent challenges associated with monitoring recreational fishers, their catch and the typically non-target nature of sharks within the broader recreational catch. There are also challenges associated with identification of sharks. Recreational fishing survey results for the Northern Territory (West *et al.* 2012) and Greater Darwin area (Matthews *et al.* 2019a; Matthews *et al.* 2019b) are shown in tables seven and eight.

Table 7: Recreational sector shark and ray catch (number of fish). * Catch for survey period only (March to November).

Survey	Total caught	Retained	Released	% released
NT 2009-10 Recreational fishing survey, NT wide	27,738	1,506	26,232	94.6%
NT 2014 Recreational fishing survey, Greater Darwin*	38,894	1,279	37,615	96.7%
NT 2015 Recreational fishing survey, Greater Darwin*	28,138	707	27,431	97.5%

Table 8: Recreational sector Grey Mackerel catch (number of fish). * Catch for survey period only (March to November).

Survey	Total caught	Retained	Released	% released
NT 2009-10 Recreational fishing survey, NT wide	3,390	2,108	1,282	37.8%
NT 2014 Recreational fishing survey, Greater Darwin*	2,796	1,170	1,627	58.2%
NT 2015 Recreational fishing survey, Greater Darwin*	2,569	1,023	1,546	60.1%

4.3.4. Aboriginal

Sharks are considered to be an important group of fish caught by Indigenous people in the NT, although there is no current quantitative data on the catch or species taken.

4.4. Environment

4.4.1. 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.

4.4.2. 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.

4.4.3. 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 i.e. 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 have been reported to 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).

5. Methodology

5.1. Ecological Risk Assessment methodology

This ERA aims to ensure the management of the Fishery is effective and efficient in achieving ESD outcomes. The principles of ESD form the basis of aquatic resource management in the Northern Territory and meet the statutory requirements of the Fisheries Act and national environmental legislation. This approach also provides the fishing industry and key stakeholders with an opportunity to shape future fisheries management outcomes.

DITT continues to collaboratively develop management arrangements under the Fisheries Act using the comprehensive issue identification, risk assessment and priority setting process. This includes the development of a harvest strategy and related research and monitoring programs.

The issue identification, risk assessment, and reporting process and the final report format is based on the National ESD Framework *How To Guide* (see www.fisheries-esd.com.au) and the Department of Fisheries Western Australia ESD performance reports pioneered by Dr Rick Fletcher and others.

An ERA workshop was facilitated by NT Fisheries in May 2020 to conduct a technical review by experts specialising in Shark, Mackerel and other related species. This was followed by a stakeholder review in collaboration with the technical experts. All stakeholders provided advice on the risk ratings and open discussion was held with the technical panel expert representatives to review and amend the preliminary risk ratings where necessary. The workshop results were collated into this final report and referred back to experts and stakeholder panel before finalisation.

5.2. Scope

This report is based on risk identification and assessment work by expert panel and stakeholder workshops. The identification of issues was informed by the generic ESD component tree approach, with each component tree refined specifically for the Fishery. This report focuses on the Ecological Wellbeing of the Fishery and the components of Human Wellbeing and Ability to Achieve will be addressed in the stakeholder consultation phase to determine relevant management objectives.

Each component tree reflects the contemporary risks of harvesting activities on retained or non-retained species. It also includes broader impacts of the activities on the marine environment. This process did not identify where additional (or reduced) management or research attention is needed; this will be done during the refinement and review of the management framework and harvest strategy.

5.3. 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 result of extensive consideration and refinement during the initial development of the National Fisheries ESD approach. The component trees are used as the starting point to ensure thorough and consistent identification and evaluation of issues in the Fishery. The component trees in this report were developed through consultation with stakeholders and provide a

realistic and practical illustration of issues facing the Fishery. Each of these components are broken down into specific sub-components for which operational objectives can then be developed.

5.4. Risk assessment and prioritisation of issues

Assessment and prioritisation of risks and opportunities facing the Fishery were considered in the context of high-level management objectives and desired ESD outcomes described in the Fisheries Act and Commonwealth environmental legislation.

The risk assessments for the components of the Fishery were based on existing management arrangements. The ESD assessment and reporting process is consistent with the Australian and New Zealand Standard *AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines*. Technical experts 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 is multiplied by the likelihood of that event occurring to produce and estimated level of risk.

The exert panel worked though each element of the component tree and conducted a qualitative risk assessment of each issue. An estimated consequence level for each issue was made and scored from 0-5, with zero being negligible and five being catastrophic/irreversible (see Appendix A for details). 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). Killing one fish 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 an individual patches or individual non-target species.

The likelihood of that consequence occurring was assigned to one of six levels from remote (1) to likely (5). This was based on a judgement about the probability of the events - or chain of events - occurring that could result in a particular adverse consequence. This judgement about conditional probability was again based on the collective experience of the expert panel. See Appendix 7.1 for details of the likelihood table. From the consequence and likelihood scores, the overall risk value (Risk = Consequence x Likelihood), was calculated. On the basis of this risk value each issue was assigned a Risk Ranking within one of four categories.

Table 9: Risk ranking definitions.

Risk rating	Description	Reporting	Likely Management Response
Negligible	Acceptable; not an issue	Minimal	Nil
Low	Acceptable; no specific control measures needed	Short justification only	None Specific
Moderate	Acceptable; with current risk control measures in place (no new management required)	Detailed analyses of issues and associated risk	Specific management needed
High	Not desirable; continue strong management actions OR new and/or further risk control measures to be introduced	Detailed analyses of issues and associated risk	Possible increase to management activities needed

The National ESD Framework suggests that only issues scored as moderate or high risk require full ESD performance reports. However, the rationale for scoring is provided for all issues identified and form part of this report. Issues scored as either nil, low, or negligible have also been included to ensure transparency and help stakeholders understand the basis for risk scores.

5.5. Ecological risk assessment likelihood and consequence tables

The Likelihood table is a generic series of definitions from any risk assessment process (appendix section 7.1) and the consequence definitions are specifically developed for each of the components detailed in section 7.2, tables 50-58. For target and secondary species there is an expectation that there is some sort of quantitative estimation of existing biomass levels in relation to that before fishing. As a result there are numerical ranges of biomass levels associated with each consequence definition (Table 51). Tertiary and Bycatch species are generally unlikely to have numerical estimations of current biomass levels (Table 52), so instead semi quantitative methods such as Productivity and Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE) assessments (Zhou and Griffiths 2008). This table has specific references associated with the HIGH, MEDIUM or LOW risk of overfishing that are provided as outputs from these analyses. The habitat table has a percentage of impact associated with individual habitat types (Table 55) while the Ecosystem Processes table has definitions associated with the likely impacts on the other components of the assessment that may cause changes in the ecosystem (Table 56).

5.6. 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, these include the operational objectives, indicators and performance measures.

The higher risk/priority issues identified through this process will be addressed though the harvest strategy and management plan for the Fishery. This includes reviewing operational objectives, indicators and performance measures.

6. Performance reports

Component trees were developed for retained and non-retained species as well as general ecosystem effects. The background colour for each component relates to the risk rating determined by the expert panel according to the following scheme: light blue = negligible, green = low, yellow = moderate and red = high. No specific management is required where the risk is determined to be negligible. However, risks that are rated low, moderate, or high require either a justification or a full performance report.

6.1. Retained species

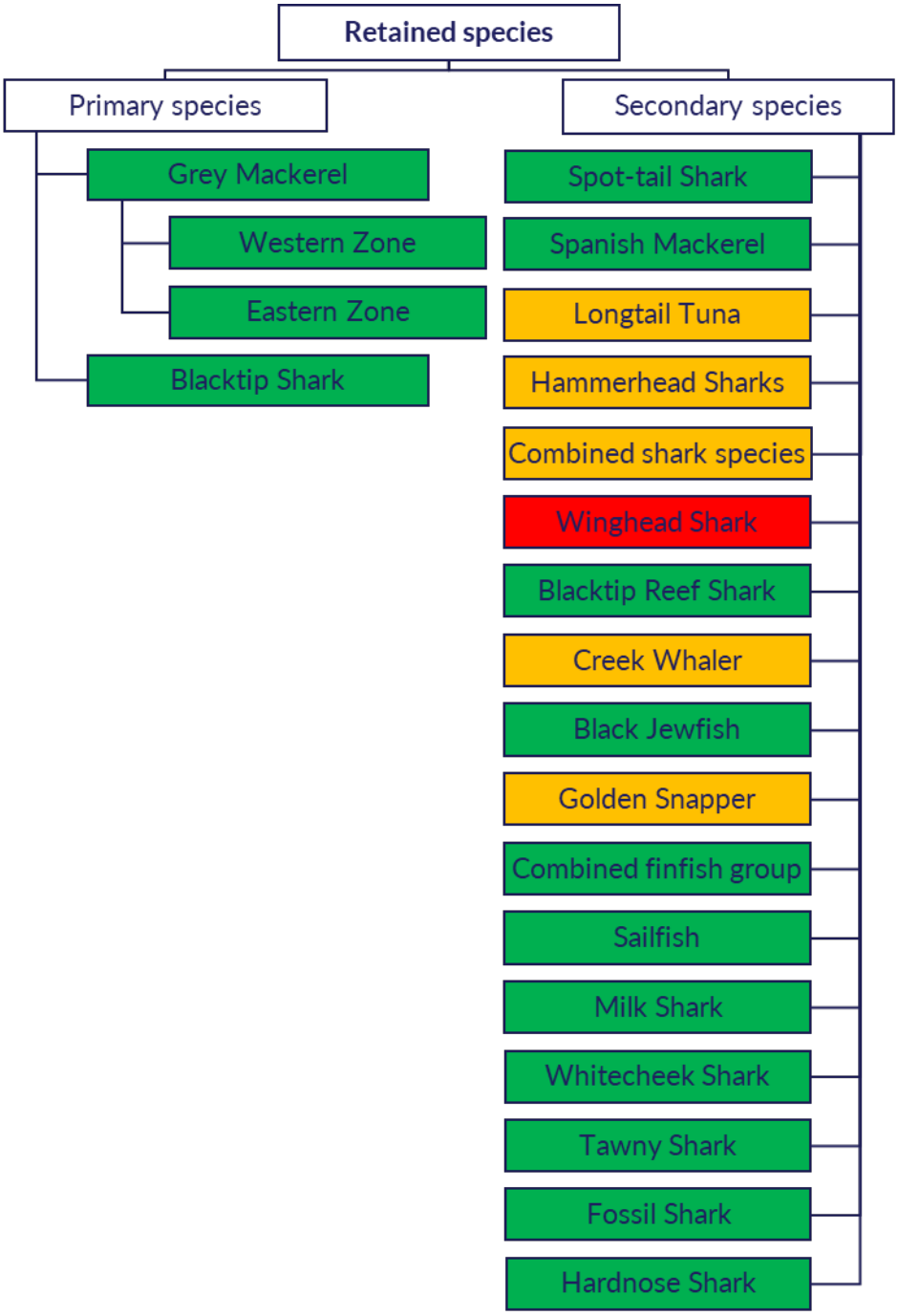

Figure 3: Component tree for retained species

6.1.1. Grey Mackerel

The risk ratings for species in the Fishery were derived from the likelihood (Table 50) and consequence tables (Table 51).

6.1.1.1. Objective:

To ensure that the harvest of Grey Mackerel remains within ecologically sustainable limits.

6.1.1.2. Risk rating

Table 10: Risk rating for the impact of the Fishery on the viability of Western Zone Grey Mackerel stocks.

Species	Consequence	Likelihood	Rating
Grey Mackerel	1	2	2

Table 11: Risk rating for the impact of the Fishery on the viability of Eastern Zone Grey Mackerel stocks.

Species	Consequence	Likelihood	Rating
Grey Mackerel	1	3	3

6.1.1.3. Sources of risk

- Grey Mackerel aggregate at known locations, which can result in hyper-stable catch rates.
- The geographic range of Grey Mackerel stocks in the NT is not well understood.
- Stock assessments are undertaken at broad geographic scales, which may overlook cases of localised depletion.

6.1.1.4. Justification

- The vast majority of Grey Mackerel is taken by the commercial sector under TACC limits.
- There is management of a shared stock across jurisdictions (GoC).
- The most recent stock assessments for Grey Mackerel indicated that current biomass was at 81 percent of unfished biomass for the western stock and 74 percent for the eastern stock 72 percent (Grubert *et al.* 2013).
- There has been a significant reduction of catch in the GoC since 2012, due to changes in QLD management.
- Grey Mackerel have an opportunity to breed at least two to three times before they are large enough to be taken in the Fishery.
- The recreational catch in the NT is extremely low.
- The risk rating is predicated on management staying similar to what it currently is, noting it is highly likely for the fishery to be the same in five years' time.

6.1.2. Blacktip Sharks

6.1.2.1. Risk rating

Table 12: Risk rating for the impact of the on the viability of North and West Coast Blacktip Shark stocks.

Species	Consequence	Likelihood	Rating
Blacktip sharks	1	2	2

Table 13: Risk rating for the impact of the on the viability of GoC Blacktip Shark stocks.

Species	Consequence	Likelihood	Rating
Blacktip sharks	1	2	2

6.1.2.2. Objective

To ensure that the harvest of Blacktip Sharks remains within ecologically sustainable limits.

6.1.2.3. Sources of risk

- Blacktip Shark is a complex of two species with differing life histories and possible differences in the geographic distribution of stocks.
- Blacktip Sharks are less productive than some finfish species.

6.1.2.4. Justification

- The vast majority of Blacktip Shark harvest is taken by the commercial sector under TACC limits.
- There were high historic catches by Taiwanese fishing fleet.
- Limited targeting of sharks by the Fishery since 2012 is due to declines in shark fin price.
- The last stock assessment undertaken on Blacktip Sharks in the NT indicated that stocks of both Common Blacktip Shark and Australian Blacktip Shark had recovered from historic overfishing, with the current biomass for each species at 81 percent and 90 percent of the unfished biomass, respectively (Grubert *et al.* 2013).
- The complex consists of Australia Blacktip Shark *Carcharhinus tilstoni* and Common Blacktip Shark *C. limbatus* that regularly hybridise and are extremely difficult to identify separately.
- Assessments were done on the scale of *C. limbatus* as that is the shark species with a more vulnerable life history.
- The shark assessment includes Illegal, Unreported and Unregulated (IUU) catches and with an estimate based on the number of apprehensions. Illegal catches are potentially lower than the original estimates of 600 t.
- The species are a relatively productive biological group, when compared to other sharks, and have had relatively low levels of fishing mortality since 2012.
- *Carcharhinus tilstoni* are the more prevalent species of the pair with the catch ratios of around 5:1 *tilstoni: limbatus*.
- The Fishery has harvest control rules, a TACC and quota as management tools for the take of this species.

6.2. Secondary species

The risk rating for secondary species in the Fishery were derived from the likelihood (Table 50) and consequence tables (Table 52).

6.2.1. Spot-tail shark

6.2.1.1. Objective

To ensure that the harvest of Spot-tail Shark remains within ecologically sustainable limits.

6.2.1.2. Risk rating

Table 14: Risk rating for Spot-tail Sharks.

Species	Consequence	Likelihood	Rating
Spot-tail Sharks	1	2	2

6.2.1.3. Sources of risk

- Less productive than some finfish species.
- Possible misidentification with Blacktip Shark by less experienced fishers.

6.2.1.4. Justification

- The vast majority of Spot-tail Shark harvest taken by the commercial sector under TACC limits.
- Historic high catches by Taiwanese fishing fleet.
- Limited targeting of sharks by the fishery since 2012 due to declines in shark fin price.
- The last stock assessment undertaken on Spot-tail Shark in the NT indicated that the stock had recovered from historic overfishing, with the current biomass at 93 percent of the unfished biomass (Grubert *et al.* 2013).
- Spot-tail Shark have a more productive biology than many other shark species, most similar to Blacktip Sharks.
- They have a broader stock structure than Blacktip Shark, likely comprises a single genetic stock in Australia.
- Spot-tail Shark have different susceptibility to being caught depending on gear type; they are caught more often with longline gear.
- The Fishery has seen an increase in discards of Spot-tail Shark between gear types.
- The last assessment was undertaken with data up to 2011, this also included a 100 t illegal catch associated with it, which may be an over estimate.
- There is a difference in the maturity of catch between Spot-tail and Blacktip Sharks. In the net component of the Fishery there are more Spot-tails in the 65-105 cm bracket with occasional mature Spot-tail.

6.2.2. Spanish Mackerel

6.2.2.1. Objective

To ensure that the harvest of Spanish Mackerel remains within ecologically sustainable limits.

6.2.2.2. Risk rating

Table 15: Risk rating Spanish Mackerel.

Species	Consequence	Likelihood	Rating
Spanish Mackerel	1	2	2

6.2.2.3. Sources of risk

- 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 is not well known.
- Stock assessments are conducted at a Territory-wide scale, which may overlook cases of localised depletion.
- Spanish Mackerel has shown declines in the Catch Per Unit Effort (CPUE) across Northern Australia.
- The Spanish Mackerel Fishery has seen an increase in catch of this species.
- Previous assessments have included high levels of illegal catches the most common illegal gear used (bottom-set longline) catches little of this species.

6.2.2.4. Statement of considerations

- The vast majority of the Spanish Mackerel harvest is taken by the commercial sector.
- The harvest of Spanish Mackerel by the ONLF is approximately 5 percent of that taken by the Spanish Mackerel Fishery.
- Commercial fishing effort is concentrated around a few key reefs and shoals.
- The most recent stock assessment for Spanish Mackerel (at a Territory-wide scale) indicated that current biomass was at 72 percent of the unfished (1973) biomass.
- Discards occasionally occur due to trip limit restrictions and TACC but these are likely to be small.
- Previous assessments have included high levels of illegal catches the most common illegal gear used (bottom-set longline) effectively does not catch this species.

6.2.3. Longtail Tuna

6.2.3.1. Objective

To ensure that the harvest of Longtail Tuna remains within ecologically sustainable limits.

6.2.3.2. Risk rating

Table 16: Risk rating Longtail Tuna (Pacific).

Species	Consequence	Likelihood	Rating
Longtail Tuna	2	3	6

Table 17: Risk rating Longtail Tuna (Indian Ocean).

Species	Consequence	Likelihood	Rating
Longtail Tuna	3	2	6

6.2.3.3. Sources of risk

- High (relative to Australian catches) historic catches by Taiwanese Gillnet fleet.
- The geographic range of Longtail Tuna stocks in the NT and potential stock connectivity with other regions not well understood.
- Recent increase in commercial harvest by ONLF licensees.
- There is no formal stock assessment for this species.

6.2.3.4. Justification

- It is a declared recreational only species under Commonwealth jurisdiction and is not targeted by the commercial sector.
- The Fishery has management in place to prevent targeting, with a limit of five percent of total catch per trip.
- The Fishery catch is a very small proportion of the stock and that the recent high catch of 20 t is minimal compared to the rest to the catch in other jurisdictions.
- In QLD the two major fisheries in the Gulf (line and inshore net) caught about 20 t in total between 2010 and 2017.
- Recreational catch is relatively small (3-4 t) and less than one tonne by the Fishing Tour Operator sector. The 2015 recreational fishing survey indicated that recreational anglers in the greater Darwin area caught 1,536 individuals from March to November, 66 percent of which were released (Matthews *et al.* 2019b).
- Little data is available on historical discard numbers.
- Longtail Tuna is an untargeted species with limited market value.
- The SAFE assessment estimated that the Fishery was only having a Minor risk on this species.
- The risk rating is dependent on the stock Longtail Tuna belongs to. The consequence is dependent on the level of interaction between this and stocks in the western Pacific or Indian Ocean.
- Longtail Tuna is subject to high exploitation in other countries.
- If there was a market for the species there would potentially be greater catch.
- There is some doubt about the stock structure of Longtail Tuna and uncertainty whether or not Australia's stock is part of the Pacific Ocean stock or the Indian Ocean stock (noting that the Indian Ocean stock is overfished).
- The risk analysis was based primarily on expertise of the panel due to a lack of certainty of stocks and data availability.

6.2.4. Hammerhead Sharks

6.2.4.1. Objective

To ensure that the harvest of Hammerhead Shark remains within ecologically sustainable limits.

6.2.4.2. Risk rating

Table 18: Scalloped Hammerhead.

Species	Consequence	Likelihood	Rating
Scalloped Hammerhead	2	3	6

Table 19: Great Hammerhead.

Species	Consequence	Likelihood	Rating
Great Hammerhead	2	4	8

6.2.4.3. Sources of risk

- High historic catches by Taiwanese fleet.
- Demonstrated susceptibility to overfishing in other regions.
- Possible stock connectivity with Indonesia.
- Hammerhead fins are highly valued.
- Likely poor post release survival.

6.2.4.4. Justification

- The Fishery has additional monitoring requirements and management measures specific to Scalloped Hammerhead and Great Hammerhead Sharks. This is linked to the WTO and Conservation Dependent listing of Scalloped Hammerhead.
- Recent stock assessment indicates that the Northern Stock of Scalloped Hammerhead may be greater than 60 per cent of the unfished biomass.
- Shared stock between the NT and QLD Gulf of Carpentaria, and there is a draft joint management strategy being developed.
- Limited targeting of sharks by the fishery since 2012 due to declines in shark fin price.
- Catch of Great Hammerhead Sharks to Scalloped is 75:25 per cent by weight and when assessed by number is almost 50 per cent for each species.
- Post release mortality of Scalloped Hammerhead Sharks is very high.
- If the species is panmictic between Indonesia, Papua New Guinea and QLD then the Fishery catch is a very small contribution to the total stock harvest.
- The Fishery only takes juveniles and a limited number of adult males out of the population regardless of its distribution.
- The Non Detriment Finding (NDF) for Scalloped Hammerhead Sharks was a product of the CITES listing and has a 50 t Total Allowable Catch (TAC) in the NT.
- There is explicit management in the Fishery including, quota, gear restrictions, electronic monitoring and trigger points.
- Current levels of longlining in the Fishery are very low with majority of effort in the Fishery in the net sector. Noting that there is the potential for a shift in effort from pelagic gillnets to longlines within the next five years.
- Current catch for all gear types is 10 t plus 2 t discards.
- There is management in place for Scalloped Hammerhead Sharks across regions and jurisdictions.

6.2.5. Combined shark species

- Bull Shark
- Tiger Shark
- Lemon Shark
- Pigeye Shark
- Grey Reef Shark

- Spinner Shark
- Dusky Shark
- Sandbar Shark

6.2.5.1. Objective

To ensure that the harvest of combined shark species remain within ecologically sustainable limits.

6.2.5.2. Risk rating

Table 20: Risk rating combined shark species.

Species	Consequence	Likelihood	Rating
Combined shark species	2	3	6

6.2.5.3. Sources of risk

- Morphological similarity between species make species level identification difficult.
- Historic high catches by Taiwanese fishing fleet.
- Likely poor post release survival.

6.2.5.4. Justification

- The vast majority of Pigeye and Bull Sharks harvested by the commercial sector are under TACC limits.
- Limited targeting of sharks by the Fishery since 2012 due to declines in shark fin price.
- Latent effort in the longline component of the Fishery.
- These shark species have higher biological vulnerability.
- Combined quota is 246 t (this quota includes Winghead and Hammerhead Sharks which were assessed separately).
- There are management measures and harvest strategy decision rules in place for combined shark species.
- The stock structure is poorly known and they are a widely distributed species.

6.2.6. Winghead Shark

The Winghead Shark was assessed separately from the combined species group shark due to its catch, distribution and vulnerability to both gear types used in this fishery.

6.2.6.1. Objective:

Maintaining the catch of secondary species at sustainable levels.

6.2.6.2. Risk rating

Table 21: Risk rating Winghead Shark.

Species	Consequence	Likelihood	Rating
Winghead Shark	4	4	16

6.2.6.3. Sources of risk

- Winghead sharks have reasonably restricted localised occurrences due to habitat specialisation which may make them more vulnerable to fishing.
- Effort, particularly gillnet effort, may be concentrated in some areas of the species restricted distribution.
- There is no stock assessment for this species.

6.2.6.4. Justification

- This species has almost disappeared in many areas of the Indo-West Pacific (e.g. Indonesia, India).
- The catch is between 4-10 tonne maximum per year.
- Historically there have not been significantly large catches.
- Inshore estuarine specialist at some life stages.
- Aggregation areas have been identified in Darwin Harbour and inshore areas around river mouths.

6.2.7. Blacktip Reef Shark

6.2.7.1. Objective:

Maintaining the catch of secondary species at sustainable levels.

6.2.7.2. Risk rating

Table 22: Risk rating Blacktip Reef Shark.

Consequence	Likelihood	Rating
1	2	2

6.2.7.3. Sources of risk

- No stock assessment for this species.
- There is potential for misidentification.

6.2.7.4. Justification

- It is one of the most resilient reef shark species.
- Catch of Blacktip Reef Shark is very low, less than 1 t per year.
- Very low catches suggest there is limited spatial overlap between habitat preferences and fishing effort.
- There is not a high level of stock connectivity throughout the distribution.
- The species is potentially benefiting from disappearance of other species from ecosystem due to its high levels of resilience.
- The SAFE assessment estimated that the Fishery was having a Medium-High risk on this species, noting that the distribution used probably overestimates the overlap of fishing with this species.

6.2.8. Creek Whaler

6.2.8.1. Objective:

Maintaining the catch of secondary species at sustainable levels.

6.2.8.2. Risk rating

Table 23: Risk rating Creek Whaler.

Species	Consequence	Likelihood	Rating
Creek Whaler	3	3	9

6.2.8.3. Sources of risk

- No stock assessment for this species.
- Potential for misidentification.
- Not a highly productive species.

6.2.8.4. Justification

- Their endemism warrants a higher level of risk.
- Telemetry work with this species in QLD suggest that immature individuals stay very coastal and adults end up further offshore, they are more vulnerable in the inshore coastal areas.
- The SAFE assessment estimated that the Fishery was having a Medium risk on this species.
- They have a very patchy distribution and are uncommonly caught in the NT.

6.2.9. Black Jewfish

6.2.9.1. Objective

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

Table 24: Risk rating Black Jewfish.

Species	Consequence	Likelihood	Rating
Black Jewfish	2	2	4

6.2.9.2. Sources of risk

- Potential discarding of these lower value species.

6.2.9.3. Justification

- Black Jewfish are caught in very low numbers.
- Management of Black Jewfish includes: Five Black Jewfish per trip, bladder tagging and fishing exclusion zones.
- High levels of compliance and enforcement.
- The current stock assessment for this species indicates that the biomass is at 93 per cent of unfished levels.

6.2.10. Golden Snapper

6.2.10.1. Objective:

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

6.2.10.2. Risk rating

Table 25: Risk rating Golden Snapper.

Species	Consequence	Likelihood	Rating
Golden snapper	3	3	9

6.2.10.3. Sources of risk

- Golden Snapper has been assessed as an overfished species.

6.2.10.4. Justification

- There are trip limits in place which restrict the catch in the Fishery to 50 kilograms.
- Data is indicating a recovery of the species.

6.2.11. Combined finfish group

- Queenfish
- Black Promfret
- Trevallies
- Mackerel Tuna
- Spotted Mackerel
- Blue Threadfin
- Batfish

6.2.11.1. Objective:

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

6.2.11.2. Risk rating

Table 26: Risk rating Combined finfish group.

Species	Consequence	Likelihood	Rating
Combined finfish group	1	2	2

6.2.11.3. Sources of risk

- No stock assessments for these species.

6.2.11.4. Justification

- These are highly productive species which are caught in low numbers in the Fishery.

- The SAFE assessment estimated that the Fishery was only having a Low risk on this species.
- Management includes a 59 t finfish quota.
- NT Fisheries has had observers on all operators in this Fishery.
- Observers have not reported seeing high discard rates of these species.

6.2.12. Sailfish

6.2.12.1. Objective:

To ensure that the harvest of low retained species by the ONLF remains within ecologically sustainable limits.

6.2.12.2. Risk rating

Table 27: Risk rating Sailfish.

Species	Consequence	Likelihood	Rating
Sailfish	1	2	2

6.2.12.3. Sources of risk

- There is a level of uncertainty of stock connectivity.
- Sailfish were caught in the Taiwanese fishery of the 1970-90s and had high historic catches.

6.2.12.4. Justification

- Sailfish are a very productive species.
- Sailfish have a much broader distribution than in the Northern Territory.
- High historic catch rates are not reflected in today's fishing activity.
- Very low levels of interactions in the Fishery.

6.2.13. Combined other shark group

- Milk Shark
- Whitecheek Shark

6.2.13.1. Objective:

Maintain the catch of secondary species at ecologically sustainable levels.

6.2.13.2. Risk rating

Table 28: Risk rating Combined other shark group.

Species	Consequence	Likelihood	Rating
Combined other shark group	1	2	2

6.2.13.3. Sources of risk

- No stock assessment for these species.

6.2.13.4. Justification

- These species have highly productive life history characteristics.
- The SAFE assessment estimated that the Fishery was only having a low risk on this species.
- Whitecheek Sharks have a greater offshore distribution than Milk Sharks.
- Catches of both species have reduced with increased targeting of Grey Mackerel.

6.2.14. Tawny Shark

6.2.14.1. Objective

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

6.2.14.2. Risk rating

Table 29: Risk rating Tawny Shark.

Species	Consequence	Likelihood	Rating
Tawny Shark	1	2	2

6.2.14.3. Sources of risk

- The stock structure is currently unknown, and there is little information available on life history.
- They are primarily a discard species.

6.2.14.4. Justification

- The species is less susceptible to net gear and is predominately caught in longline gear.
- Data show only a very small number are caught in either gear type.
- Very low post release mortality.
- The SAFE assessment estimated that the Fishery was only having a Minor risk on this species.
- They are distributed in inshore regions.

6.2.15. Fossil Shark

6.2.15.1. Objective:

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

6.2.15.2. Risk rating

Table 30: Risk rating Fossil Shark.

Species	Consequence	Likelihood	Rating
Fossil Shark	1	3	3

6.2.15.3. Sources of risk

- There is no stock assessment for these species.

- Species has low productivity.

6.2.15.4. Justification

- Fishery data shows caught in very low numbers.
- Small litter size and possibly reproduces in alternate years.

6.2.16. Hardnose Sharks

6.2.16.1. Objective:

To ensure that the harvest of low retained species by the Fishery remains within ecologically sustainable limits.

6.2.16.2. Risk rating

Table 31: Risk rating Hardnose Sharks.

Species	Consequence	Likelihood	Rating
Hardnose sharks	1	2	2

6.2.16.3. Sources of risk

- There is no stock assessment for this species.

6.2.16.4. Justification

- Are fast growing but low productivity due to small litter size.
- The SAFE assessment estimated that the Fishery was only having a Minor risk on this species.

6.3. Non-retained species

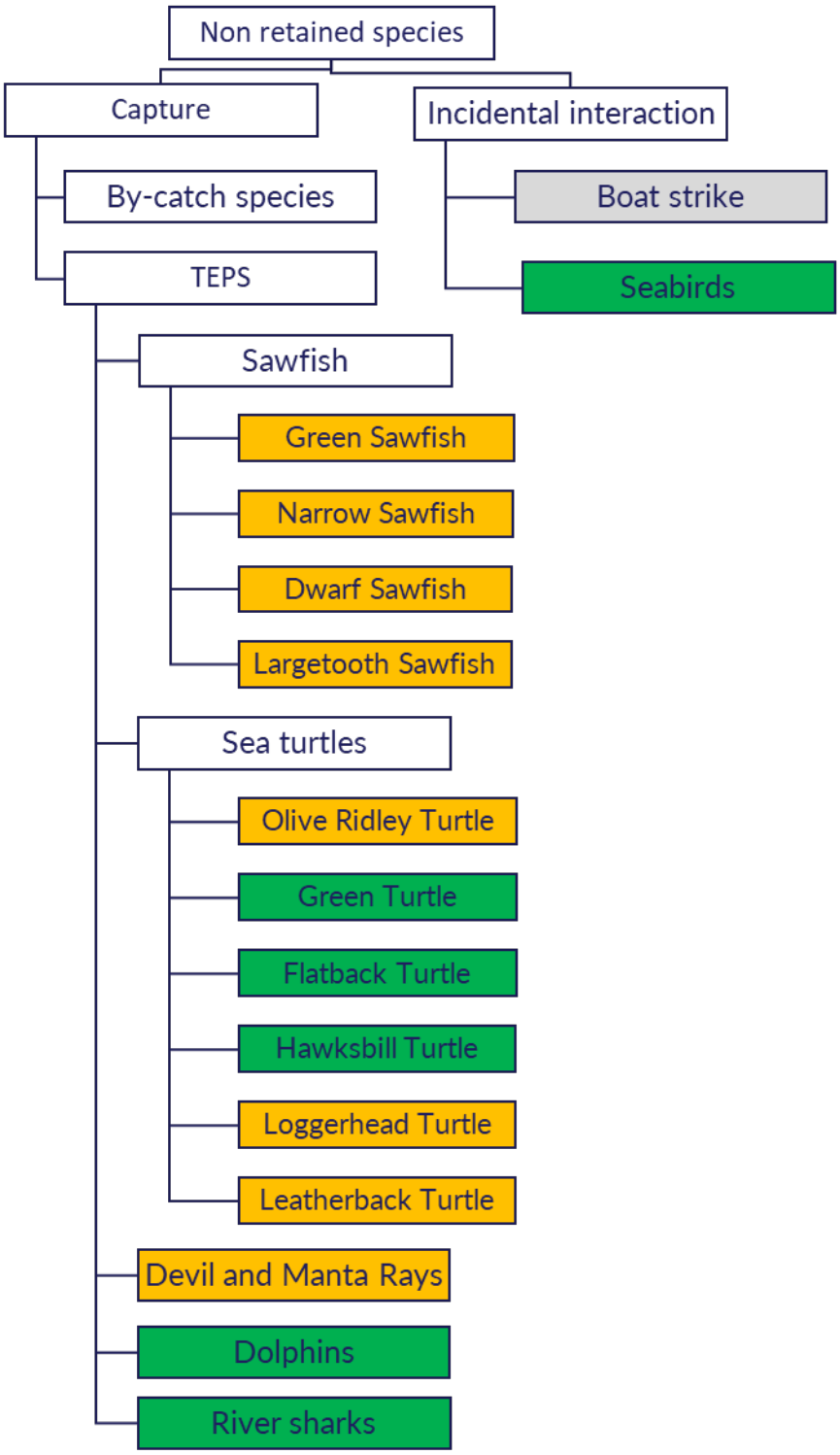

Figure 4: Component tree for non-retained species

6.3.1. Bycatch

The risk rating for bycatch species were derived from likelihood (table 50) and consequence tables (table 52).

6.3.1.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

6.3.1.2. Risk rating

Table 32: Risk rating bycatch.

	Consequence	Likelihood	Rating
Bycatch	1	2	2

6.3.1.3. Sources of risk

- Poor post release survival rates.

6.3.1.4. Justification

- The fishing is highly targeted.
- Bycatch is relatively well managed and is covered in the Management Arrangements and Harvest Strategy.

6.3.2. Threatened, Endangered and Protected Species

The risk rating for Threatened, Endangered and Protected Species in the Fishery were derived from the likelihood (Table 50) and consequence tables (Table 54).

6.3.3. Sea turtles

6.3.3.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.3.2. Risk rating

The risk raring are based on the status of the individual species.

Table 33: Risk ratings all turtle species.

Species	Consequence	Likelihood	Rating
Olive Ridley Turtle	3	2	6
Green Turtle	2	2	4
Flatback Turtle	2	2	4
Hawksbill Turtle	2	2	4
Loggerhead Turtle	3	2	6
Leatherback Turtle	3	2	6

6.3.3.3. Sources of risk

- Olive Ridley Turtle is listed as Endangered in Australia and Vulnerable Internationally.
- Green Turtle is listed as a Vulnerable species in Australia and Endangered Internationally.
- Flatback Turtle is listed as Vulnerable in Australia and Data Deficient Internationally.
- Hawksbill Turtle is listed as Vulnerable in Australia and Critically Endangered Internationally.
- Loggerhead Turtle is listed as Endangered in Australia and Vulnerable Internationally.
- Leatherback Turtle is listed as Endangered in Australia and Vulnerable Internationally.

6.3.3.4. Justification

- Predominately caught in net gear with very low post release mortality.
- Mitigation includes short set times and pelagic gillnets sit on the surface which may allow turtles to breath whilst in the net.
- Majority of turtles caught (98 per cent) are released alive.
- Very rarely are there any interactions or sightings of Leatherback Turtles in the NT – they have never been recorded in the Fishery.
- The consequence of an interaction with each species was determined based on its conservation listing.

6.3.4. Sawfish

6.3.4.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.4.2. Risk ratings

Table 34: Risk rating Green Sawfish.

	Consequence	Likelihood	Rating
Green Sawfish	3	3	12
Narrow Sawfish	3	3	16

6.3.4.3. Sources of risk

- Green Sawfish are listed in Australia as Vulnerable and listed as Critically Endangered Internationally.
- Narrow Sawfish are not currently listed in Australia however are listed as Endangered Internationally.

6.3.4.4. Justification

- There are concerns about the accuracy of species identification.
- Observer data indicates that Narrow Sawfish are the species primarily caught in the Fishery.
- *Pristis* species are caught in very low numbers.
- Demersal nets have been banned which is likely to have resulted in a significant level of catch reduction.

- Reporting requirements are in place (but identification improvement is needed).
- Sawfish species global ranges have contracted and Australia holds some of the last significant populations.
- The data source for mortalities is primarily logbooks.
- Green Sawfish grow to a large size and have low productivity.
- The lack of knowledge resulted in a higher likelihood.

6.3.5. Dwarf and Largetooth Sawfish

6.3.5.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and protected species populations.

6.3.5.2. Risk rating

Table 35: Risk rating Dwarf and Largetooth Sawfish.

Species	Consequence	Likelihood	Rating
Dwarf and Largetooth Sawfish	4	2	8

6.3.5.3. Sources of risk

- Dwarf and Largetooth Sawfish are listed in Australia as Vulnerable.
- Largetooth Sawfish are listed as Critically Endangered Internationally.
- Dwarf Sawfish are listed as Endangered internationally.

6.3.5.4. Justification

- Both species have limited interactions with the Fishery due to lack of overlap with habitat and occurrence.
- Dwarf Sawfish have a greater coastal distribution.

6.3.6. Devil and Manta Rays

6.3.6.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.6.2. Risk rating

Table 36: Risk rating Devil and Manta Rays

Species	Consequence	Likelihood	Rating
Devil and Manta Rays	4	2	8

6.3.6.3. Sources of risk

- The threatened status of Devil Rays caught in the Fishery are derived from global assessments and may not represent their status in Australian waters.
- They are extremely susceptible to depletion due to its low reproductive rate.
- Manta Rays are listed as Vulnerable.

6.3.6.4. Justification

- Species are predominately caught in pelagic gillnet.
- There is potential misreporting in terms of identification between the Mantra Rays and Devil Rays (and between the different species of each group).
- Post release mortality is potentially high (from research undertaken in purse seining).
- Potential for under reporting as they are primarily discards.
- The Devil Rays Endangered status is derived from the global numbers declining significantly.

6.3.7. Seabird interactions

6.3.7.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.7.2. Risk rating

Table 37: Risk rating seabird interactions.

Species	Consequence	Likelihood	Rating
Seabirds	0	1	0

6.3.7.3. Sources of risk

- Anecdotal reports suggest that seabird interactions may occur.

6.3.7.4. Justification

- No seabird interactions recorded in the Fishery in logbook or observer reports.

6.3.8. Dolphins

6.3.8.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.8.2. Risk rating

Table 38: Risk rating Dolphins.

Species	Consequence	Likelihood	Rating
Dolphins	1	2	2

6.3.8.3. Sources of risk

- Cetaceans such as the Common Dolphin are listed as protected species under the *Environment Protection and Biodiversity Conservation Act 1999*.

6.3.8.4. Justification

- Very limited numbers caught in the Fishery.
- Population estimates for the Eastern Tropical Pacific Dolphin population is very high > 3,000,000 individuals.
- There is no evidence to suggest that inshore species are being interacted with in the Fishery.
- The risk rating is based on the species (Common Dolphin) that is interacted with in the Fishery.

6.3.9. River sharks (Glyphis species)

6.3.9.1. Objective:

To ensure fishing impacts do not result in serious or irreversible harm to Threatened, Endangered and Protected species populations.

6.3.9.2. Risk rating

Table 39: Risk rating River sharks (*Glyphis* species).

Species	Consequence	Likelihood	Rating
River sharks (*Glyphis* spp)	2	2	4

6.3.9.3. Sources of risk

- The application of Close-Kin Mark-Recapture has shown that adult population sizes are very low naturally.
- Adults move offshore and that is when interactions may occur.

6.3.9.4. Justification

- Most interactions within the Fishery are likely to be Northern River Shark (*Glyphis garricki)* given what is known about size, habitat, and distribution.
- Very low interactions recorded.
- There is a proposal to down list both species to Vulnerable from Critically Endangered (Speartooth Shark, *G. glyphis*) and Endangered (Northern River Shark, *G. garricki*).

General ecosystem effects

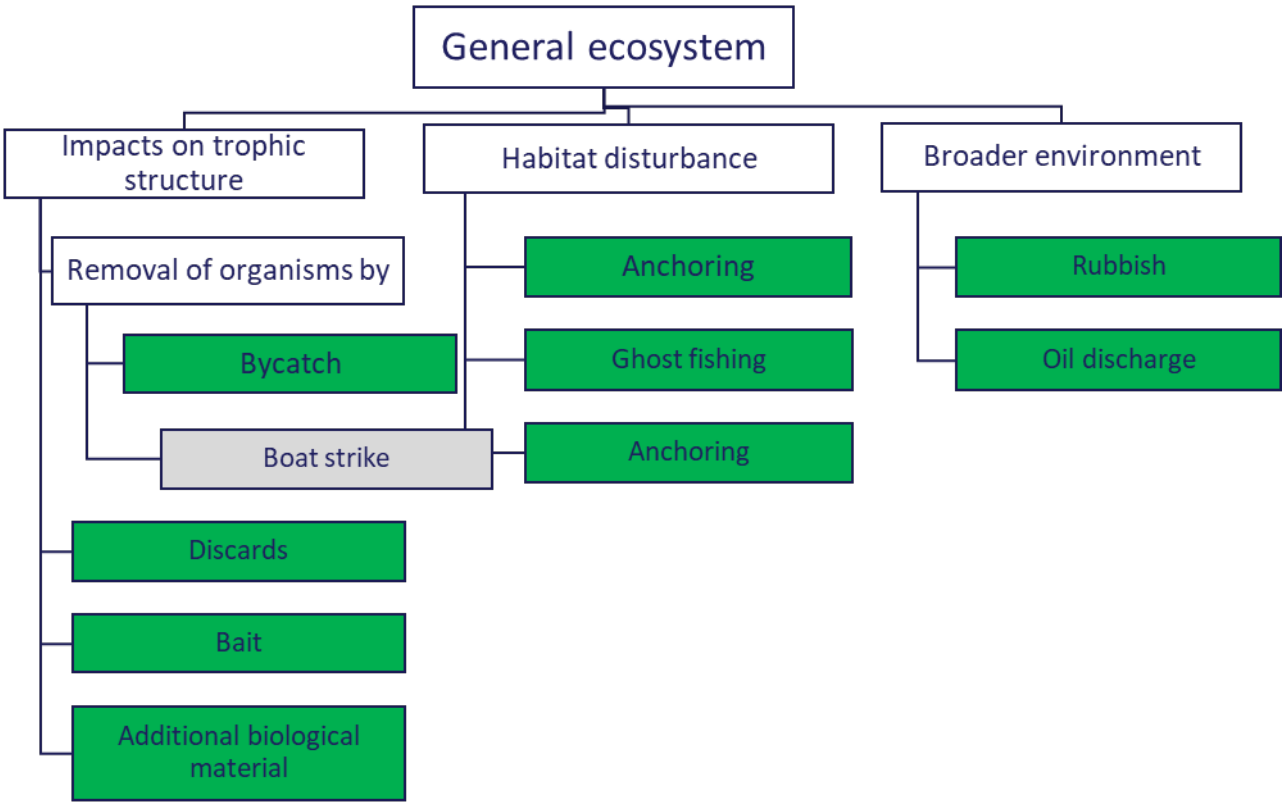

Figure 5: Component tree for general ecosystem impacts

6.3.10. General ecosystem impacts

The Consequence definitions for risk ratings for general ecosystem effects (Table 56) is different than for retained or secondary species (Tables 51 and 52).

6.3.11. Bycatch

6.3.11.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

6.3.11.2. Risk rating

Table 40: Risk rating bycatch.

	Consequence	Likelihood	Rating
Bycatch	1	2	2

6.3.11.3. Sources of risk

- Poor post release survival rates.

6.3.11.4. Justification

- Research undertaken by CSIRO showed bycatch levels were unlikely to lead to trophic cascades and that systems were stable and relatively insensitive.

6.3.12. Boat strike

6.3.12.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

6.3.12.2. Risk rating

Table 41: Risk rating boat strike

	Consequence	Likelihood	Rating
Boat strike	0	2	0

6.3.12.3. Sources of risk

- No independently validated data on boat strike.

6.3.12.4. Justification

- Boat strikes have not been observed during any Fishery observer trips.
- The Fishery comprises of a small fleet of slow moving vessels so most pelagic species can swim out of the way to avoid a strike.

6.3.13. Discards

6.3.13.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes

6.3.13.2. Risk rating

Table 42: risk rating discards

	Consequence	Likelihood	Rating
Discards	1	2	2

6.3.13.3. Sources of risk

- Discarding occurs within the Fishery.

6.3.13.4. Justification

- Discards must be reported in the log books for the Fishery.

- No discards are recorded for longline sector of the Fishery which is supported by observer data.
- There are very low levels of discards in the Fishery.

6.3.14. Bait

6.3.14.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

6.3.14.2. Risk rating

Table 43: Risk rating bait

Consequence	Likelihood	Rating
1	2	2

6.3.14.3. Sources of risk

- Species captured while fishing but not retained for sale may be used as bait.

6.3.14.4. Justification

- The take of bait for use in the Fishery is very low.
- Need to consider where the bait comes from and any biosecurity issues relating to this.

6.3.15. Additional biological material

6.3.15.1. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

Risk rating

Table 44: Risk rating additional biological material

	Consequence	Likelihood	Rating
Biological material	1	2	2

6.3.15.2. Sources of risk

- Discard of large species by some vessels.

6.3.15.3. Justification

- Limited processing of catch (no filleting).
- There are very low levels of discards in the Fishery.

6.3.16. Other environmental factors

6.3.16.1. Rubbish

6.3.16.2. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

6.3.16.3. Risk rating

Table 45: Risk rating for the impact of rubbish disposal by ONLF vessels on the broader environment.

	Consequence	Likelihood	Rating
Rubbish	1	2	2

6.3.16.4. Sources of risk

- Rubbish is generated as part of fishing activities.

6.3.16.5. Justification

- The disposal of solid, non-degradable waste in Australian waters is regulated through the *Marine Pollution Act 1999 (MARPOL).* 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.
- The compliance to these regulations is generally considered high but there are likely to be some occasions where solid, non-degradable waste such a plastic bags, containers and cans, is thrown or blown overboard from vessels.
- Social pressure and stewardship also serve as effective deterrents to littering.

6.3.16.6. Oil discharge

6.3.16.7. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to ecological processes.

Risk rating

Table 46. Risk rating for the impact of oil discharge by ONLF vessels on the broader environment.

	Consequence	Likelihood	Rating
Oil discharge	1	2	2

6.3.16.8. Sources of risk

- Fishing vessels produce exhaust emissions that emit oil directly into the water column.

6.3.16.9. Justification

- ONLF vessels produce exhaust emissions that discharge oil directly into the water column. As previously noted above, the disposal of waste (including oil contaminated bilge water) in Australian waters is regulated through MARPOL.

- There are substantial penalty provisions for non-compliance with these regulations.

6.3.16.10. Climate Change

Risk rating

Table 47: Risk rating for the impacts of climate change by the Fishery.

	Consequence	Likelihood	Rating
Climate change	1	2	2

6.3.16.11. Sources of risk

- Climate change considerations are both the impact of the fishery and its contribution to climate change and the impacts of climate change on the Fishery.

6.3.16.12. Justification

- All modelling considerations are underlined by climate change
- Need to embed more issues relating to climate change in future ERAs.

6.3.17. Habitat disturbance

6.3.17.1. Ghost fishing

6.3.17.2. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to habitat structure and function.

6.3.17.3. Risk rating

Table 48. Risk rating for the impact of ghost fishing (by gear lost by offshore net and line fishers) on trophic structure.

	Consequence	Likelihood	Rating
Ghost fishing	1	1	1

6.3.17.4. Sources of risk

- Panels of pelagic gillnet that are lost have the potential to continue to fish.

6.3.17.5. Justification

- The risk of nets becoming lost is minimised by regulation prohibiting pelagic net from coming within two meters of the seabed, requirement that nets remaining attached to vessels and a small fleet size.
- Demersal longlines likely have a limited capacity to continue to fish due to hooks rusting relatively quickly and lines ‘bundling’ overtime.

6.3.17.6. Anchoring

6.3.17.7. Objective:

To ensure that the effects of fishing do not result in serious or irreversible harm to habitat structure and function.

6.3.17.8. Risk rating

Table 49: Risk rating for the impact of anchors used by ONLF vessels on seafloor habitats.

	Consequence	Likelihood	Rating
Anchoring	1	1	1

6.3.17.9. Sources of risk

- Anchors used by vessels may have an impact on substrates and benthic communities.

6.3.17.10. Justification

- Sand anchors are usually deployed on barren ground to minimise impacts on the sea floor and to reduce the chances of the anchor becoming hung-up.

7. Appendices

7.1. Likelihood, consequence and risk matrix tables

Table 50: Likelihood definitions

Level	Score	Definition
Likely	5	Expected to occur
Occasional	4	Will probably occur
Possible	3	Evidence to suggest it may occur
Rare	2	May occur in exceptional circumstances
Remote	1	Has never occurred but is not impossible

Table 51: Consequence Categories for target and retained species

Level	Score	Definition
Negligible	0	Impact unlikely to be detectable at the scale of the stock
Minor	1	Minimal impact on the stock (biomass above 60% of unfished levels)
Moderate	2	Harvest levels at maximum yields (biomass 40-60% of unfished levels)
Severe	3	Harvest levels are impacting stock levels (biomass 20-40% of unfished levels)
Major	4	Harvest levels are significantly impacting recruitment levels (<20% of unfished levels)

Table 52: Secondary, tertiary and bycatch species consequence of definitions

Level	Score	Definition
Negligible	0	Almost zero harvest with impact unlikely to be detectable at the scale of the stock
Minor	1	Minimal impact on the stock (LOW risk in SAFE/PSA assessment)
Moderate	2	Harvest levels at maximum yields (MEDIUM risk in SAFE/PSA assessment)
Severe	3	Harvest levels are impacting stock levels (HIGH risk in SAFE/PSA assessment) or species have high vulnerability and low resilience to harvest
Major	4	Harvest levels are causing a serious impacts with a long recovery period required to return the stock to an acceptable level (HIGH risk in SAFE/PSA assessment)

Table 53: Harvestable species of concern

Level	Score	Definition
Negligible	0	Zero or near zero harvest (<10% NDF)
Minor	1	Low harvest levels with low or undetectable impacts (10<50% NDF)
Moderate	2	Harvest levels are at 50-100% of NDF levels or the impact of harvest is unknown
Severe	3	Harvest levels exceed NDF levels or there is indications of population declines
Major	4	Indication of serious declines in populations

Table 54. Threatened, Endangered and Protected Species (TEPS) consequence definitions

Level	Score	Definition
Negligible	0	Near zero interactions with impact unlikely to be detectable at the scale of the population
Minor	1	Low interaction levels with minimal impact on the population
Moderate	2	Levels of impact are at maximum levels
Severe	3	Interaction levels are causing further population declines
Major	4	Interaction levels are causing very serious declines or extinctions

Table 55: Habitat consequence definitions

Level	Score	Definition
Negligible	0	Insignificant impacts to habitat or populations of species making up the habitat which is unlikely to be measurable against background variability. (<1% of the habitat impacted)
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)
Severe	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 56 : Ecosystem consequence definitions

Level	Score	Definition
Negligible	0	Insignificant impacts on harvested or bycatch species and/or habitats resulting in effects on the ecosystem that are unmeasurable against background variation.
Minor	1	Levels of impact on harvested or bycatch species and/or habitats are significant but these are unlikely to affect ecosystem function
Moderate	2	Levels of impact are severe on harvested or bycatch species and/or habitats but these are unlikely to affect ecosystem function
Severe	3	Severe impacts on harvested or bycatch and/or habitats are causing measurable changes in ecosystem function (e.g. species replacements and community shifts)
Major	4	There are major impacts on most of the ecosystem components resulting in major regime shifts in ecosystem function (e.g. different species groups and/or habitats exist in the impacted area)

Table 57: Risk matrix

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

Table 58: Possible outcomes of each risk rating

Risk Rating	Risk value	Management response required
Negligible	0-1	Nil
Low	2-5	None specific
Moderate	6-10	Specific management actions required in Harvest strategy to ensure risk does not increase to a High rating
High	12-20	Specific management actions required to reduce risk

7.2. Assessment information for main retained species

7.2.1. Grey Mackerel

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Grey Mackerel have a restricted distribution and are confined to the waters of southern Papua New Guinea and around northern Australia from the Houtman Abrolhos Islands are on the west coast and to Northern NSW on the east coast. 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	There are at least five Grey Mackerel stocks across Australia, with a possible additional stock in the north east Gulf of Carpentaria (Broderick *et al.* 2011)
VULNERABILITY	Although the species fast growing and highly fecund (high production of spawn), they form aggregations which are predicate enough both spatially and temporally to be targeted. During spawning grey mackerel often schools together which means they can be easily targets by net fishing.

Stock status in Northern Territory

North West Northern Territory

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.

Gulf of Carpentaria

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.

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 *et al.* 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 *et al*. 2013).

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).

On the basis of the evidence provided above, the GoC biological stock is classified as a sustainable stock.

Fishing activity

Grey Mackerel are targeted by gillnet fishers with the Fishery and in the recreational sector using hook and line and lures.

Other commercial catches

Charter (management methods) In the NT, charter operators are regulated through the same management methods as the recreational sector, but are subject to additional limits on licence and passenger numbers.

Aboriginal traditional catch

There is a small amount of Indigenous catch utilising hook and line methods.

7.2.2. Blacktip and Spot-tail Sharks

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	The Common Blacktip Shark (*Carcharhinus limbatus*), Australian Blacktip Shark (*C. tilstoni*) and Spot-tail Shark (*C. sorrah*) are members of the family Carcharhinidae and are collectively known as 'blacktip sharks' due to their physical similarities (Grubert *et al*. 2013). The Australian Blacktip Shark inhabits the continental shelf from the Thevenard Island in western Australia to Sydney in NSW. Within its range it co–occurs with the Common Blacktip Shark, which is found globally in tropical and warm temperate areas. Common Blacktip Shark has been reported from the intertidal zone to a depth of 150m with larger sharks occurring in deeper water. Though it occupies the entire water column it is most common close to the surface or in the midwater. The Spot-tail Shark is found in the tropical Indo-Pacific on continental and insular shelves commonly to a depth of about 73m but possibly as deep as 140 metres. Its range extends from the East African coast, Madagascar and the Red Sea to India, Malaysia, China, the Philippines and northern Australia.
GROWTH AND REPRODUCTION	Primarily piscivorous, the Australian Blacktip Shark forms large groups of similar size and sex that tend to remain within a local area. It exhibits viviparity (unborn young are provided for through a placental connection). There is a well-defined annual reproductive cycle with mating occurring in February and March, females

BIOLOGY AND VULNERABILITY	
	bear one to six pups around January of the following year, after a 10 month gestation period. The Spot-tail Shark is viviparous with a yolk sac placenta, giving birth once a year to a litter of one to eight live young. The gestation period is 10 months and the pups measure about 50cm at birth. The young develop in shallow inshore waters. They grow rapidly at first, increasing in length by about 20cm during their first year but growth slows down thereafter. Females reach sexual maturity at two to three years and live for a maximum of seven years while males live up to five years.
STOCK STRUCTURE	Australian Blacktip Shark and Spot-tail Shark are found only in Australia and the Indo West Pacific, while the Common Blacktip Shark is globally distributed in tropical to warm temperate waters. In Australia waters, genetic studies have identified two biological stocks of Australian Blacktip Shark, a western stock extending from the western northern territory into northern Western Australia and an eastern stick extending from the Gulf of Carpentaria to the East coast of QLD and NSW. Three biological stocks of Common Blacktip Shark one across WA and the NT, One in Gulf of Carpentaria, and one across the east coast of QLD and NSW. There is a single biological stock of *C. sorrah* across northern Australia (Ovenden *et al.* 2007). Stock boundaries between the western biological stocks of *C.tilstoni* and *C.limbatus* and those in the gulf are uncertain.
VULNERABILITY	Have an inherent vulnerability to fishing due to their life history, which is generally less productive than some bony fish or invertebrates.

Stock status in the Northern Territory

The North and West Coast biological stock straddles two jurisdictions: The Northern Territory, west of the Wessel Islands–Western Australian border; and Western Australia.

In 2011, a stock assessment was undertaken for this biological stock utilising stock reduction analysis models, which rely on catch per unit effort data. The results from these models at the time estimated that the harvest rates for all species within the complex were less than 20 per cent of that required to reach MSY and current pup production was approximately 80 per cent of unfished levels (Grubert *et al*. 2013). Results from a mark-recapture study done for all species of Blacktip Shark in Northern Territory waters supports the stock assessment results (Bradshaw *et al*. 2013). Catches for this Blacktip Shark stock peaked in 2012 but have subsequently decreased to relatively low levels. This decrease in catch was predominately market driven due to a drop in market prices for shark fin.

Although there is uncertainty regarding species composition and the magnitude of historical catches of Blacktip Sharks from Western Australia, these species have not been harvested in this jurisdiction since April 2009 (Molony *et al*. 2013), allowing the biomass to increase.

The most recent assessment (Grubert *et al*. 2013) estimated that biomass in 2011 was 80 per cent of the unfished 1970 level. As current catches are well below those recorded in 2011, when the catches were assessed as sustainable, it is unlikely that current catches are having a reductive impact on the stock. The stock is not considered to be recruitment impaired and the current level of fishing is unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, the North and West Coast multispecies biological stock is classified as a sustainable stock.

Gulf of Carpentaria

The Queensland Department of Agriculture and Fisheries commissioned a scientific assessment of shark stocks which provided MSY per annum estimates for *C. tilstoni* and *C. sorrah* in the GoC. This assessment produced qualified MSY estimates of 95 t for *C. tilstoni* and 29.4 t for *C. sorrah* (Leigh GM 2015). The QLD report also, however, acknowledged a number of data limitations for Queensland Fisheries, particularly with respect to accuracy of species identifications and the quantity and reliability of available catch data.

In 2017, 103 t of *C. tilstoni* and 9 t of *C. sorrah* were reported from the GoC Inshore Finfish Fishery (GOCIFFF); catches that were above and below the respective MSY estimates. Species-specific data for the fishery showed that over the past 10 years the annual catches of *C. sorrah* (9–34 t) exceeded the MSY estimate twice, while catch of *C. tilstoni* (54–160 t) exceeded MSY seven times over the same period. An estimated 38–125 t was reported from the GOCIFFF each year for the period 2007–17 under the 'Blacktip Whaler Shark' catch category that includes Graceful Sharks (*C. amblyrhynchoides*). At present, catch reported in the 'Blacktip Whaler Shark' category cannot be differentiated into individual species.

The inability to assign more multispecies catch records to Blacktip Shark species makes it difficult to identify catch and effort trends for this species complex. Consequently, current catch levels and their impact on the biological stock are unknown, and there is insufficient information to confidently classify the status of this stock. This situation is expected to improve through time with the introduction of a new Shark and Ray logbook into the GoC on 1 January 2018, which limits the 'Blacktip Whaler' category to *C. limbatus* and *C. tilstoni only* and lists Graceful sharks (*C. amblyrhynchoides*) and Spottail shark (*C. sorrah*) individually.

On the basis of the evidence provided above, the Gulf of Carpentaria multispecies biological stock is classified as an undefined stock.

Fishing activity

The Blacktip Shark is caught in the Offshore Net and Line Fishery, Coastal Net Fishery, Coastal Line Fishery, Small Pelagic Development Fishery, Barramundi Fishery and the Bait Net Fishery. It is also encountered as bycatch in the Offshore Snapper Fisheries, in which sharks are no take species.

Aboriginal traditional catch

No reported Aboriginal catc

7.2.3. Spanish Mackerel

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Spanish Mackerel are distributed in waters from the Indo-Pacific from the Red Sea to South Africa to southeast Asia, north to China and Japan and South to Australia. In Australian waters 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 100m and are commonly associated with coral reefs, rocky shoals and current lines on outer reef areas and offshore water to inshore

BIOLOGY AND VULNERABILITY	
	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 - 50 cm fork length (FL), males between 40 - 45 cm FL, before two years of age. Females as small as 90cm 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 *et al*. 2003). However, evidence from otolith microchemistry, parasite analysis and limited adult movement (at scales greater than 100km) indicates that there are likely to be a number of smaller biological stocks with limited interaction (Buckworth *et.al*., 2007; Lester *et.al*., 2001).
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.

Stock status in Northern Territory

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 percent of the unfished level (1973); this is within sustainable limits and there may be capacity for the catch to be increased (Grubert *et al*. 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

Spanish Mackerel Fishery licensees harvested the vast majority (83 percent) of the Spanish Mackerel resource in NT waters over the last decade. The next largest extractive user is the recreational sector (8 percent), followed by ONLF licensees (5 percent), FTO clients (3 percent), Aboriginal fishers (1 percent) and DF licensees (<1 percent).

Most recreational fishing activity in the NT is concentrated within a 250km radius of Darwin, and it is here where the majority (i.e. around 70 percent) of Spanish Mackerel are caught by this sector (West *et al*. 2012). 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 FTO sector is similar.

Aboriginal traditional catch

Aboriginal fishers are entitled to use the aquatic resources of an area in a traditional manner. However, this entitlement does not extend to the sale of fish. Aboriginal people wishing to catch and sell Spanish Mackerel are encouraged to lease or purchase a commercial licence (noting that this species must not be intentionally taken under an Aboriginal Coastal Licence).

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

7.2.4. Longtail Tuna

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Longtail Tuna are found from tropical to temperate waters of the Red Sea and Indo Pacific, from East Africa, east to New Guinea, northern to southern Japan and South to Australia. Longtail Tuna are common in coastal waters of northern Australia, migrating southwards during the summer months, known from Fremantle, WA to Twofold Bay, NSW and absent from the southern coast. Epipelagic on the continental shelf. Although preferring inshore waters Longtail Tuna avoid estuaries and murky waters. They form schools of different age classes and often school with other tuna species.
GROWTH AND REPRODUCTION	Longtail Tuna reach maturity at approximately 60-70cm in length. The sexes are separate and fertilisation is external. Females mature at 40cm fork length and have a long spawning season from September to March in warm waters with temperatures above 24 degrees. They produce between 1.2 and 1.9 million eggs per spawning event. The eggs and larvae are pelagic.
STOCK STRUCTURE	There has been debate regarding the stock structure of Longtail Tuna throughout the Indo-pacific region. Serventy (1942) suggested that separate stocks and possibly even to subspecies may exist in Australian waters based on the distinct difference in the size distributions of fish off the eastern, northern and western coasts of Australia. Length frequency data shows an obvious increase in size with latitude (Griffiths et.al 2010). This data suggests that it may be possible that Longtail Tuna exist as a single stock throughout South-eastern Asia and Australia (Griffiths *et al*. 2010). In the absence of tagging data and reliable genetic analyses, the extent of mixing of fish between countries or water masses is unknown.
VULNERABILITY	Any significant increase in fishing mortality has the potential to result in recruitment overfishing due to Longtail Tuna being a slow growing species.

Stock status in Northern Territory

The current fishing rate is not viewed as exceeding biological reference points due to the large biomass of Longtail Tuna. Stock assessments are currently hindered by unreliable biological and catch data and there is an element of uncertainty in the AFZ as interactions with the broader regional stocks are uncertain.

Fishing activity

Longtail Tuna were declared a "recreational only" species by the Australian Federal Government. The species is managed by the Australian Fisheries Management Authority (AFMA) and annual bycatch limits have been imposed on Commonwealth managed fisheries. Recreational fishes must abide by the size and bag limits set by the various state fisheries agencies.

Incidental catch of Longtail Tuna is retained in the Coastal Line, Spanish Mackerel, Fishing Tour Operator and Offshore Net and Line Fisheries. The majority of catch is within the Offshore Net and Line Fishery with percentage catch limits to ensure that the species is not targeted.

Aboriginal traditional catch

There is no recorded data on traditional harvest rates.

7.2.5. Hammerhead sharks

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Scalloped Hammerhead and Great Hammerheads have circum-global distributions in tropical and sub-tropical waters. In Australia, Scalloped Hammerhead extend from New South Wales around the north of the continent to Geographe Bay, WA, though it is rarely recorded south of Houtman Abrolhos islands. Great Hammerhead range from Sydney on the east coast to Mandurah on the west coast. Scalloped Hammerhead shows strong genetic population structuring across ocean basins as it rarely ventures into or across deep ocean waters, but ranges quite widely over shallow coastal waters.
GROWTH AND REPRODUCTION	The age and size at maturity of Scalloped Hammerheads vary between temperate and topical waters. In tropical waters males mature at 5.7 years and 147cm and in temperate males mature at 8.9 years and 204cm (Harry *et.al* 2011). There are no direct estimate of the age at maturity of female hammerheads in Australian waters, however, Stevens and Lyle (1989) estimated it to be 200cm. Across northern Australia the peak pupping season spans October to January and the gestation period is 9 to 10 months (Last and Stevens 2009). A large shark, Great Hammerhead regularly reach lengths greater than 4m, with extremely large individuals approaching 6m. Both female and male Great Hammerhead mature at 227cm and 8.3 years, with maximum age estimated to be 39 years (Harry *et al.* 2011). Great Hammerhead are viviparous producing 6-33 young of 65cm (Last and Stevens 2009), with females likely breeding biennially (Stevens and Lyle 1989).
STOCK STRUCTURE	Recent research on the stock structure of Scalloped Hammerhead shark identified that a western stock exists in Western Australia waters, which is separated genetically from other national and international jurisdictions (Heupel *et al.* unpublished). This report also identified separate stocks comprising western stock in WA, a northern stock in the NT and Gulf of Carpentaria waters as well as eastern stock on the east coast of Australia. However, these stocks were not separated genetically from international jurisdictions to the north and it was proposed that there is likely to be limited connectivity from larger individuals along the continental shelf between the northern stock with Indonesia and the eastern stock with Papua New Guinea. Heupel *et al.* (unpublished) also examined the stock structure of Great Hammerhead and found support for limited movement of individuals over short timeframes, with mixing across the extent of their distribution over longer timeframes. However, further research is needed to determine if the Australian stock is connected to regional neighbours(Heupel *et al.* unpublished).
VULNERABILITY	The high value of fins of both Great and Scalloped Hammerhead make them an attractive target for fishers and the life history of these species renders them

BIOLOGY AND VULNERABILITY	
	susceptible to overfishing. Scalloped Hammerhead is considered to havea low potential to recover from increased mortality (Smith *et.al.* 1998) and re-colonization of depleted areas from neighbouring regions is expected to be a slow and complex process (Simpfendorfer *et al.* 2019).

Stock status in Northern Territory

Total catches of the northern stock were dominated by the high catches by the Taiwanese gillnet fleet between 1975 to 1984. The domestic commercial fishery and illegal catches steadily increased to a peak in 2005 before a steep decline in catches and the illegal catch becoming almost non-existent due to the high cost of crossing into Australian waters. Indonesian catches have remained relatively low throughout (<30 t) and recreational catches have remained under 10 t.

The results of the most recent study (Thor Saunders *et.al* unpublished) found that all Australian stocks of *S. lewini* are likely to be above conventional fishery target reference points (60 percent unfished levels) as well as being above EBPC listing criteria (undergone a 30-50 percent decline from pristine levels).

Fishing activity

Scalloped and Great Hammerhead are retained within the Offshore Net and Line Fishery. Juvenile Hammerhead Sharks are also discarded by the NT Demersal Fishery, in which all sharks are no take species. There is also a potential for Hammerhead Sharks to be caught as bycatch in the Coastal Line and Barramundi Fisheries however at low levels.

Aboriginal traditional catch

There are no records of traditional harvest.

7.2.6. Pigeye shark

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	The Pigeye Shark is common to coastal waters in tropical and subtropical Indo-west Pacific and Eastern Atlantic (Last and Stevens 2009). In Australia it is found in northern waters from Carnarvon in the west to Moreton Bay in the east.
GROWTH AND REPRODUCTION	Pigeye Shark reach a maximum size of 280cm. Female Pigeye Sharks mature at 13 years and live for more than 30 years, with males maturing at 12 years and living more than 26 years (Tillett *et al.* 2011). Pigeye Sharks are viviparous, with litters of 6 to 13 pups that are born at 60-65cm long (Last and Stevens 2009). Young sharks spend their first few year in sheltered in shore habitats (Tillett *et al.* 2011).
STOCK STRUCTURE	There is evidence within Australia that sub-populations may be present (Tillett *et al.* 2011). However, Tillet *et al.* (2012) failed to discern a finer population structure using nuclear microsatellite markers.
VULNERABILITY	It is sensitive to fishing pressure due to late age at maturity and limited fecundity.

Stock status in Northern territory

Not assessed.

Fishing activity

Pigeye Sharks are caught as by-product and bycatch species in the Offshore Net and Line Fishery. There is also a potential for Pigeye Sharks to be caught as bycatch in the Demersal, Coastal Line and Barramundi Fisheries, however at low levels.

Aboriginal traditional catch

There is no recorded Aboriginal catch.

7.2.7. Bull shark

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	The Bull Shark is found worldwide in coastal areas of tropical and temperate waters. Bull Sharks are a euryhaline species that frequently enters rivers and lakes. In Australia they are known from Perth, Western Australia around the tropical north to Sydney in New South Wales.
GROWTH AND REPRODUCTION	Bull Sharks are viviparous, with the young approximately 70cm at birth and litter size ranges from 1 to 13. Females usually give birth in estuaries and river mouths with the young spending time in estuarine and coastal nursery areas. Female Bull Sharks have been shown to display reproductive philopatry in Northern Australia, likely utilising the same nursey habitat across multiple breading events (Tillett *et al*. 2012). Bull Sharks in the Northern Territory are thought to mature at 9.5 years and live for more than 27 years (Tillett *et al*. 2011). Length at maturity for bull sharks is 204cm for females and 190-200cm for males (Cruz-Martínez *et al*. 2004).
STOCK STRUCTURE	There is currently little information on population size, structure or trend for Bull Sharks in the Northern Territory.
VULNERABILITY	The use of coastal areas as nursey habitat make Bull Sharks susceptible habit degradation. A relatively late age at maturity and limited fecundity make it susceptible to fishing pressure.

Stock status in Northern Territory

Not assessed.

Fishing activity

Bull sharks are caught as by-product and bycatch species with the Offshore Net and Line Fishery. There is also a potential for Bull Sharks to be caught as bycatch in the Demersal, Coastal Line and Barramundi Fisheries, however at low levels.

7.2.8. Mackerel Tuna

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Mackerel Tuna are found throughout the Indo-west Pacific region. The southern most limit of the species in Australia is the Murchison River in Western Australia and Twofold Bay on the East Coast. Mackerel Tuna are generally found in waters near the coast and rarely venture beyond the continental shelf.
GROWTH AND REPRODUCTION	Mackerel Tuna are a mid-sized tuna species, reaching a maximum size of 100cm. While there is little information is available regarding the growth and reproduction of this species in Australian waters, studies in other regions indicate that Mackerel Tuna attain maturity at 38cm (Yesaki 1994). Female Mackerel Tuna spawn multiple times during a spawning season, with larger females able to produce 2.5m ova (Yesaki 1994).
STOCK STRUCTURE	There is currently little information on population size or stock structure for Mackerel Tuna in the Northern Territory. A study examining mtDNA in Southeast Asia found genetic homogeneity throughout the region (Santos *et al.* 2010). Further studies are required to determine if the species has finer stock structuring.
VULNERABILITY	Mackerel Tuna are an abundant species that support large fisheries in other regions, and is seldom targeted by commercial or recreational fishers in Australia.

Stock status

There is currently little information on population's size or structure for Mackerel Tuna in Australia. However, Mackerel Tuna have been assessed as least concern in the IUCN red list (Collette *et.al* 2011).

Fishing activity

In the Northern Territory Mackerel Tuna are retained as by-product or discarded in the pelagic net component in the Offshore Net and Line Fishery. Recently, Mackerel Tuna have also been harvested as a by-product under a single Development Licence. Mackerel Tuna are not captured in large numbers by other commercial fisheries in the Northern Territory.

7.2.9. Tiger Sharks

BIOLOGY AND VULNERABILITY	
DISTRIBUTION	Tiger Sharks are globally distributed in tropical and temperate waters. The Australian distribution includes all northern Australia waters, extending south to Perth in the West and Bass Strait in the east. Tiger Sharks are found from close inshore to well off the continental shelf, with a depth distribution ranging from the surface to 850m. Individuals within Tiger Shark populations are thought to display varied and complex movement patterns, where some individuals undertake wide-ranging migrations, while others are restricted to more localised movement patterns with high site fidelity (Werry *et al.* 2014; Ferreira *et al.* 2015).

BIOLOGY AND VULNERABILITY	
GROWTH AND REPRODUCTION	Tiger Sharks are the largest shark in the family Carcharhinidae, reaching lengths in excess of 5m. Estimates of size and age at maturity vary greatly between studies and regions, which is unsurprising given the diverse habitat and diet preferences for this species. In Australia, L_{50} and A_{50} for Tiger Sharks has been estimated to be 297cm and between 10 and 13 years for males, and 326cm and 10 to 13 years for females (Holmes *et al.* 2015). Tiger Sharks are an ovoviviparous species with litter sizes of 10-82 pups, with an average litter size of 35. Gestation last from 15 to 16 months (Whitney and Crow 2007) and at birth tiger sharks are 80-90cm in length (Whitney and Crow 2007). It is thought that most, if not all females follow a triennial reproductive cycle, however it is possible that some females reproduce biennially (Whitney and Crow 2007).
STOCK STRUCTURE	It has been suggested that Tiger Sharks comprise a single Indo-Pacific population, which is supported by demonstrated migrations across the region by individuals (Werry *et al.* 2014; Ferreira *et al.* 2015) and an absence of genetic differentiation between the east and west coast of Australia (Holmes *et al.* 2017).
VULNERABILITY	Relatively fecund for an ovoviviparous species, with up to 80 pups in a litter. Thought to reproduce only every three years, which reduces its ability to recover from over exploitation.

Stock status

There is currently little information on population's size or trend for Tiger Sharks in the Northern Territory. Catch rates of shark control programs on the east coast of Australia have been used to suggest declining population trends for Tiger Shark (Holmes *et al.* 2012; Roff *et al.* 2018).

Fishing activity

In the Northern Territory Tiger Sharks are retained as by-product in the longline component in the Offshore Net and Line Fishery and is bycatch species within the pelagic net component where they are encountered less frequently.

Aboriginal traditional catch

There is no recorded information on traditional catch of Tiger Sharks, and it is considered negligible.

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