Status of key Northern Territory fish stocks report 2017

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Director's message

Fisheries in the Northern Territory are diverse in the area of their operation and the species they target. From recreational anglers targeting Barramundi in freshwater billabongs to commercial trawl fishers targeting a range of tropical snapper species on the continental shelf 200 km from the shore, the Territory provides some of the best fishing experiences in the world.

The Fisheries Division of the Department of Primary Industry and Resources, as the steward of these resources, is responsible for their management and utilisation for the benefit of all Territorians, both current and future generations, based on the best science available.

This is the fifth *Status of Key Northern Territory Fish Stocks Report* produced by the Fisheries Division and follows the national reporting framework used in the *Status of Key Australian Fish Stocks Reports* that was first produced in 2012. By following this framework, it ensures that the scientific assessment of biological stock status is more rigorous and provides a consistent approach to the reporting of the status of shared stocks with other jurisdictions.

The *Status of Key Northern Territory Fish Stocks Report* 2017 covers 12 key species that represent the Territory's wild-catch fisheries. While the focus of the report is on the sustainability of these 12 species, it also provides important information on the individual fisheries that target these species and how these fisheries are being managed.

This report informs interested fishers, seafood consumers and the broader community about the current biological status of these key wild-caught fish stocks in the Territory. It also provides fisheries managers and policy makers with a guide to help manage the health of our fisheries now and into the future.

Ian Curnow

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Introduction

The tropical waters of the Northern Territory (NT) are home to a wide variety of economically, socially and culturally important fish species.

The role of the Fisheries Division of the Department of Primary Industry and Resources (DPIR) is to ensure that these aquatic resources are managed in accordance with the principles of ecologically sustainable development and it publishes regular updates on their biological stock status. Knowledge of their biological stock status is an important step in the continuous improvement of fisheries management arrangements because it is a key to measure how well these resources are being managed and if they are being fished sustainably.

This report provides the status of key biological fish stocks in the NT and follows the national reporting framework used in the *Status of Key Australian Fish Stocks Reports 2018* (Stewardson et al. 2018). This framework was developed collaboratively by fisheries scientists from around Australia and uses standardised terminology and reference points for stock status classifications. The term 'fish' is used here to describe animals caught by wild-capture fisheries and includes crustaceans (such as Mud Crabs), echinoderms (such as Sea Cucumbers), finfish and sharks. Regional differences in common names for the same fish species have led to the development of the Australian Fish Names Standard (www.fishnames.com.au). This naming convention applies capital letters to the titles of most commercially important fish species (and species groups) and is employed here to facilitate comparisons with other jurisdictional reports.

A range of factors are considered beyond the harvest of the target species when determining biological stock status. These include the effects of fishing on the marine environment, the economic performance of fisheries and the governance structures that control how they operate. Although these issues are considered in each stock status determination, this information is typically given in the form of comments regarding the effects of fishing on the marine environment and environmental effects on fish stocks. These are included in response to the increasing interest in the state of fish stocks, the sustainability of fisheries and the health of the marine environment by fishers, seafood consumers, policy makers and the broader community.

Territorians value the healthy state of our fisheries. Many Aboriginal communities have strong customary links with the aquatic environment and rely on fish for food, culture and development opportunities. Our commercial fisheries and the aquaculture industry are valued at over $70 million per annum and provide high quality seafood (such as Mud Crabs, tropical snappers, Barramundi, shark and mackerel) to restaurants and retail markets.

Recreational fishing is also an intrinsic part of the NT lifestyle, with quality fishing experiences attracting many visitors and supporting a major guided fishing industry. Annual expenditure by recreational fishers and the guided fishing industry is estimated at over $100 million.

All NT managed fisheries have governance structures in place to control the harvest rate, minimise environmental impacts and ensure sustainability. Nonetheless, careful monitoring and management must continue in order to ensure the sustainable and optimal use of our aquatic resources, particularly in high-use areas near major population centres. For example, concerns regarding overfishing of Golden Snapper stocks near Darwin have led to the development of a new set of management controls that include the implementation of five protection areas to address this emerging problem. Ongoing vigilance is also required to prevent the introduction of aquatic pests and diseases into NT waters.

As steward of the aquatic resources of the NT, the Fisheries Division works with a diverse range of stakeholder groups (such as fishing guides, commercial fishers, recreational fishers, aquaculture enterprises and Aboriginal land councils) to promote fisheries and aquaculture development, and facilitate access and sharing of fisheries resources that are socially acceptable. Representatives from

these groups also provide advice to a number of management advisory groups and committees associated with specific fisheries or user groups.

Fisheries compliance is generally undertaken by the Water Police Section of the NT Police, Fire and Emergency Services, with the Australian Fisheries Management Authority being responsible for compliance in two offshore fisheries managed by the Fisheries Division. Indigenous marine rangers also play an increasingly valuable role in monitoring our fisheries and coastlines. DPIR provides training and support to enhance the skills and capacity of rangers to undertake these tasks. Adherence to the rules is essential to ensure fisheries are fished sustainably.

Biological stocks

The *Status of Key Northern Territory Fish Stocks Report 2017* focuses on the status of biological stocks of fishes wherever possible; hence, it is important to distinguish between biological stocks and fisheries. Biological stocks are discrete populations of a fish species, usually in a given geographical area and with limited interbreeding with other biological stocks of the same species. Although one fish species may exist in many locations around Australia (or worldwide), fish caught in different areas may come from separate biological stocks. Individual biological stocks may be found in a single jurisdiction or may be shared across two or more jurisdictions. In some cases, individual biological stocks may also extend into the high seas.

The number and geographic range of individual biological stocks can vary greatly between species. For example, the Australian Blacktip Shark (*Carcharhinus tilstoni*) consists of two expansive stocks, one extending from Western Australia into the western NT and another extending from the eastern NT into western Queensland and down the eastern seaboard. By contrast, Barramundi consist of numerous, localised stocks, most of which are confined to individual river catchments. Because separate biological stocks have limited connectivity, fishing one stock may not affect the others. Hence, it is important to assess each biological stock separately, wherever possible.

Biological stocks are natural resources; different biological stocks may have different natural abundance, growth rates and mortality rates. Different biological stocks may also be influenced by different environmental factors, depending on where they occur. Consequently, the number of fish (of a given species) that can be sustainably harvested from one biological stock may be very different to that from another stock.

Fisheries differ from fish stocks in that they are management units engaged in the harvest of fish. Fisheries are typically defined in terms of the people involved, the species caught, the area of water or seabed fished, fishing methods and the types of boats used. A single biological stock may be caught by one or a number of fisheries. Similarly, a single fishery may catch one or a number of different species, from one or more different biological stocks.

A key measure of fisheries management performance is the status of the fish stocks—the natural resource on which the fisheries depend. Therefore, this report provides status classifications for fish stocks. Where possible, this takes into account the impacts of all fisheries at the level of individual biological stocks. Where the stock delineation is not known (that is, it is not known exactly where one biological stock finishes and the next begins) or the numbers of biological stocks for a species are very high, reporting has been undertaken at the level of either the jurisdiction or the management unit. The level of reporting (biological stock management unit or jurisdiction) for each species is presented at the beginning of each chapter, along with the rationale for this choice. In these reports, the term ‘stock’ is used generically to refer to all three levels of stock status assessment—biological stocks, management units and populations assessed at the jurisdictional level. In future, most species currently assessed at the management unit or jurisdictional level will be assessed at the biological stock level, wherever research has revealed the biological boundaries of the stocks.

Stock status classification system

In general, stock status classifications assess whether the current abundance (i.e. number or biomass) of fish in a stock is at an adequate level and whether the level of fishing pressure (the quantity of fish being removed through fishing) is adequately controlled through management. The abundance of a wild fish stock is usually compared with an estimate of the abundance of that same stock before fishing began. Abundance is considered to be adequate if there is sufficient adult stock remaining, such that the production of juveniles (recruitment) is not significantly reduced. That is, the abundance of adults has not been depleted to the point where there is an increased risk of recruitment failure. This level of adult abundance will vary between different species of fish.

In terms of fishing pressure, stock status considers whether the current level of fishing pressure is adequately constrained, such that stock abundance is not reduced to a point where production of juveniles is significantly reduced. Where information is available, the level of fishing pressure includes consideration of Indigenous and recreational (including charter) fishing as well as commercial fishing.

The classification system used here combines information on both the current stock size and the level of catch into a single classification for each stock. There are seven classification categories (Table 1; Figure 1). To classify stocks into one of these categories, the current abundance and level of fishing pressure are compared with defined biological reference points (see 'Reference points', below). Each stock is then classified as a sustainable stock, recovering stock, depleting stock or overfished stock.

For easy interpretation, the classifications are also depicted by a colour-coding system. An 'overfished stock' classification (red) indicates that a management response is required to ensure the sustainability of the stock in question.

The term 'sustainable stock' refers specifically to the biological status of fish stocks and does not take into account broader ecological, social or economic considerations. A sustainable stock classification is given to stocks that are above the biological limit reference point of 'recruitment overfished' (see below) and for which the level of current fishing mortality is considered unlikely to cause the stock to become recruitment overfished. Given the focus of this report on stock status, the term does not have the broader meaning of such terms as 'ecologically sustainable' or 'ecologically viable', which consider the sustainability of the entire ecosystem and the role of specific stocks in the function of the ecosystem (DAFF 2007).

Table 1. Stock status terminology for the Northern Territory Status of Key Fish Stocks Reports

	Stock status	Description	Potential implications for management of the stock
	Sustainable	Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (i.e. the stock is not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished.	Appropriate management is in place.
	Depleting	Biomass (or proxy) is depleted and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.	Management is needed to reduce fishing mortality and ensure that the biomass does not deplete to an overfished state.
	Recovering	Biomass (or proxy) is not yet depleted and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.	Appropriate management is in place and there is evidence that the biomass is recovering
	Overfished	Spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (i.e. the stock is recruitment overfished). Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect.
	Undefined	Insufficient information available to determine stock status.	Data required to assess stock status are needed.
	Negligible	Catches by all fisheries are so low as to be considered negligible and that inadequate information exists upon which to base a status classification.	Assessment will not be conducted unless catches and information increase.

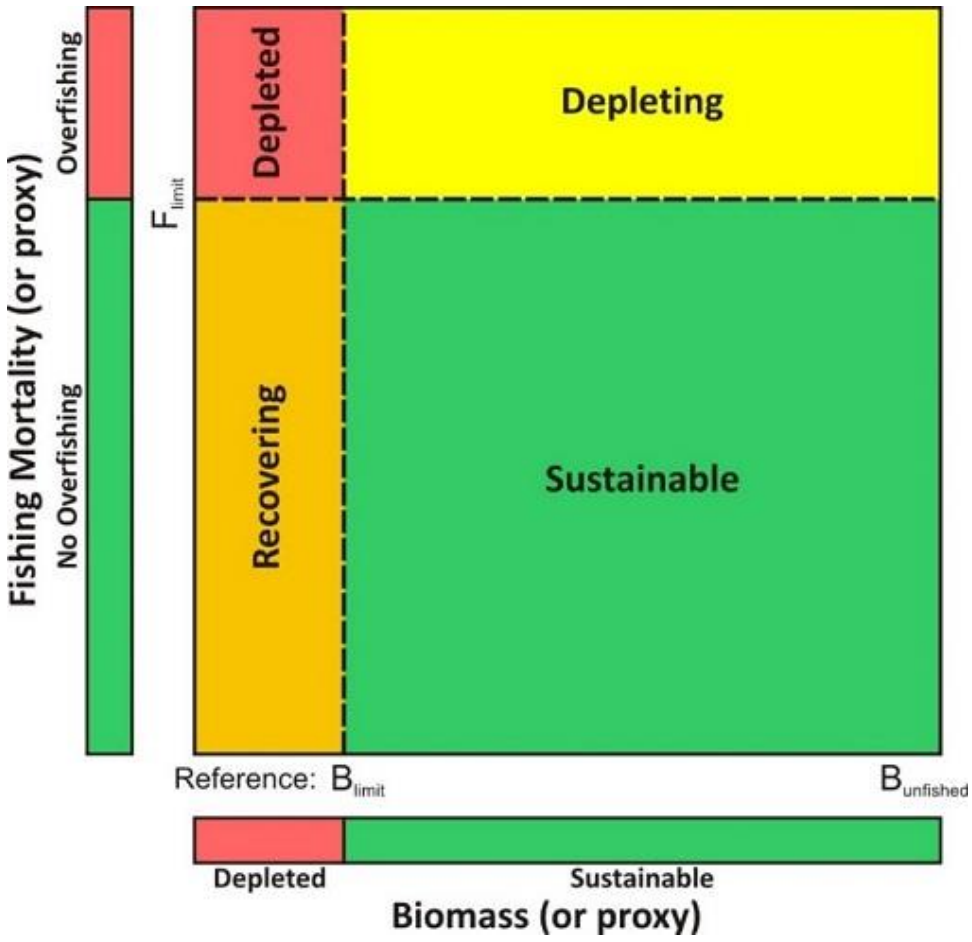

Figure 1. Diagrammatic representation of the stock status classification system, with relative fishing mortality (the ratio of current fishing mortality to the fishing mortality that would cause the stock to become recruitment overfished) on the x-axis and relative spawning biomass (the ratio of current spawning biomass to the recruitment overfished spawning biomass limit) on the y-axis

** Note that part of the recovering block has been marked as 'overfished'. This represents stocks for which adequate management measures have been put in place, but these have not yet resulted in measurable improvements.*

Reference points for performance indicators

Reference points are used to assess the performance of the fishery and are linked to defining acceptable levels of biological impact on a stock or the desired social and/or economic outcomes (DEWR 2007). They help to identify when stock abundance is too low or fishing pressure is too high. There are three types of reference points against which fishery performance can be measured. These are commonly referred to as 'limit', 'trigger' and 'target' reference points. In well-managed fisheries, pre-defined management actions occur when the performance indicator reaches a trigger reference point or is above the target reference point or below the limit reference point. The use of reference points to guide management decisions is consistent with the Food and Agriculture Organization's *Code of Conduct for Responsible Fisheries* (FAO 1995) and National Guidelines to Develop Fishery Harvest Strategies (Sloan et al. 2014).

Limit reference points

Limit reference points define the values of a performance indicator for a fish stock that are no longer considered acceptable. Although they can be used to define unacceptable economic and social outcomes, they are typically associated towards biological performance and mostly relate to

whether the stock is recruitment overfished. Recruitment overfishing puts the stocks at an unacceptable risk and is defined as:

> The point at which a stock's spawning biomass has been reduced through catch so that average recruitment levels are significantly reduced.

Limit reference points used to determine stock status vary between species and stocks due to differences in biology. They also vary between management agencies. If a stock falls below the limit reference point (e.g. stock abundance is too low or fishing pressure is too high) a drastic action is normally appropriate (e.g. closing parts of the fishery) until such time the stock recovers. In this report, 'recruitment overfished' is used as the biological limit reference point for determining whether or not a fish stock is overfished.

For a stock to be classified as sustainable, the current level of abundance, or fishing pressure, must be at a level considered to be unlikely to cause the stock to become recruitment overfished—that is, recruitment overfishing should not be occurring.

Trigger reference points

Trigger reference points define the values of a performance indicator for a fish stock at which a change in the management is considered or adopted. Trigger reference points may be used to determine management responses to different stock levels or to define when a stock is transitional-depleting or transitional-recovering.

Target reference points

Target reference points define the values of a performance indicator for a fish stock that are desirable or ideal and at which management should aim. This includes high levels of abundance or low levels of fishing pressure. Generally, fisheries management aims to ensure that stocks are maintained at an ideal level and away from limit reference levels. Target reference points commonly incorporate economic management outcomes, such as maximising the sustainable yield or economic returns. For example, the Commonwealth Fisheries Harvest Strategy Policy seeks to maintain fish stocks, on average, at a target biomass equal to the biomass that would produce maximum economic yield.

There is no single agreed national target level, so it is not yet possible to include quantitative information based on targets in stock status determinations. Although the stock status determinations provided in these reports rely on biological limit reference points, it is envisaged that, in the future, stock status classification will consider stock status in relation to targets and triggers as well as limits.

Defining stock status—weight-of-evidence approach

Assessing the status of fish stocks can be a difficult task. The methods used to monitor and assess stock status vary, ranging from simple catch levels to complex, resource-intensive, quantitative stock assessments. Smaller-volume and lower-value biological stocks and fisheries often have less data available or limited resources to undertake quantitative stock assessments. If the targeted catch from a biological stock is very low, or a species is only taken in small numbers as byproduct, it may not be cost-effective to invest in the development of quantitative stock assessment models. However, robust stock status assessments can be made without having quantitative stock assessments.

A weight-of-evidence approach is achieved by systematically considering a range of biological and fisheries information. The approach provides a structured scientific process for assembly and review of performance indicators of abundance and levels of fishing pressure. For most fish stocks,

particularly in the smaller fisheries, only a subset of the types of evidence is available and/or useful. Expert judgment plays an important role in stock status determination for these types of stocks, with an emphasis on documenting the key evidence and rationale for the decision. The decision-making process is undertaken separately for abundance and fishing pressure.

The lines of evidence used in the weight-of-evidence approach include:

- Empirical performance indicators, including catch, effort, catch rate, size- or age-based indicators, and spatial and temporal distribution of the fishery.
- Risk assessments.
- Fishery-independent surveys.
- Quantitative stock assessment models.
- Harvest strategies.

Stock assessments

Stock assessments are one of the main sources of information for determining biological stock status. Stock assessments are mathematical and statistical models that are used to predict the stock abundance and response to fishing pressure. They typically incorporate information on growth, natural mortality, the stock–recruitment relationship and carrying capacity, and data from fishery-dependent sources (e.g. catch and fishing effort) and fishery-independent sources (e.g. surveys). The outputs of these assessments generally include an indication of the unfished stock abundance (i.e. how big the stock was before fishing began), current stock abundance and current fishing pressure. In combination with biological reference points, the information from a stock assessment can be used to determine the stock status classification.

Abundance: Stock assessments use a variety of ways to express current stock size to account for differences in biology and management systems among species. Abundance descriptors may include spawning stock biomass, total biomass, or egg/pup production. However, regardless of the type of descriptor used, the basic premise is that, for the stock to be classified as a sustainable stock, the level of abundance (e.g. biomass) must be above the level that results in the stock being recruitment overfished. This means that the abundance of adults will not have been reduced to the point where there is increased risk of recruitment failure.

Fishing pressure: In some stock assessments, estimates of fishing mortality may be explicitly stated for a stock. Doing this allows a comparison between the actual fishing mortality and fishing mortality limits set by management rules to determine whether current fishing pressure is likely to cause the stock to become recruitment overfished. In other stock assessments, models are used to determine total allowable catches (TACs). Having a TAC is designed to ensure that the stock remains at (or will return to) an appropriate level—often defined by target reference points. In the latter, it is useful to compare the catch from a stock with that recommended by the TAC. If the catch is below, or equal to, a biologically meaningful TAC, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

Effects of fishing on the marine environment

The stock status classification provided for each stock does not take into account the effects of fishing on the marine environment. As discussed previously, these elements of the broader concept of ecologically sustainable development tend to be considered at the fishery level rather than at the biological stock level. Although no formal classification has been given, the effects of fishing on the marine environment are briefly explored in each species' chapter and the measures that have been put in place to mitigate detrimental effects are described.

Assessments of Northern Territory fisheries under the Environment Protection and Biodiversity Conservation Act 1999

The environmental performance of NT-managed fisheries that have an export component and/or operate in Commonwealth waters is assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Commonwealth waters are those from 3 to 200 nautical miles (nm) (see Overview of NT Fisheries).

The assessments are conducted by the Australian Government's Department of the Environment against the criteria listed in the Guidelines for the Ecologically Sustainable Management of Fisheries (DSEWPAC 2012). The guidelines outline specific principles and objectives to ensure a strategic and transparent way of evaluating the ecological sustainability of fishery management arrangements. The guidelines include the principles that:

- A fishery must be conducted in a manner that does not lead to overfishing; for those stocks that are overfished, the fishery must be conducted in such a manner that there is a high probability that the stock(s) will recover.
- Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of ecosystems.

An assessment is undertaken if:

- product from the fishery is to be exported;
- the fishery is to operate in Commonwealth waters; and/or
- the fishery is to be managed by the Commonwealth.

Part 13A Export

An Australian native wildlife specimen can only be exported for commercial purposes if it is approved for export by a program, such as an approved wildlife trade operation, or is included in the list of exempt native specimens.

Part 13 Species and Communities

Under part 13 of the EPBC Act, it is an offence to harm listed threatened species (except a conservation-dependent species) in Commonwealth waters unless a fisher has obtained a permit or the management arrangements for the fishery are accredited under the Act. Management arrangements can be accredited under Part 13 if the Environment Minister is satisfied that:

- The management arrangements require individual fishers to take all reasonable steps to avoid killing or injuring a member of a species protected under the EPBC Act (that is, a threatened species, a listed migratory species, a listed marine species or a cetacean).
- The fishery does not, or is not likely to, adversely affect the conservation status of protected species, or affect the survival and recovery of listed threatened species.

NT-managed fisheries that have been assessed under the EPBC Act (and can export product) include the Aquarium Fishery, the Demersal Fishery, the Mud Crab Fishery, the Offshore Net and Line Fishery, the Spanish Mackerel Fishery, the Timor Reef Fishery and the Trepang Fishery. Details of these assessments are not presented in the species chapters of this report because they relate to the operation of individual fisheries rather than the stock status of individual species. The reader can, however, access all EPBC Act assessments for NT-managed fisheries from http://www.environment.gov.au/marine/fisheries/nt-managed-fisheries.

Environmental effects on stocks

Many fish stocks vary naturally as a result of the effects of the environment, even in the absence of fishing. For example, recruitment of Barramundi can be affected by rainfall (Halliday et al. 2012, Robbins et al. 2009). Weather events, ocean currents, changes in climate and disease can all affect fish abundance. Where links have been established between environmental factors and stock abundance for a given species, they are outlined in the species chapters.

Non-fishing factors that affect the sustainability of fish stocks

Human activities unrelated to fishing can have a substantial impact on the sustainability of fish stocks—for example, the clearing of mangroves for coastal development. Although the impacts of human activities are not discussed on a species-by-species basis, these factors may, in some cases, have a greater impact on fish stocks than fishing.

What to expect in each species report

Each chapter describes the distribution of stocks of key species in the NT and provides stock status classifications for each. In cases where biological stock delineation is known and the number of discrete biological stocks is small, information is presented at the level of biological stocks. Otherwise, information is presented at the management unit or jurisdictional level.

Catch estimates for each stakeholder group that harvests key species are provided in summary tables. The reader is advised that there are significant differences in the currency of catch data for the commercial, recreational and Indigenous fishing sectors. Historical catch estimates for recreational and Indigenous fishers cannot be assumed to be representative of current catches due to the inherent variability in annual catches seen in the tropics (primarily due to differences in wet season rainfall).

Additional catch per unit effort information for some commercial fisheries is presented, where relevant. The effects of fishing on the marine environment (and associated mitigation measures) are also summarised, as are the environmental factors which affect fish stocks.

Reporting period

These reports present calendar year data to the end of 2017 and the results of stock assessments based on data collected to that point.

Fishing methods

Fishing gear and methods are designed to take into account the particular characteristics and behaviour of the target species, including their feeding, spawning, shoaling and migratory behaviour, their ecology or relationship with their habitat and their herding behaviour. The catchability of each species depends on the action of the gear; the composition of the catch from a particular fishing area may, therefore, depend on the type of gear used. The information presented here is based on the 1993 authoritative *Australian fisheries resources* (Kailola et al 1993) and is updated to reflect changes in fishing techniques and management over the past 20 years.

Nets

Fishing nets are used in a wide variety of configurations and designs, depending on the species targeted. Four main types of fishing gear use netting: gill-nets, seine nets, cast nets and trawls. The main components of a common net are described below in Figure 2.

The netting or mesh is the panel of net that fish will encounter and be retained in. Modern nets are typically constructed from synthetic fibres, such as monofilament nylon for gill-nets and multiple twisted or braided polymer filaments for seine and trawl nets.

The top edge of the net is attached to a rope called the headline, float-line or cork-line. Floats are attached to the headline to provide buoyancy.

The bottom edge of the net is attached by hanging twine to a rope called the footrope or lead-line. Weights or sinkers made of lead or other materials are attached to the footrope and spread the net vertically in the water. The type and number of floats and weights used depends on whether the net is to be positively or negatively buoyant (Figure 2).

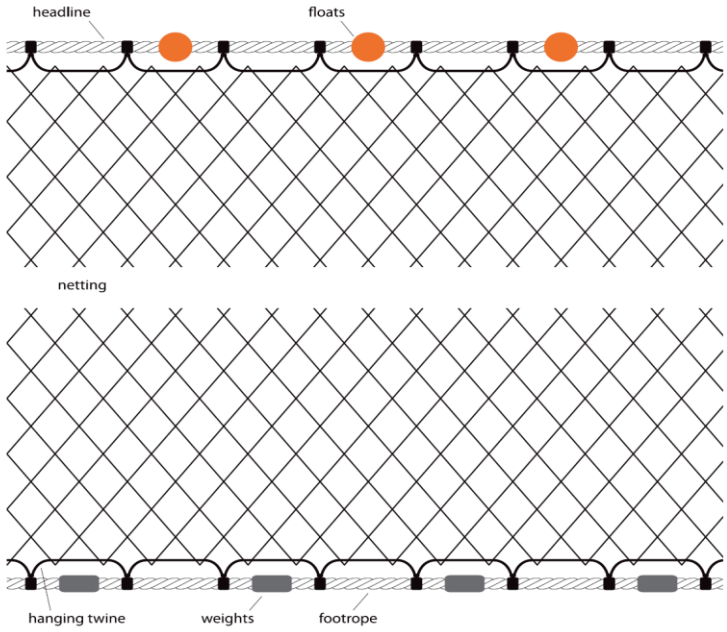

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Figure 2. A diagrammatic representation of a common net, showing the headline and footrope

Gill-nets

Gill-nets consist of a panel (or panels) of net held vertically in the water column, either in contact with the seabed or suspended from the sea surface. The size of the net mesh determines the size range of the species caught, since smaller fish are able to swim through a larger mesh. In most cases, maximum net length and minimum mesh size are regulated. Gill-nets are used in offshore and inshore waters, and estuaries.

Fish are caught in gill-nets in one of three ways:

- Gilled—the fish tries to swim through one or more meshes; if it cannot pass through, it becomes caught behind its gill covers as it tries to back out of the net.
- Wedged—the fish is tightly held in the net around the body by one or more meshes.
- Tangled—the fish is caught in the net by some part of its body, such as protruding fins or spines.

Pelagic gill-nets (also known as drifting gill-nets) are used in the NT Offshore Net and Line Fishery to target tropical sharks and mackerels. Pelagic gill-nets are made up of individual net panels tied together, allowing easy removal or replacement of damaged sections. They are set in open water and can be set with the headline on the sea surface (*positively buoyant*) or suspended below the surface (*negatively buoyant*), with one end of the net remaining attached to the vessel.

Figure 3. An estuary-set gill-net targeting Barramundi (photo courtesy of Northern Territory Seafood Council – http://www.ntsc.com.au/Barramundi)

Coastal, estuary and river-set gill-nets are set in estuaries and the coastal inter-tidal zone. They are used in the NT Barramundi Fishery to target Barramundi and King Threadfin. Estuary-set gill-nets are deployed from small dinghies and are typically orientated perpendicular to the direction of the tidal flow (Figure 3). The headline may be staked or anchored at one or both ends.

Seine nets

Seine nets usually have two long wings and a section that concentrates and retains the catch. Lengths of rope are added to the end of each of the wings. These ropes are negatively buoyant and extend the working area of the net while adding minimum drag to the hauling operation. The nets work on the principle that fish are reluctant to swim over a moving object in the water and instead try to swim in front of it. The fish are thus herded by the ropes and wing ends into the net.

Beach-seine nets are used by the NT Coastal Net Fishery to target Mullet and Blue Threadfin. The net may have a loose section of netting acting as a bunt area for retaining fish, or may have a bag at one end of the net or in the centre (Figure 4). Beach-seine nets can be set around a known school

of fish, or in an area where fish regularly congregate. The net is set from a dinghy or can be walked out in shallow water, with the first length of rope being set perpendicular to the shore, the net set parallel to the shore and the second rope set back to the shore. The ropes are then hauled onto the beach evenly by hand or vehicle, herding the fish into the net. Hauling continues until the net and fish are dragged onto the shore, or the fish are concentrated in the bag.

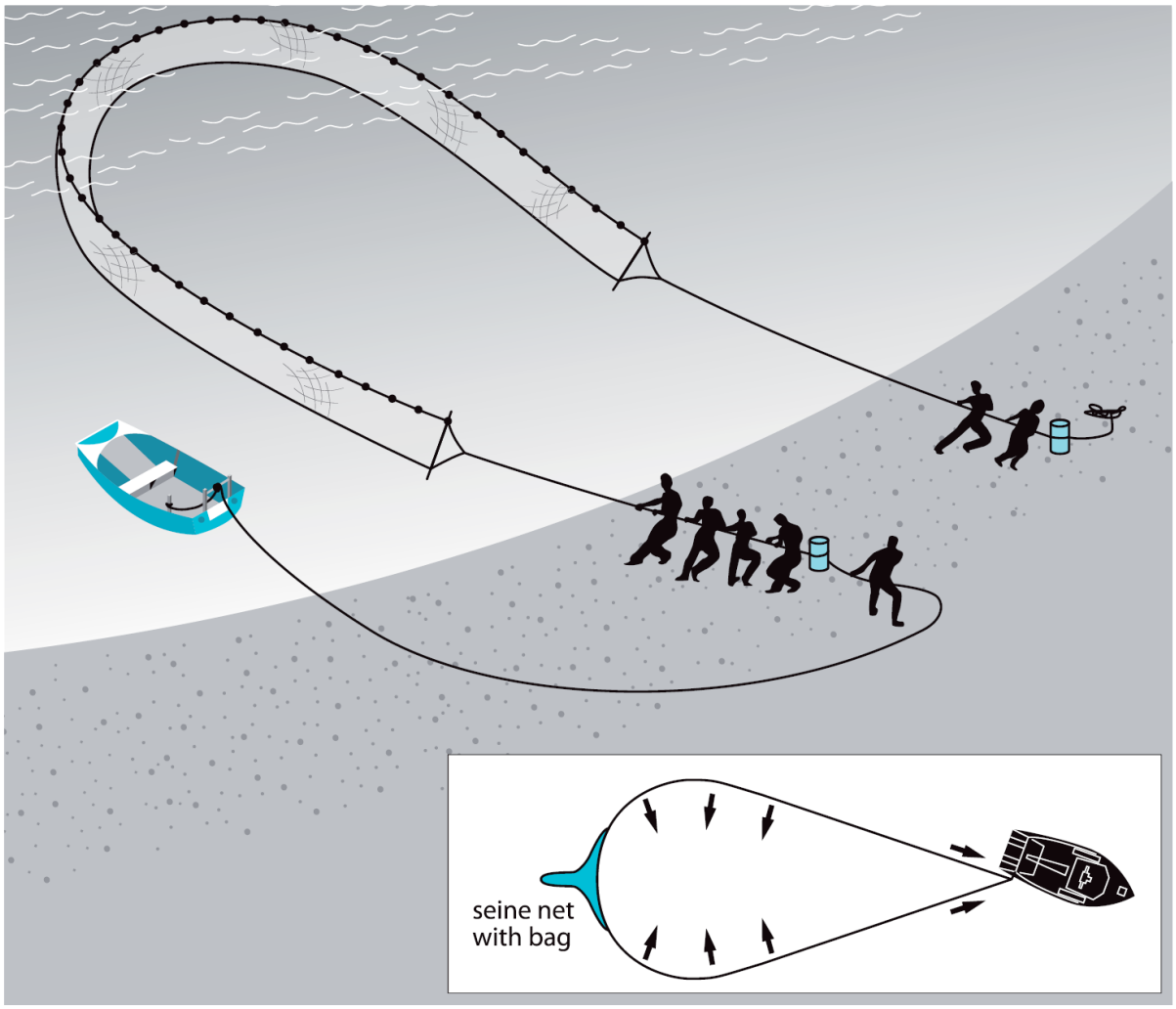

Figure 4. A diagrammatic representation of a beach-seine net

Cast nets

A *cast net*, also called a *throw net*, is a circular net with small weights distributed around its edge. The net is cast or thrown by hand in such a manner that it spreads out on the water and sinks. Fish are caught as the net is hauled back in. Cast nets are popular for catching small bait fish species by recreational anglers. They are also used by commercial fishers in the Coastal Net Fishery to catch bait for such species as Black Jewfish.

Trawl

Trawling is performed in many ways in depths of water ranging from just a few metres to 1000 m. The design of *trawl nets* is more complex than the basic nets discussed above. Trawls are made up of components that perform specialised functions, as described below:

- *Warps* are wire ropes connecting the trawl boards to the vessel. They are stored on winch drums for easy operation.

- *Trawl boards* (also known as otter boards or trawl doors) keep the net open horizontally by acting as hydrodynamic kites. They also provide weight, which is required to keep the trawl at the desired depth of operation.
- *Back stops* are short lengths of wire or chain that connect the trawl boards to the sweeps. Sweeps are used on demersal otter trawls to connect the back stop to the bridle on each side of the net. Bridles connect the sweep on each side of the net to the headline and footrope on the wing ends of the net.
- *Ground gear* is a wire or chain that is attached to the footrope by short chain droppers. The ground gear has several rubber or steel bobbins and *spacers* threaded along its length. The purpose of the ground gear is to reduce damage from snagging by lifting the footrope and net clear of the seabed.
- *Body panels* are the panels of net that make up the body of the trawl; they comprise upper and lower sections.
- The *codend* or bag is the last section of the net, where fish are collected and held during trawling operations. This area has the smallest mesh size, which determines the size of fish that the trawl will retain. The end of the codend is tied with a quick-release knot so that the fish can be easily emptied from the net.
- The *lazy line* is sometimes used to pull the codend on board so that it can be emptied.

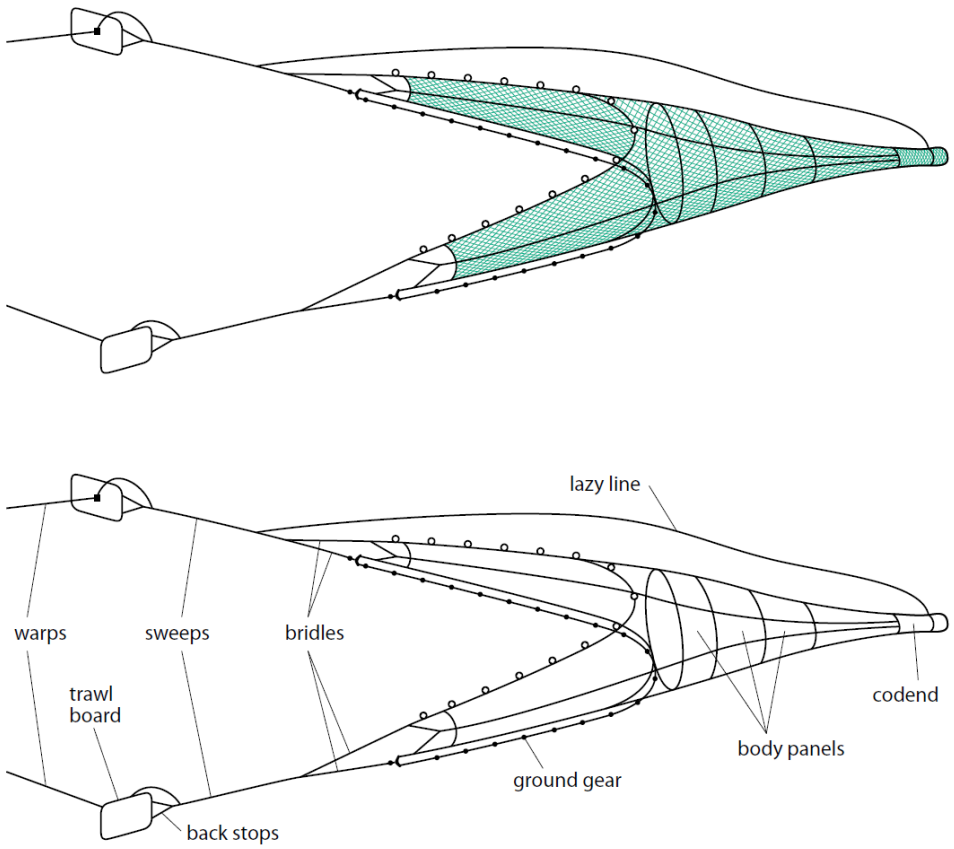

Figure 5. A diagrammatic representation of a typical demersal otter trawl net showing its main components such as warps, trawl boards, back stops, sweeps, bridles, ground gear, lazy line and codend

Demersal otter trawling (also known as *stern trawling*, *bottom trawling*, *otter trawling* or trawling) is employed by the NT Demersal Fishery to target tropical snappers, such as Saddletail and Crimson snappers. This type of trawling is also being trialled in the Timor Reef Fishery. The trawl gear fishes close to the bottom, with the trawl boards, wing-end weights and chain droppers coming in contact

with the seabed. The net is held open horizontally by the trawl boards being dragged along the seabed, spreading the sweeps, bridles and net wings. These herd the fish towards the net, where they are retained in the codend (Figure 6).

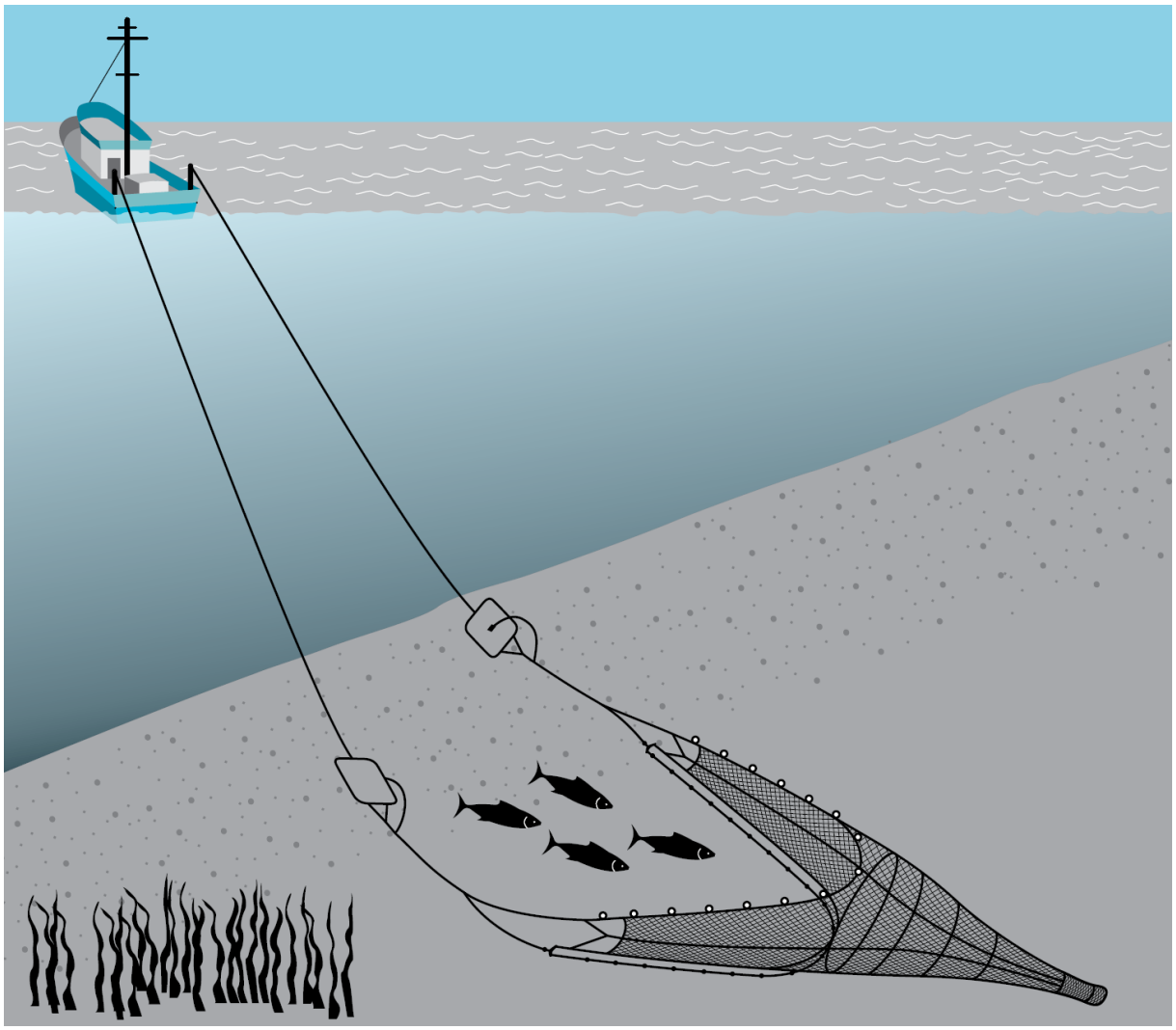

Figure 6. A diagrammatic representation of a typical demersal otter trawl gear

Hook and line

Hand lines, *hand reels* and *powered reels* (also known as rod-and-line fishing or deep-water line fishing) are used in the NT Coastal Line Fishery to catch species such as Black Jewfish and Golden Snapper. Hand lines are the simplest form of fishing; they consist of one or more baited hooks attached to a line, which is retrieved by hand. They are the most common traditional fishing method used by Indigenous fishers. Hand reels can also be used to deploy and retrieve the line. These reels can be mounted on the side of a vessel or attached to a rod (rod and line) and are usually fitted with a drag system (a 'brake' system, which is designed to create resistance in the reel as the fish takes out line). Rod and line is the predominant method used by recreational fishers in the NT. To reduce the time and effort involved in setting and hauling the line, electric or hydraulic motors are fitted to some larger reels (powered reels), particularly in deeper waters or when targeting larger fish, such as Cods.

Anchored long-lines

Anchored long-lines can be set vertically in the water column (drop-line), horizontally along the seabed (bottom-set long-line) or horizontally above the seabed (trot-line).

Drop-lines have historically been used to target tropical snappers in the NT Demersal and Timor Reef fisheries. However, they have been replaced by more efficient gear types in recent years (fish trap and trawl). *Drop-lines* consist of a main line of rope, wire or nylon that is anchored vertically in the water column with a weight on the bottom and floats attached at the surface. Short lengths of twine or nylon called snoods or traces have a clip attached to one end and a hook to the other. When being set for fishing, the desired number of pre-baited snoods (usually between 10 and 100) is clipped at regular intervals along the lower section of the mainline as it is fed out (Figure 7). Alternatively, the snoods may be permanently attached to the mainline and are baited and lined up in order along individual shooting rails while the vessel is heading for the fishing grounds. When the weight is dropped overboard, they are pulled off the rails in turn as the line is set.

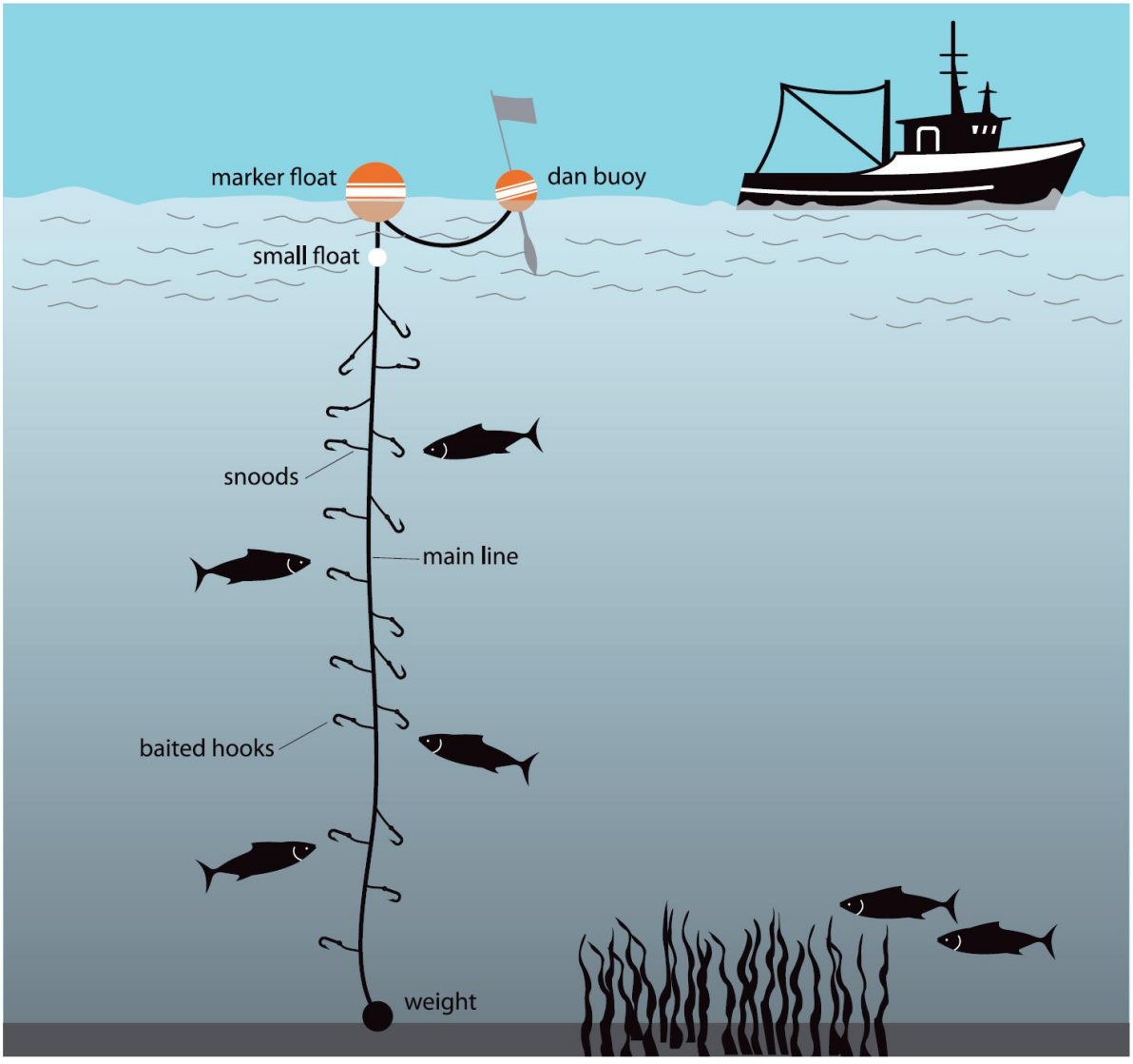

Figure 7. A diagrammatic representation of a typical drop-line

Demersal long-lines (also known as bottom-set long-lines) are used in the NT Offshore Net and Line Fishery to target Blacktip Sharks; they are also permitted in the NT Demersal and Timor Reef fisheries but are rarely used. One end of the haul-in line has a weight attached to anchor the end of the main line and the other has a dan buoy (a small buoy, with a flag, used to temporarily mark a position at sea) and float. The line is left to fish for up to 6 hours (Figure 8). Setting and hauling of long-lines can be mechanised by hydraulic line setters and haulers, with snoods stored in magazines and a baiting machine that attaches bait to the hooks as the line feeds over the vessel's stern.

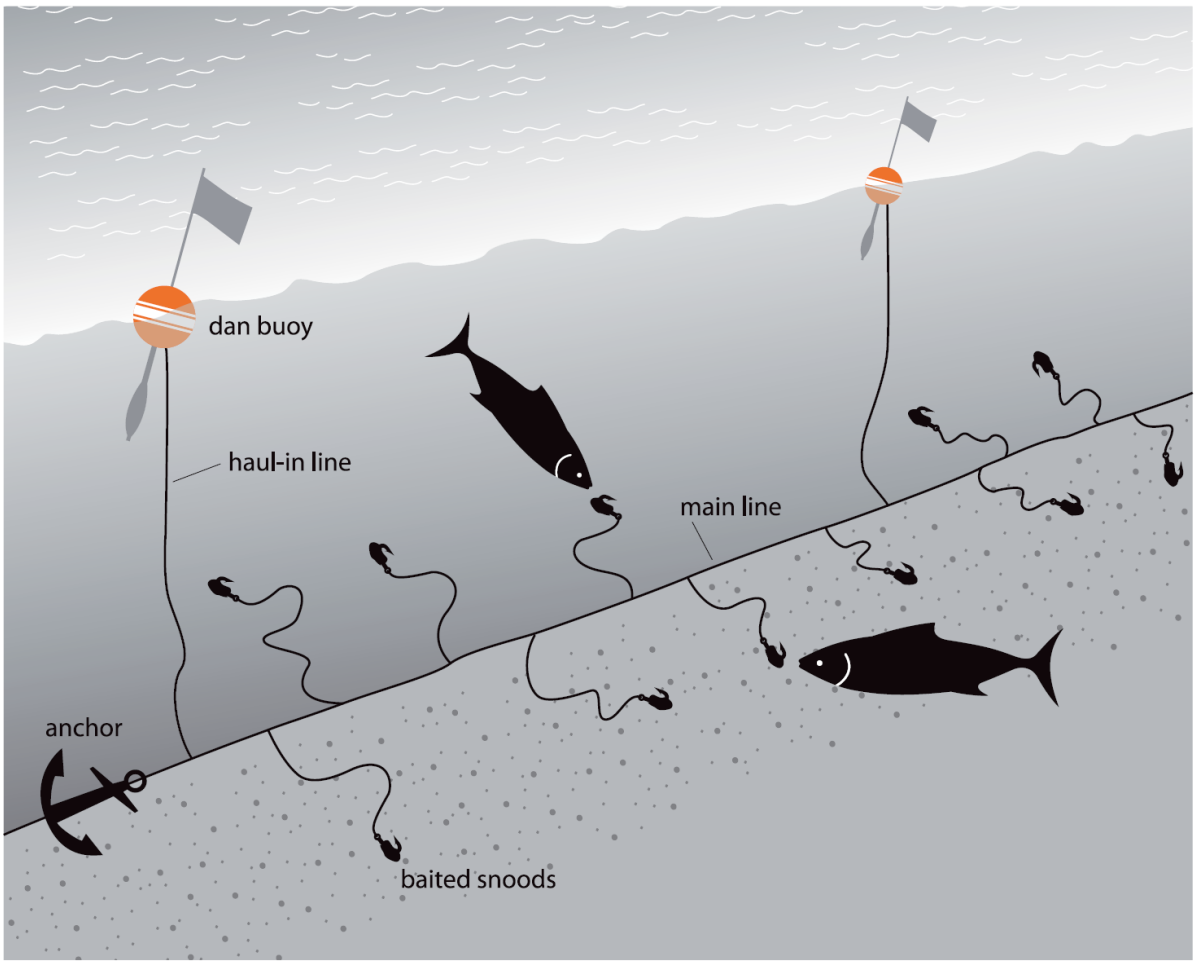

Figure 8. A diagrammatic representation of a typical demersal long-line

Trolling

Trolling is a simple method of fishing used by the NT Spanish Mackerel Fishery, in which lines with baits or lures are dragged behind a dory or mothership as it moves along at a speed of 2 to 10 knots (Figure 9). It is common for fishers to troll two to four lines behind a dory and up to eight lines from a mothership. A variety of lines, rig designs and lures or baits are used for *trolling*.

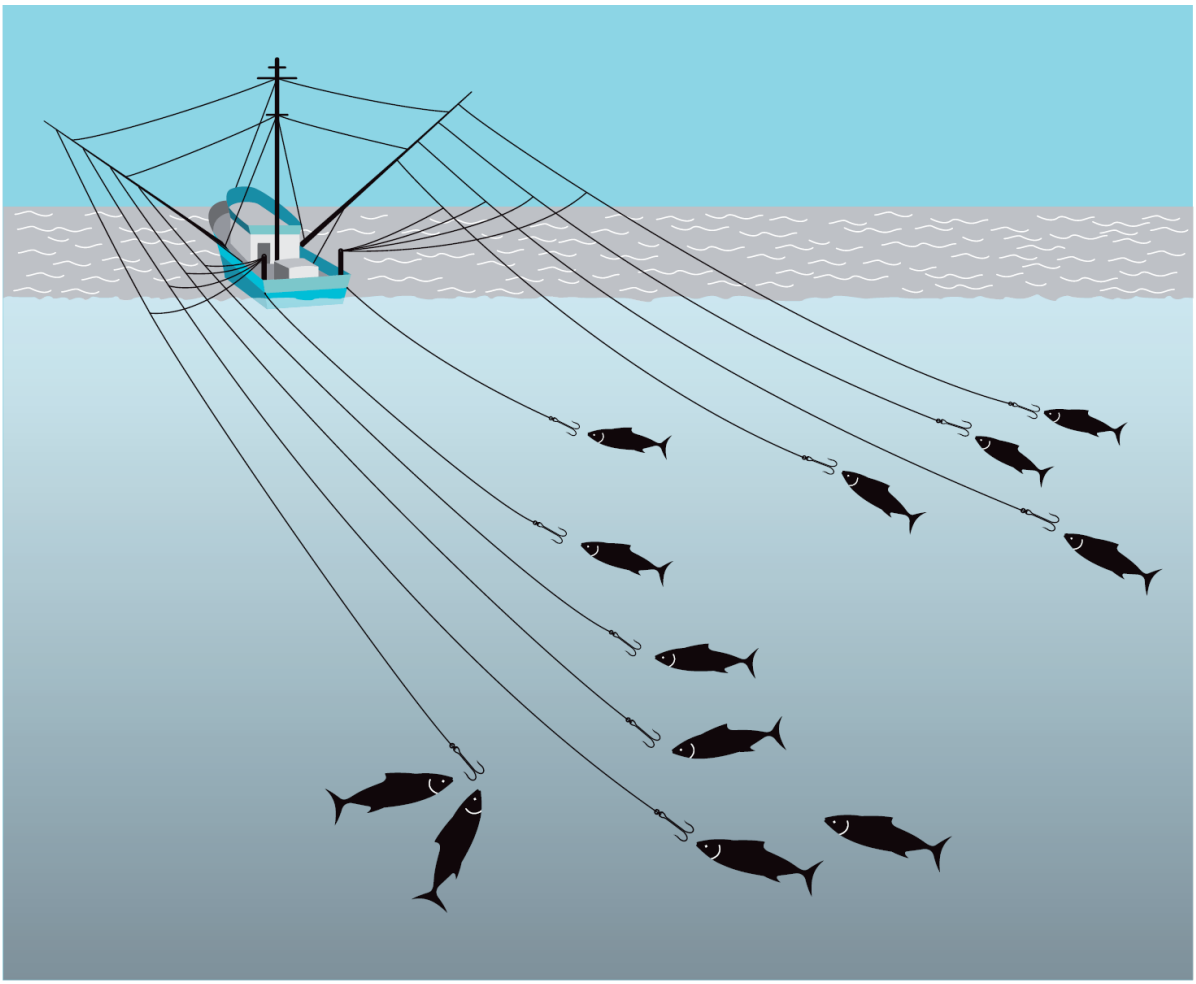

Figure 9. A diagrammatic representation of trolling for pelagic fish

Traps and pots

Traps and pots are enclosures or devices that entangle or entrap fish, crustaceans or molluscs. Animals are attracted to the enclosure either by bait or because it appears to provide refuge.

Most *traps and pots* are set on the seabed or riverbed with a haul-in line, surface float or dan buoy to mark their position. They can have one or more entrances on the top or sides, depending on the target species. A line hauler may be used to retrieve the gear for checking and re-baiting.

Fish traps

Fish traps can be set in water depths ranging from 2 m to hundreds of metres. They are made in a variety of shapes and sizes, depending on the target species. Most baited traps are set on the seabed, with at least one entrance facing down-current. The traps are left to fish for around 20 minutes to 24 hours.

Rectangular traps made of metal with tapered entrances on their side (towards the base) are used in the NT Timor Reef, Demersal and Coastal Line fisheries to target a range of reef-associated fish. The weight of these traps (approx. 100 kg) ensures that they fish on the seabed and are not moved by strong currents.

Crab pots

There are many different shapes and sizes of *crab pots* but most are less than 0.5 m^3 in volume and 80 cm in any dimension. They are baited and left to fish for around 6 to 24 hours.

Mud Crab pots can be constructed in several ways, but only rigid rectangular pots are used by commercial operators in the NT Mud Crab Fishery. These particular pots have one pair of opposing horizontally-tapered side-entry funnels (see Figure 10). Some operators fit escape gaps to their pots to reduce the retention of undersize Mud Crabs. Most recreational mud crab fishers use collapsible polyethylene mesh pots with mesh sizes ranging from 25 mm x 25 mm to 50 mm x 50 mm.

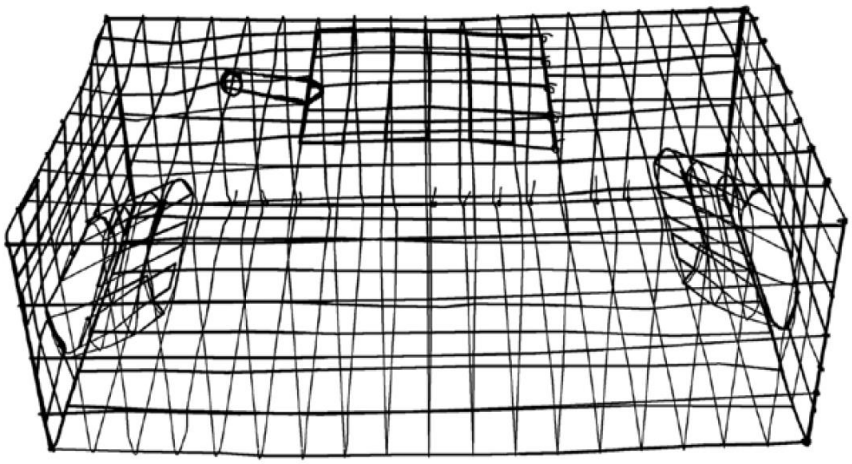

Figure 10. A diagrammatic representation of a Mud Crab pot—rigid rectangular (Butcher et al. 2012)

Diving

Diving is used as a means to collect product by the NT Trepang and Aquarium fisheries. Divers in both fisheries rely on surface-supplied air (via an air-line from a compressor on board a support vessel), a method known as *hookah diving*. Items are collected by hand and stored in netted catch bags until the diver returns to the support vessel.

Hand-held implements

Hand-held implements, such as picks, spears, gaffs and landing nets, are used as primary or ancillary fishing gears in the NT. Small steel picks are used to dislodge coral fragments by Aquarium Fishery licensees, while spears are often used by Aboriginal fishers to harvest many fish species. Gaffs and landing nets are commonly used to land large fishes caught on hook and line gear.

Bycatch reduction devices

A number of bycatch reduction devices have been developed for Australian fisheries to allow various organisms and objects to exit fishing gear without being brought on board. For instance, licensees in the NT Demersal Fishery with access to trawl gear fit turtle excluder devices and square-mesh panels to their trawl nets

Turtle excluder devices consist of a metal grid across the mouth of the codend, which forces large objects and large species out of the net while allowing smaller target species to be captured, thereby reducing turtle drowning and the retention of other large species such as sharks, rays and benthic debris. This reduces their environmental footprint.

Square-mesh panels retain their shape under tension and provide a means of escape for smaller fish and non-target species prior to entering in the codend. In some cases, the entire codend is constructed from square-mesh netting, hung to maintain open meshes when the codend fills with catch. Less bycatch improves efficiency as it reduces sorting time and the catch is in a better condition.

Approximately one quarter of licensees in the NT Mud Crab Fishery fit escape vents to their crab pots. These devices consist of a hard plastic panel with a precision-cut opening, constructed to allow under-size crabs and small bycatch species to escape while retaining legal-size crabs.

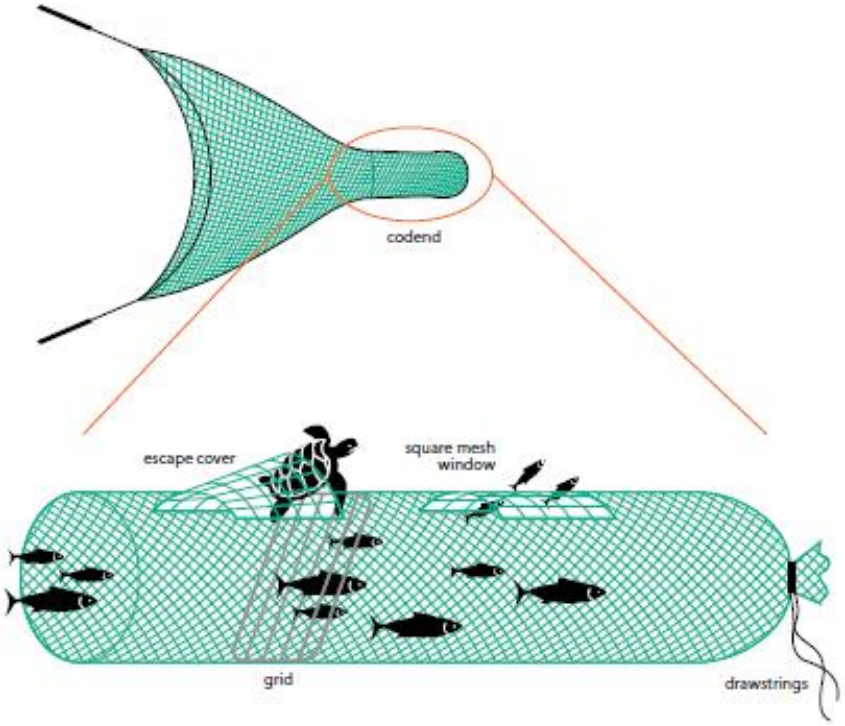

Figure 11. A diagrammatic representation of a typical design of a turtle excluder device in a trawl net

Figure 12. A turtle excluder device on a trawl net used in the Demersal Fishery

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FRDC

Line drawing: Allison Mortlock, AngelInk 2012.

Overview of Northern Territory managed fisheries

Fisheries that operate in NT waters predominantly harvest marine and estuarine species from tidal waters. For the commercial sector, the outer boundaries of these fisheries vary, extending to 3, 15 or 200 nm from the coast. Those operating in coastal waters, i.e. the water belt between the shores of the NT and a line 3 nm seaward are typically referred to as "inshore" fisheries and include the Coastal Net, Barramundi and Mud Crab fisheries. The jurisdiction over the water column and the subjacent seabed of coastal waters is vested in the NT *Fishery Act*. Nearly all of the effort of recreational and Indigenous sectors is concentrated in coastal waters. Those fisheries operating outside coastal waters of the NT (i.e. from 3 nm out to 15 nm or 200 nm of Australia's Economic Exclusion Zone) are referred to as "offshore" fisheries and fall under Commonwealth jurisdictions. These fisheries are managed under the Commonwealth *Fisheries Management Act 1991*, some of which are defined by an Offshore Constitutional Settlement (OCS). The OCS provides for the establishment of a Joint Authority that allows such fisheries as the Demersal and Timor Reef fisheries to be regulated by the Act. The commercial sector is responsible for almost all of the effort outside coastal waters. Most fisheries span the entire coastline, although some (like the Coastal Net and Timor Reef fisheries) are restricted to discrete regions. Commercial and recreational fishers operating within estuaries must avoid Aboriginal sacred sites and observe any other area restrictions. Additionally, Section 53 of the NT *Fisheries Act 2016* recognises the customary fishing rights of local Aboriginal people, thereby exempting traditional harvest by Aboriginal people from most management controls.

In general, fisheries are managed to ensure the ongoing sustainability of harvest from the fish stocks in that fishery. The management of fisheries also aims to optimise resource allocation (balancing social and economic considerations) and to minimise adverse impacts of fishing on the environment. Australian fisheries are managed in line with the United Nations Convention on the Law of the Sea (UNCLOS), which is reflected in the legislation and policies of the Commonwealth, States and Territories. The FAO *Code of Conduct for Responsible Fisheries* provides guidelines for the implementation of UNCLOS, with the high-level requirement that:

> States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization. States should take measures to rehabilitate populations as far as possible and when appropriate

All fisheries operate in accordance with a number of local, national and international acts, plans and conventions. These include the *Territory Parks and Wildlife Conservation Act 2014*, the *Environment Protection and Biodiversity Act 1999*, the National Plan of Action for the Conservation and Management of Sharks 2012 and the Convention on the International Trade in Endangered Species.

To achieve ecologically sustainable development, fisheries managers typically set limits on the amount of fishing effort (including when, where and with what gear catches can be taken—referred to as input controls) or the quantity of catch that can be taken from a stock (referred to as output controls). These decisions are usually based on the best available science at the time of the decision, but may also take into account other factors, such as economics and social acceptance. Fisheries management is generally an adaptive process because fish stocks can be influenced not only by the fishery's harvest but also by environmental effects and natural variation. Fisheries also change in response to changes in market demand, fuel prices and other factors.

Management arrangements for NT fisheries are primarily developed through advisory groups (or committees) related to specific fisheries or user groups. In most cases, these bodies consist of local representatives. However, the Timor Reef, Demersal and Offshore Net and Line fisheries are jointly managed by the NT and Commonwealth Governments through the NT Fisheries Joint Authority.

Catch and effort data for all commercial fisheries, fishing tour operators (FTOs) and Aboriginal Coastal licensees is collected through compulsory monthly logbooks. The data in these logbooks

must be submitted 28 days after the end of the month in which fishing occurred. Fishery-independent data for the commercial and FTO sectors is also collected on occasion by fishery observers. This includes an assessment of their environmental performance.

The catch and effort data for the recreational and Indigenous subsistence sectors is poorly understood. Some data is collected on the former from periodic surveys. The last recreational survey was undertaken in the greater Darwin region in 2016.

Prior to entering a fishery, or if more than five years have passed since their last interview, commercial licensees must attend an interview with a fishery manager. The purpose of these interviews is to familiarise the licensee with current legislation, the status of the fishery, fisheries research programs, reporting requirements and any industry codes of conduct or environmental management systems. Regular contact with licensees also allows the fishery manager to keep abreast of any emerging issues in the fishery.

The following sub-sections provide a background on each of the primary fisheries in the NT. This includes a description of the area of the fishery, the target species, the allowable gear and the restrictions on catch and/or effort. Catch, byproduct and bycatch statistics are also presented, as are the details of any recent compliance issues.

While most of this information refers to the commercial sector, where other sectors target the same species, the relative importance of these species to each user group (in terms of the catch/harvest fraction and/or the proportion of fishing effort) is provided. Relative (rather than absolute) estimates are given in these instances due to differences in the currency of catch estimates for the different sectors and the inherent variability in annual catches seen in the tropics. Catch statistics for FTOs are also expressed in relative terms because the FTO catch is reported by number rather than weight.

A1 Coastal Line Fishery

The NT Coastal Line Fishery extends seaward from the high water mark to 15 nm from the low water mark and primarily targets Black Jewfish (*Protonibea diacanthus*) and reef species using hook and line gear. The fishery spans the entire NT coastline and is managed as two fishing zones. The Western Zone extends from the Western Australia border to Vashon Head on Cobourg Peninsula at the point of latitude 11° 07.516' South, longitude 131°59.650' East. The Eastern Zone extends from the same point on Vashon Head to the Queensland border. Most fishing activity is concentrated around rocky reefs in the Western Zone, within 150 km of Darwin. To a lesser extent, fishing activity is also relatively high around other popular coastal locations, such as Nhulunbuy and Borroloola (King Ash Bay).

Licensees are permitted to use several gear types. Rod and line, hand lines, cast nets (for bait only), scoop nets or gaffs can be used throughout the fishery. Drop-lines and a maximum of five fish traps may also be used beyond 2 nm from the coast. However, fish traps can only be used in the Eastern Zone of the fishery. A maximum of five hooks may be fitted to hand lines and rod and line gear. Drop-lines may be rigged with a minimum of six and a maximum of 40 hooks. Drop-lines comprise less than 0.8% of the total catch by licensees in 2017.

Coastal Line Fishery licensees harvested 172 tonnes (t) of fish in 2017, with Black Jewfish and Golden Snapper forming most of the harvest (98% and 0.45%, respectively). Blue salmon and cods were the main byproduct species taken in any significant quantity (0.38% and 0.32% respectively). No bycatch was reported in this fishery in 2017. The total value of the catch by this fishery is estimated at $2.1 million.

Recreational anglers and FTO clients predominantly use rod and line gear to target the same reef-associated species as licensees, often at the same location. The harvest by these groups is constrained through the use of personal possession limits.

Snappers of the genus *Lutjanus* account for almost one in four of all fishes caught by recreational fishers in the NT. The retention rate of different species encountered during recreational reef fishing varies markedly, from around 75% for snappers, emperors (Family Lethrinidae) and Black Jewfish to less than 5% for catfish (Family Ariidae) and sharks (primarily Family Carcharhinidae) (West et al. 2012). Reef fishing constitutes around 40 of all fishing effort (in hours) expended by FTO clients. The catch composition and retention rate of reef fishes by FTO clients is similar to that of recreational fishers.

Forty five percent of all fishing events by Indigenous fishers in the NT involve line fishing, with most of this effort (93%) concentrated onshore. Less than 2% of the fishes caught by Indigenous fishers are released, as fishing is undertaken as a subsistence activity.

Coastal Line Fishery licensees, recreational fishers and FTO clients are all capable of exerting substantial impacts on reef-associated species and recent sustainability concerns have led to the development of new management controls on the harvest of these species. This includes the establishment of five protection areas in the Western Zone where no fishing is allowed, including Charles Point and Lorna Shoal.

The primary fishing gear used in the Coastal Line Fishery (hook and line) poses little risk of interaction with threatened, endangered and protected species (TEPS) (such as turtles, dugongs and sawfish) and there were no reported interactions between the Coastal Line Fishery and TEPS in 2017. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

There have been few reported problems with compliance in the Coastal Line Fishery and there is no evidence of systematic non-compliance. The primary area of concern is the potential for the black market sale of Black Jewfish swim bladders by unlicensed fishers.

A2 Coastal Net Fishery

The NT Coastal Net Fishery extends seaward from the high water mark to 3 nm from the low water mark and harvests a range of species, including mullets (Family Mugilidae), Blue Threadfin (*Eleutheronema tetradactylum*), sharks and queenfish (*Scomberoides* spp.).

The fishery is regionalised and the five licensees can only fish in one of three discrete zones: Darwin (from Cape Hotham to Native Point and Cape Ford to Cape Dooley); Gove (between Cape Arnhem and Cape Wilberforce); or Borroloola (between Bing Bong Creek and Pelican Spit).

Licensees are permitted to use a gill-net of no more than 300 m in length with a maximum drop of 5 m and a mesh size not exceeding 65 mm. Nets may be anchored at one end only. Licence holders are also permitted to use a cast net with a diameter of not more than 6 m and mesh size not exceeding 25 mm. Based on historical use, one operator is permitted to use a gill-net with a mesh size up to 100 mm. Nets must be cleared in water not less than 30 cm deep to facilitate the release of any bycatch or prohibited species.

Coastal Net Fishery licensees harvested 6.8 t of fishes in 2017, 30.5% of which were mullet, 20.6% were Black-tip Shark and 18.4% were Blue Salmon. Byproduct species included whiting (Family Sillaginidae), queenfish, garfish (Family Hemiramphidae), Milk Shark and Golden Snapper. The total value of the catch by this fishery is estimated at $19 055.

Recreational fishers can use drag nets and cast nets to target fish and prawns for bait or human consumption. Drag nets must not exceed 16 m in length, a 2-m drop, or have a mesh size of more than 28 mm. The dimensional limits for recreational cast nets are the same as those for licensees. The use of nets by recreational fishers and FTO clients account for less than 1% of the fishing effort (in hours) by these groups. Around 10% of all fishing events by Indigenous fishers in the NT involve the use of some form of net (West et al. 2012).

The small number of licensees in the Coastal Net Fishery (five) in conjunction with the restricted area of the fishery limits the risk of interactions with TEPS. There were seven reported interactions between the Coastal Net Fishery and TEPS in 2017; six Green Sawfish and 1 Narrow Sawfish, all released alive. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

There have been few reported problems with compliance in the Coastal Net Fishery and there is no evidence of systematic non-compliance. The primary areas of concern are the illegal use of nets and the potential for the black market sale of fish by unlicensed operators.

A4 Spanish Mackerel Fishery

The NT Spanish Mackerel Fishery extends seaward from the high water mark to the outer limit of the Australian Fishing Zone (AFZ) and targets Spanish Mackerel (*Scomberomorus commerson*) using trolled lures or baited lines. The primary fishing grounds include waters around Bathurst Island, New Year Island, the Wessel Islands, Groote Eylandt and the Sir Edward Pellew Group of islands.

Licensees typically fish from a mother ship and dories, with a maximum of two dories permitted per licence. They may use any number or combination of troll lines, floating hand lines or rods. Operators generally troll two to four lines behind a dory and up to eight lines from a mother boat.

Spanish Mackerel Fishery licensees harvested 390.6 t of fish in 2017, with all but 0.7 t of this being Spanish Mackerel. Almost all (>99%) of the byproduct of the fishery was Grey Mackerel. Small numbers (<50) of trevallies and sharks were also reported as bycatch in 2017. The total value of the catch by this fishery is estimated at $3.0 million.

Recreational fishers and FTO clients target Spanish Mackerel in waters close to population centres, such as Darwin, Nhulunbuy and Borroloola, using baited hooks and lures (West et al. 2012). Only 1% of all fish caught by recreational fishers in the NT are Spanish Mackerel and 50% of these are released. Incidental catches during targeted recreational fishing for Spanish Mackerel include other mackerels (*Scomberomorus* spp.), trevallies and queenfish, many of which are released alive (West et al. 2012).

The Spanish Mackerel Fishery is managed through a catch-sharing arrangement between all user groups. This agreement aims to maintain the cumulative harvest of Spanish Mackerel within a precautionary allowable catch of 450 t per annum. The proportion of the allowable catch allocated to each user group was based on historical logbook data and catch estimates from the National Recreational and Indigenous Fishing Survey (West et al. 2013) as follows: 76% (342 t) to Spanish Mackerel Fishery licensees, 3% (13.5 t) to Offshore Net and Line Fishery licensees, 1% (4.5 t) to Demersal Fishery licensees, 3% (13.5 t) to FTO licensees, 16% (72 t) to recreational fishers and 1% (4.5 t) to Indigenous fishers. Both Spanish Mackerel and Offshore Net and Line Fishery licensees breached the catch allocations for their fisheries in 2017, with catches of 389.9 t and 21.3 t, respectively.

The primary fishing gear used by the Spanish Mackerel Fishery (trolled lures and baited lines) poses little risk of interaction with TEPS and there were no reported interactions between the Spanish Mackerel Fishery and TEPS in 2017. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

There have been few reported problems with compliance in the Spanish Mackerel Fishery and there is no evidence of systematic non-compliance.

A5 Offshore Net and Line Fishery

The NT Offshore Net and Line Fishery extends seaward from the high water mark to the outer limit of the AFZ and targets Australian Blacktip Sharks (*Carcharhinus tilstoni*), Common Blacktip Sharks (*C. limbatus*), Spottail Sharks (*C. sorrah*) and Grey Mackerel (*Scomberomorus semifasciatus*) using pelagic gill-net and long-line gear.

Demersal long-lines can be used throughout the fishery whereas pelagic gill-nets and pelagic long-lines can only be used beyond 2 nm and 3 nm of the coast, respectively. Pelagic gill-nets are the primary gear used by this fishery and are generally set within 15 nm of the coast. Long-lines have not been used in the fishery since 2013, primarily as a result of the drop in the price of shark fins.

Licensees can use nets up to 2000 m in length, but most choose to use nets in the order of 1000 m to 1500 m. The drop of the net must not exceed 100 meshes and the size of each mesh panel typically ranges from 160 mm to 185 mm when stretched. Pelagic gill-nets are weighted and have a buoyed headline. Pelagic long-lines must not exceed 15 nm in length and cannot have more than 1000 snoods (hooks) attached. Automated baiting gear is prohibited.

Two of the target species in this fishery, the Australian Blacktip Shark and the Common Blacktip Shark, are very difficult to separate by eye and have traditionally been reported as “Blacktip Shark”. Although the shark identification skills of many licensees are improving, some grouping still occurs in logbook returns. The grouping convention is also used here so as not to misrepresent the harvest of either species.

Offshore Net and Line Fishery licensees harvested 640.8 t of fishes in 2017. Grey Mackerel formed the bulk of the harvest (73.2%) followed by the Blacktip Shark group (11.8%) and Spanish Mackerel (3.1%). Other significant byproduct species included hammerhead sharks (3%), tuna (2.1%) and queenfish (2%). Bycatch (by weight) was less than 1% of the harvest in 2017. Non-retained species included the Tawny Shark (*Nebrius ferrugineus*), rays (Family Dasyatidae), trevallies and queenfish. The proportion and composition of bycatch in this fishery is routinely validated by on-board observers. The total value of the catch by this fishery is estimated at $4.33 million.

Grey Mackerel form a minor component (less than 1%) of the overall catch by other fishing parties in the NT. Sharks are taken in significant quantities by Indigenous fishers, the vast majority of whom (93%) fish from shore. By contrast, sharks are rarely targeted (or retained) by recreational fishers or FTO clients. This being the case, there is very little overlap in the harvest activities of the Offshore Net and Line Fishery and other marine user groups.

The Offshore Net and Line Fishery operates beyond the geographical range of many TEPS and so the risk of interaction with this group of species is low. In 2017, licensees reported interactions with 100 sawfish of various species (99 released alive, 1 dead), 43 various turtles (all released alive), 12 Giant Manta Rays (11 released alive) and 1 dolphin (dead).

There have been few reported problems with compliance in the Offshore Net and Line Fishery and there is no evidence of systematic non-compliance.

A6 Demersal Fishery

The NT Demersal Fishery extends from 15 nm from the low water mark to the outer limit of the AFZ (excluding the area of the Timor Reef Fishery) and targets a range of tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.) using a variety of gear. Fish traps, hand lines and drop-lines are permitted throughout the fishery and demersal trawl nets are permitted in two defined zones.

The harvest by the Demersal Fishery is limited through a set of TACs applied to goldband snappers (*Pristipomoides* spp.) (400 t), red snappers (*L. malabaricus* and *L. erythropterus*) (2500 t) and a “grouped fish” category (915 t). The latter group includes all fish other than Barramundi (*Lates*

calcarifer), King Threadfin (*Polydactylus macrochir*), Spanish Mackerel, shark and Mud Crabs (*Scylla* spp.). Any protected species that are caught must be released.

Demersal Fishery licensees harvested 3388.8 t of fishes in 2017. Red snappers and goldband snappers formed the bulk of the harvest (70.8% and 10.1%, respectively) with Painted Sweetlip (5.7%), Redspot Emperor (2.8%) and trevally (2%) being the primary byproduct species. Reported bycatch (by weight) during 2017 was less than 1% of the drop-line and trap harvest and 27.4% of the trawl harvest in 2017. Common bycatch species included trevallies, scads (Family Carangidae) and sharks. On-board observers routinely verify the proportion and composition of bycatch in the trawl component of this fishery. The total value of the catch by this fishery is estimated at $17.9 million.

Relatively few recreational fishers, Indigenous fishers or FTOs fish outside 15 nm of the NT coast and there is little overlap in the harvest activities of the Demersal Fishery and other marine user groups. However, the numbers of recreational anglers and FTOs fishing these grounds has increased in recent times due to a combination of increases in boat size, technology and weather forecasting.

The logbook data for the Demersal Fishery reported 285 TEPS interactions during in 2017. This included 178 various sawfish species (134 released alive, 44 dead) 67 sea snakes (44 released alive, 23 dead), 46 hammerhead sharks (six alive, 40 dead) and four dolphins (one released alive and three dead). The Demersal Fishery mandates turtle excluder devices and square mesh codends to reduce the retention of non-target species which lessens the impact on TEPS. The trawl gear used by the Demersal Fishery limits the disturbance to the benthic environment and the area impacted in 2017 was <3% of the total area zoned for trawling.

There have been few reported problems with compliance in the Demersal Fishery and there is no evidence of systematic non-compliance.

A7 Barramundi Fishery

The NT Barramundi Fishery operates within 3 nm of the low water mark and targets Barramundi and King Threadfin using gill-nets. The inner boundary of the fishery is convoluted, with some rivers (or parts thereof) open to netting and others closed. Licensees are not permitted to set nets within Kakadu National Park, the Mary River Fish Management Zone, Bynoe Harbour, Darwin Harbour or Shoal Bay. Furthermore, operators may not set nets or anchor within the Dugong Protection Area in the south-western Gulf of Carpentaria (GoC).

The commercial fishing season extends from 1 February through to 30 September each year, with most of the catch taken from Anson Bay, Van Diemen Gulf, East Arnhem Land, Central Arnhem Land and Limmen Bight. Gill-nets set in the open sea must have a mesh size of at least 150 mm (6 inches), while those set in rivers must have a mesh size of at least 175 mm (7 inches). No more than 1000 m of net can be used under a licence and there are restrictions on the amount of spare net that may be stored on board vessels.

Barramundi Fishery licensees harvested 703.8 t of fishes in 2017. Barramundi and King Threadfin formed the bulk of the catch (55.8% and 42.2%, respectively), with Black Jewfish (0.9%) and sharks (0.2%) taken as byproduct. Non-retained species included catfishes, queenfishes and other sharks. The total value of the catch by this fishery is estimated at $5.1 million.

Recreational fishers target Barramundi using baited hooks and artificial lures, with the latter being more popular. Around 20% of all fishes caught by recreational fishers in the NT are Barramundi, the highest proportion of any species (West et al. 2012). Out of all the Barramundi caught by this sector, 72% are released. Blue Threadfin, King Threadfin, snappers, grunters (Family Terapontidae) and catfish are incidentally caught during targeted recreational fishing for Barramundi (West et al. 2012).

Approximately 50% of all fishing effort (in hours) expended by FTO clients in the NT is directed towards the capture of Barramundi. The release rate of Barramundi by FTO clients is similar to that of recreational fishers, as is the mix of incidental captures.

The commercial sector is excluded from many estuarine systems and consists of relatively few licensees (13). These factors, in conjunction with restrictions on the length and operation of gill-nets, limit the risk of interactions with TEPS. Commercial operators reported 423 TEPS interactions in 2017. This included 163 interactions with Saltwater Crocodiles (111 released alive, 52 dead), nine interactions with dugongs (five released alive, four dead) and the capture of seven Green Sawfish, 170 Dwarf Sawfish and 64 Narrow Sawfish and 10 sea turtles, all of which were released alive. The actions of this fishery are considered to have little impact on other ecosystem components.

There were relatively few compliance issues in the Barramundi Fishery in 2017 and there was no evidence of systematic non-compliance. Detected offences related to fishing in closed waters and inadequate marking of gear. Recreational fishing offences that year included exceeding the Barramundi possession limit, retaining undersize Barramundi, removing skin from fillets and fishing in seasonally-closed areas.

A8 Mud Crab Fishery

The NT Mud Crab Fishery is confined to the tidal waters of the Top End and targets Giant Mud Crabs (*Scylla serrata*) using baited pots. Orange Mud Crabs (*S. olivacea*) are occasionally caught to the west of Cobourg Peninsula and constitute <1% of the overall commercial harvest. Licensees are not permitted to operate in Darwin Harbour and in most creeks adjoining Shoal Bay, Leaders Creek, Kakadu National Park or parts of the Cobourg Marine Park.

There are 98 units of entitlement in the fishery, each permitting the use of up to 30 crab pots (i.e. 2940 pots in total). A licensee must hold at least two units of entitlement (60 pots) to be able to enter the fishery. Most licensees operate in the GoC, with a small number based along the Arnhem Land coast or near Darwin. Crab pots are set within estuaries or along the coastal fringe and are checked and re-baited daily.

Licensees may also use restricted bait nets (gill-nets) up to 100 m in length to catch fish for use as crab bait. These nets may only be set in the open sea within 3 nm of the coast and the fisher must attend the net at all times. The use of this gear is prohibited between Bing Bong and the Queensland border and in a number of other areas around the coast.

Mud Crab Fishery licensees harvested 287.5 t of Mud Crabs in 2017. The total value of the catch by this fishery is estimated at $8.7 million.

Recreational fishers may harvest Giant Mud Crabs using pots, dillies, spears, crab hooks, hook and line, hand net, cast net or drag net. A gear limit of five pots or dillies per person applies, with a maximum of 10 pots/dillies per vessel. The use of pots and traps accounts for around 15% of fishing effort (in hours) by recreational fishers in the NT (West et al. 2012). However, this statistic includes soak times of “cherabin pots” used to target Giant Freshwater Prawns (*Macrobrachium spinipes*) and Redclaw (*Cherax quadricarinatus*).

Most (85%) of Mud Crabs harvested by Indigenous fishers are taken by hand or with spears. These two collection methods account for around 50% of all fishing events by Indigenous fishers in the NT. Very few FTO clients target Giant Mud Crabs, with “crabbing” constituting around 1% of the reported fishing effort (in hours) by this user group.

The gear trap gear used by the Mud Crab Fishery is highly selective and interacts with few TEPS. There were no reported interactions between the Mud Crab Fishery and TEPS in 2017. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

There were few compliance issues in the Mud Crab Fishery in 2017 and there is no evidence of systematic non-compliance. Detected offences included the possession of either under-size crabs or commercially unsuitable (soft-shelled) crabs.

A12 Aquarium Fish/Display Fishery

The NT Aquarium Fish/Display Fishery operates in both tidal and non-tidal waters of the Top End, to the outer limit of the AFZ. It supplies a range of aquarium fishes, plants and invertebrates (including corals) to local and interstate pet retailers and wholesalers. Some specimens are also sold to overseas buyers.

Aquarium Fishery licensees can operate in most areas, but must have permission to access private land or sea country. Harvesting is not permitted in designated protected areas, such as Doctor's Gully and East Point Aquatic Life Reserves in Darwin Harbour, Aboriginal sacred sites, aquaculture farm leases and sanctuary zones.

Aquarium Fishery/Display Fishery licensees can use several types of nets, hand pumps, freshwater pots and hand-held instruments to collect specimens. The harvest consists of a wide range of fishes and invertebrates, as well as coral rubble and substrates covered in encrusting organisms (known as "live rock").

The fishery currently has Wildlife Trade Operation accreditation under the EPBC Act, allowing licensees to harvest and export Appendix II CITES-listed hard coral species. A Non Detrimental Finding was undertaken for CITES-listed species harvested in the fishery. This resulted in catch limits for some species. For example, the annual harvest of corals in the NT is limited to between 10 kg and 200 kg (depending on species), while that of Giant Clams (*Tridacna* spp.) is restricted to 200 individuals.

Aquarium/Display Fishery licensees harvested 2.0 t of product in 2017, valued at about $0.19 million.

Members of the public wishing to collect specimens for personal aquaria must comply with recreational fishing controls, such as minimum legal size and personal possession limits.

The small number of Aquarium Fish/Display Fishery licensees (12) in conjunction with the selective fishing methods used, minimises the risk of interactions with TEPS. No interactions between the Aquarium Fish/Display Fishery and TEPS were reported in 2016. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

There have been few reported problems with compliance in the Aquarium Fish/Display Fishery and there is no evidence of systematic non-compliance.

A13 Trepang Fishery

The NT Trepang Fishery extends seaward from the high water mark to 3 nm from the coast and targets Sandfish (*Holothuria scabra* - a type of sea cucumber), by means of hookah diving. The fishery is managed through individual TAC limits across 32, 60 X 60 nm grids. Most fishing activity is concentrated along the Arnhem Land coast, from Cobourg Peninsula to Groote Eylandt.

Sea cucumbers may only be taken by hand and must attain a minimum legal size, which differs between species. The number of collectors permitted under a licence is limited to four. Collection is generally restricted to neap tides during the dry season when water clarity improves.

Although licence conditions permit the harvest of all types of sea cucumbers, Sandfish is the only species to have been taken in the last decade.

Trepang licensees harvested 79.1 t of Sandfish in 2017, valued at about at $0.66 million.

All six Trepang Fishery licences are owned by a single entity. Sea Cucumbers are not targeted by other fishing parties and so management arrangements for the fishery are negotiated with the single licensee. Three of the six commercial licences were active in 2017.

Hand harvesting by the Trepang Fishery avoids bycatch TEPS interactions. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

The recreational harvest of Trepang is not known, but is likely to be low with no catch being reported by recreational fishers during surveys conducted on this sector.

No catch of Trepang by Indigenous fishers was reported during the National Recreational and Indigenous Fishing Survey of northern Australia. Information collected during survey visits suggested that Trepang were never used as food by the Indigenous people of the NT.

There have been few reported problems with compliance in the Trepang Fishery and there is no evidence of systematic non-compliance.

A18 Timor Reef Fishery

The Timor Reef Fishery operates offshore in a zone covering roughly 8400 nm to the north-west of Darwin and targets tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.) using a variety of gear. Most of the catch is taken using baited traps, but hand lines, drop-lines and demersal long-lines may also be used. Trawl gear is also currently being trialled in the fishery.

The harvest by the Timor Reed Fishery is limited through a set of TACs applied to goldband snappers (*Pristipomoides* spp.) (900 t), red snappers (*L. malabaricus* and *L. erythropterus*) (1300 t) and a "grouped fish" category (415 t). The latter group includes all fish other than Barramundi (*Lates calcarifer*), King Threadfin (*Polydactylus macrochir*), Spanish Mackerel, shark and Mud Crabs (*Scylla* spp.). Any protected species that are caught must be released.

Licensees harvested 837.3 t of fishes in 2017, with red snappers and goldband snappers constituting most of the harvest 40.2% and 29.7%, respectively). Cods (5.3%), trevally (4.1%), Red Emperor (3.8%) Mangrove Jack (3.4%) and Robinsons Sea Bream (2.1%) were the most common byproduct species. The total value of the catch by this fishery is estimated at $4.9 million.

Reported bycatch (by weight) in 2017 was less than 1% of the drop-line and trap harvest and the bycatch recorded by observers for trawl gear in 2017 was 16.2%. Non-retained species included sharks, tropical snappers (*Lutjanus* spp.), triggerfish (Family Balistidae), Scads (Family Carangidae), Black Tripodfish (*Trixiphichthys weberi*), Common Saury (*Saurida tumbil*) and Largehead Hairtail (*Trichiurus lepturus*).

Relatively few recreational fishers, Indigenous fishers or FTOs fish outside 15 nm of the NT coast and there is little overlap in the harvest activities of these user groups and the Timor Reef Fishery. However, the numbers of recreational anglers and FTOs fishing these grounds have increased in recent times due to a combination of increases in boat size, technology and weather forecasting.

The Timor Reef Fishery operates beyond the geographic range of most TEPS and so the risk of interaction with this group of species is low. Turtle excluder devices are required by law on trawl vessels and square mesh codends are used voluntarily to reduce the retention of non-target species and increase the value of the landed product. The logbook data for the Timor Reef Fishery recorded 16 interactions with various species of sawfish (15 alive, one dead), 13 interactions with sea snakes (11 alive, two dead), nine hammerhead sharks (two alive, seven dead), eight sharks (two alive, eight dead), one Spotted Shovelnose (dead) and one stingray (dead).The trawl gear used in the trial can disturb the benthic environment and the area impacted in 2017 was <3% of the fishery area.

There have been few reported problems with compliance in the Timor Reef Fishery and there is no evidence of systematic non-compliance.

D2 Fishing Tour Operator Fishery

FTOs assist their clients in the pursuit of a wide range of sport fish in the non-tidal and tidal waters of the Top End to the outer limit of the AFZ. Guide vessels range in size from small dinghies to luxury mother ships. Some operators also utilise fan-propelled “air boats” or helicopters.

Most FTOs are based near coastal population centres (such as Darwin, Nhulunbuy and Borroloola) and operate in areas accessible to the general public. However, some licensees negotiate financial agreements with Aboriginal or pastoral landholders for exclusive rights to access certain areas and, in some cases, build and maintain fishing camps or lodges.

All persons engaged in guided fishing trips in the NT must observe recreational fishing regulations. Clients typically use rod and line gear, rigged with either baited hooks or artificial lures. The latter may be trolled or cast, depending on the target species. Around three quarters of the fish caught by FTO clients are released. Barramundi form the highest proportion of the catch (30%) with other common species, including Golden Snapper (11%), Stripey Snapper (*L. carponotatus)* (6%), Grass Emperor (*Lethrinus laticaudus)* (4%) and Saddletail Snapper (*L. malabaricus)* (4%).

While the survivorship of released Barramundi is high, the same is not true for reef-associated species, such Golden Snapper and Black Jewfish. Both species are susceptible to pressure-induced injuries (barotrauma), with the rate of injury and post-release mortality proportional to capture depth. Concerns regarding the impacts of barotrauma on reef fishes (and other factors) have led to the development of new management controls on the harvest of these species.

The primary fishing gear used by FTO clients (hook and line) poses little risk of interaction with TEPS and there were no reported interactions between FTOs and TEPS in 2017. Similarly, the actions of this fishery are considered to have little impact on other ecosystem components.

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Mud Crabs

Scylla spp., Scylla olivacea, Scylla serrata

Mark Grubert

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Arafura-West Mud Crab Fishery	AWMCF	Sustainable	Catch, effort, catch rate
Northern Territory	Western Gulf of Carpentaria Mud Crab Fishery	WGOCMCF	Sustainable	Catch, effort, catch rate, biomass, fishing mortality

AWMCF Arafura-West Mud Crab Fishery, WGOCMCF Western Gulf of Carpentaria Mud Crab Fishery

Stock structure

Two species of Mud Crabs are found in Northern Territory (NT) waters: the Giant Mud Crab (*Scylla serrata*) and the Orange Mud Crab (*S. olivacea*) (Keenan et al. 1998). The former constitutes more than 99% of the commercial catch of Mud Crabs in the NT (Hay and Calogeras 2001).

In northern Australia, Female Giant Mud Crabs migrate up to 95 km offshore to release their eggs (Hill, 1994), which average around 4.5 million per individual (Mann et al. 1999). Coupled with a planktonic larval stage that can last for several weeks (Nurdiani and Zeng 2007), this may facilitate significant gene flow between areas (depending on local oceanography).

Genetic evidence suggests that there are at least two biological stocks of Giant Mud Crabs in Australian waters: one to the west and another to the south-east of the Torres Strait (Gopurenko and Hughes 2002), referred to as the northern Australian and east-coast biological stocks, respectively. Despite this, there have been significant changes in the commercial catch of Giant Mud Crabs in different regions of the NT in recent years suggesting that the level of demographic connectivity between areas is not particularly strong and that there may be further genetic separation within the northern Australian stock. In light of this, stock status of Giant Mud Crabs in NT waters is presented for the Arafura-West and Western Gulf of Carpentaria (GOC) management units, with the point of separation being Cape Grey; 13°00'S, 136°39'E.

Stock status

Arafura-West

The Arafura-West Mud Crab Fishery (AWMCF) encompasses the city of Darwin and the non-commercial harvest of Mud Crabs close to this population centre is substantial. The only concurrent estimates of the harvest by visiting recreational fishers, resident recreational fishers and Indigenous fishers within the AWMCF (derived from surveys in 2000–01) indicate that their combined take accounted for around 40% of the overall harvest within this management unit at that time (Coleman, 2004, Henry and Lyle, 2003) (using a regional weight multiplier of 0.80 kg per crab: Henry and Lyle, 2003). A more recent, non-Indigenous, resident only angler survey confirms the significance of the recreational harvest in this region (West et al. 2012). However, a lack of annual catch estimates for recreational and Indigenous fishers means that the assessment presented here is primarily based on data from commercial logbooks.

Commercial catch rates during the period 2007–16 have been variable, ranging from 0.2 kg per pot-lift to 0.7 kg per pot-lift (average 0.5 kg per pot-lift). Both the catch and catch rate for this fishery in 2016 were the lowest in more than a decade, with a similar pattern seen in the WGOCMCF that year. However, the catch across the AWMCF increased in 2017 to 92 tonnes (t) (28% above the 2016 catch) and the catch rate increased to 0.4 kg per pot-lift (double the 2016 catch rate). The catch rate in 2017 was 30% above the upper-most trigger reference point in the harvest strategy for this fishery (NTG 2017).

The performance of the AWMCF in 2016 is considered to have been affected by ocean warming events (Benthuysen et al. 2018) and a concurrent influx of fishers from the Western GOC Mud Crab Fishery (where fishing conditions were even more strongly affected) that increased fishing pressure in a few key areas, temporarily reducing catch rates. The rebound in the fishery in 2017, which saw the return of more typical environmental and operational conditions, illustrates the resilience of the stock to a range of perturbations.

A range of protective management measures (contained in the management plan and harvest strategy for the fishery), long sections of sparsely populated coastline subject to little or no crab fishing (particularly in Arnhem Land) and a strong, westward flowing long-shore wet season current (that can facilitate long distance dispersal of larvae (Schiller 2011)) lessen the impact of moderate fishing pressure in a few discrete areas within the AWMCF. Commercial minimum size limits for both species of *Scylla* found in the NT are the same: 140 mm CW for males and 150 mm CW for females. In the case of the Giant Mud Crab, these limits ensure that more than 50% of male crabs and over 98% of female crabs reach sexual maturity before harvest (Knuckey 1999). Although the size at maturity of Orange Mud Crabs within the AWMCF is not known, contemporary market monitoring data indicates that less than 1% of individuals harvested by licensees are female.

On the basis of the evidence presented above, the Arafura-West stock is classified as a **sustainable stock**.

Western Gulf of Carpentaria

The Western GOC Mud Crab Fishery (WGOCMCF) has accounted for 64% of the commercial harvest of Mud Crabs in the NT over the past 10 years. There are no records indicating the presence of Orange Mud Crabs within this management unit (Keenan et al. 1998, The Atlas of Living Australia 2018) and so the catch of Mud Crabs in this region is assumed to consist entirely of Giant Mud Crabs. The harvest of this species by resident recreational fishers, visiting recreational fishers and Indigenous fishers within the WGOCMCF in 2000–01 was estimated to be relatively low, at around 10% of the overall take within this management unit (Coleman APM 2004, Henry and Lyle 2003).

A more recent (2009–10) survey of NT anglers (which also collected information on visiting fisher activity at three popular fishing sites) confirmed that the harvest of Giant Mud Crabs by resident anglers within the WGOCMCF is less than 5% of the overall harvest of *Scylla* spp. by this sector across the NT (West et al. 2012). It also showed that the Giant Mud Crab harvest by interstate fishers visiting King Ash Bay (on the McArthur River) was almost eight times greater than that of resident recreational fishers at this site. The lack of current estimates of the overall harvest of Giant Mud Crabs by visiting recreational fishers, resident recreational fishers and Indigenous fishers within this management unit means that the assessment presented here is based on data from commercial logbooks.

The oceanography of the southern GOC and topography of the adjacent coast differ markedly from those of other areas in northern Australia. Wind is a significant driver of seasonal fluctuations in sea level in this semi-enclosed water body and its impact on biological processes in this region can be profound (Wolanski 1993). Large areas of low-lying salt pans (behind the mangrove fringe) can be inundated during temporary rises in sea level and flood events, providing extensive nursery areas for juvenile Mud Crabs.

By contrast, prolonged declines in sea level may compromise survival of mangroves, which form a key habitat for juvenile and adult Mud Crabs (Alberts-Hubatsch 2015). Duke et al. (2017) cite a temporary drop in sea level as one of several potential factors that caused a widespread mangrove die-back in the GOC in 2015—16. Other possible causes of natural mortality of Mud Crabs at that time include a prolonged period of drought (Duke et al. 2017) and a series of extreme ocean warming events in the area (Benthuysen et al. 2018).

The commercial catch in 2016 was 51 t, a historically low level (NTG 2018). The combination of reduced coastal productivity during a protracted drought, loss of mangrove foliage and associated mortality of juvenile Giant Mud Crabs (through increased desiccation and/or predation) and extreme water temperatures (avoided by adult crabs so that they were temporarily unavailable to the fishery) are considered to be likely causes of the historically low catch and catch rate in the WGOCMCF in 2016. The subsequent substantial increase in catch in 2017 (to 185 t) is attributed to above average rainfall during the 2016–17 monsoon season, recovery of juvenile nursery areas and a return to average sea surface temperatures that year (COA BOM 2017, IMOS 2018).

Estimates of spawning biomass within the WGOCMCF at the end of 2017 (B_t) as a proportion of spawning biomass at maximum sustainable yield (B_{MSY}) derived by Grubert et al. (2019), ranged from 1.04 to 1.07, indicating that the stock is currently above the target reference level. Estimated female spawning stock biomass (FSSB) at the end of the most recent fishing year (which is used as a performance indicator in the harvest strategy for the fishery (NTG 2017) was 61 t, roughly twice the previous five year average and 87% of the harvest strategy target of 70 t. The year 2015 was also the first time in over five years when recruitment was above average.

The analysis by Grubert et al (2019) estimates that overfishing (defined as $F/F_{MSY} > 1$) is not currently occurring under any modelled catchability scenario. The WGOCMCF has been operating under a formal harvest strategy for two years, with the strategy supported by a year-round market monitoring program and a fishery observer program targeting the months of April and May (to validate catch rate estimates derived from logbook data). Commercial minimum size limits of 140 mm CW for males and 150 mm CW for females ensure that at least 50% of male and around 98% of female Giant Mud Crabs reach sexual maturity before harvest (Knuckey 1999).

On the basis of the evidence presented above, the Western GOC stock is classified as a **sustainable stock**.

Biology

Giant Mud Crab biology (Butcher et al. 2003, Grubert and Lee 2013, Heasman 1980, Jebreen et al. 2008, Knuckey 1999)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Mud Crabs	3–4 years, 230 mm CW, but rarely exceeds 200 mm CW in most areas	Varies by sex and location but generally 120–150 mm CW

CW Carapace width

Distribution

Figure 1. Spatial distribution of reported commercial catch of Giant Mud Crabs in the Northern Territory for 2017

Catch

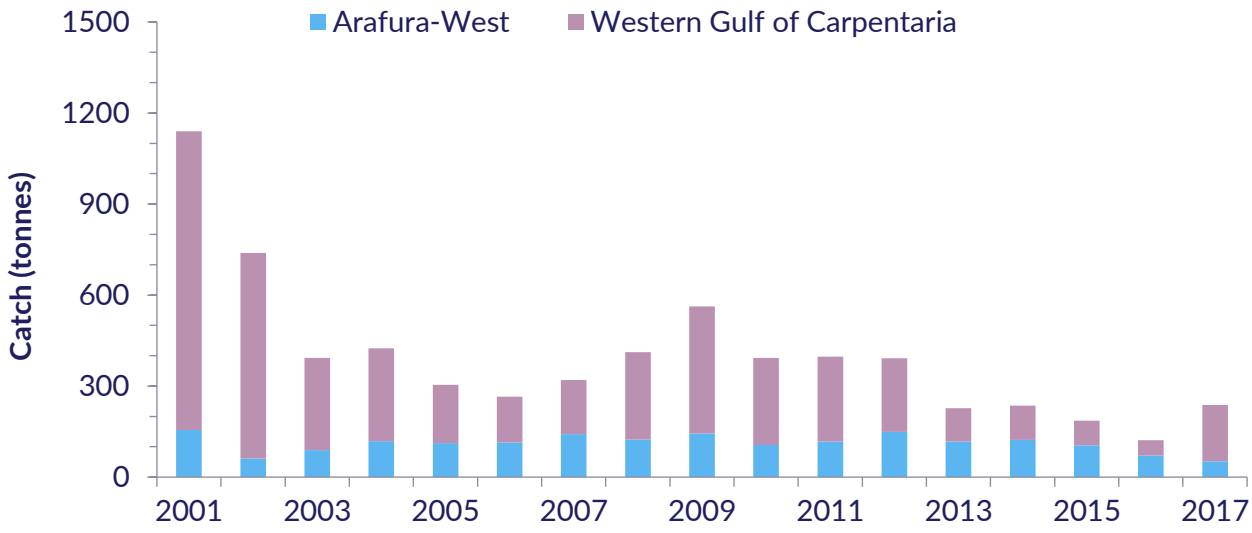

Figure 2. Commercial catch of Giant Mud Crabs in Northern Territory waters by stock from 2001 to 2017

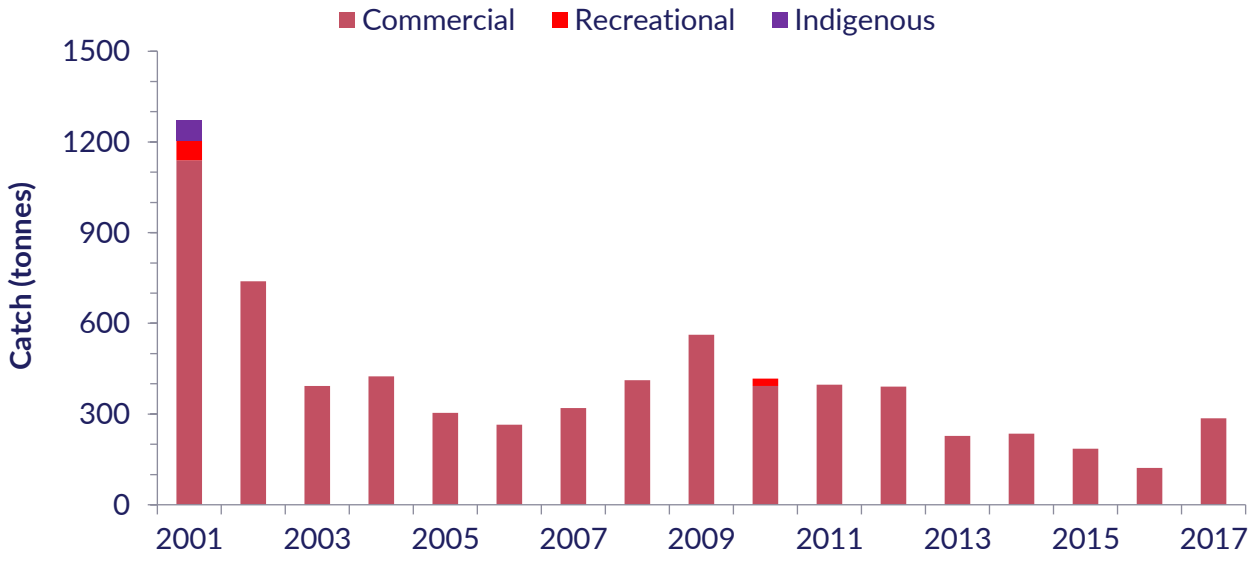

Figure 3. Catch of Giant Mud Crabs in Northern Territory waters by fishing sector from 2000 to 2017*

*The increase in the commercial minimum legal size implemented in 2006 had a significant impact on the fraction of the catch that commercial fishers can retain, particularly in the Gulf of Carpentaria. Any comparison of commercial catches before and after this time must be made with extreme caution.

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Trap	✓	✓	✓
Rod and line		✓	✓
Dilly net	✓	✓	✓
Scoop net		✓	✓
Cast net		✓	✓
Beach seine net		✓	✓
Hand collection		✓	✓
Spearfishing		✓	✓
Management methods			
Limited entry	✓		
Spatial closures	✓	✓	
Size limits	✓	✓	
Catch limits		✓	
Gear restrictions	✓	✓	✓
Protection of berried females	✓	✓	
Catch			
	287 t	33 t (2014)^ FTO 0.8 t	69 t (2001)
Active commercial licences	35 in Mud Crab Fishery		

FTO Fishing Tour Operator

^Darwin region only

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 license and passenger numbers.

Indigenous (management methods) The NT *Fisheries Act* 1988 specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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Sandfish

Holothuria scabra

Mark Grubert

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Trepang Fishery	TF	Undefined	Catch, effort

TF Trepang Fishery

Stock structure

Sandfish (*Holothuria scabra*) are widespread in the tropical Indo-West Pacific between latitudes 30˚ N and 30 ˚S, but no farther east than Fiji (Purcell et al. 2012). They inhabit soft sediments and seagrass beds in shallow coastal waters. Genetic analyses of Sandfish from Northern Territory (NT) waters suggest that there are separate stocks either side of the Wessel Islands (Gardner et al. 2012). Given the difficulty in obtaining relevant biological and catch-and-effort information to assess each individual biological stock, status is reported at the NT-wide level.

Stock status

The harvest of Sandfish in northern Australia dates back to at least the 1700s, when traders from Makassar (Ujung Pandang) visited the area to fish for this delicacy. Fishing in what is now known as the NT (but formerly part of South Australia) declined around 1880, and the South Australian Government ceased issuing licences to Macassans in 1907 (MacKnight 1976). Small catches continued until 1945, but exports were negligible from then until the early 1980s. Prior to this downturn, commercial fishing activity was coordinated by European Australians with assistance from the Aboriginal people of Arnhem Land. Increasing interest in the late 1980s led to the re-emergence of the Trepang Fishery. Catches of Sandfish peaked at 247 tonnes (t) (whole weight) in 2000 and fluctuated between 100 t and 200 t for

the next seven years. Catches thereafter were comparatively low because of a four-fold decrease in annual fishing effort. Fishers have indicated that this reduction in fishing effort was caused by difficulties in sourcing divers and crew rather than any noticeable decline in Sandfish abundance. The zero catch in 2014 was due to zero fishing effort.

Three of the six commercial licences were active in 2017 (for a total of 150 days fished) and caught 79.1 t of Sandfish. Catch rates are considered an unreliable indicator of Sandfish abundance at present because of the dynamic and sporadic nature of fishing activities targeting this species.

Neither the recreational nor the Aboriginal take of Sandfish has been quantified, but it is assumed to be negligible. Limited knowledge of the fishery biology of Sandfish in NT waters, combined with highly variable catch, effort and catch rates in recent years, means that it is not possible to confidently classify the status of this species.

On the basis of the evidence provided above, the NT Sandfish stock is classified as an **undefined stock**.

Biology

Sandfish biology (Purcell et al. 2012; Vail, 1989)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Sandfish	Unknown, 380 mm TL	Maturity (160-250 mm), 2 years

TL = Total length

Distribution

Figure 1. Distribution of reported commercial catch of Sandfish in Northern Territory waters during 2017

Catch

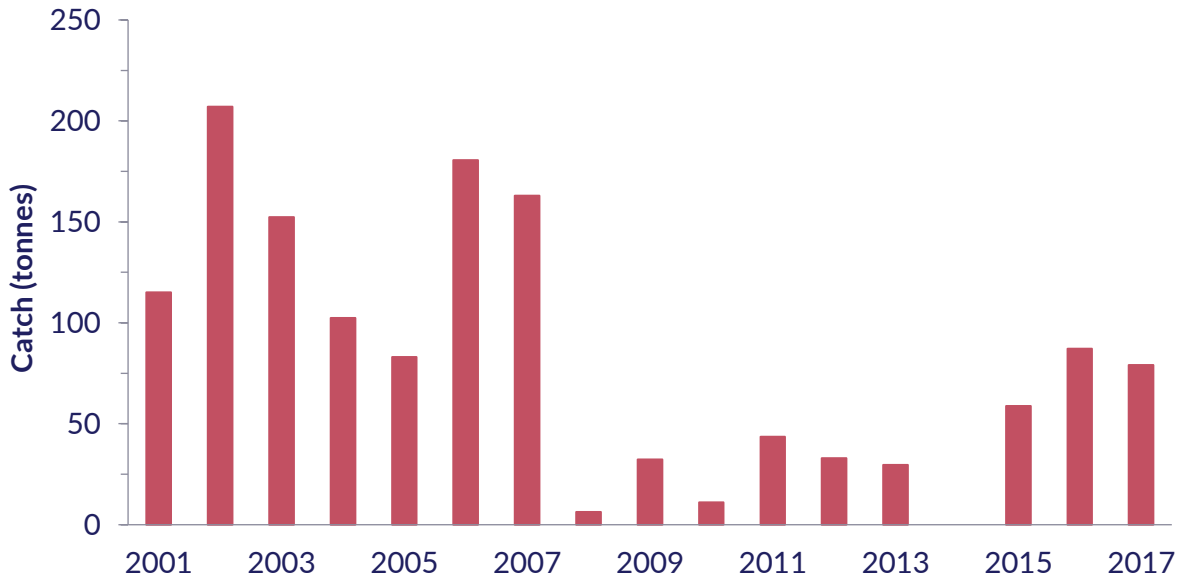

Figure 2. Commercial catch of Sandfish in Northern Territory waters from 2001 to 2017

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
SCUBA or hookah diving	✓	✓	✓
Hand collection	✓	✓	✓
Management methods			
Limited entry	✓		
Spatial zoning	✓		
Size limits	✓		
Gear restrictions	✓		
Catch			
	79 t	Unknown	Unknown
Active commercial licences	3 licences in Trepang Fishery		

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Blacktip Sharks

Carcharinus limbatus, C. sorrah, C. tilstoni

Grant Johnson

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	North and West Coast	BF, BNF, CNF, ONLF, SPDF	Sustainable	Catch, mark recapture, CPUE, pup production
Northern Territory, Queensland	Gulf of Carpentaria	GOCIFFF, GOCLF, ONLF	Undefined	Catch, pup production

BF Barramundi Fishery, BNF Bait Net Fishery, CNF Coastal Net Fishery, ONLF Offshore Net and Line Fishery, SPDF Small Pelagic Developmental Fishery

Stock structure

In the context of Australian fisheries, the Blacktip Shark species complex, part of the family Carcharhinidae (whaler sharks), comprises three species: *Carcharhinus tilstoni* (Australian Blacktip Shark), *C. limbatus* (Common Blacktip Shark) and *C. sorrah* (Spottail Shark). Whereas *C. tilstoni* and *C. sorrah* are distributed only within Australian and Indo–West Pacific waters, respectively, *C. limbatus* is globally distributed in tropical and warm temperate waters. In Australian waters, genetic studies have identified two biological stocks of *C. tilstoni* (a western stock extending from the western Northern Territory (NT) into northern Western Australia, and an eastern stock extending from the Gulf of Carpentaria (GOC) to the east coast of Queensland and New South Wales), three biological stocks of *C. limbatus* (one across Western Australia and the NT, one in the GOC and one on the east coast of Queensland and New South Wales) and 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 GOC are uncertain.

Carcharhinus limbatus and *C. tilstoni* are similar in appearance and can only be taxonomically differentiated by genetic analyses, precaudal vertebral counts or, in certain size classes, their differences in size of maturity (Harry 2011). There are two new techniques - one using machine learning models and the other using differences in pelvic fin colouration - that may assist in distinguishing between these two species; however, accurate field identification remains difficult and is not practical during fishing operations (Johnson et al. 2017). Hybridisation between *C limbatus* and *C. tilstoni* has also been recorded, though the impacts of this remain poorly understood

(Harry et al. 2012, Johnson 2017, Morgan et al. 2011). Because a suite of three species of differing stock structures is grouped together for this assessment, stocks have been assessed on the finest known scale—using the three biological stock areas identified for *C. limbatus*.

Here, assessment of stock status for the Blacktip Shark multispecies group is presented at the biological stock level—North and West Coast and GOC.

Stock status

North and West Coast

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

The most recent assessments (Grubert et al. 2013) estimated that biomass in 2011 in relation to unfished (1970) levels was 80 to 90% for *C. tilstoni*/*C. limbatus* and 93% for *C. sorrah*. 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 negative impact on the stock. Additionally, results from a mark-recapture study done for all species of Blacktip Shark in NT waters support 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 driven by changing operational practices in the Offshore Net and Line Fishery.

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.

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 tonnes (t) for *C. tilstoni* and 29.4 t for *C. sorrah* [Leigh 2015]. This 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 the NT component of the GOC only 7.9 t of *C. tilstoni*/*C. limbatus* and 0.3 t of *C. sorrah* were caught by the Offshore Net and Line Fishery. In the Queensland component of the stock, 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 was 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 *C. sorrah* individually.

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

Biology

Blacktip Sharks biology [Harry et al. 2012, Harry 2011, Last and Stevens 2009]

Species	Longevity / Maximum Size	Maturity (50 per cent)
Blacktip Shark	*C. tilstoni*: Females 15 years, males 13 years, 2 000 mm TL *C. limbatus*: Maximum age unknown, 2 500 mm TL *C. sorrah*: Females 14 years, males 9 years, 1 600 mm TL	*C. tilstoni*: 5–6 years, females 1 350–1 400 mm, males 1 200 mm TL *C. limbatus*: females unknown, males 1 800 mm *C. sorrah*: 2–3 years, both sexes 900–950 mm TL

TL Total length

Distribution

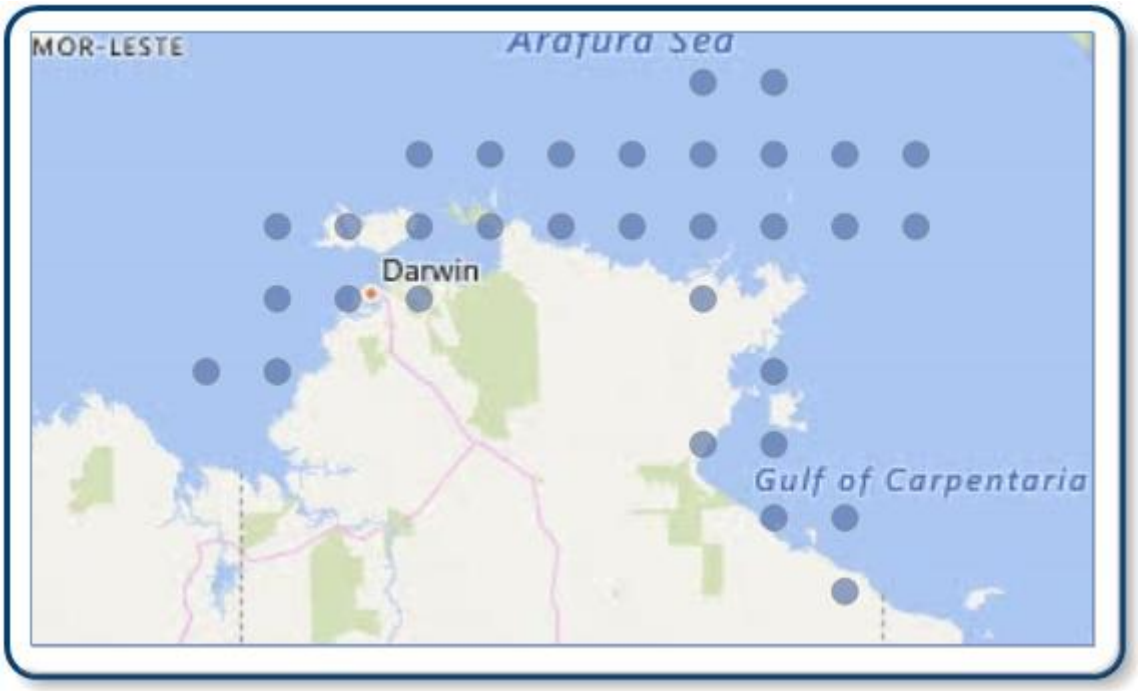

Figure 1. Distribution of reported commercial catch of Blacktip Sharks in Northern Territory waters during 2017

Catch

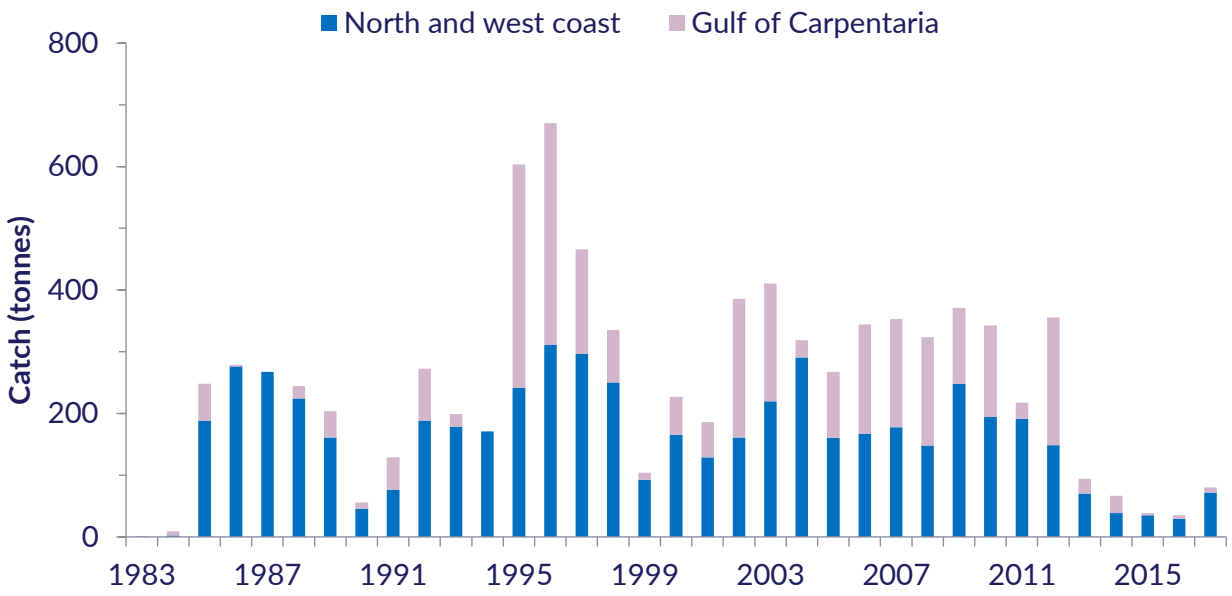

Figure2. Commercial catch of Blacktip Sharks in Northern Territory waters from 1983 to 2017

*Recreational and Fishing Tour Operator shark catch is not reported separately for shark species

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Pelagic gillnet	✓		
Otter trawl	✓		
Gillnet	✓		
Demersal longline	✓		
Purse seine	✓		
Spearfishing			✓
Hook and line	✓	✓	✓
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓	✓	
Spatial closures	✓	✓	
Temporal closures	✓	✓	

Fishing sector	Commercial	Recreational	Aboriginal
Management methods			
Gear restrictions	✓	✓	✓
Possession limits		✓	
Catch			
	BF 0.3 t BNF 0.14 t CNF1.4 t ONLF 78.1 t SPDF 0.1 t	Unknown	Unknown
Active commercial vessels	14 licences in BF, 7 licences in ONLF, 13 licences in BNF, 3 licences in CNF, 3 licences in SPDF.		

BF Barramundi Fishery, ONLF Offshore Net and Line Fishery, BNF Bait Net Fishery, CNF Coastal Net Fishery, SPDF Small Pelagic Developmental Fishery

Indigenous (management methods) The NT *Fisheries Act 1988* specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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.

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Barramundi

Lates calcarifer

Thor Saunders

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Barramundi Fishery	ACL, BF	Sustainable	Catch, CPUE, length and age, low harvest rate

ACL Aboriginal Coastal Licence, BF Barramundi Fishery

Stock structure

Barramundi (*Lates calcarifer*) are distributed throughout coastal areas of the Indo-West Pacific region – from the eastern edge of the Persian Gulf to southern Japan and southward to northern Australia. In Australia, they are found in rivers from Exmouth Gulf in Western Australia to northern New South Wales. Separate biological stocks of Barramundi exist at the scale of individual catchments across northern Australia (Keenan 1994, Keenan 2000). However, the difficulty in obtaining relevant biological and catch-and-effort information to assess each individual biological stock means the status is reported at the Northern Territory (NT)-wide level. This assessment is based on the river catchments that receive the highest harvest rates (Daly and Mary rivers) (Figure 1) and whose status is assumed to be representative of the highest level of exploitation that occurs on any stock within the NT.

Stock status

The commercial catch and nominal catch per unit effort (CPUE) have both declined substantially in recent years, primarily due to the below average wet seasons since 2013 in the NT. However, CPUE levels are still 20% above the long-term average (1983–2016) and CPUE increased in 2017 (Figure 3). Monitored stocks have a healthy length and age distribution with little sign of reduction in the proportion of older age classes, despite abundance surveys showing low levels of recruitment during recent wet seasons. The above evidence indicates that the biomass of the stock is unlikely to be depleted and that recruitment is unlikely to be impaired.

Recaptures from tagging programs indicate that the annual harvest rate from all sectors combined is consistently below 5% and this level of fishing pressure is unlikely to cause the stocks to become recruitment impaired.

On the basis of the evidence provided above, the NT Barramundi Fishery management unit is classified as a **sustainable stock.**

Biology

Barramundi biology (Davis 1982)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Barramundi	35 years, 1500 mm TL	Maturity (50%) Northern Territory: Males 2–5 years, 730 mm TL; Females 5–7 years, 910 mm TL Queensland: Males 2–5 years, 640 mm TL; Females 5–7 years, 820 mm TL

TL Total length

Distribution

Figure 1. Distribution of reported commercial catch of Barramundi in Northern Territory waters during 2017

Catch

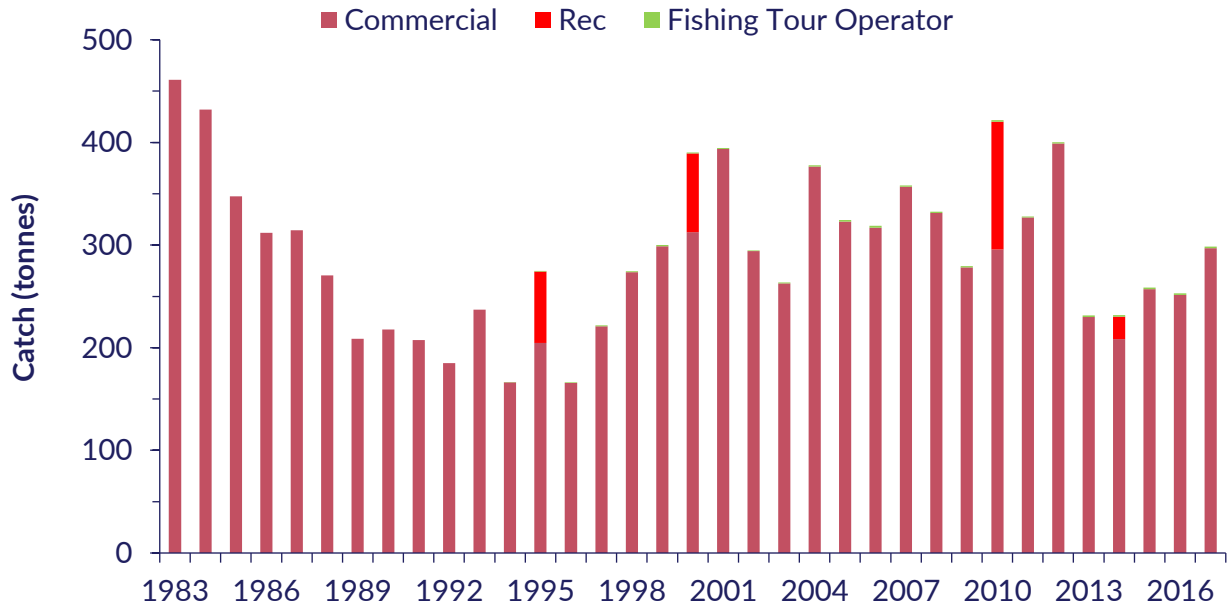

Figure 2. Catch of Barramundi in Northern Territory waters by fishing sector^ from 1983 to 2017

BF Barramundi Fishery, Rec Recreational sector, FTO Fishing Tour Operator

^ 2014 Recreational fishing catch is for the Darwin area only

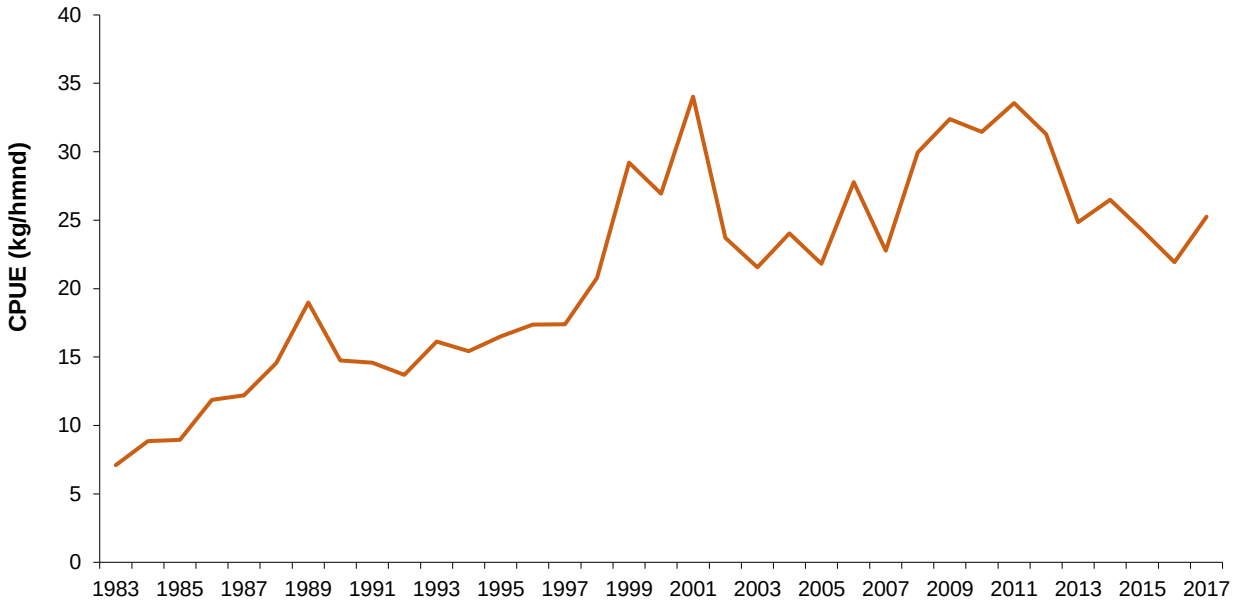

Figure 3. Commercial catch per unit effort (CPUE; kg/100 m of net per day) for Barramundi in Northern Territory waters from 1983 to 2017

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Gill net	✓		
Rod and line		✓	✓
Spearfishing		✓	✓
Hand line		✓	✓
Management methods			
Size limits	✓	✓	
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits		✓	
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	✓
Possession limits	✓	✓	✓
Catch			
	BF 393.6 t ACL 0.06 t	Recreational: 21.9 t (2014)^ FTO 37.3 t	110 t (2000)
Active commercial vessels	13 licences in BF		

ACL Aboriginal Coastal Licence, BF Barramundi Fishery, FTO Fishing Tour Operator

^Catch for Darwin area only

Indigenous (management methods) The *Fisheries Act 1988* (NT), specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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.

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Black Jewfish

Protonibea diacanthus

Shane Penny

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Northern Territory	BF, CLF, DF, ONLF, TRF	Recovering	Biomass, egg production

BF Barramundi Fishery, CLF Coastal Line Fishery, DF Demersal Fishery, ONLF Offshore Net and Line Fishery, TRF Timor Reef Fishery

Stock structure

Black Jewfish is a widespread Indo-Pacific species found from Exmouth Gulf in Western Australia, north and east across northern Australia, to the east coast of Queensland. The stock structure for this species has been investigated in the north-western part of its range from the western Gulf of Carpentaria to its southern extent along the west Australian coastline (Saunders et al. 2016). The results indicated that separate stocks exist at the scale of tens of kilometres. However, it is extremely difficult to collect relevant biological and catch and effort information to assess each of these individual fine-scale biological stocks, although this fine-scale stock structure is an explicit consideration for fishery managers. Due to the logistic and operational constraints of the relevant monitoring, assessment and management agencies, assessment is only feasible at the jurisdictional level. This assumes that the assessment of stock status within a jurisdictional assessment unit is relevant to all biological stocks within that assessment unit.

Here the assessment of stock status is presented at the Northern Territory (NT)-wide level.

Stock status

Black Jewfish are harvested by commercial and recreational sectors across most of the NT, with the majority of catch occurring within the Greater Darwin Region (i.e. within a radius of approximately 150 km of this population centre). Within this region, Black Jewfish is targeted by the Coastal Line Fishery, contributing 68% of the total harvest, the recreational fishing sector contributing 21% and Fishing Tour Operators contributing 5%. No estimates of the Indigenous harvest of Black Jewfish are available for the NT.

A 2014 stock assessment using a Stock Reduction Analysis (Grubert et al. 2013) indicated that Black Jewfish were overfished and that overfishing was occurring. The most recent assessment (NTG 2018, unpublished), updates the previous assessment incorporating data up to and including 2017. The results of the model indicate that, despite high recent exploitation levels, the Greater Darwin Region stocks were not overfished in 2017 and there was a 24% probability that the stock is overfished and 5% probability that current harvest rates are causing overfishing. Biomass and egg production were estimated to be at 50% and 47%, respectively of the unfished biomass. Given the recent information on the stock structure of this species (Saunders et al. 2016), it is likely that the assessment incorporates several populations. As the model is driven by the populations that receive the highest harvest rates in the NT, the assigned status can be assumed to be representative of these heavily-fished areas, with other less accessible areas being more lightly-fished. The recovery of this species is primarily driven by successive years of above-average recruitment (indicated by the reduction in average length of monitored catches and an increase in the number of fish caught) as well as the management measures (catch limits and area closures) introduced in 2015 aimed to reduce the harvest of the species by 20% in exploited areas. There is a high likelihood that the illegal harvest of this species, which historically has been non-existent, will increase the risk of this species being overfished in the future as the price of swim bladders exceeds $750 per kg. The swim bladders are considered a delicacy and an aphrodisiac in some Asian countries. The current level of fishing mortality should allow further recovery, though the development of any illegal fishing mortality and its potential impact will need to be assessed.

On the basis of the evidence provided above, Black Jewfish in the NT are classified as a recovering stock.

Biology

Black Jewfish biology (Phelan 2002, Welch et al. 2014)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Black Jewfish	15 years, 1 500 mm TL, 30 kg	Northern Territory: 2 years, TL 890 mm

TL Total length

Distribution

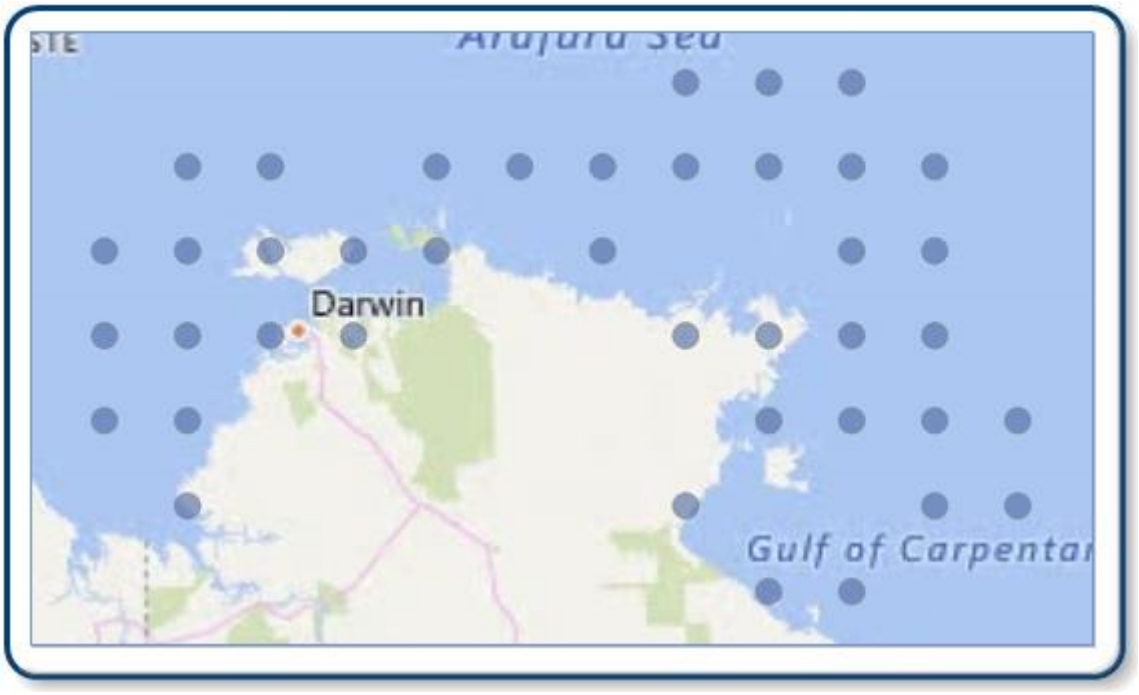

Figure1. Distribution of reported commercial catch of Black Jewfish in Northern Territory waters during 2017

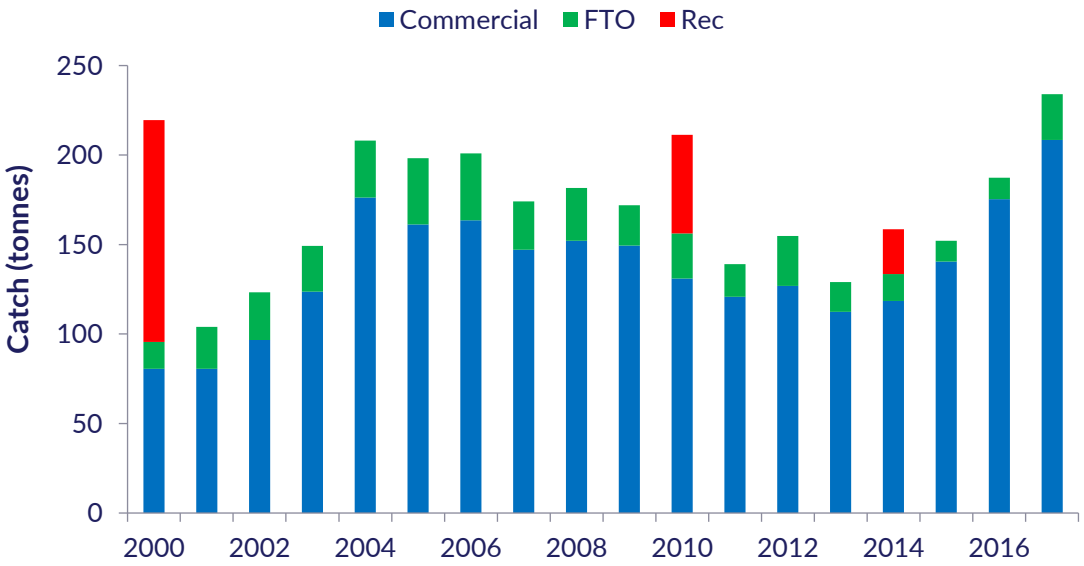

Figure 2. Catch of Black Jewfish in Northern Territory waters by fishing sector from 2000 to 2017

Rec Recreational sector, FTO Fishing Tour Operator

^ Recreational catches have only been periodically recorded during NT wide surveys. 2014 Recreational fishing catch is for the Darwin area only

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Gill net	✓		
Rod and line		✓	✓
Spearfishing		✓	✓
Hook and line	✓	✓	✓
Otter trawl	✓		
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓		
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	
Possession limits	✓	✓	
Catch			
	BF 6.7 t CLF 168.8 t DF 21.332 t ONLF 0.3 t TRF 11.3 t	Recreational 155 t (2010) FTO 25.5 t	Unknown
Active commercial vessels	14 licences in BF, 14 licences in CLF, eight licences in DF, seven licences in ONLF and five licences in TRF		

BF Barramundi Fishery, CLF Coastal Line Fishery, DF Demersal Fishery, FTO Fishing Tour Operator, ONLF Offshore Net and Line Fishery, TRF Timor Reef Fishery

Indigenous (management methods) The *NT Fisheries Act 1988* specifies that "...without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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.

References	
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Phelan 2008,	Phelan, M. (2008). Assessment of the Implications of Target Fishing on Black Jewfish (*Protonibea diacanthus*) Aggregations in the Northern Territory. Fisheries Research and Development Corporation Project 2004/004. Fishery Report 91, Northern Territory Government.
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Welch et al. 2014	Welch, D. J., Robins, J., Saunders, T., Courtney, T., Harry, A., Lawson, E., Moore, B. R., Tobin, A., Turnbull, C., Vance, D. and Williams, A. J. (2014). Implications of Climate Change Impacts on Fisheries Resources of Northern Australia. Part 2: Species Profiles. Final Report to the Fisheries Research and Development Corporation, project 2010/565, James Cook University, Townsville.

King Threadfin

Polydactylus macrochir

Thor Saunders

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Northern Territory	BF	Sustainable	Catch, CPUE, length and age frequencies

BF Barramundi Fishery

Stock structure

King Threadfins have numerous populations across northern Australia that are separated by 10s to 100s of km or by large, coastal geographical features (Moore et al. 2011, Welch et al. 2010). With the exception of the Gulf of Carpentaria, there is a lack of information on the degree to which this separation indicates separate biological stocks and on boundaries between possible stocks. Given the difficulty in obtaining relevant biological and catch-and-effort information to assess each individual biological stock, status is reported at the Northern Territory (NT)-wide level.

Stock status

Commercial catch in the Barramundi Fishery has declined in recent years, but is still above the long-term (1983–2016) average (Figure 2). Additionally, monitored stocks have a healthy size and age distribution and nominal catch per unit effort has increased substantially over the past 10 years, with the 2017 value being the highest in the history of the fishery (Figure 3). The above evidence indicates that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. Furthermore, the current fishing pressure is unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, King Threadfin in the NT is classified as a **sustainable stock**.

Biology

King Threadfin biology (Welch et al. 2010)

Species	Longevity / Maximum Size	Maturity (50 per cent)
King Threadfin	22 years, 1 600 mm TL	Males 2 years, 610 mm TL Females 6 years,1 000 mm TL

TL Total length

Distribution

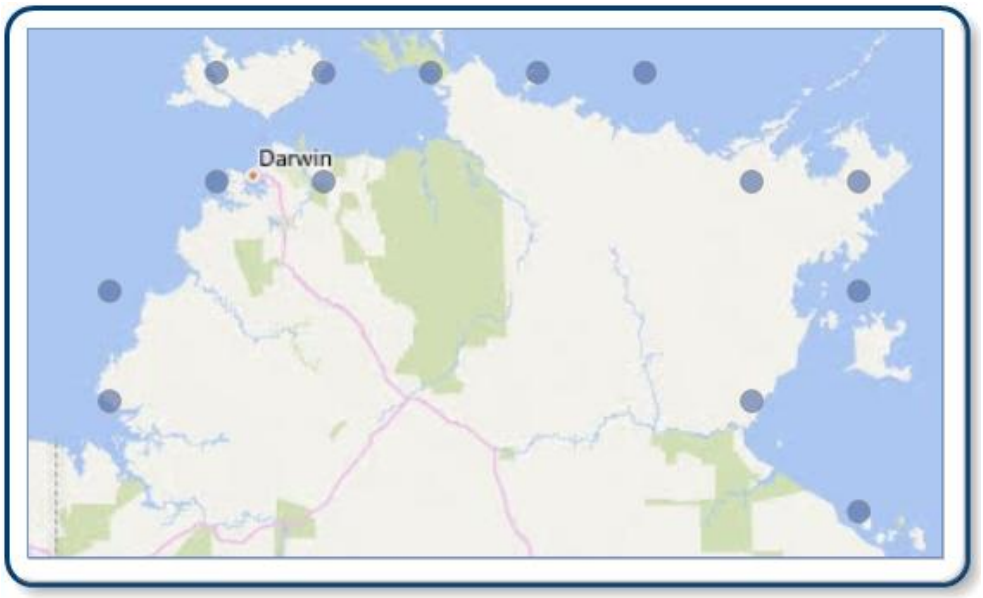

Figure 1. Distribution of reported commercial catch of King Threadfin in Northern Territory waters during 2017

Catch

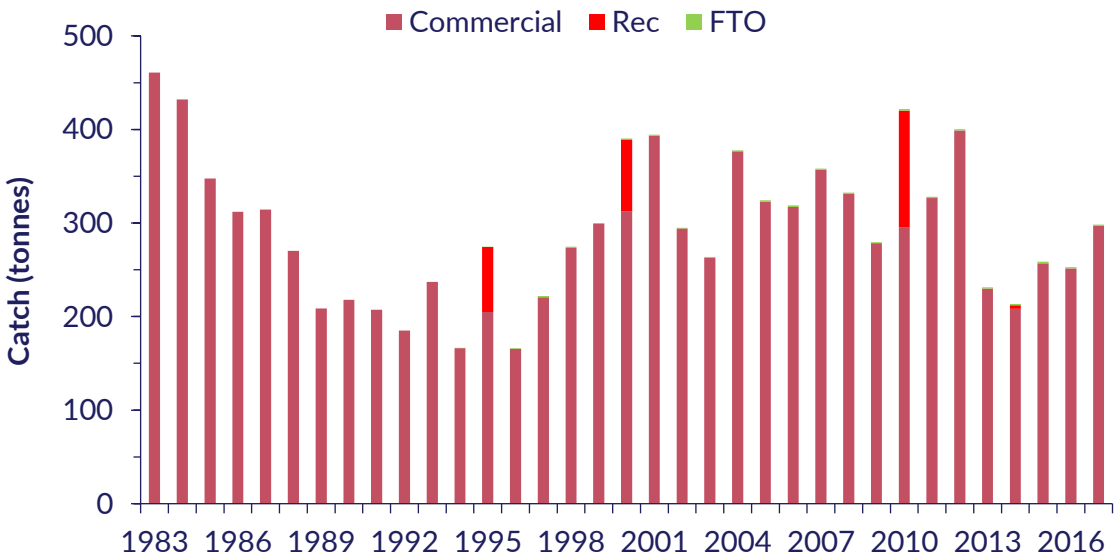

Figure 2. Catch of King Threadfin in Northern Territory waters by fishing sector^ from 1983 to 2017
Rec Recreational sector, FTO Fishing Tour Operator
^ 2014 Recreational fishing catch is for the Darwin area only

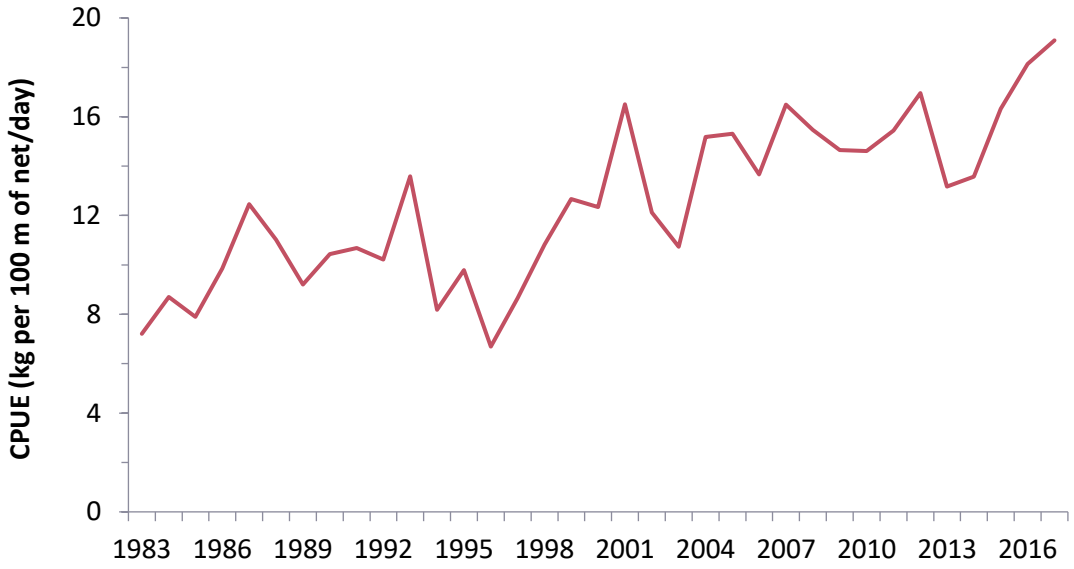

Figure 3. Commercial catch per unit effort (CPUE: kg/100 m of net per day) for King Threadfin from 1983 to 2017

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Gill net	✓		
Rod and line		✓	✓
Spearfishing		✓	✓
Hand line		✓	✓
Management methods			
Size limits	✓	✓	
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits		✓	
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	✓
Possession limits	✓	✓	✓

Fishing sector	Commercial	Recreational	Aboriginal
Catch			
	296.9 t	Recreational 3.6 t (2014)^ FTO 1.5 t	Unknown
Active commercial vessels	13 licences in BF		

BF Barramundi Fishery, FTO Fishing Tour Operator

^Catch for Darwin Area only

Indigenous (management methods) The NT *Fisheries Act 1988* specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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 license and passenger numbers.

References	
Moore et al. 2011	Moore, B. R., Welch, D. J. and Simpfendorfer, C. A. (2011). Spatial patterns in the demography of a large estuarine teleost: king threadfin, *Polydactylus macrochir*. *Marine and Freshwater Research*, **62:** 937–951.
Welch et al. 2010	Welch, D. J., Ballagh, A., Newman, S. J., Lester, R. J., Moore, B., van Herwerden, L., Horne, J., Allsop, Q., Saunders, T., Stapley, J. and Gribble, N. A. (2010). Defining the Stock Structure of Northern Australia's Threadfin Salmon Species. Draft Final Report to the Fisheries Research and Development Corporation, Project 2007/032. Fishing and Fisheries Research Centre, James Cook University, Townsville, Australia.

Spanish Mackerel

Scomberomorus commerson

Lewis Christensen

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Northern Territory	ACL, DF, ONLF, SMF	Sustainable	Biomass

DF Demersal Fishery (NT), ONLF Offshore Net and Line Fishery (NT), SMF Spanish Mackerel Fishery (NT), ACL Aboriginal Coastal License (NT)

Stock structure

Genetic evidence indicates 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 100 km) indicates that there are likely to be a number of smaller biological stocks with limited interaction (Buckworth et al. 2007, Lester et al. 2001, Moore et al. 2003). Each jurisdiction is likely to have multiple biological stocks within its boundaries; however, due to the difficulty in obtaining relevant biological, and catch and effort information to assess each stock individually, it has not been possible to conduct all assessments at the biological stock level. This current assessment is based on the stocks that are subject to the highest harvest rates and whose status is assumed to be representative of the highest level of exploitation that occurs on any stock within the Northern Territory (NT).

Stock status

Spanish Mackerel stocks have been assessed at a territory-wide level. The most recent assessment (using data to 2015) indicated that stocks had declined substantially because of high Taiwanese catches in the 1970s and 1980s but have recovered since the implementation of more stringent management in the early 1990s. Estimated biomass at the conclusion of 2015 was 72% of the unfished level (1973); this is within sustainable limits and there may be capacity for the catch to be increased (Grubert et al. 2013). The stock is not considered to be recruitment impaired. The current level of fishing mortality is unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, Spanish Mackerel in the NT is classified as a **sustainable stock**.

Biology

Spanish Mackerel biology (McPherson 1992, McPherson 1993, QDAFF 2013)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Spanish Mackerel	26 years, 2400 mm FL	~2 years, 800 mm FL

Distribution

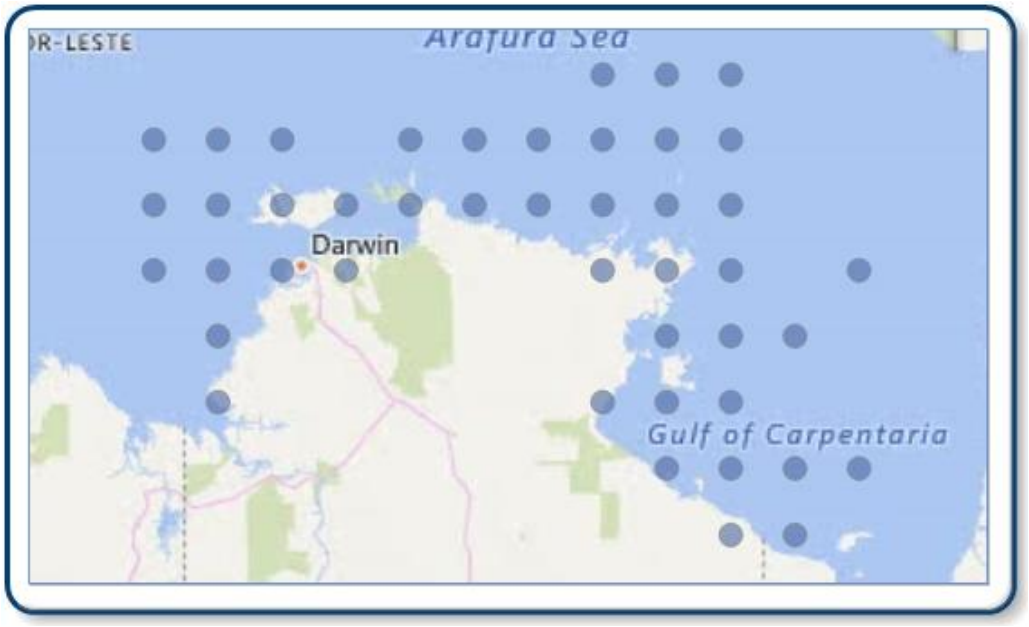

Figure 1. Distribution of reported commercial catch of Spanish Mackerel in Northern Territory waters during 2017

Catch

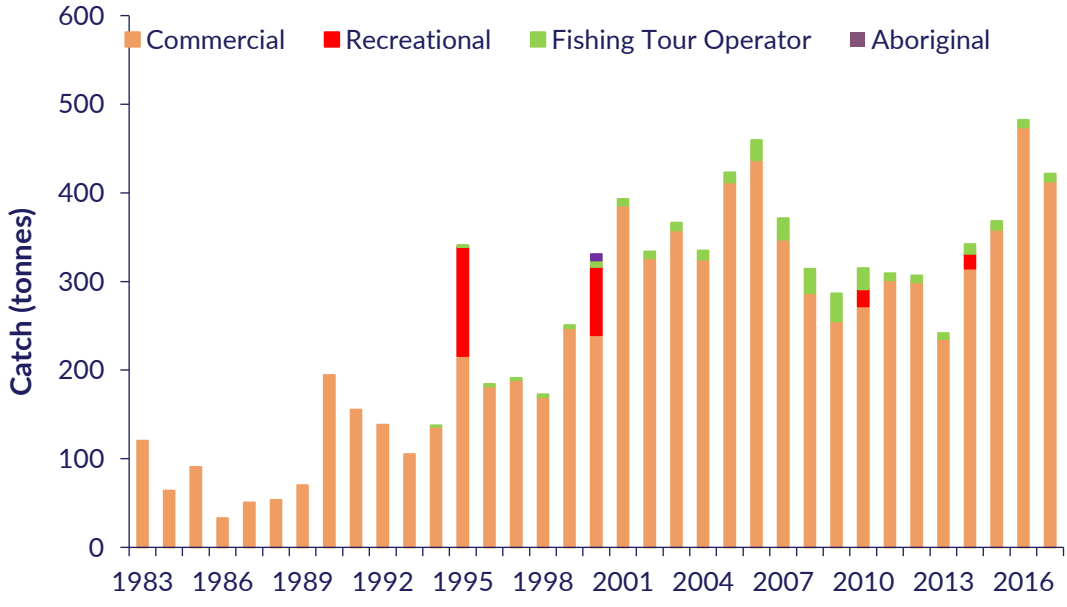

Figure 2. Catch of Spanish Mackerel in Northern Territory waters by fishing sector from 1983 to 2017

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Trolled baits	✓	✓	
Lures	✓	✓	
Gill net	✓		
Fish trawl	✓		
Rod and line		✓	
Spearfishing		✓	✓
Hand line		✓	✓
Management methods			
Limited entry	✓		
Spatial zoning	✓		
Vessel restrictions	✓		
Catch limits	✓	✓	
Spatial closures	✓	✓	
Gear restrictions	✓	✓	✓
Possession limits		✓	✓
Catch			
	SMF 389.8 t ONLF 20.95 t DF 2.07 t	16.6 t (2014)^ FTO 8.78 t	7 t (2000)
Active commercial vessels	13 licences in SMF, 9 licences in ONLF, 7 licences in DF		

DF Demersal Fishery, FTO Fishing Tour Operator, ONLF Offshore Net and Line Fishery, SMF Spanish Mackerel Fishery

^ Darwin region only

Indigenous (management methods) The NT, *Fisheries Act* 1988 specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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 license and passenger numbers.

References	
Buckworth et al. 2007	Buckworth, R., Newman, S., Ovenden, J., Lester, R. and McPherson, G. (2007). The Stock Structure of Northern and Western Australian Spanish Mackerel. Final Report to the Fisheries Research Development Corporation, Project 1998/159, Northern Territory Department of Primary Industry and Fisheries, Darwin
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McPherson 1993	McPherson, G. R. (1993). Reproductive biology of the narrow-barred Spanish Mackerel (*Scomberomorus commerson* Lacepede, 1800) in Queensland waters. *Asian Fisheries Science*, **6:** 169–182.
Moore et al. 2003	Moore, B. R., Buckworth, R. C., Moss, H. and Lester. R. J. G. (2003). Stock discrimination and movements of narrow-barred Spanish Mackerel across northern Australia as indicated by parasites. *Journal of Fish Biology*, **63:** 765–779
QDAFF 2013	Queensland Department of Agriculture, Fisheries and Forestry 2013. Stock Status of Queensland's Fisheries Resources 2012.
West et al. 2012	West, L. D., Lyle, J. M., Matthews, S. R., Stark, K. E. and Steffe, A. S. (2012). Survey of Recreational Fishing in the Northern Territory, 2009-10. Fishery Report 109, Northern Territory Department of Primary Industry and Fisheries, Darwin

Grey Mackerel

Scomberomorus semifasciatus

Grant Johnson

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	North West Northern Territory	ONLF, SMF	Sustainable	Stock Reduction Analysis, fishing mortality, catch, CPUE
Northern Territory, Queensland	Gulf of Carpentaria	GOCIFFF, ONLF, SMF	Sustainable	Stock Reduction Analysis, catch, effort

ONLF Offshore Net and Line Fishery, SMF Spanish Mackerel Fishery

Stock structure

There are at least five Grey Mackerel biological stocks across northern Australia, with a possible additional stock in the north-east Gulf of Carpentaria (GOC) (Broderick et al. 2011, Charters et al. 2010, Newman et al. 2010, Welch et al. 2009, Welch et al. 2015).

Here, assessment of stock status is presented at the biological stock level in the Northern Territory (NT), north-west NT and the GOC.

Stock status

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–80s, but have since recovered with the cessation of foreign fishing and more stringent management of the domestic fishery. The most recent assessment estimates that the biomass in 2011 was 81% of the unfished level (Grubert et al. 2013). Furthermore, the current harvest rate is 12% of that required to achieve maximum sustainable yield (MSY) (Grubert et al. 2013). Supporting this assessment is that catch per unit effort has increased over the past 10 years, while catches have remained relatively consistent.

On the basis of the evidence provided above, the North West Northern Territory biological stock is classified as a **sustainable stock**.

Gulf of Carpentaria

Grey Mackerel in the GOC is primarily a commercial gillnet-caught species. Queensland and the NT share management of the GOC biological stock through the Queensland Fisheries Joint Authority. Queensland took most of the commercial harvest (61%) 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 dropped in 2013 to 60 kg/100 m net, it steadily rose in 2015 to 86 kg/100 m net; but in 2017 it was 54.2 kg/100 m net, below the 10-year catch rate limits, ranging from 57 kg/100 m net to 119 kg/100 m net. The most recent assessment estimated that the GOC biomass in 2011 (896 tonnes (t)) was 74% 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% 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 27 km to 9 km 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 (1322 days fished) are above the 10-year average (1104 days fished from 2007 to 2016).

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

Biology

Grey Mackerel biology [Cameron and Begg 2002, Department of Agriculture and Fisheries 2016]

Species	Longevity / Maximum Size	Maturity (50 per cent)
Grey Mackerel	14 years, 1 200 mm FL	Females 2 years, 650–700 mm FL Males 1–2 years, 550–600 mm FL

FL Fork length

Distribution

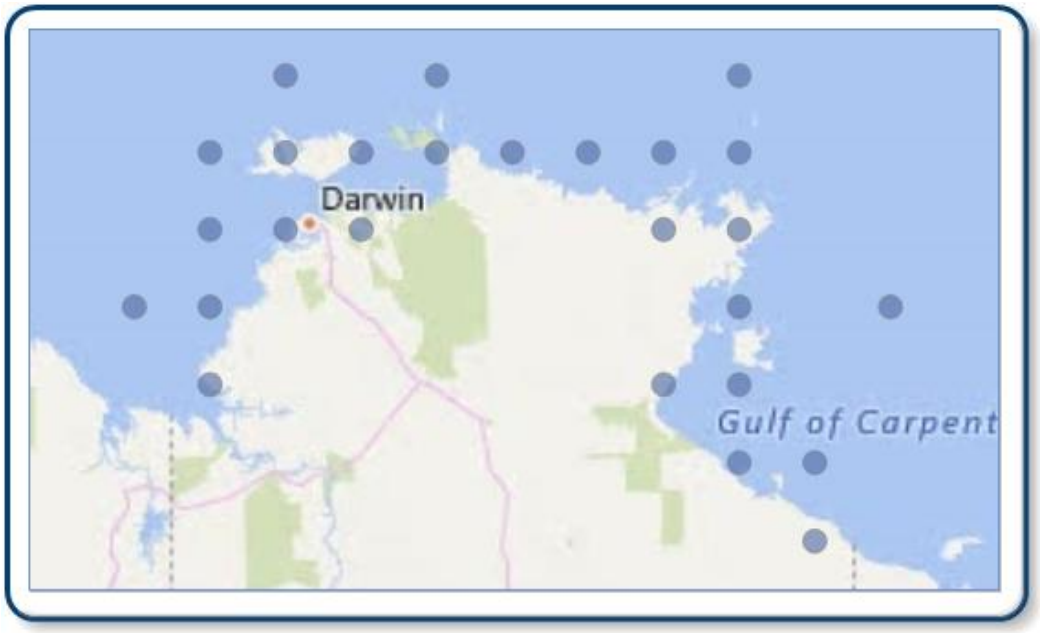

Figure 1. Distribution of reported commercial catch of Grey Mackerel in Northern Territory waters during 2017

Catch

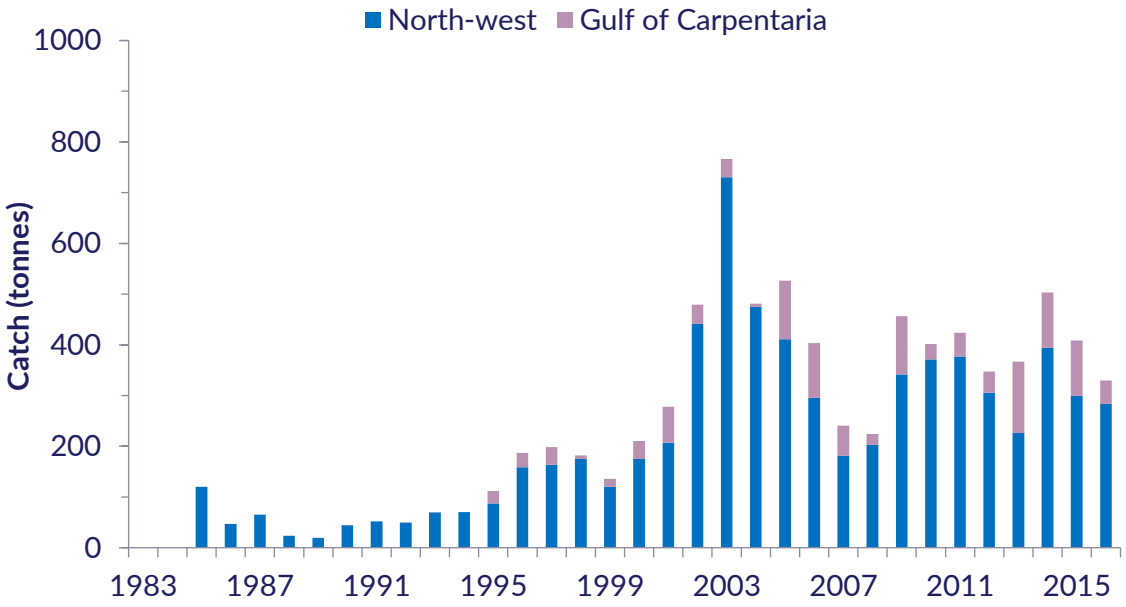

Figure 2. Commercial catch of Grey Mackerel in Northern Territory waters from 1983 to 2017

*Recreational and Fishing Tour Operator Grey Mackerel catch is negligible

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Pelagic gillnet	✓		
Hook and line	✓	✓	✓
Trolled bait	✓		
Lures	✓	✓	
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓	✓	
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	
Possession limits		✓	
Catch			
	ONLF 498.5 t, SMF 0.75 t	2.7 t (2010)	Unknown
Active commercial vessels	7 licences in ONLF, 14 licences in SMF		

ONLF Offshore Net and Line Fishery, SMF Spanish Mackerel Fishery

Indigenous (management methods) The NT *Fisheries Act 1988* specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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.

References	
Broderick et al. 2011	Broderick, D., Ovenden, J., Buckworth, R., Newman, S., Lester, R. and Welch, D. (2011). Genetic population structure of grey mackerel *Scomberomorus semifasciatus* in northern Australia. *Journal of Fish Biology*, **79:** 633–661.
Charters et al. 2010	Charters, R., Lester, R., Buckworth, R., Newman, S., Ovenden, J., Broderick, D., Kravchuk, O., Ballagh, A. and Welch, D. (2010). The stock structure of grey mackerel *Scomberomorus semifasciatus* in Australia as inferred from its parasite fauna. *Fisheries Research*, **101:** 94–99.
Newman et al. 2010	Newman, S., Wright, I., Rome, B., Mackie, M., Lewis, P., Buckworth, R., Ballagh, A., Garrett, R., Stapley, J., Broderick, D., Ovenden, J. and Welch, D. (2010). Stock structure of grey mackerel, *Scomberomorus semifasciatus* (Pisces: Scombridae) across northern Australia, based on otolith isotope chemistry. *Environmental Biology of Fishes*, **89:** 357–367.
Welch et al. 2009	Welch, D., Buckworth, R., Ovenden, J., Newman, S., Broderick, D., Lester, R., Ballagh, A., Stapley, J., Charters, R. and Gribble, N. (2009). Determination of Management Units for Grey Mackerel Fisheries in Northern Australia. Fisheries Research and Development Corporation Project 2005/010, Fishing and Fisheries Research Centre Technical Report 4, Fishing and Fisheries Research Centre, James Cook University, Townsville, Australia.
Welch et al. 2015	Welch, D., Newman, S., Buckworth, R., Ovenden, J., Broderick, D., Lester, R., Gribble, N., Ballagh, A., Charters, R., Stapley, J., Street, R., Garrett, R. and Begg, G. (2015). Integrating different approaches in the definition of biological stocks: A northern Australian multi-jurisdictional fisheries example using grey mackerel *Scomberomorus semifasciatus*. *Marine Policy*, **55:**73-80.
Grubert et al. 2013	Grubert, M., Saunders, T., Martin, J., Lee, H. and Walters, C. (2013). Stock Assessments of Selected Northern Territory Fishes. Fishery Report 110, Northern Territory Government, Australia.
Department of Agriculture and Fisheries 2016	Department of Agriculture and Fisheries 2016. Grey Mackerel Update. www.daf.qld.gov.au/fisheries/monitoring-our-fisheries/commercial-fisheries/species-specific-programs/monitoring-reporting/grey-mackerel-update
Broderick et al. 2011	Broderick, D., Ovenden, J., Buckworth, R., Newman, S., Lester, R. and Welch, D. (2011). Genetic population structure of grey mackerel *Scomberomorus semifasciatus* in northern Australia. *Journal of Fish Biology*, **79:** 633–661.

Crimson Snapper

Lutjanus erythropterus

Thor Saunders

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Northern Australia	CLF, DF, GOCDFFTF, GOCLF, TRF	Sustainable	Catch, CPUE, egg production, fishing mortality

CLF Coastal Line Fishery, DF Demersal Fishery, GOCDFFTTF Gulf of Carpentaria Demersal Finfish Trawl Fishery, GOCLF Gulf of Carpentaria Line Fishery, TRF Timor Reef Fishery

Stock structure

Crimson Snapper (*Lutjanus erythropterus*) is a widespread Indo-Pacific species found throughout tropical Australian waters. Research on the biological stock structure of this species in Australian waters has only occurred in northern Australia, including the Timor Sea, the Arafura Sea and the Gulf of Carpentaria (GOC) (Salini et al. 2006). A single genetic stock was found across this region. In addition to this northern Australia biological stock, it is considered that the species has a similar biological stock structure to Saddletail Snapper (*Lutjanus malabaricus*), with a Western Australia (North Coast Bioregion) biological stock and a biological stock off the east coast of Queensland (Salini et al. 2006).

Here, assessment of stock status is presented at the biological stock level of northern Australia, which incorporates catch from the Northern Territory (NT) and Queensland's GOC.

Stock status

The NT manages the commercial harvest of Crimson Snapper and Saddletail Snapper together as 'red snapper'. Crimson Snapper has made up around 22% of the red snapper catch for the past 15 years. Analysis of Crimson Snapper using data up to 2016 in a stochastic stock reduction analysis model estimated egg production to be around 70% of that prior to the start of the fishery (Martin 2018), well above conventional fishery targets. Results of this stock assessment additionally indicated that the current harvest rate has a very low (< 8%) probability of causing the stock to become recruitment impaired (Martin 2018).

Harvest of the Queensland component of this stock is estimated to have been below maximum sustainable yield (MSY) (~170 tonnes (t)) (Leigh and O'Neill 2016) since 2012 due to reduced fishing, with no fishing occurring since the 2016–17 financial year. This contrasts with harvests of 150–350 t per year during the period 2004–11. The total allowable commercial catch (TACC) for target species for the Queensland component of the GOCDFFTF was reduced from 1250 t to 450 t in 2014 and changed to a species-specific non-transferable quota entitlement with a TACC of 169 t in 1 July 2016, as part of new permit arrangements. Less than 1 t of Crimson Snapper has been landed by the GOC LF since 2011. There is no reliable estimate of recreational or Indigenous harvest of Crimson Snapper in the GOC, but it is likely to be minor given the offshore nature of the fishery.

The above combined evidence indicates that the current level of fishing mortality is unlikely to cause the northern Australia stock of Crimson Snapper to become recruitment impaired. Based on the evidence provided above, the northern Australia biological stock is classified as a **sustainable stock**.

Biology

Crimson Snapper biology (DAF unpublished data, Fry and Milton 2009, Fry et al. 2009, McPherson et al. 1992, McPherson and Squire 1992, Newman et al. 2000

Species	Longevity / Maximum Size	Maturity (50 per cent)
Crimson Snapper	Northern Australia: 42 years, 470 mm SL East Coast Queensland: 32 years, 790 mm FL	Northern Australia: Males 270 mm SL, Females 350 mm SL East Coast Queensland: Females 485 mm (+/- 1.7) FL

SL Standard length

Distribution

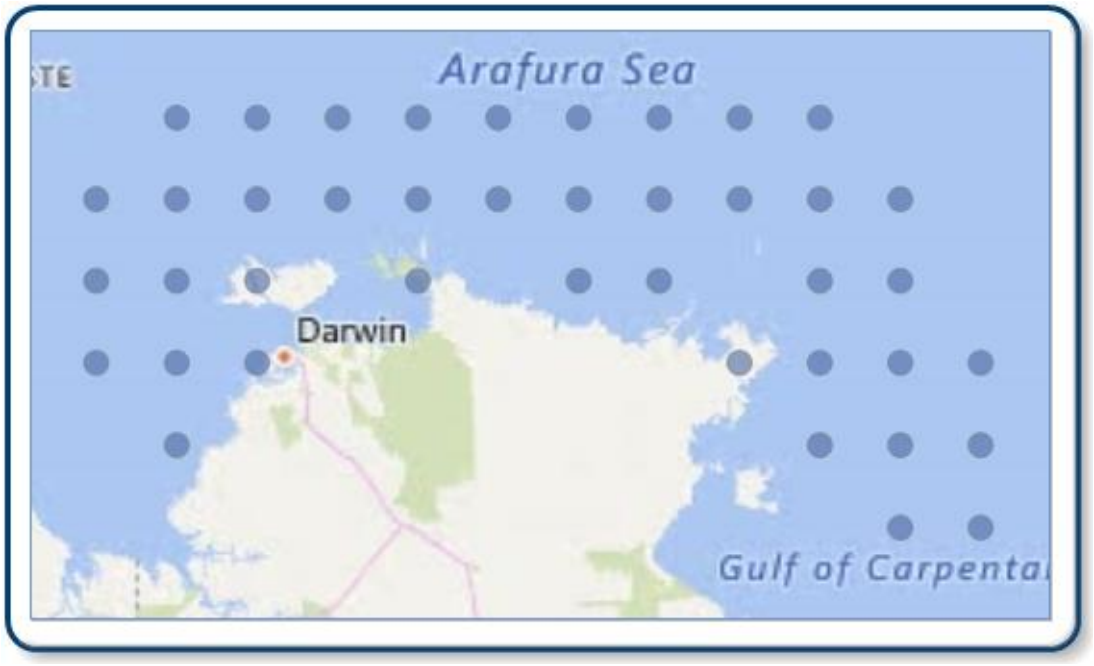

Figure 1. Distribution of reported commercial catch of Crimson Snapper in Northern Territory waters during 2017

Figure 2. Catch of Crimson Snapper in Northern Territory waters by fishing sector from 2000 to 2017

*Recreational and Fishing Tour Operator catch is combined for Crimson and Saddletail Snapper

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Otter trawl	✓		
Fish trap	✓		
Midwater trawl	✓		
Hook and line	✓	✓	✓
Drop line	✓		
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓		
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Management methods			
Gear restrictions	✓	✓	✓

Fishing sector	Commercial	Recreational	Aboriginal
Catch			
	CLF 0.1 t DF 505.5 t TRF 151.8 t	Recreational 20.5 t (2014)^ FTO	Unknown
Active commercial vessels	14 licences in CLF, 8 licences in DF, 5 licences in TRF		

CLF Coastal Line Fishery, DF Demersal Fishery, FTO Fishing Tour Operator, TRF Timor Reef Fishery

^Recreational and FTO catch includes the both Crimson and Saddletail Snapper. The 2014 catch is from the Darwin area only

Indigenous (management methods) The NT *Fisheries Act* 1988 specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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 license and passenger numbers.

References	
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Fry et al. 2009	Fry, G., Milton, D. A., Van Der Velde, T., Stobutzki, I., Andamari, R., Badrudin and Sumiono, B. (2009). Reproductive dynamics and nursery habitat preferences of two commercially important Indo-Pacific red snappers *Lutjanus erythropterus* and *L. malabaricus*. *Fisheries Science*, **75**: 145–158.
Leigh and O'Neill 2016	Leigh, G. M. and O'Neill, M. F. (2016). Gulf of Carpentaria Finfish Trawl Fishery: Maximum Sustainable Yield. Agi-Science Queensland, Department of Agriculture and Fisheries, Queensland.
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Goldband Snapper

Pristipomoides multidens

Thor Saunders

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory, Queensland	Northern Australia	DF, TRF	Sustainable	Catch, Egg production

DF Demersal Fishery, TRF Timor Reef Fishery

Stock structure

Goldband Snapper is widely distributed throughout northern Australia and the tropical Indo–West Pacific. Ovenden et al. (2002) examined the genetic connectivity of Goldband Snapper using mitochondrial DNA from samples collected at six Australian locations (four in Western Australia: Exmouth, Pilbara, Broome, Northern Kimberley; two in the Northern Territory (NT): Timor Sea, Arafura Sea; and three south-East Asian locations (Kupang, Irian Jaya and Madang). The mitochondrial DNA data for Goldband Snapper did not differ genetically among Australian locations, except for the northern Kimberley location that exhibited restricted gene flow. Ovenden et al. (2002) reported that samples taken from locations in South-East Asia were genetically distinct from those sampled from Australian locations. This study indicates that Australian populations of Goldband Snapper are likely to form a single biological stock.

Newman et al. (2000) examined otolith stable isotopes in each of three management regions in Western Australia (Kimberley, Pilbara and Gascoyne) and across northern Australia. Significant differences in stable isotope ratios provided evidence that there was limited mixing of adult Goldband Snapper between all sites sampled in Australia, Indonesia and Papua New Guinea. Therefore, each of these broad locations could be treated separately for the purposes of fishery management, if management arrangements were mediated in a way that harmonised with the spatial patterns of exploitation. The study of Newman et al. (2000) indicates that Goldband Snapper is likely to consist of a number of separate management units around western, northern and eastern Australia.

For assessment purposes, stock status is presented at the management unit (NT-wide level).

Stock status

Goldband Snapper was assessed in using data up to 2016 using a stochastic stock reduction analysis (SRA) model (Martin 2018). Egg production was estimated to be between 60 and 70% of unfished levels, well above conventional fisheries target levels. The SRA outputs also indicated that there is less than a 3% chance of current fishing mortality causing the stock to become recruitment impaired (Martin 2018).

Around 90% of the catch is from the Timor Sea and the western Arafura Sea and most of this catch has been harvested using trap and line. A reduction in effort using these gear types since 2013 has resulted in a decrease in the total catch. On the basis of the evidence provided above, the northern Australia management unit is classified as a sustainable stock.

On the basis of the evidence provided above, the NT Goldband Snapper stock is classified as a sustainable stock.

Biology

Goldband Snapper biology (Newman et al. 2001, Newman and Dunk 2003, Wakefield et al. unpublished data)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Goldband Snapper	30 years, 700 mm FL, 810 mm TL	4.6 years, 417 mm FL , 526 mm TL

FL Fork length; TL Total length

Distribution

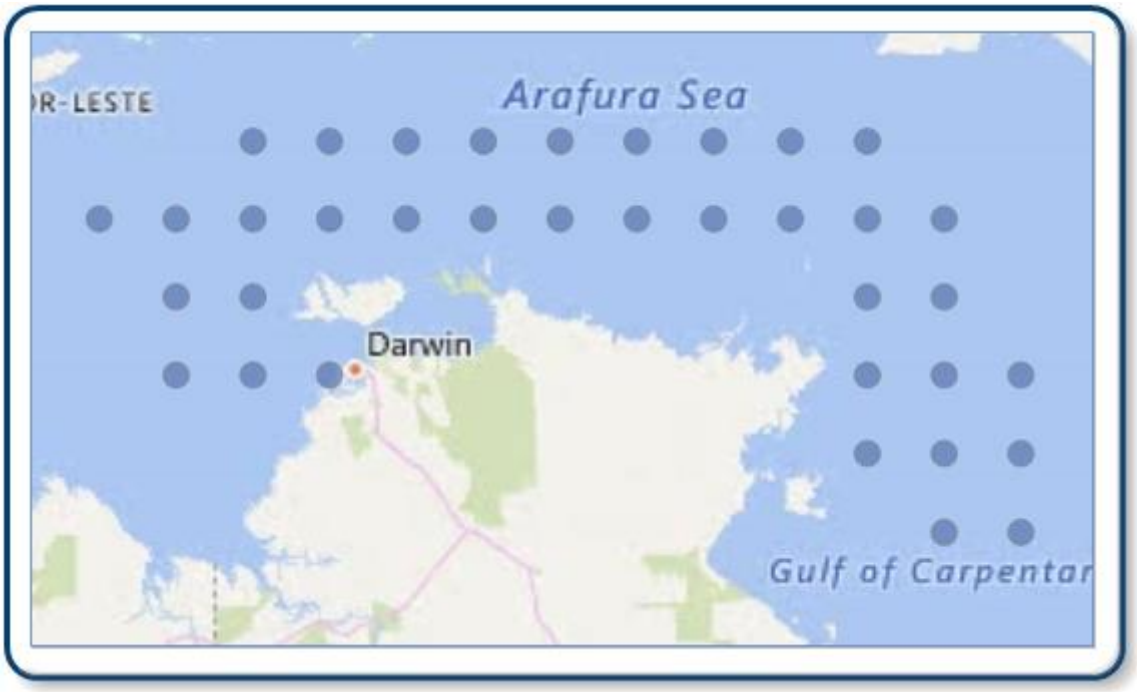

Figure 1. Distribution of reported commercial catch of Goldband Snapper in Northern Territory waters during 2017

Figure 2. Catch of Goldband Snapper in Northern Territory waters by fishing sector from 2000 to 2017 Recreational catch is not reported for this species.

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Otter trawl	✓		
Fish trap	✓		
Midwater trawl	✓		
Hook and line	✓	✓	✓
Drop line	✓		
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓		
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	✓
Possession limits		✓	

Fishing sector	Commercial	Recreational	Aboriginal
Catch			
	DF 340.7 t TRF 194.5 t	FTO 0.6 t^	Unknown
Active commercial vessels	8 licences in DF, 5 licences in TRF		

DF Demersal Fishery, TRF Timor Reef Fishery, FTO Fishing Tour Operator

^Recreational catch is not reported for Goldband Snapper

References	
Martin 2018	Martin, J. (2018). Stock assessment of Goldband Snapper (Pristipomoides multidens) in the Northern Territory Demersal and Timor Reef Fisheries. Unpublished Report, Northern Territory Department of Primary Industry and Fisheries, Darwin.
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Golden Snapper

Lutjanus johnii

Shane Penny

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Darwin Region	CLF, CNF, DF, ONLF	Depleted	Catch, biomass, egg production
Northern Territory	Regional Northern Territory	ACL, CLF, DF, ONLF, TRF	Undefined	Catch

ACL= Aboriginal Coastal Line; CLF = Coastal Line Fishery; FTO = Fishing tour operators; DF = Demersal Fishery; BF = Barramundi Fishery; TRF = Timor Reef Fishery; CPUE = Catch per unit effort

Stock structure

Golden Snapper is a moderately long-lived (i.e. 30 years), late-maturing species that can reach a length of 1 metre (Cappo et al. 2013). It is broadly distributed throughout the tropical and sub-tropical Indo-West Pacific and exhibits a biphasic life history pattern, where juveniles spend several years in estuarine and inshore reef habitats before migrating offshore (to a depth of at least 80 m) as they near sexual maturity (Allen 1985, Kiso and Mahyam, 2003, Tanaka et al. 2011).

The distribution of this species within Australian waters extends from the Kimberley region in Western Australia, around the north of the continent to the southern Great Barrier Reef (Travers et al. 2009). A study of the stock structure of Golden Snapper across this range suggests that many adult populations may exist at a scale of tens of kilometres, although boundaries are unknown (Saunders et al. 2016).

Golden Snapper experience moderate to high harvest rates in some Australian fisheries (particularly those targeting adults of this late-maturing species) which can cause localised depletion. However, it is extremely difficult to collect relevant biological and catch-and-effort information to assess each adult population unit. There are known differences between the concentrated fishing effort around Darwin and the more diffuse effort in other surrounding areas of the Northern Territory (NT). As such, the species is assessed and managed in different management units in the NT.

Stock status

Darwin Region

Golden Snapper are harvested by commercial and recreational sectors across most of the NT, with more than 90% of the total catch occurring within the Greater Darwin Region (i.e. within a radius of approximately 150 km of this population centre). The Greater Darwin Region is therefore assessed as a distinct management unit from the rest of the NT. Within this region, Golden Snappers are a target species for recreational anglers contributing over 70% of the total harvest, 18% from Fishing Tour Operators and 5% predominantly from the Coastal Line Fishery. No estimates of the Indigenous harvest of Golden Snapper are available for the NT. For the purpose of this assessment, only commercial logbooks and recreational data from the Greater Darwin Region have been used.

The most recent assessment (NTG 2018 unpublished) was an update of the 2014 Stock Reduction Analysis model (Grubert et al. 2013) including data up to and including 2017. The results indicate that the Greater Darwin Region remained overfished in 2017 (99% probability) and existing fishing pressure is likely to maintain the level of overfishing. It is estimated that biomass and egg production were 29% and 23%, respectively of the unfished biomass in 1973, indicating this stock is recruitment overfished despite the improvements. Given the recent information on the stock structure of this species (Saunders et al. 2016), it is likely that the assessment incorporates several populations. As the model is driven by the populations that receive the highest harvest rates in the NT, the assigned status can be assumed to be representative of these heavily fished areas, with other less accessible areas being more lightly-fished. The above evidence indicates that the stock is likely to be depleted and that recruitment is likely to be impaired.

In the Darwin area, abundance, catch and catch rate have substantially declined over the past 10 years. The fisheries accessing these exploited stocks operate inshore and include the Coastal Line Fishery, the Barramundi Fishery, Fishing Tour Operators (FTOs) and recreational fishers. Catch limits and area closures were implemented in 2015 to reduce harvest by an estimated 50% to allow for the biomass of Golden Snapper stocks to recover (Grubert et al. 2013). However, it is unlikely the measures introduced in 2015 will have allowed significant recovery of the species given their relatively slow growth. Furthermore, the results of the stock assessment indicate the stock continues to be overfished and the harvest rate is expected to prevent the stock from recovering from its recruitment impaired state. This is despite some above average recruitment events, which have allowed stocks to increase. This level of fishing mortality is expected to prevent the stock from recovering from its recruitment impaired state.

On the basis of the evidence provided above, Golden Snapper in the Darwin Region (NT) management unit is classified as a **depleted stock**.

Regional Northern Territory

Regional NT encompasses all waters outside of approximately 150 km from Darwin. There are populations of Golden Snapper in waters off Arnhem Land, the Gulf of Carpentaria and offshore of population centres in the NT that are unlikely to be overfished because they have been subject to low fishing pressure (Saunders et al. 2016). Less than 10% of the total harvest of Golden Snapper in the NT occurs outside of the Greater Darwin Region, of which recreational anglers contribute nearly 90% of the total catch of Golden Snapper. Less than 6% of the total harvest is attributed to FTOs and commercial fisheries. No estimates of the Indigenous harvest of Golden Snapper are available for the NT. There is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Golden Snapper in the Regional NT management unit is classified as an **undefined stock**.

Biology

Golden Snapper biology (Cappo et al. 2013, Hay et al. 2005, Welch et al. 2014)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Golden Snapper	30 years, 990 mm FL, 15 kg	Varies by location and sex: Males 4–9 years and ~400–600 mm FL, Females 6–10 years and 400–650 mm FL

TL = Total length

Distribution

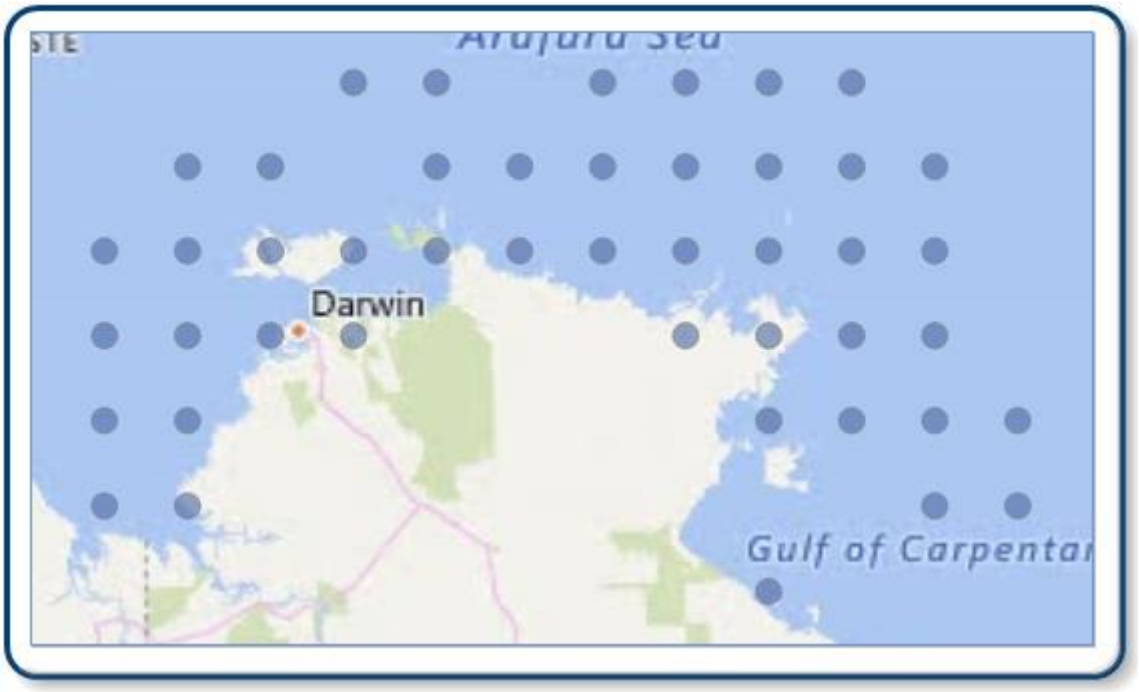

Figure 1. Distribution of reported commercial catch of Golden Snapper in Northern Territory waters during 2017

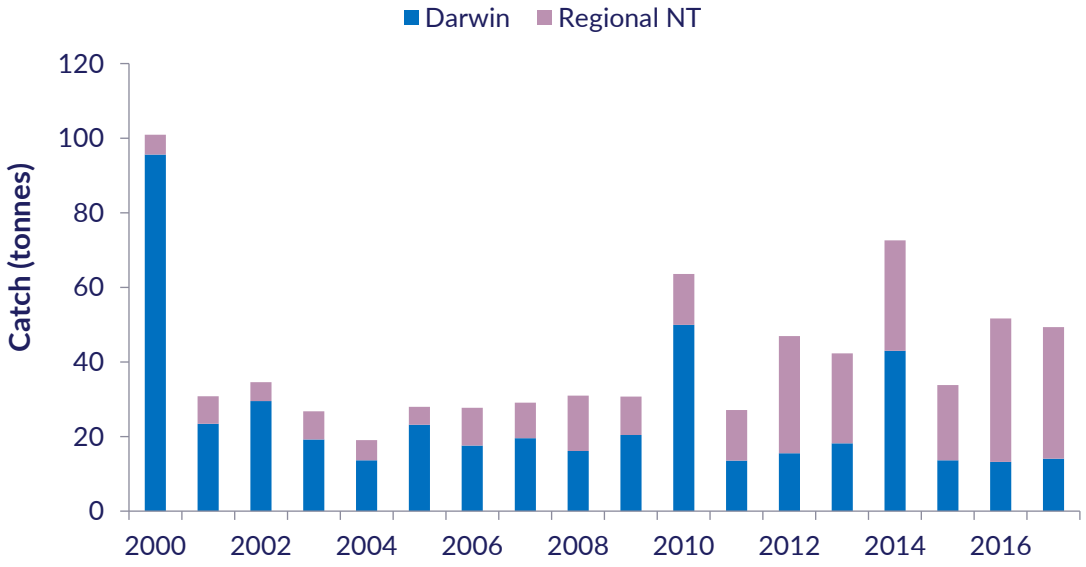

Figure 2. Catch of Golden Snapper in Northern Territory waters by management unit from 2000 to 2017

Darwin, Darwin Area management unit; Regional NT, Regional Northern Territory management unit

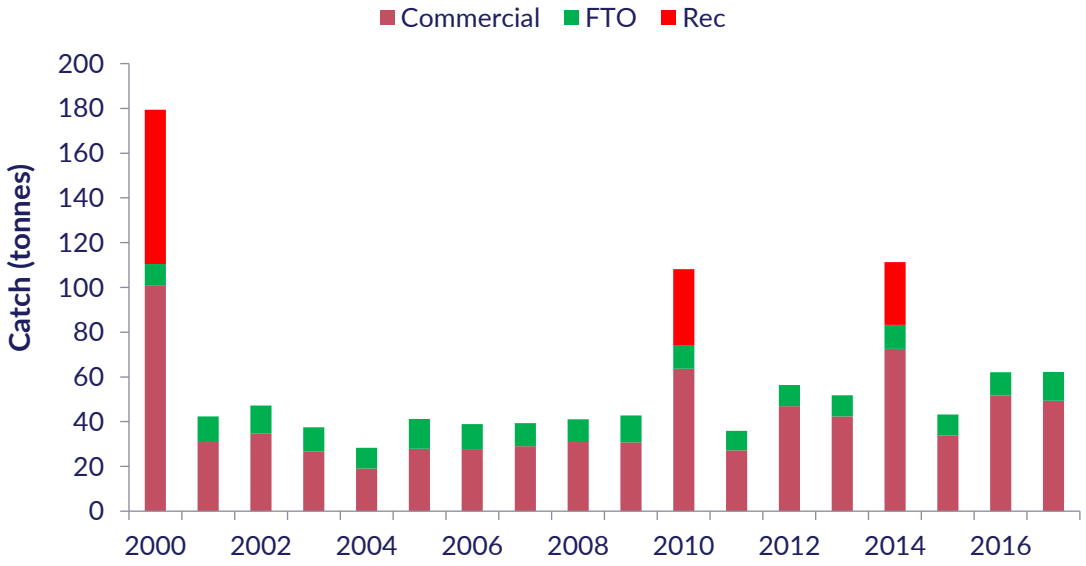

Figure 3. Catch of Golden Snapper in Northern Territory waters by fishing sector from 2000 to 2017

FTO, Fishing Tour Operator; Rec, Recreational

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Gill net	✓		
Rod and line		✓	✓
Spearfishing		✓	✓
Hook and line	✓	✓	✓
Otter trawl	✓		
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓		
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	
Possession limits	✓	✓	
Catch			
	CLF 0.8 t DF 33.4 t ONLF 1.0 t TRF 1.0 t	Recreational: 28 t (2014)^ Fishing tour operators: 25.5 t	Unknown
Active commercial vessels	14 licences in BF, 14 licences in CLF, 8 licences in DF, 7 licences in ONLF, 5 licences in TRF		

CLF Coastal Line Fishery, DF Demersal Fishery, FTO Fishing Tour Operator, ONLF Offshore Net and Line Fishery, TRF Timor Reef Fishery

^Catch for Darwin Area only

Indigenous (management methods) The NT *Fisheries Act 1988* specifies that "…without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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.

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Saddletail Snapper

Lutjanus malibaricus

Thor Saunders

Stock status overview

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Northern Australia	CLF, DF, GOCDFFTF, GOCLF, TRF	Sustainable	Catch, CPUE, egg production, fishing mortality

DF = Demersal Fishery; TRF = Timor Reef Fishery; CLF = Coastal Line Fishery

Stock structure

Saddletail Snapper (*Lutjanus malabaricus*) is a widespread Indo-Pacific species found throughout tropical Australian waters. Research on the biological stock structure of this species in Australian waters has only occurred in northern Australia; including the Timor Sea, the Arafura Sea and the Gulf of Carpentaria (GOC) (Salini et al. 2006). A single genetic stock was found across this region.

Here, assessment of stock status is presented at the biological stock level of northern Australia which incorporates catch from the Northern Territory (NT) and Queensland's GOC.

Stock status

Saddletail snapper is included in the group known as 'red snappers' with a combined total allowable commercial catch of 3800 tonnes (t). Saddletail Snapper has averaged 78% of the annual red snapper catch over the past 10 years, with the 2017 commercial catch of this species being 2077 t. Saddletail Snapper was assessed in 2016 using a stochastic stock reduction analysis (SRA) model (Martin 2017). Egg production in 2016 was estimated to be around 60% of that prior to the start of the fishery; harvest levels in 2016 were considered to only have a 12% chance of causing the stock to be overfished.

Saddletail Snappers in the Queensland component of the stock are mainly taken by the commercial GOC Developmental Fin Fish Trawl Fishery (GOCDFFTF). The maximum sustainable yield for this part of the stock is approximately 150 t (Leigh and O'Neill 2016) and the average catch from 2006 to 2015 was slightly below this level. Less than 0.5 t has been landed by the GOC Line Fishery (GOCLF) since 2013.

The total allowable commercial catch (TACC) for target species for the Queensland GOCDFFTF was reduced from 1250 t to 450 t in 2014 and changed to a species-specific non-transferable quota entitlement with a TACC of 150 t for Saddletail Snappers on 1 July 2016 as part of new permitting arrangements. There has been no fishing in the GOCDFFTF since the start of the 2016–17 financial year. This contrasts with catches of 150 to 250 t per year during the period 2006–2011 and catches of 0–67 t during the period 2012–2015. There is no reliable estimate of recreational or Indigenous harvest of Saddletail Snappers in the GOC, but it is expected to be minor given the offshore nature of the fishery.

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

Biology

Saddletail Snapper biology (DAF unpublished data, Fry and Milton 2009, Fry et al. 2009, McPherson et al. 1992, McPherson and Squire 1992, Newman et al. 2000)

Species	Longevity / Maximum Size	Maturity (50 per cent)
Saddletail Snapper	Northern and Western Australia: 33 years, 680 mm SL East coast Queensland, 20 years; 1000 mm TL	Northern and Western Australia: 9 years, males 280 mm SL, females 370 mm SL East coast Queensland: females 576 mm FL

SL Standard length

Distribution

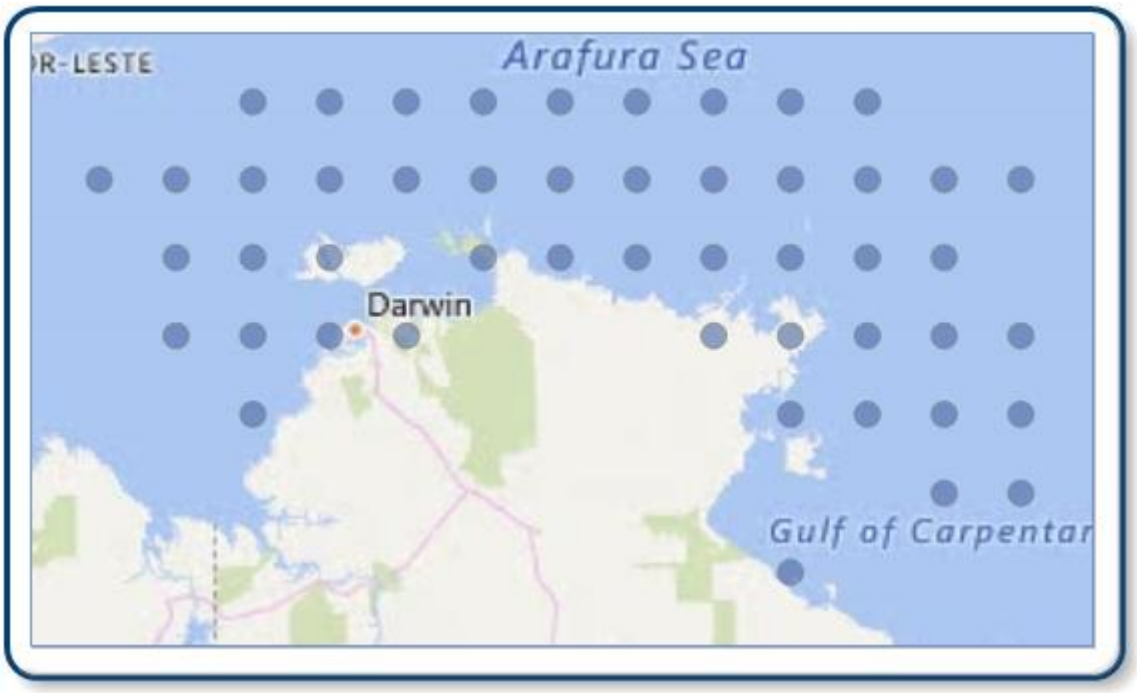

Figure 1. Distribution of reported commercial catch of Saddletail Snapper in Northern Territory waters during 2017

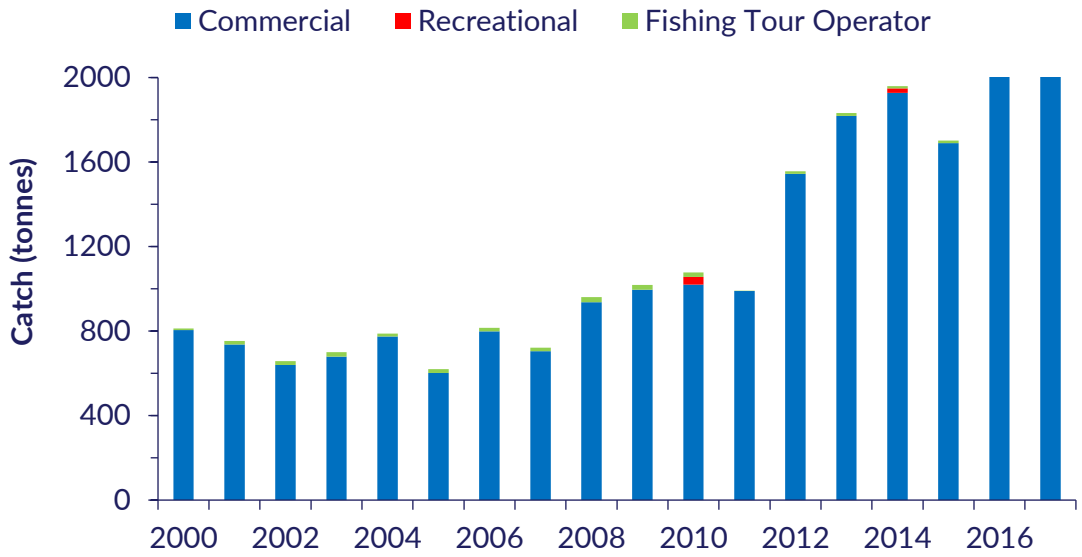

Figure 2. Catch of Saddletail Snapper in Northern Territory waters by fishing sector from 2000 to 2017

*Recreational and Fishing Tour Operator catch is combined for Crimson and Saddletail Snapper

Management and catch table for all fishing sectors

Fishing sector	Commercial	Recreational	Aboriginal
Fishing methods			
Otter trawl	✓		
Fish trap	✓		
Midwater trawl	✓		
Hook and line	✓	✓	✓
Drop line	✓		
Management methods			
Limited entry	✓		
Spatial zoning	✓	✓	
Vessel restrictions	✓		
Catch limits	✓		
Spatial closures	✓	✓	
Temporal closures	✓	✓	
Gear restrictions	✓	✓	✓
Limited entry	✓		
Possession limits		✓	

Fishing sector	Commercial	Recreational	Aboriginal
Catch			
	CLF 0.05 t DF 1892 t ONLF 0.01 t TRF 185.2 t	Recreational 20.5 t (2014)	Unknown
Active commercial vessels	14 licences in CLF, 8 licences in DF, 7 licences in ONLF, 5 licences in TRF		

CLF Coastal Line Fishery, DF Demersal Fishery, FTO Fishing Tour Operator, TRF Timor Reef Fishery

^Recreational and FTO catch includes the both Crimson and Saddletail Snapper. The 2014 catch is from the Darwin area only

Indigenous (management methods) The NT *Fisheries Act* 1988 specifies that "...without derogating from any other law in force in the Territory, nothing in a provision of this Act or an instrument of a judicial or administrative character made under it limits the right of Aboriginals who have traditionally used the resources of an area of land or water in a traditional manner from continuing to use those resources in that area in that manner".

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 license and passenger numbers.

References	
Fry and Milton 2009	Fry, G. and Milton, D. A. (2009). Age, growth and mortality estimates for populations of red snappers Lutjanus erythropterus and L. malabaricus from northern Australia and eastern Indonesia. *Fisheries Science*, 75: 1219–1229.
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Glossary

A

Aggregation. Group of fish that come together, often to feed or spawn.

Area closure. Closure of a given area/fishing ground, often for a defined period. Used as a tool in the management of a fishery.

Australian Fishing Zone (AFZ). The area extending seaward of coastal waters (that is, from 3 nautical miles from the territorial sea baseline) to the outer limits of the Exclusive Economic Zone (EEZ). In the case of external territories, such as Christmas Island, the AFZ extends from the territorial sea baseline to the outer limit of the EEZ. The AFZ is defined in the *Fisheries Management Act 1991*, which also specifies a number of 'excepted waters', notably in Antarctica and the Torres Strait, that are excluded from the AFZ.

B

Benthic. Associated with the bottom of a water body.

Berried female. Female crustacean carrying eggs.

Biodiversity. Biological diversity; variety among living organisms, including genetic diversity, diversity within and between species, and diversity within ecosystems.

Biological reference point. Biomass or fishing mortality level used to guide management decisions. Can be either a 'target reference point' or a minimum biologically acceptable limit ('limit reference point').

Biological stock. Functionally discrete population that is largely distinct from other populations of the same species and can be regarded as a separate entity for management or assessment purposes.

Biomass. Total weight of a stock or a component of a stock.

Biomass proxy. A relative biomass level used in place of a quantitatively estimated biological reference point when the latter is not available. For example, the biomass that sustains maximum economic yield (BMEY).

Bioregion. A region defined by common oceanographic characteristics in its marine environment, and by climate/rainfall characteristics in its inland river systems.

Boat-days. A measure of fishing effort. Refers to the number of 'days' that a fishing licence holder is permitted to fish/has fished.

Bycatch. A species that is (a) returned to the sea either because it has no commercial value or because regulations preclude it being retained, or (b) is affected by interaction with the fishing gear, but does not reach the deck of the fishing vessel.

Bycatch reduction device (BRD). A device that allows fish and other animals to escape immediately after being taken in or with fishing gear.

Byproduct. A species taken incidentally in a fishery during fishing for another species. The species is retained for sale because it has some commercial value.

C

Carapace. The exoskeleton covering the upper surface of the body of a crustacean.

Catch per unit effort (CPUE). The number or weight of fish caught by a unit of fishing effort. Often used as a measure of fish abundance.

Catch rate. *See* Catch per unit effort.

Coastal waters. The waters extending seaward from the territorial sea baseline to a distance of 3 nautical miles. The states and the Northern Territory have jurisdiction over the coastal waters adjacent to them.

Codend. The closed end of a trawl net.

Cohort. Individuals of a stock born in the same spawning season.

Conservation dependent species. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the conservation dependent category at a particular time if, at that time, (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a state or territory; and (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Continental shelf. The continental shelf has been defined in a number of ways. It can mean the area of relatively shallow water that fringes a continent from the shoreline to the top of the continental slope. The top of the continental slope is often defined by the 200 m isobath. Continental shelf is also a defined maritime zone and comprises the continental shelf where it extends beyond the limit of the Exclusive Economic Zone to the limit of the continental margin. This area is also sometimes referred to as the 'extended continental shelf', and its limit is determined by the United Nations Commission on the Limits of the Continental Shelf.

Continental slope. Region of the outer edge of a continent between the relatively shallow continental shelf and the abyssal depths; often characterised by a relatively steep slope.

Cryptic mortality. Substantial mortality of a fish stock, occurring in part of the fishery that cannot be detected in fishery data.

D

Decision rules. Agreed responses that management must make under predefined circumstances regarding stock status. Also called 'control rules' or 'harvest control rules'.

Demersal. Found on or near the benthic habitat (*c.f.* Pelagic).

Developmental fishery. A fishery managed under developmental fishery permits. Developmental fishing involves fishing in an area of Australian jurisdiction as specified in the permit; activities include (a) assessing the commercial viability of a fishery, and (b) assessing the commercial viability of kinds of fishing activities, vessels or equipment specified in the permit.

Discarding. Any part of the catch that is returned to the sea, whether dead or alive

E

Ecologically sustainable. 'Use of natural resources within their capacity to sustain natural processes while maintaining the life-support systems of nature and ensuring that the benefit of the use to the present generation does not diminish the potential to meet the needs and aspirations of future generations'.

Ecological risk assessment. A process of estimating the effects of human actions on a natural resource.

Ecologically sustainable development (ESD). ESD principles require that:

decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations

if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation

the principle of inter-generational equity: that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations

the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making and

improved valuation, pricing and incentive mechanisms should be promoted.

Ecosystem. A complex of plant, animal and microorganism communities that, together with the non-living components, interact to maintain a functional unit.

Effort. A measure of the resources used to harvest a fishery's stocks. The measure of effort appropriate for a fishery depends on the methods used and the management arrangements. Common measures include the number of vessels, the number of hooks set, and the number of fishing days or nights.

Effort restriction. Restriction of the permitted amount of fishing effort (for example, the total number of hooks) in a particular fishery; used as a management tool.

Endangered species. Species in danger of extinction because of its low numbers or degraded habitat, or likely to become so unless the factors affecting its status improve. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the endangered category at a particular time if, at that time, (a) it is not critically endangered, and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Endemic species. Species that occurs naturally and exclusively in a given place.

Environmentally limited. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'overfished stock' as follows: Spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes/impacts or disease outbreaks (i.e. the stock is not recruitment overfished). Fisheries management has responded appropriately to the environmental change in productivity.

***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).** Australia's national environment law. The legislation focuses on protecting matters of national importance, such as World Heritage sites, national heritage places, wetlands of international importance (Ramsar

wetlands), nationally threatened species and ecological communities, migratory species, Commonwealth marine areas and nuclear actions.

Escapement. The number, expressed as a percentage, of fish that survive a particular event (for example, predation, natural mortality, fishing mortality), often to spawn.

Exclusive Economic Zone (EEZ). The area that extends from the limit of the territorial sea, which is 12 nautical miles offshore from the territorial sea baseline, to a maximum of 200 nautical miles, measured from the territorial sea baseline. The EEZ is less than 200 nautical miles in extent where it coincides with the EEZ of another country. In this case, the boundaries between the two countries are defined by treaty. Australia has sovereign rights and responsibilities over the water column and the seabed in its EEZ, including the exploration and exploitation of natural resources.

Exploitation rate. The fraction of total animal deaths caused by fishing, usually expressed as an annual value. Can also be defined as the proportion of a population caught during a year.

F

Fecundity. Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

Fishery-dependent data (survey). Data collected directly on a fish or fishery from commercial fishers, processors and retailers. Common methods include logbooks, fishery observers and port sampling (*c.f.* Fishery-independent data [survey]). More difficult to interpret than fishery-independent data because the fishery-dependent data are influenced by fishers' attempts to maximise economic returns.

Fishery-independent data (survey). Data collected by systematic survey, carried out by research vessels or contracted commercial fishing vessels, to gather information independently of normal commercial fishing operations.

Fishing effort. Amount of fishing taking place, usually described in terms of gear type, and the frequency or period of operations (for example, hooks, trawl hours, net length).

Fishing mortality (F). The instantaneous rate of fish deaths due to fishing a designated component of the fish stock. F reference points may be applied to entire stocks or segments of the stocks, and should match the scale of management unit. Instantaneous fishing mortality rates of 0.1, 0.2 and 0.5 are equivalent to 10 per cent, 18 per cent and 39 per cent, respectively, of deaths of a stock due to fishing. *See also* Mortality, Natural mortality (M).

Fishing power. Effectiveness of a vessel's fishing effort relative to that of other vessels or in other periods of time. Also used to describe the average fishing mortality per unit of effort of a fishing fleet—this often tends to increase with time as a result of improvements in technology and fisher knowledge.

Fishing season. The period during which a fishery can be accessed by fishers. Sometimes referred to as fishing year.

Fishing year. *See* Fishing season.

Fork length. Length of a fish measured as the distance between the tip of the snout and the point of the fork or 'V' of the tail. Commonly used to record the length of commercial fish because it is little affected by damage to the tail fin (*c.f.* Total length). Fork length is measured flat, from point to point, not by stretching a tape along the body surface, which would result in a longer measurement for full-bodied fish like tuna. *See also* Lower-jaw fork length.

G

Gear restriction. Restriction on the amount and/or type of fishing gear that can be used by fishers in a particular fishery; used as a management tool.

Generation time. Average time taken for an individual animal to replace itself in a population.

Ghost fishing. Capture of fish in gear—usually nets or traps—that has been lost.

Gross value of production (GVP). A value obtained by multiplying the volume of catch (whole weight equivalent) by the average per unit beach price. In the case of a multispecies fishery, the fishery's GVP is the sum of the GVP of each species.

H

Harvest control rules. See Decision rules.

Harvest strategy. A set of management actions necessary to achieve defined biological and economic objectives in a given fishery.

High seas. Waters outside national jurisdictions (that is, outside Exclusive Economic Zones).

Hyperstability. A relationship between catch per unit effort (CPUE) and abundance in which, initially, CPUE declines more slowly than true abundance.

I

Incidental catch. *See* Bycatch

Index of abundance. Relative measure of the abundance of a stock (for example, catch per unit of effort).

Index of annual recruitment. Estimate of the relative number of individuals entering the fishery each year, usually based on a data source dedicated to the purpose.

Individual transferable effort. Shares of a total allowable effort that are allocated to individuals. They can be traded permanently or temporarily. Analogous to individual transferable quotas in a fishery managed with a total unit allowable catch. Usually issued at the start of a fishing season.

Individual transferable quota. Management tool by which portions of the total allowable catch quota are allocated to fishers (individuals or companies). The fishers have long-term rights over the quota, but can trade quota with others. *See also* Quota.

Input controls. Management measures that place restraints on who fishes (licence limitations), where they fish (closed areas), when they fish (closed seasons) or how they fish (gear restrictions).

Inshore waters. Waters of the shallower part of the continental shelf, usually less than 3 nautical miles from the coast.

Intrinsic productivity. The natural rate of growth of a population, measured as births minus deaths per capita in the absence of environmental constraints on population increase.

J

Joint authority. An Offshore Constitutional Settlement arrangement whereby a fishery is managed jointly by the Australian Government and one or more states or territories under a single (Commonwealth, or state or territory) jurisdiction.

K

Key commercial species. A species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

Key threatening process. The *Environment Protection and Biodiversity Conservation Act 1999* defines a key threatening process as a process that threatens the survival, abundance or evolutionary development of a native species or ecological community, requiring the formal development of a threat abatement plan. A threatening process is eligible to be treated as a key threatening process if (a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent, or (b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment, or (c) it adversely affects two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities.

L

Latency. Fishing capacity that is authorised for use but not currently being used. Depending on how a fishery is managed, latency might appear in effort (for example, unused vessel statutory fishing rights [SFRs], gear SFRs, quota SFRs, permits or nights fishing) or in quota (for example, where total allowable catches [TACs] are not fully caught in a quota-managed fishery). It is a low-cost indicator of fishers' views about the profitability of a fishery. High levels of latency can suggest that low expected profits in the fishery do not justify fishing. It is likely that fisheries in which latency exists are close to the open-access equilibrium. Apart from being an indicator of efficiency, a high level of latency in a fishery may be detrimental to the fish stock and to any chances the fishery has of being profitable in the future. For example, a significant increase in the market price of a fishery's product is likely to entice inactive effort into the fishery. In input-controlled fisheries, if enough inactive effort is triggered, the fish stock could be jeopardised and/or profits dissipated as soon as they arise if the fishery is driven to a point of open-access equilibrium. In an output-controlled fishery, this is less of a problem, provided that TACs are set in accordance with appropriate targets.

Limited-entry fishery. Fishery in which the fishing effort is controlled by restricting the number of operators. Usually requires controlling the number and size of vessels, the transfer of fishing rights and the replacement of vessels (*c.f.* Open-access fishery).

Logbook. Official record of catch-and-effort data completed by fishers. In many fisheries, a licence condition makes the return of logbooks mandatory.

M

Mark–recapture. A method for estimating population size and other parameters by tagging and releasing fish, and comparing the ratios of marked (tagged) to unmarked (untagged) individuals in future catches.

Maximum economic yield (MEY). The sustainable catch level for a commercial fishery that allows net economic returns to be maximised. For most practical discount rates and fishing costs, MEY implies that the equilibrium stock of fish is larger than that associated with maximum sustainable yield (MSY). In this sense, MEY is more environmentally conservative than MSY and should, in

principle, help protect the fishery from unfavourable environmental impacts that could diminish the fish population.

Maximum sustainable yield (MSY). The maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions. MSY defined in this way makes no allowance for environmental variability, and studies have demonstrated that fishing at the level of MSY is often not sustainable.

Migration. Non-random movement of individuals of a stock from one place to another, often in groups.

Minimum size (minimum legal size). Size below which a captured animal may not legally be retained. Usually specified by species. May be varied as a management tool.

Model (population). Hypothesis of how a population functions; often uses mathematical descriptions of growth, recruitment and mortality.

Mortality. Deaths from all causes (usually expressed as a rate or as the proportion of the stock dying each year).

Multispecies fishery. A fishery in which fishers' profits depend on the catch of more than one species. Fishery data from multispecies fisheries are more difficult to interpret because of uncertainty around the relative targeting of individual species.

N

Natural mortality. Deaths of fish from all natural causes except fishing. Usually expressed as an instantaneous rate or as a percentage of fish dying in a year. *See also* Fishing mortality (F), Mortality.

Nautical mile. A unit of distance derived from the angular measurement of one minute of arc of latitude, but standardised by international agreement as 1852 metres.

Nominal catch. The sum of the catches that are landed (expressed as live-weight equivalent). Nominal catches do not include unreported discards.

Non-target species. Species that is unintentionally taken by a fishery or not routinely assessed for fisheries management. *See also* Bycatch, Byproduct.

O

Observer. A certified person on board fishing vessels who collects scientific and technical information for the management authority on the fishing operations and the catch. Observer programs can be used for monitoring fishing operations (for example, areas fished, fishing effort, gear characteristics, catches and species caught, discards, collecting tag returns). Observers may or may not have legal coercion powers, and their data may or may not be used for nonscientific purposes (for example, enforcement), depending on the situation.

Oceanic. Open-ocean waters beyond the edge of the continental shelf.

Offshore Constitutional Settlement (OCS). The 1982 package of uniform national, state and territory laws that forms the basis for Australian governments (national, state and territory) to enter into agreements for specified fisheries to be managed by a particular government or group of governments. A fishery might be managed by the Australian Government, one or more state or territory governments, or any combination of the two acting through a joint authority. Fisheries for which OCS arrangements are not in place may be managed under joint control or continue under current management arrangements.

Open-access fishery. Fishery in which there is no limit on the number of operators or vessels allowed to operate in the fishery (*c.f.* Limited-entry fishery). Such a fishery is liable to suffer the 'tragedy of the commons', where a 'race to fish' generally leaves a fish stock below its maximum sustainable yield and unable to support an economically sustainable fishery. Under open access, a fishery operates with a harvest and effort that result in total revenue-equalling costs, with no economic profits being generated. The fishing effort employed at this point exceeds the level that would achieve maximum economic yield.

Otoliths. Bone-like structures formed in the inner ear of fish. The rings or layers can be counted to determine age.

Otolith microchemistry. A technique used in fisheries management and fisheries biology to delineate stocks, and characterise movements and natal origin of fish.

Output controls. Management measures that place restraints on what is caught, including total allowable catch, quota, size limits and species.

Overfished stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'overfished stock' as follows: Spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (i.e. recruitment overfished). Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.

Ovigerous. Carrying or bearing eggs.

P

Panmictic. A panmictic population is one where all individuals have equal opportunity of mating. This assumes that there are no mating restrictions, either genetic or behavioural, on the population.

Pelagic. Inhabiting surface waters rather than the sea floor. Usually applied to free-swimming species such as tunas and sharks (*c.f.* Demersal).

Performance indicator (performance measure). Parameter used to assess the performance of a fishery against predetermined sustainability objectives.

Planktonic larval stage. An early life stage of many marine organisms, when larvae are dispersed in the water column before settling on suitable habitat and developing into their adult form.

Population modelling. Mathematical description of a population that is designed to fully simulate the life cycle of animals in that population. Can project the effects on the population of environmental factors or biological characteristics of these animals.

Possession limit. The maximum number of fish that a person is allowed to have in their possession at any time. It discourages the accumulation of large quantities of fish by recreational fishers.

Precautionary approach. Approach to fisheries management where the absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.

Pre-recruits. The proportion of a population that has not yet entered a fishery (that is, not able to be caught or retained).

Productivity (biological). An indication of the birth, growth and death rates of a stock. A highly productive stock is characterised by high birth, growth and mortality rates, and can sustain high harvesting rates.

Productivity (economic). The ability of firms or an industry to convert inputs (labour, capital, fuel, etc.) into output. Economic productivity is often measured using productivity indexes, which show whether more or less output is being produced over time with a unit of input. The index is calculated by comparing changes in total output (fish) to changes in total inputs such as fuel, labour and capital.

Protected species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Q

Quota. Amount of catch allocated to a fishery as a whole (total allowable catch), or to an individual fisher or company (individual transferable quota).

Quota species. Species for which catch quotas have been allocated.

R

Recruit. Usually, a fish that has just become susceptible to the fishery. Sometimes used in relation to population components (for example, a recruit to the spawning stock).

Recruitment failure. A situation in which a population is not able to naturally produce viable offspring as a consequence of physical factors (for example, damaged spawning areas) or biological factors (for example, inadequate numbers of fish).

Recruitment overfished. The point at which a stock is considered to be recruitment overfished is the point at which the spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced.

Recruitment overfishing. A level of exploitation that, if maintained, would result in the stock falling to levels at which there is a significant risk of recruitment and stock collapse. The corresponding term for the state of the stock is 'recruitment overfished', in which the average annual recruitment to the stock is significantly reduced. Both terms define a limit reference point (for exploitation rate or stock size) beyond which urgent management action should be taken to reduce exploitation and recover the stock.

The following uses of the term provide some guidance to how it should be interpreted and applied.

The FAO fisheries glossary (**www.fao.org/fi/glossary/default.asp**) defines recruitment overfished as 'a situation in which … annual recruitment … has become significantly reduced. The situation is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year'.

Cook[1] defines recruitment overfished as a situation in which 'a reduction in the proportion of fish caught would be more than compensated for by the increased number of recruits to the fishery as a result of increased escapement of mature fish'.

The EPBC *Guidelines for the ecologically sustainable management of fisheries*[2] define recruitment overfishing as occurring 'where fishing activities are causing a reduction in recruitment in succeeding years and cause the mortality of too many fish in total, too many pre-productive fish, or

[1] Cook, JG 1984, Glossary of technical terms, in RM May (ed.), *Exploitation of marine communities*, Springer-Verlag, Berlin, 341–348.
[2] Australian Government Department of the Environment and Water Resources 2007, *Guidelines for the ecologically sustainable management of fisheries*, 2nd edn, DEWR, Canberra.

too many fish that have only spawned a few times. The end result is that the stock can no longer replenish itself adequately'.

Various jurisdictions have defined a biomass limit reference point (B_{LIM}) that also corresponds to this concept of recruitment overfishing. These limit reference points (LRPs) are often related to the biomass at which maximum sustainable yield (MSY) occurs. Examples of LRPs include the following:

$B_{LIM} = 0.5B_{MSY}$ (Commonwealth of Australia).

$B_{LIM} = 0.5B_{MSY}$ (or greater) (United States).

B_{LIM} is usually defined relative to fishing mortality rates rather than biomass (European Union).

$B_{LIM} = 0.5B_{MSY}$ (or greater—for example, for forage fish) (Marine Stewardship Council).

New Zealand explicitly uses the concept of recruitment overfishing, which is defined as occurring 'when excessive fishing effort or catch reduces the spawning stock biomass to a level below which future recruitment levels may be jeopardised; this spawning biomass level should correspond closely to the biomass limit reference point'.

No jurisdictions appear to have explicitly defined how much recruitment would be reduced to constitute recruitment overfishing, perhaps because recruitment tends to fluctuate much more than overall stock biomass.

Reference point. Indicator of the level of fishing (or stock size); used as a benchmark for assessment (*see also* Biological reference point).

Relative abundance. The number of living individuals at a point in time, expressed as a fraction of the average number of living individuals estimated before the beginning of fishing.

Risk analysis. Analysis that evaluates the possible outcomes of various harvesting strategies or management options.

S

Seasonal closure. Closure of a fishing ground for a defined period; used as a management tool, often to protect a particular component of the stock.

Settlement. Transition from a pelagic larval stage to a substrate-associated juvenile or adult existence.

Shared biological stock. A biological stock that spans the waters of more than one jurisdiction.

Shark finning. The removal and retention of shark fins. The remainder of the body is generally discarded, often still alive. The process has been banned in Australian waters, and management measures are in place to reduce or restrict targeting of sharks for fin markets by illegal, unreported and unregulated fishing.

Size frequency. *See* Length-frequency distribution.

Spatial closure. A method of fisheries management that prevents fishing in a defined area.

Spawning biomass (SB). The total weight of all adult (reproductively mature) fish in a population.

Species complex. Group of similar species that are often difficult to differentiate without detailed examination.

Species group. *See* Species complex.

Standardised data. Data that have been adjusted to be directly comparable to a unit that is defined as the 'standard' one. Standardised catch-per-unit-effort data are often used as an indicator of fish abundance.

Standard length (SL). The length of a fish measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the midlateral portion of the hypural plate.

Statutory fishing right (SFR). Right to participate in a limited-entry fishery. An SFR can take many forms, including the right to access a particular fishery or area of a fishery, the right to take a particular quantity of a particular type of fish, or the right to use a particular type or quantity of fishing equipment.

Stochastic demographic modelling. Stock assessment method used to estimate the intrinsic productivity and response to fishing of fish stocks, based on age structure, allowing for variation in annual recruitment. Mostly used for stock assessment of shark species.

Stock. Within the *Status of key Australian fish stocks reports*, the term 'stock' is used generically in reference to all three levels of stock status assessment—that is, biological stocks, management units and populations assessed at the jurisdictional level. *See also* Biological stock.

Stock–recruitment relationship. Relationship between the size of the parental biomass and the number of recruits it generates. Determination of this relationship is difficult, and involves studying the population's size–age composition, and growth and mortality rates.

Stock reduction analysis. A method of inferring the extent to which a fisheries stock is likely to have been reduced by fishing, assuming constant recruitment. Requires only a time series of total catch data, but can also incorporate other information.

Stock synthesis model. A statistical framework for calibration of a population dynamics model, using a range of fishery and survey data. It is designed to accommodate both age and size structure in the population, and multiple stock subareas. Selectivity can be cast as age specific only, size specific in the observations only, or size specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents that simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data.

Sustainable stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'sustainable stock' as follows: Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (that is, not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished.

T

Tagging. Marking or attaching a tag to an animal so that it can be identified when recaptured; used to study fish growth, movement, migration, stock structure and size.

Target fishing (targeting). Fishing selectively for particular species or sizes of fish.

Target species. *See* Key commercial species.

Temporal closure. Closure that is implemented to protect fish stocks during specific stages of their life cycle (for example, while spawning).

Territorial sea (12 nautical mile limit). 'The Territorial Sea is a belt of water not exceeding 12 nautical miles in width measured from the territorial sea baseline. Australia's sovereignty extends to the territorial sea, its seabed and subsoil, and to the air space above it. This sovereignty is exercised in accordance with international law as reflected in the Convention on the Law of the Sea.

The major limitation on Australia's exercise of sovereignty in the territorial sea is the right of innocent passage for foreign ships. The territorial sea around certain islands in the Torres Strait is 3 nautical miles'[3].

Territorial sea baseline. The baseline from which all the zones (for example, the Exclusive Economic Zone) of Australia's maritime jurisdiction are measured. The baseline is defined as the level of lowest astronomical tide, but straight baselines and bay or river closing lines may be drawn further out from the low-water mark to encompass areas such as the mouths of rivers, bays, ports and fringing reefs.

Threatened species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Total allowable catch (TAC). For a fishery, a catch limit set as an output control on fishing (*see also* Output controls). Where resource-sharing arrangements are in place between commercial and recreational fishers, the term total allowable commercial catch (TACC) applies. The term 'global' is applied to TACs that cover fishing mortality from all fleets, including Commonwealth, state and territory fleets.

Total allowable catch (TAC), actual. The agreed TAC for the species with amendments applied, such as carryover or debits from the previous year.

Total allowable commercial catch (TACC). *See* Total allowable catch (TAC).

Total allowable effort (TAE). An upper limit on the amount of effort that can be applied in the fishery.

Total length (TL). The length from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, not measured over the curve of the body (*c.f.* Fork length).

Transitional–depleting stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'transitional–depleting stock' as follows: A deteriorating stock—biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished.

Transitional–recovering stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'transitional–recovering stock' as follows: A recovering stock—biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring.

Trigger points. Pre-specified quantities (total catch, spawning biomass, etc.) that indicate the need for a review of fishery management.

[3] Geoscience Australia 2012, *Maritime boundary definitions*, Geoscience Australia, Canberra, **www.ga.gov.au/marine/jurisdiction/maritime-boundary-definitions.html.**

U

Undefined stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'undefined stock' as follows: Not enough information exists to determine stock status.

Unfished biomass. Biomass of a stock that has not been fished (also called the 'unfished' or 'unexploited' biomass or unfished level).

V

Vessel monitoring system (VMS). Electronic device that transmits the identity and location of a vessel.

Virgin biomass. *See* Unfished biomass.

Vulnerable species. Species that will become endangered within 25 years unless mitigating action is taken. *See also* Endangered species. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the vulnerable category at a particular time if, at that time (a) it is not critically endangered or endangered, and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

W

Warp strike. Incident of seabirds striking trawl gear while interacting with fishing activity. Often results in mortality.

Weight-of-evidence approach. The systematic consideration of a range of biological and fisheries information for assembly and review of indicators of biomass status and levels of fishing mortality, to support a status determination. Lines of evidence used in the weight-of-evidence approach include empirical indicators (catch, effort, catch rate, size- or age-based indicators, spatial and temporal distribution of the fishery), risk assessments, fishery-independent surveys, quantitative stock assessment models and harvest strategies.

Y

Yield. Total weight of fish harvested from a fishery.

Yield-per-recruit analysis. Analysis of how growth and natural mortality interact to determine the best size of animals to harvest; for example, it may be more economically beneficial to catch fish when they are young and plentiful, or when they are older and larger but fewer. Biological reference points based on yield-per-recruit analysis will be expected to lack precaution because the potential for reduced future recruitment resulting from decreased parental biomass is not considered.