Review of Recovery Planning for Threatened Sharks:

Status, Analysis & Future Directions

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A report prepared for
Australian Marine Conservation Society
and Humane Society International

December 2019

Disclaimer:

In preparing this report the author has made all reasonable efforts to ensure the information it contains is based on evidence. The views expressed in this report are those of the author based on that evidence. The author does not guarantee that there is not further evidence relevant to the matters covered by this report and therefore urges those with an interest in these matters to conduct their own due diligence before drawing their own conclusions.

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Ventral view of the green sawfish, *Pristis zijsron*.
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Executive Summary

Since recovery plans, conservation advice and management strategies have been implemented for shark and ray species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) there have been no measurable improvements in their status. They all remain threatened with extinction; none have been downgraded since being listed and several have had their threatened status upgraded by the International Union for the Conservation of Nature (IUCN). As a statutory 10-year review of the EPBC Act has recently been announced it is timely to consider how to make the next 10 years a decade in which the status of threatened sharks is dramatically improved.

Fishing mortality was the primary reason for shark species being listed as threatened and remains a threat to their recovery due to no reliable independent verification of interactions with threatened shark populations (with the exception of some Commonwealth fisheries) and the unwillingness to implement spatial closures to protect sufficient areas of critical habitat for most populations. Both climate change and human population growth are also having a significant impact on threatened sharks by making parts of their range uninhabitable or degraded so that it is less productive. Unless these factors are addressed it is highly likely that shark species already listed as threatened will remain so, with some up-listed and new species added over time.

Measuring the performance of recovery plans has been hampered by vague high-level objectives and no quantitative tools to track changes in population sizes. Recent progress on measurement has been made using close-kin genetics that will enable future changes in the population size of threatened sharks to be better measured and tracked. In addition, recovery plans, like management strategies, need to set reference points related to population status to be clear about what levels of recovery are necessary to change the threat level or remove a shark species from the threatened species list.

Regarding recovery plan actions, there is a tendency to include and/or complete actions that can be done rather than those that need to be done to recover the species, often due to funding constraints or impacts on regional/national economic development. So, while many actions have been completed at a total cost of many millions of dollars there has been no measurable improvement in the conservation status of threatened sharks. It may be that those completed actions are helping offset increasing threats from elsewhere (e.g. climate change, economic development and international inaction). While there is some evidence that this is true of climate change, there is no reliable information to demonstrate this for other threats.

The weight of evidence is that the current system of policy, management and science being used to protect and recover threatened shark species has not worked for the past 20 years and must change. Solutions (and the expenditure that goes with them) must be shown to have a high chance of success and their success or failure must be measurable. Such solutions may include; for fishing: further buying out of commercial fishing effort in critical habitats, placing cameras on boats with pre-agreed threatened shark interaction responses and preventing recreational fishing in critical habitats; for society: not undertaking economic development that negatively affects critical habitats, providing measurably equivalent offsets and taking far stronger action nationally to support the global reduction of greenhouse gas emissions.

Findings

GENERAL

Most threatened species listed under the EPBC Act do not have recovery plans but almost all have conservation advice which provide guidance for recovery objectives and actions.

The steadily increasing number of threatened species over 20 years has overwhelmed the processes originally put in place when the EPBC Act was promulgated in 1999 that supported their recovery through compulsory recovery plans and greater funding.

The EPBC Act was amended in 2006 to give the Environment Minister discretion over the making of recovery plans for threatened species, and government funding has not kept pace with increased threatened species listings.

Notwithstanding the usefulness of the Species Profile and Threats (SPRAT) database, assimilating all the information on a threatened species, then determining recovery objectives and actions takes significant time and resources.

While the making, broad content and review of recovery plans is set out in the EPBC Act there is no requirement to implement any of the recovery actions and no effective accountability if objectives are not achieved.

The role of economics and society in species recovery is significant, that is, economic and/or social incentives affect the attitude of government and non-government stakeholders towards supporting species recovery or not.

The accumulated direct and indirect human impacts on threatened species mean that the recovery of many species to former population levels is no longer realistic and this places a greater onus on humanity to manage their preservation in the wild at lower population levels.

THREATENED SHARKS

No threatened shark listed under the EPBC Act has had its listing downgraded or removed despite some having been listed for over 20 years with international bodies like IUCN upgrading the threat level for some populations during that time.

All threatened shark species either have a recovery plan or a management strategy (for Conservation Dependent listed species), except for the Maugean skate which has conservation advice only.

Current recovery efforts for threatened shark species have not been successful and it is highly likely that additional species will be added to the list in future particularly as sources of human induced mortality continue unmeasured and/or unmanaged.

Despite progress being made to reduce fishing mortality on some threatened shark species, measuring how successful it has been remains problematic with no reliable independent verification of interactions across fishery jurisdictions (except for the Commonwealth) in recent years.

Threatened shark recovery plans are written in broad terms in relation to species recovery whereas management strategies are more specific in terms of a recovery reference point and the timeframe in which it is to be achieved.

The absence of a recovery plan or management strategy has not stopped action being taken to protect the Maugean skate which benefits from significant local support within Tasmania, but its unique circumstances mean that drawing parallels with other threatened sharks is of limited use.

The absence of knowledge until recently about numbers or biomass of threatened sharks combined with uncertainty about the quantum of human induced mortality means that it has been difficult to determine whether the conservation status of threatened sharks should be changed.

The rate of change in shark population sizes is in part driven by their life history and measurable change is likely only to be observed on a decadal basis.

As sharks have life histories closer to those of mammals and birds many of the conservation approaches used in protecting these groups of animals may be applicable to them.

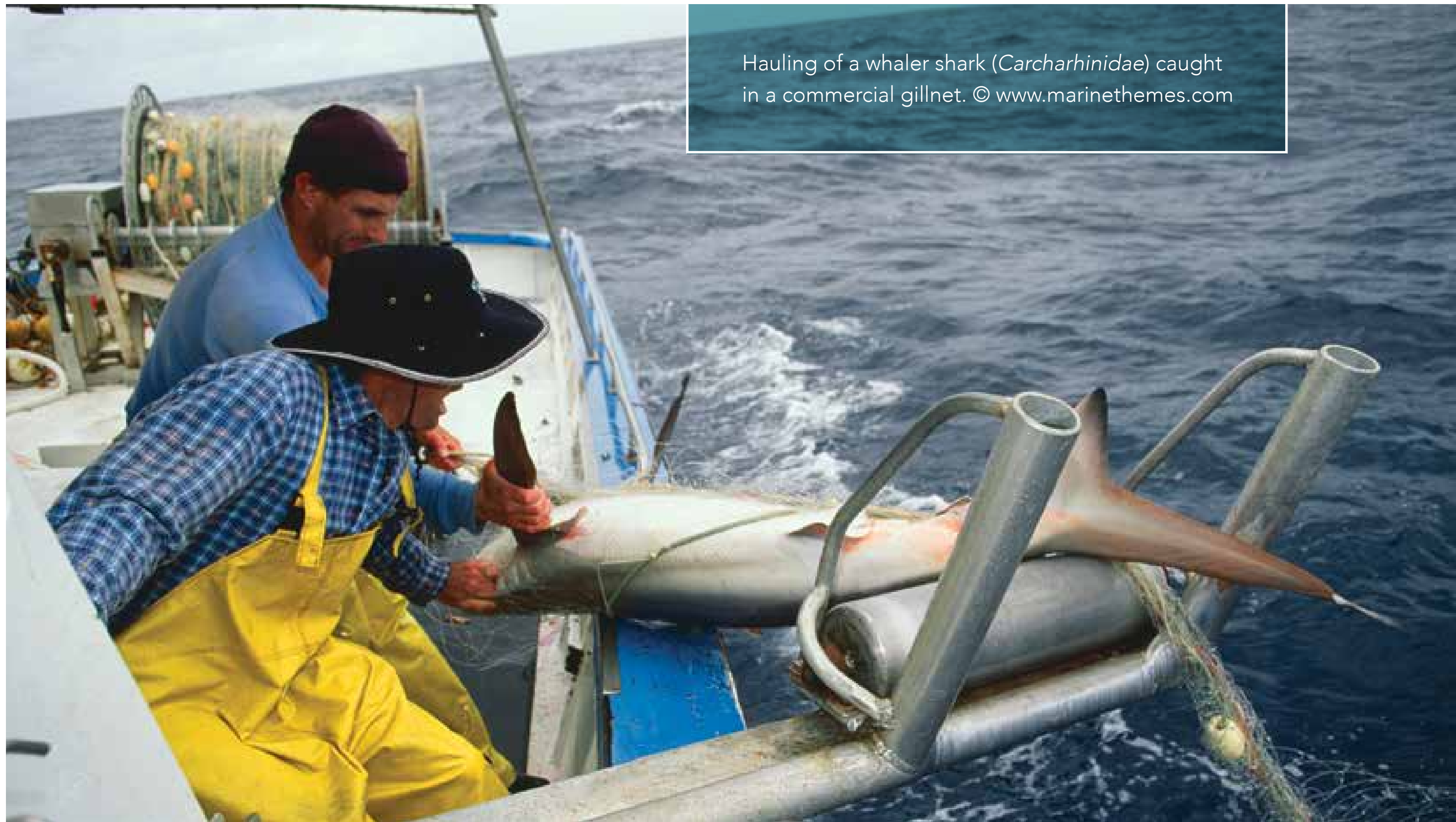
Reviewing shark recovery plans and management strategies does appear to have benefits in terms of marking progress and focussing the next plan on resolving outstanding issues and adding new actions to pursue the plan's objective(s).

The identification and mapping of critical habitat for threatened sharks is improving but remains relatively poor for some species, and habitat protection is yet to be linked to quantifiable productivity improvements and measurable recovery.

Key river systems and their estuaries remain open to fishing using methods that are known to impact on threatened river sharks and sawfishes without the verification and management tools in place to measure or respond to any interactions.

The costing of shark recovery plans is poor with management strategies for Conservation Dependent listed species relatively better. Both rely at least in part on competitive project-based funding from a variety of Australian and state/NT government bodies, and in some cases the fishing industry, that can lead to patchy progress in addressing actions.

Recovery coordination across jurisdictions, both domestically within Australia and internationally, varies from good to poor with the same species often listed at different levels of threat or sometimes not at all. Occasionally this can be appropriate as in the case of grey nurse shark eastern and western populations.



Hauling of a whaler shark (*Carcharhinidae*) caught in a commercial gillnet. © www.marinethemes.com

Critically endangered (east coast) grey nurse shark, *Carcharias taurus*, with a hook lodged in its mouth. Hook ingestion by *C. taurus* causes significant internal injuries which are often fatal. © Mark Gray

Recommendations

GENERAL

1 The Department of Environment must introduce a formal risk assessment process prior to the Minister (or their delegate) deciding on whether or not a recovery plan is required to ensure that the instrument most likely to lead to the recovery of a threatened species is implemented.

2 Sufficient resources must be allocated by government so that recovery plans can be developed for all eligible species resulting from the risk assessment.

3. To improve accountability, the EPBC Act must be amended to compulsorily require the implementation of the priority actions of a recovery plan or conservation advice to be funded by the government to reduce the risk of further decline in the status of all listed threatened species.

THREATENED SHARKS

4 That the TSSC reconsider the threatened status of the three sawfish populations currently listed as Vulnerable under the EPBC Act at the time the multispecies recovery plan is reviewed or by 2022, whichever is the sooner.

5 That the narrow sawfish be considered for listing as soon as possible.

6 That there be improved collaboration between the various Australian jurisdictions and funding sources to ensure policy and projects on threatened shark species demonstrate a clear link with improving population status.

7 A national shark strategy, supported by a standing stakeholder body, be developed with the aim of preventing further populations being listed as threatened that includes policy-based or statutory recovery reference points (based on population numbers or biomass) to be achieved within set timeframes.

8 The 'Species in Peril' and the CSIRO extinction risk processes should be monitored for their application to threatened sharks as a future means of better allocating limited recovery resources.

9 The common assessment method (CAM) process is applied by all states and territories with one of its success criteria to minimise the disparity of listing classification for shark species across Australian jurisdictions, and a second to reach agreement on a national funding model for threatened species recovery.

10 Where it is not known already, the highest priority must be placed on determining a reliable estimate of the current number and/or biomass of each threatened shark species, using non-lethal techniques.

11 Close-kin genetics should be the current preferred option for determining the population size once a species is listed (if not done already) subject to feasibility and cost-effectiveness tests.

12 Reference points should be implemented in conjunction with rules that compel management action by the relevant jurisdiction(s) to halt any decline well before a population approaches the limit reference point.

13 The effect of externalities (e.g. climate change & economic development) must be recognised as part of the species recovery process to ensure that recovery reference points and associated timelines account for them.

14 Mapping and protection of critical habitat for threatened shark species should receive further investment and its contribution to their productivity and recovery potential quantified.

15 That jurisdictions whose fisheries interact with threatened shark species develop and implement a consistent and cost-effective means of accurately monitoring and reporting interactions, and expand it to all fishing sectors as technology becomes available to do so.

16 Australian government reviews the related processes of Wildlife Trade Operations and threatened species recovery to ensure consistency with the aim of compelling recovery action under both parts of the EPBC Act.

17 The Australian government develops guidelines to support the development, implementation and administration of recovery plans (and equivalent documents) for threatened marine species.

18 Recovery plan and management strategy reviews should continue and be provided with adequate funding to engage the relevant scientists and other stakeholders, and given threatened shark life histories, are best undertaken at five-year intervals.

19 Indigenous Australians are consulted in the process to recommend whether or not a shark species should be listed as threatened, but the decision whether or not to do so remains based on scientific evidence.

20 Indigenous Australians are engaged in the development and implementation of recovery plans and participate in the review of recovery plans.

21 That a broad human effects assessment for threatened shark species is undertaken with reference to impacts on abundance, distribution, phenology, physiology and variability.

Introduction

Australia's aquatic domain contains a diverse range of sharks, skates and rays, some of which are only found here and others which we share with our neighbours and sometimes most of the world. Because of our relative isolation and relatively small (and city dwelling) human population large parts of our aquatic domain remain in good condition and support what are now globally rare or threatened shark populations. However, even within Australia we have significantly impacted many shark populations through fishing and habitat change to the point where some are faced with the threat of extinction. In response we have put in place laws and policies to recover these populations, but are they working and, if not, how can we do better? This report explores those questions and seeks to find ways to better ensure the recovery of our threatened sharks.

Please note that through-out this report 'sharks' is used as a generic term for sharks, skates and rays.

Background

In 1999 the United Nations Food and Agriculture Organisation (FAO) released the International Plan of Action for Sharks (IPOA-Sharks) in recognition of both the importance of sharks as a source of food and because of their vulnerability to over-fishing. The objective of the IPOA-Sharks was, 'to ensure the conservation and management of sharks and their long-term sustainable use' and prescribed the following aims:

- Ensure that shark catches from directed and non-directed fisheries are sustainable.
- Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with the principles of biological sustainability and rational long-term economic use.
- Identify and provide special attention, in particular to vulnerable or threatened shark stocks.
- Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management and educational initiatives within and between States.
- Minimise unutilised incidental catches of sharks.
- Contribute to the protection of biodiversity and ecosystem structure and function.
- Minimise waste and discards from shark catches in accordance with article 7.2.2.(g) of the *Code of Conduct for Responsible Fisheries* (for example, requiring the retention of sharks from which fins are removed).
- Encourage full use of dead sharks.
- Facilitate improved species-specific catch and landings data and monitoring of shark catches.
- Facilitate the identification and reporting of species-specific biological and trade data.

In response to the FAO IPOA-Sharks, Australia produced Shark-Plan 1 and, following a review, Shark-Plan 2. Both comprised a Plan and Action and Operational Strategy that were agreed by Commonwealth, state and territory governments, and both pursue the objectives and aims for the FAO IPOA-Sharks consistent with Australian domestic environmental and fisheries laws.

At the same time as the FAO released the IPOA-Sharks, Australia brought into law the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as the primary environmental statute for the nation. Both before 1999 and in the subsequent 20 years an increasing number of shark populations have been listed as threatened under the EPBC Act. Section 522A of the EPBC Act requires that the operation of the Act is reviewed every ten years from its commencement. So, after 20 years it is appropriate to undertake a performance review of recovery plans and similar instruments for threatened shark populations and for this to be taken into consideration in the 10-year review of the Act that is currently underway.

TO ALIGN LISTING PROCESSES NATIONALLY AND REDUCE CONFUSION AND DUPLICATION OF EFFORT ACROSS ALL JURISDICTIONS, THE AUSTRALIAN GOVERNMENT AND ALL STATES AND TERRITORIES ARE ESTABLISHING A COMMON ASSESSMENT METHOD (CAM) FOR THE ASSESSMENT AND LISTING OF THREATENED SPECIES (DEPT OF ENVIRONMENT, 2018).

One of the functions of the EPBC Act is to provide the mechanisms for the recognition and recovery of threatened native species. Under the EPBC Act, species are included on the threatened species list in one of six categories; Extinct, Extinct in The Wild, Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Conservation Dependent (CD). Inclusion in the CD category is only available for species of fish (or harvested marine species) where a management plan (often referred to as a strategy) is currently in place and where the cessation of the plan would adversely affect the conservation status of the species. This is so even if a commercially fished species may be eligible for listing as Vulnerable, Endangered or Critically Endangered. The Department of Environment (the Department) is responsible for the administration of the EPBC Act. The Threatened Species Scientific Committee (TSSC) is appointed by the Department to assess nominations for species listings and provide recommendations to the Minister on the threat abatement and recovery of threatened species.

The EPBC Act provides an annual cycle for nominating and assessing species for listing as threatened. The TSSC identifies priority species for listing assessment, taking into account candidate species identified by the community. Once the Minister has finalised the list of species for assessment, the TSSC seeks comments on those species, and assesses them against the criteria specified in the EPBC Act. The Minister then decides whether to list the species as threatened and a conservation advice is published.

To align listing processes nationally and reduce confusion and duplication of effort across all jurisdictions, the Australian Government and all states and territories are establishing a Common Assessment Method (CAM) for the assessment and listing of threatened species (Dept of Environment, 2018). The method is based on the best practice standard developed by the International Union for Conservation of Nature (IUCN), as used to create the Red List of Threatened Species. Using the CAM, species are assessed by all jurisdictions applying the IUCN criteria, categories and thresholds. Note that this does not mean that the threat category for each species that is assessed will always be the same as that determined by the IUCN.

Largetooth Sawfish, *Pristis pristis*, released after being rescued from a drying floodplain waterhole in northern Australia. © Brit Finucci

The CAM is seeking a more consistent and efficient process between Australian jurisdictions. Coordinated threatened species listing should help align protection across levels of government and is intended to improve outcomes for Australia's threatened animals, including sharks. The primary aim of the CAM is stated as reducing the confusion and duplication of effort by establishing a consistent method for the assessment and listing of nationally threatened species across Australia. It may also support a more efficient and effective listing process.

As at July 2019, the CAM memorandum of understanding for threatened species had been signed by Western Australia, Tasmania, the Northern Territory, the Australian Capital Territory, New South Wales, Victoria, Queensland and the Australian Government. Only South Australia is yet to sign, although is expected to shortly. Implementation has begun as some states were already using assessment criteria like the IUCN so they can transition easily while others may have more work to do. The use of the Conservation Dependent category may require states/NT to amend their legislation to accommodate it.

As noted above, when a species is listed as threatened under the EPBC Act a conservation advice must be developed to assist its recovery. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to support the recovery of a newly listed species.

Where needed, the Minister may prepare a more comprehensive recovery plan to guide recovery of the species. This discretion was introduced via the *Environment and Heritage Legislation Amendment Act (no. 1) 2006*. Recovery plans are more likely to be prepared where the listed species has complex management needs due to its ecology, the nature of threats affecting it, or the number of stakeholders affected by or involved in implementing the necessary recovery actions. However, these are loose criteria considering the future viability of a species is at stake, and a more formal and comprehensive risk assessment process is warranted.

Once a species is included on the threatened species list, the Minister has 90 days to decide whether a recovery plan is required to be made, taking into account the advice from the TSSC. Following a decision to develop a recovery plan, it must be in force within three years.

The primary objective of the recovery planning process is to improve the population status of a species, or group of species, to the point where it can be removed from the threatened species list of the EPBC Act (Bottrill *et al*., 2011). Recovery plans also set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or ecological communities. Recovery plans can be developed by the Commonwealth or prepared by an external party, commonly a state or territory government, and then 'adopted' as a national recovery plan by the Federal Minister.

The EPBC Act specifies the content requirements of a recovery plan, such as objectives, performance criteria, threats to recovery, and actions, and requires the Minister to consider the advice of the TSSC on a draft plan. Advice from the TSSC is also required before approving conservation advice.

Almost all nationally listed species and communities have a recovery plan or conservation advice. Of the 449 fauna species listed 337 have a conservation advice and 206 have a recovery plan in place, noting some species have both. All marine species, including all sharks, have either a recovery plan, management strategy and/or conservation advice.

RECOMMENDATION 1: The Department of Environment must introduce a formal risk assessment process prior to the Minister (or their delegate) deciding on whether a recovery plan is required to ensure that the instrument most likely to lead to the recovery of a threatened species is implemented.

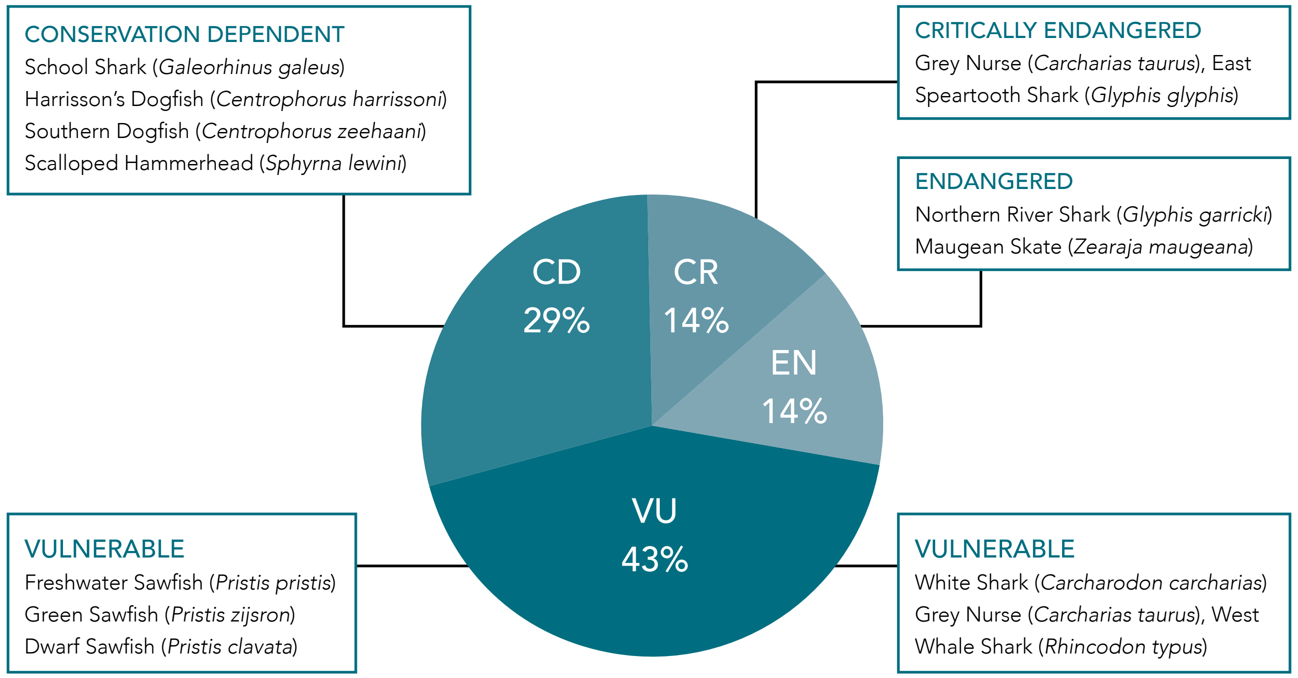
RECOMMENDATION 2: Sufficient resources must be allocated by government so that recovery plans can be developed for all eligible species resulting from the risk assessment.

The effectiveness of recovery plans at improving the status of a threatened population is still the subject of debate (Bottrill *et al.,* 2011; McDonald *et al.,* 2015). Recent research on the efficacy of recovery plans in Australia has shown that the presence or absence of these plans did not have a significant effect on whether the species' status was improving, stable or declining (Bottrill *et al.,* 2011). Similarly, the State of the Environment 2016 reported that population trends were unclear for sharks, most seabirds, sea snakes, some marine turtles and most marine mammals.

However, the effectiveness of recovery plans for conserving Australia's threatened species can be compromised by insufficient funding to prepare and implement recovery actions (Bottrill et al. 2011). Furthermore, the EPBC Act does not require the identified actions in a recovery plan or conservation advice to be implemented effectively making the recovery process voluntary and inaction without consequence.

RECOMMENDATION 3: To improve accountability, the EPBC Act must be amended to compulsorily require the implementation of the priority actions of a recovery plan or conservation advice to be funded by the government to reduce the risk of further decline in the status of all listed threatened species.

Figure 1. Percentage of threatened sharks and ray species listed within each EPBC category. Includes both the East Coast and West Coast Populations of Grey Nurse Sharks.



Analyses of recovery plans implemented under the EPBC Act have identified that one of the major issues in achieving tangible outcomes is the technique of drafting plans that allow for equivocal, inexact, aspirational or indefinite courses of action (Lindsay & Trezise, 2016). These issues contrast with management strategies developed for Conservation Dependent listed species where there are more specific objectives, biological reference points and recovery timeframes.

Globally, sharks are recognised to possess life history characteristics that make them vulnerable to population declines, particularly for species that are subject to fishing pressure or habitat degradation (Davidson *et al.*, 2015; Dulvy *et al.*, 2014). In many ways they possess life history characteristics more akin to birds and mammals than teleost (bony) fishes. To date, 13 species of sharks have been included on the EPBC Act List of Threatened Species. (Fig. 1). Recovery plans have been prepared for many species listed in the threatened categories (CR, EN and VU). For shark species included as Conservation Dependent, management strategies are required to be in place to mitigate the impact of fisheries on their population status. It is only the Maugean skate that has been listed in a threatened category but lacks any formal recovery document.

Shark species currently represent half of these species that have been listed as Conservation Dependent on the EPBC Act Threatened Species List.

Objectives & Scope

This report's objectives are to assess the recovery (or lack thereof) of sharks listed as threatened under the EPBC Act, to consider whether and why recovery plans or management strategies have been effective or not (including the impact of not having one), and to make recommendations to improve recovery outcomes for listed threatened sharks.

The following threatened species are in scope for this report:

1 Sawfishes and river sharks (Critically Endangered to Vulnerable – Recovery Plan)

2 Maugean skate (Endangered – No Recovery Plan or Management Strategy)

3 Upper slope dogfish (Conservation Dependent – Management Strategy)

4 School shark (Conservation Dependent – Management Strategy)

5 East coast grey nurse shark (Critically Endangered – Recovery plan)

6 Great white shark (Vulnerable – Recovery Plan).

Methodology

This methodology draws upon a range of academic and government sources, including published literature and expert opinion, to build an effective set of strategic review criteria. In doing so it also involves some preliminary analysis of available data and a recovery plan implementation review based on the following table.

TOPIC	REQUIREMENTS
Species information and general requirements	Species name, conservation status, taxonomy, description of target species/community; objects of the EPBC Act; international obligations; affected interests; role and interests of indigenous people; benefits to other species/communities; and social and economic impacts.
Species distribution and location	Distribution; habitat critical to the survival of the species/community; mapping of critical habitat; and important populations.
Known and potential threats	Biology and ecology relevant to threatening processes; identification of threats; areas and populations under threat.
Objectives, performance criteria and actions	Recovery objectives and timelines; performance criteria; evaluation of success or failure; and recovery actions.
Estimated costs of plan implementation	Cost of plan implementation and resources allocation.

Also relevant was a review the threat profile for Australian threatened species recently completed by Allek *et al.* (2018) who found that for fish species the most threatening processes were; biological resource use, invasive species, pollution and natural systems modification. Building on this, a more specific desk-top review for threatened sharks and rays in Australian waters was undertaken by using information available through recovery plans, issues papers and the Department's species profile and threats database. These sources highlight; biological resource use (e.g. commercial fisheries, IUU fishing and recreational fisheries) and; natural systems modification (e.g. habitat degradation and modification) as the primary threats to the majority of EPBC listed shark species.

Having considered both the recovery plan requirements and current threats to listed sharks in Australia a methodology for the review was developed in two parts. Part one is an implementation review of the performance of shark recovery plans in relation to the actions set out in those plans. It examines the degree to which they have been achieved in each of several action areas. The results of the implementation review are at Appendix 1 and are discussed further in the results and discussion sections of this report. The second part of the methodology builds on the implementation review and undertakes a strategic review of recovery plans, management strategies and measures introduced by Tasmania to protect the Maugean Skate, using a set of performance criteria (see below). The results and discussion of the strategic review then form the basis of making recommendations about how to improve the effectiveness of recovery plans and management strategies. They also provide some indicators of when the path to recovery may be going off track and what steps can be taken to avoid a species getting listed in the first place.

Consistent with legislative requirements recovery plans and management strategies often have the following **components**:

Objectives or goals to be achieved;

Criteria against which to measure progress against objectives;

Timeframes for both objectives to be achieved and/or progress to be made;

Resources to support the recovery plan; and

Unit of listing which can vary from species groups, a species or a population (a discrete biological unit which may or may not be equivalent to a fish stock and can be divided further into sub-populations).

Recovery Plan/Management Strategy objectives include:

Biologically based recovery, although these are often specified indirectly since (until recently) current population sizes have not been known. As a result, most original listings of threatened sharks are based on data/observations about declining catches, changes in size captured and/or species distribution.

Sustainable catch is used for species or stock(s) which have a history of commercial fishing, and is often combined with biological-based recovery, e.g. to a certain biomass, proportion of initial biomass or number of adults or total number in the stock over a specified timeframe.

Habitat protection and/or rejuvenation is also common and sometimes a proxy for population size. However, what is regarded as adequate habitat is often poorly specified, usually due to the absence of habitat data or difficulties in specifying or obtaining it.

Some refer to **ecosystem structure and function**, but this is rarely expressed in a way that can be used to inform success or failure since it is reliant on a level of ecosystem understanding that is not often available.

Some have a significant number of *technical sub-objectives* that usually relate to improved identification of the species, monitoring and reporting, often including age, sex, size and where caught etc. Such objectives demonstrate that listings are often precautionary and occur in the absence of at least some basic biological data about the unit of listing.

A speartooth shark (*Glyphis glyphis*) pup. Sightings of adults are rare, the first two (one male, one female) recorded by western science was in 2015. © Charlotte Klempin

Performance (and other) Criteria include such things as:

Abundance and productivity indicators, including changes in abundance, distribution and phenology (includes when and where reproduction occurs).

Spatial structure of populations and sub-populations across the known historic range of the species, and how these are changing over time.

Diversity is increasingly used as genetic tools improve to check the heterogeneity of the gene pool and the risks associated with it narrowing, especially where there is significant population structuring.

REVIEW CRITERIA

While considering the content of existing recovery plans is important in determining review criteria it is equally important to step out of those specific circumstances and consider the context in which recovery plans have been formed, examine similar reviews and account for the experiences of those involved with them.

Statutes guiding recovery plans not only require them to have objectives, criteria, timeframes and resources, but also that they be regularly reviewed, that stakeholders will be consulted and there will be public reporting of progress. These 'process' elements can be expanded into a series of questions about the characteristics of criteria that need to be considered when choosing effective review criteria (as adapted from Australian National Audit Office Director of National Parks Audit 2019):

RELEVANCE

- will they measure the species benefit from the activity and how it will benefit?
- do they inform whether the objective is being achieved, and the attribution of the activities to them is clear?
- are they stated in plain English and signal the impacts of activities to inform stakeholders?

Unspooling of a commercial gillnet. © www.marinethemes.com

RELIABLE

- are they capable of being measured to demonstrate progress in pursuing the objective (this includes documenting a basis or baseline for measurement or assessment, for example a target or benchmark)?
- do they allow for clear interpretation of results and provide an unbiased basis for assessment?

COMPLETE

- do they reflect a balance of measurement types (effectiveness and efficiency), bases (quantitative and qualitative) and timeframes (short, medium and long-term)?
- can they demonstrate the extent of achievement against the objective(s) through the activities identified in the recovery plan?

A further consideration in the formation of recovery plan review criteria is to account for the experience of those engaged in developing, implementing, supporting and administering recovery plans. Following conversations with academics, fishery managers, marine scientists and environmental managers some of the matters raised included:

- the recovery plan and management strategy processes are lengthy (takes years and are complex)
- ensuring a range of informed perspectives are gained and accounted for in recovery plan/ management strategy development
- that there is adequate funding for implementation and monitoring of progress
- the bespoke nature of each recovery plan/management strategy is recognised in the context of the matters it is dealing with
- externalities need consideration as relevant factors, and
- the administration of recovery plan/management strategy reviews (timeliness etc).

When the recovery plan/management strategy components are considered in light of the characteristics of review criteria and the experience of plan/strategy users is accounted for, the following high-level questions arise as a possible basis for review criteria (adapted from Boersma et al, 2001, Bioscience). Each of these questions can be reframed into recovery plan/management strategy review criteria by making them statements rather than questions. These are in ***bold italics*** below each question.

1 How does the planning process affect pursuing/meeting objectives (time to make and complexity/length)?
The planning process supports the pursuit and/or meeting of recovery plan/management strategy objectives.

2 Does who is involved in developing, implementing, administering and reviewing recovery plans/management strategies make a difference?
Recovery plan/management strategy objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

3 How important is it that objectives prioritise better understanding species (unit) biology, ecological attributes and ecosystem linkages?
Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of recovery plan/management strategy objectives.

4 What unit for a recovery plan/management strategy gets the best results against objectives?
The biological unit subject to the recovery plan/management strategy makes a difference to pursuing/meeting the objectives.

5 How does monitoring and reporting affect progress?
Levels of monitoring and reporting are commensurate with the requirements of the recovery plan/management strategy to pursue/meet its objectives.

6 How effective are recovery plan/management strategy reviews?
The review of the recovery plan/management strategy has led to a measurable improvement in pursuing/meeting the objectives.

7 What role do externalities play? (economic and social interests, cross jurisdictional and/or international management, climate change etc).
Externalities have been appropriately considered in the recovery plan/management strategy, particularly their impact on pursuing/meeting the objectives.

By necessity any assessment of recovery plans/management strategies against these criteria will draw on a combination of quantitative and qualitative data, and related evidence. Most recovery plans/management strategies have been formally reviewed at least once but there is little external analysis of their performance. Further, most reviews are conducted by the same groups of people who wrote the original recovery plan/management strategy and so challenging what was originally specified and, perhaps changing direction, can be problematic. Often these same groups are resource constrained and do not have time to conduct a strategic review of the recovery plan/ management strategy.

Results

IMPLEMENTATION REVIEW

The implementation review of shark recovery plans was undertaken using the framework of Ortega-Argueta *et al*. (2011) and the compliance of recovery plans for threatened sharks and rays in Australian waters was assessed based on their compliance with legislative requirements and the consistency of design of these plans (Ortega-Argueta *et al*., 2017). The degree to which each plan met these requirements was categorised using a scale from Not Addressed, Partially Addressed, Poor in Information and Complete (Dr Matthew Heard, unpublished report). See Appendix 1 for further details.

The implementation review of school shark and upper-slope dogfish (Harrisson's and Southern dogfishes) was based on the management strategies developed and implemented by the Australian Fisheries Management Authority (AFMA) with the agreement of the Minister for the Environment. These were structured differently from recovery plans but there are also several common elements including objectives, actions, a research program and review timeframes so useful comparisons can be made.

Management strategies tend to be narrower in focus than recovery plans in part because AFMA's objectives, powers and functions dictate this. However, because of its focus on commercial fisheries and the requirements of the government's Harvest Strategy Policy (HSP), great weight is placed on understanding the current status of a fish stock and the setting of a limit biomass reference point (based on recruitment impairment) to ensure the stock does not decline below a level where consideration for threatened species listing may occur. A higher target reference point is also set that reflects a biomass level approximating maximum economic yield. As reference points were introduced in 2007 with the first version of the HSP some Commonwealth managed fish stocks were immediately in breach of one or both. For the limit reference point these included eastern gemfish and orange roughy, with school shark, blue warehou and eastern redfish subsequently found to be in breach following updated stock assessments. In more recent years state/NT governments have begun to apply harvest strategies to their fisheries consistent with the National Harvest Strategy Guidelines making the use of reference points common fisheries management practice and the benefits of this in relation to threatened species are considered later in this report.

ONE OF THE MAJOR HURDLES IDENTIFIED BY MANY RECOVERY PLANS IS THE POOR LEVEL OF KNOWLEDGE ON THE POPULATION SIZE OR TREND, AND THE DISTRIBUTION OF SOME SPECIES.

Except for the Maugean skate, all the threatened shark and ray species listed under the EPBC Act have been the subject of a recovery plan or management strategy. The evaluation of current and past recovery plans found a high level of compliance with most plans scoring either complete or close to complete in information for all categories. When compared to the analysis by Ortega-Argueta *et al*. (2011) of 236 recovery plans, shark and ray recovery plans scored lower for estimated costs and for objectives, performance criteria and actions. While it is unclear why this is the case it may be due to less public or stakeholder interest in marine species (high public profile threatened species issues are predominantly terrestrial) and related to economic development issues, e.g. agriculture, energy and urban planning.

The current status of all the threatened shark species (except the Maugean skate) has been recently captured in Australia's National Shark Report Card (Simpfendorfer et al, 2019) and the relevant species summaries are at Appendix 2. These are largely consistent with the threatened species listings under the EPBC Act and the Status of Australian Fish Stocks Report (FRDC, 2018) which categorises threatened sharks as depleted. Note that the IUCN categorises narrow and dwarf sawfish as Endangered and green and largetooth sawfish Critically Endangered (EPBC Act category is Vulnerable for the three listed sawfish species). The IUCN has also listed green-eye spurdog (another upper slope dogfish) as Endangered which is not listed in any threat category in Australia. It is important to note that the differences between the report card and IUCN are largely due to the former using information up to 2017 and the latter a reflection of current IUCN listings.

One of the major hurdles identified by many recovery plans is the poor level of knowledge on the population size or trend, and the distribution of some species. Further, the implementation review showed that compliance was highest for fulfilling the species information and known or potential threats sections. Objectives of recovery plans were largely lacking in information to set timelines for individual actions and in outlining a method to evaluate the success or failure of actions or objectives. Recovery plans put in place a scheme to monitor and evaluate their implementation and effectiveness, but there is little evidence that this requirement was adhered to. All plans included objectives to improve community awareness but most neglected to outline any monitoring to measure the success of these actions. Most recovery plans were also lacking detailed costing structures, even for high priority objectives. Measures were largely incorporated into 'core government business' without specifying the agency responsible or, if they did so, not providing the evidence that the funding was made available.

These implementation review results helped guide the development of the strategic review criteria for recovery plans and management strategies. The results of this strategic review are below.

EAST COAST GREY NURSE SHARK

The east coast population of the grey nurse shark (*Carcharias Taurus*) is listed as Critically Endangered under the EPBC Act and a recovery plan was first made in 2002. It was subsequently reviewed and a second recovery plan made in 2014. There has been no measured recovery in the population although modelled estimates suggest it may have commenced.

The population size of east coast grey nurse shark is estimated to be between 956 and 3078 mature individuals (NESP News, 2018). The wide range is due to uncertainty about age at maturity. The grey nurse shark (Eastern Australia subpopulation) is assessed as Critically Endangered (IUCN) and Australia's national shark report card lists the population as depleted (Appendix 2).

The overarching objective of the recovery plan is to assist the recovery of the grey nurse shark in the wild (the west coast population is listed as vulnerable), throughout its range in Australian waters, with a view to:

- improving the population status, leading to future removal of the grey nurse shark from the threatened species list of the EPBC Act
- ensuring that anthropogenic activities do not hinder the recovery of the grey nurse shark in the near future, or impact on the long-term conservation status of the species.

The planning process supports the pursuit and/or meeting of recovery plan objectives.

The 2009 review of the 2002 recovery plan suggested that while most recovery actions may have been progressed or completed, there was no evidence of this translating into the objectives being met. Similarly, there is no evidence of objectives being met under the 2014 recovery plan, noting there is now (in 2018) a better estimate of population size from close-kin genetics as a baseline against which to monitor any future increase or decrease in population size. Resources to collect the additional close-kin data on a regular basis in future are required.

Critically endangered (east coast) grey nurse shark *Carcharias taurus* with a probably fatal hook and line injury. © Steve Gillespie

Recovery plan objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

The original plan benefitted from the National Shark Recovery Group (NSRG), but this was discontinued, limiting stakeholder engagement for the 2009 review to mainly written submissions or direct approaches to the Department of Environment or the Minister. Some groups were more competent at this than others, that is, they had the organisational structure, funding and membership to be effective. This can result in an uneven information base on which to make decisions and a high degree of reliance by the Department on its own staff and a few specialist scientists.

Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of recovery plan objectives.

The biology and life history of grey nurse shark is well documented with little new information being added in past 10-15 years. However, the value of some historic datasets (e.g. dive surveys) has been recently questioned along with the need to address longstanding data gaps such as vertebrae ageing (essential for many types of population assessment). This reconsideration of existing data when combined with close-kin genetics data collection and possible data from other sources (e.g. the beach netting program and sub-lethal effects analysis) is providing a clearer picture of the current status of the population and the information required to track its future trend.

The biological unit subject to the recovery plan makes a difference to pursuing/meeting the objectives.

East coast population of the species is spatially well-defined extending from southern QLD into NSW and adjacent Commonwealth waters thereby ensuring that any actions can be appropriately targeted. The main challenge has been coordination of actions between the three jurisdictions which has largely been achieved, but the regular exchange of data and understanding its implications could be improved. There is no biologically justifiable alternative to managing the east coast grey nurse shark population other than as a single unit given currently available movement and genetic information. NSW remains the lead agency for the recovery of the stock with support from CSIRO, FRDC, QLD and AFMA.

Levels of monitoring and reporting are commensurate with the requirements of the recovery plan to pursue/meet its objectives.

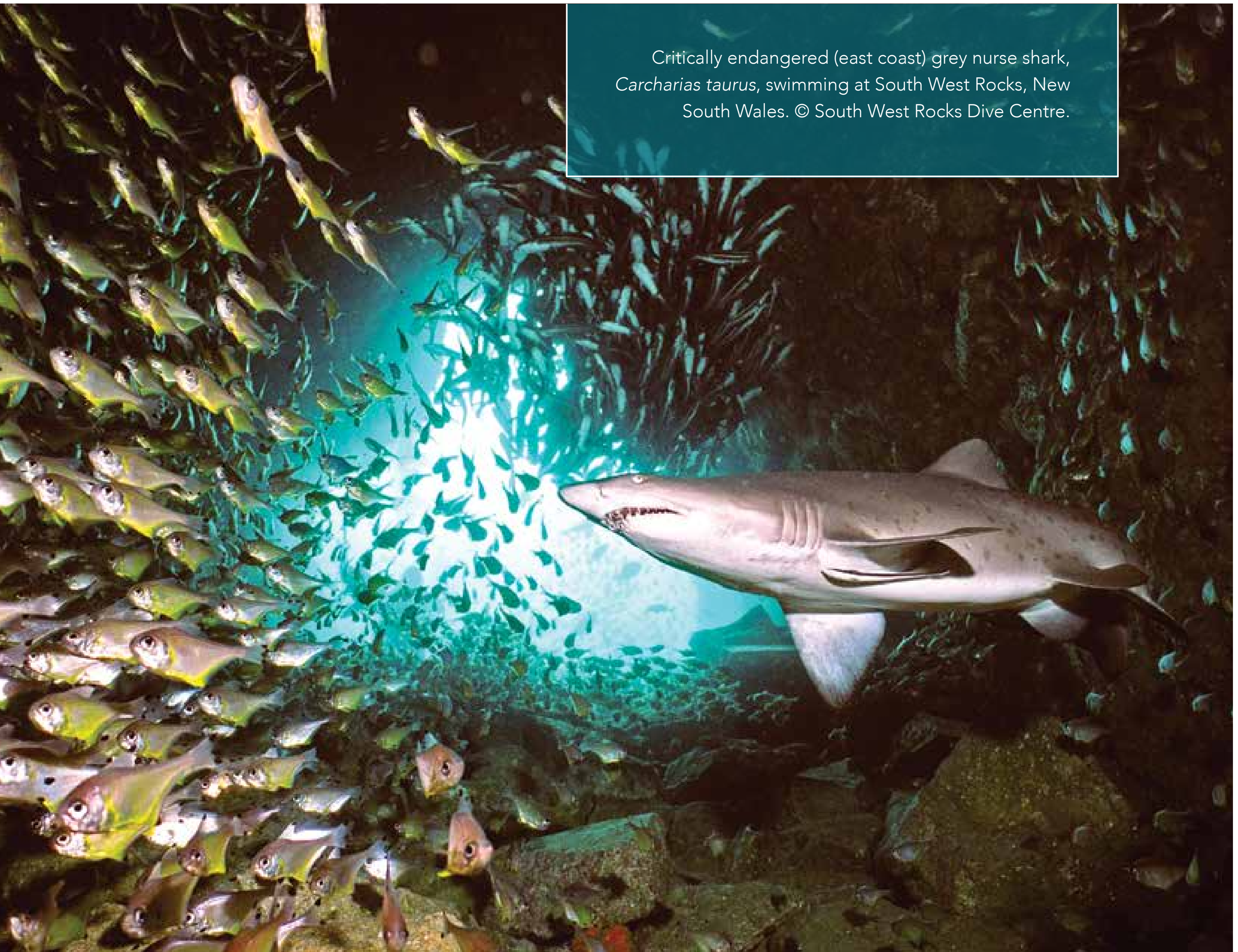
There is regular monitoring of grey nurse shark at a range of critical habitat sites. However, whether this monitoring is effective in measuring performance against the recovery plan objectives is currently problematic since further close-kin data collection and analysis are required to determine the size and trajectory of the population within acceptable error bounds. Doing so is important since without it poorly informed debate amongst stakeholders about the status of the population will continue. In addition, bycatch reporting of the species in commercial and recreational fisheries remains largely voluntary. As with most protected species interactions, underestimates of bycatch common when it relies on self-reported information. Verification programs, including observers and electronic monitoring (remote vessel monitoring and cameras on-board), would help address this.

The review of the recovery plan has led to a measurable improvement in pursuing/meeting the objectives.

While the review of the recovery plan may have been operationally useful in marking the progress of actions and agreeing on new ones, it is unclear whether the review has improved the likelihood of the objectives being progressed or met. This is due to a disconnect between the actions and their contribution to the objectives. That they have a positive contribution in aggregate is intuitively expected but direct measurement of whether they do so has not been undertaken. Greater effort needs to be put into linking actions with objectives.

Externalities have been appropriately considered in the recovery plan, particularly their impact on pursuing/meeting the objectives.

While significant efforts have been made to protect a proportion of the critical habitat for the population many of these are tourist and/or recreational fishing hotspots. A balance has had to struck between ecological and economic/social impacts, which has been contentious for many years. An example is the revocation of protections around the Solitary Islands and Fish and Green Rocks after persistent lobbying from recreational fishers. The effects of general habitat degradation due to coastal development and what role climate change has been playing are currently regarded as second order issues, but this is primarily due to an absence of data and analysis with which to understand their effects on the population. Furthermore, inconsistent levels of protection under law between Australian jurisdictions (QLD and NSW) may have led to differing priorities being accorded to recovery plan actions.



Critically endangered (east coast) grey nurse shark, *Carcharias taurus*, swimming at South West Rocks, New South Wales. © South West Rocks Dive Centre.

RIVER SHARKS & SAWFISHES

A recovery plan was first put in place in 2015 and has not been reviewed to date. The five species are listed from critically endangered to vulnerable under the EPBC Act. There has been no measurable recovery in any of the five EPBC Act listed threatened species. The IUCN has recently upgraded the threat status of the three sawfishes to Endangered or Critically Endangered, all of which are depleted in Australia's national shark report card (Appendix 2).

There are estimated to be no more than 2,500 adult speartooth sharks (*Glyphis glyphis*) in the world (Campagno et al, 2009) and 250 northern river sharks (*G. garricki*) (Pogonoski & Pollard, 2003). However, these estimates are over a decade old and may not be current. There are no reliable population estimates for dwarf (*Pristis clavata*), largetooth (*P. pristis*) or green (*P. zijsron*) sawfishes.

The overarching objective of this recovery plan is to assist the recovery of these species in the wild throughout their range in Australian waters by increasing their total population size, with a view to:

- improving the population status leading to the removal of these species from the protected species list of the EPBC Act
- ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future.

The planning process supports the pursuit and/or meeting of recovery plan objectives.

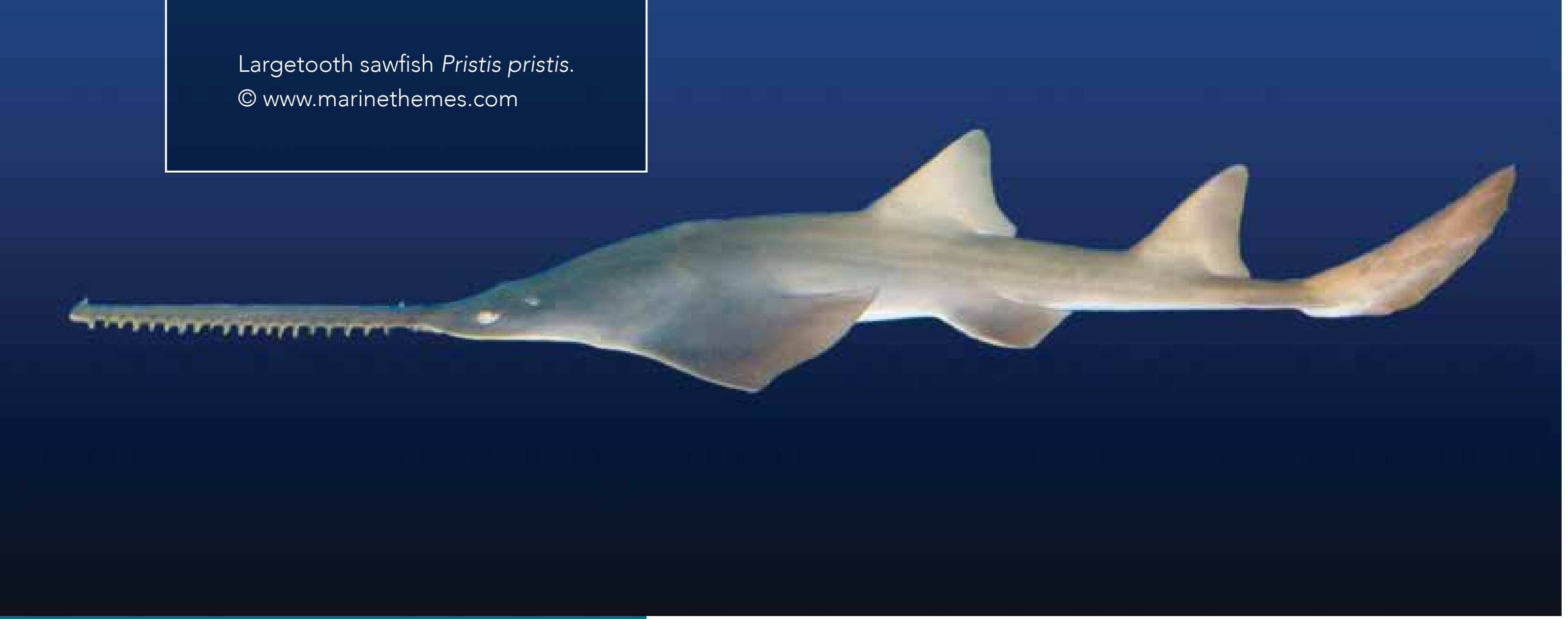
This recovery plan is the only one that covers multiple species, noting also the species have different threatened status levels. However, at the time of its introduction the IUCN global threat status for the three sawfish species differed from that of the EPBC Act which has them all listed as Vulnerable. IUCN lists dwarf sawfish as Endangered, largetooth sawfish as Critically Endangered and green sawfish as Critically Endangered. IUCN also lists narrow sawfish as Endangered (it is not listed in any threatened category under the EPBC Act but has been nominated for listing. The TSSC has commented that Australia probably represents the last secure populations of largetooth sawfish, green sawfish, dwarf sawfish, speartooth sharks and northern river sharks across their global ranges (Stevens et al., 2005; Phillips, 2012). For largetooth sawfish in the Indo-west Pacific region, Australia may represent the last viable population stronghold and may be a globally important population centre (Kyne et al., 2013b). In such circumstances and given the adoption of IUCN listing criteria through the CAM, reconsideration of the Vulnerable listing under the EPBC Act should be undertaken at the same time the recovery plan is reviewed.

RECOMMENDATION 4: That the TSSC reconsider the threatened status of the three sawfish populations currently listed as Vulnerable under the EPBC Act at the time the multispecies recovery plan is reviewed or by 2022, whichever is the sooner.

RECOMMENDATION 5: That the narrow sawfish be considered for listing as soon as possible.

Recovery plan objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

There has been engagement with key stakeholders (relevant fishing jurisdictions, science, industry, eNGOs and some indigenous groups) in the formation of the recovery plan, but the remoteness



Largetooth sawfish *Pristis pristis*.
© www.marinethemes.com

THE RECENT AUSTRALIAN NATIONAL SHARK REPORT CARD (SIMPFENDORFER ET AL 2019) IS THE PRIMARY REPORTING DOCUMENT FOR THESE FIVE SPECIES AS THEY ARE MAINLY AN INCIDENTAL BYCATCH IN COMMERCIAL AND RECREATIONAL FISHERIES.

of many of the remaining populations of these species makes direct on-going engagement difficult and expensive. Currently much of the focus is on the collection of new or additional information on the biology and ecology of each species, including population size, range and structure. Once complete this will assist with the recommendation made above.

Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of recovery plan objectives.

There have been recent advances in understanding the behaviour and ecology of this group of sharks, although much remains unknown. For largetooth sawfish there may be distinct populations across the north of Australia. Similarly, green and dwarf sawfish populations are genetically structured in northern Australian waters. The implication from this is that local population declines or extinctions will not be replenished in the short to medium term through immigration. The largetooth and green sawfish have undergone large global declines since the 1960s and are locally extinct throughout much of their former range. The dwarf sawfish is now possibly restricted to Australia. Both green and dwarf sawfish are now largely extinct from the east coast of Australia.

There has been no genetic research completed into the population structure of the two river shark species but based on available data from immature animals, speartooth shark were or are present in several river systems across the NT and northern QLD. Northern river sharks have been recorded in rivers and estuaries, as well as the marine environment, within Western Australia and the Northern Territory. The two river shark species are only found in Australia and Papua New Guinea (Compagno *et al*., 2008).

These different circumstances for the five species under the one recovery plan can make it difficult to find the best solutions to recover each of them. Species differences are most pronounced between river sharks and sawfishes, with the former appearing to require more local (catchment scale) actions where-as the latter require local, regional (across Australian jurisdictions) and international actions.

The biological unit subject to the recovery plan makes a difference to pursuing/meeting the objectives.

This recovery plan is the only one for threatened sharks that covers a range of species. As noted above while all of them are euryhaline, and some of the threats to them are the same (e.g. commercial fishing), they have different life histories, distributions and jurisdictional issues (nationally and internationally). As this multispecies recovery plan is relatively new it is difficult to draw any conclusions as to its success or otherwise but given the differences between the species groups an open minded, evidence-based approach should be taken to whether or not these five species should remain under on the one recovery plan.

Levels of monitoring and reporting are commensurate with the requirements of the recovery plan to pursue/meet its objectives.

Commercial fishing activity that interacts with river sharks and sawfishes generally relies on self-reporting except for the Commonwealth Northern Prawn Fishery, which has a vessel monitoring system (VMS) with combined crewmember and AFMA observer coverage, albeit at low levels. The NT has introduced VMS in most of its commercial fisheries and several boats have camera systems on-board, but these are not currently used to verify protected species interactions. Queensland is in the process of implementing VMS across its fisheries and has no camera or observer programs. Based on experience in Commonwealth fisheries it is highly likely that many commercial fisheries are under reporting their interactions with river sharks and sawfishes in the absence of independent verification. Furthermore, fishing mortality of these species is unknown from both the recreational and indigenous fishing sectors but may be significant given the status of the river shark and sawfish populations. The capability of any fishing sector to accurately identify each species is also unclear.

The recent Australian national shark report card (Simpfendorfer et al 2019) is the primary reporting document for these five species as they are mainly an incidental bycatch in commercial and recreational fisheries. Some have also been assessed in the Status of Australian Fish Stocks Report. Work currently being conducted by CSIRO, including close kin genetics analysis, may provide further information on the status of one or more of the species in this recovery plan by 2020.

The review of the recovery plan has led to a measurable improvement in pursuing/meeting the objectives.

There has been no review of this recovery plan, which was introduced in 2015, noting a review is due by 2022.

Externalities have been appropriately considered in the recovery plan, particularly their impact on pursuing/meeting the objectives.

Domestic fishing (commercial and recreational) remain the greatest threats to these species, along with harvesting for food and body parts (sawfish rostrums) in neighbouring jurisdictions (e.g. Papua New Guinea and Indonesia), climate effects and human impacts on habitat quality and extent. None of these are well quantified or understood for any of the species covered by this recovery plan. A greater understanding of fishing and non-fishing anthropogenic effects is urgently needed.

MAUGEAN SKATE

This review needs to be prefaced on the basis that while the Maugean skate (*Zearaja maugeana*) has conservation advice it is the only shark species without a recovery plan or management strategy. The species is listed as Endangered under the EPBC Act. The Maugean skate may have one of the smallest populations (no reliable estimates available) and distributions of any chondrichthyan species, highlighting its vulnerability. It was added to the EPBC Act threatened species list in 2004 as Endangered and there have been no formal reviews of its status. There are no publicly articulated recovery objectives for the species. It is also unique among threatened sharks in having a range that is fully within the Internal Waters of Tasmania. The IUCN lists the species as Endangered. It has not been assessed under the Australian national shark report card.

The planning process supports the pursuit and/or meeting of objectives.

The Tasmanian government along with the University of Tasmania (UTas) has taken the lead in developing and implementing actions to conserve the species, but there is no formal plan or similar document which guides or explains this. Consequently, there are no publicly articulated objectives against which progress can be measured.

Objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

Fishery and conservation managers along with experienced marine scientists have been engaged along with the local fishing community. Efforts are now being made to extend this to the broader regional Tasmanian community through engagement with local schools and community groups to help them understand how special the Maugean skate is to the west of Tasmania. Several of the Atlantic salmon companies are also co-funding skate research, noting that conflicts of interest and the independence of scientific reporting both require careful management in such circumstances. Given there is no formal recovery plan or team the success or otherwise of Tasmania's actions will be reliant on the government's public reporting.

Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of Management Strategy objectives.

Considerable effort is being made by UTas to better understand the life history of the species, particularly its reproductive biology and juvenile phases which are understood to have some specific biological requirements (water depth, turbidity and oxygen levels). The aim of this work is to understand what can be done to support the reproductive capacity of the species. A video transect survey is also planned to get a better measure of population size in Macquarie Harbour.

The biological unit subject to the management strategy makes a difference to pursuing/meeting the objectives.

There are only two known populations of Maugean skate, one in Macquarie Harbour and the other in Bathurst Harbour, with skate in the latter not recorded for more than 20 years. Therefore, almost all the effort to better understand the species is occurring in Macquarie Harbour.

Levels of monitoring and reporting are commensurate with the requirements of the recovery plan to pursue/meet its objectives.

All the monitoring of the species occurs through projects undertaken in the field on the species and any information on interactions volunteered by local fishers. There is no dedicated, on-going monitoring program for Maugean skate which given its vulnerability and the threats it faces needs to be addressed.

Maugean skate (*Zearaja maugeana*) surveyed by researchers in Macquarie Harbour, Tasmania. © Cynthia Awruch

WHILE RECREATIONAL GILLNETTING REMAINS A THREAT, THE THREE EXTERNALITIES THAT HAVE AND ARE AFFECTING MAUGEAN SKATE ARE THE MODIFICATION OF RIVERS ENTERING MACQUARIE HARBOUR THROUGH DAMMING AND MINING, THE DEVELOPMENT OF SALMON AQUACULTURE AND CLIMATE CHANGE.

The review of the recovery plan has led to a measurable improvement in pursuing/meeting the objectives.

There is no recovery plan or management strategy. The Maugean skate was added to the threatened species list in 2004 and there have been no formal reviews of its status since that time.

Externalities have been appropriately considered in the recovery plan, particularly their impact on pursuing/meeting the objectives.

While recreational gillnetting remains a threat, the three externalities that have and are affecting Maugean skate are the modification of rivers entering Macquarie Harbour through damming and mining, the development of salmon aquaculture and climate change. The first of these is somewhat historic and unlikely to change in future so may have caused a permanent shift in productivity arising from modification of freshwater inflows into the harbour. Atlantic salmon aquaculture is more recent and the ecologically sustainable carrying capacity for this species in Macquarie Harbour is strongly contested by various sections of the community. In response, over that last two years the salmon aquaculture industry has been directed by the Tasmanian Environment Protection Authority (EPA) to reduce the biomass in its farms from around 14,000 to around 9,500 tonnes (until 31 May 2020). It is not known what the effects of the historic stocking of salmon farms have been on the Maugean skate population. Assessments of the impact of salmon farming on the Macquarie Harbour environment are on-going and the limited range of the skate suggests that it has quite specific bio-physical and chemical requirements to complete its life cycle. Unlike the development of salmon aquaculture, climate change has not been considered as a threat to the Maugean skate but understanding the skate's physiological tolerances and keeping the population well above any recruitment impairment thresholds (limit reference point) should be a priority.

GREAT WHITE SHARK

The species is listed as Vulnerable under the EPBC Act and a recovery plan was first made in 2002 and has been reviewed with a new recovery plan made in 2013. There has been no measurable recovery in the population. The size of the eastern population is in the range of 470 to 1030 adult animals and in the southern-western population 760 to 2250 adult animals (CSIRO News 2018).

The great white shark (*Carcharodon carcharias*) is assessed as globally vulnerable (IUCN) and depleted in the Australian national shark report card (Appendix 2).

The overarching objective of the 2013 recovery plan is to assist the recovery of the white shark in the wild throughout its range in Australian waters with a view to:

- improving the population status, leading to future removal of the white shark from the threatened species list of the EPBC Act
- ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future.

The planning process supports the pursuit and/or meeting of recovery plan objectives.

The review of the 2002 recovery plan concluded that there had been no reliable published information suggesting the great white shark population in Australian waters was recovering. The review considered the lack of documented recovery was not unexpected given the white shark's low reproductive rate, ongoing uncertainty about the size of the population and the relatively short period of time since the original recovery plan was made. This remains the case in 2019, noting there is now (2018) a better estimate of population size from close-kin genetics as a baseline against which to monitor any future increase or decrease in population size. Resources to collect the additional data to update the close-kin analysis on a regular basis in future remain uncertain.

Recovery plan objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

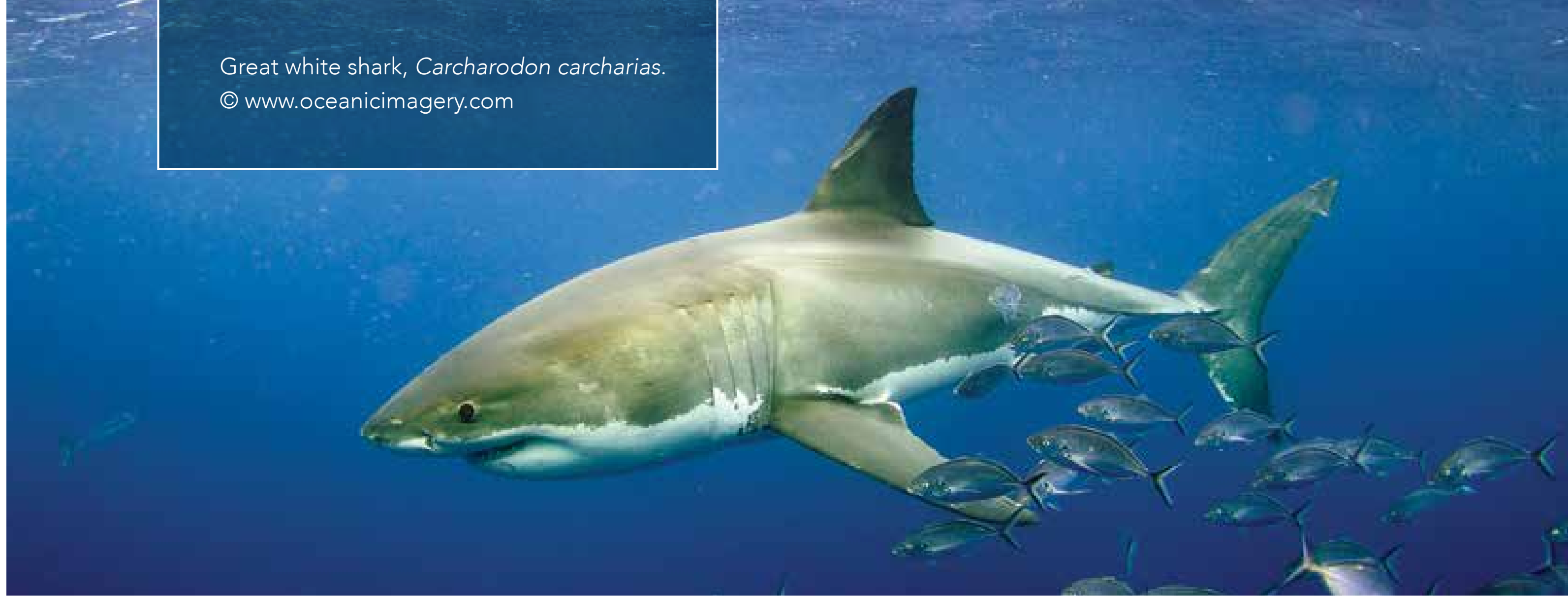
The comments here reflect those made for eastern grey nurse shark with the addition that the great white shark is a global species and as such engaging with international scientists, conservation and management bodies is an important aspect of understanding the status of the species beyond Australia's jurisdiction.

Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of recovery plan objectives.

The general biology and ecology of great white shark is well known with more recent genetic studies distinguishing two populations around Australia, one on the east coast (Queensland to eastern Tasmania) and another south-west (western Tasmania to WA). Further, close-kin genetics has now clarified the current sizes of these populations, but original population sizes cannot be determined. Trends in these populations will become evident provided sampling continues for future close-kin analysis. This will clarify whether recovery actions are effective or not, noting many of those in the 2002 plan have been completed and a number of those in the 2013 plan are well under way.

The biological unit subject to the recovery plan makes a difference to pursuing/meeting the objectives.

Both great white shark populations are likely to extend across multiple Australian and international jurisdictions given the significant range adults occupy. New Zealand recently up-listed great white shark from 'at risk' to 'threatened' with estimates of population numbers not dissimilar to the east



Great white shark, *Carcharodon carcharias*.

coast population in Australia. Given the threats listed appear similar and there is likely population overlap between NZ and the east Australian population, cooperation between the two countries on recovery actions could prove useful. This could be facilitated through the Convention on Migratory Species (CMS) and the associated CMS Shark MoU, and through relevant regional fisheries management organisations (RFMOs).

Levels of monitoring and reporting are commensurate with the requirements of the recovery plan to pursue/meet its objectives.

Monitoring and reporting of fishery interactions relies largely on self-reporting with exception being several Commonwealth managed fisheries which carry observers and/or cameras on board that are used to verify protected species interactions. It is common for protected species to be under reported in the absence of observers or on-board cameras. This is usually due to misidentification or deliberate non-reporting. For great white shark this is further complicated by adults ranging onto the high seas where international fishing fleets have a variable record of accurately reporting protected migratory species. While some observer coverage is present on many high seas fleets its primary role is often commercial catch-effort reporting.

The review of the recovery plan has led to a measurable improvement in pursuing/meeting the objectives.

While a significant number of actions had been completed or progressed by the time the 2002 recovery plan was reviewed there was no evidence as to whether these actions had led to improving the status of great white shark or not. This remained the case until 2018 when close-kin genetics provided estimates of population sizes. Given the life history of great white shark (slow growing, long lived, small numbers of young and late maturing) any measurable trend in either population will likely take until around 2030 to become evident.

Externalities have been appropriately considered in the recovery plan, particularly their impact on pursuing/meeting the objectives.

Key externalities are climate effects and social/community attitudes to great white shark, including shark control programs. The former may have both primary and secondary effects, e.g. it may cause the species to follow the oceanic waterbodies it has historically inhabited as they move or change their characteristics, and the species may respond to changes in prey abundance which are themselves affected by climate change. In terms of social/community attitudes these both support shark control programs (with a preference for those that are non-lethal for the shark) and recovery actions for great white shark.

UPPER-SLOPE DOGFISH

Both species are listed as Conservation Dependent under the EPBC Act. A management strategy was first put in place in 2012 and a review has been commenced (AFMA, pers. comm.). There has been no measurable recovery of either Harrisson's or southern dogfish noting that they, like most threatened sharks, are slow growing with low levels of fecundity. There are no population estimates for either species.

Harrisson's dogfish (*Centrophorus harrissoni*) is assessed as globally Endangered (IUCN) and depleted in the Australian national shark report card. Southern dogfish (*C. zeehaani*) has not been evaluated by the IUCN as it is data deficient and has been assessed as depleted in the Australian national shark report card (Appendix 2). They are both listed as Conservation Dependent under the EPBC Act.

The management strategy aims to rebuild upper slope dogfish stocks to their limit reference point of 20 percent of unfished biomass within a biologically reasonable timeframe of three generation times (80 – 90 years) from 2012. This is consistent with the Commonwealth Harvest Strategy Policy (CHSP) 2007 and will be reconsidered for consistency with the new 2018 CHSP as part of the 2019-20 review of the management strategy. Note that the populations of Harrisson's dogfish on east coast seamounts were estimated as being well above the limit reference point when the species was listed as Conservation Dependent.

> ***The planning process supports the pursuit and/or meeting of management strategy objectives.***

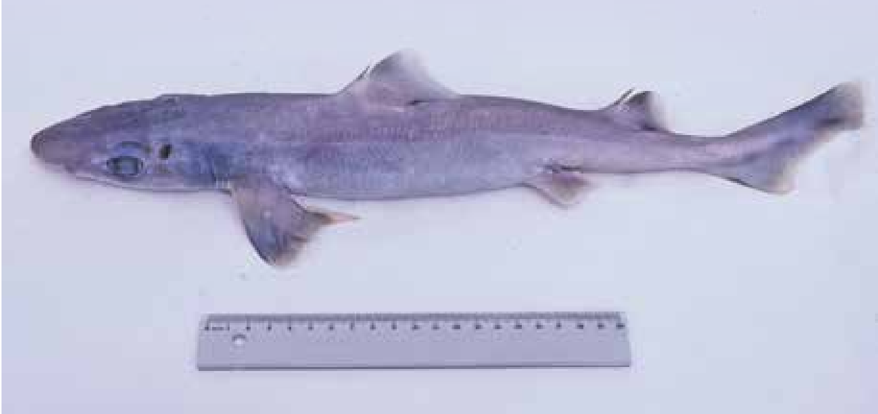
The management strategy was developed by AFMA with advice from its South East Management Advisory Committee (SEMAC) and Shark Resource Assessment Group (SharkRAG). Given there is more than one stock of each species the aim is first to rebuild the stocks that are below 20% of initial biomass back to that level within three generations. The approach to achieving this is somewhat unique given the difficulties of measuring stock size. The habitat of upper slope dogfish was used as a surrogate and to give effect to this, areas the species was known to still inhabit were protected from demersal trawling and additional constraints placed on demersal line fishing.

> ***Management strategy objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.***

Given commercial fishing is almost the only source of human induced mortality there was direct engagement between AFMA, the scientific community and the relevant industry bodies in developing the management strategy. The draft strategy was then considered by SEMAC and SharkRAG. These bodies have a broad, experienced stakeholder membership (fishing industry, management, science and eNGOs, with an independent chair). MAC and RAG advice is then provided to the AFMA Commission that decides the final strategy with agreement from the Minister for the Environment.

> ***Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better*** pursuit/meeting of management strategy objectives.

While the specific biology and ecology of the two species of upper slope dogfish listed as Conservation Dependent remains relatively poorly understood, the general biology and ecology of the broader group dogfishes they belong to is better known. In these circumstances a decision was taken to protect known populations of each species from key threats, demersal fish trawling and demersal line fishing. Both the Commonwealth (via AFMA) and NSW have taken action to protect remaining upper slope dogfish populations primarily based on spatial exclusion of certain types of fishing.



Harrisson's dogfish, *Centrophorus harrissoni*. Typical of deep-water shark species, it likely reaches maturity at a late age, and has very low fecundity (max. two pups every two years) making it extremely vulnerable to fishing pressure. © Ken Graham.

> ***The biological unit subject to the management strategy makes a difference to pursuing/meeting the objectives.***

One of the unknowns about each species of upper slope dogfish is their stock structure. Both species are widely distributed in southern and eastern Australia - southern dogfish from South Australia to NSW (including Tasmania) and Harrisson's dogfish from eastern Tasmania to southern Queensland and New Zealand waters. However, both species are also understood to be highly resident to their local area for most of their lifecycle which was a key reason why spatial protection was preferred. A greater understanding of their life history and stock structure may assist future recovery efforts.

> ***Levels of monitoring and reporting are commensurate with the requirements of the management strategy to pursue/meet its objectives.***

AFMA committed to a regular monitoring program for both species, the preferred design of which is about to be released for stakeholder consultation. NSW has no specific monitoring program for these species. AFMA's current review of the management strategy will be reported to the AFMA Commission and includes a stakeholder consultation phase. In addition to specific monitoring the general AFMA observer program and/or e-monitoring (cameras on boats) provides additional information on any interactions between upper slope dogfish and commercial fishing.

> ***The review of the management strategy has led to a measurable improvement in pursuing/meeting the objectives.***

As noted above the management strategy is currently undergoing its first review by AFMA since being introduced in 2012.

> ***Externalities have been appropriately considered in the management strategy, particularly their impact on pursuing/meeting the objectives.***

Given the range and habitat of these species commercial fishing is the primary threat with almost no others. The exception is climate change and while the deeper water the dogfish inhabit has been less affected by ocean warming and changes in ocean current activity to date it is unlikely that this will remain the case. This is particularly so for Harrisson's dogfish given it is largely confined to waters affected by the East Australian Current and the Tasman Sea which in recent years have seen some of the most significant ocean warming anywhere on Earth. Monitoring climatic changes that may affect upper slope dogfish should be an essential part of any future monitoring program.

SCHOOL SHARK

Following its listing as Conservation Dependent a management strategy was put in place in 2010 and was reviewed in 2015. Based on the latest (2018-19) stock assessment the recovery of the species is tentative only, with more certain evidence that any decline ceased around 2010. The adult population size of school shark is estimated to be around 80,000 individuals based on close kin analysis.

The global population of school shark (*Galeorhinus galeus*) is assessed as Vulnerable (IUCN) and depleted in the Australian national shark report card (Appendix 2).

The management strategy aims to rebuild school shark stocks to their limit reference point of 20 per cent of unfished biomass within a biologically reasonable timeframe of three generations (~66 years) from 2010. This is consistent with the Commonwealth HSP 2007 and will be reconsidered for consistency with the new 2018 CHSP. The management strategy is scheduled for review in 2020-21.

School shark, *Galeorhinus galeus.*

The planning process supports the pursuit and/or meeting of management strategy objectives.

The management strategy was developed by AFMA with advice from SEMAC and SharkRAG. The objective is to rebuild the stock from the current ~10% Bo to 20% Bo within three generations (~66 years from 2010) with actions focussed on minimising fishing mortality and gaining a current estimate of stock size and trajectory. Fishing mortality is lowered by applying a bycatch (no target fishing) TAC, 20% catch ratio (school to gummy shark), release of all live school shark, pupping area closures, 100kg bycatch limit on the scalefish hook fishing sector and an annual cumulative school shark catch trigger limit of 5t on automatic longline permits. AFMA conducts checks on school shark catches at the boat level (measured against recent years catches) to address any evidence of target fishing. Previously, companion species analysis was used to detect targeting but there were concerns about its reliability. While AFMA leads this process there is a significant harvest of school shark by state-based commercial and recreational fishers which relies on self-reported information.

Management strategy objectives are better pursued/met by engaging people with a wide range of relevant expertise, experience and skills.

Both SEMAC and SharkRAG have a broad stakeholder membership (with the former focussed on management and the latter on science) and receive on-going funding from AFMA via commercial fishing levies and government funds. These are expertise based rather than representative bodies. Most members have decades of experience in their relevant field. Both bodies report directly to the AFMA Commission which has responsibility for making decisions regarding the sustainable harvesting of Commonwealth fisheries resources, including school shark.

Greater understanding of species (unit) biology, ecology and ecosystem linkages leads to better pursuit/meeting of Management Strategy objectives.

While the general biology of school shark has been well studied, recent work by the CSIRO in collaboration with AFMA on close-kin genetics has led to a re-consideration of the current and future productivity of the species, along with its stock structure. This is likely to lead to estimates of a current virgin biomass (B_o) that are lower than historic estimates and a recalibration of recovery estimates and timeframes. The reason for this change is attributed to a combination of historic overfishing (1950s to 1990s), poor estimates of total fishing mortality (especially state commercial and recreational catch), habitat loss across its range (e.g. pupping in Port Phillip Bay and Western Port Bay) and climate effects on an already depleted resource. The latter warrants specific attention to build on the information in the CSIRO Decadal Projections Report (2018) as the prevalence of impacts on marine fisheries globally is increasing.

The biological unit subject to the management strategy makes a difference to pursuing/meeting the objectives.

School shark has been managed as a single stock in Australia, noting there are low level exchanges with the NZ school shark stock, but these are regarded as insufficient to manage them as a single Trans-Tasman stock. Within Australia there may be several semi-independent stocks that overlap in space and time. While the Commonwealth fishery is the main source of fishing mortality, WA, SA, VIC, TAS and NSW collectively make up a significant proportion of the catch. This complex of data, stock and jurisdictional issues needs to be better understood if management strategy objectives are to be achieved.

Levels of monitoring and reporting are commensurate with the requirements of the recovery plan to pursue/meet its objectives.

Monitoring of the fishery against the total allowable catch (TAC) and individual transferable quota is undertaken by AFMA on an on-going basis and catch against TAC is regularly publicly reported (see CatchWatch, AFMA Website). Both SEMAC and SharkRAG report at least annually on school shark status and this forms some of the advice for the AFMA Commission when setting next season's TAC. The Commission recently decided to reduce the TAC from 215 t to 189 t. ABARES has independently concluded that the fishing mortality of school shark is not in excess of the TAC noting that recreational catch and state commercial catch of the species are estimated only (due to poor data quality) and are in addition to the TAC. AFMA has recently amended how it calculates total fishing mortality to explicitly include Commonwealth commercial discards and recorded state catches. Further consideration is being given to how to account for recreational catch given there is little species-level data from this sector.

The review of the recovery plan has led to a measurable improvement in pursuing/meeting the objectives.

The school shark management strategy was last reviewed in 2015 and prompted consideration of the use of close-kin genetics to get a better estimate of current stock size and trajectory. AFMA and its stakeholders had lost confidence in the use of the catch-effort series as a reliable indicator of abundance and other modelling options had produced spurious results. Today, catch, ageing and close-kin results are used in combination to estimate stock size and trajectory. These suggest that the stock reached a low point around 2010 and may have been recovering slowly since then within wide error bounds. Further close-kin sampling needs to be undertaken to confirm whether there has been any recovery. In terms of recovery timeframes, three generations was chosen given the biology of the species and this equates to around 66 years to reach 20% of initial biomass (the HSP default limit reference point).

Externalities have been appropriately considered in the recovery plan, particularly their impact on pursuing/meeting the objectives.

While there is recognition of some externalities (e.g. coastal development removing nursery habitat in Port Phillip and Western Port Bays) they are not quantified. Other externalities are not considered in the stock assessment at all (e.g. the impacts of climate change). These could have significant implications for the stock. Indeed, the school shark catch-effort and ageing data prior to the mid-1990s cannot be reconciled with the same data post this period suggesting there has been a major shift (downward) in productivity and potential maximum stock size. The fishing industry has sought an independent review of the latest school shark assessment as it holds the view that the stock is recovering faster than the assessment suggests. It should also be noted that New Zealand school shark stocks are mostly regarded as above the limit reference point and some at the target reference point. However, the NZ assessments rely on CPUE data which have proven to be unreliable for the assessment of Australian school shark stock(s). The use of close-kin genetic analysis on NZ school shark stocks may be a useful way to better understand their status.

Discussion

GENERAL COMMENTS

Since the EPBC Act was introduced in 1999, successive governments have changed how threatened species are managed. Initially there was significant funding available for the development and implementation of recovery plans for threatened species, including for sharks. These funds also supported stakeholder consultative bodies such as the National Shark Recovery Group and the writing of NPOA-Sharks. However, this funding gradually reduced and it has become more difficult for the Department and stakeholders to keep pace with the requirements of existing recovery plans let alone new ones. This has led the Department to find less costly means to manage the growing threatened species list, such as using just conservation advice for many species, and relying on other sources of funding to support essential scientific projects to advance many of the recovery actions (e.g. National Environmental Science Program (NESP), CSIRO, Universities and FRDC). Non-government domestic stakeholders have also had to find resources to participate in both planning and review processes which has ultimately meant a lower quality of stakeholder participation in recovery plan reviews. Internationally, several major eNGOs have steadily increased their funding of marine species conservation (e.g. Pew Charitable Trusts & The Nature Conservancy) but these are often not species specific or Australia focussed. There is a reasonable expectation that as a wealthy nation Australia can fully fund recovery actions from its own resources. As the variable recovery efforts within Australia show the coordination of recovery actions and their funding have room for improvement, particularly across disciplines (science, management and policy) and jurisdictions.

RECOMMENDATION 6: That there is improved collaboration between the various Australian jurisdictions and funding sources to ensure policy and projects on threatened shark species demonstrate a clear link with improving species status.

This progressive change in approach to threatened species recovery has led to a disconnect between the processes of declaring a species as threatened and the capacity to then act on the conservation advice, whether through a recovery plan or not. The process leading up to a species being declared threatened is based on whether a species meets scientific criteria, while the decision about what to do once a species is declared threatened has more discretion. The Minister can decide whether to have a recovery plan and, along with the Department and TSSC, decide on what actions a recovery plan contains. The process of reviewing the recovery plan rests with the Department and funding for actions is largely competitive through various government programs. This means for many species there is no specific funding to address priority recovery actions, indeed the requirement to implement a recovery plan at all seems to be a significant gap in the EPBC Act.

A further issue is the long list of species with conservation advice but without a recovery plan or management strategy. There is no process around how and what should be done to address the priorities the advice recommends, who takes responsibility, where funding will come from or reporting on progress back to government. The nearest example that threatened sharks have to such a circumstance is the Maugean skate where Tasmania has self-initiated conservation actions. While this may be the most appropriate course for a species whose range is completely within the Internal Waters of that state, not all threatened species can rely on similar action, particularly where there are multiple jurisdictions involved and/or international connections. Relying on voluntary action presents additional risks to an already threatened species, which for some species may mean no action on the conservation advice at all.

As a means of having this high-risk state addressed there is a need for a national shark strategy that goes a lot further than the NPOA-Sharks. It should apply what the Commonwealth, states and NT have already accepted for commercial fisheries, that is, reference points that refer directly to the species biomass or numbers of adult animals. Commonly known as a harvest strategy, it is also a conservation strategy with pre-agreed management responses when reference points are approached or breached. A national strategy would be best supported by a standing stakeholder body to both improve the quality of advice and increase support for high priority actions.

RECOMMENDATION 7: A national shark strategy, supported by a standing stakeholder body, be developed with the aim of preventing further species being listed as threatened that includes policy-based or statutory recovery reference points (based on numbers or biomass) to be achieved within set timeframes.

Terrestrially the 'Species in Peril' process was an effort to focus on a shorter, more manageable threatened species list within which to allocate limited resources to support recovery actions. At the same time, efforts are being undertaken to reduce generic risks to many terrestrial threatened species such as feral cats and foxes. As these are relatively recent initiatives only time will tell if they are successful and whether there are lessons from them that will aid the recovery marine species, including sharks.

In a related process the CSIRO and others (Geyle et al, 2018) have developed risk of extinction criteria for terrestrial animals, noting they were not used in this review given the extensive time and investment required to apply them. However, they may be useful in a future study looking at extinction risk for sharks. The CSIRO method was based on an extension of existing IUCN and NatureServe criteria, and used expert elicitation to rank the extinction risk to the most imperilled species, assuming current management. Based on these assessments, and using two additional approaches, CSIRO estimated the number of extinctions likely to occur in the next 20 years. However, the estimates of extinction risk derived from the tighter IUCN categorisations, NatureServe assessments and expert elicitation were poorly correlated, with little agreement among the methods for which species were most in danger. This highlighted the importance of integrating multiple methods when considering extinction risk and using weight of evidence approaches as a basis on which to make decisions.

RECOMMENDATION 8: The 'Species in Peril' and the CSIRO extinction risk processes should be monitored for their application to threatened sharks as a future means of better allocating limited recovery resources.

Key Matters to Resolve

IMPROVING THE SUCCESS OF RECOVERY PLANS

The primary objective of all recovery plans is to improve the status of the species to the point where it can be either downgraded or removed entirely from the threatened species list of the EPBC Act. To date this objective has not been achieved for any species of shark. Repeatedly, the reviews of recovery plans have stated that there is insufficient new information to change the listing status. Such an outcome after 20 years of the EPBC Act and tens of millions of dollars spent on recovery actions must be regarded as a failure of policy and science, but there are several courses of action that are and could be taken towards a more successful future. These relate to improvements in governance, measurement and/or scope and are considered below.

One improvement may be to apply the Species Expert Assessment Plan approach that has been developed by the TSSC in association with the Department to encourage and support expert groups to review a taxon or group of species. The TSSC may then use the assessments prepared by these expert groups to pursue amendments to the EPBC Act list of threatened species based on re-analysis of existing data. With population estimates for a growing number of threatened sharks now available (see below) it may be timely to do so as these estimates themselves, along with more recent work conducted by the IUCN, raise issues about whether some of the threatened sharks are listed in the most appropriate category.

A second improvement that the CAM is aimed at providing is a consistent approach to listing of a species across jurisdictions. While a shark species may be listed in one of several threatened categories under the EPBC Act the equivalent state/NT legislation may list it differently or not at all. This is further complicated by international processes through IUCN, CITES and CMS. The result is that the responses to the listing of a shark species can vary from jurisdiction to jurisdiction. With the CAM based on IUCN assessment criteria current listing inconsistencies should be able to be addressed.

One matter the CAM does not address is adequacy of funding. Funding formulae already exist in several spheres between the Commonwealth and the states/NT, e.g. biosecurity. Consideration could be given to a similar funding model for threatened species.

Great white shark, *Carcharodon carcharias.*

CURRENTLY, EARTH REMAINS ON THE RELATIVE CONCENTRATION PATHWAY (RCP) 8.5 FOR CARBON EMISSIONS WHICH WILL SEE MORE RAPID CLIMATE CHANGE THROUGH WARMING, ACIDIFICATION AND DEOXYGENATION OF THE OCEANS.

RECOMMENDATION 9: The common assessment method (CAM) process is applied by all states and territories with one of its success criteria to minimise the disparity of listing classification for a species across Australian jurisdictions, and a second is to reach agreement on a national funding model for threatened species recovery.

In this review several priority areas affecting threatened shark species have come to the fore: the absence of an effective baseline for the size of the population (either in numbers or biomass), the time it takes for measurable recovery to occur and the influence of factors outside those normally considered in recovery plans and management strategies (so-called externalities).

The consideration for listing a threatened shark species is undertaken by the TSSC based on the best available information, but it is rare that this has included a reliable estimate of current or original population size. Indirect measures are most commonly used including population decline (e.g. recorded mortalities from shark mesh netting of bathing beaches), applying a precautionary approach and changes in the spatial extent of the species (e.g. range contraction). It is only recently that population estimates for some threatened shark species have become available using close-kin genetics. This method has been applied to great white shark, the eastern population of grey nurse shark and school shark. It is now being applied to northern river and speartooth sharks and is planned to be applied to sawfishes. For the first time we have a quantitative measure of population size that can be used to monitor future changes in abundance of threatened sharks. More information on these population estimates is at Appendix 3.

RECOMMENDATION 10: Where it is not known already, the highest priority must be placed on determining a reliable estimate of the current number and/or biomass of each threatened shark species, using non-lethal techniques.

RECOMMENDATION 11: Close-kin genetics should be the current preferred option for determining the population size once a species is listed (if not done already) subject to feasibility and cost-effectiveness tests.

Recovery times for sharks are slow with most taking decades to show measurable changes in population size, and this simply reflects the biology of the taxa. Recovery plans don't set specific recovery times in terms of population size (biomass or numbers), but management strategies do because it is a government policy requirement (Harvest Strategy Policy 2018) for AFMA to comply with. The benefit of this is that progress can be measured against a reference point rather than using more qualitative indicators suggesting that things may be getting better or worse. School shark and upper-slope dogfish have had reference points applied to them, noting that different approaches have been used in each case. While the biomass-based approach used for school shark is most common the absence of data meant a biomass proxy of spatial extent of residual populations was used for upper-slope dogfish.

Many other Australian fisheries jurisdictions along with other nations such as the United States and New Zealand are also using harvest strategies containing reference points with some success in reducing overfishing and the number of overfished stocks. It would be worthwhile considering this approach for other threatened shark species to improve the public accountability of those responsible for species recovery and measure progress towards the goal of species recovery.

RECOMMENDATION 12: Reference points should be implemented in conjunction with rules that compel management action by the relevant jurisdiction(s) to halt any decline well before a species approaches the limit reference point.

External factors outside recovery plans and management strategies can play a key role in determining their success and these are in two related categories. The first mainly concerns the impact of the economy and society on the species and applying realistic recovery frameworks for threatened species. The second is the growing impact of climate change as a force working mostly against species recovery.

Economic development is an inevitability of the continuing increase in human population and the expectation of human society of a continuously higher standard of living. It is also inevitable that this development impacts the natural world meaning that its ability to collectively support all other species is diminished. Given these circumstances it is unlikely that threatened species populations can be rebuilt to their former (pre-depletion) levels. Accepting that many species on the Earth are both threatened by human activities and only still here due to human conservation intervention is an increasingly common state, as is the consequence that many of these threatened species will remain at small population sizes due to the direct and indirect effects of humans on them. To date in the management of threatened species this reality has been largely ignored but has recently come to the fore for species like school shark when setting reference points that account for at least some of the impacts of humans on the species. This is proving a difficult conversation and is in its infancy for marine species, but it must be had if realistic recovery goals are to be set and achieved, and Australian society is to be accountable for the responsibility it has given itself.

Currently, Earth remains on the Relative Concentration Pathway (RCP) 8.5 for carbon emissions which will see more rapid climate change through warming, acidification and deoxygenation of the oceans. In its most recent publication on the status of US fisheries resources, NOAA has stated that climate change is overtaking fishing as the primary concern regarding species that are overfished. While great strides have been made in reducing overfishing, several US species have shown little sign of recovery and remain overfished. The same pattern is emerging in Australian fisheries with eastern gemfish and blue warehou examples of overfished species which have also been affected by climate induced changes to the East Australian Current. The forecast effects of climate change on Australian fishes (including threatened sharks) are contained in a recent report led by the CSIRO and supported by FRDC and AFMA entitled 'Decadal scale projection of changes in Australian fisheries stocks under climate change' (FRDC Project No. 2016-139). These projections are stable or negative for the abundance, productivity and phenology of demersal sharks and somewhat more optimistic for pelagic species. The project's results can assist in prioritising recovery actions in the context of continuing climate change and the analysis should be updated every five years to account for rapidly developing climate models.

RECOMMENDATION 13: The effect of externalities (e.g. climate change & economic development) must be recognised as part of the species recovery process to ensure that recovery reference points and associated timelines account for them.

Another matter that requires addressing is the protection of critical habitat, particularly for species that have a small range and/or require specific habitat to undertake key parts of their life history. For early Australian shark and ray recovery plans, the identification and mapping of critical habitats were largely lacking (e.g. EA, 2002a; EA, 2002b). Eastern grey nurse shark was the exception and led the way in connecting critical habitat protection with species recovery. While the importance of critical habitat has been better recognised in more recent recovery plans (e.g. DoE, 2014a; DoE, 2015b) it remains a work in progress. For most of the threatened sharks some critical habitat has been already lost through human use or impact and choices to redress this for marine species are more limited than for terrestrial animals. Relocation and captive breeding are simply not practical or effective. Preservation and protection of enough natural habitat is the best solution with how much constitutes 'enough' being the difficult (and often species specific) question to answer. This can partly be answered by accounting for climate change and human development to focus on those critical habitats which are most likely to endure.

While the fishing industry may argue that the recovery of threatened sharks has been overly focussed on commercial fishing activity it is the unavoidable consequence of being a readily identifiable threat and being one of the most cost-effective threats to have lessened. As noted above, alternatives such as preventing economic development and climate change are a much tougher socio-political proposition that carry with them greater costs.

RECOMMENDATION 14: Mapping and protection of critical habitat for threatened shark species should receive further investment and its contribution to their productivity and recovery potential quantified.

MONITORING AND REPORTING

Throughout this review the significant issue of having accurate data about the interactions with threatened species from both fishing and non-fishing sources remains largely unaddressed. The currently poor monitoring and reporting is reflected in the recent report by Steve Kennelly 'Developing a National Bycatch Reporting System' (FRDC Project 2015/208) who rated several jurisdictions' reporting of bycatch, with protected species reporting rated as very poor. However, Australian fisheries management agencies are making steady progress with increasing deployment of vessel monitoring systems (VMS) on commercial fishing boats, which can give an accurate location of where interactions with threatened sharks are occurring. In some fisheries, such as the Commonwealth Gillnet, Hook and Trap Fishery and the Eastern Tuna and Billfish Fishery, on-board cameras have been deployed that have greatly improved both the monitoring and reporting of interactions. Despite this progress, in most Australian fisheries interactions remain self-reported which results in considerable under reporting of threatened shark interactions, based on the Commonwealth fisheries experience. While claims have been made by fishing industry bodies about the invasive and costly nature of putting cameras on boats to get accurate protected species reporting, these rarely stand up to scrutiny. Commercial fishing boats are a workplace and like many workplaces cameras are used to monitor business activity. As for costs, 100% camera coverage is not essential to gain a good estimate of threatened shark interactions, but expert advice is needed to determine what level and spread of coverage is necessary to get an accurate estimate for each fishery and species of interest.

There remains the largely unmanaged issue of other fishing sectors such as fishing tourism (to which much of the above can equally be applied), recreational fishing (where time/spatial closures are often used but not always well complied with) and indigenous fishing (to which a specific set of laws and precedents apply). Non-fishing on-water activity can also have an impact on threatened sharks, particularly through shark control programs run by some states, but these alone are unlikely to be significant source of mortality in most cases. However, the collective effect of these sources of mortality remains unknown and may be significant for individual protected species, including sharks.

Irrespective of the monitoring tools employed there is no impediment to having standardised, public and near-current reporting of interactions with threatened shark species.

RECOMMENDATION 15: That jurisdictions whose fisheries interact with threatened shark species develop and implement a consistent and cost-effective means of accurately monitoring and reporting interactions, and expand it to all fishing sectors as technology becomes available to do so.

ONE GROUP OF AUSTRALIANS HAS OFTEN BEEN ABSENT FROM DISCUSSIONS ABOUT THREATENED SHARK SPECIES: THE INDIGENOUS PEOPLE OF THE LAND AND SEA. IT IS LONG OVERDUE THAT THEY BE INVITED AS EQUALS TO THE TABLE WHEN SHARK SPECIES ARE BEING CONSIDERED FOR LISTING AS THREATENED AND SUBSEQUENTLY THE DEVELOPMENT OF ACTIONS THAT MAY BE TAKEN TO PROTECT THEM.

RECOVERY PLAN ADMINISTRATION

In terms of recovery plan administration for threatened sharks, this can be improved by better specifying the roles and responsibilities of stakeholders including government departments, management authorities and conservation organisations. To be truly effective, and as noted earlier, there needs to be a standing group of key stakeholders who meet regularly to check progress and deal with issues that can arise during the term of a recovery plan. This should include issues around monitoring and budgets, both of which have been identified by the TSSC as weaknesses in recovery plans. Furthermore, there appears to be no requirement in the EPBC Act to implement recovery plans resulting in concerned stakeholders often resorting to the Wildlife Trade Operation (WTO) process to press for recovery action on threatened sharks. This should not be necessary and consistency across these related EPBC Act processes is required with the WTOs supporting recovery plan actions. Internationally there are some useful case studies to draw upon in terms of recovery plan administration such as the US smalltooth sawfish (see Appendix 4).

RECOMMENDATION 16: The Australian government reviews the related processes of Wildlife Trade Operations and threatened species recovery to ensure consistency with the aim of compelling recovery action under both parts of the EPBC Act.

Management strategies developed and implemented by AFMA are an example of how to improve some of the matters raised above in relation to recovery plans, noting they too are yet to be fully proven in terms of species recovery. Management advisory committee (MAC) and resource assessment group (RAG) processes regularly report on school shark and upper slope dogfish status to the AFMA Commission. This reporting is subsequently made public, including the technical information that underpins it. Further, it includes performance measures in relation to limit and target biomass reference points. While this process is not cost free or perfect it maintains a higher level of public accountability than recovery plans which often have no public reporting for many years and only broad, unmeasurable recovery objectives.

Guidelines for the preparation of recovery plans for terrestrial species and ecological communities have been developed but are still lacking for aquatic and marine species (DoE, 2014b). Given the experience with such recovery plans over two decades, and because sharks have life histories more like those of mammals and birds than teleost (bony) fish, a foundation for doing so is now available. It is unreasonable to expect concerned stakeholders to take useful actions without such guidance since it is ultimately the TSSC, the Department and the Minister who determine whether those actions have contributed to the case for a change in the conservation status of a species.

RECOMMENDATION 17: The Australian government develops guidelines to support the development, implementation and administration of recovery plans (and equivalent documents) for threatened marine species.

While the SPRAT database is a useful starting point there is an increasing body of knowledge that accumulates both before and after a species is listed as threatened, with the latter often acting as a stimulus to increase research efforts. However, it is often difficult and time consuming to find all the public peer reviewed literature that includes departmental reports, projects by other government agencies and governments, university projects and international research. Doing so remains the role of a few dedicated scientists who also translate much of the science into understandable prose for all other stakeholders. Their role becomes a cornerstone of the recovery/management plan review process as without them that task would be almost impossible.

Improvements in compliance scores were recorded between the first and second versions of the White Shark Recovery Plan and Grey Nurse Shark Recovery Plans. This indicates that the process of reviewing recovery plans appears to be valuable in improving the compliance of the plan with the legislated requirements and if nothing else is a reminder to government that the species remains threatened and further action is required to recover it.

RECOMMENDATION 18: Recovery plan and management strategy reviews should continue and be provided with adequate funding to engage the relevant scientists and other stakeholders, and given threatened shark life histories, are best undertaken at five-year intervals.

One group of Australians has often been absent from discussions about threatened shark species: the indigenous people of the land and sea. It is long overdue that they be invited as equals to the table when shark species are being considered for listing as threatened and subsequently the development of actions that may be taken to protect them. This may require greater outreach to relevant indigenous clans and nations but to not do so fails to recognise the importance of threatened sharks to indigenous culture and the role indigenous Australians can play protecting threatened shark species. A relevant example of this is the indigenous marine ranger program run by several jurisdictions across northern Australia to support fisheries compliance and removal of marine debris – including releasing protected species from that debris.

RECOMMENDATION 19: Indigenous Australians are consulted in the process to recommend whether a shark species should be listed as threatened, but the decision whether to do so remains based on scientific evidence.

RECOMMENDATION 20: Indigenous Australians are engaged in the development and implementation of recovery plans and participate in the review of recovery plans.

Conclusions

There is only one way to stop species population declines and make them more abundant over time - reduce their current mortality rate. This can happen in two ways – reducing human-induced mortality or increasing natural productivity. The former has traditionally centred around the easy to see and measure sources of human-induced mortality, e.g. commercial and recreational fishing. For most threatened shark species reported fishing mortality has reduced over the past two decades, but this may in part be an artefact of chasing down the biomass, that is, there are simply fewer of the threatened species to interact with. Other sources of human induced mortality are also likely playing an increasing role in species trajectory (e.g. habitat loss and climate change). For most species these threats have got worse over the last 20 years, perhaps offsetting any benefits from any lower fishing mortality.

Increasing the natural productivity of a species means not just identifying and protecting what critical habitat is left but rebuilding what has been lost. In most cases the losses are due to direct coastal and in-catchment human development and their indirect impacts on coastal ecosystems (physical, chemical and biological processes). Most critical habitat modification cannot be undone, which has consequences for expectations about the extent of recovery that can occur for a threatened shark species, that is, working out what recovery is possible now has to be the measure rather than what might have been without human impacts. This will be a challenging issue to address and all stakeholders will need to be realistic about recovery reference points when ecosystem function may have been compromised.

The effects of climate change are becoming more apparent for marine species and probably began having impacts decades ago but have not been specifically measured for their effects on threatened sharks. However, this is changing with an improved understanding of which marine species groups (including protected species) may fare better or worse under future climate change scenarios. Sharks as a group generally do poorly, except for more pelagic species, with some tropical populations also able to move into cooler, higher latitudes or deeper water. The most at-risk are demersal species that have insufficient habitat to move to in order to escape changed conditions that may affect their physiology or reproduction. A more detailed analysis of threatened sharks as a group under an updated climate change analyses would be useful so we better understand what the future may hold for them and how to best plan for it.

That we cannot accurately measure the effects of any of these human activities on the status of threatened sharks means that many recovery plan actions may be poorly directed and not value for money. It is essential that this shortcoming is addressed immediately through the application of ecosystem modelling that accounts for climate effects and economic development. This must be supported by applying new technologies such as close kin genetics, better data collection from fisheries (VMS, cameras on boats & ships of opportunity) and remote data collection with drones (both aerial and sub-surface).

RECOMMENDATION 21: That a broad human effects assessment for threatened shark species is undertaken with reference to impacts on abundance, distribution, phenology, physiology and variability.

The Commonwealth's management of school shark provides perhaps the most information rich example of the impacts of human induced mortality and changed productivity on a threatened shark species. It has had almost continuous management and scientific attention for more than three decades. What it tells us is not to expect a species to return to its 'original' state in the face of shifting ecological and anthropogenic baselines. It also tells us that having realistic, time bound, compulsory rebuilding reference points does support halting the decline of a species and potentially promoting its recovery (albeit at a slow pace). Further, it demonstrates that involving key stakeholders through an on-going process of engagement garners support for recovery actions (including funding) that are more likely to benefit the species. Good monitoring of the rules (in this case through VMS and observers and/or cameras on boats) also ensures high levels of compliance so there can be greater certainty about fishing mortality.

On the other hand, the Maugean skate, which is relatively data poor, does not have a recovery plan or management strategy. It provides an example of what actions can be taken while basic biological information is still being gathered. Many of the elements of a recovery plan are taking shape with several science projects underway and coordination of activities through state-based institutions. Community and stakeholder engagement have been successfully undertaken to gain support for recovery actions. However, effective monitoring of the fishing rules remains problematic due to insufficient resources and there is no on-going funding source specifically allocated to this species. Despite this being a state-based response, it remains beneficial for Tasmania to engage with other groups dealing with threatened shark species across Australia. This is particularly so when dealing with the broader issues of climate change and economic development where many other organisations are active in trying to find solutions to impacts on marine ecosystems.

It is important to conclude this report by recognising the very many people who have responded to the threatened status of sharks in Australia over recent decades, yet measurable improvement in their status remains elusive. Any recovery is set against an ever-increasing human population with its growing demand for land, food and water. While humanity has the intelligence and resources to recover threatened shark species and we have the capability to develop the science and technologies to support doing so, our self-interest is what drives real change. Governments and their governance structures currently guide our self-interest in a direction that does not highly value sustainability or efficient use of resources but instead consumption and economic growth. While this remains the case the options for recovering our threatened species reduce over time and the odds of successfully doing so shorten. It is ultimately the path to widespread species decline or extinction unless we act nationally and internationally to change course as some nations are starting to do. We should join them before it's too late.

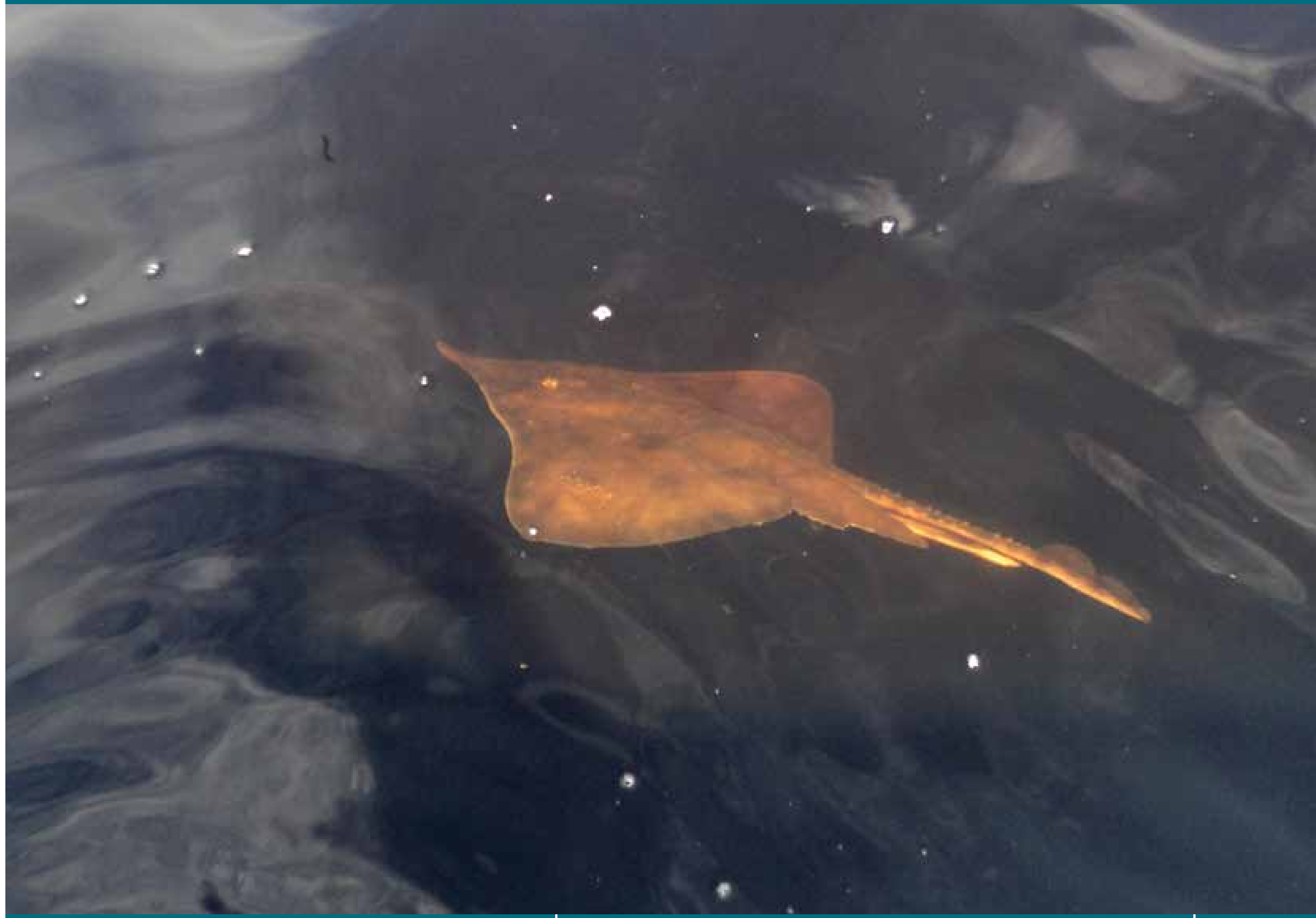
List of Appendices

Review of progress against threatened shark recovery plans by Dr Matthew Heard

Australian National Report Card on Sharks

Other useful links & references

International example of a recovery plan approach – US Smalltooth sawfish (*Pristis pectinata*)



Maugean skate (*Zearaja maugeana*) surveyed by researchers in Macquarie Harbour, Tasmania. © Cynthia Awruch

Appendix 1

REVIEW OF PROGRESS AGAINST THREATENED SHARK RECOVERY PLANS BY DR MATTHEW HEARD

WHITE SHARK (*CARCHARODON CARCHARIAS*)

The white shark was listed as Vulnerable on the *Commonwealth Endangered Species Protection Act, 1992* in 1997 following a nomination from Humane Society International. It was included in the *Environment Protection and Biodiversity Conservation Act* (EPBC) threatened species list at its enactment on July 16th, 2000. This listing was based on evidence of a declining population, slow life history characteristics, limited local distribution and abundance; and, significant ongoing threats from capture in the commercial fishing industry (Environment EA, 2002b).The main threats to the white shark in Australian waters are mortality associated with accidental and illegal capture by commercial and recreational fisheries as well as mortality related to shark control activities on the east coast of Australia (DSEWPaC, 2013; EA, 2002b).

The first recovery plan for this species came into effect in 2002 and reviewed in 2008 following which the current recovery plan was released in 2013. The 2008 review of initial recovery plan found that, of 34 actions, 14 had been complete, nine partially completed, four are ongoing. Actions that were related to threat abatement and education were more likely to have been completed than actions related to research on the ecology and distribution (Fig. 1). Despite some progress based on the actions of the 2002 recovery plan there remained no evidence at the time that would indicate a recovery of the population of white sharks in Australian waters (DEWHA, 2008).

The white shark has been the subject of the highest number of research publications of all Australian threatened sharks and rays. The white shark is also the focus of a range of the National Environmental Science Programme (NESP) Marine Biodiversity Hub projects including;

- White shark population and abundance trends https://www.nespmarine.edu.au/project/project-5-white-shark-population-and-abundance-trends
- National assessment of the status of white sharks https://www.nespmarine.edu.au/project/project-a3-national-assessment-status-white-sharks
- Identification of near-shore habitats for juvenile white sharks in south-western Australia https://www.nespmarine.edu.au/project/project-a14-identification-near-shore-habitats-juvenile-white-sharks-south-western-australia

Reliable estimates of population size and trends in population growth are critical to assess the effectiveness of recovery plan actions (DSEWPaC, 2013). Progress has been made in estimating the population size of adult white sharks through the NESP project – White Shark Population and Abundance Trends. This project recently published population growth estimates for adult white sharks for populations on the east and south-west of Australia (Bruce *et al.*, 2018). The trend in population growth for adult white sharks is estimated to be near zero since the early 2000's (Bruce *et al.*, 2018). An extended period of sampling is required to produce an estimate of population size and trends so further research is required to establish the total population trends for both eastern and western populations (Bruce *et al.*, 2018).

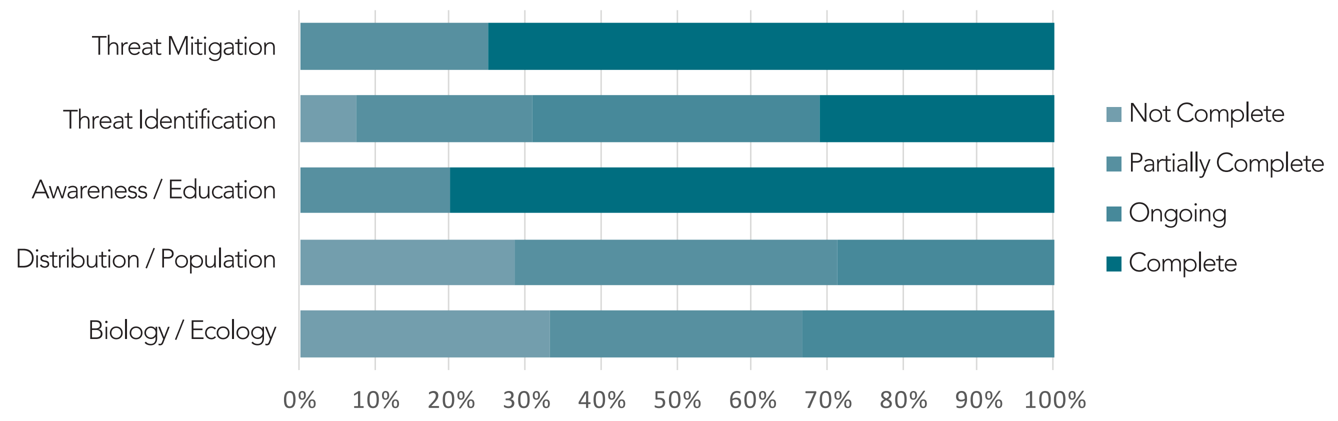


Figure 1. Summary of reviewed action outcomes from the 2002 White Shark Recovery Plan (DEWHA, 2008)

GREY NURSE SHARK (*CARCHARIAS TAURUS*)

Two separate populations of the grey nurse shark are listed on the EPBC threatened species list with the eastern population assessed as Critically Endangered and the western population assessed as Vulnerable. The first recovery plan for the grey nurse shark came into force in June 2002 (EA, 2002a). A review of the progress of this recovery plan was completed in January 2009. This review found that, of the 40 actions listed in the recovery plan, 12 had been completed 25 partially completed and three had little or no action recorded (Fig. 2, DEWHA, 2009). Justification was provided for some actions not being pursued where alternate actions were taken, for example, sites identified as critical habitats for grey nurse sharks were not nominated for the EPBC Act Register for Critical Habitats as alternate forms of protection were deemed more effective (DEWHA, 2009).

The review noted that 18 of the 19 key aggregation sites identified in the 2002 recovery plan had been given some level of protection in the form of fishing closures, marine parks, protection areas and marine reserves. While all 19 sites listed as critical habitats have been given some level of protection, these protections are limited to restrictions on fishing methods and gear for some sites (DEWHA, 2009). As of 2009, one site in QLD and three in NSW still allow some form of baited fishing within the sites.

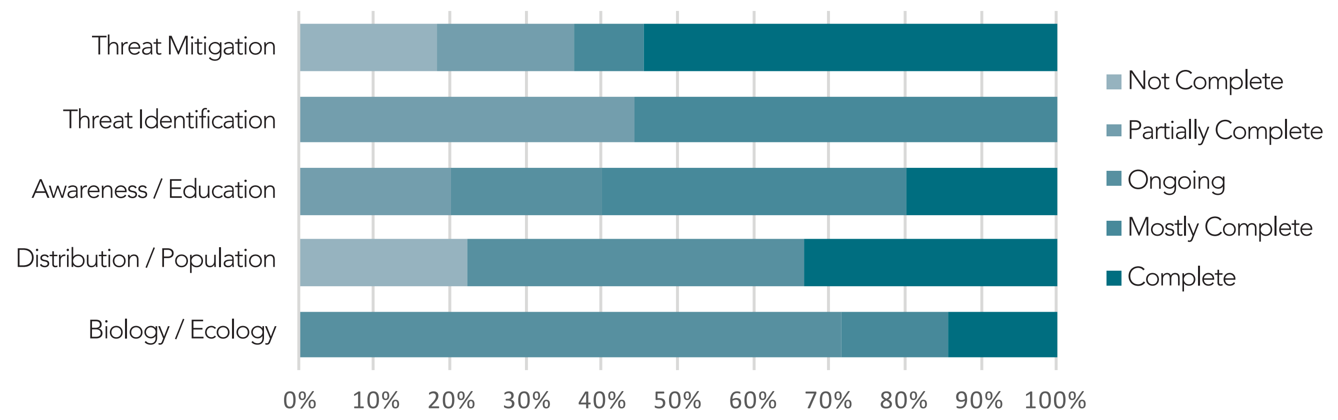


Figure 2. Summary of review of action outcomes from the 2002 Grey Nurse Shark Recovery Plan (DEWHA, 2009)

Like most of the recovery plans reviewed in this report, the cost of implementation was not outlined in complete detail in either the original or the 2014 recovery plan. For example, of the 18 high priority actions identified in the 2014 recovery plan, only four have estimated costings with the remainder being listed as 'core government business'.

The total population size for the east coast population was originally estimated to be between 300 and 3,000 individuals (Otway *et al*., 2004). A population estimate protocol for the east coast population of grey nurse sharks has been developed and implemented (Smith & Roberts, 2010). This protocol uses a combination of underwater visual census and baited remote underwater video method and has estimated the population to be between 1465 and 3249 individuals (Smith & Roberts, 2010). This estimate does not indicate a trend in the population and an additional five years of data is required to be collected to provide any estimates in population trends.

SAWFISH AND RIVER SHARKS (*PRISTIS* SPP. AND *GLYPHIS* SPP.)

The freshwater sawfish (*Pristis microdon*) was listed as vulnerable in 2000 with this listing recently being updated to recognise this species as the largetooth sawfish (*P. pristis*) reflecting changes to the taxonomy of the Pristis genus (Faria *et al*., 2013). The green sawfish (*P. zijsron*) and dwarf sawfish (*P. clavata*) were included on the EPBC threatened species list in 2008 and 2009 respectively. The two species of river sharks present in Australian waters (*Glyphis glyphis* and *G. garricki*) were listed on the EPBC threatened species list in 2000 and 2001. The principal threats to sawfish and river sharks have been identified as; incidental capture by commercial, recreational and indigenous fishing and; habitat degradation and modification.

In 2005 a conservation assessment was completed for the two river sharks (*Glyphis spp*.) and two of the sawfish species (*P. microdon* and *P. zijsron*) (Stevens *et al*., 2005). This report highlighted the threats to these species and provided the basis for the nomination of the EPBC nominations for *P. zijsron* and *P. clavata*. Field *et al*. (2008) investigated the distribution and abundance of these species as well as their interactions with commercial fisheries. One of the major knowledge gaps identified for sawfish and river sharks is a lack of monitoring of population trends.

The Sawfish and River Shark Multispecies Recovery Plan was implemented in 2015 (DoE, 2015b). This plan contains 10 objectives and 34 actions that are required to initiate the recovery of these species in Australian waters. One of the major objectives of this recovery plan highlights the need for more targeted research for all sawfish and river sharks on the EPBC threatened species list (DoE, 2015a). These species are currently the subject of two major NESP threatened species hub projects:

- Project A1
  https://www.nespmarine.edu.au/project/project-a1-northern-australian-hotspots-recovery-threatened-euryhaline-species and;
- Project A12
  https://www.nespmarine.edu.au/project/project-a12-%E2%80%93-australia%E2%80%99s-northern-seascape-assessing-status-threatened-and-migratory-marine

Additionally, the number of peer-reviewed scientific articles for these species in Australia has more than doubled every five years since 2004 (Fig. 5).

MAUGEAN SKATE (*ZEARAJA MAUGEANA*)

The Maugean Skate was listed as Endangered in 2004 based on its small population size and restricted geographic distribution. Despite a Threatened Species Scientific Committee (TSSC) recommendation that a recovery plan for the Maugean Skate was a high priority, no recovery plan has been prepared and the plan was included on the Not Commenced List in 2009. While the Maugean Skate is only known to occur in Tasmania and is listed as Endangered under the Tasmanian *Threatened Species Protection Act 1995*, no listing advice is available, and a recovery plan has not been prepared for the Maugean Skate under Tasmanian legislation. Threats to the Maugean Skate include pollution, fishing mortality and the impacts of aquaculture in Macquarie Harbor (Treloar *et al*., 2017).

Management measures have been introduced to reduce the likelihood of fishery interactions with the Maugean Skate and monitoring of the harbor is conducted to assess the impacts of the aquaculture industry (Treloar *et al*., 2017). Recent research has estimated a population size for the Maugean Skate in Macquarie Harbor to be approximately 3177 individuals (Bell *et al*., 2016). This study also highlighted the potential impacts of human activities on the range of the Maugean Skate and the importance of dissolved oxygen levels in the harbor (Bell *et al*., 2016).

SCHOOL SHARK (*GALEORHINUS GALEUS*)

The school shark was listed as Conservation Dependent (CD) on the EPBC threatened species list in 2009 as a result of a Humane Society International nomination. The main threats identified for school sharks mortality from targeted and incidental capture in the fisheries of south-eastern Australia (AFMA, 2015). As a CD species, a rebuilding strategy was developed for the school shark by the Australian Fisheries Management Authority (AFMA) in 2008 (AFMA, 2008) and has since been reviewed and revised (AFMA, 2015). The School Shark Rebuilding Strategy uses a combination of closed areas, gear restrictions, size limits and setting of total allowable catches. These measures are used with the aim of rebuilding school shark stocks while still allowing fishing for gummy sharks (*Mustelus antarcticus*).

The stock rebuilding strategy incorporates similar elements and objectives to a threatened species recovery plan and is reviewed over a five-year timeframe. In addition, annual reviews of school shark catch rates are conducted by AFMA's shark resource assessment group (SharkRAG). Despite a decade of the rebuilding strategy, the most recent ABARES assessment found that the status of the school shark stock remains overfished in Australian waters (Patterson, H., Williams, A., Woodhams, J. and Curtotti, R 2019). This assessment was based on the estimate that the stock remains below the limit reference point of 20 per cent of unfished biomass.

UPPER SLOPE DOGFISH (*CENTROPHORUS* SPP.)

Harrisson's dogfish (*Centrophorus harrissoni*) and southern dogfish (*C. zeehaani*) were included on the EPBC threatened species list in 2013 under the Conservation Dependent category. The Upper-Slope Dogfish Management Strategy was developed by AFMA in 2010 and revised in 2012 based on a review of the original measures (AFMA, 2012). The main threat to these species is mortality from capture within the Southern and Eastern Shark and Scalefish Fishery (SESSF), Commonwealth Trawl Fishery and some NSW fisheries (AFMA, 2012 ; NSW-DPI, 2012).

The Upper-Slope Dogfish Management Strategy uses a combination of a network of spatial closures, 100% monitoring and non-retention of dogfish. The primary objective of the Upper-Slope Dogfish Management Strategy is to promote the recovery of Harrisson's dogfish and southern dogfish but both of these species are still considered overfished in Australian waters according to the most recent assessment from ABARES. Populations remain below the 20% reference point and fishing mortality remains uncertain despite low landed catch and protection from closures (Patterson, H., Williams, A., Woodhams, J. and Curtotti, R 2019).

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Appendix 2

AUSTRALIAN NATIONAL SHARK REPORT CARD

(Note that there is no report card for the Maugean skate)

Dwarf Sawfish, *Pristis clavata*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Endangered
Assessors	Kyne, P.M., Rigby, C.L. & Simpfendorfer, C.		
Report Card Remarks	Significant historical declines and now protected in Australia but still susceptible to capture		

Summary

Source: Australian National Fish Collection/CSIRO. License: CC By Attribution-NonCommercial.

The Dwarf Sawfish is a coastal and inshore sawfish species restricted to northern Australia. Its protruding toothed rostrum makes it highly susceptible to capture. Historical records suggest it was distributed throughout the Indo-West Pacific Ocean however it is possibly now extinct in these areas and it is now restricted to northern Australia. In Australia, it has undergone significant declines inferred to be 50-80% and it is now protected under the EPBC Act and State legislation. However, it is susceptible to capture and there is no evidence of population recovery. Therefore, the Dwarf Sawfish is assessed as Endangered (IUCN) and Overfished (SAFS). Listed on Appendix I of CITES and Appendix I and II of CMS.

Distribution

The Dwarf Sawfish is likely restricted to northern Australian waters. Historically it may have occurred throughout a much broader area of the Indo-West Pacific with records present from Papua New Guinea, India, Indonesia and more broadly the West Pacific (Faria et al. 2013). Within Australia, it is found from the Pilbara coast (Western Australia) through the Northern Territory and into the Gulf of Carpentaria, Queensland (Last and Stevens 2009). The Kimberley and northern Pilbara represent an important region for the Dwarf Sawfish (Thorburn et al. 2008, Morgan et al. 2011).

Stock structure and status

A lack of confirmed records of the Dwarf Sawfish outside of Australia since the 1800s implies large scale population declines, range contraction and possible regional extinction in the Indo-West Pacific outside of Australia. All sawfish species have undergone significant population declines in Australia, although they are largely unquantified. From continuing commercial fisheries, it is inferred that the Dwarf Sawfish has declined by of 50-80%. Distinct genetic stocks of the Dwarf Sawfish exist in Western Australia, northern coast of Northern Territory and the Gulf of Carpentaria (Phillips et al. 2011, Phillips 2012). It is considered rare in areas of the Gulf of Carpentaria and Northern Territory (Peverell 2005,

Largetooth Sawfish (Indo-West Pacific subpopulation), *Pristis pristis*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Indo-West Pacific subpopulation Assessment – Critically Endangered	IUCN Red List Global Assessment	Critically Endangered
Assessors	Kyne, P.M., Carlson, J. & Smith, K.		
Report Card Remarks	Listed as Vulnerable on EPBC, CITES Appendix I, CMS Appendix II, protected in all states in Australian range		

Summary

The Largetooth Sawfish is a very large tropical sawfish that was widely distributed. The species comprises four distinct subpopulations: Eastern Atlantic, Western Atlantic, Eastern Pacific and Indo-West Pacific. All four subpopulations have undergone significant population declines and the species is now apparently extinct in many former range states. In most others, records are rare and therefore the species is assessed as globally Critically Endangered (IUCN). The Indo-West Pacific subpopulation was once widespread however, large scale population declines and extirpations have occurred across the Indo-West Pacific range, and while there is uncertainty regarding its status in parts of the region, Australia now likely comprises a high proportion of the Indo-West Pacific subpopulation (indeed, the global population of the species). Recent records from elsewhere in the Indo-West Pacific are now extremely rare; in places the species was once described as 'common' or 'abundant'. In Australia, all sawfishes have also undergone significant, albeit largely unquantified declines, and although protection and management is in place in Australia (EPBC Act and State legislation), there is no evidence to suggest population recovery at this time. In the Indo-West Pacific, a population reduction of ≥80% is inferred based on a reduction in extent of occurrence from 1969 to the present. Much of the species' former Indo-West Pacific range, with the exception of northern Australia, is subject to intense human pressure, particularly through generally unregulated and unmanaged fisheries, and habitat loss and degradation in critical sawfish habitats. Therefore, the Indo-West Pacific subpopulation is assessed as Critically Endangered (IUCN) and in Australia, Overfished (SAFS). Listed on Appendix I of CITES and Appendix I and II of CMS.

Distribution

The Indo-West Pacific subpopulation of the Largetooth Sawfish was formerly wide ranging from parts of the Western Indian Ocean through India and southeast Asia to New Guinea and northern Australia.

Its current distribution is now patchy across its range. It had been confirmed from several major river systems of Papua New Guinea, Indonesia and Malaysia, Cambodia, Viet Nam and the Philippines (Roberts 1978, Tan and Lim 1998, Compagno et al. 2005, Stevens et al. 2005). Its occurrence in many of these rivers is now uncertain or non-existent. It may now be extinct in several range states, including South Africa, the Seychelles, Thailand and others; elsewhere it has been severely depleted. Northern Australia may be the last viable population stronghold in the Indo-West Pacific, although it may persist in remote parts of the region. In Australia, it occurs across the tropical north from the northeast coast of Queensland, across Cape York, the Gulf of Carpentaria, the Northern Territory and the Kimberley region (Western Australia). It has occurred as a vagrant to southwestern Australia (Last and Stevens 2009).

Stock structure and status

The species comprises four distinct subpopulations: Eastern Atlantic, Western Atlantic, Eastern Pacific and Indo-West Pacific. All four subpopulations have undergone significant population declines and the species is now apparently extinct in many former range states. In northern Australia there was evidence of significant genetic structure in *P. pristis*, which has strong habitat partitioning with freshwater juveniles and marine adults (Phillips et al., 2017). While there have been large population declines throughout its range, Australia remains one of the few locations where there are demonstrated viable populations (Morgan et al 2011). There are almost no data on population status of Largetooth Sawfish across the Indo-West Pacific. ; all populations are however, probably severely depleted. Although the St Lucia estuary system of South Africa was once an important breeding area, sawfishes (including Largetooth Sawfish) now appear to be extinct in that country. They also now appear to be absent from southern Mozambique (S. Pierce pers. comm. 2012) and while once common in the Zambezi River (Wallace 1967) no recent sightings have been documented. Madagascar, the Seychelles, Pakistan and India, amongst other Indian Ocean range states, have all seen depletions of sawfishes, including Largetooth Sawfish. In southeast Asia, localised depletions and extinctions of sawfishes have been reported or inferred from across the region. All sawfish species have undergone significant, albeit largely unquantified, declines in Australia.

Fisheries

The primary threat to the Largetooth Sawfish is fishing. The long toothed rostrums of sawfishes make them extraordinarily vulnerable to entanglement in any sort of net gear, gillnetting and trawling in particular. The exploitation of elasmobranchs is high in many parts of the Largetooth Sawfish's range in the Indo-West Pacific, particularly in coastal areas and freshwater systems. Unregulated and unmanaged fisheries, and habitat loss and degradation all threaten sawfishes across the region. In addition to fishing mining activities, in northern Australia, New Guinea and elsewhere, pose a risk to Largetooth Sawfish through freshwater habitat alteration or potential pollution events. Alterations to river courses are a realised threat to Largetooth Sawfish which migrate upstream in early life stages. These range from smaller barrages and road crossing in northern Australia to large scale river alterations in southeast Asia. In Australia, net fisheries account for the greatest bycatch of sawfish (all species) (80.2%) followed by trawling (16.6%), line fishing (9.2%) and recreational fishing (0.3%) (Stevens et al. 2005). This species is protected under both federal (EPBC) and state legislation, and a recovery plan is in place. A number of Queensland, Northern Territory and Western Australian inshore net fisheries continue to catch Largetooth Sawfish incidentally. Despite requirements to release these, there is no doubt a continuing level of bycatch associated mortality. Its international trade is restricted by a CITES Appendix I listing. It is listed on Appendix I and II of the Convention on Migratory Species.

Habitat and biology

The Largetooth Sawfish are generally restricted to shallow (<10 m) coastal, estuarine, and fresh waters (Thorburn et al. 2007, Whitty et al. 2008, Whitty et al. 2009). Juveniles occur in freshwater and estuarine areas, while adults are mostly marine. Maximum size is 656 cm total length (TL) although it has been estimated up to 700 cm TL (Compagno and Last 1999). Maximum age is estimated at 35 years in northern Australia (Peverell 2008). Males mature at 280-300 cm TL and females at approximately 300 cm TL with age at maturity estimated at 8-10 years (Thorburn et al. 2007, Peverell 2008, Whitty et al. 2008). The litter sizes are 1-13 with an average of 7 pups (Thorson 1976).

Longevity and maximum size	Longevity: estimated 35 years Max size: 656 cm TL
Age and/or size at maturity (50%)	Males: estimated 8-10 years, 280-300 cm TL Females: estimated 8-10 years, 300 cm TL

Link to IUCN Page: https://www.iucnredlist.org/species/18584848/18620395
Link to page at Shark References: https://shark-references.com/species/view/Pristis-pristis

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Green Sawfish, *Pristis zijsron*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Critically Endangered
Assessors	Simpfendorfer, C.		
Report Card Remarks	Listed as Vulnerable on EPBC, CITES Appendix I, CMS Appendix II, protected in all states in Australian range		

Summary


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The Green Sawfish is a very large ray species that historically occurred throughout coastal areas of the Indo-West Pacific. Green Sawfish population size and historic abundance is poorly known, however the species is believed to have substantially declined throughout its range. Data from northern Australia indicated that Green Sawfish has low rates of population increase. Therefore, the species is naturally highly sensitive to fishing pressure and will likely be slow to recover from population depletion. Its toothed rostrum and use of habitat near the sea floor means the Green Sawfish is extremely susceptible to capture in gillnets and demersal trawl nets. As a result, Green Sawfish has been negatively affected by inshore net and trawl fisheries. Globally, Green Sawfish populations are suspected to decline more than 80% over three generations (approximately 44 years), and there have likely already been localised extinctions in a number of areas due to intensive fishing. Australia has some of the last remaining viable populations of Green Sawfish in the world, however its Australian range has also significantly decreased. Therefore, it is assessed as Critically Endangered (IUCN) and in Australia, Overfished (SAFS). Listed on Appendix I of CITES and Appendix I and II of CMS.

Distribution

Green Sawfish have a broad Indo-West Pacific distribution, from South Africa, north along the east coast of Africa, through the Red Sea, Persian (Arabian) Gulf, southern Asia, Indo-Australian archipelago, and eastern Asia as far north as Taiwan and southern China (Fowler 1941, Blegvad and Løppenthin 1944, Smith 1945, Misra 1969, Compagno 2002a, b, Last and Stevens 2009). Its current occurrence in much of this range is uncertain due to a lack of reliable data, but it is presumed to have been extirpated from much of this area because of intensive inshore gillnet and trawl fisheries. In Australia, the Green Sawfish is most abundant in the tropics, but has historically been found in New South Wales (NSW), However, it is likely now extinct in NSW with southern extent of Green Sawfish on the east coast contracted from Sydney, NSW, to the Whitsunday region of Queensland (Johnson 1999, NSWDPI 2007, Harry et al. 2011).

Stock structure and status

There are limited data available on Green Sawfish populations. Extensive surveys of fish landing sites throughout Indonesia have not observed the species since 2001 (W. White pers. comm. 2012), suggesting that its occurrence in this region is now questionable. In Australian waters, all sawfish species have undergone significant declines. The lack of data from surveys and fisheries in much of its range suggests that Green Sawfish abundance has significantly declined in most, if not all, areas. A population decline of more than 80% is suspected across its global range over the last three generations.

Fisheries

Globally, the primary threat to the Green Sawfish is fishing. Its large size, low biological productivity, propensity for entanglement, and high value all contribute to this vulnerability (Salini et al*.* 2007, Tobin et al*.* 2010). Inshore gillnet and trawl fisheries, which are common and intensive throughout much of its global range, are the greatest threat. Although sawfishes are rarely targeted in these fisheries, they are regularly retained bycatch because of the value of their fins, rostrum and meat. Other threats to Green Sawfish include habitat loss (particularly loss of intertidal areas and coastal development), pollution, loss of genetic diversity, and climate change. However, relative to fishing, these threats are unlikely to substantially affect global status.

This species is protected under both federal (EPBC) and state legislation, and a recovery plan is in place. Data on sawfish in fisheries are sparse, and rarely species specific, making conclusions about the extent of threats difficult to determine. Data for northern Australia shows that gillnets were responsible for approximately 80% of records of sawfish captures (Stevens et al. 2005). The gillnet fisheries in northern Australia that are likely, or known, to interact with Green Sawfish include the Queensland East Coast Inshore Finfish Fishery (Harry et al*.* 2011), Gulf of Carpentaria Inshore Gillnet Fishery (Peverell 2005), Gulf of Carpentaria Offshore Gillnet Fishery (Peverell 2005), Northern Territory Barramundi Fishery (Field et al*.* 2008), Northern Territory Offshore Net and Line Fishery (Field et al*.* 2008), and the Kimberley Gillnet and Barramundi Fishery. Prawn trawl fisheries known, or suspected, to interact with Green Sawfish include the Northern Prawn Fishery, Queensland East Coast Trawl Fishery, and smaller prawn fisheries in Western Australia and NSW. The species is also encountered in fish trawl fisheries in northern Australia. The capture of Green Sawfish in recreational line fisheries likely occurs at low levels. Green Sawfish were also taken in shark control programs in NSW and Queensland (Giles et al*.* 2004). The capture of Green Sawfish in these programs is now non-existent (NSW) or extremely rare (Queensland). Ecological risk assessments of fisheries in northern Australia that interact with Green Sawfish have demonstrated that the species is one of the most at-risk elasmobranch species within the region. Trawl data from Australia's Northern Prawn Fishery indicated that the recent level of take was close to the sustainable limit (Zhou and Griffiths 2008), and when combined with the gillnet take in the same area, it undoubtedly exceeds the sustainable take. As such, even in Australian waters, threats to the species are ongoing and populations are likely to continue to decline without additional conservation measures. Its international trade is restricted by an CITES Appendix I listing. It is listed on Appendix I and II of the Convention on Migratory Species.

Habitat and biology

Green Sawfish are most common in shallow coastal and estuarine areas, but occur at depths of over 70 m (Stevens et al*.* 2005). The young are known to use nearshore and estuarine areas as nurseries. Adults occur more broadly and will use deeper areas (Stephenson and Chidlow 2003). Green Sawfish may be the largest of the sawfishes, with reports of individuals in excess of 700 cm total length (TL). However, most reports suggest lengths over 600 cm TL are currently rare.

Longevity and maximum size	Longevity: unknown Max size: 600-700 cm TL
Age and/or size at maturity (50%)	Both sexes: estimated 300 cm TL

Link to IUCN Page: http://www.iucnredlist.org/details/39393/0
Link to Species page at Shark References: http://shark-references.com/species/view/Pristis-zijsron

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Northern River Shark, *Glyphis garricki*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Critically Endangered
Assessors	Pogonoski, J. & Pollard, D.		
Report Card Remarks	Rare species with possibly very few mature individuals remaining		

Summary

Source: White et al. 2015. License: CC By

The Northern River Shark is a rare species found in northern Australia and Papua New Guinea. It is suggested that fewer than 250 mature individuals exist. It is threatened by fishing pressure and is presumably taken as bycatch in commercial and recreational fisheries. Habitat degradation is another likely threat due to its coastal and estuarine distribution. It is listed as Endangered on the *Environment Protection Biodiversity Conservation Act 1999* list of threatened species and hence protected under Commonwealth law. A recovery plan has been developed. Until abundance can be proven to be greater than suspected levels, it is assessed as Critically Endangered (IUCN) and in Australia, Overfished (SAFS).

Distribution

The distribution of the Northern River Shark is uncertain. It occurs in marine, freshwater and estuarine habitats and is known to occur in several areas in Western Australia (Ord and King Rivers, King Sound and Joseph Bonaparte Gulf) and Northern Territory (South and East Alligator Rivers and Wessel islands) (Last and Stevens 2009). It has been confirmed as occurring in Papua New Guinea with the finding of two individuals in the coastal marine waters of the Daru region (White et al. 2015). This was the first confirmed record of this species in Papua New Guinea since the 1970s (White et al. 2015). Genetic analyses confirmed the samples from PNG cluster well with samples collected in northern Australia (White et al. 2015).

Stock structure and status

The population size of the Northern River Shark is unknown but suspected to be small based on their rarity and current knowledge. Surveys targeting freshwater and estuarine elasmobranchs in northern Australia (Western Australia, Northern Territory, Queensland) in mid-late 2002 collected no *Glyphis* specimens, despite sampling in 136 sites in 38 rivers. Surveys are currently being conducted in the Northern Territory to better understand the population of the species. It is inferred that the population contains fewer than 250 mature individuals and no subpopulation contains more than 50 mature individuals.

Fisheries

The primary threats to Northern River Sharks are likely fishing pressure and habitat degradation (Compagno 2002). The Northern River Shark may be largely restricted to freshwater and brackish parts of rivers which combined with the very small population places the species at greater risk to fishing and habitat changes than more widely ranging species. Commercial fishing in the form of gillnetting (legal or illegal) or longlining in northern Australian probably accounts for most of the take. Commercial net fishing is prohibited in the mouth of the Adelaide River (Northern Territory) to protect *Glyphis* spp. including *G. garricki*. The species is totally protected in Western Australia under the FRMA. Recreational fishing may be in the form of illegal gillnetting or hook and line fishing (using bait and/or lures). The potential impacts of fishing operations on this species need further investigation.

Habitat and biology

Northern River Sharks are found in large tidal tropical river systems and coastal habitats with high turbidity. The juveniles and sub-adults have been found in freshwater, estuarine and marine habitats (salinities of 2-36 part per thousand), while adults have only been recorded in marine habitats (Larson 2000, Pillans et al. 2010, White et al. 2015). Maximum size is estimated at 250-300 cm total length (TL), with males mature at approximately 142 cm TL and a 177 cm TL female was mature (Last and Stevens 2009). In northern Australia, a single female was recorded with 9 pups and free swimming young have been found in October, which suggests they give birth in October (Pillans et al. 2010). Little else is known of the biology.

Longevity and maximum size	Longevity: unknown Max size: 250-300 cm TL
Age and/or size at maturity (50%)	Males: ~142 cm TL Females: unknown

Link to IUCN Page: http://www.iucnredlist.org/details/42712/0
Link to page at Shark References: https://shark-references.com/species/view/Glyphis-garricki

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Speartooth Shark, *Glyphis glyphis*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Endangered
Assessors	Compagno, L.J.V., Pogonoski, J. & Pollard, D.		
Report Card Remarks	Rare species with possibly few mature individuals remaining		

Summary

The Speartooth Shark is a very rare, estuarine and coastal shark species found in northern Australia and Papua New Guinea. It is suggested that fewer than 2,500 mature individuals exist and that no subpopulation contains more than 250 mature individuals. It is presumably threatened by fishing pressure as it is taken as bycatch in commercial and recreational fisheries. Habitat degradation in rivers and estuaries is also a likely threat. It is listed as Critically Endangered on the *Environment Protection Biodiversity Conservation Act 1999* list of threatened species and a recovery plan developed. Until abundance can be proven to be greater than suspected levels, it is assessed as Endangered (IUCN) and in Australia, Overfished (SAFS).

Source: White et al. 2015. License: CC By Attribution.

Distribution

The distribution of the Speartooth Shark is known from limited specimens in scattered locations off northern Australia and New Guinea (Compagno et al. 2008). Within Australia it has been recorded in the Bizant and Wenlock Rivers (Queensland) and the Adelaide and East and South Alligator Rivers (Northern Territory) (Last and Stevens 2009). Within New Guinea, it has been recorded close to Port Romilly and the Fly River (Compagno et al. 2008), and from the Daru region (White et al. 2015). The three individuals from Daru were the first confirmed records of this species in New Guinea since the 1960s (White et al. 2015).

Stock structure and status

The population size of the Speartooth Shark is poorly known, but is suspected to be small based on current knowledge and their apparent rarity. Surveys targeting freshwater and estuarine elasmobranchs in northern Australia (Western Australia, Northern Territory, Queensland) in mid-late 2002 collected no *Glyphis* specimens, despite sampling in 136 sites in 38 rivers. Research in the Northern Territory and Queensland to better understand the population of the species have identified areas where juveniles are common (e.g. Lyon et al. 2017). It is inferred that the global population contains fewer than 2,500 mature individuals and that no subpopulation contains more than 250 mature individuals. Populations should be conserved to maintain genetic diversity. No information on stock structure is currently available.

Fisheries

The Speartooth Shark may be largely restricted to freshwater and brackish parts of rivers and coastal inshore waters which combined with the very small population places the species at greater risk to fishing and habitat changes than more widely ranging species. They are taken as bycatch in gillnet fisheries for barramundi and shark, and are also caught in crab traps in rivers (R. Dwyer pers. comm.). Juveniles are also caught be recreational anglers fishing in rivers.

Habitat and biology

The Speartooth Shark is found inshore in highly turbid estuarine and freshwater habitats of salinities of 0.8-28.0 parts per thousand (Pillans et al. 2010; Lyon et al. 2017). In northern Australia, small juveniles have been recorded up to 100 km inland late in the dry season with larger individuals found closer to the river mouth (Pillans et al. 2010). Maximum size is estimated at 260 cm total length (TL), based on the first adults of this species recently recorded from Papua New Guinea that were taken in coastal marine waters (White et al. 2015). The pregnant female was estimated to be 237-260 cm TL, and the two adult males approximately 228 cm TL and 251-256 cm TL (White et al. 2015). Anecdotal information suggests litter sizes of 6 or 7 pups (White et al. 2015). Little else is known of the biology.

Longevity and maximum size	Longevity: unknown Max size: approximately 260 cm TL
Age and/or size at maturity (50%)	Unknown

Link to IUCN Page: http://www.iucnredlist.org/details/39379/0
Link to page at Shark References: http://shark-references.com/species/view/Glyphis-glyphis

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Grey Nurse Shark (Eastern Australia subpopulation), *Carcharias taurus*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Eastern Australian subpopulation Assessment- Critically Endangered	IUCN Red List Global Assessment	Vulnerable
Assessors	Pollard, D.A., Gordon, I., McAuley, R.B. & Simpfendorfer, C.		
Report Card Remarks	Significant declines with slow recovery		

Summary

The Grey Nurse Shark (Eastern Australia subpopulation) is a large bodied species that inhabits coastal and continental shelf waters of eastern Australia. Significant declines in population size occurred in the 1960s and 1970s from targeted and incidental capture in commercial and recreational fisheries and shark control programs. The population has declined by 94-99% in less than three generations (40 years). It has been protected in New South Wales since 1984 and nationally since 1999. However, due to its slow life history characteristics and poor rebound potential its recovery is slow with numbers still likely below 1700. Therefore, the Grey Nurse Shark (Eastern Australia subpopulation) is assessed as Critically Endangered (IUCN) and Overfished (SAFS). The global population is assessed as Vulnerable (IUCN).

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Distribution

Grey Nurse Sharks (Eastern Australia subpopulation) are distributed throughout Queensland and New South wales. It is a migratory species and is known to aggregate in gutters and caves near rocky reefs and islands. Overfishing has led to localised depletion of Grey Nurse Sharks at many former aggregation sites (Last and Stevens 2009). A separate subpopulation of Grey Nurse Sharks occurs off Western Australia.

Stock structure and status

This subpopulation was estimated to consist of as few as 500 individuals (Otway and Parker 2000). Recent analyses estimate a population size of 1146-1662 (Cardno Ecology Lab 2010). Both estimates suggest that this subpopulation of Grey Nurse Sharks has declined by more than 90%. The Eastern Australia subpopulation is genetically distinct from the Western Australia subpopulation (Stow et al. 2006).

Fisheries

The primary threat to Grey Nurse Sharks (Eastern Australia subpopulation) was current and historic fishing. Currently, it is taken as bycatch in commercial and recreational fisheries as well as shark control programs. It is no longer present at a number of sites where aggregations of 40 or more individuals were common. In the 1950s and 1960s, 36 Grey Nurse Sharks were captured annually on average in New South Wales shark control programs. By the 1980s only three were caught per year and in the 1990s only three were caught in total. A similar declining trend was apparent in Queensland shark control programs. Although protected since 1986, it is still taken as bycatch in the New South Wales Trap and Line Fishery (Fletcher and McVea 2000). From 1998-2001 a diver survey showed that 5-7% of Grey Nurse Sharks had fishing gear embedded in their jaws from wobbegong set lines (Otway and Parker 2000).

Habitat and biology

The Grey Nurse Shark is found in coastal and continental shelf waters, often associated with rocky reefs and gutters. It occurs from the surface to depths of 200 m. It migrates in association with seasonal and reproductive events (Otway and Ellis 2011, Bansemer and Bennett 2011). There are no life history data specific to the Eastern Australia subpopulation, so data is inferred from other populations. Maximum age for another subpopulation was recorded to be at least 40 years (Passerotti et al. 2014).

Longevity and maximum size	Longevity: ~40 years Max size: 320 cm TL
Age and/or size at maturity (50%)	Males: 190 cm TL Females: 220 cm TL

Link to IUCN Page: http://www.iucnredlist.org/details/3854/0

Link to page at Shark References: http://shark-references.com/species/view/Carcharias-taurus

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Gulper Shark, *Centrophorus granulosus*

<table>
<tr><td>Report Card assessment</td><td colspan="3">Depleted</td></tr>
<tr><td>IUCN Red List Australian Assessment</td><td>Refer to Global Assessment</td><td>IUCN Red List Global Assessment</td><td>Vulnerable</td></tr>
<tr><td>Assessors</td><td colspan="3">Guallart, J., Serena, F., Mancusi, C., Casper, B.M., Burgess, G.H., Ebert, D.A., Clarke, M. & Stenberg, C.</td></tr>
<tr><td>Report Card Remarks</td><td colspan="3">Taken in fisheries on the Australian east coast where management measures implemented following large population declines, but recovery is expected to be slow</td></tr>
</table>

Summary

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The Gulper Shark is a rare deepwater dogfish with a widespread global distribution. It is taken as bycatch in deepwater fisheries and population declines of 80-95% have been estimated in the northeast Atlantic. In Australia, it is may be exposed to fishing pressure on the east coast and although there is little information on the catch of the species, declines of >90% have been recorded for other *Centrophorus* species in the region. This part of its range is still continually fished and there is no evidence that numbers have recovered on these fishing grounds. The Gulper Shark has one of the lowest reproductive potentials of all sharks with only one pup per litter and a two-year gestation period. This makes it extremely vulnerable to overexploitation and population depletion. There is the potential for increased exposure to unmanaged fishing effort as global fishing fleets move deeper. In Australia, management measures have been implemented to promote recovery of depleted deepwater sharks on the east coast. Therefore, the species is assessed as globally Vulnerable (IUCN) and in Australia, Overfished (SAFS), because although management is in place, recovery of *Centrophorus* species has not yet been shown and is expected to take decades.

Distribution

The Gulper Shark is widely distributed in all ocean basins in temperate and tropical waters, except the eastern Pacific. In Australia, it has a disjunct distribution on the east and west coasts; in the east it is found from northeast Queensland to Wooli (New South Wales) and in Western Australia from Dirk Hartog Island to Montebello Islands (White et al. 2013). There has been taxonomic confusion in the past with this species also reported under the names *C. niaukang* and *C. acus.* These are now both known to be *C. granulosus* (White et al. 2013).

Stock structure and status

The Gulper Shark is rare and determination of population status has been hindered by taxonomic issues that have only recently been resolved. Consequently, there is currently no information on population structure or trend for the species. However, dramatic declines of >90% in other *Centrophorus* species have been recorded where exposed to fishing pressure in the region (Graham et al. 2001). On the west coast fishing effort is low within its known range.

Fisheries

The species is reported to be caught as bycatch of deepwater fisheries in the northeast Atlantic, the northwest Pacific and other regions. In Australia, it is likely taken in the trawl sector of the Southern and Eastern Scalefish and Shark Fishery along the east coast in the southern part of its range, although there is no catch data. Large declines in *Centrophorus* spp. were reported in that fishery at depths of 200-399 m and 400-649 m, which include the depths at which Gulper Shark occurs (Kyne and Simpfendorfer 2010). Subsequently, catch limits and spatial and depth closures were implemented to promote recovery of other overfished dogfish populations, with recovery estimated to take many decades (AFMA 2006, AFMA 2012).

Habitat and biology

The Gulper Shark is demersal on the upper continental slopes and outer continental shelves at depths from 98 to 1700 m, mostly between 300 to 800 m (Baino et al. 2001, Compagno 1984, White et al. 2013). Maximum size is 165 cm total length (TL), with males mature at 105-118 cm TL and females at 143 cm TL (White et al. 2013). The species has only one pup per litter, a gestation period of about two years and possible resting periods between pregnancies (Guallart 1998). This makes it one of the shark species with the lowest reproductive potential.

Longevity and maximum size	Longevity: unknown Max size: 165 cm TL
Age and/or size at maturity (50%)	Males: 105-118 cm TL Females: 143 cm TL

Link to IUCN Page: http://www.iucnredlist.org/
Link to page at Shark References: https://www.shark-references.com/species/view/Centrophorus-granulosus

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Harrisson’s Dogfish, *Centrophorus harrissoni*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Endangered
Assessors	Graham, K.		
Report Card Remarks	In Australia, severely depleted with management measures implemented but recovery expected to be slow		

Summary

Source: CSIRO National Fish Collection.

The Harrisson’s Dogfish is a deepwater species of eastern Australia and New Zealand. It is taken as bycatch by deepwater fisheries and depletion estimates for this dogfish off eastern Australia indicated a 79% reduction in virgin population size. This part of its range is still fished and there is no evidence that numbers have recovered on these fishing grounds. It has very low productivity that make the species extremely sensitive to rapid population depletion by commercial fishing and also means very slow recovery after such depletion. A number of conservation measures have been implemented to promote recovery following its listing as Conservation Dependent (EPBC Act). These include a total ban on retaining any specimens for sale, gulper shark (*Centrophorus* spp.) protection areas off Sydney and eastern Bass Strait that are closed to all methods of fishing, and a ban on trawling below 700 m along the east coast south from Sydney. Therefore, the species is assessed as globally Endangered (IUCN) and Overfished (SAFS) because although management is in place, recovery has not yet been shown and is expected to take decades.

Distribution

Harrisson’s Dogfish occurs off eastern Australia and the seamounts and ridges off New Zealand (Duffy 2007, Last and Stevens 2009). In Australia, it is found from southern Queensland to South East Cape (Tasmania) and on all the Tasmantid seamounts (except for Gascoyne Seamount) (K. Graham pers. obs.).

Stock structure and status

Harrisson’s Dogfish has been depleted off New South Wales between Sydney and the Eden-Gabo Island area where over 20 years from 1976–1977 to 1996–1997 there was a >99% decline in relative abundance of all gulper sharks (*Centrophorus* spp.) (Andrew et al. 1997, Graham et al. 2001). It is likely that there is still some low level fishing mortality in both the lightly fished northern part of its range and the severely depleted southern part of its range, possibly resulting in a continuing slow decrease in the total population size. There is no knowledge of the relative abundance of this dogfish outside Australian waters.

Fisheries

The primary threat to the Harrisson’s Dogfish is fishing. The core depth of the species (350 to 800 m) coincides with the most heavily fished depths by trawlers and longliners operating on the upper slope around southeast Australia. In the period 1975–2000, the population south of Newcastle (NSW) was severely affected with its relative abundance reduced to <5% of historical levels (Graham et al. 2001, Daley et al. 2002, Wilson et al. 2009). Commercial fishing in the Commonwealth Trawl and Scalefish Hook Sectors of the Southern and Eastern Scalefish and Shark Fishery (SESSF) continued to affect the remaining stock, despite a ban on trawling below 700 m implemented in 2007 (AFMA 2006). In 2010, the stock status for the three species of upper slope gulper sharks (Harrisson’s Dogfish, Endeavour Dogfish *C. moluccensis* and Southern Dogfish *C. zeehaani*) on southeast Australian grounds was assessed as ‘overfished’ and ‘subject to overfishing’ (Stobutzki et al. 2011). Further south off eastern Bass Strait and Tasmania, trawling and targeted gillnet fishing in the 1980s and 1990s also severely depleted numbers (Daley et al. 2002). As a result of population declines a plan of management was implemented (AFMA 2012) and the species was listed as Conservation Dependent under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) in 2013. This plan includes closures to allow the recovery of the population, no retention and other spatial and temporal closures. Incidental fishing mortality by demersal trawlers and auto longliners targeting upper slope teleosts may continue to maintain pressure on the remnant population of Harrisson’s Dogfish off southeast Australia. There is limited deepwater commercial fishing activity across New Zealand Exclusive Economic Zone waters, the north Tasman and Coral Sea where it also occurs.

Habitat and biology

Harrisson’s Dogfish inhabits the upper to mid-continental slope, mainly at depths between 350 and 800 m but with an overall depth range of 275–1,050 m. Maximum size is 112 cm total length (TL), with males mature at 84 cm TL and females at 99 cm TL (Graham and Daley 2011). It has a very low fecundity of one to two pups every two (or possibly three) years and an estimated age at first maturity of >23 years (Whitely 2004).

Longevity and maximum size	Longevity: unknown Max size: 112 cm TL
Age and/or size at maturity (50%)	Males: 84 cm TL Females: estimated >23 years, 99 cm TL

Link to IUCN Page: http://www.iucnredlist.org/details/41740/0
Link to page at Shark References: http://www.shark-references.com/species/view/Centrophorus-harrissoni

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School Shark, *Galeorhinus galeus*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Vulnerable	IUCN Red List Global Assessment	Vulnerable
Assessors	Walker, T.I., Cavanagh, R.D., Stevens, J.D., Francis, M.P., Carlisle, A.B., Chiaramonte, G.E., Domingo, A., Ebert, D.A., Mancusi, C.M., Massa, A., McCord, M., Morey, G., Paul, L.J., Serena, F. & Vooren, C.M.		
Report Card Remarks	Dramatic population reductions in Australia, restrictive Australian catch limits introduced. This species has been assessed in the Status of Australian Fish Stocks Reports (SAFS 2019) as Depleted http://www.fish.gov.au/		

Summary


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The School Shark is a widespread shark of temperate areas which has been fished in all parts of its distribution. In southern Australia, where it was primarily fished for meat for fish and chips, the current mature biomass is estimated to be below 20% of the level before commercial target fishing began in the 1920s. As a result, it was listed as Conservation Dependent (EPBC Act) in 2009 and a recovery plan developed. The species has very low biological productivity; maximum age is potentially 60 years, age at maturity in females exceeds 10 years and mature females breed only every third year. Fisheries for the species are managed by Individual Transferrable Quotas in Australia that should allow stocks to gradually rebuild. Increasing abundances of juveniles suggests some population recovery is occurring. In Australia the species is assessed as Vulnerable (IUCN), and assessed in the Status of Australian Fish Stocks Reports as Depleted (SAFS). The global population is assessed as Vulnerable (IUCN).

Distribution

The School Shark is distributed widely in temperate coastal regions of the world. Within Australasia, the species occurs around New Zealand and off southern Australia from Perth (Western Australia) to Moreton Bay (Queensland), including Lord Howe Island (uncertain) and Tasmania (Last and Stevens 2009).

Stock structure and status

The School Shark has six widely separated sub-populations that do not mix; Australasia, Northeast Pacific, Southeast Pacific, southern Africa, Southwest Atlantic and Northeast Atlantic (Ward and Gardner 1997, Chabot and Allen 2009, Hernández et al. 2015). In Australia the biomass has been reduced to below 20% (1990) and pup production at the start of 1997 was 12–18% of the level before commercial target fishing began (Punt et al. 2000, Marton and Curtotti 2014). Declines in juvenile abundance during 1940 to 1950 in Tasmanian nursery areas were attributed to fishing for pregnant females. Continued nursery area sampling during the 1990s (Stevens and West 1997) indicated a substantial further reduction in abundance of pups and small juveniles in Tasmanian and Victorian embayments and estuaries. Recent sampling in these nursery areas has recorded increasing abundances of juveniles suggesting some population recovery may be occurring. While management measures have been introduced to promote recovery, it is unclear whether fishing mortality has been adequately reduced to allow the stock to recover from its recruitment overfished state. Measurable improvements in biomass are yet to be detected, and the stock is considered to be Depleted (see link to SAFS website below).

Fisheries

The primary threat to the School Shark is fishing with gillnets and longlines in southeastern Australia. Historically this species was targeted, but is now only taken as a byproduct of gummy shark targeted fishing. The species has a long history of exploitation for liver oil, meat and fins in target fisheries in most parts of its range. Minor threats include fishing with trawls and other methods. In southeast Australia, the harvest of School Shark began in the mid-1920s. With establishment of the shark meat market in 1964, production rose rapidly to peak during 1969 at 3,158 t. This declined after the ban on the sale of large school sharks in 1972 because of their mercury content but increased again with relaxation of the mercury laws, reaching 3,060 t during 1986. After 1986, the total annual catch from the shark fishery declined to 170 t by 2001 as a result of management restrictions (Walker 1999, Walker and Gason 2009). Recreational catch is currently unknown, but previous records show 7208 animals retained by recreational anglers in South Australia in 2013-2014.The species was listed as Conservation Dependent under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) in 2009 and a rebuilding plan developed. This included a range of regulations and bycatch limits designed to promote population recovery. Approximately 210 t of School Shark were caught in 2017.

Habitat and biology

The School Shark is primarily demersal and occurs from shallow water to well offshore (Compagno et al. 2005). In Australasia, the species is found to about 800 m depth. Life history characteristics vary regionally (Walker 1999). In Australasia, maximum size is 175 cm total length (TL) and individuals take at least 8 years to mature (Walker 1999, Ebert 2003, Walker 2005).

Longevity and maximum size	Longevity: 50 yrs Max size: 175 cm TL
Age and/or size at maturity (50%)	Males: 8-10 years, 126-131 cm Females: 10-15 years, 142 cm

Link to State of Australian Fish Stocks Page: http://www.fish.gov.au
Link to IUCN Page: http://www.iucnredlist.org/details/39352/0
Link to page at Shark References: http://www.shark-references.com/species/view/Galeorhinus-galeus

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White Shark, *Carcharodon carcharias*

Report Card assessment	**Depleted**		
IUCN Red List Australian Assessment	Refer to Global Assessment	IUCN Red List Global Assessment	Vulnerable
Assessors	Fergusson, I., Compagno, L.J.V. & Marks, M.		
Report Card Remarks	Low productivity and likely declines in catches; Recovery Plan in Australia		

Summary

The White Shark is widely distributed throughout tropical and temperate waters. It is known to move long distances along coastlines and across the open ocean. It is fairly uncommon throughout much of its distribution but is commonly recorded in South Africa, California, Australia and northeast United States. The species is taken as incidental catch in commercial and recreational fisheries. It is targeted in shark control programmes in Australia and South Africa with data indicating long term declines have occurred. The teeth, jaws and fins are highly prized. The White Shark has a low reproductive rate which limits its ability to recover from exploitation. The species is listed on Appendix II of CITES. The White Shark is currently protected in Australia (listed as Vulnerable on EPBC Act), New Zealand, South Africa, USA, Mediterranean and European countries and many small Island States. Australia has a Recovery Plan in place, though without accurate estimates of population size it is not possible to determine if populations are recovering. Therefore, the White Shark is assessed as globally Vulnerable (IUCN) and in Australia as OVerfished (SAFS), with actions underway to more accurately assess the population trend.

Source: sharkdiver.com/Wikimedia Commons. Licence: Public Domain.

Distribution

The White Shark is cosmopolitan throughout much of the ocean with a preference for temperate waters (Compagno 2001). It is concentrated in coastal and pelagic shelf waters but is also found in the open ocean. It probably occurs throughout Australian waters but is more common in the south, from North West Cape (Western Australia), across southern Australia and north to central Queensland (Last and Stevens 2009, DoE 2013). There are known linkages between White Sharks that occur in Australian waters and New Zealand and South Africa (Bonfil et al. 2005, Francis et al. 2015).

Stock structure and status

There is some limited information on population size, structure, and trend for the White Shark. Genetic evidence suggests that there are separate populations around the world, despite the White Shark being highly mobile (Andreotti et al. 2016a). In Australia, genetics and movement data suggests there are two populations of White Sharks, one on the east coast and another on the southwest coast that are separated by Bass Strait (Blower et al. 2012). Based on genetics, a theoretical population size of breeding adults across all of Australia was approximately 1500 individuals. This estimate was preliminary due to a low number of samples and must be interpreted with caution. It was not possible to estimate the east coast population size, while the west coast preliminary population estimate was approximately 700 breeding individuals (Blower et al. 2012). Recent analysis using a close-kin genetic approach estimated the eastern Australian (including New Zealand) adult population size was approximately 750 individuals, and the West Coast population was approximately 1460 individuals (Bruce et al. 2018).

Defining the trend in Australian White Shark population is difficult as the species is widely dispersed, highly mobile, occurs in low density and there is limited catch data because it is not targeted by commercial fishers (DoE 2013). Data from the New South Wales (NSW) shark control programme suggests White Shark numbers may have stabilised in NSW over the last 30 years (DoE 2013). Similar evidence comes from the close-kin genetic analysis (Bruce et al. 2018)There is historical evidence of a decline in White Shark numbers across Australia over the last 60 years with no evidence that numbers have substantially recovered since they were protected in Australia by a listing as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and protected under various state legislation in the late 1990s due to population decline (DoE 2013). Australia has a National Recovery Plan in place that aims to halt the decline and support the recovery of the White Shark in Australian waters with actions identified to more accurately assess population trends (DoE 2013).

Fisheries

White Sharks are caught as bycatch in commercial and recreational fisheries, and also killed in shark control programs in Queensland and New South Wales. As a Threatened species this species cannot be targeted by fishers. The teeth, jaw sets and fins are highly prized (Ebert et al. 2013). It has a relatively low intrinsic rebound potential that limits its ability to recover from exploitation (Smith et al. 1998). The majority of catches worldwide are through incidental catch in recreational fisheries and commercial fisheries operating longlines, setlines, gillnets, trawls and other gear. The overall, long-term impact of these causes of mortality upon regional populations is probably detrimental. The White Shark is also currently protected in New Zealand, South Africa, USA, Mediterranean and European countries and many small Island States (Ebert et al. 2013). Exemptions are made for shark control programmes. The White Shark is also protected through international agreements, that is, the Convention on International Trade in Endangered Species (CITES) Appendix II and Convention on Conservation of Migratory Species (CMS) Appendices I and II.

Habitat and biology

The White Shark prefers temperate coastal and shelf waters and occurs from the surface to depths of 1,300 m (Last and Stevens 2009, Ebert et al. 2013). Adults are most commonly observed in aggregations near rocky reefs around pinniped colonies (Ebert et al. 2013). Juveniles in the eastern Australian subpopulation occur along sandy beaches and in estuarine environments (). Maximum size is around 600 cm total length (TL) possibly up to 640 cm TL (Compagno 2001). Maximum age is estimated to be 30–44 years (Natanson and Skomal 2015, Christiansen et al. 2016). Reported litters sizes are 2–17, though the maximum number of confirmed pups is 10 (Francis 1996). It has a long gestation estimated up to 18 months (Mollet et al. 2000) and it may only reproduce once every three years (Last and Stevens 2009).

Longevity and maximum size	Longevity: estimated 30-44 years Max size: 600 cm, possibly 640 cm TL
Age and/or size at maturity (50%)	Males: 7-9 years, 360-380 cm Females: 12-17 years, ~450-500 cm TL

Link to IUCN Page: http://www.iucnredlist.org/details/3855/0
Link to page at Shark References: http://shark-references.com/species/view/Carcharodon-carcharias

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Appendix 3

USEFUL LINKS & REFERENCES

GENERAL

https://academic.oup.com/bioscience/article/51/8/643/220596

https://www.anao.gov.au/sites/default/files/Auditor-General_Report_2018-2019_49.pdf

http://www.agriculture.gov.au/SiteCollectionDocuments/abares/shark-assessment-report-2018.pdf

http://www.publish.csiro.au/pc/pdf/PC18006

file:///C:/Users/seaqu/Downloads/Climate-projections-Australian-fisheries-factsheet.pdf

OTHER GREAT WHITE SHARK ARTICLES & REFERENCES

https://www.nature.com/articles/s41598-018-20593-w

https://www.australiangeographic.com.au/news/2018/02/groundbreaking-study-calculates-australias-shark-populations-for-the-first-time/

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0098078

https://www.doc.govt.nz/news/media-releases/2018/new-science-report-lists-sharks-as-threatened/

CSIRO News, 'Putting a number on white shark populations', CSIRO, 9 February 2018, CSIRO.AU/NEWS

OTHER GREY NURSE SHARK ARTICLES & REFERENCES

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https://blog.csiro.au/nursing-grey-nurse-shark-populations-back-to-health/

https://www.nespmarine.edu.au/news/sizing-australia's-eastern-grey-nurse-shark-population

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Appendix 4

INTERNATIONAL EXAMPLE OF A RECOVERY PLAN APPROACH

US SMALLTOOTH SAWFISH (*PRISTIS PECTINATA*)

NOAA Fisheries website - Smalltooth Sawfish, Conservation and Management

The *Endangered Species Act* (ESA) specifies that ***recovery plans must include***: (1) A description of management actions necessary to achieve the plan's goals for the conservation and survival of the species; (2) objective, measurable criteria which, when met, would result in the species being removed from the list; and (3) estimates of the time and costs required to achieve the plan's goal and the intermediate steps towards that goal.

Categories of requested information include: (1) Species biology including, but not limited to, population trends, distribution, abundance, demographics, and genetics; (2) habitat conditions including, but not limited to, amount, distribution, and suitability; (3) conservation measures that have been implemented that benefit the species; (4) status and trends of threats; and (5) other new information, data, or corrections.

In regards to the recovery plan, we are ***soliciting relevant information*** related to smalltooth sawfish and their habitats, including: (1) Criteria for removing smalltooth sawfish from the list of threatened and endangered species; (2) human activities that contribute to the ESA listing factors (section 4(a)(1)(A)-(E)); (3) strategies and/or actions necessary to recover smalltooth sawfish; (4) critical knowledge gaps and/or uncertainties that need to be resolved to better inform recovery efforts; and (5) research, monitoring and evaluation needs to address knowledge gaps and uncertainties, to assess the species' status, or to evaluate progress in addressing the ESA listing factors relative to recovery goals.

OBJECTIVE 1 – MINIMIZE HUMAN INTERACTIONS, AND ASSOCIATED INJURY AND MORTALITY.

DOWNLISTING CRITERIA

A. Effective ongoing programs are in place to educate the public about population status and the prohibitions against capturing, harming, or harassing smalltooth sawfish.

B. Safe handling and release guidelines have been developed, adopted, distributed, and are being effectively implemented in all state and Federal fisheries (commercial and recreational) that may interact with smalltooth sawfish within all recovery regions.

C. State and/or Federal fishing regulations specific to smalltooth sawfish are in place to ensure that injury and mortality from commercial and recreational fishing is maintained below or at levels that ensure the population increases at the rate, or stabilizes at the levels, described in the criteria identified in Objective 3.

DELISTING CRITERIA

A. All downlisting criteria continue to be met.

B. State and/or Federal measures (not including those provided under the ESA) are in place to either prohibit harm or possession of smalltooth sawfish, or ensure that impacts are appropriately assessed, authorized, and minimized.

C. State and/or Federal measures (not including those provided under the ESA) are in place to maintain the population at levels at or above those required for delisting.

Delisting criteria will be addressed once downlisting criteria are met.

OBJECTIVE 2 PROTECT AND/OR RESTORE SMALLTOOTH SAWFISH HABITATS.

DOWNLISTING CRITERIA

A. At least 95% of mangrove shoreline habitat existing at time of listing is maintained and effectively protected in recovery regions G, H, and I.

B. Sufficient mangrove shoreline or alternate scientifically documented non-mangrove nursery habitat are available and accessible to support viable subpopulations of juvenile smalltooth sawfish in recovery regions J and K, and one additional recovery region (apart from G, H, I, J, and K). This level should be a minimum of 25% of the mangrove shoreline habitat that existed in 1940, in each of the above recovery regions. The level of non-mangrove nursery habitat must be determined once specific nursery habitat features are identified.

C. Freshwater flow regimes (including timing, distribution, quality, and quantity) into recovery regions G, H, I, J, K, and the one additional region used to meet the two previous criteria are appropriate to ensure natural behaviour (e.g., feeding, resting, and predator avoidance) by maintaining salinities within preferred physiological limits of juvenile smalltooth sawfish.

D. Habitat areas of adult smalltooth sawfish abundance, including those used for aggregation, mating and pupping are identified, mapped, and effectively protected as appropriate.

DELISTING CRITERIA

A. All habitat-based downlisting criteria continue to be met.

B. Sufficient mangrove shoreline or alternate scientifically documented non-mangrove nursery habitat is available and accessible to support viable subpopulations of juvenile smalltooth sawfish in recovery regions J and K, and one additional recovery region (apart from G, H, I, J, and K). This level should be a minimum of 25% of the mangrove shoreline that existed in 1940, in each of the above recovery regions. The level of non-mangrove nursery habitat must be determined once specific nursery habitat features are identified.

C. Freshwater flow regimes (including timing, distribution, quality and quantity) into recovery regions G, H, I, J, K and the four additional used to meet the previous delisting criteria appropriate to ensure natural behaviour (e.g. feeding, breeding, and pupping) by maintaining salinities within preferred physiological limits of juvenile smalltooth sawfish.

OBJECTIVE 3 ENSURE SMALLTOOTH SAWFISH ABUNDANCE INCREASES SUBSTANTIALLY AND THE SPECIES REOCCUPIES AREAS FROM WHICH IT HAD BEEN PREVIOUSLY EXTIRPATED.

DOWNLISTING CRITERIA

A. In recovery regions G, H, I, J, and K and at least one other recovery region the relative abundance of small juvenile smalltooth sawfish (<200 cm) either has increased at an average annual rate of at least 5% over a 27-year period with greater than 95% certainty or is at greater than 80% of carrying capacity.

B. Relative abundance of adult smalltooth sawfish in combined recovery regions J through L (east coast of Florida) has increased to a level at least 15-times higher than the level at the time of listing with greater than 95% certainty that abundance at this level has been sustained for a period of at least 14 years.

C. Relative abundance of adult smalltooth sawfish in combined recovery regions F through H (west coast of Florida) has increased to a level at least 15-times higher than the baseline level determined in Action 3.2.4 with greater than 95% certainty that abundance at this level has been sustained for a period of at least 14 years.

D. Verified records of adult smalltooth sawfish are observed in 12 out of 14 years, with consecutive records occurring in the last 3 years in recovery regions M or N, and in at least one of recovery regions A, B, C, or D.

The current downlisting criteria are unachievable and require revision.

DELISTING CRITERIA

A. In recovery regions G, H, I, J, and K and at least 4 other recovery regions, one of which must be west of Florida, the relative abundance of small juvenile smalltooth sawfish (<200 cm) is stable or increasing over a period of 14 years following downlisting.

B. Relative abundance of adult smalltooth sawfish (>340 cm) in combined recovery regions J through L (east coast of Florida) is at least 20-times higher than the baseline level with greater than 95% certainty that abundance at this level has been sustained for a period of at least 14 years.

C. Relative abundance of adult smalltooth sawfish (>340 cm) in combined recovery regions F through H (west coast of Florida) is at least 20-times higher than the baseline level with greater than 95% certainty that abundance at this level has been sustained for a period of at least 14 years.

D. Verified records of adult smalltooth sawfish are observed in 12 out of 14 years, with consecutive records in the last 3 years, in recovery regions M or N, and in at least one of recovery regions A, B, C, or D.

E. In addition to the 6 downlisting recovery regions (G, H, I, J, and K and one additional region), the relative abundance of small juvenile smalltooth sawfish (<200 cm) in 3 other recovery regions, at least one of which must be west of Florida, is either increasing at an average annual rate of at least 5% over a 27- year period with greater than 95% certainty or at greater than 80% of carrying capacity.

Delisting criteria will be addressed once downlisting criteria are evaluated, revised, and met.

This report was prepared for the Australian Marine Conservation Society and Humane Society International

This project was funded by the Shark Conservation Fund, a philanthropic collaborative pooling expertise and resources to meet the threats facing the world's sharks and rays. The Shark Conservation Fund is a project of Rockefeller Philanthropy Advisors.