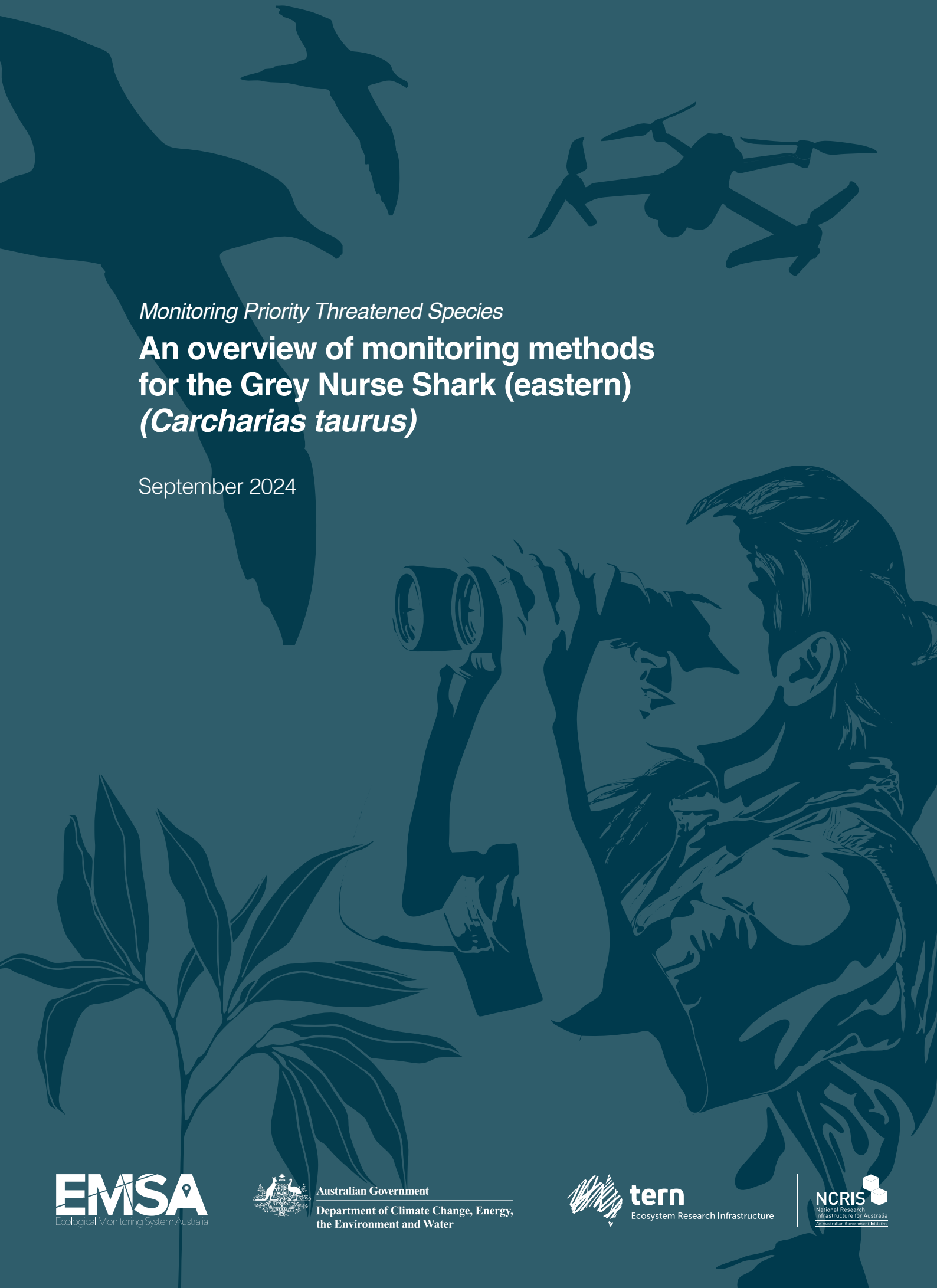


Monitoring Priority Threatened Species

An overview of monitoring methods for the Grey Nurse Shark (eastern) *(Carcharias taurus)*

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We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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About

This literature overview collates information on one of the 110 priority threatened species identified in the *Threatened Species Action Plan 2022-2032* and has been reviewed by invited practitioners experienced in monitoring the species.

The *Survey Guidelines for Monitoring Threatened Species* project, a collaboration of the Department of Climate Change, Energy, the Environment, and Water (DCCEEW) and the Terrestrial Ecosystem Research Network (TERN), aims to improve our knowledge of threatened species by enhancing accessibility and sharing of quality scientific threatened species data. By developing best practice field survey guidelines and recommendations, practitioners will be better equipped to conduct standardised, repeatable surveys.

By identifying the monitoring methods typically implemented by practitioners, documenting and assessing the techniques known to work, and identifying opportunities to standardise the methods, we can move towards ensuring all monitoring is species-appropriate, comparable between practitioners and populations, and repeatable over time. Further, together with consistent terminology, guidelines, instructions, and data collection, we can refine efforts and resources to measure and share information. Data collected using robust, standardised methods will improve our knowledge of threatened species and underpin threatened species recovery at scale. This project is essential to establishing monitoring protocols and data repositories to enhance the accessibility and sharing of threatened species data.

TERN has prepared the literature overviews for the Department of Climate Change, Energy, the Environment, and Water. For further information, please visit the EMSA Threatened Species Survey Guidelines website. Additional information, particularly monitoring methods and techniques not included that should be considered, can be brought to the author's attention by emailing tern@adelaide.edu.au for consideration for future updates.

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1 Background

1.1 Conservation status and species trajectory

1.1.1 Current EPBC Act status

- Critically Endangered

1.1.2 Summary of data held in the Threatened Species Index

The Threatened Species Index (TSX) provides reliable and robust measures of change in the relative abundance of Australia's threatened and near-threatened species at national, state and regional levels. Understanding these changes in species populations is crucial for monitoring Australia's conservation progress and allows users to measure and report on the benefits of conservation investments, and to justify and design targeted management responses. Currently, the index is restricted to birds, plants and mammals, with new groups to be added in the near future.

The TSX does not hold data on the Grey Nurse Shark. More information on the TSX, including how to contribute threatened species monitoring data to the index, can be found at tsx.org.au

1.2 Distribution

- The known range of the east coast population of Grey Nurse Shark (*Carcharias taurus)* covers approximately 2700 km, extending from the Capricornia coast in central Queensland to Narooma in southern New South Wales (Otway *et al.* 2003; Bansemer 2009; Otway *et al.* 2009). The species has been sighted as far south as the NSW/Victoria border (DPI 2002; DOE 2014b).
- The estimated effective population size and number of effective breeders is around 400 individuals (Reid-Anderson *et al.* 2019).
- Grey Nurse Sharks tend to congregate at specific locations (Otway *et al.* 2003). These locations are known as aggregation sites (DOE 2014b).

1.3 Habitat

- Grey Nurse Sharks gather around inshore rocky reefs or islands (DOE 2014b).
- The species usually occur in deep sandy or gravel-filled gutters at the bottom (at depths of 10-40 m) or in rocky caves (Otway and Burke 2004; Dicken 2006; Last and Stevens 2009). They have also congregated at shallower depths (5-15 m) adjacent to or above pinnacles or wrecks (DOE 2014b).
- In addition to being found at regular aggregation sites, juvenile Grey Nurse Sharks have also been observed close to known aggregation sites, but segregated from other adult sharks in small gutters and crevices in shallow, wave-exposed waters (Bansemer 2009; Cardno Ecology Lab 2010; DOE 2014a).

1.4 Ecology

- Grey Nurse Sharks migrate north during autumn-winter and southerly during spring and summer months. This migration pattern is in synchrony with the breeding cycles of Grey Nurse Sharks (Otway *et al.* 2003; Otway and Burke 2004; Bruce *et al.* 2005; Otway and Ellis 2011).
- Adults travel north to southern Queensland and northern New South Wales to mate and then pregnant female aggregate at Wolf Rock in southern Queensland before travelling to their

distribution's central and southern reaches to give birth (Bansemer and Bennett 2011; Reid-Anderson *et al.* 2019).

- Wolf Rock is the only known aggregation site along the Australian east cost where this behaviour occurs (Bansemer and Bennett 2009).
- The Grey Nurse Shark's longevity exceeds 35 years (Goldman *et al.* 2006).
- Male Grey Nurse Sharks reach sexual maturity at 4 - 6 years of age, and females at 6 - 8 years (DEH 2004).
- Late reproductive age, low fecundity and low genetic variability (Stow *et al.* 2006; Reid-Anderson *et al.* 2019) mean that recovery from overfishing is slow and requires a minimum of decades for the population to recover (Smith *et al.* 1998; Mollet and Cailliet 2002; Otway *et al.* 2004; Otway *et al.* 2021).
- Twenty 'key aggregation sites' (defined as sites where 5 or more Grey Nurse Sharks can be consistently found throughout the year) have been identified in Queensland, New South Wales and Commonwealth (off the New South Wales coast) waters (DOE 2014b)
- Key aggregation sites for Australian waters are listed in Table 1 (DOE 2014b).

Table 1. Known aggregation sites critical to the survival of the Grey Nurse Shark in Australian Waters. Adapted from (DOE 2014b).

Queensland waters
Wolf Rock off Rainbow Beach
Cherubs Cave off Moreton Island
Henderson's Rock off Moreton Island
Flat Rock off North Stradbroke Island
New South Wales waters
Julian Rocks near Byron Bay
North Solitary Island (Anemone Bay)
South Solitary Island (Manta Arch)
Green Island near South West Rocks
Mermaid Reef near Laurieton
The Pinnacle near Forester
Big Seal, Seal Rocks
Little Seal, Seal Rocks
Little Broughton Island near Port Stephens
Magic Point at Maroubra, Sydney
Tollgate Islands near Bateman's Bay
Montague Island near Narooma
Commonwealth Waters (off New South Wales coast)
Pimpernel Rock off Broom Head (northern section of Solitary Islands Marine Park
Cod Grounds off Laurieton

1.5 Threats

- Historically (1950s through to the 1970s), the Grey Nurse Shark was overfished and often killed by recreational spear fishers and line fishers, who targeted the sharks at their aggregation sites, however protection of Grey Nurse Sharks under state and Commonwealth legislation means that this species can no longer be targeted.
- The principal current threats are:
  - mortality related to incidental (accidental and/or illegal) capture by commercial and recreational fisheries
  - mortality related to shark control activities such as beach meshing or drumlining.
- Other potential threats to the species include impacts from ecotourism, pollution and disease and ecosystem effects as a result of habitat modification and climate change, including changes in sea temperature and ocean acidification (DOE 2014b).

2 Existing monitoring methods

2.1 Summary of existing methods used

- Genetic sample analysis – e.g. see Reid-Anderson *et al.* (2019)
- Direct observation:
  - Primarily by recreational divers at known aggregation sites and bycatch/accidental capture by professional and recreational fishermen. See Otway *et al*. (2003).
- Tagging:
  - Pop-up Archival Transmitting (PAT) and acoustic tags are attached to the side of the first dorsal fin by inserting the plastic dart through a 5-mm incision in the skin covering the epaxial muscle mass (Otway and Ellis 2011) detailed descriptions in Smith (1992) and Otway *et al.* (2009).

2.2 Existing survey requirements

- Optimal time of year/season/climate conditions (timing with resource availability etc)
  - The optimal timing of monitoring for Grey Nurse Sharks depends on the monitoring objective. Breeding, migration up and down the east coast, aggregations and dispersal need to be considered. Surveys are typically undertaken during the daytime (DSEWPC 2011).
- Optimal location of surveys
  - Depends on monitoring objective, but likely to be known aggregation sites such as Julian Rocks (off Byron Bay, NSW) see Table 1 (known aggregation sites)
  - Note north:south sex bias at NSW aggregation sites (DOE 2014a).
- Minimum survey effort
  - Weeks of work to find, capture and process
  - Days of work per site to dive and collect DNA or eDNA samples.
  - Months of satellite or acoustic tag monitoring are required.
- Survey personnel
  - At least four survey personnel are required if capturing (using SCUBA to lasso tail and move shark to the boat), then measuring, tagging, etc.

2.3 Existing protocols

Existing protocols identified are identified in Table 1.

Table 2. Survey guidelines, protocols, and key resources that identify Grey Nurse Shark (eastern) monitoring methods

Protocol	Comments	Reference
Tail lasso capture	Detailed guidelines for SCUBA capture of *Carcharias taurus*, towing to side of boat, and processing (such as tagging) before release.	Smith (1992); Otway *et al*. (2009)
Survey guidelines for Australia's threatened fish. Guidelines for	Outlines general survey methods for threatened marine sharks. None of the listed species can be reliably collected from an area where they might occur without potentially adverse affects. Visual	(DSEWPC 2011)

detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.	surveys to determine the presence or absence of the species are more desirable and less destructive practices, but such surveys may be expensive and time consuming. There are various observational monitoring programs now in existence, such as the Great Australian Shark Watch (see Australian Underwater Federation, www.auf.com.au), involving a national monitoring program with a few thousand observations. Similarly, various jurisdictions monitor commercial and angling catches of sharks. Grey Nurse Sharks on the east coast of Australia undergo some migratory movements (probably associated with breeding). Any visual techniques to sample for these animals will need to account for such movements before it could be assumed that there are no sharks in a particular area. Determining the presence of Grey Nurse Sharks in inshore areas could be attempted by visual SCUBA diving surveys in a particular area to determine whether the habitat is appropriate and/or to conduct targeted surveys for the sharks.

2.4 Methods to consider

The methods listed below have been identified as potential methods and techniques to survey for the species, either to identify presence or absence, or to assist determining population size and status. Further review of the literature and consultation with experts is required, particularly to identify and assess specific techniques for examining population ecology factors.

2.4.1 Available methods

- Visual SCUBA diving survey to determine presence (DSEWPC 2011).
- Capture and satellite tagging (Smith 1992; Otway and Ellis 2011)

2.4.2 Additional methods

- eDNA (e.g. Schweiss *et al.* 2020)
  - Eastern Australian *Carcharias taurus* have low genetic variability (Stow *et al.* 2006).
  - Dugal *et al*. (2022) collected water samples ~3m from behind whale sharks.
  - Sigsgaard *et al.* (Sigsgaard *et al.* 2016) inferred population characteristics of a large whale shark aggregation from seawater eDNA.
  - Postaire *et al.* (2020) was able to track established seasonal occurrence of blacktip sharks (*Carcharhinus limbatus*) in a semi-enclosed subtropical bay.
- Citizen Science using UAVs/drones – DroneSharkApp; 113 sightings of *Carcharias taurus* (the most sightings for any species, though sharks were the observer's focus) between October 2017 and September 2021 (Pirotta *et al.* 2022).

2.4.3 Methods to rule out

- All survey methods typical for fish are considered suitable (no specific methods ruled out).
- Stereo-BRUVs (stereo-BRUVS; Langlois *et al.* 2020).

2.4.4 Relevant Ecological Monitoring Standards Australia (EMSA) modules

No Ecological Monitoring System Australia (EMSA) modules developed by TERN for the Australian Government have been identified for consideration in surveying the Grey Nurse Shark. EMSA protocols to date have only focussed on terrestrial ecosystems.

2.4.5 Other 110 priority species with potential links

- Similar distribution but different habitat:
- White's Seahorse (*Hippocampus whitei*)

3 Considerations for survey guidelines development

Key considerations should a full literature review and/or survey guidelines be developed for the Grey Nurse Shark are highlighted below.

Special equipment required:

- Boat hire and diving gear.
- Satellite tags.
- For eDNA surveys: Niskin bottle water sampling gear, water filtration products, cold chain storage, eDNA analysis costs.

Estimated time and surveyor effort:

- Weeks of effort for tagging and months of tag data collection. Survey effort required is variable, and depends on a variety of factors such as weather, location, habitat availability, season. Experts should be consulted (DSEWPC 2011).

Vegetation communities or landscapes of the species' preferred habitat not suitable for the optimal survey methods:

- None have been identified to date.

3.1 Key documents for further review

The documents listed below have been identified as key documents to review should a full literature review and/or survey guidelines be developed for the Grey Nurse Shark.

- Protocols:
  - Tail lasso capture (Otway *et al.* 2009)
- Scientific papers and reports:
  - https://www.awe.gov.au/environment/marine/marine-species/sharks/greynurse
  - Department of the Environment (DOE) (2014a). Issues paper for the Grey Nurse Shark (*Carcharias taurus*). Commonwealth of Australia.
  - Otway, N. M. and Ellis, M. T. (2011). Pop-up archival satellite tagging of *Carcharias taurus*: movements and depth/temperature-related use of south-eastern Australian waters. Marine and Freshwater Research 62: 607-620.

3.2 Key agencies and organisations involved in the species research and recovery

- Dr. Nicholas Otway, NSW Department of Primary Industries, Port Stephens Fisheries Institute, Taylors Beach
- Adam Stow, Department of Biological Sciences, Macquarie University

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