

Supplementary Materials

Professional fishers' knowledge informs distribution and interaction dynamics of Sawfish and River Sharks in coastal fishing grounds of the Northern Territory, Australia

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Supplementary Material 1

Background on management of NT Commercial fisheries (as of 2024)

Northern Territory Barramundi Fishery (NTBF)

The NTBF operates annually between the 1st of February to the 30th of September. The fishery operates from the high-water mark to three nautical miles seaward of the low water mark, and is restricted to waters seaward from the coast, river mouths and legislated closed lines (Figure S1). Operators fish over tidal mud flats and within the mouths of some river systems using monofilament gill nets. Nets are set and retrieved based on tides, and operators generally work from smaller dinghies with fish processed onboard larger motherships. In addition to the primary catch species Barramundi (*Lates calcarifer*) and King Threadfin (*Polydactylus macrochir*), the fishery also retains by-product species including Blue Threadfin (*Eleutheronema tetradactylum*), Black Jewfish (*Protonibea diacanthu*), Blacktip Shark (*Carcharhinus limbatus/tilstoni/sorrah*), Queenfish (*Scomberoides commersonnianus*), Tripletail (*Lobotes surinamensis*), Scale Croaker (*Nibea squamosa*) and Barred Javelin (*Pomadasys kaakan*) (Figure S2).

Since its initial development in the early 1960s, the NTBF has undergone several management changes including permanent spatial closures, gear restrictions, catch and size limits (Table S1). Many of the past management actions were enacted to maintain sustainability of the fishery and reduce interactions with TEPS (e.g. Dugong closure areas in the Gulf of Carpentaria). As of 2024, there were 14 Barramundi fishery licences available in the NT which are fully transferable (i.e., can be sold or leased). Each licence has net unit entitlements attached to it, with a “full licence” being allowed a maximum of 1000 meters of gill nets, with a minimum mesh size of 6 inches. In 2024, the combination of full and partial licences totalled an equivalent of 10,700m of net in the fishery.

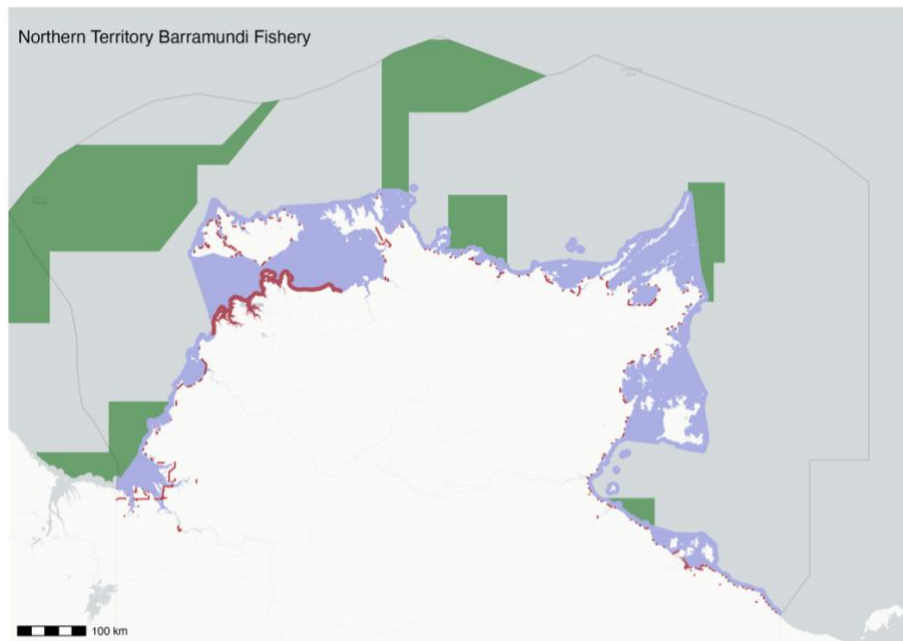


Figure S1. Spatial extent of the Northern Territory Barramundi Fishery (blue region) with closure lines and areas (red lines and polygons) along the coast, additional closures due to Scared Sites are not included in this map. North Marine Parks Network presented as green polygons on each map, with the grey line representing the Northern Territory marine boundary (Source: NT Fisheries).

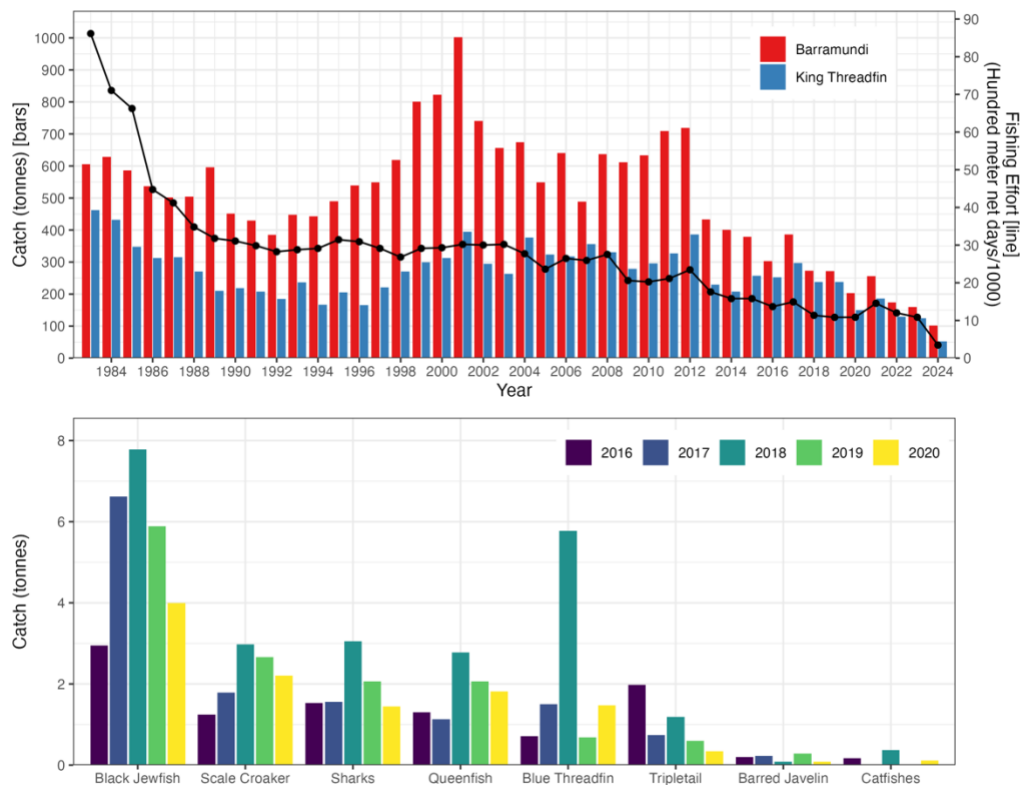


Figure S2. Historic catch trends in the Northern Territory Barramundi Fishery, show a (top) decreasing trend in catch of target species (Barramundi and King Threadfin) coinciding with a decreased fishing effort since 1983. Apart from the target species, the catch of by-product species (bottom) has fluctuated, over the period between 2016 – 2020. (Source: NT Fisheries; Department of Trade, Business and Asian Relations)

Table S1. Changes in management actions to the Northern Territory Barramundi Fishery between 1962 – 2024 (Source: Northern Territory Seafood Council).

Year	Management action
<i>Spatial Closures</i>	
1962	All fresh waters closed to gillnetting and traps between April and December
1969	Closure lines established across significant river mouths around the NT coast
	Prohibition on closing more than half of a stream by netting
1977	Introduction of total seasonal closure from 1 November to 31 January
1980	Closed season extended (1 October to 31 January inclusive)
1986	Mary River closed at the mouth for half of fishing season
1988	Mary River closed to commercial fishing at the mouth
	East Alligator River closed to commercial fishing at the mouth
	Castlereagh and Howard Island closure
1989	Mary River Fish Management Zone extended to incorporate Chambers Bay within a line 3 nautical miles offshore and 3km west of Tommycut Creek and to the east of Sampan Creek Commercial fishing excluded within Anson Bay within the Daly River seasonally closed area South Alligator River closed at mouth to commercial fishing
1993	Partial closure of Victoria River
1998	Darwin Harbour and Shoal Bay closure
2002	McArthur River closed
2004	Adelaide River closed
2009	Bynoe Harbour and the Finniss River (inc. part of Fog Bay) closed
2013	Chambers Bay and Finke Bay closed
2023	Mini-Mini and Murgellia Region closed (including Coopers Creek and East Alligator River)
2024	Arnhem and Buckingham Bay Region closed
<i>Size Limits</i>	
1966	Minimum size limit of 580mm established for Barramundi
1991	Minimum size limit of 550mm applied to Barramundi
<i>Licences</i>	
1976	Maximum number of Barramundi licences that could be issued in the fishery was fixed at 170 (maximum of 255,000m of net in the fishery)
1980	Barramundi licences were made non-transferable (except between immediate family)
1982	Buy back scheme introduced
1982	Licence fees increased to \$60 per unit
1984	Licence fees increased to \$100 per unit
1986	Transferability of licences was reintroduced once the total amount of gill net in the fishery had been reduced to 35 000m.
1998	Buy back scheme
2002	Buy back scheme
2008	By this time additional buy back schemes had resulted in 19,100 m of net in the fishery
2009	Buy back scheme leaving 16,500m of net in the fishery
2013	Buy back scheme leaving 10,700m of net in the fishery
<i>Gear Restrictions</i>	
1966	A minimum mesh size of 150mm imposed on gillnets used in all rivers upstream of the mouth.
1969	Minimum mesh size in rivers increased to 180mm
1980	Maximum net length of 1500m imposed
1982	Maximum net length of 1000m imposed (with some exceptions based on historical use) Net amounts were broken into 250m units. Full licences entitled to 4 units (1000m)
1983	Net unit amount reduced. One unit equals 100m of net
1985	Minimum gillnet mesh size of 6 inches introduced

Management	
1979	NT Fish and Fisheries replace Fisheries Ordinance
1989	Declaration of Barramundi Managed Fishery under Section 22 of the Fisheries Act 1988 Establishment of Barramundi Management Advisory Committee
1991	Northern Territory Barramundi Fishery Management Plan came into effect
2016	Vessel Monitoring Systems (VMS) units mandatory on all mother boats and tenders
2024	Electronic logbooks introduced Commercial Barramundi Fishery Harvest Strategy Threatened Endangered and Protected Species Strategy NT Government commits to a complete phase-out of gillnets in the fishery by 2028
Guides	
2006	Development of industry Code of Practice and Environmental Management System
2013	Revised Environmental Management System, including ID guidelines for Sawfish
2020	TEPS Marine User Guide (NTG)
Catch Limits	
2005	Voyage limit for Shark product
2015	Voyage limit for Golden Snapper (6kg fillet weight) and Black Jewfish (80kg weight)
2024	Effort limits set for operations in Anson Bay, Moyle River and Roper River

Northern Territory Offshore Net and Line Fishery (NTONLF)

The NTONLF is a quota managed fishery that is allowed to operate from the low water mark to the boundary of the Australian Exclusive Economic Zone (Figure S3), however most fishing effort takes place within 12 nautical miles of the coast, and immediately offshore in the Gulf of Carpentaria. The area of the fishery is approximately 542,000 m², with two management zones relating to the Grey Mackerel catch. The fishery includes areas within the North Marine Parks Network, with only certain fishing methods (e.g., pelagic longline and net) are allowed within specific zones of each Marine Park (i.e., Special Purpose and Multiple Use Zones) under additional permits. The fishery is not permitted to fish within five Reef Fish Protection Zones (red polygons in Figure S3) enforced by NT Fisheries to allow for the protection and recovery of ‘at risk’ reef fish populations within the NT.

Licence holders are entitled to use Demersal or pelagic longlines or pelagic net gear, with bottom set nets prohibited. Pelagic nets are near surface monofilament nets that are set vertically in the water column with buoys and weights. Nets can be a maximum of 2000 meters long with a mesh size of between 160 – 185 mm, and a drop length of 50 – 100 meshes. Longlines can be set for pelagic or demersal fishing, with pelagic longlines only restricted to waters seaward of the 3 nautical mile limit. Demersal longlines are main lines anchored to the seabed at both ends, to which hooks, or branch lines are attached. Pelagic longlines, are not anchored to the seabed, and are often deployed attached to the fishing vessel with floats and weight. A vessel may use up to 15 nautical miles of longlines with a maximum of 1000 snoods.

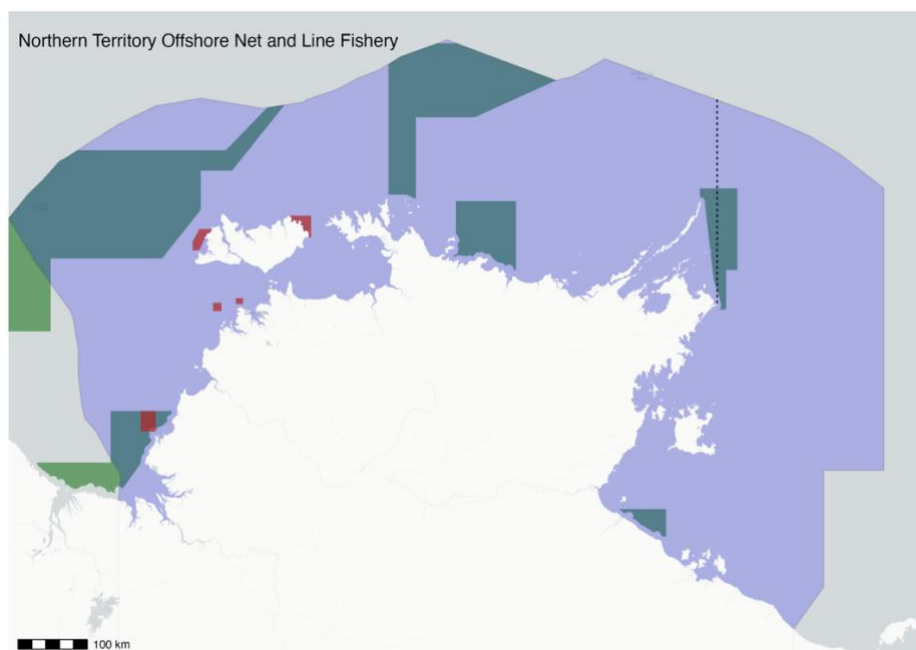


Figure S3. Spatial extent of the Northern Territory Offshore Net and Line Fishery (blue region) with Reef Fish Protection Zones (red polygons). Broken line signifies the Grey Mackerel Management Zone division. North Marine Parks Network presented as green polygons on each map, with the grey line representing the NT marine boundary (Source: NT Fisheries).

The main target species for this fishery includes Grey Mackerel (*Scomberomorus semifasciatus*), and Blacktip Shark (*Carcharhinus tilstoni* and *C. limbatus*). The fishery also retains by-product species including Spanish Mackerel (*S. commerson*), Spot-tail Shark (*C. sorrah*), Pigeye Shark (*C. amboinensis*), Longtail Tuna (*Thunnus tonggol*) Queenfish (*Scomberoides commersonnianus*) and Black Pomfret (*Parastromateus niger*) (Figure S4). In addition to these retained by-product species, the NTONLF also capture other Shark species that are not retained including Great Hammerhead (*Sphyrna mokarran*), Winghead Shark (*Eusphyra blochii*) and Tiger Sharks (*Galeocerdo cuvier*).

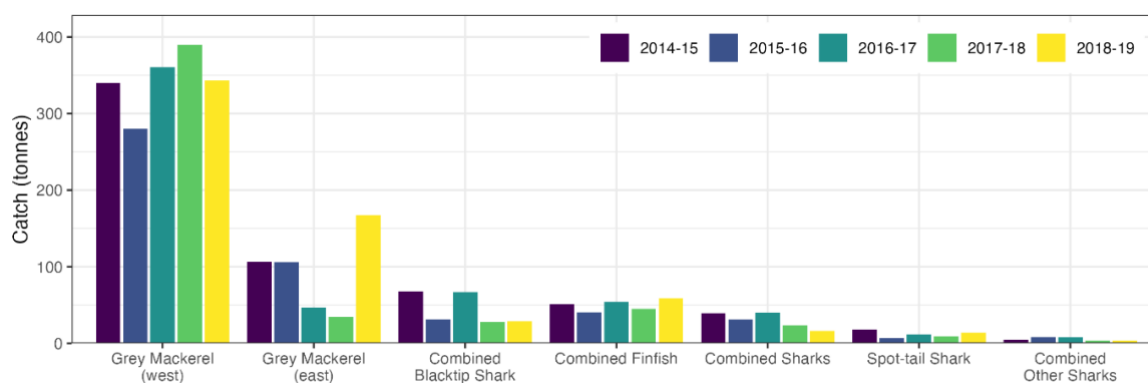


Figure S4. Summary of historic target and by-product catch in the NT Offshore Net and Line Fishery between 2014 – 2019. (Source: NT Fisheries, Department of Industry, Tourism and Trade). Grey Mackerel catches are divided between the two Management Zones.

Northern Territory Coastal Net Fishery (NTCNF)

The NTCNF is a small fishery restricted to five licences in four specific areas within the NT. The fishery extends from the high-water mark to the 3 nautical mile limit within the four regions (Figure S5). Licence holders are allowed to use nets of up to 300 meters long with a maximum drop of 5 meters and a mesh size of 65 mm or less, that is deployed either from the beach or from vessels if the net is anchored at only one end. Cast nets with a maximum 6-meter width and mesh size up to 25 mm can be used. The primary catch in this fishery is Mullet (*Mugil cephalus*) and Blue Threadfin (*Eleutheronema tetradactylum*) with the fishery also retaining Queenfish (*Scomberoides commersonnianus*), Snapper (*Lutjanus* spp.) and Whiting (*Sillago* spp.) as by-product species. Licence holders are not permitted to take Barramundi, King Threadfin, Spanish Mackerel or Mud Crab under a Coastal Net Licence.

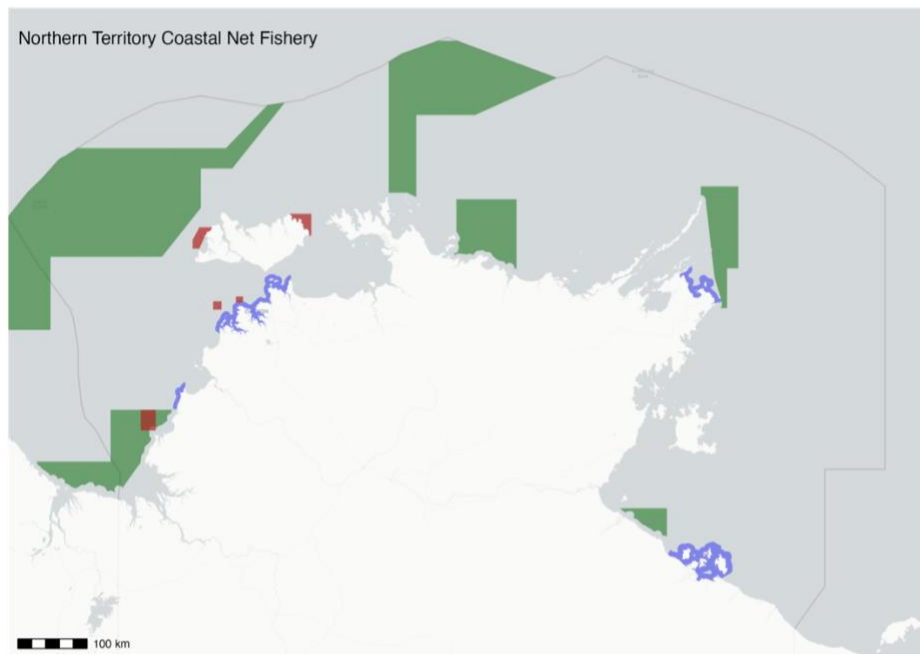


Figure S5. Spatial extent of the Northern Territory Coastal Net Fishery (blue regions) with Reef Protection Zones (red polygons). North Marine Parks Network presented as green polygons on each map, with the grey line representing the NT marine boundary (Source: NT Fisheries).

Supplementary Material 2 – Interview Questions

Professional fishers' knowledge to inform research and management of Sawfish and River Sharks project

** Questions marked with asterisk may involve the use of maps and ask interviewees to draw on maps

Introduction and Consent (Pre interview)

1. Provide the interviewee a brief background to the project, the project team and roles, and what we aim to achieve with these interviews and knowledge.
2. Are you happy to be interviewed for this project, and do you provide consent to participate and for the interview to be recorded?

Theme 1: Experience operating in fishery

3. How long have you been operating within the NT Barramundi or NT Offshore Net and Line Fishery?
4. Are you currently active in either fishery?
5. What areas of the NT coastline do/did you operate in primarily?**
6. Have there been area(s) where you have stopped fishing, or new areas you have started fishing over the period you were operated in the fishery?**

Theme 2: Experience with identifying species/ history of interactions

7. Of the different species we are interested in, which ones are you most familiar with (refer to photos and fact sheets)
8. During your time as a commercial fisher, have you interacted with River Sharks or Sawfish? How have you primarily interacted with these species? (e.g., sighted while fishing, incidentally captured in nets)
9. What happened to individuals accidentally captured in nets while fishing (e.g., released, killed/retained for sale, kept for trophies)
10. Have you had to change your fishing practices to avoid them?
11. Do you/ have you in the past kept logbook records of interactions with River Sharks or Sawfish?
12. Do you have any historically collected rostrums from Sawfishes you have interacted in the past? If so, where were they collected from and may we take a photo to identify which species?**

Theme 3: Spatial distribution of interactions

13. Where have you commonly seen or caught River Sharks?**
14. How large are the River Sharks you have interacted with/have you observed locations where River Sharks feed or pup?**

15. Where have you commonly seen or caught Sawfishes? **
16. How large are the Sawfishes you have interacted with/have you observed locations where sawfishes feed or pup? **

Theme 4: Temporal trends in interactions

17. Has there been a change in where you interact with River Sharks during your time operating in the fishery? **
18. Has there been a change in where you interact with Sawfishes during your time operating in the fishery? **
19. Has there been a change in the numbers or size of these species you have interacted over your time operating in the fishery?

Theme 5: Environmental variables

20. Are there areas or season you avoid fishing to avoid interactions with specific species of Sawfishes or River Sharks? **
21. Are there areas that are now closed to commercial fishing where you used to *avoid* fishing to reduce interactions?
22. Are there any specific conditions where you capture (or sight) River Sharks or Sawfishes (e.g., river flow/discharge, tidal phases, moon phase, time of day, season)?
23. Are there any specific conditions where you capture (or sight) specific life stages (e.g., adults, pups, gravid females) of these species (e.g., river flow/discharge, tidal phases, moon phase, time of day, season)?

Theme 6: Recommendations for future management, and feedback

24. In your opinion, what locations should scientists search for/go to catch these species, to get more information? **
25. What would you like to see/recommend for fishery managers regarding commercial fishing with regards to these species? (it might be improved training for fishers, ideas to minimise interactions, further research areas)
26. Would you be happy for any follow up interviews if we have more questions?
27. Would you like a summary of the information you have provided?
28. How would you like to get feedback about the results of this project?

Supplementary Material 3 – Species specific interaction maps

Large tooth Sawfish (*Pristis pristis*):

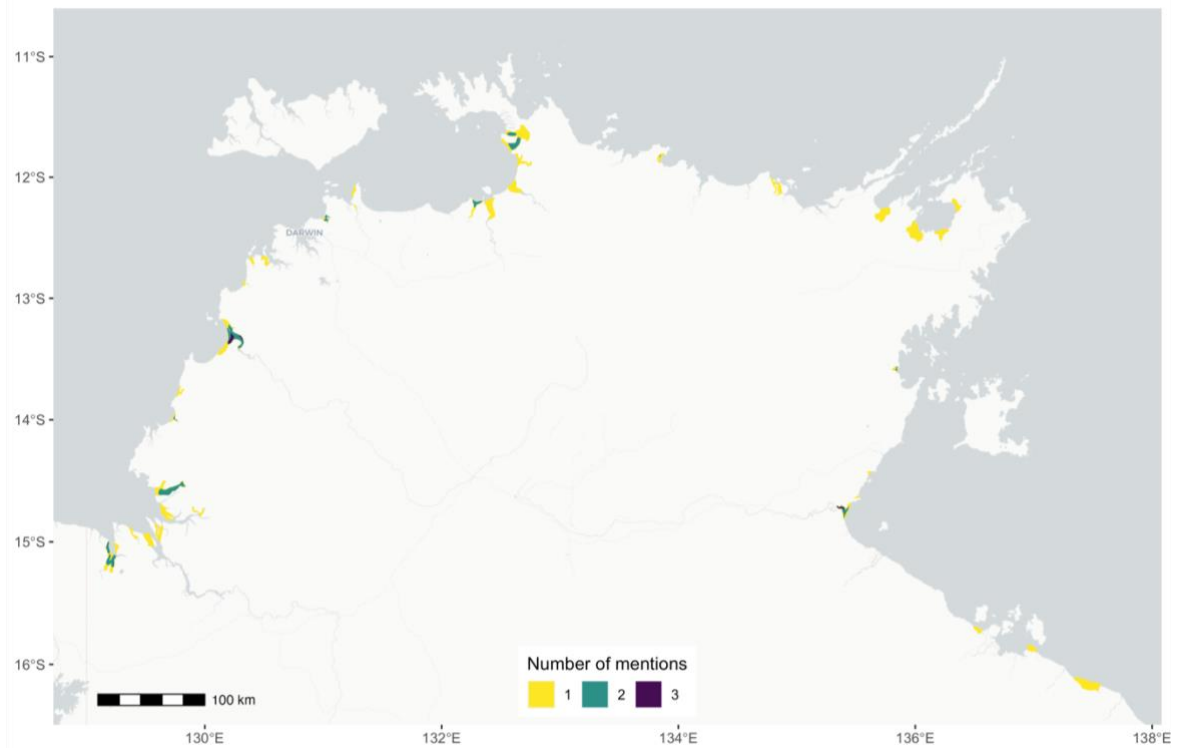


Figure S6. Summarised map of fisher interactions with *Pristis pristis* indicated by 16 interviewees.

Green Sawfish (*Pristis zijsron*):

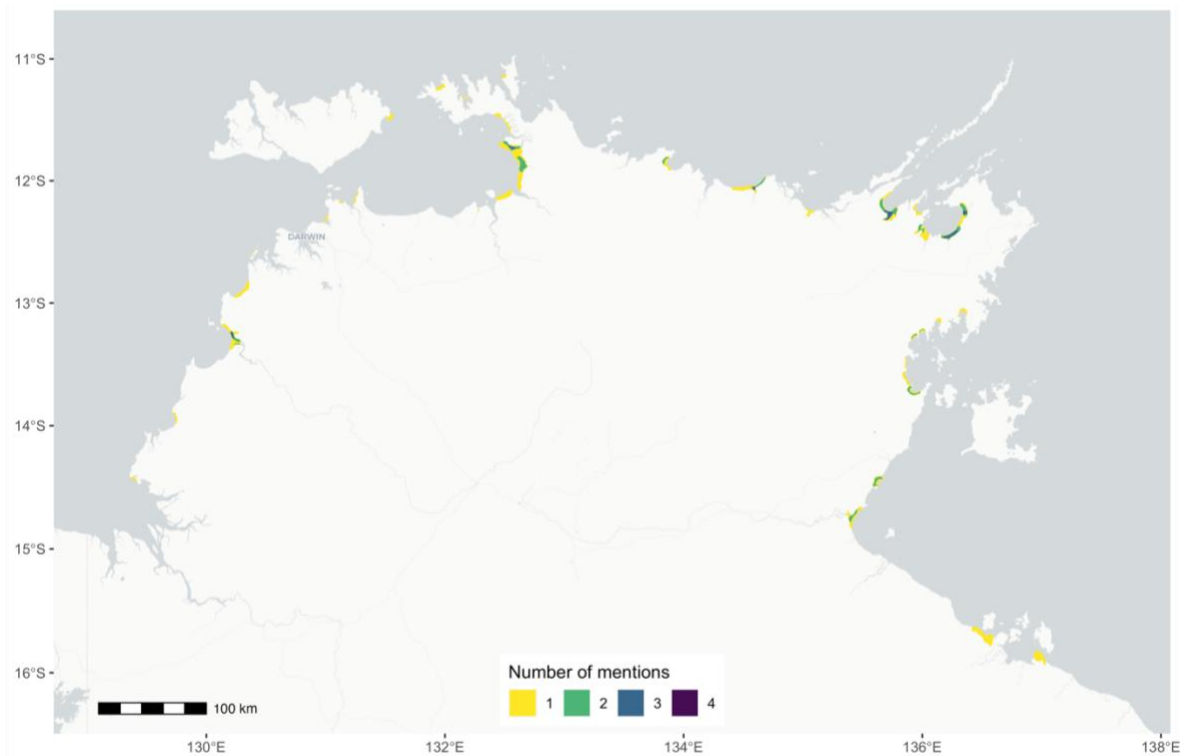


Figure S7. Summarised map of fisher interactions with *Pristis zijsron* indicated by 16 interviewees.

Dwarf Sawfish (*Pristis clavata*):

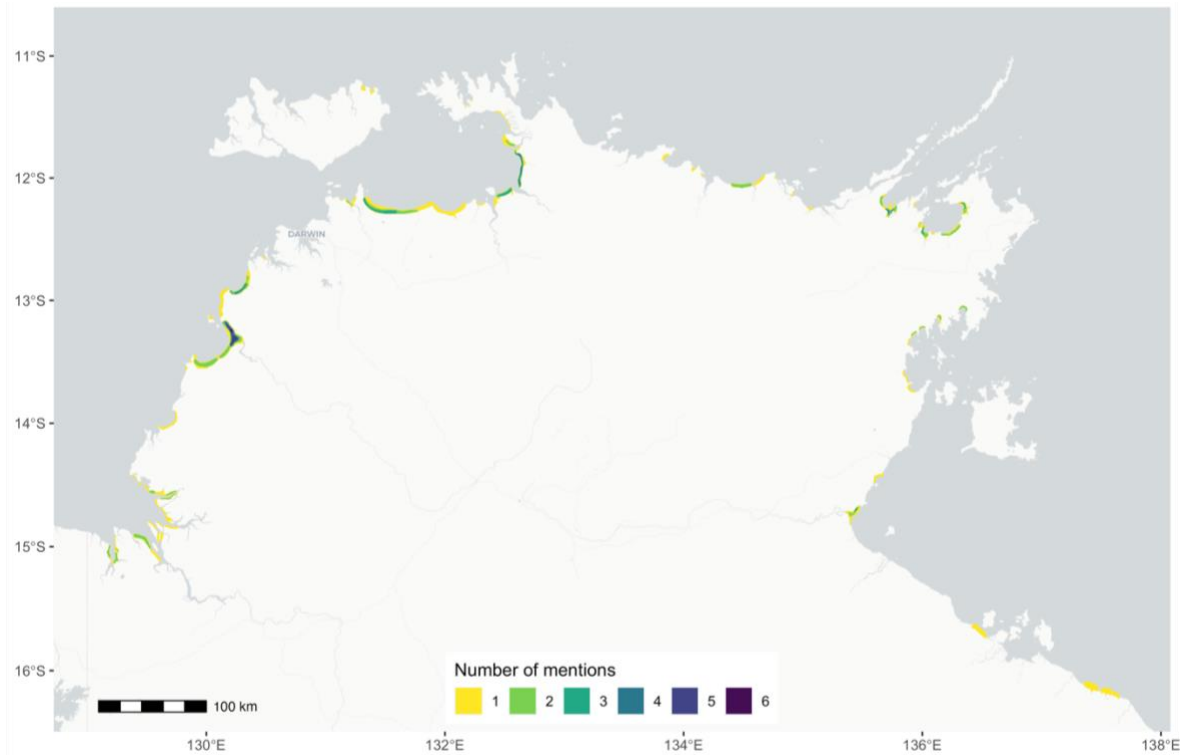


Figure S8. Summarised map of fisher interactions with *Pristis clavata* indicated by 16 interviewees.

Narrow Sawfish (*Anoxypristis cuspidata*):

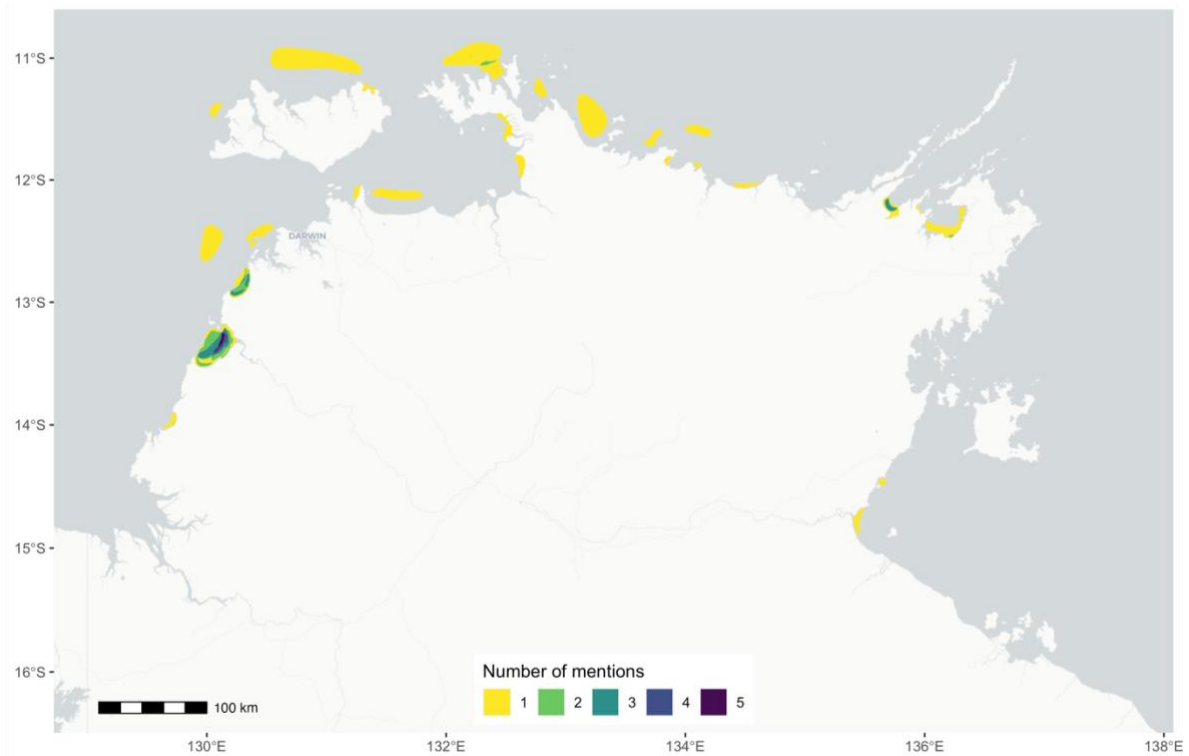


Figure S9. Summarised map of fisher interactions with *Anoxypristis cuspidata* indicated by 16 interviewees.

River Sharks (*Glyphis* spp.):

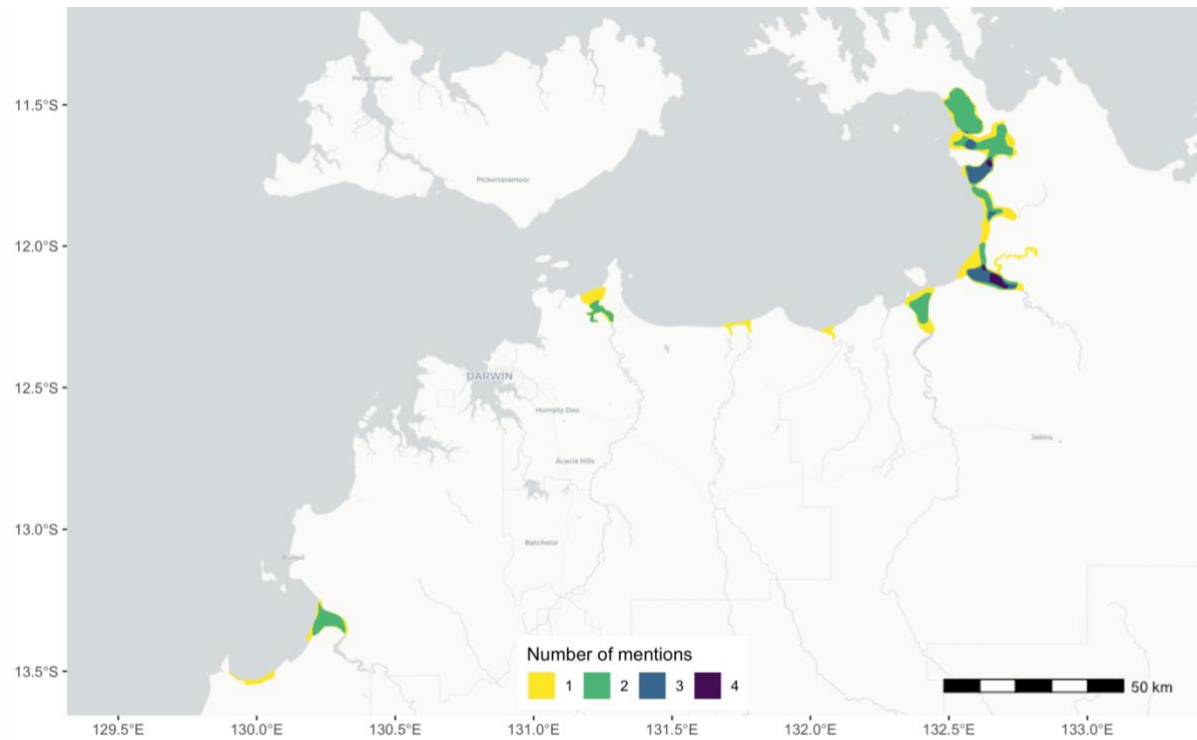


Figure S10. Summarised map of fisher interactions with *Glyphis* spp. indicated by 16 interviewees.

Wedgefish and Guitarfish species (Rhino^{pr}istiformes):

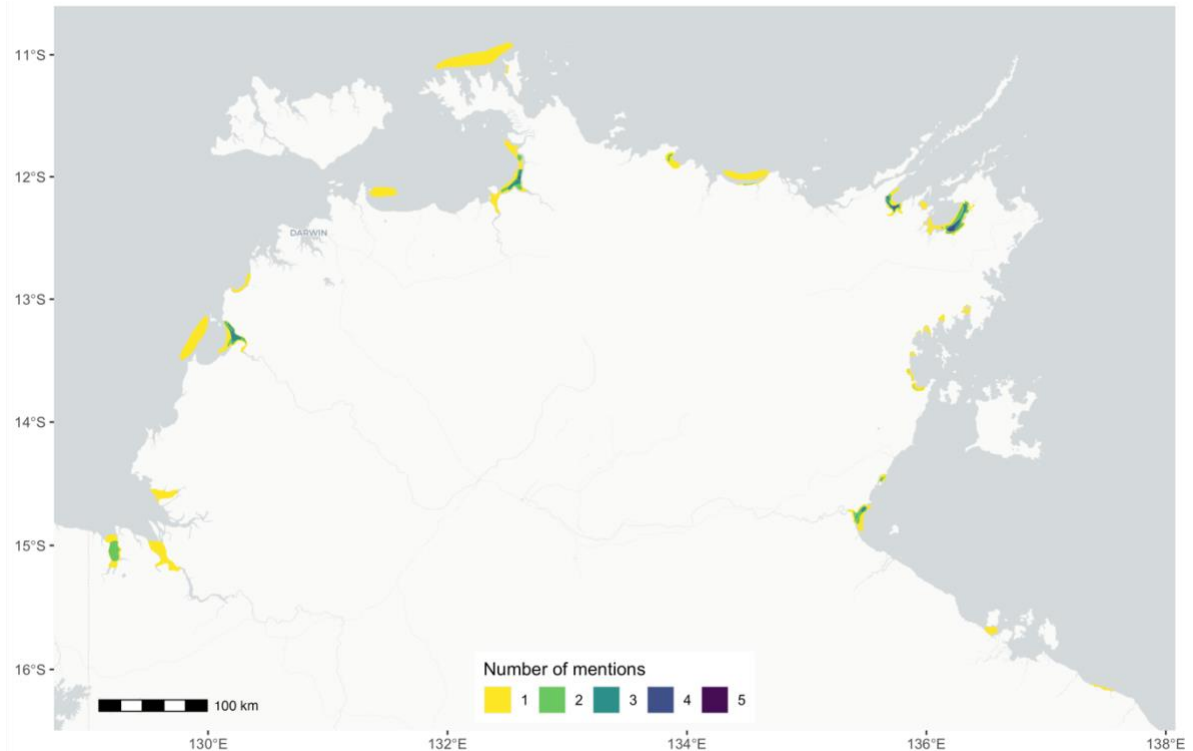


Figure S11. Summarised map of fisher interactions with other ray species in the Rhinopristiformes family (Wedgefishes and shovelnose rays) indicated by 16 interviewees.