Eramurra Sawfish Survey

August 2024

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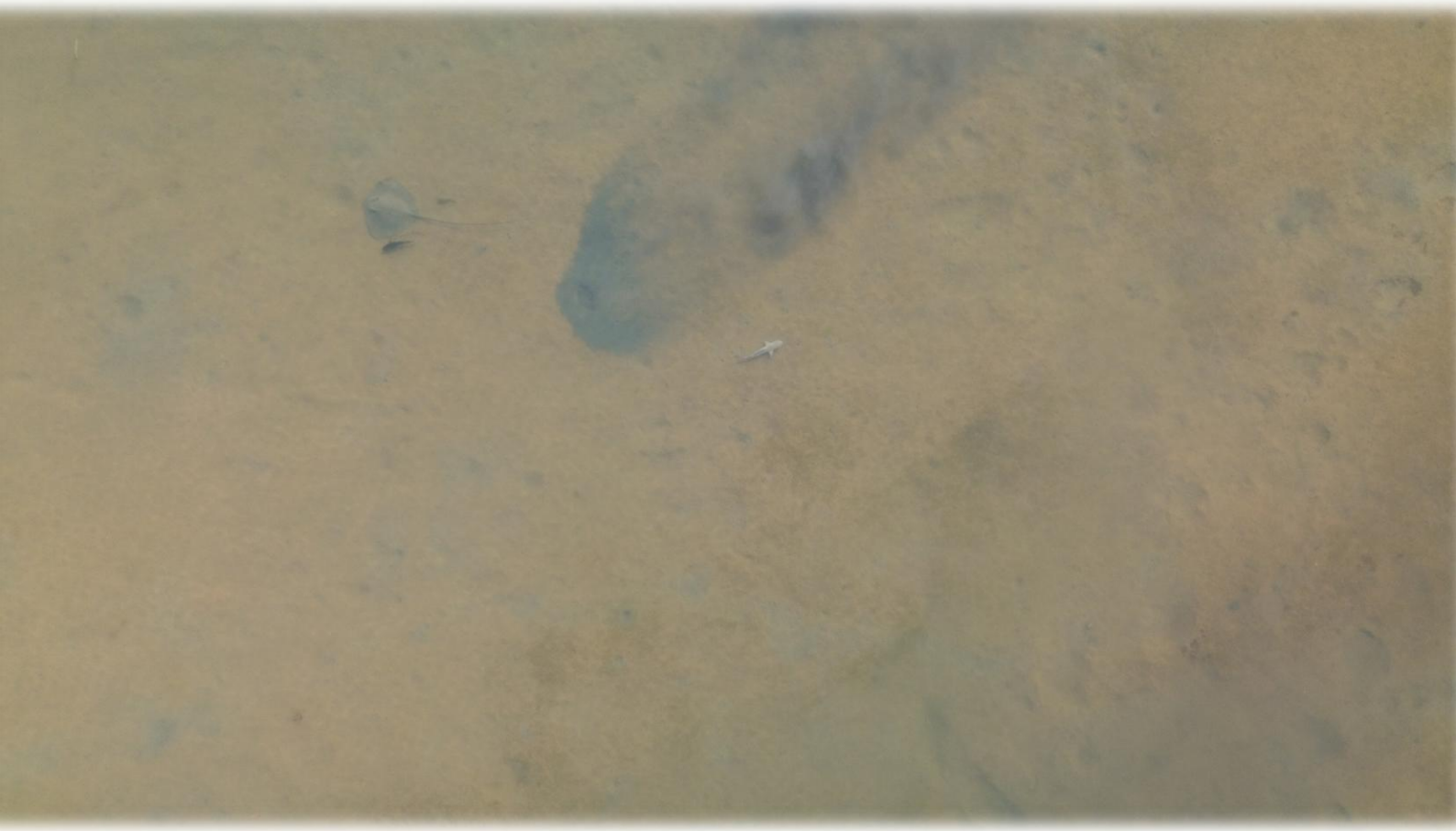

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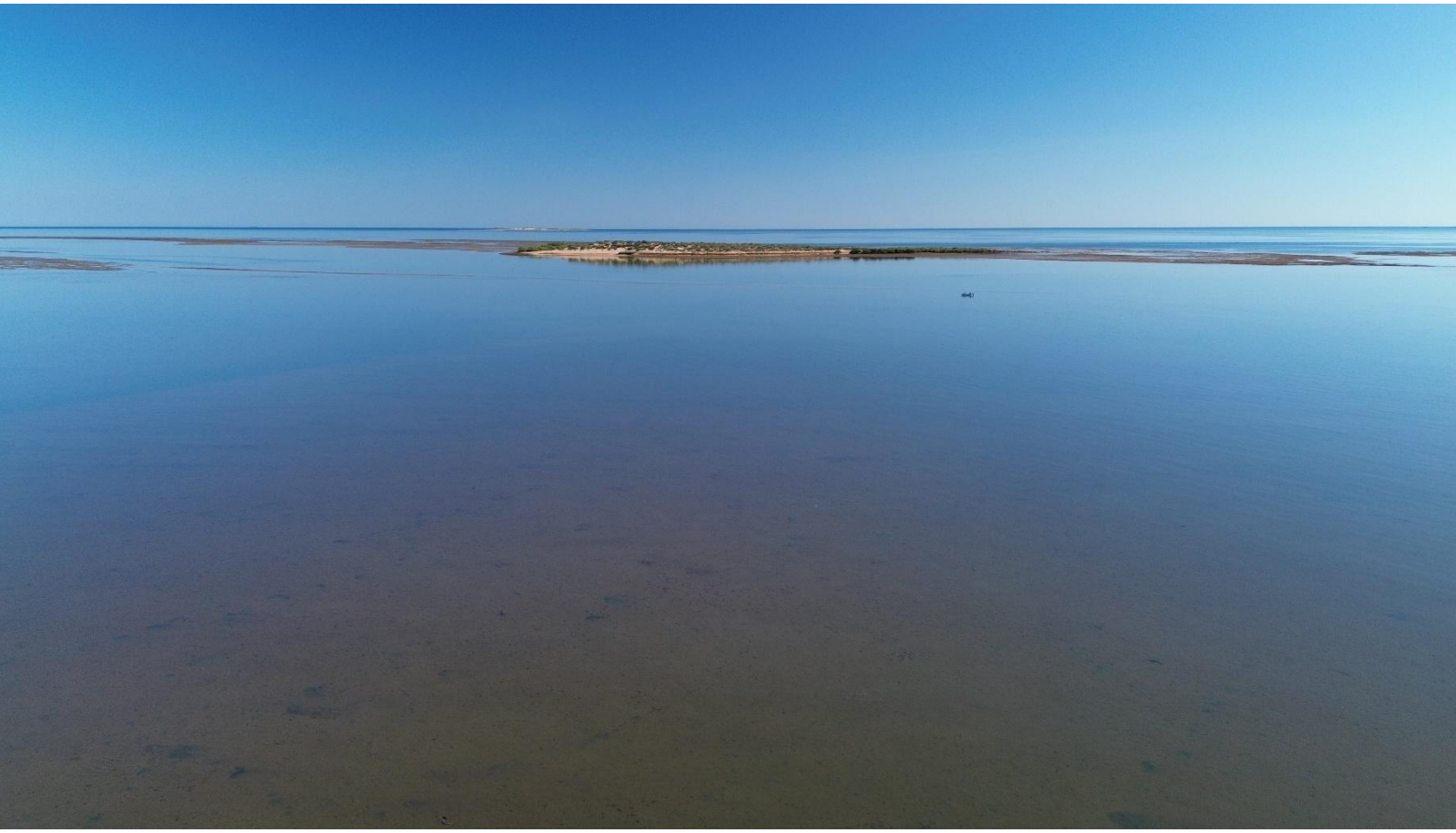
January, 2025



Summary

During August 2024, surveys of tidal creeks surrounding the Eramurra Solar Salt Project were conducted to elucidate the fish fauna of this area, with a particular focus on locating the presence of Green Sawfish (*Pristis zijsron*). Surveys were conducted using a 4.6 m aluminium side console, with a shallow draft of 0.3 meters, launched daily from Gnoorea Point Campground between the 26th and 29th August. Targeted sampling for sawfish was conducted by deploying a monofilament gill net of 60 m length, 2 m depth with a stretched mesh size of 150 mm perpendicular to the banks of Mackay Creek and adjacent mangrove systems, as well as along the sandbar adjacent to Great Sandy Island Reserve. Targeted sampling was accompanied by visual surveys from the Brutus vessel or using a DGI Mini 3 unmanned aerial vehicle (UAV). Gill net surveys of Mackay Creek, adjacent Outlet Creek and the sandbar of Great Sandy Island Reserve did not result in the capture of any sawfish, nor were any sawfish observed during visual surveys. However, both gill net and visual surveys indicated a high abundance of sympatric elasmobranchs within the study area, particularly the mouth of Mackay Creek, many of which occupy threatened categories on the International Union for Conservation of Nature's Red List of Threatened Species. Specifically, we encountered numerous giant shovelnose rays, Australian whiprays, broad cowtail rays and spotted eagle rays. Lemon sharks, nervous sharks, a porcupine ray, a great hammerhead, and spinner sharks were also observed. The abundance of large predators was attributed to the high biological productivity of the survey area, inferred from seine net surveys conducted in 2022 and 2023. The marine environments of Cape Preston and Gnoorea may act as a secondary nursery area for green sawfish and/or support long-distance movement of this species along the northern coastline of Western Australia, by forming part of a network of suitable 'stopover' habitats. However, movement of sawfish, particularly small juveniles, is likely to be hindered by coastal development (e.g., the Cape Preston groyne), due to the preference of immature sawfish for extremely shallow water. This report highlights the importance of the study area for numerous other elasmobranch species and indeed other aquatic vertebrates.

Introduction

The sawfishes (Pristidae) are a group of iconic elasmobranchs that are identifiable by their denticle-toothed rostrum, consisting of a blade of elongated cranial cartilage, with teeth protruding from the lateral edges (Last & Stevens, 2009; Morgan et al., 2016; Wueringer et al., 2009). These large-bodied, shark-like rays typically occupy tropical, inshore waters, which are often subjected to disproportionately high levels of fishing pressure and coastal disturbance (Last & Stevens, 2009). Currently, the sawfishes are among the most threatened marine fishes; all five extant species are classified as Critically Endangered on the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (Carlson et al., 2022; Espinoza et al., 2022; Grant et al., 2022; Haque et al., 2023; Harry et al., 2022), having experienced massive declines in extent of occurrence (30–81%), primarily due to overexploitation by fisheries and habitat loss, and are believed to be extinct from at least 46 nations that they once inhabited (Dulvy et al., 2016; Morgan et al., 2009; Yan et al., 2021). Northern Australia is a vital stronghold for the four sawfish species occurring in the Indo-West Pacific: the narrow sawfish (*Anoxypristis cuspidata*), the dwarf sawfish (*Pristis clavata*), the smalltooth sawfish (*Pristis pectinata*), the largetooth sawfish (*Pristis pristis*) and the green sawfish (*Pristis zijsron*), comprising approximately 50% of the total area where these rays are legally protected (Dulvy et al., 2016). The Pilbara and Kimberley regions of Western Australia are especially important refuges, containing populations that are genetically distinct from, and more diverse than, populations in eastern Australia or the Gulf of Carpentaria, as well as several of the world's most important pupping and nursery areas for sawfishes (Morgan et al., 2011, 2015; Phillips et al., 2011, 2017).

Leichhardt Salt Pty Ltd has proposed the development of the Eramurra Solar Salt Project (Ranford, 2022) in the Pilbara region, approximately 55 km southwest of Karratha, Western Australia. The purpose of this report is to document the aquatic fauna encountered during August 2024 surveys, in addition to those conducted during 2022 and 2023, with the primary objective being to assess the presence of sawfishes within this area (Cape Preston & Gnoorea) and identify any biologically meaningful periods for key environmental/life cycle events (e.g., pupping).

Additional information on the green sawfish provided includes:

- Information on the distribution and habitat preference.
- Information on the conservation value of surveyed habitats from a regional perspective.
- Information on the population size and importance from a regional perspective.
- Discussion and determination of the significance of potential direct and indirect residual and cumulative impacts to sawfish, as a result of the proposed development.
- Mitigation of potential impacts to sawfish.

We also provide information on notable sympatric species (including potential prey), which were encountered between Cape Preston (20.8649° S, 116.2517° E) and Gnoorea (20.8396° S, 116.3450° E). For a regional (Pilbara) perspective on sawfish sightings, our own catch data, along with sightings reported by Bateman et al. (2024) collected between Exmouth and Pardoo, are also included.

Methods

Survey environment

The coastal environments of Cape Preston and Gnoorea are characterised by several distinct habitat types: sandy beaches, which are specific mostly to the western side of Cape Preston and provide important nesting areas for marine turtles; rocky/pebble beaches, which are particularly common adjacent to Preston Island; and extensive mudflats, which are specific mostly to the southern end of Cape Preston and are largely

characterised by mangroves (EPA, 2002). Surveys were conducted in each of these habitats, but were targeted primarily towards estuarine, sand and mud flats proximal to mangroves, because these habitat types are known to support critical life stages of sawfishes (Ingelbrecht et al., 2024; Morgan et al., 2017) and reportedly have the greatest biological significance across the survey area, due to their utilisation by various marine fauna, birds and bats (see EPA, 2002).

Cape Preston and Gnoorea are subject to strong tidal currents, which typically run parallel to the coast (EPA, 2002). Furthermore, the area is surrounded by shallow sand, silt and mud flats that extend several hundred meters offshore, presenting several challenges for accessing and navigating survey sites. Prior to field work, tidal and weather conditions were examined using a number of applications, including Seabreeze, Windy, and the Bureau of Meteorology (BOM).

Sampling was conducted during neap tides (1.20–2.85 m), to allow access into mangrove creeks, which have very shallow entrances (< 0.6 m). We used a 4.6 m aluminium side-console flat bottom boat with a shallow draft; however, even with the shallow draft of the vessel (0.3 m), creeks were often inaccessible, except during high tides. Measurements of water quality were recorded at survey sites using a YSI Plus Multiparameter Meter (YSI Inc., Yellow Springs, United States of America).

Sawfish surveys

Targeted surveys for sawfish were conducted using a 60 m gill net, consisting of 150 mm stretched monofilament mesh. Gill nets were deployed perpendicular to creek banks proximal to the mouth of mangrove tidal systems (Table 1) (see Morgan et al., 2015, 2017). Nets were checked upon signs of fish entanglement, or at least once per hour. Bycatch species were measured for total length (mm) and released at the site of capture. Captured elasmobranchs were measured for total length, sexed (by the presence or absence of claspers), examined for ectoparasites, biopsied for tissue and released at the capture site. Catch-per-unit-effort (CPUE) was calculated for each species, based on the number of individuals captured per 20 m of net/hour (see Morgan et al., 2015). Gill nets were deployed five times, for a total of nine hours over three days, during August 2024. This was in addition to eight deployments, for a total of 13 h 45 min, during October 2023, and three deployments, for 4 h 40 min, during August 2022 (see Figure 1).

Visual surveys for sawfish were conducted using an Unmanned Aerial Vehicle (UAV) (drone) within the vicinity of gill net deployments (see Figure 1), as well as opportunistically when travelling between the launch site (Gnoorea Point Campground) and sample sites. Drone surveys were conducted using a DJI Mini 3 UAV, fitted with a CPL polarising filter, with flights generally conducted at 10–20 m above sea level (ASL). To optimise flight conditions, 50% of all UAV flights were conducted between 9:00 and 11:00, when windspeed was expected to be lowest and visibility greatest. If a sawfish was sighted by the UAV operator, video was then taken (at ~5 m ASL) to determine whether the sawfish had previously been tagged (as indicated by a visible t-bar tag adjacent to first dorsal fin), and to record any scarring and the number of rostral teeth (for comparison to those individuals previously captured and tagged). To compare the detection rates across various altitudes, the UAV was also flown at 60 m ASL, to compare detectability.

During each flight, the following variables were recorded:

• Flight start and finish time.

• Altitude of flight.

• Turbidity, recorded at the beginning and end of each flight, with water clarity graded on a scale of 1 to 5, where 1 is extremely poor and 5 is extremely clear.

• Cloud cover, ranging from 0 to 8 oktas (measured as to how many eighths of the sky is covered), with 0 and 8 equivalent to 0% and 100% cloud coverage, respectively.

• Sea State, ranging from 0 to 12 on the Beaufort Scale, with 0 being less than 1 knot (i.e., calm); 1 being 1–3 knots (i.e., light air); 2 being 4–7 knots (i.e., light breeze); 3 being 7–10 knots (i.e., gentle breeze); 4 being 11–16 knots (i.e., moderate breeze); 5 being 17–21 knots (i.e., fresh breeze); 6 being 22–27 knots (i.e., strong breeze); 7 being 28–33 knots (i.e., near gale); and 8 being 34–40 knots (i.e., gale force winds).

• Wind direction (offshore, onshore, E, W, N, SSE etc.)

• Air temperature

• Number of sawfish sighted (including species identifications where possible)

• Tidal information

• Bycatch species sighted.

Visual survey transects were also incorporated while driving the vessel at low speeds (~2 knots), with investigators recording fauna from each side of the vessel, primarily within the vicinity of tidal creek mouths where gill nets were deployed (see Figure 1).

Figure 1. Locations of seine netting (SN) and gill netting (GN) in August 2022 and October 2023. Included are the locations of two VR2W acoustic receivers situated within the study area.

Seine net surveys (Figure 2) were used to investigate potential sawfish prey-species along shallow banks during 2022 and 2023 sampling, and was supported by visual observations. The 41.5 meter-long seine nets consisted of a 1.5 m wide bunt (pocket) made of 9 mm mesh and two 20 m long wings, comprising 25 mm mesh, covering an area of 274 m^2. Seine nets were deployed in a semicircle from the bank and pulled in immediately following deployment. Captured fish were taxonomically identified, enumerated and measured for total length (mm). Seine nets were deployed a total of 12 times in 2023 and two times in August 2022 (see Figures 1, 2).

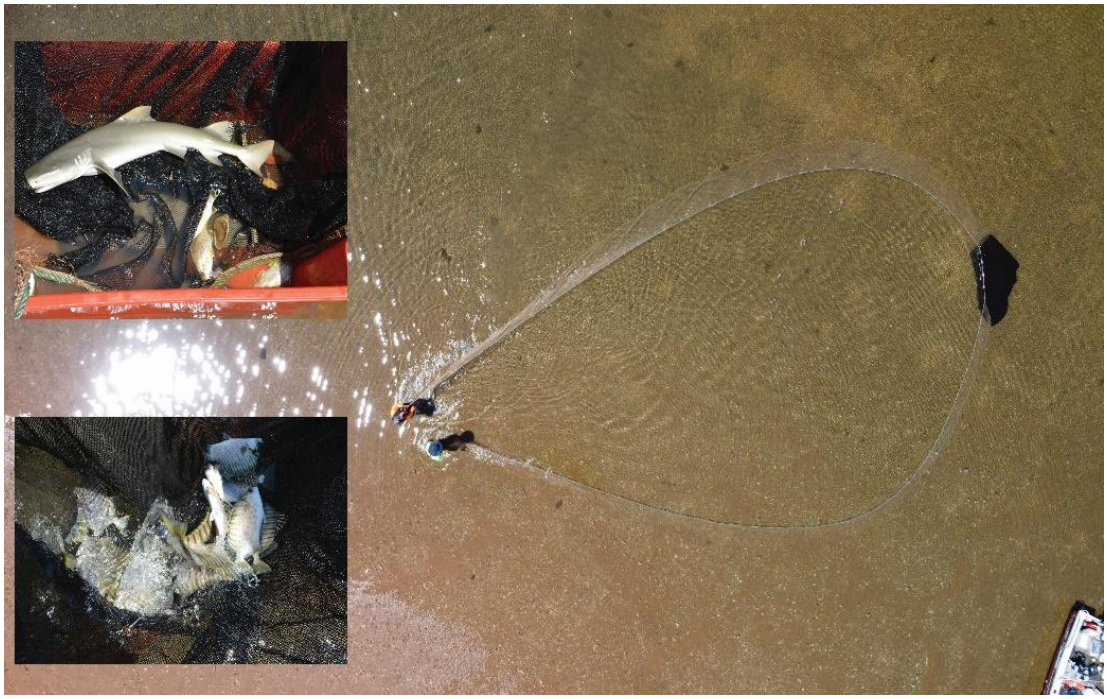


Figure 2. Deploying a seine net in the study area. Inset – catch species.

Table 1. Location and duration of gill net sets for sawfish during August 2024, October 2023 and August 2022.

Set No.	Site	Lat° (S)	Long° (E)	Date	Start	Gill net	Set length
GN 2024-1	Outlet Creek	20.8617	116.2661	27/8/2024	10:30	60 × 150 mm	2:00
GN 2024-2	Mackay Creek mouth	20.8795	116.2988	27/8/2024	13:15	60 × 150 mm	1:30
GN 2024-3	Sandbar opposite Great Sandy Island	20.8656	116.2887	28/8/2024	9:45	60 × 150 mm	2:25
GN 2024-4	Sandbar opposite Great Sandy Island	20.8670	116.2842	29/8/2024	8:45	60 × 150 mm	0:55
GN 2024-5	~300 m outside Mackay Creek mouth	20.8731	116.2970	29/8/2024	11:50	60 × 150 mm	2:10
GN 2023-1	Sandbar opposite Great Sandy Island	20.8654	116.2869	07/10/2023	8:45	60 × 150 mm	2:20
GN 2023-2	Second Creek west of Intake Creek	20.8739	116.2821	07/10/2023	12:30	60 × 150 mm	1:00
GN 2023-3	Sandbar opposite Great Sandy Island	20.8655	116.2876	08/10/2023	8:50	60 × 150 mm	2:30
GN 2023-4	Intake Creek	20.8807	116.2952	08/10/2023	12:50	60 × 150 mm	1:20
GN 2023-5	West Creek	20.8634	116.2543	09/10/2023	9:30	60 × 150 mm	2:00
GN 2023-6	West Creek	20.8661	116.2511	09/10/2023	11:40	60 × 150 mm	1:00
GN 2023-7	Intake Creek	20.8796	116.2980	10/10/2023	7:25	60 × 150 mm	1:45
GN 2023-8	Intake Creek	20.8790	116.2991	10/10/2023	9:25	60 × 150 mm	1:50
GN 2022-1	Second Creek	20.8774	116.2894	23/8/2022	10:10	60 × 150 mm	2:00
GN 2022-2	Great Sandy Island	20.8604	116.2830	23/8/2022	13:10	Composite	1:05
GN 2022-3	Creek entrance	20.8644	116.2723	23/8/2022	14:40	Composite	1:05

Acoustic receiver array

Prior to the August 2024 survey, three VR2W (Innovasea) acoustic receivers were installed inside the study area (VR2W 137850 (Mackay Creek), VR2W 137854 (east of Cape Preston), VR2W 137858 (east of Great Sandy Island). Additional acoustic receivers were installed both east and west of the immediate study area by Murdoch University (VR2W 112988, Fortescue River mouth) and Leichhardt Salt (VR2W 137851 (west of Cape Preston) and VR2W 137853 (east of Gnoorea). Only the three acoustic receivers within the immediate survey area (SN 137858, 137850, 137854) (see Figure 3) were considered for downloading during this survey due to their close proximity using a small vessel.

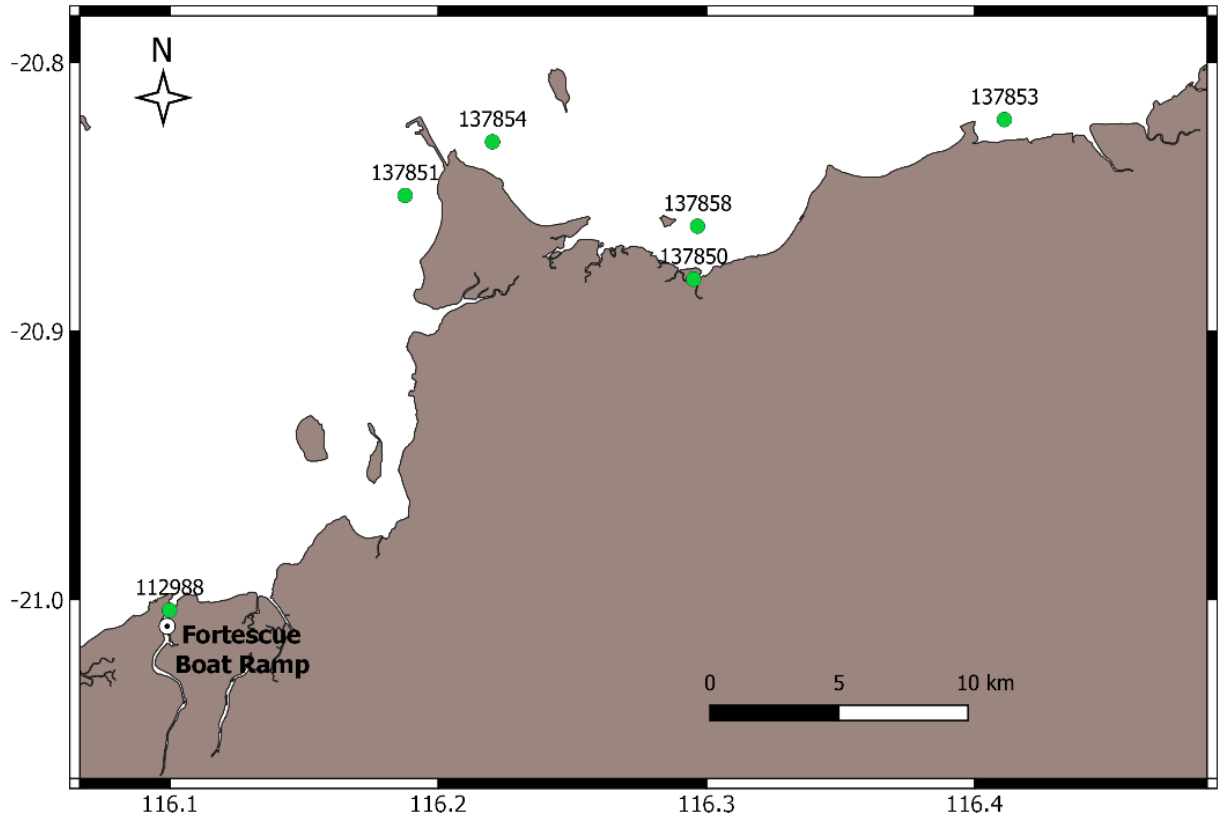


Figure 3. Receiver locations (green points) for the six acoustic receivers in the study area. Receiver serial numbers are indicated above each point location.

Results

Environment

Throughout sampling, many of the mangrove creeks within the study area were only accessible during high tides, with shallow areas extending up to ~1000 m from the mouths of Outlet Creek and Mackay Creek (see Figure 1). However, even during the neap tides, entering and exiting Mackay Creek was challenging due to the extremely narrow and shallow entrance channel, and was inaccessible when tides were less than 2.5 m. Water quality variables are presented in Table 2 and are consistent with other localities where sawfish have been observed.

Table 2. Environmental variable measured during August 2024 surveys: water temperature (°C), specific conductance (SPC), total dissolved solids, salinity (ppt) and pH.

Location	E4 Receiver	E4 Receiver channel	Outlet Creek
GPS	20.8626° S 116.2934° E	20.8587° S 116.2897° E	20.8617° S 116.2661° E
Variable			
Temperature	22.9 (± 0.00)	22.2 (± 0.00)	24.0 (± 0.00)
Conductivity (SPC)	53801 (± 6.08)	54393 (± 17.02)	56199 (± 350.04)
Total Dissolved Solids	34970 (± 0.00)	35360 (± 5.49)	36725 (± 37.53)
Salinity	35.58 (± 0.00)	36.03 (± 0.02)	37.58 (± 0.03)
pH	8.25 (± 0.00)	8.22 (± 0.00)	8.11 (± 0.00)

Sawfish surveys

No sawfish were captured during 2022, 2023 or 2024 gill net surveys. Gill nets were deployed for a total of nine hours, across five sets, during 2024 sampling. Gill net captures consisted almost exclusively of elasmobranchs, with four elasmobranch species, corresponding with 38 individuals, encountered (Table 3). The giant shovelnose ray (*Glaucostegus typus*) and the nervous shark (*Carcharhinus cautus*) were the most commonly encountered species, accounting for approximately 70% of total captures, with occasional captures of the spinner shark (*Carcharhinus brevipinna*). The total number of elasmobranchs sampled during 2024 was relatively high compared to 2023 surveys (i.e., 32 individuals captured across 13 h 45 min of gill net sets) (Table 4), and substantially higher than the number of elasmobranchs encountered during 2022 surveys (i.e., six individuals captured across 4 h 10 min of gill net sets) (Table 5). Additionally, juvenile green turtles (*Chelonia mydas*) were captured in each year of surveys, most with a carapace length of less than 450 mm.

Table 3. Total number of each fish species (T), percentage contribution (%C) and total length range in mm (LR) of each species captured during gill net surveys in August 2024. Lengths of green turtles correspond with carapace lengths. Net sets correspond with GN 2024-1 to 5 on Figure 1.

Family	**Scientific name**	**Common name**	**Gill nets**		
			T	**%C**	**LR (mm)**
Carcharhinidae	*Negaprion acutidens*	sicklefin lemon shark	1	2.27	1121
	Carcharhinus brevipinna	spinner shark	6	13.64	695–938
	Carcharhinus cautus	nervous shark	13	29.55	579–1064
Glaucostegidae	*Glaucostegus typus*	giant shovelnose ray	18	40.91	611–2000
Carangidae	*Caranx* sp.	trevally	1	2.27	461
Cheloniidae	*Chelonia mydas*	green turtle	5	11.36	420–513
	Number of sets			8	
	Total number of species			6	
	Mean number of fish per set			5.5	
	Mean effort (h) per set			1.13	
	Total number of fish			44	

Table 4. Total number of each fish species (T), percentage contribution (%C) and total length range in mm (LR) of each species captured during seine and gill net surveys in October 2023. Dasyatidae lengths = disc width (DW). Net sets correspond with SN 2023-1 to 12 and GN 2023-1 to 8 on Figure 1.

Family	Scientific name	Common name	Seine nets		Gill nets		
			T	%C	T	%C	LR (mm)
Carcharhinidae	*Negaprion acutidens*	sicklefin lemon shark	1	0.09			650
	Carcharhinus brevipinna	spinner shark			2	6.25	795-922
	Carcharhinus cautus	nervous shark	2	0.19	18	56.25	538-1095
	Carchahinus leucas	bull shark			1	3.12	1113
Glaucostegidae	*Glaucostegus typus*	giant shovelnose ray	1	0.09	8	25.0	300-1170
Dasyatidae	*Himantura* sp.	Australian whipray	2	0.19	3	9.38	~400-800
Hemiramphidae	*Arrhamphus sclerolepis*	snubnose garfish	1	0.19			173
Atherinidae	*Craterocephalus mugiloides*	spotted hardyhead	870	82.15			16-66
Platycephalidae	*Platycephalus australis*	bartail flathead	1	0.09			400
Sillaginidae	*Sillago burrus*	W. trumpeter whiting	17	1.61			25-160
Gerreidae	*Gerres subfasciatus*	common silverbiddy	29	2.74			19-46
Sparidae	*Acanthopagrus morrisoni*	W. yellowfin bream	9	0.85			163-268
Terapontidae	*Amniataba caudavittata*	yellowtail trumpeter	22	2.08			105-185
Mugilidae	Mugilidae sp.		30	2.83			89-271
Gobiidae	*Favonigobius melanobranchus*	blackthroat goby	6	0.57			16-122
Scatophagidae	*Selenotoca multifasciata*	striped scat	68	6.42			210-282
	Number of sets			12		8	
	Total number of species			14		5	
	Mean number of fish per set			88.25		4.0	
	Mean effort (h) per set					1.72	
	Total number of fish			1059		32	

Over 1000 individuals from 14 fish species were recorded during seine net surveys in October 2023 (Table 4). Sampling in 2022 (Table 5), which involved the use of a larger vessel, was unable to access shallow sites for sampling. Visual surveys recorded a suite of additional teleost and crustacean species that are suitable as sawfish prey. Catches in both years were comprised mostly of atherinids, as well as other species that would be suitable prey for sawfish (see Tables 4 and 5). Species diversity was relatively high in Intake Creek (mean number of species per seine = 7.67 ± 0.67 SE) compared to the sandbar opposite Great Sandy Island Reserve, where only a single species was recorded in each of the three replicate seines, and the most western creek surveyed (mean species per seine = 3.67 ± 0.33 SE).

Table 5. Total number of each fish species (T), percentage contribution (%C) and total length range in mm (LR) of each species captured during seine and gill net surveys in August 2022. Dasyatidae lengths = disc width (DW). Net sets correspond with SN 2022-1 to 2 and GN 2022-1, GN 2022-2 and GN 2022-3 on Figure 1.

Family	Scientific name	Common name	Seine nets		Gill nets		
			T	%C	T	%C	LR (mm)
Carcharhinidae	*Negaprion acutidens*	sicklefin lemon shark			3	23.08	785-1175
	Carcharhinus brevipinna	spinner shark			1	7.69	810
	Carcharhinus cautus	nervous shark			2	15.38	1020-1070
Glaucostegidae	*Glaucostegus typus*	giant shovelnose ray			1	7.69	795
Dasyatidae	*Pastinachuas ater*	broad cowtail ray	5	0.50			~400-500
Chanidae	*Chanos chanos*	milkfish			1	2.22	480
Hemiramphidae	*Arrhamphus sclerolepis*	snubnose garfish	1	0.10			110-185
Atherinidae	*Craterocephalus capreoli*	north-west hardyhead	987	99.39			20-66
Sillaginidae	*Sillago schomburgkii*	yellowfin whiting			1	7.69	216
Mugilidae	*Ellochelon vaigiensis*	diamondscale mullet			2	7.69	173-515
	Moolgarda buchanani	bluetail mullet			2	7.69	410-430
	Number of sets			2		3	
	Total number of species			3		8	
	Mean number of fish per set			496.5		4.67	
	Mean effort (h) per set					1.38	
	Total number of fish			993		13	

During October 2023 and August 2024, a total of 25 UAV flights were conducted across the study area (17 during 2023; eight during 2024), with the primary aim to detect the occurrence of sawfish. These flights also assisted in identifying various aquatic fauna throughout the study area (Table 6, Figure 4). A single green sawfish (*Pristis zijsron*) was detected during high tide on October 10th, 2023 (flight 14), at the mouth of Mackay Creek (Table 6), and was observed feeding. It was estimated to be approximately 2.5 m total length and was identified based on the unique rostral morphology of green sawfish (i.e., rostral tooth spacing and tooth indentations). This individual was observed for approximately 10 minutes and was last seen moving upstream, further into MacKay Creek.

Table 6. Summary of drone surveys conducted at the study site during August 2024 and October 2023. Abbreviations: GSI, Great Sandy Island Reserve.

Flight	Site	Altitude (m)	Date	Start	End	Turbidity	Cloud cover	Sea state	Tide	Sawfish	Duration
2024-1	Mackay Creek	15–20	26/8/24	13:40	14:00	5	0	1	high	0	0:20
2024-2	E4 Receiver	10–20	27/8/24	9:00	9:33	5	0	1	low	0	0:33
2024-3	Outlet Creek	15–20	27/8/24	10:45	11:09	3–5	0	1	low	0	0:24
2024-4	Mackay Creek	15–20	27/8/24	13:50	14:05	3–5	0	0	high	0	0:15
2024-5	E4 Receiver	15–20	28/8/24	9:03	9:28	5	0	0	low	0	0:15
2024-6	Mackay Creek	15–20	28/8/24	15:07	15:15	3–5	0	2	high	0	0:08
2024-7	Little Creek	15–20	29/8/24	9:02	9:19	3–5	0	4	low	0	0:17
2024-8	Mackay Creek	15–20	29/8/24	12:08	12:19	3	0	4	low	0	0:11
2023-1	40 Mile camp	15–20	06/10/2023	7:10	7:24	5	0	0	low	0	0:14
2023-2	40 Mile camp	15–20	06/10/2023	8:03	8:20	5	0	0	low	0	0:17
2023-3	GSI sandbar	15–20	07/10/2023	8:17	8:34	5	0	0	low	0	0:17
2023-4	Third Creek	15–20	07/10/2023	11:30	11:39	4	0	0	low	0	0:09
2023-5	Third Creek	15–20	08/10/2023	7:43	7:50	5	0	0	low	0	0:07
2023-6	Third Creek	15–20	08/10/2023	8:16	8:25	5	0	0	low	0	0:09
2023-7	GSI channel	15–20	08/10/2023	9:16	9:23	5	0	0	low	0	0:07
2023-8	GSI sandbar	15–20	08/10/2023	9:55	10:10	5	0	1	low	0	0:15
2023-9	Mackay Creek	15–20	08/10/2023	13:29	13:35	3	0	1	low	0	0:06
2023-10	GSI sandbar	15–20	09/10/2023	8:37	8:51	4	0	0	low	0	0:14
2023-11	Outlet Creek	15–20	09/10/2023	9:45	10:10	4	0	1	high	0	0:25
2023-12	GSI	15–20	09/10/2023	14:05	14:10	5	0	1	high	0	0:05
2023-13	Elasmo-bank	15–20	09/10/2023	14:40	14:47	5	0	1	high	0	0:07
2023-14	Mackay Creek	15–20	10/10/2023	7:25	7:37	5	0	1	high	1	0:12
2023-15	Mackay Creek	15–20	10/10/2023	7:46	7:50	5	0	1	high	0	0:04
2023-16	Mackay Creek	15–20	10/10/2023	8:14	8:34	5	0	1	high	0	0:20
2023-17	Mackay Creek	15–20	10/10/2023	9:58	10:06	5	0	1	high	0	0:08

We did not observe any sawfish during 2024 surveys (Table 5, Figure 4); however, numerous other elasmobranchs were witnessed during UAV flights, including giant shovelnose rays, Australian whiprays, broad cowtail rays (*Pastinacus ater*), bottlenose wedgefish (*Rhynchobatus australiae*), spotted eagle rays (*Aetobatus ocellatus*) and porcupine rays (*Urogynmus asperrimus*) (see Figure 5). Most individual whiprays, cowtail rays and giant shovelnose rays were found within inundated shallows during the high tide, presumably to avoid predators and/or to hunt prey, with small nervous sharks also observed patrolling the shallows. We also observed numerous teleost species, including members of the Mugilidae, Carangidae, Sillaginidae, Sparidae, as well as green turtles (> 66 individuals) and a sea snake.

To the south-east of the E4 receiver, during low tide and between 10:10 am and 10:28 am on the 28/08/2024, we observed (from the bow of the Brutus vessel) seven Australian whiprays, eight nervous sharks, one giant shovelnose ray, one great hammerhead (*Sphyrna mokarran*), two blue swimmer crabs (*Portunus pelagicus*), two sea snakes, over 70 green turtles and various terapontids, sparids and chanids, at depths less than one meter.

Figure 4. Imagery from UAV flights conducted in 2024 and 2023 (see Table 6 for flight summary).

Figure 5. Imagery from UAV flight 14 of 2023, demonstrating the high abundance of elasmobranchs and teleosts observed in Intake/McKay Creek during high tide.

Figure 6. Imagery from visual observations along the mangrove fringed shoreline to the immediate west of Intake Creek.

Acoustic receiver detections

Of the receivers downloaded during surveys, none had recorded transmissions from any sawfish implanted with an acoustic tag. Despite showing adequate voltages during March 2023, batteries on all downloaded receivers were depleted by September of the same year and were subsequently replaced during October 2023 surveys. Although we did not capture any sawfish within the study area, two immature male green sawfish (2001 and 2015 mm TL, respectively) were tagged with acoustic transmitters in the Fortescue River estuary during August 2022; these transmitters are expected to be active for at least 500 days since deployment. Additionally, one neonate green sawfish (790 mm TL) was caught with these larger males in the Fortescue River, but was not fitted with an acoustic tag whereas 12 green sawfish captured in the Onslow area, between October 2021 and October 2022, were fitted with acoustic transmitters and each were active during the study period.

Two of the receivers were unable to be located during the 2024 survey, one was replaced at Great Sandy Island. The acoustic receiver inside MacKay Creek did not have any detections. Note that for detected sawfish to be recorded, they would have to have migrated from Onslow or the Fortescue River, as no sawfish have been acoustically tagged in the study area.

The acoustic receiver located in the Fortescue River mouth had received more than 13,000 detections from the two sawfish tagged there in August 2022 (Figure 7). One of these sawfish (Pz02), showed near constant residency to the Fortescue River mouth, while the other sawfish (Pz03), showed more sporadic residency, but continued to return to the Fortescue River mouth up to the point of receiver download.

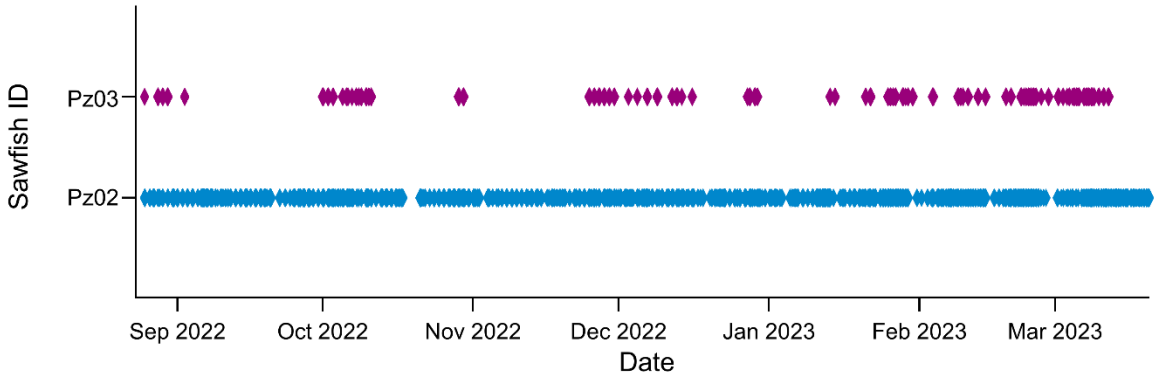


Figure 7. Acoustic detections of two green sawfish (*Pristis zijsron*) within the Fortescue River mouth.

Discussion

Distribution and habitat use of green sawfish

Information relating to the habitat preferences and abundance of the green sawfish (*Pristis zijsron*) is somewhat limited, with recent studies mostly restricted to the coastline of north-western Australia (see Ingelbrecht et al., 2024; Lear et al., 2023; Morgan et al., 2015, 2017, Lear & Morgan, 2023). Telemetry studies indicate that green sawfish are typically benthic, spending their entire lives in marine and estuarine environments, with juveniles favouring nearshore habitats, particularly those associated with mangroves, likely due to the relatively high abundance of prey and lack of large predators (Phillips et al., 2017). Our previous research in the southern Pilbara region has demonstrated that green sawfish are regionally philopatric, with mature females known to re-use the same site for pupping, whereas mature males are philopatric perhaps to mating sites (see Ingelbrecht et al., 2024). The habitat preferences (depth use and home range) of green sawfish also change with growth; small juveniles (i.e., < 2.5 m TL) remain in shallow waters and occupy restricted ranges, whereas large juveniles (i.e., 2.5–3.5 m TL) occupy deeper, coastal habitats and have expanded home ranges, before moving offshore upon reaching maturity (Morgan et al., 2017). Based on telemetric and growth rate data, green sawfish in the Onslow region are thought to be impeded by an offloading facility constructed in the area roughly a decade ago (Lear et al., 2023, 2024; Morgan & Lear, 2023). There is also genetic evidence to suggest that green sawfish are capable of moving long-distances (i.e., > 100 km), including between the Ashburton River (southwest of Onslow, Western Australia) and both Cape Keraudren and Broome, Western Australia (approximately 370 and 700 km northeast of Gnoorea, respectively) (Ingelbrecht et al., unpublished data). However, despite extensive sampling in the region, there has been no evidence of similar movements since 2014, which corresponds with the construction of an offloading facility adjacent to Onslow and east of the Ashburton River (Ingelbrecht et al., 2024; WAPC, 2015). Green sawfish captured in the Fortescue River mouth may be impeded by the off-loading facility at Cape Preston, as movement around such facilities appears to be specific only to individuals larger than 2.5 m in length. Plans to construct offloading facilities in future should consider these impacts on the short- and long-term movement behaviour of green sawfish, and other threatened, coastal species.

Conservation value of the study area from a regional and international perspective

Of the elasmobranch species encountered during 2022–2024 surveys, only the green sawfish is listed as Vulnerable under the *Environmental Protection and Biodiversity Conservation Act 1999*; however, we observed numerous other elasmobranchs that occupy threatened categories on the IUCN Red List of

Threatened Species (Table 7). For example, the giant shovelnose ray (*Glaucostegus typus*), whose distribution overlaps with the green sawfish, is listed as Critically Endangered on the IUCN Red List, globally (Kyne et al. 2019a), but is classified as a species of Least Concern within Australian waters, based on IUCN criteria applied at the national level (Kyne et al., 2021; Simpfendorfer et al., 2019), and was abundant in the study area, with nearly 20 individuals captured during 2024 gill net surveys. During 2023 and 2024 surveys, the abundance of giant shovelnose rays appeared to be greatest proximal to the mouth of Mackay Creek. Similarly, the spinner shark (*Carcharhinus brevipinna*), which is classified as Vulnerable on the IUCN Red List (Rigby et al., 2020), was also captured relatively frequently, particularly at the mouth of Mackay Creek during high tide in 2024, highlighting the importance of the marine environments of Cape Preston and Gnoorea for numerous elasmobranchs.

Table 7. Global and national (i.e., Australian) IUCN classifications (see Finucci et al., 2024; Harry et al., 2022; Kyne et al., 2019a, b; 2021; Rigby et al., 2020, 2021; Sherman et al., 2021, 2024a, b; Simpfendorfer et al., 2019, 2021) for elasmobranchs encountered during 2022–2024 surveys of Cape Preston and Gnoorea.

Scientific name	Common name	Global status	National status
Pristis zijsron	green sawfish	Critically Endangered	Critically Endangered
Glaucostegus typus	giant shovelnose ray	Critically Endangered	Least Concern
Rhynchobatus australiae	bottlenose wedgefish	Critically Endangered	Near Threatened
Negaprion acutidens	sicklefin lemon shark	Endangered	Least Concern
Carcharhinus brevipinna	spinner shark	Vulnerable	Least Concern
Carcharhinus leucas	bull shark	Vulnerable	Near Threatened
Aetobatus ocellatus	spotted eagle ray	Endangered	Least Concern
Pastinachus ater	broad cowtail ray	Vulnerable	Least Concern
Pateobatis fai	pink whipray	Vulnerable	Least Concern
Urogymnus asperrimus	porcupine ray	Endangered	Least Concern

Intriguingly, the majority of encountered rays were observed in extremely shallow waters (depth < 50 cm), particularly at Mackay Creek, during 2024 and 2023, respectively (see Figure 8). It therefore seems likely that the shallow waters of Cape Preston and Gnoorea represent an important habitat for these rays. It is also possible that individuals in deeper waters were simply not observed, due to greater depths occasionally not being as visible from above the water's surface; however, we think this is unlikely, as substrate was often visible during UAV flights and from the bow of the vessel. Similar patterns of habitat use have been observed for tagged green sawfish in the Ashburton River and adjacent tidal creeks, where neonates and young juveniles appear to restrict themselves to shallow depths less than 1 m (and occasionally less than 20 cm), likely in relation to refuging and foraging behaviours (Morgan et al., 2023). Access to these extreme shallow areas is often limited to specific periods during the tidal cycle. It is therefore imperative that access opportunities for elasmobranchs to these shallow areas during high tides are maintained, and should be considered in proposals for sea water intake. Specifically, it is important that any extraction of sea water from the survey area does not result in a significant reduction of water level within creeks during any part of the tidal cycle, as it may lead to more restricted access to shallow habitats, which are already naturally constrained by the flow of tides.

Although only a single green sawfish was observed during 2022–2024 surveys, the study area appears to suit the key habitat requirements of this species, specifically juveniles, with an abundance of shallow, estuarine, mangrove systems that appear to be highly productive, based on seine net surveys. It is therefore likely that the study area is capable of supporting critical life stages of green sawfish, potentially providing

a secondary nursery area for large juveniles. Sawfish surveys conducted in the Pilbara are scarce, with the exception of the long-term green sawfish project currently undertaken adjacent to Onslow. Pupping sites near Onslow appear to be restricted to three small tidal creeks (i.e., Four Mile Creek, Hooley Creek and Hooley Lagoon) and one large river estuary (i.e., the Ashburton River), based on research conducted in 2011 and biannual surveys between 2019 and 2022. Interestingly, a single survey conducted in 2022 indicated that the Fortescue River estuary may act as a pupping site for green sawfish; however, additional surveys are required to confirm this. Sporadic sightings of sawfish have also been recorded elsewhere along the Pilbara coast, although none have been documented previously within the survey area, except during this study (see Bateman et al., 2024; Figure 9). It is also possible that the marine environments of Cape Preston and Gnoorea form part of a network of 'stop over' sites that support long-distance movement of green sawfish along Western Australia's coastline, which has been known to occur between Broome and Onslow, situated to the north-east and south-west of Cape Preston, respectively (Ingelbrecht et al., unpublished data).

Figure 8. Threatened elasmobranchs (according to the IUCN Red List of Threatened Species, as of 29th September 2024) that were recorded during surveys.

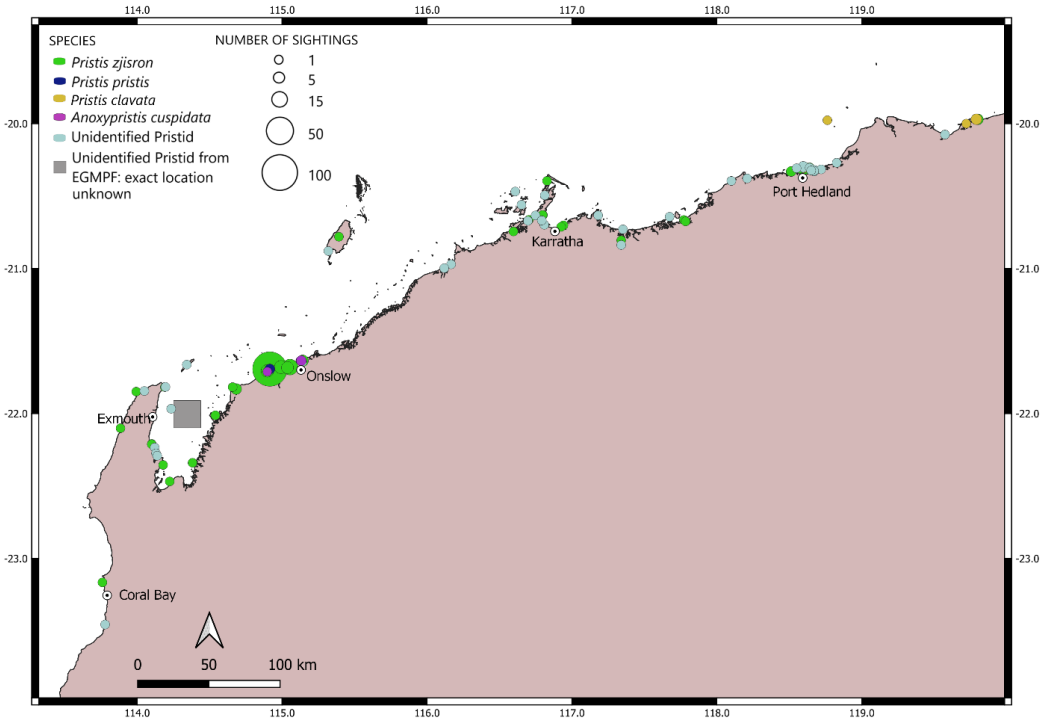


Figure 9. Sawfish sightings along the Pilbara coastline (adapted from Bateman et al., 2024).

The distributions of the giant shovelnose ray, nervous shark, Australian whipray and broad cowtail ray each strongly overlap with that of the green sawfish within Australian waters, with each species appearing to be relatively abundant along the Pilbara coast (Morgan et al., 2023). However, even in systems where these sympatric species are common, it is fairly typical for green sawfish to not be encountered, similar to our observations at Mackay Creek during 2024 and 2023, respectively. The home range of juvenile green sawfish increases with size, particularly at four years of age and older, noting that the age at maturity is approximately nine years for this species in Western Australia (Lear et al., 2023; Morgan et al, 2017). Regarding the individual green sawfish observed at the mouth of Intake Creek in October 2023, it is unclear whether this individual emigrated from a nursery area outside of this region; however, the groyne constructed at Cape Preston likely inhibits the movement of smaller green sawfish from the south (Lear et al., 2023). Future industrial developments along the Pilbara coast, and indeed elsewhere, should consider the potential to impede migration pathways of shallow water species, including juvenile green sawfish (Lear et al., 2024). Comprehensive aquatic fauna assessments are much needed for elasmobranchs along the Pilbara coastline and should be prioritised in future, particularly for highly threatened, philopatric species, such as the green sawfish. Furthermore, acoustic arrays previously established in this region could be applied in future to examine the movement patterns not only of other sawfish species, but also other sympatric elasmobranchs, including those recorded during this research.

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