Eramurra - Sawfish Risk Assessment Workshop

Eramurra Sawfish Workshop Outcomes Report

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Executive Summary

Leichhardt Salt Pty Ltd (the Proponent) propose to develop the Eramurra Solar Salt Project (the Proposal) in the Cape Preston East area, Western Australia (WA). The Proposal will produce high purity industrial grade sodium chloride salt from seawater via a solar evaporation and crystallisation operation. Supporting infrastructure includes seawater intake, bitterns outfall, desalination plant and groundwater bores, power supply and other infrastructure.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cth) and Western Australian *Environmental Protection Act 1986* (EP Act) govern the environmental approval process. They aim to support environmentally sustainable development while protecting environmental values, including biodiversity. 'Marine Fauna' are a key environmental factor to be considered during environmental impact assessment under the EP Act (WA). They are defined as "Animals that live in the ocean or rely on the ocean for all or part of their lives" (EPA 2016a). The EPA's objective for marine fauna is: "To protect marine fauna so that biological diversity and ecological integrity are maintained".

This document presents the outcomes for the sawfish risk assessment workshop, held to better predict, avoid and mitigate impacts to sawfish (and other species), and identify information gaps.

The objectives of the sawfish risk assessment workshop were:

1. To identify known critical periods for sawfish environmental/life cycle events;
2. Determine the likely presence of these listed threatened species or their habitat within/near the proposed development area, in addition to any other EPBC Act listed species;
3. Evaluate the significance of potential direct, indirect (including downstream) residual and cumulative impacts as a result of the Proposal at a local and regional level;
4. Identify potential secondary impacts from alterations to coastal processes resulting from the presence of the proposed marine pipeline infrastructure which may impact on the availability of important habitat, including if there is a significant change to infrastructure approved by Cape Preston East (MS 949);
5. Formulate an environmental outcome for sawfish;
6. List potential management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts; and
7. Develop a cumulative impact assessment approach which can be applied to other EPA marine factors.

The sawfish species identified in the sawfish risk assessment workshop were: green sawfish (*Pristis zijsron*), narrow sawfish (*Anoxypristis cuspidata*), dwarf sawfish (*Pristis clavata*) and largetooth sawfish (*Pristis pristis*). The green sawfish was identified as having the highest likelihood of occurrence within the project area and has the greatest risk of impacts by the Proposal. The green sawfish population that occurs in the Pilbara appear to be genetically distinct from the other populations across the world.

This report outlines the green sawfish's population, habitat use, ecological window, and also identifies gaps in the species ecology. Potential impacts to the green sawfish are identified, with formulated mitigation

hierarchy (avoid, minimise and rehabilitate) implemented to guide management to ensure the residual impacts on sawfish are not greater than predicted.

Acronyms and Abbreviations

Acronyms and Abbreviations	Description
AOO	Area of occupancy
BIA	Biologically Important Area
BC Act	Biodiversity Conservation Act 2016
CITES	Convention on International Trade in Endangered Species
CMS	Conservation of Migratory Species
CR	Critically Endangered
Cth	Commonwealth
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DoE	Department of Environment
DPIRD	Department of Primary Industry and Regional Development
E	Endangered
EIA	Environmental Impact Assessment
EOO	Extent of occupancy
EP Act	Environmental Protection Act 1986
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	Environmental Scoping Document
FRM Act	Fish Resources Management Act
HBI	Harry Butler Institute
IUCN	International Union for the Conservation of Nature
Km	Kilometre
LAUs	Local Assessment Units
m	metre
MI	Migratory
MNES	Matters of National Environmental Significance
MOFs	Marine Offloading Facilities
MS	Ministerial Statement
P	Priority

Acronyms and Abbreviations	Description
PLFs	Product Loading Facilities
SME	Subject matter experts
TP	Totally Protected
VU	Vulnerable
WA	Western Australia

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1. Introduction

Leichhardt Salt Pty Ltd (the Proponent) proposes to develop the Eramurra Solar Salt Proposal (the Proposal) in the Cape Preston East area, Western Australia (WA) (Figure 1). The Proposal will produce high purity industrial grade sodium chloride salt from seawater via a solar evaporation and crystallisation operation. Supporting infrastructure includes seawater intake, bittern's outfall, desalination plant and groundwater bores, power supply and other infrastructure. A short summary of the Proposal is presented in Table 1.

The Proposal has been referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Part IV of WA's *Environmental Protection Act 1986* (EP Act) and will be assessed under a Bilateral Agreement. The Environmental Scoping Document (ESD) highlights the relevant State and Commonwealth matters which may be impacted by the Proposal and provides recommendations to address these. Marine Fauna have been identified as a key environmental factor.

Sawfish are conservation significant species, protected at the State and Commonwealth levels (see section 2.1), and have been identified as being potentially at risk by habitat modification. This report summarises discussions and outcomes of the sawfish risk assessment workshop, held to better predict, avoid and mitigate impacts to sawfish (and other species), and identify information gaps.

Table 1 Short Summary of the Proposal

Proposal Title	Eramurra Solar Salt Proposal
Proponent Name	Leichhardt Salt Pty Ltd
Short Description	Leichhardt Salt Pty Ltd (Leichhardt) is seeking to develop a solar salt project in the Cape Preston East Area, approximately 55 kilometres (km) west-south-west of Karratha in Western Australia (WA) (the Proposal). The Proposal will utilise seawater and evaporation to produce a concentrated salt product for export. The Proposal includes the development of a series of concentration and crystalliser ponds and processing plant. Supporting infrastructure includes bitterns outfall, drainage channels, product dewatering facilities, desalination plant and/or groundwater bores, pumps, pipelines, power supply, access roads, administration buildings, workshops, laydown areas, landfill facility, communication facilities and other associated infrastructure. The Proposal also includes dredging in the Cape Preston East Port and either offshore disposal of dredge material or onshore disposal.

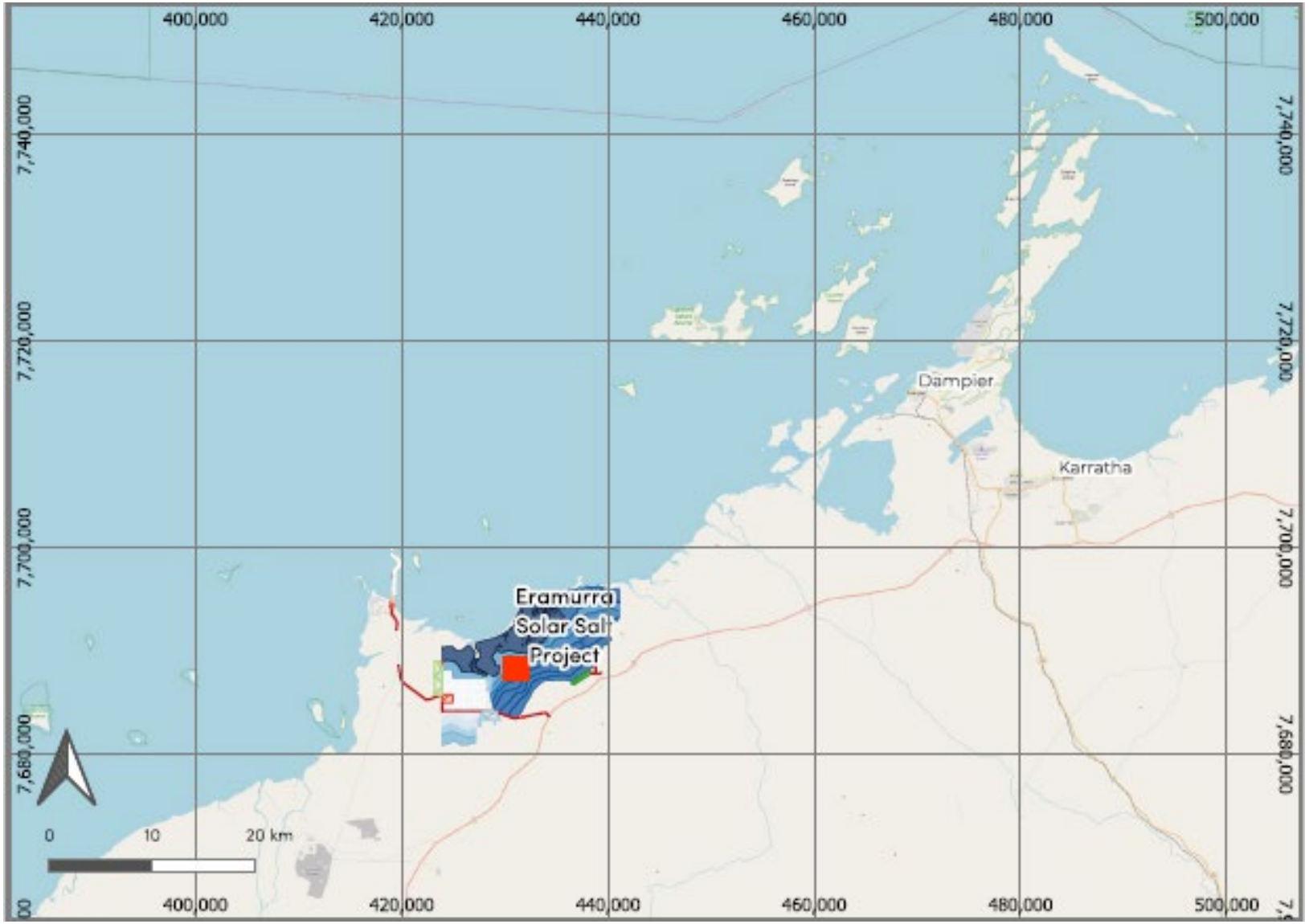

Figure 1 Regional location of the Proposal

1.1. Workshop Purpose, Objective and Approach

A workshop was conducted on 16 March 2022 conducted to identify risk factors and information gaps for sawfish species that could be affected by the Proposal. The workshop was structured to address the requirements and recommendations outlined in the ESD (Table 2), and DCCEEW's Significant Impact Guidelines for Threatened and Migratory species.

Table 2 Sawfish workshop objectives.

Objectives	Corresponding report section
1. Known critical periods for sawfish environmental/life cycle events	2.6.3
2. The likely presence of these listed threatened species or their habitat within/near the proposed development area, in addition to any other EPBC Act listed species	2.4 and 2.5
3. Significance of potential direct, indirect (including downstream) residual and cumulative impacts as a result of the Proposal at a local and regional level	2.7 and 3
4. Potential secondary impacts from alterations to coastal processes resulting from the presence of the proposed marine pipeline infrastructure which may impact on the availability of important habitat, including if there is a significant change to infrastructure approved by Cape Preston East (MS 949)	3.1.1
5. Formulate an environmental outcome for sawfish	4.1
6. List potential management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts	4.2
7. Develop a cumulative impact assessment approach which can be applied to other EPA marine factors.	3.2

Workshop participants included Proposal representatives, marine specialist consultants involved in preparing environmental approval documentation; and sawfish and environmental impact assessment subject matter experts (SME), as listed below.

Workshop Participants

- Daniella Hanf, Principal Scientist / Marine Fauna Lead, O2 Marine.
- David Morgan, Sawfish SME, Harry Butler Institute (HBI), Murdoch University.
- Karissa Lear, Sawfish SME, Harry Butler Institute (HBI), Murdoch University.
- Max Wellington, Scientist, O2 Marine.
- Phoebe Ranford, Environmental Scientist, Preston Consulting.
- Ray Masini, Marine Proposal Approvals SME, O2 Marine.
- Regina Flugge, Environment Lead, Leichhardt.
- Rob Crawford, Project Director, Leichhardt.

2. Sawfish

Sawfish are large cartilaginous fish. They are modified rays, although they possess shark-like dorsal and caudal fins. They belong to the Pristidae family, characterized by the long and narrow rostrum with uniform transverse teeth on either side. While their rostrum is vital for detecting and hunting prey, it is also unfortunately a factor in species decline, due to its susceptibility to become entangled in commercial fishery gill and trawl nets and its lure for trophy hunters and subsequent illegal fishing.

Four of the five extant sawfish species occur in Australian waters, including those of northern WA: green sawfish (*Pristis zijsron*), narrow sawfish (*Anoxypristis cuspidata*), dwarf sawfish (*Pristis clavata*) and largetooth sawfish (*Pristis pristis*) (Figure 2). The largetooth sawfish was previously named freshwater sawfish (*Pristis microdon*). The narrow sawfish is a recently described species.

The maximum length varies across species, with largetooth sawfish adults reaching approximately seven metres and dwarf sawfish adults approximately three metres (DoE 2015). Sawfish are slow growing, late to sexually mature and have low fecundity (Harrison and Dulvey 2014). They are relatively long lived with the green and largetooth sawfish believed to live up to 50 years (Morgan et al. 2017). Peverell (2008) estimated longevity of 34 years for dwarf sawfish, and an age at maturity of eight years for males.

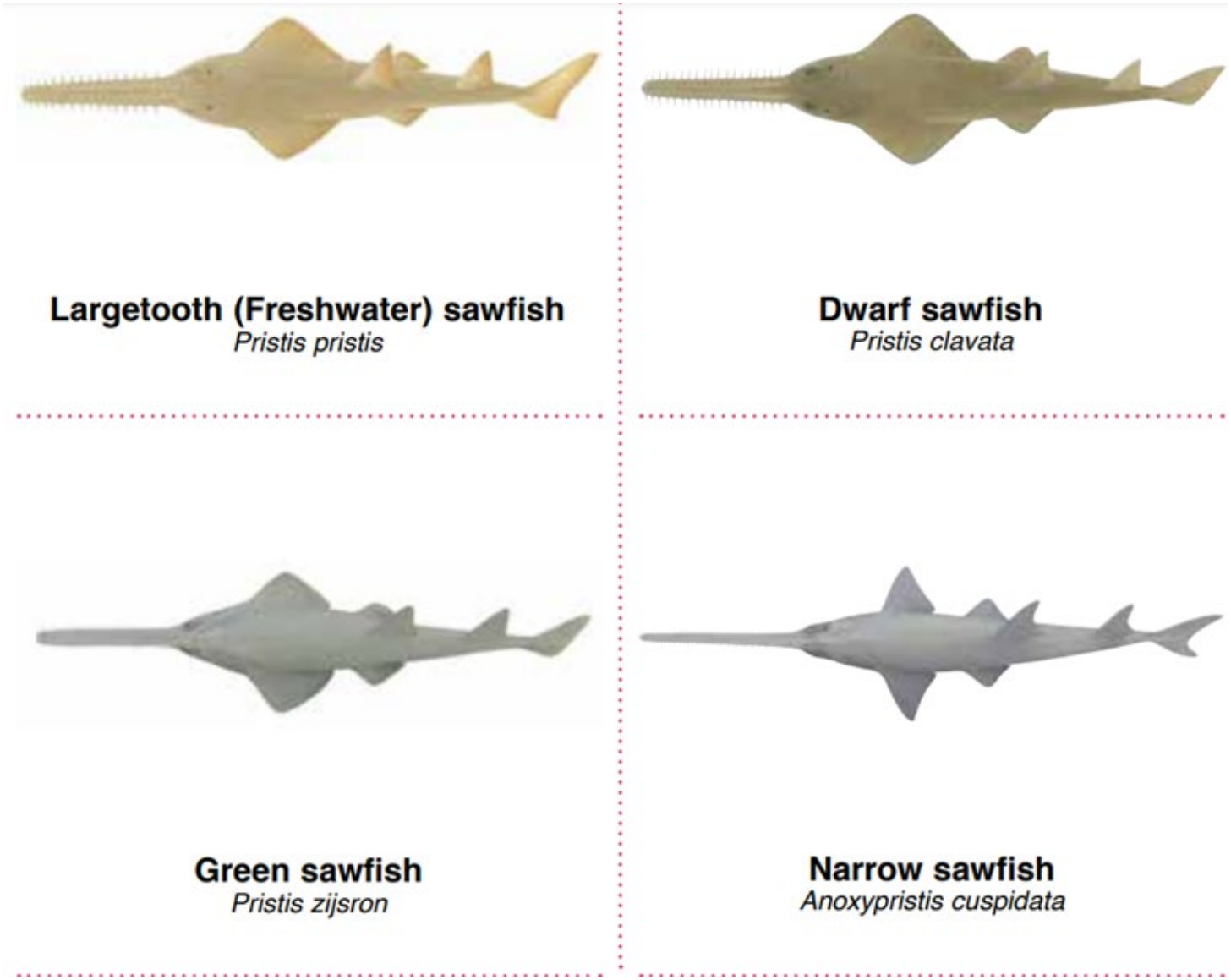

Figure 2 Sawfish species (DPIRD 2021)

2.1. Conservation Status

Sawfish have high conservation status at International, National and State levels (Table 3).

2.1.1. International

Green and largetooth sawfish are currently listed as Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, and narrow and dwarf as Endangered. These listings are undergoing revision.

All Australian sawfish species are listed on Appendix I (Endangered migratory species) and Appendix II (Migratory species conserved through Agreements) of the Convention on the Conservation of Migratory Species of Wild Animals 1979 (CMS, also referred to as the Bonn Convention).

All Australian sawfish species are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Appendix I lists the most endangered species among CITES-listed animals and plants.

2.1.2. National

Green and largetooth and dwarf sawfish are all listed as Vulnerable under the EPBC Act, while the threatened status assessment is underway for the narrow sawfish. All species are recognised as Migratory under the EPBC Act, reflecting the CMS.

2.1.3. State

In WA, green sawfish are listed as Vulnerable, dwarf as Priority 2 (in urgent need of further survey), and largetooth as Priority 3 (in need of further survey) under the *Biodiversity Conservation Act 2016* (BC Act). Assessment is underway for narrow sawfish.

All sawfish are Totally Protected under the *Fish Resources Management Act 1994* (FRM Act).

Table 3 Australian sawfish conservation status at International, National and State levels.

Species	International			National	State (WA)	
	IUCN	CMS	CITES	EPBC Act	BC Act	FRM Act
Green sawfish (*Pristis zijsron*)	CR	App. I & II	App. I	VU, MI	VU	TP
Largetooth sawfish (*Pristis pristis*)	CR	App. I & II	App. I	VU, MI	P3	TP
Narrow sawfish (*Anoxypristis cuspidata*)	E	App. I & II	App. I	MI*	*	TP
Dwarf sawfish (*Pristis clavata*)	E	App. I & II	App. I	VU, MI	P1	TP

*The threatened status of narrow sawfish is currently under assessment.

Note - International (IUCN, CMS and CITES), National (EPBC Act) and State (WA BC and FRM Acts). Threatened categories include CR: Critically Endangered; E: Endangered; VU: Vulnerable; MI: Migratory; P: Priority; TP: Totally Protected.

2.2. Conservation Threats

Globally, overfishing and habitat alteration have caused major declines in sawfish populations. Entanglement in fishing nets result in sawfish commonly caught as bycatch in a range of commercial trawl fisheries. In addition, loss of nursery habitat and reduction in habitat quality as a result of river regulation has had major impacts on sawfish populations worldwide (Kyne et al. 2013).

Australia represents the last secure populations of sawfish across their global ranges (Stevens et al. 2008; Phillips 2012). The principal threats to sawfish in Australia are from commercial fishing activities; recreational fishing; Indigenous fishing; illegal, unreported and unregulated fishing; and habitat degradation and modification (DoE 2015). In relation to coastal development, key threats to sawfish include habitat degradation from changes to coastal processes and reduction in water quality.

2.3. Regulatory Guidance

2.3.1. WA EP Act

The objective set out by the WA Environmental Protection Authority (EPA) for Marine Fauna is: "to protect marine fauna so that biological diversity and ecological integrity are maintained". Ecological integrity is the composition, structure, function and processes of ecosystems, and the natural variation of these elements (EPA 2021a).

2.3.2. Commonwealth EPBC Act

The Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) administer the EPBC Act and works to ensure that development Proposals are not at odds with the objectives for species' conservation. Information to assist regulatory considerations for Pilbara sawfish under the EPBC Act are presented in the following Conservation Advice, Listing Advice, Recovery Plan and other Policy Statements and Guidelines. As the conservation status of narrow sawfish is currently under assessment, conservation and listing advice are yet to be prepared, and they are to be included in the next revision of the multispecies recovery plan. Listing advice for largetooth sawfish is contained within the approved conservation advice. No threat abatement plans have been adopted or made for sawfish.

Approved conservation advice

- Approved conservation advice for green sawfish (DEWHA 2008)
- Approved conservation advice for *Pristis clavata* (dwarf sawfish) (DEWHA 2009)
- Approved conservation advice for *Pristis pristis* (largetooth sawfish) (DoE 2014)

Listing advice

- Listing advice for *Pristis zijsron* (green sawfish) (TSSC 2008)
- Commonwealth listing advice on *Pristis clavata* (dwarf sawfish) (TSSC 2009)

Recovery Plan

- Sawfish and river sharks multispecies recovery plan (DoE 2015)

The recovery plan is subsequent to conservation and listing advice (listed above). The primary objective of the recovery plan is to assist the recovery of sawfish and river sharks in Australian waters with a view to:

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

Recovery Plan Objectives and Actions

The objective with greatest relevance to the Proposal is:

Objective 5: Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species

Actions to achieve this objective are:

Priority One

5a. Ensure all future developments will not significantly impact upon sawfish and river shark habitats critical to the survival of the species, or impede upon the migration of individual sawfish or river sharks.

5b. Determine the effect of river and estuarine barriers on the movements of sawfish and river sharks and undertake an audit of barriers to establish whether removal or modification is feasible to allow for the riverine migration of sawfish and river sharks.

Priority Two

5c. Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.

5d. Implement measures to reduce adverse impacts of habitat degradation and/or modification.

Other objectives with some relevance to the Proposal are:

- Objective 6: Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life;
- Objective 8: Improve the information base to allow the development of a quantitative framework to assess the recovery of, and inform management options for, sawfish and river shark species;
- Objective 9: Develop research programs to assist conservation of sawfish and river shark species;
- Objective 10: Improve community understanding and awareness in relation to sawfish and river shark conservation and management; and,
- awareness in relation to sawfish and river shark conservation and management.

When conducting an impact assessment, it is important to note that all sawfish populations are considered to be of high conservation value and protected throughout their Australian ranges (DoE 2015). Furthermore, given the declines in sawfish populations and the lack of detailed information on their distribution, all areas where aggregations of individuals have been recorded displaying biologically important behaviour such as breeding,

foraging, resting or migrating, are considered critical to the survival of the species unless population survey data suggests otherwise (DoE 2015).

Marine Bioregional Plan

- Marine bioregional plan for the north-west marine region (DSEWPaC 2012)

The bioregional plan describes the marine environment and conservation values (protected species, protected places and key ecological features) of the North-west Marine Region, sets out broad objectives for its biodiversity, identifies regional priorities, and outlines strategies and actions to achieve these. Supplementary to the plan are Conservation Value Report Cards which present a summary of the scientific information on the distribution, conservation status and pressures on the conservation values in the region, including for sawfish species.

In the region, and of relevance to the Proposal, 'changes to hydrological regime' is identified as a threatening process of concern. Neonate and juvenile sawfish are range-restricted to the nursery areas of estuaries and creeks and so are susceptible to disturbances to those habitats.

A search of the Conservation Values Atlas, an interactive web-based tool developed to support implementation of Marine Bioregional Plans, indicated that there are currently no recognised Biologically Important Areas (BIAs) around the Proposal area. However, the area has not been adequately surveyed to understand sawfish occurrence and use of the area.

Threat Abatement Plan

- Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE 2018)

Marine debris has been recognised as a key threatening process that 'threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community', which includes sawfish. Environmental management plans pertaining to Proposal waste management should reference this threat abatement plan.

Survey Guidance

- Protocols for surveying and tagging sawfishes and river sharks (Kyne and Pillans 2014)
- Survey guidelines for Australia's threatened fish. EPBC Act survey guidelines 6.4 (DSEWPaC 2011)

The above survey guidance outlines expectations for survey design and implementation which would ensure the robustness of survey findings.

2.4. Distribution

Current knowledge of sawfish distribution is limited, and maps are currently in the review and update process. A summary of species with some potential to be found in the vicinity of the Proposal is provided below, with Figure 3 illustrating records of sawfish in the Pilbara.

To quantify impact under the MNES framework and provide context for the environmental assessment, it is necessary to define populations and population spatial boundaries.

The known distribution of the green sawfish is from the Whitsundays in Queensland across northern Australian waters to Shark Bay in WA. They pup along the coast, from Shark Bay (at the mouth of Gascoyne River) and throughout the Kimberley to the Gulf of Carpentaria. However, their distribution is not clearly defined due to confusion with other members of the genus (Thorburn et al. 2008). They are known to primarily occur in inshore and offshore marine waters, or in shallow estuarine waters, however, they do not penetrate freshwater.

Largetooth sawfish are found mostly in the Kimberley, where the Fitzroy River is a globally important nursery (Lear et al. 2019). They pup in the Fitzroy River, followed by migration down the whole Pilbara Coast to the top of the Exmouth Gulf.

Narrow sawfish have been found from Onslow through to the northern Kimberley. Compared to other species, they are found in larger numbers offshore, preferring deeper waters. This is reflected in trawl fisheries bycatch in 50-200m depth. However, they do occur in smaller numbers along the coast.

There are very little movement and distribution data for dwarf sawfish apart from those in the Kimberley region, north of the Pilbara region (Morgan et al. 2021). They are not likely to be found south of Cape Keraudren, with records in the area south of Port Hedland (Figure 3), likely to be erroneous (pers comm, D.L. Morgan, 2022).

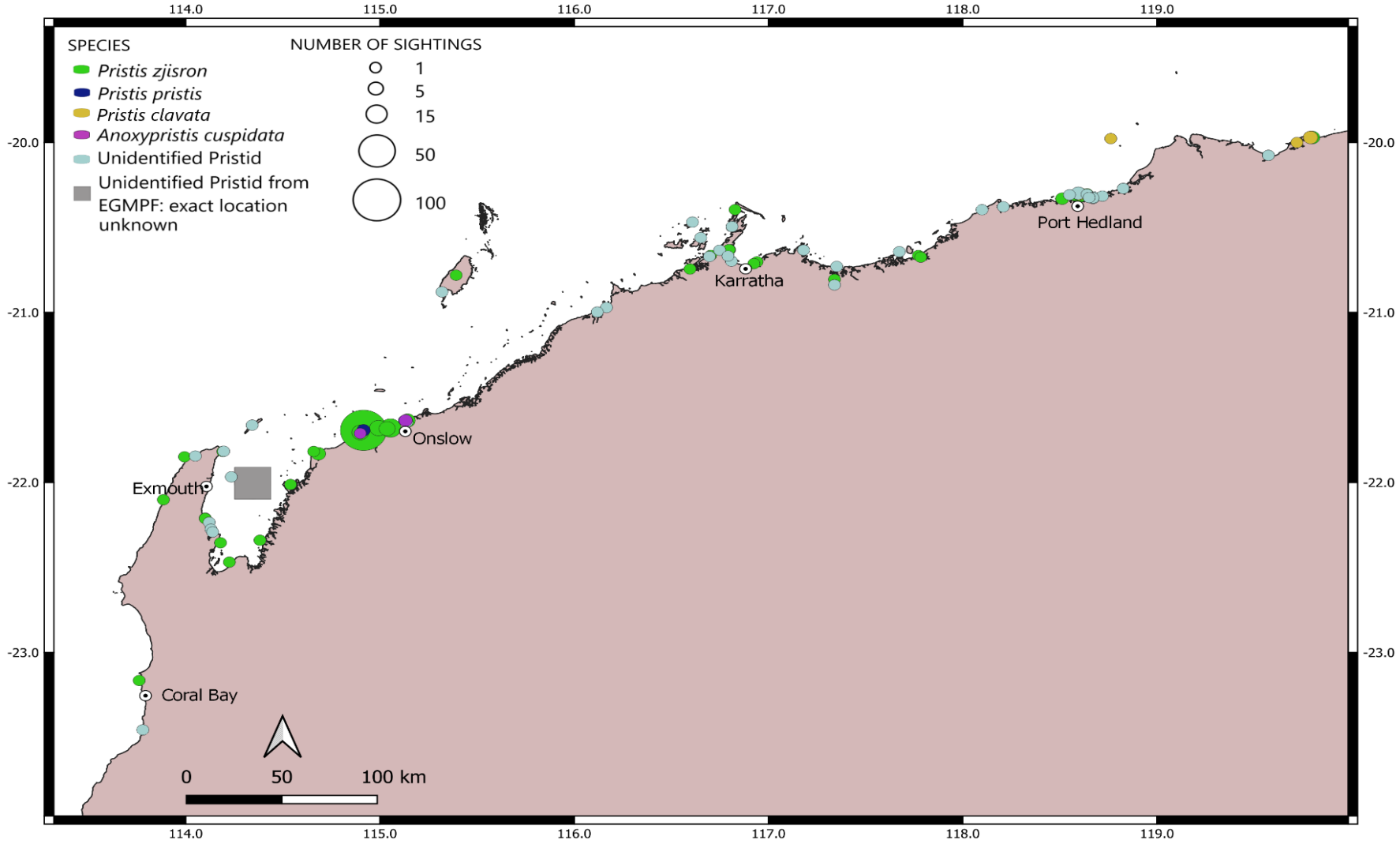

Figure 3 Distribution records of green (*Pristis zijsron*), largetooth (*Pristis pristis*), dwarf (*Pristis clavata*), narrow (*Anoxypristis cuspidata*) and unidentified sawfish species in the Pilbara (Murdoch University, 2022 – unpublished data).

2.5. Species' Occurrence

A summary of area of occupancy (AOO) and extent of occurrence (EOO) estimates and the proportion of marine and inland range that is considered protected for each species as calculated by Devitt et al. (2015) is presented in Table 4. A species' EOO is defined as the minimum area that encompasses all known, projected, or inferred records of a species, excluding cases of vagrancy. The AOO refers to the area within the EOO that the species actually occurs in.

Table 4 Sawfish area of occupancy (AOO) and extent of occurrence (EOO) in Australia (km^2)

Range (km)	Green sawfish	Largetooth sawfish	Dwarf sawfish	Narrow sawfish
AOO (km^2)				
- Total	1,304,319	895,617	486,977	1,256,400
- Marine	1,301,507	815,515	468,079	1,253,731
- Inland	2812	80,103	18,898	2669
EOO (km^2)				
- Total	1,322,191	1,203,565	504,631	1,541,120
- Marine	1,301,507	908,000	468,079	1,517,829
- Inland	20,684	295,565	36,552	3548

Green sawfish have the highest likelihood of occurring in the area and thus at greatest risk of impact by the Proposal. As such, green sawfish have a proportionately larger focus through this document.

The Ashburton River Delta near Onslow, also within the Pilbara region but approximately 150 km from the Proposal, is recognised as a globally important nursery area for green sawfish (Morgan et al. 2015, 2017). The mouth of Eramurra tidal creeks within and adjacent to the Proposal Area may act as a feeding and resting area for post-nursery and pre-maturation green sawfish individuals.

2.6. Green Sawfish

2.6.1. Population

Abundance and Trends

There is limited information on current population sizes or trends in Australian waters for sawfish species, but there is evidence that all species have experienced recent population declines and some species are considered to have been extirpated from former parts of their range (DoE 2015).

Genetic Structure

Green sawfish populations in the Pilbara appear to be genetically distinct from other populations worldwide, with some clear morphological differences evident, including differing number and shape of rostral teeth. In the Pilbara, population studies exploring the connectivity for several sawfish species are ongoing, although it

is hypothesised that for Pilbara green sawfish populations, the Dampier Archipelago may act as a natural barrier limiting genetic connectivity between western Pilbara and eastern Pilbara populations. Only one main pupping site is known to be located coastally in the Pilbara, being the Ashburton River Delta, while it is suspected that the other large delta in the region, De Grey River Delta, may also be important. The Ashburton River Delta and surrounds are therefore critically important to the green sawfish population in the vicinity of the Proposal, and the recovery of the species globally (Morgan et al. 2015). There is significant uncertainty regarding the impact of existing Cape Preston Port infrastructure (as a barrier) on coastal sawfish movements and potential effect on green sawfish movements in each direction.

2.6.2. Habitat Use

Green sawfish occur in inshore coastal environments including estuaries, river mouths, embayments and along sandy and muddy beaches, as well as offshore marine habitat (Stevens et al. 2008; Thorburn et al. 2008). They have been recorded in very shallow water (less than one metre) and in offshore trawl grounds in over 70 m of water (Stevens et al. 2005). Green sawfish do not utilise freshwater environments.

The habitat in which adult and juvenile sawfish are found differs slightly and therefore for some species, adults and juveniles may only occur in fresh or marine habitats dependant on their lifecycle stages (Harrison and Dulvy 2014). A study by Morgan et al. (2017), found that juvenile green sawfish have a high site fidelity for at least 3 to 6 months and remain in their chosen nursery for at least three to four years, later migrating into nearshore marine waters after the wet season.

All sawfishes are thought to be philopatric (Phillips et al. 2012), with females returning to their natal estuaries to pup after reaching sexual maturity.

Green sawfish have a strong association with mangroves and mudflats (DoE 2015). In general, mangrove habitat provides shelter and foraging opportunities. Sawfish foraging areas include shallow, sandy or muddy substrate during high and low tides. A movement study using acoustic telemetry near the Onslow area tracked individuals and found that they occupied shallow depths up to two metres, moving up to 10 km during each tidal cycle (Morgan et al. 2017). Individuals often returned to within 100 m of previous high tide resting sites, demonstrating the repeated use of habitat (Stevens et al. 2008). They moved towards the shore on the rising tide and away from the shore on the falling tide, remaining in water mostly less than 1.5 m deep. Generally, they stay within 500-700 m of the mouth of tidal creeks and avoid the upper reaches of these systems.

The Ashburton River delta is a globally important nursery area for green sawfish (Morgan et al. 2015, 2017). It is the only location where pupping of green sawfish has been found to occur annually over many years. Pregnant females are thought to return annually or biannually to the same location to give birth. Sawfish pupping occurs before the wet season in northern WA, generally from October to December. Juveniles up to 3.5 m total length remain in shallow areas at the mouths of marine tidal creeks and estuaries.

Preferred habitat changes with growth; as juveniles increase in size, they move out of nursery areas and begin to move along the coast, occasionally venturing into deeper waters and foraging in tidal creeks further afield. At 1 year old, individuals usually stay in very shallow waters and depth use increases with age and growth, although depth use of green sawfish up to approximately age 5 is dominated by shallow areas <2 m (Morgan et al. 2017). This pattern continues with adults moving into deeper waters as they mature.

2.6.3. Ecological Windows and Temporal Patterns

Green sawfish pupping occurs during spring to early summer (late dry season and pre-cyclone season). This is based on surveys conducted at Ashburton River Delta, an important area for neonates and juveniles, with many captured in this area in previous field surveys following the pupping period.

The diet of sawfish varies across age classes, with small fish, crabs and prawns dominating diets of juveniles, while a predominantly fish diet prevails for adults. Sawfish are most active at night and on larger tides. Green sawfish hunt on the low tide and incoming tide and leave on the outgoing. They are likely to feed nocturnally when prawns leave burrows. Sawfish occurrences have been shown to have some association with increased prawn abundance, occasionally following rainfall events where freshwater runoff and nutrient input is higher into major river systems.

2.7. Summary and Gaps

A summary of the information available to undertake an assessment of significant impacts (DoE 2013) is presented below (Table 5).

Table 5 Criteria and information on which to base an assessment of significant impacts to sawfish

Significant impact criteria	Available Information	Knowledge Gap
Will the action lead to a long-term decrease in the size of a population?	Section 2.5.	Uncertainty surrounds relative density and abundance. Uncertainty exists regarding the importance of Eramurra and adjacent creeks as sawfish habitat. It is unlikely to be an important pupping habitat, but this is an assumption.
Will the action reduce the area of occupancy of the species?	Section 2.5	NA
Will the action fragment an existing population into two or more populations?	Section 2.4	Uncertainty exists regarding population connectivity and movement ecology in the Pilbara.
Will the action adversely affect habitat critical to the survival of a species?	Section 2.5	Uncertainty exists regarding the importance of Eramurra and adjacent creeks as sawfish habitat. It is unlikely to be an important pupping habitat, but this is an assumption that requires validation. The extent of impact to algal mats, and thus secondary impact potential, is unclear.
Will the action disrupt the breeding cycle of a population?	Section 2.5	It is unlikely to be an important pupping habitat, but this is an assumption requiring validation. This would inform avoidance measures for construction activities.
Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Section 2.6	Availability of prey species in the area for potential foraging by sawfish is not known. Hydrological (i.e., surface water) and coastal processes changes are unclear, as are the secondary impacts to mangrove and algal mat habitats, including their structure and function.
Will the action result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?	Standard procedures for managing introduced marine pest species. Introduced Marine Pest risk assessment.	Risk assessment of potential introduced marine pest species associated with dredge vessels.
Will the action introduce disease that may cause the species to decline?	NA – deemed to be unforeseeable and unlikely to be a key impact pathway.	

Significant impact criteria	Available Information Knowledge Gap
Residual impact	Determined that there will be a low or negligible residual impact if knowledge gaps are addressed sufficiently, and guide application of environmental management and mitigation strategies (Section 4.2).

3. Potential Impact Pathways

Barriers to movement, such as rock walls associated with Marine Offloading Facilities (MOFs) and Product Loading Facilities (PLFs) are key threats to sawfish populations, with many species exhibiting a return to key river delta systems for pupping. In addition, sawfish are known to become more mobile (move further afield) with ontogeny (growth/age). Analysis of the movements of acoustically tagged sawfish have shown that these hard barriers cause individuals moving along the coast to turn around, rather than following the structure offshore into deeper water and continuing along the coast (Morgan and Lear unpublished data). Dredged channels or increased depths in coastal areas could also restrict movement, particularly of juveniles which are limited to shallow areas. Barriers to movement could dampen the recovery of sawfish populations through restricting available habitat and potential range extensions.

3.1. Key Potential Impacts

Key impacts listed below have potential to be significant impacts on sawfish populations resulting from the Proposal.

3.1.1. Hydrological Regimes/Coastal Processes (indirect impacts)

It is predicted that the Proposal will alter surface and groundwater flows significantly within the development envelope, but this will be confirmed by hydrological modelling. In addition, physical modification of intertidal areas - particularly the placement of pond walls - is predicted to influence tidal flows and sedimentation patterns in the surrounding areas. As a flow-on effect, changes in the frequency and depth of inundation of some mangrove creeks are likely which would affect juvenile green sawfish reliant on shallow areas at the mouth of tidal mangrove creeks. Depth changes as a result of increased sedimentation or dredging may degrade or alter important habitat. Significant alteration could subsequently cause changes to key behaviors resulting in population consequences.

Another flow-on impact of changes in sedimentation and hydrology involves the potential for reduced vigour or loss of mangrove and associated ecosystems that rely on a particular inundation regime. The loss of important mangrove areas could reduce the availability of suitable prey items (small fish, crabs and prawns) for sawfish. The alteration and potential restriction of freshwater runoff during intermittent rainfall events may impact the ecological integrity of estuarine and nearshore areas, which have evolved in the arid-tropical Pilbara climate, characterised by episodic weather events.

Hydrological regimes and impacts on tidal creeks, deltas and associated mangrove ecosystems will be a fundamental impact resulting from the Proposal and must be considered as part of a cumulative assessment (see Section 3.2).

Additionally, sawfish have a preference for sandy or muddy bottom areas. Development of coastal structures has the potential to change sedimentation patterns. This could result in de-sedimentation or exposure of bedrock in areas that are characterized by sand or mud, therefore reducing the area of preferred sawfish habitat.

Hydrodynamic modelling (inclusive of intermittent runoff events as well as tidal action) and coastal processes assessment is expected to provide key information on the potential for indirect impacts on sawfish in and surrounding the Proposal Area.

3.1.2. Barriers (direct impacts)

Barriers to movement are recognised as impacts to sawfish under the Commonwealth Sawfish and River Sharks Multispecies Recovery Plan (DoE 2015) for freshwater and estuarine species. Studies on the impact of barriers on largetooth sawfish have been undertaken (Morgan et al. 2014) although a focus has been on internal waterways.

Barriers to movement have also been shown (Morgan and Lear, unpublished data) to impact juvenile green sawfish in the coastal marine environment and understanding this further is a key action of the Recovery Plan (DoE 2015). Field investigations using acoustic transmitters surgically inserted in green sawfish have shown that longshore movements/migrations have been prevented by rock walls associated with MOFs in the Pilbara. Juveniles and young adults are closely connected with shallow coastal areas and there is evidence that these individuals will not move into deeper areas, even to bypass a coastal barrier such as a rock wall. Coastal barriers therefore have potential to directly limit the distribution of green sawfish and negatively impact population recovery.

As a precautionary approach to impact assessment, it has been assumed that other coastal infrastructure and modification of the environment could also effectively provide barriers to sawfish movement. This includes physical presence of Port facilities not part of the Proposal (as previously approved under the EP and EPBC Acts, see MS949/1149). The following structures were discussed and determined to be potential barriers to sawfish during the workshop:

- pipelines laid immediately above the seabed, in the inter-tidal zone,
- abutments,
- rockwalls, and
- creation of a channel via dredging.

Pylon jetties were deemed unlikely to create a barrier to sawfish movement. This Proposal includes the bitterns pipeline. The approved Port includes an offloading facility, with a pylon jetty which extends 650 m from the shoreline, potentially with a small (<20 m) coastal abutment yet to be determined during final engineering design. However, this abutment will be positioned to minimise impacts on longshore sawfish movements. In addition, an 800 m long outfall pipeline is proposed to extend 150 m from the end of the pylon jetty.

Juvenile sawfish are highly constrained to shallow areas and a dredged channel may therefore act as a barrier to sawfish movement. The impact assessment will be based on a refined version of the Proposal description. In the hypothetical scenario that dredging of the mouth of tidal seawater intake creek is undertaken to ensure a sufficient volume of seawater for operations, the deepening of the existing tidal channel could create a longshore barrier to sawfish movement.

Section 4.2 details the design and engineering strategies discussed during the workshop to minimise the impact of these structures on sawfish movements.

Note: The workshop raised the question of the potential for the existing Cape Preston West development creating an artificial barrier to sawfish movement and possibility for a 'trapping or isolating effect' between Cape Preston and the Dampier Archipelago.

3.2. Cumulative Impact Assessment Approach

Key considerations were discussed for developing an approach to cumulative impact assessment for the Proposal.

- Maintenance of ecological integrity as an underlying theme throughout.
- Consider the EPA Arid Zone Mangrove Policy (EPA 2001) and ecological relevance in the setting of Local Assessment Units (LAUs).
    - Specifically, recommendations to reconsider the setting of boundaries of LAU's coincident with 'Area 9' and the regionally significant mangrove.
- Impacts on mangroves (including mangrove ecosystem) and the subsequent flow-on impacts will be the key focus of the environmental impact assessment. Consider EPA Technical Guidance - Protection of Benthic Communities and Habitats (EPA 2016b).
- Hydrological effects - interruption to hydrological flow by construction of ponds and flow-on implications to the mangrove community. Ponds will affect the intertidal zone. Key information to feed into this will be:
    - Surface water modelling (by Land and Water Consulting) impact on surface water runoff with and without ponds.
    - Cumulative Loss Assessment
- Sea-level rise through life of Proposal
- Potential for existing Proposal developments to cause a barrier effect to sawfish (e.g., Cape Preston causeway)

The recommended approach to assess cumulative impacts:

- Spatial definition of impacts and populations (scale of Proposal), with attention to LAUs. LAUs are established at appropriate spatial scales to assess impacts on sessile benthic communities. However, there is a need to consider and apply the ecologically relevant scale for assessing potential impacts on motile fauna such as populations of different sawfishes. For example, for green sawfish, the area including Exmouth Gulf to Dampier Archipelago is likely to be the spatial extent of a single population. Within this, the Ashburton River area is known to be critically important as a breeding area for this population. The importance of the Eramurra area in a wider population context is unknown, but based on its physical characteristics, is unlikely to be critical.
- Consider the impacts of existing developments and approved Proposals (Can only consider Proposals that are already known about and approved).
- Look at environmental context (i.e., Pilbara intermittent/episodic events are critical to long term maintenance of the ecosystems and environment).

- Look at Proposal timescale (assumed to be 63 years, based on three 21-year mining leases, but could be up to 100+, dependant on in-exhaustive salt harvest potential) and factor in sea-level rise and physical changes that may occur in the area during this time.
- Record the Proposal design process including any actions taken to mitigate Proposal impacts and present the final residual impact.

3.3. Other Potential Impacts

The full range of readily foreseeable potential impacts to sawfish associated with the Proposal were identified and their level of significance assessed during the workshop. The impact pathways described below were assessed and determined to be unlikely to be significant to sawfish populations.

3.3.1. Light Pollution

Light pollution has not been shown to deter presence of sawfish, however, impact on sawfish behaviour is unknown.

3.3.2. Noise Pollution

Noise impacts from the Proposal during Proposal operations are anticipated to be low. The main sources will be from construction dredging and operational-phase seawater intake via pumps. The greatest potential concern for sawfish during dredging would be short-term area avoidance of an important area. However, if creeks are identified to be important pupping sites, they would likely be shielded from noise by physical land barriers. In addition, underwater noise management procedures will be informed by an underwater noise assessment and will incorporate mitigation protocols such as soft starts (if practicable) to protect noise-sensitive marine fauna.

3.3.3. Water Quality

It is possible for nutrients to leach into groundwater and coastal waterways. The potential for this occurring is under investigation, although it is expected to have minimal negative implications for sawfish.

4. Management

4.1. Sawfish Environmental Outcomes

An objective of the workshop was to formulate an environmental outcome for sawfish to ensure residual impacts are not greater than predicted. The following Environmental Outcomes were formulated based on workshop discussions of major potential impacts and have considered EPA advice (EPA 2021b):

1. *No adverse effects to green sawfish populations by the Proposal.*
2. *Sawfish migration routes will not be restricted by Proposal elements.*
3. *Ecological integrity of regionally significant mangroves will be maintained.*

4.2. Mitigation Hierarchy

The mitigation hierarchy (avoid, minimise and rehabilitate) has been used to guide the mitigation of the key potential impacts to sawfish (detailed in Section 3.1). As the Proposal is still currently in the planning, design and development stages, the majority of potential significant impacts may be minimised through avoidance strategies.

4.2.1. Avoidance

Engineering design

Introduction of barriers and changes to hydrographic processes are the two key potential impact pathways to sawfish identified during the workshop. The principal mechanisms of the impact are both related to the design of Proposal infrastructure. Hydrological (i.e., surface water) modelling and a coastal processes assessment will support greater understanding of the potential for impact.

Controls	Barriers (Abutment, Jetty, Pipeline and Dredged Channel)	Changes to Hydrology
Elimination	• Potential for coastal abutment be eliminated	
Substitution	• Dredging of a channel will only be necessary if siltation occurs due to altered coastal processes. The potential for siltation will be informed by a coastal processes assessment.	
Engineering controls	• Outfall pipeline to be either elevated off the seabed (below jetty) or buried/trenched below seabed	• Modification of straight-line tenure boundary of pond wall to reduce interruption to key ecological processes that sustain local arid-zone mangrove communities. Change to reflect environmental considerations identified via tidal flushing and surface water modelling,

Ecological Windows

If pupping is found to occur in Eramurra Creek and/or adjacent creeks, the timing of construction activities will be scheduled to avoid this period (see Section 2.6.3), where practicable. There is the assumption, however, that the area is unlikely to support an important pupping habitat as is present at Ashburton River Delta (see Section 2.5), and that sawfish are more likely to migrate here for foraging.

4.2.2. Mitigation

Administrative Controls

The development of effective administrative controls will be informed by further refinement of the Proposal design, sawfish field study findings and the outcomes of hydrological modelling, and coastal processes, introduced marine pest species and underwater noise assessments. For instance, clarity around how sedimentation will change resulting from the development of the ponds will provide valuable information on potential barriers to movement and potential alteration (loss or gain) of habitat.

4.2.3. Rehabilitation

None identified.

5. Further Studies

Further studies are recommended in relation to key knowledge gaps and assumptions outlined during the workshop. There is a lack of knowledge regarding sawfish distribution, habitat use or movement between the important nursery area at Ashburton River Delta and Karratha, largely because of the remote nature of that coastline. Eramurra tidal creek mouths are likely to be a foraging area for post-nursery and pre-maturation green sawfish individuals which are transient and moving along the coastline. Understanding barriers to movement is a key action to achieve the Recovery Plan objective “Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species” (DoE 2015).

It was proposed that a field study, compatible with studies undertaken elsewhere in the Pilbara and with regulatory guidance (see Section 2.3), could be undertaken to:

- identify sawfish species presence;
- assess the potential for creeks at the Proposal site to serve as pupping and/ or foraging habitat; and
- understand movement of sawfish from the Onslow area to Eramurra and whether an anthropogenic barrier exists at Cape Preston.

The impact assessment will be strengthened by outcomes of hydrological modelling, and coastal processes, introduced marine pest species and underwater noise assessments.

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