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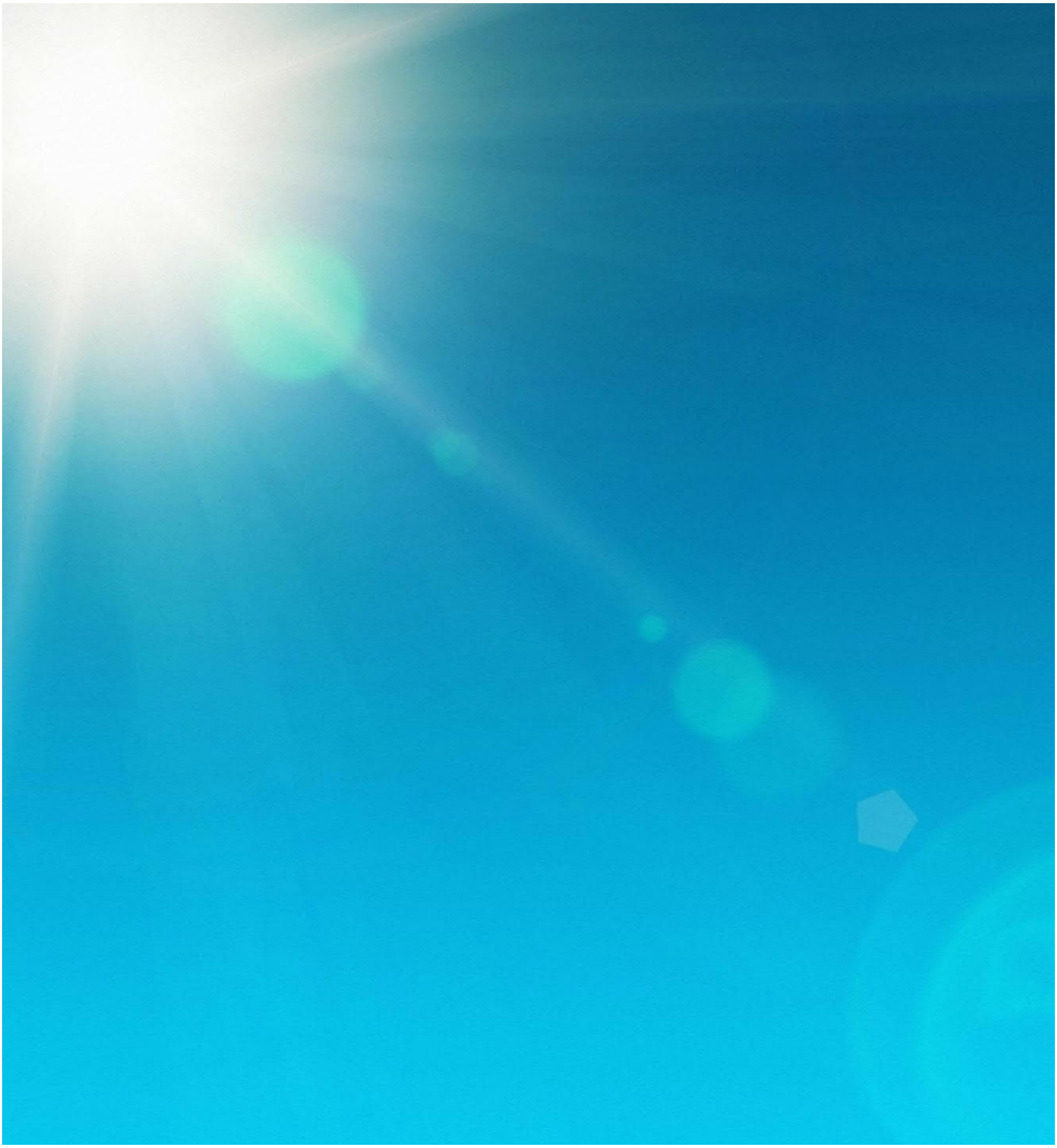
Chapter 10 – Marine Ecosystems

Australia-Asia PowerLink Environmental Impact Statement



Chapter 10 – Marine Ecosystems

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Revision history

Revision	Date	Purpose	Reviewed by	Approved by
0	17/03/2022	Draft EIS Submission	Joe Sheridan	Mark Branson

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10 Marine Ecosystems

The NT EPA's objective for the Marine ecosystems factor is:

> *"Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning."*

This chapter describes and assesses the significance of potential impacts to marine habitats and species associated with the Australia-Asia PowerLink (AAPowerLink) proposal. The potential impacts considered in this chapter were identified with reference to the EIS Terms of Reference (TOR) issued by the NT Environment Protection Authority (NT EPA) (Appendix A), issues raised by stakeholders, and professional judgement of the EIS team (Appendix D) based on their knowledge and understanding of the AAPowerLink components and activities described in Chapter 2 Proposal Description that could interact with the marine environment. Potential impacts were then assessed using the Environmental Impact Assessment (EIA) methods described in Chapter 3 Impact Assessment. This chapter presents the findings of the EIA process for the Marine ecosystems factor.

This chapter focuses on impacts to marine habitats and fauna associated with the installation of the AAPowerLink Subsea Cable System, which will comprise six high voltage power cables laid and buried in the seabed. Two nearshore route options are under consideration (Route A & B); both were considered through the EIA process, with a single route option assessed through the offshore area. For each route, a 1.2 km wide corridor was assessed which allows for installation of up to six cables, each of which will disturb a 12 m section of the seabed. The EIA process also considered impacts to the marine environment and ecosystems that could occur as a result of activities conducted on shore at the Shore Crossing Site and Cable Transition Facilities located at Murrumujuk, Gunn Point Beach. Impacts to the Commonwealth marine area[1] are regulated under the *EPBC Act* and are addressed in Chapter 16 Matters of National Environmental Significance.

10.1 Information sources

The information within this chapter is based on a review of existing studies and information available in relation to marine ecology, geophysical and geotechnical field surveys undertaken within the Subsea Cable System corridor and site inspections at the Cable Transition Facilities footprint. There is a fair amount of information available in relation to the nearshore marine habitats in Shoal Bay, and the offshore habitats in the Commonwealth Marine Area. This information is synthesised in the *Marine Ecology Report* (EcOz, 2021) (Appendix T), which provides a detailed description of marine habitats and protected species relevant to the AAPowerLink Subsea Cable System corridor, and the broader region. The *Cable Route Survey Report* (Guardian Geomatics, 2020) (Appendix Z) provides information on the seabed characteristics and habitat present within the offshore parts of the Subsea Cable System corridor; this information has been used to infer the presence/absence of important habitats in these deep-water areas that are less studied than nearshore environments.

Description of the marine habitats that are likely to occur in the nearshore environment of Shoal Bay, which is most sensitive to disturbance, has been based on habitat modelling and assessment undertaken for the Darwin-Bynoe region habitat mapping program (Galaiduk et al. 2019; Smit et al. 2019; Siwabessy et al. 2020). Targeted marine habitat surveys were not considered necessary as the presence/absence of important or sensitive habitats can reasonably be inferred from the available modelling and mapping datasets, combined with the mapping of seabed features provided by the geophysical survey of the cable corridor.

[1] Protected under section 24 of the Commonwealth Government's Environment Protection and Biodiversity Conservation Act (1999), the Commonwealth marine area is the area of sea extending from the NT coastal water limits to the edge of the Continental Shelf.

This chapter draws on the information presented in Chapter 9 Marine Environmental Quality in relation to the predicted impacts to marine water quality from the AAPowerLink Subsea Cable System cable laying and burial activities. Marine water quality impacts were predicted using hydrodynamic and sediment transport modelling (Appendix R).

As humans have been laying submarine cables for more than 200 years, the EIA undertaken for both the Marine Environmental Quality and Marine Ecosystems chapters has drawn on experience from around the world. Worldwide, in 2015 there were around one million kilometres of all submarine cable types on the seabed, with almost 8,000 km of these being high voltage direct current (Taormina et al. 2018). Modern cable design and laying methodologies are such that impacts to the marine environment are very localised and/or short-term. The International Cable Protection Committee (ICPC) recently synthesised the available peer-reviewed literature on the impacts of submarine cables on the marine environment (ICPC 2021) and that information has been used as a key source of information for the EIA, as well as publicly available EIAs for submarine cable laying activities in other jurisdictions.

10.2 Relevant policies and guidelines

The EIA for the Marine Ecosystems factor references the following policies and guidelines:

Darwin Harbour Water Quality Objectives

The *Darwin Harbour Water Quality Objectives* (WQO) (Fortune 2010), provide guideline values for physical and chemical parameters relevant to Darwin Harbour and Shoal Bay. These guideline values have been adopted as the basis for assessment of impacts to marine water quality associated with the AAPowerLink cable laying and burial activities documented in Chapter 9 Marine Environmental Quality and referenced in the assessment of impacts to marine ecosystems.

Guidelines on Best Environmental Practices in Cable Installation and Operation (OSPAR 2012)

The ICPC endorses the *Guidelines on Best Environmental Practices in Cable Installation and Operation* (OSPAR 2012). Sun Cable will design, install and operate the AAPowerLink Subsea Cable System in accordance with these guidelines.

National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia 2017)

The *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna 2017* provides guidance on understanding and reducing the risk of vessel collisions and the impacts they may have on marine megafauna. The strategy has been used to inform the EIA for marine ecosystems and the selection of mitigation measures that will reduce vessel strike incidents.

National Biofouling Guidelines for Non-Trading vessels (DAWR 2009)

Along with most shipping and boating sectors in Australia, non-trading vessels have been recognised as presenting a risk of marine pest translocation and introduction via biofouling. The voluntary biofouling management guidance for non-trading vessels has been developed to assist industry manage this risk. All ships and vessels used for construction and operation of the AAPowerLink will adhere to these guidelines, which will minimise the risk of introducing marine pests.

International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO 2017)

Under the Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. All ships and vessels used for construction and operation of the AAPowerLink will adhere to these guidelines, which will minimise the risk of introducing marine pests.

International Convention for the Prevention of Pollution from Ships (MARPOL)

MARPOL has been adopted by the Commonwealth and Northern Territory governments in multiple regulations and policies. These laws are in place to minimise environmental impacts associated with ballast water management, marine biosecurity, pollution and waste dumping, and oil spill response. Ship operators are legally responsible for those measures, which are regulated by the Northern Territory Government and Commonwealth Government of Australia. All ships and vessels used for construction and operation of the proposal will adhere to the relevant regulations that comply with MARPOL commitments, which inherently reduces the risks associated with activities such discharge of ballast water and dumping of waste at sea.

Plans and strategies

The following plans and strategies have also been referenced where relevant:

- *Darwin Harbour Strategy* (Darwin Harbour Advisory Committee 2020)
- *National biofouling guidelines for non-trading vessels* (DAWR 2009)
- *National light pollution guidelines for wildlife* (DEE 2020)
- *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna* (DEE 2017).
- *North Marine Parks Network Management Plan 2018* (Director of National Parks 2018a)
- *North-west Marine Parks Network Management Plan* (Director of National Parks 2018a)
- *Recovery Plan for Marine Turtles in Australia* (DOEE 2017)

10.3 Environmental values

This section describes the marine habitats and species that could be directly impacted within the proposal footprint and indirectly impacted within the surrounding marine environment (area of influence). The information in this section is a summary of the *Marine Ecology Report* (Appendix T); refer to that report for further detail[2].

The objective of the Marine ecosystems factor identifies the environmental values as including biodiversity, ecological integrity and ecological function. The majority of the Subsea Cable System will be laid and buried in the seabed in nearshore and offshore waters. The marine environment within which the Subsea Cable System footprint occurs can be broadly categorised into the water column and the seabed. The focus of the EIA undertaken for marine ecosystems is on the seabed benthic habitats, which are used as a proxy for assessment of impacts to marine fauna and ecosystems more broadly as explained below.

Much of the marine environment traversed by the Subsea Cable System corridor comprises largely featureless shelfs and basins. The nature and composition of the seafloor structure greatly influences the presence of benthic communities (flora and fauna living at the bottom of the ocean) (Kostylev et al. 2001). Benthic species are not randomly distributed among varying habitats, but are associated with the physical properties and structural complexity of the surrounding environment (Guisan & Zimmermann 2000). Across these homogenous areas the benthic communities[3] are relatively uniform, and so levels of biodiversity, degree of ecological integrity and the ecological function are broadly similar.

[2] The Subsea Cable System route changed slightly between completion of the Marine Ecology Report and preparation of this chapter. Any material differences as a result have been incorporated into this chapter.

[3] The focus is on benthic habitats because they are comparatively the best studied in the region. It is assumed – and has been identified as probable – that demersal fish communities (i.e. those that live near the seabed) are generally more diverse around the less common benthic habitats (Nichol et al. 2013).

In contrast, the benthic habitats along the Subsea Cable System route that featureless common bathymetric features and/or sediments have higher levels of biodiversity (in terms of abundance and species) and more specific ecological functions – such as providing habitat at critical life stages (e.g., refugia, foraging, migratory, spawning and/or breeding). The area of influence associated with the proposal's marine activities is spatially narrow and short-term, such that impacts on the majority of the marine environment are unlikely to compromise the environmental values it supports. The less common habitats are of higher environmental value per unit area, and therefore any proposal-related impact to them will be more significant. These habitats – seagrass meadows, seaweed communities and hard corals – are therefore considered 'higher value benthic habitats' and consequently are the focus of this chapter.

10.3.1 Habitats

A broad understanding of regional substrate types present in the AAPowerLink Subsea Cable System corridor has been attained through modelling based on bathymetry, whereby benthic habitats are derived based on physical seabed characteristics – using the results of the *Cable Route Survey Report* (Appendix Z).

10.3.1.1 Nearshore

As detailed in Chapter 9 Marine Environmental Quality, 'nearshore' is defined as 3 nautical miles off the NT coast (including the Tiwi Islands) and includes Shoal Bay and the Beagle Gulf. Shoal Bay has had physical and biological attributes modelled as part of the Darwin-Bynoe region habitat mapping program (Galaiduk et al. 2019; Smit et al. 2019; Siwabessy et al. 2020). Predictive modelling was used to determine the likely benthic habitat in Shoal Bay based on bathymetry, aspect, slope, and other physical variables (Galaiduk et al. 2019 and Siwabessy et al. 2020). The extent of modelled benthic habitat is shown on Figure 10-1.

Within the footprints of both Subsea Cable System routes (A and B), the seabed slopes rapidly in the inter-tidal zone, then follows a smooth contour towards Beagle Gulf. The most abundant benthic habitat is filter-feeding biota such as sponges and octo-corals, followed by bare sediment. Three much less common – and therefore higher value – benthic habitats are seagrass, seaweed (also called macro-algae) and hard corals. The 1.2 km wide corridor for route A crosses a high likelihood[4] areas of seagrass (~0.034 km^2) – most of which is close to the shore at Murrumujuk; seaweed meadows (~0.066 km^2) and hard coral (~0.064 km^2). The corridor for route B crosses high likelihood areas of seagrass (~0.034 km^2) – again, most of which is close to the shore at Murrumujuk; seaweed meadows (~0.122 km^2) and hard coral (~0.009 km^2). Table 10-1 contextualises these occurrences and they are depicted in Figure 10-1. Both route options have been sited to avoid higher value benthic communities in the regional area as much as possible. Note the suspended sediment contours shown on Figure 10-1 are discussed in Section 10.3.4.2, and explained in detail in Chapter 9 Section 9.4.2.1.

[4] In other words, areas of the seabed that are between 60 and 100% likely to have that benthic community present.

Table 10-1. Extent of higher value benthic communities in Shoal Bay and the Subsea Cable System corridors

Community	% likelihood occurrence	Shoal Bay		Cable System route A		Cable System route B	
		Area (km^2)	% cover	Area (km^2)	% of Shoal Bay habitat[5]	Area (km^2)	% of Shoal Bay habitat
Hard coral	60 to 80	1.429	0.21	0.0454	3.17	0.0073	0.51
	80 to 100	0.883	0.13	0.0185	2.09	0.0020	0.22
Seagrass	60 to 80	2.707	0.40	0.0220	0.81	0.0222	0.82
	80 to 100	1.625	0.24	0.0118	0.73	0.0117	0.72
Seaweed	60 to 80	5.114	0.76	0.0582	1.13	0.0698	1.37
	80 to 100	2.937	0.44	0.0076	0.26	0.0520	1.77
Total	-	14.695	2.19	0.1635	8.21	0.1650	5.41

10.3.1.2 Offshore

Away from the coast, the marine landscape becomes a mostly featureless shelf, characterised by sediments of biogenic gravels and sands, grading to biogenic muds offshore. The offshore landscape is then dominated by three Key Ecological Features (see Section 10.3.2.2) – the shoals of the Van Diemen Rise and Sahul Shelf, separated by the Bonaparte Basin that is punctuated throughout by tall pinnacles.

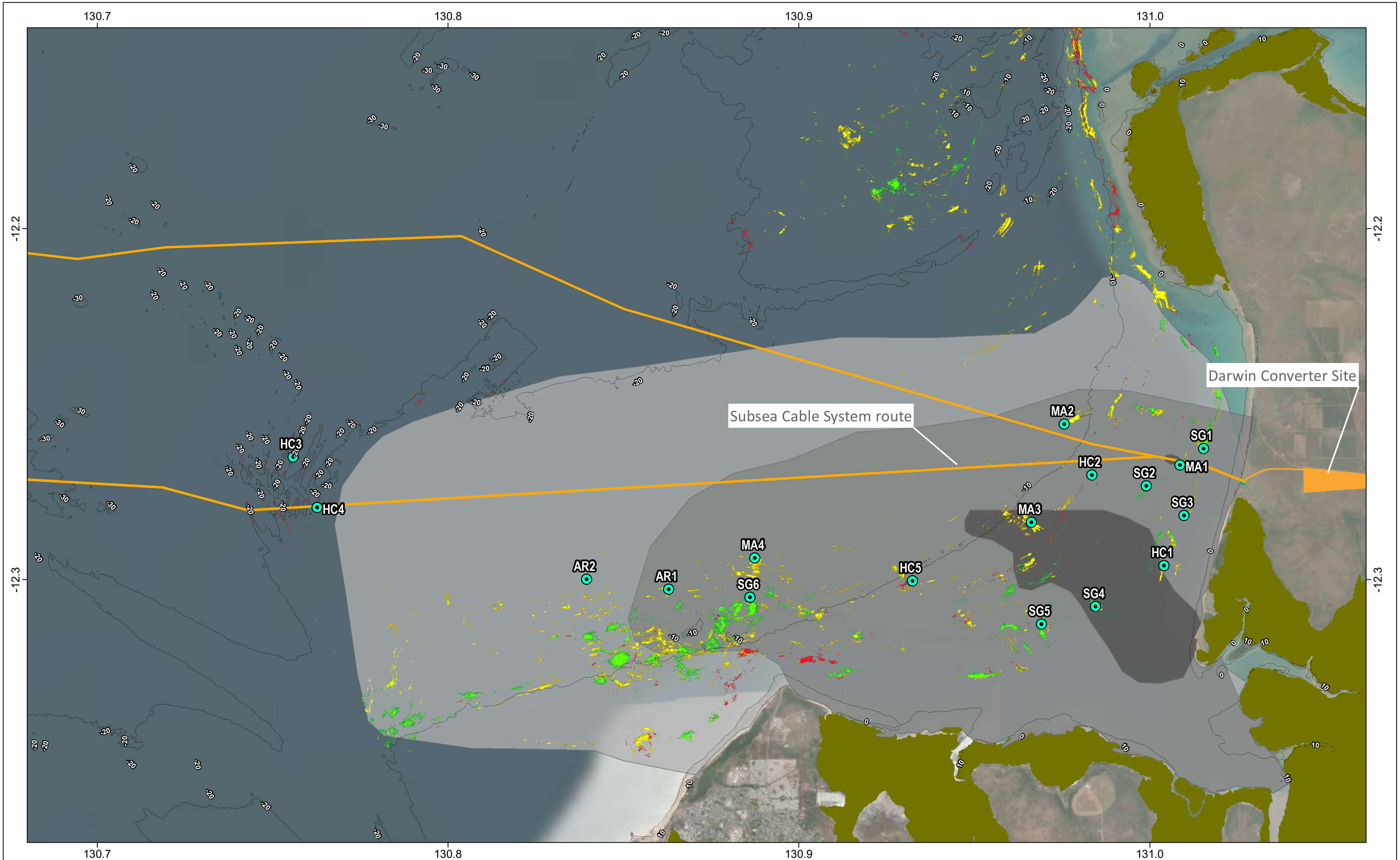
By design, the Subsea Cable System route predominantly transects largely featureless shelfs and basins. It has been chosen to avoid areas of significant elevation changes as much as possible, and consequently only intersects a few key features that may support higher biodiversity values relative to surrounding habitats. These features are listed below and are shown onFigure 10-2:

- Sections of terrace with rocky areas in the Van Diemen Rise region (although these are quite deep, which reduces the likelihood of higher biodiversity) – approximately 20 km of the route between 128.35º and 128.55º, and at 128.0º (Note: locations are in longitudinal degrees, refer to the figures in Section 4.2 of Appendix T)
- Pinnacles (but at depths much greater than those associated with high biodiversity) – each less than 1 km of the route, around 127.9º, 127.2º to 127.3º and 128.55º.
- Two banks in the Sahul Shelf region that rise to 60 m depth, have some rock, and therefore may support hard corals – one approximately 6 km of the route between 126.4º and 126.5º, the other is approximately 2 km of the route between to 126.1º and 126.2º.
- A valley in western Sahul Shelf region – approximately 2 km of the route between 125.7º and 125.8º.
- A saddle between two reefs on the continental shelf (but at a depth much greater than that associated with high biodiversity) – less than 1 km of the route between 123.5º and 123.6º.

The key ecological features generally align with changes in bathymetry; bathymetry is shown on Figure 9-1 in Chapter 9 and is discussed in detail in that chapter and also the *Marine Environmental Quality Report* (Appendix S), *Marine Ecology Report* (Appendix T) and the *Cable Route Survey Report* (Guardian Geomatics 2021, Appendix Z).

[5] This represents the portion (as a percentage) of habitat mapped as likely to occur within Shoal Bay which occurs within the cable route corridor.

Figure 10-1: Map showing potential occurrence of higher value benthic habitats and modelled extent of elevated suspended sediment concentrations during AAPowerLink construction



Legend

- AAPowerLink Infrastructure
- Contour (10m)
- Benthic habitat receptors

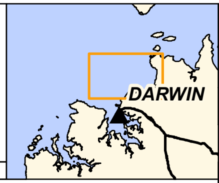
Habitat

- Seagrass 60-80%
- Seagrass 80-100%
- Macroalgae 60-80%
- Macroalgae 80-100%
- Hardcoral 60-80%
- Hardcoral 80-100%
- Mangrove

SSC contours

- 5th percentile contour
- 20th percentile contour
- 50th percentile contour

Source: Sun Cable, EcOz, NTG (NR Maps). Benthic community mapping from Galadiuk et al. 2020. Percentile contour mapping from MetOcean 2021.



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Coordinate System: GDA2020	Date: 10/03/2022
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10.3.2 Important areas

10.3.2.1 Nearshore

The first 3 nautical miles of the Subsea Cable System route crosses the Shoal Bay Site of Conservation Significance (SOCS)[6]. Shoal Bay is identified as an NT SOCS for its internationally-significant wildlife aggregations, including marine turtles, shorebirds, seabirds and waterbirds. Nationally-significant values include the extensive tidal flats that support the migratory birds, as well as rainforest patches occurring on the margin of the tidal flats. These tidal flats are mostly located within the Tree Point Conservation Area and the Shoal Bay Coastal Reserve (which are not intersected by the Subsea Cable System footprint but are in the regional area).

10.3.2.2 Offshore

The Subsea Cable System footprint traverses 300 km of the Ocean Shoals Marine Park which is protected under Commonwealth law. The park comprises multiple protected zones within which various activities are allowed or prohibited. As detailed in Chapter 9, the Subsea Cable System footprint traverses two zones which are both designated protection category VI. Category VI is for the conservation of ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. Such areas are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management, and where low-level non-industrial use of natural resources compatible with nature conservation is one of the main aims. Activities associated with laying of subsea cables is allowable with authorisation in the two zones crossed by the Subsea Cable System, and Sun Cable will obtain all necessary authorisations for works in the Oceanic Shoals Marine Park (OSMP).

Key Ecological Features (KEF's) are defined by the Commonwealth Government (and for the Oceanic Shoals Marine Park) as nationally- or regionally-significant biodiversity or ecosystem features. The Subsea Cable System footprint intersects three KEF's – the carbonate bank and terrace system of the Van Diemen Rise (for 72 km), the carbonate bank and terrace system of the Sahul Shelf (for 220 km), and the Pinnacles of the Bonaparte Basin – see Figure 10-2. These KEF's are all well-presented within the OSMP. The three KEF's have similar carbonate parent material and appear to operate in similar ways regarding their relationship with pelagic and benthic biodiversity in the region.

Van Diemen Rise

The Van Diemen Rise is a KEF due to its unique seafloor features with ecological properties of regional significance. In particular, it is important for enhancing biodiversity and local productivity relative to the surrounding area, and supporting high species diversity (DSEWPC 2012c). The raised geomorphic features of the Van Diemen Rise includes terraces, ridges and banks that all contain higher levels of hard substrate, which supports sponges and octocoral (soft coral) gardens. These creatures provide structure in a mostly flat environment and, due to their distance from the coast, are less influenced by tides and the associated turbidity compared to central Joseph Bonaparte Gulf. This results in a higher diversity of epifauna, and creates a biodiversity hotspot (Przeslawski et al. 2011 & Przeslawski et al. 2014).

Sahul Shelf

The Sahul Shelf is a KEF due to its unique seafloor features with ecological properties of regional significance. It is important for enhancing biodiversity and local productivity relative to the surrounding area and supports high species diversity for the region. Located in the western Joseph Bonaparte Gulf, the carbonate banks and terraces are part of the larger group of banks in the North Marine Region (DSEWPC 2012d). The Sahul Shelf comprises extensive banks and terraces in an almost continuous series of complex submerged algal banks on the middle and outer reef. These provide elevated hard substrates that are ideal for sessile species, exposing them to higher levels of passing nutrients and allowing light dependent organisms to thrive (DAWE 2021a).

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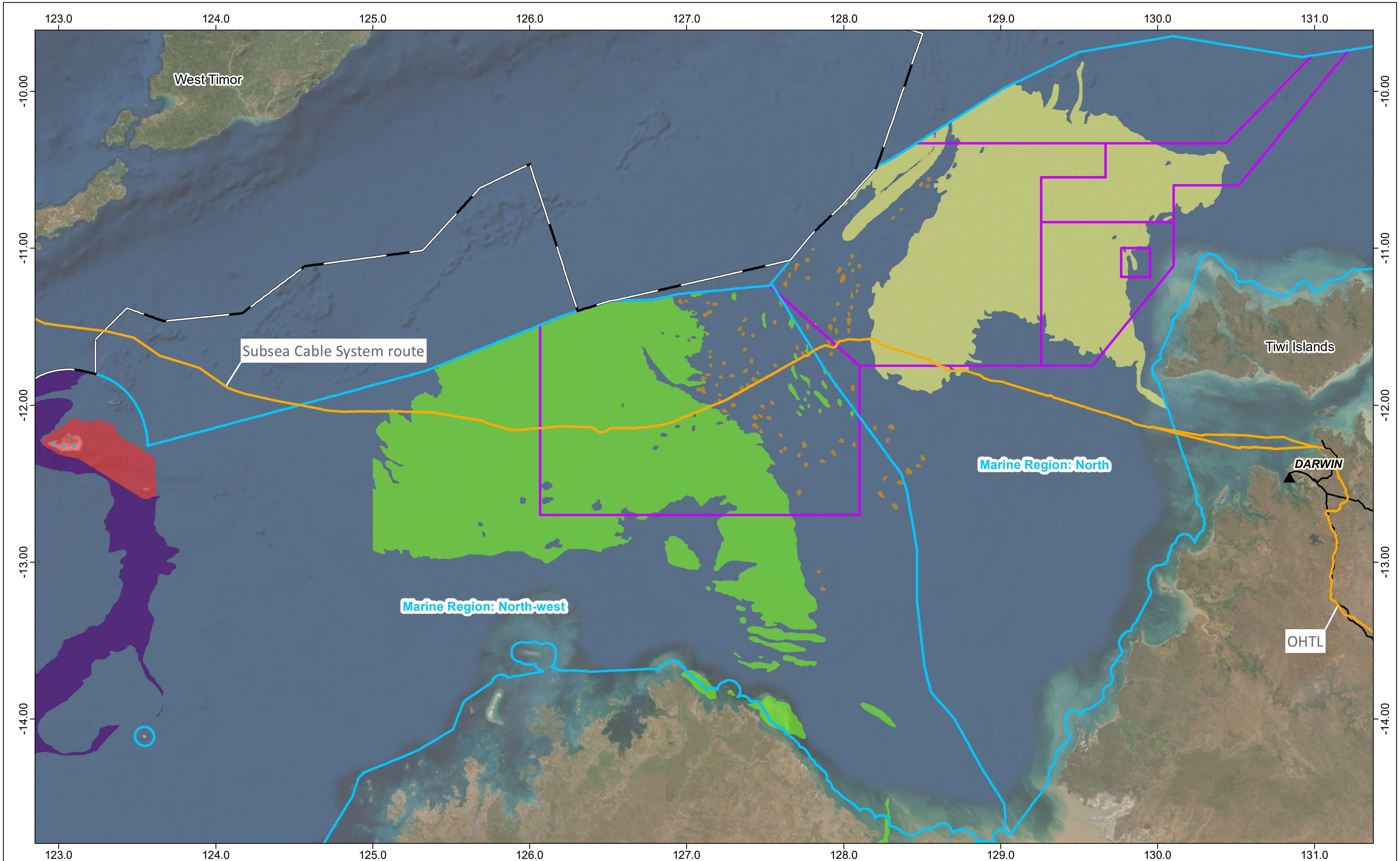
[6] Refer to Chapter 5 for an explanation of SOCS.

The Sahul Shelf is a macro-tidal carbonate/clastic environment, dominant in calcareous sediment that masks imported terrigenous material originating from the Joseph Bonaparte Gulf. Deep erosion has occurred on the inner shelf due to the macro-tidal environment (Lees 1992). A barrier reef complex was thought to have extended from the Sahul platform to the Ashmore Reef during the last sea-level regression approximately 1,800 years ago (George & Cauquil 2010).

Pinnacles of the Bonaparte Basin

The Bonaparte Basin is a drowned landscape of estuarine valleys and coastal lowlands, comprising broad, deep and mostly flat plain between the Sahul Shelf and the Van Diemen Rise. Pockmarks are present in high density in this region, forming in soft sediment and ranging in orders of magnitude size differences (Picard et al. 2018). Between the soft sediments, hard pinnacles up to 50 m high and 50 to 100 km long (Baker et al. 2008) rise steeply from depths of about 80 m to within 30 m of the water surface. The upper reaches of the pinnacles (from 45m depth upwards) support a higher biodiversity of light-dependent organisms – particularly sponges – than the seafloor (NERP MBH 2014). The pinnacles are unique features with ecological properties of regional significance.



Legend

- AAPowerLink Infrastructure
- Commonwealth Marine Area
- Marine regions
- Oceanic Shoals Marine Park

National key ecological features

- Ashmore Reef and Cartier Island and surrounding Commonwealth waters
- Carbonate bank and terrace system of the Sahul Shelf
- Carbonate bank and terrace system of the Van Diemen Rise
- Continental Slope Demersal Fish Communities
- Pinnacles of the Bonaparte Basin

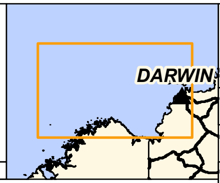


Figure 10-2: Map of Subsea Cable System footprint within the Commonwealth Marine Area

Project: Australia-Asia PowerLink	Reference: M-Files ID 208370	Revision: 1
Coordinate System: GDA2020	Date: 10/03/2022	
0 30 60 90 120 Kilometers	Scale: 1:3,350,000	A4

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Source: Sun Cable, EcOz, NTG (NR Maps)

10.3.3 Condition of the existing marine environment

The North and North-west Marine Plans have identified and assessed the key sources of pressure on conservation values (Director of National Parks 2018 a and b). Overall, the conclusion was that human pressures on marine conservation values in the North Marine Region are low because of the relatively low levels of marine resource use and low coastal population pressure across the region (except in proximity to Darwin). The only pressures of potential concern relevant to the region within which the Subsea Cable Systems occurs were changes in fishing, sea temperature and ocean acidification, none which will be influenced by AAPowerLink activities[7].

Water quality in the Shoal Bay area has been assessed in the Darwin Harbour Report Cards for the 2009 to 2019 period for the following indicators: nutrients, water clarity (turbidity), dissolved oxygen and algae. Outer Shoal Bay has been graded A or ‘excellent’ eight times and B or ‘very good’ three times over this period, indicating that the water quality complies with the Darwin Harbour Water Quality Objectives indicators at least 85% of the time. These positive water quality outcomes are likely linked to the limited population and industry that feeds into this zone (DEPWS 2020). The offshore portion of the proposal area in Beagle Gulf has not been routinely assessed but is likely to be in near-pristine condition given its expanse, the fact that developments and infrastructure are sparse, that there is relatively low-density shipping, and that commercial fisheries within Australia’s EEZ are highly regulated.

In the near coast region, a key potential threatening process is the introduction of marine pests – i.e. introduced species that have been moved from their natural distribution into area where they may threaten biodiversity, or commercial and recreational values. There are three marine pests – all species of mussel – that are considered major threats to NT waters. All of these species are found in countries from which boats frequently visit the NT, but none of these pests are currently found in NT waters. The NT aquatic biosecurity unit conducts hull inspections for visiting boats to ensure no pests are introduced into Darwin’s marinas (NTG 2016).

As illustrated in Figure 10-3, the density of shipping traffic is high for the first 50 to 100 km of the Subsea Cable System route because of its proximity to Darwin. The Port of Darwin in 2018-2019 received 2,154 vessels, including industrial traffic (e.g. cargo, livestock, LNG tankers) and cruise ships (Darwin Port Authority 2019). The next ~200 km of the Subsea Cable System route follows the shipping route to the Bayu-Undan offshore gas field. The remainder of the Subsea Cable System route is in an area of low vessel density.

In terms of existing levels of disturbance to the marine ecosystem, the Subsea Cable System footprint runs parallel with existing cables and pipelines for most of its first ~320 km.

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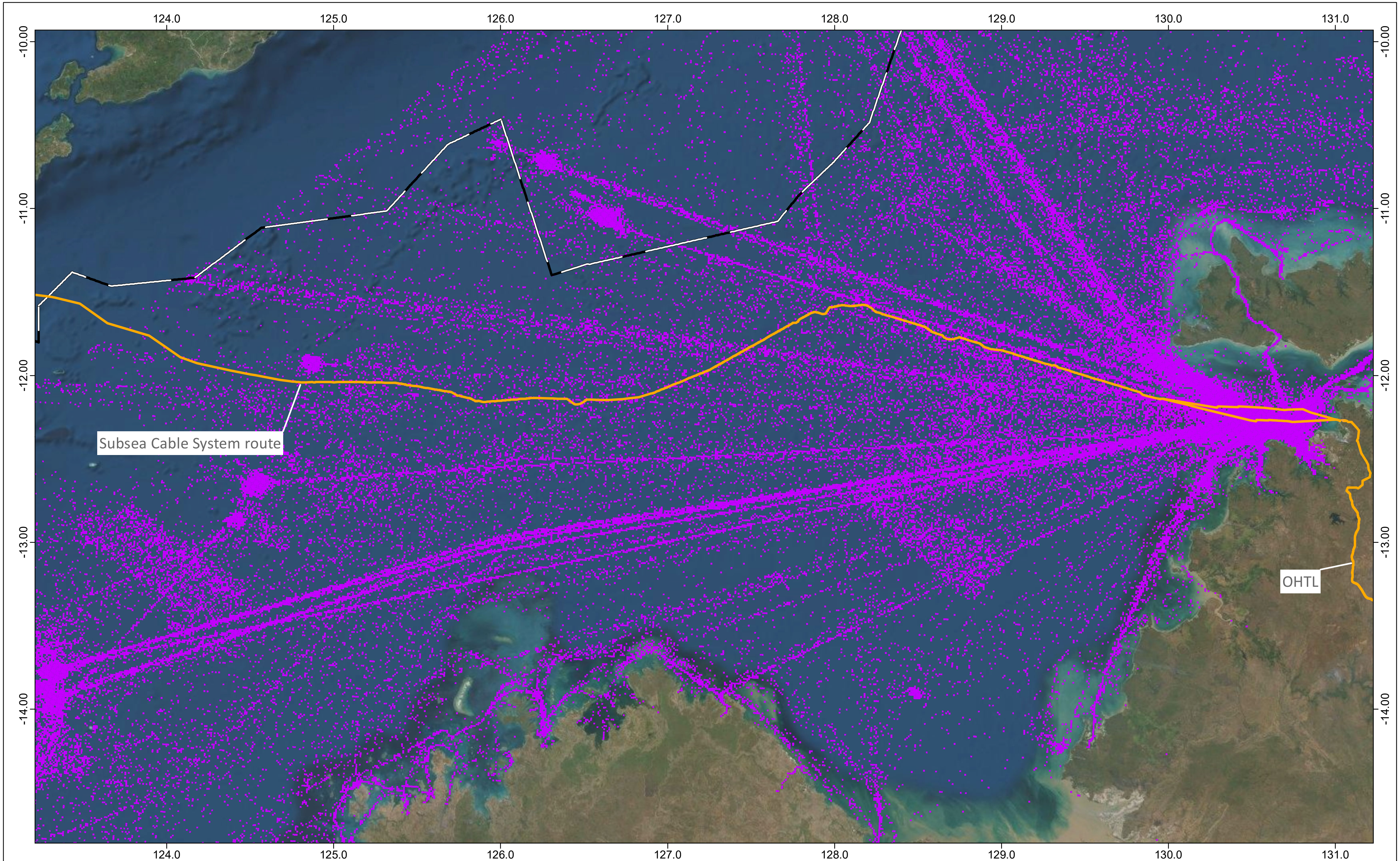
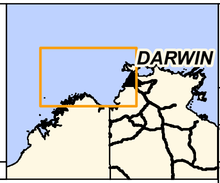
[7] Noting that ocean acidification and rising temperatures are threats associated with climate change and large scale renewable energy projects such as the AAPowerLink will assist in reducing the NT, Australia and Singapore’s greenhouse gas emissions.





Legend
- AAPowerLink Infrastructure
- Commonwealth Marine Area
- Vessel tracking data

Source: Sun Cable, EcOz, NTG (NR Maps), Australian Maritime Safety Authority (AMSA) 2019

Figure 10-3: Map of vessel traffic (2019) relevant to the Subsea Cable System footprint

Project: Australia-Asia PowerLink	Reference: M-Files ID 208370	Revision: 1
Coordinate System: GDA2020	Date: 10/03/2022	
0 30 60 90 120 Kilometers	Scale: 1:3,150,000	A4

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10.3.4 Fauna

The Subsea Cable System traverses a large area of marine habitat, and therefore intersects with suitable habitat for many marine fauna species. However, given that proposal activities within the marine environment occur within a very localised footprint – and over a short time frame in any one location during cable laying and burial – the likelihood that most of these species will be affected is very low. To narrow down which fauna species are most at risk of being negatively impacted by proposal activities, the *Marine Ecology Report* (Appendix T) identified significant species for which there is important habitat – i.e. critical for feeding, nesting, breeding and/or migrating – within the proposal footprint. The species considered most relevant are discussed below.

10.3.4.1 Nearshore

The nearshore component of the Subsea Cable System footprint supports many fauna species, but in general, does not intersect with important habitat areas. For a few species, however, there are known important habitats proximate to the Subsea Cable System footprint. The following species therefore require further consideration:

The first 175 km of the Subsea Cable System footprint crosses critical[8] nesting and inter-nesting[9] habitat for **Flatback Turtles** – see Figure 10-4.

- Individuals that nest on the Pilbara coast disperse to feeding areas extending from Exmouth Gulf to the Tiwi Islands. In particular, the species has been recorded foraging on the carbonate banks of the Joseph Bonaparte Gulf and around the pinnacles of the Bonaparte Basin.
- There is seagrass habitat present (see Figure 10-1) and **Dugongs** have been recorded in the area. Important areas for Dugong include Gunn Point Reef and Shoal Bay (north of Tree Point).
- **Sea snakes** may occur within the seagrass communities within Shoal Bay. Sea snakes are heavily dependent on seagrass beds to forage and seek refuge. Biologically-important areas have not yet been identified in the region.
- Based on proximate records, four species of significant elasmobranchs[10] could occur within the Shoal Bay region – **Freshwater or Largetooth Sawfish, Narrow Sawfish, Green Sawfish** and **Dwarf Sawfish**.

Our understanding of Dugong abundance and distribution in the NT is reasonably robust; however, further studies are required to understand marine turtle abundance (season, duration and frequency) and habitat use for feeding and roosting. The regional movements and coastal habitat use by sawfish are also poorly understood. Notwithstanding the knowledge gaps that exist, where these species do occur proximate to the Subsea Cable System corridor, as explained above, they are unlikely to be directly affected by the proposal activities, which will involve short-term disturbance to the seabed and marine water quality during cable installation and burial.

Estuarine Crocodiles are likely to be common in the higher orders rivers and creeks traversed by the OHTL corridor as far south as Mataranka. Estuarine Crocodiles also occur in Shoal Bay; however, the species is highly mobile, and more frequently inhabits rivers as opposed to the ocean. Similar to the above-mentioned species, Estuarine Crocodiles are unlikely to be directly affected by the proposal activities.

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[8] Under the EPBC Act, habitat critical to the survival of the threatened marine turtle species must be identified in the Recovery Plan for Marine Turtles (DoE 2017). In addition, the marine bioregional planning program led to the identification and mapping of biologically-important areas (BIA's) for Commonwealth protected species. Those relevant to the Subsea Cable System footprint are depicted in

Figure 10-4, noting that there is some overlap with the abovementioned critical habitat.

[9] Female marine turtles generally lay several clutches of eggs each nesting season and rest in the time between laying clutches (the inter-nesting period) in the waters off the nesting beach.

[10] A collective term for sharks, skates and rays

10.3.4.2 Offshore

There are regional records of threatened and migratory species relevant to the offshore component of the Subsea Cable System footprint. For most species, that footprint avoids important habitat – the exceptions are:

The final section of the Subsea Cable System footprint in Australian waters crosses a biologically-important area for **Pygmy Blue Whale** migration – see Figure 10-5. The sub-species migrates annually through Australian waters along the WA coast from their feeding grounds in the Antarctic to tropical breeding locations, and back again. The Pygmy Blue Whale tends to pass through a broad migration corridor along the edge of the continental shelf at depths of 500 to 1000 m.

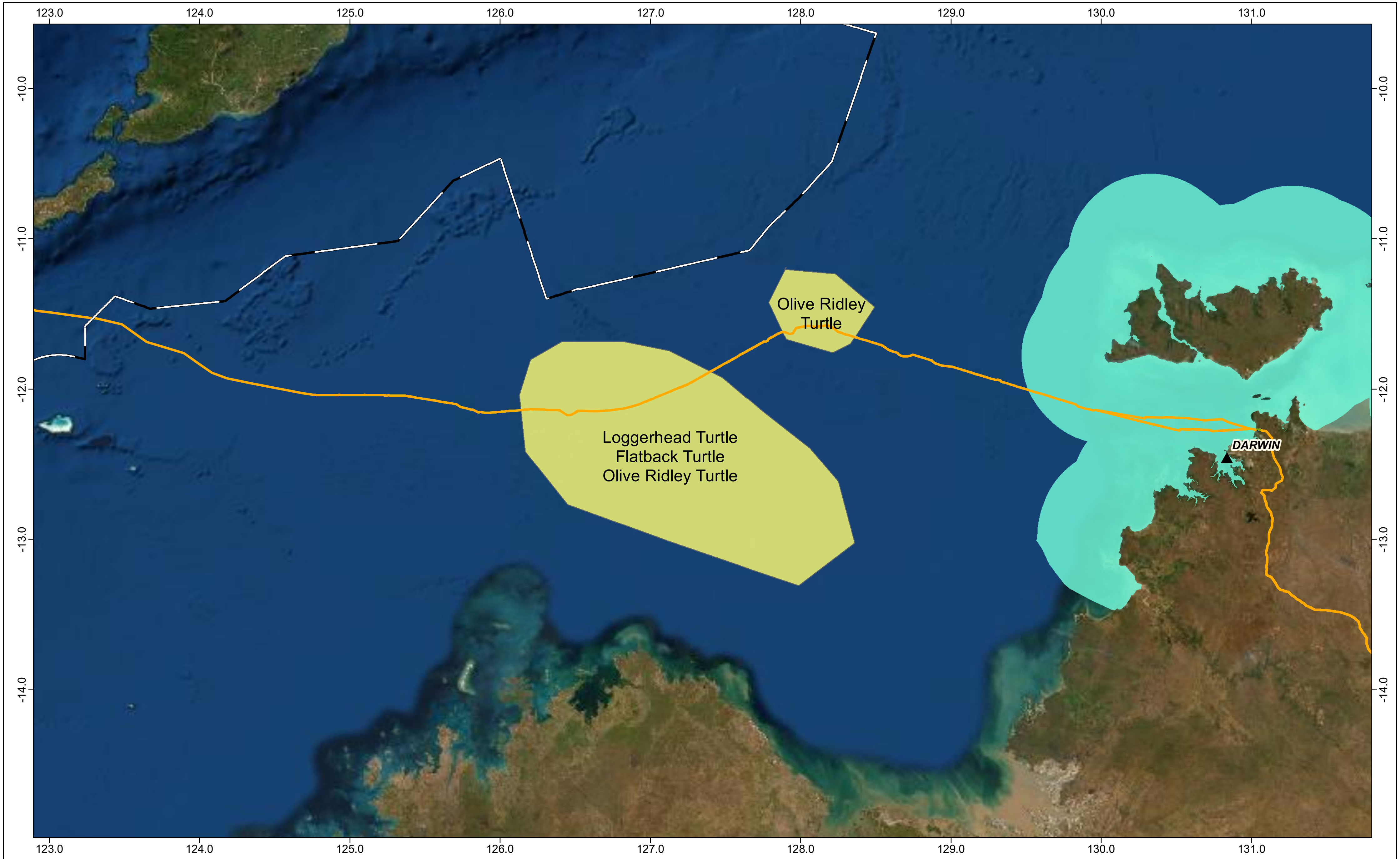
The 200 m isobath[11] along the northern part of the Western Australian coast is an important migration route, for the **Whale Shark**, with migration occurring mainly between July and November. Consequently, the WA offshore waters from Shark Bay northwards are considered biologically-important foraging areas. The Subsea Cable System footprint crosses the northernmost section of those waters – see Figure 10-5.

Midway along the route, the Subsea Cable System footprint crosses a biologically-important foraging area on the carbonate banks of the Joseph Bonaparte Gulf and around the pinnacles of the Bonaparte Depression for **Loggerhead, Flatback** and **Olive Ridley Turtles** – for the latter, there are two such areas (see Figure 10-4).

All of these species nest along the coastline either to the east and/or west of the footprint (i.e. not to the south or on Gunn Point beach).

The first 175 km of the Subsea Cable System route coincides with critical nesting habitat for **Flatback Turtles** (i.e. within a 60km buffer of the coastline from Anson Bay south-west of Darwin, to the Tiwi Islands) – see Figure 10-4. A biologically-important inter-nesting zone overlaps the critical nesting habitat.

[11] An imaginary line connecting all points of a certain depth, in this case – 200 m



Legend

AAPowerLink infrastructure
Commonwealth marine area

Marine turtles biologically important areas

Foraging

Marine turtles critical habitat

Flatback Turtle

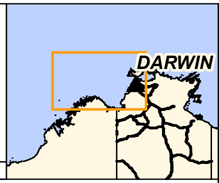


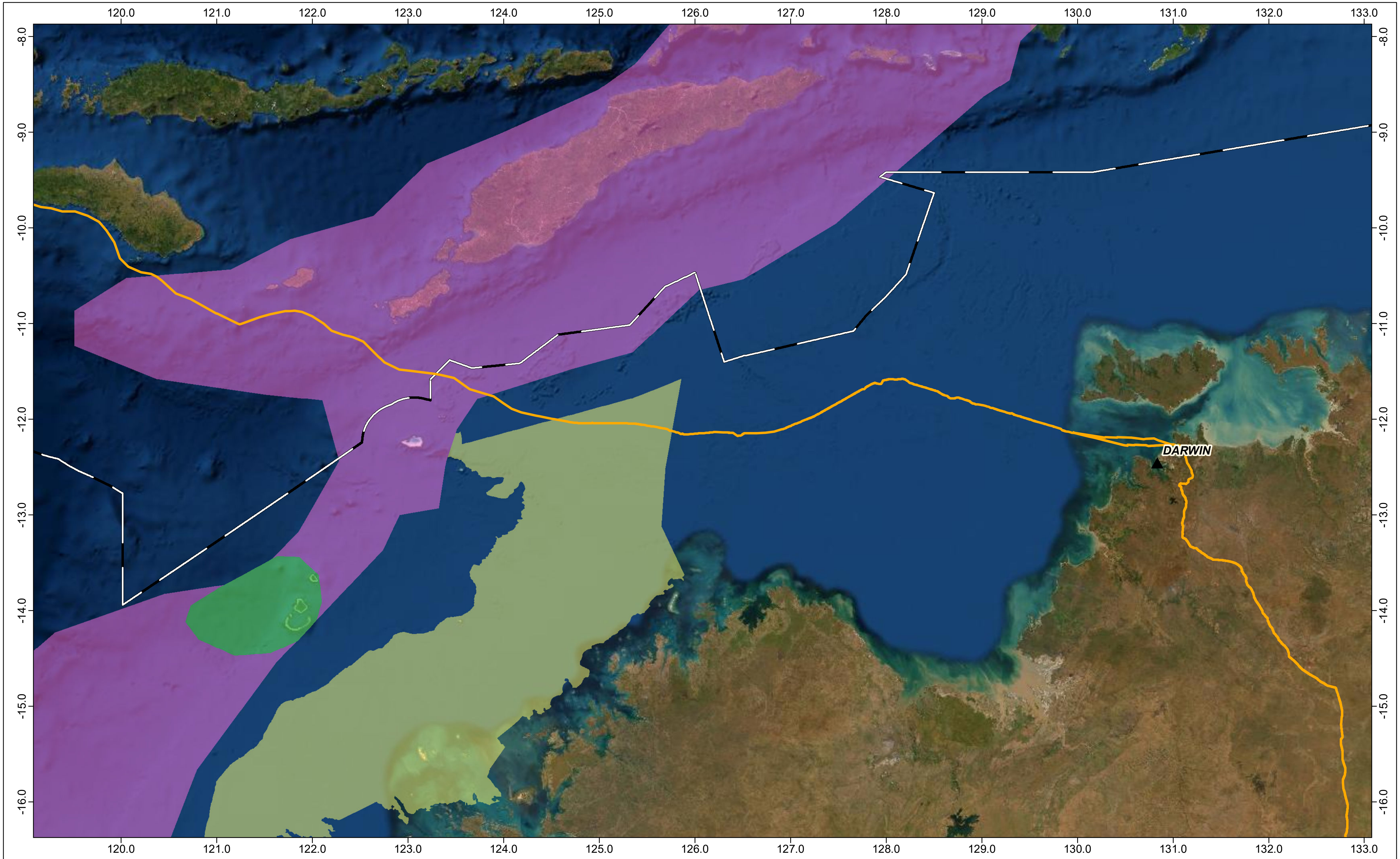
Figure 10-4: Map of important habitat for marine turtles relevant to the Subsea Cable System footprint

Project: Australia-Asia PowerLink	Reference: M-Files ID 208370	Revision: 1
Coordinate System: GDA2020	Date: 15/03/2022	
0 50 100 150 Kilometers	Scale: 1:3,500,000	A4

N

SUN CABLE

Source: Sun Cable, EcOz, NTG (NR Maps), National Conservation Values Atlas 2020



Legend

- AAPowerLink infrastructure
- Commonwealth marine area
- Pygmy Blue Whale, Foraging
- Pygmy Blue Whale, Migration
- Whale Shark, Foraging

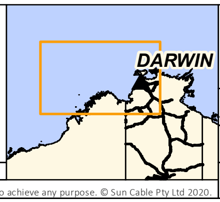


Figure 10-5: Map of important habitat for whales and sharks relevant to the Subsea Cable System footprint

Project: Australia-Asia PowerLink	Reference: M-Files ID 2008370	Revision: 1
Coordinate System: GDA2020	Date: 15/03/2022	
0 50 100 150 200 Kilometers	Scale: 1:5,500,000	A4

N

SUN CABLE

Source: Source: Sun Cable, EcOz, NTG (NR Maps), National Conservation Values Atlas 2020

10.3.5 Beneficial uses

The main beneficial uses of the marine ecosystem in the regions traversed by the Subsea Cable System are recreational and commercial fishing.

10.3.5.1 Recreational fishing

Darwin Harbour, including Shoal Bay, provides recreational fishing opportunities for the Darwin community and surrounding areas. According to Handley (2010), approximately 75% of the annual recreational fishing effort and spending in the NT occurred in the Darwin region[12].

Shoal Bay where the Subsea Cable System will be laid, is popular with recreational fishers and crabbers. A 2015 survey found that most recreational fishing in the Greater Darwin Area is in the Darwin Harbour region (40 per cent), followed by Bynoe Harbour (14 per cent) and Shoal Bay (6 per cent) (Department of Agriculture, Water and Environment n.d). In 2014, Shoal Bay was the source of 45 per cent of the Darwin-based recreational crab catch, making it the single most important crabbing location for the NT's valuable recreational fishing sector (AFANT 2021). Marsden Jacob Associates (2012), note that the Shoal Bay region is popular with recreational fishers due to its proximity to Darwin, the reliable barramundi and mud crab fishing, and multiple nearby boat ramp facilities.

The Subsea Cable System routes lie about seven kilometres offshore of Lee Point and 15 kilometres offshore of Charles Point. Both routes of the AAPowerLink Subsea Cable System routes avoid known high value recreational fishing areas (natural and artificial reefs and fish attracting devices). A cluster of these artificial reefs are to the north of Route Option A (~35 km west of Gunn Point Beach), with a few closer to shore and south of Route Option B off Lee Point.

10.3.5.2 Commercial fishing

The NT commercial fishing industry is active in 15 different wild harvest fisheries, the largest of which by volume and value are the offshore demersal and the Timor Reef fisheries. Fisheries that may operate in marine waters proximate to the Subsea Cable System route are listed in Table 10-2.

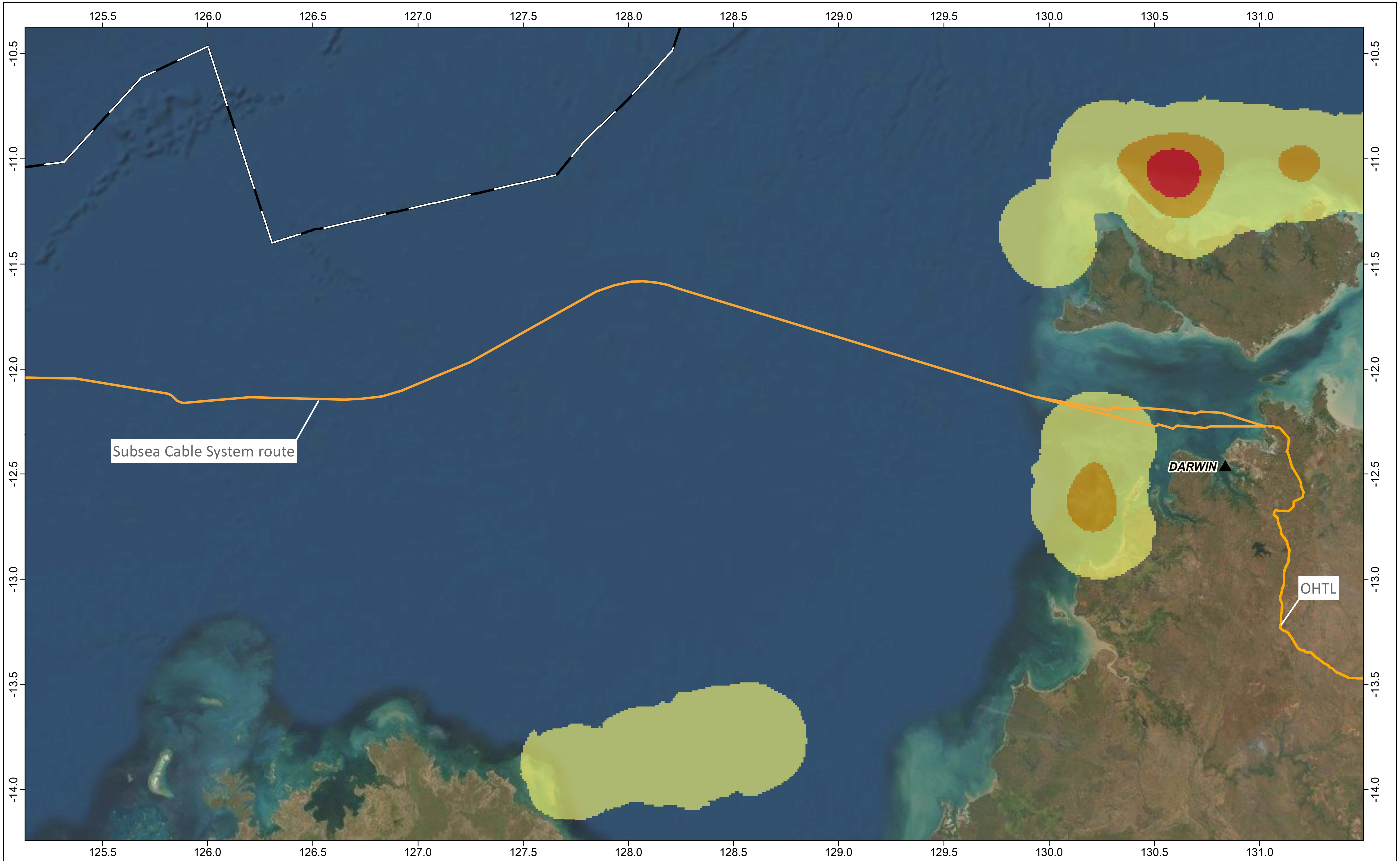
In the nearshore areas of Shoal Bay, there is a ban on commercial barramundi fishing; however, commercial crabbing is permitted. The Amateur Fisherman's Association NT (AFANT) has recently called for a ban on crabbing in the area (AFANT n.d.)

Table 10-2. NT fisheries that operate in marine waters proximate to the AAPowerLink Subsea Cable System

Fishery	Extent	Key areas	Method	Value
Spanish Mackerel Fishery	High-water mark of NT waters to the outer limit of the AFZ	Reefs, headlands and shoals near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands	Trolled lures or baited lines	$3.0 million
Coastal Line Fishery	High-water mark to 15 nm from the low water mark	Rocky reefs within 150 km of Darwin	Hook and line	$2.1 million
Demersal Fishery	15 nm from the NT low water mark to the outer limit of the AFZ	Unknown offshore areas	Fish traps, hand lines and drop-lines. Trawl nets are permitted in two defined zones	$17.9 million

12 This is the most recent Territory-wide recreational fishing survey.

The Northern Prawn Fishery (NPF) is the only active Commonwealth-managed fishery that operates within the region. It extends from Joseph Bonaparte Gulf across the Top End to the Gulf of Carpentaria. Fishing is undertaken using bottom trawl nets over two seasons: a banana prawn season that runs from 1 April to 15 June, and a tiger prawn season that runs from 1 August to 30 November. The prawn fishery area most relevant to the proposal is the Fog Bay region west of Darwin (see Figure 10-6). The Subsea Cable System route crosses an area mapped as having Low fishing intensity based on 2020 data (intensity represented by days of fishing per km^2).



Legend

AAPowerLink Infrastructure
Towns
Commonwealth Marine Area

Fishing intensity, 2020

Low
Medium
High

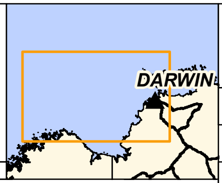


Figure 10-6: Map of Northern Prawn Fishery areas to the extent relevant to the Subsea Cable System

Project: Australia-Asia PowerLink | Reference: M-Files ID 208370 | Revision: 1

Coordinate System: GDA2020 | Date: 10/03/2022

0 25 50 100 Kilometers | Scale: 1:2,500,000 | A4

N

SUN CABLE

Source: Sun Cable, EcOz, NTG (NR Maps)

10.4 Potential impacts

The potential impacts to marine ecosystems associated with construction and operation of the AAPowerLink have been assessed using the EIA methodology described in Chapter 3 Impact Assessment. The EIA identified and assessed the following impacts that could occur during construction of the Subsea Cable System:

- Direct disturbance or loss of benthic habitat
- Habitat degradation due to elevated turbidity in marine waters
- Habitat and fauna impact due to spills of fuels or hazardous chemicals
- Impacts to threatened and migratory species, including their habitat
- Introduction of marine pests
- Direct fauna mortality/collision with vessels
- Loss of mangrove vegetation (note this is in the EIS TOR; however, there will be no mangrove loss)

The EIA identified and assessed the following impacts that could occur during operation of the Subsea Cable System:

- Habitat loss and degradation associated with cable repairs
- Changes to fauna behaviour due to EMF and heat.

The EIA considered the impact avoidance and mitigation measures detailed in Section 10.5 and assessed the residual impacts to marine ecosystems assuming these measures are effectively implemented. A residual impact rating was then assigned taking into consideration the scale, magnitude and duration of the impacts, the presence/absence of environmental values and/or sensitive receptors and the level of certainty with respect to the intensity of the impact and the effectiveness of the mitigation measures. The residual impact ratings adopted in the assessment are provided in Table 10-3.

The outcomes of the EIA are summarised in Table 10-4 and Table 10-5, from the Impact Assessment Matrix provided at Appendix E and discussed in the subsequent sections.

Table 10-3. Residual impact ratings adopted for the AAPowerLink EIA

Ratings and Description
Minor: A minor residual impact is unlikely to be significant.
A minor impact generally has two or more of the following characteristics: Scale: Limited/Localised Magnitude: Negligible/Minor Duration: Short-term/ Medium-term/Reversible. **OR** There are no sensitive receptors or land uses present, and the environment does not contain any aspects that are valuable or otherwise important or unique (i.e. Very Low/Low rating), and there is moderate to high degree of certainty about the likelihood and intensity of the impact, and the effectiveness of proposed mitigation measures.
Moderate: A moderate residual impact has potential to be significant. The significance depends on the acceptability of the impacts and the effectiveness of mitigation measures.
A moderate impact generally has two or more of the following characteristics: Scale: Localised/Regional Magnitude: Moderate Duration: Medium-term/Long-term **AND/OR** There are sensitive receptors or land uses present, or environmental aspects that are valuable or otherwise important or unique (i.e. Medium-High value rating), and there is a low degree of certainty about the impact, and the effectiveness of proposed mitigation measures.
Major: A major residual impact is likely to be significant. The level of acceptability will depend on offsets or benefits compensating for the impact.
Impact generally has two or more of the following characteristics: Scale: Regional/ Widespread Magnitude: Moderate/Major Duration: Long-term/Permanent **AND** There are sensitive receptors or land uses present, or environmental aspects that are valuable or otherwise important or unique (i.e. Medium-High value rating).

Table 10-4. Summary of EIA results – Marine ecosystems factor – Construction

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
Direct disturbance or loss of benthic habitat Section 10.4.2.1	Subsea Cable System	**Likely** Benthic habitat will be directly impacted by cable laying and burial activities	**Limited** A 12m wide corridor of habitat will be disturbed for each of 6 cables. The cumulative area disturbed is large but habitat disturbance associated with a narrow corridor is limited.	**Medium-term** Benthic habitats predicted to recover over time. Recovery is likely to occur quickly in soft sediment habitats but will take longer for hard substrates.	**Minor** Narrow corridor of habitat disturbance is unlikely to impact marine biota or beneficial uses.	**Medium** Most of the habitat in the footprint is bare substrate. Some small patches of locally important benthic habitat potentially present – seagrass, seaweed and hard coral.	**Low** Nearshore cable route has not been surveyed. Benthic habitat occurrence assessed based on publicly available mapping data.	**Minor**
Habitat degradation due to elevated turbidity in marine waters Section 10.4.2.2	Subsea Cable System	**Possible** Sediment transport and timeseries modelling indicates turbidity will be elevated for short periods during cable burial activities.	**Localised** Elevated turbidity could be widespread; however, any impact to benthic habitats would be localised as only small patches of sensitive habitats occur in the area of influence.	**Short-term** Turbidity elevated for short-periods (days to hours) over one month during the cable burial. Benthic habitats are resilient to short periods of increased turbidity and will recovery rapidly.	**Minor** Darwin Harbour Water Quality Objective for turbidity exceeded, but over such a short timeframe that there is no measurable impact to benthic habitats.	**Medium** Most of the habitat in the footprint is bare substrate. Some small patches of locally important benthic habitat potentially present – seagrass, seaweed and hard coral.	**High** Sediment transport and time series modelling used to predict area of impact and influence (Appendix R).	**Minor**
Changes to fauna behaviours due to noise or light Section 0	Subsea Cable System	**Likely** Artificial light and noise will be produced by cable laying vessels and equipment could alter	**Localised** Noise emissions are predicted to have a localised deterrent effect causing fauna to avoid the cable installation	**Short-term** Noise and light impacts in any one area will occur intermittently for days in any given area as the cable	**Minor** Noise and light could deter or attract marine fauna moving through the area; however, there is unlikely to be a	**Medium** Subsea Cable System footprint traverses important habitat for some species, but that habitat covers large areas	**High** Literature indicates cable laying has minimal noise impacts. Good information is available in	**Minor**

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
		behaviour of marine fauna.	activities. Artificial light could attract certain species, such as turtles, but the impact is localised due to there being no proximate nesting beaches.	laying and burial activities can progress at a rate of 500 m per hour and will take place 24 hours/day.	measurable change in any population due to the low level and short duration of noise and light impacts.	and is not restricted to area of influence.	relation to noise and light sensitive marine species, and there are no important habitat areas proximate to the proposal footprint.	
Marine habitat and fauna impact due to spills of fuels or hazardous chemicals Section 10.4.2.4	Subsea Cable System Shore Crossing Site Land Sea Joint Station	**Possible** Ships and barges are powered by marine fuel oil. Temporary storages of fuel and hazardous chemicals located at the Land Sea Joint Station.	**Limited** Spills may occur but extent would be limited due to small volumes and spill response measures.	**Short-term** Spill response measures and on-site visual observations will ensure spills are detected, contained, and cleaned up within hours.	**Minor** No detectable change in water quality beyond the direct spill location.	**Medium** Patches of locally important benthic habitats present in footprint and surrounding areas.	**High** Adherence to Australian Standards and MARPOL are proven effective in mitigating risk of spills to marine environment.	**Minor**
Introduction of marine pests Section 10.4.2.5	Subsea Cable System	**Unlikely**	Not assessed because the impact is unlikely. All vessels used in the Subsea Cable System installation will comply with marine pest regulations and guidelines. Marine pest incursions are unlikely to occur.				**High** Marine pest regulations and guidelines are proven effective in mitigating the risk of marine pest incursions.	**Minor**
Direct fauna mortality/collisions with vessels Section 10.4.2.6	Subsea Cable System	**Possible** Vessels will be moving through areas where	**Isolated** Impacts will be limited to the area directly	**Short-term** Impacts in any one area will be for days only as	**Negligible** Due to low speeds collisions that	**Medium** Locally important fauna such as marine mammals	**High** Speed is known to be the key factor associated with	**Minor**

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
		fauna are known to occur	proximate to vessels	the cable laying and burial activities can progress at a rate of 500 m per hour and will take place 24.	cause death are unlikely to occur.	and turtles are known to inhabit the area.	fauna strikes, as low speeds will be adopted there is high certainty around the impacts.	
Loss of mangrove vegetation	Shore Crossing Site	Unlikely	Identified as a potential impact in the EIS TOR, this was not assessed as there are no mangroves within the proposal footprint, and mangroves located adjacent to the proposal area are unlikely to be impact by proposal activities.				**High** Surveys of footprint have not identified any mangrove vegetation	**None**

Table 10-5. Summary of EIA results – Marine Ecosystems – Operations

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
Habitat loss and degradation Section 10.4.3.1	Subsea Cable System	**Possible** Cable repair (if required) will disturb benthic habitat.	**Limited** Only a small area of benthic habitat would be disturbed during repairs	**Long-term** Benthic habitat will recover following construction, and habitat disturbed during repairs should also recover. Recovery of habitat occurring over months or years, depending on the type of benthic habitat.	**Minor** Habitat loss will occur but unlikely to impact on surrounding environment or other uses	**Medium** Patches of locally important benthic habitats present in footprint and surrounding areas.	**High** Habitat mapping provides certainty that habitats are present and marine modelling identifies potential impacts	**Minor**
Changes to fauna behaviour due to EMF or heat Section 10.4.3.2	Subsea Cable System	**Likely** Operation of the HVDC cables will generate heat and EMF that could deter or attract fauna.	**Limited** EMF and heat emissions from the cables will be minor and restricted to the sediment directly around the cable.	**Long-term** Impacts will occur for the duration of operations.	**Minor** The behaviour of some species will be impacted, and not in a way that significantly alters local biodiversity.	**Medium** Locally important marine habitats and fauna are present in proposal footprint	**High** Peer reviewed studies of other similar cables have informed impact assessment.	**Minor**

10.4.1 Areas of potential impacts

10.4.1.1 Proposal footprint (direct disturbance)

The area within which marine habitats and biota may be directly impacted is within the footprint of the Shore Crossing Site and the Subsea Cable System. Details of the locations and footprints are provided in Chapter 2 Section 2.7 and Section 2.8. The direct disturbance footprint for the Shore Crossing Site will be within an approximately 500 m x 500 m area covering the beach and intertidal zone where excavators will be used to excavate six cable trenches (three for the initial installation and a further three in the future) approximately 2 m deep and 2 m wide. Trenches will be backfilled and the area reinstated following cable laying activities, and there will be no ongoing disturbance associated with routine operations.

The Subsea Cable System corridor required to accommodate six cables with the required spacing is 1.2 km wide, but the direct disturbance footprint within this corridor is restricted to a footprint of 12 m per cable which is the footprint of the machines used to bury the cable. This direct disturbance footprint will extend from the Shore Crossing Site on Gunn Point Beach to the boundary of the Commonwealth marine area, which is ~895 km.

10.4.1.2 Area of influence (indirect disturbance)

Marine ecosystems could be indirectly impacted by any changes to water quality that occur during construction of the Subsea Cable System. The key potential impact relates to increased suspended sediment concentrations (SSC) in the water column from cable laying and burial activities, and reduced penetration of light which benthic habitat relies upon. The 'area of influence' to marine water quality from the construction activities has been determined by hydrodynamic and sediment transport modelling (Appendix R) and is discussed in Chapter 9 Marine Environmental Quality. The area that could experience elevated SSC is predicted to be widespread throughout shallow (<20 m depth) waters in Shoal Bay and outer Darwin Harbour and is shown on Figure 10-1. As detailed in Chapter 9, in the offshore environment, modelling indicates very little change in water quality surrounding the cables during laying and burial and so potential suspended sedimentation impacts to marine ecosystems are restricted to the direct disturbance footprint.

Fauna in the vicinity of the construction footprint may also be disturbed by noise and light although only for a short period of time as construction progresses along the Subsea Cable System route. The extent of this impact varies according to species sensitivity but is predicted to be localised around the active works areas.

During operations, the area of influence associated with potential impacts from heat and/or electromagnetic fields generated by the cables will be confined to within a few metres of each cable.

10.4.2 Construction

The potential for impacts to marine ecosystems will be greatest during the construction phase, when habitat is disturbed by cable laying and burial activities within the Subsea Cable System footprint and at the Shore Crossing Site, and there will be large numbers of vessels and equipment operating 24 hours/day creating disturbance associated with noise, light and ship movements. The number of vessels and equipment also establishes risks related to storage and handling of fuels and hazardous chemicals and introduction of marine pests. The sections below discuss the potential impacts of cable laying and burial activities through the nearshore and offshore environments, and impacts associated with construction activities at the Shore Crossing Site at Murrumujuk, Gunn Point Beach to the extent that they could affect marine ecosystems.

10.4.2.1 Direct disturbance or loss of benthic habitat

During construction, the physical changes to the seabed may lead to habitat loss or degradation within the direct disturbance footprint of the Subsea Cable System. Methods for Subsea Cable installation are detailed in Section 2.8 of Chapter 2, and include pre-clearance activities, cable laying and burial. Jetting to fluidise the seabed to allow cables to sink into the sediment will be feasible on around 60-70% of the route based on preliminary geotechnical information. For the remainder of the route, cable burial will be undertaken using the plough method (burial via a plough towed by the cable lay vessel), or mechanical trenching (cutting of a trench using a wheel or chain cutter). For each of six cables, a 12 m wide corridor of the seabed will be disturbed.

Any method of reworking the seabed may lead to direct disturbance of benthic habitats – i.e. displacement, damage and/or crushing of organisms. The impact will depend on the cable installation method, the sensitivity/resilience of the habitats affected, and the relative occurrence of the habitats that will be impacted upon (Taormina et al. 2018). Regarding the former, the ICPC (2021) validated in the *Guidelines on Best Environmental Practices in Cable Installation and Operation* (OSPAR 2012) that, of all the burial techniques, installation via jetting or ploughing involves the lowest environmental impacts. Taormina et al. (2018) discusses the habitat considerations, explaining that:

> *…Habitat resilience is characterised by the capacity to return to its initial ecological state after a perturbation (cabling in this case), and the duration of this response. The magnitude of biological changes is also dependent on the composition of the community itself – i.e. the relative occurrence of benthic species (abundance and biomass) and assemblages (richness) along the cable route, compared with their occurrence at the regional scale. Due to the small spatial footprint of cabling, the overall impact on benthic communities is negligible if its spatial distribution is significantly homogeneous.*

In other words:

a. Habitats that are used to natural disturbance – e.g. strong tides that cause frequently shifting sediments – will likely be more resilient.

b. The overall impact of disturbance depends on the 'rareness' of the habitat being disturbed. The more common the habitat, regionally, the lower the impact.

How quickly the seafloor recovers depends primarily on the environmental setting and natural processes, with recovery fastest in areas with high sediment supply due to waves, currents, tides and/or run-off. Kraus and Carter (2018) note that physical recovery within the inner to middle continental shelf (0 to 80 m water depth) can occur within weeks to less than two years but may be longer in deeper water because sediment supply generally (but not always) decreases offshore. The recovery time for habitat such as seagrass and coral depends on factors such as the resilience of the species' disturbed and growth rates, with seagrass and seaweed generally quicker to recover than coral.

Kraus and Carter (2018) noted that surveys suggest that after jetting and trenching, benthic communities recover at rates similar to physical restoration (i.e. at the same time as the seabed settles post-laying, benthic communities return) and, with few exceptions, 'the physical presence of a cable and the disturbance caused by its burial have little effect on the benthos studied.'

Nearshore

The benthic habitats within the Subsea Cable System nearshore footprint are described in Section 10.3.1.1. Within the Shoal Bay region, the footprint is predominantly sand and gravel, but some areas of seaweed, seagrass and hard coral may be disturbed (refer Figure 10-1). Section 10.3.2.1 presents the total modelled, high-likelihood areas of these higher value benthic habitats within the 1.2 km wide Subsea Cable System corridor. However, as noted, only a portion of the corridor will be directly disturbed by cable-laying activities (i.e. 12 m wide strip for each of six cables). The higher value benthic habitats mostly occur as patches within the corridor, and so without exact cable positions it is not possible to accurately determine the area of each habitat that will be directly disturbed. A very conservative calculation – i.e. one that assumes each of the six cables crosses all instances of the modelled habitat within the corridor – results in a total of 0.1 km^2 of all higher value nearshore benthic habitat being directly disturbed. This is equivalent to 0.08% of such habitat modelled for Shoal Bay.

Generally, seagrass and seaweed are quite resilient to disturbance due to natural seasonal and monthly physical processes (Smit and Palmer 2020), and will re-establish following the disturbance, and so impacts to these habitats are expected to be relatively short term. Hard coral grows slowly (actual growth rates vary depending on the species) and may take years to recolonise.

Offshore

By design, the offshore sections of the Subsea Cable System route predominantly transect largely featureless shelfs and basins – the dominant habitat type in the region. It has been chosen to avoid areas of significant topography as much as possible, and consequently only intersects a few key features that may support higher biodiversity values relative to surrounding habitats – noting that, as mentioned in Section 10.3.1.2, the depths at which these features generally occur reduce the likelihood that they support high biodiversity. These habitats are associated with harder substrates, meaning that the cables may have to be laid directly on them and covered in armour, as opposed to being buried. A very conservative calculation of offshore direct disturbance – i.e. one that assumes that all the above-mentioned key features support high biodiversity (totalling up to, but likely a lot less than, 35 km of the route) – results in 2.52 km^2 of such habitat being directly disturbed by cable-laying. This disturbance occurs in narrow corridors that spread over hundreds of kilometres, and as such the magnitude of impact in any given area is minor.

10.4.2.2 Habitat degradation due to elevated turbidity in marine waters

Cable laying and burial activities disturb sediments which can settle on trench margins – forming berms – and disperse as suspended clay and silt (Kraus and Carter 2018). The dispersal of suspended sediment leads to a short-term in turbidity, which can limit light for primary producers, impact feeding ability of fish that detect their prey visually, and can also directly impact species such as fish, whose gills may be clogged or damaged (Taormina et al. 2018). The severity of impact depends on both the suspended sediment concentration (SSC) that are experienced, and the duration of elevated concentrations.

As discussed in Chapter 9 Marine Environmental Quality, the hydrodynamic and sediment transport modelling (Appendix R) predicts that elevated SSC (exceeding the Darwin Harbour WQO of 10 mg/L) will occur over a large area of Shoal Bay, for short windows during the cable burial activities. The predicted SSC concentrations are within the natural variability experienced by the marine environment of Shoal Bay during the wet season but will exceed the lower background levels typical during the dry season. Sustained exceedance of the WQO is only predicted to occur for approximately three days during and following each pass of the jet trenchers during cable burial. Following the final pass of the jet trenchers, the SSC are predicted to gradually dissipate to below the WQO within 11 days. If three passes of the jet trenchers are required along each cable[11], then measurable water quality impacts could occur over approximately one month (30 days). If cable burial occurs separately for each cable, then the SSC's will be less than modelled; however, water quality impacts could extend over a few months. Irrespective of the final approach and method, the period of elevated SSC in the marine environment will be limited in duration and the predicted SSC are within the natural variability, which limits the potential for impacts to occur to benthic habitats from elevated turbidity.

Benthic habitat is also unlikely to be affected by sediment deposition or smothering as the Shoal Bay environment is a dynamic coastal system adapted to sediment resuspension and deposition (see Andutta et al. 2019). Smothering is also unlikely because tides, currents and waves will regularly resuspend and move unconsolidated sediment from the surface of seagrass, coral and seaweed (Rogers 1990). This process of re-suspension over the daily tidal cycles is illustrated by the time series modelling undertaken at key benthic habitat locations as discussed in relevant sections below.

Nearshore

Hydrodynamic and sediment transport modelling (Appendix R) was used to define risk zones within which the model predicts SSC to be elevated above the Darwin Harbour WQO of 10 mg/L at times during the cable laying and burial activities. The modelling methods and approach to defining the risk zones are described in detail in Chapter 9 Marine Environmental Quality. The resulting zones of High, Medium and Low risk are shown on Figure 10-1. Within these zones, water clarity is likely to be impacted (much more so in the high-risk zone than the low-risk zone), which in turn could impact on marine ecosystems, for example by limiting primary production (as discussed above). Higher value benthic habitat mapped as likely to occur within the various SSC risk zones is shown on Figure 10-1 (based on habitat modelling data from Siwabessy et al. 2020, as presented in Section 10.3.1.1).

To further assess whether benthic habitats are likely to be impacted, time series plots were derived from the modelling data to show the concentration and duration of elevated SSC (above the Darwin Harbour WQO) likely to be experienced at sensitive benthic habitats in Shoal Bay. The benthic habitat receptor locations that were modelled are shown on Figure 10-1, and Figure 10-7 and Figure 10-8 show the time series plots. Each plot shows three spikes in SSC because the model assumed the jet trenchers would undertake three passes (runs) along each trench. In between each pass, SSC rapidly declines as sediments settle out of the water column, but also fluctuates with the daily tidal cycles as sediments are re-suspended.

It is evident from the plots that, for the majority of modelled sites, peak SSC concentrations are low (<20 mg/L), well within the natural range experienced in the Shoal Bay region during the dry season (~0 to 25 mg/L). Concentrations are higher at a small number of sites (shown on Figure 10-9), with the highest modelled peak SSC concentrations (~450 mg/L) occurring at seagrass site SG2 (see location on Figure 10-1). Generally, the sensitive receptor sites proximate to the proposed Subsea Cable System experience the highest SSC concentrations, and SSC concentrations reduce moving further away from the route (as would be expected due to sediment settling and being dispersed by tides, waves etc). Notably, very high SSC are only predicted to be experienced for a brief period (i.e. hours) and are within the natural range measured by Yang et. al (2020) at Casuarina Beach.

Table 10-6 quantifies the areas of each benthic habitat that occur in the high, medium and low risk zones and the cumulative number of days that those habitats could experience elevated SSC above the Darwin Harbour WQO. The data indicates that a small proportion (3-5%) of the extent of each habitat type occur in the modelled high-risk area, with larger portions within the medium and low-risk areas. The data also indicates that exposure to elevated SSC could occur for up to 18.5 days (for seagrass habitat) over the construction period (for seagrass in the medium-risk zone), but for most habitats the period of exposure ranges between 9 days and 11 days. The time series plots illustrate that periods of high SSC will occur intermittently during and following each pass of the jet trenchers, but will drop below the Darwin Harbour WQO for periods of time in between (i.e. the period of elevated SSC will not be continuous). The longest period of sustained elevated SSC exceeding the Darwin Harbour WQO is approximately four days.

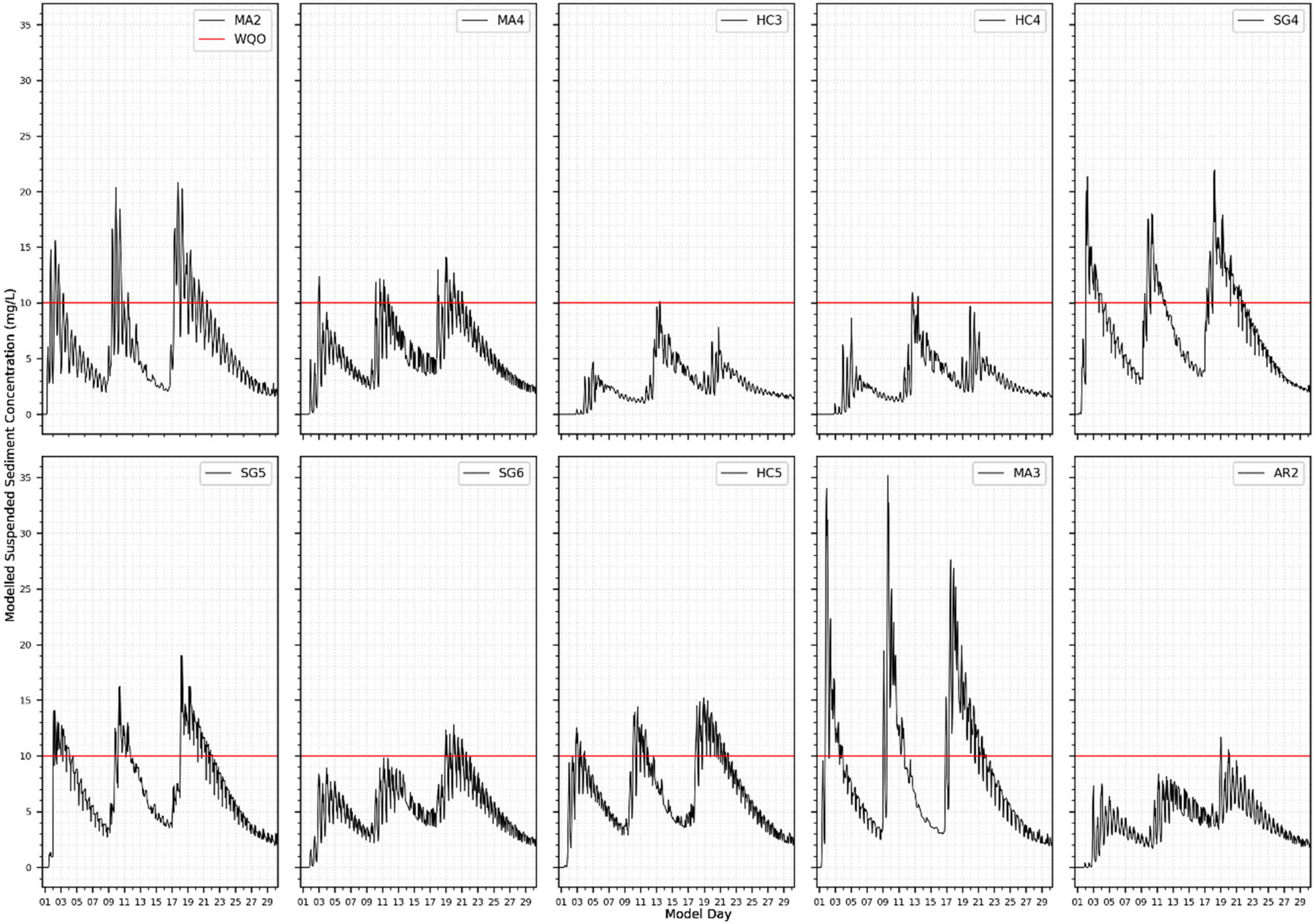


Figure 10-7. Time-series plots - modelled suspended sediment concentrations at nearby sensitive receptors (1)

SG= seagrass, MA = macroalgae (seaweed), HC = hard coral and AR = artificial reef

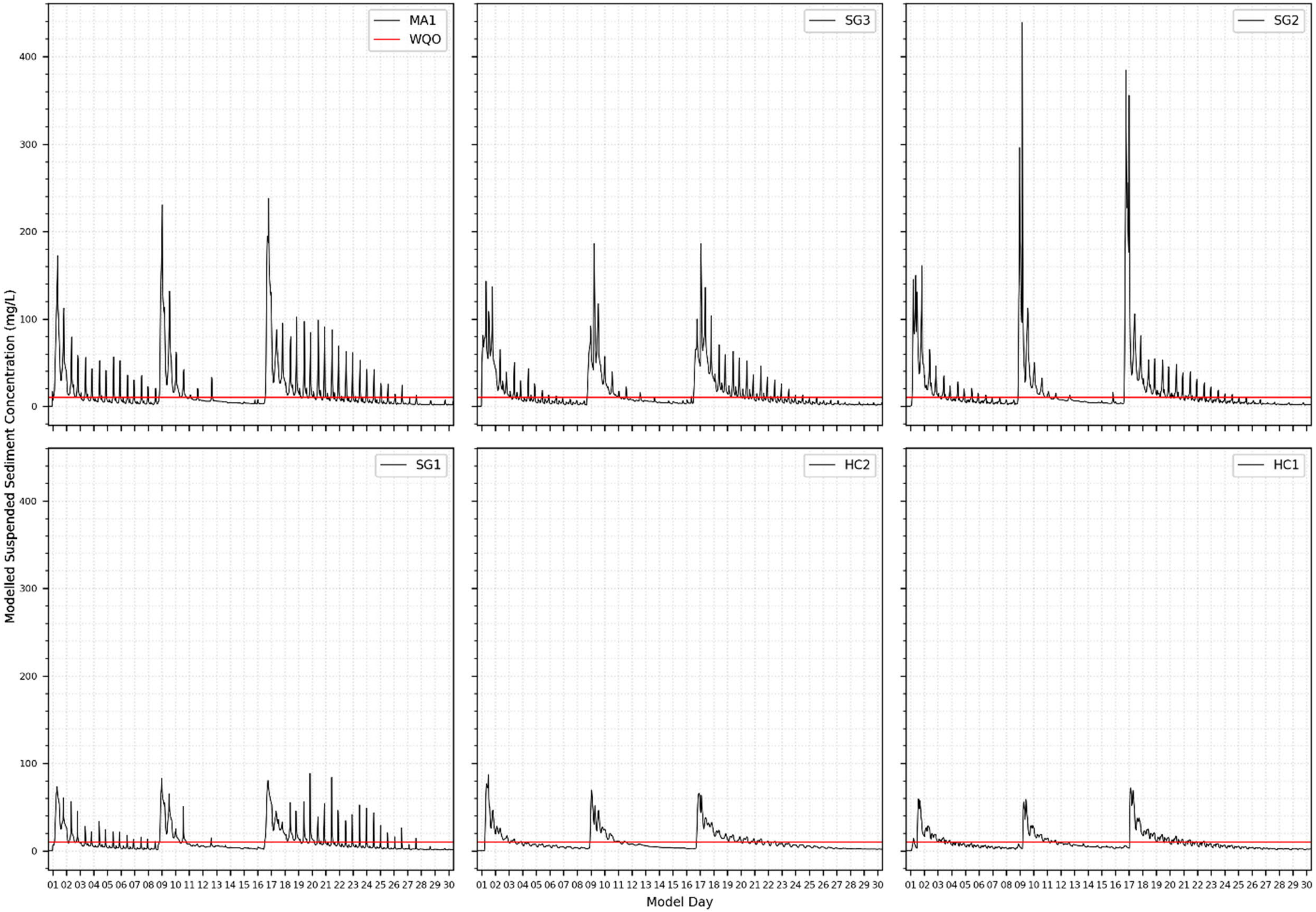


Figure 10-8. Time-series plots - modelled suspended sediment concentrations at nearby sensitive receptors (2)

SG= seagrass, MA = macroalgae (seaweed), HC = hard coral and AR = artificial reef

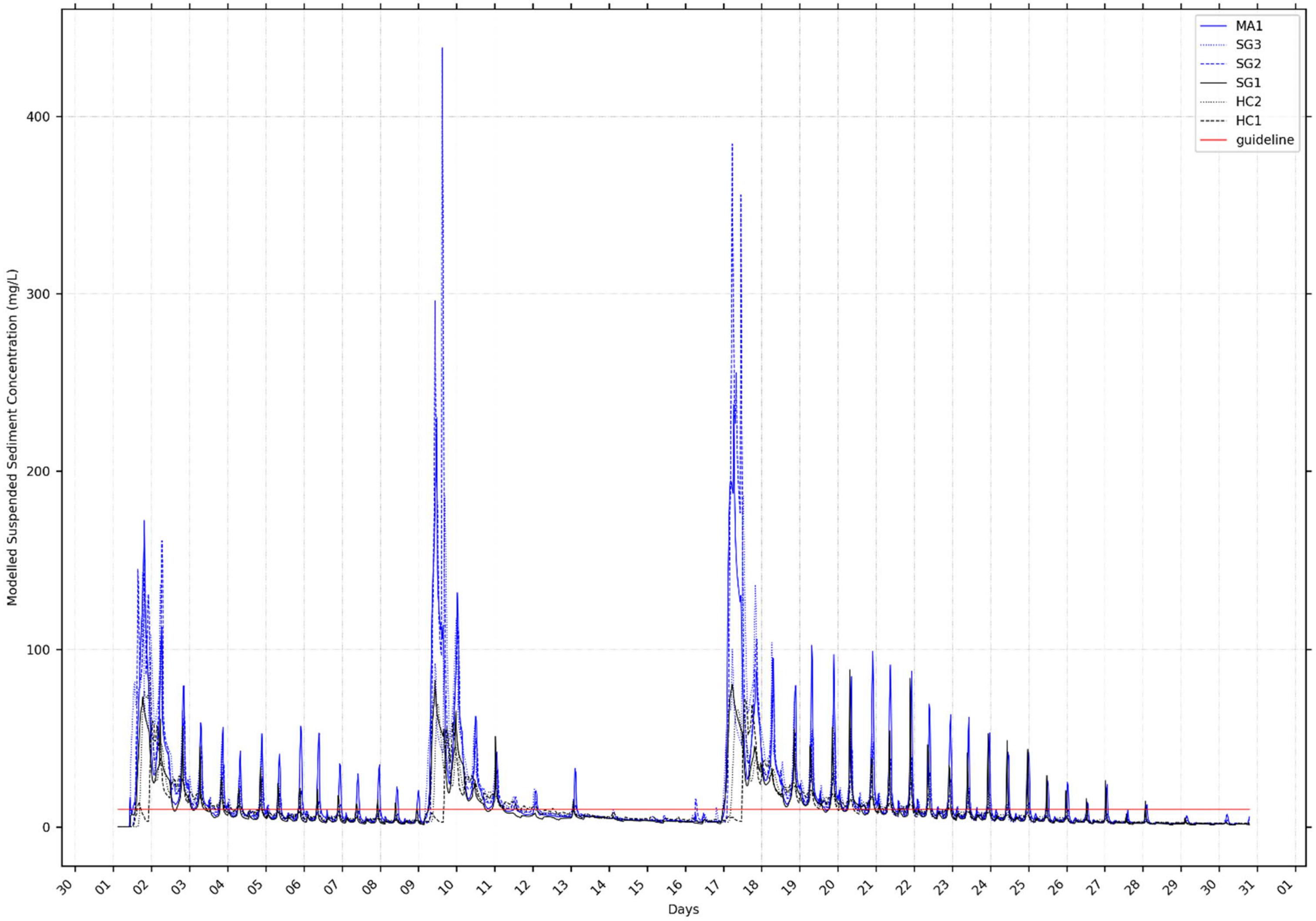


Figure 10-9. Time-series plots – sites with highest suspended sediment concentrations grouped

Table 10-6. Summary of risk factors to higher value benthic habitat species.

Benthic habitat	Risk (based on percentile concentration less than 10 mg/L)	Proportion of the Shoal Bay habitat affected (%)	Cumulative (days) affected by SSC above 10 mg/L*
Seagrass	High	3.37	9.1
	Medium	50.12	18.5
	Low	88.21	-
Seaweed	High	4.72	10.0
	Medium	37.81	11.0
	Low	67.66	-
Hard coral	High	4.15	11.6
	Medium	20.37	9.2
	Low	36.25	< 1

*Missing values indicate there were no timeseries modelling output available for the risk level and benthic habitat.

As marine ecosystems in the Shoal Bay region are naturally exposed to fluctuating SSC – for durations of up to weeks during monsoonal conditions in the wet season (see Section 9.3.3 of Chapter 9) – it can be assumed that they are adapted to withstanding periods of reduced light availability associated with elevated SSC, as explained below.

There are two dominant seagrass species present in Shoal Bay – those belonging to the genera *Halophila* (depth range to 1 m) and *Halodule* (depth range typically 4 m, but has been seen at 9.6 m). According to Palmer and Smit (2020):

> *The extent and biomass of documented seagrass meadows in Darwin Harbour varies greatly between seasons and years. Although the extent of Halodule meadows remains stable through the Wet and Dry Seasons, their density (percentage cover) varies between 5% in the Wet and 20% during the Dry. Halophila, however, shows considerable changes in seasonal distribution. During the Wet, it can completely disappear and return to more than 50% cover in the Dry. There are also considerable changes in distribution from year to year.*

This indicates that the seagrass habitat is dynamic and is able (and adapted) to recolonise after disturbance (e.g. from wet season wave action and reduced light availability). Palmer and Smit (2020) state that within Shoal Bay, any changes in light availability at the seafloor could have potential implications for seagrass health. The fluctuation in extent and density of seagrass between wet and dry seasons indicates that seagrass are naturally disturbed during the wet season, but recover during the dry season, and so the dry season is an important period of recovery. Sediment re-suspension associated with cable-laying could reduce seagrass coverage in some locations within Shoal Bay, and the impact of this could be greater if trenching occurs in the dry season, when seagrasses are recovering, and turbidity and suspended sediment is naturally low. If trenching does occur in the dry season and seagrass were impacted, the species affected are pioneer species that have evolved to rapidly recolonise areas disturbed by sedimentation (Palmer and Smit 2020). Any loss of seagrass, therefore, would only be short term (i.e. within one season).

It is reasonable to assume that seaweed and hard coral communities present in Shoal Bay have also evolved to be resilient to the periodically-turbid conditions that occur. For instance, WAMSI (2019) reported that most hard corals can tolerate SSC of 10 mg/L over a 42-day period, which is less than what is predicted to occur in association with the Subsea Cable System cable laying and burial activities. As with seagrass, the dry season is likely to be a period of recovery for seaweed and hard coral. As shown in Figure 10-7 to Figure 10-9, modelled SSC are elevated for a period of days after trenching, and SSC return to very low levels (<10 mg/L) prior to the end of the 30-day simulation period at all sites. The modelling is based on trenching a 50 km length of the route, with three trenchers operating simultaneously (to bury three separate cables), with three passes along each cable. This is the worst-case scenario and therefore if, under these model conditions, SSC returns to pre-disturbance conditions within 30 days, it can be concluded that any lost recovery time for benthic habitats (due to unseasonably high SSC from dry season cable laying and burial activities) would be less than 30 days.

In summary, expected maximum SSC from the Subsea Cable System cable laying and burial activities is within the natural range for the Shoal Bay region; however, trenching may result in unseasonal periods of elevated SSC, given that the highest natural turbidity occurs during the wet season. The duration of elevated SSC from trenching is generally likely to be shorter than those experienced naturally as part of wet season monsoons (of which there are ~1 to 4 per year). Consequently, it is concluded there will be minimal environmental impact from short periods of elevated SSC concentrations in shallow waters because the ecosystem is adapted to periods of highly turbid water with high sediment loads.

Although the focus has been on benthic habitats because they are sessile, and therefore more vulnerable, it is assumed that the fauna occurring within Shoal Bay is adapted to regular elevated turbidity, and so the environmental impact to them will also be minimal. This includes species targeted by recreational and commercial fisheries in Shoal Bay (i.e. barramundi and crabs).

Offshore

Turbidity is naturally lower in the offshore region due to substrate (i.e. more sand, less silt and clay), dilution and water depth (i.e. less impact from waves and wind). The literature generally agrees that the seabed environment is more turbid than the rest of the water column because tidal currents drive the resuspension of bed sediment.

Hydrodynamic and sediment transport modelling was undertaken at the Oceanic Shoals Marine Park (OSMP), as the most sensitive marine ecosystem in the offshore section of the Subsea Cable System (Appendix R). The modelling identified limited impact from cable laying and burial activities in the OSMP. There was no elevated SSC in the top layer of the water and SSC did not exceed 1 mg/L for the 5th, 20th or 50th percentile model runs. The maximum SSC concentration recorded was 4 mg/L (i.e. very low), and SSC dropped back to very low levels (<0.05 mg/L) within 3-5 days of trenching. The low level of sediment suspension from trenching is likely due to higher sand content in the seabed material, as well as impacts from dilution, and less resuspension from wind, waves and tidal movements.

It is highly unlikely that the low suspended sediment concentrations that will occur as a result of cable laying and burial activities in the offshore environment will impact on marine habitat or marine fauna in the region. In general, the localised direct disturbance associated with cable laying has not been reported as having a significant negative impact on marine ecosystems. Andrulewicz et al. (2003) concluded that there were no significant changes in benthic diversity, abundance or biomass on a submarine power cable route (or in its close proximity) one year after installation on soft bottoms of the Baltic Sea.

10.4.2.3 Changes to fauna behaviours due to noise and light

Construction activities will produce noise and, during night works, light which have the potential to impact fauna behaviours.

Noise

The physics and associated impacts of noise in the marine environment is very complex – Appendix 15 of the Ichthys Gas Field Development Project EIS (INPEX 2009) presents a very comprehensive review of the literature on sound in the ocean and effects of noise on marine fauna. The most significant behavioural and physiological impacts of noise on marine fauna arise when the noises are sudden, intense / high pressure, or continuous over a long period.

AAPowerLink activities will generate noise from vessel traffic, cable laying and burial (i.e. jetting, ploughing or mechanical trenching for cable burial). The exact intensity and propagation of noise is not currently known, and will vary according to bathymetry, seafloor characteristics (e.g. sediment type and topography), vessels and machines used, and water column properties (Taormina et al. 2018). However, it is known that the nature of activities means that the noises generated will not be sudden, intense / high pressure, or continuous over a long period. Based on previous studies of marine vessels and jetting technology, noise levels are likely to be in the vicinity of 180 dB re 1 µPa[13] (frequency range of 0.5 to 5 kHz[14]) at 1 m for vessels, and around 180 dB re 1 µPa (frequency range of 7 to 50 kHz) at 1 m from the trenching area during cable laying (Nedwell and Howell 2004, Bald et al. 2015). These noise frequencies and levels are similar to those generated by the large commercial ships that frequent the area (INPEX 2009, Appendix 15).

Marine mammals have functional hearing ranges from 0.01 to 200 kHz (Richardson et al. 2013), while fish typically hear at much lower frequencies, often from 0.015 to 1 kHz (Gotz et al. 2009). Cetaceans (whales and dolphins) predominantly use acoustic senses to monitor their environment and so may be impacted by loud noises. Dolphins have reduced sensitivity to low frequency sounds, such as those generated by vessels, and are known to ride bow waves and interact with vessels, indicating they are not deterred from them (Richardson et al. 1995). Conversely, the noise generated by vessels generally coincides with the optimal hearing frequency for whales, and whales have been known to be deterred from areas where seismic activities and drilling are occurring. There is little data on impacts of noise on turtles, however they have been known to startle due to sudden loud noises, and the noise generated from vessels is within the hearing range of turtles (McCauley et al. 2000). It is known that fish avoid approaching vessels when the radiated noise levels exceed their threshold of hearing by 30 dB or more (INPEX 2009).

It is likely that noise emitted during cable-laying activities will deter marine animals from the area. However, compared with other anthropogenic percussive noise sources – such as sonar, piling or explosions – underwater noise associated with cable installation is low level, spatially-localised and temporary (Hale 2018). The Ichthys EIS (2009) assessed the potential impact of noise generated during construction of that project's infrastructure – the levels and durations of which are significantly greater than for the AAPowerLink – and concluded it would be temporary and localised, and therefore not have a significant impact on marine ecology values. Based on this, and available literature, noise impacts as a result of cable laying and burial are likely to have a short-term deterrent impact on marine animals, but are unlikely to result in any significant impacts to the marine ecosystem. The AAPowerLink work front will move along the route (up to 500 m per hour), meaning that the impact of noise on marine fauna is expected to be minor and short-term. Environmental values are expected to quickly recover once the work-front has passed.

Light

To some degree, the presence of artificial lighting inevitably changes the behaviour of all local wildlife. In the marine context, it is known that this impact can be particularly significant for marine turtles. Light pollution has been known to disorientate marine turtles, particularly nesting females and hatchlings making their way to the sea from the shore (Pendoley 2005). Light pollution is considered of greater risk if it can be seen from the nesting beach, nearshore or adjacent waters, which could attract turtles and hatchlings away from the water (DEE 2020). Artificial lights can also interfere with the in-water dispersal of hatchlings (Witherington & Bjorndal 1991) in coastal waters.

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[13] Underwater decibels (dB) are referenced to a pressure of 1 microPascal (µPa), which is then abbreviated to dB re 1 µPa. This ensures relative intensities in dB can be compared to one another, as a standard reference pressure must always be used (and pressure beneath the sea changes with depth).

[14] Hertz (Hz) is a unit of frequency and is defined as one cycle per second.

[15] Under the EPBC Act, habitat critical to the survival of the threatened marine turtle species has been identified in the Recovery Plan for Marine Turtles (DoE 2017). In addition, the marine bioregional planning program led to the identification and mapping of biologically-important areas (BIA's) for Commonwealth protected species – including marine turtles. For the purpose of the light pollution guidelines, 'important habitat for turtles' includes all areas that have been designated as either habitat critical or BIA's.

Under the *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds* (Commonwealth of Australia 2020), where there is important habitat for turtles[15] within 20 km of a project, an impact assessment should be undertaken. Gunn Point is not a known turtle breeding beach (despite significant survey effort; see Chatto (2008)) and so the risk of light pollution impacting nesting females and hatchlings is considered low.

The first 175 km of the Subsea Cable System route crosses an area mapped as critical nesting and inter-nesting habitat for Flatback Turtles (i.e. within a 60 km buffer of the coastline from Anson Bay south-west of Darwin, through to the Tiwi Islands). The route actually only passes within 20 km of two low-density nesting beaches (Chatto 2008) – Casuarina and Cox Peninsula Beaches – the closest of which is approximately 6.3 km from route A. These beaches are not the reason the area is considered critical nesting habitat. The nearest critical nesting beaches are on the south coast of Melville Island and south-western tip of Bathurst Island, more than 35 km to the north of the closest point along the route (Chatto 2008). Although the Subsea Cable System footprint overlaps an area mapped as important Flatback Turtle inter-nesting habitat, actual suitable inter-nesting habitat for this species is water depths shallower than 16 m (Whittock et al. 2016), which are limited to the first ~15 km of the Subsea Cable System route and therefore more than 40 km from critical nesting beaches. The concern with light impacts on marine turtles is associated with disorientation of hatchlings. The distance between the Subsea Cable System footprint and critical nesting habitat is such that hatchlings will not be affected.

At worst, light emitted during cable installation could have an impact on a few individual marine turtles. As with noise impacts – the continual movement of the work front during construction means that impacts associated with light will not occur in one location for more than a few days.

10.4.2.4 Habitat and fauna impact due to spills of fuels or hazardous chemicals

Spills of marine fuel oils or other hazardous chemicals can impact on marine and shoreline fauna. The potential impact to marine water quality from spills was assessed under the Terrestrial environmental quality factor (see Chapter 9 Section 9.4.2.4). The residual impact was rated as Minor due to the minor volumes that will be stored and handled in the proposal footprint. A large spill would only result from a major incident such as a collision or refuelling incident – both of which are very unlikely in modern seafaring. All vessels will comply with the *International Convention for the Prevention of Pollution from Ships* (MARPOL; see IMO 1983), which is proven effective at minimising the likelihood and impact of marine oil spills. An Environmental Emergency and Spill Response Plan will be in place and equipment provided at the Land Sea Joint Station and on vessels to respond to small spill events. With these measures in place minor spill incidents are unlikely to cause impacts to marine water quality, and therefore will not impact marine habitats or fauna.

10.4.2.5 Introduction of marine pests

Marine pests are introduced species which may impact marine ecosystems, and commercial and recreational values. Three marine pests are identified as major threats to NT waters; the Asian Bag Mussel (*Musculista senhousia*), Asian Green Mussel (*Perna viridis*) and Black-Striped Mussel (*Mytilopsis sallei*) (NTG 2016). Marine pests can be introduced by vessels travelling from other countries where these pests are found, in ballast water, or on surfaces such as hulls, anchors and ropes.

[15] Under the EPBC Act, habitat critical to the survival of the threatened marine turtle species has been identified in the Recovery Plan for Marine Turtles (DoE 2017). In addition, the marine bioregional planning program led to the identification and mapping of biologically-important areas (BIA's) for Commonwealth protected species – including marine turtles. For the purpose of the light pollution guidelines, 'important habitat for turtles' includes all areas that have been designated as either habitat critical or BIA's.

Construction activities are unlikely to result in the introduction of marine pests. All vessels and barges used during construction will comply with the *National Biofouling Guidelines for Non-Trading vessels,* which includes measures for minimising risks of biofouling, and managing biofouling to avoid the introduction of marine pests into Australian waters (DAWR 2009). All vessels will comply with the *International Convention for the Control and Management of Ships' Ballast Water and Sediments* (IMO 2017), which stipulates control measures for the management of ballast water such that marine pest introduction is avoided.

10.4.2.6 Direct fauna mortality/collisions with vessels

Marine fauna susceptible to collisions with vessels include dolphins, dugongs, turtles, whales and whale sharks, all of which are known to occur in the vicinity of the Subsea Cable System corridor. Collision risk is higher in breeding areas, along seasonal migration routes, and in shallow waters (AMSA 2021). There are several major shipping routes that leave from Darwin Harbour and intersect with the Subsea Cable System route, including routes to offshore oil and gas, Asia, the Tiwi Islands and Queensland. It is expected that given the relatively high marine traffic through these routes, there are some fauna collisions, particularly for less manoeuvrable large ships that may be unable to reduce speed around marine fauna.

The *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna* states that vessel speed is a key factor in fauna strikes (Commonwealth of Australia 2017). The nature of the construction process means that vessel speeds will be low; cable laying can progress at speeds of up to 600 m/hour (but typically 400 to 500 m/hour). Vessels which are not cable laying will also adhere to low speeds in areas which are high risk for marine fauna strike – i.e. shallow waters in the nearshore area, and migration and foraging areas identified in Section 10.3.3. In the event that marine fauna (e.g. whales) are spotted by travelling vessels, speed will be reduced to 6 knots (or a speed which does not create a wake) and the animal will not be approached (AMSA 2021). It is therefore unlikely that vessels involved in construction of the Subsea Cable System will strike marine fauna.

10.4.3 Operations

10.4.3.1 Habitat loss and degradation

Whilst the physical environment disturbed during cable-laying may take up to a few years to re-settle, there is not expected to be any further habitat loss or degradation during the operational phase except if sections of the cable need to be repaired – the process is detailed in Chapter 2 Section 2.8.4 – in which case the disturbance would be limited to that small section and impacts would be similar to those considered in Section 10.4.2 above but smaller-scale, duration and magnitude.

As explained in Chapter 2, some short sections of the cable that are unable to be buried because of the hard seafloor may be covered with rock armour. Taormina et al. (2018) presents an overview of how this could lead to the creation of artificial reefs. This is generally considered a positive impact because of the increased biodiversity typically associated with reefs, and because the cable route is often designated a fisheries exclusion area (to avoid negative interactions between fishing activity and the cable), meaning the reefs may function as refuges protected from many forms of disturbance (Wilhelmsson & Langhamer 2014).

Once the cables are installed, the 1.2 km wide Subsea Cable System Corridor is expected to be sufficiently protected (buried or other protection) such that there is no limitation on recreational fishing. Chapter 2 outlines construction methodology and protection measures under consideration for the Subsea Cable System. Regarding commercial fishing, Sun Cable will work with the relevant government agencies and representative bodies to develop appropriate protection measures and determine if exclusion zones are required.

The marine habitats that re-generate following cable installation and any artificial habitats that are created (as described above) will be protected from future disturbance by the presence of the cables and associated cable protection measures. If exclusion zones are required, these habitats will be further protected.

10.4.3.2 Changes to fauna behaviour due to heat or EMF

The EIS TOR required considered of the potential for changes to fauna behaviour due to heat generated and/or by the electromagnetic fields (EMF) emitted by the cables.

Heat

When the cables are in operation, they generate thermal radiation that will cause localised heating of the surrounding environment – the sediment for buried cables and the water in the spaces between rock armouring for surface-laid cables. For buried cables, this effect is restricted to, at most, a metre from the cable – depending on the cohesiveness of the sediments (Emeana et al. 2016). For cables exposed to sea water, the effect is even more restricted because heated water is dispersed quickly through movement of water.

Temperature increases near the cable may modify chemical and physical properties of the sediment, affecting the development of micro-organisms and the benthic communities that rely on them. The warmer sediment may attract some species and deter others, altering the biodiversity immediately adjacent to the cable. However, this phenomenon has been poorly studied. Taormina et al. (2018) concludes that knowledge gaps prevent 'drawing conclusions about ecological impacts of long-lasting thermal radiation on ecosystems, but considering the narrowness of the corridor and the expected weakness of thermal radiation, impacts are not considered to be significant.' ICPC (2021) argues that, in the absence of direct studies, one approach is to compare the biota at cable sites and at cable-free control sites; if there is a heat effect, there should be some difference – and yet in three relevant studies this has not been found (Sherwood et al. 2016; Kogan et al. 2006; Andrulewicz et al. 2003).

In conclusion, any heating of the seabed would be very localised, only occurring in the sediment immediately surrounding the buried cables, with adjacent seawater remaining at background temperatures very close to the seabed surface. Such a restricted area of influence within the common habitats traversed is unlikely to have a negative impact on environmental values.

Electromagnetic Fields

The operating High Voltage Direct Current (HVDC) Subsea Cable System will generate EMF. The physical effects of EMF on the marine environment are very localised (confined to within a few metres of the cable). Many marine species – from rays and sharks to molluscs and crustaceans – are known to be sensitive to EMF because they use electromagnetic fields for orientation, migration and/or prey detection. It is possible that the EMF generated by the Subsea Cable System could negatively impact the behavioural ecology of some marine species through:

- Effects on predator/prey interactions
- Avoidance/attraction and other behavioural effects
- Effects on species navigation/orientation capabilities
- Physiological and developmental effects (Taormina et al. 2018).

ICPC (2021) reviewed studies of EMF impact on marine biota and found that the research undertaken to-date indicates a lack of evidence for positive or negative effects of cable EMF on the species studied, with studies finding no change in biological assemblages along energised cables. Consequently, as for the potential heat effect discussed above, it is reasonable to conclude that any potential impact of EMF on marine biota will be very localised.

10.5 Avoidance, mitigation and monitoring

Sun Cable is committed to applying the environmental decision-making hierarchy when making decisions that could affect the environment. Consistent with Section 26 of the *EP Act* this involves applying the following approaches in order of priority:

1. Avoid – Ensure that actions are designed to avoid adverse impacts on the environment.
2. Mitigate – Identify management options to mitigate adverse impacts on the environment to the greatest extent practicable.
3. Offset – If appropriate, provide for environmental offsets for residual adverse impacts on the environment that cannot be avoided or mitigated.

The environmental management framework that will be adopted for the construction and operation of the AAPowerLink is detailed in Chapter 17 Environmental Management. The framework comprises a Construction Environmental Management Plan (CEMP) and Operations Environmental Management Plan (OEMP) that sit within an overarching Environmental Management System (EMS).

For each of the impacts to marine ecosystems discussed in this chapter, Table 10-7 summarises the actions taken to avoid environmental impacts (through site selection and design) and actions proposed to minimise impacts during construction, operation and decommissioning of the proposal. Relevant measures have been referred to in the above discussion of the likelihood and severity of potential impacts associated with the Subsea Cable System of the AAPowerLink. The proposed controls are routine for the installation of Subsea Cables, and assuming proper implementation and adaptive management, will be effective in ensuring no unacceptable impacts to marine ecosystems. The measures provided in this chapter, along with any additional measures required to address conditions of approvals, permits and licences, will be integrated into the CEMP and OEMP prepared for the AAPowerLink.

Table 10-7. Marine ecosystems – Avoidance, mitigation, monitoring and reporting commitments

Impact	Avoidance	Mitigation	Monitoring	Reporting
Habitat loss and degradation	Route design, where possible, has avoided topographical areas along the sea floor which are associated with areas of higher habitat value.	Design, install and operate Subsea Cable System in accordance with the Guidelines on Best Environmental Practices in Cable Installation and Operation (OSPAR 2012)	Turbidity monitoring in impact zone and baseline/reference site during cable installation in high-risk area (shallow, <10m depth).	Internal reporting on environmental performance. External reporting in accordance with environmental approval conditions.
Introduction of marine pests	Manage vessels in accordance with National Biofouling Guidelines to avoid establishment of marine pests on vessels.	Marine Environment Management Plan to provide controls for ensuring vessels comply with the appropriate marine pest management guidelines/requirements.	Monitoring in accordance with the Marine Environment Management Plan	External reporting of any marine pest incursion.
Direct fauna mortality/collision with vessels	Nil	Marine Environment Management Plan to provide following controls: Cable-laying vessels will move slowly (up to 600m/hr). Support vessels will adhere to low speeds, particularly in high-risk areas (shallow waters and migration and foraging zones). If marine fauna is spotted, vessels will reduce speeds to below 6 knots until fauna has passed. No marine fauna will actively be approached by vessels.	Visual observation for marine fauna activity in accordance with the Marine Environment Management Plan	Internal incident reporting. Fauna strikes recorded and reported to the Marine Wildwatch Hotline 1800 453 941
Changes to fauna behaviours due to noise, light and other disturbances	Route selection avoids important turtle breeding beaches. Cable laying activities move up to 600m per hour which limits the duration of noise emissions in any given area.	Lighting will be energy efficient and designed to minimize harsh contrasts, without compromising navigation safety and security Minimized use of lights at night as feasible to reduce light trespass and to maintain dark skies Where possible, lights will be shielded with exterior cut-off fixtures to limit light emissions at a vertical angle of no more than 90 degrees from straight down	Visual observation for signs of changes in behaviour of marine fauna activity in accordance with the Marine Environment Management Plan	Visual observations reporting as required.

Impact	Avoidance	Mitigation	Monitoring	Reporting
Storage and handling of fuels and hazardous chemicals	Besides marine fuel oil, no HAZMAT materials will be used on vessels during construction. Any HAZMAT stored at Land Sea Joint Station will be >300 m from beach and on bunded storages.	Compliance with MARPOL requirements regarding refuelling and spill prevention. Fuels and hazardous chemicals will be stored and handled in accordance with Australian standards and guidelines An Environmental Emergency and Spill Response Plan will be in place and equipment provided at all storage and handling locations. Construction and operations staff will be trained in spill response.	Visual inspections of land-based storages and during refuelling activities for early spill detection. In the event of a significant spill, water quality monitoring.	Internal records of volumes used and stored in accordance with Workplace Health and Safety Regulations. Internal inspection records Internal incident reporting. Incidents of off-site pollution or nuisance reported to the NT EPA within 24 hours.
Impacts to threatened/significant species	Impact avoidance measures as per to minimise habitat loss, degradation and direct fauna mortality and spills.	Mitigations as per above to minimise habitat loss, degradation and direct fauna mortality and spills.	Nil	Nil

10.6 Residual impact

As stated at the start of this chapter, the NT EPA's objective for the Marine ecosystems factor is to:

> *"Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning."*

The residual impact of the AAPowerLink is summarised below, assuming the adoption of impact avoidance, mitigation and monitoring measures described in this chapter.

Each impact to marine ecosystems was assigned a residual impact rating taking into consideration the scale, magnitude and duration of the impacts, the presence/absence of environmental values and/or sensitive receptors and the level of certainty with respect to the intensity of the impact and the effectiveness of the mitigation measures. The residual impact ratings adopted in the assessment were provided earlier in Table 10-3. The combined residual impact to marine ecosystems from AAPowerLink construction and operations of the Subsea Cable System, and Cable Transition Facilities, is summarised in Table 10-8.

Table 10-8. Residual impact ratings for impacts to Marine ecosystems

Impact	Residual impact rating
Construction	
Direct disturbance or loss of benthic habitats	Minor
Habitat degradation due to elevated turbidity	Minor
Changes to fauna behaviours due to noise or light	Minor
Habitat and fauna impact due to spills	Minor
Introduction of marine pests	Minor
Direct fauna mortality/collisions with vessels	Minor
Operations	
Habitat loss and degradation from cable repairs	Minor
Changes to fauna behaviour due to EMF or heat	Minor

The results of the EIA undertaken for the Marine ecosystems factor indicate that the AAPowerLink is likely to have a Minor residual impact to marine water quality across the construction and operations phase of the proposal. Each of the impacts discussed in this chapter are either very confined spatially (i.e. within the 12 m wide direct disturbance footprint associated with each cable) and/or temporally (i.e. the impact is restricted to a period of days to weeks at most during construction or repair activities). The Subsea Cable System traverses a large area of marine habitat, and therefore intersects with suitable habitat for many significant marine species. Nevertheless, given that proposal activities within the marine environment occur within a long, but narrow (and therefore, very localised) footprint – and over a short time frame in any one location – the likelihood that any of these species will be affected is very low.

The only impact that may require a longer timeframe for recovery is direct disturbance to hard corals, if they occur along the selected cable route. The area and proportion of such habitat that is likely to be disturbed is very small, such that its loss is unlikely to have permanent ramifications for the local occurrence of that habitat and the biodiversity it supports.

10.7 Cumulative impacts

The framework used to assess cumulative impacts from the Australia-Asia PowerLink and other existing and future developments is described in Chapter 3 Impact Assessment. The process involves considering the cumulative or combined impacts to marine environmental quality associated with the residual impacts from the AAPowerLink, residual impacts from existing activities, and impacts associated with reasonably foreseeable developments described in Chapter 3. The EIA undertaken for the Marine ecosystems factor predicted very minor and short-duration residual impacts to marine ecosystems from the AAPowerLink activities and therefore there is limited potential for cumulative impacts to occur.

For almost its entire route, the Subsea Cable System lies on a seabed that is not subject to any other activities i.e. the ecosystem is minimally disturbed and intact. Therefore, its construction and operation will not contribute to any cumulative impact. The Subsea Cable System is expected to be sufficiently protected (buried or other protection) such that there is no limitation on recreational fishing. Regarding commercial fishing, Sun Cable will work with the relevant government agencies and representative bodies to develop appropriate protection measures and determine if exclusion zones are required. If exclusion zones are required, this may create a *de facto* marine reserve. During construction and maintenance, the addition of a small number of cable-laying vessels will see a negligible increase to the existing high levels of boat traffic in the region.

Through the EIA process the following potential cumulative impacts were identified:

- In the nearshore areas, which are close to Darwin Harbour, there are several reasonably foreseeable developments, including the Middle Arm Sustainable Development Precinct proposal and the Darwin Pipeline Duplication (DPD) Project, that could contribute to increased shipping activity and other disturbances that could cause cumulative impacts to marine fauna. The AAPowerLink will have a large number of vessel movements occurring over the construction phase; however, once the cable is installed vessel traffic will be minimal and therefore will not contribute to cumulative impacts to marine ecosystems associated with shipping.
- Combined development of the AAPowerLink and proposed Sea Dragon Hatchery will disturb the shoreline and intertidal areas along a short section of Gunn Point Beach, and in the longer term there is potential for large parts of the Shoal Bay catchment to be altered by development on the Gunn Point Peninsula. There is potential for cumulative impacts to marine ecosystems to occur through combined impacts to water quality from construction activities (i.e. increased turbidity), wastewater discharges and stormwater runoff into the marine environment. Impacts to water quality from the AAPowerLink are limited to the construction phase, and therefore cumulative impacts are only likely to occur if the Sea Dragon Hatchery is being constructed or is already operational at the time.

Sun Cable will liaise with relevant proponents/operators, and authorities, regarding timing and location of works to minimise the risk of cumulative impacts on the environment. Sun Cable has already engaged with Sea Farms and will continue to liaise with them in relation to construction scheduling and potential conflicts.

10.8 Offsets

The EIA did not identify any significant residual impacts to marine ecosystems that require offsets.

10.9 References

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