Marine Environment

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Chapter 9 - Table of Contents

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9.1 Introduction

This chapter of the EIS describes the likely impacts of the proposed Lindeman Great Barrier Reef Resort Project on beaches and intertidal areas, coral assemblages, aquatic vegetation and key marine species arising from the construction and operation activities. It proposes practicable measures for protecting or enhancing natural values (including coral and other marine species) and assesses how the nominated quantitative indicators and standards may be achieved for nature conservation management. The impact assessment focuses on the marine area in front of the existing resort (where the safe harbour was formerly proposed), as this would be where the majority of project activity with potential to affect marine habitats and species will occur. In order to help determine the effects of the project on local habitats and biota, it is necessary to understand baseline conditions including the physical and chemical environment as well as the stressors that can cause changes to habitats and biota and whether the project activities could lead to these increasing from current (baseline levels).

This section is informed by modelling of waves, sediments and currents as reported in **Chapter 8** and an assessment of Matters of National Environmental Significance included in **Chapter 26**. Further information is included in **Appendix Z – Marine Ecology Assessment.**

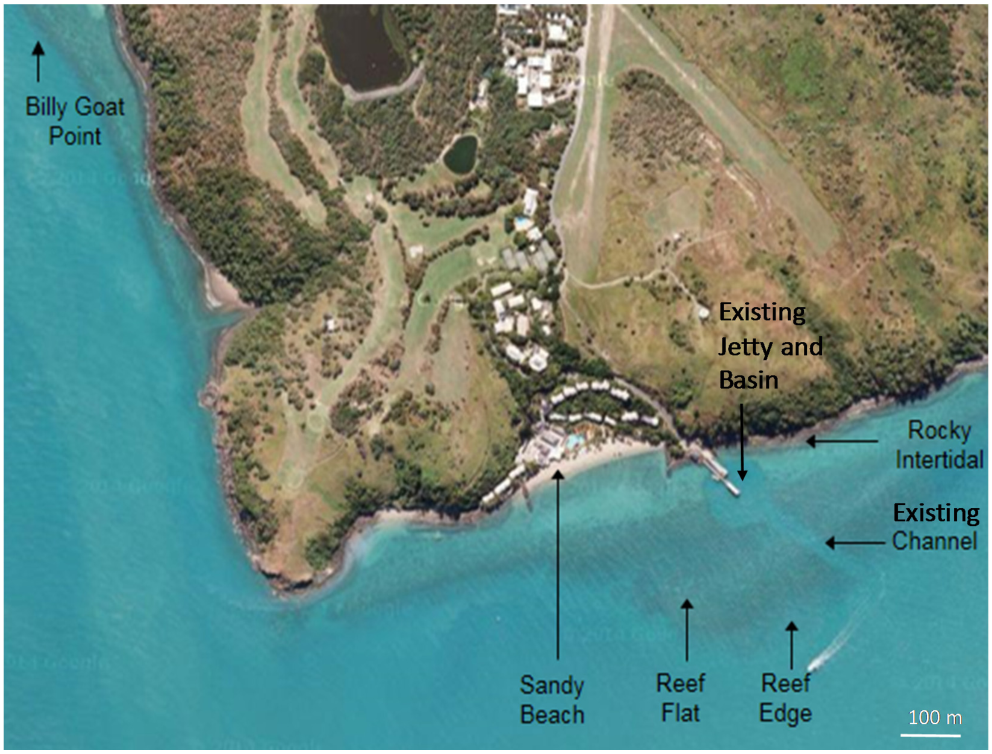
Addendum: *This EIS was initially prepared assuming that the safe harbour was to be part of the Lindeman Great Barrier Reef Resort Project. With the commencement of the Great Barrier Reef Marine Park Authority's (GBRMPA) Dredging Coral Reef Habitat Policy (2016), further impacts on Great Barrier Reef coral reef habitats from yet more bleaching, and the recent impacts from Tropical Cyclone Debbie, the proponent no longer seeks assessment and approval to construct a safe harbour at Lindeman Island. Instead the proponent seeks assessment and approval for upgrades to the existing jetty and additional moorings in sheltered locations around the island to enable the resort's marine craft to obtain safe shelter under a range of wind and wave conditions. Accordingly, remaining references to, and images of, a safe harbour on various figures and maps in the EIS are no longer current.*

9.2 Existing Marine Environment

The marine habitats surrounding Lindeman Island have a high ecological value and recognised conservation significance (BMT WBM 2013) (refer to **Appendix X**). The project marine area (i.e. the south-western tip of the island) includes sandy beaches, rocky shores, fringing coral reef, soft bottom areas, sparse seagrass and macroalgae (Cardno Survey 2015, BMT WBM 2013). A search of marine matters of State Environmental Significance has identified that the project marine waters includes areas located within the Great Barrier Reef Coast Marine Park (Conservation Park Zone). It does not include a Declared Fish Habitat Area, Dugong Protection Areas or High Ecological Significance Wetlands. A sandy beach occurs in front of the existing resort on the southern coast of the island, bounded on both sides by rocky shore (**Figure 9-1**). A shallow rock platform occurs offshore from this, extending to a maximum distance of about 350 m directly offshore from the beach. A wooden jetty about 100 m long was built from the rocky shore to the right of the beach to service the existing resort. An existing 25 m wide man-made channel cut to a depth of about -3.0 m LAT runs through the reef platform and a turning basin cut to a similar depth occurs at the jetty.

The reef extends furthest from the shore adjacent to the existing jetty whereas the reef to the east and west of the jetty does not extend as far from the shore. The edge of the reef, which occurs in about -1 m LAT, drops quickly down a slope to deeper water (-4 m LAT) where the substratum is comprised of soft sediment (BMT WBM 2013). Seagrass habitat occurs further offshore from the fringing coral reef (BMT WBM 2013). The rocky shore further west of the proposed development is bordered by a narrow coral reef and some seagrass, as indicated by aerial imagery (**Figure 9-1**) and survey results south of Billy Goat Point (BMT WBM 2013).

Figure 9-1. Existing marine environment surrounding the proposed development (project marine area).



9.2.1 Coral Assemblages

Coral assemblages typically include hard corals mixed among soft corals, sponges, ascidians, gastropods, macroalgae and other invertebrate taxa. The most diverse coral communities generally occur in clear, offshore waters, however extensive coral communities, such as those adjacent to Lindeman Island can also be found in inshore tropical waters. The marine habitats surrounding Lindeman Island are within the Inner Shelf Lagoon Continental Island bioregion and Whitsunday region of the Great Barrier Reef Marine Park (GBRMP) (Kerrigan et al. 2010). This bioregion is characterised by strong currents, some gorgonians and low reef sites, very turbid water and seagrass meadows in some bays. Within this area, there are scattered coastal fringing reefs that generally develop around the mainland and high continental islands and these can have high coverage of hard coral, soft coral and macroalgae, but generally low coral diversity (Kerrigan et al. 2010).

Key values of the Whitsunday region of the GBRMP and issues are outlined in Great Barrier Reef Marine Park Authority's (GBRMPA) *Whitsundays Plan of Management 2008*. GBRMPA has identified the following values relating to corals and associated biota in the Whitsunday Planning Area:

(a) corals and associated biota are an integral part of the GBRMP and the Great Barrier Reef World Heritage Area;

(b) the relatively clear waters of the northern part of the Planning Area have allowed for the growth and development of extensive and diverse reef structures and corals that are relatively uncommon on fringing reefs;

(c) surveys of fringing reefs have identified a number of reefs of outstanding species richness, coral cover, uniqueness and aesthetic appeal;

(d) a previously undescribed coral species (*Goniastrea sp.)* has been recorded at Double Bay, and a species of sponge (*Rhabderemia sorokinae*) has been recorded at Deloraine Island reef.

GBRMPA has also identified the following issues relating to corals and associated biota in the Planning Area:

(a) fringing reefs are a limited resource throughout the GBRMP and especially in the Planning Area—this relatively scarce resource has important conservation and aesthetic values;

(b) the accessibility of fringing reefs make them vulnerable to degradation from excessive human use, particularly damage from anchoring, diving, reef walking and collecting;

(c) there is a higher risk that anchoring equipment associated with larger vessels will cause greater damage to coral and associated biota;

(d) coral and associated biota have the potential to be affected by run-off from adjacent coastal development;

(e) species of biota that are thought to have only limited geographic distribution (for example, *Goniastrea* sp., *Rhabderemia sorokinae*) require protection.

Water Quality

Ambient suspended solids (SS) varies in reef environments from only a few mg/L in clear waters to upwards of 200 mg/L in turbid waters (Fabricius and Wolanski 2000) with a variety of different coral assemblages adapted to ambient SS concentrations. Coral reefs in the Whitsundays are affected by turbid water from coastal runoff which can be influenced by erosion, poor drainage controls and increasing development within the coastal catchments. Records of SS from 12 of the 74 Whitsunday islands over many years of monitoring show SS ranging from 0.50 mg/L to 17.50 mg/L (**Table 9-1**). The SS at Lindeman Island and Seaforth Island from 2002 to 2015 ranged between 1.46-4.70 mg/L, with an average of 2.35 mg/L. This appears to be mid-range compared to the average ambient SS at other Whitsunday Islands (**Table 9-1**).

Table 9-1. Water quality of the Whitsundays (source: AIMS, unpublished data).

Reef	Average SS (mg/L)	SS Range (mg/L)	Number of Records (n)	Data Date Range
Repulse Bay	4.05 ± 1.73	0.85-10.76	5	8/8/2004-6/3/2015
Shaw Island	2.33 ± 0.30	1.17-5.17	13	31/10/1992-26/8/2005
North Pine Island	4.14 ± 0.86	0.74-17.50	25	5/10/2007-6/3/2015
South Pine Island	3.61 ± 0.62	0.79-11.18	23	5/10/2007-6/3/2015
Dent and Henning Islands	2.87 ± 0.89	0.81-16.84	17	31/10/1992-15/1/2009
Border Island	1.25 ± 0.23	0.59-2.36	8	30/3/1994-8/1/2006
Edward Island	2.78 ±1.14	1.22-6.16	4	11/2/2007-27/2/2010
Deloraine Island	0.90 ± 0.20	0.61-1.50	4	11/2/2007-27/2/2010
Eastern Whitsunday Island	4.56 ± 0.94	0.50-11.75	14	10/2/1993-10/2/2007
Lindeman and Seaforth Islands	2.35 ± 0.24	1.46-4.70	11	28/10/2002-6/3/2015

Local Diversity and Cover of Coral

Aerial imagery indicates approximately 10 linear kms of reef fringes at Lindeman Island, extending variable distances from the shoreline between 10s to 100s of metres. BMT WBM conducted a marine ecology survey at four locations at Lindeman Island in August 2013 (BMT WBM 2013) and found that coral cover on these reefs was variable (refer to **Appendix X**). Apart from the large bombora offshore from Plantation Beach on another part of the island where coral cover approached 100%, BMT WBM estimated living coral cover to be generally <25% with most of the reef area consisting of 5-10% cover. Although data were limited, it would appear that the largest area of high density of living coral assemblages occurred on the southern side of the island nearby to the existing jetty and channel.

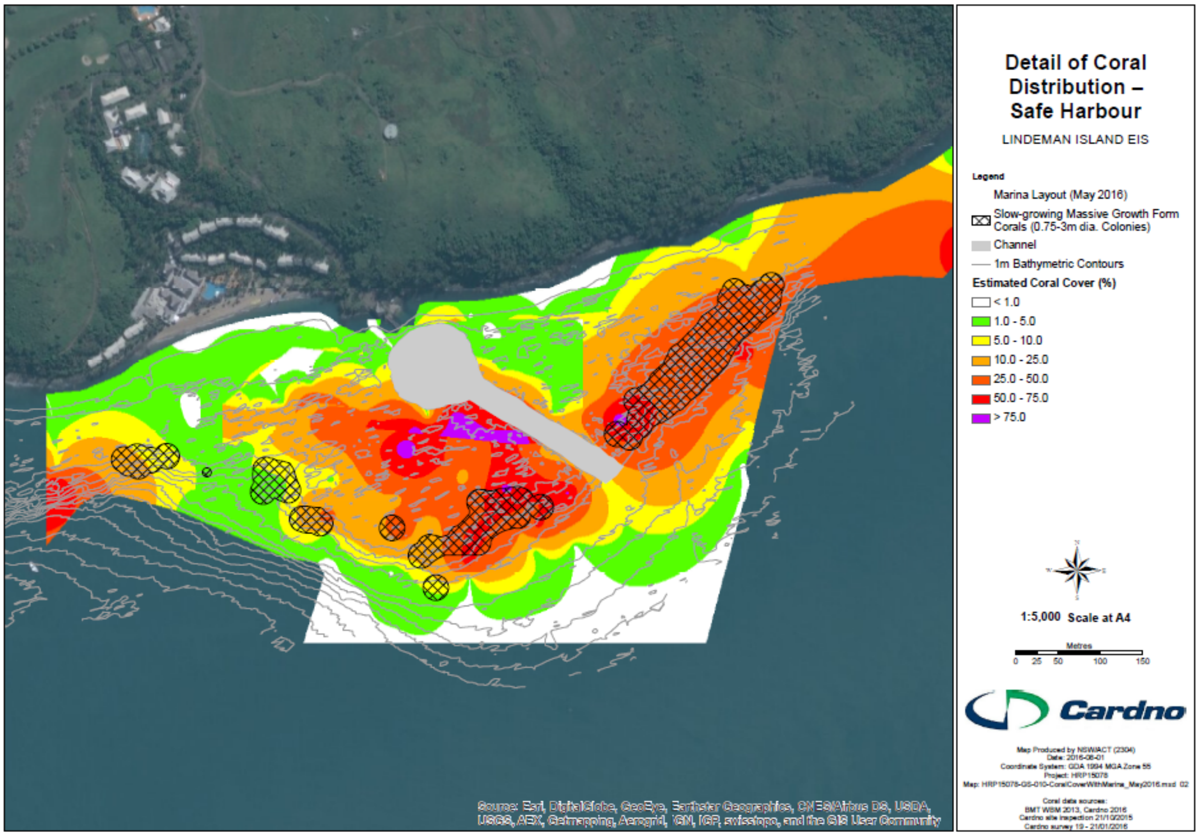
GBRMPA conducted a site visit in September 2015 that confirmed the findings (i.e. assemblage and percentage cover) of BMT WBM (2013) regarding the coral assemblage in the general vicinity of the formerly proposed safe harbour location (GBRMPA 2015). Importantly, it would appear that coral cover had changed very little in the intervening two-year period between these two surveys. In the absence of large storms, cyclones, crown of thorns outbreaks or bleaching, temporal stability in coral assemblages over this time scale is normal (Cardno 2013). Further, given the large size and cover of the branching *Acropora*, it is likely that the assemblage had not experienced a major disturbance for at least five years prior to Cyclone Debbie.

Cardno conducted two additional surveys to assess the current condition of the coral assemblage in and adjacent to the formerly proposed safe harbour location. The first, in October 2015, verified existing data on the assemblage and located large, old coral bomboras. The second, in January 2016, refined information about corals. The characteristics of the coral assemblage at the location of the formerly proposed safe harbour and in front of the existing resort (the Survey area) are shown in **Figure 9-**2 noting that these surveys were undertaken prior to Cyclone Debbie. These data are based on data combined from the BMT WBM (2013), GBRMPA (2015) and the two additional Cardno surveys.

The existing resort at Lindeman Island is fronted by a fringing reef (a rock platform with coral growing upon it). The reefs extends about 350 m from the shore in the middle of the Survey area, and about 100 m from the shore on the eastern and western sides of the Survey area (Cardno Survey 2015, BMT WBM 2013). Generally, coral cover becomes greater with increasing depth in the Survey area in front of the existing resort, before a short transition into soft sediment habitat (i.e. with no hard substratum for coral) further offshore. The intertidal parts of the Survey area have a very low coral cover, with only some small hard coral colonies from a variety of taxa in front of the existing resort, as well as some soft coral belonging to the *Sinularia, Sarcophyton, Lobophytum* and *Cladiella* genera of the Alcyoniidae family.

Some areas within the Survey area in front of the existing resort have a dense cover of coral as well as massive *Porites* coral colonies (coral bomboras) (Cardno Survey 2015, BMT WBM 2013). An area located in the middle of the Survey area has more than 25% (and up to 100%) live coral cover (indicated by the red and purple areas on **Figure 9-2**). This area of dense coral cover begins at a distance of about 100 m from the shore and extends to the edge of the fringing reef. Dense coral cover is also found on the eastern side of the channel servicing the existing jetty. Another area of dense coral cover occurs on the western side of the Survey area to the south-west of the existing resort. This area is part of the reef edge and has a steeper depth profile compared to other parts of the Survey area (BMT WBM 2013). The dense coral cover in these areas is mostly due to large stands of bushy and branching coral (Acroporidae Family). Other common coral taxa are needle corals (Genus *Seriatopora*, Family Pocilloporidae), soft corals especially leather coral of the genus *Sinularia* and massive corals belonging to the Poritidae and Oculinidae Families (refer to **Figure 9-3, Table 9-2**). These areas of dense coral cover together represent the widest section of continuous fringing coral reef on the southern shore of Lindeman Island (Cardno Survey 2015, BMT WBM 2013). The morphology and characteristics of the reef in proximity of the existing jetty is variable with the area surrounding the channel having a steeper gradient and denser coral cover compared to the shoreward area of the reef which is flatter.

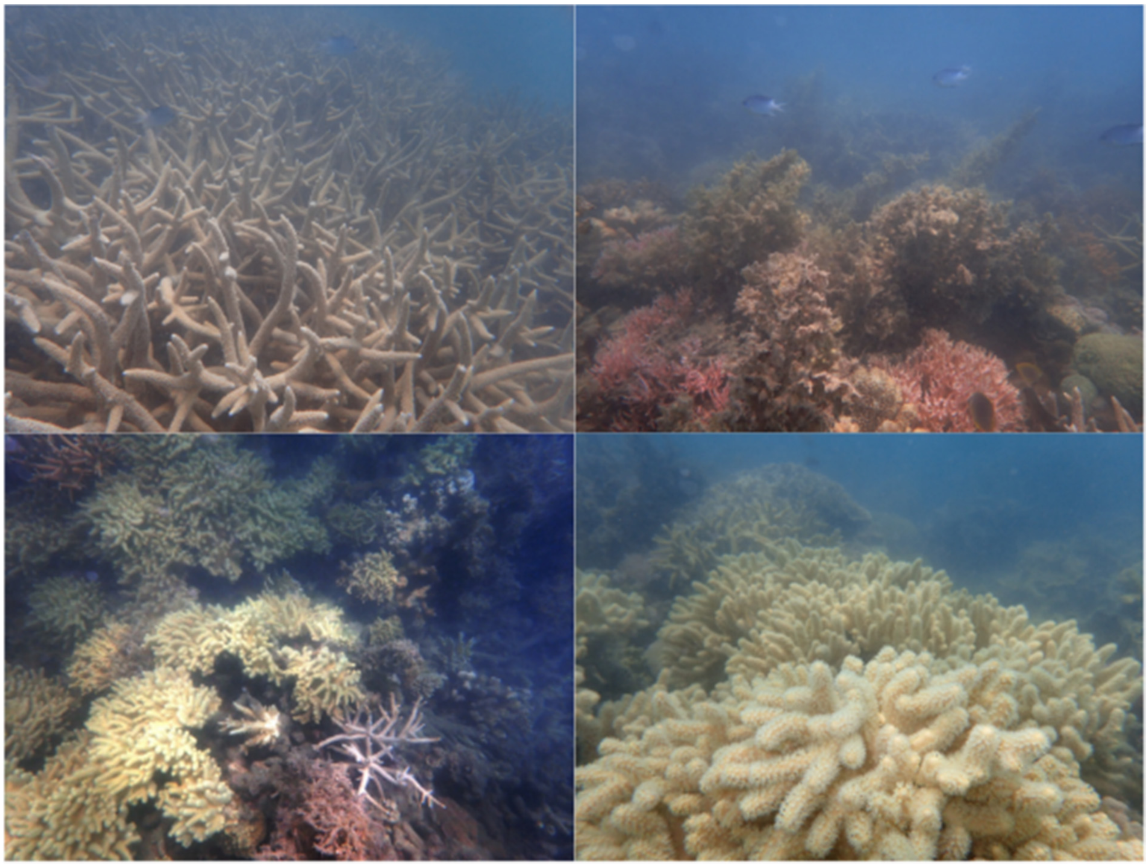
Figure 9-2. Coral distribution within the Survey area in front of the existing resort, estimated from Cardno Survey 2015/2016 and BMT WBM 2013 (prior to Cyclone Debbie).



Closer to the shore within the Survey area (i.e. <100 m), cover of coral is generally <25%, and typically much less than this (as indicated by green, yellow and orange colours on **Figure 9-2**). Here it consists of isolated small colonies of various growth forms. In front of the beach adjacent to the existing resort, the low coral cover extends from the shore all the way to the edge of the reef (Cardno Survey 2015).

The hatched areas in **Figure 9-2** indicate where colonies of the slow-growing, massive *Porites* genus were observed in the Survey area (Cardno Survey 2015). These colonies ranged in size between 0.75 and 3 m diameter, with the larger colonies potentially hundreds of years old (given an approximate growth rate of 10 mm per year, Lough and Barnes 1990). These colonies were mostly observed on the outer edge of the fringing reef or just beyond it. The short, outer fringing reef slope is manly inhabited by large colonies of the day coral *Alveopora* spp., sea whips (*Junceella* spp.) and soft corals such as branching *Nephthya* sp. growing in patches of rock interspersed among softer substratum. The dredged channel near the existing jetty has a low cover of hard and soft corals. The most common taxa are *Alveopora* spp., sea whips and few, small colonies of the Poritidae and Acroporidae families growing on rubble around the edges (refer to **Figure 9-3**). The metal structure of the jetty provides substratum for numerous, very large soft coral colonies, mostly of the genus *Sarcophyton* (Cardno Survey 2015, BMT WBM 2015).

Figure 9-3. High density coral habitat within the Survey area: Stands of branching coral of the Acroporidae family (top left); Needle corals (*Seriatopora sp.*) and macroalgae (top right); Soft corals of the Alcyoniidae family (bottom left and right).



A complete list of coral taxa observed inside the Survey area (Cardno 2016 and BMT WBM 2013) is given in **Table 9-2.** The survey within the formerly proposed safe harbour footprint did not identify notable additional taxa compared to the greater Survey area, indicating that coral taxa inside the footprint of the formerly proposed safe harbour are generally similar to that of the greater area on the fringing reef outside of the footprint.

The *Whitsundays Plan of Management 2008* requires protection of species with a limited distribution and points to a new species of the coral *Goniastrea* sp., and the sponge *Rhabderemia sorokinae*, previously identified from fringing reefs in the region. Although targeted searches for these species were not undertaken at Lindeman Island for this EIS and individuals from the genus *Goniastrea* do occur in the Survey area, there are subtle differences in the habitats of these rare species that potentially indicate they would probably not occur in the Survey area. The new species of the coral, *Goniastrea* sp., was found at Double Bay on the Whitsunday mainland on a reef that is 0-2 m deep at low water (De Vantier et al. 1992). In the Survey area at Lindeman Island, the fringing reef at this similar depth occurs on the outer part of the fringing reef, well away from the Survey Area. Further, the sponge, *Rhabderemia sorokinae*, collected at Deloraine Island (Hooper et al. 1990) was found on the edge of the reef, where there is a steep drop-off. Again, at Lindeman Island this habitat occurs on the outer parts of the fringing reef, well away from the formerly proposed safe harbour footprint and existing jetty. Notwithstanding this, video transects from the entire Survey were searched for possible specimens of *Rhabderemia sorokinae*. However, none were observed.

Table 9-2. Coral taxa recorded within the formerly proposed safe harbour footprint (Version 4).

Groups	Taxon	Safe Harbour Layout Version 4 May 2016 (Cardno 2016)	Survey Area (BMT WBM 2013)
SCLERACTINIAN CORALS			
Branching	*Acropora spp.*	✓	✓
	Seriatopora hystrix		✓
	Stylophora pistillata	✓	✓
	Pocillopora spp.	✓	✓
	Porites cylindrica	✓	✓
	Indeterminate	✓	✓
Massive	*Porites lobata*	✓	✓
	Moseleya latistellata		✓
	Favia spp.		✓
	Favites spp.	✓	✓
	Cyphastrea sp.		✓
	Goniastrea spp.	✓	✓
	Montastrea sp.		✓
	Lobophyllia spp.	✓	✓
	Platygyra spp.		
	Indeterminate	✓	✓
Submassive	*Porites spp.*	✓	✓
	Montipora spp.	✓	✓
	Pachyseris speciosa		✓
	Caulastrea furcata		✓
	Indeterminate	✓	✓
Columnar	*Galaxea fascicularis*	✓	✓
	Alveopora spp.	✓	✓
	Isopora palifera		✓
Plate or Lettuce like	*Turbinaria mesenterina*	✓	✓
	Platygyra spp.		✓
	Merulina ampliata		✓
	Merulina scabricula		✓
	Montipora spp.	✓	✓
	Indeterminate	✓	✓
Encrusting	Indeterminate	✓	✓
Lettuce	*Pavona cactus*		✓
Solitary	*Fungia sp.*		✓
	Polyphyllia talpina	✓	✓
	Indeterminate		✓
NON-SCLERACTINIAN CORALS			
Helioporacea (blue corals)	*Heliopora* spp.	✓	✓
Alcyonacea (soft corals)	*Nephthya* spp.	✓	✓
	Xenia spp.	✓	✓
	Sarcophyton spp.	✓	✓

Groups	Taxon	Safe Harbour Layout Version 4 May 2016 (Cardno 2016)	Survey Area (BMT WBM 2013)
	Sinularia spp.	✓	✓
	Lobophyton spp.	✓	✓
	Junceela spp. (Seawhip)		✓
No. scleractinian coral taxa		20	34
No. non-scleractinian coral taxa		6	7
No. all taxa		26	41

A Comparison with Coral Assemblages in the Region

There have been clear declines in the condition of inshore coral communities in many regions of the Great Barrier Reef for many years due to cumulative impacts from physical disturbance associated with tropical cyclones and storms along with elevated loads of nutrients and suspended sediment (Thompson et al. 2016). In the Mackay Whitsunday Region, however, coral communities have been the exception with average coral cover remaining at a similar level over the last decade. Further, in the Mackay Whitsunday Region the level of coral cover has been consistently 'high', even though turbidity in the area is considered to be relatively high compared to other regions (Thompson et al. 2016). The high cover in the Mackay Whitsunday Region has been maintained due to a lack of acute disturbances in recent decades as well as the selection for species tolerance of high turbidity (Thompson et al. 2016). AIMS monitors inshore corals along transects at 2 and 5 m depths at 10 Whitsunday Islands and has recently published data from the 2014-15 surveys (Thompson et al. 2016). They indicated average hard coral cover among islands ranges between 13 and 68% at 5 m below LAT and between 19 and 59% at 2 m below LAT (**Table 9-3**). Data collected by BMT WBM (2015) and Cardno (2015 and 2016 Surveys) measured the average cover at Lindeman Island in front of the existing jetty to be 51% at 5 m below LAT and between 19 and 68% at 2 m below LAT (**Table 9-3, Figure 9-3**). While there are definite patches of higher coral cover at Lindeman Island, these data indicate that average coral cover near the resort is comparable to other Whitsunday islands, although in the upper range of cover observed for the region. These data are also in contrast to statement made in a report by GBRMPA (2015) who considered the coral cover to be particularly high and unusual for the Whitsundays region, based on observations at a small number of spot dives.

GBRMPA's (2015) report also considered that the large proportion of habitat forming corals (bushy and branching *Acroporidae* corals) on the south side of Lindeman Island on the fringing reef in front of the existing jetty to be uncommon for inner-shelf fringing reefs which are generally characterised by patches of massive corals and very low cover of branching corals. Bushy and branching corals are known to provide habitat for numerous reef fish (Wilson et al. 2008) and invertebrate species (Stella et al. 2011) by increasing the habitat complexity and providing food resources. Again, the recently published data presented in Thompson et al. (2016) indicates that the average cover of bushy and branching corals (*Acropora, Pocillopora* and *Seriatopora* combined) for Lindeman Island on the fringing reef in front of the existing jetty (totalling 33.8%) is at similar levels at 2 m LAT to many of the Whitsunday islands and much less at 5 m LAT (**Table 9-3**). Cover of massive *Porites* corals at Lindeman was within the range seen at similar depths at the other Whitsunday islands. Given the differences between the lengths of transect used in Thompson's (2016) study with those used at Lindeman Island it is difficult to compare diversity of corals at Lindeman Island with that at other Whitsunday islands.

In summary, although the coral community on the fringing reef in front of the existing jetty appears to have flourished despite the majority of inshore reefs in much of the Great Barrier Reef suffering high levels of degradation, coral cover and growth form in the project area is not considered to be particularly high or unusual for the Whitsundays region.

Table 9-3. Coral cover (%) at two depth strata in the vicinity of the formerly proposed safe harbour at Lindeman Island and at other locations in the Whitsunday region.

Reef	Depth (m)	*Acropora*	*Alveopora*	*Caulastrea*	*Cyphastrea*	*Diploastrea*	*Echinophyllia*	*Echinopora*	*Favia*	*Favites*	*Fungia*	*Galaxea*	*Goniastrea*	*Goniopora*	*Hydnophora*	*Leptoseris*	*Lobophyllia*	*Merulina*	*Montipora*	*Mycedium*	*Oxypora*	*Pachyseris*	*Pavona*	*Pectinia*	*Platygyra*	*Pleisiastrea*	*Pocillopora*	*Podobacia*	*Porites*	*Psammocora*	*Seriatopora*	*Stylophora*	*Symphyllia*	*Turbinaria*	*Other*	*TOTAL HARD*	*Soft Coral*
Hayman Is	5	3.8		0.1		1.9	0.2	1.3	0.9	0.5	*	0.1	0.6	0.2			0.6	2.3	11.6	0.8	0.5	3.1	0.2	0.7	0.5		0.2		2.1		1.8	*	0.2	0.2	0.5	35	3
Langford Is	5	2.7			0.1	0.8		1.5	1.3	0.4			0.5	6.1	0.2		0.7	0.2	1.1	0.1	*	0.1	3.0	0.4	0.1		0.1	*	4.1		0.2	*		0.1	1.2	25	3
Border Is	5	3.0			0.2	0.4	0.2	0.3	1.2	0.4	0.1	0.1	0.4	11.5	0.6		1.2	0.3	1.2	0.3	0.7	0.5	0.5	1.1	0.6		0.2		5.4		1.0	0.3	*	0.3	0.6	33	3
Hook Is	2	2.7				1.1		0.2	0.4	1.6	*	*	0.3	0.1		0.4		0.2	2.3		0.3	0.6			0.3		0.1		5.1			1.1		1.6	0.5	19	4
	5	2.6			0.2	0.2		0.3	1.3	0.2		0.2	0.5	5.6	*		0.5		3.7		0.1	1.0	0.8	0.1	0.5		0.1		8.8			0.1		1.3	1.8	30	3
Double Cone Is	2	34.3	0.4		*		0.1	1.3	*		*	5.4	0.3	4.0	0.3		0.9	1.8	5.6		0.1	0.3		0.8	0.3		0.3		0.6					1.2		58	6
	5	5.4	0.1		0.2	0.9		0.7	0.2	0.5	0.1	2.1		48.4			1.7	0.3	0.1		0.3	0.6	1.1	1.1		0.2	0.1	0.1	4.1						0.1	68	2
Daydream Is	2	16.6						0.3			*		*	0.1			0.7	0.1	0.9	0.3	0.7	0.3		0.4			0.4	0.1	1.4						0.3	23	1
	5	16.6						0.3	0.4		*	*	0.2				0.3		4.3	0.8	0.3		0.5	0.2			0.1	3.1		0.8	0.2				0.3	28	0
Dent Is	2	27.9			0.3			0.9	*			1.6	0.2	4.3		0.2	1.9	1.8	0.6			0.3	2.3	2.9	0.1				11.1	0.2		0.3		1.1	0.6	59	3
	5	18.7	0.2				0.1	0.8	0.4	0.3	*	1.7	0.2	12.6	0.2	1.2	1.5	1.4	0.8	0.3	2.9	2.1	0.4	.51	0.3		0.1	0.3	2.3			0.4		0.1	1.1	51	1
Shute Harbour	2	31.1		0.4	*				0.3	0.3		0.1		3.6	0.4		0.6	0.3	3.2	0.8	0.6	0.1	0.6	1	0.3		0.8		0.3	0.1	0.1	0.3		0.1	0.9	46	2
	5	8.0			0.1	*			*	0.2		0.4	0.3	3.2			1.4	0.6	3.1	0.7	1.6	0.3	0.1	2.1				0.3	1.2			0.4		0.1	1.4	26	1
Pine Is	2	6.8			*			*	0.2	0.2	0.1	21.6	*	0.3	0.5	*	1.4	0.7	7.6	0.1	1.3	0.9		3.1			0.8	0.3	2.6					0.1	0.4	49	1
	5	1.8					1.3	0.3	0.4	0.1	0.1	8.3	0.1	2.9	0.2	0.3	2.3	0.1	3.9	1.8	2.0	5.1		6.0				1.2	1.0					0.1	1.7	41	1
Seaforth Is	2	0.8	0.3					0.3	0.5	1.0	0.1	*	0.2	1.9	*		0.6	0.1	0.1			0.3	6.5		0.1		0.3	0.2	6.7					0.1	0.9	21	2
	5	0.3		0.3		0.5		*	0.3	0.1	*	*	0.6	5.7	*		0.2		0.7		0.1	0.1	0.7		0.3			0.1	1.8					0.4	0.8	13	2
Lindeman Is	2	13.3	20.5						1	1							3										8.5		4.7		11			3	2	68	14
	5	1.0	39.8										1.0				1.0												7.5						1.0	51	4

*data <0.1%

[1] Data estimated at each site from 5 x 20 m transects (Thompson et al. 2016)

[2] Data estimated from 7 x 5 m transects

9.2.2 Beaches and Intertidal Rocky Shores

There is limited information available regarding the beaches and intertidal rocky shores of Lindeman Island. Although there have been no studies of biota specifically occurring on the existing resort beach or adjacent rocky shores there have been many studies of biota on similar beaches and shores in other parts of Australia from which to draw inferences about biota at Lindeman Island.

Beaches

Lindeman Island has seven beaches, including the resort beach immediately west of the existing Jetty (refer to **Figure 9-1, Figure 9-4**); Plantation Beach in the southeast; Turtle Bay in the northeast, Gap Beach in the north; Boat Port in the northwest; and Coconut Beach on the western side of the Island. The existing resort beach consists of coarse sediment and extends for about 225 metres west of the existing jetty. The main structures of the existing resort are located directly behind the beach. Sandy beaches were once regarded as marine deserts by many ecologists because of their apparent lack of life (reviewed by McLachlan 1983). Although their ecology is not completely understood, they are now recognised as dynamic habitats that have great productivity and diversity.

There are four main groups of biota found in beach habitats: infauna and epifauna, plankton, fish and birds. Broad-scale studies of macroscopic infauna (macrofauna) have identified three major taxonomic groups (crustaceans, polychaetes and molluscs) but over 100 species can occur (Dexter 1983). Smaller animals (meiofauna) live in the interstices between sediment particles, and these have received less attention than the macrofauna. Meiofaunal assemblages are thought to be dominated by nematodes (Nicholas and Hodda 1999). The upper area of exposed sandy beaches (i.e. above the swash zone) is typically inhabited by several species of amphipods, isopods, insects and ghost crabs (Brown and McLachlan 1990, in Barros 2001). In times of rough weather, the upper area of exposed sandy beaches may have vast amounts of dislodged seaweed washed onto them. These depositions of seaweed, known as ‘wrack’, provide refugia by serving as food or shelter to numerous intertidal invertebrates or birds (Chown 1996 and Pennings et al. 2000, in Orr et al. 2005). They also release nutrients following bacterial decomposition. Very little is known of the plankton in beach habitats. Phytoplankton (planktonic plants) can occur in the water column and in beach sediment. Diatoms often dominate both groups. Zooplankton (planktonic animals) can also occur in beach habitat and provide food for fish and shore birds (see below). Fish, that would generally reside on the subtidal reef flat offshore from the resort beach (refer to **Section 9.2.5**), or in deeper water, would potentially forage on the lower parts of the beach at high tide.

Shore birds are one of the few large organisms that can occur on intertidal and dry sandy beach habitats and in waters adjacent to beaches. Shore bird foraging habitat typically includes shallow waters and sandflats and along open coasts. Roosting is common along sheltered and occasionally open coastlines on sandy beaches above the high tide mark, while some shore birds roost on elevated areas. Although the majority of the species are diurnal, some forage nocturnally as well (e.g. Eastern Curlew). Shorebirds are typically carnivorous or omnivorous, eating worms, molluscs, crustaceans, fish and insects (refer to **Section 9.2.8**).

Figure 9-4. The beach in front of the existing resort at Lindeman Island. Photo: Dr Marcus Lincoln Smith, 20/1/2016.

Intertidal Rocky Shores

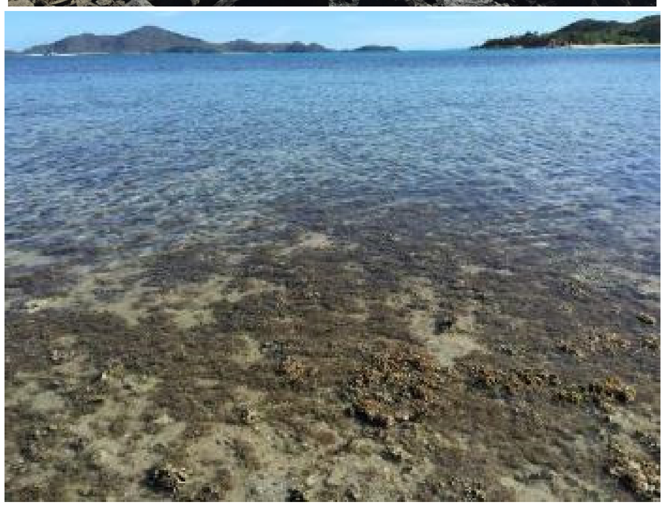
Intertidal rocky shores generally support diverse floral and faunal assemblages, including gastropods, sponges, ascidians, soft and hard coral and macroalgae (e.g. Underwood and Denley 1984). Intertidal rock shores can be grouped broadly into two categories; rock platforms and boulder fields, and both of these occur in the south western tip of the island within the project marine area (refer to **Figure 9-1, Figure 9-5**).

The most general intertidal habitat is the broad expanse of a rock platform. Rock platforms occur in intertidal areas, seaward of the boulder fields and beaches of the south western tip of the island. The effects of waves and tide, which vary from low to high levels across the rock platform, influence the types of plants and animals in the intertidal habitat. As a result, assemblages on intertidal rock platforms are usually categorised within the low, mid and high shore. Although there is much overlap of species into each shore level, generally the low shore is dominated by foliose algae, ascidians and some corals, mid shore by gastropods and oysters and high shore by barnacles. Taxonomic richness is typically greater on the lower portions of rocky shores. Shore birds forage on intertidal boulder field and rock platforms (refer to **Section 9.2.8**). Intertidal habitats, particularly rock platforms, are subject to human disturbance. In populated areas, some people collect animals and plants for food or bait, overturn boulders for inspection, or step on organisms during their passage over the rock platform, causing damage to flora and fauna. Trampling, particularly where there are mats of algae present, can have localised impacts and may alter the abundance and composition of species in the intertidal zone (Povey and Keough 1991).

Boulder fields occur where large or small boulders accumulate on a shore, this occurs between the rock platforms and beaches of the south western tip of the island. Intertidal boulder fields are very important habitats in some parts of the world, although in this region, they are very scattered along the coastline. Intertidal boulder fields provide a habitat for a wide variety of animals and plants, which can live on the tops and sides of boulders, the underside of boulders and below boulders (Underwood and Chapman 1995). While many species living on the surface of boulders are generalists and are often found in other intertidal habitats (i.e. rock platforms) some species, are found only on the underside of boulders and can be considered habitat-specialists. The diversity and abundance of organisms living on intertidal boulders can vary between individual boulders, due to the size of boulders and different placements. Diversity is generally greater on the underside of boulders and this could be due to these areas providing refuge from abrasion (McGuiness and Underwood 1986).

Artificial structures in the project marine area, such as the existing jetty, also provide hard intertidal surfaces for sessile marine communities.

Figure 9-5. Boulder field (top) with the resort beach in background and intertidal rock platform (bottom) at Lindeman Island. Photo: Dr Marcus Lincoln Smith, 20/1/2016.



9.2.3 Aquatic Vegetation

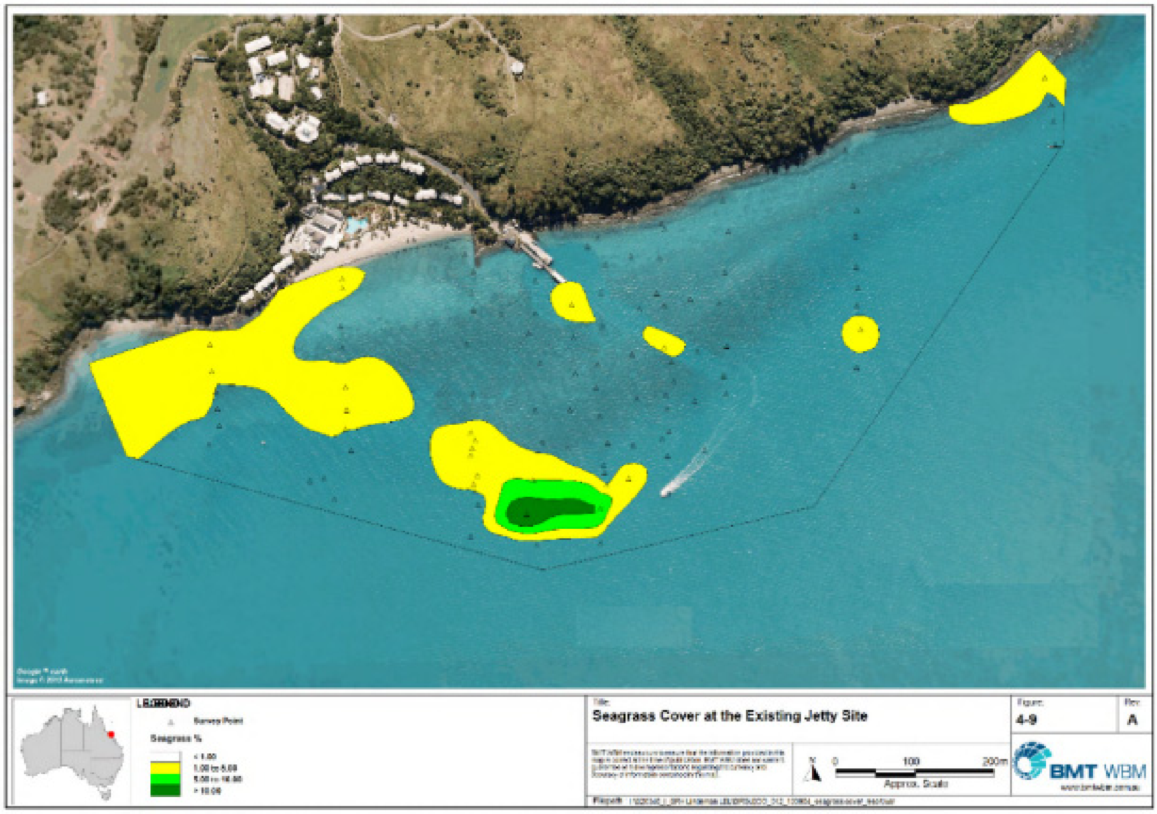
Seagrass

Seagrass assemblages are generally sparse throughout the shoreline around Lindeman Island (BMT WBM 2013). The densest seagrass meadows are located south of the existing jetty in soft sediment beyond the edge of the reef (BMT WBM 2013; refer to **Figure 9-6**) and, outside of the project marine area, at Boat Port and Coconut Beach. *Halophila* spp. (including *H. ovalis*, *H. decipiens* and *H. spinulosa*) and *Halodule uninervis* are the two most common seagrass taxa in the project marine area. These are fast growing, early colonising species that are known to survive well in unstable (shifting sediments) or depositional (subject to sedimentation) environments (Green and Short 2003). Both *Halophila* and *Halodule* are known to recover rapidly after disturbances, as they often establish large seed reserves in the sediment and/ or grow and expand rapidly from remaining patches (Short et al. 2010a, 2010b).

During a recent survey, seagrass meadows were generally sparse (mostly between 1% and 5% cover and one patch south of the existing jetty with cover > 10%), with a low above-ground biomass, with some soft and hard corals occurring in the same area (BMT WBM 2013). Some *Halophila spinulosa* was found in the dredged channel at the jetty site. A comparison of the distribution of seagrass in the latest available survey (BMT WBM 2013) with the survey undertook by Hyland et al. (1988) indicates that seagrass distribution did not change substantially over time.

Halophila and *Halodule* are a preferred seagrass food source sought by Dugongs (*Dugong dugon*) (Anderson 1998) and also a food source of Green Turtles (*Chelonia mydas*) (Lanyon et al. (1989).

Figure 9-6. Map of seagrass cover in the Survey area in the vicinity of the existing jetty (Source: BMT WBM).

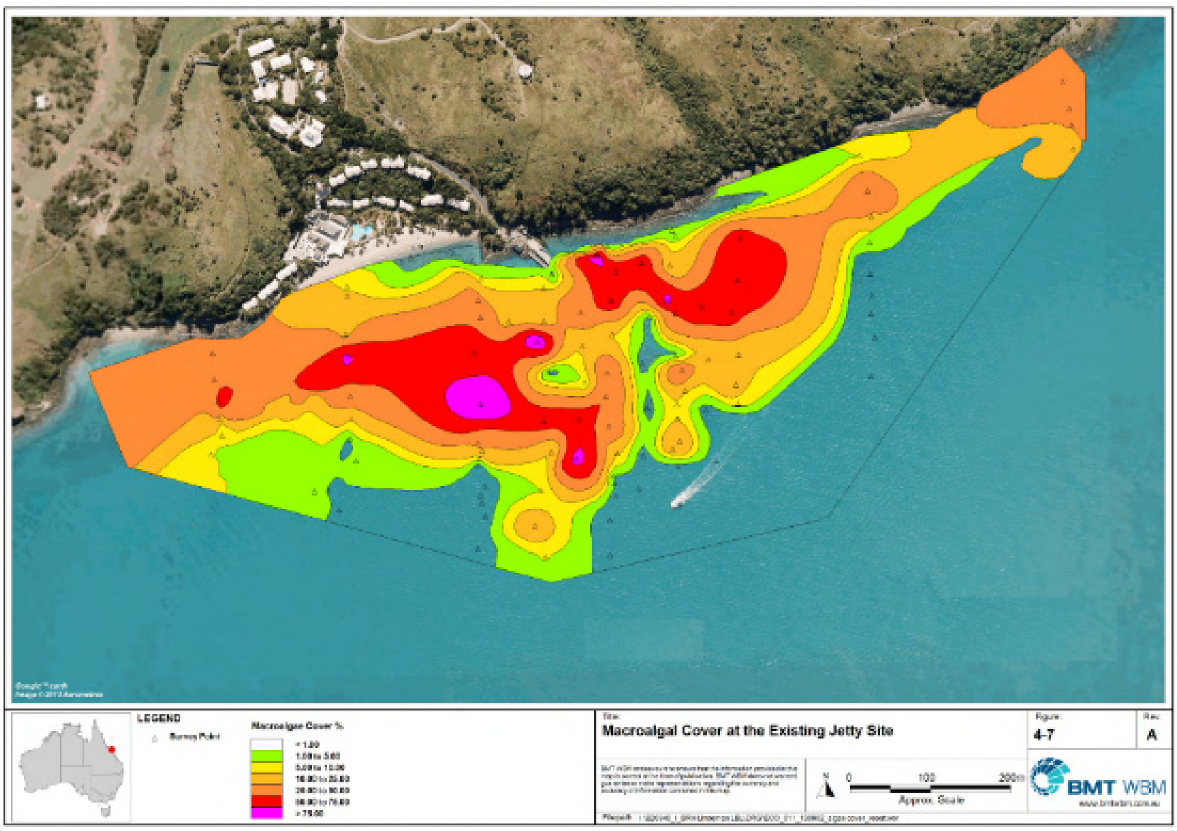


Macroalgae

Macroalgae generally requires hard, rocky reef for attachment and is common on the reef flat on the southern side of Lindeman Island (refer to **Figure 9-7**). Beds of macroalgae are highly productive (Biber et al. 2004) and may exert physical control over other attached benthic fauna, including corals (McCook et al. 2001, River and Edmunds 2001, McClanahan et al. 2002a, Box and Mumby 2007, Foster et al. 2008) and provide structural and functional integrity for macrofauna and fish (Tuya et al. 2008; Pérez-Matus et al. 2010). Detached, floating rafts of *Sargassum* also provide an important pelagic habitat and facilitate dispersal of biota among reefs, including juvenile sea turtles (Costen-Clements et al. 1991, Vandendriessche et al. 2006). Tropical *Sargassum* exhibits a seasonal growth pattern, where the biomass of individual plants is greater in summer than in winter, resulting in a larger standing crop during the summer months (Cribb 1990; Martin-Smith 1993; Vuki and Price 1994). Monitoring of algae is important as an increase in cover of algae of a particular type may indicate local nutrient enrichment or increased siltation or excess turbidity (Fabricius et al. 2005). *Sargassum* spp., in particular, may be an effective indicator of nutrient loads (Schaffelke and Klumpp 1998), as well as increases in filamentous algae (McClanahan et al. 2002b).

Macroalgae is common on intertidal and shallow subtidal reefs all around Lindeman Island (BMT WBM 2013). Macroalgae in the Survey area in the vicinity of the existing jetty occurs in amongst living and dead coral as well as on loose rocks in soft bottom substratum with a distribution and abundance pattern virtually complementary to that of corals. The main taxa characterising the assemblages found in the project marine area were *Padina, Sargassum, Dictyota, Laurencia* and *Lobophora*. Macroalgae were abundant west of the existing jetty and in the area in front of the resort beach. The high cover of coral-associated macroalgae within the Survey area is characteristic of many of Queensland's fringing reefs (McCook et al 1997).

Figure 9-7. Macroalgae cover in the vicinity of the existing jetty (Source: BMT WBM).



9.2.4 Subtidal Soft Sediment Fauna

Soft sediment habitat exists in the existing channel and turning basin and the benthic habitat beyond the edge of the reef flat fringing Lindeman Island is also soft sediment, which hosts infaunal and epifaunal assemblages. Tropical benthic infaunal assemblages generally contain burrowing organisms such as polychaete worms, amphipod crustaceans, bivalve and gastropod molluscs and other worm-like phyla such as nemerteans and nematodes (which are often abundant). These animals are generally found within the upper 30 cm of the sediment. Species richness and abundance are typically lowest in fine muddy sediment of intertidal areas, and highest in coarse sandy sediments. Benthic infaunal invertebrate communities of the region are typically dominated by filter feeders, which can account for more than 50% of the total abundance and nearly 30% of the species richness (FRC Environmental 2012). As well as being a source of food for organisms higher up the food chain, such as fish and large invertebrates, including some sharks, stingrays and Loggerhead Turtles (Kirkwood and Hooper 2004), they also drive nutrient cycling through reworking of the sediments (bioturbation), altering physical and chemical processes, excreting nutrient-rich wastes and feeding on phytoplankton (Pennifold and Davis 2001).

9.2.5 Fish, Sharks and Rays, Sea Snakes and Macrocrustaceans

The subtidal rock and reef habitat at Lindeman Island is used by a range of adult and juvenile fish species including cod, butterflyfish, damselfish, wrasses and parrotfish (Cardno Field Survey 2016, **Figure 9-8**). Over 48 taxa of fish were recorded from depths ranging from 2 to 4 m water depths in the vicinity of the formerly proposed safe harbour (**Table 9-4**, Cardno Field Survey 2016).

Figure 9-8. Damsel and butterflyfish in branching corals near the navigation channel at Lindeman Island. Photo: Dr Marcus Lincoln Smith, 20/1/2016.

Fish assemblages of Lindeman Island are typical of inshore waters of the Great Barrier Reef and major reef fin-fish families are likely to be generally similar to those found on reefs located a comparable distance from the mainland. Generally, inshore reefs of the central Great Barrier Reef tend to host fewer fin-fish species compared to mid-shelf or outer-shelf reefs. The dominant fish species of inshore reefs are Pomacentrids, Lutjanids, Chaetodontids and Labrids, while Acanthurids and Scarids are generally found in lower numbers on inshore reefs compared to mid or outer-shelf reefs (Williams 1982, Williams and Hatcher 1983).

Table 9-4. Fish taxa observed in the Survey Area 19 to 21 January 2016. SJ (small juvenile), J (juvenile), A (adult). Occurrence represented as the number of sites where species was seen from a total of 42 sites visited.

Family	Genus	Species	Common name	Size class / Sex	Occurrence (No. sites)	Abundance (Range)
Clupeidae	-	-	Unidentified "baitfish"	SJ	5	> 50
Serranidae	*Epinephelus*	*merra*	Honeycomb cod	A	2	2 - 5
Serranidae	*Epinephelus*	*sp.*	Unidentified cod	A	1	1
Apogonidae	-	-	Unidentified cardinalfish	SJ	1	1
Plectropomidae	*Plectropomus*	*maculatus*	Bar-cheek trout	J; A	7	6 - 20
Lutjanidae	*Lutjanus*	*decussatus*	Checkered seaperch	J; A	12	6 - 20
Lutjanidae	*Lutjanus*	*quinquelineatus/kasmira*	Five-lined seaperch	J	5	2 - 5
Lutjanidae	*Paracaesio*	*xanthurus*	Yellowtail blue snapper	J	4	> 50
Lethrinidae	*Lethrinus*	*laticaudis?*	Grass emperor	J	11	21 - 50
Nemipteridae	*Nemipterus*	*sp. 1*	Unidentified threadfin bream	J	3	2 - 5
Nemipteridae	*Nemipterus*	*sp. 2*	Unidentified threadfin bream	A	1	1
Mullidae	*Upeneus*	*tragula*	Bar-tailed goatfish	A	2	6 - 20
Chaetodontidae	*Chaetodon*	*sp.*	Unidentified butterflyfish	A	7	6 - 20
Chaetodontidae	*Chaetodon*	*auriofasciatus?*	Golden-striped butterflyfish	J	10	6 - 20
Chaetodontidae	*Chaetodon*	*guentheri?*	Gunthers butterflyfish	A	2	2 - 5
Chaetodontidae	*Chaetodon*	*lineolatus*	Lined butterflyfish	A	2	2 - 5
Chaetodontidae	*Chaetodon*	*rostratus*	Beaked coralfish	A	4	2 - 5
Pomacanthidae	*Pomacanthus*	*sexstriatus*	Six-banded angelfish	A	3	2 - 5
Pomacanthidae	*Chaetodontoplus*	*duboulayi*	Scibbled anglefish	A	1	1
Pomacentridae	*Abudefduf*	*septemfasciatus*	Banded sergeant	A	11	6 - 20
Pomacentridae	*Abudefduf*	*sp. 1*	4-bar sergeant	A	1	1
Pomacentridae	*Chromis*	*margaritifer*	Bicolor chromis	A	25	> 50
Pomacentridae	*Chrysiptera*	*glauca*	Grey demoiselle	A	2	2 - 5
Pomacentridae	*Pomacentrus*	*moluccensis*	Lemon damsel	A	11	21 - 50

Family	Genus	Species	Common name	Size class / Sex	Occurrence (No. sites)	Abundance (Range)
Pomacentridae	*Neoglyphidodon*	*melas*	Black damsel	A; J	3	2 - 5
Pomacentridae	*Pomacentrus*	*sp.*	Unid blue-lined head	J	5	6 - 20
Pomacentridae	-	-	Unid grey+pale yellow throat	J	1	1
Pomacentridae	-	-	Unid translucent, yellow caudal ped	SJ	5	> 50
Pomacentridae	-	-	Light grey gregory	A	11	21 - 50
Pomacentridae	-	-	Unidentified dark grey damsel	J	4	2 - 5
Pomacentridae	-	-	Very pale grey/torquoise	SJ	1	2 - 5
Sphyraenidae	*Sphyraena*	*obtusata*	Striped seapike	J	1	6 - 20
Labridae	*Cheilinus*	*fasciatus*	Scarlet-brested maori wrasse	A	2	2 - 5
Labridae	*Cheilinus*	*undulatus*	Maori wrasse	J	3	2 - 5
Labridae	*Choerodon*	*schoenleinii*	Blackspot tuskfish	A; J	4	2 - 5
Labridae	*Choerodon*	*anchorago*	Anchor tuskfish	J	17	21 - 50
Labridae	*Epibulus*	*insidiator*	Slingjaw wrasse	A	3	2 - 5
Labridae	*Halicoeres*	*sp.*	Unidentified wrasse	J	2	2 - 5
Labridae	*Hemigymnus*	*fasciatus*	Thick-lipped wrasse	A	10	6 - 20
Labridae	-	-	Unidentified wrasses (sev. Spp.)	J	14	> 50
Scaridae	*Scarus*	*globiceps*	Violet-lined parrotfish?	J/Female	3	21 - 50
Scaridae	*Scarus*	*ghobban*	Blue-bar parrotfish	J; SA	8	21 - 50
Mullidae	*Upeneus*	*tragula*	Bar-tailed goatfish	J	2	2 - 5
Blenniidae	*Meiacanthus*	*grammistes*	Black-banded blenny	A	1	1
Blenniidae	*Plagiotremus*	*tapeinosoma*	Yellow sabretooth blenny	A	1	1
Gobiidae	-	-	Unidentified shrimpgoby	A	1	2 - 5
Siganidae	*Siganus*	*vulpinus*	Foxface rabbitfish	A	16	21 - 50
Acanthuridae	*Acanthurus*	*grammoptilus*	Ring-tailed surgeonfish	A	1	2 - 5

Fish species protected under Great Barrier Reef Marine Parks Regulations (1983) include Syngnathiforms (e.g. seahorses, pipefish, seadragons), all species of the *Pristidae* family (Sawfish), all species of the genus *Epinephelus* (greater than 100 cm in size), *Epinephelus lanceolatus* (Queensland Groper), *Epinephelus tukula* (Potato Rockcod)*, Chelinus undulatus* (Humphead Maori Wrasse) and *Cromileptis altivelis* (Barramundi Cod).

Sharks and rays also occur in the project marine area. Black Tip Reef Sharks (*Carcharhinus melanopterus*) were observed over shallow subtidal reef by Cardno in October 2015. Many other sharks and rays would forage in the various nearshore and deeper habitats of the project marine area, including White Tip Reef Sharks (*Triaenodon obesus*), Grey Reef Sharks (*Carcharhinus amblyrhynchos*), as well some threatened or migratory species which would potentially be found on the edge of the reef or in deeper waters of the project marine area very occasionally (i.e. Great White Shark, *Carcharodon carcharias;* Whale Shark, *Rhincodon typus;* Giant Manta Ray, *Manta birostris*; Reef Manta Ray, *Manta alfredi*) (refer to **Chapter 26**).

Sea snakes are predatory marine reptiles that inhabit a range of habitats, including sandy bottom habitats, reef habitats and pelagic habitats (Stokes 2004). Sea snakes are likely to forage in all of the subtidal marine habitats in the project marine area. Sea snakes (family Hydrophiidae) are listed under the 'marine' schedule of the EPBC Act, and are consequently protected within Commonwealth Marine Waters such as the GBRMP. The highest diversity of taxa occurs in northern Australia and south-east Asia. Basic biological, distributional, and ecological information is limited for most Sea snakes (Lukloschek 2008), with the Olive Sea snake (*Aipysurus laevis*) one of the most studied species. The Olive Sea snake typically occurs at discrete reefs, with habitat preference related to reef location, exposure and area; their distribution does not appear to be related to the protection status of reefs (GBRMP zoning) (Lukoschek 2008). Factors driving spatial and temporal changes in abundances of Sea snakes are poorly understood (Lukoschek 2008 and references cited within).

The conservation status of Sea snakes is poorly known. Recent reports suggest declining abundances and loss of endemic species on protected Australian reefs. Threatening processes for reef-associated species, such as the Olive Sea snake, are unclear, but appear to include habitat degradation and loss and fisheries bycatch (Lukoschek 2008 and references cited within).

Artificial structures in the project marine area, such as the existing jetty, also provide hard surfaces for sessile marine communities. This structure is likely to provide habitat for several taxa including fishes, sea snakes, echinoderms, polychaetes and crustaceans.

There is limited information available regarding macrocrustacean communities of the region and in the waters around Lindeman Island. Communities are expected to be typical of other Queensland inshore waters and include (Queensland Museum 2011):

- Prawns and shrimps from the genera *Penaeus*, *Periclimenes*, *Stenopus* and *Thor;*
- Mantis shrimps from the genus *Odontodactylus*;
- Lobsters and crayfish from the genera *Allogalathea*, *Callianassa*, *Ibacus*, *Neaxius*, *Panulirus* and *Thenus*;
- Hermit crabs from the genera *Cilianarius* and *Dardanus*; and
- Crabs from several genera including *Uca*, *Mictyris*, *Trapezia*, *Charybdis*, *Portunus*, *Scylla* and *Ocypode*.

9.2.6 Marine Turtles

Four of the six species of marine turtles known to occur along Australian coasts would be common in the project marine area. These include Flatback (*Natator depressus*) and Green (*Chelonia mydas*) turtles, and less commonly the Loggerhead (*Caretta caretta*) and Hawksbill turtles (*Eretmochelys imbricata*). The Leatherback (*Dermochelys coriacea*) and Olive Ridley (*Lepidochelys olivacea*) turtles are less likely to occur in the project marine area but may occur there very occasionally. All of these turtles are listed threatened and migratory species under the EPBC Act (refer to **Chapter 26**).

Marine turtles are migratory and highly mobile species, moving between feeding grounds and rookeries, with males and females undertaking migrations of up to 3000 km. Marine turtles tend to nest on mainland or island beaches. In the Mackay region, Flatback and Loggerhead turtles generally nest on the mainland but there are occasional records of individuals nesting on the Whitsunday Islands. The Queensland Museum has a record of a hawksbill turtle nesting at Lindeman Island and the Queensland Department of Environment and Heritage Protection marine turtle nesting turtle database also has a record of a Flatback turtle nesting there. Although some of Lindeman Island's 16 beaches offer potential nesting habitat, it is sub - optimal at best given there is generally only a narrow strip of sand (i.e. having a width of up to 10 m at most and generally much less than this) above the high tide level. No true dunes occur at the rear of any of the beaches. Although the rear of some of the beaches contain isolated patches of sand these are heavily vegetated and would be difficult to nest within. The sandy area of Home Beach, in particular, is not considered a potential nesting beach given it has historically been the subject of development associated with the existing resort, is bounded by the built structures of the existing resort and has consequently historically been the subject of light pollution and only contains a narrow strip of sand (i.e. with a width of only a few metres) potentially available to nesting above the high tide mark.

Although the diets among Flatback, Green, Loggerhead and Hawksbill turtles vary, they would be likely to occur with the intertidal (during inundation) and subtidal parts of the project marine area given the mosaic of habitats there include forage areas for seagrass, coral and invertebrates inhabiting soft sediment or hard substrata. These forage habitats are also common throughout the Whitsunday region. Some marine turtles can exhibit strong fidelity to foraging habitats throughout their life (Limpus 2007).

Marine turtle species are experiencing serious threats to their survival (Environment Australia 2003; EHP 2015). The main threats include:

- Habitat degradation and destruction, particularly nesting beaches, seagrass meadows, mangrove forests and coral reefs;
- Entanglement and drowning in fishing gear (e.g. trawler nets) and shark nets and drum lines;
- Ingestion of plastic bags;
- Pollution and declining water quality;
- Disease; and
- Indigenous over-harvesting of both turtles and eggs, and predation of eggs by native and introduced animals.

The threat posed by trawler nets has been substantially reduced with the implementation of the *Fisheries East Coast Trawl Management Plan 1999*, which requires trawlers to use approved turtle exclusion devices. Fibro-papillomatosis disease is a common disease amongst turtles in some areas, which may be related to high industrial or agricultural runoff (Kirkwood and Hooper 2004). There is limited information on the prevalence of this disease in the project marine area.

The number of marine turtle strandings (sick, injured or dead individuals) recorded in the GBRMP from 1999 to 2011 is presented in **Table 9-5**, giving an indication of the threats to these species. The most common species across all years is the Green Turtle *Chelonia mydas* with 73% of records, followed by the Hawksbill Turtle *Eretmochelys imbricata* with 6% of records (EHP 2011a). The major causes of marine turtle strandings along the Queensland coast from 1999 to 2011 included:

- Boat strike, propeller damage or fractures;
- Queensland coast shark safety program;
- Dredging;
- Ingestion of synthetic material;
- Hunting;
- Fisheries bycatch or entanglement in fishing gear;
- Predation (e.g. shark attack); and
- Disease not directly linked to anthropogenic sources.

Table 9-5. Summary of sick, injured or dead marine turtles by geographical location around the Queensland coast, January 1999 to 2011. Lindeman latitude is 20.5. From EHP 2011a.

Year	GOC	Qld (east coast in 1° latitude blocks)																				Total
		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
1999*	18		2		2		4	1	7	1	9	37	8	21	4	31	51	110	39	203	6	554
2000*	4					1		1	9	7	10	44	18	15	11	36	26	71	38	197	7	495
2001*	8				1			2	12	4	21	64	28	20	15	24	43	62	31	192	6	533
2002*	30								15	5	8	54	12	14	4	46	31	61	25	229	9	543
2003*	6+ 11?							3	5+1?	6	4	36+3?	8+1?	25	10	68	26	57	55+ 1?	212+5?	6	527+22?
2004*	26							1	25	6	4	61+2?	13	10	2	53	25+ 1?	59+2?	53	225+3?	3	566+8?
2005*	73								21+2?	6+ 2?	6	40	9	11	2	29 +1?	16	43+1?	49	259_{35}+7?	1	563+14?
2006*	14							1	19	14	5	29	16+1?	24+ 7?	10	57	30+ 1?	69+1?	75	253_{19}+22?	3	617+32?
2007*	22	8	2						16	14 +1?	11 +1?	39 +2?	23 +4?	25 +1?	2	21 +5?	15	65+2?	126	352+29?	9	749+45?
2008*	19	1	3	1			2	1	26	7	6	35	25+1?	26+ 1?	9	55	20+1?	69+ 1?	111	368+33?	4	788+37?
2009*	1			7	1			2	16	7	10	44	21+1?	20	4	51	31	113	101	489+8?	4	918+9?
2010*	18						5	6+1?	16+1?	10	23+ 4?	147+3?	37+2?	14	19	52	28+1?	73+5?	78	328+2?	2	856+19?
2011	7		5				5	9	52+4?	35+ 1?	66+ 1?	308+16?	76+2?	84	43	323^{f}+ 1?	52	146	146	431+8?	5+1?	1793+34?

9.2.7 Marine Mammals

Several marine mammals (whales, dolphins and porpoises) listed under the 'cetaceans' schedule of the EPBC Act and the Sirenian *Dugong dugon* would occur in the project marine area. Several species are also listed as under the 'threatened' or 'migratory' schedule of the EPBC Act and NCWR, and in the IUCN Red List (refer to **Chapter 26**). The number of marine mammal strandings in the region (latitudinal block 20°of the Queensland coast) from 1999 to 2011 is presented in **Table 9-6**. The major causes of marine mammal strandings along the Queensland coast give an indication of threats to these species. These were:

- The Queensland coast shark safety program;

- Hunting;
- Fisheries bycatch or entanglement in fishing gear;
- Boat strike, propeller damage or fractures; and
- Disease not directly linked to anthropogenic sources.

Table 9-6. Summary of cetaceans and pinniped strandings by year and identified sources of mortality (suspected or confirmed) for Queensland, from 2001 to 2011. Lindeman latitude is 20.5. From EHP 2011b.

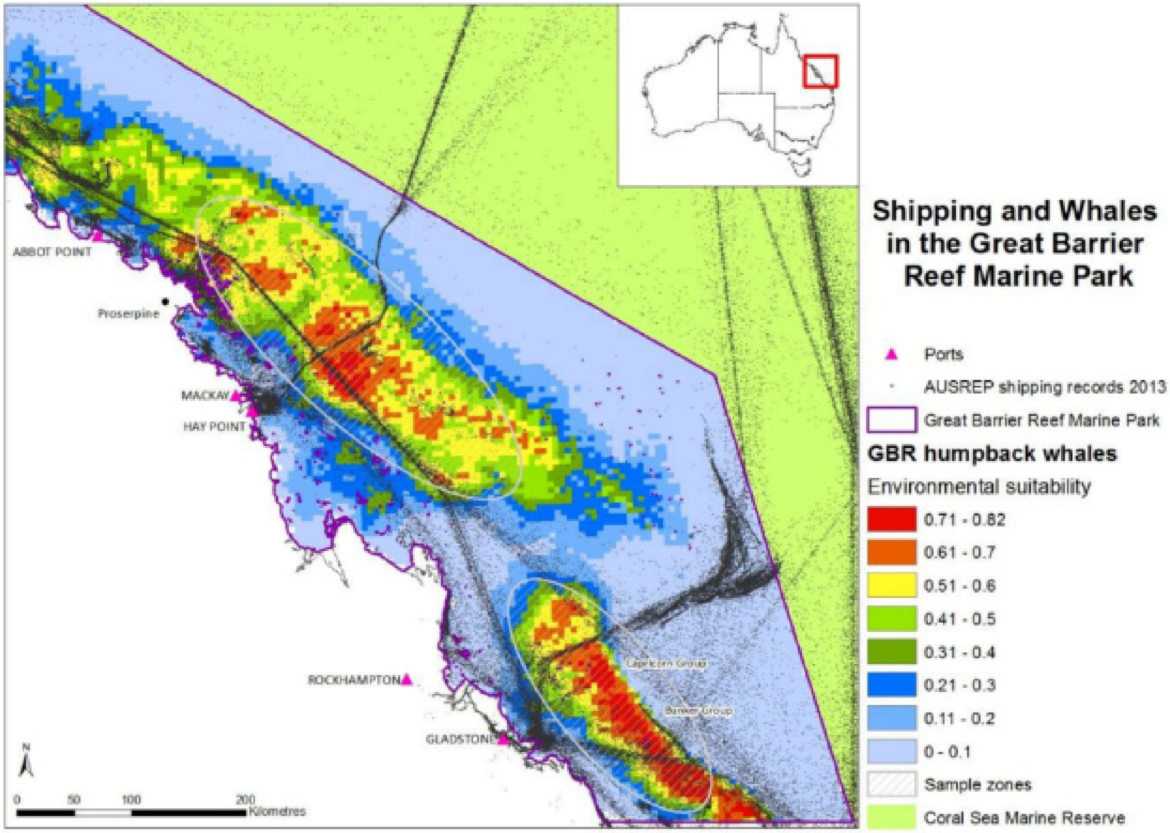
Cause of stranding and mortality	Year										
	2001*	2002*	2003*	2004*	2005*	2006*	2007*	2008	2009	2010	2011
Natural causes											
Disease and ill health	3	2				4	3	3	4	1	9
Trapped by natural event		1				(1)	(3)				
Stingray barb	1										
Predation/ predator attack				2	1				(1)		1
Other	3								1	2	
Anthropogenic causes											
Disease			1								
Boat strike/ fractures			1	3	2	(2)	(3)	(5)	1		(1)
Netting/crabbing/ entanglement in ropes or fishing line	4	1(1)	(2)	3(3)	1	1(5)	(11)	(2)	2 (1)+(1^{r})		(5)
Non-permitted hunting											
Shark control program	10 (1)	8 (1)	14 (2)	12(7)	21 (9)	21 (6)	21 (4)	25 (8)	14 (7)+(1^{r})	21 (1)	15 (5)
Ingested foreign material/fishing hooks									1		
Research											
Undetermined	1	1			2(1)	3	3	(1)	1		2
Undetermined cause	19(4)	22(6)	15(1)	28(1)	25(5)	20(4)	31(8)	20(10)	31(3)	34(3)	43(4)
Total	41(5)	35(8)+2?	31(5)+2?	47(8)+8?	52(15)+3?	49(18)+6?	52(29)+2?	48(26) +2?	55(12)+2^{r}+3?	58(4)+6?	70(15) + 3?

The most common cause of mortality was 'undetermined'. Of the known causes of mortality, the Queensland coast shark safety program was the most common known source of mortality, followed by commercial fishing and disease and ill health. Injury from boat strike was a small proportion of the reported strandings.

Whales

There are two core Humpback Whale habitat areas in the Southern Great Barrier Reef (refer **Figure 9-9**). One of these is located southeast of Lindeman Island, within the inner reef area and extending for approximately 100 km parallel to the coast. The 'Whale Protection Area' is designed to minimise disturbance to whales and is an important calving ground for humpback whales between May and September. Despite no sightings of marine mammals during a recent marine ecology survey at Lindeman Island, whale sounds were heard loudly and continuously underwater in a survey by BMT WBM (2013). Along with Humpbacks, Minke and Bryde's whales are also likely to use deeper waters of the project marine area.

Figure 9-9. Model prediction of average environmental suitability for Humpback whales in the Great Barrier Reef Marine Park along the southern coast of Queensland. From Smith et al. 2012.



Dolphins

Indo-Pacific Humpback, Australian Snubfin, Bottlenose, Common and Risso's dolphins are likely to occur in all subtidal habitats of the project marine area where they would hunt, often in groups, for fish and cephalopods.

Dugongs

The dugong *(Dugong dugon)* is listed under the 'marine' and 'migratory' schedule of the EPBC Act and under the 'vulnerable' schedule of the NCWR Act (refer **Chapter 26**). Internationally, it is listed under the CMS and the CITES and as 'vulnerable' on the IUCN Red List. Dugongs feed almost exclusively on seagrass, particularly *H. uninervis*, *H. ovalis* and *H. spinulosa*, and principally inhabit seagrass meadows (Lanyon & Morris 1997). Their dependence on seagrass for food generally limits them to waters within 20 km of the coast, although individuals have been sighted further from the coast during aerial surveys (Marsh and Lawler 2002). While there is little scientific data on dugong within the project marine area, dugong may occur in the project marine area on occasion where seagrass occurs.

9.2.8 Marine Birds

Marine birds, including a number of threatened and migratory birds (refer **Chapter 26**), would occur in the project marine area. These can be grouped broadly into those found commonly on coastal shores, including beaches, rocky shores, mudflats, tidal wetlands and lagoons (shore birds) and those that spend most of their time at sea (sea birds).

Shore Birds

Shore bird foraging habitat typically includes shallow waters and mudflats/sandflats of estuaries, channels, coastal lagoons, harbours and along open coasts. Shorebirds are typically carnivorous or omnivorous, eating worms, molluscs, crustaceans, fish and insects. Although the majority of species are diurnal, some forage nocturnally as well (e.g. Eastern Curlew). For many shore birds, roosting occurs along sheltered and occasionally open coastlines on sandy beaches above the high tide mark, while some roost on elevated areas. Foraging and roosting habitats for shore birds occur in the project marine area. Life cycles of shore birds vary. Some nest in colonies while others are solitary nesters or nest amongst other birds. Many shore birds first breed from one year of age though some breed later. The nesting period is generally between 20 to 35 days with 2 to 5 eggs in each clutch. Ground nesting is common with the nest consisting of a scrape in the ground, sometimes lined by pebbles or seaweed. Nesting along exposed beaches, islands and spits, or among sparse vegetation is not uncommon; however, most of the threatened or migratory bird species potentially occurring in the project marine area do not breed in Australia.

Migratory shore birds travel up to 26,000 km and on these return journeys they may cross state boundaries, countries and oceans, linking the ecosystems, communities and governments responsible for providing suitable habitat to support the survival of these species. Migratory shore birds are those species that are listed under one or more of the following international conventions to which Australia is a signatory:

(a) Bonn Convention on the Conservation of Migratory Species of Wild Animals 1979;

(b) Japan-Australia Migratory Bird Agreement (JAMBA);

(c) China-Australia Migratory Bird Agreement (CAMBA); or

(d) Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

There is little potential for shore bird roosting habitat on the upper parts of the sandy beach habitat of Home Beach in front of the existing resort given the height of the nearby bushes and trees and the proximity of built structures. Shorebirds generally prefer roosting habitat where there is a wide viewshed, that allows them to see approaching predators.

The lower sandy beach habitat at Home Beach in front of the existing resort, as well as the intertidal foreshore, offers potential foraging habitat for shorebirds. Surveys of shore birds were done in 2015 in Autumn and Spring/Summer during peak migratory shore bird abundance in Australia (see **Chapter 10**). No migratory shorebirds were observed at Home Beach in front of the existing resort or indeed, generally on other beaches monitored at Lindeman Island. The only shore birds observed were a pair of Sooty Oystercatchers (*Haematopus fuliginosus*) and these were flying south along the shoreline in the bay to the south of Coconut Beach on the western side of the island during the May 2015 survey period. This non-migratory species has occurs on coasts and islands throughout Australia.

Sea Birds

Sea birds can be found foraging and breeding across all Australian Commonwealth Waters. Potential foraging habitats for sea birds occur in the deeper waters of the project marine area. The lifestyle, behaviour and physiology of sea birds are varied but species exhibit similar feeding niches. Sea birds feed on the surface as well as dive for prey. They are mainly colonial, with nesting sites usually densely populated and on islands further south than Lindeman Island. Many species are highly dispersive or undertake long annual migrations both north-south and east-west, which can occur both after the breeding season for longer periods and to forage for chick provisioning.

9.3 Potential Impacts and Mitigation Measures

This section considers the potential impacts of proposed activities on the marine area, noting that a safe harbour is no longer proposed. A qualitative risk analysis was carried out to identify potential risks associated with the project, to determine and evaluate the level of risk associated with activities and to assist in identifying appropriate options to mitigate these risks. The risk assessment process was adapted from the GBRMPA Environmental Assessment and Management (EAM) Risk Management Framework (GBRMPA 2009a), itself based on the *Australian and New Zealand Standard guidelines for risk management (AS/NZS 4360:2004)* and the *Handbook for Environmental Risk Management – Principles and Process (HB 203:2006)* (Standards Australia 2006) which are considered international benchmarks in standard risk management. Risk is defined as the chance of something happening that will have an impact on objectives. It is measured in terms of consequences and their likelihood. 'Risk' in the environmental context should be thought of as the environmental consequences of a given severity and the likelihood of that particular consequence occurring (AS/NZS 4360: 2004).

Note: Due to GBRMPA's framework, this section varies from the standard risk assessment adopted in other sections.

Potential impacts/hazards from the project in relation to the existing marine environment of the project marine area were identified through a combination of specialist advice, literature review, stakeholder consultation and from issues identified in the terms of reference for the EIS. The risk analysis identified the relative significance of hazards both before and after the treatment of risks (i.e. after consideration of proposed mitigation).

Potential impacts/hazards may be associated with construction upgraded jetty/moorings as well as operational activities of the resort.

The following construction phase activities were considered to be potential hazards:

- Transport to and from the island of construction workforce, equipment and materials;
- Increased presence and visitation to the island;
- Generation of construction and domestic waste; and
- Stormwater and waste water management from civil construction works.

The following operational phase activities were considered:

- Increased presence and visitation to the island;
- Increased vessel traffic;
- Transport to and from the island of guests and resort and maintenance personnel;
- Reef utilisation including, recreational fishing, diving, snorkelling; and

> Utilisation of resort services including spa resort, golf course.

These activities may result in the following potential impacts to the marine environment:

> Increased turbidity and sediment deposition;

> Altered hydrodynamics;

> Degradation of water quality through spills of hydrocarbon and other contaminants, nutrient enrichment, littering and waste disposal;

> Vessel strikes on marine mammals;

> Disturbance to marine fauna from artificial lighting;

> Introduction of marine pests;

> Underwater noise; and

> Damage and disturbance from increased reef visitation.

A risk analysis was conducted to estimate the level of consequence of individual potential impact and the likelihood of the impact occurring, and a score was assigned to each consequence and likelihood. The product of the likelihood and consequence ratings of each potential impact was used to derive a risk level for individual natural values as shown in **Table 9-9.**

The rationale for scoring likelihood and consequence of a potential impact occurring is given in **Table 9-7** and **Table 9-8**. Scores of likelihood and consequence are then combined into a matrix to provide a qualitative assessment of risk. Based on this, each risk is identified as low, moderate, high or extreme. This does not mean that the project should not proceed (i.e. if the level of risk is high) or that an issue should be ignored if the level of risk is considered low, but rather that the issue may need greater or less effort in management and mitigation or that further research on the receiving environment is required. Consequence criteria were formulated based on the Significant Impact Guidelines for EPBC Act MNES and the EAM Risk Management Framework (GBRMPA 2009) and considered the potential for direct impacts (for example, loss of coral habitat) and indirect impacts (for example, altered community structure in response to altered water quality), and irreversible or temporary impacts.

Table 9-7. Qualitative measures of likelihood.

Level	Descriptor	Description
A	Almost Certain	Is expected to occur as a result of the project under most circumstances.
B	Likely	Will probably occur as a result of the project in most circumstances.
C	Possible	Could occur and has occurred in similar circumstances.
D	Unlikely	Could occur as a result of the project but is not expected.
E	Rare	Could occur only in exceptional circumstances.

Table 9-8. Qualitative measures of consequence, based on the EAM Risk Management Framework (GBRMPA 2009) and adjusted to the spatial scale of the project marine area.

Environment		
Level	**Descriptor**	**Description**
1	Catastrophic	Adverse impact to habitat/species throughout 'Conservation Park Zone' of Lindeman Island and potentially outside of this zone – recovery longer than 20 years.
2	Major	Significant local or widespread impact to habitat/species within the project marine area (nearshore areas of the southwestern side of Lindeman Island) – recovery over 10 to 20 years.
3	Moderate	Localised or widespread impact to habitat/species within the project marine area (nearshore areas of the southwestern side of Lindeman Island) - recovery over 5 – 10 years.
4	Minor	Localised impact to habitat/species within the project marine area (nearshore areas of the southwestern side of Lindeman Island) - recovery measurable within 1-5 years.
5	Insignificant	No impact on baseline environment (habitat/species) within the project marine area (nearshore areas of the southwestern side of Lindeman Island) - no additional mitigation required.

Table 9-9. Risk Matrix (After AS/NZS 4360:2004 and GBRMPA 2009).

			Consequence				
			5	4	3	2	1
			Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	A	Almost Certain	Moderate	Moderate	High	Extreme	Extreme
	B	Likely	Moderate	Moderate	High	High	Extreme
	C	Possible	Low	Moderate	High	High	Extreme
	D	Unlikely	Low	Low	Moderate	Moderate	High
	E	Rare	Low	Low	Moderate	Moderate	Moderate

E	Extreme risk	Risk is unmanageable and cannot be justified under any circumstances. Measures to reduce risk to a lower level are required.
H	High risk	Risk is significant and requires significant cost-effective measures for risk reduction and/or management.

M	Moderate risk	Routine and cost-effective measures required to reduce and/or manage risk. Risk may be acceptable.
L	Low risk	Risk can be managed by routine procedures and/or no further measures to manage the risk are required.

Key points that need to be recognised in relation to the general risk analysis:

- Potential impacts were identified through a combination of specialist advice, modelling, literature review and stakeholder consultation.
- The categories for environmental consequence are based on duration and spatial scale of potential impacts. Those that are localised but reversible in 1 - 5 years were considered minor, whereas those that would last longer and more widespread have a greater consequence.
- Detailed discussion of the potential impacts of the project and the rationale for the levels of risk are discussed in the following sections.
- The risk analysis identifies the relative significance of risks before mitigation (e.g. implementation of Construction and Operational EMPs). Risks are re-evaluated with these construction plans in place assuming they include the given recommendations.
- Although some risks are considered to be ‘low’, further action may be recommended (through routine procedures) as appropriate.
- Risk analysis is an ongoing process and is a tool to help identify the appropriate level of management or mitigation required.

Key Mitigation Strategies

The key mitigation strategy for reducing potential for impacts is the development of an Environmental Management Plan (EMP) for the project (refer to **Chapter 28**). The EMP states the commitments and objectives that are relevant to controlling risk. The EMP contains specific, measurable targets to achieve the objectives. In turn, those targets necessitate the application of certain management actions. In order to continuously improve the effectiveness of the project’s environmental management system, key performance indicators (KPIs) and monitoring activities are proposed to measure success in meeting the requirements and identify the need for corrective actions, for instance through proactive, responsive or contingency adaptive management. Reporting, terms and responsibilities complete the EMP which includes a number of supporting management plans such as the Construction EMP and Operational EMP.

Table 9-10. Overview of Monitoring Plans.

Program	Purpose
Dugong, cetacean and turtle monitoring	To minimise the risk of disturbance or injury to large marine vertebrates (dugongs, cetaceans and marine turtles) resulting from construction and ongoing resort activities
Marine pest monitoring	To trigger and inform emergency response on detection of a marine pest species

9.3.1 Coral Assemblages

A safe harbour is no longer proposed and as potential impacts arising from the project would be limited to indirect impacts (through changes in water quality and chemistry or hydrodynamics, and introductions of marine pests).

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas near the resort. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction and from exposed soils. Exposed (P)ASS leaching into the marine environment could reduce marine water quality and compromise the health of intertidal marine life. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**. The risk to coral habitats is low (refer to **Table 9-11**).

Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon spills, pollutants, nutrients and other waste associated with the jetty, barge landing, moorings or resort from the resort have the potential to contribute to the degradation of water quality. Best practice site management can be expected to result in a negligible amount of other pollutant material from dredging and construction entering the marine environment. Where the spill is a ‘once off’ and no other cumulative impact occurs, recovery is likely and hence spills are considered to be short-term, reversible impacts. Best-practice vessel management and site management will be used to minimise the risk of contaminant spillage. There will be no refuelling or vessel maintenance facilities at the jetty/barge landing point. Live-aboards will not be allowed at the moorings nor emptying of waste-water or bilges.

The Construction and Operational EMPs will establish and maintain personnel awareness of the importance of spill prevention and response management practices. Construction vessels and resort vessels are to provide sufficient spill response materials and locate those in close proximity to storage of hydrocarbons and chemicals as well as operational areas. .

During the construction of the resorts and ongoing operations, waste and sewage will be generated. Wastewater will be generated from the airstrip, pools, spa, restaurants, bars and the range of resort accommodation facilities. The Construction and Operational EMPs will contain criteria for disposing, managing, monitoring, minimising or avoiding the generation of different types of waste in line with applicable Acts, Regulations and International conventions.

Potential contamination of marine water has been assessed in terms of storm water contaminant concentrations and flushing times (described as e-folding times, refer to **Appendix H**). Model simulations were undertaken for the introduction of a conservative contaminant into the whole of the formerly proposed safe harbour (after two days of hydrodynamic warm-up). The simulations were run during a period of neap tides when flushing will be slowest and determined that the formerly proposed safe harbour will flush satisfactorily.

The risk of potential contamination or nutrient enrichment from wastewater and stormwater flowing into the marine environment is considered low given any spills will be of a temporary and reversible nature and the resort would use best practice filtering, storage and containment (refer to **Table 9-11**).

Introduction of Marine Pests or Diseases

Vessels and movement of offshore equipment have potential to act as vectors for introduced species. Introduced species may be translocated into the project marine area through the release of ballast water (in the case of planktonic larvae or species) or via reproduction from individuals attached to the hull of a vessel. Marine pests are considered to be a long-term, reversible impact to which marine communities have an existing level of exposure. The resort will not service international routes although occasional yachts may visit, but there would be regular local vessel movement to and from the island. The risk of vessel traffic introducing marine pests or disease to coral reefs would be moderate (refer to **Table 9-11**). Mitigation measures include standard practice procedure such as compliance with Australia's mandatory ballast water management requirements, with the addition of regular inspection of niche areas of high risk vessels. The risk assessment process will consider the known transmission vectors and the vessels operational and maintenance history to assess the overall risk status of a vessel. High risk vessels will be inspected to determine the presence or absence of marine pests. These inspections will focus on confirming that the vessel (including any residual sediment) presents a low risk of introducing marine pests to the area.

Increased Reef Visitation Impacts

Damage to corals in the vicinity of the resort may result from increased vessel traffic and increased reef utilisation (e.g. boating, fishing, snorkelling, swimming and diving). This impact is considered long term but reversible and the risk of it occurring is moderate (refer to **Table 9-11**). As part of the Operational EMP there would be clear communication to skippers about approved anchor locations/areas and no-go areas, including clear indication of these areas on board resort vessels as well as visible signage. If an underwater trail public education concept is adopted, the Operational EMP would include education material such as surface water signage to guide snorkelers and SCUBA divers and manage their behaviour on coral reef communities.

Vessel Wash

Vessel wash has been put forward as one of many factors contributing to erosion and other damage to natural foreshore areas, which are vulnerable to short duration erosion events and longer term recession or accretion (AECOM 2010). The biota on low-profile rock or coral reef platforms has potential to be physically damaged. This gives rise to a tendency of steepening of the cross-shore beach profile and sediment accumulation in the run-up zone. Profile steepening can be counteracted by natural waves to some degree.

Turbidity can be generated by large vessels' waves (which can also be a train of up to a dozen waves) but studies have shown that turbidity generally returns to ambient conditions quickly (within seconds or minutes) after the cessation of waves. During each event where vessel-generated waves increases turbidity, suspended sediment in the water column is likely to be transported long-shore according to tidal movement. Although there would be very little long-shore transport within each wave event, the effect would be incremental over time, so that sediment could be moved throughout the nearshore reef at Lindeman Island in front of the existing resort. Coral requires light to grow and survive and turbidity (suspended sediment) in the water column reduces light availability and causes a reduction in photosynthesis of these biota living in subtidal habitats. Suspended sediment can also lead to smothering and burial of biota from sedimentation. During the period of increased turbidity following vessel-generated waves there would potentially for localised reductions in light available to coral.

As the size and period of vessel wash is related to the speed at which vessels travel, slow vessel speed is a mitigation control that would be incorporated into the Operational EMP. There will be a designed 'no wash zone' within 500 m of the jetty that includes signage controlling vessel speeds to 4 kts and keeping boat wash at negligible levels.

Table 9-11. Summary of project impact risk assessment on coral habitat in the project marine area.

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	**O**				**L**	**C**	**Risk Level**
●		Acid sulfate or potential acid sulfate sediment	Degradation of water quality, toxicity effect to corals	• Prepare and implement an Acid Sulfate Soils Management Plan.	E (Rare)	3	Moderate
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Changes to water quality from contaminants, pollutants or nutrients may impact on coral health, reproduction, community composition and resilience to other stressors	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of vessels permitted; • Checking of vessel to prevent drips, leaks or failures; • Spill kits would be available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited; • Appropriate stormwater retention, filtering and treatment; • Golf course operations and maintenance including fertiliser application in accordance with Environmental Management Plan; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with Environmental Protection Policy (Waste) (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility.	E (Rare)	4	Low
●	●	Introduction of Marine Pests	Pests can out-compete native species and result in loss of biodiversity	• Standard practice procedure such as compliance with Australia's mandatory ballast water management requirements;	E (Rare)	3	Moderate

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
				• Regular inspections of high risk vessels.			
	●	Increased Reef Visitation	Damage to coral colonies caused by resort activities and visitation, vessel wash and anchoring.	• Install appropriate signage regarding anchoring areas and no go area and no wash zone; • Underwater snorkel/SCUBA trail to restrict spatial scale of damage.	C (Possible)	4	Moderate

9.3.2 Beaches and Intertidal Rocky Shores

Change in Habitat Extent

The present resort beach is held between headlands and groynes and ongoing loss by longshore transport is negligible. From time-to-time sand may be lost by transport seaward beyond the reef edge, but that loss is not quantifiable. Some wind-blown sand loss may occur, but the new revetments will generally prevent this process and resort management procedures will likely return any windblown sand to the beach (refer to **Appendix H – Coastal Processes**). Over time, the beach at this end might show minor accretion in the order of a couple of metres.

Vessel wash has been put forward as one of many factors contributing to erosion of natural foreshore areas, which are vulnerable to short duration erosion events and longer term recession or accretion (AECOM 2010). Mass transport of beach sediment in the direction of wave propagation occurs due to the wave orbital motion and the surface rollers in the breaker zone. The run-up height is higher for long-period boat-generated waves (e.g. larger vessels) than for natural wind waves with the same height. Thus, the wash zone of beaches has the potential to become wider and higher due to waves from large vessels. This gives rise to a tendency of steepening of the cross-shore beach profile and sediment accumulation in the run-up zone. Profile steepening can be counteracted by natural waves to some degree.

The overall volume of beach would not change and the accretion and erosion of the resort beach represents a very small proportion of the extent of this habitat in the project marine area and generally at Lindeman Island (refer to **Table 9-12**). As the size and period of vessel wash is related to the speed at which vessels travel, slow vessel speed is a mitigation control that would be incorporated into the Operational EMP. There will be a designed 'no wash zone' within 500 m of the jetty that includes signage controlling vessel speeds to 4 kts and keeping boat wash at negligible levels.

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas near the resort. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction and from exposed soils. Exposed (P)ASS leaching into the marine environment could reduce marine water quality and compromise the health of intertidal marine life. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**. The risk to beaches and intertidal habitat is low (refer to **Table 9-12**).

Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon spills in the marine environment, pollutants and other waste associated with the resort and nutrients from the resort have the potential to contribute to the degradation of water quality and may pose a direct hazard to intertidal biota. Contaminants, pollution and nutrient impacts on the intertidal biota are considered to be short term and reversible in nature and the risk is considered moderate. Best-practice vessel management and site management will be used to minimise the risk of contaminant spillage. There will be no refuelling or vessel maintenance facilities. Live-aboards will not be allowed, nor emptying of waste-water or bilges.

The Construction and Operational EMPs will establish and maintaining personnel awareness of the importance of good spill prevention and response management practices. Construction vessels and resort vessels are to provide sufficient spill response materials and locate those in close proximity to storage of hydrocarbons and chemicals as well as operational areas.

During the construction of the resorts and ongoing operations, waste and sewage will be generated. The Construction and Operational EMP will contain criteria for disposing, managing, monitoring, minimising or avoiding the generation of different types of waste, in line with applicable Acts, Regulations and International conventions.

Introduction of Marine Pests or Diseases

Vessels and movement of offshore equipment have potential to act as vectors for introduced species. Introduced species may be translocated into the project marine area through the release of ballast water (in the case of planktonic larvae or species) or via reproduction from individuals attached to the hull of a vessel. Marine pests are considered to be a long-term, reversible impact to which marine communities have an existing level of exposure. However, given some intertidal pests with potential to be introduced could compete with intertidal biota, the risk is moderate (refer to **Table 9-12**).

Increased Reef Visitation Impacts

There is potential for damage to intertidal rock platform biota in the vicinity of the resort due to trampling and the risk of it occurring is moderate (refer to **Table 9-12**). Damage may occur on a small scale around the resort but it would not amount to an ecologically significant impact to intertidal biota in the project marine area. This risk could be managed through education and the delineation of walking trails on the reef flat.

Table 9-12. Summary of project impact risk assessment on beaches and intertidal rocky shore habitat in the project marine area.

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Toxicity effect to marine flora and fauna, including birds utilising the intertidal habitat	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of guest vessels permitted; • Checking of vessel to prevent drips, leaks or failures; • Spill kits would be available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited; • Appropriate stormwater retention and treatment; • Golf course operations and maintenance including fertiliser application in accordance with Irrigation Management Plan; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with Environmental Protection Policy (Waste) (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility;	E (Rare)	4	Low
●		Acid sulphate or potential acid sulphate sediment.	Degradation of water quality, toxicity effect to marine flora and fauna	• Prepare and implement an Acid Sulfate Soils Management Plan;	E (Rare)	2	Moderate
●	●	Introduction of Marine Pests	Pests can out-compete native species and result in loss of biodiversity	• Standard practice procedure such as compliance with Australia's mandatory ballast water management requirements; • Regular inspection and cleaning of niche areas of commercial vessels before travelling to and from jetty/barge landing;	E (Rare) #N/A	3	Moderate

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	**O**				**L**	**C**	**Risk Level**
	●	Increased Visitation	Trampling of rock platform biota caused by resort activities and visitation.	• Walking trails provided in appropriate locations and information signage.	B (Likely)	4	Moderate

9.3.3 Aquatic Vegetation

Change in Habitat Extent

Tropical seagrasses of the type at Lindeman Island generally show a seasonality where there is a general expansion of distribution spatial extent and density (cover) during the dry season and reduction during the wet season (Cardno 2015) (refer to **Figure 9-10**). Importantly, the surveys done by BMT WBM were done in late August near the end of the dry season, when cover would have been approaching maximum. The low cover in the small area of seagrass in the Survey Area suggests it would not be an important habitat for any species, including its potential for being an important food source to marine turtles or dugongs. The residual risk to seagrass habitat from the upgrades to jetty/moorings and resort operation are low (refer to **Table 9-13**). The Survey Area also intersects with macroalgae habitat which is not proposed to be disturbed as a result of the project (refer to **Figure 9-11**). This habitat is very common around the island and in the region.

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas near the resort. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction and from exposed soils. Exposed (P)ASS leaching into the marine environment could reduce marine water quality and compromise the health of intertidal marine life. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**. The risk to beaches and aquatic vegetation is low (refer to **Table 9-13**).

Figure 9-10. Footprint of the formerly proposed safe harbour (Version 4) over seagrass distribution.

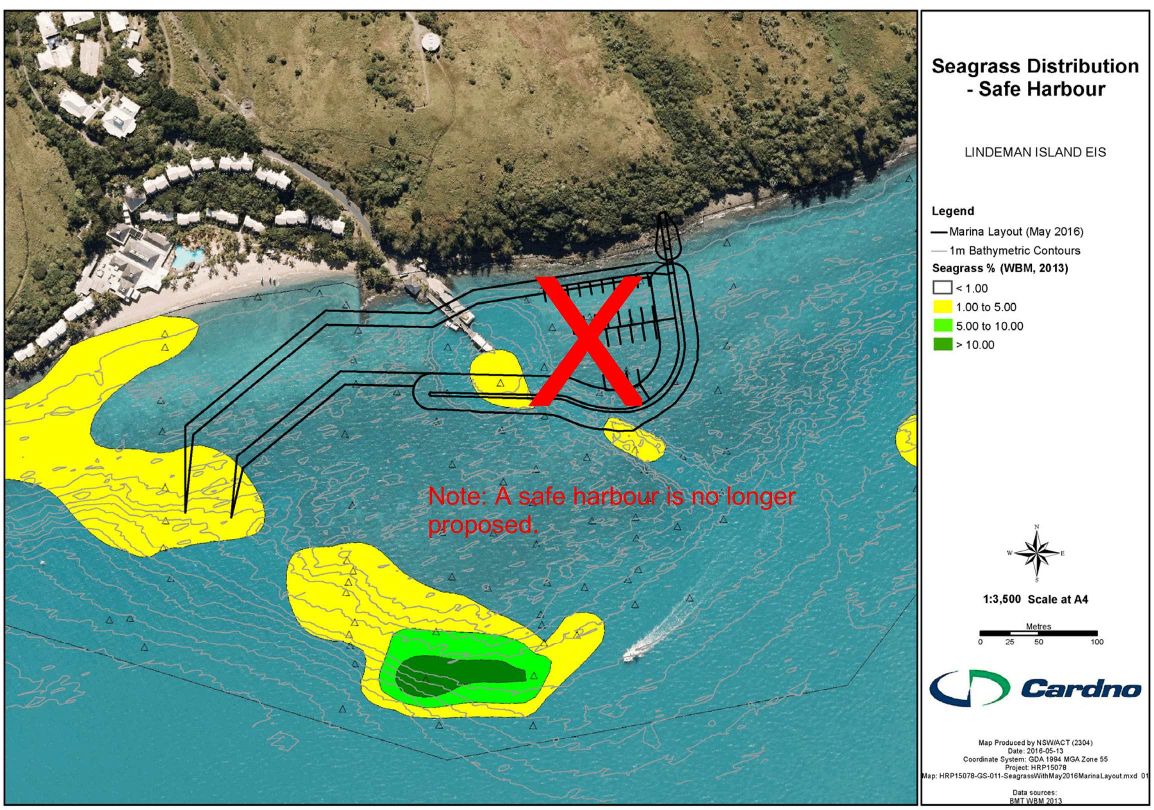
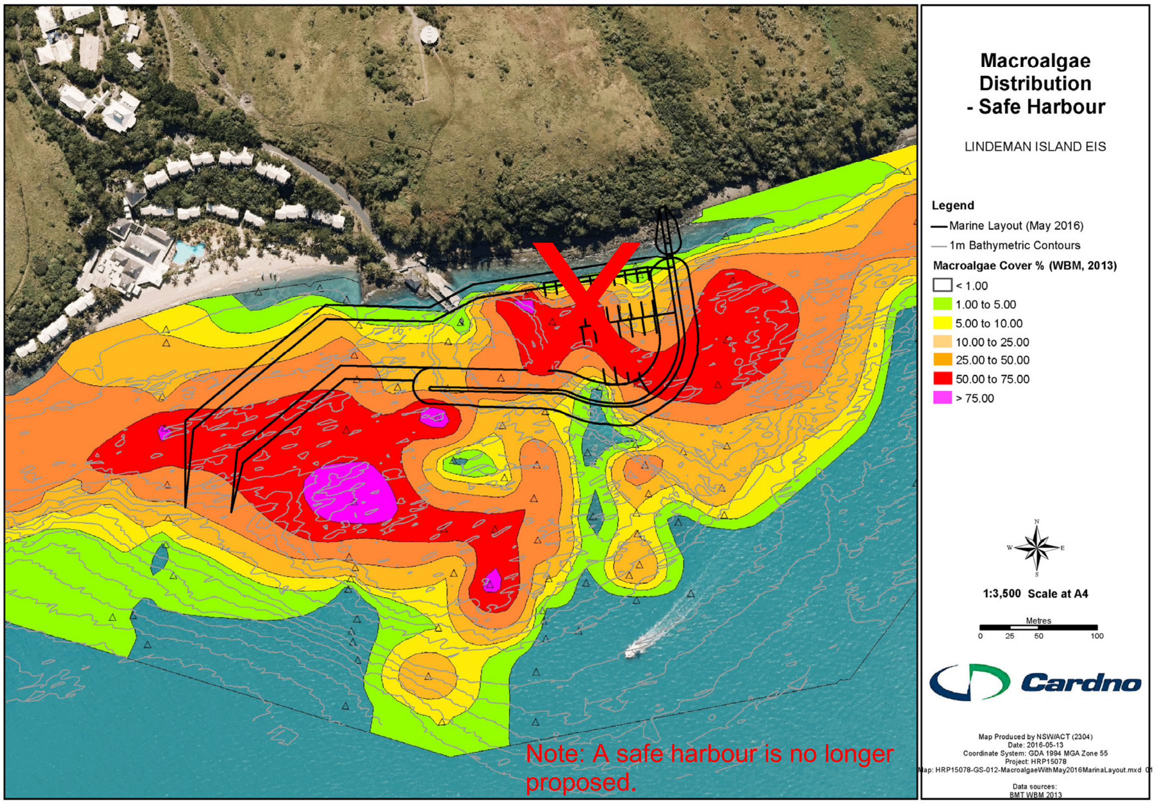


Figure 9-11. Footprint of the formerly proposed safe harbour (Version 4) over macroalgae distribution.



Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon and other waste associated with the resort and nutrients from the resort have the potential to contribute to the degradation of water quality and may pose a direct hazard to marine vegetation (refer to **Appendix H**). Best practice site management can be expected to result in a negligible amount of other pollutant material deposited into the marine environment. Contaminants, pollution and nutrient impacts on the inshore marine vegetation are considered to be short term and reversible in nature and the risk is considered low (refer **Table 9-13**).

Introduction of Marine Pests or Diseases

Vessels and movement of offshore equipment have potential to act as vectors for introduced species. Introduced species may be translocated into the project marine area through the release of ballast water (in the case of planktonic larvae or species) or via reproduction from individuals attached to the hull of a vessel. Marine pests are considered to be a long-term, reversible impact to which marine communities have an existing level of exposure however, no pests are likely to be introduced that would affect seagrass or macroalagae and the risk to aquatic flora is low (refer **Table 9-13**).

Increased Reef Visitation Impacts

There is potential for damage to seagrass or macroalgae in the vicinity of the resort to result from increased vessel traffic and increased reef utilisation (e.g. boating, fishing, snorkelling, swimming and diving) but the risk of it occurring is low (refer **Table 9-13**). Seagrass closest to shore to the western end of the resort beach would be most affected due to its potential to be trampled but given proposed management strategies it is unlikely that people would be walking in the area. Further as the density of seagrass in this area is very low, any damage is unlikely and if it did occur, it would not amount to ecologically significant impact to seagrass in the project marine area.

Table 9-13. Summary of project impact risk assessment on seagrass and macroalgae habitat in the project marine area.

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Toxicity effect of contaminants or pollutants to seagrass and algae Potential for overgrowth of seagrass/algae by epiphytes, limiting light available for photosynthesis and reducing productivity and growth	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of vessels permitted; • Checking of vessel to prevent drips, leaks or failures; • Spill kits would be available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited; • Appropriate stormwater retention and treatment; • Golf course operations and maintenance including fertiliser application in accordance with Environmental Management Plan; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with *Environmental Protection Policy (Waste)* (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility;	E (Rare)	4	Low
●	●	Introduction of Marine Pests	Pests can out-compete native species and result in loss of biodiversity	• Standard practice procedure such as compliance with Australia's mandatory ballast water management requirements;	E (Rare)	4	Low

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
				• Regular inspections of high risk vessels using the jetty/barge landing point;			
	●	Increased Visitation	Trampling of seagrass caused by resort activities and visitation.	• Walking trails provided in appropriate locations and information signage restricting access to sensitive locations;	D (Unlikely)	4	Low
●	●	Acid sulfate or potential acid sulfate sediment	Degradation of water quality, toxicity effect to corals	• Prepare and implement an Acid Sulfate Soils Management Plan.	E (Rare)	3	Moderate

9.3.4 Subtidal Soft Sediment Fauna

Change in Habitat Extent

No dredging of the soft sediment is proposed. This habitat is very common around the island and in the region but nonetheless the newly created habitat would support infaunal and epifaunal assemblages. As well as being a source of food for organisms higher up the food chain, such as fish and large invertebrates, including some sharks, stingrays and loggerhead turtles, they would also drive nutrient cycling through reworking of the sediments (bioturbation).

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas and the risk to marine habitats and biota is low. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction and from exposed soils. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**.

Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon spills, pollutants and other waste associated with the resort have the potential to contribute to the degradation of water quality and may pose a direct hazard to soft sediment fauna in deeper waters beyond the nearshore reef. Best practice site management can be expected to result in a negligible amount of other pollutant material from construction to the marine environment. Contaminants, pollution and nutrient impacts on the soft sediment fauna in deeper waters beyond the nearshore reef are considered to be short term and reversible in nature and the risk is considered moderate (refer **Table 9-14**).

Introduction of Marine Pests or Diseases

Vessels and movement of offshore equipment have potential to act as vectors for introduced species. Introduced species may be translocated into the project marine area through the release of ballast water (in the case of planktonic larvae or species) or via reproduction from individuals attached to the hull of a vessel. Marine pests are considered to be a long-term, reversible impact to which marine communities have an existing level of exposure however, and given there are potential subtidal soft sediment pests with potential to be introduced that would compete with native biota the risk is moderate (refer to **Table 9-14**).

Table 9-14. Summary of project impact risk assessment on subtidal soft sediment fauna in the project marine area.

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
●	●	Acid sulfate or potential acid sulfate sediment	Degradation of water quality, toxicity effect to corals	• Prepare and implement an Acid Sulfate Soils Management Plan;	E (Rare)	3	Moderate
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Toxicity effect to marine flora and fauna, including fish utilising the subtidal soft sediment habitat	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of vessels permitted; • Checking of vessel to prevent drips, leaks or failures; • Spill kits would be available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited • Appropriate stormwater retention and treatment • Golf course operations and maintenance including fertiliser application in accordance with an Irrigation Management Plan • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with *Environmental Protection Policy (Waste*) (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility;	E (Rare)	4	Low
●	●	Introduction of Marine Pests	Pests can out-compete native species and result in loss of biodiversity	• Standard practice procedure such as compliance with Australia's mandatory ballast water management requirements; • Regular inspection and cleaning of niche areas of commercial vessels before travelling to and from the jetty and barge landing point.	E (Rare)	3	Moderate

9.3.5 Fish, Sharks and Rays, Sea snakes and Macrocrustaceans

The following sections assess project impacts generally to Fish, Sharks and Rays, Sea snakes and Macrocrustaceans. For an assessment of impacts to Sharks and Rays listed as threatened or migratory under the EPBC Act refer to **Chapter 26.**

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas and the risk to marine habitats and biota is low. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction and from exposed soils. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**.

Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon spills, pollutants, nutrients and other waste associated with the resort have the potential to contribute to the degradation of water quality. The risk to Fish, Sharks and Rays, Sea snakes and Macrocrustaceans would be low as these species would move away from any potentially affected areas**.**

Increased Reef Visitation Impacts

There is potential for fishing to affect the abundance of some fish species. Shark and Rays and Sea snakes wold not be affected by fishing given they would not be targeted. Some reef fish may be caught in the project marine area but the removal of some individuals would not amount to ecologically significant impact to fish assemblage in the project marine area and the risk is low (refer to **Table 9-15**).

Table 9-15. Summary of project impact risk assessment on fish, sharks and rays, sea snakes and macrocrustaceans in the project marine area

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Toxicity effect to marine fauna	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of guest vessels permitted; • Checking of vessel to prevent drips, leaks or failures; • Spill kits would be available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited; • Appropriate stormwater retention and treatment; • Golf course operations and maintenance including fertiliser application in accordance with Environmental Management Plan; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with *Environmental Protection Policy (Waste)* (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility;	E (Rare)	4	Low
●		Acid sulfate or potential acid sulfate sediment	Degradation of water quality, toxicity effect to marine fauna	• Undertake work in accordance with Acid Sulfate Soils Management Plan.	E (Rare)	4	Low
	●	Increased Reef Visitation	Resort activities, fishing, visitation and fish feeding.	• Fishing locations and effort managed as part of the Environmental Management Plan; • Install appropriate signage.	E (Rare)	4	Low

9.3.6 Marine Turtles, Marine Mammals and Marine Birds

The following sections assess project impacts generally to Marine Turtles, Marine Mammals and Marine Birds. For an assessment of impacts to specific threatened or migratory species listed under the EPBC Act see **Chapter 26**.

Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste

Hydrocarbon spills, pollutants, nutrients and other waste associated with the resort have the potential to contribute to the degradation of water quality and may pose a direct hazard to Marine Turtles, Marine Mammals and Marine Birds temporarily foraging or resting in the habitats close to the resort. The risk to Marine Turtles, Marine Mammals and Marine Birds would be low (refer to **Table 9-16**) given the controls proposed for the Construction and Operational EMPs.

Litter and Waste Generated by Construction, Resort Activities and Recreational Fishing

There is potential for accidental release of litter and other hard wastes by vessels used during construction and operations of the resort. There is also potential for litter and other hard wastes to enter the nearshore waters of the project marine area via resort stormwater outlets and from vessels, fishing and boating. Some marine debris have potential to entangle or harm marine mammals, marine turtles or marine birds. This type of threat is listed in the EPBC Act as the key threatening process 'Injury and fatality caused by ingestion of, or entanglement in harmful marine debris'. Given the following controls on the project regarding the release of litter and other hard waste, the risk of this impact, and consequently the key threatening process, is low (refer to **Table 9-16**).

- Monitor incidence of injury/fatalities and fishing effort and manage as appropriate;
- Education on responsible fishing;
- Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil;
- Allocated areas for solid and liquid waste storage on board of vessels;
- All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with *Environmental Protection Policy (Waste)* (refer EPP Waste);
- Waste removed from vessels and disposed of at an approved facility; and
- Housekeeping procedures implemented to minimise the generation of waste and all waste stored appropriately.

Acid Sulfate Soils

There is a low potential for potential acid sulfate soils in the intertidal areas and the risk to marine habitats and biota is low. Notwithstanding this, there is potential for runoff from potential acid sulfate soils ((P)ASS) on the island during construction. As such an Acid Sulfate Soils Management Plan is proposed in accordance with **Chapter 28 – Environmental Management Plan**.

Vessel Strikes to Some Marine Fauna

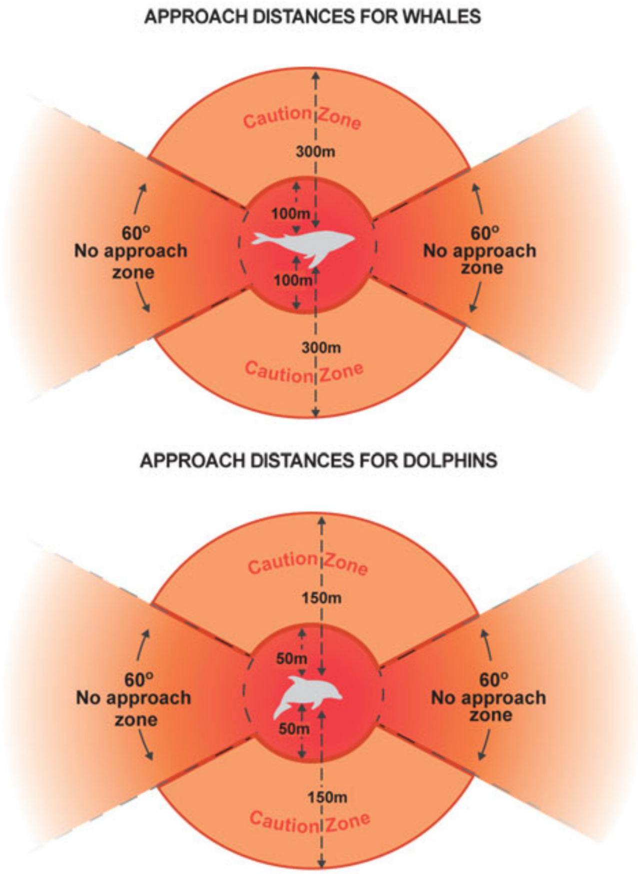
Increased vessel traffic near the project marine area during both construction and resort operation has the potential to increase the risk of collision between vessels and marine fauna. Marine Turtles, Cetaceans and Dugongs are susceptible to harm from vessel strike.

Mitigation measures include the establishment of 'go slow' zones in line with Maritime Safety Queensland (MSQ) boating safety requirements, and signage for general best boating practice. The Operational EMP would be prepared and actioned to educate skippers as to how best to avoid boat strikes and any boat strikes or stranding would be reported to management and relevant agencies. Skippers are to respond to whale observations in accordance with vessel interaction procedures including the application of 300 m observation zone and 100-m exclusion zone (refer to **Figure 9-12**). Skippers are to respond to dolphins and dugong observations in accordance with vessel interaction procedures including the application of 150 m observation zone and 50 m exclusion zone. Skippers are to respond to turtle observations in accordance with vessel interaction procedures including the application of 100 m observation zone and 50 m exclusion zone. Skippers are to respond to sightings in accordance with vessel interaction procedures outlined in **Figure 9-12** including application of a "no wash" speed for fauna approaching the vessel within the Observation Zone during operations

All reasonable efforts to reduce these impacts will be implemented as preventive management actions to manage the impact to protected marine species. In the unlikely event that vessel strikes occur, corrective actions will be considered and implemented on a case by case basis in order to adaptively respond and to prevent re-occurrence.

Vessel strike impacts are considered to be long term, but reversible if mitigated by slow boat speeds that minimise collisions or result in minor harm from which fauna may recover. The risk is moderate (refer to **Table 9-16**).

Figure 9-12. DoE guidelines on approach distances for whales and dolphins.



Artificial Lighting

Artificial lighting has potential to disturb species such as Marine Turtles or Marine Birds that are migrating, nesting or breeding. Artificial lighting is considered a long-term impact with moderate risk on marine fauna (refer to **Table 9-15**), due to the current artificial lighting profile on the island, the lack of turtle nesting in the project marine area and the availability of alternate roosting sites on the island. A range of measures are proposed to mitigate the impact of lighting throughout the resort, including:

- Maximum use will be made of bollard lighting for night-time safety and direction finding, with taller mast lighting used only where necessary;
- Lighting in the Eco Resort Precinct, Spa Resort Precinct, Tourist Villa Precinct and Beach Resort Precinct including the Central Facilities building in the Spa Resort Precinct will be downward-directed with minimal glare spillage, with no flood-lighting of trees or external walls above the surrounding vegetation screening height;
- Lighting of rooms associated with decks and large picture windows (if any) in eco-tourism villas will be fitted with dimmers and timers; and

- Lighting within the Central Facilities building in the Spa Resort Precinct will be downward-directed with minimal glare spillage.

Underwater Noise

Vessel noise has the potential to modify species behaviour and result in avoidance of the area by Marine Turtles and Marine Mammals. This potential impact is considered short term and project activities are considered unlikely to generate noise of an intensity or duration that may result in physiological impacts on species. The risk is moderate (refer to **Table 9-16**).

As a safe harbour is no longer proposed underwater sound from construction operations is not expected to exceed the underwater noise criteria. The observation that the sound generated by project activities could deter fauna away from the vicinity is considered advantageous to the species of interest. However, management measures will be applied to further reduce underwater noise impacts to protected marine species.

The Construction EMP will include procedures to limit physiological impact to marine megafauna as a result of sound and vibrations generated during construction activities. The construction Contractor is to ensure that all equipment is maintained in good operating condition and has proper sound control systems in place. The construction Contractor is to apply any of the following sound minimisation tools, where appropriate and practical:

- Mufflers;
- Use of special enclosures;
- Sound-insulation mounts;
- Propeller shrouds; and
- Tuned propellers and drive shafts.

The construction Contractor is to minimise the sound generation of equipment (thrusters and auxiliary plant) by switching them off when not used (e.g. avoid running on standby mode).

In the event that any sound- or noise-related incident takes place, the incident will be investigated and discussed to further improve awareness.

Table 9-16. Summary of project impact risk assessment on marine turtles, marine mammals and marine birds in the project marine area.

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	O				L	C	Risk Level
●	●	Degradation or Contamination of Water Quality from Hydrocarbons, Nutrients and Waste	Toxicity effect to marine fauna	• Fuel, oil and chemical storage and handling undertaken in accordance with AS1940. Minimised volume stored in a secure area; • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM (Department of Environment and Resource Management); • No refuelling of vessels permitted; • Refuelling of other vessels in designated areas and by licensed suppliers in accordance with their Standard Operating Procedures; • Checking of vessel to prevent drips, leaks or failures; • Spill kits available and a register of Materials Safety Data Sheet relating to all hazardous substances on board maintained and audited; • Education on responsible fishing; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • Waste removed from vessels and disposed of at an approved facility; • Housekeeping procedures implemented to minimise the generation of waste and all waste stored appropriately.	E (Rare)	4	Low
●	●	Litter and waste generated by construction, resort activities and recreational fishing.	Litter and waste from vessels, fishing and boating. Injury and fatality caused by ingestion of, or entanglement in harmful marine debris (EPBC Act)	• Monitor incidence of injury/fatalities and fishing effort and manage as appropriate; • Education on responsible fishing; • Waste material contained within the designed maintenance area and disposed of in designated bins to prevent contamination of water and soil; • Allocated areas for solid and liquid waste storage on board of vessels;	E (Rare)	4	Low

Phase		Impacting Process	Potential Impact	Adopted Mitigation Strategies	Residual Risk Level		
C	**O**				**L**	**C**	**Risk Level**
				• All waste disposed lawfully and wastes listed as 'trackable wastes' handled or transferred in accordance with *Environmental Protection Policy (Waste)* (refer EPP Waste); • Waste removed from vessels and disposed of at an approved facility; • Housekeeping procedures implemented to minimise the generation of waste and all waste stored appropriately.			
●		Acid sulfate or potential acid sulfate sediment.	Degradation of water quality, toxicity effect to marine flora and fauna	• Levels of acid sulfate likely to be low based on sampling done according to NAGD guidelines.	E (Rare)	2	Moderate
●	●	Vessel Strike	Boat strikes to marine turtles and mammals (whales and dugong) due to increased marine traffic. Collisions may result in injuries or death.	• Designation of 'go slow' zones; • Resort Tours Management Plan prepared and actioned as part of the Environmental Management Plan; • Any boat strikes or strandings reported to management and relevant agencies.	E (Rare)	3	Moderate
●	●	Artificial Lighting	Disorientation and behavioural changes in adults and juvenile marine turtles, some birds	• Sympathetic lighting strategies included in the design of resort and infrastructure	C (Possible)	4	Moderate
●	●	Underwater Noise	Disorientation and behavioural changes in adults and juvenile marine turtles and marine mammals	• Sympathetic lighting strategies included in the design of resort and infrastructure	C (Possible)	4	Moderate

9.4 Summary

The project's marine area includes sandy beaches, rocky shores, fringing coral reef, soft bottom areas, sparse seagrass and macroalgae. These marine habitats are important to mobile fauna including fish, shark, rays, sea snakes, macrocrustaceans, marine turtles, marine mammals and marine birds. Some of which are listed threatened or migratory species. Coral habitat, in particular, is considered carefully with respect to developments proposed in the Whitsunday region of the Great Barrier Reef Marine Park. In order to avoid impacts on coral habitats a safe harbour is no longer proposed. Instead the proponent seeks approval for upgrades to the existing jetty and additional moorings to be located around the island to provide access for resort craft under a range of wave and wind conditions.

Any impacts associated with proposed marine access arrangements will be appropriately addressed through the Environmental Management Plan includes a range of commitments and objectives that are relevant to controlling risk. The Environmental Management Plan contains specific, measurable targets to achieve the objectives. In turn those targets necessitate the application of certain management actions. The following provides a summary of the key matters addressed in this section.

Coral

Coral assemblages typically include hard corals mixed among soft corals, sponges, ascidians, gastropods, macroalgae and other invertebrate taxa. While the most diverse coral communities are in clear, offshore waters, extensive coral communities are also common in inshore tropical waters such as those adjacent to Lindeman Island. The coastal waters of Lindeman Island are within the Inner Shelf Lagoon Continental Island bioregion of the Great Barrier Reef (Kerrigan et al. 2010). This bioregion is characterised by strong currents, some gorgonians and low reef sites, very turbid water and seagrass meadows in some bays. Within this area, there are scattered coastal fringing reefs that generally develop around the mainland and high continental islands and these can have high coverage of hard coral, soft coral and macroalgae, but generally low coral diversity (Kerrigan et al. 2010).

Prior to Cyclone Debbie, the inshore coral habitats on fringing reefs in the Whitsundays were in very good condition, showing some of the highest coral cover for inshore corals the Great Barrier Reef, and in contrast to many areas, long-term stability. Indeed, GBRMPA's *Whitsundays Plan of Management 2008* indicates coral habitat in the Whitsunday region is valued for its extensive and diverse reef structures and corals that are relatively uncommon on fringing reefs in the Great Barrier Reef Marine Park and that there are a number of reefs of outstanding species richness, coral cover, uniqueness (e.g. a high cover of branching corals for inshore reefs) and aesthetic appeal. The *Whitsundays Plan of Management 2008* also indicates that given fringing reefs are a relatively scarce resource they have important conservation and aesthetic values, and are vulnerable to degradation.

Lindeman Island is one of 74 islands in the Whitsunday region and many of these islands have fringing reefs. A comparison of the coral cover and communities on the reef in the vicinity of the proposed safe harbour with coral habitat on other Whitsunday islands indicated it was not unique, but rather it shows characteristics typical of fringing reefs in the region (see **Section 9.2.1**).

No impacts on the existing coral communities are now proposed as the proponent no longer seeks approval to establish a safe harbour.

Beaches and Intertidal Rocky Shores

The present resort beach is held between headlands and groynes and as such loss by longshore transport is likely to be negligible. From time-to-time sand may be lost by transport seaward beyond the reef edge, but that loss is not quantifiable. Some wind-blown sand loss may occur but resort management procedures will likely return any windblown sand to the beach.

Seagrass and Macroalgae

Seagrass assemblages are generally sparse throughout the shoreline around Lindeman Island (BMT WBM 2013). The densest seagrass meadows are located south of the existing jetty in soft sediment beyond the edge of the reef and, outside of the project's marine area, at Boat Port and Coconut Beach. *Halophila spp.* (including *H. ovalis, H. decipiens and H. spinulosa*) and *Halodule uninervis* are the two most common seagrass taxa in the project marine area. These are fast growing, early colonising species that are known to survive well in unstable (shifting sediments) or depositional (subject to sedimentation) environments (Green and Short 2003). Both *Halophila* and *Halodule* are known to recover rapidly after disturbances, as they often establish large seed reserves in the sediment and/ or grow and expand rapidly from remaining patches. During a recent survey, seagrass meadows were generally sparse (mostly between 1% and 5% cover and one patch south of the existing jetty with cover > 10%), with a low above-ground biomass, with some soft and hard corals occurring in the same area (BMT WBM 2013). Some *Halophila spinulosa* was found in the dredged channel at the jetty site. A comparison of the distribution of the latest available survey (BMT WBM 2013) with the survey undertook by Hyland et al. (1988) indicates that seagrass distribution did not change substantially over time. The low cover in the small area of seagrass near the resort beach suggests it would not be an important habitat for any species, including its potential for being an important food source to marine turtles or dugongs. There will be negligible impacts on this community arising from the construction and operation of the resort, including proposed jetty upgrades and additional moorings.

Subtidal Soft Sediment Fauna

Soft sediment habitat exists in the existing channel and turning basin and the benthic habitat beyond the edge of the reef flat fringing Lindeman Island is also soft sediment benthic. Infaunal and epifaunal assemblages reside in soft sediment and would also recruit to the newly created habitat. Tropical benthic infaunal assemblages generally contain burrowing organisms such as polychaete worms, amphipod crustaceans, bivalve and gastropod molluscs and other worm-like phyla such as nemerteans and nematodes (which are often abundant). These animals are generally found within the upper 30 cm of the sediment. As well as being a source of food for organisms higher up the food chain, such as fish and large invertebrates, including some sharks, stingrays and loggerhead turtles, they also drive nutrient cycling through reworking of the sediments (bioturbation). There will be negligible impacts on this community arising from the construction and operation of the resort, including proposed jetty upgrades and additional moorings.

Fish, Sharks and Rays, Sea snakes and Macrocrustaceans

The subtidal rock and reef habitat at Lindeman Island is used by a range of adult and juvenile fish species including cod, butterflyfish, damselfish, wrasses and parrotfish. Over 48 taxa of fish were recorded from depths ranging from 2 to 4 m water depths in the vicinity of the formerly proposed safe harbour. Fish assemblages of Lindeman Island are typical of inshore waters of the Great Barrier Reef and major reef fin-fish families are likely to be generally similar to those found on reefs located a comparable distance from the mainland. Generally, inshore reefs of the central Great Barrier Reef tend to host fewer fin-fish species compared to mid-shelf or outer-shelf reefs. The dominant fish species of inshore reefs are Pomacentrids, Lutjanids and Chaetodontids, Labrids, while Acanthurids and Scarids are generally found in lower numbers on inshore reefs compared to mid or outer-shelf reefs (Williams 1982, Williams and Hatcher 1983). The risk to fish, sharks and rays, sea snakes and macrocrustaceans from upgrades to the jetty, proposed moorings and ongoing operations would generally be low given only a negligible amount of their habitat would be affected (relative to the extent in entire region).

Marine Turtles, Marine Mammals and Marine Birds

Marine turtles, marine mammals and marine birds would occasionally utilise the habitats in the project marine area and many of these are listed threatened and migratory species under the EPBC Act (see **Chapter 26**). Four of the six species of marine turtles known to occur along Australian coasts would be common in the project marine area. These include Flatback (*Natator depressus*) and Green (*Chelonia mydas*) turtles, and less commonly the Loggerhead (*Caretta caretta*) and Hawksbill turtles (*Eretmochelys imbricata*). The Leatherback (*Dermochelys coriacea*) and Olive Ridley (*Lepidochelys olivacea*) turtles are less likely to occur in the project marine area but may occur there very occasionally. Marine turtles are migratory and highly mobile species, moving between feeding grounds and rookeries, with males and females undertaking migrations of up to 3,000 km.

Several marine mammals (whales, dolphins and porpoises) listed under the 'cetaceans' schedule of the EPBC Act and the Sirenian *Dugong dugon* would occur in the project marine area. There are two core Humpback Whale habitat areas in the Southern Great Barrier Reef. One of them is located southeast of Lindeman Island, within the inner reef area and extending for approximately 100 km parallel to the coast. Along with Humpbacks, Minke and Bryde's whales are also likely to use deeper waters of the project marine area. Indo-Pacific Humpback, Australian Snubfin, Bottlenose, Common and Risso's dolphins are likely to occur in all subtidal habitats of the project marine area where they would hunt, often in groups, for fish and cephalopods. The dugong (*Dugong dugon*) is listed under the 'marine' and 'migratory' schedule of the EPBC Act and under the 'vulnerable' schedule of the NCWR Act. Dugongs feed almost exclusively on seagrass, particularly *H. uninervis, H. ovalis* and *H. spinulosa*, and principally inhabit seagrass meadows (Lanyon and Morris 1997). Their dependence on seagrass for food generally limits them to waters within 20 km of the coast, although individuals have been sighted further from the coast during aerial surveys (Marsh and Lawler 2002). While there is little scientific data on dugong within the project marine area, dugongs may occur in the area on occasion where seagrass occurs.

Marine birds, including a number of threatened and migratory birds, would occur in the project marine area. These can be grouped broadly into those found commonly on coastal shores, including beaches, rocky shores, mudflats, tidal wetlands and lagoons (shore birds) and those that spend most of their time at sea (sea birds).

For many shore birds, roosting occurs along sheltered and occasionally open coastlines on sandy beaches above the high tide mark, while some roost on elevated areas. Foraging and roosting habitats for shore birds occur in the project marine area. Ground nesting is common with the nest consisting of a scrape in the ground, sometimes lined by pebbles or seaweed. Nesting along exposed beaches, islands and spits, or among sparse vegetation is not uncommon; however, most of the threatened or migratory bird species occurring in the project marine area do not breed in Australia. Migratory shore birds travel up to 26,000 km and on these return journeys they may cross state boundaries, countries and oceans, linking the ecosystems, communities and governments responsible for providing suitable habitat to support the survival of these species.

Sea birds can be found foraging and breeding across all Australian Commonwealth Waters. Potential foraging habitats for sea birds occur in the deeper waters of the project marine area. Sea birds feed on the surface as well as dive for prey. They are mainly colonial, with nesting sites usually densely populated and on islands further south than Lindeman Island. Many species are highly dispersive or undertake long annual migrations both north-south and east-west, which can occur both after the breeding season for longer periods and to forage for chick provisioning.

All of the marine turtles, marine mammals and marine birds that could potentially utilise the marine habitats in the project marine area were considered temporary visitors and none were considered to reside permanently or breed in marine habitats on the foreshore or in waters in close proximity to Lindeman Island. As such, they do not rely implicitly on the marine habitats in the project area, which account for only a very small proportion of the regional habitat potentially used by these species. Hence, the potential impacts to marine turtles, marine mammals and marine birds would be limited to those associated with disturbance or injury to individuals visiting the island. It is considered that most marine turtles, marine mammals and marine birds visiting the foreshore or the waters in close proximity to Lindeman Island and that would be disturbed (during foraging, resting or while in transit between areas) by increased activity associated with project construction or ongoing operations on the south-western corner on the island, would be able to move to other (undisturbed) parts of the island or to similar habitats within the region. This may be inconvenient to individuals but not harmful and would not be a significant impact to these species. In addition, given resort and marina operations would be best practice and include a comprehensive environmental management plan as part of the Resort EMP, the risks of water pollution, degradation of water quality and transmission of water borne diseases would be acceptably low as would the potential for the key threatening process to occur 'Injury and fatality caused by ingestion of, or entanglement in harmful marine debris'.

The greatest risk to marine turtles, marine mammals and marine birds would be vessel strike to marine mammals, marine turtles and possibly the Whale Shark given there would be increased vessel activity associated with ongoing operations of the Project. Approach distances and interaction with marine mammals is regulated under State and Commonwealth regulations and the risks would be reduced further given marine operations would be best practice and include a management plan (as part of the Resort EMP) for vessels leaving and entering the jetty, barge landing point and moorings to ensure slow speeds as well as education to skippers on behaviours when in the vicinity of marine mammals and turtles and keeping appropriate vigilance. These arrangements would make the risk of vessel strike acceptably low.