Noosa Oyster Reef Restoration

Baseline Pre-Deployment Monitoring Report

Prepared for: The Nature Conservancy

Prepared by Ecological Service Professionals Pty Ltd

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Acknowledgement of Country: In the spirit of reconciliation Ecological Service Professionals acknowledges the Kabi Kabi, the Traditional Custodians of country where we have worked, and we recognise their connection to land, sea and community. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples through our scientific work on country.

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Executive Summary

This report has been prepared by Ecological Service Professionals (ESP) for The Nature Conservancy. It presents the results of the pre-deployment monitoring event completed in July and August 2022 for the Noosa Oyster Reef Restoration Project (the Project), prior to oyster reef deployment. The Project is being completed by deploying reefs in four restoration areas, under a Development Approval issued by Noosa Council.

The primary aim of the monitoring program is to assess the effectiveness of restoration on estuarine diversity (primarily oysters and other invertebrates, but also fish assemblages), and on marine plants and erosion potential of the shoreline.

The monitoring program has several components, including:

- Assessment of the response of estuarine organisms to the reintroduction of the oyster reefs into the estuary, including establishment of control locations;
- Assessment of the distribution of benthic habitats adjacent to the reef areas; and,
- Establish photo control points and assess the current position of the shoreline to assess potential erosion as a result of the reef construction.

Benthic Habitat

Benthic habitat was assessed using a combination of visual assessment on foot at low tide, underwater georeferenced photo transects and underwater spot checks using a surface view camera. Where visibility was low (due to turbidity of waters) a grapple was used to confirm the presence of subtidal seagrass. The assessment was used to update the habitat mapping layers established during a previous benthic habitat study in 2020.

Prior to deployment of reef substrate, it was confirmed that the substrate below reef restoration areas was bare sand at Goat Island, Noosa Sound East and Noosa Sound West. The areas adjacent to Tewantin were rock, gravel and mud; however, we were unable to obtain a good assessment of the presence of any macroalgae on the rocky reefs further offshore due to poor visibility. Macroalgae (such as *Padina* and turf forming algae), has previously been recorded in deeper water further out in the river channel, and will likely recruit onto the reef substrates once deployed.

Small patches of seagrass downstream of the restoration area at Goat Island that were previously mapped in 2020, were absent in the survey completed in July 2022. The small seagrass patches had died back, most likely due to recent prolonged turbid water conditions associated with flooding in 2022. Similarly, a small patch of seagrass directly upstream of the restoration area at Tewantin was also not recorded in 2022.

Shoreline Erosion Assessment

The position of the shoreline adjacent to the primary restoration areas and control areas of a similar size were mapped into a GIS for future temporal comparison. The position of the shoreline and bank edge was confirmed using RTK GPS (+/-10 cm), approximately 100 m up and down current of each restoration location (where access was possible) along the shoreline. Field observations and photographs of any obvious areas of erosion were collected for future annual monitoring of shoreline erosion or accretion.

There were signs of existing coastal erosion of the banks adjacent to most of the restoration areas; in some cases, the erosion was creating steep sloped banks and undercutting existing tree roots. The erosion was most prominent at Goat Island.

Several restoration areas had fringing mangroves along the coastline, which were not previously mapped due to a GIS error. The mangrove fringe at all restoration areas has now been mapped in finer detail, and habitat maps updated where required.

Oyster Assemblages

At each site, three 10 m long x 2 m wide belt transects were run parallel to the shoreline along a similar depth contour (as determined using RTK GPS (+/-10 cm)). The number and size of living oysters and other sessile organisms was assessed.

Oysters grew on some mangrove roots and rock adjacent to the restoration areas. The average density was typically less than 21 ind.m^{-2}. Where rock oysters occurred, they ranged in size from 2 to 58 mm, and were typically larger growing on rock at Tewantin and Noosa Sound West than on mangrove roots. Oysters only occurred in unstructured control sites on occasional small rocks scattered along the sites on bare sand, but these areas otherwise consisted of bare sand without rock oysters present.

Additional monitoring of the oyster density is planned for the restoration areas, positive (structured) and negative (unstructured) control areas following the summer spatfall in Autumn 2023.

Fish Assemblages

At each monitoring site, three replicate stereo Baited Remote Underwater Video Stations (BRUVS) were deployed in arrays for a minimum of 30 minutes at each location within 1.5 hours of high tide. Due to poor visibility, fish could only be assessed effectively using the BRUVS method at sites in Noosa Sound. The fish assemblages generally were dominated by yellowfin bream, with several other species that commonly occur in estuaries also present.

For each stereo-BRUV deployment, the total length of each fish will be measured (i.e. tip of fish nose to tip of the longest caudal lobe), but is pending an additional recalibration due to unforeseen changes in the initial camera setup (image resolution). These results will be included in the next monitoring report assessing changes in the fish assemblages following the installation of reefs.

Additional surveys of fish are planned once the reefs have been deployed. The assessments will compare and contrast the change in assemblages among restoration areas, structured and unstructured habitats around the estuary.

1 Introduction

This report has been prepared by Ecological Service Professionals (ESP) for The Nature Conservancy. It presents the results of the pre-deployment monitoring event completed in July and August 2022 for the Noosa Oyster Reef Restoration Project (the Project), prior to oyster reef deployment. The Project is being completed by deploying reefs in four restoration areas, under a Development Approval issued by Noosa Council.

1.1 Scope of Works

Baseline environmental compliance monitoring for the Noosa Oyster Reef Restoration Project was completed in accordance with the approved monitoring program provided in the Development Approval and *Oyster Habitat Restoration Monitoring and Assessment Handbook* (Baggett et al. 2014). The primary aim of the monitoring program is to assess the effectiveness of restoration on estuarine diversity (primarily oysters and other invertebrates, but also fish assemblages), and on marine plants and erosion potential of the shoreline.

The monitoring program has several components, including:

- Assessment of the response of estuarine organisms to the reintroduction of the oyster reefs into the estuary, including establishment of control locations;
- Assessment of the distribution of benthic habitats adjacent to the reef areas; and,
- Establish photo control points and assess the current position of the shoreline to assess potential erosion as a result of the reef construction.

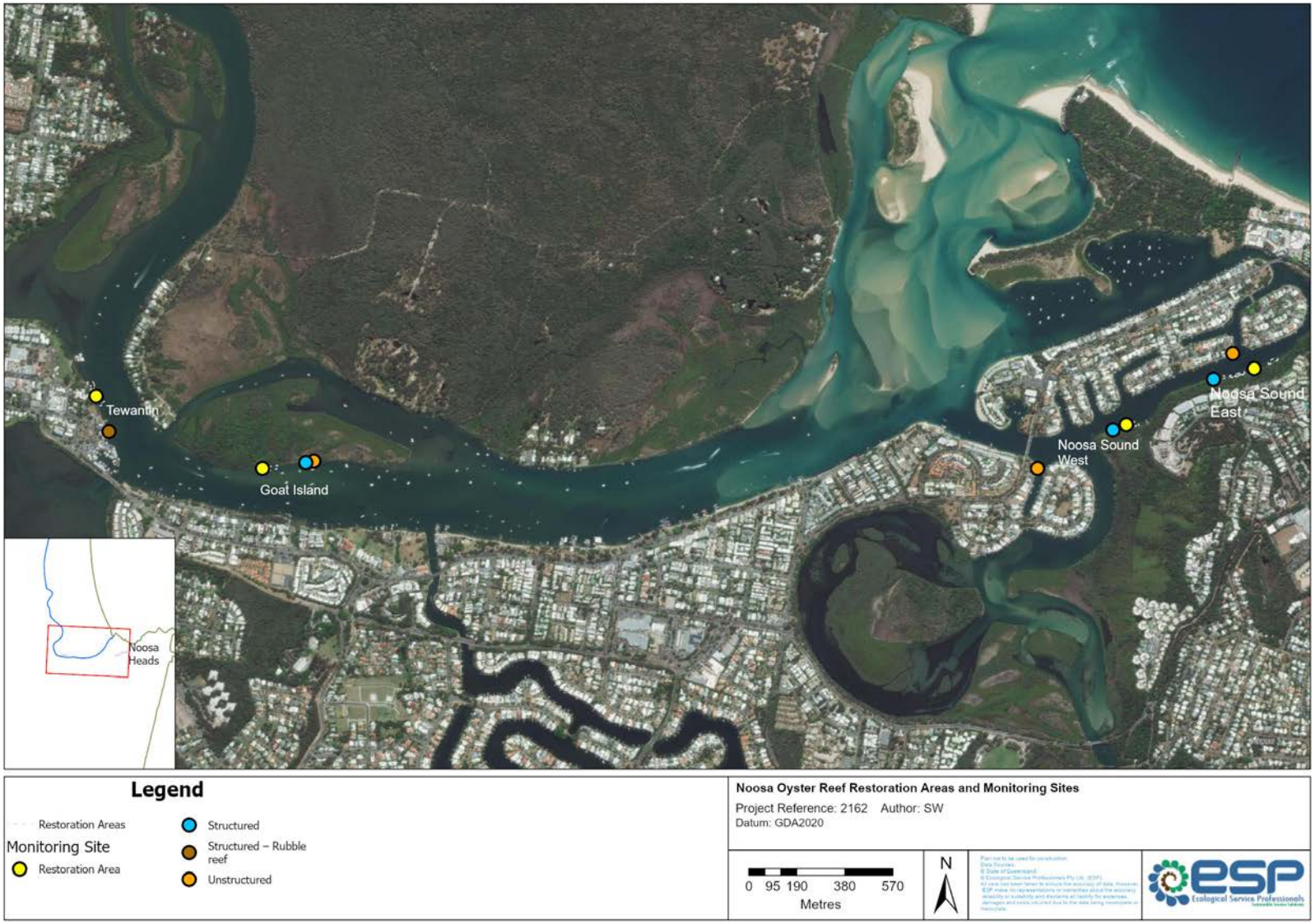

Figure 1.1 Restoration areas and monitoring sites

2 Methods

2.1 Timing

Baseline monitoring was completed in July and August 2022, prior to oyster reef deployment. Assessments of the benthic habitat, invertebrates and fish was completed at 12 sites surrounding the four restoration areas prior to reef deployment (Figure 1.1; Table 2.1).

2.2 Monitoring Site Details

Table 2.1 Monitoring sites in each restoration area

Restoration Area	Site	Easting ^	Northing	Habitat Type	Comment/Justification
Tewantin	Tewantin Restoration Area	504133.543	7080858.830	Restoration Area	Area on the shoreline adjacent to the restoration area at similar tidal height
	Tewantin Reef Control	504184.965	7080718.158	Structured – Rubble reef	Area on the shoreline adjacent to the restoration area next to swimming enclosure
Goat Island	Goat Island Restoration Area	504792.737	7080573.528	Restoration Area	Area on the shoreline adjacent to the restoration reef patches at similar tidal height. Bare sand including occasional mangrove root to be restored oyster reef habitat
	Goat Island Bare Control	504996.320	7080602.540	Unstructured	Bare sand negative control for reef areas. Shared control area with Tewantin
	Goat Island Mangrove Control	504963.0033	7080595.613	Structured	Positive control for structured habitat consisting of mangrove root fringe and sand adjacent to the restoration area
Noosa Sound East	Noosa Sound East Restoration Area	508717.4036	7080968.725	Restoration Area	Bare sand to be restored to oyster reef habitat
	Noosa Sound East Bare Control	508632.1623	7081027.813	Unstructured	Bare sand beach used for BRUV assessment only
	Noosa Sound East Mangrove Control	508555.292	7080926.639	Structured	Structured habitat consisting of mangrove root fringe used for BRUV assessment only
Noosa Sound West	Noosa Sound West Restoration Area	508210.961	7080745.344	Restoration Area	Bare sand to be restored to oyster reef habitat
	Noosa Sound West Bare Control	507858.965	7080572.241	Unstructured	Bare sand plus scattered rock – negative control for reef areas
	Noosa Sound West	508157.187	7080724.890	Structured	Positive control for structured habitat consisting of mangrove root fringe and sand

Restoration Area	Site	Easting ^	Northing	Habitat Type	Comment/Justification
	Mangrove Control				
	Noosa Sound West Rubble Control	508085.046	7080679.971	Structured	Positive control for rocky rubble area. Note that this area was only large enough for a single transect.

^ Datum: UTM Zone 56J, GDA2020

2.3 Benthic Habitat Assessment

2.3.1 Benthic Habitats

The benthic habitat at each of the restoration areas were confirmed and mapped using established techniques, including georeferenced image analysis and spot assessments. Surveys were completed using a combination of remote techniques from a vessel, and visual assessments on foot at low tide (where possible) to verify the presence of the mapped marine plants / habitats, and to update the habitat mapping layers established during a previous 2020 benthic habitat study (ESP 2021). A description of the habitat categories used was provided in ESP (2021) and is also summarised in Appendix A.

Additional detailed assessments were completed in areas where seagrass or macroalgae were present, to determine the species composition, coverage and condition (where possible). These detailed assessments were completed using a combination of visual assessment on foot at low tide, underwater georeferenced photo transects and underwater spot checks using a surface view camera. Where visibility was low (due to turbidity of waters) a grapple was used to confirm the presence of subtidal seagrass.

It was not possible to confirm the presence of subtidal macroalgae around Tewantin due to extremely low visibility (<5 cm) during the survey, which prevented a visual assessment of these habitats. The prolonged period of low water clarity and reduced salinity prior to the baseline surveys would have likely reduced the coverage of any macroalgae in that area. Macroalgae were absent from the intertidal areas along the shore at Tewantin.

Benthic habitat and the coverage of sessile organisms are still to be quantified by assessing the coverage type under 20 randomly placed points in each photo quadrat using Squidle+ online data annotation platform[1] due to delays in upload logistics using the platform.

A detailed map based on the initial desktop mapping and the field data was produced using ESRI ArcGIS, showing the extent of habitat present in each of the four restoration areas, including other broad marine habitats (e.g. bare substrate, rocky rubble or oyster reef) and marine plants (including seagrass and macroalgae).

2.3.2 Current Shoreline Position

The position of the shoreline adjacent to the primary restoration areas and control areas of a similar size were mapped into a GIS for future temporal comparison of changes in th position of the shoreline due to the reef restoration. The position of the shoreline and bank edge was

[1] Friedman A. 2022 https://squidle.org/

confirmed using a Trimble Catalyst DA2 GNSS RTK GPS (+/-10 cm), approximately 100 m up and down current of each restoration location (where access was possible), using a series of control points and regular high resolution GPS fixes along the shoreline. Field observations and photographs of any obvious areas of erosion were collected for future annual monitoring of shoreline erosion or accretion.

2.4 Oyster Assemblages

During a spring low tide the distribution, density and size of rock oysters was assessed at up to four monitoring sites in each of the four restoration areas (Noosa Sound East, Noosa Sound West, Goat Island and Tewantin), including structured (mangrove forest), structured (rubble), and unstructured (bare sand) habitat types (Table 2.1). At each site, three 10 m long x 2 m wide belt transects were run parallel to the shoreline along a similar depth contour (as determined using GNSS RTK GPS (+/-10 cm)). The number and size of living rock oysters was assessed in ten 0.5 x 0.5 m quadrats placed at random along each of the three transects per site (i.e. a total of 30 quadrats per site). Quadrat placement was randomised using a random number generator for distance along the transect and perpendicular to the transect mid-line. Within each quadrat, the number of oysters and mussels were counted and size (shell height) measured using callipers to the nearest millimetre. The density of live oysters (individuals per 0.25 m^2) was determined for each quadrat and converted to the density of oysters per square metre.

2.5 Fish Assemblages

At each four restoration areas (Noosa Sound East, Noosa Sound West, Goat Island and Tewantin), the fish assemblage was assessed at up to three sites (restoration area, unstructured (bare sediment), and in structured habitat (mangroves or rocky reef) (Table 2.1). At each site, three replicate stereo Baited Remote Underwater Video Stations (BRUVS) (Cappo et al. 2003) were deployed in arrays separated by approximately 20 metres, for a minimum of 30 minutes at each location. The units were deployed among the sites 1.5 hours either side of high tide (i.e. slack water). Each BRUVS was baited with three slightly crushed pilchards (*Sardinops sagax*). BRUVS were deployed as stereo units to allow for biomass estimates during post-processing at a later date.

While BRUVS were deployed at sites in Tewantin and Goat Island, it was not possible to assess the composition of fish assemblages at due to extremely poor water clarity for those sites.

Figure 2.1 SeaGIS stereo BRUV unit deployed in Noosa Sound

2.5.1 Video Processing

Videos were processed using the SeaGIS EventMeasure software. Fish were identified to the lowest taxonomic level possible and the MaxN per species assessed from the footage as the maximum number of individuals of the same species present in a frame at a time across each video (Cappo et al. 2003). Only footage from the left camera in the stereo pair was processed for MaxN and fish presence.

For each stereo-BRUVS deployment, the total length of each fish will be measured (i.e. tip of fish nose to tip of the longest caudal lobe), but is pending an additional recalibration due to unforeseen changes in the initial camera setup (image resolution). Total length will be used as this equates to a measure of the minimum legal length (MLL). These results will be included in a future monitoring report. The stereo cameras were calibrated using a SEAGIS calibration cube to allow for accurate length measurements from the stereo footage.

Additional observations of fish species were also included, where they were observed by the field team in shallow water, or using underwater video or ROV during habitat assessments.

Fish biomass for each species will be calculated (g/m^2 or kg/ha) for each survey location, assuming that fish that occur on the BRUVS have a daily home range of within 50 m of each BRUV unit. Biomass will be calculated following additional calibration of camera setup, and will be reported on in a future monitoring report.

3 Results

3.1 Benthic Habitat

As previously assessed (ESP 2021), the dominant habitat type in the restoration areas in 2022 prior to reef deployment was bare sand (Figure 3.1 to Figure 3.4). There were some small patches of seagrass (<30 m^2) recorded adjacent to the restoration areas at Tewantin and Goat Island in 2020 that were not present in July 2022, due most likely to habitat contraction in response to flooding and prolonged periods of high turbidity (and therefore low light penetration necessary for seagrass growth) in 2022. The closest patch of seagrass to the Goat Island restoration area was recorded approximately 200 m upstream, and the closest patch of seagrass adjacent to the Tewantin restoration areas was 43 m upstream.

Mangroves occurring along the shoreline at the Goat Island and Noosa Sound East restoration areas were incorrectly mapped in ESP 2021, due to a display error. The location of mangroves have subsequently been updated in the maps provided below (Figure 3.2 & Figure 3.3). Note that the full extent of mangroves occurring more than 5 m landward of the shoreline at Goat Island were not mapped in detail as they are unlikely to be impacted by the restoration area.

Figure 3.1 Habitat map and shoreline at Tewantin restoration area

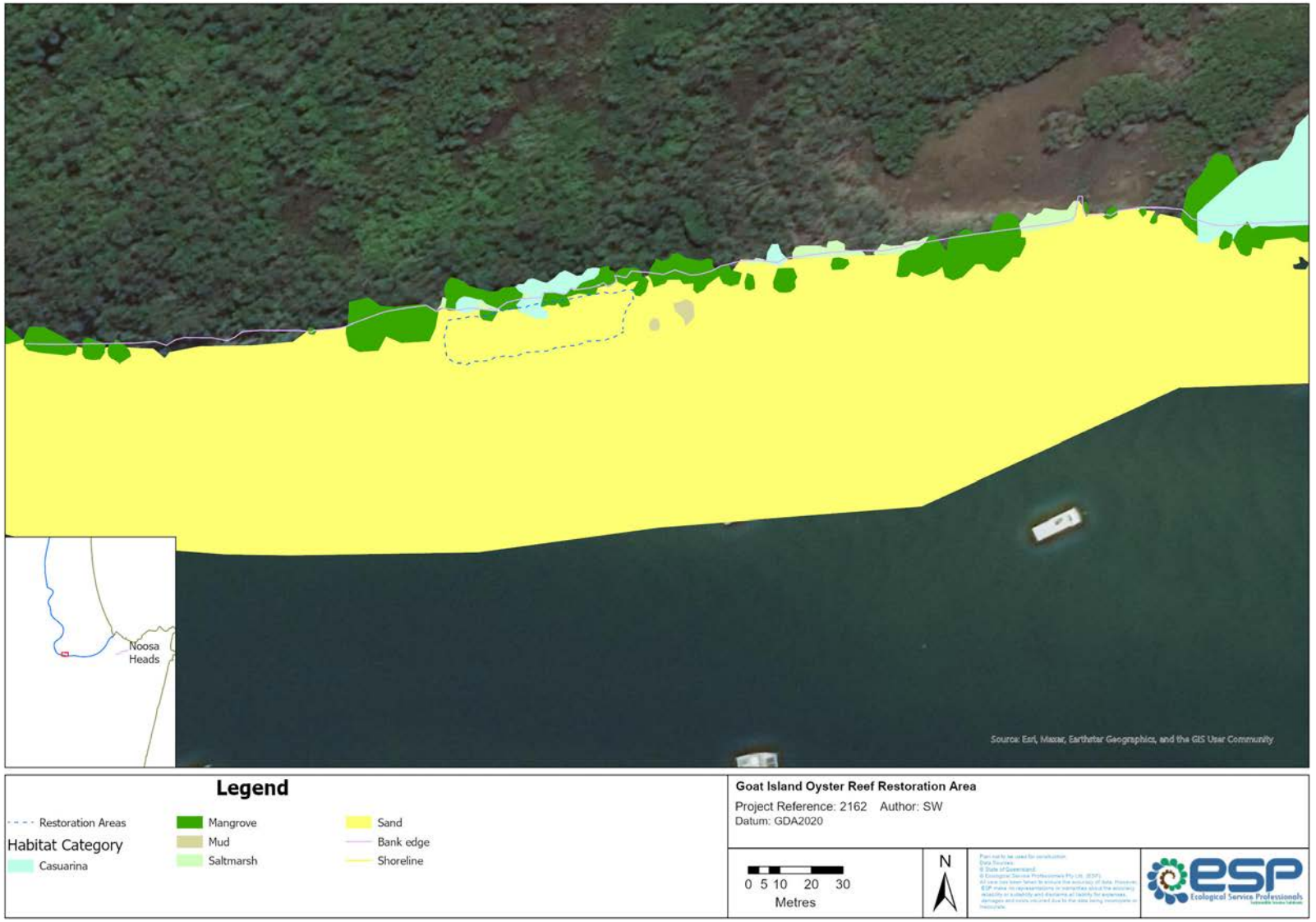

Figure 3.2 Habitat map and shoreline at Goat Island restoration area

Figure 3.3 Habitat map and shoreline at Noosa Sound East restoration area

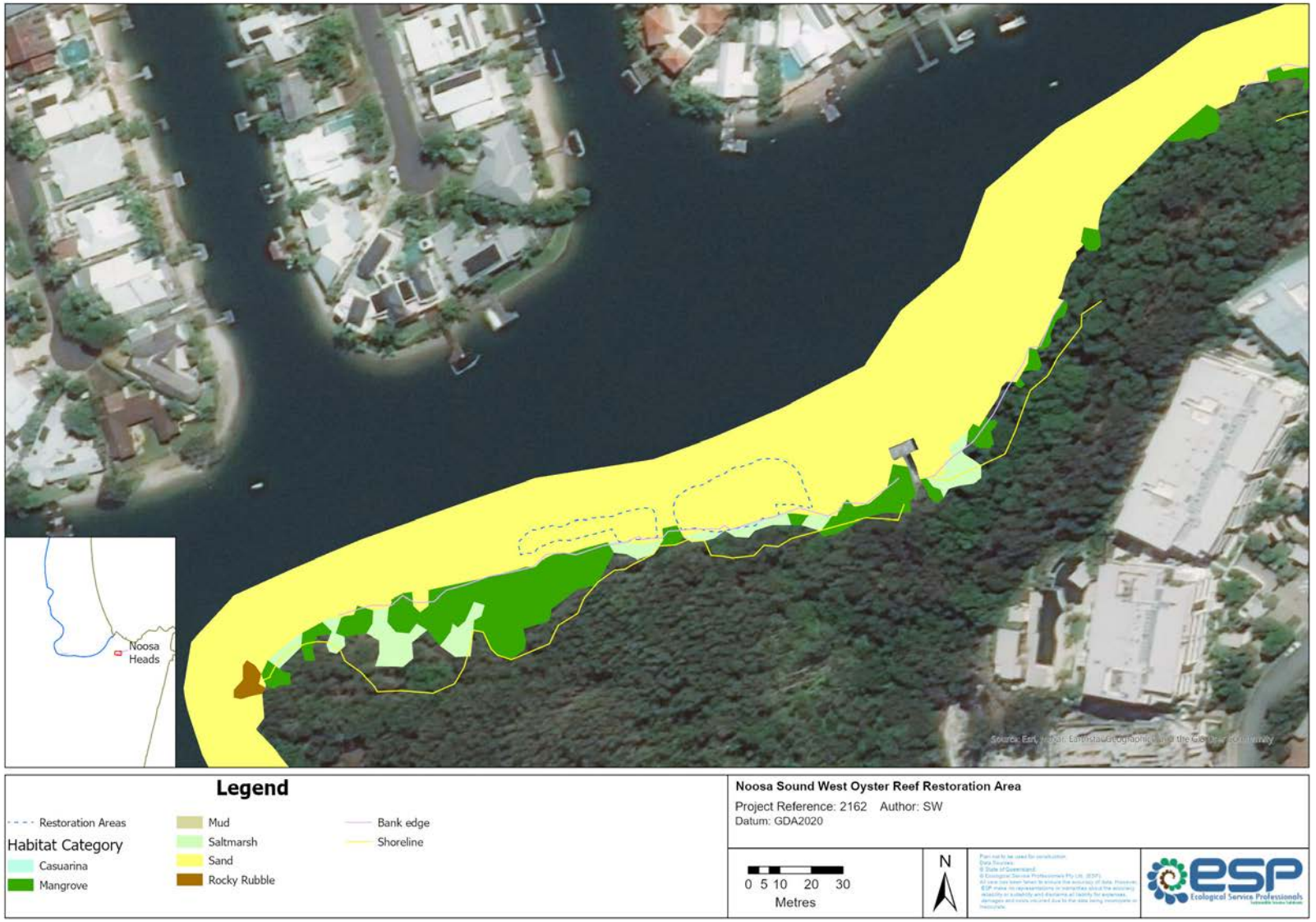

Figure 3.4 Habitat map and shoreline at Noosa Sound West restoration area

3.2 Shoreline Adjacent to Restoration Areas

There was evidence of significant shoreline erosion at two of the restoration areas (Tewantin and Goat Island), with steep banks and erosion of sediment, particularly around existing mangrove roots and swamp sheoak (*Casuarina glauca*) where present on the bank (Figure 3.5 to Figure 3.7). The existing erosion at these sites prior to restoration is likely due to scouring from recent flood flows in early 2022, as well as wave driven disturbance from boat wake along the main river channel.

At the Noosa Sound East and West restoration areas, the shoreline and mangroves were mapped adjacent to existing terrestrial habitat, which was typically on a steep slope. It is unlikely that the shoreline will erode in this location due to the underlying geology, so the bank edge was also mapped to allow for any changes as a result of reef deployment to be assessed at those sites.

Figure 3.5 Existing shoreline erosion along vegetated banks adjacent to Goat Island Restoration Area

Figure 3.6 Shoreline erosion and undercutting adjacent to Goat Island restoration area

Figure 3.7 Shoreline along the Tewantin restoration area

3.3 Oyster Assemblages

The highest average density of oysters (15.6 ind.m^{-2} ± 3.0) was observed at Tewantin (Figure 3.8 & Figure 3.9) and Noosa Sound West (21.2 ind.m^{-2} ± 6.4) (Figure 3.11) occurring on narrow intertidal rock and gravel outcrops along the shoreline. Oysters were also observed growing on some mangrove roots adjacent to some restoration areas, although at lower average densities (2 to 8 ind.m^{-2}) (Figure 3.10).

Oysters were largely absent from sandy substrates, except on occasional rocks within the negative (unstructured) control sites.

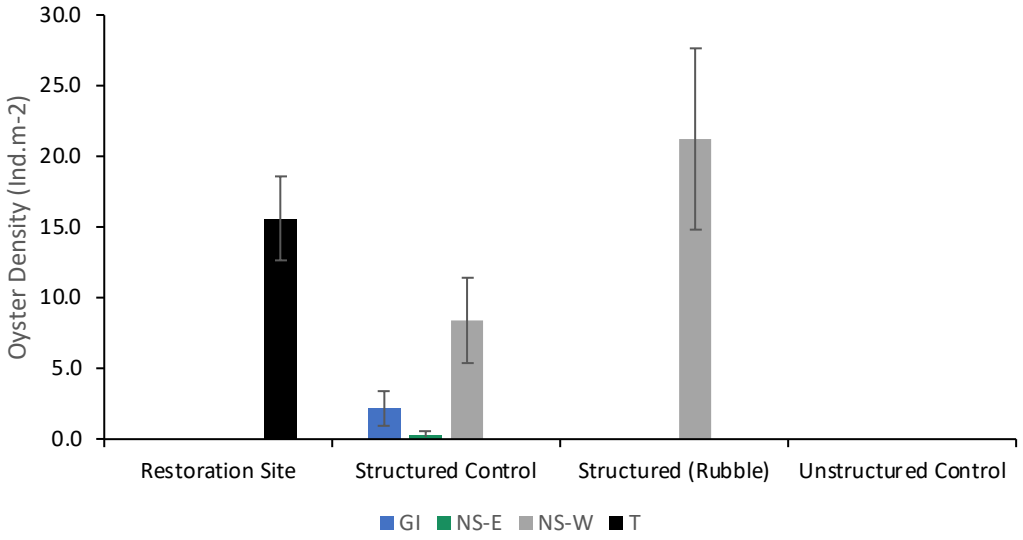

Figure 3.8 Average (± SE) oyster density among monitoring sites and habitat type[2]

[2] Restoration Areas assessed: Goat Island (GI); Noosa Sound East (NS-E); Noosa Sound West (NS-W); Tewantin (T).

Figure 3.9 Rock oysters growing on rocks at Tewantin

Figure 3.10 Existing low density and patchy distribution of rock oysters growing on mangroves at Goat Island

Figure 3.11 Oysters growing of rocky rubble at the mouth of Weyba Creek (adjacent to Noosa Sound West restoration area)

3.3.1 Oyster Size

Oysters growing on rocky rubble ranged in size (as measured by the shell height) from 2 to 58 mm, with the majority of oysters in the 20 to 40 mm size classes (Figure 3.12). The largest oysters were recorded on rocky rubble at both Tewantin and Noosa Sound West.

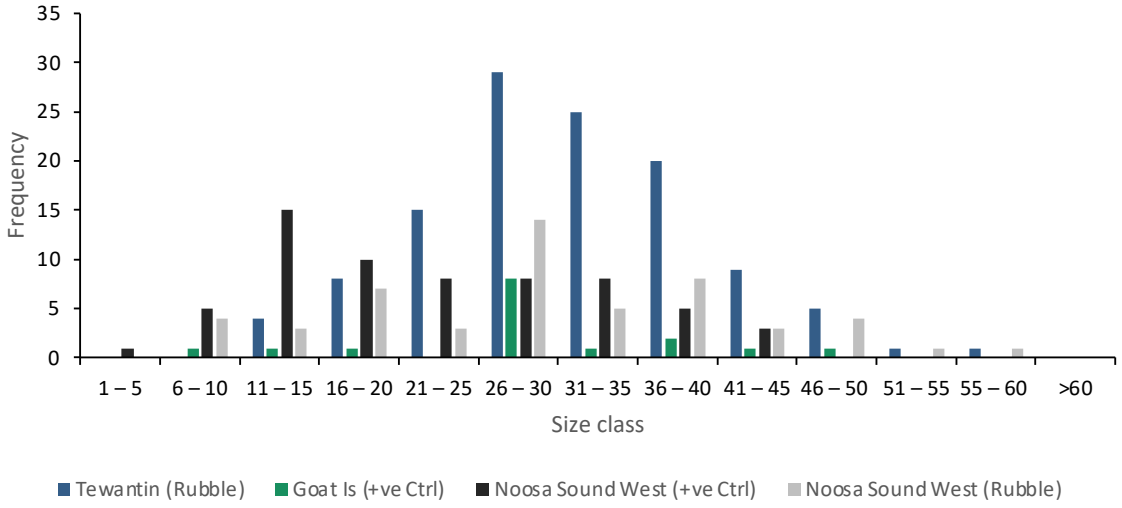

Figure 3.12 Size-frequency of oysters adjacent to restoration areas in July 2022

3.4 Fish Assemblages

A total of 9 bony and cartilaginous fish species, from 7 families were recorded across all reefs in the July/August 2022 pre-deployment survey. Most fish species recorded are common to estuaries in the region. No threatened or protected fish species listed under the Queensland's *Nature Conservation Act 1992* or nationally under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* were recorded.

Generally, a greater abundance (maxN) and diversity of fish were recorded in structured habitat than in unstructured habitat. The most common and widely occurring species was yellowfin bream, which was present at all survey sites except the Noosa Sound west unstructured site (Table 3.1). The most abundant species was the estuary glass fish occurring in structured mangrove habitat (Table 3.1). This is a well-established pattern, with several past assessments showing a greater richness and biomass of fish in structured habitats such as seagrass meadows or mangroves, than are caught over bare sand or mud (unstructured) habitats (Bell & Westoby 1986; Pittman et al. 2004; Laegdsgaard & Johnson 2001). The reintroduction of oyster reefs into the Noosa Estuary is expected to result in an increase in the diversity and biomass of fish species, as has occurred in other oyster reef restoration projects (Peterson et al. 2003; Grabowski et al. 2012).

Table 3.1 Abundance (MaxN) of each fish species recorded in the restoration areas, structured and unstructured control sites in Noosa Sound

Scientific Name	Common Name	Noosa Sound East			Noosa Sound West		
		Restoration Area	Structured	Unstructured	Restoration Area	Structured	Unstructured
Ambassidae							
Ambassis marianus	estuary glassfish	0	9	0	0	38	0
Gobiidae							
Acentrogobius janthinopterus	robust mangrove goby	0	1	0	0	2	0
	Unidentified goby	0	0	0	0	0	3
Dasyatidae							
Pastinachus ater	cowtail stingray				*		
Hemitrygon fluviorum	estuary stingray	0	0	1	0	0	0
Melanotaeniidae							
Pseudomugil signifer	pacific blue-eye	0	32	0	0	8	0
Mugilidae							
Mugil cephalus	sea mullet	0	0	0	6	0	0
Sparidae							
Acanthopagrus australis[3]	yellowfin bream	11	12	12	18	16	2
Tetraodontidae							
Tetractenos hamiltoni	common toadfish	0	0	0	0	1	0
Total Species		**1**	**4**	**2**	**3**	**5**	**2**

* Species only observed or on underwater footage, not recorded on BRUVS footage

[3] This species is typically *Acanthopagrus australis* (yellowfin bream), but may be confused with *Rhabdosargus sarba* (tarwhine). Using the BRUVS method, confidently distinguishing between these two species may not possible for some smaller size classes.

Figure 3.13 Numerous yellow-fin bream at recorded on BRUVS at Noosa Sound West

Figure 3.14 Cowtail stingrays observed foraging on bare sediment at Noosa Sound

4 Conclusions

Benthic Habitat

Prior to deployment of reef substrate, it was confirmed that the substrate below reef restoration areas was bare sand at Goat Island, Noosa Sound East and Noosa Sound West. The areas adjacent to Tewantin were rock, gravel and mud; however, we were unable to obtain a good assessment of the presence of any macroalgae on the rocky reefs further offshore due to poor visibility. Macroalgae (such as *Padina* and turf forming algae), has previously been recorded in deeper water further out in the river channel, and will likely recruit onto the reef substrates once deployed.

Small patches of seagrass downstream of the restoration area at Goat Island that were previously mapped in 2020, were absent in the survey completed in July 2022. The small seagrass patches (<40 m^2) had died back, most likely due to recent prolonged turbid water conditions associated with flooding in 2022. Similarly, a small patch of seagrass directly upstream of the restoration area at Tewantin was also not recorded in 2022. The closest seagrass meadow was recorded 46 m further upstream of Tewantin.

There was fringing mangroves along the shoreline at Goat Island and Noosa Sound East, which were recorded but not previously mapped in 2020 due to a GIS error. The mangrove fringe at all restoration areas has now been mapped in finer detail, and habitat maps updated where required.

Shoreline Erosion Assessment

There was signs of existing coastal erosion of the banks adjacent to most of the restoration areas. In some cases creating steep sloped banks and undercutting existing tree roots along the shoreline. The erosion was most prominent at Goat Island.

Oyster Assemblages

Oysters grew on some mangrove roots and rock adjacent to the restoration areas. The average density was typically less than 21 ind.m^{-2}. Where rock oysters occurred, they ranged in size from 2 to 58 mm, and were typically largest growing on rock at Tewantin and Noosa Sound West. Oysters only occurred in unstructured control sites on occasional small rocks scattered along the sites on bare sand, but these sites otherwise consisted of bare sand.

Additional monitoring of the oyster density is planned for the restoration areas, positive (structured) and negative (unstructured) control areas following the summer spatfall in Autumn 2023.

Fish Assemblages

Due to poor visibility, fish could only be assessed effectively using the BRUVS method at sites in Noosa Sound. The fish assemblages generally were dominated by yellowfin bream, with several other commonly occurring species present. The length and biomass of fish is still be assessed and will be presented in subsequent report assessing the change in fish assemblages associated with the reef restoration.

Additional surveys of fish are planned once the reefs have been deployed. The assessments will compare and contrast the change in assemblages among restoration areas, structured and unstructured habitats around the estuary.

5 References

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Appendix A Mapped Habitat Categories

5.1 Seagrass

Seagrass species recorded in the intertidal and subtidal zone of the Noosa Estuary included dense beds dominated by *Zostera muelleri subsp. capricorni,* with sparse patches of *Halophila ovalis*. Where *Zostera* was present, it usually formed dense patches with plants having a long blade length of approximately 50-60 cm. The epiphyte load on each blade varied throughout the estuary from less than 10% coverage to more than 60% coverage of blades. *Halophila* was recorded in sparse patches (<10% cover) or on the fringe of dense *Zostera* beds. A description of the seagrass communities recorded in each of the investigation reaches is provided in Table 5.1.

Table 5.1 Description of seagrass habitat with each investigation area

Area	Description	Photo
Noosa Sound	No seagrass was recorded within the reach, intertidal and subtidal habitats were dominated by unvegetated sand.	No Seagrass was observed
Goat Island	Several small patches of seagrass generally less than 5 m in diameter were observed growing along the channel edge adjacent to Goat Island. The patches were dominated by *Zostera* with long blades and covering more than 75% of the patch area (typically more than 90%). No seagrass was recorded adjacent to the restoration area. The seagrass further upstream was in moderate condition with low epiphyte growth; however, some patches were being actively smothered by unconsolidated sand. Numerous boats are moored in the vicinity of the seagrass patches.	 Dense but small patch of *Zostera (<30m^2)* upstream of the restoration area

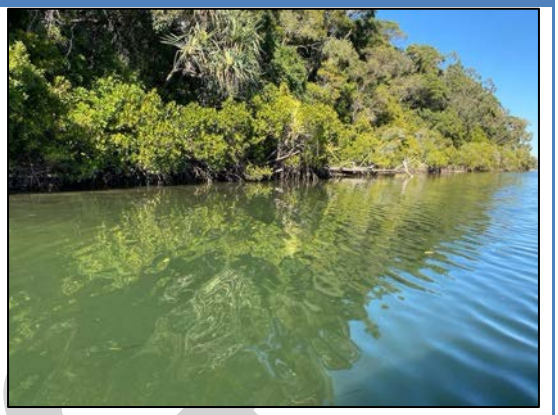
Area	Description	Photo
Tewantin	Several small patches of seagrass generally less than 5 m in diameter were observed along the channel edge north of the investigation area. The patches were dominated by *Zostera* with long blades (>50 cm) and covering more than 75% of the patch area (typically more than 90% of the patch area). A much larger continuous *Zostera* bed extends throughout the small bay to the north of the restoration area, with smaller patches of seagrass growing upstream along the main river channel. The seagrass was typically in good condition with low epiphyte growth. There was a high fine sediment load with small disturbances mobilising the sediment within the bed.	 Patchy seagrass at upstream end of investigation area  Extensive seagrass bed upstream of investigation area

5.2 Mangroves

Several mangrove species were growing adjacent to the investigation areas. The mangrove assemblages were dominated by red mangroves (*Rhizophora stylosa*) and grey mangroves (*Avicennia marina*) with occasional orange mangroves (*Bruguiera gymnorhiza*) predominantly growing along the edge of the channel. These assemblages transitioned to a low canopy of yellow mangroves (*Ceriops tagal var australis*), river mangroves (*Aegiceras corniculatum*) and mangrove fern (*Acrostichum speciosum*) landwards.

Generally, mangroves grew in a narrow fringe along the sections of the proposed restoration areas (Table 5.2). The mangrove patches were not continuous along the channel, being separated by coastal forests growing on top of steep banks that did not support mangroves. The canopy height of mangroves was no greater than 5 m and the trees were in moderate to good condition, with some signs of insect damage and yellowing of leaves.

Table 5.2 Mangrove community in each reach in November 2020

Area	Description	Photo
Noosa Sound	Narrow fringing mangrove forest between coastal rainforest communities dominated by red and grey mangroves with occasional orange and yellow mangroves. The lower canopy was dominated by jointed rush (*Juncus kraussii*), rusty sedge (*Fimbristylis ferruginea*), and saltcouch (*Sporobolus virginicus*) occurring particularly towards the mouth of Weyba Creek. While the mangrove fringe was generally <10 m wide, the mangroves were generally in good condition. There is a small creek halfway along the reach which extends to a large wallum swamp, landward of the investigation area.	
Goat Island	Patchy and narrow fringing mangrove forest between coastal rainforest communities dominated by grey mangrove. Canopy height of 4 to 6 m. Forest extends to a large low canopy forest to the north east of the island, away from the restoration area. The mangroves in this reach are in good condition.	
Tewantin	A narrow (<5 m wide) fringing forest dominated by grey and river mangroves, with an upper canopy of coastal hibiscus. Mangroves are in moderate condition, growing on rock and gravel on an erosion prone bank.	

5.3 Saltmarsh

Saltmarsh was recorded along the proposed restoration areas adjacent to the Noosa Sound site and along the channel at Goat Island. The saltmarsh at Noosa Sound was dominated by salt couch (*Sporobolus virginicus*) with jointed rush (*Juncus kraussii*), and rusty sedge (*Fimbristylis ferruginea*) (Figure 5.1). At Goat Island the saltmarsh was dominated by salt couch. Swamp she-oak (*Casuarina glauca*) grew landward of the saltmarsh along the Noosa Sound and on Goat Island. Saltmarsh and casuarina forest are not expected to be impacted by the restoration works, so no further assessment of these habitats was completed.

Figure 5.1 Fringing saltmarsh and mangrove communities adjacent to the Noosa Sound investigation area in 2020

Figure 5.2 Fringing saltmarsh, sparse casuarina and mangrove communities adjacent to the Goat Island investigation area

5.4 Rocky Rubble

The Tewantin reach has several large areas of gravel with dead oyster shell (Figure 5.3) and rocky rubble (Figure 5.4) that have been buried in places by up to 0.5 m of fine sediment (Figure 5.5), particularly in areas of accretion adjacent to seagrass beds and upstream of the rocky reef surrounding an existing channel marker. In intertidal habitat, oysters aggregated in a narrow band in moderate to low densities on the rock rubble adjacent to the existing mangroves along the bank edge (Figure 5.4). The densest aggregation of oysters were limited to intertidal areas on existing pylons and the rock around jetties. In July 2022, water clarity was extremely poor and we were unable to confirm the presence of subtidal habitats around Tewantin visually. A grappling hook and pole were used to confirm the presence or absence of seagrass and macroalgae at these sites.

Figure 5.3 Gravel with dead oyster shell at Tewantin in 2020

Figure 5.4 Narrow area of rock rubble with rock oysters adjacent to council chambers with narrow band of grey mangroves further landward in 2020

Figure 5.5 Intertidal rock rubble and gravel adjacent to the existing boat ramp and jetty in 2020

In subtidal areas, exposed rock surfaces had a high coverage of fine algal turf that trapped a thick sediment layer. Macroalgae growing on rocks was dominated by *Padina* sp., particularly in shallow subtidal areas along the edge of the existing navigation channel and around the existing channel marker (Figure 5.6). These species were generally restricted to subtidal areas and cover was typically sparse (less than 15% of the surface area), particularly in rocky areas close to the shoreline (Figure 5.6). There was a small section of more substantial rocky reef with high vertical relief around the existing channel marker sign, where the densest aggregation of macroalgae (<30% cover) occurred (Figure 5.8). There was also denser macroalgae growing on rubble at the edge of the main river channel and also south of the existing boat ramp adjacent to the bathing area and marina (Figure 5.9). The macroalgal assemblages were in relatively poor condition due to high sediment loads observed on and around the existing rocky reef and rubble areas, with some sections of reef having a high coverage of fine sediment (Figure 5.10).

Given the speed at which *Padina* can colonise hard surfaces (dead oyster shell) elsewhere in the estuary, it is anticipated that supplementary habitat provided as part of the proposed restoration project would be colonised rapidly within 1 year of deployment, and that coverage would be similar to the current condition within 2 to 3 years post deployment, particularly in sections that remain subtidal and not covered by fine silt.

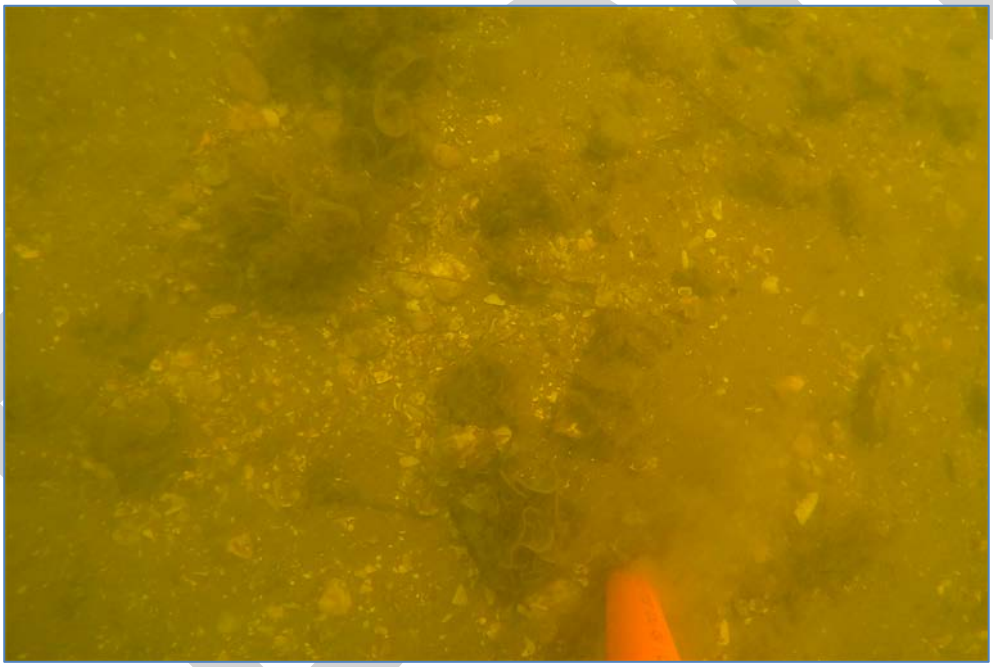


Figure 5.6 Sparse macroalgae (*Padina* sp.) growing on rock at Tewantin

Figure 5.7 Turfing algae and oysters on rocky rubble at the edge of the main river channel with gravel and shell grit between rocks

Figure 5.8 High relief rocky reef at existing channel marker with aggregation of oysters and turf algae over surface of rocks

Figure 5.9 Rocky reef with oysters and macroalgae to the south of the investigation area seaward of Tewantin baths

Figure 5.10 Patchy rock surrounded by fine mud in the north of the investigation area

A small rock rubble area was recorded at the western end of the Noosa Sound investigation area around an existing 6 knot sign at the mouth of Weyba Creek. The rock was mostly intertidal and had a moderate coverage of rock oysters.

5.5 Unvegetated (Bare) Sediment (Sand/Mud)

The most dominant habitat in most of the investigation areas was unvegetated (bare) sediments, which ranged in particle size from soft muds (usually next to seagrass and mangroves) to well sorted sand, which covered the majority of habitats within each of the reaches investigated particularly in channel habitat (Figure 5.11 to Figure 5.12). No epifaunal invertebrates were recorded on the surface of the unvegetated habitats during the survey and there was typically a low density of burrows observed in most reaches.

Some sections of the sediment in Noosa Sound were covered by benthic microalgae, particularly where there were freshwater inputs.

Figure 5.11 Bare sand with sparse yabby burrows in Noosa Sound

Figure 5.12 Bare sand adjacent to Goat Island