Ecological Service Professionals
Sustainable Science Solutions

Alannah Duffy
Environmental Officer
Noosa Shire Council
PO Box 141
TEWANTIN QLD 4565
cc: Noosa Biosphere Reserve Foundation & Noosa Parks Association

Our Reference: 1533L2020.1

19 February 2020

RE: Noosa Oyster Reef Restoration – 2nd Annual Monitoring Report 2019

Dear Council and Steering Committee,

Please find attached the second annual assessment of the success of the Noosa oyster reef restoration trial, which includes assessments completed at the end of the second spat settlement season in May 2019 and start of the third spat settlement season in October 2019.

Project Background:

The University of the Sunshine Coast (USC) constructed 14 reefs throughout the Noosa Estuary in November 2017, to trial the potential for restoration of oyster reefs in the estuary (Gilby et al. 2017[1]). Each reef area consisted of three stacks of three coir bags that were filled with oyster shell in a pyramid in accordance with approved plans. The reefs were monitored in accordance with the monitoring program key performance indicators[1]. The first annual monitoring report covered the period November 2017 to November 2018 (Gilby et al. 2018[2]). Ten of the 14 reefs deployed were removed in February 2019, due to incidental damage from boat strike (all reefs were removed from within the main Noosa River channel)[3]. An example of the damage caused to reefs at Site 10 in provided in Figure 16. The restoration units were removed in February 2019 and all shell and coir mesh disposed of at the council waste disposal site in accordance with State Permitting and Approval requirements. Note that all signage remains in place to date and will be removed by a licensed contractor at the completion of the trial.

Monitoring of the remaining four oyster restoration areas was completed on 10 May and 25 October 2019 by Dr Simon Walker from Ecological Serve Professionals (ESP) and Mr Bryan Walsh from Noosa Parks Association (NPA), to fulfil requirements of Council's approval to restore oyster reefs in the Noosa Estuary (Table 1; Figure 1). Monitoring was completed generally in accordance with the USC monitoring program as approved by Queensland Department of Primary Industries (DPI) as part of the Resource Allocation Area approval to Noosa Council, with the following exceptions.

---

[1] Gilby et al. 2017. Noosa River Oyster Reef Restoration Plan and Monitoring Schedule in accordance with Approved Resource Allocation Department of Agriculture and Fisheries - 6 January 2017.
[2] Gilby et al. 2018. Monitoring of the Noosa River Oyster Reefs; November 2017 - November 2018: Report to Noosa Council, and Queensland Department of Agriculture and Fisheries

1) The location of each patch reef was measured directly from a fixed point (signpost) using a tape measure on each occasion and with handheld GPS unit, to determine if the reef patches had moved. A survey of the final reef locations and heights will be provided at the completion of the project where necessary.

2) Additional 5 replicate oyster shells were assessed for settlement in each patch reef (i.e. 10 replicate shells per patch – 30 shells per restoration area) to increase the accuracy of the oyster settlement density measure.

3) The presence of additional sessile invertebrates was assessed on each shell rather than specifically on the outside of coir mesh bags as it was not possible to get suitable underwater photo-quadrats due to the reduced height of shell and shallow depth of water. Foliose macroalgae was recorded growing on coir mesh and oyster shell at most sites.

Table 1 Centre position of the four remaining restoration sites

Site	Easting*	Northing
Site 12	507681.973	7079962.501
Site 13	507106.028	7078792.976
Site 14	507093.310	7078704.485
Site 16	506201.831	7075593.654

*Datum: GDA 94 Zone 56

Figure 1 Oyster reef restoration sites assessed in May 2019

A summary of the results of the monitoring completed in 2019 against the performance objectives is provided in Table 2, with detailed responses in the subsequent sections.

Table 2 Summary of assessment against restoration Performance Objectives

Performance Objective	Monitoring Outcome	Emerging Issues	Knowledge Gained
1. Oyster Restoration Unit Location Stability (Refer to Page 8)			
Oyster Restoration Units Remain within the Resource Allocation Area	Achieved - All oyster reef patches remain within the RAA, although have moved up to 0.5 m from the original location. Ten of the fourteen reefs deployed sustained significant boat damage and were removed by USC in early 2019. Four reefs remain at Sites 12, 13, 14 & 16, in Weyba Creek and Lake Weyba. In May 2019, the remaining four restoration areas were assessed. The restoration units (coir bags) had lost rigidity and coir mesh had started to degrade allowing some shell to spill from bags at several sites. All shell remains within the RAA, however, it has started to settle into the surrounding unconsolidated sediment.	Several of the reefs were damaged by boats over the summer of 2018-19 resulting in significant damage to reef restoration units that was beyond repair (Gilby et al. 2019[3]). Several of the restoration units had either been completely buried in sand or damaged so much that they could not be re-established without a complete redeployment. Despite early indications of high recruitment of oysters on the restoration structures, a decision was made by the project team to remove any remaining components due to the degree of damage sustained. An example of boat damage at Site 10 (Figure 16)	Additional and ongoing community engagement and education required to reduce the frequency of boat damage. Possible production of flyer to hand out to tourists and provision of information signage at key boat ramps. Consideration of the wording of signage to reduce potential for damage from boats mooring on the restoration areas. In our opinion the use of the term “fishing permitted” was not necessary as part of the signage, as it may have indicated to tourists that the restoration areas were suitable for fishing and contributed to increased incidental anchoring and vessel damage. Consideration of future signage to simply state that the area is a restoration area completed under approval and contact details for questions/complaints would be sufficient. Additional educational signage at boat ramps and boat hire businesses should

[3] Gilby et al. 2019. Bringing fish life back to Noosa: restoring lost oyster reef habitats in the Noosa Biosphere. Final report prepared by The University of the Sunshine Coast for Noosa Biosphere Reserve Foundation

Performance Objective	Monitoring Outcome	Emerging Issues	Knowledge Gained
			be considered for future restoration projects.
2. Natural Recruitment Processes (Refer to Page 13)			
Oysters and other sessile benthic invertebrates recruit to reef restoration units to establish a biogenic matrix, which binds oyster shells in place prior to degradation of coir material	Settlement was assessed on 10 oyster shells collected at random from within each patch reef (i.e. a total of 30 shells were assessed at each restoration site). Average density of oysters (oysters/m^2) across all sites remained consistent over monitoring period due to naturally low settlement in winter months: April 2019 – 340/m^2 October 2019 – 348/m^2 We expect settlement to increase over summer months during the regular spat fall season.	–	Settlement and growth continues onto oyster shell – substrate limited system. Some consolidation of shell in bags largely by other invertebrates such as sponges and ascidians (sea squirts) has occurred.
2.1. Oyster recruitment	The density of oysters recruiting to the restoration structures is variable, although has increased over time. The average density of rock oyster recruits across all sites was 340 oysters/m^2 in April 2019, and 348 oysters/m^2 in October. The maximum size of oysters increased	Reduction in the overall height of restoration units (reefs remain submerged) due to settling may reduce the density of oysters recruiting to the reefs, due to smothering from surrounding sediment and increased predation.	

Performance Objective	Monitoring Outcome	Emerging Issues	Knowledge Gained
	between April and October, with the largest individual oyster measured at 8.85cm at Site 12. This demonstrates that oysters can settle, survive and grow at these restoration sites		
2.2. Increasing coverage of oysters and other benthic invertebrates over time	There was substantial recruitment of encrusting sponges on many of the shells, which in some cases had consolidated shell into larger clumps (refer to Figure 13 & Figure 14).	The intent of the restoration units had always been to provide a natural substrate to hold oysters together until they could become consolidated into a reef, and to allow removal if unsuccessful. Unfortunately, the coir mesh bags holding the oysters have failed, resulting in mounds of shell that are below the area of greatest recruitment. For successful establishment we would suggest the trial of more substantial structures such as coir or wooden logs as fences, filled with shell to a sufficient height, or thin gauge metal mesh bags filled with shell that would rust and degrade over time more slowly than the coir mesh. This could provide a more substantial engineered structure to elevate oysters above the existing unconsolidated sediment for an	

Performance Objective	Monitoring Outcome	Emerging Issues	Knowledge Gained
		extended time. Consideration should be given to providing suitable warning signage where necessary and increasing the size of restoration structures would make them more visible.	
2.3. Establishment of stable biogenic matrix – i.e. structural rigidity 3 years post deployment	Some consolidation of oyster clumps with shells being bound together by new rock oysters or more often sponges, although majority of shell in bags remained unconsolidated approximately 2 years post-deployment in October 2019. Deposition of fine sediment on reefs may be accelerating the burial of existing restoration units and shell.	–	Degradation of coir mesh has allowed the reefs to collapse in height. This may require reestablishment of bags or trial of alternative deployment method to elevate shell above the existing substrate and at suitable height in the shore to maximise oyster recruitment.
3. Community use and enjoyment of the declared Fish Habitat Area (Refer to Page 16)			
	Complaints of boat strike anecdotally from locals due to hire boats anchoring on reefs and fishing. No observed detrimental impact on fisheries or enjoyment of fish habitat area. No complaints to that effect.	Oyster restoration units damaged due to boat strikes were removed by USC and habitat remediated back to pre-deployment condition[4]. Signage was not removed to date and will be removed by a licensed contractor at the end of the trial.	Careful consideration of the message to non-locals including ongoing campaign to educate public on the outcomes of the project. Reefs that were outside of the area of operation for hire vessels have remained

Performance Objective	Monitoring Outcome	Emerging Issues	Knowledge Gained
	An investigation was completed into the damage of restoration units. Due to substantial damage, it was decided to remove reefs at 10 sites throughout the main boating channel of the Noosa River [4].		intact without signs of impact from boat strike.
4. Other Potential Effects (Refer to Page 17)			
Oyster reefs do not have a detrimental impact on the extent of marine plants within 50m radius of the restoration units and are not attributed to erosion of the shoreline or other ambient impacts	There is no evidence of an impact on the shoreline as a result of the placement of units. Some minor build-up of sediment has occurred around the reefs as they have settled due to the unconsolidated sediments in these areas. There has been recruitment and growth of seagrass observed, particularly around the reefs at Site 13 with recent recruitment of *Halophila ovalis*, a pioneer seagrass species, around each of the restoration units.	Any removal of restoration units close to seagrass should be done by hand if necessary.	Stabilising sediment and reducing resuspension may increase the likelihood of recruitment and growth of seagrass on bare sediment in the estuary. Oyster reef restoration units may therefore be an effective tool for multi-faceted habitat restoration in estuarine systems by creating stable ambient condition suitable for other species to recover naturally. The deployment of reefs may have also inadvertently protected against human induced disturbance from propeller damage on the banks as the reefs are signed with an Underwater Obstruction warning sign.

Detailed Assessment Against Performance Objectives

Performance Objective 1: Oyster Reef Stability

The positions of each of the four corners of the reef were measured relative to the known position of the signpost using a tape measure for centimetre accuracy and handheld GPS unit. The accurate position of each corner was then mapped in ESRI ArcGIS and any change in the location relative to the original survey was assessed. A full survey of the final position and height of the reefs will be done at the completion of the trial using a Registered Surveyor.

Site 12

Restoration units have largely settled into the unconsolidated sandy substrate. The reefs have not moved substantially from their original deployment position; however, the coir mesh has lost strength, broken apart in places and degraded to the point where it is not possible to restitch the bags by hand. The degradation of the bags has released some shell (although oyster shell had moved less than 0.5 m from the original position in October 2019). Fine sediment has surround and buried much of the remaining shell in bags at this site and they have lost height due to the collapse of the top bags. It was not possible to repair the bags due to degradation of the coir mesh.

Figure 2 Oyster reef and wooden stakes at Site 12 in October 2019

Site 13

Restoration units have settled into the unconsolidated sandy substrate. Restoration units have lost substantial vertical relief and in October 2019 were only approximately 10 to 15 cm above the surrounding substrate surface. Oyster shell remains largely intact at the site (Figure 3) (moving less than 0.5 m) despite the coir bags degrading to the point where it is no longer possible to repair the mesh by hand.

Figure 3 Oyster reefs at Site 13.

Figure 4 Oyster reef with high coverage of macroalgae at Site 13

Site 14

Restoration units have largely been consolidated by foliose macroalgae (Figure 4). The restoration units at this site are surrounded by established seagrass beds (dense, long bladed *Zostera mulleri*), which have increased in extent since deployment, particularly closing gaps over bare sediment around the restoration units (Figure 4, Figure 5 & refer to Table 4). Numerous juvenile fish were observed using the reef restoration units and moving between them and the surrounding seagrass in both April and October 2019 (Figure 7).

Figure 5 Oyster restoration unit at Site 14 in May 2019

Figure 6 Oyster reef at Site 14 covered with *Padina* and surrounded by dense seagrass and seagrass wrack in October 2019

Figure 7 Juvenile fish schooling around oyster reefs at Site 14

Figure 8 Dense seagrass and restoration units at Site 14 in October 2019

Site 16

Reef units have not moved substantially from their original position (<0.5m), although due to breakdown of coir mesh observed in October 2019, the oysters contained in the bags have begun to spread to the northwest due to wind driven wave action. There was a high cover of macroalgae observed on bags at this site in October 2019 (Figure 10)

Figure 9 Oyster reefs surrounding sign at Site 16

Figure 10 Oyster reef covered with macroalgae at Site 16

Knowledge Gained

The coir mesh used for restoration units has degraded within 2 years of deployment, to the point it is no longer possible to repair the bags by hand. The shell on the surface has remained largely in the same location despite the bags spilling shell, although the vertical height gained by stacking bags has been lost, with insufficient time for the shell to bind together prior to the bags degrading. Excess coir mesh is gradually being removed from sites where necessary.

Existing shell remains in place and within the RAA; however, the reefs have lost vertical height, indicating that a structure with greater rigidity may be necessary to allow sufficient time for the reefs to consolidate. Alternatively, supplementing the reef areas with additional bags (at least annually) may be sufficient to enable a gradual build-up of shell base over time. The addition of supplemental shell should be timed to maximise recruitment potential of natural oysters (i.e. spring/summer).

Anecdotally, we have observed greater recruitment of oysters on shell with greater rugosity rather than relatively flat shells.

Performance Objective 2: Natural Recruitment Processes

Oyster Settlement & Recruitment

In May 2019, the average density of oysters (number/m^2) was relatively consistent among sites ranging from 320 to 367 oysters/m^2 (Figure 11). In October, there was a large increase in the density of oysters at Site 13, which is due to increased settlement of smaller oysters. The average height of oysters increased between May and October 2019 at all sites, with the greatest increase occurring at Site 16 (Figure 12). The largest oyster was 8.85 cm, recorded at Site 12 in October 2019. Oysters greater than 6 cm are most likely from the first spawning season in 2018-2019, as this was the maximum size of oysters found among the sites surveyed (Gilby et al. 2018).

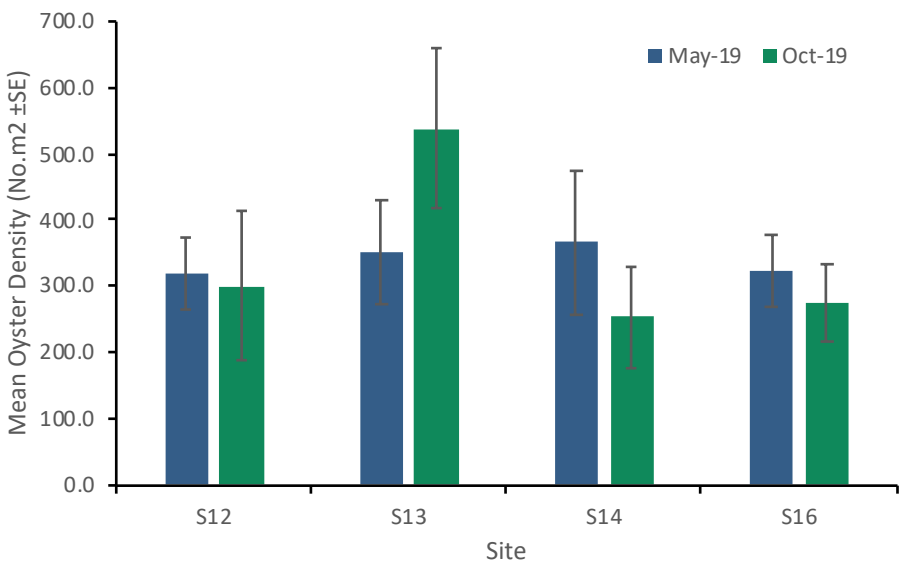


Figure 11 Average (± SE) density of oysters/m^2 among sites in May and October 2019

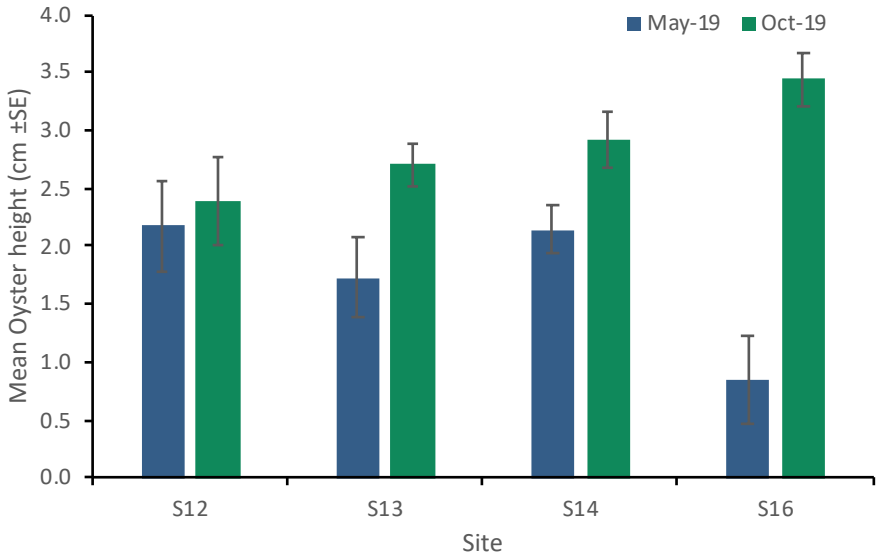


Figure 12 Average (± SE) height (cm) of oyster recruits among sites in May and October 2019

Presence of other Sessile Invertebrates and Macroalgae

A variety of other sessile invertebrates had recruited to several of the restoration units including other shellfish (hairy mussels, pearl and leaf oysters), sponges and ascidians. These sessile invertebrates are critical for consolidating the oyster shells into clumps (Figure 13 & Figure 14). In October 2019, three sea hares (*Aplysia* sp.) approximately 15 to 20 cm long were also observed grazing on macroalgae growing on the reefs at Site 13 (Figure 15).

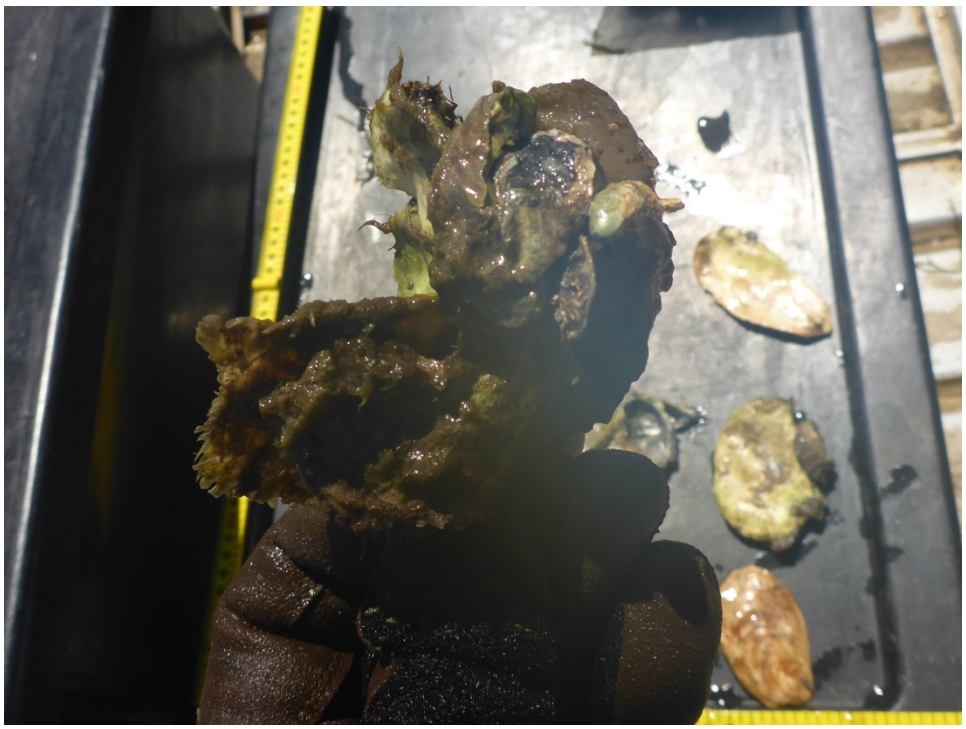


Figure 13 Oyster shell consolidated by encrusting sponges and oysters at Site 12

Figure 14 Oyster shell consolidated by encrusting sponges and macroalgae at Site 14

Figure 15 One of three large sea hares (*Aplysia* sp.) consuming algae on oyster reefs at Site 13

Performance Objective 3: Community Use

Community use and complaints are monitored through Noosa Council. A community member raised a concern to the restoration steering committee about the state of several reefs along the main Noosa River channel in February 2019. An investigation into the status of the reefs revealed that there had been substantial damage, most likely from repeated boat strikes during the Christmas holiday period (Figure 16), which was supported by anecdotal evidence provided by several local community members during the investigation. Wording on the project signage may have made the restoration areas highly attractive for tourists operating hire boats, who are unfamiliar with local fishing laws and were observed anchoring directly on the reefs in some areas of the main river channel. Despite these areas showing good signs of oyster settlement (Gilby et al. 2018)[4], it was decided to remove remaining reef structures from 10 restoration sites, due to the high degree of damage to those areas.

Figure 16 Example of boat damage sustained on reef at Site 10 in January 2019 (reef now removed)

Knowledge Gained

While many of the reef areas in the main river channel had good to very good recruitment of oysters, a key learning from the trial is to provide additional communication and education to river users to reduce potential accidental damage. This could be achieved through dedicated signage at boat ramps and accessible information handouts for tourists hiring vessels who may have limited boating experience and be unfamiliar with the objective of the study.

The local community remain supportive of the reef restoration activity (as evidenced by no recorded complaints); however, targeted communication with tourists via tour operators, may have reduced damage caused by boats within the main river channel. The small-scale of the trial reefs may have also made them susceptible to incidental disturbance from boats.

[4] Gilby et al. 2018. Monitoring of the Noosa River Oyster Reefs; November 2017 - November 2018: Report to Noosa Council, and Queensland Department of Agriculture and Fisheries

Performance Objective 4: Other Potential Effects

The presence, type and location of marine plants within a 50 m radius of the restoration unit was recorded in May and October 2019. The coverage of seagrass was assessed visually from the surface and from footage collected using an underwater camera. Due to the shallow nature of the sites, it was not possible to obtain vertical pictures for quantitative assessment of seagrass cover.

There is no evidence of any negative impact to the existing location of marine plants or impact on the coastline as a result of the reef units (Table 4). In May 2019 and October 2019, there was no change in the extent of seagrass adjacent to Site 12.

In May 2019, *Halophila ovalis* was observed growing within the RAA at site 13 (as indicated by the darker patch around the restoration structures - Figure 17 & Figure 18), which prior to the installation of restoration structures was an unconsolidated bare sand bank. There was a reduction in the cover of the *Zostera* bed along the shoreline between July 2017 and May 2018 (Figure 19; Table 3 & Table 4). The causal mechanism for this broader change is unclear; however, this area is adjacent to a stormwater outlet and the reduction in seagrass cover is likely due to existing environmental factors, not the placement of restoration structures at site 13 or 14. We completed an additional historical assessment to examine the change in seagrass coverage within 50 metres of the restoration area using imagery sourced from Queensland Globe between 2015 and 2019, and found that the coverage of seagrass adjacent to Site 13 peaked in 2017, then declined by approximately half the area between 2017 and 2018 (Table 3). In 2019 was back to a similar coverage as assessed in 2016 (Table 3). In contrast, coverage of seagrass has increased over time within 50 metres of Site 14 (Table 3).

In contrast, at site 14 there has been an increase in cover of seagrass (and seagrass wrack) adjacent to the restoration structures (Table 4). This indicates that the presence of structures and potential administrative signage may reduce direct impacts from river users, and stabilise sediments that would otherwise not be suitable to seagrass recruitment in this area. This unintended positive consequence highlights the potential for oyster reef restoration to provide a mosaic of important fish habitat types.

Table 3 Area (m^2) of seagrass within 50m of each restoration site pre- and post-deployment

Site	Seagrass Area (m^2) within 50 m radius				
	2019	2018	2017	2016	2015
	Post deployment		Pre-deployment		
Site 12	341				
Site 13	1369	733	1490	1350	947
Site 14	1103	941	861	702	421
Site 16	Sparse *H. ovalis* recorded				

Knowledge Gained

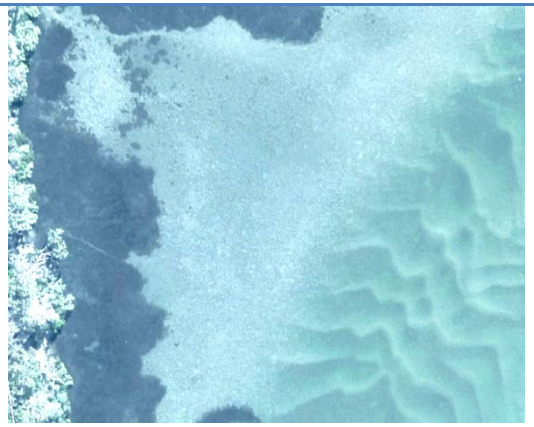
There has been a positive influence from the remaining oyster reefs on the distribution of marine plants, particularly pioneer seagrass species where there is suitable seedbank or source of recruits nearby without the need for direct planting intervention. There is no

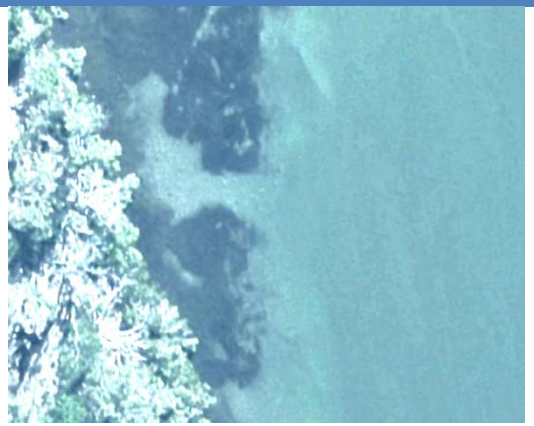
evidence of any adverse impact on coastal erosion due to the placement of the restoration units or impacts to fringing mangroves.

Figure 17 Extent of sparse *H. ovalis* (outlined in green) growing within the restoration area at Site 13 in 2019

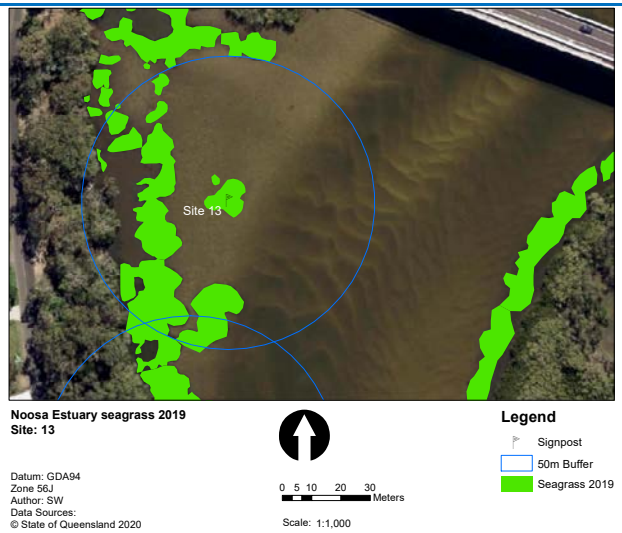
Figure 18 Sparse *H. ovalis* growing adjacent to the oyster reefs at Site 13

Table 4 Queensland Globe imagery of remaining restoration sites pre- (July 2017) and post- reef deployment (May 2018 & 2019)

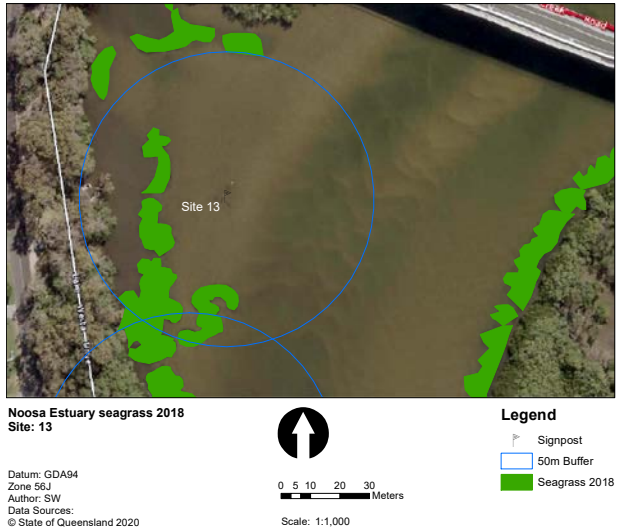
Site	July 2017 Pre-deployment	May 2018 Post-deployment	May 2019
Site 12			
Site 13			

Site	July 2017 Pre-deployment	May 2018 Post-deployment	May 2019
Site 14			
Site 16			

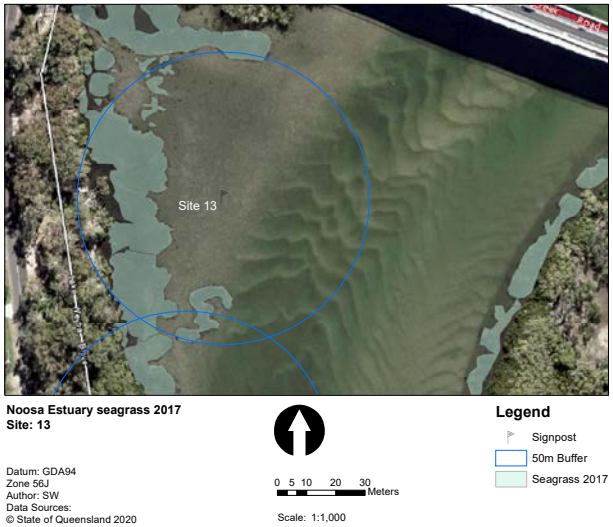
a) Post-deployment 2019



b) Post-deployment 2018



c) Pre-deployment 2017



d) Pre-deployment 2016

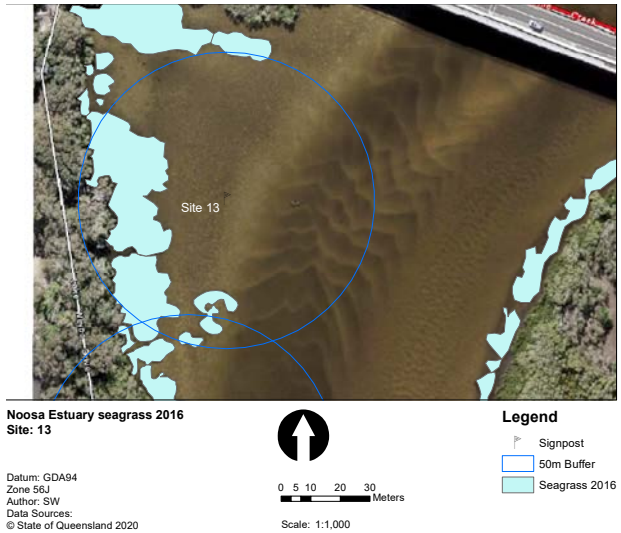


Figure 19 Seagrass area in proximity to Site 13, pre- and post-deployment of oyster reefs

Summary

In summary, the performance objectives of the RAA are being met for the four oyster reefs that remain in place. The reefs will remain in place and will be monitored again in May 2020, with the trial being completed in November 2020. All signage has been left in place to date and will be removed using the licensed contractor who installed them at the end of the trial.

Key knowledge gained during this trial includes:

- There has been good recruitment of oysters to the restoration units, demonstrating that the Noosa River Estuary is a suitable location for oyster reef restoration and that the estuary is substrate limited.
- A structure with greater rigidity, or supplementing the reef areas with additional coir bags and shell (at least annually during spring/summer), may be necessary to allow sufficient time for the reefs to consolidate at the appropriate height on the shore to maximise oyster recruitment.
- Additional communication and education to river users, particularly tourists using hire boats, is required to reduce potential accidental damage to the restoration units.
- The presence of the oyster reef structures and potential administrative signage may reduce direct impacts to seagrass beds from river users, and stabilise sediments that would otherwise not be suitable to seagrass recruitment in this area. This unintended positive consequence highlights the potential for oyster reef restoration to provide a mosaic of important fish habitat types.

Please contact me via email (swalker@ecosp.com.au) of phone should you require any clarification or additional information.

Regards,

Dr Simon Walker

On behalf of Ecological Service Professionals Pty Ltd

Appendix A

Photos of restoration sites after trial reefs were removed (note that signs will be removed by licensed contractor following the completion of the trial in November 2020):

Site 2 – Post reef removal	
Site 3 – Post reef removal	

Site 4 – Post reef removal	
Site 5 – Post reef removal	
Site 6 – Post removal	

Site 7 – Post removal	
Site 8 – Post removal	
Site 9 – Post removal	Not photographed
Site 10 – Post removal	Not photographed
Site 11 – Post removal