Pumicestone Passage Shellfish Reef Habitat Restoration Project – December 2018 deployment

3 Month Invertebrate Monitoring

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Summary

Samples of oyster shells were obtained from two experimental subtidal oyster patch reefs deployed as part of the Pumicestone Shellfish Habitat Restoration Trial. Two samples of 100 oyster shells from different parts of each reef (n = 200 per reef) were examined for evidence of natural rock oyster (*Ostrea*, *Crassostrea*, *Dendostrea*, and *Saccostrea* spp.) spatfall and colonization by various other invertebrates. Results from these samples confirm that natural rock oyster spatfall continues to occur subtidally in the restoration area, including species of *Ostrea*, *Dendostrea* and *Crassostrea* that may be undescribed by science. The southern patch reef (constructed with dead oyster shells surrounded by 55 besser block fence modules) averaged 65 spat (range 58-72) per 100 shells, while the northern patch reef (a mix of live and dead oyster shells covered with a geofabric cover surrounded by 45 besser block fence modules) averaged 34.5 spat (range 22-47) per 100 shells, with the lower spat settlement on this reef probably due to smothering of half of the reef by the coir mesh. The uncovered southern reef displayed prolific colonisation by invertebrate epibionts including corraline algae, bryozoans, hydroids, colonial and solitary tunicates and soft corals, which helped cement the loose shells together into a reef formation. In contrast, observations by divers together with underwater video (available at https://youtu.be/2C32392FKTg) confirmed that sedimentation was problematic only along the section of the northern reef where the geofabric cover remained intact. In contrast, the other half of the northern reef where the current had removed the coir mesh appeared in excellent condition. Underwater videos revealed at least 15 species of finfish were associating with the reefs, while comparison between videos from random and non-random camera drops revealed the importance of fine scale orientation of cameras for reef monitoring. These results confirm that rock oyster spatfall is occurring on uncovered subtidal shellfish reefs in Pumicestone Passage. These results also confirm that regulatory requirements to cover shellfish reefs with geofabric covers will likely result in smothering of the covered reefs by sediment, ultimately resulting in their failure.

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1.0 Introduction

Archaeological and historical records indicate the existence of extremely abundant populations of reef forming shellfish in the coastal bays and estuaries of Pumicestone Passage, Moreton Bay and other estuaries in Southern Queensland prior to European settlement (Diggles 2015). However, today most shellfish reef habitats in Australia are functionally extinct (Beck et al. 2011), including 100% loss of subtidal shellfish reefs and around 96% loss of vertical zonation of oysters in Pumicestone Passage over the last 125 years, due mainly to ecological processes associated with catchment development (Diggles 2013). Realization of the large extent of the loss of ecosystem services historically provided by shellfish reefs in Australia has led to recent efforts to restore them (Gilles et al. 2015), with shellfish reef restoration projects now occurring in several Australian States (Gilles et al. 2018, McLeod et al. 2018).

In Moreton Bay the historically dominant reef forming shellfish species was thought to be the Sydney rock oyster (*Saccostrea glomerata*) (see Smith 1981, Diggles 2015). Despite the extinction of subtidal shellfish reefs in Pumicestone Passage, micro-trials in 2014-16 confirmed the presence of natural subtidal recruitment of rock oysters in that waterway, suggesting shellfish restoration was feasible provided clean substrate was deployed at an appropriate time of year (Diggles 2017). Armed with that knowledge, the Pumicestone Shellfish Habitat Restoration Trial was undertaken with the aim of investigating various methods for restoring lost subtidal oyster reefs to the lower Pumicestone Passage.

In early December 2017, 16 modules of six different types of experimental oyster reefs (patch reefs filled with recycled oyster shells and surrounded by artificial (concrete module) fences with and without live oysters on top, steel wire cages (crates) filled with recycled oyster shells with and without live oysters on top, and a biodegradable matrix (BESE) with and without oyster shells) were deployed into a site in southern Pumicestone Passage (Figures 1, 2). A fish monitoring study 6 months later (May 2018) found a doubling in both total fish abundance and species richness when compared to baseline data from the area (Gilby et al. 2018). A study of invertebrate recruitment 9 months post–deployment found evidence of natural subtidal recruitment of rock oysters and substantial colonization and binding of the shell reefs by various other invertebrates, indicating significant increases in biodiversity and abundance had occurred compared to the shelly mud bottom previously present in the restoration area (Diggles et al. 2018). The present study is the first of 4 quarterly longitudinal studies of the invertebrate colonisation of 2 larger (c. 7 meter diameter) patch reefs that were deployed in the Pumicestone Passage shellfish reef restoration site in early December 2018 (Figure 2).

2.0 Method

During the high tide on 11 March 2019 divers undertook sampling of two 3 month old subtidal shellfish patch reefs c. 7 meters diameter, which had been deployed in 3.5-3.7 meters of water in the Pumicestone Passage shellfish reef restoration study area on 4-10 December 2018 (Figures 1, 2). The southern patch reef (constructed with c. 20 m^3 of dead oyster shells surrounded by 55 besser block fence modules), was located around 30 meters south east of the marker buoy, while the northern patch reef (a mix of 1.5 m^3 of live and c. 14 m^3 of dead oyster shells covered with a geofabric cover surrounded by 45 besser block fence modules) was located around 20 meters north east of the marker buoy (Figure 2). Each of the reef modules was first located and marked with a marker buoy before the divers inspected them and obtained samples of shells by hand which were placed in a fine mesh (3 mm) dive bag and taken to the surface.

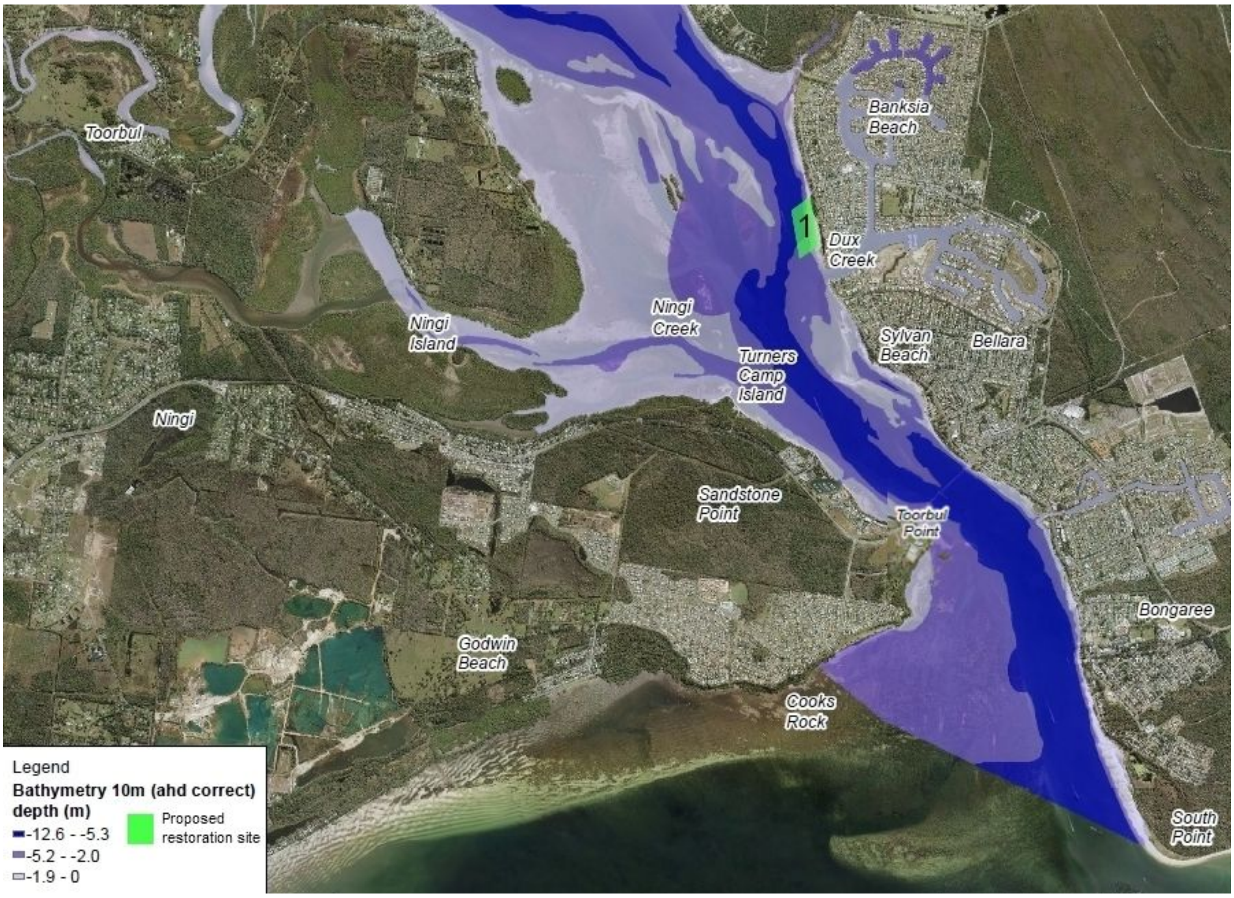

Figure 1. Location of the study area (1) in Pumicestone Passage, Northern Moreton Bay.

Table 1. Details of the locations and types of experimental oyster reefs examined.

Reef Number / Name	GPS co ordinates Latitude	Longitude	Depth (m at LAT)	Reef type	Mean spatfall / 100 shells	Condition
17 North	27.03.027 S	153.07.974 E	3.7	Patch reef, c. 6.5 meters dia. 14 m³ dead and 1.5 m³ live shells with coir mesh cover, surrounded by 45 besser fence modules	34.5	Poor, smothered under coir mesh
18 South	27.03.054 S	153.07.985 E	3.5	Patch reef, c. 7.5 meters dia 20 m³dead shells, surrounded by 55 besser fence modules	65	Excellent
Total				Mean spatfall per 100 shells	49.75	

Two samples of 100 oyster shells from different parts of each reef (n = 200 per reef) were collected by divers and returned to the boat in dive bags. Once on board the attending boat the shell samples were placed into fish bins and visually examined for recruitment of rock oyster (*Saccostrea* spp.) and other invertebrate symbionts. Photographs of the condition of the reefs were taken using an underwater camera (GoPro Hero3+) hand held by divers while videos of minimum 12 minute duration were opportunistically taken next to each reef using another unattended GoPro deployed on a brick to examine fish activity and ascertain whether these larger patch reefs were providing functional fisheries habitat.

In a concurrent study, researchers from Griffith University monitored invertebrate colonization and rock oyster spatfall on besser blocks deployed subtidally in the Pumicestone Passage shellfish reef restoration study area for periods of 3 to 6 weeks beginning from 17 December 2018 up until 11 March 2019. Invertebrates were visually grouped into taxa and rock oyster spat collected from besser blocks were examined and sampled for DNA analysis. The DNA sequences were aligned and compared to gene databases in order to ascertain the taxonomic affinities of the rock oysters sampled.

Water quality data was obtained using a YSI85 DO/Temp/salinity/conductivity probe and a secchi disk.

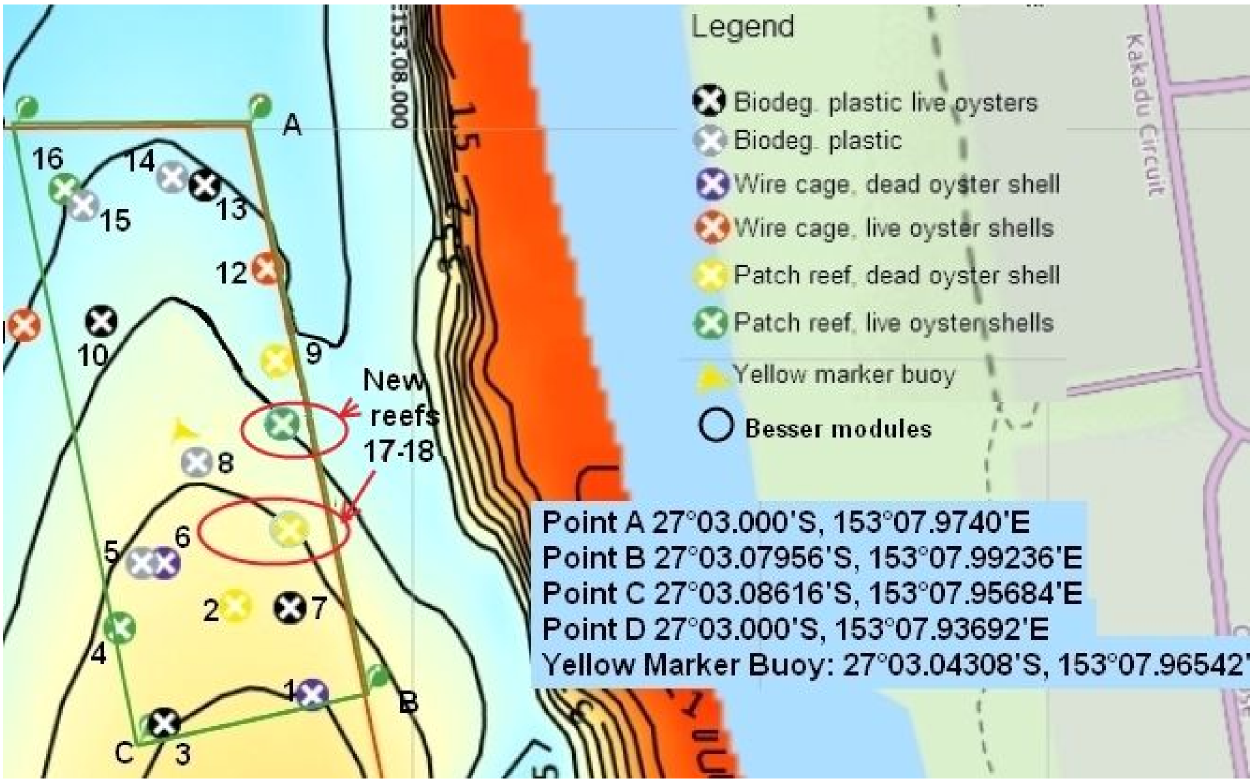

Figure 2. Detailed map of the project area showing bathymetry and layout of the new experimental reef module #17 (north) and #18 (south). Description of reefs as per Table 1.

3.0 Results

3.1 Water quality

Water quality data obtained on the day (Temperature 27.7°C, salinity 35.5 ppt, DO 6.8 mg/L (105% saturation), secchi depth c. 4 meters) showed that conditions were suitable for oyster survival and growth.

3.2 Rock oyster spatfall

Data from these samples confirm that natural rock oyster spatfall continues to occur subtidally in the restoration area. The samples from the northern patch reef (#17) averaged 34.5 spat per 100 shells (range 22-47) (Figure 3). However, the oyster shells sampled from under the coir mesh cover (within an arms length of the outer edge of the cover) had only 22 spat per 100 shells, while the sample of shells taken from the uncovered part of this reef returned 50 spat per 100 shells. Diver inspection of this reef revealed that the current had peeled part of the coir mesh cover off of around half of the reef (Figure 4), and that the section where the coir mesh remained was smothered in sediment (Figure 5, underwater video available at https://youtu.be/2C32392FKTg). The lower mean spat settlement on this reef (mean 34.5 spat per 100 shells) was therefore likely due to covering of the reef by the coir mesh. Nevertheless, the 34.5 spat/100 shells was still slightly higher than the mean 32 spat/100 shells recorded from degraded small scale (c. 2 meter diameter) patch reefs sampled 9 months after their deployment in December 2017 (Figure 3). In contrast, the samples from the southern patch reef (#18) averaged 65 spat per 100 shells (range 58-72), with the sample of 72 spat/100 shells obtained from the shells taken on the southern side of the reef, and 58 spat/100 shells from the shells taken from the northern side. This result was closer to the mean 88.33 spat/100 shells obtained from crate reefs examined in September 2018 (Figure 3). Diver inspections revealed that reef #18 was in excellent condition with noticeably more fish present compared to reef #17.

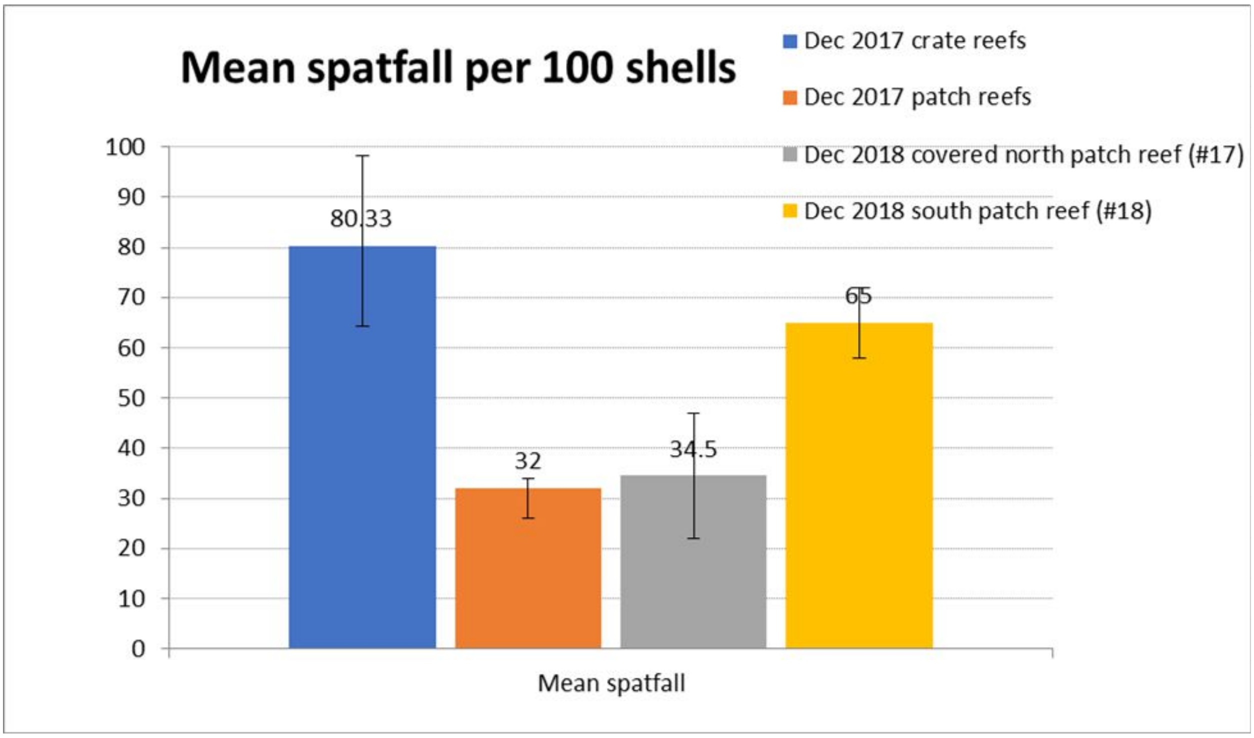

Figure 3. Results for natural rock oyster spatfall on subtidal oyster shells collected in March 2019 from patch reefs (#17 north and #18 south) deployed in December 2018, compared to data from crate and patch reef modules deployed in the same area in December 2017. Spatfall was higher on the patch reef which was not covered in coir mesh.

The mean size of rock oyster spat obtained from the south reef (#18) was 15.6 mm (range 5-38 mm, SD = 6.67mm) which was impressive for natural spatfall less than 3 months old. Of these, 71% were alive (mean size 14.8 mm, range 5-38 mm), and the remaining 29% were dead (mean size 17.5 mm, range 8-35 mm). The mean size of rock oyster spat

Figure 4. The coir mesh cover on the north reef (#17) had been partially dislodged by the current, exposing oyster shells and making them accessible to fish and natural rock oyster spatfall at a rate of 50 spat/100 shells.

Figure 5. The section of reef #17 where the coir mesh remained was smothered in sediment which prevented access to the reef by fish and oyster spat. The spatfall rate on shells sampled within an arms length of the edge of the cover was only 22 spat/100 shells.

Figure 6. Examples of rock oyster spatfall on shells obtained from 3 month old patch reefs in Pumicestone Passage. A colony of tunicates (*Botrylloides* sp.) is also evident on one shell.

oyster spat obtained from north reef #17 was 14.7 mm (range 7-30 mm, SD = 5.68 mm) which was very similar to that found for reef #18 (Figure 6). Survival of spat for reef #17 was higher at 91% (vs 71% for reef #18) (mean size of live spat 14.3 mm, range 7-30 mm), and the remaining 9% were dead (mean size 19.7 mm, range 10-30 mm). Sampling of shells also found recruitment of glory scallops (*Mimachlamys gloriosa*) (Figure 7) as well as several other reef forming organisms which cemented the shells together into a reef matrix, including several species of corralline algae, bryozoans, hydroids, solitary and colonial tunicates, and soft corals (Table 2, Ramos Gonzalez et al. 2019). When the DNA of rock oyster spat was examined by Griffith University, they found evidence that the species recruiting to subtidal besser bricks were uncharacterized *Ostrea*, spp., *Dendostrea* spp. and *Crassostrea* spp., while oysters sampled from nearby intertidal areas conformed to Sydney rock oysters (*Saccostrea glomerata*) (see Ramos Gonzalez et al. 2019).

3.3 Reef condition

All of the besser fence modules had their exteriors heavily fouled with barnacles and reef forming invertebrates including corraline algae, solitary sea squirts (*Pyura* sp.), colonial seasquirts, brown and green macroalgae and sea urchins (underwater video available at https://youtu.be/2C32392FKTg). Diver inspection of the northern reef revealed that the current had peeled part of the coir mesh cover off of around half of the reef (Figure 4), and that the section where the coir mesh remained was smothered in sediment (Figure 5, underwater video available at https://youtu.be/2C32392FKTg). The condition of this reef was therefore rated as poor. Diver inspection of the southern reef (#18) revealed it to be in excellent condition with shells already organically cemented into position by invertebrate biofouling organisms.

Figure 7. A glory scallop (*Mimachlamys gloriosa*) recruited to an oyster shell deployed on a 3 month old patch reef in Pumicestone Passage. A small rock oyster spat is also evident to the right of the glory scallop.

Table 2. Details of rock oyster spatfall and other bivalves and invertebrates found in samples of 200 shells obtained from the 3 month old patch reefs.

Reef Number	Reef type	Mean spatfall /100 shells	Mean (range) spat size (mm)	Spat survival	Other invertebrates
17	Patch reef, c. 6.5 meters dia. with coir mesh cover	34.5	Overall 14.7 (7-30) Alive 14.3 (7-30) Dead 19.7 (10-30)	91%	+++ corraline algae +++ barnacles 6 amphipods 1 glory scallop 6 seasquirts 4 colonial ascidians 1 flatworm 1 porcellanid crab 1 snapping shrimp
18	Patch reef, c. 7.5 meters dia.	65	Overall 15.6 (5-38) Alive 14.8 (5-38) Dead 17.5 (8-35)	71%	+++ corraline algae +++ barnacles 7 amphipods 7 sea squirts 16 colonial ascidians 1 Brittle starfish 2 flatworms 2 gastropods 1 snapping shrimp 3 serpulid polychaetes

3.4 Gopro footage of reef units

To ascertain what fishes were associating with patch reefs, a GoPro camera was deployed on a brick near each patch reef and the number of fish evident in the first 12 minutes of video were counted. The activity around patch reef #18 (south reef) was videoed from around 11 am to 11.20 am on 11 March 2019. The resulting video has been uploaded on the internet at:

https://youtu.be/pBC97OtMCis

The video revealed association with the patch reef by at least 13 species of finfish (Table 3). In order of greatest to least abundance, the species observed included whiptail, silver biddy, stripey, grass tuskfish, blacksaddle goatfish, fan bellied leatherjackets, Gunther's wrasse, happy moments, moses perch, tarwhine, yellowfin bream, crested morwong and Mullers coralfish (Table 3, Figures 8-11). As the camera was not retrieved immediately after the first 12 minutes had elapsed, additional footage of this reef after the 12 minute survey period found other notable fishes including adult male grass tuskfish and a juvenile tawny nurse shark (*Nebrius ferrugineus*)(Figure 12).

Table 3. Species of fish observed swimming past southern patch reef #18 in a 12 minute video taken from 11 am on 11 March 2019 from a camera oriented to face towards the reef.

Fish name	Latin name	Approx # views	Activity
whiptail	*Pentapodus paradiseus*	>100	swim by
silver biddy	*Gerres subfasciatus*	>50	swim by
stripey	*Microcanthus strigatus*	>50	swim by
grass tuskfish	*Choerodon cephalotes*	30-40	swim by
blacksaddle goatfish	*Parupeneus spilurus*	10-20	swim by
Fan bellied leatherjacket	*Monacanthus chinensis*	10-20	swim by
Gunthers wrasse	*Pseudolabrus guentheri*	10-20	swim by
happy moment	*Siganus fuscescens*	10-20	swim by
moses perch	*Lutjanus russelli*	10-20	swim by
tarwhine	*Rhabdosargus sarba*	10-20	swim by
yellowfin bream	*Acanthopagrus australis*	10-20	swim by
crested morwong	*Cheilodactylus vestitus*	5-10	swim by
Mullers coralfish	*Chelmon muelleri*	1-2	swim by

The activity around patch reef #17 (north reef) was videoed from around 12 noon to 12.20 pm on 11 March 2019. The resulting video has been uploaded on the internet at:

https://youtu.be/CxUQ9V7Rljw

This video showed the importance of camera orientation. Because of the random drop of the camera, even though it was deployed within 4 meters of the north reef, it was facing away from the reef and as a result it is estimated around 10 times fewer fish were observed, mainly whiptails with 1 small school of happy moments, as well as occasional silver biddy, grass tuskfish, and fan bellied leatherjackets (Table 4, Figures 13, 14).

Table 4. Species of fish observed near the northern patch reef #17 in a 12 minute video taken from 12 pm on 11 March 2019 from a randomly dropped camera located around 4 meters from the reef but facing away from the reef.

Fish name	Latin name	Approx # views	Activity
whiptail	*Pentapodus paradiseus*	5-10	swim by
happy moment	*Siganus fuscescens*	5-10	swim by
silver biddy	*Gerres subfasciatus*	3-5	swim by
grass tuskfish	*Choerodon cephalotes*	1-2	swim by
Fan bellied leatherjacket	*Monacanthus chinensis*	1-2	swim by

As mentioned previously, diver inspection of the northern reef (#17) revealed that the coir mesh cover required by fisheries legislation to "securely retain" live oyster shells had peeled off around half of the reef (Figure 4), and that the section where the coir mesh remained was smothered in sediment (Figure 5, also see video at https://youtu.be/2C32392FKTg). Also evident during the swim-around were large numbers of at least 2 species of cardinalfish (Family Apogonidae) which were closely associated with the besser fence modules (Figure 15).

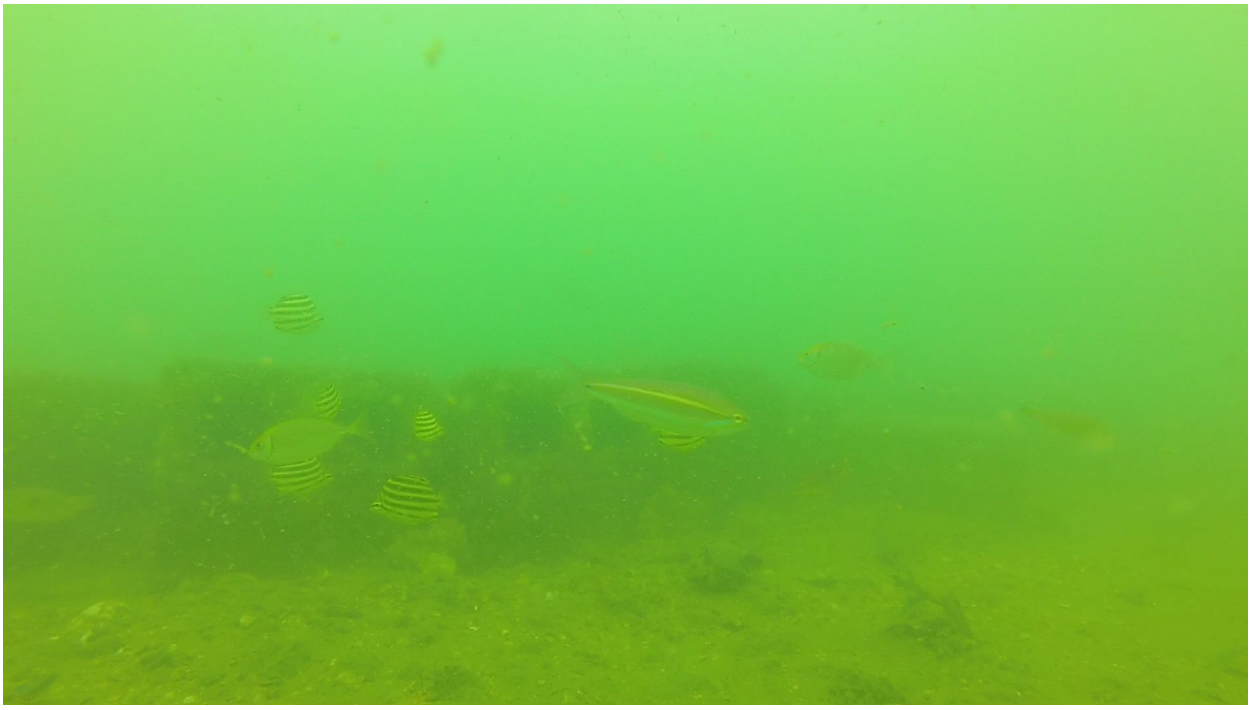

Figure 8. A whiptail (*Pentapodus paradiseus*), happy moment (*Siganus fuscescens*) and a school of stripeys (*Microcanthus strigatus*) swimming past the south reef (#18).

Figure 9. A moses perch (*Lutjanus russelli*) swimming past the south reef (#18).

Figure 10. A juvenile crested morwong (*Cheilodactylus vestitus*) and a school of stripeys (*Microcanthus strigatus*) swimming past the south reef (#18).

Figure 11. A fan bellied leatherjacket (*Monacanthus chinensis*) and a yellowfin bream (*Acanthopagrus australis*) swimming past the south reef (#18).

Figure 12. An adult grass tuskfish (*Choerodon cephalotes*) and juvenile tawny nurse shark (*Nebrius ferrugineus*) swimming past the south reef (#18).

Figure 13. A silver biddy (*Cheilodactylus vestitus*) swimming near the north reef (#17).

Figure 14. An adult grass tuskfish (*Choerodon cephalotes*) swimming near the north reef (#17).

Figure 15. Numerous cardinal fish (at least 2 species within the Family Apogonidae) were closely associated with the besser fence modules of the north reef (#17).

Discussion

Results from these samples confirmed that natural rock oyster spatfall continues to occur subtidally in the restoration area, with mean spat counts of 65 spat per 100 shells found for shells sampled from the uncovered southern patch reef (#18). This rate of spatfall is close to that obtained from shells obtained from crate reefs in the December 2017 deployment (mean 80.33 spat per 100 shells) and is much higher than recorded from shells on smaller 2x2 meter patch reefs in the December 2017 deployment (mean 32 spat per 100 shells). It is hypothesised that the revised design of the taller, more robust fence modules and the larger size of the experimental reefs in the December 2018 deployment have better protected the reefs from sedimentation compared to shells on the original 2x2 meter patch reefs deployed in December 2017, which were highly susceptible to damage by boat anchors and sedimentation "edge effects" (Diggles et al. 2018).

Interestingly, the DNA studies done by Griffith University (Ramos Gonzalez et al. 2019) found that the identities of the rock oyster spat recruiting to besser blocks located near the subtidal reefs was not the Sydney rock oyster (*Saccostrea glomerata*) found in adjacent intertidal areas, but instead included other species such as *Ostrea*, spp., *Dendostrea* spp. and *Crassostrea* spp. for which the DNA sequences obtained did not appear on international databases. It remains to be seen if these juvenile oysters recruiting to subtidal reefs in Pumicestone Passage are previously described species of *Ostrea*, *Dendostrea* and *Crassostrea* , or new species.

The video camera deployments described here and in the previous invertebrate monitoring report (Diggles et al. 2018) were undertaken opportunistically to provide us with some idea of the sort of fish activity occurring on the reefs. While these camera deployments are only opportunistic and have not been standardized (due to the fact that other groups are doing the standardized scientific finfish monitoring), our results show the importance of fine scale camera orientation. These trial shellfish reefs are very small (2 meters diameter in the December 2017 deployment, 7 meters diameter in the December 2018 deployment) and visability in the trial area is generally poor (mostly <2 meters, exceptionally up to 4 meters). Because of this, a random drop of the camera (even if deployed within 4 or 5 meters of the reef, see https://youtu.be/2C32392FKTg) will inevitably mean the camera is pointing away from the reef, which can equate to a difference of an order of magnitude or more of fish activity compared to videos taken of reefs where the camera has been correctly oriented by divers to directly sit on the edge of the patch reef facing the deployed shells (e.g. as in the footage gathered of a degraded patch reef in September 2018, see https://youtu.be/lBuN0dCKjb4). The limited visibility and fine scale spatial sensitivity of camera placement on such small reefs means that attribution of effects of different reef types on fish populations (e.g. see figure 3 of Gilby et al. 2018) would not be possible using a random camera drop approach. Without use of divers to ensure specific orientation of the cameras towards the reefs being investigated (i.e. camera placement on or within 2 meters and facing the reef so that the footage collected shows fish behavior on the actual reef type being monitored), it would be impossible to attribute increases of fish numbers to any particular type of module (i.e. BESE vs patch reef vs crate reef), especially given that so many different types of reef modules are interspersed in such a small area (Figure 2).

As was previously recorded for the December 2017 deployments, the oyster shells on both of the reefs deployed in December 2018 were quickly colonised by prolific epibiont growths of various invertebrates including, amongst others, corralline algae, bryozoans, hydroids, solitary and colonial tunicates, and soft corals. Consultations with taxonomists at Griffith University and the Queensland Museum suggest that many of these invertebrates are likely to be undescribed new species, thus detailed taxonomic surveys will be required to properly determine the full invertebrate biodiversity associated with these restoration trials. Regardless of whether they are new to science or not, these epibionts help cement the loose shells together (Burkett et al. 2010) into a monolithic reef formation (Diggles et al. 2018), in a natural process which negates any need to cover the reefs with coir netting or other mesh to "adequately contain" live shells that may be used to enhance the reefs.

Advice from the State Government Fisheries (Aquaculture Licensing) Department relating to the release of aquaculture fisheries resources (i.e. live oysters) back onto trial shellfish reefs in Pumicestone Passage prior to our December 2018 deployment stated a requirement to demonstrate that the oysters would be "*adequately contained*" and "*secured in such a way to ensure that are not able to escape*"". The intent of the wording used by the Fisheries Department was to ensure that "*any animals which are released are contained within the site*".

However, our results from the December 2017 deployments found that the oyster shells deployed on patch reefs were quickly consolidated into a monolithic biogenic reef (Diggles 2018). Furthermore, the results from our surveys of the December 2018 deployment of the north reef (#17) show that using coir mesh netting over the top of the reef not only did NOT make a difference to the containment of the oysters on that reef (i.e. the oysters remained contained within the fence modules regardless of whether they were covered by the coir mesh or not (see Figures 4 and 5 and the video at https://youtu.be/2C32392FKTg), the coir mesh was also shown to be extremely detrimental to the reef. As was pointed out to the Fisheries Department prior to deployment of the reefs in December 2018, the requirement to cover reef #17 with artificial netting was considered to be disadvantageous to the scientific and practical function of the reef trials for the following reasons:

1. The netting artificially restricts fish access to the reef for grazing, contradicting a fundamental objective of reef restoration to enhance fish populations by allowing them free access
2. The netting makes sampling of the reef by divers more difficult, the netting will need to be cut to retrieve samples of shells needed during monitoring of invertebrate recruitment etc.
3. The netting will make it extremely difficult to generate "apples with apples" comparisons between last year's results with uncovered patch reefs against this year's results
4. Since similar netting is not used in any of the other restoration projects instigated or being planned interstate (or overseas for that matter), comparisons between the results from Pumicestone Passage and elsewhere may not be possible
5. Since netting cannot be used for large scale reef restoration, the results generated from small scale trials with netting may not accurately reflect those of larger scale restoration
6. The netting represents additional unnecessary artificial "junk" placed into the system in an age where humans are becoming aware of the need to reduce underwater pollution.

Now, after 3 months observations of reef #17 and comparisons between it and reef #18, we can also add to this list that covering shellfish reefs with artificial netting encourages (indeed promotes) sedimentation that will smother the covered area of the reef.

Therefore, we now have 2 years of strong empirical evidence from Pumicestone Passage that demonstrates that live oysters deployed over the top of experimental shell reefs in both 2017 and 2018 remained exactly where we put them, as they are quickly bound together by natural processes (cemented together by natural oyster cement (Burkett et al. 2010) and/or encrusting algae and calcifying invertebrates). This is not surprising as the scientific literature on shellfish reef restoration interstate and overseas has proven that the natural interlocking and cementing mechanisms of oyster shells (Burkett et al. 2010) are more than sufficient to adequately retain those shells on site during restoration of subtidal shellfish reefs. Because we now have 2 years of empirical proof that any live oysters used will be adequately contained within the subtidal reef area (particularly if it is surrounded by an appropriate sized fence system) and rapidly cemented together by natural processes, we strongly recommend that in the future the State Government should permit use of live oysters from an aquaculture lease for restoration of shellfish reefs without any requirements to cover the oysters with artificial netting. Furthermore, given its detrimental impact on the existing trial, an amendment of the existing condition to allow removal of the coir mesh netting should also be discussed.

Besides the detrimental impact of the coir netting over reef #17, these initial invertebrate monitoring results from the December 2018 deployment are very encouraging. We will follow up these results with additional invertebrate sampling periods at 6, 9 and 12 month intervals, so that the progress of establishment of the December 2018 reefs can be better understood.

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Project partners

The various partners involved with this project are listed below. Many thanks to all partners together with Bribie's oyster gardeners and the broader community for their efforts and support as we continue our journey towards restoration of the lost shellfish reefs in Pumicestone Passage and Moreton Bay.

Joondoburri Land Trust

Sebastiani Oyster Farm

Pumicestone Passage Fish Restocking Assoc.

Kabi Kabi First Nation