Annex III

Impact of the relaying of seed mussel on the inter-tidal sand flat: Benthic fauna

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General Ecological effects

Potential ecological effects of relaying mussels on intertidal mud or sand flats are complex. Mussel deposition have the capacity to both enhance and degrade components of the original benthic community (Saurel *et al.* 2004). Relaying of seed mussels at high density and percentage cover onto pristine habitats leads to substantial and complex changes in the physical and biological habitat which enhances certain biotic groups and suppresses others. Enhancement can occur through the provision of a more complex habitat on the surface of the shell matrix and the production of organically enriched sediment microhabitat. Degradation can occur through competition, smothering, anoxia, destabilisation of the sediment due to the increased flux between the bed and the water column and removal of larvae in the water column through filter-feeding. There is generally an enhancement of mobile epifauna and a suppression of typical infauna. Inter-tidal mussel beds are inherently unstable and prone to catastrophic mortality resulting from physical destabilisation, predation and overcrowding leading to detachment (Saurel *et al*. 2004)

The Castlemaine nursery

In the intertidal seed mussel nursery area in Castlemaine Harbour a mosaic of mussel patches, interspersed with clear patches of muddy sand, with no mussel cover is present as a result of previous relaying, harvesting for ongrowing and natural spat fall. The mussels have attached macroalgae (mainly *Fucus* spp).

Although the co-op is licenced to relay mussels throughout the mussel order area it does so only in a narrow intertidal strip on the mid and lower shore north west of the main sub-tidal channel (Figure 1). The co-operative has sub-divided the nursery area into 48 plots which are allocated to different members of the co-op for the purpose of relaying seed mussel. Each member of the co-op then has discretion on the volume, if any, of seed that is to be re-laid into the allocated plot. In effect the majority of members may not be able to source seed in a given year so the plot will remain vacant. The length of time seed may be left on each plot also varies depending on availability of sub-tidal ongrowing areas which in turn may be dependent on market conditions.

This pattern of activity over recent years has led to the development of variable degrees of mussel cover in the intertidal nursery.

Figure 1. Castlemaine Harbour showing transects erected to evaluate bird use of the mussel nursery area. Benthic samples were taken in the lower and mid shore of transects 11, 13 and 14.

Monitoring of benthic fauna in the intertidal nursery

The maintenance of favourable conservation status of the wetland habitats as a resource for migratory waterbirds is a stated conservation objective for the Castlemaine Harbour SPA (NPWS 2010).

Methods

Forty six core samples were taken at mid and lower shore level in transects 11, 13 and 14 on 26th April 2010. Half of the samples were taken on clear sand/mud areas with no mussel cover and the remainder were taken underneath mussels after first removing the mussel cover. This sampling design tested the null hypothesis that inbenthic fauna in clear areas was similar to fauna underneath mussels.

All fauna was retained on a 1mm sieve and subsequently identified to species level by the Aquatic Services Unit, UCC.

Summary statistics and ANOVA for the main faunal components were compiled for samples in mid and lower shore under mussel and in clear sand. A multivariate analysis (Cluster analysis using PRIMER® 6.0) was undertaken to evaluate differences in the benthic communities in sand and under mussel and to identify species contributing to these differences.

Results

Univariate analysis:
The benthic fauna in the nursery area was generally of low diversity and abundance (Table 1). A total of 16 species were recorded and the average total number of animals per sample was 4.7. The fauna was dominated by polychaetes (80%) with lesser numbers of bivalves (14%) and crustaceans (7%).

Table 1. Species recorded in benthic core samples (1mm sieve) in the intertidal mussel nursery area in Castlemaine Harbour.

Species	**Number**
Arenicola marina	1
Mytilus edulis	6
Nepthys hombergii	53
Macoma balthica	14
Caulierella sp.	44
Capitella capitata	19
Scoloplos armiger	31
Gammarus locusta	3
Cerastoderma edule	7
Crangon crangon	2
Littorina obtusata	1
Pygospio elegans	26
Carcinus maenas	2
Tubificoides benedii	8
Owenia fusiformis	1
Hydrobia ulvae	3
Total	**221**

Mean number of benthic fauna was 8.7 in mid-shore clear sand samples compared to 3.7 in mid-shore samples taken under mussel. This difference was mainly due to higher abundance of polychaetes in clear sand compared to beneath mussels.The abundance of crustaceans was low in all samples but especially so under mussel. These differences, found at mid-shore level, were not apparent in the lower shore where the abundance of all 3 faunal components was similar in sand and under mussel.

Analysis of variance of transformed (Ln+1) abundance data showed as suggested by the summary statistics significant ($p<0.01$) differences in the abundance of polychaetes in mussel and clear sand.

Table 2. Mean (±s.d) numbers of benthic fauna, molluscs, polychaetes and crustaceans in core samples taken in mid and lower shore in clear sand and under mussel cover in the intertidal mussel nursery area in Castlemaine.

		All Fauna		**Molluscs**		**Polychaetes**		**Crustaceans**	
	N	Mean	S.d.	Mean	S.d.	Mean	S.d.	Mean	S.d.
	Mid shore								
Mussel	12	3.75	3.22	1.00	1.35	2.75	3.17	0.00	0.00
Sand	12	8.75	6.51	0.92	1.38	7.75	6.41	0.08	0.29
	Lower shore								
Mussel	11	2.82	2.75	0.36	0.81	2.09	1.97	0.36	0.67
Sand	11	3.36	1.75	0.36	0.92	2.81	1.53	0.18	0.40

Multivariate (community) analysis:

Cluster analysis of the benthic core data showed some grouping (clustering) of samples according to whether samples were taken in clear sand or under mussels although these groups were not significantly different from each other mainly because within group similarity was low indicating small spatial scale differences in abundance and species composition (Figure 2). The pattern was similar when replicate samples within sites were grouped (Figure 3).

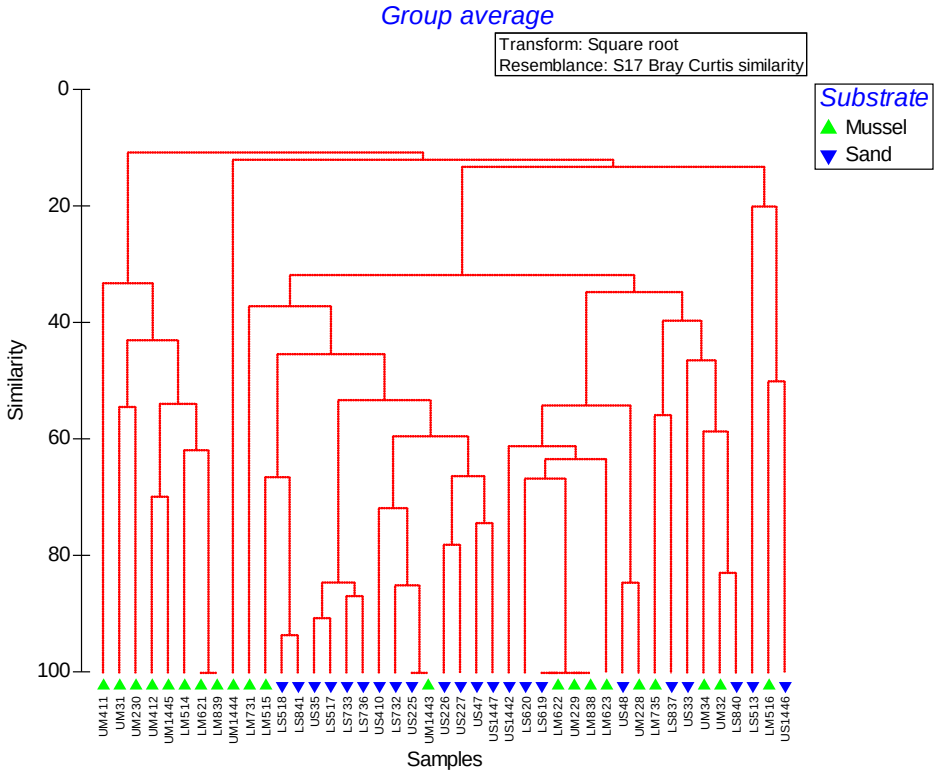

Figure 2. Hierarchial agglomerative cluster analysis of macrobenthic core data (April 2010) from Castlemaine Harbour. Samples where no fauna were recorded were not included in the analysis. A SIMPROF significance test was carried out using the labelling factor. There is no significant difference between samples

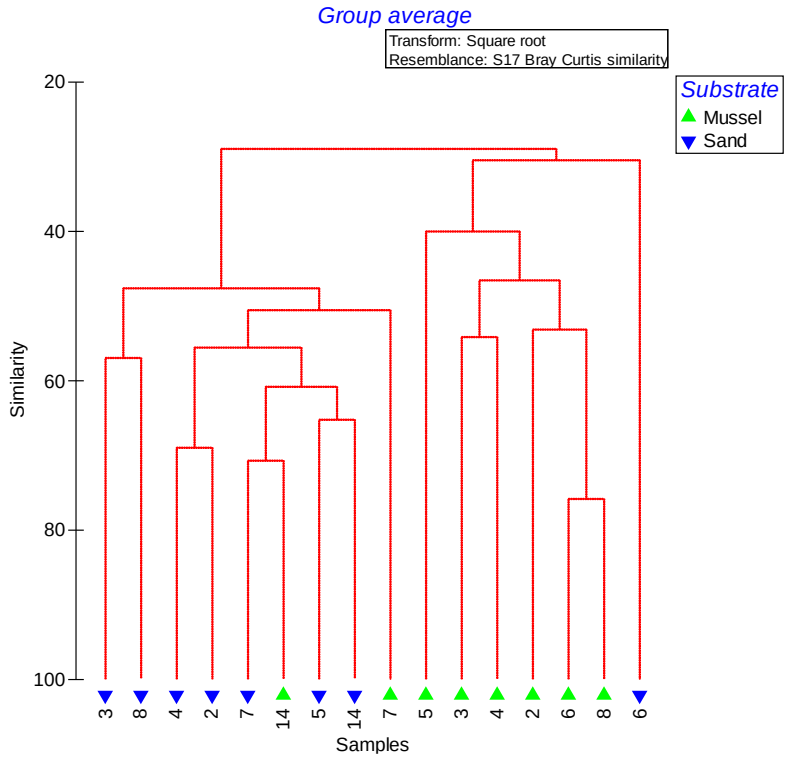

Figure 3. Hierarchial agglomerative cluster analysis of macrobenthic core data from Castlemaine Harbour. Samples where no fauna were recorded were not included in the analysis. Fauna from replicates at each site were averaged and a SIMPROF significance test was carried out using the labelling factor. Samples or sample groupings are not significantly different from each other.

Species contribution to similarity and dissimilarity

SIMPER analysis of macrobenthic core data from mussel beds and sandy substrate showed that the highest percentage of similarity within each group was contributed by the polychaete worm *Nepthys hombergii* (45.29% in mussel beds and 47.1% in sandy substrate). *Nephtys hombergii* is a predatory worm which consumes a variety of small benthic invertebrates.

The four species of polychaete worm (*Capitella capitata*, *Scoloplos armiger*, *Caulierella* sp., and *Pygospio elegans*) that cumulatively make up 54% of the contribution to the dissimilarity between mussel bed and sandy sites are opportunistic deposit feeders. *Capitella capitata*, found only in samples taken from under the mussel beds, is common in muddy sediments and is often found in polluted waters where it out-competes less tolerant species. *Scoloplos armiger*, predominantly associated with samples taken from sandy substrates, belongs to the family Orbiniidae and are known to attain dense populations in sediments that are of mixed sands and muds. Spionids, of which *Pygospio elegans* is a member, are selective deposit feeders and are common in soft sediments, while *Caulierella* sp. belongs to the family Cirratulidae that burrow or crawl through the substratum. In addition *Tubificoides benedii* is more common under mussel.

Table 3. SIMPER analysis of core data showing species contribution to sample similarity in sand and mussel bed samples

Group: Mussel	**Average Similarity : 42.56**				
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nepthys hombergii	0.75	19.27	2.85	45.29	45.29
Capitella capitata	0.83	16.28	1.52	38.25	83.54
Macoma balthica	0.39	3.03	0.51	7.12	90.67
Group: Sand	**Average Similarity : 49.21**				
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nepthys hombergii	1.28	23.18	3.83	47.1	47.1
Scoloplos armiger	0.86	8.93	0.98	18.16	65.25
Caulierella sp.	0.88	7.11	0.98	14.45	79.7
Pygospio elegans	0.8	6.82	0.97	13.86	93.57

Table 4. SIMPER analysis of core data showing species contribution to sample dissimilarity across sand and mussel bed samples

Group: Mussel & Sand	**Average dissimilarity : 67.57**					
Species	Av.Abund (mussel)	Av.Abund (sand)	Av.Diss	Diss/SD	Contrib%	Cum.%
Capitella capitata	0.83	0	10.31	1.73	15.26	15.26
Scoloplos armiger	0.28	0.86	8.94	1.26	13.23	28.5
Caulierella sp.	0.38	0.88	8.84	1.29	13.09	41.58
Pygospio elegans	0.1	0.8	8.16	1.28	12.07	53.65
Nepthys hombergii	0.75	1.28	6.14	1.99	9.09	62.74
Macoma balthica	0.39	0.39	5.39	1.02	7.98	70.72
Mytilus edulis	0.25	0.07	3.12	0.65	4.62	75.34
Tubificoides benedii	0.23	0.07	2.93	0.43	4.33	79.68
Cerastoderma edule	0.19	0.14	2.81	0.66	4.16	83.83
Crangon crangon	0	0.18	2.73	0.52	4.04	87.88
Hydrobia ulvae	0.07	0.16	2.17	0.65	3.21	91.09

Summary

The species composition of benthic macrofauna in sand and in sand/mud under mussel cover in the intertidal mussel nursery area in Castlemaine Harbour is largely similar. The relative abundance of a number of species of polychaete however is different. The overall abundance of polychaetes is lower under mussel and the abundance of a number of species of deposit feeding polychaetes is reduced. Two species of deposit feeding worms, *Capitella capitata* and *Tubificoides benedii,* occur in higher abundance under mussel.