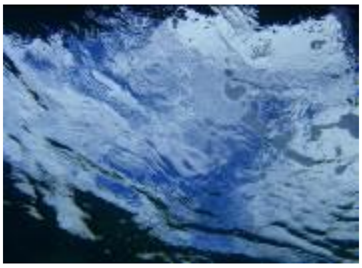
MF55 Long Bay Port Arthur
BASELINE ENVIRONMENTAL ASSESSMENT

FINAL REPORT (VERSION 1.0)

August 2017

Report to:

Tassal Limited

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18/8/2017		Tassal	Electronic	1.0	1
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1 Summary

Marine Farming Lease MF55 Long Bay, Port Arthur, is located along the eastern shore of the entrance to Long Bay. MF55 is located within Zone 15 B of the Marine Farming Development Plan for the Tasman Peninsula and Norfolk Bay. The lease is predominantly marine, although it is influenced to a minor degree by freshwater inputs from the surrounding catchment during high rainfall events. MF55 is relatively sheltered, but is subject to episodic southern ocean swells which periodically influence the southern section of the lease. Short waves generated by sea breezes also affect the site. Water depths range from 10 m MSL in the northern end of the lease to 26 m MSL in the southern end.

Fish farming has been undertaken previously at MF55, with salmonid farming activities occurring between 1986 and 2005. Tassal ceased farming activities in 2005 for operational reasons. The lease was subject to a minor variation in 2007, with the lease boundary adjusted away from a section of rocky reef. In accordance with Schedule 3B for MF55, a finfish baseline environmental survey was required prior to recommencement of aquaculture operations. Baseline information on the seafloor appearance and sediments at MF55 was collected by Tassal Pty Ltd and Aquenal Pty Ltd.

Current flow data was collected by Marine Solutions Pty Ltd. In order to measure localised current movement, an Acoustic Doppler Current Profiler (ADCP) was deployed inside the lease (55G 570393 5224347) at a depth of approximately 16 m for a period of 6 weeks between 8th January 2015 and 22nd February 2015. The ADCP was set to measure current velocity and direction throughout the water column every 20 minutes, with the data grouped into three depth bins (surface, middle, bottom waters). Current velocities were considerably higher in surface waters, averaging 22.6 cm s^{-1}, compared to 4.6 cm s^{-1} and 4.9 cm s^{-1} for middle and bottom waters, respectively. Flow direction in surface waters was strongly aligned along a NW-SE orientation. A relatively high proportion of stronger currents (i.e. >50 cm s^{-1}) were measured flowing in a north westerly direction for surface waters. This pattern is likely to be attributable to episodic southerly or south-easterly wind events causing wind driven current flowing towards the north-west. Patterns of current direction for mid-water and bottom-water were very similar and broadly comparable with surface waters, with flows generally aligned along a NW-SE orientation. Current velocities in mid and bottom-water were mainly in the 0-10 cm s^{-1} range. Overall, based on the 6 week deployment period, it appears current direction is generally aligned along the NW-SE orientation. Higher current velocities in surface waters tend to flow towards the NW, with lower velocities of similar direction measured in mid and bottom waters.

Filming of the seabed was conducted by Tassal with a Remote Operated Vehicle (ROV), with video analysis conducted by Aquenal. Filming of the seabed at all compliance, control and internal habitat sites showed considerable variability between sites. Sandy substrates were the most common habitat overall, these were typically light grey in colour with dead bivalve shells and animal burrows present. A very small patch section of unvegetated rocks (<1 m^2) was observed at internal site 5. Most of the habitat variation was attributable to differing levels of attached and unattached drift algae. Attached algae was mainly comprised of *Caulerpa trifaria*, a green alga that grows from rhizomes on or under the sediment surface. Occasional attached red algae were also observed, these were most commonly attached to pieces of dead mollusc shells.

The variability in cover of both attached and drift algae most likely reflects the considerable bathymetric variation across the lease area. The lease traverses a deep channel section, with

shallower edges on the eastern and western boundary. There is also a trend of increasing depth towards the southern end of the lease area. At the deeper sites, cover of both attached and drift algae tended to be very low, with increasing levels of algae observed at the shallower sites.

Evidence of animal activity in the form of burrows was noted on most spot dives. The New Zealand screw shell *Maoricolpus roseus* was observed at all sites in low to moderate densities. The majority of these appeared to be dead shells based on the ROV footage. Other invertebrates recorded during the survey included flat oysters (*Ostrea angasi*), spider crabs (*Leptomithrax gaimardii*) and scallops (*Pecten fumatus*). The most common fish recorded on spot dives was the sand flathead (*Platycephalus bassensis*), which was recorded in low densities on most dives. Weed whiting (*Neoodax balteatus*) and gobies were also relatively common. At compliance site 1.1a, the habitat was patchy with a mix of sand and reef patches. Reef patches at this site were dominated by the brown alga *Ecklonia radiata*, with a variety of reef fish also present. There were no gas bubbles, *Beggiatoa*, or any signs of organic enrichment in the sediments at any site based on the video footage.

Visual assessment of cores showed that sediments were generally similar across sampling sites. Sediments typically consisted of fine sand with shell grit observed in most cores. At some sites (e.g. 1.1a-1.3a; S8.1-S8.3) coarse shell grit was evident in deeper sections of the core. Sediment colour showed some variation with grey, light yellowish brown and brown colouration observed. Faint darker patches or streaks were evident with increasing depth in cores from some sites (e.g. 2.1., 3.1, 3.2, 4.2, S8.3). In these cores, the darker streaks were generally below 50 mm sediment depth and are indicative of low oxygen levels in the sediment. These observations are not considered evidence of organic enrichment, such a pattern is not unusual in circumstances where sandy, well compacted sediments are present. The sandy nature of the sediments indicates that wave and/or swell action influences the seabed sediments and the rate of deposition of finer sediment fractions is low.

Redox measurement revealed well oxygenated sediments at 3 cm depth, averaging 159 mV across all sites. Sulphide concentration in sediments was very low at all sites, averaging 2.7 µM. The observed redox and sulphide values were consistent across compliance and control sites and are considered indicative of well oxygenated, unimpacted sediments.

Sediments across the survey area were generally clean with a relatively low proportion of fine clay and silt fractions (i.e. < 0.063 mm; average 15.5% v/v across all sites). Sediments were typically dominated by the 'medium sand' (0.5-0.25 mm) category (average 40 % v/v across all sites). Some variation in sediment particle size distribution was evident between sites. Patterns of particle size distribution at sites 1.1a and 1.2a, in particular, were different from the remaining sites, with a relatively high proportion of coarse particle size fractions. For example, at site 1.1a and 1.2a, the proportion of sediment fractions > 0.5 mm averaged 37.3%, compared to an average of 8.1% across the remaining sites. Overall, patterns of particle size distributions were indicative of a sedimentary environment with moderate agitation of seabed sediments and associated low abundance of fine silt and clay fractions.

The organic content of the sediments was low (< 10%) at all sites, as expected in sandy sediments. There was only minor variation between sampling sites, with no strong spatial pattern. Results from heavy metal analysis showed that the ANZECC Interim Sediment Quality Guideline (ISQG) 'high' trigger value was not exceeded for any of the analytes measured. With the exception of Arsenic, the observed levels were also well below the ANZECC ISQG 'low' trigger values. Arsenic levels slightly exceeded the ANZECC ISQG 'low' trigger value of 20 mg/kg at site 3.1, where a level of 25 mg/kg was recorded. Across the remaining sites, arsenic levels averaged 9 mg/kg. Overall, there was only minor variation between control and compliance sites for those heavy metals analysed.

Targeted sampling for the threatened screw shell *Gazameda gunnii* was undertaken across the lease area. No shells of *Gazameda gunnii* (either alive or dead) were detected during the targeted survey.

Benthic faunal samples were collected from each compliance, control and internal farm dive site. The area possessed very high faunal diversity, with a total of 2184 individuals from 109 families identified across the 21 samples. Faunal communities were dominated by polychaetes, accounting for 55.2% of individuals and 29.4 % of families identified. Crustaceans were also a prominent component of faunal communities, accounting for 30.3% of individuals and 37.6 % of families. Molluscs represented a minor component of the fauna in terms of abundance (11.4% of individuals), but they made an important contribution to overall diversity (23.9% of families). Abundance and diversity of other fauna (including anthozoans, echinoderms, nemerteans, phoronids and platyhelminths) was relatively low, accounting for 3.1% of individuals and 9.2% of families.

The most common taxa recorded during the survey was a polychaete from the family Spionidae, which represented 17.1 % of individuals recorded across all samples. Other commonly recorded taxa included Nephtyidae (polychaete), Lumbrineridae (polychaete), Callianassidae (amphipod) and Ampeliscidae (amphipod). Representatives from the family Capitellidae, *Mediomastus australiensis* and *Notomastus* sp., were recorded in low densities at some survey sites. While some capitellids can be indicators of organic enrichment, these particular taxa are not regarded as pollution indicator species.

The introduced New Zealand screw shell *Maoricolpus roseus* was recorded in variable numbers, with a total of 84 individuals recorded across all sites. Other introduced species recorded in very low numbers across the survey included the bivalves *Varicorbula gibba* (24 individuals), *Theora lubrica* (7 individuals) and *Crassostrea gigas* (5 individuals). The introduced sabellid polychaete *Euchone limnicola* was also recorded in very low numbers (3 individuals).

Multivariate analysis showed two broad groupings based on faunal similarity patterns between sites. The majority of sites grouped together at the 40% similarity level (based on cluster analysis). These patterns are indicative of relatively consistent faunal community structure across these particular survey sites. A second broad grouping included compliance sites 1.1a, 2.2, 2.3 and internal farm dive site INT-1. Differences in benthic fauna community structure are likely to reflect variation in environmental characteristics across the survey area. Sites 2.2, 2.3 and INT-1 located in the shallower northern part of the survey area, while site 1.1a was located in relatively shallow water adjacent to fringing reef on the south-eastern edge of the lease.

Based on the benthic faunal patterns present, any future benthic impacts outside the lease area should be readily observable. Reduced faunal diversity and an increase in species dominance patterns would be one of the main indicators of organic enrichment. Such a pattern would be expected to be readily discernible, given the high diversity measured during the baseline survey.

2 Operational Summary

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Field work: Aquenal Pty Ltd (seabed sampling)
Tassal (ROV)

Dates of fieldwork:
20-21/3/2017 Seabed sampling
19/4/2017 ROV survey

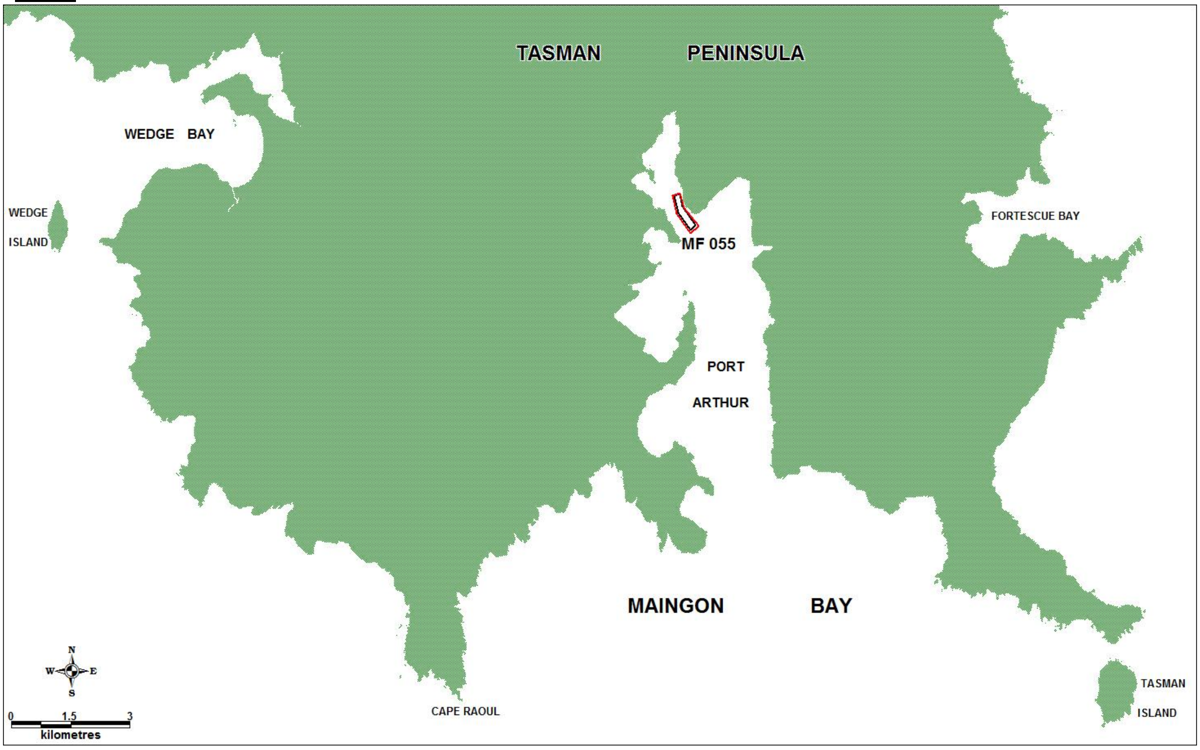
Weather:	20/3/2017	21/3/2017	19/4/2017
Wind:	S 10 knots	Light and variable	NE 5 knots
Sky:	Cloudy	Cloudy	Clear
Rain:	Light	Nil	Nil
Sea:	0.5 m	< 0.5 m	< 0.5 m
Current:	Negligible	Negligible	Negligible

Laboratory Analysis: Heavy metals, organic content: Analytical Services Tasmania (AST)
All other analysis by Aquenal Pty Ltd

ADCP analysis: Marine Solutions Pty Ltd

Filming for this assessment was carried out by Tassal using a Seabotix LBV150SE Remote Operated Vehicle (ROV). Positioning during the ROV survey was undertaken using a Garmin GPS and Nomad TDS. Seabed and ROV sampling was undertaken by Aquenal using a Craib Corer and Van-veen Grab. Positioning for seabed sampling was undertaken using a Garmin GPS178C/ Omnistar 3000L Differential Global Positioning System. Both GPS systems used provide real-time, differentially corrected DGPS positions accurate to ~2m and were referenced to a State Permanent Mark (SPM) prior to commencement of fieldwork.

3 Map



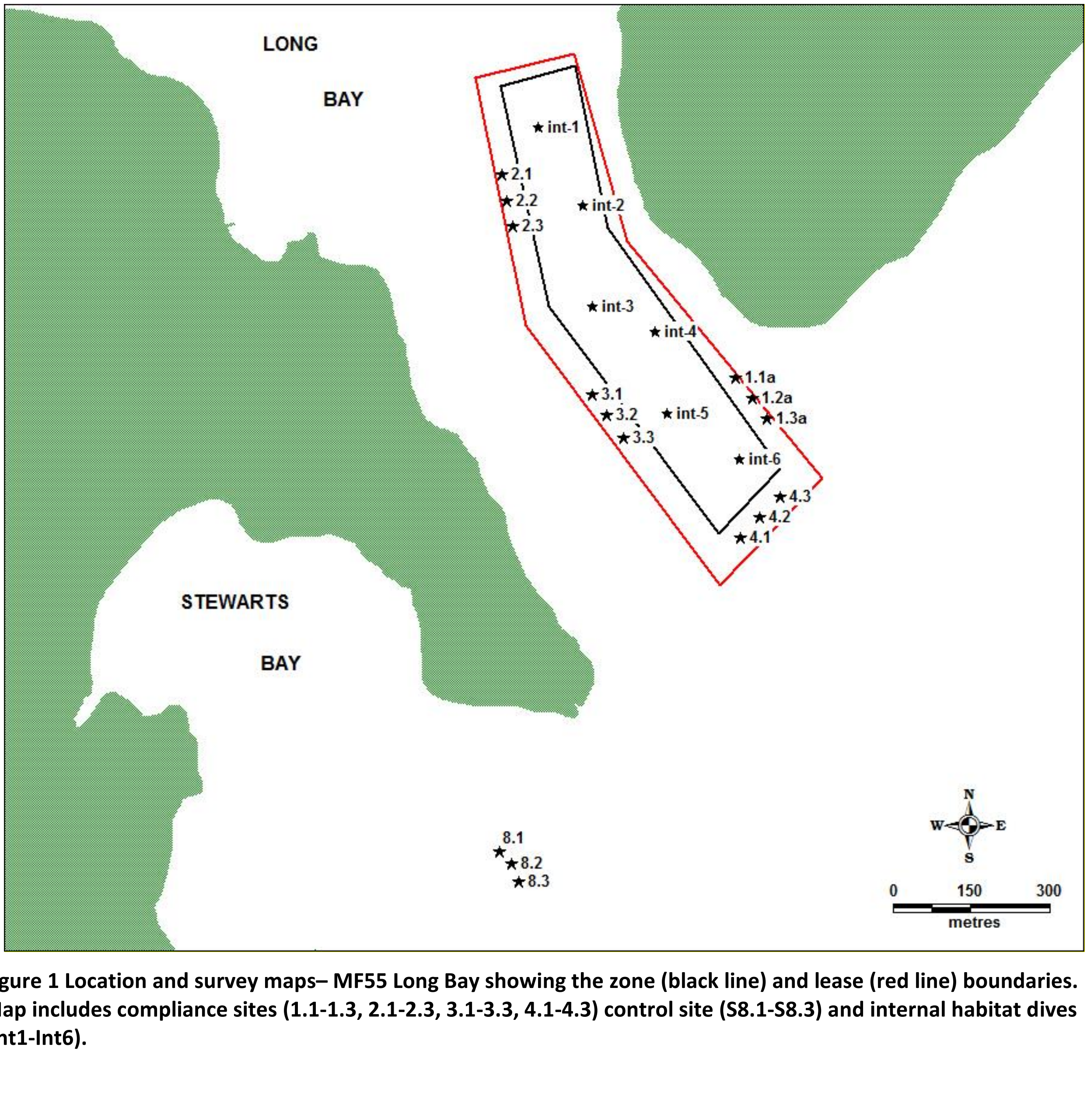


Figure 1 Location and survey maps– MF55 Long Bay showing the zone (black line) and lease (red line) boundaries. Map includes compliance sites (1.1-1.3, 2.1-2.3, 3.1-3.3, 4.1-4.3) control site (S8.1-S8.3) and internal habitat dives (Int1-Int6).

4 Current Measurements

The ADCP was set to measure current velocity and direction throughout the water column every 20 minutes, with this data grouped into three depth bins (surface < 5 m, middle 5 – 10 m, bottom waters 10 – 15 m).

Data from the ADCP deployment was processed and presented as current roses for surface, mid-water and bottom waters (Figures 2, 3 & 4). Current roses summarise water movement direction and velocity over the deployment period. The roses are read as if the current flow moves from the inner circle towards the outer circle of the graph.

Results and interpretation

Current velocities were considerably higher in surface waters, averaging 22.6 cm s^{-1}, compared to 4.6 cm s^{-1} and 4.9 cm s^{-1} for middle and bottom waters, respectively. Flow direction in surface waters was strongly aligned along a NW-SE orientation. A relatively high proportion of stronger currents (i.e. >50 cm s^{-1}) were measured flowing in a north westerly direction (Figure 2). This pattern is likely to be attributable to episodic southerly or south-easterly wind events causing wind driven current flowing towards the north-west.

Patterns of current direction for mid-water and bottom-water were very similar and broadly comparable with surface waters, with flows generally aligned along a NW-SE orientation (Figure 3). Current velocities in mid and bottom-water were typically lower than surface waters and mainly in the 0-10 cm s^{-1} range (Figure 4).

Overall, based on the 6 week deployment period, it appears current direction is generally aligned along the NW-SE orientation. Higher current velocities in surface waters tend to flow towards the NW, with lower velocities of similar direction measured in mid and bottom waters.

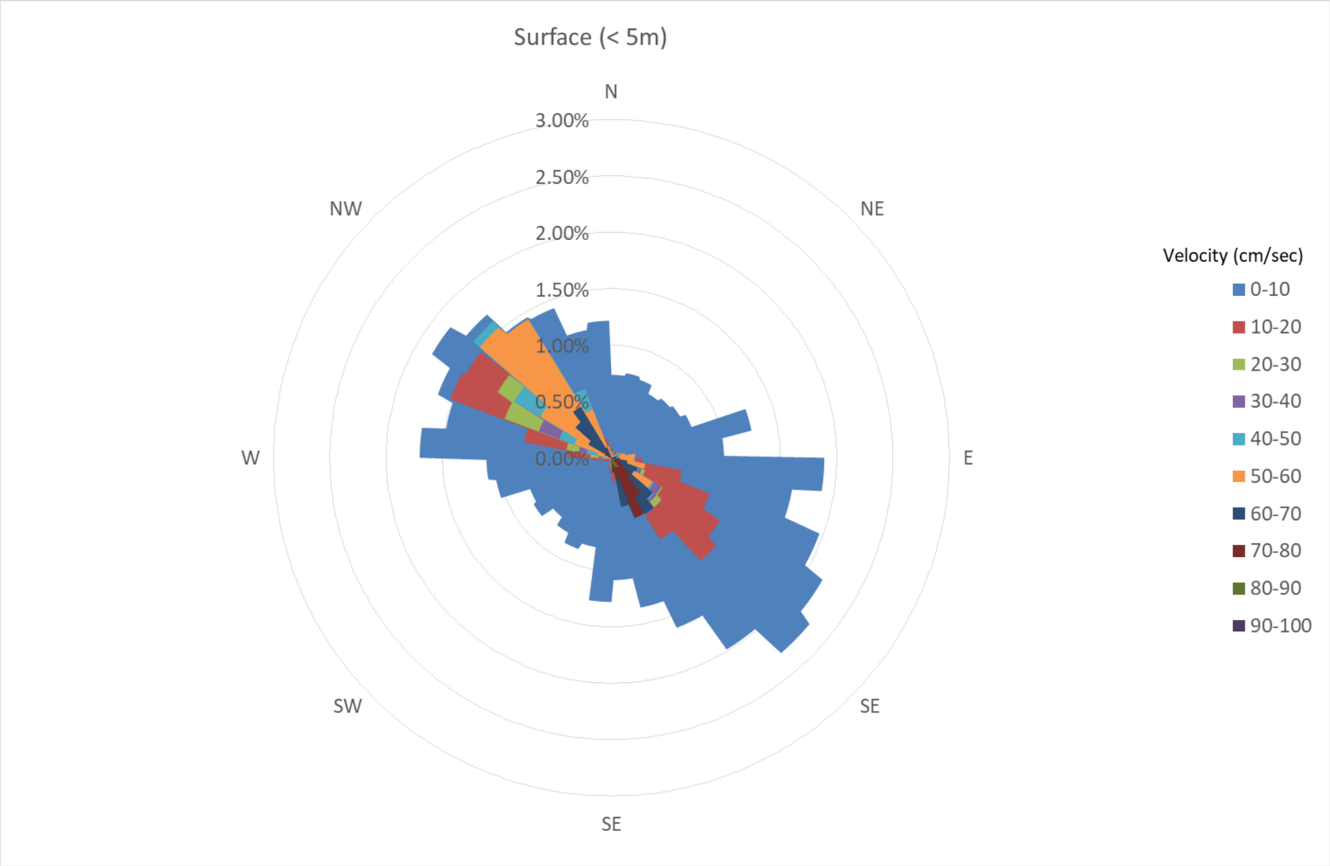


Figure 2 Polar plots of current velocity and direction for surface waters. The plots are read as if the current flow moves from the centre towards the outer circle of the graph.

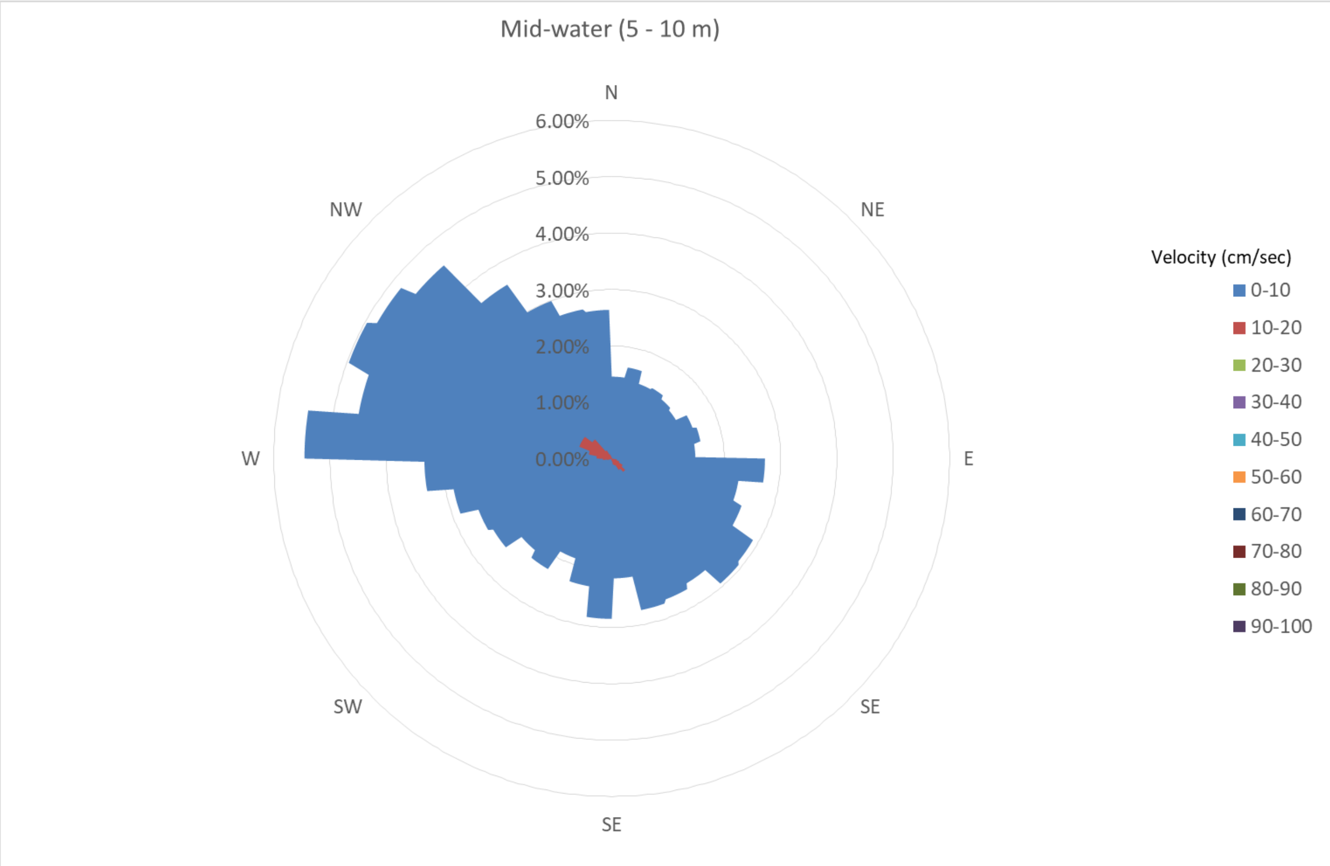


Figure 3 Polar plots of current velocity and direction for mid-water. The plots are read as if the current flow moves from the centre towards the outer circle of the graph.

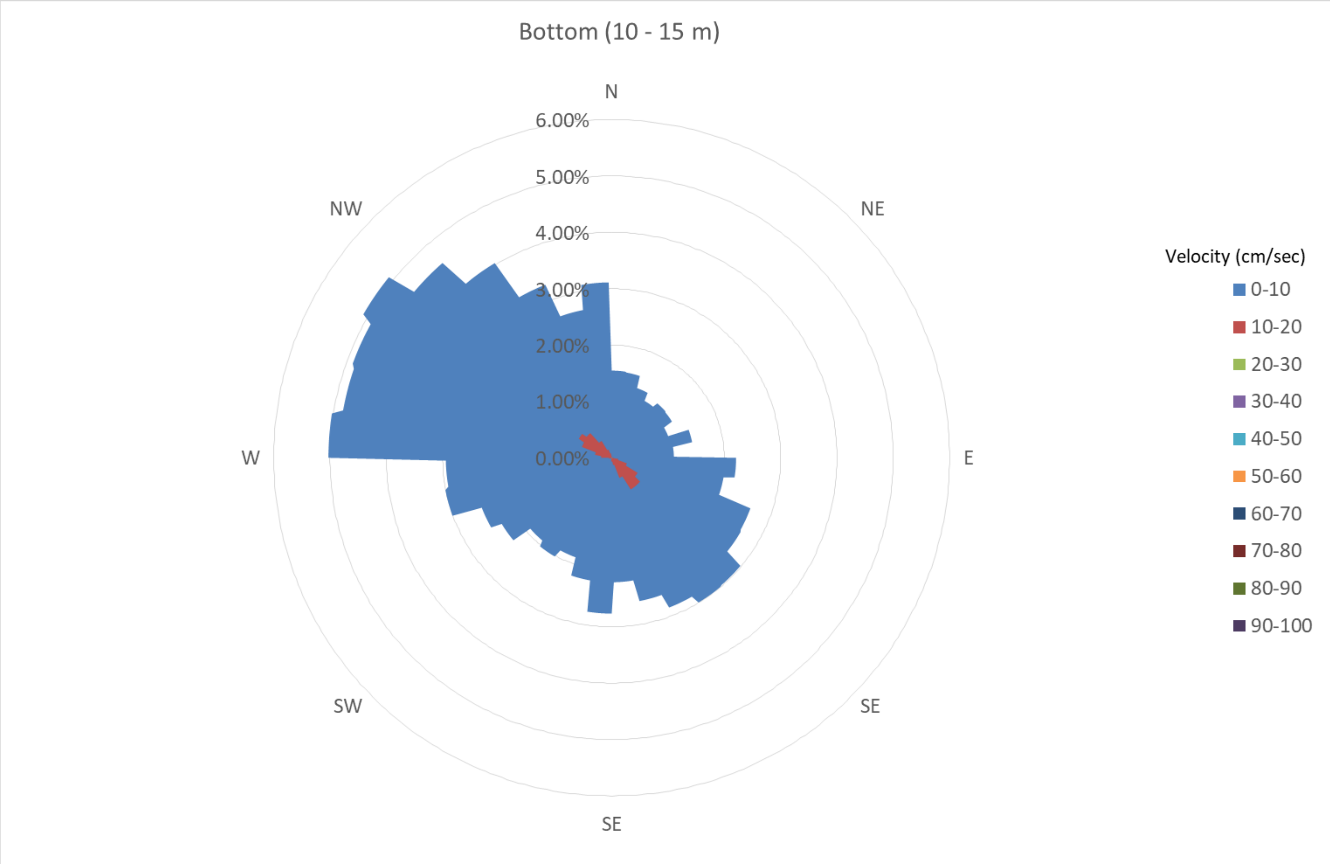


Figure 4 Polar plots of current velocity and direction for bottom water. The plots are read as if the current flow moves from the centre towards the outer circle of the graph.

5 Bathymetric Profile

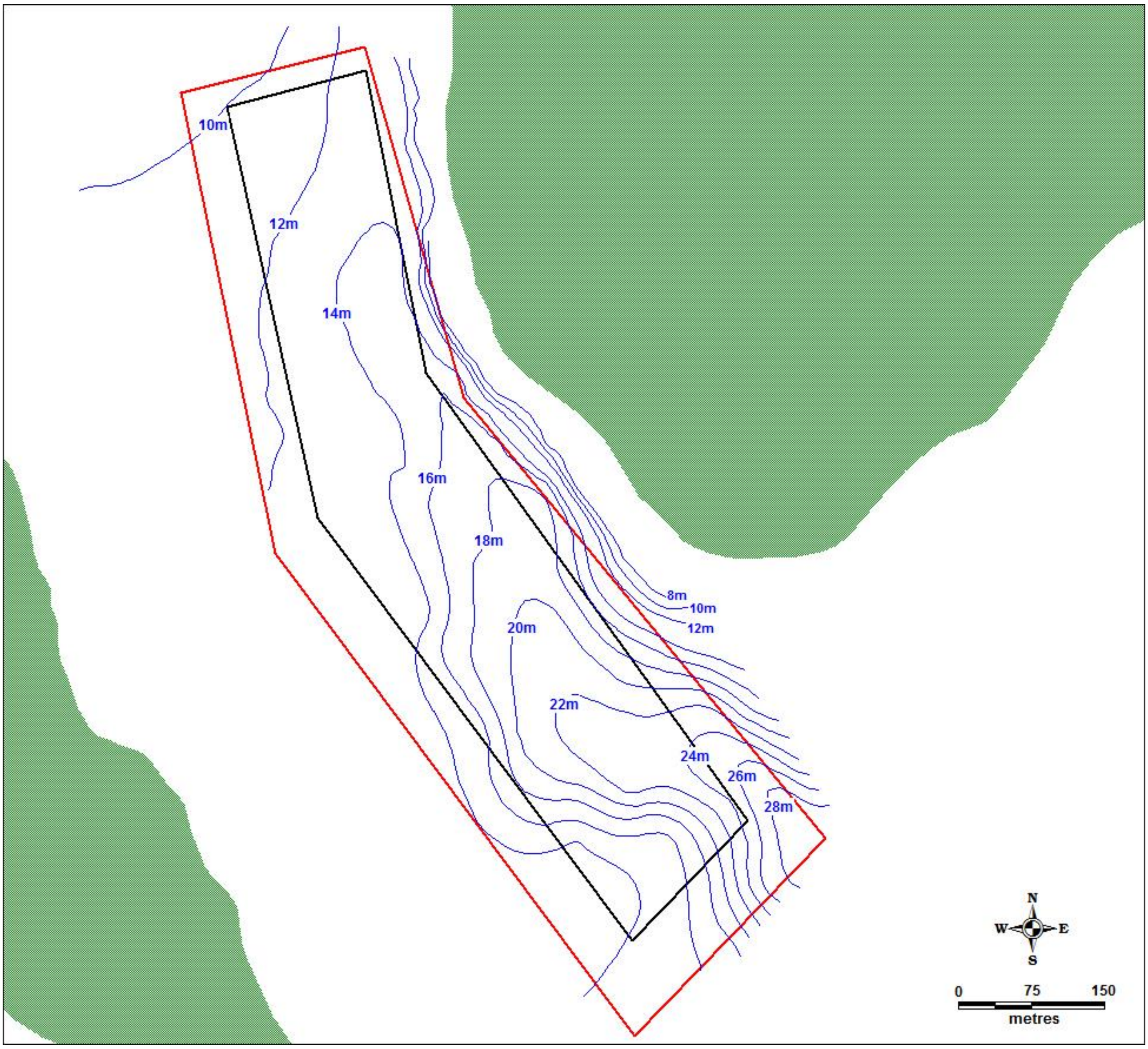


Figure 5 Bathymetric map. Contour interval = 2 m.

6 Seabed Characteristics and habitat profile

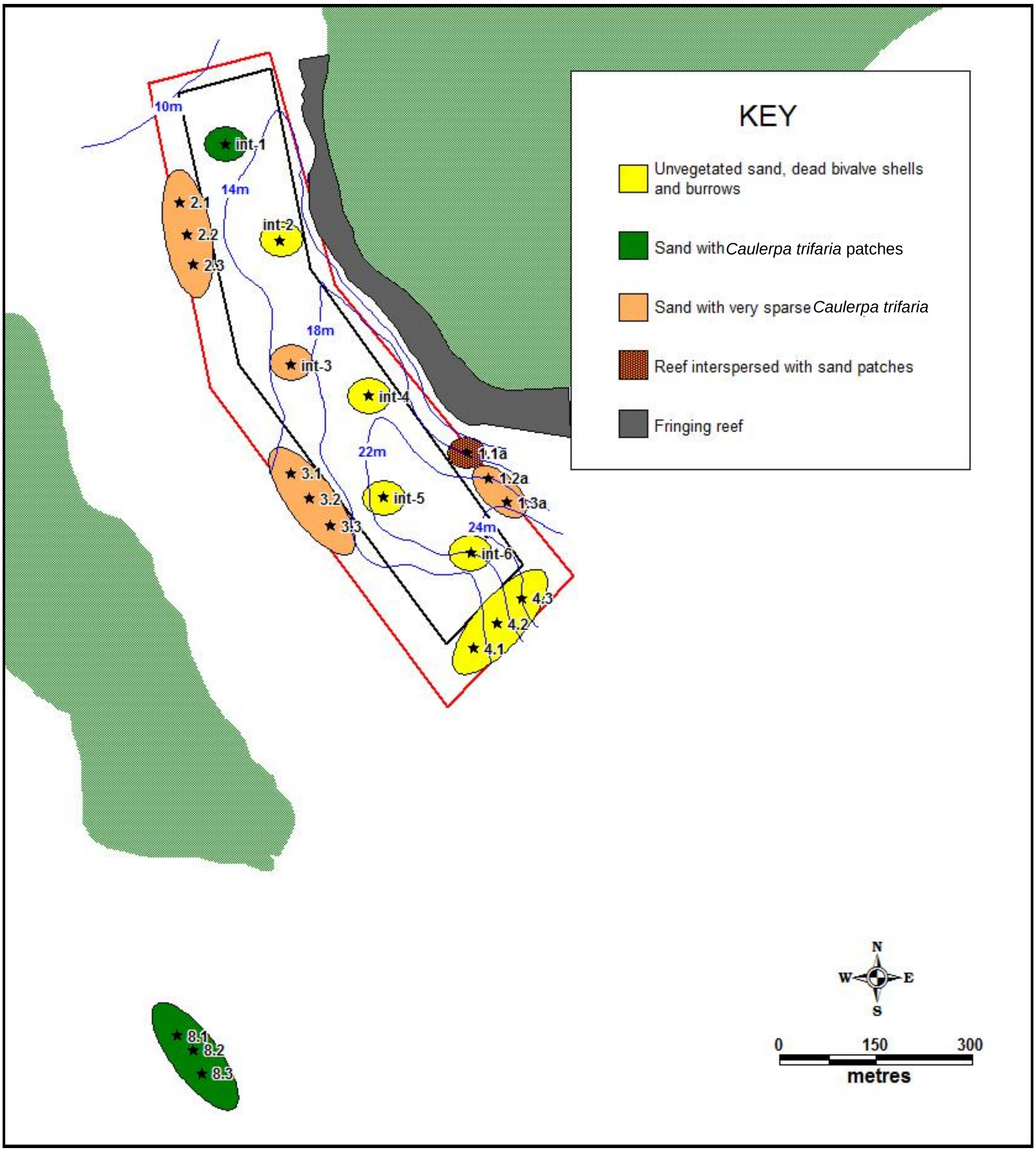


Figure 6 Habitat map. The zone boundary is shown in red, while the lease boundary is indicated by the black line.

7 Underwater Video Survey

7.1 Filming summary

The appearance of the seabed in the vicinity of MF78 was recorded by filming spot dives of the sea floor using a Seabotix LBV150SE Remote Operated Vehicle (ROV). The spot dive locations were:

- Compliance sites at 35 m outside the lease boundary (sites 1.1a-1.3a, 2.1-2.3, 3.1-3.3, 4.1-4.3).
- Control site at least 200 m from the lease boundary (sites 8.1-8.3)
- Internal habitat dives (Int1-Int6).

Survey sites were located at positions specified by the DPIPWE, as illustrated in Figure 2 and listed in Table 1. Note that due to the presence of unsuitable habitat for seabed sampling, the position of some sites supplied by DPIPWE as part of the 3B specifications required adjustment in the field. This applied to sites 1.1a, 1.2a, and 1.3a.

Descriptions of video footage are provided below in Table 2 below.

7.2 Observations from filming

Table 1 Descriptions of of dives performed.

Site	Dive type	Easting	Northing	Video start	Video end	Depth (m)
1.1a	35m Compliance	570707	5224164	1034	1037	16.8
1.2a	35m Compliance	570740	5224122	1025	1028	19.4
1.3a	35m Compliance	570767	5224084	1015	1018	24.8
2.1	35m Compliance	570262	5224553	830	834	12.4
2.2	35m Compliance	570269	5224503	840	843	12.4
2.3	35m Compliance	570279	5224451	850	853	12.6
3.1	35m Compliance	570433	5224128	903	906	16.6
3.2	35m Compliance	570456	5224089	914	917	16.8
3.3	35m Compliance	570493	5224046	928	931	17.1
4.1	35m Compliance	570716	5223853	938	941	18.2
4.2	35m Compliance	570755	5223897	951	954	20.7
4.3	35m Compliance	570794	5223934	1002	1005	28
S8.1	Control	570254	5223256	1052	1055	18.4
S8.2	Control	570281	5223227	1103	1106	19.3
S8.3	Control	570295	5223194	1114	1117	20.1
Int1	Internal habitat	570329	5224645	1129	1132	12.6
Int2	Internal habitat	570416	5224494	1138	1141	18.6
Int3	Internal habitat	570422	5224295	1202	1205	17
Int4	Internal habitat	570555	5224251	1212	1215	22.6
Int5	Internal habitat	570576	5224089	1221	1224	24.9
Int6	Internal habitat	570713	5224005	1232	1235	21.7

***Note that due to the presence of unsuitable habitat for seabed sampling, the position of some sites supplied by DPIPWE as part of the 3B specifications required adjustment in the field. This applied to sites 1.1a, 1.2a, and 1.3a.**

Interpretation

General comments on the spot dive locations are provided below:

- Filming of the seabed at all compliance, control and internal habitat sites showed considerable variability between sites.
- Sandy substrates were the most common habitat overall, these were typically light grey in colour with dead bivalve shells and animal burrows. A very small patch section of unvegetated rocks (<1 m^2) was observed at internal site 5.
- Most of the variation was attributable to differing levels of attached and unattached drift algae. Attached algae was mainly comprised of *Caulerpa trifaria*, a green alga that grows from rhizomes on or under the sediment surface. Occasional attached red algae were also observed, these were most commonly attached to pieces of dead mollusc shells.
- Variability in cover of attached and drift algae most likely reflects the considerable bathymetric variation across the lease area. The lease traverses a deep channel section, with shallower edges on the eastern and western boundary. There is also a trend of increasing depth towards the southern end of the lease area. At the deeper sites, cover of both attached and drift tended to be very low, with increasing levels of algae observed at the shallower sites.
- Evidence of animal activity in the form of burrows was noted on most spot dives
- The New Zealand screw shell *Maoricolpus roseus* was observed at all sites in low to moderate densities. The majority of these appeared to be dead shells based on the ROV footage. Other invertebrates recorded during the survey included flat oysters (*Ostrea angasi*), spider crabs (*Leptomithrax gaimardii*) and scallops (*Pecten fumatus*).
- The most common fish recorded on spot dives was the sand flathead (*Platycephalus bassensis*), which was recorded in low densities on most dives. Weed whiting (*Neoodax balteatus*) and gobies were also relatively common on most dives. At site 1.1a, common reef species were recorded including blue-throated wrasse (*Notolabrus tetricus*), butterfly perch (*Caesioperca lepidoptera*), southern hulafish (*Trachinops caudimaculatus*) and cod (*Pseudophycis* sp.). The threadfin leatherjacket (*Paramonacanthus filicauda*) was also observed during the survey, this species is considered a vagrant from northern Australia. Large numbers of threadfin leatherjacket were reported washed ashore around the time of the baseline survey.
- At compliance site 1.1a, the habitat was patchy with a mix of sand and reef patches. Reef patches at this site were dominated by the brown alga *Ecklonia radiata*.
- There were no gas bubbles, *Beggiatoa*, or any signs of organic enrichment in the sediments at any site based on the video footage.

Table 2 Description of each ROV dive performed at MF55 – seabed characteristics.

Site	Easting	Northing	Date	Time	Depth	Dive type	Visibility	Comments
1.1a	570707	5224164	19/5/2017	1034	16.8	35 m	3-4 m	**Seabed:** Patchy reef interspersed with sand patches. Sand areas light grey with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in moderate densities. Other fauna = flat oyster (*Ostrea angasi*), weed whiting (*Neoodax balteatus*), blue-throated wrasse (*Notolabrus tetricus*), butterfly perch (*Caesioperca lepidoptera*), southern hulafish (*Trachinops caudimaculatus*), cod (*Pseudophycis* sp.), sand flathead (*Platycephalus bassensis*), threadfin leatherjacket (*Paramonacanthus filicauda*), swarming crustaceans. Finger sponges on reef. **Flora:** Reef patches - *Ecklonia radiata* dominant. Sand patches - occasional *Caulerpa trifaria*, drift algae.
1.2a	570740	5224122	19/5/2017	1025	19.4	35 m	3-4 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = weed whiting (*Neoodax balteatus*), gobies. **Flora:** Occasional *Caulerpa trifaria* attached to seabed. Occasional red algae attached to shells. Sparse drift algae.
1.3a	570767	5224084	19/5/2017	1015	24.8	35 m	3-4 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster (*Ostrea angasi*), sand flathead (*Platycephalus bassensis*), spider crab (*Leptomithrax gaimardii*), hermit crab, gobies, fanworm (*Myxicola infundibulum*). **Flora:** Occasional *Caulerpa trifaria* attached to seabed. Sparse drift algae.
2.1	570262	5224553	19/5/2017	830	12.4	35 m	3-4 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster (*Ostrea angasi*), brittle star, sand flathead (*Platycephalus bassensis*). **Flora:** Sparse *Caulerpa trifaria* attached to seabed. Drift algae abundant. Small patches of cyanobacterial mat
2.2	570269	5224503	19/5/2017	840	12.4	35 m	3-4 m	**Seabed:** Light grey sand. Sparse rubble. **Fauna:** Dead shells of *Maoricolpus roseus* in moderate densities. Other fauna = sand flathead (*Platycephalus bassensis*). **Flora:** Drift algae abundant.
2.3	570279	5224451	19/5/2017	850	12.6	35 m	3-4 m	**Seabed:** Light grey sand with dead bivalve shells. Sparse rubble. **Fauna:** Dead shells of *Maoricolpus roseus* in moderate densities. Other fauna = sand flathead (*Platycephalus bassensis*), threadfin leatherjacket (*Paramonacanthus filicauda*). **Flora:** Sparse *Caulerpa trifaria* attached to seabed, high epiphyte coverage on some *Caulerpa* plants. Red algae attached to dead shells. Drift algae abundant.

Site	Easting	Northing	Date	Time	Depth	Dive type	Visibility	Comments
3.1	570433	5224128	19/5/2017	903	16.6	35 m	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = sand flathead (*Platycephalus bassensis*). **Flora:** Sparse red algae attached to dead shells. Sparse drift algae.
3.2	570456	5224089	19/5/2017	914	16.8	35 m	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in moderate densities. Other fauna = sand flathead (*Platycephalus bassensis*), scallop (*Pecten fumatus*). **Flora:** Sparse *Caulerpa trifaria* attached to seabed. Sparse red algae attached to dead shells. Moderate cover of drift algae.
3.3	570493	5224046	19/5/2017	928	17.1	35 m	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = weed whiting (*Neoodax balteatus*). **Flora:** Sparse *Caulerpa trifaria* attached to seabed. Sparse red algae attached to dead shells. Moderate cover of drift algae.
4.1	570716	5223853	19/5/2017	938	18.2	35 m	5 m	**Seabed:** Light grey sand with shell grit, dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = sand flathead (*Platycephalus bassensis*). **Flora:** Occasional red algae attached to dead shells. Sparse cover of drift algae.
4.2	570755	5223897	19/5/2017	951	20.7	35 m	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster (*Ostrea angasi*), sand flathead (*Platycephalus bassensis*). **Flora:** Occasional red algae attached to dead shells.
4.3	570794	5223934	19/5/2017	1002	28	35 m	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster (*Ostrea angasi*), sand flathead (*Platycephalus bassensis*), threadfin leatherjacket (*Paramonacanthus filicauda*), scallop (*Pecten fumatus*). **Flora:** Very sparse drift algae.
S8.1	570254	5223256	19/5/2017	1052	18.4	Control	5 m	**Seabed:** Light grey sand with burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = threadfin leatherjacket (*Paramonacanthus filicauda*). **Flora:** *Caulerpa trifaria patches*. Red algae attached to shells. Sparse drift algae.
S8.2	570281	5223227	19/5/2017	1103	19.3	Control	5 m	**Seabed:** Light grey sand with burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = weed whiting (*Neoodax balteatus*). **Flora:** *Caulerpa trifaria patches*. Red algae attached to shells. Sparse drift algae.
S8.3	570295	5223194	19/5/2017	1114	20.1	Control	5 m	**Seabed:** Light grey sand with burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster

Site	Easting	Northing	Date	Time	Depth	Dive type	Visibility	Comments
								(*Ostrea angasi*), sand flathead (*Platycephalus bassensis*), goby, squid egg mass. **Flora:** *Caulerpa trifaria patches*. Red algae attached to shells. Sparse drift algae.
Int1	570329	5224645	19/5/2017	1129	12.6	Internal	5 m	**Seabed:** Light grey sand with dead bivalve shells and burrows, interspersed with *Caulerpa trifaria* patches. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = flat oyster (*Ostrea angasi*), weed whiting (*Neoodax balteatus*), goby. **Flora:** *Caulerpa trifaria* attached to seabed, moderate to high coverage. High epiphyte coverage on some *Caulerpa* plants.
Int2	570416	5224494	19/5/2017	1138	18.6	Internal	3 m	**Seabed:** Light grey sand with dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = sand flathead (*Platycephalus bassensis*), spider crab (*Leptomithrax gaimardii*). **Flora:** Nil.
Int3	570422	5224295	19/5/2017	1202	17	Internal	4 m	**Seabed:** Light grey sand with sparse rubble and abundant drift algae. **Fauna:** Dead shells of *Maoricolpus roseus* in moderate densities. **Flora:** Sparse *Caulerpa trifaria* attached to seabed. Red algae attached to dead shells. Drift algae abundant
Int4	570555	5224251	19/5/2017	1212	22.6	Internal	4 m	**Seabed:** Light grey sand with shell grit, dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = sand flathead (*Platycephalus bassensis*), flat oyster (*Ostrea angasi*). **Flora:** Sparse red algae attached to dead shells. Sparse drift algae in seabed depressions.
Int5	570576	5224089	19/5/2017	1221	24.9	Internal	3 m	**Seabed:** Light grey sand with shell grit, dead bivalve shells and burrows. Patch of small unvegetated ~~boulders~~ rocks (3.00 min GoPro). **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. **Flora:** Sparse red algae attached to dead shells. Moderate cover of drift algae.
Int6	570713	5224005	19/5/2017	1232	21.7	Internal	3 m	**Seabed:** Light grey sand with shell grit, dead bivalve shells and burrows. **Fauna:** Dead shells of *Maoricolpus roseus* in low densities. Other fauna = sand flathead (*Platycephalus bassensis*), flat oyster (*Ostrea angasi*), hermit crab. **Flora:** Very sparse red algae attached to dead shells.

8 Sediment Chemistry

8.1 Visual Assessment

Methods

A Craib corer was used to collect 50 mm diameter sediment cores in transparent Perspex tubes. These were handled carefully and retained in a vertical orientation to minimise disturbance of the sediment surface until they were described and redox and sulphide readings taken. The cores were described in terms of length, colour (using a Munsell soil chart), plant and animal life, gas vesicles, and smell. Odour from hydrogen sulphide gas, if present, was noted after the water was removed from the core barrels.

Results and interpretation

Visual assessment showed that sediments were generally similar across sampling sites. Sediments typically consisted of fine sand with shell grit observed in most cores. At some sites (e.g. 1.1a-1.3a; S8.1-S8.3) coarse shell grit was evident in deeper sections of the core. Sediment colour showed some variation with grey, light yellowish brown and brown colouration observed.

Faint darker patches or streaks were evident with increasing depth in cores from some sites (e.g. 2.1., 3.1, 3.2, 4.2, S8.3). In these cores, the darker streaks were generally below 50 mm sediment depth and are indicative of low oxygen levels in the sediment. These observations are not considered evidence of organic enrichment, such a pattern is not unusual in circumstances where sandy, well compacted sediments are present.

Animals or evidence of their presence (i.e. animal burrows) were observed in many sediment cores. No odour or gas bubbles were noted in any core sample. The sandy nature of the sediments indicates that wave and/or swell action influences the seabed sediments and the rate of deposition of finer sediment fractions is low.

Descriptions of the sediment cores are tabulated in Table 3.

Table 3 Visual description of sediment cores at MF55.

Site	Length (mm)	Colour 1 (Munsell score)	Sediment 1	Depth 1 (mm)	Colour 2 (Munsell score)	Sediment 2	Depth 2 (mm)	Colour 3 (Munsell score)	Sediment 3	Depth 3 (mm)	Plants	Animals	Gas	Smell
1.1a	140	10YR/5/1 Grey	Fine sand with shell grit	100	10YR/5/1 Grey	Coarse grit	140				Nil	Burrows	Nil	Nil
1.2a	145	10YR/5/1 Grey	Fine sand with shell grit	50	10YR/5/1 Grey	Sand with coarse shell grit	145				Nil	Burrows	Nil	Nil
1.3a	170	10YR/5/1 Grey	Fine sand with shell grit	70	10YR/5/1 Grey	Sand with coarse shell grit. Faint dark streaks 50-90 mm, 160-170 mm	170				Nil	Burrows, ghost shrimp at 20 mm	Nil	Nil
2.1	170	10YR/6/4 Light yellowish brown	Fine sand	70	10YR/5/2 Greyish brown	Fine sand. Faint dark patches 50-100 mm	170				Red filamentous algae on sediment surface	Burrows	Nil	Nil
2.2	110	10YR/5/2 Greyish brown	Fine sand. Coarse shell grit 40-80 mm	110							Nil	Burrows	Nil	Nil
2.3	140	10YR/5/2 Greyish brown	Fine sand with sparse shell grit	140							Red filamentous algae on sediment surface	Burrows, gastropod on sediment surface	Nil	Nil
3.1	160	10YR/6/4 Light yellowish brown	Fine sand with sparse shell grit	70	10YR/5/2 Greyish brown	Fine sand with sparse shell grit. Faint dark streaks at 110 mm	160				Nil	Burrows	Nil	Nil
3.2	170	10YR/3/1 Very dark grey	Very fine sand/silt	3	10YR/6/4 Light yellowish brown	Fine sand with sparse shell grit. Dark streaks 0-90 mm	80	10YR/5/2 Greyish brown	Fine sand with sparse shell grit	170	Nil	Nil	Nil	Nil
3.3	140	10YR/5/1 Grey	Very fine sand/silt	3	10YR/5/2 Greyish brown	Fine sand with sparse shell grit	140				Nil	Burrows	Nil	Nil

Site	Length (mm)	Colour 1 (Munsell score)	Sediment 1	Depth 1 (mm)	Colour 2 (Munsell score)	Sediment 2	Depth 2 (mm)	Colour 3 (Munsell score)	Sediment 3	Depth 3 (mm)	Plants	Animals	Gas	Smell
4.1	190	10YR/6/4 Light yellowish brown	Fine sand with sparse shell grit	70	10YR/5/2 Greyish brown	Fine sand with sparse shell grit	190				Nil	Nil	Nil	Nil
4.2	190	10YR/6/4 Light yellowish brown	Fine sand with sparse shell grit	50	10YR/5/2 Greyish brown	Fine sand with sparse shell grit. Faint dark streaks 60-90 mm	190				Nil	Nil	Nil	Nil
4.3	160	10YR/5/2 Greyish brown	Fine sand with sparse shell grit. Very faint dark streaks 90-150	160							Nil	Burrows	Nil	Nil
S8.1	150	10YR/5/3 Brown	Fine sand	40	10YR/5/2 Greyish brown	Fine sand. Coarse shell grit 130-150 mm	150				Nil	Burrows	Nil	Nil
S8.2	150	10YR/5/3 Brown	Fine sand	80	10YR/5/2 Greyish brown	Fine sand. Coarse shell grit 140-150 mm	150				Nil	Burrows. Polychaete at 10 mm	Nil	Nil
S8.3	140	10YR/5/3 Brown	Fine sand	80	10YR/5/2 Greyish brown	Fine sand. Faint black streak at 130 mm	140				Nil	Nil	Nil	Nil

8.2 Redox Potential

Methods

Redox potential was measured in millivolts at 30 mm below the sediment surface using a WTW pH 320 meter with a Mettler Toledo Ag/AgCl combination pH/Redox probe. Calibration and functionality of the meter were checked before each test using a Redox Buffer Solution (248 mV at 10 °C). Measurements were made within 3 hours of the samples being collected. Corrected Redox potential values were calculated by adding the standard potential of the reference cell to the measured redox potential and are reported in millivolts.

In all cases the lowest reading observed was recorded as the Redox value. In low permeability, muddy sediments, the recorded value is determined when the reading is stable or dropping at less than 1 mV per second. In permeable, sandy sediments the lowest reading is often observed while the probe is being worked to the measurement depth. As soon as the probe stops moving in sandy sediments with low Redox values, the readings normally start to increase when water is drawn down by the probe diluting the interstitial fluids.

Results and interpretation

Sediment redox values at 30 mm sediment depth averaged 159 mV and were well above 100 mV at each site (Figure 7). The observed high redox values at all lease, compliance and control sites are indicative of well oxygenated sediments (Macleod and Forbes 2004). Raw data is presented in Appendix 2.

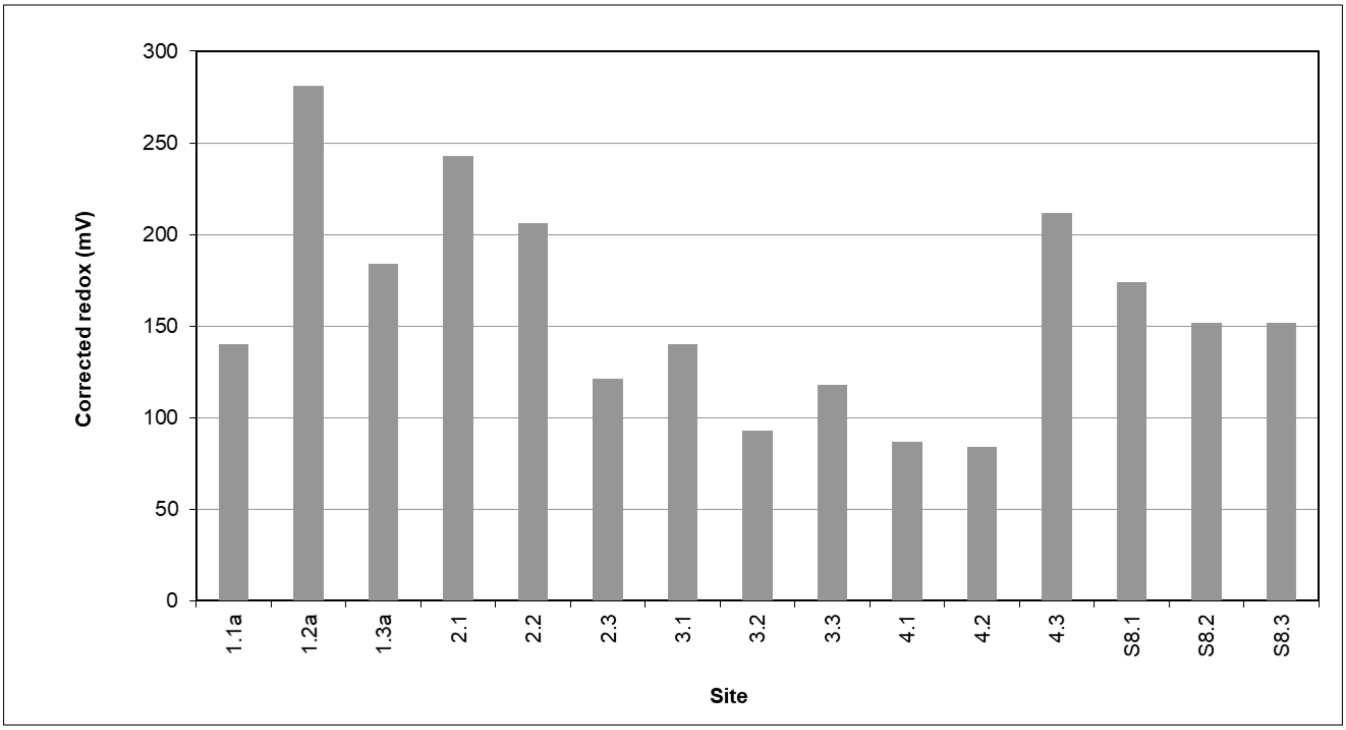


Figure 7 Redox potential at 30 mm depth in sediment cores at each site. Bars represent corrected redox values at each site.

8.3 Sulphide Analysis

Methods

Sediment sulphide was measured in accordance with the prescribed DPIPWE protocols (Macleod and Forbes 2004). Measurements were made using a TPS uniPROBE Sulphide ISE and a WTW pH 320 meter. Using a modified syringe, 2 mL of sediment was removed at 30 mm depth from the core and mixed with 2 mL of reagent (sulphide anti-oxidant buffer, SAOB) in a small beaker. The sediment/SAOB mixture was carefully stirred with the probe for 15-20 seconds, until the reading stabilised. The accuracy and functionality of the meter and probe was assessed prior to analysis commencing, using standards of known concentration. A calibration curve was produced using three standards of known concentration.

Results and interpretation

Sulphide concentration in sediments was typically very low across the survey sites, averaging 2.7 µM across all sediment cores (Figure 8). Sulphide concentrations were below levels expected for organically enriched sediments (i.e. < 100 µM; Macleod and Forbes 2004) and there was no spatial pattern of sulphide concentration across the compliance and control sites.

Raw data is presented in Appendix 3.

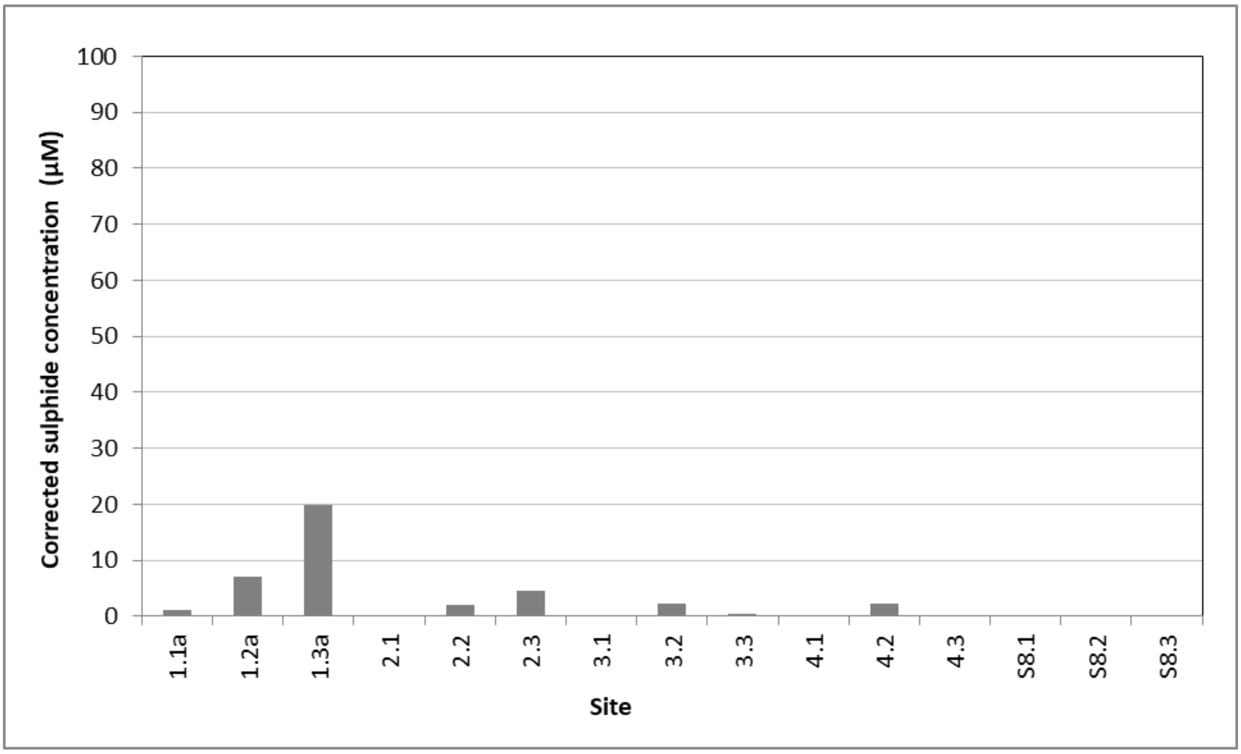


Figure 8 Sulphide concentrations in sediment core samples, measured at 30 mm depth.

8.4 Particle Size Analysis

Methods

The top 100 mm of each sediment core was homogenised and then 73-74 ml of sediment was sub-sampled for particle size determination.

Results and interpretation

Overall, the sediments were clean with a relatively low proportion of fine clay and silt fractions (i.e. < 0.063 mm; average 15.5% v/v across all sites). Sediments across the area sampled were typically dominated by the 'medium sand' (0.5-0.25 mm) category (average 40 % v/v across all sites). Some variation in sediment particle size distribution was evident between sites. Patterns of particle size distribution at sites 1.1a and 1.2a, in particular, were different from the remaining sites, with a relatively high proportion of coarse sand fractions. For example, at site 1.1a and 1.2a, the proportion of sediment fractions > 0.5 mm averaged 37.3%, compared to an average of 8.1% across the remaining sites.

Patterns of particle size distribution were indicative of a sedimentary environment with moderate agitation of seabed sediments and associated low abundance of fine silt and clay fractions. The similarity in particle size distribution between most sites implies similar depositional environments. The reason for the variation in particle size distribution evident at sites 1.1a and 1.2a is likely due to the close proximity of these sites to the reef edge, where a greater proportion of coarser particle size fractions would be expected. These sites were also relatively exposed and in shallower water depths compared to adjacent sites. The associated higher energy conditions would also explain the higher proportion of coarser particle size fractions evident at these sites.

Particle size results are depicted in Figure 9, while raw data is included in Appendix 4.

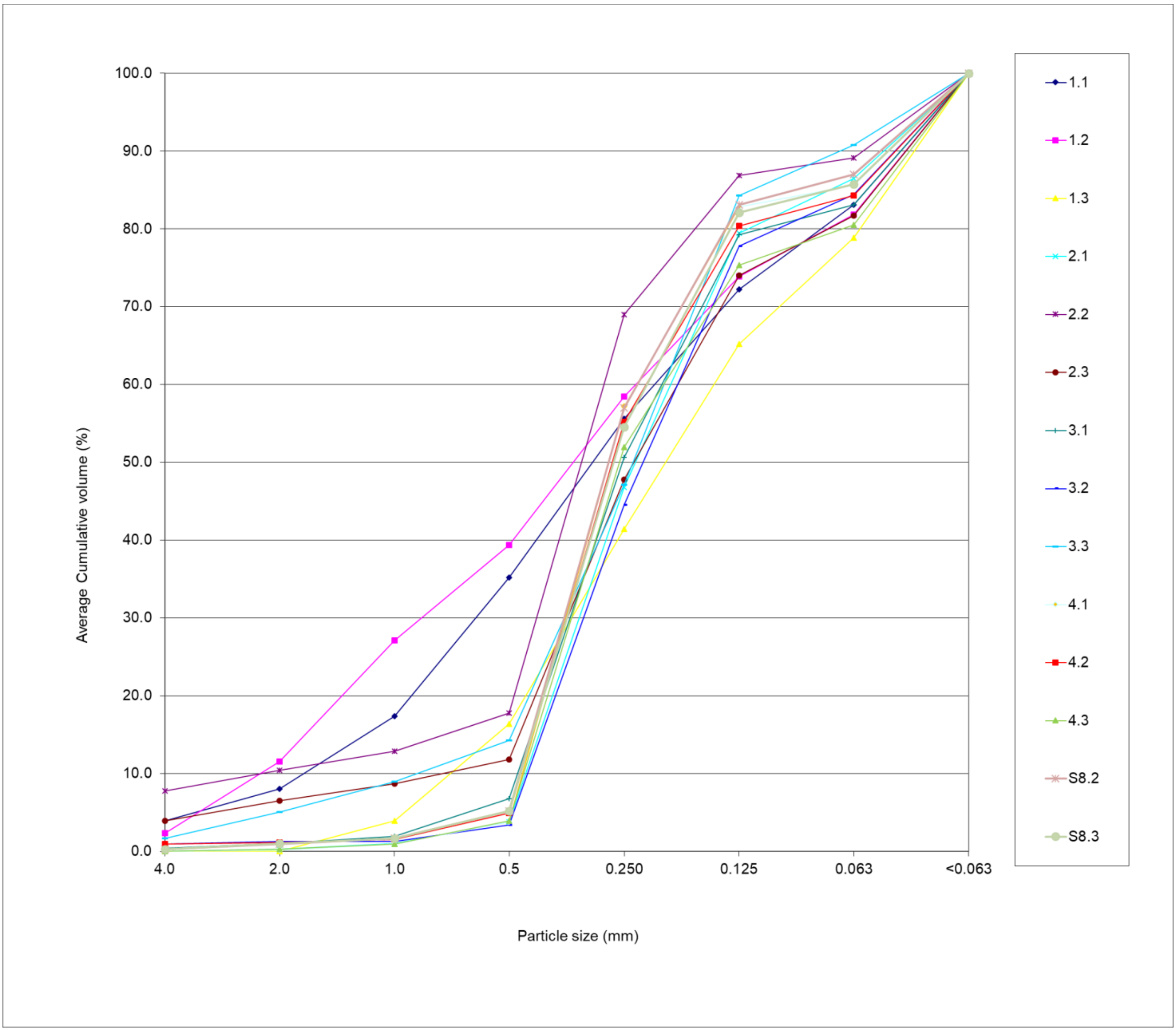


Figure 9 Particle size analyses of the top 100 mm of sediment. Plots represent mean percentage cumulative volume for size fractions at each site. Note that sample 8.1 was lost during analysis due to laboratory glassware breakage.

8.5 Organic Content

Methods

A single undisturbed sediment core sample taken using a perspex core with an internal diameter of at least 50 mm at each sample site specified in the survey for the purposes of organic content analysis. The top 3 cm of each core was oven dried at 60 °C prior to analysis of total organic carbon. Total organic carbon was measured by loss on ignition (450 °C in a muffle furnace for 4 hours) by AST.

Results and interpretation

Results from the organic content analysis are presented in Figure 10. The organic content was low, ranging from 1.0% to 6.7%, with an average of 2.1% across all sites. The observed low organic content levels were consistent with those expected for sandy sediments.

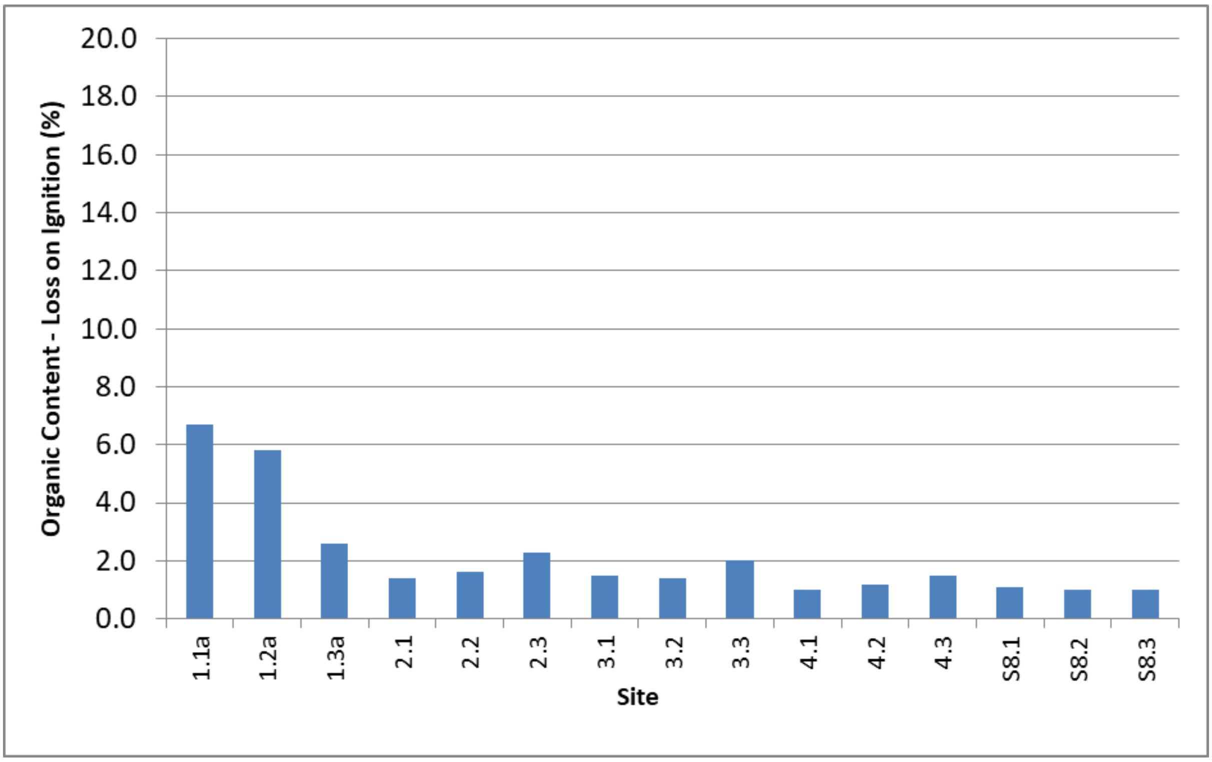


Figure 10 Organic content in sediment core samples at each site.

8.6 Heavy Metal Analysis

Methods

Sediment cores of 50 mm diameter were collected and the top 30 mm of each core was transferred to a clean jar for metal analysis. Heavy metals analysed in sediment samples included: arsenic, cadmium, cobalt, chromium, copper, manganese, nickel, lead and zinc. The analyses were conducted by AST using the test methods specified in the following Australian Standards:

2301-Soil: Metals in Soil, Sediment and Dust by ICPAES

Results and interpretation

Results from the heavy metal analysis are presented in Table 4. The ANZECC Interim Sediment Quality Guideline (ISQG) 'high' trigger value was not exceeded for any of the analytes measured. With the exception of Arsenic, the observed levels were also well below the ANZECC ISQG 'low' trigger values. Arsenic levels slightly exceeded the ANZECC ISQG 'low' trigger value of 20 mg/kg at site 3.1, where a level of 25 mg/kg was recorded. Across the remaining sites, arsenic levels averaged 9 mg/kg.

Overall, there was only minor variation between control and compliance sites for those heavy metals analysed.

Table 4 Results of heavy metal analysis of sediment samples and the ANZECC 2000 trigger values.

Site	Metal (mg/kg DMB)								
	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
1.1	7	<0.5	2	9	6	32	3	12	30
1.2	12	<0.5	2	15	7	31	5	10	36
1.3	9	<0.5	2	13	5	27	4	7	24
2.1	10	<0.5	<1	13	1	8	1	3	12
2.2	13	<0.5	2	16	3	16	4	7	30
2.3	14	<0.5	1	19	2	13	2	20	26
3.1	25	<0.5	2	21	2	15	3	6	19
3.2	10	<0.5	1	13	2	14	2	5	15
3.3	18	<0.5	3	24	5	29	6	11	35
4.1	6	<0.5	<1	10	<1	7	2	3	9
4.2	5	<0.5	<1	9	1	10	2	4	11
4.3	5	<0.5	2	11	3	16	4	7	25
S8.1	5	<0.5	<1	8	1	9	1	4	10
S8.2	5	<0.5	<1	8	<1	8	1	4	9
S8.3	6	<0.5	1	9	1	10	2	5	11
ANZECC 2000 ISQG-Low (trigger value)	20	2		80	65		21	50	200
ANZECC 2000 ISQG-High (trigger value)	70	10		370	270		52	220	410

9 **Threatened Species**

Gunn's screw shell (Gazameda gunnii)

Methods and Results

In accordance with Schedule 3B, 10 van-veen grab samples were taken across the survey area. No *Gazameda* sp. shells, either alive or dead, were detected from the grab samples during the targeted survey (Figure 11).

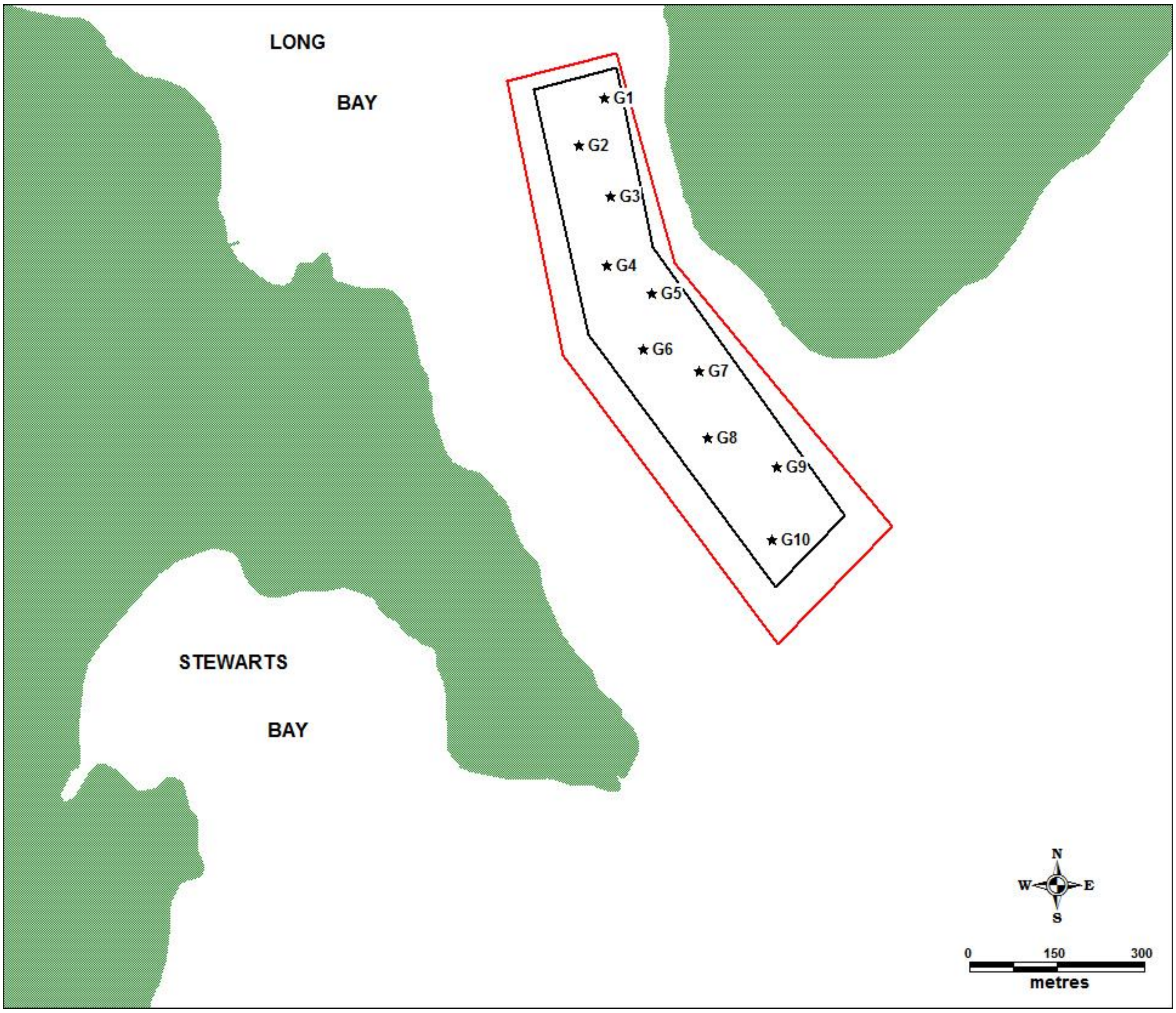


Figure 11 Location of grab samples taken during *Gazameda gunnii* survey for MF55. No *G. gunnii* were detected during the targeted survey.

10 **Benthic faunal analysis**

Methods

Benthic fauna samples were collected using a Van Veen grab which sampled a 0.07 m^2 area of seabed. A single grab sample was collected at each of the compliance and control sites, with a total of 21 grabs collected. Grab samples were sieved in the field using 1 mm mesh sieve bags, with animal and sediment material retained in the mesh bags placed in 5% buffered formalin.

Results and interpretation

Abundance and patterns of family richness are summarised in Table 5 below (see Appendix 5 for raw data). The area possessed very high faunal diversity, with a total of 2184 individuals from 109 families identified across the 21 samples. Faunal communities were dominated by polychaetes, accounting for 55.2% of individuals and 29.4 % of families identified. Crustaceans were also a prominent component of faunal communities, accounting for 30.3% of individuals and 37.6 % of families. Molluscs represented a minor component of the fauna in terms of abundance (11.4% of individuals), but they made an important contribution to overall diversity (23.9% of families). Abundance and diversity of other fauna (including anthozoans, echinoderms, nemerteans, phoronids and platyhelminths) was relatively low, accounting for 3.1% of individuals and 9.2% of families.

The most common taxa recorded during the survey was a polychaete from the family Spionidae, which represented 17.1 % of individuals recorded across all samples. Other commonly recorded taxa included Nephtyidae (polychaete), Lumbrineridae (polychaete), Callianassidae (amphipod) and Ampeliscidae (amphipod). Representatives from the family Capitellidae, *Mediomastus australiensis* and *Notomastus* sp., were recorded in low densities at some survey sites. While some capitellids can be indicators of organic enrichment, these particular taxa are not regarded as pollution indicator species.

The introduced New Zealand screw shell *Maoricolpus roseus* was recorded in variable numbers, with a total of 84 individuals recorded across all sites. Other introduced species recorded in very low numbers across the survey included the bivalves *Varicorbula gibba* (24 individuals), *Theora lubrica* (7 individuals) and *Crassostrea gigas* (5 individuals). The introduced sabellid polychaete *Euchone limnicola* was also recorded in very low numbers (3 individuals).

The MDS analysis showed two broad groupings based on faunal similarity patterns between sites (Figure 12). The majority of sites grouped together at the 40% similarity level (based on cluster analysis). These patterns are indicative of relatively consistent faunal community structure across these particular survey sites. A second broad grouping included sites 1.1a, 2.2, 2.3 and INT-1. Differences in benthic fauna community structure are likely to reflect variation in environmental characteristics across the survey area. Sites 2.2, 2.3 and Int-1 located in the shallower northern part of the survey area, while site 1.1a was located in relatively shallow water adjacent to fringing reef on the south-eastern edge of the lease.

It should also be noted that in some instances there was some variability between replicate sites. Although replicate sites were 20 m apart, such a small distance was sufficient for considerable variation in environmental characteristics at some locations. For examples, depths at sites 1.1a, 1.2a and 1.3a ranged from 16.8 m to 24.8 m, despite them being only 60 m apart. Given the change in depth and environmental characteristics between replicates, differences in faunal community structure between replicates should not be unexpected.

Dominance patterns as described by K-dominance plots are shown in Figure 13. Single taxa dominance patterns were low-moderate across all control and compliance sites, ranging from 13.2 – 54.9 %, with an overall average of 22.9%. These values fall within ranges expected for unimpacted ecosystems, with relatively diverse communities and low levels of dominance by a single family (see Figure 13).

Based on the benthic faunal patterns present, any future benthic impacts outside the lease area should be readily observable. Reduced faunal diversity and an increase in species dominance patterns would be one of the main indicators of organic enrichment. Such a pattern would be expected to be readily discernible, given the high diversity measured during the baseline survey.

Table 5 Summary of benthic faunal analysis. The category 'other' included anthozoans, echinoderms, nemerteans, phoronids and platyhelminths.

Site	Abundance (No's per sample)					Family diversity (No. families per sample)			
	Crustaceans	Molluscs	Polychaetes	Other		Crustaceans	Molluscs	Polychaetes	Other
1.1a	45	6	47	8		12	5	13	4
1.2a	26	9	102	2		12	4	13	2
1.3a	21	13	144	4		8	5	12	2
2.1	30	11	35	4		12	5	10	2
2.2	94	35	88	1		14	9	16	1
2.3	28	13	15	3		6	3	7	1
3.1	15	14	14	2		7	5	10	1
3.2	12	9	16	1		5	4	10	1
3.3	37	16	89	4		10	4	13	3
4.1	26	8	22	1		8	2	10	1
4.2	68	5	31	1		12	1	6	1
4.3	54	14	104	7		14	5	11	4
S8.1	42	7	82	6		12	5	13	4
S8.2	30	4	57	5		10	4	13	3
S8.3	35	16	42	2		14	5	9	2
INT-1	25	19	92	0		17	7	12	0
INT-2	16	7	22	0		6	3	8	0
INT-3	17	13	31	3		7	3	9	2
INT-4	15	15	65	5		7	8	8	3
INT-5	13	4	47	7		6	3	8	3
INT-6	12	11	61	2		6	4	8	2
Total	661	249	1206	68		41	26	32	10
%	30.27	11.40	55.22	3.11		37.61	23.85	29.36	9.17

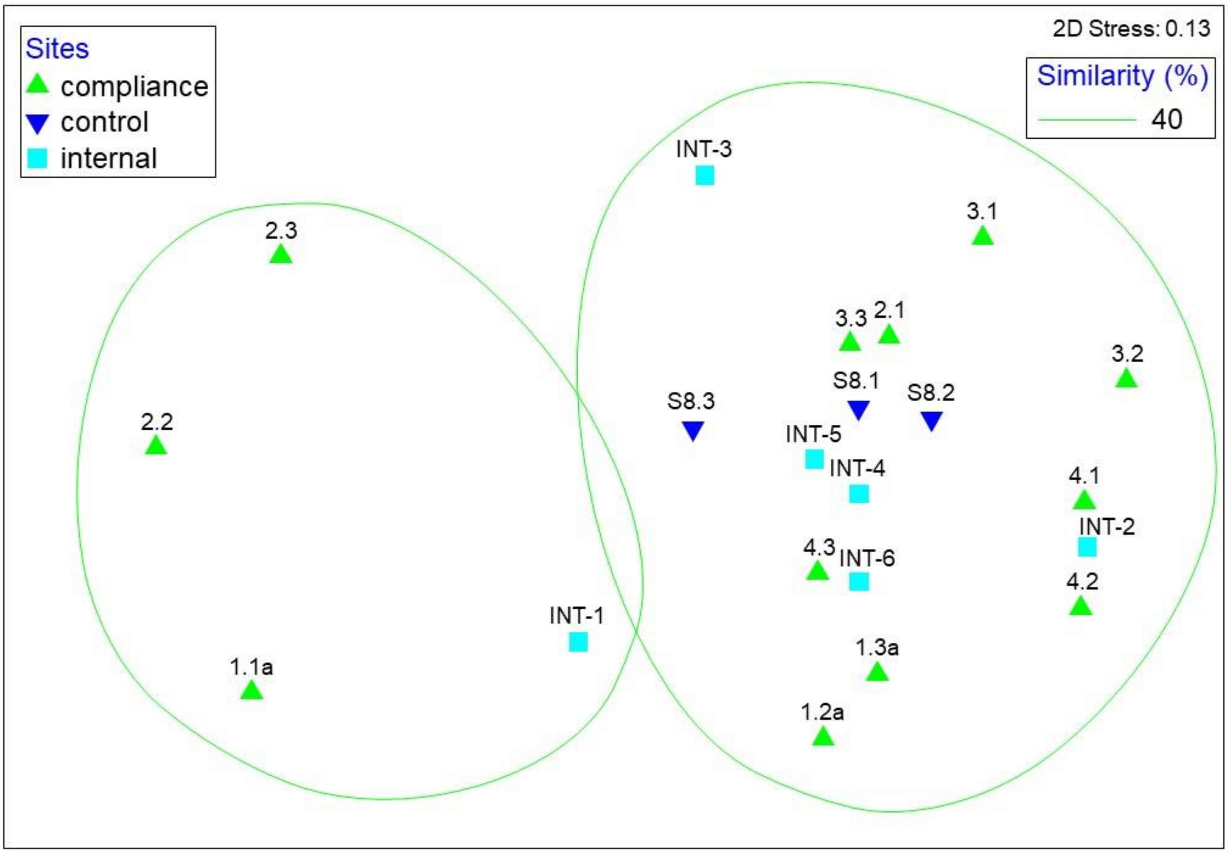


Figure 12 Results of MDS analysis using benthic faunal data collected from internal farm, compliance and control sites for MF55. Ellipses indicate community similarity (%), based on cluster analysis.

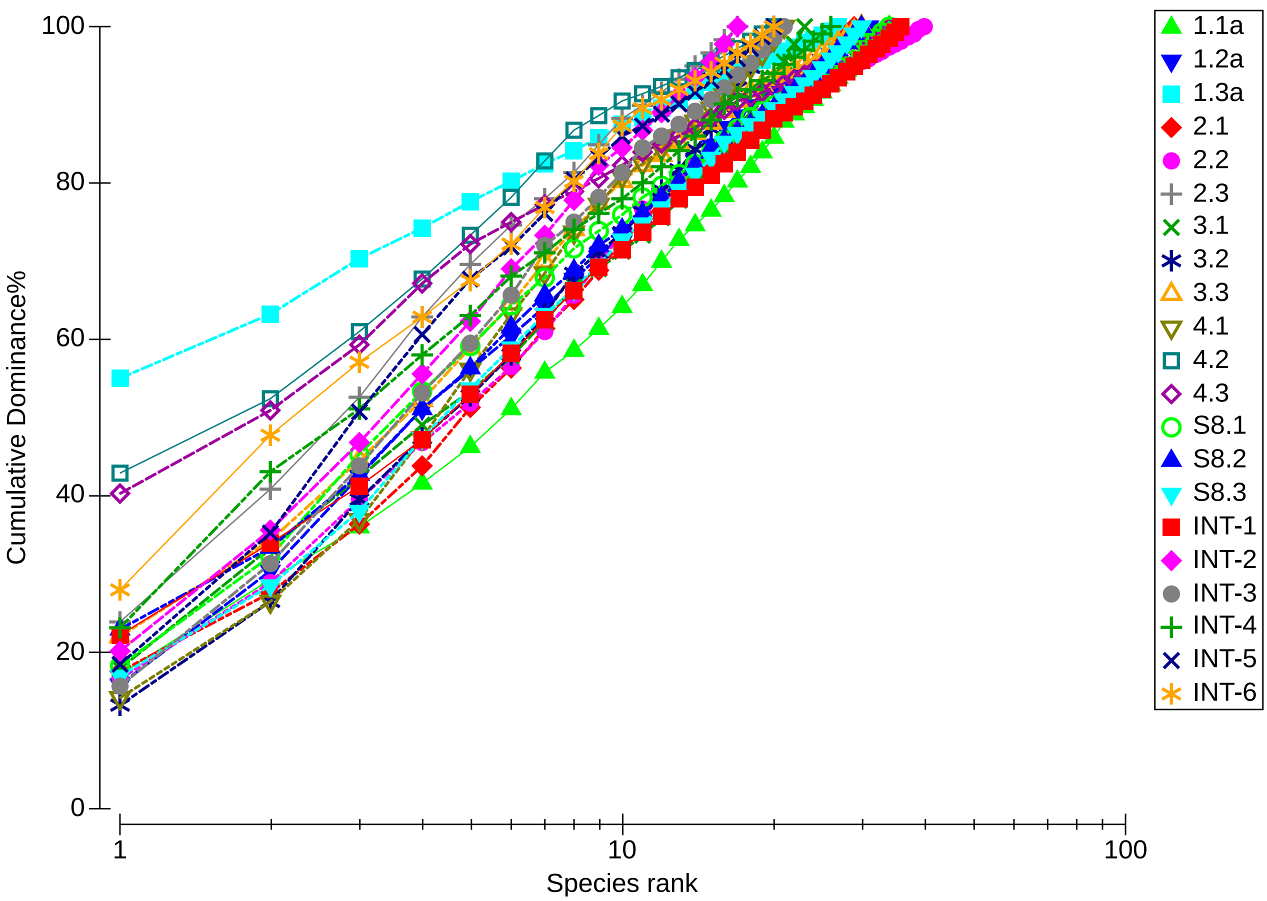


Figure 13 Benthic faunal analysis of seabed samples – MF55. K – dominance curves. Analysis based on data from compliance, control and internal farm sites.

References

Macleod, C.K. and Forbes, S. (2004) Guide to the assessment of sediment condition at marine finfish farms in Tasmania. Tasmanian Aquaculture and Fisheries Institute – University of Tasmania, Hobart, Australia, 65 pp.

Appendix 1 Survey coordinates for seabed sampling provided by DPIPWE, based on the Mapping Grid of Australia Zone 55 (Datum GDA94).

Site name	Easting	Northing
1.1a	570707	5224161
1.2a	570739	5224122
1.3a	570767	5224084
2.1	570260	5224549
2.2	570270	5224501
2.3	570279	5224451
3.1	570432	5224128
3.2	570460	5224091
3.3	570491	5224049
4.1	570717	5223857
4.2	570751	5223896
4.3	570791	5223936
S8.1	570329	5224641
S8.2	570415	5224491
S8.3	570432	5224298
Int1	570552	5224249
Int2	570576	5224092
Int3	570713	5224005
Int4	570255	5223255
Int5	570279	5223233
Int6	570293	5223197
SPM 11190	539420	5257816

Appendix 2 – Raw data – redox analysis (3 cm core depth)

Site	Uncorrected Redox (mV)	Corrected Redox (mV)
1.1a	-108	140
1.2a	33	281
1.3a	-64	184
2.1	-5	243
2.2	-42	206
2.3	-127	121
3.1	-108	140
3.2	-155	93
3.3	-130	118
4.1	-161	87
4.2	-164	84
4.3	-36	212
S8.1	-74	174
S8.2	-96	152
S8.3	-96	152

Appendix 3 – Raw data – sulphide analysis

Site	Sulphide (uM)
1.1a	1.231524454
1.2a	6.988031382
1.3a	19.8016751
2.1	0.182448397
2.2	2.073082483
2.3	4.527692199
3.1	0.140622004
3.2	2.261060444
3.3	0.516995945
4.1	0.070224484
4.2	2.261060444
4.3	0.23671557
S8.1	0.23671557
S8.2	0.020832927
S8.3	0.032153499

Appendix 4 – Raw data – particle size analysis

Sample No	Vi	V4	V2	V1	V0.5	V0.25	V0.125	V0.063	Volume of water
	ml	ml	ml	ml	ml	ml	ml	ml	ml
1.1a	77	28	31.2	38.4	52.1	67.8	80.6	89	25
1.2a	77	26.8	33.9	45.9	55.3	70	81.9	88	25
1.3a	77	25	25	28	37.6	56.9	75.2	85.7	25
2.1	77	25	25.2	25.8	27.9	61	86.2	91.6	25
2.2	77	31	33	34.9	38.7	78.1	91.9	93.6	25
2.3	77	28	30	31.7	34.1	61.8	82	87.9	25
3.1	77	25.3	25.8	26.5	30.2	64	86	89	25
3.2	77	25.7	26	26	27.6	59.3	84.9	90	25
3.3	77	26.3	28.9	31.9	36	61.3	89.9	94.9	25
4.1	77	25	25.1	25.7	27.9	69	88.8	90.9	25
4.2	77	25.7	25.9	26.2	28.8	67.5	86.9	89.9	25
4.3	77	25	25.2	25.7	28	65	83	87	25
S8.1	77	Sample lost - glassware damaged during analysis							
S8.2	77	25.2	25.7	26.3	29	68.9	89	92	25
S8.3	77	25.2	25.8	26.3	29	67	88.2	91	25

Appendix 5 – Results of benthic fauna analysis – raw data

Group	Family	1.1a	1.2a	1.3a	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	S8.1	S8.2	S8.3	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6
Anthozoa	Edwardsiidae		1							1			3		3				2	1	3	1
Crustacean - amphipod	Ampeliscidae		4	7					5		8	45	19	7	5		1	2		2	1	4
Crustacean - amphipod	Corophiidae					1					1						1					
Crustacean - amphipod	Dexaminidae					27	4	1						1		2	1					
Crustacean - amphipod	Photidae													5	1							
Crustacean - amphipod	Lysianassidae	3	1	2		2	1						1				1					
Crustacean - amphipod	Melitidae	2	1	1	1	10	14							1								
Crustacean - amphipod	Oedicerotidae			2	1								1					1				
Crustacean - amphipod	Phoxocephalidae		1	2	8	4	1	7	3	4	5	7	5	1	5	4		1	10	1	1	1
Crustacean - amphipod	Platyischnopidae										1	1										
Crustacean - amphipod	Aoridae	2				11				2												
Crustacean - amphipod	Urohaustoriidae				4					1				1								
Crustacean - amphipod	Synopiidae		2																			
Crustacean - copepod	Copepoda (sCl.)				1	1																
Crustacean - caprellid	Caprellidae															1						
Crustacean - crab	Hymenosomatidae					2							1	1	1	1	3		1		1	
Crustacean - crab	Leucosiidae		1		1												1		1			
Crustacean - crab	Hexapodidae												1									
Crustacean - cumacean	Bodotriidae				3			1		1	3	1		2	2		2	9	1			
Crustacean - cumacean	Diastylidae		1	1							3	1		3		1	1			1		
Crustacean - cumacean	Lampropidae								1													
Crustacean - hermit crab	Paguridae	2	4	1												2	1					1
Crustacean - isopod	Cirolanidae												1				1					
Crustacean - isopod	Anthuridae		1									1	2	1		1						
Crustacean - isopod	Sphaeromatidae	2														1						
Crustacean - mysid	Mysidae	3				1	1	1					1				1				1	
Crustacean - nebalid	Nebaliidae					1																
Crustacean - ostracod	Myodocopida	2																		1		
Crustacean - ostracod	Cypridinidae														1		1					
Crustacean - ostracod	Philomedidae	2	6								1	2	4			2	1	2		1	2	2

Group	Family	1.1a	1.2a	1.3a	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	S8.1	S8.2	S8.3	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6
Crustacean - ostracod	Cylindroleberididae				1							1	1		1	1	1	1	2	2		
Crustacean - shrimp	Alpheidae	7				4																
Crustacean - shrimp	Pasiphaeididae											1			1	2	3					
Crustacean - shrimp	Pasiphaeididae				1			1		1												
Crustacean - shrimp	Callianassidae		3	5	6			3	2	18	4	6	15	18	10	11	4		1	7	7	3
Crustacean - shrimp	Crangonidae				1																	
Crustacean - shrimp	Galatheidae	18				10				3			1			5	1					1
Crustacean - shrimp	Palaemonidae											1							1			
Crustacean - shrimp	Axiidae												1									
Crustacean - tanaid	Apseudidae	1				4				1												
Crustacean - tanaid	Kalliapseudidae		1		2			1	1	5		1		1	3							
Crustacean - tanaid	Leptocheliidae	1				16	7			1						1						
Echinoderm - brittle star	Ophiotrichidae	1																				
Echinoderm - brittle star	Amphiuridae													1								
Echinoderm - brittle star	Ophiuridae	5					3			1	1	1	1									
Echinoderm - heart urchin	Loveniidae		1		1								2	1		1			1	2	1	
Echinoderm - holothurian	Synaptidae													2								
Echinoderm - seastar	Asterinidae	1																				
Mollusc - bivalve	Arcidae																2					
Mollusc - bivalve	Nuculidae	2	1										1									
Mollusc - bivalve	Ostreidae *Crassostrea gigas*	1				1											2			1		
Mollusc - bivalve	Psammobiidae													1			3					
Mollusc - bivalve	Tellinidae		1	1													2			1		1
Mollusc - bivalve	Veneridae		3		1			8	5	2	6	5	1	2	1		1	3		3		3
Mollusc - bivalve	Galeommatidae			1					2	1						2			1	1		
Mollusc - bivalve	Semelidae *Theora lubrica*			2																5		

Group	Family	1.1a	1.2a	1.3a	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	S8.1	S8.2	S8.3	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6
Mollusc - bivalve	Corbulidae *Varicorbula gibba*		4	6									9		1		1					3
Mollusc - bivalve	Carditidae							2							1	1						
Mollusc - bivalve	Cardiidae				1																	
Mollusc - bivalve	Condylocardiinae							1														
Mollusc - bivalve	Vulsellidae													1								
Mollusc - chiton	Chitonidae						1															
Mollusc - gastropod	Columbellidae					4	2									1						
Mollusc - gastropod	Nassariidae	1		3	7	1		2	1	2	2		1	2	1	3		3	2	2	1	
Mollusc - gastropod	Pyramidellidae					2			1													
Mollusc - gastropod	Trochidae				1																	
Mollusc - gastropod	Mangeliidae					1																
Mollusc - gastropod	Onchidiidae	1																				
Mollusc - gastropod	Opisthobranchia (Infraclass)																			1	1	
Mollusc - gastropod	Turritellidae *Maoricolpus roseus*				1	23	10	1		11			2	1		9	8	1	10	1	2	4
Mollusc - gastropod	Cerithiopsidae					1																
Mollusc - gastropod	Scissurellidae					1																
Mollusc - gastropod	Batillariidae					1																
Mollusc - limpet	Patellidae	1																				
Nemertean	Nemertea (Phylum)			3	3	1		2	1	2			1	2	1	1				2	3	1
Phoronid	Phoronida (Phylum)			1											1							
Platyhelminth	Platyhelminthes (Phylum)	1																				
Polychaete - acrocirrid	Acrocirridae							1														
Polychaete - ampharetid	Ampharetidae	1	12	3	2			1	1	8	2	9	2	5	2	2	10	4		3	1	4
Polychaete - capitellid	Capitellidae *Mediomastus australiensis*	2	3	1	4	1				10	1		3	2	2	6	3	1	4	2	3	

Group	Family	1.1a	1.2a	1.3a	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	S8.1	S8.2	S8.3	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6
Polychaete - capitellid	Capitellidae *Notomastus* sp.	3			1	2		1						1	2		6		8			
Polychaete - cirratulid	Cirratulidae		7	1	1	1	2		1	2			3	1	1					8	5	8
Polychaete - dorvellid	Dorvilleidae	1				2											2					
Polychaete - eunicid	Eunicidae	5	2			9	2										5					
Polychaete - flabelligerid	Flabelligeridae	3				7																
Polychaete - glycerid	Glyceridae	1				2													2			1
Polychaete - hesionid	Hesionidae					3																
Polychaete - lumbrinerid	Lumbrineridae	3	5	15	14		1	1	2	32		5	2	8	8	9	30	5	4	23	13	5
Polychaete - maldanid	Maldanidae		3	1																		
Polychaete - nephtyid	Nephtyidae	6	22	13	6	1	1	4	2	15	6	10	14	19	9	16	8	7	6	20	12	17
Polychaete - nereid	Nereididae					1													1			
Polychaete - oenonid	Oenonidae		2																			
Polychaete - onuphid	Onuphidae											2		11	4	1						
Polychaete - opheliid	Opheliidae					1													1			
Polychaete - orbiniid	Orbiniidae			2					1		1		1					1				
Polychaete - oweniid	Oweniidae		1																			
Polychaete - paraonid	Paraonidae		17	4				1	1													
Polychaete - pectinariid	Pectinariidae									1					1							
Polychaete - phyllodocid	Phyllodocidae			1	1					1	1	1		1				1			1	
Polychaete - poecilochaetid	Poecilochaetidae									2												
Polychaete - polynoid	Polynoidae	5				10	2							1		1	2					
Polychaete - sabellid	Sabellidae *Euchone limnicola*			1									1					1				
Polychaete - sabellid	Sabellidae								1	1	1				2							
Polychaete - scalibregmatid	Scalibregmatidae		3					2	1	2	1			2	1							
Polychaete - serpulid	Serpulidae					1							3				2					
Polychaete - spionid	Spionidae	13	20	100	2	36	6	1	5	8	7	4	72	25	22	3	7	2	1	5	11	24

Group	Family	1.1a	1.2a	1.3a	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	S8.1	S8.2	S8.3	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6
Polychaete - syllid	Syllidae	3				3											1					
Polychaete - terebellid	Terebellidae	1	5	2	3	8	1	1		6	1		2	3	2	1	16		4	2	1	1
Polychaete - trichobranchid	Trichobranchidae				1			1	1	1	1		1	3	1	3				2		1