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Tasman Bay State of the Environment Baseline Benthic Ecological Survey, 2006

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Tasman Bay State of the Environment Baseline Benthic Ecological Survey, 2006

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Prepared for
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1. INTRODUCTION

1.1. Background

As part of the Motueka Integrated Catchment Management (ICM) programme (http://icm.landcareresearch.co.nz/), Cawthron Institute (Cawthron) maintains a buoy-mounted oceanographic data collection facility at a site in western Tasman Bay (Figure 1). The site is situated 6 km off the Motueka River mouth, between the central and northern Tasman Bay Aquaculture Management Areas (AMAs). The primary reason for deployment of the data collection buoy was to assess the influence of the river plume on water column characteristics, however its location (1 km outside the boundaries of each of the AMAs) makes it also potentially useful as a State of the Environment (SOE) monitoring site for assessment of environmental disturbance due to fisheries, aquaculture and other activities.

Another Motueka ICM project assessing the effects of the river plume on benthic habitats includes the buoy site along with a network of additional sites in Tasman Bay. Sediments are presently being analysed for a variety of environmental properties including a full suite of trace metals (R. Forrest, unpublished). These data will be made available to provide a more detailed description of the seabed habitat at the site.

Cawthron was contracted by the Tasman District Council (TDC) to undertake a benthic ecological survey of the soft sediment environment at the site (GPS coordinates 2517648E, 6014874N) in order to begin compilation of a comparative SOE database in anticipation of future aquaculture development. This report provides a description of methods and baseline results with brief interpretation and recommendations regarding the design and timing of ongoing monitoring.

Key objectives were to establish habitat/community profiles and repeatable quantitative baseline data of sediment physical and chemical properties that will enable detection of changes over time.

The survey methods were consistent with those used in a soft sediment ecological survey of the Horoirangi Marine Reserve (Keeley et al. 2006) and additional sites described by Forrest et al. (in press).

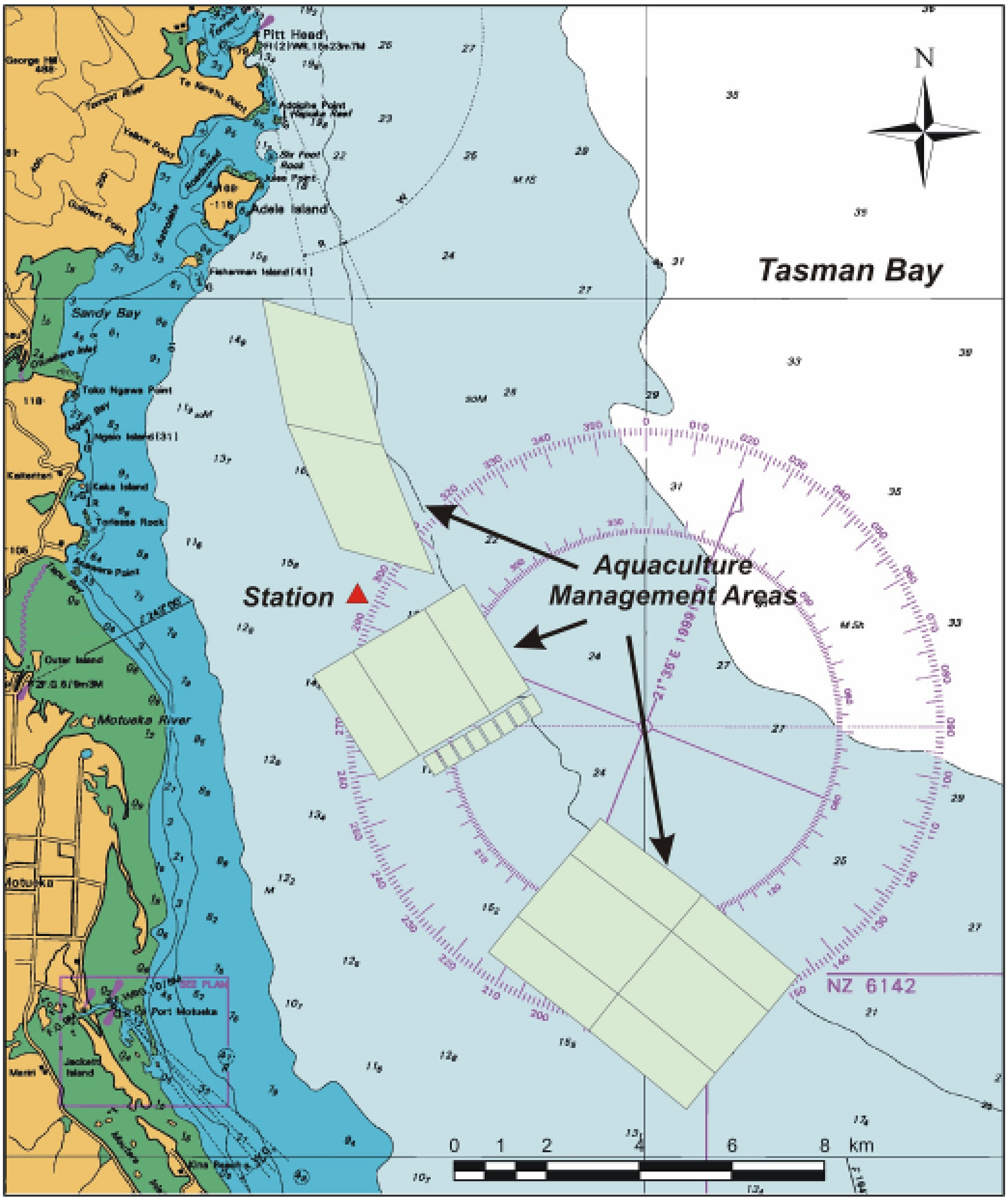

Figure 1. Location of the survey station and nearby aquaculture management areas.

2. SURVEY METHODS

2.1. Rationale for soft sediment sampling

Soft sediment habitats comprise a large percentage of the seabed habitat of Tasman Bay and are therefore a defining feature within the Tasman Bay ecosystem.

Because the majority of these habitats are inside the 30 m bathymetry line, they are exposed to sufficient sunlight to support photosynthetic activity. Benthic microalgal communities on the sediment surface, along with phytoplankton, are major contributors to food webs of shallow coastal environments (Charpy-Raubaud & Sournia 1990). Due to their spatial dominance and ecological importance, soft sediment habitats play a major role in supporting the productivity of fish and shellfish resources in Tasman Bay (Gillespie 2003). Offshore mud habitats in western Tasman Bay have long been subjected to disturbances from riverine (catchment) influences (Gillespie & Rhodes 2006; Forrest et al. in press), and trawling and dredging activities, however little attention has previously been given to establishing monitoring sites as a means of assessing long term environmental change.

2.2. Sampling and field analyses

Soft sediments were sampled by SCUBA divers at locations haphazardly selected within 10 m of the Motueka ICM long-term data collection buoy. Because of their close proximity to the buoy site, the samples were considered as replicates that can provide information on within-site variation. A combination of techniques was used at each location in order to target specific benthic habitat characteristics. The characteristics assessed, and the survey techniques, were largely identical to those used during a soft sediment baseline assessment of the Horoirangi Marine Reserve in eastern Tasman Bay (Keeley et al.2006).

Six Perspex tubes (62 mm internal diameter) were inserted into the sediment to obtain intact cores. Core profiles were assessed in terms of the depth of the RPD (Redox Potential Discontinuity) layer, which represents the transition between oxidised and reduced conditions. The cores were then inspected for patches of sediment anoxia and sulphide odours and a representative core was photographed. The surface 20 mm of each core was removed to a sample container and stored on ice until analysed.

Six additional sediment cores (131 mm diameter by 100 mm deep, area = 0.0135 m^2) were collected for analysis of infauna community characteristics. The cores were gently washed through a 0.5 mm mesh sieve and the residue preserved with a solution of 3% glyoxal and 70% ethanol.

2.2.1. Sediment physical and chemical properties

Sediments were analysed for particle size distribution (as percentage gravel, sands, and mud), organic matter content (as ash free dry weight or AFDW), total nitrogen (TN) and total phosphorus (TP). A summary of the analytical methods is presented in Table 1.

Table 1. Analytical methods used for sediment characterisation.

Analyte	Method	Description
Particle grain size	Extended series (PGX), Cawthron SOP No. 33074	Wet sieving and calculation of dry weight percentage fractions*: >2 mm = Gravel <2 mm – >1 mm = Coarse Sand <1 mm - >500 µm = Medium Sand <500 µm - >250 µm = Medium/Fine Sand <250 µm - >125 µm = Fine Sand <125 µm - >63 µm = Very Fine Sand <63 µm = Mud (Silt and Clay)
Organic Content as Ash Free Dry Weight (AFDW)	Luczak et al. 1997 (modified)	Sample dried at 105°C then ashed at 550°C. Gravimetric determination.
Total Nitrogen	APHA 20th Edn 4500N C	
Total Phosphorus	ICP-MS Aqua Regia Digest	

* Size classes from Udden-Wentworth scale.

2.2.2. *Infauna*

Infauna within the preserved samples were identified and counted with the aid of a binocular microscope. Identifications were made to the lowest practicable taxonomic level. For some groups, species-level identification is very difficult and, in such instances, infauna was grouped into recognisable taxa (morphologically similar groups). Results from the infauna samples were entered directly into Cawthron's marine database before being analysed to ascertain levels of abundance, species richness and diversity.

2.2.3. *Epibiota*

Conspicuous epibiota were quantitatively assessed from 16 randomly positioned photographic quadrats within an approximately 20 m radius of the site. The photographs were taken with an eight mega pixel digital Canon Eos camera (Figure 2) which, upon each lowering, is designed to take a photograph with a set frame of reference (0.1 m^2) at a fixed distance directly above the seabed. This method is favoured over dredging for epifauna as it is non-destructive and more quantitative. Remote photography methods such as this are also favoured over hand-held diver photo-quadrats, which are inherently subject to human bias, compromising the random sampling premise. The images were analysed on a high resolution computer screen and conspicuous biological features were identified (where possible) and enumerated. Benthic microalgal coverage and the degree of visible sediment reworking/bioturbation were assigned a value based on a relative scale of coverage from 1 to 5; i.e. 1= <10%, 2=11-30%, 3=31-60%, 4=61-90%, 5=>>90%. We note that these measurements are subject to some operator bias, however, all images are held by Cawthron for direct comparison with subsequent monitoring results.

Figure 2. Quad cam apparatus for collecting seabed images.

2.3. Data analysis

Analysing the data with an appropriate suite of univariate and multivariate statistical procedures can facilitate the baseline description and later interpretation of spatial and temporal changes in biotic community structure. Relationships with other (i.e. physical and chemical) characteristics can also be explored in an effort to construct a general picture of the existing soft sediment habitats for application to a monitoring framework.

Raw data from infauna samples were summarised according to a suite of common univariate diversity statistics, including: abundance, species richness, evenness and diversity (Table 2). The infauna assemblages recorded during later monitoring surveys can then be compared using non-metric multidimensional scaling or MDS (Kruskal & Wish. 1978) and ordination and cluster diagrams based on Bray-Curtis similarities in PRIMER v5, (Clark & Warwick 1994; Clarke & Gorley 2001).

Table 2. Descriptors of macro-invertebrate community characteristics.

Descriptor	Equation	Description
No. species (S)	**Count (taxa)**	**Total number of species in a sample.**
No. individuals (N)	**Sum (n)**	**Total number of individual organisms in a sample.**
Richness (d)	$d = (S-1)/\log_e N$	Margalef's species Richness. A measure of the number of species present, making some allowance for the number of individuals. Values increase strongly with the number of species (H') and decrease with relative increases in the number of individuals.
Evenness (J')	$J' = H'/\text{Log}_e(S)$	Pielou's evenness. A measure of equitability, or how evenly the individuals are distributed among the different species. Values can theoretically range from 0.00 to 1.00, where a high value indicates an even distribution and a low value indicates an uneven distribution or dominance by a few taxa.
Diversity (H' $\log_e$)	$H' = -\text{SUM}(Pi*\log_e(Pi))$	Shannon-Wiener diversity index ($\log_e$ base). A diversity index that describes, in a single number, the different types and amounts of animals present in a collection. Varies with both the number of species and the relative distribution of individual organisms among the species. The index ranges from 0 for communities containing a single species to high values for communities containing many species and each with a small number of individuals.

3. RESULTS AND DISCUSSION

3.1. Sediment properties

The sediments were generally pale brown in colour, and there were no indications of elevated rates of oxygen consumption e.g. sulphide odours or darkened anoxic RDP layers due to organic enrichment. Representative photographs (Figures 3 and 4) demonstrate general, seabed features.

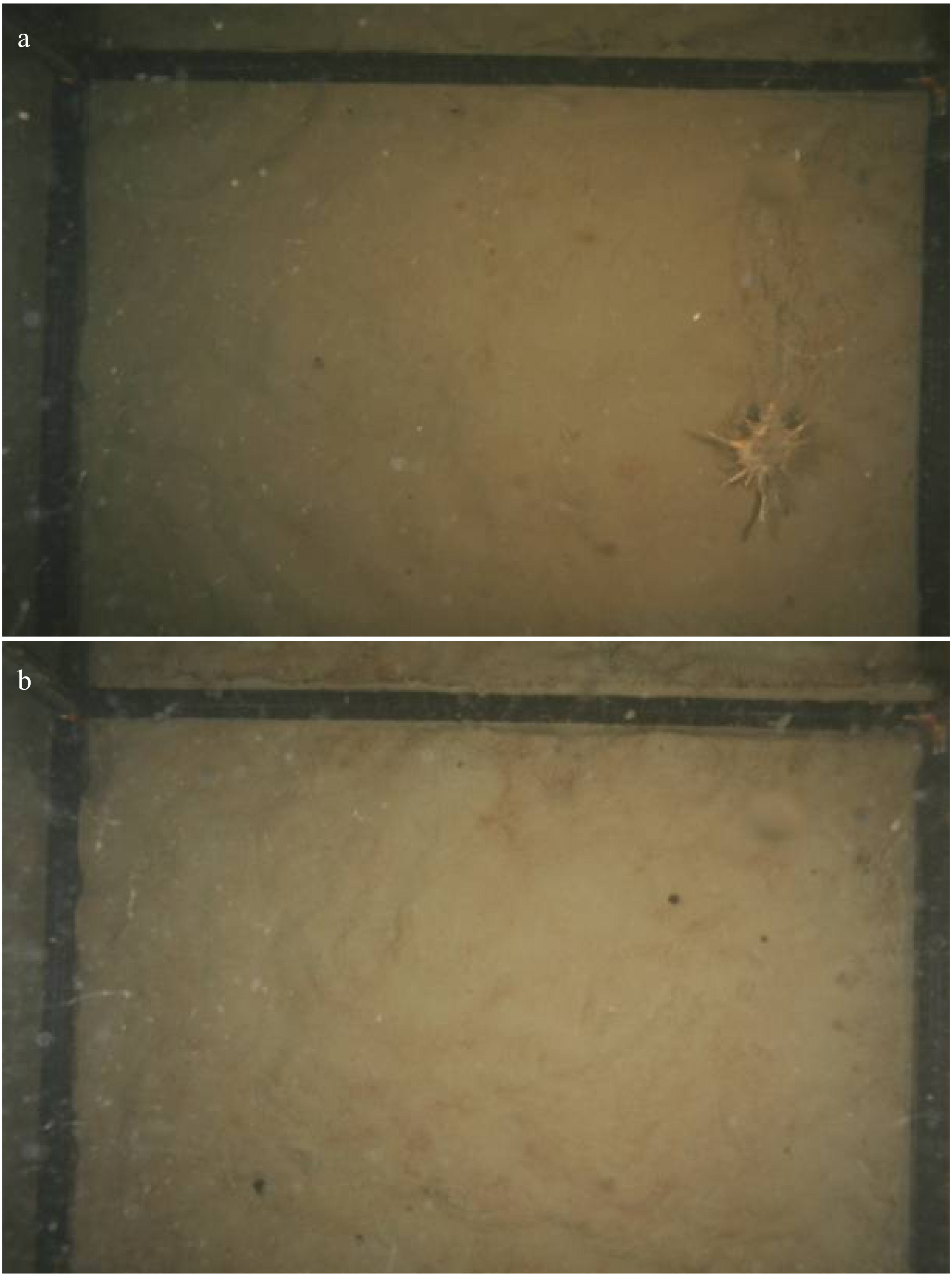

Figure 3. Representative Quad cam seabed images. Note the gastropod, spiny murex, in lower right corner of (a) and polycheate burrows and bio-turbation evidence in (b). A full set of seabed images, providing better resolution of detail, has been written to CD and appended to this report.

Figure 4. A representative sediment core photograph.

Particle size distribution, organic content (AFDW) and nutrient concentrations of the six replicate samples were very uniform (Figures 5-7). Sediment texture was dominated by the silt/clay fraction (>86%), with a minor sand component and small but variable amounts of shell debris (Table 3).

The average sediment organic content (6.3 ±0.3%), Total N (1767 ±52 mg/kg) and Total P (891 ±40 mg/kg) contents were typical of those reported for numerous sites of similar particle size distribution in other regions of Tasman Bay (Forrest et al. 2006 in press). These results indicate generally unenriched, but moderately productive, soft sediment habitats. Low molar N/P ratios (mean ±sd = 4.5 ±0.2) are indicative of the high sediment denitrification rates reported for nearby sites in Tasman Bay (Christensen et al. 2003).

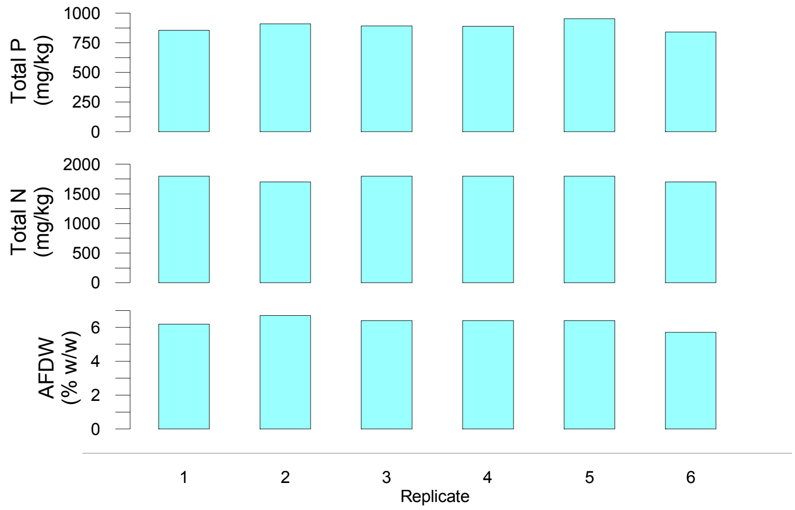

Figure 5. Sediment organic matter and nutrient concentrations.

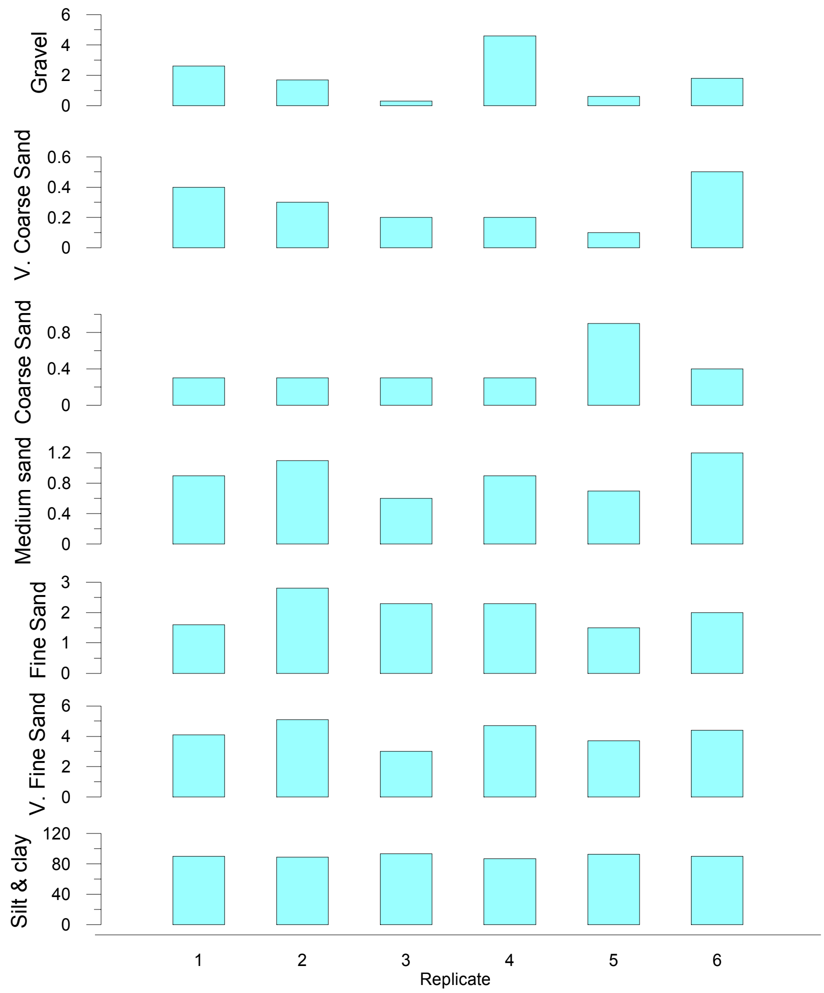

Figure 6. Sediment grain size characteristics (% w/w). Note different vertical scales are used for each size fraction.

Table 3. Physical and chemical properties of sediments.

	Replicate						Mean (±1 sd)
	1	2	3	4	5	6	
Silt and clay (% w/w)	90.0	88.7	93.3	86.9	92.6	89.6	90.2±2.4
V. Fine Sand (% w/w)	4.1	5.1	3	4.7	3.7	4.4	4.2±0.7
Fine Sand (% w/w)	1.6	2.8	2.3	2.3	1.5	2	2.1±0..5
Medium sand (% w/w)	0.9	1.1	0.6	0.9	0.7	1.2	0.9±0.2
Coarse Sand (% w/w)	0.3	0.3	0.3	0.3	0.9	0.4	0.4±0.2
V. Coarse Sand (% w/w)	0.4	0.3	0.2	0.2	0.1	0.5	0.3±0.1
Gravel* (% w/w)	2.6	1.7	0.3	4.6	0.6	1.8	1.9±1.6
AFDW (%w/w)	6.2	6.7	6.4	6.4	6.4	5.7	6.3±0.3
Total N (mg/kg)	1800	1700	1800	1800	1800	1700	1767±52
Total P (mg/kg)	857	910	894	890	954	841	891±40
Molar N/P	4.7	4.3	4.6	4.6	4.3	4.7	4.5±0.2

* The gravel component was determined to be 90-95% shell debris.

3.2. Infauna community

A total of 29 taxa (Appendix 2) were identified from the six infauna cores collected. In terms of biomass, the site was dominated by the heart urchin (*Echinocardium cordatum,* mean ±sd = 1 ±0.6/core equating to 74 ±46/m^2). The heart urchin is a relatively large-bodied deposit-feeding species that is generally considered to be of ecological importance when present in significant densities. This is due to its sediment mixing (bioturbation) activity (Lohrer 2003) and role as a food source for bottom-feeding fish.

Table 4. Summary of descriptors of infauna community structure (based on a core area of 0.0135 m2). See Table 2 for definitions of these statistics).

	Replicate						Mean (±1 SE)
	1	2	3	4	5	6	
No. species (S)	14	13	15	18	16	12	14.7±0.9
No. individuals (N)	35	28	22	45	27	20	29.5±3.8
Richness (d)	3.7	3.6	4.5	4.5	4.6	3.7	4.1±0.2
Evenness (J')	0.9	0.9	1.0	0.9	0.9	0.9	0.9±0.0
Diversity (H'(loge))	2.5	2.4	2.6	2.7	2.6	2.3	2.5±0.1

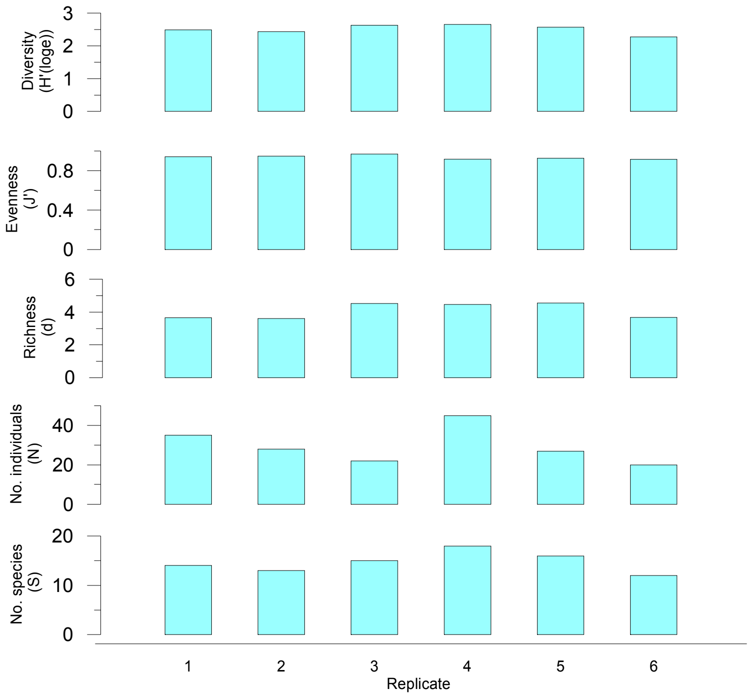

Figure 7. Descriptors of infauna community structure (based on a core area of 0.0135 m2).

3.3. Conspicuous epibiota

Conspicuous animals on the surface of the seabed (epifauna) were sparsely represented (Table 5). The low epifauna density was not surprising due to the location of the site within a region strongly affected by the Motueka River plume (Forrest et al. in press). Only one taxon was identified to species level. The gastropod mollusc, spiny murex (*Poirieria zelandica*) was observed in only one of 16 replicate photographs (Figure 3a). We note, however, that the reduced size of the images in Figure 3 and Appendix 1 does not allow definition of many of the habitat features that were evident on high resolution computer screen.

In spite of the low epifauna densities, considerable activity (bioturbation) was in evidence in the form of worm and crustacean burrowing, surface grazing, tracks, bio-deposits and sediment reworking (Figure 3). It was assumed that much of the sediment reworking in evidence was due to the heart urchin population just below the sediment surface (see Section 3.2).

A visually evident, yellow-brown microalgal film covered an estimated 20 to 60% of the seabed (Figure 3b). Benthic microalgae (primarily diatoms) are an ecologically important component of the seabed environment of Tasman Bay. They add significantly to the total photosynthetic biomass and production (Gillespie et al. 2000; Gillespie 2003) and are an important food source for benthic shellfish and infauna (Gillespie 1997; Gillespie & Rhodes 2006). Christensen et al. (2003) report that benthic microalgal production, at depths less than 30 m in Tasman Bay, has an important stimulatory effect on microbial denitrification rates due to oxygenation of the surface sediments. Benthic microalgae can also affect the physical integrity of the water-sediment boundary layer due to production of polysaccharide materials that glue sediment particles together.

Table 5. **Summary values for epifauna quadrat observations (n=16). Bracketed values = standard error. Relative 1-5 scale: 1= <10%, 2=11-30%, 3=31-60%, 4=61-90%, 5=>90%.**

Epifauna (average/0.1 m^2)	
Spiny murex (*Poirieria zelandica*)	0.06 (0.06)*
Animal activity	
# Holes-A (large, average/0.1 m^2)	0.87 (0.27)
# Holes-B (small, average/0.1 m^2)	4.6 (0.4)
Sediment reworking (1-5 scale)	3.4 (0.1)
Microalgal coverage (1-5 scale)	2.8 (0.1)

* only one individual observed.

4. SUMMARY AND RECOMMENDATIONS

Comparison of the survey results with those of similar measurements of soft sediment habitats in other parts of Tasman Bay (Keeley et al. 2006; Forrest et al. in press) suggests that the SOE monitoring station has been affected to some degree by natural and/or anthropogenic disturbances. The uniformity of sediment grain size distribution and nutrient concentrations and relatively low number of species and abundance of individuals indicate low physical (and related biological) habitat complexity. Since the study site is located within the area influenced by the Motueka River plume (Tuckey et al. 2006; Forrest et al. in press), it is subjected to periodic flood events with associated sediment discharges. The site is also subjected to variable trawling and dredging disturbances.

These results provide a point-in-time baseline of the general condition of the seabed environment. Reassessment of the site at yearly intervals would provide some understanding of inter-annual variability of benthic characteristics. The resulting data base could then be used to facilitate assessment of the impacts of subsequent development within the nearby AMAs. If the site surrounds are protected from dredging and trawling, it would also provide a basis for comparison with nearby unprotected sites that are subjected to direct disturbances from these activities. This would require deployment of buoyed anchor blocks at corner positions around the site, preferably providing a buffer zone at least 100 m wide on all sides. Data collected at the Tasman Bay SOE site, could potentially provide synergistic benefits with a Department of Conservation programme designed for monitoring of soft sediment habitats inside and outside the Horoirangi Marine Reserve on the eastern side of the Bay (Keeley et al. 2006).

5. ACKNOWLEDGEMENTS

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7. APPENDICES

Appendix 1. Seabed Quad cam images (also supplied on CD providing better resolution of features).

Appendix 2. Infauna taxa and abundance (individuals/core).

				CORE					
GROUP	**TAXA**	**COMMON NAME**	**FEEDING TYPE**	**1**	**2**	**3**	**4**	**5**	**6**
Nemertea	Nemertea	Ribbon worms	Carnivorous	0	0	0	0	0	1
Nematoda	Nematoda	Roundworm		1	4	2	1	0	0
Gastropoda	Gastropoda (unident.)			0	1	0	0	0	0
Gastropoda	*Austrofusus glans*			3	0	1	1	1	0
Opisthobranchia	*Philine auriformis*	White Slug		0	1	0	0	0	0
Bivalvia	*Arthritica bifurca*	Small bivalve	Infaunal deposit feeder	0	3	2	0	1	0
Bivalvia	*Dosinia lambata*		Infaunal suspension feeder	0	2	1	1	1	0
Bivalvia	*Ennucula strangei*			1	0	0	1	0	0
Bivalvia	*Leptomya retiaria retiaria*		Infaunal deposit feeder	0	1	0	0	0	0
Bivalvia	*Neilo australis*			0	0	0	0	1	0
Bivalvia	*Nucula cf gallinacea*		Infaunal deposit feeder	0	0	0	0	1	0
Bivalvia	*Theora lubrica*	Window shell	Infaunal deposit feeder	3	2	1	2	4	1
Polychaeta	*Cossura consimilis*		Deposit feeder	2	3	0	3	1	1
Polychaeta	Paraonidae		Infaunal deposit feeder	0	1	2	1	0	1
Polychaeta	Lumbrineridae		Infaunal carnivore & deposit feeder	2	2	0	2	0	1
Polychaeta	*Aglaophamus macroura*		Infaunal carnivore	6	3	3	5	5	3
Polychaeta	Sigalionidae	Scale worm	Infaunal carnivore	3	4	1	5	1	4
Polychaeta	Cirratulidae		Deposit feeder	2	0	2	4	3	4
Polychaeta	Terebellidae		Infaunal deposit feeder	0	0	1	1	0	1
Polychaeta	*Terebellides stroemi*		Infaunal deposit feeder	1	0	0	0	0	0
Mysidacea	Mysidacea	Mysid shrimp	Filter and deposit feeder	0	0	0	1	0	0
Cumacea	Cumacea	Cumaceans	Infaunal filter or deposit feeder	5	0	0	8	2	1
Tanaidacea	*Tanaid sp.*	Tanaid Shrimp	Epifaunal scavenger	0	0	1	2	0	0
Amphipoda	Amphipoda a	Amphipods	Epifaunal scavenger	2	0	1	0	1	0
Amphipoda	Amphipoda b	Amphipods	Epifaunal scavenger	0	0	2	2	2	0
Amphipoda	Amphipoda c	Amphipods	Epifaunal scavenger	1	0	1	0	0	0
Ostracoda	Ostrocoda	Ostracods	Omnivorous scavenger	3	0	0	3	1	0
Echinoidea	*Echinocardium cordatum*	Heart Urchin	Deposit feeder	0	1	1	2	1	1
Ophiuroidea	Ophiuroidea	Brittle stars	Epifaunal deposit feeder	0	0	0	0	1	1