EMP FIELD GUIDE A
BROAD-SCALE MAPPING

1. Assemble the equipment

- 4WD vehicle
- Small boat and outboard (if necessary)
- GPS unit with data logger (*e.g.* Trimble Pathfinder Pro, with TD1 data logger)
- White polythene sheeting cut into 2 x 2 m squares
- Black polythene sheeting cut into 30 cm x 2 m rectangles
- Chest-high waders
- Waterproof notebook and pencils
- Camera
- Checklist of likely dominant plant and substrate types (preferably include taxonomic keys/photographs to enable easy identification)
- Plastic bags for any samples that may later require identification
- 6 fine tipped felt pens (3 different colours)
- Laminated colour aerial photographs of whole estuary and margins (scale 1:5000 to 1:10,000)
- Watch and tide chart

2. Identify reference points

In some larger estuaries there may not be enough prominent landmarks present within areas of open intertidal flats. In such cases, peg out polythene markers **prior to the aerial survey** and collect GPS coordinates. Remove the markers immediately after the survey.

After the photographs are available, collect GPS coordinates for at least six prominent landmarks per photograph (*e.g.* road intersections, islands, buildings, polythene markers).

3. Ground-truth the photographs

Field surveys are undertaken to verify photography, and identify dominant habitat and map boundaries. The approach involves at least one experienced estuarine scientist plus a technician walking over the whole estuary at low-mid tide, identifying dominant habitat and their boundaries

and recording these as codes on aerial images at a scale of between 1:5,000 and 1:10,000. For example, approximately 25 images were used to ground-truth the New River estuary. The codes and list of dominant habitat types, including various categories of bare and vegetated substrate, are shown in Table 1.

Access

A four wheel drive vehicle is the preferred option for access to the estuary and its margins, although for some areas a small boat and outboard may be necessary (e.g. islands). Participants in the survey require a reasonable level of fitness particularly for those areas where deep mud conditions exist. Participants should be trained in negotiating mud conditions prior to the survey commencing. Flexible-leg chest waders have proven the most effective footwear for survey work within the estuary. Adequate drinking water supplies and some snack food are essential.

Weather Conditions and Timing

This survey must be undertaken during dry weather or it becomes impossible to record habitat types on the laminated photographs. Ideally the survey should be undertaken during the period September through till May when most plants are still visible and have not died back.

Extent of Survey

For the purposes of the intertidal survey the upper boundary of each estuary could be set at MHWS, however we have included supra-littoral categories in the classification system in case these are required. The lower boundary is set at MLWS.

Identification and Recording

The aim in this survey is to coarsely map the intertidal features of the estuary. This will require the guidance of a specialist scientist to make decisions on what features should be mapped and what they should be called. This survey is not designed to record detail. The substrate types and their extents are confirmed by field verification of the textural and tonal patterns identified on the aerial photographs.

Table 1: Adapted estuarine components of UNEP-GRID classification

Level I Hydrosystem	**Level IA Sub-System**	**Level II Wetland Class**	**Level III Structural Class**	**Level IV Dominant Cover**	**Habitat Code**
Estaurine	Intertidal/supratidal	Saltmarsh	Grassland	*Ammophila arenaria*, "Marram grass'	Amar
(alternating				*Agrostis stolonifera* "Creeping bent"	Agst
saline and				*Elytrigia pycnanph*,, "Sea couch"	Elpy
freshwater)				*Festuca arundinacea*, "Tall fescue"	Fear
				Paspalum distichum, "Mercer grass"	Padi
			Herbfield	*Apium prostratum*, "Native celery"	Appr
				Cotula coronopifolia , "Bachelor's button"	Coco
				Leptinella dioica	Ledi
				Plantago coronopus, "Buck's-horn plantain"	Plco
				Samolus repens, "Primrose"	Sare
				Sarcocornia quinqueflora, "Glasswort"	Saqu
				Selliera radicans, "Remuremu"	Sera
				Suaeda novae – zelandiae, "Sea blite"	Suno
				Triglochin striata, "Arrow-grass"	Trst
			Reedland	*Glyceria maxima*, "Reed sweetgrass"	Glma
				Spartina anglica, "Cord grass"	Span
				Spartina alterniflora, "Smooth cord grass"	Spal
				Typha orientalis, "Raupo"	Tyor
			Rushland	*Baumea juncea*, " Bare twig rush"	Baju
				Isolepis nodosa, "Knobby clubrush"	Isno
				Juncus artoiculatus, "Jointed rush"	Juar
				Juncus effuses, "Softrush"	Juef
				Juncus kraussii, "Searush"	Jukr
				Juncus pallidus, " Pale rush"	Jupa
				Leptocarpus similis, "Jointed wirerush"	Lesi
				Wilsonia backhousei	Wiba
			Sedgeland	*Cyperus eragrostis*, "Umbrella sedge"	Cyer
				Cyperus ustulatus, "Giant umbrella sedge	Cyus
				Eleocharis sphacelata, "Bamboo spike-sedge"	Elsp
				Isolepis cernua, "Slender clubrush"	Isce
				Schoenoplectus pungens, "Three-square"	Scpu

Table 1 continued.

Level I Hydrosystem	Level IA Sub-System	Level II Wetland Class	Level III Structural Class	Level IV Dominant Cover	Habitat Code
			Scrub	*Avicennia marina var. resinfera*, "Mangrove"	Avre
				Cordyline australis, "Cabbage tree"	Coau
				Cytisus scoparius, "Broom"	Cysc
				Leptospermum scoparium, "Manuka"	Lesc
				Plagianthus divaricatus, "Saltmarsh ribbonwood"	Pldi
				Ulex europaeus, "Gorse"	Uleu
			Tussockland	*Cortaderia* sp., "Toetoe"	Co sp
				Phormium tenax, "New Zealand flax"	Phte
				Poa, "Silver tussock"	Poa
				Puccinella stricta, "Salt grass"	Pust
				Stipa stipoides, "Needle tussock"	Stst
		Seagrass meadows	Seagrass meadow	*Zostera novazelandica*, "Eelgrass"	Zo sp
		Macroalgal bed	Macroalgal bed	*Enteromorpha* sp.	En sp
				Gracilaria chilensis	Grch
				Ulva rigida, "Sea lettuce"	Ulri
		Mud/sandflat	Firm shell/sand (<1cm)		FSS
			Firm sand (<1cm)		FS
			Soft sand		SS
			Mobile sand (<1cm)		MS
			Firm mud/sand (0-2cm)		FMS
			Soft mud/sand (2-5cm)		SM
			Very soft mud/sand (>5cm)		VSM
		Stonefield	Gravel field		GF
			Cobble field		CF
		Boulderfield	Boulder field		BF
		Rockland	Rockland		RF
		Shell bank	Shell bank		Shell
		Shellfish field	Cocklebed		Cockle
			Musselreef		Mussel
			Oysterreef		Oyster
		Worm field	Sabellid field		Sabellid
	Subtidal	Water	Water		Water

Level III Structural classes are defined as follows:

Cushionfield: Vegetation in which the cover of cushion plants in the canopy is 20-100% and in which the cushion-plant cover exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions.

Herbfield: Vegetation in which the cover of herbs in the canopy is 20-100% and in which the herb cover exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.

Lichenfield: Vegetation in which the cover of lichens in the canopy is 20-100% and in which the lichen cover exceeds that of any other growth form or bare ground.

Reedland: Vegetation in which the cover of reeds in the canopy is 20-100% and in which the reed cover exceeds that of any other growth form or open water. If the reed is broken the stem is both round and hollow – somewhat like a soda straw. The flowers will each bear six tiny petal-like structures – neither grasses nor sedges will bear flowers, which look like that. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either hollow or have a very spongy pith. Examples include *Typha, Bolboschoenus, Scirpus lacutris, Eleocharis sphacelata,* and *Baumea articulata.* Some species covered by the Rushland or Sedgeland classes (below) are excluded.

Rushland: Vegetation in which the cover of rushes in the canopy is 20-100% and in which the rush cover exceeds that of any other growth form or bare ground. A tall grasslike, often hollow-stemmed plant, included in the rush growth form are some species of *Juncus* and all species of *Leptocarpus*. Tussock-rushes are excluded.

Juncus krausii (searush)

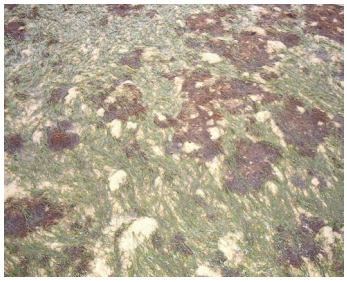
Sedgeland: Vegetation in which the cover of sedges in the canopy is 20-100% and in which the sedge cover exceeds that of any other growth form or bare ground. "Sedges have edges." Sedges can be differentiated from grass by feeling the stem. If the stem is flat or rounded, it's probably a grass or a reed, if the stem is clearly triangular, it's a sedge. Included in the sedge growth form are many species of *Carex, Uncinia,* and *Scirpus*. Tussock-sedges and reed-forming sedges (c.f. REEDLAND) are excluded.

Scrub: Woody vegetation in which the cover of shrubs and trees in the canopy is > 80% and in which shrub cover exceeds that of trees (c.f. FOREST). Shrubs are woody plants < 10 cm diameter at breast height (dbh).

Tussockland: Vegetation in which the cover of tussocks in the canopy is 20-100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussocks include all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and > 10 cm height. Examples of the growth form occur in all species of *Cortaderia, Gahnia,* and *Phormium,* and in some species of *Chionochloa, Poa, Festuca, Rytidosperma, Cyperus, Carex, Uncinia, Juncus, Astelia, Aciphylla,* and *Celmisia.*

Forest: Woody vegetation in which the cover of trees and shrubs in the canopy is > 80% and in which tree cover exceeds that of shrubs. Trees are woody plants ≥ 10 cm dbh. Tree ferns ≥ 10cm dbh are treated as trees.

Seagrass meadows: Seagrasses are the sole marine representatives of the Angiospermae. They all belong to the order Helobiae, in two families: Potamogetonaceae and Hydrocharitaceae. Although they may occassionally be exposed to the air, they are predominantly submerged, and their flowers are usually pollinated underwater. A notable feature of all seagrass plants is the extensive underground root/rhizome system which anchors them to their substrate. Seagrasses are commonly found in shallow coastal marine locations, salt-marshes and estuaries.



Zostera novazelandica (eelgrass)

Macroalgal bed: Algae are relatively simple plants that live in freshwater or saltwater environments. In the marine environment, they are often called seaweeds. Although they contain cholorophyll, they differ from many other plants by their lack of vascular tissues (roots, stems, and leaves). Many familiar algae fall into three major divisions: Chlorophyta (green algae), Rhodophyta (red algae), and Phaeophyta (brown algae). Macroalgae are algae that can be seen without the use of a microscope.

Firm mud/sand: A mixture of mud and sand, the surface appears brown and may have a black anaerobic layer below. When walking on the substrate you'll sink 0-2 cm.

Soft mud/sand: A mixture of mud and sand, the surface appears brown and may have a black anaerobic layer below. When walking on the substrate you'll sink 2-5 cm.

The simple way to classify mud/sand: how deep you sink

Very soft mud/sand: A mixture of mud and sand, the surface appears brown, often with a black anaerobic layer below. When walking on the substrate you'll sink greater than 5 cm.

Mobile sand: The substrate is clearly recognised by the granular beach sand appearance and the often rippled surface layer. Mobile sand is continually being moved by strong tidal currents and often forms bars and beaches. When walking on the substrate you'll sink less than 1 cm.

Firm sand: Firm sand flats may be mud-like in appearance but are granular when rubbed between the fingers, and solid enough to support an adult's weight without sinking more than 1-2 cm. Firm sand may have a thin layer of silt on the surface making identification from a distance impossible.

Soft sand: Substrate containing greater than 99% sand. When walking on the substrate you'll sink greater than 2 cm.

Stonefield/gravelfield: Land in which the area of unconsolidated gravel (2-20 mm diameter) and/or bare stones (20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether stones or gravel form the greater area of ground surface. Stonefields and gravelfields are named from the leading plant species when plant cover of ≥ 1%.

Boulderfield: Land in which the area of unconsolidated bare boulders (> 200mm diam.) exceeds the area covered by any one class of plant growth-form. Boulderfields are named from the leading plant species when plant cover is ≥ 1%.

Rockland: Land in which the area of residual bare rock exceeds the area covered by any one class of plant growth-form. Cliff vegetation often includes rocklands. They are named from the leading plant species when plant cover is ≥1%

Cocklebed: Area that is dominated by cockle shells.

Musselreef: Area that is dominated by one or more mussel species.

Oysterreef: Area that is dominated by one or more oyster species.

Sabellid field: Area that is dominated by extensive raised beds of sabellid polychaete tubes.

EMP FIELD GUIDE B
FINE-SCALE SAMPLING AND FIELD ANALYSES

1. Assemble the equipment

General

- Chest waders (lightweight PVC)
- Handheld GPS unit
- Clipboard, waterproof notebook and pencils, marker pen
- Field taxonomic guide
- Camera (digital optional)
- Sleds (3) with rope and storage bins (optional, for transporting equipment across mudflats)
- Spade (hand)
- Cell phone
- Wooden stakes and tape measure(to mark out site)

Epifauna

- Quadrat(s) (0.25 m²)
- Waterproof field sheets (with expected species list)

Infauna

- PVC corer (130 mm, with 0.5 mm mesh bag)
- Wide-mouth funnel (bag → plastic container)
- 500 or 1000 ml plastic containers (10 per site)
- Waterproof labels to place inside containers
- Ethanol preservative (95%)

Macroalgae

- Gridded quadrat (0.25 m² with 36 equally spaced internal squares)

Microalgae

- Cut-off 10 ml (15 mm internal diam.) syringe barrels (4)
- 50 ml centrifuge tubes (10 per site)

Sediments

- Perspex corer (about 60 mm diameter) with plunger
- Labels

- Re-sealable polyethylene (plastic) bags
- Ruler (x 2)
- 250 ml plastic jars (acid rinsed) (10 per site)
- Plastic spatula
- Chilly bin (and ice)
- White, shallow plastic display tray

2. Carry Out the Field Work (between January-March)

See Figure 1 for a summary diagram of the sampling strategy. Ideally you will require three trained and reasonably fit staff to undertake the sampling.

1. A person capable of identifying estuarine epifauna.
2. A person able to operate the hand-held GPS and camera.
3. A person able to collect physical, chemical and infauna core samples.

Each of these people should be wearing lightweight, flexible leg, chest waders so they can easily sit and keep warm and dry in soft mud conditions.

Sampling can be undertaken on wet days, but ideally it should be dry. The work will need to be carried out over the low tide period beginning approximately 1.5 hrs prior to low water. It will usually take around two hours per site. Don't leave the sampling till too late in the day because an hour or two is required to sieve infauna samples before preserving. All samples should be clearly labelled with estuary, site, station (plot), date/time and collectors (pre-labelling is a must given the generally muddy conditions at each site). Tide (spring or neap) and weather conditions and any site features of interest should be recorded in the field notebook.

Marking out the sites: The areal extent of the sand/mud habitat may differ considerably from one estuary to another. Thus there may be reason to consider the use of sites proportional to the size of the estuary or habitat. To simplify this decision, we suggest that sites of a standard size of 60 x 30 m would be suitable in most cases.

- Sites of 60 x 30 m are marked out with the aid of a tape measure for placement of wooden stakes at each corner.

- Corner positions are recorded using differential GPS to enable subsequent repeat surveys.
- The site is then subdivided into 12 equal-sized (*i.e.* 15 x 10 m) plots. Plot intersections can be marked with temporary stakes (*e.g.* bamboo) to provide reference points when sampling. It is recommended that 10 of these plots be sampled on each occasion.

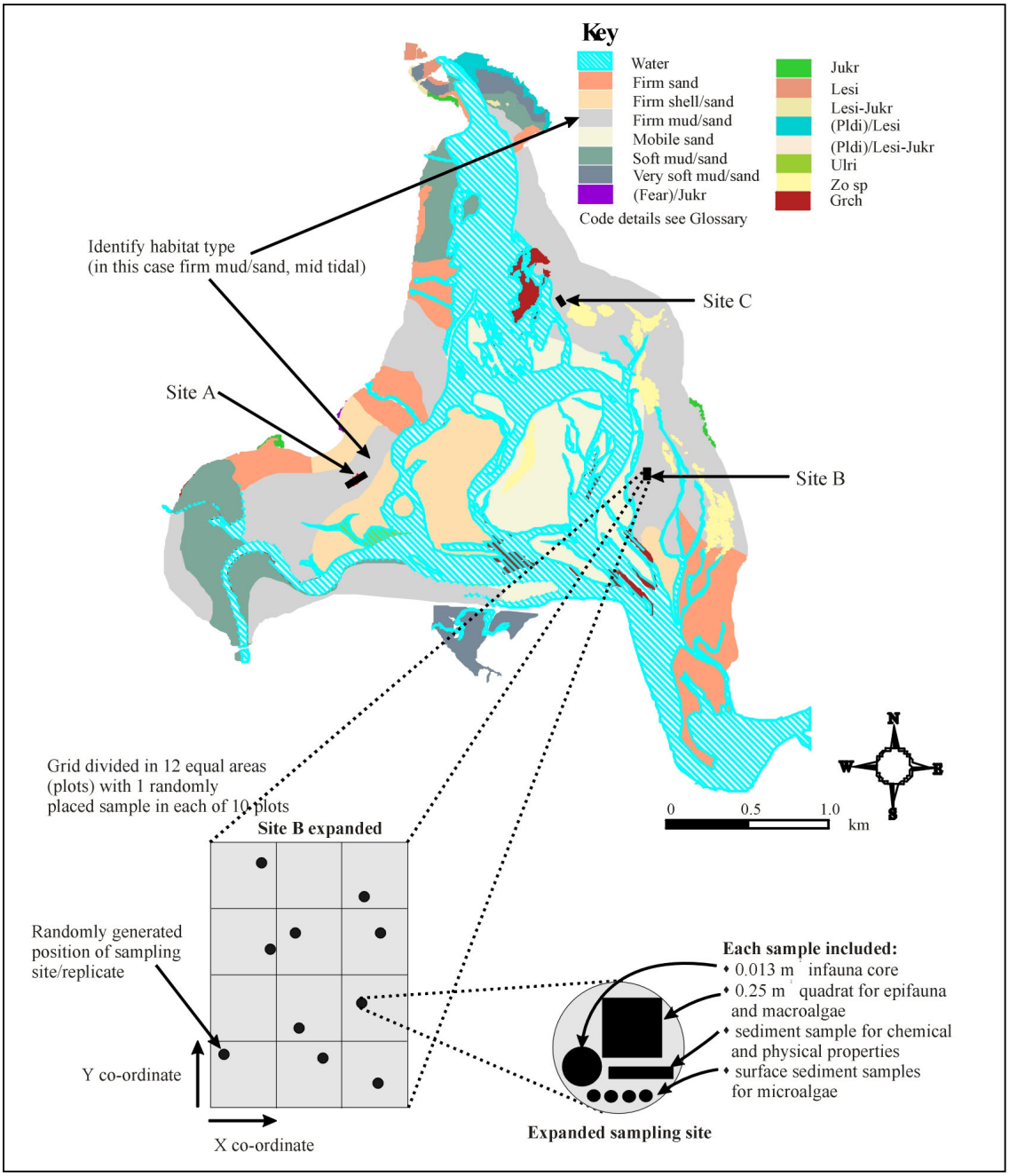


Figure 1: Summary of the sampling strategy applied to each estuary, with a sampling site and station expanded for clarity. The Avon-Heathcote Estuary is used as the example.

***Photographs*:** Photographs are taken to provide a record of the general site appearance. If a digital camera is available, these can easily be archived for comparison with subsequent survey results.

***Sediment core profiles (and the depth of the Redox Discontinuity Layer)*:**

- One randomly positioned 60 mm perspex core is collected to a depth of at least 100 mm from each plot.
- The core is extruded onto a white plastic tray, split lengthwise (vertically) into two halves and photographed along side a ruler and a corresponding label.
- The stratification of colour and texture are described with particular attention to the occurrence of any black (anoxic) zones. Where these occur, the average depth of the lighter-coloured surface layer is recorded as the depth of the Redox Discontinuity Layer (RDL).

Notes:

- Distinct RDLs were not observed at any of the REs. However in highly enriched situations, the black anoxic layer may be at, or very near, the sediment surface and a strong rotten egg odour of hydrogen sulphide gas will be evident. In extreme situations a patchy, white bacterial mat may be visible on the surface of the sediment. These are the white sulphur bacteria (*Beggiatoa* sp.) that help to detoxify the system by oxidising the H_2S.

***Epifauna*:** (surface-dwelling animals):

- Epifauna are assessed from 10 replicate 0.25 m^2 quadrats within each site (one randomly placed within 1m of the Perspex core sample within each plot). All animals observed on the sediment surface are identified and counted, and any visible microalgal mat development is noted. Crab burrows may be counted as a relative indicator of mud crab populations, but the data can not be used as a direct measure of abundance without calibration. The species, abundance and related descriptive information are recorded on specifically designed,

waterproof field data sheets containing a checklist of expected species (see the example provided in Table 1).

- Photographs of representative quadrats are taken and archived for future reference.

Macroalgae *(seaweeds)* ***% cover*****:**

- Where a significant macroalgal cover exists, the percent coverage is estimated from the epifauna quadrats, but with gridlines dividing it into 36 equally-spaced squares. The number of grid intersections (49 in total, including the outer frame) that overlap vegetation are counted and the result converted to a percent (*i.e.* No. x 2 = %). The data can be recorded on the same field data sheets used for epifauna analyses.

Infauna (animals living buried in the sediments)**:**

- Ten sediment cores (one randomly placed within 1m of the Perspex core sample within each plot) are collected from each site using 130 mm diameter (area = 0.0133 m^2) PVC tubes with 0.5 mm nylon mesh bags affixed to the top to act as a sieve.

- The core tubes are manually driven 150 mm into the sediments, removed with core intact and inverted so that the core is retained in the mesh bag.

- The contents of the core are washed through the attached sieve using seawater from a nearby source. The remaining contents are carefully emptied into a plastic container with a waterproof label and preservative is added. Although 4% formalin (made up in seawater) is traditionally used as a preservative, **it is a potentially dangerous chemical**. We recommend using 95% ethanol instead (enough to roughly double the volume of the sample).

Table 1: Checklist of expected epibiota for New Zealand estuaries

Plot		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Species	**Common name**										
Cominella glandiformis	Mudflat whelk										
Cominella maculosa	Spotted Whelk										
Diloma surostrata	Mudflat topshell										
Diloma zelandica											
Micrelenchus huttoni	Topshell										
Zeacumantus subcarinata	Small spire shell										
Zeacumantus lutulentus	Spire shell										
Amphibola crenata											
Notoacmea helmsi	Estuarine limpet										
Austrovenus stutchburyi	cockle										
Paphies australis	pipi										
Mactra discors	large trough shell										
Macra ovata	oval trough shell										
Crassostrea gigas	Pacific oyster										
Crab holes											
Halicarcinus varius	Pilbox crab										
Enteromorpha											
Isopod											
Edwardsia tricolor	Burrowing anemone										
Anthopleura aureoradiata	Mudflat anemone										
Elminius modestus	Estuarine barnacle										
Gracilaria											
Ulva											
Equipment: 10 Quadrats, Cores, (grain size and AFDW) bags, Pottles (nutrients, org C, metals), syringe (microalgae), photos, benthic algae, GPS.											

Notes:

- In firm substrates, it may be necessary to remove the core by digging.
- Avoid rigorous handling of samples (especially during rinsing through mesh) to avoid damaging organisms.
- If water for sieving the infauna samples is too far away, you may need to use larger plastic bags (well-labelled) to transport the cores to the water (after sampling is finished at that site). Do not pour water through the mesh bag. Just immerse the closed end of the bag into the water and gently agitate to wash the fine sediment through the sieve. Then transfer the remaining contents into plastic containers (labelling and adding preservative).
- When transporting preserved samples, care must be taken to avoid spillage. Place containers in a large, tied-off plastic bag to minimise leakage.

Benthic microalgae:

- Cut-off 10 cc syringe barrels (15 mm internal diameter) are used to collect sediment cores (four per plot from within 0.5m of the epifauna quadrat).
- The top 5 mm of the cores are sliced off and mixed in a 50 ml centrifuge tube to obtain one sediment composite per plot.
- Samples are stored on ice (in the dark) while in the field and frozen (-20^{o}C) upon return.

Notes:

- The primary objective of benthic microalgal analyses is to identify any major bloom occurrences that could be indicative of eutrophic (highly enriched) conditions. Sediment chl *a* and phaeopigment concentrations provide an indication of the degree of mat development
- Some species of benthic microalgae (*e.g.* euglenoids) and cyanobacteria (blue green algae) may be indicative of nutrient enrichment; particularly if they dominate the microalgal community. However, more data is required before this can be developed as a useful indicator. If you would like to contribute to this process, collect one additional composite sample using the same procedure as for chl a, but preserve it with Lugol's Iodine solution (do not freeze).

Physical and chemical analyses:

- Ten replicate samples (one from each plot) are collected from an area within 300 mm of the position of the infauna cores. The top 20 mm of sediment is scraped into a clean, acid-rinsed (see note) 250 ml plastic jar and stored on ice until processed (preferably within 12 hours).

Notes:

- The clean plastic container should be rinsed thoroughly with 10% HCl, followed by deionised water, prior to use.
- Avoid cross-contamination of samples and any contact with metal implements (use a plastic spatula).
- Do **not** place a label inside the plastic container. If necessary, cover the outer label with Cellotape to keep dry.