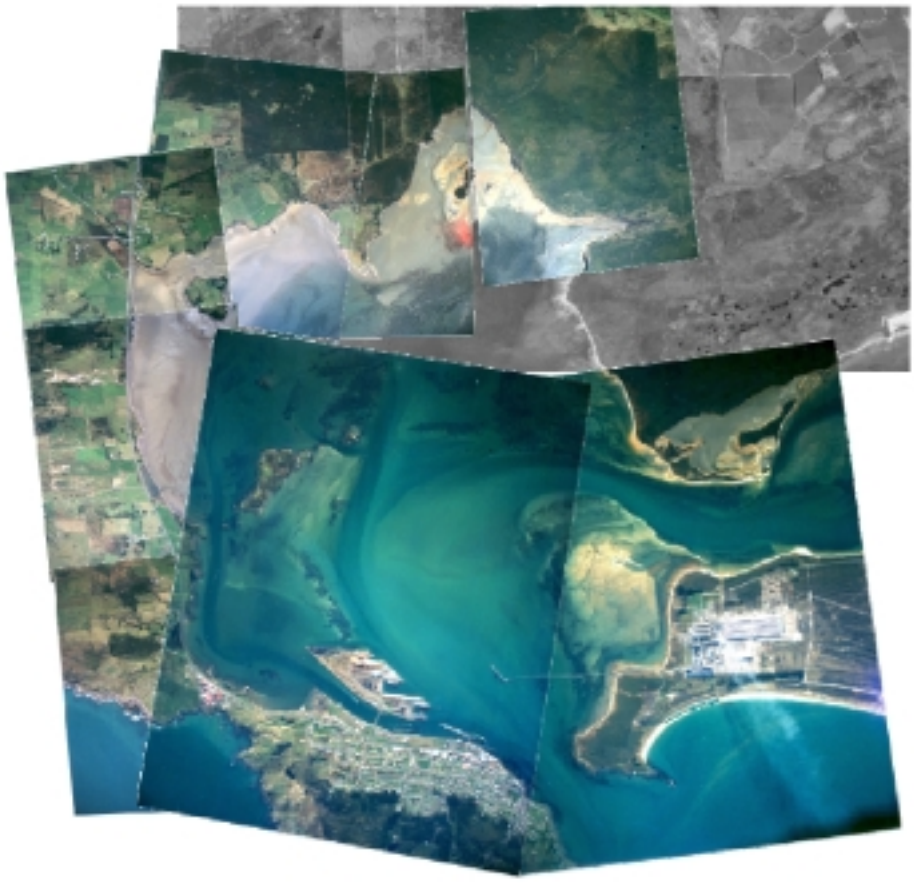
Cawthron Report No. 940

Broad Scale Intertidal Habitat Mapping of Bluff Harbour



Prepared for

environment SOUTHLAND
Te Taiao Tonga

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1. INTRODUCTION

Estuarine intertidal areas play an important role in the nourishment of coastal ecosystems, linking terrestrial and marine environments and often encompassing high value ecological habitats and resources of cultural, recreational and/or commercial importance. Environment Southland (ES) are monitoring a number of estuaries in their region and the Cawthron Institute (Cawthron) has previously undertaken both broad and fine scale habitat mapping and assessment of estuaries in the Southland region (*e.g.* Jacobs River, New River, Mataura) to assist in regional strategic planning, and in the management of specific issues associated with estuarine habitat (*e.g.* resource consents, pollution, and state of the environment monitoring).

To further extend the spatial coverage of the estuaries being monitored, ES and Cawthron recently undertook broad scale mapping of the intertidal substrate and habitat complexes present in Waikawa Estuary (Robertson *et. al* 2004a) and Awarua Bay (Robertson *et. al* 2004c). Subtidal habitats of Bluff Harbour were also mapped in March 2004 (Stevens and Clark 2004). This report summarises the results of a detailed point-in-time, spatial survey of major habitats in the intertidal regions of Bluff Harbour. This report includes the following components:

- A CD-ROM containing the completed habitat maps (titled "*Broad Scale Intertidal Habitat Mapping: Bluff Harbour*").
- A summary report (this document) which includes:
    - a methodology outline.
    - a map showing the broad scale habitats present (*e.g*. Rushland, Tussockland).
    - a map representing the pattern of dominant cover (*e.g. Leptocarpus similis*).
    - a summary table of major habitats and substrates within the estuary, providing the area and relative proportions of each grouping.
    - a brief summary of results for Bluff Harbour.
    - a combined summary of results for Bluff Harbour and Awarua Bay.

2. METHODS

2.1 Overview

The methodology used to collect data was based on the National Estuary Monitoring Protocol (Robertson *et al.* 2002) which uses field-verified broad scale mapping of habitat zones. This

procedure involves the use of aerial photography together with detailed ground-truthing and digital mapping using Geographical Information System (GIS) technology. The broad scale habitat mapping approach provides a description of the intertidal environment according to dominant habitat types based on substrate characteristics (mud, sand, cobble, rock, shellfish beds, *etc*) and the vegetation present (*e.g.* rushes, tussocks, eelgrass, seaweed, *etc*), in order to develop a baseline map of the estuary. Once a baseline map has been constructed, changes in the position and/or size of habitats (MfE Confirmed Indicators for the Marine Environment, ME6 2001) can be assessed by repeating the mapping exercise. This information can then be used to evaluate the implications of natural perturbations such as flood/climate events and human impacts such as land management practices (and related river water quantity and quality) on the structure and function of the intertidal ecosystem.

2.2 Colour aerial photography

Aerial photographs of Bluff Harbour and Awarua Bay were taken on 9 April 2000 and 14 August 1996 by Les McGraw (ES) and provided to us as rectified tiff files at a scale of 1:8,000 and 1:9,500 respectively.

2.3 Ground-truthing of habitat features

Aerial photographs, through different textural and tonal patterns, indicate the presence of different substrate types and their spatial extents. To identify the dominant habitat present, and confirm the boundaries between substrates, an experienced estuarine scientist (Cawthron) supported by ES staff walked over the whole estuary at low-mid tide during April 2004. Dominant habitat types, including various categories of bare and vegetated substrate were recorded directly onto laminated aerial photographs (scale 1:5,000 to 1:10,000) using the codes listed in Table 1. The upper boundary was set at MHWS (Mean High Water Spring), unless supra-littoral habitat was considered integral with the upper intertidal, in which case it was included. The lower boundary was set at MLWS (Mean Low Water Spring). Some terrestrial vegetation was also mapped to indicate where shrub, scrub, and forest areas were present around the edge of the estuary.

2.4 Digitisation of habitat boundaries

Vegetation and substrate features were then digitally mapped on-screen from the rectified photographs using Arcmap 8.3 GIS software. This procedure involved copying, as precisely as possible, the habitat features recorded on aerial photographs during the field surveys onto rectified

aerial photographs within the GIS. Each drawing was then saved to a shape file (or GIS layer) associated with each specific feature. The software was then used to produce maps and calculate the area cover for each habitat type. Additionally, the GIS information from the subtidal mapping (Stevens and Clark 2004) was used to delineate the intertidal-subtidal boundary to produce a seamless, albeit somewhat arbitrary, interface between the surveys.

3. CLASSIFICATION AND DEFINITIONS OF HABITAT TYPES

3.1 Classification of habitat features

The classification of substrate and habitat features has been based on the proposed estuarine national classification system (with adaptations), which was developed under a Ministry of the Environment SMF (Sustainable Management Fund) programme (Monitoring Changes in Wetland Extent: An Environmental Performance Indicator for Wetlands) by Lincoln Environmental, Lincoln. The classification system for wetland types is based on the Atkinson System (Atkinson 1985) and covers four levels, ranging from broad to fine-scale. The broad-scale mapping focuses on Levels III and IV (see Table 1). Substrate classification is based on surface layers only and does not consider underlying substrate; *e.g.* gravel fields covered by sand would be classed as sand. A list of all the classification types used in the study and their codes are given in Table 1, with definitions for classification of the Level III structural class provided in Section 3.3.

3.2 Habitat codes and terminology

Dominant biota with a spatial coverage of >2m in diameter has been classified using an interpretation of the Atkinson system. In this report biota and substratum are listed in order of dominance as described below:

- Individual plant species are coded using the two first letters of their Latin species and genus names *e.g.* Pldi = *Plagianthus divaricatus* (ribbonwood), Lesi = *Leptocarpus similis* (jointed wire rush).
- _ is used to indicate subdominant species *e.g.* Lesi_Pldi = Pldi is subdominant to Lesi. The classification is based on the subjective observation of which vegetation is the dominant or subdominant species within the patch, and not on percentage cover.
- Shape files in the GIS have been labelled in the same manner as that described above.

Table 1 Classification of estuarine habitat types in Bluff Harbour, April 2004.

Level I Hydrosystem	**Level IA Sub-System**	**Level II Class**	**Level III Structural Class**	**Level IV Dominant Cover**	**Habitat Code**
Estuary (alternating saline and freshwater)	Intertidal/ supratidal	Saltmarsh	Shrub/Scrub/Forest	*Cupressus macrocarpa* "Macrocarpa" *Cytisus scoparius*, "Broom" *Hebe sp.*, "Hebe species" *Lupininus arboreus*,"Tree lupin" Native trees *Plagianthus divaricatus*, "Saltmarsh ribbonwood" *Pteridium esculentum*, "Bracken fern" *Salix fragilis* "Crack willow" *Ulex europaeus*, "Gorse"	Cuma Cysc Hesp Luar Natr Pldi Ptes Safr Uleu
			Estuarine Shrubland	*Plagianthus divaricatus*, "Saltmarsh ribbonwood"	Pldi
			Tussockland	*Carex* spp. "Sedge" *Chionochloa rubra*, "Red Tussock" *Phormium tenax*, "New Zealand flax" *Poa cita*, "Silver tussock"	Casp Chru Phte Poci
			Grassland	*Ammophila arenaria*, "Marram grass' *Festuca arundinacea*, "Tall fescue"	Amar Fear
			Sedgeland	*Isolepis cernua*, "Slender clubrush"	Isce
			Rushland	*Isolepis nodosa*, "Knobby clubrush" *Leptocarpus similis*, "Jointed wirerush"	Isno Lesi
			Herbfield	*Samolus repens*, "Primrose" *Sarcocornia quinqueflora*, "Glasswort" *Selliera radicans*, "Remuremu"	Sare Saqu Sera
			Introduced weeds	Unidentified Introduced Weeds	Inwe
		Seagrass meadow	Seagrass meadow	*Zostera sp*, "Eelgrass"	Zosp
		Macroalgal bed	Macroalgal bed	*Gracilaria chilensis*	Grch
		Artificial Structure	Boulder Field man-made Rock Wall man-made Sand Field man-made Bridge Wharf		BFmm RFmm SFmm BRG WHF
		Mud/sandflat	Firm shell/sand Firm sand Soft sand Mobile sand Firm mud/sand Soft mud/sand Very soft mud/sand		FSS FS SS MS FMS SM VSM
	Subtidal	Boulderfield Rockfield Stonefield Shell bank Water	Boulder field Rockfield Cobble field Gravel field Shell bank Water		BF RF CF GF Shell Water

3.3 Definitions of classification Level III Structural Class

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.

Treeland: Cover of trees in canopy 20-80%. Trees are woody plants >10cm dbh.

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).

Shrubland: Cover of shrubs in canopy 20-80%. Shrubs are woody plants <10 cm diameter at breast height (dbh).

Tussockland: Vegetation in which the cover of tussock in the canopy is 20-100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussock includes all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and >100 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.

Grassland: Vegetation in which the cover of grass in the canopy is 20-100%, and in which the grass cover exceeds that of any other growth form or bare ground. Tussock-grasses are excluded from the grass growth-form.

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 vary 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. Sedges include many species of Carex, Uncinia, and Scirpus. Tussock-sedges and reed-forming sedges (c.f. REEDLAND) 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.

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.

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.

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 occasionally 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.

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 observable without using a microscope.

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

Very soft mud/sand: A mixture of mud and sand, the surface appears brown, and many have 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 or wind-generated 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.

Stone field/Gravel field: 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. Stonefields and gravelfields are named based on which form has the greater ground cover. They are named from the leading plant species when plant cover of ≥ 1%.

Cobble field: Land in which the area of unconsolidated cobbles/stones (20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. Cobble fields are named from the leading plant species when plant cover of ⩾1%.

Boulder field: 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%.

Rock/Rock field: 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%.

Artificial structures: Introduced natural or man-made materials that modify the environment. Includes rip-rap, rock walls, wharf piles, bridge supports, walkways, boat ramps, sand replenishment, groynes, flood control banks, stopgates.

Cockle bed: Area that is dominated by primarily dead cockle shells.

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

Oyster reef: Area that is dominated by one or more oysters species.

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

4. RESULTS

The results of the broad scale survey of intertidal habitat within Bluff Harbour are summarised in Figure 1 and Table 2, with additional detail presented in Tables 3 and 4, and graphically in Figures 2 and 4. Figure 3 provides the legend and species codes for the dominant habitats in Figure 4. In total, 3130 Ha of estuary was mapped (Table 2), including 42 Ha of terrestrial vegetation present around the margins of the estuary. Within the estuary itself, 1432 Ha of intertidal habitat was mapped, along with a large extent of subtidal habitat represented as water (1656 Ha). Intertidal habitat consisted of 1195 Ha of unvegetated substrata (83% of the intertidal area) with only 238 Ha (17%) of the estuary having vegetation as the dominant cover.

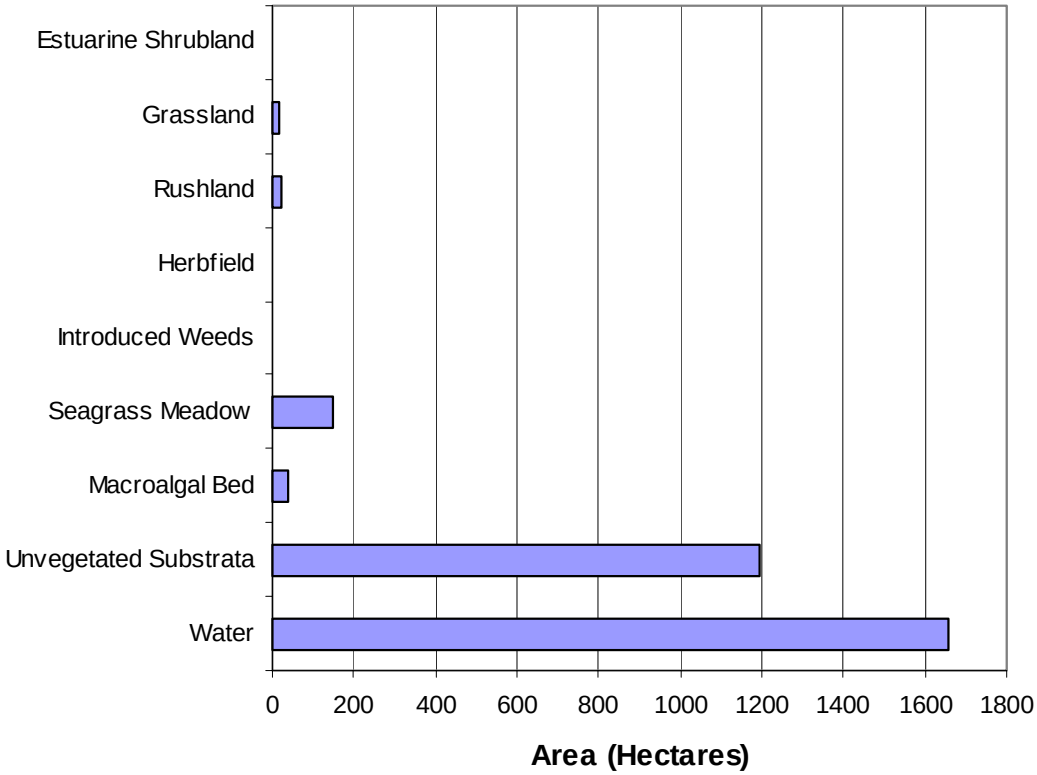

Figure 1 The area of structural class habitats (based on dominant cover) in Bluff Harbour.

Table 2 Area of areas mapped within Bluff Harbour, April 2004.

OVERALL SUMMARY - Bluff Harbour	Area (Ha)	% of Total
Water (subtidal)	1656.1	52.9
Unvegetated Substratum	1194.8	38.2
Estuarine Vegetation	237.6	7.6
Terrestrial Vegetation	41.8	1.3
Grand Total	**3130.2**	

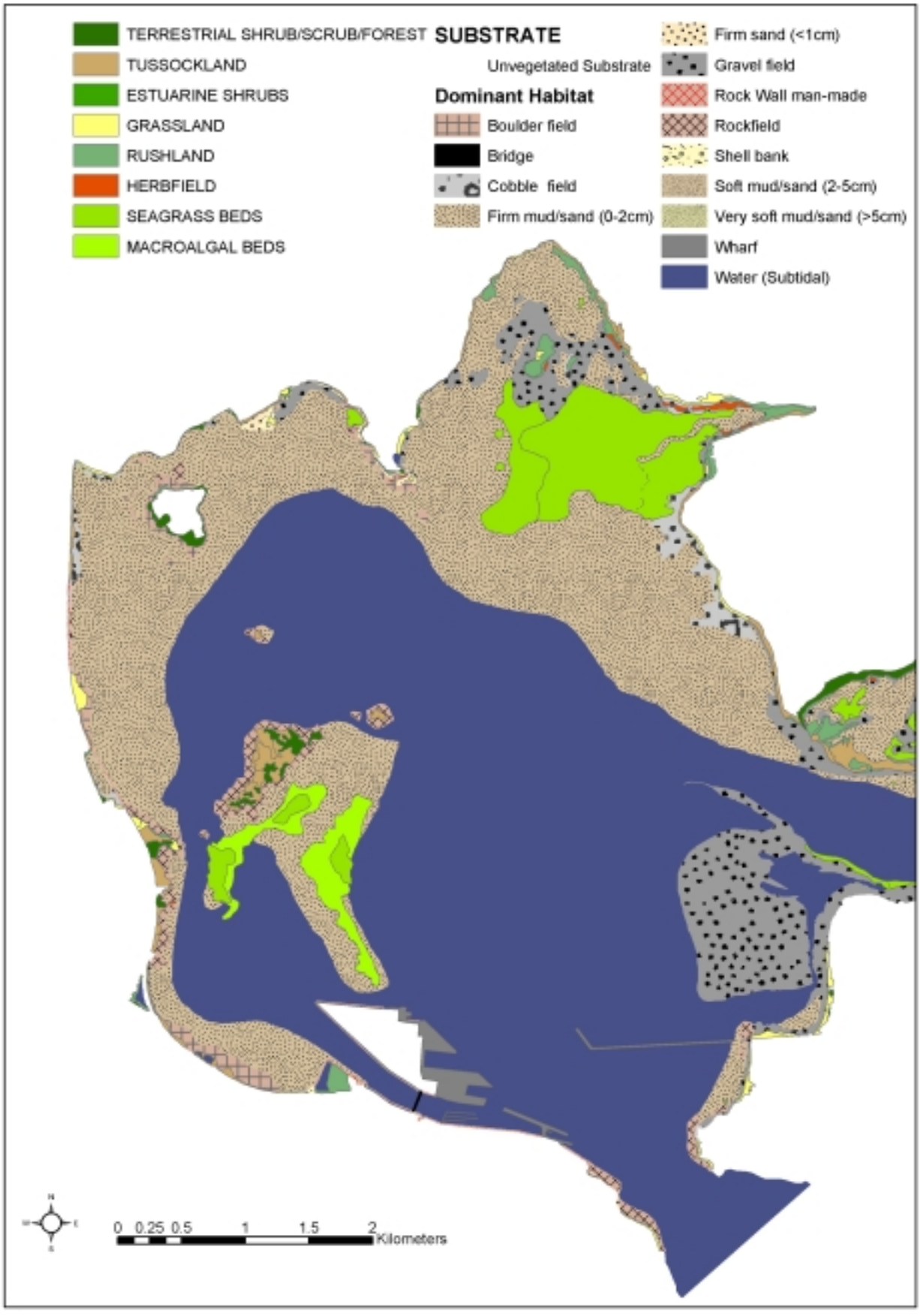

Figure 2 Broad structural habitat of Bluff Harbour, April 2004.

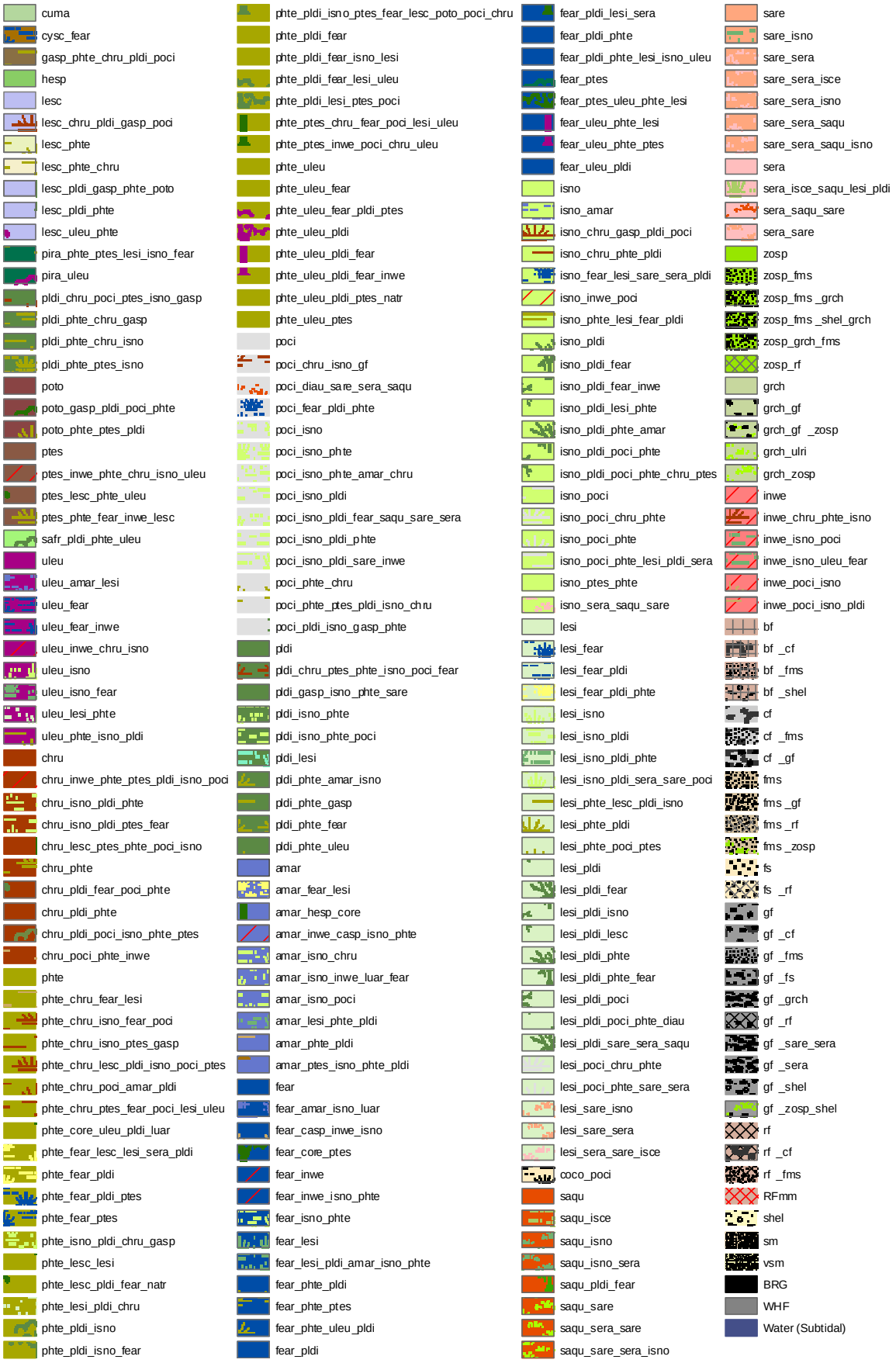

Figure 3 Colour legend and species codes for the habitat and substrate complexes identified in Bluff Harbour (refer to Figure 4).

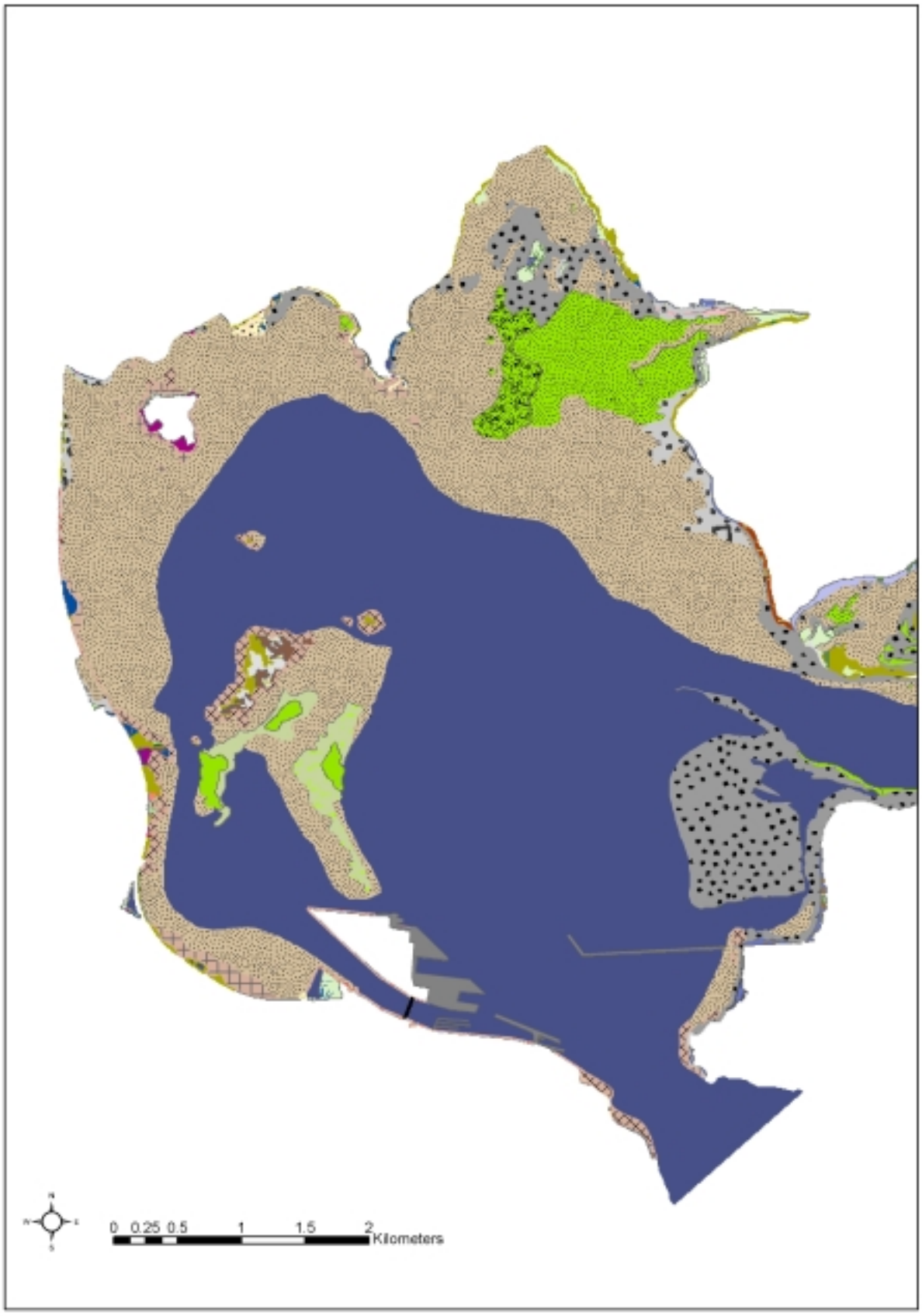

Figure 4 Detail of the dominant habitat cover within the Bluff Harbour, April 2004 (legend in Figure 3).

Within the unvegetated area of Bluff Harbour (Table 3), 869 Ha (73%) was classified as firm muddy sand, with 200 Ha (17%) of gravel field. The remaining areas consisted of a relatively even mix of boulder fields (30 Ha, 2.5%), rock fields (34 Ha, 2.8%), and cobble fields (31 Ha, 2.6%). Artificial substrates (bridges, wharfs, and rockwalls) accounted for 23 Ha (1.9%) of the unvegetated estuary. Rockwalls were common along the western edge of the estuary flanking the railway tracks. Shell bank, soft mud, and very soft mud accounted for the remaining 1%.

Table 3 Areas of dominant unvegetated substrata, and primary subdominant cover in Bluff Harbour, April 2004.

UNVEGETATED SUBSTRATA Class	Dominant substrata	Primary Sub-dominant	Area (Ha)	% of Total
Bridge			**0.33**	**0.03**
Wharf			**19.25**	**1.61**
Rock Wall man-made			**3.01**	**0.25**
Boulder field			**30.06**	**2.52**
	Boulder field		8.28	0.69
		Cobble field	3.43	0.29
		Firm mud/sand (0-2cm)	12.60	1.05
		Shell bank	5.74	0.48
Rock field			**33.68**	**2.82**
	Rockfield		31.42	2.63
		Cobble field	2.13	0.18
		Firm mud/sand (0-2cm)	0.12	0.01
Cobble field			**30.84**	**2.58**
	Cobble field		24.16	2.02
		Firm mud/sand (0-2cm)	0.99	0.08
		Gravel field	5.70	0.48
Gravel field			**200.35**	**16.77**
	Gravel field		64.44	5.39
		Cobble field	5.67	0.47
		Firm mud/sand (0-2cm)	8.54	0.71
		Firm sand (<1cm)	3.31	0.28
		Rockfield	2.02	0.17
		Shell bank	1.71	0.14
		Zostera sp (Eelgrass)	114.65	9.60
Shell bank			**3.63**	**0.30**
Firm sand			**2.68**	**0.22**
	Firm sand (<1cm)		0.94	0.08
		Rockfield	1.74	0.15
Firm mud/sand			**869.43**	**72.77**
			575.64	48.18
		Gravel field	26.27	2.20
		Rockfield	0.55	0.05
		Zostera sp (Eelgrass)	266.97	22.35
Soft mud/sand			**1.26**	**0.11**
Very soft mud/sand			**0.25**	**0.02**
Grand Total			**1194.8**	

Where vegetation was the dominant cover (Table 4), seagrass meadows (*Zostera* – eelgrass) were by far the most dominant, covering 151 Ha (63%) of the vegetated estuary. Beds were present throughout the harbour in lower intertidal areas. Macroalgal beds (*Gracilaria chilensis*) were also present covering 41 Ha (17%) of the intertidal area, located mainly to the south of Tikore Island.

Table 4 Area of dominant estuarine vegetation within Bluff Harbour, April 2004.

ESTUARINE VEGETATION Class	Dominant species	Primary Sub-dominant	Area (Ha)	% of Total
Estuarine Shrubland			**0.38**	**0.16**
	Plagianthus divaricatus (Saltmarsh ribbonwood)		0.17	0.07
		Isolepis nodosa (Knobby clubrush)	0.05	0.02
		Phormium tenax (New Zealand flax)	0.16	0.07
Grassland			**18.84**	**7.93**
	Ammophila arenaria (Marram grass)		1.79	0.75
		Festuca arundinacea (Tall fescue)	2.05	0.86
		Hebe spp. (Hebe species)	0.08	0.03
		Isolepis nodosa (Knobby clubrush)	2.42	1.02
		Leptocarpus similis (Jointed wirerush)	0.18	0.08
		Phormium tenax (New Zealand flax)	0.28	0.12
		Pteridium esculentum (Bracken fern)	2.66	1.12
		Unidentified introduced weeds	0.50	0.21
	Festuca arundinacea (Tall fescue)		0.82	0.35
		Ammophila arenaria (Marram grass)	0.21	0.09
		Coprosma repens (Taupata)	0.38	0.16
		Isolepis nodosa (Knobby clubrush)	0.25	0.10
		Leptocarpus similis (Jointed wirerush)	0.59	0.25
		Phormium tenax (New Zealand flax)	0.76	0.32
		Plagianthus divaricatus (Saltmarsh ribbonwood)	1.50	0.63
		Pteridium esculentum (Bracken fern)	0.41	0.17
		Ulex europaeus (Gorse)	3.02	1.27
		Unidentified introduced weeds	0.93	0.39
Rushland			**22.82**	**9.61**
	Isolepis nodosa (Knobby clubrush)		0.20	0.09
		Phormium tenax (New Zealand flax)	0.25	0.10
		Plagianthus divaricatus (Saltmarsh ribbonwood)	0.08	0.03
		Poa cita (Silver tussock)	0.20	0.08
	Leptocarpus similis (Jointed wirerush)		9.97	4.20
		Festuca arundinacea (Tall fescue)	5.26	2.22
		Isolepis nodosa (Knobby clubrush)	0.95	0.40
		Phormium tenax (New Zealand flax)	0.42	0.18
		Plagianthus divaricatus (Saltmarsh ribbonwood)	4.29	1.81
		Poa cita (Silver tussock)	0.92	0.39
		Samolus repens (Primrose)	0.07	0.03
		Selliera radicans (Remuremu)	0.20	0.08
Herbfield			**3.47**	**1.46**
	Samolus repens (Primrose)	Selliera radicans (Remuremu)	0.16	0.07
	Sarcocornia quinqueflora (Glasswort)	Isolepis nodosa (Knobby clubrush)	0.16	0.07
		Plagianthus divaricatus (Saltmarsh ribbonwood)	0.09	0.04
	Selliera radicans (Remuremu)		3.06	1.29
Introduced Weeds			**0.64**	**0.27**
	Unidentified introduced weeds		0.40	0.17
		Isolepis nodosa (Knobby clubrush)	0.24	0.10
Seagrass Meadow			**150.69**	**63.42**
	Zostera sp (Eelgrass)		16.09	6.77
		Firm mud/sand (0-2cm)	133.26	56.09
		Rockfield	1.35	0.57
Macroalgal Bed			**40.75**	**17.15**
	Gracilaria chilensis (Agar-agar)	(blank)	15.21	6.40
		Zostera sp (Eelgrass)	25.55	10.75
Grand Total			**237.6**	

Rushland species were the next most common habitat, covering 23 Ha. Two species were dominant, *Leptocarpus similis* - Jointed wirerush (22 Ha) and *Isolepis nodosa* - Knobby clubrush (1 Ha). Rushland was located predominantly in the upper tidal reaches of the estuary, and tall fescue (*Festuca arundinacea*) and the estuarine shrub *Plagianthus divaricatus* (Saltmarsh ribbonwood) were the primary subdominant species. Grassland formed quite extensive cover (19 Ha, 8%) dominated by marram grass - *Ammophila arenaria* (10 Ha, 53%) and tall fescue - *Festuca arundinacea* (9 Ha, 47%). Herbfields (3.5 Ha, 1.5%) were dominated by beds of remuremu – (*Selliera radicans*) in upper intertidal areas in the eastern part of the harbour. Tussockland was not recorded as a dominant cover in the estuarine areas.

In addition to the intertidal mapping, 42 Ha of terrestrial vegetation was mapped to indicate the presence of shrub, scrub and forest cover along the riparian margin of the Harbour. However, no consistent boundary has been applied to the mapping of terrestrial areas (*e.g.* catchment boundaries), and mapping has not included other vegetation present such as pasture. Therefore terrestrial estimates shown in Table 5 should not be directly compared to the intertidal mapping results.

Table 5 Areas of dominant terrestrial vegetation mapped adjacent to Bluff Harbour, April 2004.

TERRESTRIAL VEGETATION Class	Dominant species	Primary Sub-dominant	Area (Ha)	% of Total
Terrestrial Shrub/Scrub/Forest			**12.84**	**30.72**
	Cupressus macrocarpa (Macrocarpa)		0.50	1.19
	Cytisus scoparius (Broom)	Festuca arundinacea (Tall fescue)	0.23	0.56
	Hebe spp. (Hebe species)		0.24	0.57
	Pteridium esculentum (Bracken fern)		6.20	14.84
	Salix fragilis (Crack willow)	Plagianthus divaricatus (Saltmarsh ribbonwood)	0.14	0.34
	Ulex europaeus (Gorse)		3.05	7.30
		Ammophila arenaria (Marram grass)	0.28	0.67
		Festuca arundinacea (Tall fescue)	1.48	3.53
		Isolepis nodosa (Knobby clubrush)	0.22	0.52
		Leptocarpus similis (Jointed wirerush)	0.26	0.61
		Phormium tenax (New Zealand flax)	0.25	0.59
Tussockland			**28.96**	**69.28**
	Phormium tenax (New Zealand flax)		5.16	12.34
		Chionochloa rubra (Red Tussock)	0.92	2.20
		Coprosma repens (Taupata)	1.89	4.52
		Festuca arundinacea (Tall fescue)	6.53	15.61
		Leptospermum scoparium (Manuka)	1.51	3.60
		Plagianthus divaricatus (Saltmarsh ribbonwood)	1.29	3.09
		Ulex europaeus (Gorse)	4.56	10.92
	Poa cita (Silver tussock)	Phormium tenax (New Zealand flax)	7.11	17.01
Grand Total			**41.8**	

The mapped terrestrial vegetation was dominated by tussockland species – predominantly flax *Phormium tenax* (21.9 Ha, 52%), silver tussock *Poa cita* (7.1 Ha, 17%), bracken fern *Pteridium esculentum* (6.2 Ha, 15%), and gorse *Ulex europaeus* (5.5 Ha, 13%).

Full details on the vegetation and substrates present, from which the broad scale figures and tables are derived, are included on the accompanying CD-ROM, "*Broad Scale Intertidal Habitat Mapping: Bluff Harbour*".

5. OVERVIEW

The broad scale habitat characterisation of the Bluff Harbour identified the following features:

- A well flushed harbour dominated by firm sand and gravel with very little mud present
- Estuarine vegetation dominated by seagrass and macroalgal beds.
- Extensive modification of the western estuary margin, including the railway embankment and port reclamations, and drainage and bush clearance activities along the northern margin.

6. COMBINED SUMMARY OF BLUFF HARBOUR AND AWARUA BAY

Bluff Harbour and Awarua Bay are two parts of a single harbour system. They have been separated for the purposes of reporting primarily to make data presentation more manageable. However, the two parts of the harbour also have physical differences which may require different management approaches. Broad scale habitat mapping of Awarua Bay was undertaken at the same time as Bluff Harbour (April 2004) and the results are presented in Robertson *et al* (2004c).

Table 6 summarises the combined results for Bluff Harbour and Awarua Bay, and shows the major differences between the two areas. Overall, about 37% of the combined system is subtidal, 41% unvegetated, 17% estuarine vegetation, and 5% terrestrial vegetation. When compared directly to Bluff Harbour, Awarua Bay has approximately three times more estuarine vegetation, a similar amount of unvegetated substratum, and about three times less subtidal habitat. Although the areas of terrestrial vegetation do not provide an accurate indication of cover, Awarua Bay also has much more terrestrial vegetation around the margins than Bluff Harbour.

Table 6 Summary of combined results for Bluff Harbour and Awarua Bay, April 2004.

OVERALL SUMMARY	Bluff Harbour			Awarua Bay			Bluff/Awarua Combined	
	Area		% of combined Bluff/Awarua	Area		% of combined Bluff/Awarua	Area	
	Ha	%		Ha	%		Ha	%
Water (subtidal)	1656.1	52.9	27.1	605.8	20.4	9.9	2261.9	37.1
Unvegetated Substratum	1194.8	38.2	19.6	1333.9	44.9	21.9	2528.7	41.4
Estuarine Vegetation	237.6	7.6	3.9	797.2	26.8	13.1	1034.8	17.0
Terrestrial Vegetation	41.8	1.3	0.7	234.9	7.9	3.8	276.7	4.5
Grand Total	**3130.2**	**100**	**51.3**	**2971.9**	**100**	**48.7**	**6102.1**	**100**

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