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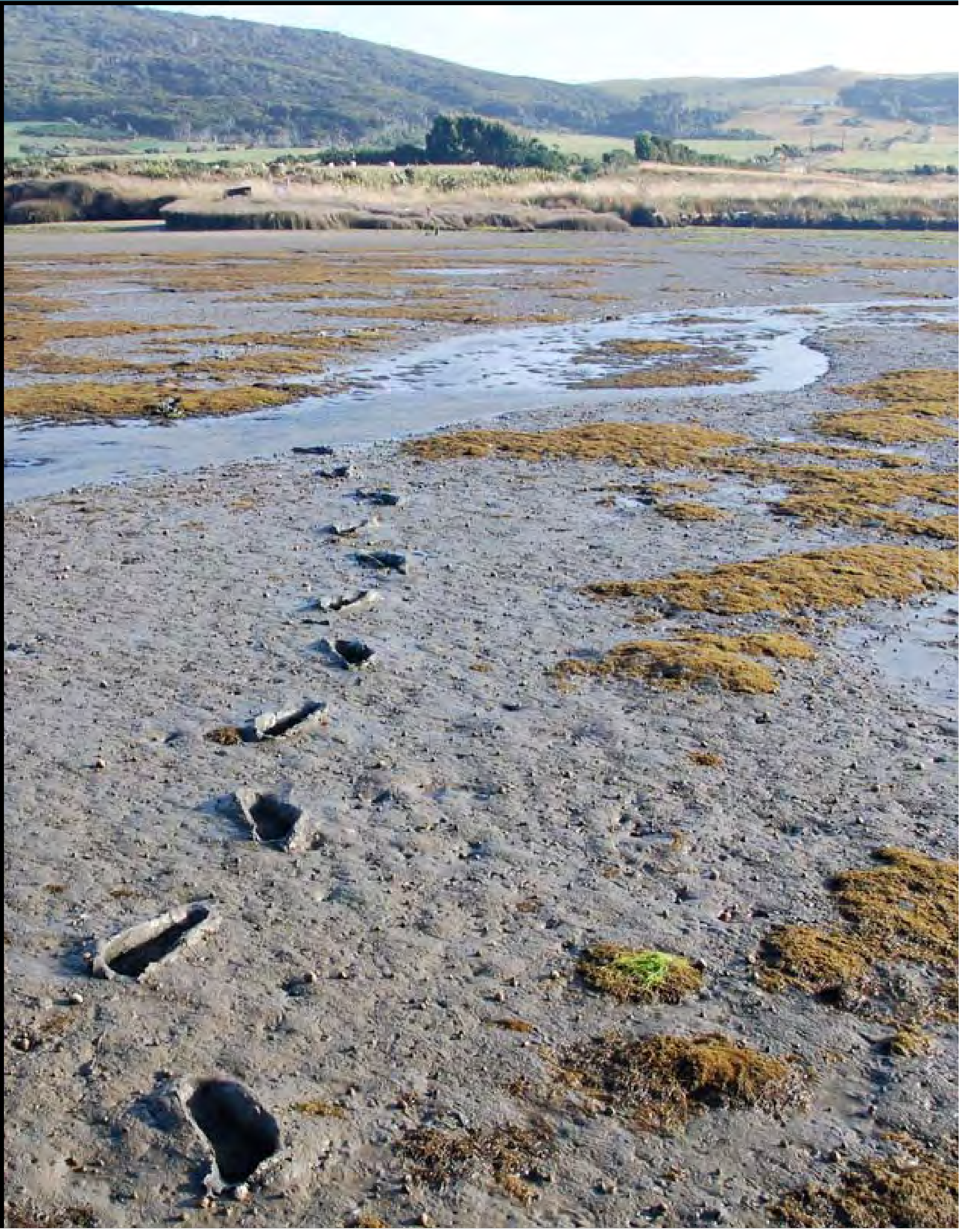
Jacobs River Estuary

Broad Scale Habitat Mapping 2007/08



Prepared for

Environment Southland
September 2008

Cover Photo: Jacobs River Estuary

Jacobs River Estuary

Broad Scale Habitat Mapping 2007/08

Prepared for
Environment Southland

By

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All photos by Wriggle except where noted otherwise.

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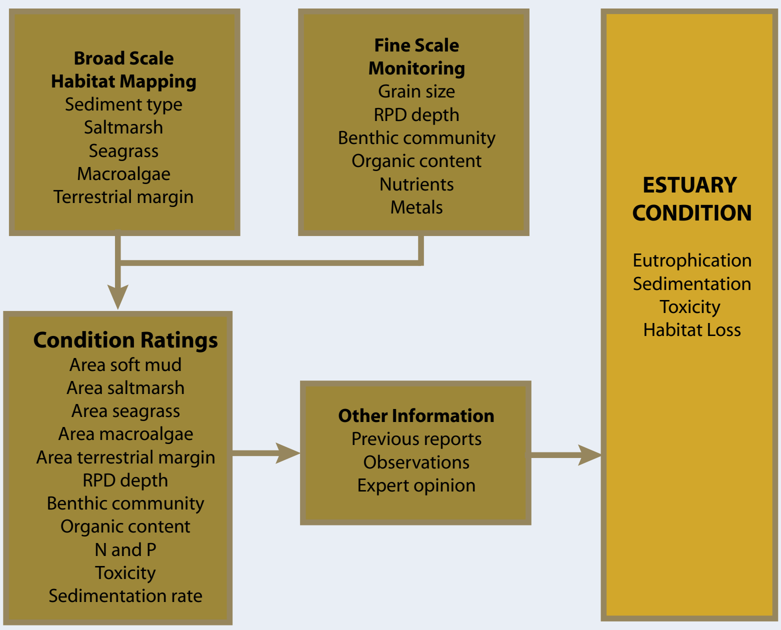
EXECUTIVE SUMMARY

In the 1990's, Environment Southland (ES) established a long-term monitoring programme to assess the condition of key estuaries in its region. Estuaries monitored to date include Jacobs River, Bluff Harbour and Awarua Bay, Toetoes (Fortrose) Harbour, and Haldane, Waikawa, Waiau, and Freshwater Estuaries. In 2008, ES contracted Wriggle Coastal Management to undertake broad scale mapping of Jacobs River Estuary.

The current report describes the broad scale habitat mapping undertaken in February 2008. Broad scale habitat mapping is a tool used to assess the condition of estuaries. It includes mapping and condition ratings for key habitat elements including: estuary sediment types, macroalgal beds (i.e. *Ulva* (sea lettuce), *Gracilaria, Enteromorpha*), macrophytes (e.g. *Zostera* - seagrass), saltmarsh vegetation, and the 200m terrestrial margin surrounding the estuary. The methods used were based on the tools included in the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002), and a number of extensions (Table 1).

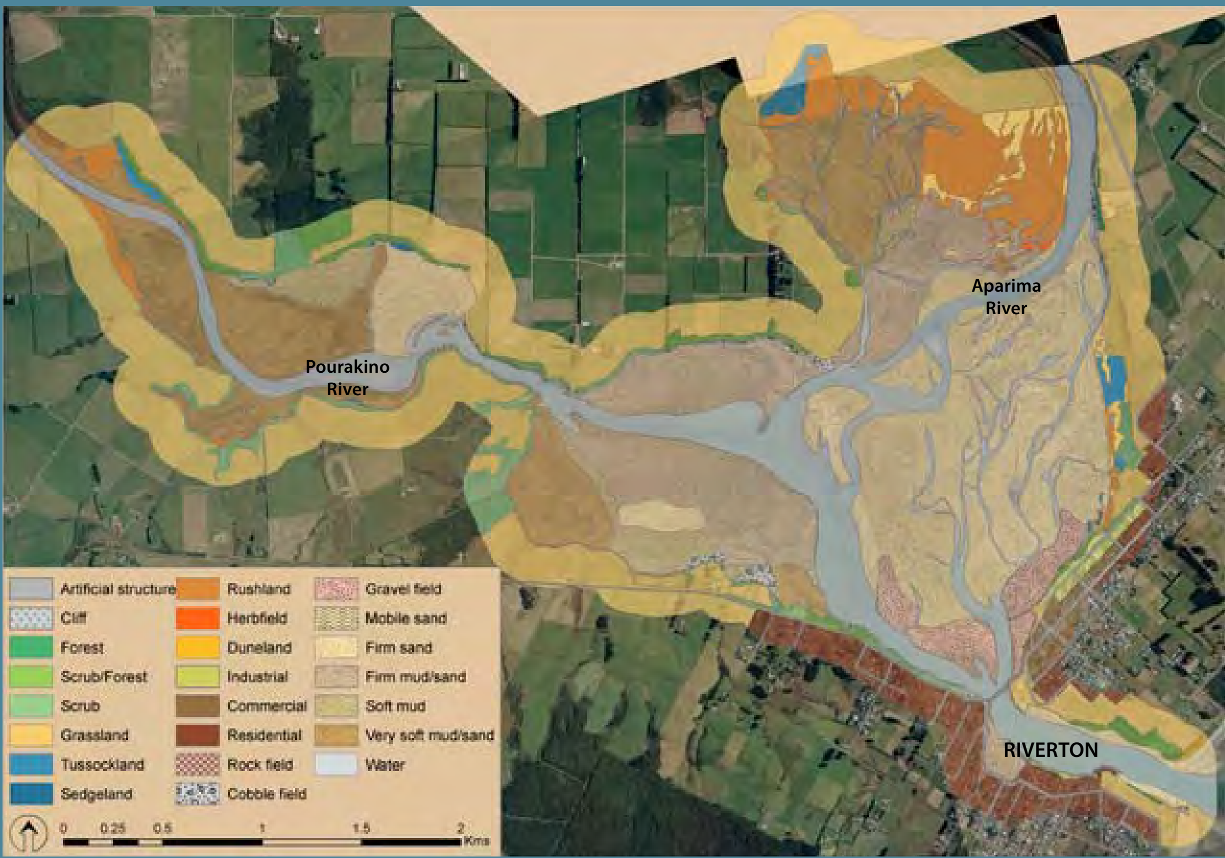
The outcome is a series of GIS-based habitat maps (often complex), that provide measures of the extent of different types of habitat cover. Taken in combination with fine scale physical, chemical and biological monitoring results, these measures are applied into different rating scales which are used alongside other relevant expert information to assess the condition of the estuary in relation to the key issues of sedimentation, eutrophication and habitat loss. Toxicity is addressed as part of fine scale monitoring, while disease risk is monitored and reported separately, principally through recreational water quality monitoring programmes. A summary of the approach is outlined in the figure below.



A broad scale summary map is presented on the next page (much reduced but included as a reminder of the more user-friendly GIS-based maps that accompany this report).

EXECUTIVE SUMMARY (CONTINUED)

Summary of the broad scale features of Jacobs River Estuary, February 2008.



BROAD SCALE RESULTS

The broad scale monitoring of Jacobs River showed that 79% of the estuary is exposed at low tide, with the intertidal zone predominantly unvegetated sand and mud - 60% firm sand and firm mud/sand located mainly in the lower estuary; and 33% soft and very soft mud primarily in the upper reaches of both arms.

Within the estuary, resuspension of sediment is expected to be significant due to the large wind fetch and shallow nature of the estuary. This is likely to push sediment (and macroalgae) into localised areas where prevailing wind and waves deposit it on shorelines and in sheltered arms. As a result, such areas will tend towards having muddy, anoxic, black sulphide-rich sediments, low dissolved oxygen and low clarity - conditions that may promote undesirable algal growth.

Macroalgal growth was widespread and present in very high densities in localised areas, particularly in the upper estuary where *Gracilaria* covered much of the surface, and underlying sediments were commonly very soft, anaerobic, and sulphide rich with the Redox Potential Discontinuity (RPD) layer close to the surface (~1cm).

Seagrass (*Zostera*) beds were not widespread, located in firm sands in the southeast of the estuary (20-50% cover), in smaller areas (50-100% cover) in very soft muds on the southern side of the Pourakino Arm, and immediately north of the confluence between the Pourakino and Aparima rivers. In many cases, beds were covered in windblown macroalgae.

EXECUTIVE SUMMARY (CONTINUED)

Saltmarsh vegetation was generally limited to a narrow strip around the estuary, with the most extensive areas located in the northern Aparima Arm where wide beds of rushland extended out over large intertidal flats, and in the upper Pourakino Arm and to the southeast of the estuary.

The dominant terrestrial margin habitats bordering the estuary (a 200m wide margin was mapped) were grassland (69%) - primarily dairy grazing, and the urban features of Riverton (14%). Much of the estuary edge around Riverton featured reclaimed shorelines and artificial structures (e.g. rockwalls, wharfs). Most of the remaining area was scrub (6%) or scrub/forest (4%), dominated by exotic species e.g. gorse, pine, macrocarpa, and common weeds e.g. blackberry, broom.

The intertidal broad scale mapping data were used to determine condition ratings for key broad scale indicators. The results were as follows.

BROAD SCALE CONDITION RATINGS

BROAD SCALE RATING 2008	% COVER INTERTIDAL SOFT MUD	% COVER INTERTIDAL MACROALGAE	% COVER SEAGRASS	% COVER SALTMARSH	TERRESTRIAL VEGETATED BUFFER
JACOBS RIVER ESTUARY	POOR	FAIR	FAIR	MODERATE/HIGH	POOR

ESTUARY ISSUES

The intertidal results, in combination with other available information, are used in the following subsections to provide an overview of likely estuary condition in relation to the key issues examined in this broad scale assessment, namely sedimentation, eutrophication and habitat loss.

SEDIMENTATION: The lower estuary was predominantly sandy, well flushed and in good condition. However, the upper estuary near the Aparima and Pourakino Rivers was dominated by deep soft muds. Such conditions reduce biodiversity and human values and uses. Further, the muddy, anoxic, black sulphide-rich sediments, low dissolved oxygen and low clarity conditions present will be stressing aquatic macrophytes, promoting undesirable growths of macroalgae and creating unfavourable conditions for sediment dwelling animals.

EUTROPHICATION: Nuisance macroalgae were present throughout the estuary, with large areas of the upper estuary covered in a thick layer of macroalgae resulting in eutrophic conditions, with the RPD very close to the surface and a high degree of sediment enrichment evident. There was a large increase in the extent of macroalgal cover from 2007 to 2008.

HABITAT LOSS: There has been extensive saltmarsh and margin habitat loss from past human activities e.g. forest clearance, reclamations, seawalls, grazing, drainage, and erosion protection. The vegetated terrestrial buffer is now dominated by grassland which has greatly reduced the buffering function provided by the previously bush-covered margin, and has almost certainly contributed to reduced biodiversity and increased sedimentation in the estuary.

EXECUTIVE SUMMARY (CONTINUED)

MONITORING

Jacobs River Estuary has been identified by ES as a priority for monitoring, and is a key part of ES's existing estuary monitoring programme being undertaken in a staged manner throughout Southland. Based on existing monitoring results, it is recommended that monitoring continue as outlined below:

Fine Scale Monitoring	Repeat fine scale monitoring on a five yearly cycle (next scheduled for 2011) and as deemed necessary thereafter based on the condition ratings. Due to the extreme eutrophication apparent in the northern Aparima Arm, a new upper estuary fine scale site should be established in this area.
Broad Scale Macroalgal Mapping	Map macroalgal cover in January-March 2009. After this, schedule monitoring as deemed necessary based on the condition ratings.
Broad Scale Sedimentation Rate Mapping	Install sediment plates in representative parts of the estuary (e.g. one in each upper Arm and one in the central basin) in January-March 2009. Monitor annually thereafter.
Broad Scale Habitat Mapping	Repeat broad scale habitat mapping at five yearly intervals (next scheduled for 2013) and then as deemed necessary based on the condition ratings.

The ongoing monitoring will provide a robust framework for identifying, evaluating and providing management options for any significant issues within Jacobs River Estuary.

RECOMMENDED MANAGEMENT

The following management actions are encouraged:

Monitor Key Stressors

- Monitor changes in catchment land use with any changes in the key stressors triggering an evaluation of the likely impact on the estuary.

Identify and Implement Catchment BMPs

- Catchment runoff is one of the major stressors in estuaries with the likely ecological response one of lowered biodiversity and lowered aesthetic and human use values. To prevent avoidable inputs, best management practices (BMPs) should be identified and implemented to reduce sediment, nutrient, and pathogen runoff from catchment "hotspots".

Restore Saltmarsh Habitat

- The reduction in saltmarsh habitat as a result of drainage and reclamation has certainly contributed to reduced biodiversity and increased sedimentation of the estuary, while also lowering aesthetic and human use values. It has also allowed weeds and grass to establish to the estuary edge. Because of the importance of saltmarsh, it is recommended that a plan be developed to encourage its re-establishment, and to support community restoration initiatives.

Reinstate Margin Buffer

- Human development of the estuary margin has resulted in clearance of surrounding bush and almost certainly contributed to reduced biodiversity and increased estuary sedimentation. Many areas are also adversely affected by nuisance weeds. Because of the importance of a natural vegetated margin around the estuary, it is recommended that a strategy be developed to encourage its re-establishment where possible.

Coastal Squeeze

- Sea level rise is a key estuary stressor. The ability of estuary vegetation to respond to sea level rise relies to a large extent on saltmarsh and terrestrial margin vegetation being able to migrate landward to maintain suitable growing conditions. Areas where coastal squeeze is likely to occur should be identified and used to guide future revegetation efforts, and to identify where conflict may occur between existing uses and estuary expansion as a consequence of sea level rise.

1. INTRODUCTION

OVERVIEW

Developing an understanding of the condition and risks to estuarine habitats is critical to the management of biological resources. In the 1990's, Environment Southland (ES) established a long-term monitoring programme to assess the condition of key estuaries in its region. Those monitored to date include Jacobs River, New River, Haldane, Waikawa, and Freshwater Estuaries, and Toetoes (Fortrose) Harbour, Bluff Harbour and Awarua Bay (see references). Jacobs River Estuary was broad scale mapped in 2003, with fine scale monitoring undertaken in 2003, 2004, 2005 and 2006. Results for Jacobs River, along with other key estuaries in the ES monitoring programme, have been presented in a series of separate reports (e.g. Robertson et al. 2002, 2003, 2004, Stevens & Asher 2005, Robertson & Asher 2003, 2006, Robertson & Stevens, 2006). In 2008, Wriggle Coastal Management were contracted to undertake broad scale habitat mapping of Jacobs River Estuary using the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002) plus recent extensions (see Table 1 and Table 3).

The estuary monitoring programme consists of three components:

1. **Ecological Vulnerability Assessment** of the estuary to major issues (see Table 2) and appropriate monitoring design. A high level overview has been completed as part of a recent wider coastal assessment (see Robertson and Stevens 2008).
2. **Broad scale habitat mapping,** (EMP approach). This component, which documents the key habitats within the estuary, and changes to these habitats over time, is the subject of the current report.
3. **Fine scale physical, chemical and biological monitoring**, (EMP approach) including sedimentation plate deployment. This component provides detailed information on estuary condition (past monitoring is summarised in Robertson and Stevens 2006).

This report documents the results of the broad scale monitoring undertaken in February 2008 of Jacobs River Estuary. It includes:

- Broad scale mapping of intertidal sediment types.
- Broad scale mapping of macroalgal beds (i.e. *Ulva* (sea lettuce), *Gracilaria, Enteromorpha*).
- Broad scale mapping of seagrass beds (i.e. *Zostera muelleri*).
- Broad scale mapping of saltmarsh vegetation.
- Broad scale mapping of the 200m terrestrial margin surrounding the estuary.
- Condition ratings for the Jacobs River Estuary (based on Robertson & Stevens, 2006, 2007). A suggested monitoring or management response is linked to each condition rating.

REPORT STRUCTURE

The report is structured as follows:

Section 1 Introduction to the scope and structure of the study.
Section 2 Methods - broad scale mapping and estuary condition ratings.
Section 3 Results and Discussion.
Section 4 Changes in the Estuary: 2003-2008.
Section 5 Conclusions.
Section 6 Monitoring.
Section 7 Recommended Management.
Section 8 Acknowledgements.
Section 9 References.
Appendix 1 Substrate and vegetation classification.

This report characterises the baseline conditions of the estuary, providing detailed information on key broad scale indicators of sedimentation, eutrophication and habitat loss (Table 3). The results will help determine the extent to which the estuary is affected by major estuary issues (Table 2), both in the short and long term.

1. INTRODUCTION (CONTINUED)

Table 1. Coastal Monitoring Tools (Wriggle Coastal Management).

Resource	Tools for Monitoring and Management
Estuaries	Estuary vulnerability matrix. Broad scale estuary and 200m terrestrial margin habitat mapping. Fine scale estuary monitoring. Sedimentation rate measures (using plates buried in sediment). Historical sedimentation rates (using radio-isotope ageing of sediment cores). Macroalgae and seagrass mapping (reported as separate GIS layers). Condition ratings for key indicators. Georeferenced digital photos (as a GIS layer). Upper estuary monitoring and assessment.
Beaches, Dunes	Beach and dune vulnerability matrix. Broad scale beach, dune and terrestrial margin mapping. Fine scale beach monitoring. Condition ratings for key indicators. Georeferenced digital photos (as a GIS layer).
Rocky Shores	Rocky shore vulnerability matrix. Broad scale rocky shore and terrestrial margin mapping. Fine scale rocky shore monitoring. Georeferenced digital photos (as a GIS layer).

Table 2. Summary of the major issues affecting most NZ river mouth estuaries.

Key Estuary Issues	
Sedimentation	Because estuaries are a sink for sediments, their natural cycle is to slowly infill with fine muds and clays. Prior to European settlement they were dominated by sandy sediments and had low sedimentation rates (<1 mm/year). In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, New Zealand's estuaries have begun to infill rapidly. Today, average sedimentation rates in our estuaries are typically 10 times or more higher than before humans arrived.
Nutrients	Increased nutrient richness of estuarine ecosystems stimulates the production and abundance of fast-growing algae, such as phytoplankton, and short-lived macroalgae (e.g. sea lettuce). Fortunately, because most New Zealand estuaries are well flushed, phytoplankton blooms are generally not a major problem. Of greater concern is the mass blooms of green and red macroalgae, mainly of the genera *Enteromorpha, Cladophora, Ulva,* and *Gracilaria* which are now widespread on intertidal flats and shallow subtidal areas of nutrient-enriched New Zealand estuaries. They present a significant nuisance problem, especially when loose mats accumulate on shorelines and decompose. Blooms also have major ecological impacts on water and sediment quality and the animals that live there.
Disease Risk	Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the estuarine environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks posed to humans through recreational contact and shellfish consumption, pathogen contamination can also cause economic losses due to closed commercial shellfish beds. Diseases linked to pathogens include gastroenteritis, salmonellosis, and hepatitis A.
Toxic Contamination	In the last 60 years, New Zealand has seen a huge range of synthetic chemicals introduced to estuaries through urban and agricultural stormwater runoff, industrial discharges and air pollution. Many of them are toxic in minute concentrations. Of particular concern are polycyclic aromatic hydrocarbons (PAHs), toxic heavy metals, polychlorinated biphenyls (PCBs), and pesticides. These chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to people and marine life.
Habitat Loss	Estuaries have many different types of habitats including shellfish beds, seagrass meadows, saltmarshes (rushlands, herbfields, reedlands etc.), forested wetlands, beaches, river deltas, and rocky shores. The continued health and biodiversity of estuarine systems depends on the maintenance of high-quality habitat. Loss of habitat negatively affects fisheries, animal populations, filtering of water pollutants, and the ability of shorelines to resist storm-related erosion. Within New Zealand, habitat degradation or loss is common-place with the major causes cited as sea level rise, population pressures on margins, dredging, drainage, reclamation, pest and weed invasion, reduced flows (damming and irrigation), over-fishing, polluted runoff and wastewater discharges.

1. INTRODUCTION (CONTINUED)

Table 3. Summary of the broad and fine scale EMP indicators.

Issue	Indicator	Method
Sedimentation	Soft Mud Area	Broad scale mapping - estimates the area and change in soft mud habitat over time.
Sedimentation	Sedimentation Rate	Fine scale measurement of sediment deposition.
Eutrophication	Nuisance Macroalgal Cover	Broad scale mapping - estimates the change in the area of nuisance macroalgal growth (e.g. sea lettuce (*Ulva*), *Gracilaria* and *Enteromorpha*) over time.
Eutrophication	Organic and Nutrient Enrichment	Chemical analysis of total nitrogen, total phosphorus, and total organic carbon (calculated from ash free dry weight) in replicate samples from the upper 2cm of sediment.
Eutrophication	Redox Profile	Measurement of depth of redox potential discontinuity profile (RPD) in sediment estimates likely presence of deoxygenated, reducing conditions.
Toxins	Contamination in Bottom Sediments	Chemical analysis of indicator metals (total recoverable cadmium, chromium, copper, nickel, lead and zinc) in replicate samples from the upper 2cm of sediment.
Toxins, Eutrophication, Sedimentation	Biodiversity of Bottom Dwelling Animals	Type and number of animals living in the upper 15cm of sediments (infauna in 0.0133m^2 replicate cores), and on the sediment surface (epifauna in 0.25m^2 replicate quadrats).
Habitat Loss	Saltmarsh Area	Broad scale mapping - estimates the area and change in saltmarsh habitat over time.
Habitat Loss	Seagrass Area	Broad scale mapping - estimates the area and change in seagrass habitat over time.
Habitat Loss	Vegetated Terrestrial Buffer	Broad scale mapping - estimates the area and change in buffer habitat over time.

BACKGROUND TO TIDAL LAGOON ESTUARIES

Jacobs River Estuary - Photo Environment Southland, 2008

Most of the large Southland estuaries (e.g. Jacobs River, New River, Waikawa) fit the "tidal lagoon estuary" category. These estuaries are shallow, with large basins and simple shorelines with extensive tidal flats. They generally have a narrow entrance to the sea that is often constricted by a sand bar. Most of the estuary water volume in tidal lagoon estuaries is drained each tidal cycle and hence they have low water residence times (often <3 days) and good flushing.

The volume of river water inflow is generally small in comparison to marine inputs. Wind has a large influence and affects currents, mixing, and sediment resuspension. The combination of wave resuspension and good flushing means that the majority of sediments tend to be sandy and homogeneous. However, muddy sediments can be present near freshwater inputs and in sheltered arms. Tidal lagoon estuaries are also well-mixed and salinity is close to that of the sea. The coastal plumes from such estuaries are generally much cleaner than from tidal river lagoons. Biodiversity is generally high.

1. INTRODUCTION (CONTINUED)

JACOBS RIVER ESTUARY

Source: Robertson and Stevens (2008)

Estuary Type/Area	Tidal Lagoon
Catchment	1527 km^2
Dairy cows	64,611 cows
Nitrogen loading	Low-Mod: 7 kg/ha/yr
Catchment geology	Gravel, sandstone/siltstone, igneous
Saltmarsh (ha)	70 ha primarily *Leptocarpus*
Salinity	Well mixed, sea water dominated
Mean depth (m)	1-2m
Tidal flats	High
Uses/Values	Walking, shellfish collection, birds, scenic, fishing, duckshooting, whitebaiting, bathing.

Jacobs River Estuary - whitebait stands and macroalgal blooms in Aparima Arm.

Human Use		Moderate
Ecological Value		Moderate
Existing Condition		Fair
Susceptibility		Moderate
Stressors		Moderate
OVERALL VULNERABILITY		Moderate

Jacobs River Estuary is a medium-sized "tidal lagoon" type estuary (area 725 ha), that discharges to Oreti Beach at Riverton (details in Robertson and Stevens 2008). Situated at the confluence of the Pourakino and Aparima Rivers, it drains a primarily agricultural catchment. The estuary is triangular shaped and relatively shallow (mean depth approximately 2m) and bordered by a mix of vegetation and landuses (urban and grazed pasture). The estuary has extensive mudflats (79% of estuary exposed at low tide), seagrass and saltmarsh areas. The township of Riverton, its fishing wharves, and a road bridge are located near the mouth. This estuary is regularly monitored by Environment Southland, including testing of bathing water quality and shellfish health. Nuisance blooms of macroalgae (*Enteromorpha* and *Gracilaria*) are common within the estuary.

Uses and Values. Human use of the estuary is moderate, mainly for walking, shellfish collection, bird study, scenic, fishing, duckshooting, whitebaiting, and bathing.

Ecological Values. Ecologically, habitat diversity is moderate, given benefits of tidal flats and saltmarsh and detriments of historical drainage, extensive weed growth, grazing of margins, and eutrophication. Such conditions provide moderate habitat for native fish, birdlife and tidal flat organisms.

Existing Condition. Water quality is moderately degraded (low clarity, elevated faecal coliforms, elevated nutrients), particularly in high river flows. Nuisance macroalgal blooms are common and the water often has a greenish tinge. Sediment type is mixed with areas of firm muddy sands and soft and very soft muds - often poor in oxygen with elevated sulphide concentrations. Several very eutrophic arms tend to collect organic matter. Metal concentrations are low. Estimated nitrogen (the major driver of eutrophication) loadings are moderate.

Presence of Stressors. The presence of stressors is expected to be "moderate". Landuse intensification, absence of natural vegetated margins, grazed margins and weed and pest invasions are the main threats.

Susceptibility to Stressors. Susceptibility to stressors is expected to be moderate given that the estuary is well flushed (low residence time), and already modified.

Issues	Monitoring	Management
• Algal blooms, eutrophic arms. • Grazing near margin. • Developed margin. • Elevated pathogens under high flow.	• Map intensive landuse every 5 years. • Habitat map estuary every 5 years. • Fine scale phys/chem/biota monitoring 5 yearly (after baseline established).	• Limit intensive landuse development. • Low impact point source discharges only. • Encourage margin vegetation enhancement. • Plan for estuary expansion with sea level rise.

Jacobs River Estuary	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Fair	Fair	Good	Very Good	Fair	Good	Good
Susceptibility Rating	Low	Moderate	Low	Very Low	Low	Low	Very Low
Vulnerability Rating	Moderate	Moderate	Low	Very Low	Moderate	Low	Very Low

2. METHODS

BROAD SCALE HABITAT MAPPING

>1 %
1-5%
5-10 %
10-20 %
20-50 %
50-80 %
80-100 %

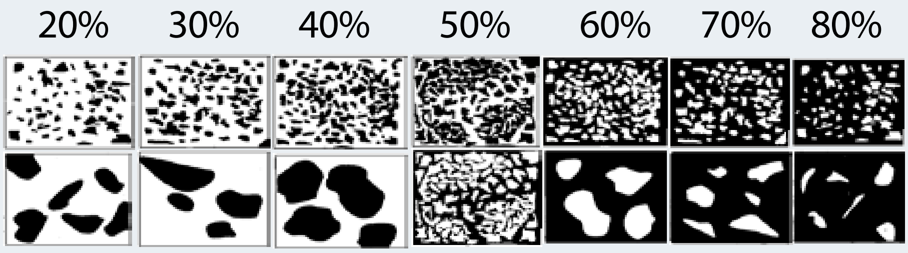
Broad-scale mapping is a method for describing habitat types based on the dominant surface features present (e.g. substrate: mud, sand, cobble, rock; or vegetation: macrophyte, macroalgae, rushland, etc). It follows the EMP approach originally described for use in NZ estuaries by Robertson et al. (2002) with a combination of aerial photography, detailed ground-truthing, and GIS-based digital mapping used to record the primary habitat features present. Very simply, the method involves three key steps:

- Obtaining laminated aerial photos for recording dominant habitat features.
- Carrying out field identification and mapping (i.e. ground-truthing).
- Digitising the field data into GIS layers (ArcMap 9.2).

For the 2008 study, ES supplied rectified ~0.3m/pixel resolution colour aerial photos. Photos covering the estuary at a scale of 1:5,000 were laminated, and two scientists ground-truthed the spatial extent of dominant habitat and substrate types by walking the extent of the estuary recording features directly on the laminated aerial photos over two days in February 2008.

Classification of macroalgae and macrophyte percentage cover within the estuary was assessed using a seven category visual rating scale (see examples below and left). The results are used to describe macroalgae and macrophyte density and distribution within the estuary.

Visual rating scale for percentage cover estimates



Sampling positions and photographs were georeferenced and the information collected was used to produce GIS-based habitat maps showing the following:

- Dominant substrate.
- Percent cover of dominant intertidal macroalgae (e.g. *Gracilaria, Enteromorpha*).
- Percent cover of intertidal macrophytes (*Zostera*).
- Dominant saltmarsh vegetation.
- 200m wide terrestrial margin vegetation/landuse.

Appendix 1 lists the class definitions used to classify substrate and vegetation. Vegetation was further classified using an interpretation of the Atkinson (1985) system, whereby dominant plant species were coded by using the two first letters of their Latin genus and species names e.g. marram grass, *Ammophila arenaria*, was coded as Amar. An indication of dominance is provided by the use of ( ) to distinguish subdominant species e.g. Amar(Caed) indicates that marram grass was dominant over ice plant (*Carpobrotus edulis*). The use of ( ) is not always based on percentage cover, but the subjective observation of which vegetation is the dominant or subdominant species within the patch. A measure of vegetation height can be derived from its structural class (e.g. rushland, scrub, forest).

2. METHODS (CONTINUED)

BROAD SCALE HABITAT MAPPING (CONTINUED)

Digital mapping

Results were entered by digitising features directly off aerial photos in the GIS using a Wacom Intuos3 electronic drawing tablet within ArcMap 9.2.

The spatial location, size, and type of broad scale habitat features in the estuary are provided as ArcMap 9.2 GIS shapefiles on a separate CD. Georeferenced digital field photos (GPS-Photolink) are also supplied as a GIS layer.

The broad scale results are summarised in the current report in Section 3, with the supporting GIS files providing much more detail in a data set designed for easy interrogation to address specific monitoring and management questions.

CONDITION RATINGS

At present, there are no formal criteria for rating the overall condition of estuaries in NZ. Therefore, to help ES interpret monitoring data, a series of interim broad scale estuary "condition ratings" (presented below) have been proposed for Jacobs River Estuary (based on the ratings developed for New Zealand estuaries - Robertson & Stevens 2006, 2007, 2008a). The condition ratings are designed to be used in combination with each other (usually involving expert input) when evaluating overall estuary condition and deciding on appropriate management responses.

The ratings are based on a review of monitoring data, use of existing guideline criteria, and expert opinion. They indicate whether monitoring results reflect good or degraded conditions, and also include an "early warning trigger" so that ES is alerted where rapid or unexpected change occurs. For each of the condition ratings, a recommended monitoring frequency is proposed and a recommended management response is suggested.

In most cases the management recommendation is simply that ES develop an Evaluation and Response Plan (ERP) to further assess an issue and consider what response actions may be appropriate. It is expected that the proposed ratings will continue to be revised and updated as better information becomes available, and as new ratings are developed for other indicators.

SOFT MUD PERCENT COVER

Estuaries are a sink for sediments. Where large areas of soft mud are present, they are likely to lead to major and detrimental ecological changes that could be very difficult to reverse, and indicate where changes in land use management may be needed.

SOFT MUD PERCENT COVER CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<2% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Good	2%-5% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Fair	5%-15% of estuary substrate is soft mud	Post baseline, monitor 5 yearly. Initiate ERP
Poor	>15% of estuary substrate is soft mud	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	>5% of estuary substrate is soft mud	Initiate ERP (Evaluation and Response Plan)

2. METHODS (CONTINUED)

SOFT MUD AREA

Soft mud in estuaries decreases water clarity, lowers biodiversity and affects aesthetics and access. Increases in the area of soft mud indicate where changes in catchment land use management may be needed.

SOFT MUD AREA CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Area of cover (ha) not increasing	Monitor at 5 year intervals after baseline established
Good	Increase in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Increase in area of cover (ha) 5-15% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Poor	Increase in area of cover (ha) >15% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	Trend of increase in area of cover (ha)	Initiate ERP (Evaluation and Response Plan)

MACROALGAE INDEX

Certain types of macroalgae can grow to nuisance levels in nutrient-enriched estuaries causing sediment deterioration, oxygen depletion, bad odours and adverse impacts to biota. A continuous index (the macroalgae coefficient - MC) has been developed to rate macroalgal condition based on the percentage cover of macroalgae in defined categories using the following equation: ***MC=((0 x %macroalgal cover <1%)+(0.5 x %cover 1-5%)+(1 x %cover 5-10%)+(3 x %cover 10-20%)+(4.5 x %cover 20-50%)+(6 x %cover 50-80%)+(7.5 x %cover >80%))/100.*** Overriding the MC is the presence of either nuisance conditions within the estuary, or where >5% of the intertidal area has macroalgal cover >50%. In these situations the estuary is given a minimum rating of FAIR and should be monitored annually with an Evaluation & Response Plan initiated.

MACROALGAE CONDITION RATING

RATING	DEFINITION (+Macroalgae Coefficient)	RECOMMENDED RESPONSE
Over-riding rating: Fair	Nuisance conditions exist, or >50% cover over >5% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
Very Good	Very Low (0.0 - 0.2)	Monitor at 5 year intervals after baseline established
Good	Low (0.2 - 0.8)	Monitor at 5 year intervals after baseline established
	Low Low-Moderate (0.8 - 1.5)	Monitor at 5 year intervals after baseline established
Fair	Low-Moderate (1.5 - 2.2)	Monitor yearly. Initiate ERP
	Moderate (2.2 - 4.5)	Monitor yearly. Initiate ERP
Poor	High (4.5 - 7.0)	Monitor yearly. Initiate ERP
	Very High (>7.0)	Monitor yearly. Initiate ERP
Early Warning Trigger	Trend of increasing Macroalgae Coefficient	Initiate ERP (Evaluation and Response Plan)

SEAGRASS INDEX

Seagrass (*Zostera muelleri*) grows in soft sediments in NZ estuaries where its presence enhances estuary biodiversity. Though tolerant of a wide range of conditions, it is vulnerable to fine sediments in the water column and sediment quality (particularly if there is a lack of oxygen and production of sulphide). A continuous index (the seagrass coefficient - SC) has been developed to rate seagrass condition based on the percentage cover of seagrass in defined categories using the following equation: ***SC=((0 x %seagrass cover <1%)+(0.5 x %cover 1-5%)+(2 x %cover 5-10%)+(3.5 x %cover 10-20%)+(6 x %cover 20-50%)+(9 x %cover 50-80%)+(12 x %cover >80%))/100.***

SEAGRASS CONDITION RATING

RATING	DEFINITION (+Seagrass Coefficient)	RECOMMENDED RESPONSE
Poor	Very Low (0.0 - 0.2)	Post baseline, monitor 5 yearly. Initiate ERP
Fair	Low (0.2 - 0.8)	Post baseline, monitor 5 yearly. Initiate ERP
	Low Low-Moderate (0.8 - 1.5)	Post baseline, monitor 5 yearly. Initiate ERP
Good	Low-Moderate (1.5 - 2.2)	Monitor at 5 year intervals after baseline established
	Moderate (2.2 - 4.5)	Monitor at 5 year intervals after baseline established
Very Good	High (4.5 - 7.0)	Monitor at 5 year intervals after baseline established
	Very High (>7.0)	Monitor at 5 year intervals after baseline established
Early Warning Trigger	Trend of decreasing Seagrass Coefficient	Initiate ERP (Evaluation and Response Plan)

2. METHODS (CONTINUED)

SALTMARSH PERCENT COVER

A variety of saltmarsh species (commonly dominated by rushland but including scrub, sedge, tussock, grass, reed, and herb fields) grow in the upper margins of most NZ estuaries where vegetation stabilises fine sediment transported by tidal flows. Saltmarshes have high biodiversity, are amongst the most productive habitats on earth and have strong aesthetic appeal. Where saltmarsh cover is limited, these values are decreased.

SALTMARSH PERCENT COVER CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	>20% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
High	10%-20% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Moderate	5%-10% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Low	2%-5% of estuary area is saltmarsh	Post baseline, monitor 5 yearly. Initiate ERP
Very Low	<2% of estuary area is saltmarsh	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	<5% of estuary area is saltmarsh	Initiate ERP (Evaluation and Response Plan)

SALTMARSH AREA

Saltmarshes are sensitive to a wide range of pressures including land reclamation, margin development, flow regulation, sea level rise, grazing, wastewater contaminants, and weed invasion. Decreases in saltmarsh extent is likely to indicate an increase in these types of pressures.

SALTMARSH AREA CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Area of cover (ha) not decreasing	Monitor at 5 year intervals after baseline established
Good	Decline in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Decline in area of cover (ha) 5-20% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Poor	Decline in area of cover (ha) >20% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	Trend of decrease in area of cover (ha)	Initiate ERP (Evaluation and Response Plan)

TERRESTRIAL VEGETATED BUFFER PERCENT COVER

The presence of a terrestrial margin dominated by a dense assemblage of scrub/shrub and forest vegetation acts as an important buffer between developed areas and the saltmarsh and estuary. This buffer protects against introduced weeds and grasses, naturally filters sediments and nutrients, and provides valuable ecological habitat.

TERRESTRIAL VEGETATED BUFFER PERCENT COVER CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	80%-100% cover of terrestrial vegetated buffer	Monitor at 5 year intervals after baseline established
High	50%-80% cover of terrestrial vegetated buffer	Monitor at 5 year intervals after baseline established
Fair	25%-50% cover of terrestrial vegetated buffer	Post baseline, monitor 5 yearly. Initiate ERP
Poor	5%-25% cover of terrestrial vegetated buffer	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	<50% cover of terrestrial vegetated buffer	Initiate ERP (Evaluation and Response Plan)

TERRESTRIAL VEGETATED BUFFER AREA

Estuaries are sensitive to a wide range of pressures including land reclamation, margin development, flow regulation, sea level rise, grazing, wastewater contaminants, and weed invasion. Reduction in the vegetated buffer around the estuary is likely to result in a decline in estuary quality.

TERRESTRIAL VEGETATED BUFFER AREA CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Terrestrial buffer is 100% dense vegetation	Monitor at 5 year intervals after baseline established
Good	Decline in vegetated buffer (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Decline in vegetated buffer (ha) 5-10% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Poor	Decline in vegetated buffer (ha) >10% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	Trend of decrease in area of vegetated buffer (ha)	Initiate ERP (Evaluation and Response Plan)

3. RESULTS AND DISCUSSION

OVERVIEW

This section provides a summary of the dominant features of the estuary (Tables 4 and 5), followed by the results and a discussion of each broad scale GIS layer that has been mapped. For each layer (substrate, macroalgae, seagrass, saltmarsh, and the 200m terrestrial margin), condition ratings are used to assess each indicator, which are then evaluated along with other relevant expert information to assess the condition of the estuary in relation to the key issues of sedimentation, eutrophication and habitat loss. Changes in the estuary since it was first broad scale mapped in 2003 are discussed in Section 4.

Table 4 summarises the key features of the estuary. It shows the estuary is moderate in size compared with other New Zealand tidal lagoon estuaries. It has a relatively large intertidal area (79%), and this combined with its generally shallow nature (average high tide depth ~2m) and riverine inputs, means it is generally well flushed (most of the estuary drains at low tide). Consequently salinities will be close to that of seawater when the tide comes in and the water column is expected to be well mixed. Also, because the estuary is generally broad and flat, and exposure to wind fetch is high, wave generated resuspension of sediment within the estuary is also likely to be high.

Table 4. Summary of dominant intertidal features, February 2008.

Dominant Feature	Area (Ha)	Area (%)
Saltmarsh	74	10.2
Intertidal flats	499	68.8
Water	152	21.0
TOTAL	**725**	**100**

Table 5 summarises significant vegetation cover other than saltmarsh in the intertidal area of the estuary. It shows that macroalgae was present as a significant cover across a large portion (65%) of the estuary. Seagrass was much less abundant (8%).

Table 5. Summary of dominant intertidal vegetation, February 2008.

Dominant Feature	Ha	%
Macroalgal Cover >5%	325.8	65.3
Seagrass Cover >5%	41.9	8.4

3. RESULTS AND DISCUSSION (CONTINUED)

SUBSTRATE MAPPING

Very soft mud on the northern side of the Aparima Arm.

Deep mud showing the shallow RPD and anoxic sediment in the northern Aparima Arm.

Extensive sand flats in the central estuary.

Gravel field near Riverton.

Cobble and rock field in the neck of the Pourakino Arm.

Driftwood filled drain parallel to the eastern shoreline.

Soil erosion is a major issue in NZ and resulting suspended sediment can cause increased muddiness and turbidity, shallowing, increased nutrients, changes in saltmarsh and seagrass habitats, less oxygen, increased organic matter degradation by anoxic processes (e.g. sulphate reduction), and alterations to fish and invertebrate communities.

The broad scale mapping showed the dominant intertidal substrate was firm sand and firm mud/sand (60%, 299ha) located mainly in the lower estuary, with soft and very soft mud (33%, 165ha) also widespread - predominantly in the upper reaches of both arms (Table 6 and Figure 1). The soft mud condition rating placed the estuary in the "poor" category (>15% of the estuary is soft mud), and when wading though these areas it was common to sink 20-30cm deep (see top 2 photos).

Associated with the soft sediments were large accumulations of macroalgae - primarily *Gracilaria* (see Page 16 and Figure 2). Where this occurred, the Redox Potential Discontinuity (RPD) was generally close to the surface (<1cm) and sediments beneath the RPD were black and anoxic showing highly eutrophic conditions. Consequently the benthic invertebrate community is likely to be limited to only a few opportunistic species.

The dominant sandflats were located primarily south of the Aparima River channel and there was a transition from firm mud/sand to firm sand to gravel between the arms of both rivers and the mouth of the estuary. This area was well flushed by the tide and the RPD was mostly around 10cm deep in firm sand, and 5cm deep in firm mud/sand. Some localised areas of soft mud were present near low tide channels with an RPD <5cm. Gravel fields dominated upstream of the Riverton Road Bridge.

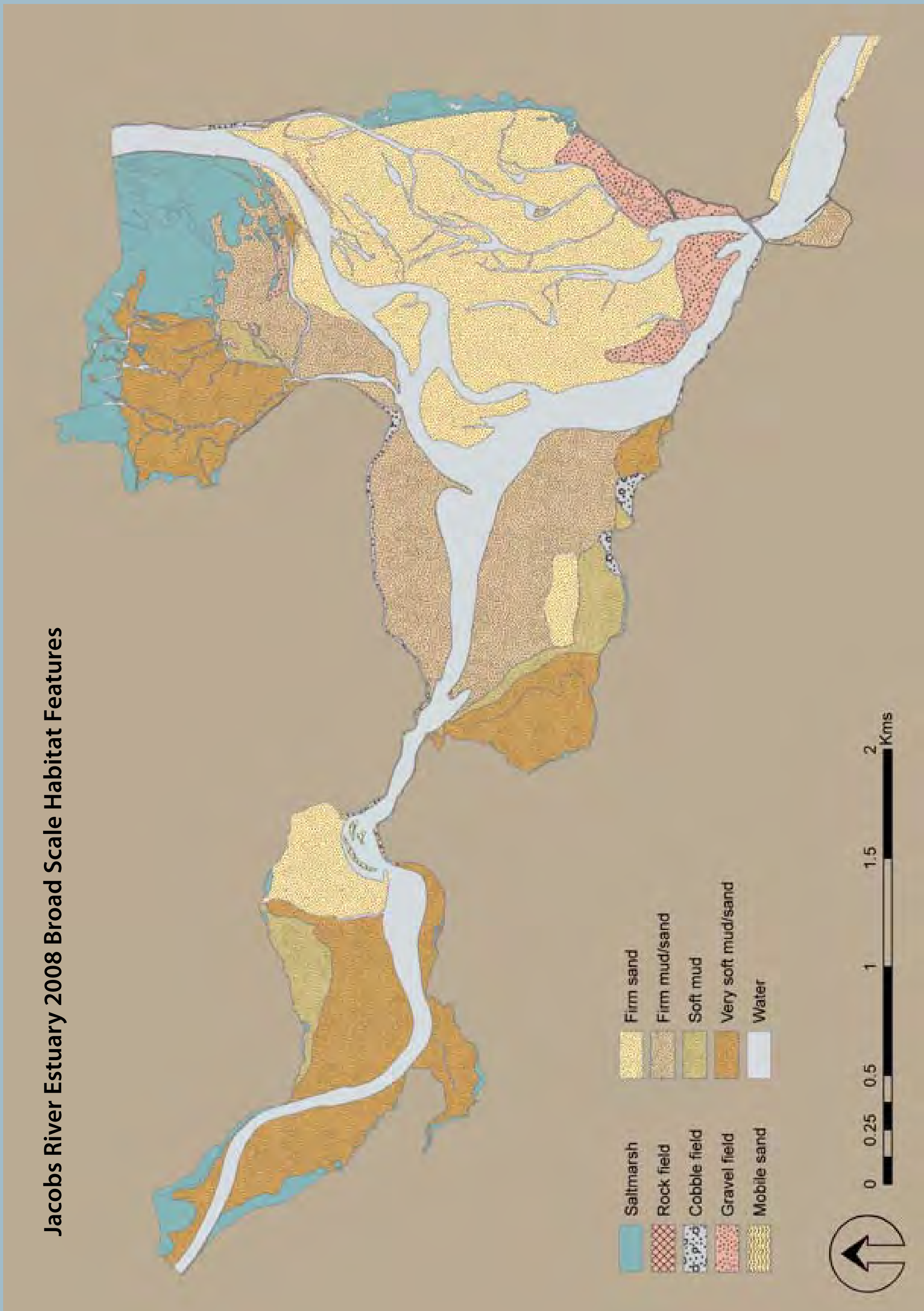
The sharp transition between muddy and sandy parts of the estuary appeared due primarily to physical tide and river flushing, with prevailing wind-generated waves also resuspending and depositing sediment and macroalgae in localised areas.

Other less prominent features of the estuary were wharfs and seawalls protecting reclaimed shorelines near Riverton. These structures generally had steep faces providing few places for intertidal saltmarsh to grow. Similarly, on the eastern side of the estuary, drains running parallel to the shoreline (see lower photo) limit seawater ingress, with historical saltmarsh areas now appearing freshwater dominated.

Table 6. Summary of dominant unvegetated substrate, February 2008.

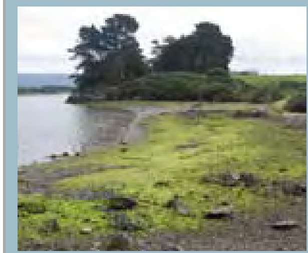
Dominant Substrate	Area (ha)	%	Comments
Artificial Structure	0.97	0.2	Primarily seawalls, bridge and wharf structures near Riverton, and whitebait stands in the upper Aparima.
Rockfield	0.94	0.2	Primarily located near the estuary mouth and in the narrow part of the Pourakino Arm.
Cobblefield	6.89	1.4	Mostly upstream of the Riverton road bridge, and narrow bands along the upper intertidal and in river channels.
Gravelfield	25.51	5.1	
Mobile Sand	0.67	0.1	Small islets in the Pourakino Arm.
Firm Sand	184.78	37.0	Widespread in the southeast of the estuary by Riverton.
Firm Mud/Sand	113.93	22.8	In the upper reaches of the central estuary basin particularly near where the Pourakino Arm enters.
Soft Mud	30.34	6.1	Predominantly in the north Aparima Arm embayment, the Pourakino Arm, and southwest of the central basin.
Very Soft Mud	134.75	27.0	
TOTAL	**498.8**	**100**	

Figure 1. Map of Unvegetated Substrate and Saltmarsh - Jacobs River Estuary, Feb. 2008



3. RESULTS AND DISCUSSION (CONTINUED)

MACROALGAL MAPPING



Enteromorpha (80-100% cover) in the lower Pourakino Arm.

Enteromorpha (10-20% cover) in the central estuary basin.

Gracilaria (50-80% cover) in the upper Pourakino Arm.

Macroalgal blooms are a symptom of estuary eutrophication. These can deprive seagrass areas of light causing their eventual decline, while decaying macroalgae can accumulate on shorelines causing localised depletion of sediment dissolved oxygen and nuisance odours. Figure 2 and Table 7 summarise the results of macroalgal mapping within Jacobs River Estuary. Overall, 326ha (65% of the intertidal area) had a macroalgal cover >5%. Cover was dominated by the red alga *Gracilaria chilensis* and, to a lesser extent, by the green alga *Enteromorpha* which was most common along the edges of the main river channels. The Macroalgae Coefficient (MC) for the estuary was "moderate" (3.3), a condition rating of "fair", although a large portion of the estuary (35%) had a high (>50%) cover and was associated with nuisance conditions of anoxic muds and sulphide odours (see photos at bottom).

Table 7. Summary of macroalgal cover results, February 2008.

MACROALGAE	Jacobs River Estuary		
Percentage Cover	**Area (ha)**	**Percentage**	**Dominant Species**
<1%	62.6	12.5	
1-5%	110.7	22.2	*Enteromorpha, Gracilaria chilensis*
5-10%	63.4	12.7	*Gracilaria chilensis, Enteromorpha*
10-20%	17.7	3.5	*Gracilaria chilensis, Enteromorpha*
20-50%	72.2	14.5	*Gracilaria chilensis, Enteromorpha*
50-80%	81.8	16.4	*Gracilaria chilensis, Enteromorpha*
>80%	90.7	18.2	*Gracilaria chilensis, Enteromorpha*
TOTAL	**499**	**100**	

When compared to the 2007 monitoring results (see Robertson and Stevens 2007) there was a significant increase in both the cover and density of macroalgae.

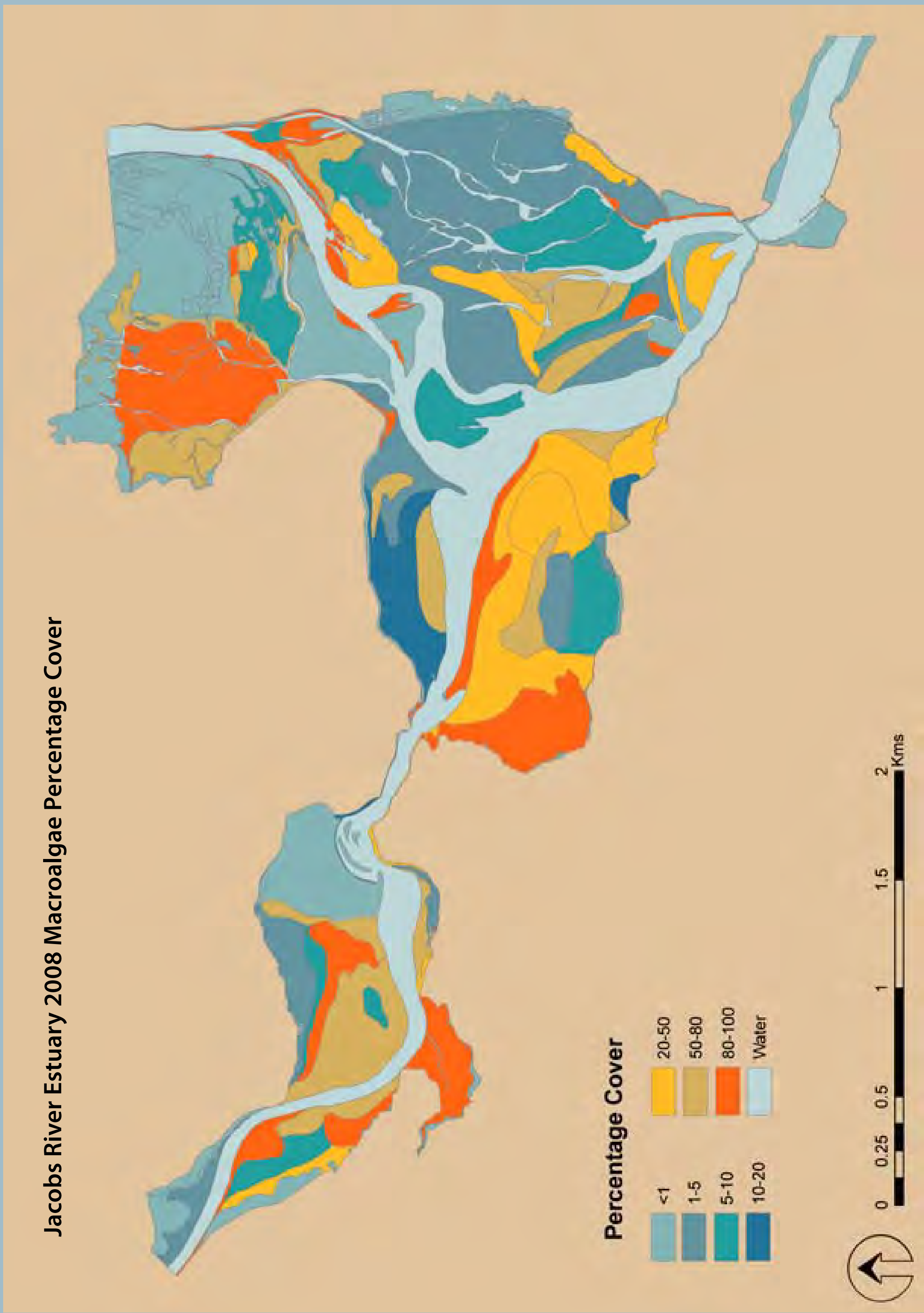
While macroalgae was present throughout most of the estuary, the highest densities were found at certain locations, particularly in sheltered embayments (mostly *Gracilaria)* and along channel margins (mostly *Enteromorpha*). As in 2007, the areas of highest percentage cover (>50% cover) tended to be on the soft muds of the poorly flushed arms on the southern side of the estuary, and the embayment north of the Aparima River. These high cover areas receive drainage from agricultural lands bordering their margin as well as sediment and nutrients from wider afield, including marine sources. They also act as settling areas for algae carried in from around the estuary with the tide and prevailing wind.

Areas of moderate cover (5-50% cover) tended to be situated near the river mouths, sheltered areas, or along the area near Riverton exposed to the greatest wind fetch.

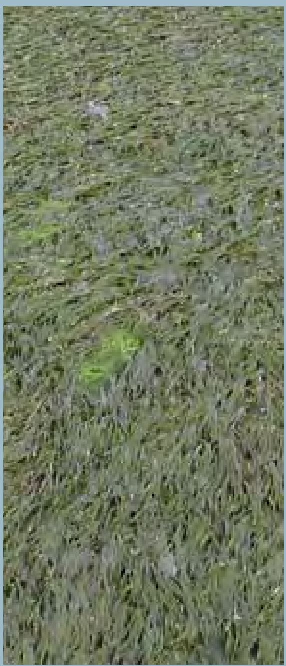
Areas of low cover (<5% cover) tended to be restricted to exposed areas with coarser sediments and in the well flushed eastern side of the main estuary basin.

Extensive *Enteromorpha* and *Gracilaria* cover (80-100%) and anoxic sediment north of the Aparima River.

Figure 2. Map of Macroalgae Percentage Cover - Jacobs River Estuary, Feb. 2008



SEAGRASS MAPPING



Seagrass (*Zostera muelleri*) is highly valued ecologically for its multiple roles in primary production, nutrient cycling, sediment stabilisation, and as a feeding and nursery area for fish and invertebrates. Seagrass meadows are also a major source of detrital material, and the bacteria and fungi that decompose this material provide a food source for zooplankton, worms, etc. which are the base of the predatory food web. Seagrass is also an important forerunner to the establishment of saltmarsh on tidal flats, and grows subtidally where water clarity allows light to penetrate to it. Table 8 and Figure 3 summarise the results of seagrass mapping within Jacobs River Estuary.

Table 8. Summary of seagrass cover results, February 2008.

SEAGRASS	Jacobs River Estuary	
Percentage Cover	Area (ha)	Percentage
<1%	457.1	91.6
1-5%	0.0	0.0
5-10%	4.9	1.0
10-20%	5.1	1.0
20-50%	22.7	4.5
50-80%	2.3	0.5
>80%	7.0	1.4
TOTAL	**499**	**100**

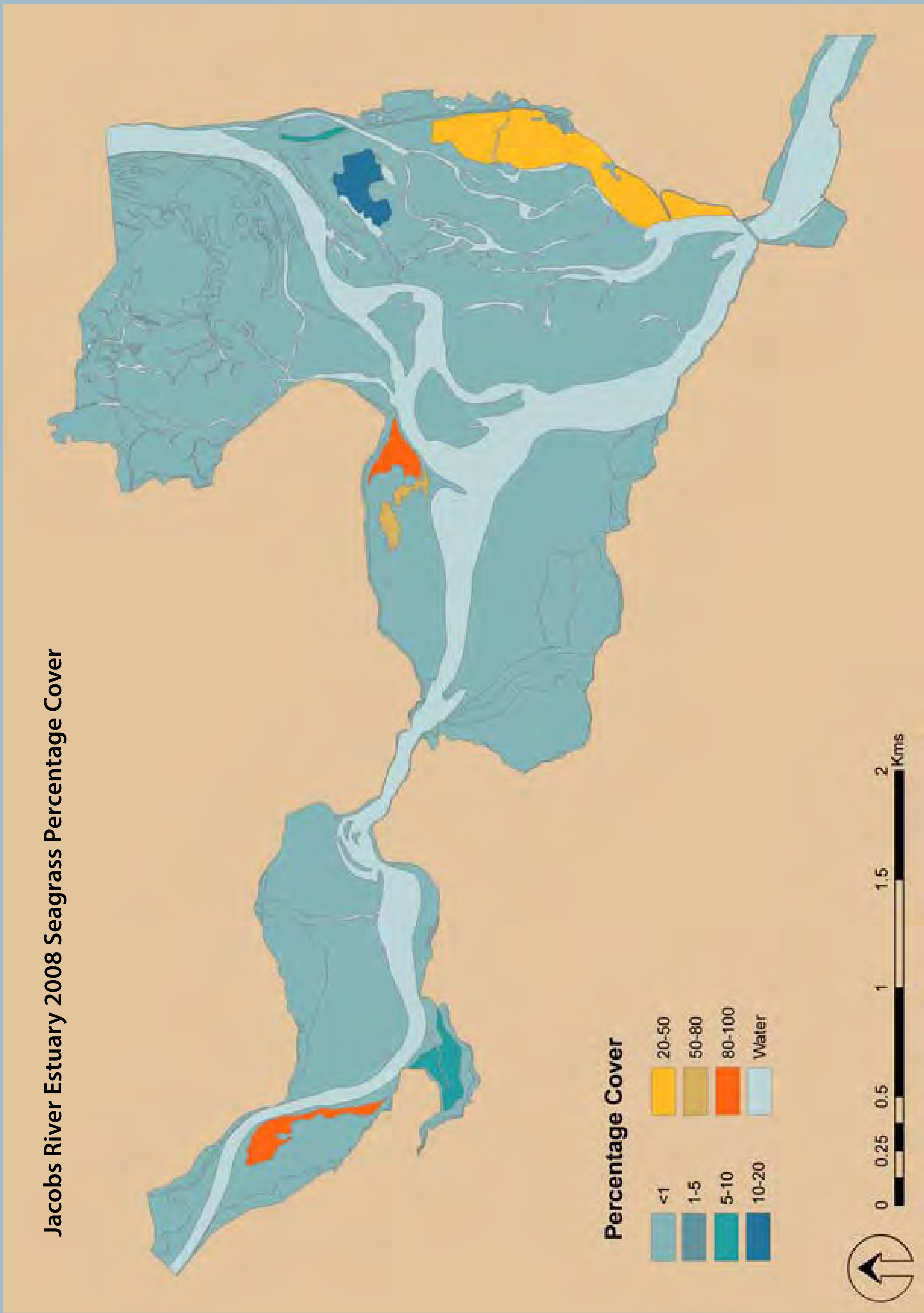
The Seagrass Coefficient (SC) for the estuary was "low" (0.4), a condition rating of "fair" reflecting that seagrass cover >5% was not widespread in the estuary although some relatively large patches of high cover were present. The largest area of seagrass was in firm sands in the southeast of the estuary where there was a 20-50% cover. Higher densities (50-100% cover) were present in smaller areas in very soft muds on the southern side of the Pourakino Arm, and immediately north of the confluence between the Pourakino and Aparima rivers. The beds appeared healthy and relatively stable although in many cases, beds were covered in wind-blown macroalgae.

The current survey provides a baseline for comparing future changes using the condition ratings proposed in Section 2.

Example of extensive (80-100%) cover of *Zostera* in northern Jacobs River Estuary.

Example of sparse (5-10%) cover of *Zostera* in southern Jacobs River Estuary.

Figure 3. Map of Seagrass Percentage Cover - Jacobs River Estuary, Feb. 2008



SALTMARSH MAPPING

Saltmarsh vegetation (able to tolerate saline conditions and where terrestrial plants are unable to survive) is highly productive, provides important habitat for a variety of species, naturally filters sediments and nutrients, and acts as an important buffer that protects against introduced weeds and grasses. Results are summarised in Figure 5 with the broad vegetation class and species composition shown in Table 9.

Overall, saltmarsh covered 10% of the estuary (condition rating = "moderate / good"), a pattern similar to comparable estuaries in Southland and elsewhere in NZ (Figure 4). The saltmarsh was dominated by rushland (mostly jointed wire rush - 75%) with grassland (tall fescue - 17%) also prominent. A common vegetated sequence was a narrow strip of tussockland (flax) and grassland (tall fescue) landward of an often wide band of jointed wire rush extending down to the unvegetated intertidal mud or sand flats. Small sedgefields (three square) or herbfields were occasionally present at the top of the intertidal flats.

Saltmarsh was located predominantly in the north and east of the estuary, and in the upper Pourakino Arm. The saltmarsh to the east was largely cut off from direct tidal inundation by drainage ditches running parallel to the shore, and the vegetation reflected this, being dominated by freshwater tolerant species e.g. flax, tall fescue, and three square.

Elsewhere saltmarsh was either absent or present as narrow strips around the upper intertidal zone. In the lower estuary, there was little suitable habitat available for saltmarsh because of seawalls and wharfs, while elsewhere, natural rockfields or low cliffs often limited how far saltwater (and therefore saltmarsh) could extend inland (see example in lower photo).

Figure 4. Summary of vegetated habitat cover in selected NZ estuaries.

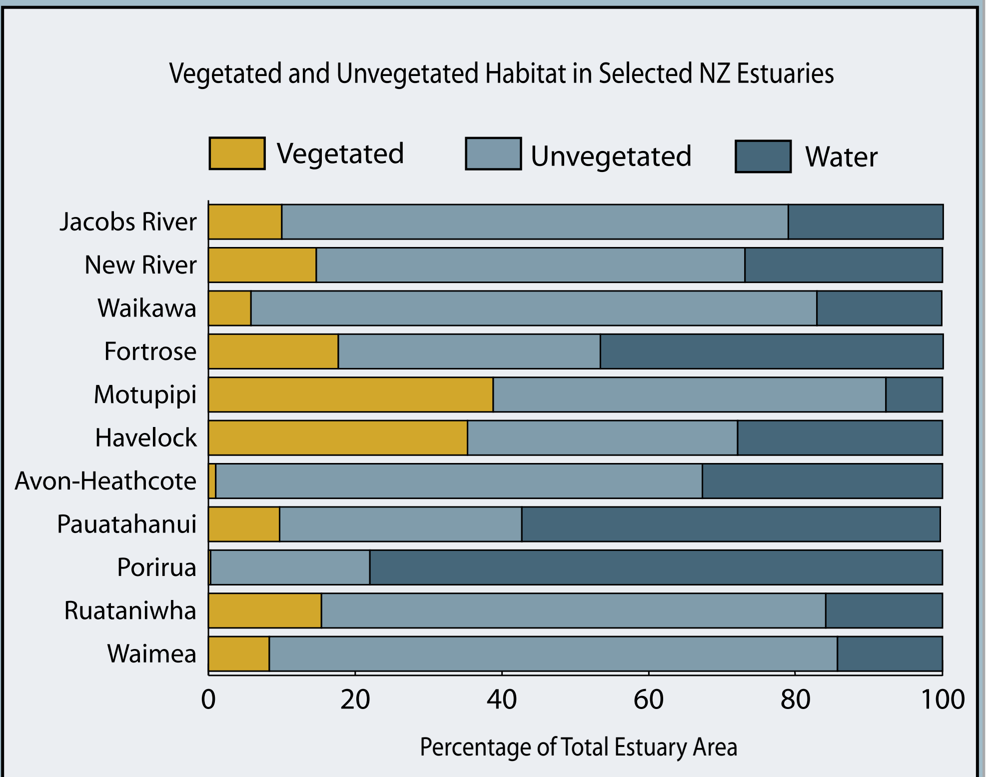


Figure 5. Map of Saltmarsh Vegetation Class - Jacobs River Estuary, Feb. 2008

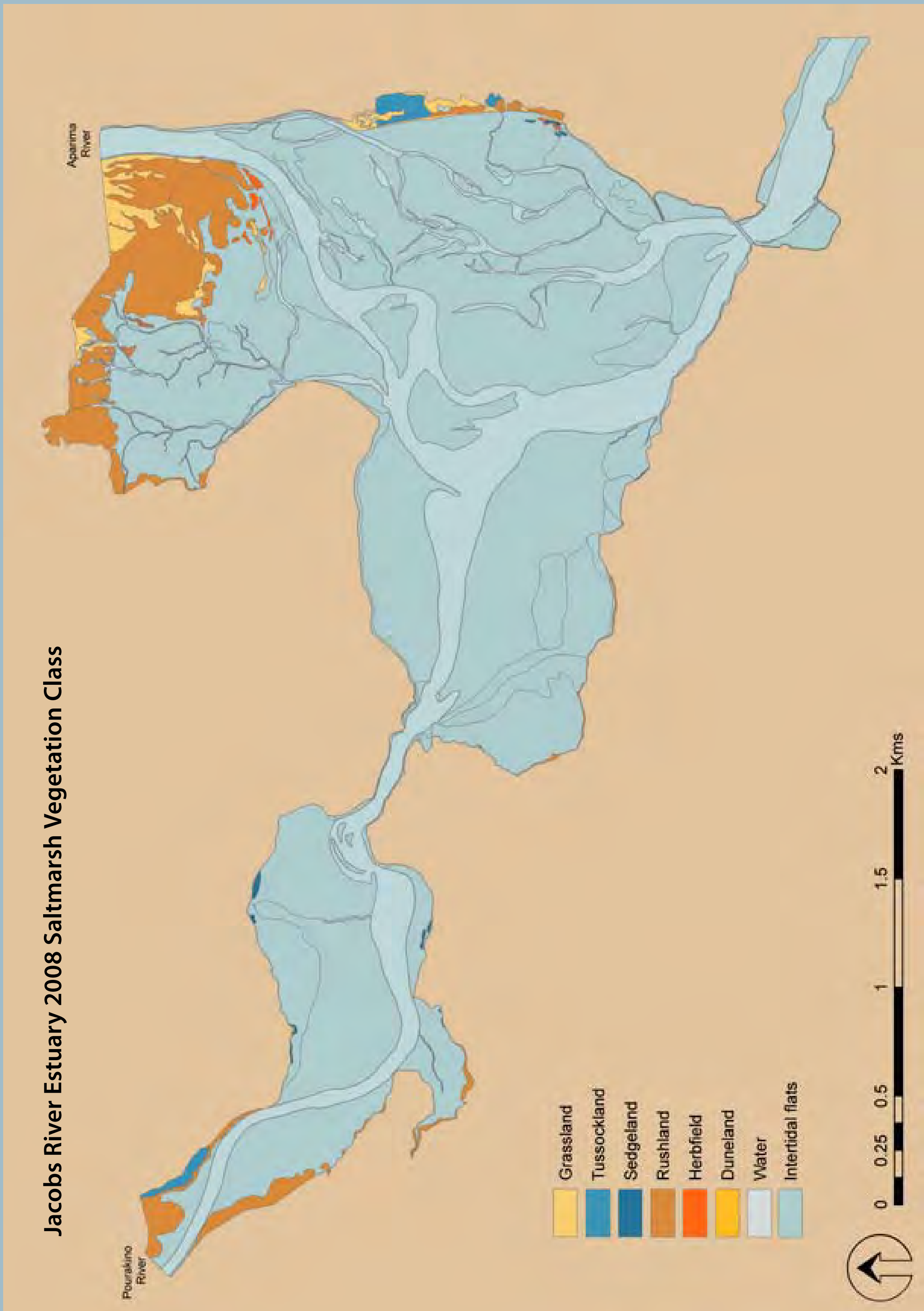
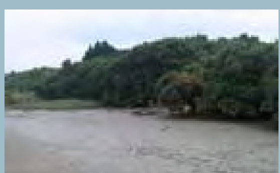
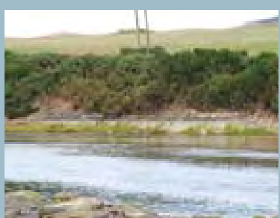


Table 9. Summary of saltmarsh vegetation results, February 2008.

Class	Dominant Species	Primary subdominant species	Ha	%
Tussockland			4.3	5.8
	Phormium tenax (New Zealand flax)		*0.3*	*0.4*
		Apodasima similis (Jointed wirerush)	*4.0*	*5.4*
		Native scrub	*0.04*	*0.1*
Sedgeland			0.9	1.3
	Schoenoplectus pungens (Three-square)		*0.8*	*1.1*
		Selliera radicans (Remuremu)	*0.1*	*0.1*
Grassland			12.4	16.9
	Festuca arundinacea (Tall fescue)		*0.4*	*0.6*
		Apodasima similis (Jointed wirerush)	*9.4*	*12.7*
		Plagianthus divaricatus (Saltmarsh ribbonwood)	*1.3*	*1.8*
		Phormium tenax (New Zealand flax)	*0.8*	*1.1*
		Ammophila arenaria (Marram grass)	*0.5*	*0.7*
Rushland			55.0	74.6
	Apodasima similis (Jointed wirerush)		*42.0*	*57.0*
		Plagianthus divaricatus (Saltmarsh ribbonwood)	*7.4*	*10.1*
		Schoenoplectus pungens (Three-square)	*4.1*	*5.6*
		Festuca arundinacea (Tall fescue)	*1.0*	*1.4*
		Phormium tenax (New Zealand flax)	*0.4*	*0.6*
Herbfield			1.1	1.5
	Samolus repens (Primrose)	*Selliera radicans (Remuremu)*	*0.6*	*0.9*
	Selliera radicans (Remuremu)	*Samolus repens (Primrose)*	*0.5*	*0.6*
Grand Total			73.7	100

TERRESTRIAL MARGIN MAPPING





Like saltmarsh, a densely vegetated terrestrial margin provides important habitat for a variety of species, naturally filters sediments and nutrients entering the estuary, and acts as an important buffer protecting against introduced weeds and grasses. The results of the 200m terrestrial margin mapping are summarised in Table 10 and Figure 6. Overall, 69% of the estuary margin was grassland, primarily used for dairy farming. Residential and smaller commercial and industrial uses around Riverton accounted for 14%, while most of the remaining area was scrub (6%) or scrub/forest (4%), dominated by exotic species e.g. gorse, pine, macrocarpa, and common weeds e.g. blackberry, broom. Overall, the amount of terrestrial margin dominated by a dense assemblage of scrub/shrub and forest vegetation was in the 5-25% range, a condition rating of "poor".

The only area where a moderate amount of native-dominated vegetation backed onto the estuary was in the north Aparima Arm where (tussockland (flax) extended to the edge of rushland (Figure 6). Elsewhere, much of the estuary had a narrow (~10m) strip of scrub (mostly gorse) providing a buffer between the dominant grassland cover and the estuary (see lower two photos). This scrub buffer appears to remain simply because the steep margins of the estuary are unsuitable for farming. It offers some capacity to filter sediment and nutrient inputs to the estuary, and while currently providing limited habitat value, regeneration of native species in such areas would greatly enhance this.

Around Riverton itself, the estuary margin has been modified, with artificial seawalls and reclamations present along much of the estuary edge. Various industries have established along the foreshore in the south east and very limited natural buffering capacity remains.

Figure 6. Map of 200m Terrestrial Margin Features - Jacobs River Estuary, Feb. 2008

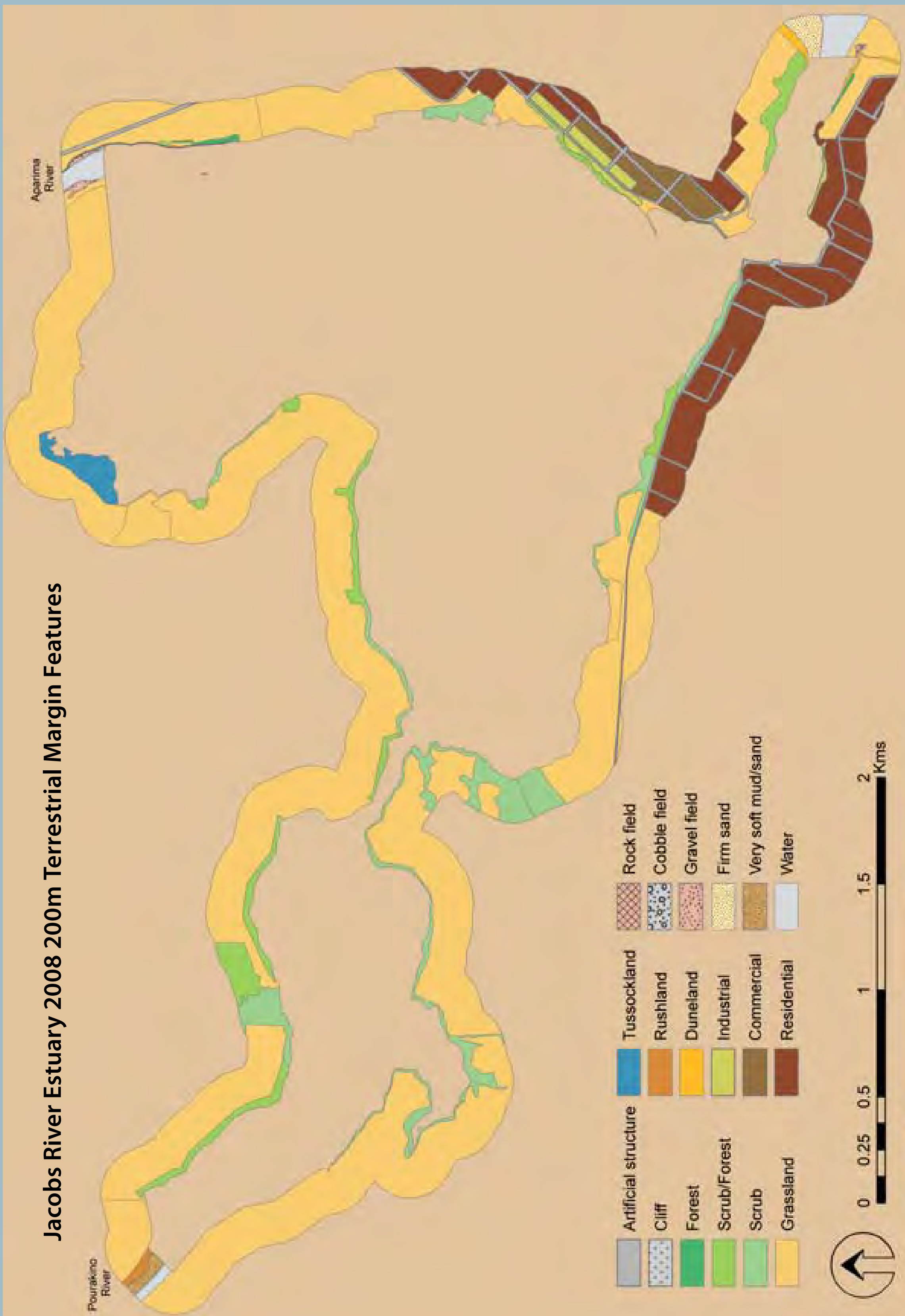


Table 10. Summary of 200m terrestrial margin vegetation, February 2008.

Class	Dominant Species	Primary subdominant species	Ha	%
Forest			0.7	0.2
	Exotic forest	*Unidentified grass*	*0.7*	*0.2*
Scrub/Forest			19.1	4.2
	Pinus radiata (Pine tree)		*11.6*	*2.5*
	Cupressus macrocarpa (Macrocarpa)	*Unidentified introduced weeds + Pinus radiata (Pine tree)*	*2.1*	*0.4*
	Exotic scrub/forest	*Unidentified introduced weeds*	*1.9*	*0.4*
	Native scrub/forest		*3.6*	*0.8*
Scrub			27.7	6.1
	Ulex europaeus (Gorse)	*Mixed native and exotic scrub + unidentified grass*	*18.4*	*4.0*
	Exotic Scrub	*Unidentified introduced weeds*	*3.3*	*0.7*
	Mixed native and exotic scrub		*3.3*	*0.7*
	Native scrub		*2.8*	*0.6*
Tussockland			4.5	1.0
	Phormium tenax (New Zealand flax)	*Apodasima similis (Jointed wirerush)*	*4.5*	*1.0*
Grassland			313.1	68.8
	Festuca arundinacea (Tall fescue)	*Ulex europaeus (Gorse)*	*3.1*	*0.7*
		Plagianthus divaricatus (Saltmarsh ribbonwood)	*0.8*	*0.2*
	Unidentified grass		*296.6*	*65.2*
		Ulex europaeus (Gorse)	*11.0*	*2.4*
		Mixed native and exotic scrub	*1.5*	*0.3*
Duneland			1.1	0.2
	Ammophila arenaria (Marram grass)		*0.2*	*0.0*
		Lupininus arboreus (Tree lupin)	*1.0*	*0.2*
Rushland			0.8	0.2
	Apodasima similis (Jointed wirerush)		*0.8*	*0.2*
Residential			50.6	11.1
Commercial			7.9	1.7
Industrial			5.0	1.1
Artificial structure (Road)			13.3	2.9
Cliff			0.4	0.1
Rock field			0.2	0.0
Gravel field			0.7	0.2
Firm Sand			2.3	0.5
Very soft mud/sand			1.1	0.2
Water			6.4	1.4
Grand Total			455.0	100

CONDITION RATINGS

The 2008 broad scale mapping has enabled condition ratings to be applied for the key issues of sedimentation (extent of soft mud), eutrophication (macroalgal cover), and habitat loss (extent of seagrass, saltmarsh, and terrestrial vegetated buffer). In addition a baseline has been established against which future changes in the estuary can be assessed. A summary of condition ratings is presented in Table 11, and results discussed for each issue in Section 5.

Table 11. Summary of Condition Ratings for indicators of estuary issues.

BROAD SCALE RATING 2008	% COVER INTERTIDAL SOFT MUD	% COVER INTERTIDAL MACROALGAE	% COVER SEAGRASS	% COVER SALTMARSH	TERRESTRIAL VEGETATED BUFFER
JACOBS RIVER ESTUARY	POOR	FAIR	FAIR	MODERATE/HIGH	POOR

4. CHANGES IN THE ESTUARY: 2003-2008

CHANGES IN THE ESTUARY: 2003-2008

Jacobs River Estuary was first mapped in 2003 (see Robertson et al. 2003) and the following tables present key changes in the estuary from 2003 to 2008. Where appropriate, the condition ratings presented in Section 2 are used to evaluate changes to the key estuary issues of sedimentation, eutrophication, and habitat loss. Some reclassification of 2003 habitat was made in 2008 to better reflect the features present, and to incorporate improved methods for assessing macroalgae and seagrass. For example, macroalgae-covered gravelfield was recorded as macroalgae 2003, but gravelfield in 2008.

SOFT MUD: The major substrate classes of the estuary are summarised in Table 12 for 2003 and 2008 data. Because the substrate underlying macroalgae was not recorded in 2003, it was estimated for 2003 in Table 12 based on local knowledge, aerial photos and field notes. Overall, the total area of soft mud appears to have changed little since 2003, with minor differences attributable to re-classification of existing substrate features. The condition rating for soft mud area (based on a percentage change from an established baseline) was rated "very good / good", with a less than 5% increase in the area of soft mud cover.

Table 12. Comparison of 2003 and 2008 broad substrate categories.

Substrate Class	2003 Area (ha)	2003 Percent	2008 Area (ha)	2008 Percent
Artificial Structure	-	-	1.0	0.2
Rockfield	0.4	0.1	0.9	0.2
Cobblefield	4.4	0.9	6.9	1.4
Gravelfield	6.7	1.4	25.5	5.1
Mobile Sand	-	-	0.7	0.1
Firm Sand	204.0	41.7	184.8	37.0
Firm Mud/Sand	110.4	22.6	113.9	22.8
Soft Mud	31.4	6.4	30.3	6.1
Very Soft Mud	132.4	27.0	134.7	27.0
TOTAL	**498.8**	**100**	**498.8**	**100**

SEAGRASS: A combination of improvements in how seagrass cover was recorded, and the extensive cover of macroalgal cover overlying seagrass beds in 2008 restricted the ability to directly compare the 2003 and 2008 results. However, based on field observations, there was no obvious change in the distribution of seagrass between 2003 and 2008.

MACROALGAE: Because macroalgae mapping was not developed under the EMP in 2003, a macroalgal baseline was not established until 2007 (see Robertson and Stevens 2007). Comparison of 2007 and 2008 results showed a very noticeable increase of *Gracilaria* and *Enteromorpha* in 2008 causing in nuisance conditions and poor sediment quality across most of the upper estuary.

SALTMARSH VEGETATION: Table 13 shows the saltmarsh area in 2003 and 2008. Overall, the total area of saltmarsh vegetation had changed little since 2003, with minor changes resulting from re-classification of existing vegetation features. Specifically, in 2008 some areas of rushland were more accurately classified as grassland, 2003 features of scrub (gorse) and tussockland (flax) were reclassified as terrestrial margin, and herbfield was separated from underlying substrate. The condition rating for changes in saltmarsh area (a percentage change from an established baseline) was "very good" with a less than 5% decrease in the area of saltmarsh.

4. CHANGES IN THE ESTUARY: 2003-2008 (CONTINUED)

CHANGES IN THE ESTUARY: 2003-2008

Table 13. Comparison of 2003 and 2008 saltmarsh area.

Vegetation Class	2003 Area (ha)	2003 Percent	2008 Area (ha)	2008 Percent
Scrub	1.0	1.3	0	0
Tussockland	8.2	10.9	4.3	5.8
Sedgeland	1.5	2.0	0.9	1.3
Grassland	7.9	10.4	12.4	16.9
Rushland	57.3	75.5	55.0	74.6
Herbfield	0	0	1.1	1.5
TOTAL	75.8	100	73.7	100

5. CONCLUSIONS

In conclusion, the broad scale monitoring of Jacobs River Estuary showed that 79% of the estuary is exposed at low tide, with the intertidal zone predominantly unvegetated sand and mud (60% - firm sand and firm mud/sand located mainly in the lower estuary; and extensive areas of soft and very soft mud (33%) in the upper reaches of both arms). Macroalgal growth was widespread and present in very high densities in localised areas, particularly in the upper estuary where *Gracilaria* covered much of the surface, and underlying sediments were commonly very soft, anaerobic, and sulphide rich with the RPD close to the surface (~1cm).

Seagrass (*Zostera*) beds were not widespread, located in firm sands in the south-east of the estuary (20-50% cover), and in smaller areas (50-100% cover) in very soft muds on the southern side of the Pourakino Arm, and immediately north of the confluence between the Pourakino and Aparima rivers. In many cases, beds were covered in windblown macroalgae.

Saltmarsh vegetation was generally limited to a narrow strip around the estuary, with the most extensive areas located in the northern Aparima Arm where wide beds of rushland extended out over large intertidal flats, and in the upper Pourakino Arm and to the southeast of the estuary. The 200m terrestrial margin was dominated by grassland (69%), primarily dairy grazing, and the urban features of Riverton (14%). Much of the estuary edge around Riverton featured reclaimed shorelines and artificial structures (e.g. rockwalls, wharfs).

Apart from an increase in macroalgal cover, there were no significant changes in broad scale features recorded between 2003 and 2008.

The broad scale intertidal monitoring results, in combination with other available information, are used in the following subsections to provide an overview of likely estuary condition in relation to the key issues examined in this broad scale assessment, namely sedimentation, eutrophication and habitat loss.

Aparima River entering the upper estuary

SEDIMENTATION: If sediment inputs to an estuary are excessive, they infill quickly with muds, and may result in muddy, anoxic, black sulphide-rich sediments, low dissolved oxygen and low clarity - conditions that can stress aquatic macrophytes and promote undesirable growths of macroalgae and phytoplankton. The likely ecological response is one of lowered biodiversity and lowered aesthetic and human use values in the upper estuary, particularly in muddy sediments which have a greater tendency to become anoxic. The primary fine scale indicators of sediment deposition are grain size and sedimentation rate, with the broad scale indicator being the area of soft mud.

The results show much of the upper estuary near the Aparima and Pourakino Rivers is dominated by deep soft muds. As such, deposition of soft muds is a significant issue in Jacobs River Estuary requiring ongoing monitoring and management. A combination of 5 yearly broad scale mapping of the intertidal area, and annual measurement of the sedimentation rate in representative intertidal areas (through the deployment of buried sediment plates at 3-4 intertidal sites) is recommended.

EUTROPHICATION: Typical New Zealand estuaries are shallow, well-flushed and have a large intertidal area. In such estuaries, nuisance intertidal macroalgal growth is a key broad scale indicator of eutrophication. In addition, the depth of the RPD layer is also a key indicator. As the RPD gets close to the surface, a "tipping point" is reached where the pool of sediment nutrients (which can be large), suddenly becomes available to fuel algal blooms and to worsen sediment condition, while the resulting anoxic sediments contain toxic sulphides and support little aquatic life.

The results for Jacobs River Estuary show nuisance macroalgae present throughout the estuary, with large areas of the upper estuary covered in a thick layer of macroalgae creating eutrophic conditions with the RPD very close to the surface. The amount of macroalgal cover increased significantly from 2007 to 2008, increasing sediment enrichment in the estuary. The presence of such highly eutrophic conditions in Jacobs River Estuary is a concern and ongoing monitoring and management is required. Annual broad scale mapping of macroalgal cover is recommended, along with initiation of an Evaluation and Response Plan to determine the cause of increased growth and consider what response actions may be appropriate.

HABITAT LOSS: Estuaries function best with a large area of rooted vegetation, i.e. saltmarsh and macrophytes, as well as a healthy vegetated terrestrial margin. Loss of this habitat reduces wildlife, recreational and aesthetic values, while also adversely impacting on an estuary's role in flood and erosion protection, contaminant mitigation, sediment stabilisation, and nutrient cycling.

There has been extensive saltmarsh and margin habitat loss from past human activities e.g. forest clearance, reclamations, seawalls, grazing, drainage, and erosion protection. The vegetated terrestrial buffer is now dominated by grassland which has greatly reduced the buffering function provided by the previously bush-covered margin, and has almost certainly contributed to reduced biodiversity and increased sedimentation in the estuary. The scope for restoration of the terrestrial margin is large.

Modification of the estuary margin has also contributed to "coastal squeeze" where the capacity for estuarine vegetation to respond to changes in sediment and water levels has been greatly reduced. This has significant implications for the ability of the estuary to respond to predicted sea level rise, one of the major stressors identified in the recent vulnerability assessment of the Southland coast (see Robertson and Stevens 2008). Broad scale mapping of the terrestrial margin 5 yearly is recommended.

6. MONITORING

Jacobs River Estuary has been identified by ES as a priority for monitoring, and is a key part of ES's existing estuary monitoring programme being undertaken in a staged manner throughout Southland. Based on existing monitoring results, it is recommended that monitoring continue as outlined below:

Fine Scale Monitoring	Repeat fine scale monitoring on a five yearly cycle (next scheduled for 2011) and as deemed necessary thereafter based on the condition ratings. Due to the extreme eutrophication apparent in the northern Aparima Arm, a new upper estuary fine scale site should be established in this area.
Broad Scale Macroalgal Mapping	Map macroalgal cover in January-March 2009. After this, schedule monitoring as deemed necessary based on the condition ratings.
Broad Scale Sedimentation Rate Mapping	Install sediment plates in representative parts of the estuary (e.g. one in each upper Arm and one in the central basin) in January-March 2009. Monitor annually thereafter.
Broad Scale Habitat Mapping	Repeat broad scale habitat mapping at five yearly intervals (next scheduled for 2013) and then as deemed necessary based on the condition ratings.

The ongoing monitoring will provide a robust framework for identifying, evaluating and providing management options for any significant issues within Jacobs River Estuary.

7. RECOMMENDED MANAGEMENT

The following management actions are encouraged:

Monitor Key Stressors

- As intensification of land use is a key stressor, monitor changes in catchment land use with any changes in the key stressors triggering an evaluation of the likely impact on the estuary.

Identify and Implement Catchment BMPs

- Catchment runoff is one of the major stressors in estuaries with the likely ecological response one of lowered biodiversity and lowered aesthetic and human use values. To prevent avoidable inputs, best management practices (BMPs) should be identified and implemented to reduce sediment, nutrient, and pathogen runoff from catchment "hotspots".

Restore Saltmarsh Habitat

- The reduction in saltmarsh habitat as a result of drainage and reclamation has certainly contributed to reduced biodiversity and increased sedimentation of the estuary, while also lowering aesthetic and human use values. It has also allowed weeds and grass to establish to the estuary edge. Because of the importance of saltmarsh, it is recommended that a plan be developed to encourage its protection, re-establishment, and to support community restoration initiatives.

Reinstate Margin Buffer

- Human development of the estuary margin has resulted in clearance of surrounding bush and almost certainly contributed to reduced biodiversity and increased estuary sedimentation. Many areas are also adversely affected by nuisance weeds. Because of the importance of a natural vegetated margin around the estuary, it is recommended that a strategy be developed to encourage its re-establishment where possible.

Coastal Squeeze

- Sea level rise is a key estuary stressor. The ability of estuary vegetation to respond to sea level rise relies to a large extent on saltmarsh and terrestrial margin vegetation being able to migrate landward to maintain suitable growing conditions. Areas where coastal squeeze is likely to occur should be identified and used to guide future revegetation efforts, and to identify where conflict may occur between existing uses and estuary expansion as a consequence of sea level rise.

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9. REFERENCES

REPORT REFERENCES

Atkinson, I.A.E. 1985. Derivation of vegetation mapping units for an ecological survey of Tongariro National Park Nth Island, NZ. NZ Journal of Botany, 23; 361-378.

Robertson, B.M. Gillespie, P.A. Asher, R.A. Frisk, S. Keeley, N.B. Hopkins, G.A. Thompson, S.J. Tuckey, B.J. 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Robertson B.M., Tuckey B.J., Robertson B. 2003. Broadscale mapping of Jacobs River Estuary intertidal habitats. Prepared for Environment Southland.

Robertson B.M., Asher R. 2003. Environment Southland Estuary Monitoring 2003. Prepared for Environment Southland.

Robertson B.M., Asher R., Sneddon R. 2004. Environment Southland Estuary Monitoring 2004. Prepared for Environment Southland.

Robertson B.M., Asher, R. 2006. Environment Southland Estuary Monitoring 2006. Prepared for Environment Southland.

Robertson, B.M. and Stevens, L. 2006. Southland Estuaries State of Environment Report 2001-2006. Prepared for Environment Southland.

Robertson, B.M. and Stevens, L. 2007. Waikawa Estuary 2007 Fine Scale Monitoring & Historical Sediment Coring. Prepared for Environment Southland. 29p.

Robertson, B.M. and Stevens, L. 2008. Southland Coast, Te Waewae Bay to the Catlins Habitat Mapping, Risk Assessment, and Monitoring. Prepared for Environment Southland.

Stevens, L., Asher, R. 2005. Environment Southland Estuary Monitoring 2005. Prepared for Environment Southland.

ENVIRONMENT SOUTHLAND COASTAL MONITORING REPORTS

Robertson, B.M. and Stevens, L. 2008. Southland Coast, Te Waewae Bay to the Catlins Habitat Mapping, Risk Assessment, and Monitoring. Prepared for Environment Southland.

Robertson, B., Stevens, L. 2007. New River Estuary 2007 Broad Scale Habitat Mapping and Sedimentation Rate. Prepared for Env. Southland. 34p.

Robertson, B., Stevens, L. 2007. Waikawa Estuary 2007 Fine Scale Monitoring and Historical Sediment Coring. Prepared for Env. Southland. 29p.

Robertson B.M., Asher, R. 2006. Environment Southland Estuary Monitoring 2006. Prepared for Environment Southland.

Robertson, B., Stevens, L. 2006. Southland Estuaries State of Environment Report 2001-2006. Prepared for Env. Southland.

Robertson B.M., Asher R., Sneddon R. 2004. Environment Southland Estuary Monitoring 2004. Prepared for Env. Southland.

Robertson, B., Stevens, L., Thompson, S., Robertson, B. 2004. Broad scale intertidal habitat mapping of Awarua Bay. Prepared for Env. Southland.

Robertson, B., Stevens, L., Thompson, S., Robertson, B. 2004. Broad scale intertidal habitat mapping of Bluff Harbour. Prepared for Env. Southland.

Robertson, B., Stevens, L., Thompson, S., Robertson, B. 2004. Broad scale intertidal habitat mapping of Waikawa Estuary. Prepared for Env. Southland.

Robertson B.M., Asher R. 2003. Environment Southland Estuary Monitoring 2003. Prepared for Env. Southland.

Robertson B.M., Tuckey B.J., Robertson B. 2003. Broadscale mapping of Jacobs River Estuary intertidal habitats. Prepared for Env. Southland.

Robertson B.M., Tuckey B.J., Robertson B. 2003. Broadscale mapping of Fortrose Estuary intertidal habitats. Prepared for Env. Southland.

Robertson, B.M., Gillespie, P.A., Asher, R.A., Frisk, S., Keeley, N.B., Hopkins, G.A., Thompson, S.J., Tuckey, B.J. 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Robertson, B.M. 1997. Southland Coastal Ecology Programme 1996-7. Report prepared for Southland Regional Council. Barry Robertson, Consultant, Nelson. 50p.

Robertson, B.M. 1995. Southland Estuaries: heavy metal monitoring. Report prepared for the Southland Regional Council. Robertson Ryder & Associates, Dunedin. 35p.

Robertson, B.M. 1992. Aparima Catchment Water Quality Review. Report prepared for the Southland Regional Council. Barry Robertson & Associates, Dunedin. 67p.

Robertson, B.M. 1992. New River Estuary: Review of Existing Water Quality. Report prepared for Southland Regional Council. Barry Robertson & Assoc, Dunedin. 76p.

Stevens, L. Robertson, B., 2008. Waiau Lagoon 2008. Broad scale habitat mapping 2007/08. Report prepared for Environment Southland. 19p.

Stevens, L. Robertson, B., 2008. New River Estuary 2008. Macroalgal monitoring 2007/08. Report prepared for Environment Southland. 5p.

Stevens, L. Robertson, B., 2007. Jacobs River Estuary 2007. Macroalgal monitoring. Report prepared for Environment Southland. 4p.

Stevens, L. Robertson, B., 2007. Waituna Lagoon 2007. Broad Scale Habitat Mapping and Historical Sediment Coring. Report prepared by Wriggle Coastal Management for Environment Southland. 36p.

Stevens, L. Robertson, B., 2007. Waituna Lagoon 2007. Ecological Vulnerability Assessment and Monitoring Recommendations. Report prepared by Wriggle Coastal Management for Environment Southland. 40p.

Stevens, L., Asher, R. 2005. Broad scale intertidal habitat mapping of Haldane Estuary. Prepared for Environment Southland.

Stevens, L., Asher, R. 2005. Environment Southland Estuary Monitoring 2005. Prepared for Environment Southland.

Stevens, L. Clarke, M. 2004. Broad scale mapping of subtidal habitat and ecology of Bluff Harbour, 2004. Prepared for Environment Southland.

APPENDIX 1. BROAD SCALE HABITAT CLASSIFICATION DEFINITIONS

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 diameter at breast height (dbh). Tree ferns ≥10cm dbh are treated as trees. Commonly sub-grouped into native, exotic or mixed forest.
Treeland: Cover of trees in the canopy is 20-80%. Trees are woody plants >10cm dbh. Commonly sub-grouped into native, exotic or mixed treeland.
Scrub: 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 dbh. Commonly sub-grouped into native, exotic or mixed scrub.
Shrubland: Cover of shrubs in the canopy is 20-80%. Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed shrubland.
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.
Duneland: Vegetated sand dunes in which the cover of vegetation in the canopy (commonly Spinifex, Pingao or Marram grass) is 20-100% and in which the vegetation cover exceeds that of any other growth form or bare ground.
Grassland: Vegetation in which the cover of grass (excluding tussock-grasses) in the canopy is 20-100%, and in which the grass cover exceeds that of any other growth form or bare ground.
Sedgeland: Vegetation in which the cover of sedges (excluding tussock-sedges and reed-forming 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.
Rushland: Vegetation in which the cover of rushes (excluding tussock-rushes) in the canopy is 20-100% and where rush cover exceeds that of any other growth form or bare ground. A tall grasslike, often hollow-stemmed plant, included in rushland are some species of Juncus and all species of Leptocarpus.
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. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either round and hollow – somewhat like a soda straw, or have a very spongy pith. Unlike grasses or sedges, reed flowers will each bear six tiny petal-like structures. 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 where 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 where lichen cover exceeds that of any other growth form or bare ground.
Introduced weeds: Vegetation in which the cover of introduced weeds in the canopy is 20-100% and in which the weed 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.
Cliff: A steep face of land which exceeds the area covered by any one class of plant growth-form. Cliffs are named from the dominant substrate type when unvegetated or the leading plant species when plant cover is ≥1%.
Rock field: Land in which the area of residual rock exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.
Boulder field: Land in which the area of unconsolidated boulders (>200mm diam.) exceeds the area covered by any one class of plant growth-form. Boulder fields are named from the leading plant species when plant cover is ≥1%.
Cobble field: Land in which the area of unconsolidated cobbles (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 is ≥1%.
Gravel field: Land in which the area of unconsolidated gravel (2-20 mm diameter) exceeds the area covered by any one class of plant growth-form. Gravel fields are named from the leading plant species when plant cover is ≥1%.
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 <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 difficult.
Soft sand: Substrate containing greater than 99% sand. When walking on the substrate you'll sink >2 cm.
Firm mud/sand: A mixture of mud and sand, the surface appears brown, and may have a black anaerobic layer below. When walking 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 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 you'll sink >5 cm.
Cockle bed: Area that is dominated by both live and 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.
Shell bank: Area that is dominated by dead shells.
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.