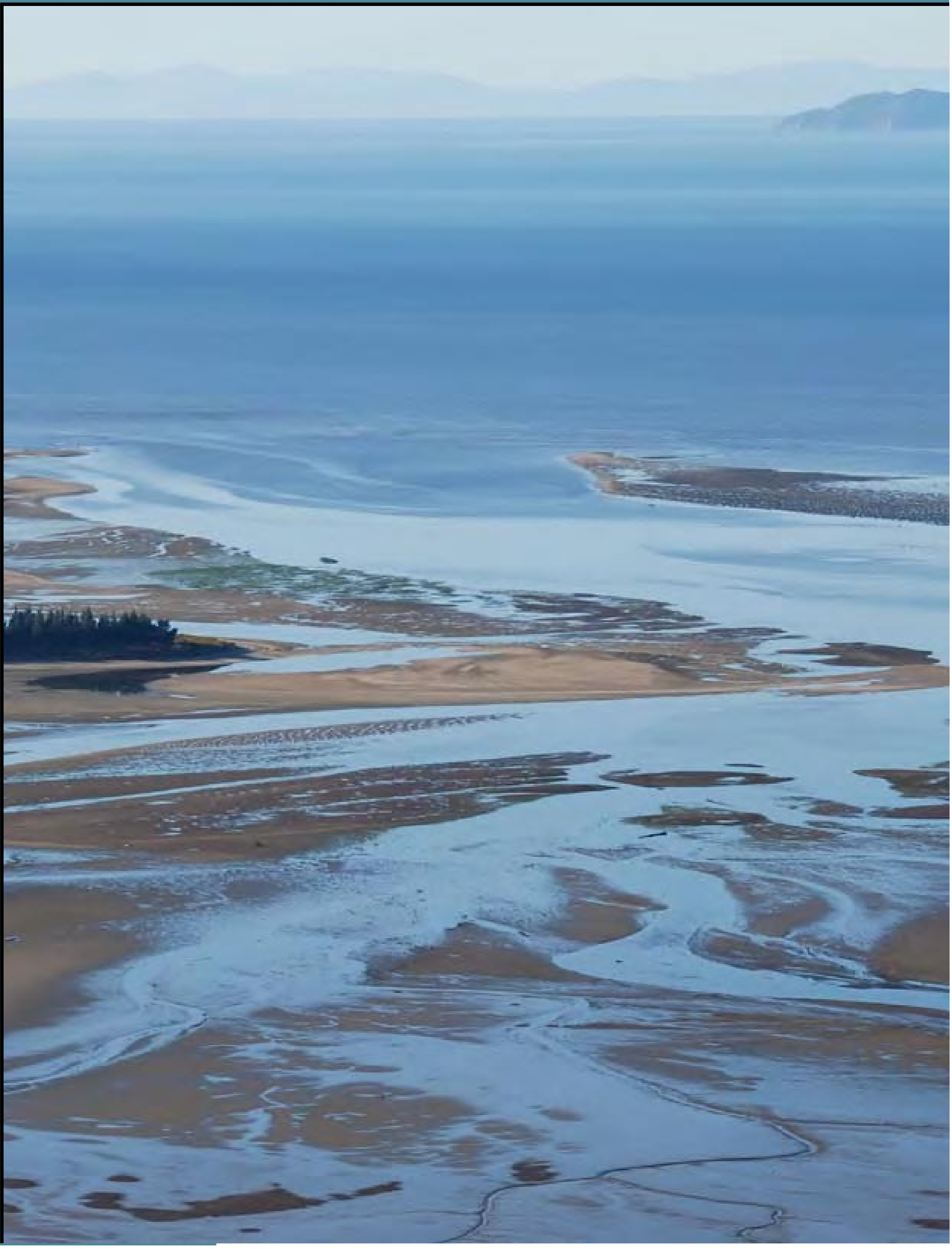
coastalmanagement

State of the Environment Report

Estuaries of Tasman District



Prepared for Tasman District Council

March 2009

State of the Environment Report
Estuaries of Tasman District

Prepared for
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By

Barry Robertson and Leigh Stevens

Cover Photo: Ruataniwha Estuary. Photo above: Motueka Estuary delta

Wriggle Limited, PO Box 1622, Nelson 7040, Ph 0275 417 935, 021 417 936, www.wriggle.co.nz

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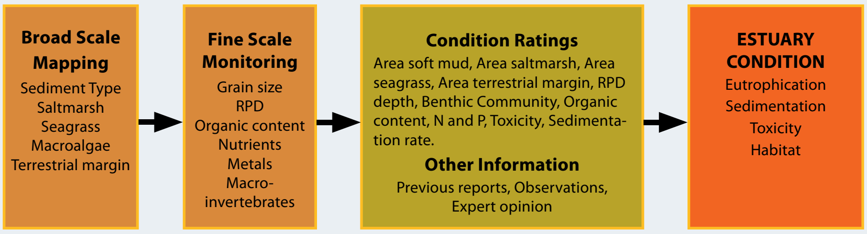
EXECUTIVE SUMMARY

Since 2000, Tasman District Council (TDC) has been monitoring the five largest estuaries in its region (the Ruataniwha Estuary, Motupipi Estuary, Motueka Estuary and Delta, Moutere Inlet, and the Waimea Estuary) using the National Estuary Monitoring Protocol (NEMP) (Robertson et al. 2002). Recently, TDC contracted Wriggle Coastal Management to assess the condition of these estuaries, and the Whanganui Inlet (monitored by the Department of Conservation in the 1980s), and to make recommendations for their future monitoring and management. For the remaining estuaries in the region, a coastal vulnerability assessment is proposed for 2011/12 to defensibly identify priorities for coastal and estuary monitoring and management across the entire region.

The approach taken in this report was to use relevant existing monitoring data to apply established broad and fine scale estuary "condition ratings" for the major issues facing most NZ estuaries: sedimentation, eutrophication, toxicity and habitat loss (see diagram below). Disease risk in estuaries, another key issue, is reported on separately by TDC.



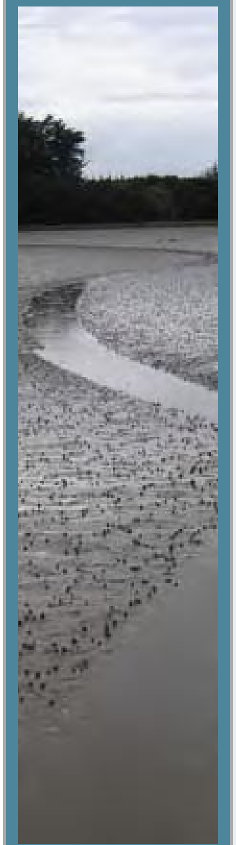
The results of the condition ratings (described in Section 2) are summarised below. These are followed by an overview of the key issues that the ratings raise, and recommendations for future monitoring and management. For each estuary, a synopsis of the issues, monitoring and management needs is then provided.

SUMMARY OF CONDITION RATINGS - TASMAN ESTUARIES

Issue	Indicator (result)	Whanganui 1989	Ruataniwha 2001	Motupipi 2008	Motueka 2003	Moutere 2006	Waimea 1988	Waimea 2001	Waimea 2006
Sedimentation	Soft Mud Area	GOOD	FAIR	POOR	FAIR	FAIR	Not Measured	POOR	POOR
	Sedimentation Rate	Not Measured	Not Measured	Baseline Established	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured
	Increase in Area Soft Mud	Not Measured	Not Measured	Baseline Established	Not Measured	Not Measured	Not Measured	Baseline Established	POOR
Eutrophication	Nuisance Macroalgal Cover	VERY GOOD	VERY GOOD	GOOD	VERY GOOD	VERY GOOD	VERY GOOD	VERY GOOD	VERY GOOD
	Organic, Nutrient Enrichment	VERY GOOD	VERY GOOD	GOOD-ENRICHED	Not Measured	GOOD-ENRICHED	Not Measured	VERY GOOD-GOOD	VERY GOOD-GOOD
	Redox Profile	Not Measured	Not Measured	GOOD-FAIR	Not Measured	GOOD-FAIR	Not Measured	Not Measured	Not Measured
	Algal Blooms (upper estuary)	Not Measured	Not Measured	POOR	Not Measured	VERY GOOD	Not Measured	VERY GOOD	VERY GOOD
Toxins	Contamination Bottom	Not Measured	GOOD-VERY GOOD	GOOD-VERY GOOD	Not Measured	GOOD-VERY GOOD	Not Measured	VERY GOOD-GOOD	VERY GOOD-GOOD
Range of Issues	Macro-invertebrates	SLIGHTLY POLLUTED	SLIGHT-MOD POLLUTED	SLIGHTLY POLLUTED	Not Measured	SLIGHTLY POLLUTED	UN-POLLUTED	SLIGHTLY POLLUTED	SLIGHTLY POLLUTED
Habitat	Saltmarsh Area	LOW	HIGH	VERY HIGH	MODERATE	HIGH	MODERATE	MODERATE	MODERATE
	Seagrass Area	VERY GOOD	POOR	POOR	POOR	POOR	FAIR	POOR	POOR
	Vegetated Terrestrial Buffer	VERY GOOD	POOR	POOR	POOR	POOR	POOR	POOR	POOR
Habitat Loss	Saltmarsh Area Decline	Baseline Established	POOR 1950-2001	POOR 1943-2007	POOR 1947-2003	POOR 1947-2006	FAIR 1946-1988	FAIR 1988-2001	VERY GOOD 2001-2006
	Seagrass Area Decline	Baseline Established	VERY GOOD	Baseline Established	Baseline Established	Baseline Established	Baseline Established	POOR 1988-2001	POOR 2001-2006

Executive Summary (continued)

Issues



Overall, the fine and broad scale monitoring results showed that of the six Tasman estuaries evaluated all, except the relatively undeveloped Whanganui, were typical of NZ tidal lagoon and tidal river mouth estuaries with developed catchments. Human and ecological values were moderate to high, and habitats included saltmarsh, seagrass, unvegetated tidal flat habitats, and highly modified terrestrial margins. The state of the dominant habitat (i.e. unvegetated tidal flats) was in relatively good to moderate condition. Poor ratings were, however, found for a few indicators. A number of key issues were highlighted for the estuaries as follows:

1. **Limited Monitoring.** The estuaries assessed have not been monitored over a consecutive multi-year period to establish a baseline of natural variation. Consequently the ability to determine if changes are natural or human influenced is significantly compromised. In addition, a coastal vulnerability assessment that defensibly identifies priorities for coastal monitoring and management across the entire region has yet to be undertaken. As a result, the estuaries currently monitored may not be the highest priority or most susceptible estuaries, and do not represent the full range of estuary types in the region.
2. **Sedimentation.** The area of soft mud in some estuaries, particularly Waimea and Motupipi, was very elevated (a "poor" rating), and was expanding in area in the Waimea. It was also elevated in the Ruataniwha, Moutere and Motueka and rated at "fair" levels. Muds decrease sediment oxygenation and lower biodiversity and, if they contain low organic material, decrease productivity. As sediment anoxia (lack of oxygen) promotes nutrient release, muddy estuaries become increasingly sensitive to nutrient inputs (which promote increased organic matter e.g. macroalgae), and further increase anoxia.
3. **Loss of Saltmarsh**. There has been a significant historical loss or modification of valuable saltmarsh habitat by drainage and reclamation activities as well as through nutrient and sediment enrichment in Waimea, Ruataniwha, Moutere, Motueka and Motupipi estuaries. Losses (mostly small) continue in most estuaries. A small overall increase was recently reported in the Waimea, attributed largely to opening of historical causeways at the Traverse.
4. **Loss of Seagrass.** Seagrass habitat was generally low in all except the Whanganui estuary. It has declined in the Waimea, the only estuary with repeat broad scale monitoring data.
5. **Loss of Terrestrial Vegetated Buffer.** All the estuaries except the Whanganui lack a natural densely vegetated buffer around their terrestrial margin. As such they have lowered biodiversity and are susceptible to weed and pest invasions, and enhanced entry of nutrients, sediment and pathogens.
6. **Intensive Landuse in Catchment.** Some estuary catchments included significant areas of intensive agriculture with excessive runoff of nutrients, sediments and pathogens. The Motupipi was the most vulnerable, but Waimea, Ruataniwha, and Moutere were also moderately vulnerable.
7. **Weed and Pest Invasions**. Most estuaries are affected by the invasion of pests and weeds. Pacific oyster, and various weeds (e.g. ice plant and gorse) have been found in the majority of estuaries. *Spartina*, which was once an issue, has now been eradicated.
8. **Algal Blooms.** Nuisance phytoplankton blooms and associated low oxygen levels occurred in the Upper Motupipi Estuary. Although nuisance macroalgal blooms occurred in localised areas of the Motupipi, Motueka, and Waimea estuaries, they were not causing widespread problems and most estuaries were rated as very good.
9. **Predicted Sea Level Rise.** Valuable saltmarsh, tidal flat and seagrass habitat in all the estuaries is susceptible to loss through accelerated sea level rise.
10. **Wastewater Discharges.** Treated municipal sewage is discharged to the Waimea and Motueka, and indirectly to the Ruataniwha estuaries. Farm effluents also indirectly enter many estuaries, particularly the Motupipi and Ruataniwha. Localised areas of toxicity occur in the Waimea around stormwater and drain discharges from urban catchments. The Waimea also receives point source inputs from other minor discharges. The results suggest that the discharges cause only localised impacts but until a full vulnerability assessment is undertaken for each estuary, the role of each in estuary-wide problems is uncertain.

Executive Summary (continued)

Monitoring

Coastal Vulnerability Assessment

The approach, undertaken at 10 yearly intervals, includes 3 main components;

(1) coastal synoptic monitoring and habitat mapping,

(2) an assessment of the "vulnerability" of the coastline habitats based on the sensitivity of the receiving environment, human uses, and the upstream catchment area risk factors (stressors) associated with each section of the coast and,

(3) a recommended coastal monitoring programme for the management of coastline biological resources in the region.

In order to address these issues the following monitoring and management approaches are recommended.

1. **Regional Coastal Vulnerability Assessment.** The first step to providing a defensible, cost effective, and robust long term coastal monitoring programme for the region is to undertake a Regional Coastal Vulnerability Assessment. This is scheduled for the 2011 and 2012 financial years and is likely to identify a number of other estuaries for priority monitoring. Because monitoring identified concerns with the Waimea Estuary, a specific vulnerability assessment of the estuary is scheduled for 2010.
2. **Establish a Long Term Monitoring Programme.** The Coastal Vulnerability Assessment will prioritise coastal and estuary monitoring in the region. Monitoring is likely to fit the following programmes for estuaries, with ongoing monitoring determined by estuary condition ratings:
   - **High vulnerability or reference estuarie**s (e.g. Motupipi, Waimea, Moutere and Whanganui): Monitor changes in landuse (5 yearly). Undertake broad scale habitat mapping (5 yearly). Monitor fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline). Monitor sedimentation rate. Monitor water column for estuaries with phytoplankton blooms (e.g. Motupipi).
   - **Moderate vulnerability estuaries** (e.g. Ruataniwha): Monitor changes in landuse (5-10 yearly). Undertake broad scale habitat mapping (5-10 yearly). Monitor fine scale phys/chem/biota in sediments 5-10 yearly (after 3-4yr baseline). Monitor sedimentation rate.
   - **Low vulnerability estuaries** (e.g. Motueka): Monitor changes in landuse (5 yearly). Undertake broad scale habitat mapping (5-10 yearly). Monitor sedimentation rate.

   Particularly at-risk estuaries with no previous data require a synoptic (semi-intensive, preliminary monitoring) survey and detailed risk assessment prior to establishment of a recommended long term monitoring programme, while estuary specific issues such as macroalgal growth monitoring should be addressed using condition ratings.

Management

Mapping Landuse Changes

Broad scale mapping, at 5 - 10 yearly intervals, of "hotspots" within catchments, i.e. sources of sediment runoff (exotic forestry, urban earthworks, erosion prone areas, easily mobilised sediment reserves, etc), sources of elevated nutrients, pathogens and toxicants (in particular, intensive grazing or N fertilizer use, sewer overflows, urban stormwater, industrial discharges), and habitat change (causeways, drainage, reclamation, forest clearance).

1. **Excessive Sedimentation.** To address the risk of sediment anoxia in estuaries with extensive areas of soft muds (e.g. Waimea, Motupipi), monitoring the extent of sediment oxidation (either as redox potential or depth to the redox potential discontinuity (RPD) layer) during broad and fine scale assessments is recommended.
2. **Best Management Practices (BMPs).** To address sedimentation and algal bloom issues it is recommended that BMPs be implemented to reduce sediment and nutrient runoff from catchment "hotspots" identified through landuse and erosion mapping.
3. **Re-establish Saltmarsh and Vegetated Terrestrial Buffer.** To improve the condition and biodiversity of estuaries where saltmarsh and the vegetated terrestrial buffer have been lost, it is recommended that re-establishment of these habitats be encouraged wherever opportunities arise.
4. **Undertake Weed and Pest Management.** To improve the condition and biodiversity of estuaries where weeds and pests have entered, it is recommended that high risk species (e.g. *Spartina*, ice plant, invasive grasses, gorse, blackberry, convolvulus, Pacific oyster, mustelids) and locations be identified, and appropriate actions be taken to control incursions.
5. **Sea Level Rise Planning.** To address predicted impacts on valuable estuarine habitat, a sea level rise plan is recommended that accounts for the natural inland migration of estuary and saltmarsh habitat as sea level rises, and addresses barriers to migration such as artificial seawalls. To aid in this planning, LiDAR data of coastal topography is being collected by TDC (currently available for Waimea Inlet).
6. **Limit Effects of Wastewater Discharges.** Ensure all waste and stormwater discharges meet appropriate nutrient, sediment, clarity, disease risk and toxicity guideline criteria within a short distance from outfalls (e.g. 50m mixing zone). Within the mixing zone, ensure no toxic effects and no nuisance conditions.

Executive Summary (continued)

The following section briefly overviews the values, and lists the key issues and recommended responses, for each of the six Tasman estuaries included in this report. The condition ratings and estuary monitoring results are described in Sections 2 and 3, with full details on estuary characteristics and site locations in Appendix 4.

WHANGANUI INLET

The results indicate a relatively unmodified "tidal lagoon" type estuary or inlet with high biodiversity values. The unmodified nature, high incidence of seagrass, high habitat diversity, a fringe of saltmarsh, and a natural vegetated margin place it in the rare company of only a few other such unmodified, high diversity inlets in NZ (e.g. Awarua Bay (near Bluff) and Freshwater Estuary (in Patterson Inlet, Stewart Island). As such, there is a strong need to ensure the estuary has robust monitoring and management in place to ensure its long term protection. However, it is recommended that a regional coastal vulnerability assessment is undertaken to defensibly identify region-wide priorities for coastal monitoring and management before establishing a monitoring programme.

Issues

Limited Monitoring. The Whanganui Inlet was last monitored in 1989. It included broad scale mapping but maps are hard copy only - no GIS mapping has been undertaken. No fine scale physical or chemical monitoring has been undertaken. However, comprehensive macro-invertebrate monitoring was undertaken. Consecutive years of fine scale baseline monitoring have not been undertaken.
Potential for Catchment Development. Contaminants in catchment runoff are a major potential threat to the Whanganui Estuary.
Predicted Sea Level Rise. Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise.
Weeds and Pests. Invasions by pests and weeds are likely.
Limited Current Protection. Current protection (marine reserve in the southern third and a wildlife reserve over the remaining two-thirds) does not protect estuary from catchment inputs.

Recommended Response

Undertake Regional Coastal Vulnerability Assessment to identify when long term monitoring should begin for Whanganui. Monitoring programme is likely to include:

- Map landuse (5 yearly).
- Broad scale habitat map (5-10 yearly).
- Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline).
- Sedimentation rate monitoring.

Management should include:

- Plan for estuary habitat expansion with sea level rise.
- Limit main inputs of fine sediment, nutrients and pathogens.
- Undertake weed and pest management.

RUATANIWHA INLET

The results indicate a modified "tidal lagoon" type estuary or inlet with high biodiversity values. The estuary is unique in the region in that it is fed by a large river (the Aorere), that to a certain extent bypasses the main body of the estuary lagoon. The estuary margin has been developed and areas of saltmarsh lost through historical reclamation.

Issues

Limited Monitoring. Broad scale mapping undertaken in 2001 (not repeated). Consecutive years of fine scale baseline monitoring have not been undertaken.
Intensive Landuse in Catchment. Currently high potential for runoff from intensive dairying in the catchment - but because of dilution in river and good estuary flushing, impacts on estuary are low-moderate.
Lack of Terrestrial Vegetated Buffer. Terrestrial vegetated buffer lost in many areas.
Sedimentation. The area of soft mud in the estuary is at moderate levels.
Predicted Sea Level Rise. Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise.
Weeds and Pests. Invasions by pests and weeds are likely.

Recommended Response

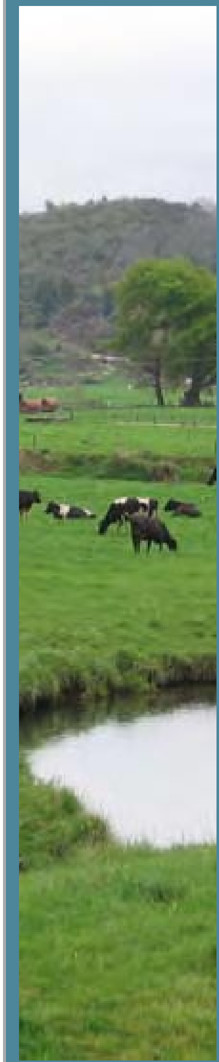
Undertake Regional Coastal Vulnerability Assessment to identify when long term monitoring should begin for Ruataniwha. Monitoring programme is likely to include:

- Map intensive landuse (5-10 yearly).
- Broad scale habitat map (5 yearly).
- Fine scale phys/chem/biota in sediments 5-10 yearly (after 3-4yr baseline).
- Sedimentation rate monitoring.

Management should include:

- Re-establish terrestrial vegetated margin buffer.
- Plan for estuary habitat expansion with sea level rise.
- Limit main inputs of fine sediment, nutrients and pathogens.
- Undertake weed and pest management.

Executive Summary (continued)



MOTUPIPI ESTUARY

The results indicate a modified "tidal lagoon" type estuary with high biodiversity and human use values. The large extent of saltmarsh, shellfish beds and presence of upper estuary subtidal seagrass beds make it especially important.

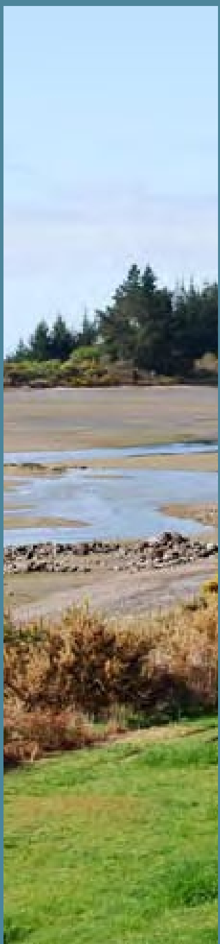
Issues	Recommended Response
Limited Monitoring. A vulnerability assessment and both broad and fine scale monitoring were undertaken in 2008. Consecutive years of fine scale baseline monitoring have not been undertaken. **Catchment Runoff Enriched.** Catchment runoff was identified as one of the major stressors in the Motupipi, with the likely ecological response one of lowered biodiversity and lowered aesthetic and human use values. **Sedimentation**. Some areas of the estuary are excessively muddy. This is likely to be the result of elevated input loads during rain events as well as the limited ability of the estuary to spread and dilute incoming sediment. **Limited Dilution**. Because the Motupipi is a relatively small tidal lagoon estuary, dilution of incoming freshwater is limited. This makes it susceptible to water and sediment quality problems, particularly in the western arm (the Motupipi River input). **Salt Wedge In Upper Estuary.** The upper estuary experiences salinity stratification during stable baseflows (i.e. salt wedge effect). The resulting high salinity bottom layer is generally more stable (less well-flushed) and it therefore has nuisance phytoplankton blooms because nutrient inputs are elevated. **Loss of Saltmarsh.** Saltmarsh habitat has, in the past, been modified through drainage and reclamation activities as well as through nutrient and sediment enrichment. **Predicted Sea Level Rise.** Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise. **Weeds and Pests**. Invasions by pests and weeds are likely.	Undertake Regional Coastal Vulnerability Assessment to identify when long term monitoring should begin for Motupipi. Monitoring programme is likely to include both upper and lower estuary programmes (see Robertson and Stevens 2008 for details). • Map intensive landuse (5 yearly). • Broad scale habitat map (5 yearly). • Broad scale macroalgal mapping (annually for 3 years then 5 yearly or as deemed necessary based on the condition ratings). • Fine scale phys/chem/biota in sediments 5 - 10 yearly (after 3-4yr baseline). • Fine scale water column monitoring (upper estuary only). • Sedimentation rate monitoring. Management should include: • Implement best management practices (BMPs) to reduce sediment, nutrient and pathogen runoff from catchment "hotspots". • Plan for estuary habitat expansion with sea level rise. • Limit main inputs of fine sediment, nutrients and pathogens. • Re-establish saltmarsh habitat where possible. • Undertake weed and pest management.

MOTUEKA ESTUARY/DELTA

The results indicate a modified small "tidal river mouth" type estuary with a large delta system with high biodiversity values and moderate human use. The estuary/delta has significant areas of saltmarsh, shellfish beds and birdlife.

Issues	Recommended Response
Limited Monitoring. Broad scale mapping undertaken in 2003 (not repeated). Fine scale monitoring has not been undertaken. **Wastewater Discharge to Estuary.** Localised enrichment effects and nuisance algal growths occur near Motueka Wastewater Treatment Plant adjacent to the estuary. **Lack of Terrestrial Vegetated Buffer.** Terrestrial vegetated buffer lost in many areas. **Loss of Saltmarsh**. Saltmarsh habitat has, in the past, been modified through drainage and reclamation activities as well as through nutrient and sediment enrichment. **Sedimentation.** The area of soft mud in the delta is at moderate levels. **Predicted Sea Level Rise.** Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise. **Weeds and Pests**. Invasions by pests and weeds are likely.	Undertake Regional Coastal Vulnerability Assessment to identify when long term monitoring should begin for Motueka. Monitoring programme is likely to include: • Map intensive landuse (5 yearly). • Broad scale habitat map (5 yearly). • Sedimentation rate monitoring. Management should include: • Re-establish terrestrial vegetated margin. • Plan for estuary habitat expansion with sea level rise. • Limit effects of wastewater discharge. • Undertake weed and pest management.

Executive Summary (continued)



MOUTERE INLET

The results indicate a modified "tidal lagoon" type estuary with high biodiversity and human use values. The estuary has significant areas of saltmarsh, and extensive shellfish beds and birdlife.

Issues	Recommended Response
Limited Monitoring. Broad and fine scale monitoring undertaken in 2006. Consecutive years of fine scale baseline monitoring have not been undertaken. **Wastewater Discharge to Estuary.** Localised enrichment effects and nuisance algal growths have occurred near the wharf area in the past but recent monitoring results suggest few current problems. **Lack of Terrestrial Vegetated Buffer.** Terrestrial vegetated buffer lost in many areas. **Loss of Saltmarsh**. Saltmarsh habitat has, in the past, been modified through drainage, causeway development and reclamation activities as well as through nutrient and sediment enrichment. **Sedimentation.** The area of soft mud in the estuary is at moderate levels. **Predicted Sea Level Rise.** Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise. **Weeds and Pests.** Invasion by pests and weeds are likely.	Undertake Regional Coastal Vulnerability Assessment to identify Moutere monitoring priorities. Monitoring programme is likely to include: • Map intensive landuse (5 yearly). • Broad scale habitat map (5 yearly). • Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline). • Sedimentation rate monitoring. Management should include: • Re-establish terrestrial vegetated margin buffer. • Plan for estuary habitat expansion with sea level rise. • Limit effects of wastewater discharge. • Undertake weed and pest management.

WAIMEA INLET

The results indicate an extensive modified "tidal lagoon" type estuary with high biodiversity and human use values. The estuary has significant areas of saltmarsh, and extensive shellfish beds and birdlife. Monitoring results for this estuary (the only estuary where such data are available for broad and fine scale measures) show a decline in the area of seagrass and saltmarsh, an increase in soft mud and organic content, and a change in the composition of the macro-invertebrate community.

Issues	Recommended Response
Limited Monitoring. Good broad scale mapping programme. Fine scale monitoring undertaken 1988, 2002 and 2006 but no baseline of consecutive years of monitoring established. **Wastewater Discharge to Estuary.** Significant input from the Bells Island Sewage Treatment plant. Localised areas of toxicity around stormwater and drain discharges. **Lack of Terrestrial Vegetated Buffer.** Terrestrial vegetated buffer lost in many areas. **Loss of Saltmarsh**. Saltmarsh habitat has, in the past, been modified through drainage and reclamation activities as well as through nutrient and sediment enrichment. **Sedimentation.** The area of soft mud in the delta is at high levels. Removal of *Spartina* has likely exacerbated this. **Predicted Sea Level Rise.** Saltmarsh and seagrass habitat is susceptible to loss through accelerated sea level rise. **Weeds and Pests.** Invasions by pests and weeds are likely.	Undertake Regional Coastal Vulnerability Assessment to identify Waimea monitoring priorities. Monitoring programme is likely to include: • Map intensive landuse (5 yearly). • Broad scale habitat map (5 yearly). • Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline). • Sedimentation rate monitoring. Management should include: • Re-establish terrestrial vegetated margin buffer. • Plan for estuary habitat expansion with sea level rise. • Limit effects of wastewater and stormwater discharge. • Undertake weed and pest management.

1. INTRODUCTION

OVERVIEW

Reviewing the condition of coastal and estuarine habitats is critical to the management of these important biological resources. Recently, Tasman District Council (TDC) contracted Wriggle Coastal Management to undertake a review of the condition of the six largest estuaries in its region, and to make recommendations for their future monitoring and management. The estuaries include the Ruataniwha Estuary, Motupipi Estuary, Motueka Estuary and Delta, Moutere Inlet, and the Waimea Estuary - monitored by TDC since 2001 using the National Estuary Monitoring Protocol (NEMP) (Robertson et al. 2002), and the Whanganui Inlet monitored by the Department of Conservation (DOC) in the late 1980's. For the large number of other estuaries in the region, a coastal vulnerability assessment is proposed for 2011-12 to defensibly identify priorities for coastal monitoring and management.

The approach taken in this report (Table 1) has been to use relevant existing monitoring data, including an estuary-specific vulnerability assessment of the Motupipi, to apply established broad and fine scale estuary "condition ratings" for the major issues facing most NZ estuaries: sedimentation, eutrophication, toxicity and habitat loss (Table 2). Disease risk in estuaries, another key issue, is reported on separately by TDC as part of the coastal bathing water monitoring programme.

The main body of the report is focused on two key components:

1. **Methods.** A description of the methods used to review each estuary and to establish condition ratings to assess monitoring data.
2. **Assessment of Estuary Condition.** This reviews the monitoring data for key indicators (where available), and compares the results with established estuary condition ratings (Table 3 summarises the indicators, and the issues that each indicator addresses). This component describes the reasons for an indicator being chosen, outlines the condition rating for each indicator, shows where each estuary fits in the rating, and highlights gaps in the assessment and recommendations for improvement. The indicators themselves fall into two broad groupings:
   * Those that provide broad scale indications of the condition of estuary habitats (including historical mapping results); and
   * Those that provide fine scale indications of the condition of the dominant estuary habitat (generally unvegetated low-midwater intertidal flats).

In addition, Appendix 4 includes a detailed overview of the key characteristics of the estuaries monitored along with the issues and values, ecological values, presence of stressors, susceptibility to stressors, existing condition, and relevant monitoring for each estuary.

Table 1. Summary of the approach used to assess estuary condition.

Broad Scale Mapping Sediment Type Saltmarsh Seagrass Macroalgae Terrestrial margin	→	**Fine Scale Monitoring** Grain size RPD Organic content Nutrients Metals Macro-invertebrates	→	**Condition Ratings** Area soft mud, Area saltmarsh, Area seagrass, Area terrestrial margin, RPD depth, Benthic Community, Organic content, N and P, Toxicity, Sedimentation rate. **Other Information** Previous reports, Observations, Expert opinion	→	**ESTUARY CONDITION** Eutrophication Sedimentation Toxicity Habitat

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

Issue	Impact
Sedimentation	If sediment inputs are excessive, an estuary infills quickly with muds, reducing biodiversity and human values and uses.
Eutrophication	Eutrophication is an increase in the rate of supply of organic matter to an ecosystem. If nutrient inputs are excessive, the ecosystem experiences macroalgal and/or phytoplankton blooms, anoxic sediments, lowered biodiversity and nuisance effects for local residents.
Disease Risk	If pathogen inputs are excessive, the disease risk from bathing, wading or eating shellfish increases to unacceptable levels.
Toxins	If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, estuary biodiversity is threatened and shellfish and fish may be unsuitable for eating.
Habitat Loss	If habitats (such as saltmarsh) are lost or damaged through drainage, reclamation, building of structures, stock grazing or vehicle access, biodiversity and estuary productivity declines.
	If the natural terrestrial margin around the estuary is modified by forest clearance or degraded through such actions as roading, stormwater outfalls, property development and weed growth, the natural character is diminished and biodiversity reduced.

Table 3. Summary of broad and fine scale indicators used to assess estuary condition.

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	Sediment Contaminants	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.

2. METHODS

The approach used to assess the condition of the six largest estuaries in the Tasman region was as follows:

1. **Review available and relevant literature** (listed for each estuary in Section 7).
2. **Summarise relevant estuary characteristics** (where information is available) including; human uses and ecological values, presence of stressors, susceptibility to stressors, existing condition and monitoring data (Appendix 4).
3. **Establish condition ratings for key indicators** using available data relevant to providing information on the condition of key habitat types (and hence estuary issues). As such the selected data tended to be those collected using the National Estuary Monitoring Protocol (NEMP) methodology (Robertson et al. 2002) or other similar approaches.

The NEMP assesses estuary condition using both broad and fine scale habitat characteristics:

- Broad-scale mapping is a method for describing habitat types based on the dominant surface features present, in particular, estuary sediment types (e.g. soft mud), macroalgal beds (e.g. sea lettuce), seagrass (*Zostera*) beds, saltmarsh vegetation, and the 200m terrestrial margin surrounding the estuary. The method involves a combination of aerial photography, detailed ground-truthing, and GIS-based digital mapping.
- Fine scale monitoring provides detailed information on indicators of physical, chemical and biological condition of the dominant habitat type in the estuary. This is most commonly unvegetated intertidal mudflats at low-mid water. Using the outputs of the broad scale habitat mapping, representative sediment sites (usually 2-4 per estuary) are selected and samples collected and analysed for the following variables:
  - Salinity, Depth to black sulphide layer (Redox Potential Discontinuity - RPD), Grain size (% mud, sand, gravel).
  - Organic Matter: Ash free dry weight (AFDW) (converted and reported as total organic content - TOC).
  - Nutrients: Total nitrogen (TN), Total phosphorus (TP).
  - Metals: Total recoverable Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Nickel (Ni) and Zinc (Zn).
  - Macroinvertebrate abundance and diversity (infauna and epifauna)

Taken in combination, the outcome is a series of (often complex) GIS-based habitat maps and fine scale data that provide measures of the extent of different types of habitat cover, and the physical, chemical and biological characteristics of the dominant habitat. These measures are then 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, toxicity and habitat loss.

The data used in the current assessment are drawn from two key sources. Like many Regional Councils, TDC has a long-term estuary monitoring programme that began in 2001 and generally follows the NEMP (Robertson et al. 2002) and recent extensions (Robertson and Stevens 2007). The TDC programme varies in that it does not include the recommended 3-4 years of fine scale baseline monitoring used to establish natural variation. All the Tasman estuaries included in this report, except for the Whanganui, have been monitored using the NMEP methodology. In addition, DOC surveys of Whanganui Inlet and Waimea Inlet (Davidson 1990, and Davidson and Moffat 1990), although differing in their methodology, provide relevant broad scale habitat and fine scale macro-invertebrate information that can be used as early baseline information for these two estuaries.

2. Methods (continued)

CONDITION RATINGS

At present, there are no formal criteria for rating the overall condition of NZ estuaries. Therefore, to help Regional Councils interpret their monitoring data, a series of interim broad and fine scale estuary "condition ratings" (presented below) have been developed based on the ratings used for estuaries in the Southland, Wellington, and Tasman regions - see references in Section 7 for details.

The condition ratings have been developed through a review of monitoring data, use of existing guideline criteria, and expert opinion. They 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 condition ratings indicate whether monitoring results reflect good or degraded conditions, and also include an "early warning trigger" to highlight where rapid or unexpected change occurs.

Fine scale monitoring usually requires a 3-4 year baseline of natural variation to reliably detect future change, whereas a single survey provides an adequate broad scale baseline. 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 to further evaluate specific issues in a targeted manner to consider what response actions may be appropriate (e.g. develop an Evaluation and Response Plan - ERP).

The remainder of this section describes the specific condition ratings used, along with a brief rationale for each.

Soft Mud Percent Cover

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 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 capricorni*) 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%)+(1 x %cover 1-5%)+(3 x %cover 5-10%)+(6 x %cover 10-20%)+(9 x %cover 20-50%)+(12 x %cover 50-80%)+(15x %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)

Seagrass Area

Seagrass is 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 seagrass extent is likely to indicate an increase in these types of pressures and a reduction in estuary biodiversity.

SEAGRASS 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)

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)

Natural Terrestrial Margin 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.

NATURAL TERRESTRIAL MARGIN 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)

2. Methods (continued)

Natural Terrestrial Margin 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.

NATURAL TERRESTRIAL MARGIN 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)

Total Organic Carbon

Estuaries with high sediment organic content can result in anoxic sediments and bottom water, release of excessive nutrients, and adverse impacts to biota - all symptoms of eutrophication. As organic input to the sediment increases the number of suspension-feeders (e.g. bivalves and certain polychaetes) declines and the number of deposit-feeders (e.g. opportunistic polychaetes) increases (Pearson and Rosenburg, 1978).

TOTAL ORGANIC CARBON CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<1%	Monitor at 5 year intervals after baseline established
Low-Mod Enrichment	1-2%	Monitor at 5 year intervals after baseline established
Enriched	2-5%	Post baseline, monitor 2 yearly. Initiate ERP. Manage source
Very Enriched	>5%	Post baseline, monitor 2 yearly. Initiate ERP. Manage source
Early Warning Trigger	>1.3 x Mean of highest baseline yr	Initiate ERP (Evaluation and Response Plan)

Total Phosphorus

In shallow well flushed estuaries, the sediments are often the largest nutrient pool in the system, and phosphorus exchange between the water column and sediments can play a large role in determining trophic status and the growth of algae.

TOTAL PHOSPHORUS CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<200mg/kg	Monitor at 5 year intervals after baseline established
Low-Mod Enrichment	200-500mg/kg	Monitor at 5 year intervals after baseline established
Enriched	500-1000mg/kg	Post baseline, monitor 2 yearly. Initiate ERP
Highly Enriched	>1000mg/kg	Post baseline, monitor 2 yearly. Initiate ERP
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate Evaluation and Response Plan (ERP)

Total Nitrogen

In shallow well flushed estuaries, the sediments are often the largest nutrient pool in the system, and nitrogen exchange between the water column and sediments can play a large role in determining trophic status and the growth of algae.

TOTAL NITROGEN CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<500mg/kg	Monitor at 5 year intervals after baseline established
Low-Mod Enrichment	500-2000mg/kg	Monitor at 5 year intervals after baseline established
Enriched	2000-4000mg/kg	Post baseline, monitor 2 yearly. Initiate ERP
Highly Enriched	>4000mg/kg	Post baseline, monitor 2 yearly. Initiate ERP
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate ERP (Evaluation and Response Plan)

2. Methods (continued)

Metals

Heavy metals provide a low cost preliminary assessment of toxic contamination in sediments and are a starting point for contamination throughout the food chain. Sediments polluted with heavy metals (poor condition rating) should also be screened for the presence of other major contaminant classes: pesticides, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). Note: ISQG = ANZECC (2000) Interim Sediment Quality Guidelines.

METALS CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<0.2 x ANZECC (2000) ISQG-Low	Monitor at 5 year intervals after baseline established
Good	<ISQG-Low	Monitor at 5 year intervals after baseline established
Fair	<ISQG-High but >ISQG-Low	Post baseline, monitor 2 yearly. Initiate ERP
Poor	>ISQG-High	Post baseline, monitor 2 yearly. Initiate ERP
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate ERP (Evaluation and Response Plan)

Sedimentation Rate

Elevated sedimentation rates may lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse, and indicate where changes in land use management may be needed.

SEDIMENTATION RATE CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Low	<1mm/yr (pre-European)	Monitor at 5 year intervals after baseline established
Low	1-5mm/yr	Monitor at 5 year intervals after baseline established
Moderate	5-10mm/yr	Monitor at 5 year intervals after baseline established
High	10-20mm/yr	Post baseline, monitor yearly, initiate ERP
Very High	>20mm/yr	Post baseline, monitor yearly, initiate ERP. Manage source.
Early Warning Trigger	Rate increasing	Initiate ERP (Evaluation and Response Plan)

Macrofauna Biotic Index

Soft sediment macrofauna can be used to represent benthic community health and provide an estuary condition classification (if representative sites are surveyed). The AZTI (AZTI-Tecnalia Marine Research Division, Spain) Marine Benthic Index (AMBI) (Borja et al. 2000) has been verified successfully in relation to a large set of environmental impact sources (Borja, 2005) and geographical areas (in both northern and southern hemispheres) and so is used here. However, although the AMBI is particularly useful in detecting temporal and spatial impact gradients care must be taken in its interpretation in some situations. In particular, its robustness can be reduced when only a very low number of taxa (1–3) and/or individuals (<3 per replicate) are found in a sample. The same can occur when studying low-salinity locations (e.g. the inner parts of estuaries), some naturally-stressed locations (e.g. naturally organic matter enriched bottoms; *Zostera* beds producing dead leaves; etc.), or some particular impacts (e.g. sand extraction, dredge spoil dumping, or fish trawling). The equation to calculate the AMBI Biotic Coefficient (BC) is a s follows;

$$BC = \{(0 \times \%GI) + (1.5 \times \%GII) + (3 \times \%GIII) + (4.5 \times \%GIV) + (6 \times \%GV)\}/100.$$

The ecological groups (GI, GII, GIII, GIV and GV) recorded from Tasman Estuaries are summarized in Appendix 1 Table3.

BENTHIC COMMUNITY CONDITION RATING

RATING	DEFINITION	BC	RECOMMENDED RESPONSE
Normal	Unpolluted	0-0.2	Monitor at 5 year intervals after baseline established
Impoverished (low abundance)	Unpolluted	0.2-1.2	Monitor at 5 year intervals after baseline established
Unbalanced assemblage	Slightly polluted	1.2-3.3	Monitor 5 yearly after baseline established
Transitional to polluted	Moderately polluted	3.3-4.3	Monitor 5 yearly after baseline est. Initiate ERP
Polluted	Moderately polluted	4.3-5.0	Post baseline, monitor yearly. Initiate ERP
Heavily polluted	Heavily polluted	5.0-5.5	Post baseline, monitor yearly. Initiate ERP
Very Heavily polluted	Heavily polluted	5.5-6.0	Post baseline, monitor yearly. Initiate ERP
Extremely polluted	Azoic (devoid of life)	>6.0	Post baseline, monitor yearly. Initiate ERP
Early Warning Trigger	Trend to slightly polluted	>1.2	Initiate Evaluation and Response Plan

3. ESTUARY CHARACTERISTICS

OVERVIEW

When interpreting the results in the following section it is important to recognise that not all of the estuaries monitored have the same characteristics, and therefore differences are expected between different estuary types. A brief overview of the characteristics of the six Tasman estuaries assessed is given below.

The Ruataniwha, Motupipi, Moutere, and Waimea are "tidal lagoon" type estuaries. Tidal lagoon estuaries are shallow, with large basins, simple shorelines and high biodiversity, and are predominantly intertidal with significant river inputs. If the rivers are clean, then biodiversity is high but if they have elevated sediment and nutrient levels, they become muddy, and are susceptible to algal blooms, low sediment oxygen levels, and lowered biodiversity.

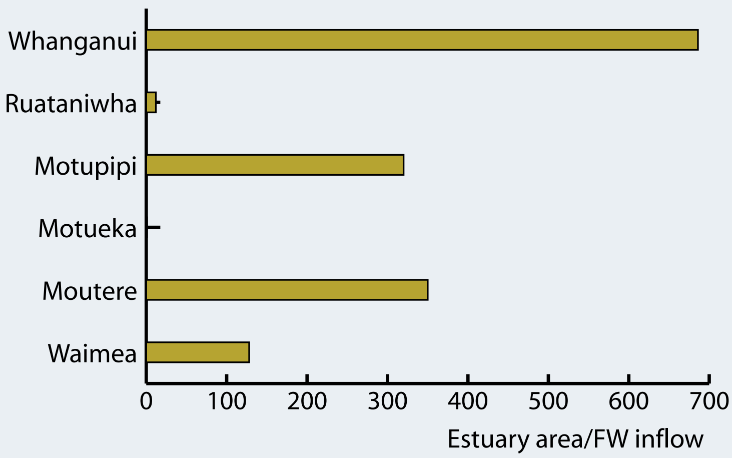
The Whanganui Inlet is also a type of tidal lagoon estuary, but has a larger subtidal area and low freshwater inputs, and therefore is more marine dominated than the others. This type of estuary, if sediment inputs are low, often have clear waters and large areas of seagrass.

The Motueka is a "tidal river mouth" estuary. Tidal river mouth estuaries are narrow, mainly subtidal, have a small area of tidal flats, lower biodiversity and are freshwater dominated. The majority of the river inputs of sediment and nutrient pass through such estuaries and are deposited in inshore coastal waters. When the outputs from such estuaries meet a low energy coastal embayment, like Tasman Bay or Golden Bay, a delta is formed. This results in extensive intertidal flats, including both exposed and protected habitats. At times of high flows, the freshwater influence on such habitats can be large. Both the Motueka Estuary and, to a lesser extent, the Ruataniwha Estuary, have extensive delta systems at their mouths.

For the Tasman estuaries assessed, the dominance of the freshwater influence in the Motueka and Ruataniwha estuaries is highlighted in the relatively low estuary area to freshwater inflow ratios, compared with the other four estuaries (Figure 1).

Additional detail on the characteristics of each estuary is included in Appendix 4.

Figure 1. Ratio of estuary area to freshwater inflow for Tasman estuaries.



4. TASMAN ESTUARY RATINGS

Motupipi Estuary - black sulphide rich muds in seagrass beds

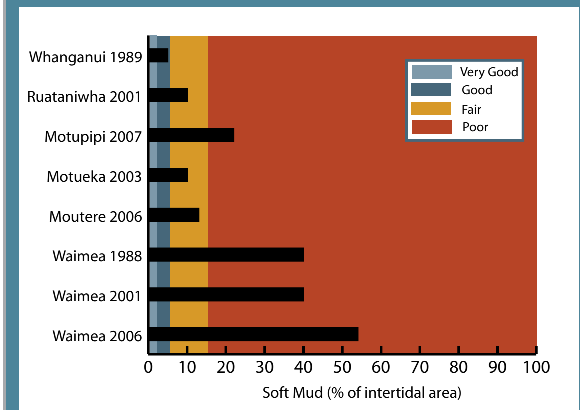
This section compares the available monitoring results for the six Tasman estuaries using the following indicators:

1. **Broad scale condition indicators:**
   - soft mud,
   - seagrass,
   - saltmarsh,
   - macroalgae,
   - natural vegetated terrestrial margin.
2. **Fine scale condition indicators:**
   - grain size,
   - sedimentation rate,
   - organic carbon,
   - phosphorus,
   - nitrogen,
   - toxicants (metals),
   - benthic macrofauna.

The results for the different indicators are presented on graphs in the following sections, along with available condition ratings. Appendix 1 contains the summarised data used, which have been drawn from the source documents listed for each estuary in Section 7.

4.1 BROAD SCALE CONDITION RATINGS

Figure 2. Soft mud as a percentage of intertidal area, Tasman estuaries



1. SOFT MUD AREA

Soil erosion is a major issue in NZ and resulting suspended sediment causes 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 habitats.

The broad scale mapping of the six Tasman estuaries showed that the percentage of soft mud in the intertidal area is relatively high in the majority of these estuaries, ranging from a low of 5% for the partially modified Whanganui Estuary, to 54% for the highly modified Waimea Estuary (Figure 2). The Waimea and Motupipi estuaries both fall within the poor rating category. The results also show that the area of soft mud in the Waimea Estuary increased significantly (by 26% - 400 ha) between 2001 and 2006. The cause of this increase is unknown but Clark et al. (2008) suggested the release of fine sediment previously held in beds of *Spartina* (eradicated from the estuary in the late 1980s) as a possible contributor.

Motupipi Estuary soft muds

Figure 3a. Saltmarsh as a percentage of intertidal area, Tasman estuaries

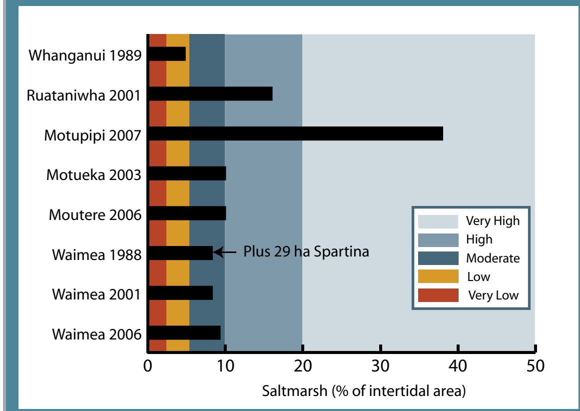


Figure 3b. Saltmarsh loss as a percentage of area, Tasman estuaries

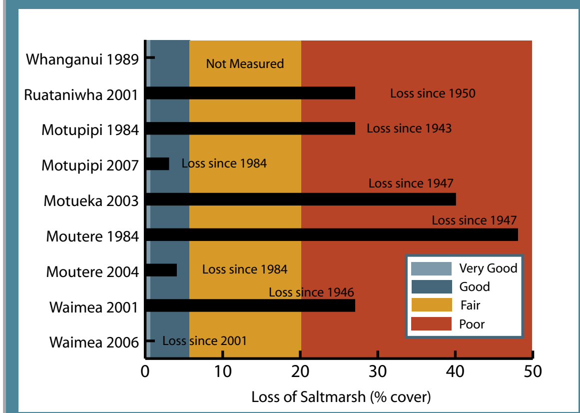
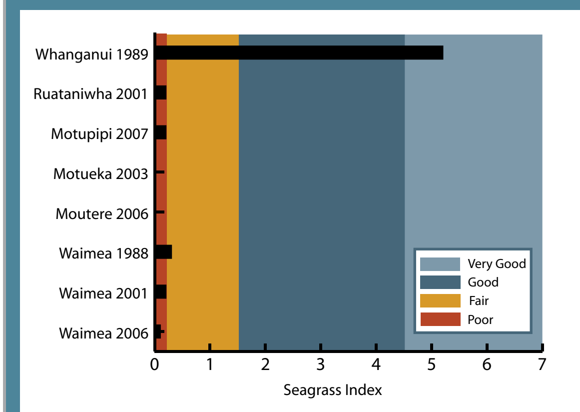
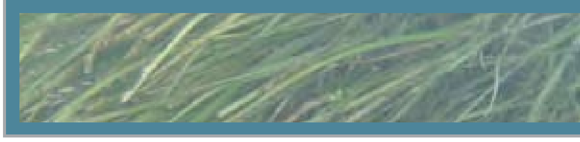


Figure 4. Seagrass index, Tasman estuaries

(Note: the ratings assume that broad scale assessments report seagrass exceeding 50% plant cover per patch, but not lower density patches).



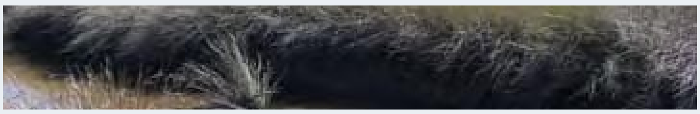


2. SALTMARSH AREA

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.

The broad scale mapping of the six Tasman estuaries showed that the area of saltmarsh (as a percentage of the intertidal area) was very high for the Motupipi (38%), and moderate to high for all the other estuaries except the Whanganui Estuary (4.8%) (Figure 3a). However, historical mapping results show the majority of these estuaries have lost significant areas of saltmarsh (27-48%) in the last 70 years (Figure 3b), losses largely due to reclamation and drainage activities (mostly prior to 1980). Since 1984 the rate of saltmarsh loss has decreased significantly (0-5%) in most estuaries. A small increase (55 ha) was recorded in the Waimea between 2001 and 2006, attributed to an increase in the area of glasswort herbfields (Clark et al. 2008).

The relatively small area of saltmarsh recorded in the Whanganui is likely to be a natural occurrence - the estuary's large subtidal area, depth regime, and geology combine to limit suitable tidal flat habitat. However, this lack of intertidal estuarine saltmarsh vegetation is offset to a large extent by the high levels of seagrass in the estuary.



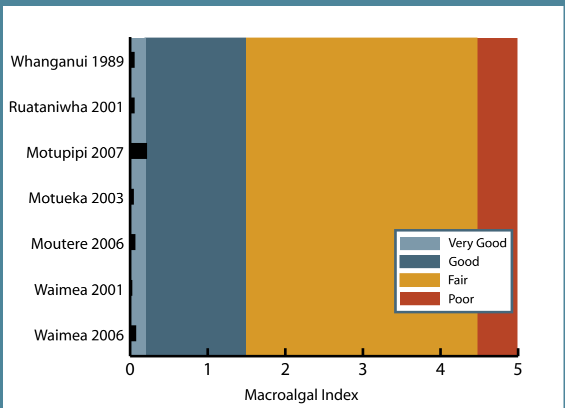
3. SEAGRASS AREA

Seagrass (*Zostera capricorni*) 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, excessive nuisance macroalgal growths and production of sulphide). Seagrass cover is commonly <5% of the intertidal area in NZ estuaries, exceptions being estuaries with relatively intact terrestrial margins and low suspended sediment inputs (e.g. Freshwater Estuary, and Awarua Bay/Bluff Harbour).

The broad scale mapping of the six Tasman estuaries showed that the area of seagrass was relatively high in the Whanganui Estuary (43% of intertidal area) but low (<2%) in the other five estuaries. The condition rating (the Seagrass Coefficient - SC) placed the Whanganui in the "very good" category, and all the others in the "poor" category (SC<0.2), (Figure 4). There has been a steady decline in the mapped area of seagrass in the Waimea Estuary from 1988 to 2006, the only estuary for which there was multi-year data.

4. Tasman Estuary Ratings (continued)

Figure 5. Macroalgal index, Tasman estuaries



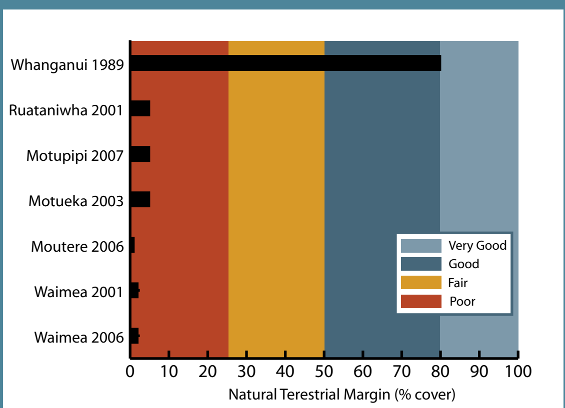
4. NUISANCE MACROALGAL AREA

Certain types of macroalgae (primarily sea lettuce (*Ulva*, *Gracilaria* and *Enteromorpha*) can grow to nuisance levels in nutrient-enriched estuaries causing sediment deterioration, oxygen depletion, bad odours and adverse impacts to biota.

The broad scale mapping of the six Tasman estuaries showed that the area of nuisance macroalgal growth was very low for all of the estuaries (range 0.3-3% of intertidal area). The Motupipi at 3% was the greatest and the Waimea in 2001 was the lowest at 0.3%.

The condition rating (the Macroalgae Coefficient - MC) placed all the estuaries in the "very good" category (MC<0.2), except for the Motupipi which was in the "good" category (Figure 5).

Figure 6. Natural terrestrial margin, Tasman estuaries



5. NATURAL TERRESTRIAL MARGIN

Like saltmarsh, a densely vegetated terrestrial margin provides important habitat for a variety of estuary species, naturally filters sediment and nutrients entering the estuary, and acts as an important buffer protecting against introduced weeds and grasses.

The broad scale mapping of the six Tasman estuaries showed that the percentage of the estuary margin covered by dense natural vegetation was very low for all of the estuaries (5% or less), except the Whanganui (approximately 80%).

The condition rating placed all the estuaries in the "poor" category (<25%), except for the Whanganui which was in the "very good" category (Figure 6). The high rating for the Whanganui is a consequence of the nationally important coastal forest that borders the estuary and covers much of the catchment. The low ratings for the other five estuaries reflects the very developed nature of the lowland areas surrounding each.

Ruataniwha Estuary developed pasture and road on terrestrial margin

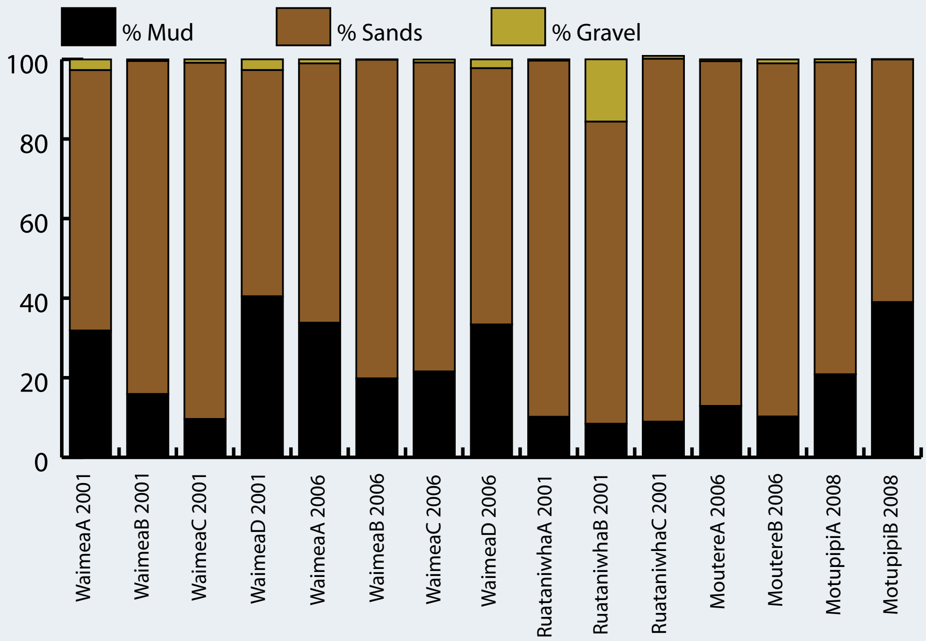
4. Tasman Estuary Ratings (continued)

4.2 FINE SCALE CONDITION RATINGS

1. GRAIN SIZE

Grain size (% mud, sand, gravel) is used to provide a measure of the muddiness of a particular site. The monitoring results (Figure 7) show that all estuaries were dominated by sandy sediments (range 56-90% sand), although there was also a significant mud fraction present (8-40% mud). Not surprisingly, the estuaries with the most developed catchments, i.e. the Waimea and Motupipi, were the muddiest, (particularly Waimea A and D, and Motupipi B). The results also indicate that the fine scale sites in the Waimea Estuary have generally become muddier since 2001.

Figure 7. Grain size, Tasman estuaries (mean data 2001-2008)



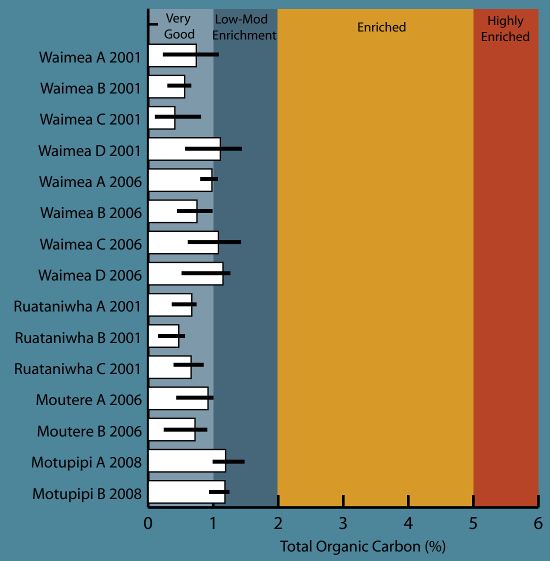
2. RATE OF SEDIMENTATION

Sedimentation rates have not yet been measured in the Tasman estuaries. However, in order to measure the sedimentation rate from now into the future, buried plates were deployed in the Motupipi, Moutere and Waimea estuaries in 2008 in areas where sediment deposition is likely to occur.

Motupipi Estuary - installing sediment plates

4. Tasman Estuary Ratings (continued)

Figure 8. Total organic carbon (mean, range), Tasman estuaries



3. ORGANIC MATTER

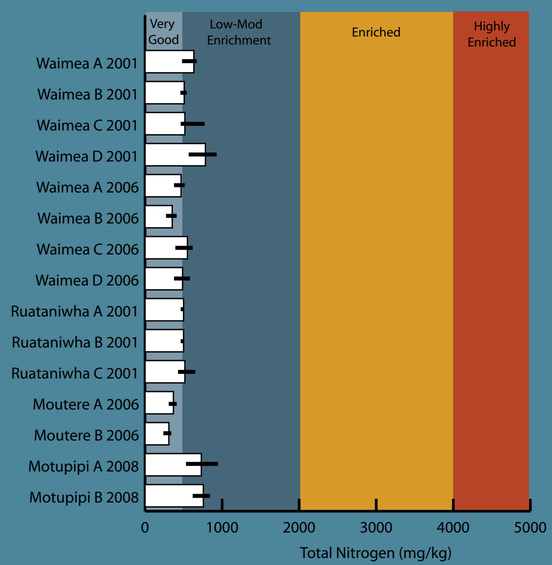
Figure 8 shows that the indicator of sediment organic enrichment (Total Organic Carbon - TOC) at all estuaries was at low concentrations (<1.5%) and met the "low-moderate enrichment" to "very good" condition ratings.

The low TOC levels reflect the large dilution capacity and generally well-flushed nature of the larger Tasman estuaries and a likely low to moderate load of organic matter depositing on the sediments.

As expected, the muddiest estuaries, i.e. the Motupipi and Waimea, had the greatest organic matter concentrations (1-1.5% TOC) whereas the Ruataniwha Estuary had the lowest (0.2-0.9% TOC). No TOC data were available for Whanganui Estuary.

Over the five year monitoring period there was a general trend of increasing organic matter concentrations in the Waimea Estuary, which reflects the increased muddiness over the same period.

Figure 9. Total nitrogen (mean, range), Tasman estuaries

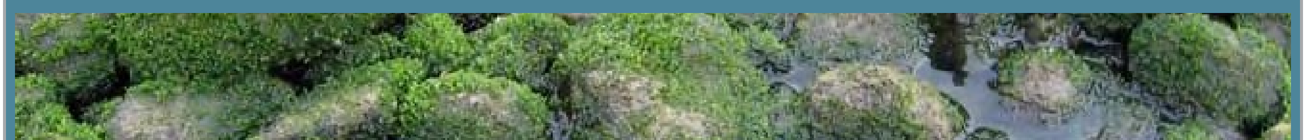


4. TOTAL NITROGEN

Sediment total nitrogen (TN) concentrations (a key nutrient in the eutrophication process) were low-moderate or below (mean less than 800mg/kg) for all estuaries which placed them in the "low-moderate enrichment" to "very good" categories (Figure 9).

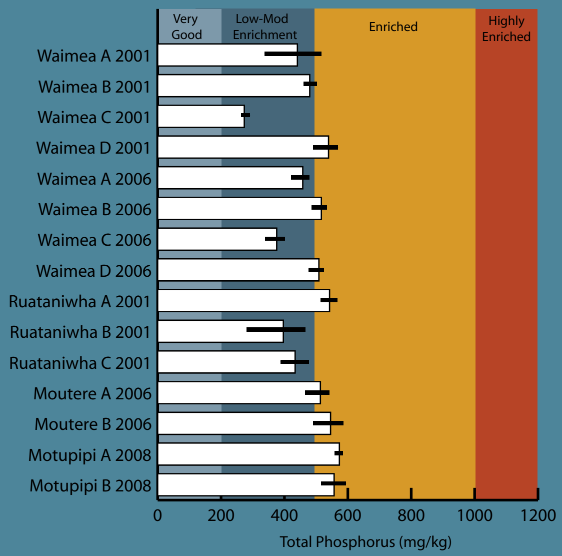
The highest TN concentrations were at the sites with the highest mud fractions, that is Motupipi Estuary Site B in 2008 (mean 756 mg/kg TN and 40% mud) and Waimea Site D in 2001 (783 mg/kg TN and 40% mud). However, Motupipi Estuary Site A differed in that it had an elevated TN concentration (753 mg/kg) despite a lower mud fraction (20% mud) - probably a result of its close proximity to eutrophic sections of the estuary (e.g. areas with algal blooms, sulphide rich sediments and low dissolved oxygen) and elevated river inputs of nitrogen (Robertson and Stevens 2008).

It was difficult to determine which estuaries had the lowest TN concentrations because of variations in the analytical detection limit and methodologies (see Appendix 3 for further discussion of this aspect).



4. Tasman Estuary Ratings (continued)

Figure 10. Total phosphorus (mean, range), Tasman estuaries



5. TOTAL PHOSPHORUS

Sediment total phosphorus (TP) concentrations (another key nutrient in the eutrophication process) were in the "low to moderately enriched" or "enriched" categories (mean 230-600 mg/kg) for all estuaries (Figure 10).

The Motupipi Estuary had the highest concentrations 550-580 mg/kg) and Waimea Site C, the lowest (270-380 mg/kg).

Although such levels are elevated and could cause eutrophication problems in some estuaries, they are unlikely to cause such problems in the six Tasman estuaries because of their nitrogen limitation status. This is because the ratio of TN:TP is below the critical 7.2:1 by weight ratio where balanced algal growth is estimated to occur, with N in shortest supply and as such limiting algal growth.

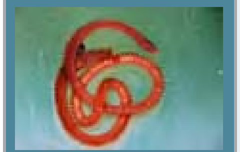
6. METALS

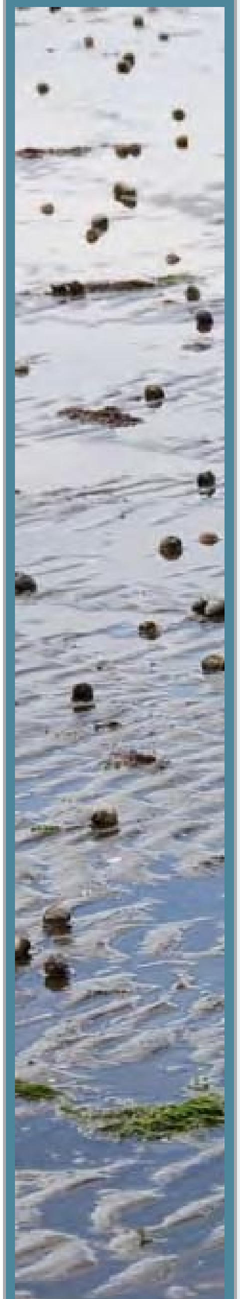
Heavy metals (total recoverable Cd, Cr, Cu, Ni, Pb, Zn), used as an indicator of potential sediment toxicants, were at very low to moderate concentrations in the estuaries (see Figure 11 on following page).

Cadmium, copper, lead and zinc concentrations were all rated in the "very good " category, while chromium and particularly nickel concentrations were elevated. Nickel generally exceeded the ANZECC (2000) ISQG-Low trigger values, except for Ruataniwha Estuary. Chromium concentrations, although they didn't exceed the ANZECC (2000) ISQG-Low trigger values, were also elevated and generally met the "good" condition rating. The cause for the elevated nickel and chromium concentrations in Tasman estuaries has been attributed to the naturally high levels of these metals in the catchment, in particular, the mineral rich ultramafic rocks of the Dun Mountain complex (Chittendon et al. 1966, Robinson et al. 1996).

The very low concentrations of copper, cadmium, lead and zinc reflects the well-flushed nature of the main bodies of these estuaries and the relatively low urban and industrial development of their catchments, which are the major sources of these metals.

Figure 11. Metals (mean, range), Tasman estuaries



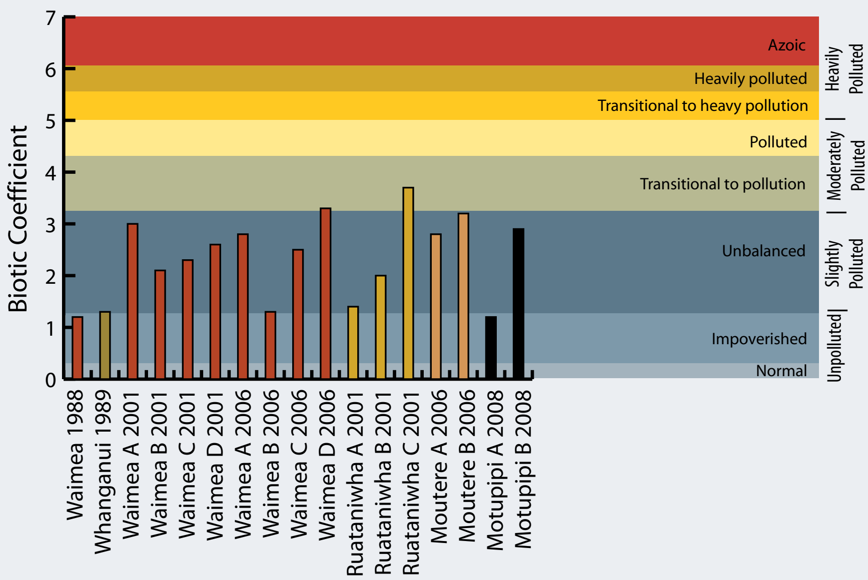


7. BENTHIC COMMUNITY INDEX

Borja et al. (2000) recently developed a new benthic community index - AMBI (the AZTI (AZTI-Tecnalia Marine Research Division, Spain, Marine Benthic Index) to assess the environmental status of coastal and estuarine systems. The AMBI assesses estuary condition by placing individual species into groups able to tolerate different levels of environmental degradation. Based on the groupings of species present it is then possible to classify the overall quality of the environmental conditions present, ranging from normal, through polluted, to azoic (without life) (Figure 12). Results from around the world have shown the AMBI to be a very promising tool, and within NZ the index has recently been successfully applied to estuaries in the Tasman, Southland and Wellington regions (Robertson and Stevens 2008, 2008a, 2008b).

The AMBI has been applied to the five Tasman estuaries for which macro-invertebrate data are available (summary data and sampling methods are included in Appendix 1 and 2 respectively). The AMBI showed that the benthic invertebrate community at all sites ranged between "slightly impoverished or slightly less than normal" to a "transitional to pollution" state (Figure 12). Such conditions signify "unpolluted to moderately polluted/unbalanced" conditions. The most enriched site was Ruataniwha Site C, located in the western arm of the estuary, with other sites in the Waimea, Moutere and Motupipi estuaries also elevated. The Waimea Estuary was the only estuary where data were available to assess changes over time. While differences over time were evident, the absence of a multi-year baseline measure of natural variation (as recommended in the NEMP) means it is not possible to determine if changes are natural or human influenced.

Figure 12. Benthic community condition rating for Tasman estuaries 1988 - 2008



NOTE: the Waimea 1988 data (from Davidson and Moffatt 1990) and Whanganui 1989 data (from Davidson 1990) were collected using different methods to the NEMP and are presented as a mean of lower intertidal sites.

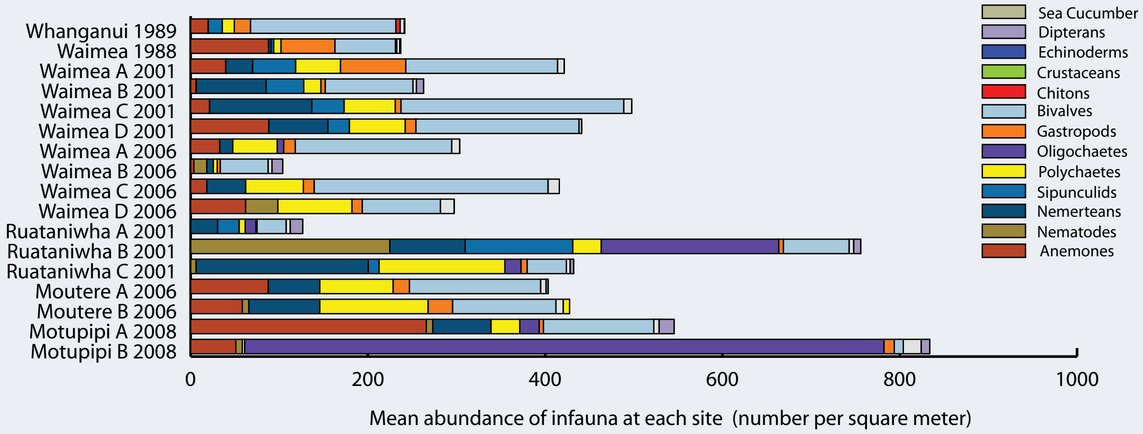
8. BENTHIC INVERTEBRATE COMMUNITY

The macro-invertebrate community (defined as sediment dwelling animals retained on a 0.5mm sieve) in the majority of estuaries was rated as "unbalanced". This rating is not unexpected, given the generally highly developed catchments of many of the estuaries, and is attributable to the presence of species able to tolerate moderate organic enrichment (i.e. species in AMBI groups III-V). In particular they include surface deposit feeding species such as tube-building spionid polychaetes, as well as those that tolerate high levels of enrichment, mainly small-sized, sub-surface deposit feeding polychaetes such as *Heteromastus*.

9. MACRO-INVERTEBRATE GROUPS

Like other NZ estuaries, the intertidal benthic community at most sites was dominated in terms of abundance by bivalves (primarily cockles, *Arthritica* sp. and the wedge shell *Macomona liliana*) and polychaetes, but also had high numbers of anemones (Figure 13). Gastropods, crustaceans, sipunculids and nematodes were moderately abundant. Unusual groupings noted were Ruataniwha Site B, which was dominated by oligochaete worms, nematodes and sipunculids, Motupipi Site A with high numbers of anemones, and Motupipi Site B which had unusually elevated numbers of oligochaetes. Whether such groupings are consistent over time has yet to be assessed for these estuaries.

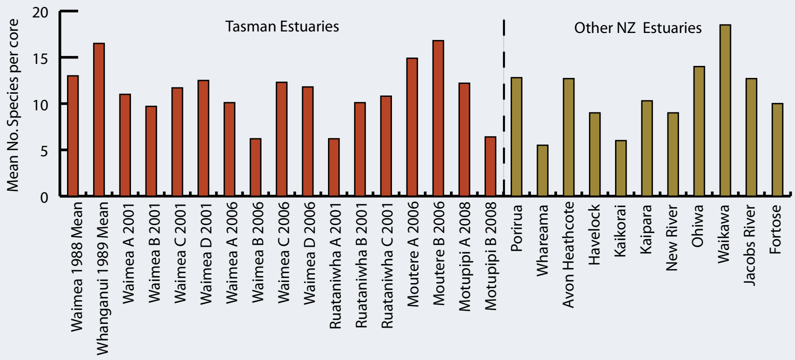
Figure 13. Mean abundance of macrofauna groups in Tasman estuaries



10. MACRO-INVERTEBRATE COMMUNITY DIVERSITY

The community in all estuaries included a wide range of species (mean 6-19 species per core). The most diverse sites were, as expected, amongst *Zostera* beds in the Whanganui Estuary (mean 16.5 species per core in 1989). The Moutere Estuary was the most diverse of the remaining estuaries (15-17 species per core). Community diversity was similar to intertidal mudflats in other NZ estuaries that drain developed catchments (Figure 14).

Figure 14. Mean number of infauna species, Tasman estuaries compared with other NZ estuaries (source: Robertson et al. 2002, Robertson and Stevens 2006)

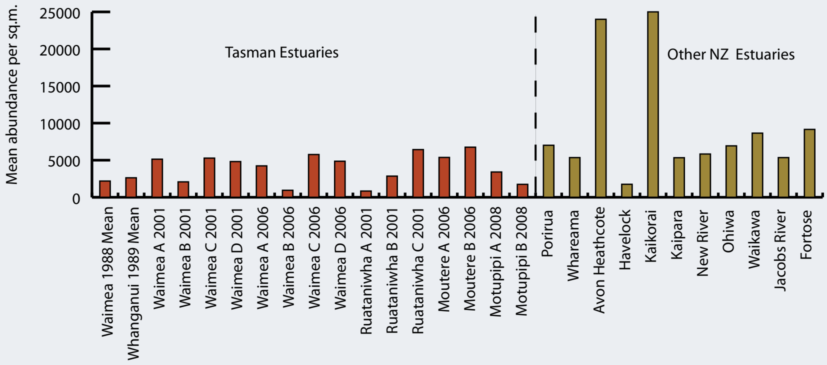


11. MACRO-INVERTEBRATE COMMUNITY ABUNDANCE

The overall community abundance in the Tasman estuaries was low-moderate at 800-6,800m^{-2} (Figure 15, Appendix 1), and similar to other NZ estuaries with developed catchments. Note that in Figure 15 the two estuaries with the greatest abundances were the eutrophic Kaikorai and Avon Heathcote estuaries in 2001.

Sabellaridae polychaete tubes

Figure 15. Mean total abundance of macrofauna in Tasman estuaries compared with other NZ estuaries



12. VARIATIONS IN MACRO-INVERTEBRATE COMMUNITY COMPOSITION

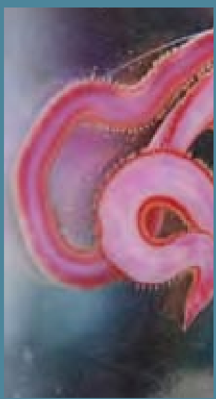
In terms of the community composition, differences were present between sites and estuaries. This is evident in Appendix 1 Table 3 which shows the 10 most abundant species present at each site for each year sampled. The differences in community composition between sites and years were explored using multivariate data analysis (nonmetric multidimensional scaling (NMDS) using PRIMER vers. 6.1.10). In simple terms, the analysis plots the site, year, and abundance data for each species as points on a distance-based matrix (a scatterplot ordination diagram). Points clustered together are considered similar, with the distance between points and clusters reflecting the extent of the differences. For example, if all Site A points are clustered close to each other in one area of the matrix and Site B points are clustered in another area but spread further apart, this shows that Site A communities are similar to each other and different from Site B communities, while Site B communities are different from Site A, but also different from each other. Differences between years are assessed in the same way. The interpretation of the ordination diagram depends on how well it represents actual dissimilarities, which are assessed by a calculated stress value. Stress values greater than 0.3 indicate that the configuration is no better than arbitrary, while it is not meaningful to try and interpret configurations unless stress values are less than 0.2.

The NMDS ordination plots for the Tasman estuaries are presented in Figures 16 and 17. Figure 16 shows the coordinate points for each of the replicate samples taken at each site in the estuaries between 1988 and 2008. The stress value of 0.24 indicates that the configuration can be interpreted, but not very reliably. Consequently, replicates for each site have been averaged and, in the cases of Waimea 1988 and Whanganui 1989, replicates for all the sites have been averaged. These results (Figure 17) have a low stress level of 0.12 and can therefore be reliably interpreted. Overall, the results indicate the following:

- Between both estuaries and years, differences in macro-invertebrate community composition were evident, but the differences were not great. These results are consistent with the AMBI Benthic Community Index which showed communities were all at the low end of the organic enrichment or pollution category (i.e. "slightly less than normal to slightly polluted or enriched" categories).
- Community composition in Whanganui Inlet in 1989, which has a relatively undeveloped catchment and has large areas of seagrass beds, tended to differ from other estuaries. The dominant species were primarily pollution-intolerant bivalves (cockles, minute clams, nut shells) and gastropods. Community composition in the sandy sites of Waimea Estuary in 1988 (but not 2001 and 2006) was similar to the sandy sites of the Whanganui Inlet and differed from other estuaries.

4. Tasman Estuary Ratings (continued)

Edwardsia **- a common burrowing anemone**



Glycera **- a common polychaete**

Scoloplos **- a common polychaete**

Figure 16. NMDS plot showing the relationship among samples in terms of similarity in community composition for Tasman estuaries (1988 to 2008) - based on Bray Curtis dissimilarity and fourth root transformed data.

Note: Coloured polygons have been added as a visual aid to show site differences and are not an NMDS output.

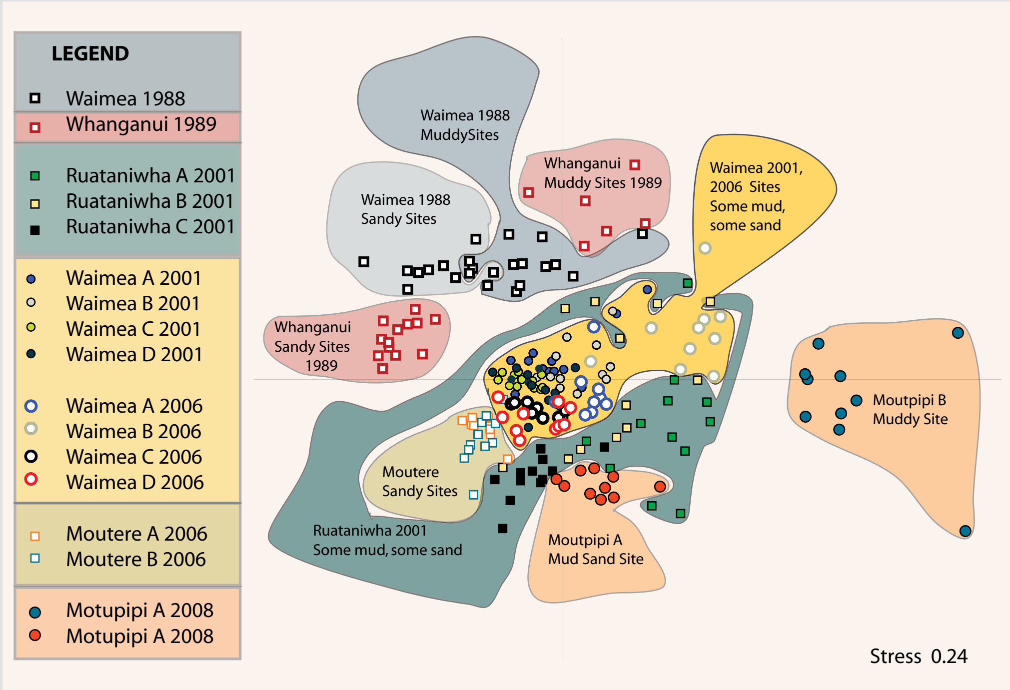
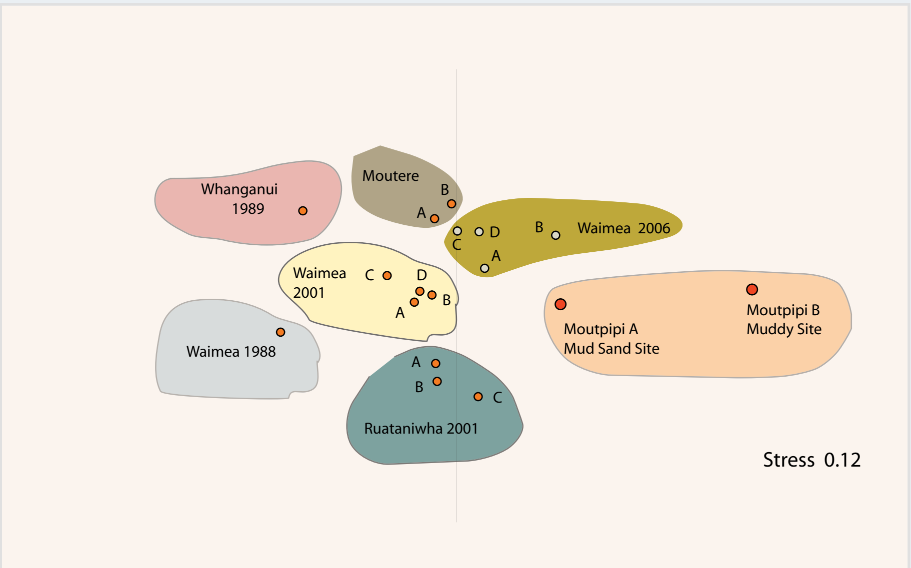


Figure 17. NMDS plot showing the relationship among means of samples in terms of similarity in community composition for Tasman estuaries (1988 to 2008) - based on Bray Curtis dissimilarity and fourth root transformed data

Note: Coloured polygons have been added as a visual aid to show site differences and are not an NMDS output.



4. Tasman Estuary Ratings (continued)

Heteromastus **- a common pollution tolerant polychaete in Tasman estuaries.**

- Differences were evident between 2001 and 2006 in the Waimea Estuary (the only estuary where the same sites were sampled in different years using the NEMP). However, the lack of a baseline of natural variation (generally a 3-4 year consecutive record) means it is difficult to determine if the differences are due to natural variation or some other reason. Similarly, because 1989 sampling methods, sites, and replication were different from those used in 2001 and 2006, it is difficult to determine the likely cause of the differences. However, the changes correlate with fine scale increases in organic content, increased soft mud and, at an estuary-wide scale, decreases in saltmarsh and seagrass area. Therefore, increased muddiness and organic enrichment is considered a likely cause of the shift in the biological community.
- Motupipi Site B was the most different to all the other sites. It was a muddy site (39% mud), dominanted by oligochaete worms, the tube-dwelling amphipod *Paracorophium* sp., mud snails and the small deposit feeding bivalve *Arthritica*.

Overall the results provide a good description of community composition in the low to moderately enriched estuaries monitored in the Tasman region. However, identification of the significance and likely cause of any long term change is difficult without a robust baseline, a key component currently missing from the estuary monitoring programme.

It is also important to note that many other Tasman estuaries have not yet been monitored and may be more vulnerable than those included in the current programme. This aspect will be addressed through a Regional Coastal Vulnerability Assessment scheduled for 2011/12. The outcome of the assessment will be a defensible and cost effective prioritisation of coastal monitoring with effort allocated based on risk or vulnerability.

Ruataniwha Estuary

5. SUMMARY AND CONCLUSIONS

Overall, the fine and broad scale monitoring results showed that of the six Tasman estuaries evaluated all, except the relatively undeveloped Whanganui, were typical of NZ tidal lagoon and tidal river mouth estuaries with developed catchments.

Human and ecological values were moderate to high, and habitats included saltmarsh, seagrass, unvegetated tidal flat habitats, and highly modified terrestrial margins. The results of the condition ratings showed that the state of the dominant habitat (i.e. unvegetated tidal flats) was in relatively good to moderate condition (an absence of widespread nuisance macroalgal cover, low levels of organic matter, nutrients and heavy metals). Poor ratings were, however, found for a few indicators. In particular, extensive loss of saltmarsh and seagrass in most of the estuaries, and increased sedimentation in the Waimea (area of soft mud increased by 26% since 2001). However, interpretation of the findings are constrained by limited monitoring, which reduces the ability to clearly identify estuary condition and potential causes of change.

To address these issues, TDC have scheduled a Regional Coastal Vulnerability Assessment for the 2011 and 2012 financial years to define a defensible, cost effective, and robust long term coastal monitoring programme for the region. In addition, because of specific concerns with the Waimea Estuary, a vulnerability assessment of the estuary is scheduled for 2010.

6. ACKNOWLEDGEMENTS

This work has been funded by Tasman District Council and has been undertaken with help from various people: local residents who have provided access to the estuaries and the large numbers of people we have talked with over the years who use the estuaries. Thanks is also due to Maz Robertson for editing, and lastly the staff of Tasman District Council (particularly Trevor James) who made it all happen, provided reports and monitoring data for review, and provided valuable comments.

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APPENDIX 1. TASMAN ESTUARY RESULTS SUMMARY

APPENDIX TABLE 1. BROAD SCALE INDICATOR RESULTS FOR TASMAN ESTUARIES.

Estuary	Intertidal Area	Soft Mud	Seagrass	Saltmarsh	Macroalgae	Natural Terrestrial Margin	Change in Saltmarsh Area	
	ha	ha (% of intertidal)				%	ha (% change)	Period
Whanganui 1988 (DOC)	1979	110 (5.6%)	860 (42.4%)	96 (4.9%)	15 (0.8%)	80%	No available baseline	
Ruataniwha 1950	776	-	-	181 (23.3%)	-		Baseline measure	1950
Ruataniwha 2001	726	89 (12.3%)	12 (1.7%)	131 (18.0%)	(<1%)	5%	-50 ha (-27%)	1950-2001
Motupipi 1943	196	-	-	86 (43.9%)	-		Baseline measure	1943
Motupipi 1984	163	-	-	64 (39.3%)	-		-22 ha (-27%)	1943-1984
Motupipi 2007	160	36 (22.5%)	2.5 (1.6%)	62 (38.8%)	5.0 (3.1%)	5%	-2 ha (-3%)	1984-2007
Motueka 1947	756			82 (10.8%)	-		Baseline measure	1947
Motueka 2001	600	60 (10%)	0 (0%)	49 (8.2%)	3.5 (0.6%)	5%	-33 ha (-40%)	1947-2001
Moutere 1947	748	-	-	151 (20.2%)	-		Baseline measure	1947
Moutere 1988	708	-	-	79 (11.2%)	-		-72 ha (-48%)	1947-1988
Moutere 2006	705	92 (13.0%)	1 (0.1%)	76 (10.8%)	6 (0.8%)	<5%	-3 ha (-4%)	1988-2006
Waimea 1946	2899	-	-	307 (10.6%)	-		Baseline measure	1946
Waimea 1988 (DOC)	2749	1126 (41.7%)	58 (2.1%)	259 (9.4%)	15 (0.5%)	<5%	-48 (-16%)	1946-1988
Waimea 2001	2749	1140 (41.5%)	28 (1.0%)	224 (8.1%)	7 (0.3%)	<5%	-35 ha (-14%)	1988-2001
Waimea 2006	2793	1541 (55.2%)	21 (0.8%)	279 (10.0%)	32 (1.1%)	<5%	+55 ha (+20%)	2001-2006

Figures are based on those reported in the relevant monitoring reports. For historical reports estimates of intertidal area are approximate only.

APPENDIX TABLE 2. PHYSICAL AND CHEMICAL RESULTS (MEANS) FOR TASMAN ESTUARIES 2001-2008.

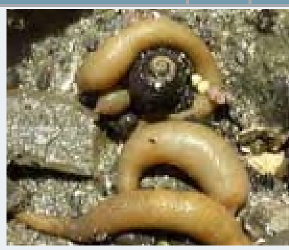
Estuary	Reps.	AFDW	TOC	Mud	Sand	Gravel	Cd	Cr	Cu	Ni	Pb	Zn	TN	TP
		%					mg/kg							
Ruataniwha A 2001	12	1.28	0.67	10.19	89.48	0.35	0.02	27.08	8.74	15.50	7.58	40.83	500.00	542.33
Ruataniwha B 2001	12	0.89	0.47	8.43	75.92	15.67	0.07	20.31	5.13	12.56	4.88	36.67	500.00	396.50
Ruataniwha C 2001	12	1.37	0.66	8.95	91.20	0.73	0.22	24.67	7.36	13.00	1.99	35.00	516.67	433.67
Motupipi A 2008	3	2.27	1.19	20.87	78.40	0.77	0.04	43.67	9.63	28.33	6.27	44.00	730.00	573.33
Motupipi B 2008	3	2.23	1.18	39.00	60.97	0.10	0.01	26.33	5.70	16.33	3.90	27.33	756.667	556.67
Moutere A 2006	10	1.75	0.92	12.93	86.61	0.48	0.10	29.60	6.14	58.40	4.64	25.00	368.00	513.40
Moutere B 2006	10	1.38	0.72	10.25	88.75	0.99	0.10	33.80	6.02	76.10	3.67	26.80	309.00	545.50
Waimea A 2001	12	1.40	0.74	31.85	65.44	2.70	0.20	69.25	10.27	65.08	4.33	44.17	633.33	440.83
Waimea B 2001	12	1.07	0.56	15.90	83.69	0.41	0.20	44.58	8.83	72.33	6.34	38.42	508.33	479.83
Waimea C 2001	12	0.78	0.41	9.63	89.51	0.87	0.38	61.33	7.00	58.25	7.68	34.50	516.67	273.25
Waimea D 2001	12	2.10	1.11	40.47	56.83	2.72	0.48	95.17	12.25	94.17	11.33	50.17	783.33	539.08
Waimea A 2006	10	1.86	0.98	33.82	65.17	1.03	0.10	48.60	7.87	64.80	6.37	34.70	468.00	457.80
Waimea B 2006	10	1.43	0.75	19.85	80.04	0.13	0.10	32.00	6.74	69.40	5.12	27.90	353.00	516.40
Waimea C 2006	10	2.06	1.08	21.60	77.61	0.76	0.10	42.30	7.83	60.60	5.88	28.20	550.00	375.60
Waimea D 2006	10	2.19	1.15	33.39	64.39	2.22	0.10	55.10	9.42	89.20	6.35	34.50	487.00	508.70

APPENDIX 1. TASMAN ESTUARY RESULTS SUMMARY (CONTINUED)

APPENDIX TABLE 3. MEAN ABUNDANCE (PER 0.133M²), 10 MOST ABUNDANT MACROFAUNA SPECIES

NA indicates AMBI group not yet assigned

Whanganui 1989	AMBI		Waimea 1988	AMBI		Moutere A 2006	AMBI		Moutere B 2006	AMBI	
Austrovenus stutchburyi	I	975	Diloma subrostrata	NA	750	Prionospio sp	IV	1494	Prionospio sp	IV	2427
Nucula hartvigiana	III	357	Austrovenus stutchburyi	I	289	Heteromastus filiformis	IV	1290	Paraonidae	III	1297
Kellia cycladiformis	I	260	Nucula hartvigiana	III	190	Austrovenus stutchburyi	I	787	Macomona liliana	I	590
Zeacumantus subcarinatus	NA	151	Macomona liliana	I	184	Macomona liliana	I	488	Heteromastus filiformis	IV	547
Nereidae	III	132	Anthopleura aureoradiata	II	176	Aglaophamus sp	II	197	Nucula hartvigiana	III	255
Prionospio sp	IV	119	Nereidae	III	93	Zeacumantus subcarinatus	NA	160	Austrovenus stutchburyi	I	226
Scolecolepides sp	III	86	Capitellidae	IV	82	Edwardsia sp	II	117	Nicon aestuariensis	III	219
Scalibregmidae	III	58	Micrelenchus tenebrosus	NA	66	Nucula hartvigiana	III	117	Zeacumantus subcarinatus	NA	211
Phoxocephalidae	NA	55	Axiothella quadrimaculata	I	61	Cumacea	NA	95	Edwardsia sp	II	117
Soletellina sp	I	45	Amphibola crenata	NA	51	Maldanidae	I	80	Amphipoda	NA	95
Waimea A 2001	**AMBI**		**Waimea B 2001**	**AMBI**		**Waimea C 2001**	**AMBI**		**Waimea D 2001**		**AMBI**
Arthritica bifurca	III	1038	Austrovenus stutchburyi	I	571	Austrovenus stutchburyi	I	1839	Heteromastus filiformis	IV	1299
Heteromastus filiformis	IV	941	Arthritica bifurca	III	304	Prionospio sp	IV	1153	Austrovenus stutchburyi	I	1196
Potamopyrgus estuarinus	NA	941	Nereidae	III	225	Heteromastus filiformis	IV	674	Prionospio sp	IV	692
Prionospio sp	IV	589	Heteromastus filiformis	IV	206	Arthritica bifurca	III	267	Arthritica bifurca	III	401
Austrovenus stutchburyi	I	419	Prionospio sp	IV	200	Nereidae	III	212	Macomona liliana	I	182
Nereidae	III	376	Macomona liliana	I	97	Nucula hartvigiana	III	194	Anthopleura aureoradiata	II	176
Macomona liliana	I	212	Scolecolepides sp	III	85	Macomona liliana	I	188	Nereidae	III	164
Amphibola crenata	NA	146	Nemertea	III	79	Aonides sp	III	176	Maldanidae	I	85
Amphipoda	NA	121	Amphipoda	NA	79	Amphipoda	NA	140	Aonides sp	III	73
Anthopleura aureoradiata	II	79	Sipuncula	I	42	Nemertea	III	115	Boccardia sp	I	73
Waimea A 2006	**AMBI**		**Waimea B 2006**	**AMBI**		**Waimea C 2006**	**AMBI**		**Waimea D 2006**		**AMBI**
Arthritica bifurca	III	1180	Austrovenus stutchburyi	I	379	Austrovenus stutchburyi	I	1574	Heteromastus filiformis	IV	1742
Nicon aestuariensis	III	1057	Arthritica bifurca	III	124	Prionospio sp	IV	1385	Prionospio sp	IV	955
Prionospio sp	IV	619	Nicon aestuariensis	III	80	Arthritica bifurca	III	831	Austrovenus stutchburyi	I	641
Austrovenus stutchburyi	I	532	Scolecolepides sp	III	66	Nicon aestuariensis	III	780	Nicon aestuariensis	III	488
Heteromastus filiformis	IV	219	Helice crassa	NA	44	Heteromastus filiformis	IV	357	Amphipoda	NA	211
Amphipoda	NA	117	Amphipoda	NA	36	Macomona liliana	I	153	Arthritica bifurca	III	124
Cominella glandiformis	NA	95	Dolichopodidae	NA	36	Amphipoda	NA	117	Anthopleura aureoradiata	II	117
Macrophthalmus hirtipes	NA	95	Macomona liliana	I	29	Macrophthalmus hirtipes	NA	102	Macrophthalmus hirtipes	NA	102
Scolecolepides sp	III	58	Cominella glandiformis	NA	22	Zeacumantus lutulentus	NA	73	Macomona liliana	I	95
Anthopleura aureoradiata	II	51	Zeacumantus lutulentus	NA	22	Nucula hartvigiana	III	73	Cominella glandiformis	NA	73
Ruataniwha A 2001	**AMBI**		**Ruataniwha B 2001**	**AMBI**		**Ruataniwha C 2001**	**AMBI**				
Austrovenus stutchburyi	I	273	Austrovenus stutchburyi	I	680	Heteromastus filiformis	IV	4535			
Heteromastus filiformis	IV	127	Aonides sp	III	461	Maldanidae	I	552			
Maldanidae	I	79	Heteromastus filiformis	IV	231	Macomona liliana	I	304			
Amphipoda	NA	67	Nematoda	III	225	Nemertea	III	194			
Macomona liliana	I	49	Prionospio sp	IV	225	Prionospio sp	IV	134			
Hexatomini sp	NA	42	Oligochaeta	NA	200	Capitella capitata	V	115			
Helice crassa	NA	30	Sipuncula	I	121	Austrovenus stutchburyi	I	109			
Nemertea	III	30	Maldanidae	I	109	Nereidae	III	79			
Sipuncula	I	24	Nemertea	III	85	Haminoea zelandiae	NA	67			
Capitella capitata	V	18	Polynoidae	II	85	Sigalionidae	II	36			
Motupipi A 2008	**AMBI**		**Motupipi B 2008**	**AMBI**							
Austrovenus stutchburyi	I	779	Oligochaeta	NA	721						
Edwardsia sp	II	532	Paracorophium sp	NA	444						
Spionidae	NA	466	Amphibola crenata	NA	153						
Macomona liliana	I	379	Arthritica bifurca	III	102						
Heteromastus filiformis	IV	277	Edwardsia sp	II	102						
Maldanidae	I	277	Capitella capitata	V	44						
Arthritica bifurca	III	87	Helice crassa	NA	44						
Nicon aestuariensis	III	73	Nicon aestuariensis	III	36						
Nemertea	III	66	Dipteran larvae	NA	29						
Capitella capitata	V	58	Potamopyrgus estuarinus	NA	22						



APPENDIX 1. SUMMARY TASMAN ESTUARY RESULTS (CONTINUED)

APPENDIX TABLE 4. MACROFAUNA RESULTS (MEANS) FOR TASMAN ESTUARIES 1988-2008.

Estuary	Infauna		Estuary	Infauna	
	Mean Abundance/m^2	Mean No. Species/core		Mean Abundance/m^2	Mean No. Species/core
Whanganui 1989 Zostera LW	3244	19.0	WaimeaA 2006	4234	10.1
Whanganui 1989 Zostera HW	3001	18.2	WaimeaB 2006	940	6.2
Whanganui 1989 LW	910	9.0	WaimeaC 2006	5764	12.3
Waimea 1988 Zostera	1660	17.0	WaimeaD 2006	4860	11.8
Waimea 1988 LW	2874	12.7	RuataniwhaA 2001	838	6.2
Waimea 1988 HW	1313	11.1	RuataniwhaB 2001	2853	10.1
WaimeaA 2001	5136	11.0	RuataniwhaC 2001	6429	10.8
WaimeaB 2001	2076	9.7	MoutereA 2006	5371	14.9
WaimeaC 2001	5281	11.7	MoutereB 2006	6755	16.8
WaimeaD 2001	4814	12.5	MotupipiA 2008	3409	12.2
			MotupipiB 2008	1741	6.4

APPENDIX 2. INVERTEBRATE SAMPLING METHODS

Estuary	Indicator	Method	Reference
Whanganui January 1989	Intertidal Soft Bottom Invertebrates	Up to 5 random core samples (15cm diameter x 15cm depth) at each major habitat site (total of 13 sites). Includes *Zostera* beds but data for saltmarsh beds was excluded for this report. Samples sieved within 10hrs of collection (0.5mm mesh), stored in 80% isopropyl alcohol for later sorting counting and identification.	Davidson 1990
	Subtidal Soft Bottom Invertebrates	5 random core samples (15cm diameter x 15cm depth) at each major habitat site (total of 8 sites). Samples sieved within 10hrs of collection (0.5mm mesh), stored in 80% isopropyl alcohol for later sorting counting and identification.	Davidson 1990
Waimea Jan 1988	Intertidal Soft Bottom Invertebrates	Up to 5 random core samples (15cm diameter x 15cm depth) at each major habitat site (total of 13 sites). Includes *Zostera* beds but data for saltmarsh beds was excluded for this report. Samples sieved within 10hrs of collection (0.5mm mesh), stored in 80% isopropyl alcohol for later sorting counting and identification. A significant number of polychaetes were counted as "unidentified polychaetes".	Davidson and Moffat 1990
Waimea Feb 2001, 2006 Ruataniwha 2001 Motueka 2003 Moutere 2006 Motupipi Feb 2008	Intertidal Soft Bottom Invertebrates	National Estuary Monitoring Protocol	Robertson et al. 2002

APPENDIX 3. TOTAL NITROGEN ANALYTICAL METHODS

TN Methodological differences as follows:

- The detection limit for all estuaries except the Motupipi was 50 mg/kg TN (Methodology; APHA 2nd ed. 4500N C).
- The detection limit for the Motupipi was 500 mg/kg TN (Methodology; Elementary Analyser - R.J. Hill Laboratories).

This latter method has become the method of choice, given the lower cost and the fact that values less than 500 mg/kg are unnecessary given their low ability to elicit eutrophication symptoms. As a consequence of this approach, a trend of increasing concentrations will only become obvious if TN exceeds the detection limit. Given the low-moderate TN concentrations, and the absence of any trend of increasing concentrations, it is recommended that the next monitoring be undertaken in 5 years time (i.e. February 2013) using 3 replicates at each site.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS

WHANGANUI INLET

Estuary Type	Tidal lagoon, sand dominated
Intertidal Area	1979 ha of predominantly tidal flats
Subtidal area	769 ha
Catchment Area	approx. 60 km^2
Dairy cows	0 cows
Nitrogen loading	Low 4-5 kg/ha/yr
Sediment loading	Low 10-50 t/km^2/yr
Catchment geology	Mixed: granites, greywacke, sandstones, limestone
Landuse	80% native forest, rest extensive grazing, wetlands
Seagrass	860 ha
Saltmarsh	96 ha
Soft mud	110 ha
Macroalgae	15 ha (density uncertain)
Mean freshwater flow	3-4 $m^3.s^{-1}$
Salinity	Close to seawater
Mean depth (m)	Unknown, estimate 2-4 m
Point discharges	Nil
Uses/Values	Duck shooting, aesthetic, fishing, boating, walking, scientific, appreciation of rich biodiversity

Whanganui Inlet (Photo: Google Earth)

Human Use		High
Ecological Value		High
Existing Condition		Very Good
Susceptibility		Low
Stressors		Low

Whanganui Inlet is a large (2744ha), tidal lagoon type estuary that is open to the sea via a narrow entrance mouth. The inlet is located on the west coast, 19km southwest of Farewell Spit. It is fed by 4 main streams, Mangarakau Drain (mean flow 0.66 $m^3.s^{-1}$), Mangarakau Stream (0.48 $m^3.s^{-1}$), Wairoa River (0.16 $m^3.s^{-1}$), and Muddy Creek (0.59 $m^3.s^{-1}$) and approximately 25 smaller streams. A number of other water bodies (e.g. the Kaihoka Lakes and Lake Otuhie) in the immediate vicinity increase the value of the estuary/freshwater complex for wildlife.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, duck shooting, whitebaiting, fishing, boating, walking, and scientific appeal. The estuary is a dual protected area with a marine reserve in the southern third and a wildlife reserve over the remaining two-thirds of the estuary.

Ecological Values. Ecologically, habitat diversity is high. It has almost all of its intertidal vegetation intact, large areas of seagrass (42% of estuary) and saltmarsh (5% of estuary), a well-vegetated terrestrial margin dominated by coastal forest, a valuable nursery area for marine and freshwater fish, is important for birdlife (particularly waders), and is connected to large areas of relatively unmodified wetland, freshwater streams and terrestrial vegetation.

Presence of Stressors. Whanganui Inlet has largely avoided permanent human impacts and consequently has few threats. Land development and logging, wetland drainage, sea level rise and invasion of weeds and pests (e.g. *Spartina*, marram grass, Pacific oyster) are the only major stressors. Less significant are historical impacts from a small rubbish dump (southeast corner), farm runoff (farms are located to the north and south of the inlet entrance), and the 18 causeways that cross embayments in the inlet.

Susceptibility to Stressors. Because Whanganui Inlet is shallow, well flushed, with a high dilution potential and a short residence time, it is not very susceptible to having water quality problems that would adversely affect habitats if the relevant stressors were present.

Existing Condition. Condition is expected to be very good. Because the catchment area of the inlet is small (approximately 2 times the area of the estuary) with over 80% as native forest/scrub, the estimated freshwater inflow is low (3-4 $m^3.s^{-1}$), as are catchment inputs of nitrogen (4-5 $kg.ha^{-1}.y^{-1}$) and suspended sediment (10-50 $t.km^{-2}.y^{-1}$) (note that these values are based on outputs from NIWA WRENZ model). Because of the absence of urban, industrial and intensive agriculture landuse, inputs of toxic contaminants (such as heavy metals, and synthetic organic compounds) and disease causing organisms are expected to be low.

The combination of the large estuarine area, and the low freshwater inflow, nutrient, contaminant and toxin loads, means that the estuary is dominated by seawater (salinities >21ppt at low tide and 31ppt at high tide), and water and sediment quality and biodiversity is expected to be high.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

WHANGANUI INLET - MONITORING INFORMATION

A summary of relevant monitoring information is presented in the following table:

Category	Results
Broad Scale Habitat Mapping (Jan 1989) Method: Davidson (1990)	Broad scale mapping was undertaken in 1989 and included hard copy maps (i.e. no GIS layers) of unvegetated and vegetated substrate. The total estuary area was 2747 ha (intertidal 1979 ha, subtidal 769 ha), and included: • Unvegetated habitat dominated by sands (789 ha), and mud (110 ha), and • Vegetated habitat dominated by seagrass (860 ha - *Zostera* sp), and the saltmarsh species searush (*Juncus kraussii*) and jointed wire rush (*Apodasmia similis*) (96 ha).
Fine Scale Habitat Mapping (Jan 1989) Method: Davidson (1990)	Includes biological monitoring only (except for a few salinity measurements) and was undertaken in January 1989. It included the following: • **Intertidal and subtidal macro-invertebrates;** sediment cores or quadrats or transects sampled from all major habitats. Data showed that the highest number of species were recorded in low-midwater muddy sand or sand sites (often including seagrass) - mean=20.3 species. Mean species numbers at other habitats were 11.2 for mud and high water seagrass, 15.5 for pebble/cobble, 6.7 for saltmarsh, 10.4 for subtidal, and 3.5 for mobile sand. Abundance of macro-invertebrates was also greatest in the low-midwater muddy sand or sandy sites. Such findings confirm the NEMP approach (Robertson et al. 2002) of using low-midwater tidal flat sites as a reliable indicator of overall estuary condition (i.e. they have the greatest biodiversity and abundance of estuary biota and are sensitive to stressors when present - e.g. sedimentation, nutrient enrichment and toxicants). • **Fish;** SCUBA and liaison with fishermen was used to assess fishlife in the estuary. Results recorded a high number of marine species (38), 13 of which were regarded as commercial species. Data do not include abundance. • **Birds**: Rated as "high value" partly as a result of its variety of birdlife (Walker 1987). A further survey was undertaken in Jan. 1989. Results showed waders (e.g. oystercatchers, godwits, knots, and dotterels) were common, with fishers (such as shags and herons) and grazers (black swans) also present.

WHANGANUI INLET CONDITION RATINGS

Summary of condition ratings (see Section 4 for details)

Issue	Indicator (result)	Rating 2001
Sedimentation	Soft Mud Area (5% intertidal area)	GOOD
	Sedimentation Rate	Not Measured
Eutrophication	Nuisance Macroalgal Cover (<1%)	VERY GOOD
	Organic and Nutrient Enrichment	VERY GOOD
	Redox Profile	Not Measured
	Phytoplankton Blooms (upper estuary)	Not Measured
Toxins	Contamination Bottom Sediments	Not Measured
Range of Issues	Macro-invertebrates (BCCR = 1.3)	SLIGHTLY POLLUTED
Habitat	Saltmarsh Area (4.8% intertidal area)	MODERATE
	Seagrass Area (43% intertidal area)	VERY GOOD
	Vegetated Terrestrial Buffer	VERY GOOD
Habitat Loss	Saltmarsh Area Decline	Not Measured
	Seagrass Area Decline	Not Measured

MONITORING RECOMMENDATIONS

Issues

Limited monitoring data. Sea level rise. Weeds and pests. Limited protection. with marine and wildlife reserves.

Monitoring

Map intensive landuse (5 yearly).
Broad scale habitat map (5-10 yearly).
Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline).
Sedimentation rate monitoring.

Management

Plan for estuary habitat expansion with sea level rise.
Limit main inputs of fine sediment, nutrients and pathogens.
Undertake weed and pest management.

RUATANIWHA INLET

Estuary Type	Tidal Lagoon (plus delta)
Intertidal Area	726 ha of predominantly tidal flats
Subtidal area	137 ha
Catchment Area	767 km^2
Dairy cows	13,000 cows
Nitrogen loading	Moderate 7-13 kg/ha/yr
Sediment loading	Moderate 150-200 t/km^2/yr
Catchment geology	Mixed: granites, greywacke, sandstones, limestone
Landuse	80% native forest, alpine tussock and scrub, 16% intensive grazing
Seagrass	12 ha
Saltmarsh	131 ha
Soft mud	89 ha
Macroalgae	Low
Mean freshwater flow	27 m^3.s^{-1}
Salinity	Variable depending on rainfall
Mean depth (m)	Unknown, estimate 1-2m at HW
Point discharges	Collingwood stormwater, indirect WWTP discharge from Burton Ale Creek.
Uses/Values	Duck shooting, aesthetic, fishing, boating, walking, scientific, appreciation of rich biodiversity.

Ruataniwha Inlet

Human Use		High
Ecological Value		High
Existing Condition		Good
Susceptibility		Low
Stressors		Moderate

Ruataniwha Inlet is a moderate-sized (863 ha), shallow, tidal lagoon type estuary that is always open to the sea via a broad entrance mouth. The inlet is located in Golden Bay, near Collingwood and consists of one shallow basin, with few tidal arms, but an extensive delta. Several large barrier spits project southwards creating a relatively stable area in the north of the inlet. A series of islands occupy the delta area of the Aorere River, the major freshwater inflow to the inlet (mean flow 73 m^3.s^{-1}). At low tide, most of the estuary consists of exposed sandy or cobble tidal flats. Much of the Aorere catchment is steep and covered with native vegetation (80% of catchment). The valley floor is relatively flat and is developed for agriculture (primarily dairying) - 16% of catchment area.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, duck shooting, whitebaiting, fishing, boating, walking, and scientific appeal. A small commercial port is located at the entrance.

Ecological Values. Ecologically, habitat diversity is moderate to high with much of its intertidal vegetation intact, large areas of saltmarsh (18% of estuary), and some seagrass (1.7% of estuary). However, the natural vegetated margin has been lost and is now developed for grazing. Also, since 1950 at least 50ha of saltmarsh has been drained and converted to pasture. The inlet is recognized as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is nationally important for birdlife due to the presence of threatened birds (banded rail and bittern).

Presence of Stressors. Catchment landuse is the major existing stressor in relation to estuary condition, particularly intensive agricultural landuse in the valley floor (predominantly dairying - approximately 13,000 cows). However, sea level rise is likely to become increasingly influential in the near future. Less significant stressors include; the presence of seawalls (road verge, northern and southern estuary), stormwater from Collingwood, and invasion of weeds and pests (e.g. *Spartina*, marram grass, Pacific oyster). In terms of point source discharges, the estuary receives (via the Aorere River) treated inputs from dairy sheds and the Collingwood oxidation ponds.

Susceptibility to Stressors. Because Ruataniwha Inlet is shallow, well flushed, has a very high freshwater inflow (particularly during rain events) and a short residence time, it is not very susceptible to water and sediment quality problems. The majority of sediment, nutrients and contaminants are expected to pass through the estuary and be deposited in the delta area within Golden Bay. However, because the northern end of the estuary lacks strong water currents, some deposition of soft muds and nutrients tends to occur there (soft muds occupy 12% of the intertidal area of the estuary).

Existing Condition. The condition of the majority of habitats in the estuary is generally good (see following page for details) despite the intensive landuse in the lower catchment and moderate nitrogen and sediment loadings.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

RUATANIWHA INLET - MONITORING INFORMATION

A summary of relevant monitoring information is presented in the following table:

Category	Results
Broad Scale Habitat Mapping (March 2001, 1950,1972) Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002, incl. GIS layers)	In March 2001, the total estuary area was 864 ha (intertidal 727 ha, subtidal 137 ha), and included: • Unvegetated habitat dominated by sands and muddy sands (418 ha), and soft mud (89 ha), and • Vegetated habitat dominated by saltmarsh species searush (*Juncus kraussii*) and jointed wire rush (*Apodasmia similis*) (131 ha). Seagrass (*Zostera* sp), occupied 12ha. • Macroalgal growth was low. Mapping of 1950 and 1972 habitats using historical aerial photographs indicated significant loss of saltmarsh habitat (50 ha) since 1950.
Fine Scale Habitat Mapping (March 2001). Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002)	Three sediment sites located in intertidal, dominant mid-low water habitat (12 replicates at each site); Results were as follows. • Grain Size; was dominated by sand (86%) with mud at approximately 12%. • Organic Content and Nutrients; organic carbon was low (<1.5%), as were the nutrients total nitrogen (TN 250-290 mg/kg) and total phosphorus low to moderate (TP 390-540 mg/kg). • Heavy Metals; were also low with all values less than the ANZECC (2000) ISQG-Low trigger levels. • Macro-invertebrates; infauna abundance and diversity dominated by polychaetes and, to a lesser extent, bivalves. Mean abundance ranged from 867 to 6,650 m^{-2} and mean number of species from 6 to 11 per core. The spectrum of feeding groups recorded at these sites was typical of those generally encountered within New Zealand estuarine sediments.

RUATANIWHA INLET CONDITION RATINGS

Summary of condition ratings (see Section 4 for details)

Issue	Indicator (result)	Rating 2001
Sedimentation	Soft Mud Area (10% intertidal area)	FAIR
	Sedimentation Rate	Not Measured
Eutrophication	Nuisance Macroalgal Cover (<1%)	VERY GOOD
	Organic and Nutrient Enrichment	VERY GOOD
	Redox Profile	Not Measured
	Phytoplankton Blooms (upper estuary)	Not Measured
Toxins	Contamination Bottom Sediments	GOOD-VERY GOOD
Range of Issues	Macro-invertebrates (BCCR = 1.4-3.7)	SLIGHTLY POLLUTED TO MODERATELY POLLUTED
Habitat	Saltmarsh Area (16% intertidal area)	HIGH
	Seagrass Area (1.6% intertidal area)	GOOD
	Vegetated Terrestrial Buffer	POOR
Habitat Loss	Saltmarsh Area Decline (27% loss since 1950)	POOR
	Seagrass Area Decline (no change since 1950)	VERY GOOD

MONITORING RECOMMENDATIONS

Issues

Limited monitoring data. Catchment landuse and enriched runoff. Sea level rise. Weeds and pests. Terrestrial margin developed.

Monitoring

Map intensive landuse (5-10 yearly).
Broad scale habitat map (5 yearly).
Fine scale phys/chem/biota in sediments 5-10 yearly (after 3-4yr baseline).
Sedimentation rate monitoring.

Management

Re-establish terrestrial vegetated margin.
Plan for estuary habitat expansion with sea level rise.
Limit main inputs of fine sediment, nutrients and pathogens.
Undertake weed and pest management.

MOTUPIPI ESTUARY

Estuary Type	Tidal Lagoon
Intertidal Area	160 ha of predominantly tidal flats
Subtidal area	12 ha
Catchment Area	2,700 km^2 (of which 1000ha flat)
Dairy cows	2,000 cows
Nitrogen loading	High 22.6 kg/ha/yr (80% from dairy grazing)
Sediment loading	Low 30 t/km^2/yr
Catchment geology	Complex: gravels, alluvium, mudstones and underlying limestone plus outcrops
Landuse	55% pasture, 40% native veg, 3% gorse/ broom, 2% exotic forest.
Seagrass	2.5 ha
Saltmarsh	62 ha
Soft mud	36 ha
Macroalgae	5 ha (*Enteromorpha*)
Mean freshwater flow	0.5 $m^3.s^{-1}$
Salinity	>27ppt.
Mean depth (m)	Unknown, estimate 1 at HW
Point discharges	Nil
Uses/Values	Bathing, shellfish collection, duck shooting, aesthetic, fishing, boating, walking, scientific, appreciation.

Motupipi Estuary (photo TDC)

Human Use		High
Ecological Value		High
Existing Condition		Fair
Susceptibility		Fair
Stressors		High

Motupipi Estuary is a small to medium-sized (160 ha), shallow, tidal lagoon type estuary that is always open to the sea via a broad entrance mouth. It has two arms, with the western arm receiving the main river input from the Motupipi River, and consequently is the most affected by freshwater influences. The 2,700 ha catchment is predominantly grazed pasture and has moderate residential development. Approximately 1,000 ha of the catchment is flat, 1,200 ha is steep hill country, and 460 ha is rolling hills. Mean annual freshwater input from the Motupipi River is relatively low at 0.5 $m^3.s^{-1}$. The estuary has a variety of habitat types including saltmarsh vegetation, seagrass beds, mud and sand intertidal flats, shellfish beds, water column, subtidal sand/mud and kelp beds. There are indications of moderate macroalgal and phytoplankton blooms.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, duck shooting, whitebaiting, fishing, boating, walking, and scientific appeal.

Ecological Values. Ecologically, habitat diversity is moderate to high with much of its intertidal vegetation intact, large areas of saltmarsh (39% of estuary), and some seagrass (1.6% of estuary). However, the natural vegetated margin has been lost and is now developed for grazing. Also, since 1943 there has been a loss of 24 ha of saltmarsh through drainage and reclamation. The estuary is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is important for birdlife.

Presence of Stressors. Catchment landuse is the major existing stressor in relation to estuary condition, particularly intensive agricultural landuse in the valley floor (predominantly dairying - approximately 2,000 cows). However, sea level rise is likely to become increasingly more influential in the near future. Less significant stressors include; the presence of seawalls (road verge, western arm of estuary), invasion of weeds and pests (e.g. *Spartina*, marram grass, Pacific oyster) and drainage of margin areas.

Susceptibility to Stressors. The Motupipi Estuary is a "tidal lagoon type" estuary. Such estuaries are shallow and generally well flushed by tidal water and consequently have moderate to low susceptibility to water quality problems. However, because the Motupipi is a relatively small tidal lagoon estuary, dilution of incoming freshwater is limited, which makes it more susceptible to water and sediment quality problems, particularly in the western arm (i.e. close to the main Motupipi River input).

In addition, the upper estuary experiences salinity stratification during stable baseflows (i.e. salt wedge effect). The resulting high salinity bottom layer is generally more stable (less well-flushed) and is therefore susceptible to nuisance phytoplankton blooms if nutrient inputs are elevated.

Existing Condition. Much of the Motupipi Estuary is in good condition (particularly the eastern arm), but in certain "at-risk" parts of the estuary, poor conditions exist (see next page).

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

MOTUPIPI ESTUARY - MONITORING INFORMATION

Category	Results
Estuary Vulnerability Assessment (Nov 2007-Feb 2008) Method: Robertson and Stevens (2008)	Synoptic Monitoring identified the following: • Upper estuary nuisance phytoplankton blooms and dissolved oxygen depletion. • Upper, mid and lower estuary macroalgal blooms (primarily in the western arm). • Middle estuary sedimentation (western arm mainly but increasing soft mud in eastern arm). • Mid and lower estuary shellfish health risk. • Upper, mid and lower estuary loss of the vegetated margin. • Saltmarsh and seagrass degradation through eutrophication and sedimentation effects, as well as sea level rise (a potential issue in the future). • Invasion by Pacific oyster and ice plant.
Broad Scale Habitat Mapping (Sept 2007, also 1943, 1984) Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002, incl. GIS layers)	In September 2007, the total estuary area was 172 ha (intertidal 160 ha, subtidal 12 ha), and included: • Unvegetated habitat dominated by sands and muddy sands (42 ha), and soft mud (36 ha), • Vegetated habitat dominated by saltmarsh species searush (*Juncus kraussii*) and jointed wire rush (*Apodasmia similis*) (62 ha). Seagrass (*Zostera* sp), occupied 2.5 ha. • Macroalgal growth (dominated by *Enteromorpha* sp.) occupied 5 ha but, because the survey was in September, it is expected that this area would be larger in the warmer months. Mapping of 1943 and 1984 habitats using historical aerial photographs indicated significant loss of saltmarsh habitat (24 ha), most (22 ha) in the 1943-84 period.
Fine Scale Habitat Mapping (Feb 2008). Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002)	Two sites located in intertidal, dominant mid-low tide habitat (10 replicates at each site); Results were as follows. • Grain Size; was dominated by sand (61-78%) with mud at approximately 20-40%. • Organic Content and Nutrients; organic carbon was low (<1.5%), total nitrogen (TN 730-756 mg/kg) was low-moderate and total phosphorus (TP 557-573 mg/kg) was enriched. • Heavy Metals; were low with all values less than the ANZECC (2000) ISQG-Low trigger levels. • Macro-invertebrates; infauna abundance and diversity dominated by bivalves and oligochaetes and, to a lesser extent, polychaetes. Mean abundance ranged from 1740 to 3,400 m^{-2} and mean number of species from 6 to 12 per core. The spectrum of feeding groups recorded at these sites was typical of those generally encountered within New Zealand estuarine sediments.

MOTUPIPI ESTUARY CONDITION RATINGS

Summary of condition ratings (see Section 4 for details)

Issue	Indicator (result)	Rating 2008
Sedimentation	Soft Mud Area (22.5% intertidal area)	POOR
	Sedimentation Rate	Baseline Established
Eutrophication	Nuisance Macroalgal Cover (<3.1%)	GOOD
	Organic and Nutrient Enrichment	GOOD-ENRICHED
	Redox Profile	GOOD-FAIR
	Phytoplankton Blooms (upper estuary)	POOR
Toxins	Contamination Bottom Sediments	GOOD-VERY GOOD
Range of Issues	Macro-invertebrates (BCCR = 1.2-2.9)	SLIGHTLY POLLUTED
Habitat	Saltmarsh Area (39% intertidal area)	HIGH
	Seagrass Area (1.6% intertidal area)	GOOD
	Vegetated Terrestrial Buffer (5%)	POOR
Habitat Loss	Saltmarsh Area Decline (14% loss since 1943)	FAIR
	Seagrass Area Decline (Baseline estab. 2007)	Baseline Established

MONITORING RECOMMENDATIONS

Issues

Limited monitoring data. Catchment landuse and enriched runoff. Moderate to high susceptibility of estuary to sedimentation, eutrophication and disease risk. Sea level rise. Weeds and pests.

Monitoring

A detailed programme has been recommended in Robertson and Stevens (2008), see table on following page.

Management

A detailed programme has been recommended in Robertson and Stevens (2008).

MOTUEKA ESTUARY/DELTA

Estuary Type	Tidal River Mouth (plus delta)
Intertidal Area	2ha tidal river, 600ha delta
Subtidal area	150 ha
Catchment Area	2,180 km^2
Dairy cows	5675 cows
Nitrogen loading	Very low 1.3 kgN/ha/yr
Sediment loading	Moderate 160 t/km^2/yr
Faecal C Loading	1.4 X10^7 FC/day (River baseflow 10-100 /100ml)
Catchment geology: Complex:: Upper headwaters ultramafic and sedimentary rocks; western tributaries sedimentary and igneous rocks; middle and lower reaches of the main stem and eastern tributaries gravels and younger alluvium.	
Landuse	18% pasture, 37% native forest, 27% exotic forest, 10% scrub, 7% tussock
Seagrass	0 ha
Saltmarsh	49 ha
Soft mud	60 ha
Macroalgae	3.5 ha (sea lettuce)
Mean freshwater flow	59 m^3.s^{-1}
Salinity	>30ppt.
Mean depth (m)	Estimate 1m at HW
Point discharges	Indirect seepage from Motueka Oxidation Pond
Uses/Values	Bathing, shellfish collection, birdwatching, aesthetic, fishing, boating, walking, scientific.

Motueka Estuary and Delta (Photo: Google Earth)

Human Use		High
Ecological Value		High
Existing Condition		Good
Susceptibility		Low
Stressors		Low

The Motueka Estuary is a short, narrow and shallow tidal river mouth estuary that discharges onto a broad delta (750 ha). The estuary/delta is located in Tasman Bay, near Motueka. A series of islands and spits occupy the delta area and includes discharges from other smaller streams and rivers (e.g. Riwaka River). The Motueka River is the major freshwater inflow to the estuary (mean flow 59 m^3.s^{-1}). At low tide, most of the estuary/delta consists of exposed sandy or cobble tidal flats. Much of the Motueka catchment is forest (37% native, 27% exotic), with pastoral use at 18%.

Uses and Values. High use - valued for its aesthetic appeal, rich biodiversity, shellfish, assimilation of wastewater, bathing, duck shooting, whitebaiting, fishing, walking, and scientific appeal.

Ecological Values. Ecologically, habitat diversity is moderate with much of its intertidal vegetation intact, moderate areas of saltmarsh (3.7% of estuary) and herbfields (4.4%). However, the natural vegetated margin has been lost and is now developed for grazing. Also, since 1947 at least 33 ha of saltmarsh has been drained and converted to pasture. Evidence also indicates a loss of a further 200-300 ha prior to 1947. The estuary/delta is recognized as a valuable nursery area for marine and freshwater fish, is rich in shellfish, and a major feeding ground for wading birds, up to 10,000 of which feed or roost on the sandspit in summer.

Presence of Stressors. Catchment landuse is the major existing stressor in relation to estuary/delta condition. Currently, estimated suspended sediment loads to the estuary/delta from nonpoint sources are moderate (160 t/km^2/yr), nitrogen loads are very low (1.3 kg/ha/yr) and faecal bacterial loads also low-moderate (14 million per day or 10-100 FC/100ml in baseflow conditions and 100-10,000 FC/100ml in high flow conditions). Sea level rise is likely to become an increasingly more influential stressor in the near future. In the past, drainage, floodgates, channelisation and reclamation have been a significant stressor and still act today as a limitation on estuary condition. Also significant is the leachate discharge of partially treated wastewater from the Motueka Treatment Plant which consists of a 6,000m^3 aeration pond with three aerators, a 4.8 ha oxidation pond with a single aerator and 3.7 ha of land soakage beds located adjacent to the estuary. Less significant stressors include; invasion of weeds and pests (e.g. marram grass, Pacific oyster).

Susceptibility to Stressors. Motueka Estuary/Delta is shallow, well flushed, has a very high freshwater inflow (particularly during rain events) and a short residence time, and as a consequence is not very susceptible to having water and sediment quality problems.

Existing Condition. Much of the Motueka Estuary/Delta is in good condition (see following page), but fine sediments do tend to settle in some "at-risk" parts of the estuary where soft muddy conditions exist (e.g. in the Kumara's area and on the delta towards the Riwaka River mouth) and localised nuisance algal blooms and anoxic sediments occur adjacent to the Motueka Treatment Plant.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

MOTUEKA ESTUARY/DELTA - MONITORING INFORMATION

A summary of relevant monitoring information is presented in the following table:

Category	Results
Broad Scale Habitat Mapping (April 2002, also 1947, 1986) Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002, incl. GIS layers)	In April 2002, the total estuary/delta area was 750 ha (intertidal 600 ha, subtidal 150 ha), and included: • Unvegetated habitat dominated by cobblefield (106 ha), sands/muddy sands (98 ha), and soft mud (60 ha). • Vegetated habitat dominated by saltmarsh species; glasswort (*Sarcocornia quinqueflora*), searush (*Juncus kraussii*) and jointed wire rush (*Apodasmia similis*) (49 ha). Seagrass (*Zostera* sp) was notably absent. • Beds of sabellariids (a polychaete worm that lives in thick-walled sand and shell fragment tubes) and the invasive Pacific oyster (*Crassostrea gigas*) occupied 5.5 and 7.5 ha respectively. • Macroalgal growth (dominated by *Ulva and Gracilaria* sp.) occupied 3.5 ha. Mapping of 1947 and 1986 habitats using historical aerial photographs indicated significant loss of saltmarsh habitat (33 ha), since 1947, and much more prior to 1947 (approximately 200-300 ha).
Fine Scale Habitat Monitoring	• Not undertaken

MOTUEKA ESTUARY/DELTA CONDITION RATINGS

Issue	Indicator (result)	Rating 2002
Sedimentation	Soft Mud Area (10% intertidal area)	FAIR
	Sedimentation Rate	Not Measured
Eutrophication	Nuisance Macroalgal Cover (0.6%)	VERY GOOD
	Organic and Nutrient Enrichment	Not Measured
	Redox Profile	Not Measured
	Phytoplankton Blooms (upper estuary)	Not Measured
Toxins	Contamination Bottom Sediments	Not Measured
Range of Issues	Macro-invertebrates	Not Measured
Habitat	Saltmarsh Area (8% intertidal area)	MODERATE
	Seagrass Area (0% intertidal area)	POOR
	Vegetated Terrestrial Buffer	POOR
Habitat Loss	Saltmarsh Area Decline (40% loss since 1947)	POOR
	Seagrass Area Decline (no seagrass present)	Not Measured

MONITORING RECOMMENDATIONS

Issues

Sea level rise.
Weeds and pests.
Past reclamation.
Wastewater leachate.

Monitoring

Map intensive landuse (5 yearly).
Broad scale habitat map (5 yearly).
Sedimentation rate monitoring.

Management

Limit intensive landuse and margin development.
Plan for estuary expansion with sea level rise.
Ensure wastewater leachate doesn't enter estuary.

MOUTERE INLET

Estuary Type	Tidal Lagoon
Intertidal Area	705 ha
Subtidal area	57 ha
Catchment Area	200 km^2
Dairy cows	<250 cows
Nitrogen loading	Moderate 8 kgN/ha/yr
Sediment loading	Moderate 101 t/km^2/yr
Catchment geology	Post glacial alluvium.
Landuse	Mainly pasture and horticulture with some exotic forest
Seagrass	1 ha
Saltmarsh	76 ha
Soft mud	92 ha
Macroalgae (summer)	Not measured (but high sea lettuce growth in past)
Mean freshwater flow	1-2 m^3.s^{-1}
Salinity	>30ppt.
Mean depth (m)	Unknown, estimate 1m at HW
Point Discharges	Talleys Food Processing.
Uses/Values	Bathing, shellfish collection, birdwatching, aesthetic, fishing, boating, walking, scientific, appreciation.

Moutere Estuary (Photo: Google Earth)

Human Use		High
Ecological Value		High
Existing Condition		Fair
Susceptibility		Low
Stressors		Low

Moutere Inlet is a moderate-sized (755 ha), shallow, tidal lagoon type estuary that is always open to the sea via two broad entrance mouths. The inlet is located in Tasman Bay near Motueka and consists of one shallow basin, with few tidal arms. The estuary drains almost completely at low tide to sand dominated tidal flats and a fringe of saltmarsh. Considerable modification/infilling of margin habitats has occurred in the past in conjunction with roading and marina developments, which almost certainly have degraded ecological values. Much of the Moutere catchment is flat or gently sloping and used for grazing and horticulture.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, waste assimilation, whitebaiting, fishing, boating, water skiing, walking, and scientific appeal. A small commercial port and marina is located at the entrance.

Ecological Values. Ecologically, habitat diversity is moderate with much of its intertidal vegetation intact, moderate areas of saltmarsh (11% of estuary), but very little seagrass (0.1% of estuary). However, the natural vegetated margin has been lost and is now developed for grazing and horticulture. Also, since 1947 at least 76 ha (50%) of remaining saltmarsh has been lost due to development around the estuary margin. In addition, the main highway cuts across several small embayments which open to the estuary through culverts. The inlet is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is important for birdlife.

Presence of Stressors.

Talley's operate fish processing, fishmeal and ice cream factories at Port Motueka which discharge nutrients and organic matter in factory wash down, stormwater, and brine-water to the estuary. Elevated nutrients, sediment, pathogens and possibly toxicants also enter the estuary from catchment runoff, however, information on these sources is limited. In the future, sea level rise is expected to become increasingly more influential. Other stressors include; the presence of seawalls, causeways, culverts, stormwater (road verge, northern and southern estuary), and invasion of weeds and pests (e.g. Pacific oyster).

Susceptibility to Stressors.

Because Moutere Inlet is shallow, well flushed, has a very low freshwater inflow and a short residence time, it is not very susceptible to having water and sediment quality problems. However, if sediment inputs are elevated, it will encourage sedimentation within the estuary, particularly in areas lacking strong water currents.

Existing Condition. Much of the Moutere Inlet is in good condition, but in certain "at-risk" parts of the estuary, poor conditions exist (see next page).

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

MOUTERE INLET - SUMMARY OF MONITORING INFORMATION

A summary of relevant monitoring information is presented in the following table:

Category	Results
Broad Scale Habitat Mapping (April 2005, also retrospective mapping for 1947, 1988) Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002, incl. GIS layers)	In April 2005, the total estuary area was 762 ha (intertidal 705 ha, subtidal 57 ha), and included: • Unvegetated habitat dominated by sands/mud sands (480 ha), soft mud (92 ha) and cobbles/gravel (44 ha). • Vegetated habitat was dominated by saltmarsh species; glasswort (*Sarcocornia quinqueflora*), searush (*Juncus kraussii*) and small areas of jointed wire rush (*Apodasmia similis*) (72 ha). Seagrass (*Zostera* sp) occupied 1 ha. • Beds of sabellariids (a polychaete worm that lives in thick-walled sand and shell fragment tubes) occupied 0.02 ha. Visible cockle beds were also present (38ha). • Macroalgal growth (dominated by *Gracilaria* sp.) occupied 6 ha. In the past large beds of *Ulva* have been observed in the lower estuary. Mapping of 1947 and 1988 habitats using historical aerial photographs indicated significant loss of saltmarsh habitat (75 ha), since 1947, and new roading along the western side of the estuary has created several embayments with restricted circulation.
Fine Scale Habitat Mapping (Feb 2008). Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002)	Two sites located in intertidal, dominant mid-low tide habitat (10 replicates at each site); Results were as follows. • Grain Size; was dominated by sand (87-89%) with mud at approximately 10-12%. • Organic Content and Nutrients; organic carbon was low (<1%), total nitrogen (TN 309-368 mg/kg) was low-moderate and total phosphorus (TP 513-545 mg/kg) was enriched. • Heavy Metals; were low with all values less than the ANZECC (2000) ISQG-Low trigger levels except for nickel. Elevated Ni levels are attributed to erosional input of sediment from local catchments containing naturally high Ni concentrations, and are typical of other coastal locations in the Nelson region. • Macro-invertebrates; infauna abundance and diversity dominated by polychaetes and bivalves. Mean abundance ranged from 5,400 to 6,750 m^{-2} and mean number of species from 15 to 17 per core. The spectrum of feeding groups recorded at these sites was typical of those generally encountered within New Zealand estuarine sediments.
Consent Monitoring	Talley's operate fish processing, fishmeal, and ice cream factories at Port Motueka which discharge nutrients and organic matter in factory wash down, stormwater, and brine-water to the estuary. Recent monitoring results were below consent conditions for total suspended solids and fats, grease and oils, however, faecal coliform concentrations were elevated.

MOUTERE INLET CONDITION RATINGS

Summary of condition ratings (see Section 4 for details)

Issue	Indicator (result)	Rating 2008
Sedimentation	Soft Mud Area (13% intertidal area)	FAIR
	Sedimentation Rate (Baseline estab. 2009)	Not Measured
Eutrophication	Nuisance Macroalgal Cover (0.9%)	VERY GOOD
	Organic and Nutrient Enrichment	GOOD-ENRICHED
	Redox Profile	GOOD-FAIR
	Phytoplankton Blooms (upper estuary)	VERY GOOD
Toxins	Contamination Bottom Sediments	GOOD-VERY GOOD
Range of Issues	Macro-invertebrates (BCCR = 2.8-3.2)	SLIGHTLY POLLUTED
Habitat	Saltmarsh Area (10% intertidal area)	HIGH
	Seagrass Area (0.1% intertidal area)	POOR
	Vegetated Terrestrial Buffer	POOR
Habitat Loss	Saltmarsh Area Decline (50% loss since 1947)	POOR
	Seagrass Area Decline (Baseline estab. 2006)	Baseline Established

MONITORING RECOMMENDATIONS

Issues

Sea level rise. Landuse. Weeds and pests. Past reclamation. Wastewater leachate.

Monitoring

Map intensive landuse (5 yearly).
Broad scale habitat map (5 yearly).
Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline).
Sedimentation rate monitoring.

Management

Re-establish terrestrial vegetated margin.
Plan for estuary habitat expansion with sea level rise.
Limit effects of wastewater discharge.
Undertake weed and pest management.

WAIMEA INLET

Estuary Type	Tidal Lagoon
Intertidal Area	2,793 ha
Subtidal area	457 ha
Catchment Area	812 km^2
Dairy cows	1645 cows
Nitrogen loading	Moderate 8 kgN/ha/yr
Sediment loading	Moderate 101 t/km^2/yr
Catchment geology	Complex and includes ultramafic rocks high in Ni, Cu and Cr
Landuse	Natie Forest 32%, Exotic Forest 31%, Pastoral 26%, Scrub 5%
Seagrass	2001 (28 ha), 2006 (21 ha)
Saltmarsh	2001 (224 ha), 2006 (279 ha)
Soft mud	2001 (1,140 ha), 2006 (1,541 ha)
Macroalgae (summer)	2001 (7 ha), 2006 (32 ha)
Mean freshwater flow	21 m^3.s^{-1}
Salinity	>30ppt
Mean depth (m)	Unknown, estimate 1-2m at HW
Point Source Discharges	Bells Island Treated Sewage (10,000 m^3/d). Stormwater (Stoke, Richmond, Mapua). Leachate from sewage land disposal.
Uses/Values	Bathing, shellfish collection, birdwatching, aesthetic, fishing, boating, walking, scientific, appreciation.

Waimea Inlet (Photo: Google Earth)

Human Use		High
Ecological Value		High
Existing Condition		Good
Susceptibility		Low
Stressors		Moderate

Waimea Inlet is a moderate-sized (3,206 ha), shallow, tidal lagoon type estuary that is open to the sea via two tidal openings. Located in Tasman Bay, the lagoon has two main basins, and several tidal arms. The inlet is well-flushed and has a residence time of < 1day. Freshwater contributions are minor relative to the size of the tidal compartment (mean flow 21 m^3.s^1, resulting in salinities >30 ppt throughout most of the estuary. Catchment landuse is mixed with forest occupying 63% and prime pastoral at 26%.

Uses and Values. High use. Valued for its aesthetic appeal, duck shooting, biodiversity, assimilation of wastes, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. A small but historically significant port is located at Mapua.

Ecological Values. Ecologically, habitat diversity is high with much of its intertidal vegetation intact, moderate areas of saltmarsh (10% of estuary), some seagrass (1% of estuary) and a small area of highly diverse, subtidal sponge-dominated community. However, a large proportion of the estuary is soft muds (55%) and most of the natural vegetated margin has been lost and is now developed. Also, since 1946 at least 83 ha of saltmarsh has been reclaimed and developed. The invasive weed, *Spartina anglica*, occupied large areas of the estuary in the 1980's (40-50 ha in 1985) after it was introduced to promote reclamation and stabilisation of soft muds entering from the catchment. In the early 1990s, it was eradicated. Despite the muddy nature of the estuary sediments, the inlet is recognised as a valuable for birdlife, nursery area for marine and freshwater fish, and shellfish.

Presence of Stressors. Waimea Inlet has a large range of stressors. The inlet is used for wastewater discharge including treated sewage (from Bells Island regional sewage treatment facility) and stormwater from industrial, agricultural (horticulture, drystock farming, dairying) and urban (Stoke and Richmond) sources. Areas of Rabbit and Bell Islands have been used for the land disposal of sewage sludge from the Bells Island oxidation ponds since 1993 and 1996, respectively. An additional stressor is chemical leachates from contaminated soils. This has occurred at a former Fruitgrowers Chemical Company industrial site bordering on the inlet at Mapua. The 3.3 ha site was found to contain high levels of primarily DDT and dieldrin and both have been observed in sediments of the Mapua channel. The site has recently been the subject of remedial action and is now ready for future development opportunities to proceed. In the future, sea level rise is likely to become increasingly more influential as a stressor. Less significant stressors include; the presence of seawalls and invasion of weeds and pests (e.g. *Spartina*, Pacific oyster).

Susceptibility to Stressors. Because Waimea Inlet is shallow, well flushed, has a low freshwater inflow and a short residence time, it is not very susceptible to having water and sediment quality problems. However, if sediment inputs are elevated, it will encourage sedimentation within the estuary, particularly in areas lacking strong water currents.

Existing Condition. Much of the Waimea Inlet is in good condition, but in certain "at-risk" parts of the estuary, poor conditions exist (see next page).

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

WAIMEA INLET - MONITORING INFORMATION

A summary of relevant monitoring information is presented in the following table:

Category	Results
Broad Scale Habitat Mapping (2001, 2006, also retrospective mapping for 1946, 1985) Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002, incl. GIS layers)	In April 2001, the total estuary area was 3,206 ha (intertidal 2,793 ha, subtidal 457 ha), and included: • Unvegetated habitat dominated by sands/mud sands (1,105 ha), soft mud (1,140 ha), cobbles/gravel (252 ha). • Vegetated habitat dominated by saltmarsh species; glasswort (*Sarcocornia quinqueflora*), searush (*Juncus kraussii*) and small areas of jointed wire rush (*Apodasmia similis*) (224 ha). Seagrass (*Zostera* sp) occupied 28 ha. • Beds of sabellariids (a polychaete worm that lives in thick-walled sand and shell fragment tubes) and the invasive Pacific oyster (*Crassostrea gigas*) occupied 1.7 ha and 32 ha respectively. • Macroalgal growth (dominated by *Enteromorpha* sp. and *Gracilaria* sp.) occupied 7 ha. Mapping of 1947 and 1988 habitats using historical aerial photographs indicated significant loss of saltmarsh habitat (86 ha), since 1946. The most recent mapping, 2006, shows that the area of soft mud has increased from 1,140 ha in 2001 to 1,541 ha in 2006 resulting in a reduction in firm muddy sand habitat. In addition, areas of herbfield (dominated by glasswort (*Sarcocornia quinqueflora*), increased from 124 ha to 154 ha, attributed in part to opening of the Traverse (an artificially closed embayment). Macroalgal growth occupied 32 ha.
Fine Scale Habitat Mapping (Feb 2001, April 2006). Method: National Estuary Monitoring Protocol, NEMP (Robertson et al. 2002)	In February 2001, 4 sites located in intertidal, dominant mid-low tide habitat (12 replicates at each site) were monitored. Results were as follows. • Grain Size; was dominated by sand (57-89%) with mud at approximately 9.6-40%. • Organic Content and Nutrients; organic carbon was low (<1%), total nitrogen (TN 279-783 mg/kg) was low-moderate and total phosphorus (TP 273-539 mg/kg) was also low-moderate. • Heavy Metals; were low with all values less than the ANZECC (2000) ISQG-Low trigger levels except for nickel at all 4 sites and chromium at one site. The elevated levels are attributed to erosional input of sediment from local catchments containing naturally high nickel and chromium concentrations, and are typical of other coastal and estuarine locations in the Nelson region. • Macro-invertebrates; infauna abundance and diversity dominated by polychaetes and, to a lesser extent, bivalves. Mean abundance ranged from 2,148 to 5,463 m^{-2} and mean number of species from 10 to 13 per core. The spectrum of feeding groups recorded at these sites was typical of those generally encountered within New Zealand estuarine sediments. Results of the 2006 fine scale monitoring of the same sites indicate little change since 2006. The monitoring information from this habitat type is used in Section 3 to assess the estuary condition for key estuary indicators in comparison to the 4 other Tasman estuaries reviewed in this report.
Fine Scale Monitoring (11-29 Jan 1988) Method: Davidson and Moffatt (1990)	Includes biological monitoring only (except for a few salinity measurements) and was undertaken between 11 and 29 January 1988. It included the following: • **Intertidal and subtidal macro-invertebrates;** sediment cores or quadrats or transects sampled from all major habitats (57 intertidal and 4 subtidal sites). Data showed that the highest number of species were recorded in low-midwater gravel/cobble and seagrass habitats - mean=17 species. Mean species numbers at other habitats were 12 for mud and fine sand, 5 for saltmarsh, 11 for subtidal, 4 for high water flats, and 3 for mobile sand. Abundance of macro-invertebrates was greatest in the gravel/cobble sites (mean 19,756 m^{-2}). Men abundance (per m2) at other habitats were 2,629 for mud, 1,660 for seagrass, 1,375 for fine sand, 8,358 for saltmarsh, 3,876 for subtidal, 483 for high water flats, and 93 for mobile sand. The high abundance and diversity at the gravel cobble sites is important given the moderate extent of this substrate type in the estuary (200 ha or 6% of the estuary area in 1988). However, the dominant sand/mudflat /seagrass habitat (60% of estuary) also had significant numbers of species and abundances and has therefore been chosen as the primary habitat for longterm monitoring. • **Fish;** SCUBA and liaison with fishermen was used to assess fishlife in the estuary. Results recorded a high number of marine species (31), 18 of which were regarded as commercial species. Data do not include abundance. • **Birds**: Rated as "outstanding" value partly as a result of its variety of birdlife (Walker 1987). Results showed Waimea is of most significance regionally for 3 groups of birds: waders (e.g. oystercatchers, godwits, knots, and dotterels); herons, egrets and spoonbills; and rails, crakes and bitterns.
Drains - TDC Sediment Monitoring Aug 2004	In August 2004 TDC monitoring of potential toxicants in sediments near and within drains discharging to the Waimea Estuary near Richmond showed some exceedances of ANZECC sediment criteria for arsenic, copper, lead, zinc, polycyclic aromatic hydrocarbons (PAHs) and tributyl tin (TBT).
Consent Monitoring	**Nelson Pine Industries Limited Discharges** Nelson Pine has two consents that authorise the discharge of contaminants to the air, and one resource consent to discharge stormwater into the Waimea Estuary. Nelson Pine's air discharge consent requires annual monitoring of sediments and inter-tidal biota in the Waimea Estuary for the purpose of assessing the impact of formaldehyde and ammonia on the estuary ecosystem. No exceedences were recorded in concentrations of formaldehyde or the other measures required under the consents. No stormwater discharge monitoring occurred during the period.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

WAIMEA INLET - MONITORING INFORMATION

Category	Results
Consent Monitoring	**Nelson (Bell Island) Regional Wastewater Outfall discharge** Outfall discharges to the main channel on the outgoing tide in a well-flushed area near the estuary mouth. Monitoring of 11 sediment sites, all located within 1 km of the outfall (6 upstream and the rest downstream), at 5 yearly intervals since 1991. The results indicate the effluent discharge has not resulted in any significant eutrophication of benthic habitats, and that rapid flushing of the estuary sees localised nutrient enrichment of receiving waters quickly return to background concentrations (within 1.6 km from the outfall) (Gillespie et al. 2001a, Gillespie et al. 2001b). The most recent available receiving water monitoring results showed dilution of nutrients to levels below which eutrophication is likely within 500m of the outfall (Gillespie et al. 2006). In addition, studies of faecal indicator bacteria concentrations in shellfish indicate that the inlet (with the exception of the immediate mixing zone down current from the Bell Island wastewater outfall) is suitable for contact recreational activities, but unsuitable for gathering shellfish for human consumption (Gillespie et al. 2006). **Discharge of Biosolids on Rabbit Island** Nelson Regional Sewage Business Unit has resource consent to discharge stabilised sludge (biosolids from Bells Island treatment plant) to 1000 ha of forest land on Rabbit Island (<7.8 t/ha, once every 3yrs and <40mm depth/application). **Dynea NZ Limited Discharge** Dynea NZ Ltd has resource consent to discharge contaminants into the air from the production of phenol and formaldehyde resins and resource consent to discharge stormwater into the Waimea Estuary. Over the 2006/2007 year all stormwater was collected and recycled back into the plant and used in the production of phenolic and formaldehyde resins. There was no discharge into the Waimea Estuary.

WAIMEA INLET CONDITION RATINGS

Issue	Indicator (result)	Rating 2001	Rating 2006
Sedimentation	Soft Mud Area 2001: 42%; 2006: 55%.	POOR	POOR
	Sedimentation Rate	Not Measured	Not Measured
	Increase in Area Soft Mud (400ha (26%) increase since 2001)	Baseline Year	POOR
Eutrophication	Nuisance Macroalgal Cover 2001: 0.3%; 2006: 1.1%	VERY GOOD	VERY GOOD
	Organic and Nutrient Enrichment	VERY GOOD-GOOD	VERY GOOD-GOOD
	Redox Profile	Not Measured	Not Measured
	Phytoplankton Blooms (upper estuary)	VERY GOOD	VERY GOOD
Toxins	Contamination Bottom Sediments	VERY GOOD-GOOD	VERY GOOD-GOOD
Range of Issues	Macro-invertebrates (BCCR = 1.3 - 3.3)	SLIGHTLY POLLUTED	SLIGHTLY POLLUTED
Habitat	Saltmarsh Area 2001, 8.3%; 2006, 9.3% of intertidal area	MODERATE	MODERATE
	Seagrass Area 2001, 0.8%; 2006, 0.9% of intertidal area	POOR	POOR
	Vegetated Terrestrial Buffer	POOR	POOR
Habitat Loss	Saltmarsh Area Decline (6% loss 1946 to 2001, no loss since)	FAIR	VERY GOOD
	Seagrass Area Decline (1988-2001: 30ha 52%; 2001-06: 7ha 25%)	POOR	POOR

MONITORING RECOMMENDATIONS

Issues	Lack of information, particularly a vulnerability assessment (to identify the main drivers of estuary issues) and baseline monitoring. Sedimentation (possibly related to *Spartina* removal). Sea level rise. Point and nonpoint discharges. Weeds and pests. Past reclamation and toxicity.
Monitoring	Undertake Vulnerability Assessment. Map intensive landuse (5 yearly). Broad scale habitat map (5 yearly). Fine scale phys/chem/biota in sediments 5 yearly (after 3-4yr baseline). Sedimentation rate monitoring.
Management	Requires vulnerability assessment prior to finalising management options (this will identify the main sources of sediment, nutrients, organic matter, metals and disease-risk). Limit main inputs of fine sediment, nutrients and disease-risk indicators. Plan for estuary expansion with sea level rise.

APPENDIX 4. TASMAN ESTUARY CHARACTERISTICS (CONTINUED)

LOCATION OF TASMAN ESTUARIES ASSESSED IN THIS REPORT