State of the Environment Report

Tasman Coast: Waimea Inlet to Kahurangi Point

Habitat Mapping, Ecological Risk Assessment, and Monitoring Recommendations

August 2012

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Habitat Mapping, Ecological Risk Assessment and Monitoring Recommendations

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This report provides information on the ecological risks to coastal and estuarine habitats. Habitat maps and colour-coded and easy to reference vulnerability assessments are provided of the entire Tasman coast from the low tide line to 200m inland from the coast, but excluding the Abel Tasman coast and Farewell Spit. Maps and risk assessments of estuaries, beaches and dunes, rocky shores and terrestrial margins were described following detailed field assessments covering the coastline of Tasman and Golden Bays, and a desktop assessment of the West Tasman coast. The major stressors are described in detail including: fine sediment, nutrients and eutrophication, disease risk, toxicants, climate change, drainage and reclamation, invasive species, shoreline armouring, duneland removal, grazing, vehicles and other disturbance, structures, harvesting living resources. Recommendations are offered to better manage the coastal environment, including a long-term monitoring programme.

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Cover Photos: Waimea Inlet, Tasman Bay
Wharariki Beach, West Tasman

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Tasman Coast

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Cover Photo: Waimea Inlet, Tasman Bay.


Ruataniwha Estuary at Collingwood.

Tasman Coast

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by

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Abbreviations

AMAs	Aquaculture Management Areas
As	Arsenic
BMPs	Best Management Practices
Cr	Chromium
Cu	Copper
CVI	Coastal Vulnerability Index
DO	Dissolved Oxygen
ERA	Ecological Risk Assessment
FC	Faecal coliforms
Ha	Hectares
HABs	Harmful Algal Blooms
ICOLLs	Intermittently Closed and Open coastal Lakes and Lagoons
LIDAR	Light Detection And Ranging
LINZ	Land Information New Zealand
Mg	Magnesium
MNZ	Maritime New Zealand
Ni	Nickel
NIWA	National Institute of Water and Atmospheric Research of New Zealand
NY	Nitrogen Yields
ORV	Off-Road Vehicles
PAHs	Polyaromatic Hydrocarbons
Pb	Lead
PSP	Paralytic Shellfish Poisoning
RPD	Redox Potential Discontinuity
SS	Suspended Sediment
TABs	Toxic Algal Blooms
TDC	Tasman District Council
TSR	Tolerable Sedimentation Rate
TSS	Total Suspended Sediment
USGS	U.S. Geological Survey
Zn	Zinc

Contents

Contents (Continued)

All photos by Wriggle except where noted otherwise.

EXECUTIVE SUMMARY

SCOPE

Developing an understanding of the distribution and risks to coastal and estuarine habitats is critical to the management of ecological resources. Recently, Tasman District Council (TDC) contracted Wriggle Coastal Management to identify the habitat vulnerability and monitoring priorities for coastal ecological resources in the Tasman region using an adaptation of an existing UNESCO methodology and a risk-based matrix developed for broad scale assessments of beaches, dunes, rocky shores, and estuaries. The approach targets the highest priority section of the coastline as the first step (i.e. the developed sections of the coast from Waimea Estuary to Marahau; Wainui Inlet to Puponga and, at a lesser level of detail, the West Tasman coast from Fossil Point to Kahurangi Point). Its three main components produce the following outputs: coastal habitat maps in GIS format, vulnerability assessments, and a recommended coastal monitoring programme for the management of coastline biological resources in the region.

HABITAT MAPPING

The habitat mapping assessed 76% (611km) of the Tasman Coast from the predominantly exposed west-facing shoreline of West Tasman (208km), to the more sheltered north-facing coasts of Tasman (232km) and Golden Bays (171km). The areas not mapped were Farewell Spit (~95km) and Abel Tasman National Park (~95km). The assessment confirmed the coastline was ecologically diverse, containing a broad range of estuary, beach, dune and rocky shore habitat types as follows:

A. ESTUARIES

Within the studied area of the Tasman region, five types of estuary were identified under the two main categories; "tidal lagoon" type estuaries and "tidal river mouth" estuaries. They included;

- the second and third largest tidal lagoon estuaries in the South Island (Waimea and Whanganui Inlets),
- large tidal river estuaries with extensive and productive intertidal deltas (Motueka, Takaka, Ruataniwha),
- many small tidal river estuaries whose entrances intermittently block or constrict and cause water quality problems (e.g. Grants Road), and
- several relatively unmodified tidal river and tidal lagoon estuaries (all located in the West Tasman region).

The estuaries with the most valuable habitats (i.e. extensive tidal flats, saltmarsh and seagrass) were predominantly the larger tidal lagoon estuaries and the delta sections of many of the tidal river estuaries.

	Tasman Bay	Golden Bay	West Tasman
Estuaries assessed	7	22	12
Coastline length (km)	187	111	136
% of mapped coastline	81%	65%	65%
Saltmarsh (ha)	509	444	194
Seagrass (ha)	23	46.5	860

B. BEACHES AND DUNES

Because of the wide range of coastal conditions, the Tasman coast included all three of the major beach categories; wave dominated, tide-modified and tide-dominated. Wave dominated beaches mainly occupied the higher energy, exposed, mesotidal West Tasman coast. Tide-modified and tide-dominated beaches occurred in the more sheltered, macrotidal Tasman and Golden Bay areas, and often included ecologically-rich expansive tidal flats, with large areas of seagrass.

Most beaches in the Tasman region were backed by vegetated sand dunes. The most extensive and active dune systems, apart from Farewell Spit, were found on the West Tasman coast. In some areas, these extensive dune formations had buried adjacent low hills. Because of calmer wind conditions and a limited sand supply, the dunes in the more sheltered Tasman and Golden Bays were much less extensive, despite the large tides in the area, and had been heavily modified for development. In general, the dunes throughout the region were dominated by weed species: marram, gorse, and lupin. However, small areas replanted in native dune species (e.g. spinifex and pingao) were present on many beaches throughout the region.

	Tasman Bay	Golden Bay	West Tasman
Beach Length (km)	39	50	43
% of mapped coastline	17%	29%	21%
Coastal Seagrass (ha)	39	1544	0
Dune area (ha)	24.2	18.8	232
Exotic Dune Length (km)	10.9	21.4	21.1
Native Dune Length (km)	0.8	2.5	0

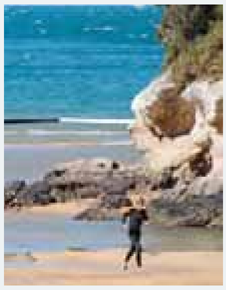
EXECUTIVE SUMMARY

C. ROCKY SHORES

Rocky shores were a significant, and often visually dramatic part of the Tasman coastline. Given the geological complexity of the region, their structure and composition varied between the different sections of the coastline.

- On the West Tasman coast, shores were very exposed, high-energy shores with sandstone rock types north of Whanganui Inlet, and mudstone and sandstone to the south. The biota were diverse and abundant, with mussels and barnacles dominating the intertidal rocky shores rather than large brown algae.
- In Tasman and Golden Bays, the rock types were variable and included granite, sandstone, mudstones and limestone. Again, mussels and barnacles dominated but diversity and abundance was lower than on the West Tasman coast, particularly in relation to macroalgal growth.

	Tasman Bay	Golden Bay	West Tasman
Length (km)	6	10	29
% of mapped coastline	3%	6%	14%



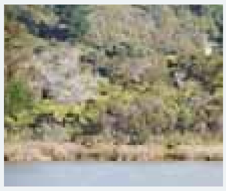

D. TERRESTRIAL MARGIN

Inland of the shoreline, the 200 metre wide terrestrial margin buffer had generally been modified from its natural vegetation state to farmland, roads, parks, exotic forest, and residential/industrial land use. In many situations the terrestrial margin had been moved, either because of reclamation of estuary margins, introduction of causeways and seawalls, or development of dune areas.

The percentage of the margin in pastoral use was greatest in the Golden Bay region (58%), followed by West Tasman (46%), and Tasman Bay (41%).

The use of seawalls to expand or maintain the terrestrial margin on the coast was very low on the West Tasman coast, but common on the coast in both Tasman and Golden Bays (10-13%), and within estuaries where margins have been extensively altered by seawalls, causeways, stopbanks and reclamations (Golden Bay 14%, Tasman Bay 33%, West Tasman 2%).

	Tasman Bay	Golden Bay	West Tasman
% Natural Margin	54%	31%	14%
Coastal seawall length	5.2km, 13%	5.1km, 10%	0km, 0%
Estuary seawall length	61km, 33%	16km, 14%	4km, 2%

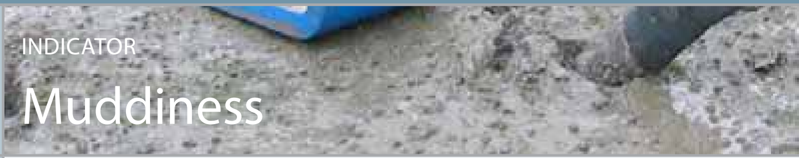



KEY ISSUES

The coastal Tasman region was shown to have a diverse range of habitats, high biological diversity, and high economic value. The health and productivity of the coastal habitats, including its extensive estuarine systems, are a cornerstone of the region's quality of life and vibrant economy, from fishing to shellfish production to tourism. Despite the high values of its coast, the vulnerability assessment identified a number of key coastal issues as follows:

- excessive muddiness and, to a lesser extent, nutrient enrichment of estuaries and embayments,
- elevated disease risk in estuaries and embayments, particularly after heavy rain,
- habitat loss through sea level rise, and ecological change through sea temperature and acidity change,
- duneland loss through overstabilisation,
- saltmarsh loss through historical reclamation,
- loss of the natural vegetated terrestrial margin buffer,
- habitat loss through shoreline armouring.

In order to address these issues, Wriggle have proposed a comprehensive monitoring programme that includes a number of key indicators of pressures that reflect the overall vitality of the coast. The key indicators, and the recommended monitoring, are as follows:



INDICATOR

Muddiness

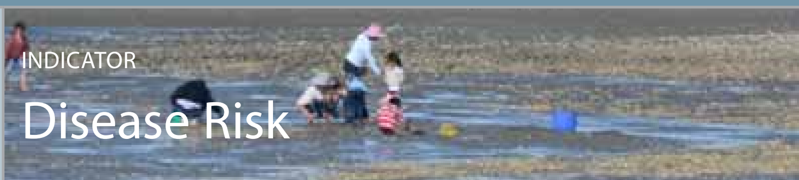
50% of Tasman and Golden Bay estuaries are excessively muddy. Tasman and Golden Bays are filling with mud which is degrading shellfish habitat.

Excess Mud Destroys Coastal Habitat in Tasman

50% of Tasman and Golden Bay estuaries are excessively muddy (greater than 10% of the estuary area filled with soft muds). Waimea is the most affected at 55% soft mud, and Waitapu and Motupipi have approximately 25%. In addition, Tasman and Golden Bays are filling with mud which is degrading shellfish habitat and causing siltation problems around rocky shores. Although a low rate of sedimentation is natural and provides a number of important functions (supplying nutrients, burying contaminated sediments, and buffering coastal erosion), environmental problems occur when the rate at which sediment is being transferred to, and deposited within, estuarine and coastal regions is significantly increased. This has the potential to profoundly alter the structure and function of estuarine and embayment ecosystems. Within the Tasman region, the major sources of sediment to the degraded estuaries and embayments were identified as being from intensive pastoral, urban and exotic forestry inputs.

Recommended Monitoring

- **Broad scale mapping** of at risk representative estuaries 5 yearly, all estuaries 10 yearly. **Reason:** To establish a baseline and to measure any change in the extent of muddy habitat over time.
- **Sedimentation rate** using sediment plates placed in all moderate-large estuaries and measured annually. **Reason:** To establish a baseline and to measure any change over time for rate of mud deposition in representative habitat.
- **Fine scale monitoring** of representative high value estuaries (Waimea, Moutere, Motueka Delta, Motupipi, Ruatanjwha, Whanganui). **Reason:** To establish a baseline and to measure any change over time to physical, chemical and biological variables.
- **Map catchment sediment source "hot spots"** 5 yearly and model catchment SS loads with potential best management practices (BMPs) in place. **Reason:** To identify likely fine sediment source areas and indicate the success of potential BMPs to guide planning and decision making.



INDICATOR

Disease Risk

The majority of Tasman's monitored estuaries and beaches are graded "good" but, particularly after heavy rain, have an elevated disease risk associated with bathing and shellfish consumption.

Bathing and shellfish gathering are highly valued in Tasman

When monitored over the summer bathing period, Tasman's beaches and estuaries are graded "good" for the vast majority of the time according to NZ Microbiological Water Quality Guideline criteria. However, particularly after heavy rain in the catchments, faecal bacterial runoff (primarily from intensive pastoral farming) presents an elevated disease risk associated with bathing and shellfish consumption. Farmland and human wastewater runoff often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged to the coast, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious human health risks posed through recreational contact and shellfish consumption, pathogen contamination can also cause economic losses due to closed commercial shellfish beds in the region.

Recommended Monitoring

- **Use catchment-based predictive models** to estimate disease risk around the coastline. **Reason:** To identify likely faecal bacterial source areas, assess their potential significance, and to evaluate the impact of BMPs to guide planning and decision making.
- Where shellfish beds are present (they are assumed to be extensive throughout the coastal area in Tasman), and high disease risk is predicted, **undertake water column monitoring** of representative coastal areas. **Reason:** to validate or refine model estimates, assess current risk, and to measure the impact of any implemented BMPs.
- **Indicate shellfish and bathing disease risk** by using validated model predictions at representative locations throughout the region. **Reason:** To cost effectively indicate likely faecal bacterial source areas, the potential success of BMPs, and conditions/locations where risk changes (e.g. rainfall events).

INDICATOR

Eutrophication

The majority of Tasman's estuaries are not eutrophic but several estuaries have some enrichment symptoms.

Maintain the low eutrophic status of Tasman estuaries

Despite moderate to high nutrient loads to a few of Tasman estuaries, they have a low to moderate eutrophic status, which is maintained by their relatively high level of flushing. However, nutrient enrichment issues (nuisance algal growths and low oxygen concentrations) were identified in the upper Motupipi Estuary and in a number of small tidal river estuaries whose outlets regularly become constricted or blocked. Additionally, the Waimea Estuary has the most extensive area of excessive macroalgal growth.

Eutrophication causes changes in plant and animal communities, favouring rapidly reproducing opportunistic algal (e.g. sea lettuce) and animal species. Opportunistic algal species can adversely affect ecosystems. For example, mass occurrence of phytoplankton and/or macroalgae and epiphytes often leads to the loss of long-lived seagrass species. Once the available nutrients have been depleted, the algal blooms decay, leading to oxygen depletion, possible kills of fish and benthic invertebrates, and the formation of toxic hydrogen sulphide (H_2S). As well as causing impacts on the ecosystem, eutrophication can affect human activities. For example, algal blooms and decaying algae can clog fishing nets, create unsightly foam masses on beaches, and unpleasant smells that adversely affect tourism and recreation. Climate change is likely to exacerbate areas prone to eutrophication through more rain and increased flooding, which is expected to enhance nutrient enrichment through increased freshwater input and run-off from land. Within the Tasman region, the major source of nutrients to the estuaries and embayments was identified as being from intensive pastoral inputs.

Recommended Monitoring

- **Broad scale mapping** of macroalgal cover of at risk estuaries (Waimea, Moutere, Motupipi, Onehau and Onekaka) 5 yearly, all estuaries 10 yearly. **Reason:** To establish a baseline and to measure any change over time in the extent of nuisance algal growth.
- **Fine scale monitoring** of representative high value estuaries (Waimea, Moutere, Motueka Delta, Motupipi, Ruataniwha, Whanganui) for key eutrophication indicators (RPD, sediment nutrients, organic carbon and macroinvertebrates). **Reason:** To establish a baseline and to measure any change over time to key physical, chemical and biological variables.
- **Map catchment nutrient source "hot spots"** 10 yearly and model catchment nutrient loads with potential BMPs in place, for key catchments (e.g. Waimea). **Reason:** To identify likely nutrient source areas and indicate the success of potential BMPs to guide planning and decision making.

INDICATOR

Eelgrass

Eelgrass and other seagrass species are used as indicators of estuarine health throughout the world.

Eelgrass is prime habitat for many species in Tasman

Eelgrass is a marine plant of high ecological value that grows in the estuaries and shallow embayments of the Tasman region. It flowers and produces seeds, unlike seaweed, and grows quickly in the spring and summer. Eelgrass is important because it provides food and habitat for birds, fish, crabs, shellfish and other marine organisms. It also dampens wave energy and traps sediment thereby protecting shorelines from erosion, and contributes to improved water quality.

Eelgrass and other seagrass species are used as indicators of estuarine health throughout the world because they respond sensitively to many natural and human-caused environmental factors that affect water quality and shoreline sedimentation. Changes in the abundance or distribution of eelgrass are likely to reflect changes in environmental conditions, particularly increased sediment loads and eutrophication. They are also likely to affect many other species that depend on eelgrass habitat.

An effective way of improving Tasman shoreline and estuary habitats is to maintain and increase the amount of eelgrass that grows in its waters, primarily through reducing fine sediment and excessive nutrient inputs, or strategic replanting if suitable conditions exist. Though some larger Tasman eelgrass beds are stable or possibly increasing in size, many of the smaller more widely dispersed beds are in decline, particularly in estuaries.

Recommended Monitoring

- **Broad scale mapping** of the area of eelgrass throughout the region at 5 yearly intervals. **Reason:** To establish a baseline and to measure any change over time in the extent of eelgrass habitat.
- **Fine scale monitoring** of representative high value estuaries with seagrass beds (Waimea, Moutere, Motueka Delta, Motupipi, Ruataniwha, Whanganui). **Reason:** To establish a baseline and to measure any change over time to key physical, chemical and biological variables.
- **Identify the source of the major stressor** (i.e. fine sediment) affecting eelgrass habitat in the region. Map catchment sediment source "hot spots" 5 yearly and model catchment SS loads with potential BMPs in place. **Reason:** To identify likely fine sediment source areas and indicate the success of potential BMPs to guide planning and decision making.

INDICATOR

Duneland

30% of active duneland has been lost to overstabilisation in the Tasman and Golden Bay areas since 1940.

Duneland is a dynamic ecosystem with high natural character

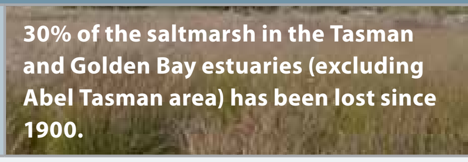
Coastal sand dunes in good condition and that are able to migrate in response to physical changes, help protect the coastal margins from erosion and sea level rise. They also provide specialised habitats for plants, birds and animals; provide a range of unique landforms; act as a filter for rain and groundwater and, if utilised wisely, provide recreational and living space. Within Tasman, ~30% of active duneland has been lost to overstabilisation in the Tasman and Golden Bay areas since 1940. Overstabilisation of dunes has occurred through plantings of exotic forest, exotic sand-binding species (marram), development for pasture or residential use, roading, and building of seawalls. Areas of particular concern were Rabbit Island (exotic forest), Motueka and Jacket Island (exotic plantings and residential development), and many spits and beach margins in Golden Bay (a mix of forest, marram, lupin, weeds and pasture). Barriers to landward migration are also common (e.g. roads, houses). However, there has also been a number of small-scale native dune plantings established throughout the region which all serve to support the likely success of any larger scale dune restoration programme.

Recommended Monitoring

- **Broad scale mapping** of area of duneland at 5 yearly intervals, and recording of dominant sand-binding species, occurrence of weed species and location of rare or threatened species. **Reason:** To establish a baseline and to measure any change over time for extent and condition of dune habitat.
- **Fine scale monitoring** of representative high value beaches bordered by dunes, (Rabbit Island, Pakawau). **Reason:** To establish a baseline and to measure any change over time to key physical and biological variables.
- **Identify the source of the sand** that feeds the dune systems. **Reason:** to enable appropriate management of source areas to ensure long term maintenance of dune systems.

INDICATOR

Saltmarsh



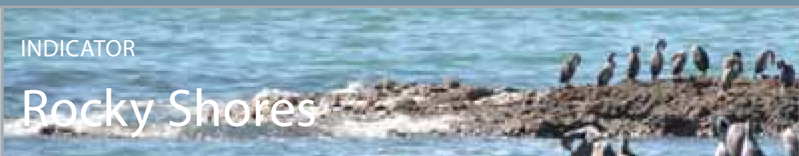
30% of the saltmarsh in the Tasman and Golden Bay estuaries (excluding Abel Tasman area) has been lost since 1900.

Saltmarsh is a cornerstone of Tasman estuary ecosystems

The assessment found that ~30% of the saltmarsh in the Tasman and Golden Bay estuaries (excluding Abel Tasman) has been lost since 1900. Moutere and Ruataniwha estuaries have suffered the largest loss at 50% and 40% respectively. This reclamation of high value habitat has severely lowered the natural assimilative capacity of these estuaries which has led to increased sedimentation rates in tidal flat areas and low habitat quality. Saltmarsh is one of the most productive environments on earth, and serves as an important nursery ground and wildlife habitat. Saltmarsh provides tremendous benefits for humans including flood and erosion control, water quality improvements, opportunities for recreation, and for atmospheric gas regulation - estuaries tend to be "carbon sinks," since carbon dioxide is absorbed in the photosynthesis carried out by the prolific plant growth. Tidal saltmarshes have the ability to respond rapidly to physical stressors, and their condition is often a dynamic balance between relative sea level rise, sediment supply, and the frequency/duration of inundation. However, if sea level rises too much or too fast, or the sediment supply or inundation through flooding is excessive, then the balance can be upset and the saltmarsh is lost or its condition deteriorates. This balance varies between different types of estuaries but their response centres around how each reacts to sediment inputs and inundation (the latter is particularly important in face of predicted accelerated sea level rise through global warming).

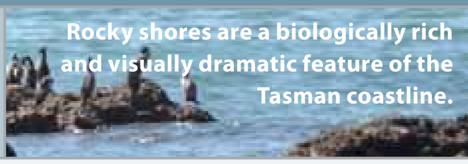
Recommended Monitoring

- **Broad scale mapping** of the area of saltmarsh throughout the region at 5 yearly intervals in areas where change is likely, and 10 yearly for other areas. **Reason:** To establish a baseline and to measure any change over time in the extent of saltmarsh habitat.
- **Fine scale monitoring** of representative high value estuaries with saltmarsh beds (Waimea, Moutere, Motueka Delta, Motupipi, Ruataniwha, Whanganui). **Reason:** To establish a baseline and to measure any change over time to key physical, chemical and biological variables.
- **Identify the source of the major stressor** (i.e. fine sediment) affecting saltmarsh habitat in the region. Map catchment sediment source "hot spots" 5 yearly and model catchment SS loads with potential BMPs in place. **Reason:** To identify likely fine sediment source areas and indicate the success of potential BMPs to guide planning and decision making.



INDICATOR

Rocky Shores



Rocky shores are a biologically rich and visually dramatic feature of the Tasman coastline.

Rocky shores are sensitive to climate change and sediment

Intertidal rocky shorelines contain a great abundance of marine life and biodiversity, and are a significant natural and economic asset. Rocky shores are relatively common around the Tasman region, and include various types (platform, boulderfields, exposed and sheltered). While generally rocky shorelines are some of the most accessible marine environments, attracting large numbers of visitors, much of the Tasman coast is accessible only on foot or by boat.

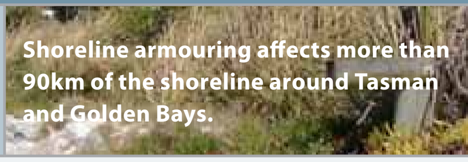
Rocky shore species are particularly useful as indicators of climate change, sedimentation and eutrophication effects as rocky shores are accessible, most species are sedentary or sessile (i.e. do not or cannot move around), and they can be easily sampled in a non-destructive way. Communities of species on rocky shores are also sensitive to a variety of both acute (e.g. oil spills) and chronic impacts (e.g. antifouling paints, recreational activities). The vulnerability assessment identified sedimentation and climate change (sea level rise, sea temperature and acidity) as major stressors on the coastal Tasman region, and oil spills as a significant risk. It is therefore important to undertake rocky shore monitoring at representative sites in the region to assess the extent and rate of any changes so that appropriate management options are developed.

Recommended Monitoring

- **Long term monitoring** of the abundance and diversity of plants and animals (including indicator species) at three high diversity rocky shores (one in Tasman Bay, one in Golden Bay and one on the West Coast) using rapid assessment methods developed under the Marine Biodiversity and Climate Change Project (Hiscock 1996) and modified for NZ use (Stevens and Robertson 2011). **Reason:** To establish a baseline and to measure any change over time to physical and biological variables from key stressors (sedimentation, climate change).

INDICATOR

Shoreline Armouring



Shoreline armouring affects more than 90km of the shoreline around Tasman and Golden Bays.

Tasman's unarmoured shores support coastal ecology

Currently, 65km (28%) of the Tasman Bay, and 21km (12%) of the Golden Bay, and 4km (2%) of the West Tasman coastal and estuarine shoreline has hard armouring e.g. seawalls, causeways, stopbanks, reclamations. Seawalls, in particular, damage beach and estuary ecology, destroy dunes, and prevent natural migration of habitat landward in response to sea-level rise. On unarmoured shorelines, sand and gravel from eroding areas and river plumes are transported by waves and currents and ultimately supply sediment to form and maintain the beaches and spits of the region. These natural processes, important because they support vital functions like providing habitat for key species in the surf zone and intertidal areas of beaches, are compromised when shorelines are armoured. Currently, the largest proportion of beach that is armoured is at Ruby Bay (~55% of the beach), and the largest proportion of an estuary is Moutere Inlet (~43%).

However, areas of beaches and estuaries are armoured throughout the Tasman region (e.g. Whanganui, Puponga, Collingwood, Marahau, Kina, Waimea). In the future, pressure to protect the Tasman coastline by artificial structures is expected to increase because of pressure to allow and protect existing coastal development, combined with the greater predicted frequency of storms. Given the high value of Tasman's coastal ecosystems, it is recommended modification of natural shoreline processes be discouraged, and armouring in the region be reduced wherever possible, by locating new structures to minimise the need for armouring, by strategically removing existing armouring where possible, or using "soft shore" designs for new and replacement armouring to reduce traditional hard armouring impacts.

Recommended Monitoring

- **Broad scale mapping** of the extent of shoreline armouring throughout the region at 5 yearly intervals. **Reason:** To establish a baseline and to measure any change over time to the extent of shoreline armouring habitat.
- **Broad scale mapping** of coarse sediment supply zones throughout the region at 5 yearly intervals. **Reason:** To establish a baseline and to measure any change over time for extent of change to sediment supply zones.

INDICATOR

Natural Terrestrial Margin

65% of the natural terrestrial margin has been highly modified in the Tasman and Golden Bay areas.

Vegetated margins provide hazard protection and protect biodiversity, aesthetic and amenity values.

Coastal shoreline habitats function best with a natural vegetated margin which acts as a buffer from development and "coastal squeeze". This buffer protects against introduced weeds and grasses, naturally filters sediment and nutrients, and provides valuable ecological habitat. The assessment found that 65% of the natural vegetated terrestrial 200m margin buffer that historically bordered shorelines in the Tasman region has been highly modified, mainly due to intensive pastoral grazing, residential properties and forestry - modification often extending a long distance inland from the coast. Development within this coastal buffer margin results in decreased resilience of the coast in the face of physical forces (particularly shoreline erosion), and reduced biodiversity, aesthetics, heritage and landscape values and public access.

Because coastal development is a major cause of natural margin loss, one way to manage change is to "setback" development a prescribed distance from the coast. Development setbacks inform property owners of the potential risk posed by coastal erosion, and are used to manage the location of new dwellings to ensure houses are safely located, avoiding the need for seawalls (Dahm & Gibberd 2009). Coastal setbacks can be calculated by a variety of methods (Scoullar 2010, Smith 2010), but most only consider hazards (particularly erosion and sea level rise) and ignore biodiversity and public access. Smith (2010) has recommended a 100m wide default setback for situations where detailed calculations have yet to be undertaken. In the current report, a 200m wide potential setback zone (terrestrial margin) has been mapped to ensure an adequate perception of current uses in this high value coastal margin zone.

Recommended Monitoring

- **Broad scale habitat mapping** of a 200m wide terrestrial margin at 5-10 yearly intervals. **Reason:** To establish a baseline and to measure any change over time to the extent of natural vegetated habitat.

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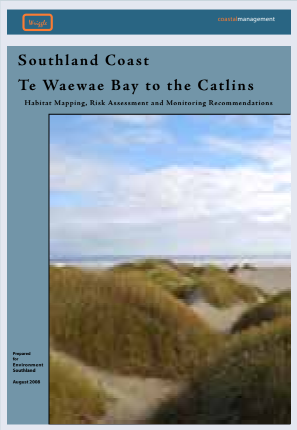
1. INTRODUCTION

AIM AND SCOPE



The coastal and marine areas of New Zealand have not been well described. According to the Government of New Zealand (2000), "current knowledge of marine life and how marine ecosystems work is not adequate to show whether we are sustainably managing New Zealand's marine biodiversity", and that "the management of the coastal and marine environment and of impacts on that environment needs to be integrated within an ecosystem-based framework with explicit biodiversity objectives." The need to gather information to inform the assessment of effects on the environment is implicit in New Zealand's legislation for sustainable management. A key mechanism in this process is coastal habitat vulnerability assessments.

Recently, Tasman District Council (TDC) contracted Wriggle Coastal Management to identify the habitat vulnerability and monitoring priorities for coastal ecological resources in the Tasman Region using a similar approach to that recently used in the Southland and Wellington regions (Robertson and Stevens 2007a, 2007b, 2007c, 2008). The approach targets the highest priority section of the coastline as the first step (i.e. the developed sections of the Tasman and Golden Bay coast from Waimea Estuary to Marahau, from Wainui Inlet to Puponga, and, at a lesser level of detail, the west Tasman coastal section from Fossil Point to Kahurangi Point). Its three main components produce the following outputs:

- **Coastal Habitat Maps:** An ArcMap GIS dataset depicting current broad-scale habitat cover types along the coast, based on aerial photographs and ground truthing techniques (Robertson and Stevens 2007a, 2007b). Completed habitat maps for each section of the coast are presented in Appendix 4.

- **Vulnerability Assessments:** 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. The approach used is an adaptation of an existing UNESCO methodology (UNESCO 2000) and a risk-based matrix developed for broad scale assessments of beaches, dunes, rocky shores and estuaries (Robertson et al. 2002, Robertson and Stevens 2007a, 2007b, 2008). Completed vulnerability assessments are presented in Section 5, with summary data in Appendices 1 and 2).

- **Monitoring Priorities:** A recommended coastal monitoring programme for the management of coastline biological resources in the region.

The remainder of the TDC coastline (i.e. Abel Tasman National Park and Farewell Spit) is expected to be assessed using a similar approach sometime in the future.

REPORT STRUCTURE


Waimea Inlet

Section 1 provides an introduction to the scope and structure of the study.

Section 2 introduces the methods used for the habitat mapping, vulnerability assessments and for identifying monitoring recommendations.

Section 3 provides a broad introduction to the coast by identifying the major coastal shoreline and estuary habitats (their characteristics, issues, values and uses).

Section 4 describes the stressors and how the influence of each has been evaluated.

Section 5 provides summary detail for the coast in a section by section approach. For each section of the coast and specific estuaries, it describes their characteristics, issues, values and uses, recommended monitoring, existing condition and susceptibility ratings. Supporting detail used in the assessment is included in Appendices 1 and 2.

Section 6 Conclusions.

Section 7 Monitoring recommendations.

2. METHODS

VULNERABILITY ASSESSMENT

The Ecological Vulnerability Assessment (EVA) is adapted from a UNESCO methodology (UNESCO 2000) that is designed to be used by experts to represent how coastline ecosystems are likely to react to the effects of potential "stressors" (the causes of coastal issues - often human activities). The EVA involves the following 8 key steps (for details see Table 2).

1. Broad scale mapping to identify habitats of selected sections of the coastline. Figure 1 shows the location of estuaries and the coastal sections assessed.
2. Assessment of key stressor influence/s based on magnitude, existing condition and susceptibility.
3. Assessment of stressor influence/s on each habitat to identify which are most at risk.
4. Assessment of stressor influence/s on monitoring indicators, and hence issues, to identify which indicators have highest priority for monitoring.
5. Assessment of the human and ecological uses and values of the coastline to identify which are important in each area of the coastline.
6. Assessment of the influence of each monitoring indicator on human use and ecological values.
7. Identification of priority indicators for monitoring.
8. Integration of the above to identify overall vulnerability, key issues, monitoring recommendations, and management targets.

Steps 2-8 are undertaken by completing a specially designed vulnerability matrix, one for estuaries, and the other for beaches, dunes and rocky shores. An outline of the approach for completing these matrices is presented in Table 3. The completed matrices for each section of the coast are presented in Section 5 along with a summary of the findings for each section of the coast. This includes the "vulnerability" ratings and any recommended monitoring using currently available tools (Table 1) including; the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002), plus recent extensions (e.g. Robertson & Stevens 2007a).

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

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

Moutere Delta

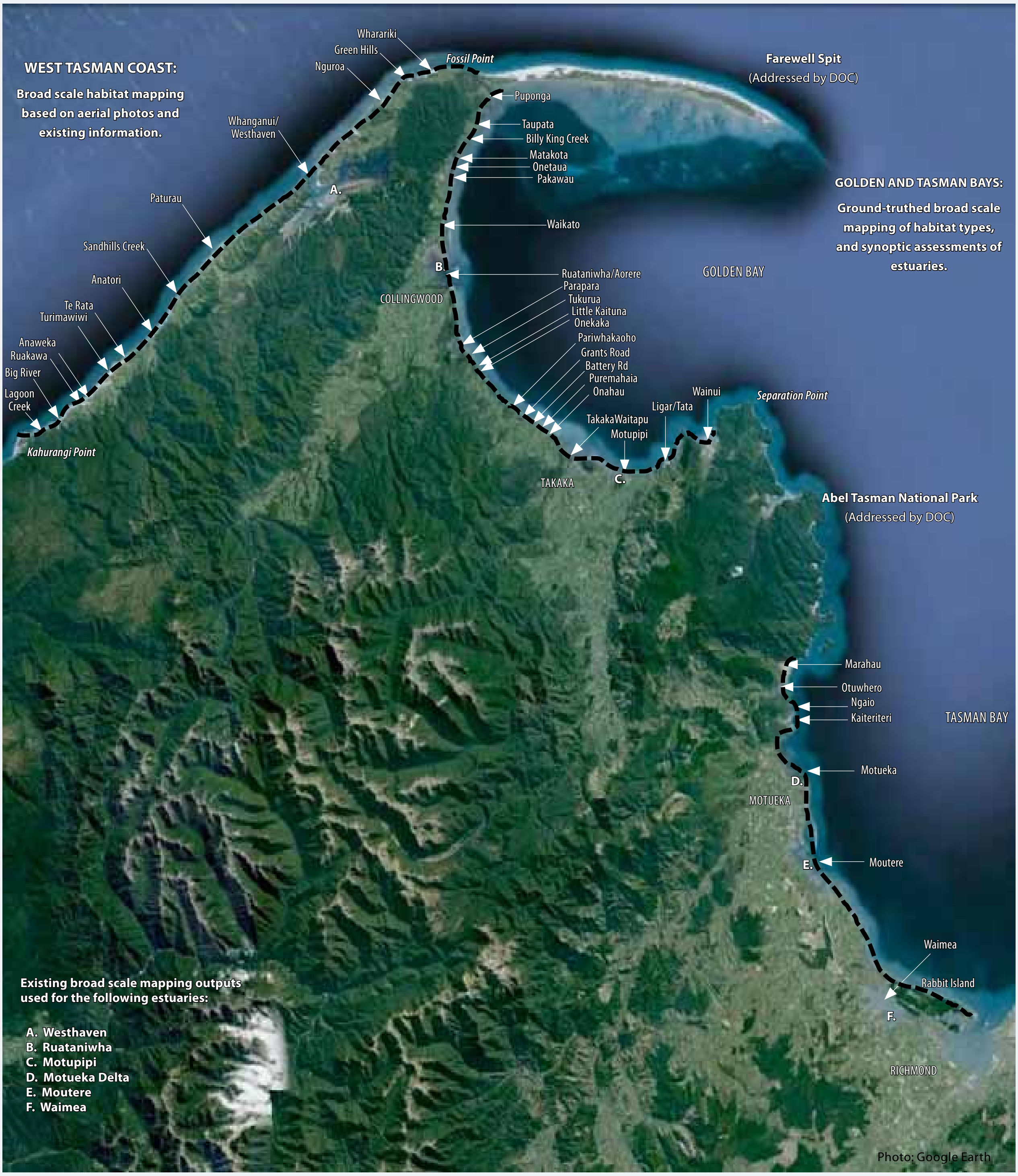


Figure 1. Tasman coastal sections and estuaries assessed in this report.

2. METHODS (CONTINUED)

Table 2. Summary of the steps used in completing a coastal ecological vulnerability assessment.

Steps	Methods
Step 1. **Generate Broad Scale Coastal Habitat Maps.**	In order to identify habitats on selected sections of the coastline, broad scale mapping based on the National Estuarine Monitoring Protocol (Robertson et al. 2002) are used to record the primary habitat features at a structural class level e.g. rushland, saltmarsh, seagrass, soft mud, sand, rocky shore. Features are ground-truthed on 1:10,000 1m/pixel colour aerials and digitised into ArcMAP 9.3 to produce GIS maps of the following: • Dominant substrate, saltmarsh, and intertidal seagrass(*Zostera*) • 200m wide terrestrial margin vegetation/landuse • Georeferenced digital f eld photos In the current assessment, ground-truthing was not undertaken for lower priority remote areas on the West Coast. Instead, habitat type was identif ed by an experienced scientist using aerial photographs. Because some of the main estuaries have been previously mapped, existing habitat maps were used for the present assessment. They are as follows: Waimea Estuary (Robertson et al. 2002, Stevens and Robertson 2010), Moutere Inlet (Clark et al. 2006), Motueka Delta Estuary (Robertson et al. 2003), Motupipi Estuary (Stevens and Robertson 2008), Ruataniwha Estuary (Robertson et al. 2002), Whanganui Inlet (Davidson 1990).
Step 2. **Assess Key Stressor Influence.** **Identify Key Stressor Influence Based on Magnitude, Existing Condition and Susceptibility.**	Stressors (or pressures) are activities that af ect the ecological condition of coastal and estuarine habitat. In this section, the key stressors are identif ed and their likely inf uence assessed based on 3 variables; stressor magnitude, existing condition in relation to stressor, and susceptibility in relation to stressor. Information on these variables is determined based on existing data, observation, and expert opinion. For priority sections of the coast, monitoring of selected variables will be undertaken, e.g. dissolved oxygen, RPD, area of soft mud, clarity, macrophyte and macroalgal growth. Also, where available, national monitoring data which gives the response of dif erent types of coastal habitats to stressors e.g. modelled inputs of nutrients, sediment and faecal coliforms, will be used.
Step 3. **Rate the Stressor Influence on Habitat.**	The inf uence of key stressors on the ecological condition of each listed coastal and estuarine habitat type is rated based on the results of Step 2 (i.e. Stressor Inf uence).
Step 4. **Identify and Rate Human Uses and Ecological Values.**	Human uses and ecological values are identif ed and their presence assessed using four broad rating categories (Very Low, Low, Moderate, High) based on a UNESCO (2000) methodology. Expert judgement is used to provide an overall rating for each use as follows: **1. Human Uses and Values**. The information used to rate human uses and values of coastal habitat is based on local knowledge and available information. The estimated number of people involved are used to guide the rating: • Very Low: <10 per year. • Low: 10 to 50 per year (<30 per day in summer). • Moderate: >30 per day (may be only in summer) but <200 per day. • High: >200 per day (any time during year). **2. Ecological Values (Richness)**. Ecological value def nes an ecosystem's natural riches (generally interpreted as habitat diversity and biodiversity). It can be supposed that the more rich and diversif ed an ecosystem is, the greater the losses will be in the event of a disruption. The ecological richness component is divided into four subcategories; birds, vegetation, f sh and other biota. The information used to rate the ecological value will be drawn from local knowledge, available reports and information, and expert opinion.
Step 5. **Rate Stressor Influence on Monitoring Indicators and Hence Issues.**	Monitoring indicators that can be used to assess the inf uence of stressors are identif ed. For each, a rating is applied based on the extent that each monitoring indicator is likely to be af ected by the stressor inf uence that was estimated in Step 2. Because each monitoring indicator is assigned into an appropriate issue category, it is then straightforward to assess which issues are likely to arise and what should be monitored. In this section, the overall stressor inf uence rating for each indicator is also determined using appropriate weightings for each stressor.
Step 6. **Identify Priority Indicators for Monitoring**	Combine the results of Steps 4 and 5 to determine the priority indicators for monitoring.
Step 7. Overall Vulnerability, Key Issues, Monitoring Recommendations.	Finally, determine overall vulnerability by combining total stressor inf uence, total human use rating, and total ecological values rating. Identify key issues for monitoring. Make monitoring recommendations based on priority monitoring indicators.

Table 3. Steps in Filling out The Vulnerability Matrix

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Broad scale mapping.	Rate overall stressor influence.	Rate the stressor influence on habitat.	Rate Human Uses and Ecological Values.	Rate the stressor influence on monitoring indicators and hence issues.	Identify priority indicators for monitoring.	Determine the overall ratings and key issues.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

SITE:

DATE:

KEY FOR RATINGS

- High
- Moderate
- Low
- Very Low

STRESSORS	STRESSOR	STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES										STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)																													
									HUMAN USES					ECOL. VALUES					Eutrophication										Sedimentation						D.	Toxins			Habitat Loss									
	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators	Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment																																																
Nutrients/Eutrophication																																																
Pathogens																																																
Toxicants																																																
Climate Change - Sea Level Rise																																																
Climate Change - pH, temp																																																
Spills (oil)																																																
Grazing of high value habitat																																																
Freshwater abstraction																																																
Reclamation/Drainage																																																
Harvesting living resources																																																
Algal blooms (from sea)																																																
Seawalls, breakwaters etc																																																
Invasive weeds/pests																																																
Vehicle damage																																																
Loss of vegetated terrestrial margin																																																
Animal/man disturbance																																																
																			PRIORITY INDICATORS FOR MONITORING																													
OVERALL RATING																																																

OVERALL VULNERABILITY RATING

Human Use		
Ecological Value		
Overall Stressor Influence		
OVERALL VULNERABILITY		
KEY ISSUES		

Wharariki Beach

COASTAL HABITAT MAPS

Broad-scale mapping is a method for describing habitat types based on the dominant surface features present (e.g. substrate: mud, sand, cobble, rock; or vegetation: seagrass, macroalgae, rushland, etc. - Appendix 3). It follows the EMP approach originally described for use in NZ estuaries by Robertson et al. (2002) and for other sections of the NZ coast by Robertson and Stevens (2006), with a combination of aerial photography, detailed ground-truthing, and GIS-based digital mapping used to record the primary habitat features present. Very simply, the method involves three key steps:

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

Example of laminated aerial photo with ground-truthing details

For the current study, TDC supplied rectified 0.5m/pixel resolution colour aerial photos flown in c.2008, with additional information derived from Google Earth imagery. Photos covering the coastline at a scale of 1:10,000 were laminated, and two scientists ground-truthed the spatial extent of dominant habitat and substrate types by walking and driving the extent of the coastline and estuaries, taking field photographs, and recording features directly onto the laminated aerial photos over a few weeks in December 2010 and March 2011.

Because the main estuaries had all been previously mapped, existing habitat maps were used for the present assessment as follows:

- Waimea Estuary (Robertson et al. 2002, Davidson and Moffatt 1990),
- Moutere Inlet (Clark et al. 2006),
- Motueka Delta Estuary (Robertson et al. 2003),
- Motupipi Estuary (Stevens and Robertson 2008),
- Ruataniwha Estuary (Robertson et al. 2002),
- Whanganui Inlet (Davidson 1990).

Appendix 3 lists the class definitions used to classify substrate and vegetation. Vegetation was further classified using an interpretation of the Atkinson (1985) system, whereby dominant plant species were coded by using the two first letters of their Latin genus and species names e.g. marram grass, *Ammophila arenaria*, was coded as Amar. An indication of dominance is provided by the use of ( ) to distinguish subdominant species e.g. Amar(Caed) indicates that marram grass was dominant over ice plant (*Carpobrotus edulis*). The use of ( ) is not always based on percentage cover, but the subjective observation of which vegetation is the dominant or subdominant species within the patch. A measure of vegetation height can be derived from its structural class (e.g. rushland, scrub, forest).

Results were entered by digitising features directly off aerial photos in the GIS using a Wacom Intuos3 electronic drawing tablet within ArcMap 9.3. The spatial location, size, and type of broad scale habitat features are provided as ArcMap 9.3 GIS shapefiles on a separate CD, with habitat maps of the coast presented in Appendix 4. The Appendix 4 habitat maps also include a detailed overlay of freshwater wetlands provided by TDC to highlight their location within the terrestrial margin. Because this wetland layer was unverified, it was not used in calculating the terrestrial margin cover statistics presented in this report.

Georeferenced digital field photos are also supplied as a GIS layer. As the GIS structure allows data to be easily managed, and contains a much greater level of detail than can be concisely presented in a summary report, the GIS should be used as the primary resource for assessing broad scale habitat data.

3. BACKGROUND

3.1 GENERAL

The Tasman region (9,786 km^2 with an ~800km coastline length) is situated in the north-west of the South Island (Figures 1 and 2). Much of the region is mountainous with large parts being inaccessible. It includes three broad areas (coastal lengths in brackets); Tasman Bay (232km), Golden Bay (171km) and West Tasman (Farewell Spit to Kahurangi Point - 208km). Farewell Spit (95km shoreline) arcs in a west-east direction and encloses and shelters northwestern Golden Bay. Tasman and Golden Bays, separated by the iconic Abel Tasman National Park (95km), are both wide, shallow inlets that open out to Cook Strait.

The major shoreline habitats of the region include: estuaries, beaches, dunes and rocky shores. Their physical structure is primarily the result of the combined actions of ocean water circulation, tides, winds, geology, landuse, and freshwater inflows.

OCEAN CIRCULATION AND TIDES

Water circulation within the bays is primarily driven by strong tidal flows which results in clockwise circulation patterns in Golden Bay, and western Tasman Bay, and an anti-clockwise circulation in eastern Tasman Bay (Figure 2). However, at times, local wind-driven flows can act to alter directions of these residual tidal flows. The West Tasman area is positioned on the more exposed west coast of the South Island where the primarily northward flowing Westland Current drives coastal circulation.

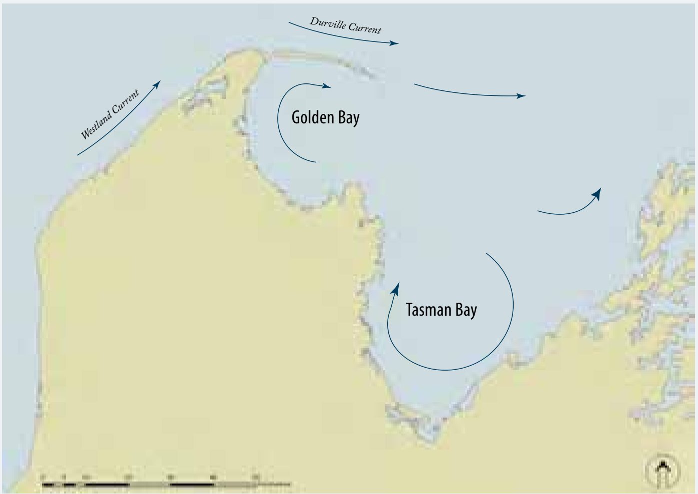


Figure 2. Schematic diagram of coastal circulation patterns in the Tasman region (adapted from Tuckey et al. 2006).

The strong tidal flows result from the high tidal range experienced in the bays. Golden Bay, at the western extremity of greater Cook Strait, is a macro-tidal environment and has the highest tidal range in the country of ~5m with a ~4.7m mean high water spring (MHWS) (LINZ 2001). Tidal speeds within Golden Bay have been recorded at 0.15 - 0.30cm/sec (Harris 1990). Tides in Tasman Bay are similar with a ~4.2m mean high water spring (MHWS). Tides on the West Tasman coast are smaller, but still large enough to be classified as high meso-tidal (MHWS of ~2.9m at Whanganui Inlet).

CLIMATE

The Tasman region generally has high annual sunshine hours and, because it is situated in the westerly wind belt, it receives most of its wind from this quarter. Most rain occurs during north to northwest flows and is lowest during southerly flows. The most intense depressions, accompanied by high rainfall and high winds from the north and northwest, occur when depressions from the Tasman Sea move southeast across the region. West Tasman is the most exposed coastline, with Golden Bay and western Tasman Bay being relatively sheltered from the influence of wind and waves.

3. BACKGROUND (CONTINUED)

3.1 GENERAL (CONTINUED)

GEOLOGY

The Tasman region has an interesting and complex geology. It contains the oldest rocks of anywhere on New Zealand's main islands. It contains all the main NZ basement rocks including; limestones, marbles, granites, mudstones and ultramafic rocks. The latter contain elevated concentrations of nickel and chromium and, in some areas (eg. Red Hills), are rich in minerals containing iron and magnesium. The main influence of geology on coastal habitats is whether the rocks in the catchment are dominated by soft or hard rock types. Those with significant areas of soft or readily erodible rock types, like the Motueka catchment, tend to have the highest sediment yields. Sediment yields are considered in greater detail in Section 4.2.

LANDUSE

Tasman is a heavily forested area, 54% is indigenous forest and a further 10% is exotic forest (Table 4). Much of the indigenous forest is included in the three national parks found in the area; Abel Tasman (22,541ha), Nelson Lakes (101,753ha) and part of the 425,000ha Kahurangi National Park. The coastal areas of the Tasman region are where the major fertile areas are located, including significant areas suitable for horticultural activities.

Table 4. Landuse in the Tasman region (from 2007 Agricultural Production Census, Statistics NZ).

Landuse	Hectares
Native Forest	750,000
Urban	20,000
Grassland and tussock	106,000
Plantation forest	84,000
Horticulture and grain/fodder	8,150
Mature native bush (on cultivatable land)	18,250
Scrub & regenerating bush	19,600
All other land	17,700

FRESHWATER FLOWS

The highest volume river in the Tasman region is the Aorere River with a mean flow of 84m^3/s (Table 5). This river, plus the slightly smaller Takaka River (mean flow 60m^3/s), both discharge into Golden Bay. The largest rivers entering Tasman Bay are the Motueka River (mean flow 68m^3/s) and the Waimea River (mean flow 18m^3/s). The largest rivers in the West Tasman area have much smaller mean flows, Paturau River (5.1m^3/s) and Anatori River (5.0m^3/s). The influence of the river plumes and associated contaminants on coastal areas in Tasman and Golden Bays is expected to be considerable based on modelling studies undertaken on the Motueka, Waimea, Aorere and Takaka River plumes (Tuckey et al. 2006). For example, during high flows, the studies indicate that the plumes are likely to influence the majority of the shorelines in Golden and western Tasman Bays.

Table 5. Major rivers, catchment areas and mean flows in the Tasman region (Source TDC and NIWA WRENZ data).

Catchment	Area (km^2)	Mean Flow (m^3/s)
Waimea River	726	18
Motueka River	2,180	68
Takaka River	900	60
Aorere River	767	84
Paturau River	76	5.1
Anatori River	76.1	5.0

3. BACKGROUND (CONTINUED)

3.2 HABITAT TYPES

The major shoreline habitats of the region include: estuaries, beaches, dunes and rocky shores. General descriptions of these habitat types are presented below.

3.2.1 ESTUARIES

Waimea Inlet, Tasman Bay

Estuaries are often under-valued by humans but contain a wide variety of plant and animal life. In good condition, they support more life per square metre than the richest New Zealand farmland. Their high value lies in two main characteristics; the wide diversity of habitats they offer, and their natural ability to collect and assimilate sediment and nutrients from the surrounding catchment and inflowing tidal waters. An important aim of this assessment was therefore to identify any "pristine or near-pristine" estuaries in the region and to identify the level of change within other estuaries (i.e. largely unmodified, modified and severely modified).

An estuary was classified as near pristine if it had:

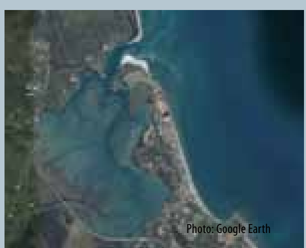
- a high proportion of natural vegetation cover in the catchment
- minimal changes to hydrology in the catchment
- no changes to tidal regime
- minimal disturbance from catchment land use
- minimal changes to floodplain and estuary ecology
- low impact from human use of the estuary
- minimal impacts from pests or weeds

ESTUARY TYPES

Because New Zealand is a narrow, mountainous country with good rainfall, it has both a large number of estuaries relative to its size, and a variety of estuary types (McLay 1976, Kirk and Lauder 2000, Hume et al. in press). In terms of ecological vulnerability, the type of estuary is important. The major factors determining estuary type are: the shape of the estuary basin, the tidal regime, the ocean swell, freshwater inflow, and wind acting on the surface of the estuary basin. The interaction of these factors produce: mixing, circulation, stratification, sedimentation, and flushing within the estuary. Within the studied area of the Tasman region, five types of estuary were identified under the two main categories; "tidal lagoon" type estuaries and "tidal river mouth" estuaries.

1. Tidal Lagoon Estuaries.

Tidal lagoon estuaries are dominated by ocean water inputs and have two general categories; those with simple shorelines and those with complex shorelines. Because of the higher tides and the flatter coastal terrain, tidal lagoon estuaries tend to be the main estuary type in Golden and Tasman Bays. If exposed to excessive nutrients, fine sediment, disease causing micro-organisms, toxicants and/or loss of important habitat, then their human and/or ecological values can become degraded.



Tidal lagoon estuary with simple shoreline - Parapara Estuary, Golden Bay

- **Tidal Lagoon Estuaries with Simple Shorelines** (e.g. Parapara Estuary). Those with simple shorelines are shallow, have one main basin, are predominantly intertidal, dominated by ocean water, and have low river inputs in relation to the tidal prism. The entrance to the sea is narrow and they are separated from the sea by barrier islands or spits. Strong flushing, well-mixed water, and wind resuspension of sediments are common characteristics that combine to produce predominantly sandy sediments. If these estuaries are in good condition then biodiversity is generally high, and there are extensive areas of high ecological value habitat (e.g. seagrass, saltmarsh, and a naturally vegetated terrestrial margin).

Tidal lagoon estuary with complex shoreline - Waimea Inlet, Tasman Bay

- **Tidal Lagoon Estuaries with Complex Shorelines** (e.g. Waimea Inlet, Whanganui Inlet). Those with complex shorelines are also shallow, predominantly intertidal, dominated by ocean water, have low river inputs in relation to tidal prism, narrow mouths, and barrier spits. However, they differ in that they generally have two or more main arms leading off one or two main basins, with deep channels draining these arms. Flushing, wind mixing and sediment resuspension is less pronounced due to reduced

3.2 HABITAT TYPES (CONTINUED)

Tidal river mouth estuary with simple shape Paturau Estuary, West Coast

Tidal river mouth estuary with delta - Motueka Estuary, Tasman Bay

Tidal river mouth estuary with lagoon/basin - Ruataniwha Estuary, Golden Bay

fetch within the arms, which means the main estuary body is sandy and well-mixed but the arms have a tendency towards muddiness, eutrophication and weak water column stratification. If these estuaries are in good condition then biodiversity is generally high, and there are extensive areas of high ecological value habitat (e.g. seagrass, saltmarsh, and a naturally vegetated terrestrial margin).

2. Tidal River Mouth Estuaries.

Tidal river mouth estuaries are dominated by freshwater inputs and can be categorised into three general categories; those with a simple shape, those that include a delta, and those that include a shallow lagoon. Because of smaller tides and coastal hill and valley terrain, tidal river mouth estuaries tend to be the main estuary type on the West Tasman coast.

Tidal River Mouth Estuary with Simple Shape (e.g. Paturau)
Tidal river mouth estuaries are narrow, mainly subtidal, 1-10m deep, have a small area of tidal flats, lower biodiversity and are freshwater dominated, particularly during floods. If the coastal plain is flat then salinity can extend a large distance upstream. They are well-flushed in that the majority of the river inputs of sediment and nutrients pass through such estuaries and are deposited in inshore coastal waters. In the deeper sections of both small and large tidal river estuaries, a salt wedge can develop. Wind mixing and resuspension of sediments is limited and sediments tend to be muddy. In the smaller tidal river estuaries, the freshwater input is often too small to flush sediment from the entrance and their mouths can block for several days to months. The majority of these estuaries are short and narrow, with saline water intrusion extending only a few hundred metres upstream or not at all. In many cases the estuary channels have been modified by past drainage and channelisation actions. The habitats available for aquatic life in such systems are very limited: tidal flats and saltmarsh are generally small or absent, and the water and sediments experience regular cycles of degradation and rejuvenation. When the mouth is restricted (i.e. intermittently closed and open) and streamflows are low, the estuary may experience symptoms of eutrophication and sedimentation (i.e. muddy, anoxic, black sulphide-rich sediments, algal blooms, low dissolved oxygen and low clarity). When the mouth is open and flows are high, the small narrow channel and lagoon is flushed clean. Although they are likely to be a natural occurrence, such low water quality conditions are exacerbated when sediment, nutrient, and pathogen loadings to the estuaries are elevated (e.g. in catchments with intensive agriculture, urban development, or catchments with high erosion).

Tidal River Mouth Estuary plus Delta (e.g. Motueka)
When the sediment outputs from such estuaries are large and they meet a low energy coastal embayment, like Tasman Bay or Golden Bay, a delta is formed (e.g. Motueka Estuary). This results in extensive intertidal flats, including both exposed and protected habitats. These habitats can include high value areas including extensive shellfish and seagrass beds, and areas of saltmarsh. At times of high flows, the freshwater influence on such habitats can be significant.

Tidal River Mouth Estuary plus Lagoon/Basin. (e.g. Ruataniwha)
In other situations, the tidal river estuary may include an interconnected shallow lagoon or basin (e.g. Ruataniwha Estuary) which can have a large intertidal area and extensive saltmarsh vegetation. However, because the shallow lagoon or basin is mostly by-passed by the river flow, flushing can be poor in situations where the connection between the estuary and lagoon or basin is constricted. In such situations, bottom water in the deeper areas can become isolated as heavier seawater gets trapped beneath the less dense freshwater layer. Wind mixing and sediment resuspension can be significant in shallow areas of these lagoons or basins and consequently can result in coarser sediment types.

3. BACKGROUND (CONTINUED)

ESTUARY ISSUES





There are five main issues that affect estuaries:

1. Sedimentation.

Because estuaries are a sink for sediments, their natural cycle is to slowly infill with fine muds and clays. Prior to European settlement they were dominated by sandy sediments and had low sedimentation rates (<1mm/year). In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, New Zealand's estuaries have begun to infill rapidly. Today, average sedimentation rates in our estuaries are typically 10 times or more higher than before humans arrived (e.g. Jones 2008, Oldman et al. 2009).

2. Eutrophication.

Increased nutrient richness of estuarine ecosystems stimulates the production and abundance of fast-growing algae, such as phytoplankton, and short-lived macroalgae (e.g. sea lettuce). Fortunately, because most New Zealand estuaries are well flushed, phytoplankton blooms are generally not a major problem. Of greater concern is the mass blooms of green and red macroalgae, mainly of the genera *Cladophora, Ulva,* and *Gracilaria* which are now widespread on intertidal flats and shallow subtidal areas of nutrient-enriched New Zealand estuaries. They present a significant nuisance problem, especially when loose mats accumulate on shorelines and decompose. Blooms also have major ecological impacts on water and sediment quality and the animals that live there.

3. Disease Risk.

Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the estuarine environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks to recreational users and human consumers, pathogen contamination causes economic loss due to closed shellfish beds, affecting an important industry in some estuaries. Diseases linked to pathogens include gastroenteritis, salmonellosis and hepatitis A.

4. Toxic Contamination.

In the last 60 years, New Zealand has seen a huge range of synthetic chemicals introduced to estuaries through urban and agricultural stormwater runoff, industrial discharges and air pollution. Many of them are toxic in minute concentrations. Of particular concern are polycyclic aromatic hydrocarbons (PAHs), toxic heavy metals, polychlorinated biphenyls (PCBs), and pesticides. These chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to people and marine life.

5. Habitat Loss.

Estuaries have many different types of habitats including shellfish beds, seagrass meadows, saltmarshes (rushlands, herbfields, reedlands etc.), forested wetlands, beaches, river deltas, and rocky shores. The continued health and biodiversity of estuarine systems depends on the maintenance of high-quality habitat. Loss of habitat negatively effects fisheries, animal populations, filtering of water pollutants, and the ability of shorelines to resist storm-related erosion. Within New Zealand, habitat degradation or loss is common-place with the major causes cited as sea level rise, population pressures on margins, dredging, drainage, reclamation, pest and weed invasion, reduced flows (damming and irrigation), polluted runoff, and wastewater discharges.

3. BACKGROUND (CONTINUED)

3.2 HABITAT TYPES (CONTINUED)

3.2.2 BEACHES AND DUNES

Wharariki Beach

New Zealand's open coastline is dominated by sandy beaches which are highly valued for human recreation and aesthetics. They are also important habitat for a diverse range of animals including birds, mammals, reptiles, and invertebrates. Several hundred species of invertebrate can be found in a single beach (Armonies and Reise 2000). Beaches also provide a range of ecological services including; filtration of large volumes of seawater, nutrient recycling, support to coastal fisheries, and provision of critical habitat (nesting and foraging sites) for birds.

Most beaches in Tasman are backed by vegetated sand dunes, built up by dry beach sand blown inland and trapped by plants and other obstructions (Figure 3). However, the dune extent is variable around the region because ideal conditions for the formation of coastal sand dunes are not found everywhere. Ideal conditions include the following;

- Large sandy beach exposed at low tide,
- Frequent strong onshore winds,
- Macrotidal range, i.e. a large difference (>4m) between high and low water levels.

Under these ideal conditions, and where there is a natural terrestrial margin, an extensive dune system develops that includes foredunes, secondary dunes and backdunes with a succession of vegetation running from the pioneer community on the beach strandline, through to climax vegetation some distance inland. Native dune systems are dynamic and have vegetation that allows for sand movement and does not cause overstabilisation.

The most extensive and active dune systems in the Tasman region, apart from Farewell Spit, are found on the West Tasman coast. These have developed because of the large supply of sand from the eroding Southern Alps being carried northwards by the Westland Current, relatively large tides, and prevailing strong onshore winds. In some areas, these extensive dune formations have buried adjacent low hills, interrupted drainage, and formed lakes and swamps. Vegetation along these dunes is now dominated by introduced marram grass (*Ammophila arenaria*) and lupin (*Lupinus arboreus*), but in many places are backed by kanuka (*Kunzea ericoides)* and broadleaf coastal forest.

In the more sheltered Tasman and Golden Bays, despite large tides, calmer wind conditions and a limited sand supply mean dunes are much less extensive. A recent study of sediment and water dynamics in Tasman and Golden Bays (Tuckey et al. 2006) indicated that the majority of coarser sediments from the major rivers in the area settle in the estuary systems that link the rivers to the coastal waters rather than settling offshore. In addition, large amounts of finer, muddy sediments have been exported into the bays, particularly post 1840, and are likely responsible for the generally muddy sea floor within Tasman and Golden Bays. Such processes mean that the available sand for nourishing beaches and sand dunes in the area is relatively low.

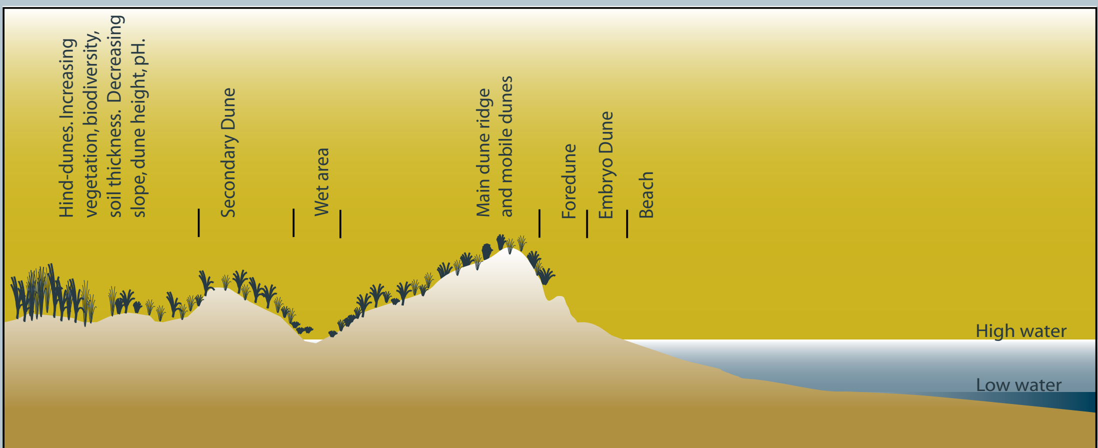


Figure 3. Schematic diagram of healthy coastal dune system.

3. BACKGROUND (CONTINUED)

3.2 HABITAT TYPES (CONTINUED)

Overstabilised and weed dominated dune, Pohara Beach

Native dune plantings, Motupipi Estuary

Pakawau Beach

Tata Beach

Ligar Bay

Maintaining healthy sand dunes is important, as these mobile terrestrial systems are naturally well adapted to protect land from storm erosion, coastal flooding and changes in sea level. In addition: they act as sand reservoirs for adjacent beaches; they provide habitats for specially adapted plants, birds and animals; they act as a filter for rainwater and groundwater; they provide a range of unique landforms and processes of scientific value; they contain some of the oldest and most significant evidence of our cultural heritage, like middens and urupa sites; they provide recreational, educational and eco-tourism opportunities; and contribute to the natural character of beaches. It is well-proven that a healthy coastal sand dune system is also the least costly way to maintain a recreational beach for future generations.

Unfortunately, the area of active duneland in the Tasman region has undergone a striking decline since 1950 (Hilton 2006). In 1950 it was 3000ha. By the 1990s the area had been reduced to 640ha; a reduction of about 78%. However, as a consequence of the growing recognition of the importance of dunes, the rate of duneland loss slowed over the 1990's, as dunes have come under the management of the Department of Conservation (DOC), Regional Councils, and unitary authorities. In many places, restoration groups are replanting active dunes with native sand-binders spinifex (*Spinifex serceus*) and/or pingao (*Desmoschoenus spiralis*), for example, Rabbit Island, Motupipi Spit, Parapara Spit.

BEACH TYPES

The New Zealand coast contains a large number of beaches and can be classified into 14 beach types using the classification of Wright and Short (1984). These include six wave-dominated, three tide-modified, and five tide-dominated beach types which are a product of wave-tide and sediment conditions (for details on each beach type see; http://www.naturalhazards.net.nz/tools/nzcoast/coastal/about/nz_beach_type_classif cation/beach_types). Wave predictions are from NIWA's Coastal Explorer; http://wrenz.niwa.co.nz/webmodel/coastal.

Because of the wide range of coastal conditions, the Tasman coast includes all three of the major beach categories; wave dominated, tide modified and tide dominated. Wave dominated beaches mainly occupy the higher energy, exposed, mesotidal West Tasman coast. Tide-modified and tide-dominated beaches occur in the more sheltered, macrotidal Tasman and Golden Bay areas.

Golden Bay.

In Golden Bay the dominant beach type is "tide-dominated" and fits the morphology of "reflective plus ridged sand flats" which is the highest energy of the tide-dominated beaches, occurring where waves average 0.5m and tides average 4.5m. They are characterised by a relatively steep, occasionally cusped high tide beach, which abruptly grades into a very low gradient sandy intertidal zone, covered by regularly spaced low amplitude (5-10cm), shore parallel sand ridges e.g. Pohara. In northwestern Golden Bay (Ruataniwha to Puponga) the intertidal flats average ~1km in width, with multiple sand ridges across the beach. In the central section of Golden Bay between Parapara and Patons Rock the beach is flatter, does not have sand ridges and fits the "tide modified - reflective plus low tide ridges" beach type category. Such beaches are common where exposed to short period waves averaging 0.45m in height, with the tide range averaging up to 10x the wave height (i.e. 4.5m). They are characterised by a relatively steep reflective high tide beach (usually composed of medium sand) that abruptly grades to low tide, where it changes to a low gradient, low tide terrace, (usually finer sand) which can extend tens of metres seaward. At high tide, waves pass over the terrace and only break on reaching the high tide beach, similar to the reflective tide-dominated beach. As the tide falls, waves begin to increasingly break across the terrace and, at low tide break, on the outer edge producing a wide, shallow surf zone.

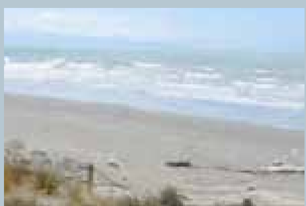
Because of the much coarser sands at Tata Beach and the fact that it is in the lee of Abel Tasman Peninsula, the beach type changes to "wave-dominated - reflective". This beach type is characterised by a relatively steep, narrow beach usually composed of coarser sand (0.4mm) and with waves less than 0.5m.

3. BACKGROUND (CONTINUED)

3.2 HABITAT TYPES (CONTINUED)

Ruby Bay

Moutere Delta



Rabbit Island Beach

West Coast beach near Kaihoka Lakes (Photo; Ali Aden)

Tasman Bay.

Between Marahau and Rabbit Island, the beaches are also primarily "tide-dominated" and include four categories; "reflective plus sand flats, reflective plus tidal sand flats, reflective plus ridged sand flats, and ultra-dissipative". In addition, several beaches near Kaiteriteri are classified as "wave-dominated reflective" beaches.

"Reflective plus sand flats" is the most common beach type in the area (e.g. Ruby Bay, Moutere Bluff, Tapu Bay). They are similar to the ridged sand flats, except waves are lower (mean=0.26m) and tides higher (mean~5m). These conditions produce a relatively small, steep high tide beach, which grades abruptly into intertidal sand flats that average 300m width. The sand flats are low and featureless apart from small wave ripples, indicating wave energy is still suf ciently high to imprint itself upon the flats, but not high enough to form sand ridges.

"Reflective plus tidal sand flats" differ from the sand flats in that they receive lower waves (mean=0.16m) though similar tides (mean~5m). They usually have a small, steep reflective coarse-grained high tide beach, fronted by intertidal sand flats averaging 350m width. The tidal energy is suf ciently high for the tidal currents to imprint themselves on the tidal flats. Many of these flats grade from inner sand flats to outer mud flats, with the sand averaging 300m wide and the mud extending out on average to 500m (e.g. Riwaka Beach, seaward side of Motueka Spit, Otuwhero, Kina Peninsula). "Reflective plus ridged sand flats", although rare in Tasman Bay, is found in one location near Marahau.

An example of a "tide-modifed" beach type is present at Rabbit Island and fits the sub-category of "ultra-dissipative". Ultra-dissipative beaches occur in higher energy (waves averaging 0.6m high) tide-modified locations, where the beaches are also composed of fine sand. They are characterised by a very wide (200-400m) intertidal zone, with a low to moderate gradient high tide beach, and a very low gradient to almost horizontal low tide beach. Because of the low beach gradient, waves break across a relatively wide, shallow surf zone as a series of spilling breakers which continually dissipate the wave energy, hence the name 'ultra-dissipative'. The fine sand and shifting breaker zone act to plane down the beach, while the continuously shifting breaker zone precludes the formation of bars and rips, which require a more stationary surf zone.

Similar to Tata Beach in Golden Bay, the"wave-dominated - reflective" beaches present near Kaiteriteri (Kaiteriteri, Little Kaiteriteri, and Towers, Honeymoon, Ngaio, Breaker, Dummy, and Stephens Bays) are characterised by relatively steep, narrow beaches. Such beaches are usually composed of coarser sand (0.4mm) and with waves less than 0.5m.

West Tasman.

Beaches on the West Coast fit within the "wave-dominated" category and have a rip-dominated intermediate type morphology. Although the intermediate category can be divided into four subcategories, this has not yet been undertaken for the West Tasman beaches. Despite the absence of details on their low tide and subtidal rips and bar morphologies, it is clear that they generally are backed by extensive dune systems which often extend high up the adjacent hill slopes.

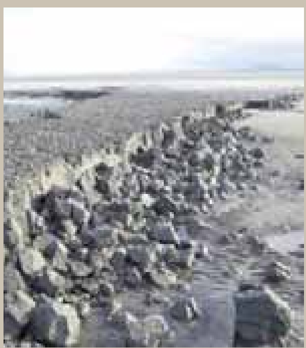
3.2.3 ROCKY SHORES

Clif ed coastline west of Fossil Point

Rocky shores are a significant, and visually dramatic, part of the Tasman coastline. They exist where the effect of waves on the coast is mainly erosive. Softer rocks are worn down, leaving harder rocks exposed. Rocky shores are the most variable coastal habitat in New Zealand; their character depends on the prevailing rock type, and their profile is usually related to strata formation. The habitat is physically complex, with changes of slope and the presence of rockpools, gullies, crevices and boulders increasing the range of habitats and consequently the number of species present. Because most of the substrate is stable, it provides a secure surface for a variety of organisms such as seaweeds, barnacles, mussels and limpets. These shores also act as important fish nurseries and roosting and feeding areas for birds.

3. BACKGROUND (CONTINUED)

BEACH AND DUNE ISSUES



There are five main issues that affect beaches :

1. Habitat Loss.

Beaches have many different types of habitats including dunes, shellfish beds, seagrass meadows, river deltas, shellbanks and sandbars. The continued health and biodiversity of beach systems and shallow subtidal areas depends on the maintenance of high-quality habitat. Loss of habitat negatively effects birdlife and fisheries, animal populations, filtering of water pollutants, and the ability of shorelines to resist storm-related erosion. Within New Zealand, beach habitat degradation or loss is common-place, with the major causes cited as duneland reclamation, weed growth, sea level rise, margin development, shoreline armouring, erosion, dredging, polluted runoff, and wastewater discharges.

2. Disease Risk.

Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the coastal environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks to recreational users and human consumers, pathogen contamination causes economic loss due to closed shellfish beds, affecting an important industry in some beaches. Diseases linked to pathogens include gastroenteritis, salmonellosis and hepatitis A.

3. Sedimentation and Erosion.

Beaches and dunes are dynamic systems that require a supply of sand to build and maintain their form. Activities that alter this natural supply, either on land (e.g. dam construction, gravel extraction, landuse changes), or at the coast (e.g. groyne or seawall construction, dredging, dune overstabilisation or reclamation), can significantly change beach processes at both local and regional scales. Where changes occur to erosion and accretion patterns, particularly from factors that increase wave action and currents (e.g. shoreline armouring, groynes, and climate change impacts such as sea level rise and increased storm events), consequences can be extreme.

Reduced water clarity from excessive fine sediment inputs (primarily from rivers but also from direct coastal erosion and sediment resuspension) also adversely impacts biota (e.g. suspension feeding shellfish, seagrass, macroalgae) and reduces aesthetic appeal. Fine sediment deposition is seldom a significant issue on exposed beaches.

4. Eutrophication.

Increased nutrient richness of beach ecosystems (particularly in poorly flushed ultra-dissipative areas) stimulates the production and abundance of fast-growing algae, such as phytoplankton, and short-lived macroalgae (e.g. sea lettuce). Fortunately, because most New Zealand beaches are well flushed, phytoplankton and macroalgal blooms are generally not a major problem. However, in sheltered embayments, mass blooms of green and red macroalgae, mainly of the genera *Ulva,* and *Gracilaria* can occur. They present a significant nuisance problem, especially when loose mats accumulate on shorelines and decompose. Blooms also have major ecological impacts on water and sediment quality and the animals that live there.

5. Toxic Contamination.

In the last 60 years, New Zealand has seen a huge range of synthetic chemicals introduced to estuaries and coastal beaches through urban and agricultural stormwater runoff, industrial discharges, oil spills, antifouling agents, and air pollution. Many of them are toxic in minute concentrations. Of particular concern are polycyclic aromatic hydrocarbons (PAHs), heavy metals, polychlorinated biphenyls (PCBs), and pesticides. These chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to people and marine life. In addition, natural toxins can be released by phytoplankton in the water column and cause mass closure of shellfish beds.

3.2 HABITAT TYPES (CONTINUED)


Wharariki Beach


Tarakohe


Coast south of Onekaka


Coast between Kaiteriteri and Marahau

The variable physical conditions, including light availability, degree of exposure, changes in temperature and salinity, aspect, substrate type and biotic features lead to the development of a characteristic zonation of species and habitats. The middle shore generally has the greatest species diversity, whilst the lower shore is most prolific. An environmental gradient is present that ranges from almost totally marine to almost completely terrestrial. Conditions on rocky shores are harsh; organisms have to be able to survive rapidly changing environmental conditions and to be capable of rapid recolonisation.

Key characteristics of Tasman's rocky shores are as follows:

West Tasman.

- Shores are very exposed, high-energy shores with sandstone rock types north of Whanganui Inlet and mudstone and sandstone to the south. The very exposed nature typically increases the vertical widths of intertidal zones, since organisms can satisfy their saltwater requirements further up the shore than they could on more sheltered shores.
- Like other typical NZ west coast sites, mussels and barnacles dominate the intertidal rocky shores rather than large brown algae, which is more typical of the east coast and Southland (Schiel 2004).
- The giant southern bull kelp (*Durvillaea antarctica)* is present on the west coast but is not common.
- On low tidal benches with considerable sand scour, tough red algae (corallines and *Gigartina* species) dominate.

Tasman and Golden Bays.

- Tasman and Golden Bays are more sheltered than the West Tasman coast.
- In Tasman Bay, the main area of rocky shore is in the Kaiteriteri to Marahau section which is dominated by granite rock types.
- In Golden Bay, rocky shores and reef areas are relatively uncommon except for the section between Wainui and Pohara which is dominated by limestone reefs, cliffs, towers and rock pedestals. Small sections of rocky shore (mudstones and calcareous siltstones) also exist at Rangihaeata Head, Paton's Rock, Onekaka, Tukurua Point and Puponga Point.
- The giant southern bull kelp (*Durvillaea antarctica)* is absent from these more sheltered shores.
- Granite zonation patterns comprise a high tide zone dominated by two species of periwinkle, an upper tidal zone dominated by barnacles, a mid-tide zone dominated by barnacles and little black mussels, and a low tide zone dominated by tube worms. Red algae and large brown algae form an almost complete cover near low water in some locations, but because of the moderately exposed conditions and eroding rock-type, many areas have sparse cover.
- The zonation pattern on limestone is quite different, including the replacement of the granite barnacle species with another barnacle species, tube worms not confined to the one zone, and the more common presence of bryozoan species.

These biologically rich and relatively accessible habitats have high value to humans as places to use, enjoy, and learn. Intertidal rocky shores are used for fishing, shellfish gathering, fossicking/exploring, tramping, sightseeing, tourism and education. Some sites are used for scientific (e.g. biological and geological) studies.

Rocky shores are also a vulnerable habitat with the main stressors being; sedimentation, pollution, global climate change, sea level rise, over-collection of living resources and introduction of invasive species.

ROCKY SHORE ISSUES

There are five main environmental issues that affect NZ rocky shores, with the main stressors being climate change and sea level rise, over-collection of living resources, introduction of invasive species, and pollution. All these can be linked to a decline in the dominant algal canopy species, on which many other species depend for food or habitat:

1. Habitat Loss or Modification.

Climate Change and Sea level Rise. Predicted climate change impacts (e.g. warmer temperatures, ocean acidification, sea-level rise, increased storm frequency) are expected to alter species ranges (e.g. increased sub-tropical introductions and/or establishment of pest species), alter planktonic and kelp production, and interfere with the formation of shells and skeletons by corals, crabs, marine snails, and bivalves. Long term predictions are the loss of rare species, a reduction in species diversity, and the loss of entire communities of organisms in some situations.

Over-collection of Living Resources and Recreation. Direct removal of living resources (e.g. fish, mussels, paua, crayfish, algae) can cause major community level changes from disruption to natural predator-prey balances or loss of habitat-maintaining species. Macroalgal harvesting can remove protective habitat, resulting in species loss and greater exposure to natural disturbances. Impacts are expected from recreational activities (e.g. algal trampling) and over-collection at both local and regional scales, and is likely to intensify as expanding human populations put further pressure on resources.

Introduction of Invasive Species. Increased global transport (hull fouling and ballast water discharges) is a major vector in the introduction of invasive or pest plants and animals. Displacement of native species, particularly following disturbance events (e.g. canopy loss), can result in less diverse communities and possibly increased ephemeral blooms. Introduced toxic microalgae, while harmless enough at low levels, can reproduce explosively when conditions are right, giving rise to toxic algal blooms (TABs), and resultant illness and/or mortality of humans, fish, sea birds and marine mammals who ingest toxic fish or shellfish poisoned by TABs. Significant effort and cost may be needed to remove or prevent the spread of unwanted species (e.g. *Undaria*).

2. Disease Risk.

If pathogen inputs to the coastal area are excessive (e.g. from coastal wastewater discharges or proximity to a contaminated river plume), the disease risk from bathing, wading or eating shellfish can increase to unacceptable levels. High flushing and dilution mean disease risk is unlikely to be significant away from point source discharges. Public health reports of illness are likely to be the first indication of faecal bacterial issues directly impacting on human values and uses.

3. Sedimentation.

Excessive suspended sediments can lower water clarity and cause ecological damage at the shoreline through reduced plant and algal production, clogging of respiratory and suspension feeding organs of sensitive organisms, and can variously affect the ability of recruits to settle and establish (e.g. Airoldi 2003, Foster and Schiel 2010). Sheltered rocky shore habitats, e.g. rockpools, are more susceptible to direct deposition and reduced sediment oxygenation. Generally high wave energy on the open coast will favour offshore sediment settlement over intertidal deposition. Increased sedimentation is likely to reduce biodiversity through lowered productivity and recruitment success, and reduced ability to recover from disturbances. Human values and uses will be reduced directly by poor clarity (swimming/diving), and indirectly through biodiversity changes.

4. Eutrophication.

Eutrophication occurs when nutrient inputs are excessive, and can have chronic broad scale impacts over whole coastlines. High nutrients support increased localised nuisance macroalgal growth, and with this, opportunistic grazers. Where dominant, they decrease diversity by excluding or out-competing other species, and can be particularly influential in the colonisation of bare space following disturbance events. Elevated nutrients have also been implicated in a trend of increasing frequency of harmful algal blooms (HABs) which can cause illness in humans and close down shellfish gathering and aquaculture operations. High flushing and dilution on relatively remote exposed rocky shores mean the most likely indicators of eutrophication effects will be increases in nuisance macroalgal growths (e.g. *Ulva*) and phytoplankton blooms, and a subsequent reduction in diversity.

5. Toxic Contamination.

If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, shoreline biodiversity is threatened and shellfish may be unsuitable for eating. Except for large-scale infrequent discharges such as oil spills, pollution tends mainly to influence embayed coastlines or areas immediately adjacent to outfalls. Increased toxins are unlikely to be a significant issue in Tasman but, if present, will reduce biodiversity and human values and uses.

4. STRESSORS

4.1 OVERVIEW

The main stressors or threats to coastal habitats are; fine sediment, nutrients, faecal bacteria and toxicants in catchment runoff and point source discharges, overstabilisation of dunes, drainage and reclamation, climate change (sea level rise, changes to pH, temperature and rainfall), harvesting living resources (e.g. shellfish), introduction of invasive species, freshwater abstraction, disruption of sediment transport through engineered structures (seawalls, breakwaters, groynes and dams), and off-road vehicles. Table 6 summarises each of the main stressors and their likelihood of influence on the three main habitat types, estuaries, beaches/dunes, and rocky shores. The following sections describe the stressors and how the influence of each has been evaluated in this report.

Table 6. Major stressors, and likely influence, to Tasman region habitats if they were to occur.

Stressor		Estuaries	Beaches, Dunes	Rocky Shores	Terrestrial Margin
Fine Sediment		High	Moderate	Moderate	Low
Nutrients		High	Moderate	Moderate	Low
Faecal Bacteria		High	Moderate	Moderate	Low
Toxicants	Urban Runoff	High	Moderate	Moderate	Low
	Wastewater	High	Moderate	Moderate	Low
	Natural Metal Inputs	High	Moderate	Moderate	Low
	Pesticides	High	Moderate	Moderate	Low
	Oil Spills	High	Moderate	Moderate	Low
Reclamation		High	High	Low	High
Climate Change		High	High	High	Moderate
Harvesting Living Resources		High	High	High	Low
Invasive Species		High	High	High	Moderate
Freshwater Abstraction		High	Low	Low	Low
Disrupting Sediment Transport	Seawalls	High	High	Low	Low
	Breakwaters	Low	High	Low	Low
	Groynes	Low	High	Low	Low
	Dams	Low	High	Low	Low
Vehicles		High	High	Low	Moderate
Infrastructure		Moderate	Moderate	Moderate	Moderate

Low	Moderate	High

4.2 FINE SEDIMENT (MUDS)

In New Zealand, deforestation and catchment development have resulted in land erosion with consequent excessive fine sediment loads accelerating the infilling of estuaries and coastal embayments. Such accelerated infilling results in prematurely aged estuaries and embayments, and a degraded ecosystem that reduces human use and ecological values. For example, excessive muddy sediment smothers habitat, turns sandflats into mudflats, reduces oxygen penetration, increases potential for eutrophication, reduces water clarity, and degrades seagrass beds and animal communities.

However, some coastal habitats are more prone to muddiness than others. Estuaries, including coastal embayments, are the most susceptible. However, susceptibility varies for different types of estuary, and for different areas within estuaries. Figure 4 provides an overview of the susceptibility to fine mud sedimentation in different estuary types.

Outside of estuaries, beaches and open coast subtidal areas are classified as having low susceptibility to deposition of fine sediments, but are considered moderately vulnerable to elevated suspended sediment (SS) concentrations and low clarity if located within river plume areas.

On the rocky coasts, studies of ecological problems caused by sedimentation have a long history, and a recent review by Airoldi (2003) identifies sedimentation as a widespread and increasing global problem.

4. STRESSORS (CONTINUED)

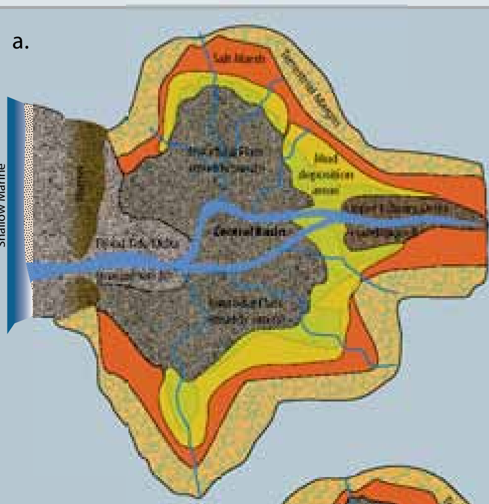
Figure 4. Conceptual diagrams of different estuary types and susceptibility to fine mud sedimentation. Main mud deposition areas shown in yellow.

a. Tidal Lagoon Estuary - where estuary flushes almost completely at low tide.

ESTUARY ZONE	Sediment Trapping Efficiency	Susceptibility to Mud Sedimentation
Intertidal Flats (main basin)	Low	Low
Tidal Sand Banks	Low	Low
Sheltered Fringe Areas (Arms)	High	High
Salt Marsh Vegetation	High	Moderate
Headwaters (Upper Estuary)	High	High

E.g. Waimea, Motupipi, Moutere, Wainui.

a.

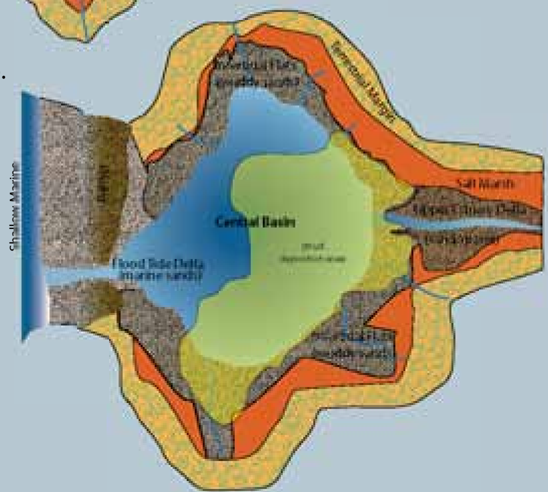


b. Tidal Lagoon Estuary - with large central basin that is submerged at low tide.

ESTUARY ZONE	Sediment Trapping Efficiency	Susceptibility to Mud Sedimentation
Intertidal Flats (main basin)	Low	Low
Central Basin (subtidal)	High	High
Tidal Sand Banks	Low	Low
Sheltered Fringe Areas (Arms)	High	High
Salt Marsh Vegetation	High	Moderate
Headwaters (Upper Estuary)	High	High

None in Tasman but Whanganui Inlet does have a lower estuary basin.

b.

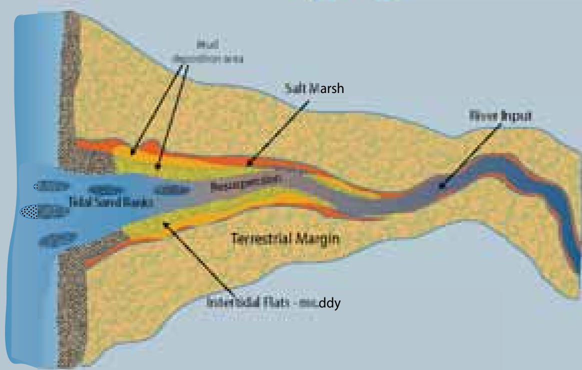


c. Tidal River Estuary - with one main channel and minimal intertidal flats.

ESTUARY ZONE	Sediment Trapping Efficiency	Susceptibility to Mud Sedimentation
Intertidal Flats (main basin)	Low	Moderate
Tidal Sand Banks	Low	Low
Sheltered Fringe Areas (Arms)	High	High
Salt Marsh Vegetation	High	Moderate
Headwaters (Upper Estuary)	Low	Low
Tidal River Estuary Margins	Moderate	Moderate

E.g. Paturau, Anatori, Big River, Lagoon Creek.

c.

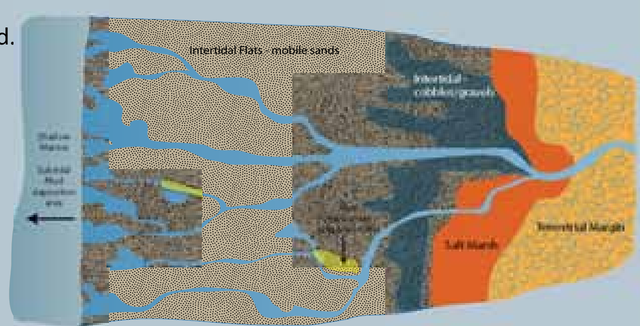


d. Tidal River Estuary - with large intertidal delta.

ESTUARY ZONE	Sediment Trapping Efficiency	Susceptibility to Mud Sedimentation
Intertidal Flats (delta)	Low	Low
Tidal Sand Banks	Low	Low
Sheltered Fringe Areas (Arms)	Moderate	Moderate
Salt Marsh Vegetation	High	Moderate
Headwaters (Upper Estuary)	Low	Low
Tidal River Estuary Margins	Moderate	Moderate

E.g. Motueka, Takaka, Ruataniwha.

d.



4. STRESSORS (CONTINUED)

Marahau Estuary, Sandy Bay

Notes on Estuary Sedimentation Zones.

Deposition Zones. High sedimentation rates generally occur at locations where the sediment transporting capacity of the estuary water is reduced due to a decrease in current and/or wave energy. The main deposition areas are:

- **Intertidal Flats.** Sediment falls out onto the flats, except when waves resuspend it. As the water deepens the waves have less and less effect on the sediment. Tidal flats that are exposed to high wind fetch and hence wave action do not tend to accumulate muds. Tidal flats that are sheltered from winds, waves and currents tend to accumulate fine sediment.
- **Subtidal Flats (Central Basin).** Like intertidal flats, sediment falls out onto the subtidal flats, except when waves resuspend it. As the water deepens the waves have less and less effect on the sediment. Deep subtidal flat areas away from channels and currents tend to accumulate fine sediment and organic material. Central basins are uniform, lower energy environments in the deeper and quieter parts of estuaries. Sedimentologically, central basins typically comprise poorly-sorted, organic-rich subtidal mud and sandy mud. The shallower margins of central basins often feature coarser sediments (sands), which result from the action of wind waves and fluctuating water level in some estuaries. Concentrations of organic material are generally very high, causing a black to dark grey appearance in the sediments. Surfaces are generally planar and not vegetated, however some seagrass growth in the shallower parts of the central basin usually occurs. Sub-surface sediments may be anoxic, but is generally heavily bioturbated due to an abundance of infauna and epifauna.
- **Tidal Sand Banks.** Commonly found within tide-dominated estuaries, deltas and tidal creeks and are typically subtidal to intertidal in elevation, and consist of elongate linear to sinuous sand bars comprised of predominantly sands - generally sourced from bedload material. Channels dissecting tidal sand banks are scoured by strong currents, exposing the underlying bedrock or leaving a lag gravel, composed of shell debris and rock fragments. The banks and channels are often approximately aligned with the main tidal currents (typically perpendicular to the shoreline), and sediments may become finer towards the head of the estuary. Concentrations of shell material are generally high, whereas concentrations of organic material is generally low. Strong tidal shear stresses and highly variable bottom morphology result in turbulent, well oxygenated, and turbid waters. Tidal sand banks may be vegetated, however high turbidity often limits primary productivity.
- **Sheltered Fringe Areas.** Along the intertidal margins, the incoming tide can move turbid plumes (originating from intertidal flats or catchment run-off) up into small, sheltered, tidal creeks or side arms. If conditions are calm then fine sediments settle out. These fringes are where macroalgae can accumulate, further enhancing sedimentation by slowing water movement.
- **Saltmarsh Vegetation.** Saltmarsh vegetation and/or seagrass beds cause currents to slow down, which facilitates sediments entrained in the water column to settle on the bottom. The lower the vegetation is in the tidal range, the greater is its effect on sedimentation (e.g. *Spartina*).
- **Headwaters (Upper Estuary Areas).** Once fine suspended particles (particularly clays) hit seawater in the upper estuary their electric charge causes them to flocculate. The resulting floccule is larger and tends to settle more readily (Xu et al. 2010). Once settled, which is usually in the upper estuary area where the tidal flow is weakest, the flocs consolidate further as their water content is forced out by the weight of overlying sediments and become more resistant to erosion.
- **Channels.** Channels carry in suspended sediment but are themselves scoured out when currents are stronger. Currents then transport the sediment until current velocities slow down enough (below the threshold of movement) to allow the sediment to settle back onto the bottom.

Three main steps are used to assess the vulnerability of estuaries (including coastal embayments) to fine sedimentation problems as follows:

1. Determine sedimentation potential.
2. Determine existing condition of each estuary habitat type.
3. Derive final sedimentation susceptibility rating.

Each step is detailed in the following sections:

4. STRESSORS (CONTINUED)

STEP 1. DETERMINE SEDIMENTATION POTENTIAL.

Background. If relevant sedimentation guidelines were available for all estuary types, then determination of a sedimentation rating would be a simple procedure of measuring the appropriate indicator and comparing it with the guideline value. Unfortunately, no such easy approach is currently available. New Zealand, Australian, Canadian and US guidelines for ensuring no adverse ecological impacts from excessive fine sediment inputs to estuarine and coastal waters and seabeds have been reviewed and are summarised in Table 7. The guidelines are generally written as narrative standards or input concentration limits that are intended to prevent excessive sedimentation and siltation in amounts that adversely affect aquatic life. However, transforming them into usable sediment input guidelines is dif cult without detailed water quality data and a proven relationship between estuary concentration and input concentration.

Table 7. Sedimentation guidelines for New Zealand and overseas estuaries and coastal waterbodies.

Australia and New Zealand				
ANZECC (2000)	Estuarine and marine waters. Turbidity 0.5-10 NTU default trigger value. Low turbidity values are normally found in offshore waters. Higher values may be found in estuaries or inshore coastal waters due to wind-induced resuspension or to the input of turbid water from the catchment. *Turbidity is not a very useful indicator in estuarine and marine waters. A move towards the measurement of light attenuation in preference to turbidity is recommended.*			
Canada				
British Columbia Guidelines. (Government BC 2002)	Guidelines are designed to protect aquatic life in fresh, estuarine and coastal marine waters from excessive suspended sediments originating from anthropogenic sources.			
	Turbidity Guideline		**Total Suspended Solids Guideline**	
	Change from background of 2 NTU at any one time for a duration of 30 days in all waters during clear flows or in clear waters		Change from background of 5mg/L at any one time for a duration of 30 days in all waters during clear flows or in clear waters	
	Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters		Change from background of 10mg/L at any time when background is 25 - 100mg/L during high flows or in turbid waters	
	Change from background of 10% when background is >50 NTU at any time during high flows or in turbid waters		Change from background of 10% when background is >100mg/L at any time during high flows or in turbid waters	
United States of America				
Arizona Guidelines (2008)	"A surface water shall not contain pollutants in amounts or combinations that settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life" (Arizona Department of Environmental Quality, 2008). Many other US States have similar guidelines.			
New Hampshire - Great Bay Estuary	Aquatic Life Use Support - to protect eelgrass. Light Attenuation Coef cient (water clarity) 0.75m for 2m depth water.			
Hawaii	**Location**	**Mean Turbidity (NTU)**	**10% of time**	**2% of time**
	All Estuaries	1.5	3	5
	Pearl Harbour	4	8	15
	Embayments	0.4	1	1.5
	Open Coastal Waters	0.02 (0.5 wet season)	0.05 (1.25 wet season)	1.0 (2.0 wet season)
	Oceanic waters	0.03	0.1	0.2
	Marine (1000m)	0.1		
Chesapeake Bay Estuary	The Chesapeake Bay Program (a multi-state effort) has a criterion based on clarity, including a measurement of the percent light through water (PLW) and secchi disk clarity. The criteria are stratified by depth and salinity regime and are adjusted by season.			
Illinois	Soil Loss: Effective January 1, 1994 to January 1, 2000, all land greater than 5% slope subject to this program shall be considered in compliance with the State program if the long term annual soil losses are kept at or below one and one-half "T" value. Effective January 1, 2000, and thereafter, all land subject to the Act shall meet "T" value. The soil loss tolerance as established by the Soil Conservation Service and as published in the Soil Conservation Service Technical Guide (United States Department of Agriculture, Soil Conservation Service, Field Of ces in Illinois) are adopted as the of cial "T" values for soils of Illinois.			
Kentucky and other States	Surface waters shall not be aesthetically or otherwise degraded by substances that: (a) Settle to form objectionable deposits;			
New Jersey	Coastal saline waters: Turbidity Levels shall not exceed 10 NTU. Saline Estuaries: Maximum 30-day average of 10 NTU, a maximum of 30 NTU at any time.			

4. STRESSORS (CONTINUED)

Waimea Inlet

Key recent research findings are:

- Sedimentation rates have been greatest following catchment development, and subsequently settle down to moderate levels.
- Sedimentation rates vary within an estuary, with the major fine sediment settling areas being located in the more poorly flushed areas like deeper basins, sheltered arms, and tidal flats exposed to onshore winds.
- Very high sedimentation rates (>20mm/yr) often occur in upper estuary areas near river inputs in estuaries with highly developed catchments (e.g. New River Estuary, Papakura Estuary).
- Large open areas in shallow estuaries often have very low sedimentation rates because of wave resuspension and subsequent sediment export to sea or to more sheltered areas within the estuary.

In the absence of detailed water quality data, the most sound and common sense approach identified is a modification of the Illinois approach (see Table 7). The approach is a "soil erosion minimisation" method that provides a maximum annual amount of soil which can be removed before the long term natural soil productivity is adversely affected, combined with a tolerable rate of estuary or embayment infilling. The approach essentially limits the rate of estuary infilling from catchment based sources to a level commensurate with SS input loads when the catchment is managed under sound and regulated soil conservation practices. Unfortunately, because this approach is not yet directly applied in coastal management in NZ, estimates of catchment SS yields under "soil erosion minimisation" management are yet to be derived.

In the absence of such a soil conservation policy, an alternative approach has been adopted for this vulnerability assessment. An acceptable average rate of infilling or "tolerable sedimentation rate" (TSR) for estuaries has been estimated based on that which was likely during the period prior to widespread catchment deforestation and downstream wetland drainage. Based on a review of available sedimentation rate data for NZ estuaries (Table 8), a TSR for NZ estuaries in the 0.5-2mm/yr range is recommended. Estuaries with easily erodible catchments (e.g. Wainui Inlet) fit at the higher end of the range, with the majority of estuaries with developed catchments meeting the 1mm/yr rate.

For management purposes, this TSR is then converted to a guideline SS input load from the catchment, based on the likely proportion of the input load that the estuary or embayment captures. Because different estuary types have different levels of susceptibility, TSR and SS input loads are specified for different estuary types in Table 9a. These are subsequently used to calculate a Sedimentation Potential rating for each estuary type (Table 9b) based on the conservative premise that most of SS catchment load to tidal lagoon estuaries and ICOLLs (intermittently closed/open lakes or lagoons) settles within the estuary, but in tidal river estuaries the majority is flushed out to sea and is deposited subtidally.

Both the sedimentation susceptibility and potential of different estuary types have been determined based on; sediment monitoring information (e.g. proportion of estuary with muddy sediments, grain size), knowledge of estuary susceptibility to sediment accumulation (Hume et al. 2007), and information on likely historical loads.

Due to their limited ability to flush sediments to the sea, ICOLLs (e.g. Southland's Waituna Lagoon) are the most susceptible estuaries to SS catchment inputs. Also high on the list of susceptibility are naturally sandy tidal lagoon estuaries (Figure 4 a), particularly those with sheltered arms and/or extensive upper estuary intertidal flats (e.g. Waimea, Motupipi estuaries).

Table 8. Sedimentation rates for various NZ estuaries.

Estuary	Sedimentation Rate (mm/yr)		Source
	Pre Polynesian	Post European	
Wharekawa (Coromandel)	0.09-0.12	3-8	Swales and Hume 1995
Whangamata	0.01	5-11	Shef eld et al. 2005
Whangapoua	0.03-0.08	0.89-1.5	Swales and Hume 1995
Raglan Harbour	0.3-0.5	1.1-8	Swales et al. 2005
Tamaki Estuary	0.11-1.6	2.4-6.2	Abrahim 2005
Papakura Estuary	0.2-0.5	0.8-32.6	Swales et al. 2002
Porirua Harbour	0.1-0.5	2.3-10.3	Gibb and Cox 2009
Wainui Inlet (Golden Bay)	0.5-1.7	2.3-3.3	Goff & Chague-Goff 1999
Totaranui Inlet (Golden Bay)	0.5-1.7	2.3-3.3	Goff & Chague-Goff 1999
Awaroa inlet (Golden Bay)	0.5-1.7	2.3-3.3	Goff & Chague-Goff 1999
Waimea Inlet (Nelson)	?	1.5-12.7	Stevens and Robertson 2011
Waikawa Harbour (Catlins)	?	3.1-10.7	Robertson and Stevens 2007d
Waituna Lagoon (Southland)	0.05-0.6	2.8	Stevens and Robertson 2007
New River Estuary (Invercargill)	?	3-60 (Waihopai Arm)	Stevens and Robertson 2010

4. STRESSORS (CONTINUED)

Tidal river estuaries have a much lower susceptibility, especially if they have one main channel with little intertidal area (e.g. Hutt Estuary). Intermediate between the latter two types, are tidal river estuaries that discharge to large delta areas with extensive intertidal flats (e.g. Motueka and Takaka estuaries), particularly if the delta is located in an enclosed bay (e.g. Havelock Estuary).

Table 9. Proposed mean sedimentation guidelines for NZ estuary types and coastal waterbodies.

Estuary Type		Mean TSR (mm/yr)	* Areal SS Input Load ($g.m^{-2}.d^{-1}$.)
PRISTINE	Pristine estuaries, embayments with natural unmodified catchments.	<0.09	<0.3
ICOLLs	Intermittently closed and open lakes or lagoons (coastal lagoons), generally large.	<0.2	< 0.6
Tidal Lagoon	Coastal embayments - dominated by seawater influence. Susceptible to inputs of SS - have large basins where fine sediment can settle. Most catchment SS settles in estuary.	<0.2	< 0.6
	Moderate freshwater influence, open basin. Susceptible to inputs of SS - have large basins where fine sediment can settle. Most catchment SS settles in estuary.	<1	< 3.2
	Extensive subtidal areas at low water and upper estuary intertidal flats, moderate freshwater influence. Susceptible to inputs of SS, especially large basins. Most catchment SS settles in estuary.	<1	< 3.2
	Shallow, extensive poorly flushed arms and upper estuary intertidal flats, moderate freshwater influence. Susceptible to inputs of SS. Most catchment SS settles in estuary.	<1	< 3.2
Tidal River	Intertidal delta with moderate-sized adjoining lagoon and moderate to high flows. The tidal river component of these estuaries is very well flushed because they have large freshwater inflows and their beds are often relatively clean. However, the associated lagoon can accumulate sediment, particularly in its upper area. Other than this lagoon accumulation, most of the SS input load is expected to be flushed out onto the delta and out to sea.	<2	All Low Susceptibility
	Intertidal delta in enclosed embayment. The tidal river component of these estuaries is very well flushed because they have large freshwater inflows and their beds are often relatively clean. As such, most of the SS input load is expected to be flushed out onto the delta and out to sea. The more sheltered the delta area, the more mud it accumulates.		
	Intertidal delta to open sea - some may have adjoining lagoons as well.		
	Moderate intertidal flats.		
	One main channel, small intertidal flat area.		
	Intermittently closed open small tidal river estuary. Have moderate freshwater inflows (catchments >10km²), variable SS inputs and are well flushed when mouth open. But when mouth closed sediment inputs can settle to estuary bed but not for long as they are flushed offshore during high flows.	<2	Moderate Susceptibility

* Based on estimated catchment SS load (t/yr) and assuming all SS settles in, and is spread evenly throughout, the estuary.
The areal SS input guideline is used to determine the boundary between High and Moderate Sedimentation Potential - see Table 9b below). The Moderate to Low Sedimentation Potential boundary is set at 50% of the Moderate-High boundary.

Determining Sedimentation Potential.

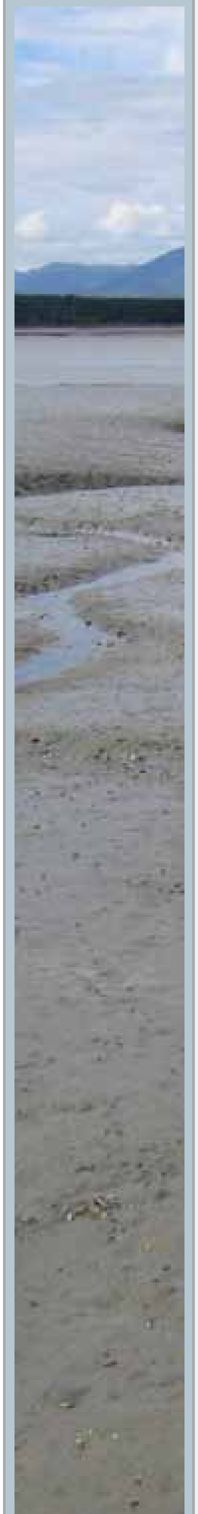
The sedimentation potential was estimated in this vulnerability assessment using the following procedure.

- Estimate catchment suspended sediment (SS) areal input to each estuary and estuary type to determine level of susceptibility as portrayed in Table 9a. For this vulnerability assessment, the catchment SS loadings to each Tasman estuary and embayment were estimated using NIWA CLUES model outputs (running default settings based on LCDB2 2001 landuse).

Table 9a. Sedimentation Potential ratings for different estuary types (assessed using catchment SS inputs).

Estuary Type	**SEDIMENTATION POTENTIAL** calculated as: Catchment SS Input (g/day) ÷ estuary area (m²) = g/m²/d		
	Low	Moderate	High
PRISTINE - Estuaries	<0.15	0.15-0.3	>0.3
ICOLLs (large)	<0.3	0.3-0.6	> 0.6
Tidal Lagoon - Coastal embayments	<0.3	0.3-0.6	>0.6
Tidal Lagoon - other	<1.6	1.6-3.2	>3.2
Tidal River	Low Susceptibility		
Small Tidal River/Creek (intermittently open closed)	Moderate Susceptibility		

NOTE: The sediment potential ratings are used to derive an overall sediment rating on the following page.



STEP 2. DETERMINE EXISTING CONDITION - FINE SEDIMENT.

The primary symptoms of excessive fine sediment deposition are as follows:

- high mud content of sediments,
- large area of the estuary covered in soft mud,
- sedimentation rates in excess of "TSRs",
- degraded water clarity (high turbidity).

Secondary symptoms include;

- a decline in sediment oxygenation,
- a shift towards mud tolerant sediment biota (Lohrer et al. 2004, Norko et al. 2002, Thrush et al. 2004),
- a decline in human use values.

Determining the existing condition of estuaries and embayments is important because current SS input loads may not be reflecting actual conditions in the estuary. For example, a tidal lagoon estuary may have a low susceptibility based on current areal SS inputs but have a poor existing condition because of high sediment loads from the past.

For the current assessment of Tasman's estuaries, the primary indicator used to assess existing condition was the area of the estuary covered in soft mud as measured by broad scale habitat mapping. These areas were assigned into ratings as indicated in the adjoining Table 10 i.

In estuaries where grain size monitoring data was available, it was used to provide an additional "grain size % mud rating". This rating assigns % mud content into three categories and places them within low, moderate and high zones of susceptibility to mud sedimentation (see the conceptual diagrams of susceptibility zones in the main estuary types in the Tasman region in Figure 4). The various combinations are then used to indicate overall % mud content condition (see adjoining Table 10 ii). For example, if highly susceptible zones have a low mud content, then that is a sign of very good estuary/embayment condition.

Overall existing condition was estimated as the mean of the combined ratings (i.e. soft mud % cover and % mud content) or the soft mud % cover rating in situations where grain size was not monitored or estimated - see adjoining Table 10 iii.

Table 10. Soft mud, grain size and existing condition ratings.

i. SOFT MUD % COVER CONDITION RATING

RATING	% ESTUARY SUBSTRATE SOFT MUD
Low	<2% soft mud
Moderate	2%-15% soft mud
High	>15% soft mud

ii. GRAIN SIZE % MUD RATING (MEAN)

Susceptibility Zones Rating	<2% mud	2-20% mud	>20% mud
High	Good Condition	Good Condition	Moderate Condition
Mod.	Good Condition	Moderate Condition	Poor Condition
Low	Moderate Condition	Poor Condition	Poor Condition

iii. EXISTING CONDITION RATING (MUD)

SOFT MUD RATING	GRAIN SIZE RATING: Good	Moderate	Poor
Low	Good	Good	Moderate
Mod.	Good	Moderate	Poor
High	Moderate	Poor	Poor

STEP 3. FINAL SEDIMENTATION RATING.

The final rating for the vulnerability of estuaries and coastal embayments to fine sedimentation was estimated as follows:

"Existing Condition Rating" + "Sedimentation Potential" = Final Sedimentation Rating (Table 10a).

Table 10a. Final sedimentation rating (combination of Existing Condition and Sedimentation Potential).

FINAL SEDIMENTATION RATING (SED FINAL)

Sedimentation Potential	Existing Condition Rating: Good	Moderate	Poor
High	Low Vulnerability	Low Vulnerability	Moderate Vulnerability
Mod.	Low Vulnerability	Moderate Vulnerability	High Vulnerability
Low	Moderate Vulnerability	High Vulnerability	High Vulnerability

4. STRESSORS (CONTINUED)

4.3 NUTRIENTS AND EUTROPHICATION

Waimea Inlet

Catchment runoff and point source discharges can carry excessive nutrients to the coast. Excessive nutrients (nitrogen and phosphorus) lead to eutrophic coastal habitats, particularly estuaries and inshore coastal areas, which reduces human use and ecological values. Eutrophication is defined as ''enrichment of water by nutrients, especially compounds of nitrogen and phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms and the quality of the water concerned.''

Eutrophication causes changes in plant and animal communities, favouring rapidly reproducing opportunistic algal and animal species. Opportunistic algal species can adversely affect ecosystems. For example, mass occurrence of phytoplankton and/or macroalgae and epiphytes often leads to loss of long-lived seagrass species. Once the nutrients have been depleted, the algal blooms decay, leading to oxygen depletion, possible kills of fish and benthic invertebrates, and the formation of toxic hydrogen sulphide (H_2S).

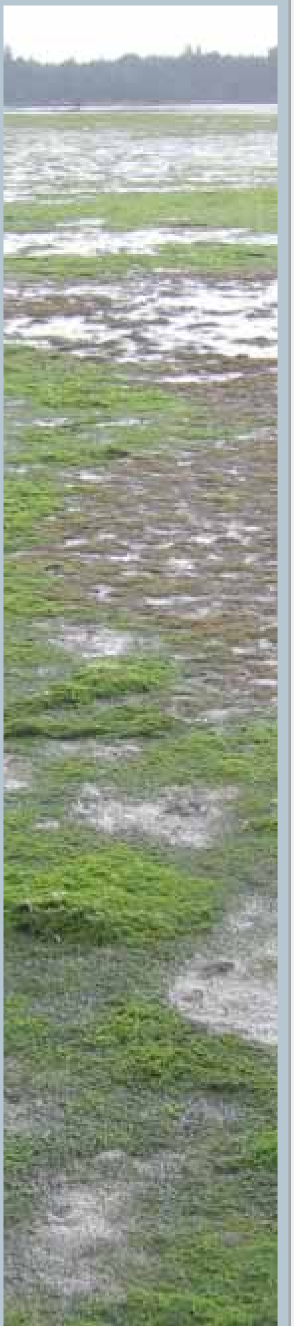
As well as causing impacts on the ecosystem, eutrophication can affect human activities. For example, algal blooms and decaying algae can clog fishing nets, create unsightly foam masses on beaches, and unpleasant smells that interfere with tourism and recreation. Although some algae produce toxins that can harm humans through consumption of contaminated shellfish, the link to nutrient enrichment is uncertain.

Eutrophication problems in coastal New Zealand are relatively widespread but mainly limited to estuaries and bays with restricted circulation. In this report, beaches and rocky shore habitat (outside of estuaries and enclosed embayments), are considered to have low susceptibility to eutrophication, based on their high dilution and flushing potentials.

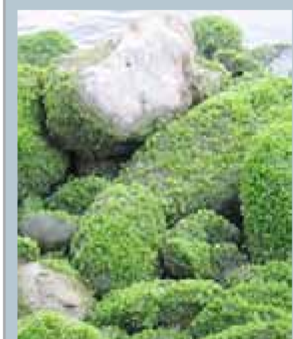
Climate change is likely to exacerbate areas prone to eutrophication through more rain and increased flooding, which is expected to enhance nutrient enrichment through increased freshwater input and run-off from land. Rising sea temperature and prolonged stratification are likely to lead to increased incidence of harmful algal blooms and changing phytoplankton composition. Ocean acidification may also promote changes in the plankton. Recent observations of the decline in sugar kelp along the southern coast of Norway indicate possible interactions between climate change and eutrophication (Moy and Stålnacke 2007).

In many countries around the world, nutrient guidelines for coastal waters have been set or are close to being set. In Europe in the North Atlantic area, guidelines were put in place in the 1990's to achieve reductions in inputs of nitrogen and phosphorus to areas affected or likely to be affected by eutrophication, in the order of 50% compared to input levels in 1985 (OSPAR 2008). In 2005, six of nine reporting countries met the 50% reduction target for phosphorus and three for nitrogen. In the US, the EPA is currently setting numeric criteria for estuaries and coastal waters (deadline August 2012). Currently, NZ has not set numeric nutrient guidelines for its estuaries and coastal waters.

Nitrogen has been identified as the element most limiting to algal production in most coastal marine ecosystems in the temperate zone and therefore the preferred target for eutrophication management (Howarth and Marino 2006). In NZ, the highest nitrogen yields (NYs) are from areas of intensive dairying (approximately 20-50 kgN/ha/yr) and the lowest from exotic forest (0.065-0.8 kgN/ha/yr).



Waimea Inlet



Motupipi Estuary

Predictive methods for assessing the vulnerability of coastal ecosystems to eutrophication in other countries have primarily revolved around three main approaches:

1. the setting of guidelines or thresholds based on available data and expert judgement,
2. the establishment of empirical relationships, and
3. the development of numerical modelling tools.

Guidelines or thresholds and empirical relationships (e.g. nutrient loads that cause eutrophication) are the most preferred methods for assessing eutrophication susceptibility and existing condition. Numerical modelling tools are available but are considered too complex and waterbody-specific for application in a broad-brush coastal risk assessment process like that currently being undertaken for the Tasman region.

Eutrophication Guidelines or Thresholds

In Australia and New Zealand, the ANZECC (2000) guidelines, developed primarily for freshwaters, provide some precautionary and limited guidance for estuaries and marine waters. However, the relevant ANZECC values are limited in scope, are very conservative when compared with European and US threshold values, and are widely acknowledged as being inappropriate for New Zealand estuaries and coastal waters. More recently, nutrient loading guidelines for Australian temperate estuaries have been put forward by Heggie (2006) and for Australian ICOLLs by Scanes (2012), which are more applicable to NZ conditions.

Internationally, simple thresholds for assessing the eutrophic status of estuaries and coastal waters (see Table 11 summary), similar to freshwater guidelines (OECD 1982), were developed by CSTT (1994, 1997 - Scotland), and more recently in Europe by OSPAR (2001, 2003) and the Swedish EPA (2002). In the US, more comprehensive guidelines have been developed which include both primary and secondary symptoms of eutrophication (Bricker et al. 1999). The primary symptoms are high levels of phytoplankton (as measured by chlorophyll a), epiphytes, and/or macroalgae. The presence of primary symptoms at high levels indicates that an estuary is in the first stages of displaying undesirable eutrophic conditions. The second, much more degraded state, occurs when secondary symptoms of depleted dissolved oxygen, sulphide-rich sediments, seagrass loss, and nuisance/toxic algal blooms begin to appear.

The primary and secondary symptom approach of the US (Bricker et al. 1999) is a comprehensive methodology for reliably detecting symptoms of eutrophication. However, it has a number of critical limitations for the shallow, macrotidal estuaries with very short residence times (<1 day) that typify many NZ tidal lagoon and river estuaries. Such limitations indicate a requirement for a modified approach for NZ estuaries. This is primarily because the US approach averages the scores of the three primary symptom expressions (phytoplankton, macroalgae and epiphytes) to define eutrophic status. However, phytoplankton is not a primary symptom in most NZ estuaries. Although phytoplankton populations have the potential to increase fourfold per day in short residence time estuaries, they are generally flushed from the system as fast as they can grow, reducing the estuary's susceptibility to eutrophication and harmful algal blooms (HABs). Therefore in such shallow estuaries, epiphytes and particularly macroalgae, along with sediment oxygenation and nutrients, become the primary symptoms of eutrophication rather than phytoplankton.

Applying an unmodified US approach to NZ estuaries that are expressing eutrophication symptoms (high macroalgal growth, surface RPD, muddy sulphide rich sediments, elevated nutrients, loss of seagrass, and a poor macroinvertebrate condition index), yet have low water column chlorophyll and elevated oxygen levels, results in a low or low/moderate rating of eutrophication symptoms, and a consequent underestimation of vulnerability.

Recommended Approach for Tasman

So for Tasman estuaries (typically shallow estuaries with high flushing potentials), it is recommended that the US approach be modified (as outlined in Table 12) to include a more quantitative macroalgal assessment, and to increase the weighting of sediment-based, secondary symptoms compared to water column DO and harmful algae. That is, add indicators for:

- Sediment RPD rating (RPD 0-1cm bad, 1-3cm poor, 3-10cm fair, >10cm good).
- Sediment "gross nuisance" zones (<0.1% estuary area low, 0.1-0.5% fair, 0.5%-1% poor, >1% bad).

4. STRESSORS (CONTINUED)

Table 11. Existing ‘thresholds’ for assessing eutrophic status.

Australia and New Zealand			
ANZECC (2000)		Summer Max Chlor. *a*	>10mg.m^{-3} (S.E. Australia default used for NZ)
		DIN, TN, DRP, TP	DIN >30mg.m^{-3}, TN 300, DRP 5, TP 30 (S.E. Australia default used for NZ)
		DO water column	60% saturation (used S.E. Australia default for NZ)
Australian Guidelines (Scanes, unpub. 2012)		Nitrogen Estuary Areal Loading (mg.m^{-2}.d^{-1})	Pristine ICOLLs 7.7, (clear waters, minimal algal blooms, strong seagrass growth, good fish assemblages) Moderately disturbed ICOLLs 17.5, (some eutrophic symptoms, but healthy seagrass and fish communities) Highly disturbed ICOLLs 38.4, (algal dominated, turbid systems, seagrass absent or reduced)
(Heggie 2006)			50mg.m^{-2}.d^{-1} Conservative estimate to avoid eutrophication and triggering of significant ecological changes for most other estuaries of temperate Australia.
United States of America			
ASSETS Approach Bricker et al. (1999)	1^{ary} Symptom	Phytoplankton (Chlorophyll *a*)	Maximum values observed over a typical annual cycle. Hypereutrophic (>60µg chl-a/l), High (>20, ≤60), Medium (>5, ≤20), Low (>0, ≤5)
		Nuisance Macroalgae	Poor (significant impact upon biological resources), Low (no significant impact)
		Nuisance Epiphytes	Poor (significant impact upon biological resources), Low (no significant impact)
	2^{dnary} Symptom	DO in Water Column	Very Poor (anoxia) (0 mg/l), Poor (Hypoxia) (>0 ≤ 2), Fair (Biol. Stress) (>2 ≤ 5) , Low (>5)
		Secchi Disc Clarity	Poor (<1m), Medium (1≥m, ≤3m), Low (>3m)
		Seagrass/Salt Marsh Loss	Maximum Spatial Coverage (% of habitat); High (>50, ≤100%), Medium (>25, ≤50), Low (>10, ≤25), Very Low (>0, ≤10)
		Harmful Algae	Problem (significant impact upon biological resources), No Problem (no significant impact)
	N	Nitrogen water	Maximum dissolved surface concentration: High (≥1mg/l), Medium (≥0.1, <1mg/l), Low (≥0, < 0.1mg/l)
	Physical Susceptibility - Dilution and Flushing	Dilution Potential	Calculated as 1 ÷ estuary volume (m^3). If answer = 10^{-12}-10^{-13} then rating is High; 10^{-11} then rating is Moderate; 10^{-9}-10^{-10} then rating is Low
		Flushing Potential	A flushing rating, calculated as freshwater inflow (m^3.d^{-1}) divided by estuary volume (m^3) and adjusted for tidal height (m). For FW inflow/Est Vol; Macrotidal (>1.8m): 0.01-1 High, 0.0001-0.001 Moderate. Mesotidal (0.8m-1.8): 0.1-1 High, 0.01 Moderate, 0.001-0.0001 Low
		Export Potential	

Flushing Potential		Dilution potential		
		High	Moderate	Low
	High	HIgh EXP & Low Susceptibility	HIgh EXP & Low Susceptibility	Moderate EXP & Moderate Susceptibility
	Mod.	HIgh EXP & Low Susceptibility	Moderate EXP & Moderate Susceptibility	Low EXP & Susceptibility
	Low	Moderate EXP & Moderate Susceptibility	Low EXP & High Susceptibility	Low EXP & High Susceptibility

Estuaries in the upper left portion of the matrix generally have a high EXP (export potential) that suggests an ability to dilute and flush nutrient loads. Estuaries in the lower right portion of the matrix have the opposite capacity, making them more susceptible to nutrient input. Note; ICOLLs are assigned into the “Low EXP and High Susceptibility” category.

Europe		
CSTT (1994, 1997)	Winter DIN	>168mg.m^{-3}
	Summer Max Chlor. *a*	>10mg.m^{-3}
EEA (1999)	Nitrate-N	Good <91, Fair 91-126, Poor 126-224, Bad >224mg.m^{-3}
European EWU and OSPAR Approach OSPAR (2001, 2003)	Winter DIN default	>210mg.m^{-3}
	Winter N:P Ratio	>25:1
	Growing Season Chlor. *a*	>50% above background
	Macroalgae	Maximal seasonal cover <15%, max seasonal biomass <1kg.m^{-2}
	DO	Minimum DO in deep water below pynocline >4.6mg.l^{-1}
	Sediment oxic layer	Depth of RPD >2cm
	Seagrass loss	Decrease 3% per annum
	Epiphytic algal cover	55% cover of leaves
Swedish Guidelines. Swedish EPA 2002.	Chlorophyll *a*	in August (Summer) (ug/l); very low <1.5, low, 1.5-2.2, moderate 2.2-3.2, high 3.2-5.0, very high >5.0.
	TN Winter	(ug/l); very low <266, low 266 to 350, moderate 350 to 490, high 490 to 756, very high >756.
	TN Summer	(ug/l): very low <252, low 252 to 308, moderate 308 to 364, high 364 to 448, very high >448.
	DIN Winter	(ug/l): very low <87 low 87 to 118, moderate 118 to 170, high 170 to 424, very high >424.

4. STRESSORS (CONTINUED)

The two key indicators used to assess the extent of gross nuisance conditions are the combined presence of high macroalgal cover (often decaying) and the presence of soft muddy, sulphide rich sediments with RPD near the surface. If both are present, then a very poor rating is likely for sediment invertebrate life.

In addition, the assessment of Tasman estuaries and embayments has included the following;

- where information is lacking (e.g. chlorophyll *a* and DO data), expert opinion has been used, and
- where water column nutrient data is lacking, nutrient load information (derived from the CLUES model) has been used in order to more accurately assess the nutrient influence for estuaries. For this, nutrient loads (on an estuary area basis) were categorised into low (<10mg.m^{-2}.d^{-1}), moderate (10-50mg.m^{-2}.d^{-1}), high (50-100mg.m^{-2}.d^{-1}) and, very high (>100mg.m^{-2}.d^{-1}) categories, based on the finding that 50mg.m^{-2}.d^{-1} will not result in eutrophication or trigger significant ecological changes in most temperate tidal lagoon estuaries (Heggie 2006). Note that this guideline is not directly applicable to ICOLLs and specific guidance for ICOLLs is presented in Table 12.

Table 12. Proposed Guidelines for assessing eutrophic status of Tasman estuaries (modified US approach).

Proposed Guidelines for assessing eutrophic status of Tasman estuaries

	Indicator	Rating Scale
1^{ary} Symptom	Phytoplankton (Chlorophyll *a*)	Maximum values observed over a typical annual cycle: Hypereutrophic (>60 µg chl-a/l), High (>20, ≤60), Medium (>5, ≤20), Low (>0, ≤5).
	Nuisance Macroalgae	Poor (significant impact upon biological resources), Low (no significant impact). Area of estuary with >50% macroalgal cover: Low = 0-5% of estuary, Fair = 5-10%, Poor = 10-30%, Very Poor = >30% (Robertson and Stevens 2011).
	Nuisance Epiphytes	Poor (significant impact upon biological resources), Low (no significant impact).
2^{dnary} Symptom	DO in Water Column	Very Poor (anoxia) (0 mg/l), Poor (Hypoxia) (>0 ≤ 2), Fair (Biol. Stress) (>2 ≤ 5) , Low (>5).
	Gross Nuisance Conditions	The extent of sediment "gross nuisance" zones (<0.1% estuary area low, 0.1-0.5% fair, 0.5%-1% poor, >1% bad).
	Sediment RPD	Depth below surface: bad 0-1cm, 1-3cm poor, 3-10cm fair, >10cm good.
	Seagrass/Salt Marsh Loss	Maximum Spatial Coverage (% of habitat); High (>50, ≤100%), Medium (>25, ≤50 %), Low (>10, ≤25%), Very Low (>0, ≤10%).
	Harmful Algae	Problem (significant impact upon biological resources), No Problem (no sig. impact).
Nutri-ents	N (water) or N Areal Loading	Maximum dissolved surface concentration: High (≥1 mg/l), Medium (≥0.1, <1 mg/l), Low (≥0, < 0.1 mg/l). N Areal Loading: low (<10 mg.m^{-2}.d^{-1}), mod (10-50), high (50-100), very high (>100).
Physical Susceptibility	Dilution Potential	Calculated as 1 ÷ estuary volume (m^3). If answer = 10^{-12}-10^{-13} then rating is High; 10^{-11} rating is Moderate; 10^{-9}-10^{-10} rating is Low.
	Flushing Potential	A flushing rating, calculated as freshwater inflow (m^3.d^{-1}) divided by estuary volume (m^3) and adjusted for tidal height (m). For FW inflow/Est Vol; Macrotidal (>1.8m): 0.01-1 High, 0.0001-0.001 Moderate. Mesotidal (0.8m-1.8): 0.1-1 High, 0.01 Moderate, 0.001-0.0001 Low.
ICOLLs	ICOLL Nitrogen Estuary Areal Loading (mg.m^{-2}.d^{-1}).	Pristine ICOLLs 7.7, (clear waters, minimal algal blooms, strong seagrass growth, good fish assemblages) Moderately disturbed ICOLLs 17.5, (some eutrophic symptoms, but healthy seagrass and fish communities). Highly disturbed ICOLLs 38.4, (algal dominated, turbid systems, seagrass absent or reduced).
Overall Eutrophication Rating (assessed based on approach used in Bricker et al. 1999).		

Verification of the proposed approach has been undertaken by comparing guideline ratings of eutrophication with historical monitoring data from New River Estuary, Southland, a typical well flushed NZ tidal lagoon estuary. Estuary monitoring data collected between 2001 and 2012 by Wriggle for Environment Southland, and water quality monitoring data collected by Invercargill City Council for the same period, clearly identifies New River Estuary as eutrophic with a clear need for management to reduce input nutrient loads. The key eutrophic symptoms in the estuary being high macroalgal cover, poor sediment RPD, and gross nuisance conditions that now occupy 8% of the estuary (Robertson and Stevens 2011), compared with 1-2% in 2007 (Robertson and Stevens 2007) and <1% in 2001 (Robertson et al. 2002).

The European (CSTT 1994, 1997; EEA 1999, OSPAR 2001, 2003; Swedish EPA 2002), NZ and Australian guidelines (ANZECC 2000, Heggie 2006) also identify the estuary as eutrophic based on nutrient concentrations and loads, phytoplankton and macroalgae abundance, and sediment RPD.

The US approach (Bricker et al. 1999) identifies the estuary as having excessive nutrient, phytoplankton and macroalgae concentrations, but not very high secondary symptoms of low water column chlorophyll a or seagrass loss - a "poor" (slightly eutrophic) rating. However, incorporating the proposed sediment symptoms of RPD, sediment nutrients, and gross nuisance conditions, correctly places the estuary in the eutrophic category.

4.4 DISEASE RISK

Cockle *Austrovenus stutchburyi*

Pacif c oyster *Crasstostrea gigas*

Runoff from farmland and human wastewater (primarily treatment plants and septic tanks) often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the coastal environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks posed to humans through recreational contact and shellfish consumption, pathogen contamination can also cause economic losses due to closed commercial shellfish beds. The impacts of pathogenic micro-organisms on human health most commonly manifest as gastro-enteritis, but other common illnesses include respiratory problems and skin rashes. Serious illness can also be attributed to infection from pathogens contained in waters, for example, Hepatitis A, giardiasis, cryptosporidiosis, campylobacteriosis, and salmonellosis (MfE/MoH, 2003).

Indicator micro-organisms are used to assess recreational water quality as it is dif cult and impractical to measure all potentially pathogenic micro-organisms. Two indicator bacteria are commonly used in recreational bathing waters; *Escherichia coli* (*E.coli*) in freshwater and Enterococci in marine waters. For bathing waters, a three-tiered management framework has been adopted to help signal when recreational waters are potentially at risk to users. The system uses the colours green (safe mode), orange (cautionary mode) and red (unsafe mode) to denote the risk to users. The indicator bacteria levels and management responses to these different modes for marine environments are listed in Table 13.

Table 13. Marine recreational water bathing guidelines (MfE/MoH, 2003).

Mode	Guideline (Enterococci cfu/100mL)	Response
Green Surveillance	Single sample <140	Routine monitoring
Orange Alert	Single sample >140 and <280	Increased monitoring, identify possible sources
Red/Action	2 consecutive single samples >280	Public warnings, increased monitoring, source investigation

The guideline for recreational shellfish gathering water quality, over a shellfish gathering season, is: a median faecal coliform count not exceeding 14 per 100ml ; and not more than 10% of samples exceeding 43 per 100ml. Non-compliance with either of these parameters indicates that the water is not suitable for recreational shellfish gathering.

The standard used for shellfish quality for consumption is based on the Ministry of Health Microbiological Reference Criteria for Food (1995). To comply, the standard faecal coliform levels in flesh should be less than 330 MPN/100g, and levels from 230 to 330 MPN/100g are marginally acceptable.

Microbiological limits have also been specified by NZFSA (2006). Faecal coliform limits have been used historically for shellfish quality assessment but these have been abandoned in recent years in favour of *E.coli*. The *E.coli* median MPN of the shellfish samples must not exceed 230 *E.coli* per 100g and not more than 10% of the samples must exceed an MPN of 700 per 100g.

Although extensive monitoring of the disease risk to persons bathing, paddling, kayaking and taking shellfish from Tasman estuaries and coastal waters has been undertaken by TDC, it focuses on summer sampling and has a restricted spatial coverage that limits its use for assessing disease risk vulnerability to all waters in the region. Specifically, data has been collected from two estuaries (Waimea Inlet and Ruataniwha Estuary at Collingwood), and nine beaches (Rabbit Island, Mapua, Kina, Kaiteriteri, Little Kaiteriteri, Marahau, Tata, Pohara, Patons Rock, Tukurua, Parapara, Totara Ave, and Pakawau). Less frequent data have been collected from Motueka, Ruby Bay, and Rangihaeata, and beaches within Abel Tasman National Park. The results for 2009-10 indicate exceedance of “Alert Mode” for Enterococci at Waimea Inlet, and Kaiteriteri, Pakawau, Pohara and Rangihaeata Beaches, and exceedance of “Action Mode” at Ruataniwha Estuary, and Totara Avenue and Tukurua Beaches. If you take out the rain-affected samples the coastal sites typically exceed guidelines less than 1% of the time that they were monitored.

Therefore, in the absence of more comprehensive data, particularly during rain events, the assessment of disease risk has been undertaken by a predictive approach based on the following assumptions;

- Faecal coliform (FC) concentrations are the main indicator of disease risk.
- Faecal coliform loads from catchment runoff to each estuary are predicted based on literature estimates of FC yields in runoff from different landuse types (Table 14) and mean input flows, or from estimates based on the CLUES Model outputs (in default mode - NIWA). Note that the FC estimates based on the former landuse approach are conservative in that they do not include in stream die-off or settlement.
- Maximum FC loads from rivers with developed catchments occur during floods when runoff is elevated, and instream die-off and settlement is low (based on Regional Council monitoring reports from throughout NZ).
- FC loads from point source discharges are estimated based on available ef uent monitoring data.
- Areal loadings of faecal coliforms to each estuary are calculated as follows; FC input to estuary (FC's/year) divided by area of estuary (m^2). These are used to decide if each estuary has high FC loadings in relation to the area available for dilution and dispersion.

Table 14. Faecal coliform (FC) yields for different landuses in New Zealand (Wilcock 2006).

Catchment	FC Yield (FC/ha/yr)
Intensive dairy	1×10^{11}
Sheep and Beef	1×10^{11}
Urban development	8.4×10^{9}
Dairy Ponds	0.2×10^{11}
Dairy Leachate/Drains	0.3×10^{11}
Exotic forest	low
Native forest	low

- **Estuaries Risk.** Areal loadings for each Tasman estuary are then compared with areal FC loading and response data for other NZ estuaries where bathing and shellfish disease risk monitoring data is available (but unfortunately is also very limited) (Appendix 1). Based on these results, ballpark categories of risk were developed (Table 15) for use on both bathing and shellfish waters in the Tasman region. It is noted that such an approach takes into account the potential for FC's that have settled to the estuary bed to be resuspended during turbulent periods.
- **Beaches and Rocky Shores Risk.** Disease risk for beaches and rocky shores in Tasman and Golden Bays was assumed to be relatively low during river baseflows but elevated at times during floods, with the greatest risk assigned to beaches near contaminated river plumes. River plume studies for the Aorere (Robertson and Stevens 2007) and Motueka Rivers (Cornelison et al. 2010) indicate widespread exceedance of shellfish faecal coliform criteria in Tasman and Golden Bays. A recent study on the Motueka River plume in Tasman Bay demonstrated that significant faecal contamination of shellfish can occur within AMAs located more than 6km offshore during moderate flood events with a river flow of $400m^3s^{-1}$ (Cornelison et al. 2010). Knight and Jiang (2012) recently found that the Motueka River plume was unlikely to affect bathing water quality at Kaiteriteri beach during fine weather summer conditions. Similarly, a preliminary modelling exercise on the Aorere plume in Golden Bay indicated most Golden Bay beaches were susceptible to exceedance of shellfish faecal coliform criteria during flood events but were compliant at other times (Robertson and Stevens 2007). West Tasman beaches were assumed to have a low risk due to the absence of any major sources.

The results indicate that shellfish guidelines are likely to be often exceeded in estuaries and coastal waters draining developed catchments, and that exceedance is most likely during and immediately following heavy rain. Bathing guidelines in coastal waters draining developed catchments are also likely to be exceeded at times but mostly only during heavy rain periods or in estuaries with little seawater dilution.

Table 15 provides guidance on likely disease risk to estuaries based on these assumptions. For beaches and rocky shores, it can be assumed that there is a disease risk if the habitat is located in a river plume area and the relevant estuary has an elevated areal FC load. The assessment also includes an estimation of the likely timing of disease risk periods (e.g. during floods for catchment runoff sources).

Table 15. Disease risk guideline criteria used to assess estuary vulnerability.

Vulnerability to Bathers	Low	Moderate	High
Areal FC Loading (FC/m²/day)	<10,000	10,000 - 1 million	> 1 million

Vulnerability to Shellfish Consumers	Low	Moderate	High
Areal FC Loading (FC/m²/day)	<1,000	1,000-100,000	> 100,000

4.5 TOXICANTS

Runoff from urban areas, and direct point source discharges of municipal and industrial wastewater, are the major sources of toxicants to NZ coastal waters. However, in some situations, runoff of pesticides from agricultural land, or from catchments naturally rich in certain potentially toxic minerals, can also be a problem. In addition, irregular release of toxicants to the coast can occur through accidental events such as oil spills. Because most toxicants generally “attach” to fine sediment particles, they tend to accumulate in areas that are susceptible to fine sediment deposition (i.e. estuaries and offshore deposition areas). Coastal beaches and rocky shores were assumed to have low susceptibility to toxicants for this reason.

4.5.1 URBAN RUNOFF

Stormwater outfall, Moutere delta

Estuarine sediments located downstream of urban stormwater discharges generally have high concentrations of zinc (Zn) - originating from tyres, and polyaromatic hydrocarbons (PAHs) - from fuel combustion products and leaked oil (Timperley and Kuschell, 1999). Estuarine sediments may also contain moderately high concentrations of copper (Cu) from brake linings and vehicle wear and tear. Lead (Pb) concentrations in urban stormwater have decreased markedly since the move to unleaded petrol. A variety of other toxic substances are found in urban stormwater (and hence in urban streams) where there have been spills.

In terms of the Tasman region, monitoring data from around Richmond, the most heavily urbanised area in the region, indicates that downstream estuary sediments had localised low levels of PAHs and above background concentrations of arsenic, lead, copper, and zinc (Stevens and Robertson 2010). However, in a few locations adjacent to industrial areas, the levels of heavy metals exceeded ANZECC guidelines. Based on these and other results from around NZ, the greatest risks are for areas around stream mouths that drain urban and particularly industrial, catchments (Table 16).

Table 16. Urban runoff guideline criteria used to assess coastal vulnerability.

	VERY LOW	LOW	MODERATE	HIGH
Vulnerability to Toxicants from Urban Runoff	Mouths of streams entering estuaries/ beaches with no urban landuse.	Mouths of streams entering estuaries/ beaches with low urban landuse.	Mouths of streams entering estuaries/ beaches with moderate urban landuse.	Mouths of streams entering estuaries/ beaches with high urban landuse.

4.5.2 MUNICIPAL AND INDUSTRIAL WASTEWATER

Bells Island wastewater ponds, Waimea Inlet

Toxicants in municipal wastewater vary depending on the source industries in the region and levels of treatment. In general, concentrations are low because they are controlled in terms of environmental effects through consent procedures. As a consequence, municipal and industrial discharges to estuaries and the coast are considered to have a low potential threat to ecological and human use values in the region.

4.5.3 NATURAL INPUTS OF HEAVY METALS

Catchment runoff from areas that are geologically rich in minerals can have very elevated concentrations of potential toxicants. For example, the high nickel (Ni) and magnesium (Mg) content inhibits the growth of vegetation on Dun Mountain and Red Hills. The headwaters of the Waimea River catchment drains from the Dun Mountain mineral belt (the Dun Mountain Ophiolites). Suspended sediments sourced from this region result in slightly elevated concentrations of nickel (Ni) and chromium (Cr) in Waimea Estuary sediments (Robertson et al. 2002). A more extreme situation occurs in the Motueka catchment where high concentrations of heavy metals (Ni, Cr and Cu), from the weathering of ultramafic rock in the Red Hills, settle in the river plume area of Tasman Bay. At sites approximately 2km offshore, Ni and Cr were present at concentrations greatly exceeding sediment quality thresholds for probable ecological effects and the benthic animal community at these sites was highly degraded (i.e. low densities of a few opportunistic taxa, with the spatial distribution of organisms strongly correlated with trace metal concentrations) (Forrest et al. 2007).

In order to assess vulnerability of estuaries and offshore sediments in the Tasman region to naturally high inputs of heavy metals, the presence of significant areas of ultramafic mineral rich rocks in the catchments is used as the primary indicator (Table 17).

Table 17. Guideline criteria used to assess coastal vulnerability of estuaries and coastal subtidal deposition areas to naturally occurring inputs of heavy metals.

Vulnerability to Naturally Occurring Inputs of Heavy Metals	VERY LOW No toxicant-rich mineral belt in catchment.	LOW Small area of toxicant-rich mineral belt in catchment.	MODERATE Moderate area of toxicant-rich mineral belt in catchment.	HIGH Large area of toxicant-rich mineral belt in catchment.

Farmland adjacent to Waimea Inlet

4.5.4 PESTICIDES

Agricultural and horticultural practices have included the use of various pesticides and herbicides. Some of these chemicals can persist in the environment and be carried to estuaries and coastal sediments attached to soil particles. In severe cases this may pose a direct hazard to people and the environment. A wide variety of pesticides has been used in NZ over the last 100 years. NZ studies have shown that some pesticide residues such as As, Pb, Cu and DDT remain in the soil as contaminants. Pesticides containing these chemicals were used extensively in the Tasman District under Government registration until they were withdrawn from sale around 1975. Some tobacco growers continued to use DDT up until about 1985. More recently, there has been a shift towards fewer chemicals that target specific pests, decay quickly in the environment, and leave few residues.

Currently, intensive use of pesticides in the Tasman region is primarily associated with the commercial production of fruit and vegetables (Manktelow et al. 2005). Forestry and pastoral practices are also significant users, but mainly of low persistence herbicides. In terms of threats to the ecology and human use values of downstream estuaries and coastal waters, it is expected that some historical persistent pesticide residues may be present in estuaries with significant areas of commercial horticulture (fruit and vegetables) in their catchments, but the impacts of recent pesticide use on downstream waterways is expected to be low. Despite the relatively high pesticide use intensity in horticultural crops, a recent study to predict leaching and soil accumulation risks in horticultural crops across a wide range of soil types indicated that current pesticide use patterns in the horticultural industry are not likely to lead to unacceptable pesticide leaching (Snow et al. 2004). Table 18 provides guidance on likely pesticide risk to estuaries and offshore subtidal deposition zones based on this information.

Table 18. Guideline criteria used to assess coastal vulnerability of estuaries and coastal subtidal deposition areas to pesticides.

Vulnerability to Pesticides	VERY LOW Receives runoff from unmodified catchments.	LOW Runoff from significant areas of pastoral and forestry in catchment.	MODERATE Runoff from small areas of intensive horticulture	HIGH Runoff from large areas of intensive horticulture, both historical and recent.

Oil leaking from the grounded vessel *Rena* in the Bay of Plenty, October 2011

4.5.5 OIL SPILLS

Oil can reach the coast from a variety of sources (spills from oil tankers, other vessels, offshore drilling rigs and oil terminals; land runoff, and natural seepage) and in a variety of forms (e.g. crude oil, light and heavy fuel oil, oily bilge wastes). Impacts are most severe to sensitive coastal habitats where macrofauna is diverse and abundant and oil can stay trapped for long periods (e.g. estuaries, dissipative and low-energy beaches, and the supra-littoral area of high energy beaches). The vulnerability of a rocky shoreline to oiling is dependent on its topography and composition, as well as its position. At one extreme, a vertical rock wall on a wave exposed coast is likely to remain unoiled if an oil slick is held at sea by the action of the reflected waves. At the other extreme, a gradually sloping boulder shore in a calm backwater of a sheltered inlet can trap enormous amounts of oil which may penetrate deep down through the substratum.

4. STRESSORS (CONTINUED)

Ensco 56 drilling rig in Tasman Bay, 2008

In addition, prior to reaching coastal shorelines, a spill may have been treated with chemical dispersants to disperse the oil slick into the water column to reduce oiling of shoreline habitats and contact with birds, marine mammals, or other organisms that exist on the water surface or shoreline. In this situation, a conscious decision has been made to expose the water column and seabed (in shallow areas) to the oil/dispersant mix rather than allowing more sensitive shoreline habitat (e.g. estuarine saltmarsh or beach) to be oiled.

This trade-off reflects the complex interplay of many variables, including the type of oil spilled, the volume of the spill, sea state and weather, water depth, degree of turbulence (thus mixing and dilution of the oil), relative abundance and life stages of resident organisms, adequacy of background knowledge on ecological risk, and the extent to which the oil has already weathered. In general, effective dispersant application must be made within two hours for most NZ crude oils, and within to 1-2 days for many others, and is most successful in situations in deeper waters (i.e.>10m) where rapid dilution has the potential to reduce the possible risk to sensitive habitat. In many instances the current understanding of key processes and likely impact of dispersed oil plumes to sensitive water-column or benthic organisms and populations is limited and relies on a relative assessment of whether impacts are expected to be less severe than to other identified high value resources e.g. birds, shorelines.

In order to assess the vulnerability of coastal areas in the Tasman region to oil spills, the following categories are used (Table 19). The two key elements of risk are: the probability of an oil spill occurring and the consequences of the spill should it occur.

Table 19. Oil Spill guideline criteria used to assess coastal vulnerability.

	Rating	VERY LOW	LOW	MODERATE	HIGH
PROBABILITY OF SPILL OCCURRING	Proximity to offshore drilling platform	None	Low	Moderate	Within trajectory
	Proximity to shipping/vessel route	Very low numbers of boats	Recreational/ commercial boats present	Small port nearby	Large port nearby servicing oil tankers.
	Proximity to land runoff source	Very remote	Semi-remote	Small communities nearby	Large town/city nearby
	OVERALL PROBABILITY	NEGLIGIBLE	SLIGHT	MODERATE	SEVERE
POTENTIAL MAGNITUDE OF IMPACT	Habitat Sensitivity	Exposed subtidal	Rip-rap man-made, subtidal embayment	Rocky shore, reef.	Saltmarsh, tidal flats, sand/gravel beach, seagrass. High biodiversity habitats with high potential to retain oil.
	Recovery Time	<1yr	1-3yrs	3-6yrs	>6yrs or irreversible
	OVERALL MAGNITUDE OF IMPACT	NEGLIGIBLE	SLIGHT	MODERATE	SEVERE

The above criteria are similar to those used by Maritime New Zealand to assess the relative risk of oil spills to the NZ coast (e.g. Lenting et al. 2004, http://www.maritimenz.govt.nz/Environmental/Marine-oil-spill-risk-assessment/).

4.6 CLIMATE CHANGE

Predicted accelerated global warming will cause an increase in the rate of sea-level rise as oceans expand, and make storm patterns more energetic. Consequently it will affect most of the world's coastlines through inundation and increased erosion. In the Tasman Region, global warming is expected to cause the following changes (Wratt et al. 2008):

- warmer by up to 2.0°C by 2090, drier in the east with increased drought frequency.
- increase in westerly winds and frequency of heavy swells.
- 5 to 10% wetter by 2090 in southern and western areas, and more extreme rainfall events.
- rate of sea level rise is likely to increase with a 0.8m rise predicted by 2090.

Tidal f apgate, Waimea Inlet

Coastal erosion protection, Ruby Bay

Coastal saltmarsh, Marahau

Other studies indicate likely shifts in biological communities in NZ as a result of climate changes to sea temperature and pH. The IPCC (2007) report indicates that future ocean acidification could significantly affect many kinds of marine organisms, and is very likely to interfere with the formation of shells and skeletons by corals and other marine calcifiers, such as crabs, marine snails, and bivalves. Ridgeway and Hill (2009) predict increases to sea surface temperature in the Tasman region of 1°C by 2030 and 2°C by 2100, driven mainly by changes to ocean circulation in the western Pacific Ocean and Tasman Sea causing the East Australian Current to push further south carrying sub-tropical species into temperate waters. Already, sub-tropical introductions to the Tasmanian east coast are altering the habitat of a wide range of species, and facilitating the introduction of new species such as the sea urchin.

The wetter climate in the west and south will likely contribute to increased runoff and greater nutrient, sediment, and pathogen loads to at-risk estuaries. In combination with increased temperatures, the increased loads will mean much greater vulnerability of Tasman estuaries to eutrophication and its associated nuisance conditions (e.g. low oxygen, algal blooms), disease risk and sedimentation.

4.6.1 SEA LEVEL RISE

The physical response of the Tasman coastline to predicted sea level rise is a particularly important issue that has not yet been accurately determined for the region. A number of methods have been developed to assess coastal land loss over long time periods (e.g., 50 to 100 years) but these have been a source of debate in the scientific community (Gutierrez et al. 2009). Basic approaches include: the Bruun Model for sandy coasts (Bruun 1962, 1988); extrapolation of historical data (e.g. coastal erosion rates), application of simple geometric models, and application of sediment dynamics/budget model (see review in Gutierrez et al. 2009).

Another popular approach is the Coastal Vulnerability Index (CVI, Gornitz and Kanciruk, 1989; Gornitz, 1990; Gornitz et al., 1994; Thieler and Hammar-Klose, 1999). Recently, the U.S. Geological Survey (USGS) used this approach to evaluate the potential vulnerability of the U.S. coastline on a national scale (Thieler and Hammar-Klose, 1999) and on a more detailed scale for the U.S. National Park Service (Thieler et al., 2002). The USGS approach reduced the CVI to include six variables (geomorphology, shoreline change, coastal slope, relative sea-level change, significant wave height, and tidal range) which were considered to be the most important in determining a shoreline's relative susceptibility to sea-level rise (Table 20).

Once each section of coastline is assigned a vulnerability value for each specific data variable, the coastal vulnerability index (CVI) is calculated as the square root of the product of the ranked variables divided by the total number of variables;

Physical CVI = $\sqrt{(a.b.c.d.e.f)/6}$

where, a = geomorphology, b = shoreline erosion/accretion rate, c = coastal slope, d =relative sea-level rise rate, e = mean wave height, and f = mean tide range.

Table 20. Physical vulnerability rankings for climate change - sea level rise.

	Rating	VERY LOW 1	LOW 2	MODERATE 3	HIGH 4	VERY HIGH 5
a	Geomorphology	Rocky cliffs, fiords	Medium cliffs, indented coasts	Low cliffs, glacial drift, alluvial plains	Cobble beaches, subtidal estuary, low cliffs.	Sand beaches, saltmarsh, tidal flats, deltas, mangroves.
b	Erosion (-)/Accretion (+) Rate (m/yr)	>2.0	1.0 to 2.0	-1.0 to 1.0	-2.0 to -1.0	>-2.0
c	Coastal Slope %	>1.2%	1.2-0.9%	0.9-0.6%	0.6-0.3%	<0.3%
d	Sea Level Change (mm/yr)	<1.8	1.8-2.5	2.5-3.0	3.0-3.4	>3.4
e	Wave Height (m)	<0.55	0.55-0.85	0.85-1.05	1.05-1.25	>1.25
f	Tidal Range (m)	>6	4-6	2-4	1-2	<1

The CVI scores are then divided into low, moderate, high, and very high-vulnerability categories based on the quartile ranges and visual inspection of the data. For Tasman region, CVI values were assigned as:

Rating	CVI Value
LOW	<13.7
MODERATE	13.7 to 15
HIGH	15 and 17
VERY HIGH	above 17

The use of this approach for Tasman was considered the first step in assessing the relative susceptibility of Tasman coastline to sea level rise. Determination of the six variables used to determine the CVI for each section of coastline was undertaken as outlined in Table 21.

Table 21. Availability of information for physical vulnerability to sea level rise.

Variable	Data Availability
1. Geomorphology	Collected in this study.
2. Erosion/Accretion rate	Provided by Eric Verstappen, TDC.
3. Coastal slope	Slope assessed using chart bathymetry and LIDAR mapping provided by TDC.
4. Relative sea level change	Use latest predicted information. A 0.8m rise by 2090 equates to an average change of +10mm/yr which puts it in the high vulnerability category.
5. Mean significant wave height (average height of the highest one third of the waves in a given sea state)	Mean significant wave height is used as a proxy for wave energy which drives the coastal sediment budget. The ability to mobilise and transport coastal sediments is a function of the wave height squared. $E = 1/8.d.g.H^2$ where E = wave energy, d = water density, g = acceleration due to gravity and H = wave height). Wave height can be modelled and a map of mean significant wave height for the NZ coastline is available on: http://www.eeca.govt.nz/images/maps-marine.jpg West Tasman coast is in the 1.5-2.0m range (i.e. high-very high vulnerability) and Tasman and Golden Bays in the 0.5-1.0m range (i.e. low vulnerability).
6. Mean tidal range	LINZ and NIWA data. West Tasman coastline has a mean tidal range of around 2.7m for MHWS which fits the moderate vulnerability category. Tasman and Golden Bays have a higher tidal range of 3.5m for MHWS which also fits the moderate vulnerability category.


South Island pied oystercatcher, Collingwood


Marram grass duneland, Moutere delta

Tasman Region Sea Level Rise Vulnerability

In general, the CVI approach shows that the most vulnerable areas are shorelines that have soft sediments, low gradients, are eroding, exposed to strong wave action, and have a low tidal range. Beaches, dunes, barrier islands, tidal wetlands, and estuarine systems are the most closely linked to sea level and therefore most vulnerable. The West Tasman tidal river estuaries and the beaches and dunes between Paturau and Kahurangi, Wainui and Puponga and Otuwhero/Marahau, all fit in the high to very high category. The majority of the other estuaries and beaches and dunes fit in the moderate category, with the Motueka Delta and the beaches between Tapu Bay and Otuwhero fitting in the low category.

Because the CVI approach only provides a relative vulnerability rating, it does not describe the actual impact of sea level rise on each coastal section or habitat. This current assessment indicates that if sea level rise is not too rapid, high value habitats that are particularly under threat from sea level rise (e.g. saltmarsh, seagrass, intertidal rocky shore communities and duneland) could re-establish if they are able to migrate inland into areas where the slope of the newly inundated habitat is the same or greater than that in the existing habitat. This requires there to be no barriers to prevent inland migration.

To facilitate targeted planning for such events, a more comprehensive assessment based on site-specific survey is required.

4.6.2 SEA ACIDITY AND TEMPERATURE

The potential for widespread negative ecological effects to estuary, beach and rocky shore ecology as a result of increased climate-change induced ocean acidity and temperature in the Tasman region is a likely possibility as a recent review article for Australia (Wernberg et al. 2011), and comments by NZ coastal ecologists, would tend to support. The abstract of Wernberg et al. (2011) is reproduced as follows:

4. STRESSORS (CONTINUED)

"Temperate Australia is a global hotspot for marine biodiversity and its waters have experienced well-above global average rates of ocean warming. We review the observed impacts of climate change (e.g. warming, ocean acidification, changes in storm patterns) on subtidal temperate coasts in Australia and assess how these systems are likely to respond to further change. Observed impacts are region specific with the greatest number of species responses attributable to climate change reported in south-eastern Australia, where recent ocean warming has been most pronounced. Here, a decline of giant kelp (*Macrocystis pyrifera*) and poleward range extension of a key herbivore (sea urchin) and other trophically important reef organisms has occurred. Although, evidence of changes on other coastlines around Australia is limited, we suggest that this is due to a lack of data rather than lack of change. Because of the east–west orientation of the south coast, most of Australia's temperate waters are found within a narrow latitudinal band, where any southward movement of isotherms is likely to affect species across very large areas. Future increases in temperature are likely to result in further range shifts of macroalgae and associated species, with range contractions and local extinctions to be expected for species that have their northern limits along the southern coastline. While there is currently no evidence of changes attributable to non-temperature related climate impacts, potentially due to a lack of long-term observational data, experimental evidence suggests that ocean acidification will result in negative effects on calcifying algae and animals. More importantly, recent experiments suggest the combined effects of climate change and non-climate stressors (overharvesting, reduced water quality) will lower the resilience of temperate marine communities to perturbations (e.g. storms, diseases, and introduced species), many of which are also predicted to increase in frequency and/or severity. Thus climate change is likely to, both by itself and in synergy with other stressors, impose change to southern Australian coastal species, including important habitat-forming algae and the associated ecological functioning of temperate coasts. Wernberg et al. (2011).

These authors also stress that there is an immediate need for monitoring programmes to assess impacts on communities, using climate-change indicator organisms as has been done by the MarClim project in the United Kingdom (Mieszkowska et al. 2005) and in Southland, New Zealand (Stevens and Robertson 2011).

Closer to home, NIWA scientist Carolyn Lundquist stated, at the 2011 International Congress for Conservation Biology, that ocean acidification is expected to cause declines in carbonate communities such as coral reefs and shellfish, with cold-water communities predicted to decline first. In addition, she stated that increasing temperature is predicted to result in migration southward for marine species, with increased mortality during extreme weather events. It was also reported that field observations and reports from fishermen in New Zealand coastal areas show tropical species popping up where they normally wouldn't in warmer than usual years.

4.7 DRAINAGE AND RECLAMATION

Herbfield growing in tidally inundated paddock reclaimed from saltmarsh adjacent to Wainui Inlet

Estuary drainage and reclamation, including construction of causeways and floodbanks, displacement of habitat with alternative surfaces (roads, buildings, golf courses, walkways, landfills, wastewater ponds), eliminates or degrades estuary saltmarsh and the terrestrial vegetated buffer, and constricts tidal flows. This greatly reduces the natural assimilative capacity of the estuary, leading to elevated sedimentation rates and low habitat quality. Development and reclamation of the margins around Waimea Inlet has resulted in the loss of most of the historical saltmarsh and terrestrial margin vegetation, and significantly reduced the extent of the estuary. On the positive side, Nelson City Council have planted 55,000 native trees adjacent to the motorway bypass; and the partial removal of previously reclaimed land has recently been undertaken near Richmond, along with the planting of 21,000 native trees by TDC.

Determining the ecological vulnerability of estuaries, beaches and bays to reclamations, causeways and floodbanks is complex. However, expert opinion suggests that the major variables are the area of habitat lost in relation to the whole estuary/beach/bay, and the ecological value of that habitat. These variables have been placed into vulnerability categories for use in assessing overall vulnerability of each estuary/beach/bay to drainage and reclamation (Table 22).

Table 22. Categories used to assess estuary vulnerability to reclamation.

Rating	VERY LOW	LOW	MODERATE	HIGH
Percentage or area affected	<1%	1-5%	5-10%	>10%
Ecological state prior to reclamation	Unvegetated habitat	Unvegetated muddy habitat	Unvegetated sandy habitat	Vegetated sandy habitat
Water and sediment quality	LOW	GOOD	GOOD	GOOD

4.8 FRESHWATER ABSTRACTION

Prior to European settlement, inflows of freshwater to NZ estuaries were strongly linked to climate, and consequently were characterised by erratic floods, droughts, and periods of in-between flows. However, since this time, the flow and flood regimes of many rivers have been altered by upstream damming and direct abstraction (and flood controls), with

4. STRESSORS (CONTINUED)


Ngaio Estuary

the result that periods of low flow have been extended and the intensity of high flows reduced. Because reduced freshwater inflows reduce dilution and flushing, water quality can be expected to decline, and in extreme situations, lead to excessive muddiness, eutrophication and disease-risk. Coastal beaches and rocky shores are considered to have low susceptibilty to freshwater abstraction.

Estuaries which are particularly susceptible to ecological damage as a result of abstraction include the following (based on the criteria presented in Table 23):

- Estuaries which are often closed at the mouth by a sand or gravel berm and that remain closed until the berm is breached by a large flood or the estuary basin fills and the berm is overtopped. Upstream water abstraction extends the period of closure with consequent detrimental impacts on water quality, access to the ocean, and estuarine biota. An increase in muddiness, eutrophication and disease risk symptoms can be expected, which can particularly affect juvenile fish species that use the estuary as a nursery area, high value seagrass and saltmarsh vegetation, and human recreational, and shellfish collection uses.
- Estuaries that are permanently open but include a poorly flushed lagoon (e.g. Waiau Lagoon in Southland - note Tasman has no examples) are also highly susceptible to ecological damage from abstraction, in particular from a decline in flushing flows.
- Estuaries that are permanently open but includes deeper areas in the upper estuary where saline bottom water accumulates and has the potential to stagnate unless regularly flushed by high flows (e.g. Motupipi Estuary).
- Estuaries that are permanently open but have degraded water/sediment quality - e.g. macroalgal blooms, depleted oxygen, extreme muddiness, disease-risk to bathers and/or shellfish consumers.
- Estuaries that are permanently open and have a very high freshwater inflow:marine water inflow ratio; i.e. dominated by freshwater inflows and therefore more likely to be affected by abstraction.

Table 23. Freshwater abstraction guideline criteria used to assess estuary vulnerability.

Rating	VERY LOW	LOW	MODERATE	HIGH
Susceptibility	Estuaries with little or no freshwater inflows.	Estuaries with low-moderate freshwater/marine water inflow ratios.	Estuaries with high freshwater/marine water inflow ratios.	Estuaries with one or more of; mouth often closed, poorly flushed lagoon or upper estuary, upper estuary bottom water stagnation, degraded water/sed quality.
Magnitude	Zero	<1% of mean flow	1-20% of base flow	>20% of base flow

4.9 HARVESTING LIVING RESOURCES


Pakawau Beach

Estuaries, beaches and rocky shores often contain resources that are harvested by humans. These include living resources (fish, shellfish, seaweed) and non-living resources (salt, energy from waves or tide). In the Tasman region, only harvesting of living resources is considered in this report.

Coastal habitats which are particularly susceptible to ecological damage as a result of such harvesting primarily consist of those whose stocks of living resources are already under stress (e.g. from pollution, sedimentation, overharvesting etc.) and are located close to human populations. Coastal habitats with little or no harvestable resources have a very low vulnerability. Table 24 provides guidance on the categories used to assess harvesting vulnerability in this report.

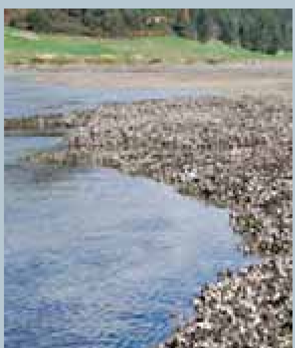
Table 24. Harvesting of living resource guideline criteria used to assess coastal estuary vulnerability.

Rating	VERY LOW	LOW	MODERATE	HIGH
Harvestable Resource Presence	None	Low	Moderate	High
Proximity to Human Population	Very remote	Semi-remote	Small communities nearby	Large town/city nearby

4.10 INVASIVE SPECIES


Example of the invasive seaweed *Undaria*


Mangrove planted in Parapara Inlet


Pacif c oyster bed - Motupipi Estuary

Coastal regions are at risk from both invasive and non-native species. Invasive species are defined as alien species whose introduction causes or is likely to cause economic or environmental harm, or harm to human health, whereas non-native species are those that are not native to that ecosystem. Human activities can greatly exacerbate the spread of non-native (including invasive) species, with key aquatic pathways including commercial shipping and barges (through ballast water, external fouling and sea chests), recreational vessel movements, aquaculture and fishing industries, the aquarium trade, and intentional introductions (e.g. Pacific Oyster and *Spartina*). The major threats to dune communities are marram grass (*Ammophila arenaria*), South African ice plant (*Carpobrotus edulis*), tree lupin (*Lupinus arboreus*) [all three were originally planted for dune stabilisation] and gorse (*Ulex europaeus*). TDC have also identified Japanese honeysuckle, tamarisk, divided sedge, saltmeadow rush, sea spurge, jelly bean plant, and mustelids as pest species near the coast.

Surveys of introduced marine species at Port Tarakohe (Morrisey 2010, 2011) list 2 species on the NZ register of unwanted organisms - the clubbed tunicate *Styela clava* (found on a vessel in 2010), and the Asian kelp *Undaria pinnatif da* (first recorded from marine farms near Collingwood in 2000 and Port Tarakohe in 2002 - Morrisey and Miller 2008). This alga is known to now have a wide distribution in southern and eastern NZ.

A survey of non-native and suspected non-native species from nearby Port Nelson (Inglis et al. 2005) found 13 non-native species and 32 suspected non-native species. Most non-native species were considered likely to have been accidentally introduced to NZ by international shipping or spread from other locations in NZ (68% from hull fouling assemblages, 5% via ballast water, 22% from either ballast water or hull fouling vectors and 5% on drift plastic). *Styela clava,* first detected on a vessel in Port Nelson in 2006, has in subsequent surveys been recorded only in very low numbers (Morrisey 2011).

In order to assess the vulnerability of coastal habitats to invasive species in the Tasman region, some form of ecological risk assessment (ERA) would generally be undertaken as the first step. To comprehensively assess regional risk, this would involve the following:

- Identifying new or existing pathways (e.g., ballast water, aquaculture, aquarium trade)
- Identifying invasive organisms/plants of concern
- Assessing probability of organism establishment
- Assessing consequence of establishment

Such a process is relatively complex and usually relies on a combination of quantitative data and expert opinion. To date, there has been no comprehensive ERA for invasive coastal species for the Tasman region. However, there has been a call for such an assessment to be undertaken (Taylor, 2006), and a Top of the South Marine Biosecurity Partnership was established in 2009 to determine priority actions to prevent the introduction and minimise the spread of damaging marine species.

Of particular relevance to the Tasman region is the recent development of a detailed ERA procedure for invasive species from recreational vessels (Acosta and Forrest 2009). Although this has not yet been used in Tasman it does highlight recreational vessels as the likely major invasive species pathway in the region. In the absence of a comprehensive ERA for the Tasman region, a preliminary assessment is undertaken using available pathway information and any known presence of invasive species. Table 25 provides guidance on the categories used to assess invasive species vulnerability in this report.

Table 25. Invasive species guideline criteria used to assess coastal vulnerability.

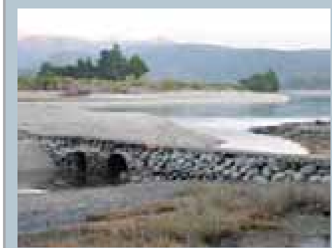
Rating	VERY LOW	LOW	MODERATE	HIGH
Pathway (aquatic only)	Remote from boating and shipping activity	Local recreational vessels present but passing through only.	National and local vessels visit: anchorage, marina, launching ramp, jetty, aquaculture area etc.	Major shipping port - international and national. Intentional release.
Existing Presence of Invasive Species	Invasive species absent.	Invasive species possible but not surveyed.	Invasive species present.	Invasive species well-established.

4. STRESSORS (CONTINUED)

4.11 STRUCTURES THAT DISRUPT SEDIMENT TRANSPORT

Causeway with tidal flapgates - Motupipi Inlet

Road causeway being removed - Moutere Inlet, 2010



Pedestrian causeway, Parapara Inlet

Road development through saltmarsh - Waimea Inlet, 2010

Sediment supply to Tasman and Golden Bay is low compared with the West Tasman coast but, because of its sheltered aspect, sedimentation rates in Tasman and Golden Bays are comparatively high compared to other shelf areas of New Zealand (Van der Linden 1968).

Sediment is introduced to Tasman and Golden Bays from two key sources; the West Coast of the South Island, and from riverine inputs from within each bay. The prevailing northward drift of currents and sediment along the West Coast results in rapid deposition of sediments on Farewell Spit, with sediment moving out past Farewell Spit from the west and ultimately being swept into Tasman Bay and Cook Strait. Direct coastal erosion is a very minor source of sediment (Shell BP and Todd Oil Services (NZ) 1975).

In Tasman Bay, the Motueka and Waimea Rivers characteristically discharge around 0.7 x 10^6 tonnes/yr of sandy silt and calcareous gravel material (Griffiths and Glasby 1985), while in Golden Bay (which is less than a third of the size of Tasman Bay) the Aorere and Takaka Rivers contribute around four times this amount - 2.7 x 10^6 tonnes/yr. Sediments discharged into Golden Bay are sandier in nature than the silts predominant in Tasman Bay, with the relatively coarse sandy bed-load sediment and fine sediments transported by the prevailing clockwise current rotation in Golden Bay.

The nature of the currents which have been modelled for the greater Cook Strait indicate that the bottom stresses in Tasman and Golden Bays are typically within the ranges where fine-grained deposition would dominate (Proctor & Carter 1989). Resuspension and transportation of bottom sediments is periodically expected under favourable wind-wave conditions, particularly those generated from northerly storms (Muir 1975), with suspended sediment redistributed by tidal and oceanic currents within the bays.

If coastal structures are erected that disrupt the natural sediment transport pathways then adverse impacts to coastal habitat can result. The most extensive alterations in beach landforms are associated with shore protection and navigation projects (e.g. seawalls, causeways, breakwaters, groynes). Ecological consequences can be substantial at local scales, and include the loss of biodiversity, productivity, and critical habitats, as well as modifications of the subtidal zone which is an important recruitment zone for many sandy beach animals (Peterson & Bishop 2005, Dugan & Hubbard 2006, Peterson et al. 2006, Speybroeck et al. 2006). In general, such structures act to disrupt the natural transport of sand and lead to erosion/accretion problems. Exposed beaches are most at risk and their impact is most severe near hard structures (Brown and McLachlan 2002).

Seawalls. Seawalls are shore-parallel structures built landward of the beach to reduce wave energy or hold beach sand in place and protect sites of human development. Damage to beach ecology results as they truncate the landward portion of the beach that would be reworked by storms, and restrict or prevent exchanges of sand and biota between the beach and dune. In many instances, once a wall is put in place the area landward of the dune is developed and the dune habitat is lost. Areas with seawalls prevent the beach from migrating landwards in response to sea-level rise or reductions in the sediment budget. Seawall establishment often leads to erosion of sand from the beach face in front of the wall, depositing it offshore. The resulting loss of sand from in front of the wall can result in increasing wave energy, undermining the wall itself, impacting on beach ecology, and limiting the supply of sand available for dune formation.

Seawalls - left to right at Marahau, Waikato, and Ruby Bay

4. STRESSORS (CONTINUED)

Tarakohe Harbour breakwater

Geotextile groyne - Moutere Delta

Such erosion is a major problem because it necessitates additional measures such as beach nourishment and the construction of groynes or detached breakwaters (Roul and Tondello 2008), each of which comes with their own suite of ecological impacts.

Breakwaters. Breakwaters are used to protect the entrances to harbours and extend from the shoreline out to sea. They may also be constructed offshore to reduce wave attack on beaches. In this case they are referred to as "detached" breakwaters and may either be submerged or emergent. These structures may be made of concrete blocks, rock piles or dolosse (geometric concrete blocks). Ironically, one major effect of these structures, whether attached or detached, is the creation of currents that can cause downdrift coastal erosion, often at some considerable distance from the structure. Detached breakwaters can also cause updrift erosion due to induced longshore currents. The ecological consequences include altered hydrology, which influences the dispersion of marine organisms, changes in grain size which affects abundance and composition of fauna, loss of habitat through erosion (Roul and Tondello 2008), and alteration of habitat by replacing soft substrata with hard structures.

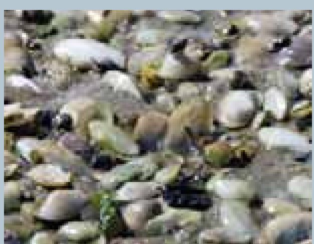
Groynes. Groynes are shore-perpendicular structures designed to trap sand moving alongshore. Apart from the loss of beach habitat directly under the groyne, other impacts may include disruption of sediment supply to downstream sections of the coastline, increased erosion (Roul and Tondello 2008), and alteration of local hydrodynamics and sediment grain size which may adversely affect the abundance, distribution and diversity of beach fauna (Walker et al. 2008).

Groynes, which may be constructed from concrete or simply piles of rocks, introduce islands of hard substrata into what would otherwise be continuous areas of intertidal sand. By removing isolating barriers, these structures provide stepping stones for the dispersal of marine biota (including invasive species) normally associated with rocky reefs (Airoldi et al. 2005). Table 26 provides guidance on the categories used to assess ecological vulnerability to seawalls, breakwaters and groynes in this report.

Table 26. Guideline for assessing vulnerability of coastal habitat to seawalls, breakwaters and groynes.

Rating	VERY LOW	LOW	MODERATE	HIGH
Seawall/Break-water	Absent	Length of structure small compared with beach length.	Length of structure moderate compared with beach length.	Length of structure greater than 1/10th of beach length.
Groyne	Absent	Groyne extends less than 1/4 width of beach.	Groyne extends 1/4 to 1/2 half width of beach.	Groyne extends half to full width of beach.
Exposure	Sheltered	Semi-sheltered	Semi-exposed	Exposed

4.12 OFF-ROAD VEHICLES



Driving off-road vehicles (ORVs) on beaches, dunes and tidal flats is a popular recreational pursuit and means of access to otherwise inaccessible areas of the coastline. In NZ, large numbers of vehicles may pass daily along some beaches and dunes during peak periods.

ORVs, however, cause severe ecological impacts such as accelerating erosion (Anders and Leatherman 1987, Priskin 2003), damaging dune vegetation (Luckenbach and Bury 1983, Rickard et al. 1994, Thompson and Schlacher 2008), destroying the nests of birds (Hosier et al. 1981, Buick and Paton 1989), crushing invertebrates such as crabs, isopods and bivalves (Moss and McPhee 2006, Schlacher et al. 2007) and impairing the burrowing performance of clams (Sheppard et al. 2009). Table 27 provides guidance on the categories used to assess ecological vulnerability to off-road vehicles in this report.

Table 27. Off-road vehicle guideline criteria used to assess coastal vulnerability.

Rating	VERY LOW	LOW	MODERATE	HIGH
Vehicles on Beaches, Dunes and Tidal Flats	Absent	Small number (1 per mth) and limited to small area	Moderate number (1-5 per month), over large area	High numbers (>1/day).
Damage	None	Slight	Moderate	Severe

4.13 TOXIC ALGAL BLOOMS

Introduced toxic micro-algae can cause illness in humans that can require the closure of shellfish gathering and aquaculture operations. Harmless enough at low levels, when conditions are right they reproduce explosively, giving rise to toxic algal blooms (TABs). Specific effects of toxic species include the illness and/or mortality of humans as well as fish, sea birds and marine mammals who ingest toxic fish or shellfish poisoned by TABs, the closure of wild and farmed shellfish harvesting, and the economic losses related to factors such as lost tourism/recreation revenues.

Over the past few decades, the world's coastal waters have experienced a large increase in TAB events. A number of factors are being actively considered as possible causes for this trend, including both natural (i.e., species dispersal) and human-related phenomena (i.e. enhanced nutrient loading, global climate change, and species introductions via ship's ballast water). Improvements in monitoring and detection methods may also be revealing previously unknown indigenous populations.

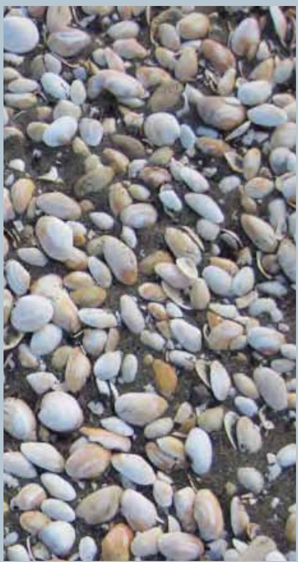
Of the approximately 5000 described marine microalgal species, about 100 have been found to be toxic. Toxic algae are found within a number of taxonomic groups such as the diatoms (predominantly *Pseudo-nitzschia*), dinoflagellates, haptophytes, raphidophytes and dictyochophytes. Within NZ many of these toxic algal species are present in our waters, but only occasionally increase to bloom proportions. In 1989, there was a bloom of the raphidopyte *Heterosigma akashiwo* that killed large numbers of fish in sea cages in Big Glory Bay, Stewart Island (Chang et al. 1990, MacKenzie 1991). In 1998, a bloom of *Gymnodinium brevisulcatum* (Chang 1999), associated with a widespread upwelling event, occurred along the lower eastern North Island coast as far south as Wellington Harbour. The bloom caused mass mortalities of marine fauna and respiratory distress in human beach visitors. In 2000, an introduced dinoflagellate (*Gymnodinium catenatum*) caused the closing of shellfish gathering and mussel farming for nine months along 1,500 kilometres of coastline. This species survives in cooler water than most other algae that produce TABs in NZ, hence it can have a longer season over a larger area. In June 2010, there was a bloom of the dictyochophyte, *Pseudochattonella verruculosa* that caused a large salmon farm fish-kill in the Marlborough Sounds, triggered by a stratified water column following a recent extended period of heavy rain that encouraged nutrient rich bottom water to the surface (MacKenzie et al. 2011). Blooms of *Alexandrium catenella* pose a different threat to marine farmers, that of paralytic shellfish poisoning (PSP). *Alexandrium catenella* can bloom year round, but often appears after late summer storms in the Bay of Plenty, possibly due to the disturbance of sediments which trigger the germination of cyst beds. In 2011, there was an *Alexandrium catenella* bloom and associated saxitoxin contamination of shellfish in the Marlborough Sounds.

Other harmful, but not toxic, algal blooms have also occurred in the Tasman region. At about 20-year intervals since at least the 1860s, there have been accounts of the accumulation of large quantities of mucilage in the waters off the northern coast of the South Island of NZ. On a few occasions these events have been associated with harmful effects, such as the mass mortality of marine fauna and the impediment of fishing activities. The Nelson Mail in 1973 recounted something that looked like "grey smoke", which extended many miles across the bay and lasted for days. The bloom is reported to have turned to black slime, killing 90 per cent of the bay's oysters. "....There was no commercial scallop fishing for three years, and trawl nets became so bogged with slime that could only be cleaned by hard pulling through the water...." the Mail said. In January 2000, there was a moderate re-occurrence of mucilage accumulation in Tasman Bay that led to the identification of the primary origin of this material as the planktonic, thecate, dinoflagellate *Gonyaulax hyalina* (Ostenfeld et Schmidt) (MacKenzie et al. 2002).

Poisoning Syndromes. Six human poisoning syndromes are caused by consumption of seafood contaminated by HAB toxins:

1. amnesic shellfish poisoning (ASP),
2. ciguatera fish poisoning (CFP),
3. diarrhetic shellfish poisoning (DSP),
4. neurotoxic shellfish poisoning (NSP),
5. paralytic shellfish poisoning (PSP), and
6. azaspiracid shellfish poisoning (AZP).

Other threats to human health are posed by toxic aerosols and water-borne compounds that cause respiratory and skin irritation. Sometimes the direct release of compounds that are, strictly speaking, not toxins (i.e., reactive oxygen species, polyunsaturated fatty acids, mucilage) can be lethal to marine animals. Nontoxic HABs cause damage to ecosystems, fisheries resources, and recreational facilities, often due to the biomass of the accumulated algae that can shade other plant species, or decay and deplete oxygen.



Causes of Toxic Algal Blooms

The conditions that favour dinoflagellate blooms are when dormant cysts in the muddy seabed (often at depths over 100m) are re-introduced in spring to the surface waters through mixing, where they grow to bloom proportions if nutrient, light, temperature and other factors are favourable. A number of studies have indicated that toxic dinoflagellate blooms often coincide with enhanced rainfall and freshwater runoff, as well as with a stable water column (Hallegraeff et al. 1995, Weise et al. 2002). The association of toxic dinoflagellate blooms with freshwater runoff has not yet been elucidated but may be due to more favourable temperature and salinity conditions, the supply of humic substances, increased water column stability, or a combination of these factors that might be physiologically important for optimum cell growth.

The conditions that favour *Pseudo-nitzschia* blooms and other species are also not entirely clear, but optimal growth conditions are similar to dinoflagellates; that is, a thermally stratified water column, warm surface waters and high nutrient concentrations (Parsons et al. 2002, Trainer and Hickey 2003, Spatharis et al. 2007, McKenzie et al. 2011). Toxic blooms are also often associated with freshwater plumes (Franks and Anderson 1992, Hallegraeff et al. 1995). Given the available information (which is very limited) the likely risks have been rated as follows for nearshore subtidal waters (Table 28).

Algal boom (non-toxic), Motupipi Estuary

Table 28. Toxic algal bloom guideline criteria used to assess coastal water vulnerability.

Tasman and Golden Bays			
Issue	**Components**	**Comment**	**Risk**
Risk of toxic algal bloom (TABs) occurring	Previous TABs	None in Tasman and Golden Bays	LOW
	Seed Source - local	Unknown, but possible	MODERATE
	Seed Source - up-current	Possible - esp. Marlborough Sounds	MODERATE
	Conditions favourable/unfavourable	Thermally stratif ed water column, warm surface waters and high nutrient concentrations at times.	LOW-MOD
Overall Risk of TAB in Tasman/Golden Bay			LOW-MOD
Risk to ecology if TAB occurred	Presence of at-risk species	TABs can harm f sh, sea birds and marine mammals who ingest toxic f sh or shellf sh poisoned by TABs. Plentiful in region.	MOD-HIGH
Risks to humans if TAB occurred	Presence of humans who eat infected shellf sh, f sh	Common	HIGH
Overall Human Risk of Eating Infected Shellf sh/Fish			HIGH
Overall Ecological Risk - Tasman and Golden Bays			MODERATE

West Tasman Coast			
Issue	**Components**	**Comment**	**Risk**
Risk of toxic algal bloom (TABs) occurring	Previous TABs	None	LOW
	Seed Source - local	Unknown, but possible	LOW
	Seed Source - up-current	Possible	LOW
	Conditions favourable/unfavourable	Thermally stratif ed water column, warm surface waters and high nutrient concentrations uncommon but possible.	LOW-MOD
Overall Risk of TAB in Tasman/Golden Bay			LOW
Risk to ecology if TAB occurred	Presence of at-risk species	TABs can harm f sh, sea birds and marine mammals who ingest toxic f sh or shellf sh poisoned by TABs. Plentiful in region.	MOD-HIGH
Risks to humans if TAB occurred	Presence of humans who eat infected shellf sh, f sh	Low	LOW
Overall Human Risk of Eating Infected Shellf sh/Fish			MODERATE
Overall Ecological Risk - West Tasman Coast			LOW-MOD

4.14 DUNE OVERSTABILISATION


Exotic pine forestry on dunes - Rabbit Island


Dune cliffing - Rabbit Island


Patons Rock


Pohara Beach

Aside from their ecological value, maintaining healthy mobile sand dunes is important to protect land from storm erosion, coastal flooding, and changes in sea level, and is also the least costly way to maintain a recreational beach for future generations. Overstabilisation compromises dune function in several ways as described below:

Overstabilisation with Exotic Forest

The planting of exotic forestry on dune systems has two direct impacts on coastal erosion:

- **Reduction in Wind Shear.** A stand of trees on top of the dunes causes onshore winds to be deflected up over the trees reducing the wind shear at the level of the beach and the surface of the dunes. As a result, the transport of windblown sand from the beach to the dunes declines, which adversely affects sand dune formation, and sand dune plants which benefit from sand supply. If the dunes are not built up and resupplied during fair-weather conditions then the reservoir of sand becomes depleted and beach erosion is accelerated during storm events because the dunes are no longer able to withstand wave attack and there is no sand available to replenish the beach.
- **Dune Cliffing.** Forestry in dunes increases cliff formation in the upper beach area when dunes are eroded because the root-plates of the trees binds the soil at the top of the dunes. With the root-plate binding the top of dune in position, the underlying unconsolidated dune sand can be eroded leaving a dangerous overhang and steep unstable cliff that is not easily revegetated.

Overstabilisation with Marram Grass

Heavy grazing of dunes in the past resulted in the reduction of native dune species and subsequent sand movement inland. In addition, marram grass and lupin were introduced for erosion control and to stop the spread of wind blown sand, with exotic forests or pasture often established on stabilised dunes. The dominance of marram grass (which is prolific and has tended to outcompete the native sand-binders spinifex and/or pingao) has caused dune instability problems. This has tended to result from overstabilisation of the dune system resulting in marram dominated dunes that are generally taller, have a steeper front, and occupy more area than native dunes. Such dunes tend to lock up sand, limiting replenishment of sand to the beach and being susceptible to erosion of the dune front during storms. They also tend to contribute to the loss of biodiversity and natural character, with blow-outs also being common (Hilton 2006).

Overstabilisation of duneland can also occur through other developments as follows:

- Building a seawall in front of, or within, the dune system.
- Using duneland for residential or industrial property developments.
- Developing duneland for pasture, cropping etc.

Table 29 provides guidance on the categories used to assess ecological vulnerability to overtstabilisation of dunes.

Table 29. Guideline for assessing vulnerability of duneland to overstabilsation.

Rating	VERY LOW	LOW	MODERATE	HIGH
Presence of exotic forest on duneland	None	<5% of Area	5-20% of Area	>20% of Area
Presence of marram and weeds on duneland	None	<10% Area	10-50% of Area	>50% of Area
Presence of dwellings on duneland	None	<5% of Area	5-20% of Area	>20% of Area
Presence of developed pasture on duneland	None	<5% of Area	5-20% of Area	>20% of Area
Presence of seawalls in front of duneland	Absent	Length of structure small compared with dune length.	Length of structure moderate compared with dune length.	Length of structure greater than 1/10th of dune length.

4.15 HUMAN/ANIMAL DISTURBANCE OF WILDLIFE

New Zealand fur seal (Kekeno)

The major threat imposed by human and or animal presence in coastal areas is to bird and marine mammal habitat, in particular, disturbance at breeding, foraging and resting sites, and competition for food resources. Currently, there are few protected sites in the Tasman Region, (the exceptions being Farewell Spit, and Whanganui Inlet and Tonga Island Marine Reserves), and there is no map of significant coastal wildlife habitats from which a regional vulnerability assessment can be undertaken. In their absence, Table 30 has been used to provide guidance on the categories used to assess wildlife vulnerability to human/animal disturbance.

Table 30. Guideline for assessing vulnerability of wildlife to human/animal disturbance.

Rating	VERY LOW	LOW	MODERATE	HIGH
Presence of vulnerable wildlife	None	Low	Moderate	High
Proximity to Human Population Centres	Very remote	Semi-remote	Small communities nearby	Large town/city nearby
Access to vulnerable wildlife habitat	Closed	Restricted	Limited	Easy

4.16 GRAZING IN HIGH VALUE HABITAT

Dairy cows grazing on reclaimed saltmarsh adjacent to the Motupipi Estuary, Golden Bay

The effect of stock grazing in saltmarsh and seagrass habitat reduces the height of plants and destroys habitat through trampling (Bellingham and Davis 2008). Birdlife and fish spawning are particularly affected.

The primary effect of excessive stock grazing in duneland is increased dune mobilisation, in addition to habitat destruction through trampling and grazing. However, a recent report on sheep grazing effects in one duneland in England (Plassman et al. 2010) found that long-term grazing management can have positive effects on species diversity, plant communities and habitat condition in sand dunes by controlling weed growth. As such, low intensity stock grazing has the potential to be used in the conservation management of dune communities and associated species where it controls weed growth to a level that allows dune species to prosper, but does not result in other significant adverse impacts.

Table 31 has been used to provide guidance on the categories used to assess grazing vulnerability to high value habitat.

Table 31. Guideline for assessing vulnerability of high value habitat to grazing.

Rating	VERY LOW	LOW	MODERATE	HIGH
Density of Grazing Animals in Foredunes and Hind-dunes.	None	Low	Moderate	High
Density of Grazing Animals in Hind-dunes Only.	None	Low	Moderate	High
Density of Grazing Animals Saltmarsh/Seagrass	None	Low	Moderate	High

4.17 LOSS OF NATURAL TERRESTRIAL MARGIN

Riparian plantings near Pakawau

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 beach or estuary. This buffer protects against introduced weeds and grasses, naturally filters sediments and nutrients, and provides valuable ecological habitat. Table 32 has been used to provide guidance on the categories used to assess the vulnerability of coastal ecology to loss of the natural vegetated terrestrial margin.

Table 32. Guideline for assessing vulnerability of coastal ecology to loss of the natural vegetated terrestrial margin.

Rating	VERY LOW	LOW	MODERATE	HIGH
Natural Terrestrial Margin (% cover of 200m wide border)	80-100%	50-80%	25-50%	<25%

5. VULNERABILITY ASSESSMENTS

The vulnerability assessments undertaken along the Tasman beaches, dunes, rocky shores, and estuaries are presented in the following sections:

Section 5.1 Tasman Bay (Rabbit Island to Marahau)
Section 5.2 Golden Bay (Wainui Inlet to Port Puponga)
Section 5.3 West Tasman (Fossil Point to Kahurangi Point)

Each section provides a short overview of the key human uses, ecological values, issues and stressors, the summary matrix used to identify and rate stressors, and the influence of stressors on monitoring indicators/issues which are used to guide monitoring recommendations. Where appropriate, similar sections of coastline have been combined to avoid repetition. Information summaries for each estuary and coastal section used to determine the vulnerabilities and monitoring recommendations are presented in Appendices 1 and 2 respectively, with GIS habitat maps presented in Appendix 4.

Rabbit Island Beach (native dune restoration plantings)

Parapara Inlet

Rabbit Island Beach

Collingwood

Coastline south of Onekaka

Sandy Bay, Marahau

5.1 TASMAN BAY - BEACHES, DUNES, ROCKY SHORES AND ESTUARIES

BEACH/DUNE/ROCKY SHORE OVERVIEW

Human Use	High
Ecological Value	Low-Moderate-High
Stressors	Moderate-High
ISSUES	
Muddiness	Very Low-Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Very Low-Low
OVERALL VULNERABILITY	
Moderate	


Ruby Bay - Kina coastline


Kina Peninsula

The Tasman Bay section assessed in this report extends ~54km (excluding estuary shorelines) northwest from the eastern entrance to the Waimea Inlet, through to Marahau Estuary at the start of Abel Tasman National Park. Beaches dominate, comprising ~50km (including spit areas), with ~4km of rocky shore. A brief overview is presented below, followed by additional detail on specific coastal sections on the following pages.

Beach Types. Western Tasman Bay beaches are predominantly a mix of sand and gravel. Rabbit Island Beach is a broad, sandy, tide-modified beach with a steep upper, and an extensive sandy low tide terrace. It is highly valued ecologically and for human use. Further northwest, the coast from Ruby Bay to Tapu Bay is characterised by steep narrow high tide gravel beaches with broad (hundreds of metres) low intertidal sand/gravel flats. The large (~700ha) intertidal Motueka/Riwaka Estuary Delta, and the extensive (243ha) Motueka sandspit and coastal tidal flat delta provide very important shellfish and bird habitat. From Tapu Bay to Otuwhero Estuary, recreationally popular reflective golden sand beaches dominate, before the extensive intertidal sand flats, sand ridges, and ecologically important seagrass beds at Sandy Bay.

Rocky Shores. Rocky shores and reef areas comprise the steep granite rocky shores and islands located mostly between Tapu Bay and Marahau, and small areas of bedrock along the Kina cliffs. In addition, hard rocky shorelines have been created by seawalls, most prominently at Ruby Bay, Kina, Port Motueka, and Marahau.

Dunes. The vast majority of duneland in Tasman Bay is located on Rabbit Island and Motueka sandspit, with smaller remnants of narrow low dune dotted along the coast e.g. Little Kaiteriteri, Marahau, Jackett Island. Elsewhere dunes have been lost directly through development (e.g. Kaiteriteri Beach), construction of seawalls (e.g. eastern Ruby Bay) or overstabilisation (e.g. Rabbit Island). While community plantings of native sand-binding duneland species (spinifex and pingao) have been undertaken on a small scale at many locations (see GIS maps at back of this document), introduced marram grass and weeds dominate most dune systems.

Terrestrial Margin. Farming, horticulture and exotic forestry plantations (concentrated on Rabbit Island) are the predominant terrestrial land uses. Coastal settlements also occur throughout, with Mapua/Ruby Bay, Kina, Motueka, and Kaiteriteri the most densely populated. The coastal margin has been extensively modified, predominantly through seawalls, dune loss, and introduced plants and weeds.

Uses and Values. Human use of the beach areas and dunes is high from both a tourist and local context. It is particularly valued for picnicking, swimming, walking, horse riding, surf-casting and shellfish collection. Public access is generally good to most areas. Scenic values are limited due the highly modified nature of the coastal margin environment.

Ecological Values. Ecologically, the animal diversity of the inshore waters, and the beach and dunes is expected to be moderately high. The river mouth areas are important for whitebait spawning (Davidson et al. 1993, James 2012 unpublished TDC data). The area has nationally important bird habitat. Outside of estuaries, extensive seagrass beds are present in Tapu Bay (12ha) and Sandy Bay (25ha), while saltmarsh (1.6ha) is common near the mouths of the Motueka and Riwaka Rivers.

Issues and Stressors.

- **Dune overstabilisation and overgrazing.**
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems. Extensive seawalls have already been established.
- **Modified terrestrial margin.** The terrestrial margin is dominated by farming, horticulture and exotic forestry and, to a lesser extent, coastal settlements.
- Other lesser stressors include; excessive muddiness (primarily to inshore waters of the Waimea and Motueka deltas) caused primarily by catchment runoff from intensive landuse and exotic forestry, and disease risk.

5.2 TASMAN BAY - BEACHES, DUNES AND ROCKY SHORES (CONT.)

BEACHES - RABBIT ISLAND TO JACKETT ISLAND

Rabbit Island Beach (extensive sandy low tide terrace)

Ruby Bay Beach (steep high tide gravel and sand/gravel f ats)

Kina Peninsula (gravel/cobble low tidal f ats)

BEACHES - JACKETT ISLAND TO MARAHAU

Motueka Delta (f ne sand with extensive tidal f ats)

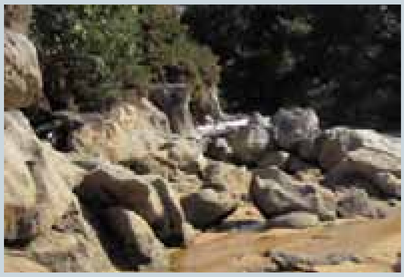
Kaiteriteri Beach (ref ective coarse golden sands)

Sandy Bay, Marahau (extensive low tide sand f ats and ridges)

ROCKY SHORES - RABBIT ISLAND TO MARAHAU

Clif s on the Kina coastline

Little Kaiteriteri



Ngaio Bay

DUNES - RABBIT ISLAND TO MOTUEKA SPIT

Rabbit Island - marram dunes and pine trees

Ruby Bay Beach - ice plant, weeds and seawall

Motueka Spit - marram dominated dunes

DUNES - MOTUEKA SPIT TO MARAHAU

Ngaio Bay - ice plant and introduced grasses

Little Kaiteriteri Beach - ice plant and weeds

Marahau/Sandy Bay - ice plant and marram

RABBIT ISLAND BEACH

Human Use	High
Ecological Value	Low-Moderate
Stressors	Mod-High
ISSUES	
Muddiness	Very Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Very Low
OVERALL VULNERABILITY	
Mod-High	

Rabbit Island with overlay of current area of active dunes.

Rabbit Island with overlay of pre-1950 active dune area (Hilton 2000).


Rabbit Island - eroding dune and pine trees

Rabbit Island Beach (8.5km long), situated between the two outlets of Waimea Inlet, is one of the two most important beach systems in Tasman Bay, the other being Tahunanui Beach (Johnston 1992). It has a relatively steep, medium sand, high tide beach, which abruptly grades into a low gradient, low tide terrace and wide, shallow surf zone. The beach type is "tide-modified, reflective plus low tide terrace".

Uses and Values. Human use of the beach areas and dunes is high from both a tourist and local context. It is particularly valued for picnicking, swimming, walking, horse riding, surf-casting and shellfish collection. Public access is generally good to certain areas, but many areas are restricted. Scenic values are limited due the highly modified nature of the environment.

Ecological Values. Animal diversity is expected to be moderately high at the two ends of the beach (rich in shellfish and fish), but lower in the steeper and more mobile, middle section. The bay in front of the beach contains surf clams, mainly trough shells (*Mactra discors*) which live in the 3-7m depth range. Pipis (*Paphies australis*) and tuatua (*Paphies subtriangulata*) are less abundant and more concentrated near the ends of the beach. The beach is bordered by a 7.9km long narrow, eroding, frontal marram-dominated dune (13.8ha remaining of what was once an extensive and healthy active dune system), backing on to a much wider belt of undulating duneland that has been artificially stabilised with exotic pine forest. A small area of the foredune (~800m) has been planted with native sand-binding species (spinifex and pingao).

Issues and Stressors.

- **Dune overstabilisation** through exotic forest plantings is the major stressor to the beach and dune system of Rabbit Island resulting in: the loss of a landscape of mobile undulating dunes; an increase in dune cliffing; a reduced ability to be a sand reservoir for adjacent beaches (i.e. Ruby Bay and Tahunanui Beach); less likelihood of being "repaired" in between storm events; increasing dune erosion in the longer term, and reduced biodiversity. Hilton (2000) indicates that prior to 1950, pine were absent and Rabbit Island had an extensive active dune system (see margin figures). To maintain existing dune habitat in the face of impending sea level rise, inland migration of natural dune vegetation will need to be facilitated.
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- **Gradual loss of larger-shelled animals and shifts in biological communities** as a result of climate changes to ocean pH and temperature.
- **Disease risk**. Shellfish guidelines are likely to be exceeded relatively often on Rabbit Island Beach as a consequence of the contamination of the Waimea Estuary river plume from catchment inputs (particularly in floods). Localised impacts are expected within the Bells Island wastewater effluent mixing zone.
- Other lesser stressors include; increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and weed growth within the dunes.

Issues	Monitoring
Duneland overstabilisation.	Map catchment FC "hot spots" (5 yearly).
Coastal erosion.	Monitor disease risk (shellfish).
Shellfish disease risk.	Fine scale monitoring of beach (morphometry, invertebrates, grain size) (5 yearly).
Biodiversity changes.	Beach/dune habitat mapping (10 yearly).
Weeds.	

5.1 TASMAN BAY - BEACHES, DUNES AND ROCKY SHORES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH SITE:

RABBIT ISLAND
DATE: (DEC 2010)

KEY FOR RATINGS
High
Moderate
Low
Very Low

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	STRESSOR: Total Stressor Vulnerability	HABITAT: Dune	Beach	Rock/Boulder	Cliff	Coastal Herbfield	Inshore water	HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Natural Vegetation/Dunes	Seagrass	Birds	Fish	Other Biota
Fine Sediment	Low						Low		Low								
Nutrients/Eutrophication	Low						Low										
Pathogens	Moderate		Moderate				Moderate	Low		Moderate		Low					
Toxicants	Low		Low														
Climate Change - Sea Level Rise	Low	Low	Low										Low		Low		Low
Climate Change - pH, temp	High	High	High				High								Low	High	High
Spills (oil)	Moderate		Moderate				Moderate	Moderate	Moderate	Moderate	Moderate		Low	Moderate	Moderate	Moderate	Moderate
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation & dune overstabilisation	High	High	Moderate						High				High		High		High
Harvesting living resources	Moderate						Moderate										Moderate
Algal blooms (from sea)	Moderate						Moderate								Moderate	Moderate	Moderate
Seawalls, breakwaters etc																	
Invasive weeds/pests	High	High							High				High				
Vehicle damage																	
Loss of vegetated terrestrial margin	High	High	Moderate						High				High		High		High
Animal/man disturbance	Moderate	Moderate	Moderate						Low				Moderate		Moderate		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Benthic Microalgal Mats	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Macrophyte Loss	Macroinvertebrates	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates
Fine Sediment												Low	Low		Low	
Nutrients/Eutrophication		Low				Low				Low						
Pathogens																
Toxicants																
Climate Change - Sea Level Rise																
Climate Change - pH, temp																
Spills (oil)																
Grazing of high value habitat																
Freshwater abstraction																
Reclamation & dune overstabilisation																
Harvesting living resources																
Algal blooms (from sea)																
Seawalls, breakwaters etc																
Invasive weeds/pests																
Vehicle damage																
Loss of vegetated terrestrial margin																
Animal/man disturbance																
PRIORITY INDICATORS FOR MONITORING																

STRESSORS	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh/Dunes	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment														
Nutrients/Eutrophication														
Pathogens	Moderate													
Toxicants		Low	Low											
Climate Change - Sea Level Rise					Low	Low		Low				Low		Low
Climate Change - pH, temp						High			Low	High	High	High	High	
Spills (oil)									Moderate	Moderate	Moderate	Moderate	Moderate	
Grazing of high value habitat														
Freshwater abstraction														
Reclamation & dune overstabilisation							High	High			High			
Harvesting living resources													Moderate	
Algal blooms (from sea)													Moderate	
Seawalls, breakwaters etc														
Invasive weeds/pests					High	High		High			High			
Vehicle damage														
Loss of vegetated terrestrial margin								High			High			
Animal/man disturbance									Moderate					
PRIORITY INDICATORS FOR MONITORING	Moderate				High	High		High		Moderate	High	Moderate	Moderate	Moderate

OVERALL VULNERABILITY RATING - RABBIT ISLAND BEACH

Human Use	High
Ecological Value	Low-Mod
Overall Stressor Influence	Mod-High
OVERALL VULNERABILITY	Moderate-High
KEY ISSUES	Habitat Loss - Loss of dunes, margin squeeze, disease risk (high rainfall), climate change, erosion, weeds.

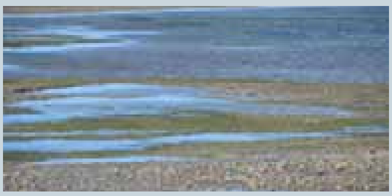
MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Fine scale beach and rocky shore transect monitoring at several representative dissipative beach types and rocky shores in the region to monitor impacts of climate change.

RUBY BAY TO JACKETT ISLAND COASTLINE

Human Use	High
Ecological Value	Moderate
Stressors	Moderate
ISSUES	
Muddiness	Very Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Very Low
OVERALL VULNERABILITY	
Moderate	

Rockwalls and stormwater outfall, Ruby Bay Beach.

Eroding clif s between Ruby Bay and Kina Beach.



Seagrass bed, mouth of Moutere Inlet.

The 12.6km section of coast between Ruby Bay and Jackett Island at the mouth of the Moutere Inlet is dominated by sand/gravel/cobble beaches and bordered by either, steep eroding cliffs, some of which are vegetated, or flat developed areas (e.g. Ruby Bay and Kina Beach). Beach types are "reflective plus sand flats", i.e. a steep narrow high tide gravel beach with broad (hundreds of metres) low intertidal sand/gravel flats. Wave height is generally less than 0.5m.

Uses and Values. Human use of the beach areas is high from both a tourist and local context. Ruby Bay and Kina Beach are particularly valued for picnicking, swimming, sunbathing, walking, surf-casting and shellfish collection. Public access is generally good to all areas.

Ecological Values. Ecologically, the animal diversity of the inshore waters, and the beach is expected to be moderately high given the low wave exposure and cobble substrate. Small black and blue mussels are common on the rocks at low water. Seagrass (*Zostera* sp.) beds (1.8ha) and herbfields (1ha) are present near the eastern mouth of Moutere Inlet. Dune habitat is minimal.

Issues and Stressors.

- **Dune overstabilisation** through seawalls (2.2km, 18% of the coastal section) and property development, particularly at Ruby Bay. Areas with seawalls prevent the beach from migrating landwards in response to sea-level rise, while reductions in the sediment budget restrict dune development. Seawall establishment in this area is likely to lead to erosion of sand from the beach face in front of the wall with deposition offshore. Currently, dunes are generally absent, but small areas of marram dominated dunes and coastal herbfields are present near the mouth of Moutere Inlet. Prior to 1960, dunes were much more abundant, particularly at Ruby Bay, Kina Beach and Jackett Island (Hilton 2000). Currently, much of Ruby Bay is bordered by seawalls and roading.
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems. Erosion in this section of the coast is common and the supply of sediment to Ruby Bay has been identified as being insuf cient to prevent long term coastal retreat (Single 2000). Its source is from erosion of the Moutere Bluffs and possibly the Motueka River.
- **Modified terrestrial margin.** The terrestrial margin is dominated by residential properties, farmland and pine plantings. A section of native scrub is situated in the northern section of Ruby Bay.
- **Disease Risk**. Shellfish guidelines are likely to be exceeded at times on Ruby Bay Beach as a consequence of the contamination of the Waimea Estuary river plume from catchment inputs (particularly in floods).
- Other lesser stressors include; increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and weed growth.

Issues	Monitoring
Duneland overstabilisation.	Monitor beach morphometry/biota regarding seawall impact assessment.
Coastal erosion.	Beach/dune habitat mapping (10 yearly).
Modified terrestrial margin.	Map catchment FC "hot spots" (5 yearly).
Shellfish disease risk.	Monitor disease risk (shellfish).
Biodiversity changes.	
Weeds.	

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH SITE:

RUBY BAY TO JACKETT ISLAND

DATE: (NOV 2010)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	

STRESSOR INFLUENCE ON HABITAT, AND ON USES AND VALUES

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Dune	HABITAT: Beach	HABITAT: Rock/Boulder	HABITAT: Cliff	HABITAT: Coastal Herbfield	HABITAT: Inshore water	HUMAN USES: Bathing	HUMAN USES: Natural Character	HUMAN USES: Shellfish Collection	HUMAN USES: Fishing/Hunting	HUMAN USES: Waste Assimilation	ECOL. VALUES: Natural Vegetation/Dunes	ECOL. VALUES: Seagrass	ECOL. VALUES: Birds	ECOL. VALUES: Fish	ECOL. VALUES: Other Biota
Fine Sediment	L						L									L	L
Nutrients/Eutrophication	L						L									L	L
Pathogens	M		M				M	M		M							
Toxicants	L																
Climate Change - Sea Level Rise	L	L	L		L	L			L				L	L	L		L
Climate Change - pH, temp	H	H	H				H								L	H	H
Spills (oil)	M		M				M	M	M	M	M		L	M	M	M	M
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation & dune overstabilisation	M	M	M						M				M		M		M
Harvesting living resources	L						L										
Algal blooms (from sea)	M						M			M						M	M
Seawalls, breakwaters etc	H	H	H						H				H		M		M
Invasive weeds/pests	L	L															
Vehicle damage																	
Loss of vegetated terrestrial margin	H	H	M						H				H		M		M
Animal/man disturbance	M	M	M						L				M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Eutrophication: Macroalgal Rating (% cover)	Eutrophication: Benthic Microalgal Mats	Eutrophication: Dissolved Oxygen in Water	Eutrophication: Oxygen sediment (RPD/Smell)	Eutrophication: Nutrients	Eutrophication: Sediment Organic Carbon	Eutrophication: Macrophyte Loss	Eutrophication: Macroinvertebrates	Eutrophication: Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation: Sedimentation rate	Sedimentation: Clarity	Sedimentation: Macrophyte Loss	Sedimentation: Sediment Grain Size	Sedimentation: Macroinvertebrates	D.: Faecal Indicators	Toxins: Heavy Metals	Toxins: SVOCs	Toxins: Toxic algal blooms (from sea)	Habitat Loss: Substrate	Habitat Loss: Macrophytes (Seagrass)	Habitat Loss: Saltmarsh/Dunes	Habitat Loss: Vegetated Terrestrial Margin	Habitat Loss: Birds	Habitat Loss: Fish	Habitat Loss: Invasive species	Habitat Loss: Benthic invertebrates	Habitat Loss: Shellfish	Habitat Loss: Sea Level
Fine Sediment												L	L		L															
Nutrients/Eutrophication		L				L				L																				
Pathogens																	M												L	
Toxicants																		L	L											
Climate Change - Sea Level Rise																					L	L		L				L		L
Climate Change - pH, temp																						H			L	H	H	H	H	
Spills (oil)																									M	M	M	M	M	
Grazing of high value habitat																														
Freshwater abstraction																														
Reclamation & dune overstabilisation																							M	M			M			
Harvesting living resources																													L	
Algal blooms (from sea)																										M			M	
Seawalls, breakwaters etc																					H	H		H			H			
Invasive weeds/pests																					L	L		L			L			
Vehicle damage																														
Loss of vegetated terrestrial margin																					H	H		H			H			
Animal/man disturbance																									M					
PRIORITY INDICATORS FOR MONITORING																	M				H	H	H	H			H	H	H	

OVERALL VULNERABILITY RATING - RUBY BAY TO JACKETT I. BEACH

Human Use	High
Ecological Value	Low-Mod
Overall Stressor Influence	Low-Mod
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Habitat Loss - seawalls, margin squeeze, loss of dunes, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

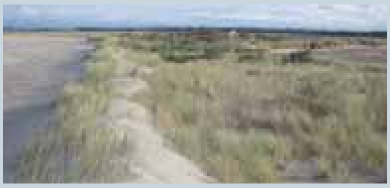
- Broad scale habitat mapping every 10 years.
- Fine scale beach and rocky shore transect monitoring at several representative dissipative beach types and rocky shores in the region to monitor impacts of climate change.

5.1 TASMAN BAY - BEACHES, DUNES AND ROCKY SHORES (CONTINUED)

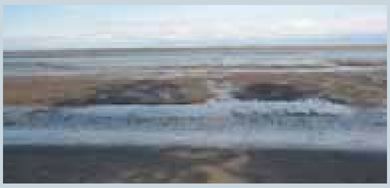
PORT MOTUEKA TO TAPU BAY COASTLINE

Human Use	High
Ecological Value	Moderate
Stressors	Moderate
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Seagrass beds, Tapu Bay.



Motueka Spit.



Tidal flats inside of Motueka Spit (above and right).

The section of coast between Port Motueka and Tapu Bay (21.5km long) is dominated by sand/gravel/cobble beaches with extensive tidal flats, bordered by a mix of residential properties and farmland. It receives freshwater from the Moutere, Motueka, and Riwaka Rivers, and sediment inputs which form a large (~700ha) intertidal delta (details under Motueka Estuary/Delta), which has extensive beds of cockles, pipi, and tuatua, and which are major feeding grounds for wading birds (Walker 1987). The very dynamic Motueka sandspit (3.3km long) is the largest bird roosting site in Tasman Bay. Its vegetation is dominated by marram grass and lupins, and has a very small planting of pingao. The area of dune vegetation has declined considerably since 1960 (Hilton 2000). Two other smaller marram dominated spits are present to the north at the Kumeras, and near the Riwaka River mouth.

A groyne was installed on the Motueka sandspit opposite the entrance to Port Motueka in 1997. Its landward edge was quickly overwhelmed by sand and, over time, much of the length of the groyne has become buried (Rob Smith, TDC, 2012 pers. comm). The groyne is in the process of being removed at present (mid. 2012) following expiry of its resource consent and the outcome of Environment Court proceedings. Other intertidal structures are present at Riwaka (wharf) and Port Motueka (seawater baths).

Uses and Values. High use - valued for its aesthetic appeal, rich biodiversity, shellfish, assimilation of wastewater, bathing, whitebaiting, fishing, walking, and scientific appeal. Public access is generally good to all areas. The Motueka Sandspit and Raumanuka Reserve are both Scenic Reserves.

Ecological Values. Ecologically, the animal diversity of the inshore waters, and the beach and dunes is expected to be moderately high. The river mouth areas are important for whitebait spawning (Davidson et al. 1993). The area has nationally important bird habitat. Small black and blue mussels are common on the rocks at low water. Dune habitat (7.3ha, 1.5km length) is present on the spits but dominated by marram grass and dune extent is much reduced from historical estimates. Outside of estuaries, extensive seagrass beds (12.3ha) are present in Tapu Bay and saltmarsh (1.6ha) is common near the mouths of the two rivers and at Riwaka Wharf.

Issues and Stressors.

- **Duneland loss** primarily through overstabilisation (from marram grass, tree plantings, weed growth e.g. Raumanuka Reserve Spit), and erosion (e.g. seaward side of Motueka Spit) are the major stressors to these beach and dune systems. Resulting changes are the loss of a landscape of mobile undulating dunes, increasing dune erosion in the longer term, and reduced biodiversity. Hilton (2000) indicates that prior to 1950, these spits had an extensive active dune system which is now much reduced.
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- **Margin Squeeze.** The presence of seawalls, roads, and buildings limiting the potential retreat of natural coastal habitat in response to sea level rise. They also alter sediment transport and deposition patterns.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a highly modified terrestrial margin, excessive muddiness (primarily to inshore waters of the delta) caused primarily by catchment runoff from intensive landuse and exotic forestry and disease risk.

Issues	Monitoring
Duneland loss.	Beach/dune habitat mapping (10 yearly).
Margin squeeze and coastal erosion.	Map catchment FC "hot spots" (5 yearly).
Modified terrestrial margin.	Monitor disease risk (shellfish).
Shellfish disease risk.	
Biodiversity changes.	

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH/DUNE SITE:

PORT MOTUEKA TO TAPU BAY
DATE: (NOV 2010)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	(blank)

STRESSOR; STRESSOR INFLUENCE ON HABITAT; STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	Total Stressor Influence	Dune	Beach	Rock/Boulder	Cliff	Coastal Herbfield	Inshore water	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Natural Vegetation/Dunes	Seagrass	Birds	Fish	Other Biota
Fine Sediment	L						L									L	L
Nutrients/Eutrophication	L						L									L	L
Pathogens	M		M				M	M		M							
Toxicants	L																
Climate Change - Sea Level Rise	L	L	L		L	L			L				L	L	L		L
Climate Change - pH, temp	H	H	H				H								L	H	H
Spills (oil)	M		M				M	M	M	M	M		L	M	M	M	M
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation & dune overstabilisation	M	M	M						M				M		M		M
Harvesting living resources	L						L										
Algal blooms (from sea)	M						M			M						M	M
Seawalls, breakwaters etc	H	H	H				H		H				H		M		M
Invasive weeds/pests	L	L															
Vehicle damage																	
Loss of vegetated terrestrial margin	H	H	M						H				H		M		M
Animal/man disturbance	M	M	M						L				M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

Eutrophication and Sedimentation:

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Benthic Microalgal Mats	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Macrophyte Loss	Macroinvertebrates	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates
Fine Sediment												L	L		L	
Nutrients/Eutrophication		L				L				L						
Pathogens																
Toxicants																
Climate Change - Sea Level Rise																
Climate Change - pH, temp																
Spills (oil)																
Grazing of high value habitat																
Freshwater abstraction																
Reclamation & dune overstabilisation																
Harvesting living resources																
Algal blooms (from sea)																
Seawalls, breakwaters etc																
Invasive weeds/pests																
Vehicle damage																
Loss of vegetated terrestrial margin																
Animal/man disturbance																
PRIORITY INDICATORS FOR MONITORING																

D., Toxins and Habitat Loss:

STRESSORS	Faecal Indicators (D.)	Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Substrate	Macrophytes (Seagrass)	Saltmarsh/Dunes	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment														
Nutrients/Eutrophication														
Pathogens	M												L	
Toxicants		L	L											
Climate Change - Sea Level Rise					L	L		L				L		L
Climate Change - pH, temp						H			L	H	H	H	H	
Spills (oil)									M	M	M	M	M	
Grazing of high value habitat														
Freshwater abstraction														
Reclamation & dune overstabilisation							M	M			M			
Harvesting living resources													L	
Algal blooms (from sea)										M			M	
Seawalls, breakwaters etc					H	H		H			H			
Invasive weeds/pests					L	L		L			L			
Vehicle damage														
Loss of vegetated terrestrial margin					H	H		H			H			
Animal/man disturbance									M					
PRIORITY INDICATORS FOR MONITORING	M				H	H	H	H			H	H	H	

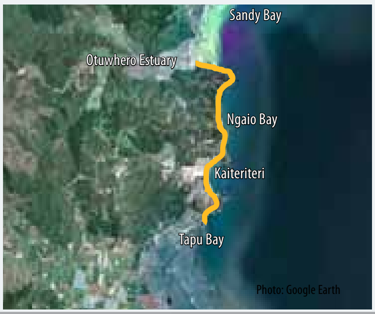
OVERALL VULNERABILITY RATING - PORT MOTUEKA TO TAPU BAY

Human Use	High
Ecological Value	Moderate
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Habitat Loss - seawalls, margin squeeze, loss of dunes, loss of natural terrestrial margin, climate change.

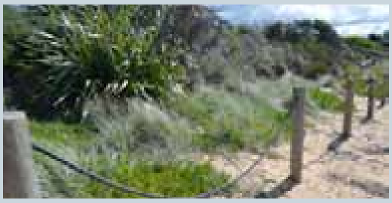
MONITORING RECOMMENDATIONS	
	• Broad scale habitat mapping every 10 years. • Fine scale beach and rocky shore transect monitoring at several representative dissipative beach types and rocky shores in the region to monitor impacts of climate change.

TAPU BAY TO OTUWHERO ESTUARY COASTLINE

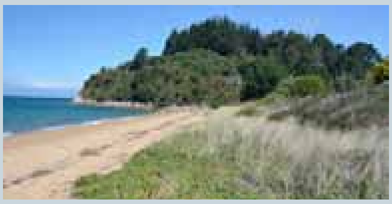
Human Use	High
Ecological Value	Moderate
Stressors	Moderate
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	



Dune loss, Kaiteriteri Beach



Spinfex plantings in dunes, Little Kaiteriteri Beach



Dunes with iceplant and marram Ngaio Bay

The sections of coast between Tapu Bay and Otuwhero Estuary are dominated by reflective golden sand beaches (3.2km long) (e.g. Stephens Bay, Dummy Bay, Little Kaiteriteri, Kaiteriteri, Honeymoon Bay, Ngaio Bay) and granite rocky shores (3.7km long). The beaches are bordered by a mix of residential properties, regenerating bush and exotic forest but very little saltmarsh or duneland (~250m). They receive freshwater predominantly from the Motueka and Riwaka River plumes. Most beaches are heavily used and Kaiteriteri Beach is a popular tourist and holiday destination and is flanked by rocky promontories and small islands. Fishing pressures have significantly modified the intertidal and subtidal fauna.

Uses and Values. High use - valued for its aesthetic appeal, golden sand beaches, shellfish, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Public access is generally good.

Ecological Values. Ecologically, the animal diversity of the inshore waters and beaches is expected to be low, and duneland is now minimal. Historically, most of the beaches had narrow areas of duneland at their upper margin. These have subsequently been lost or degraded, either through roading, as at Kaiteriteri, or by weed growth (particularly ice plant). A small area of duneland is currently being restored with spinifex at Little Kaiteriteri Beach and Stephen's Bay. The stream mouth areas are important for whitebait spawning.

Issues and Stressors.

- **Duneland loss** through roading, property developments and weed growth is the major stressor to the beach and dune system of this area, resulting in the loss of a landscape of mobile undulating dunes, increasing dune erosion in the longer term, and reduced biodiversity. Although the area of duneland was never large in this section, it is recognised that restoration of the natural beach margin would improve ecology and human use values in the area.
- **Margin Squeeze.** The presence of seawalls, roads, and buildings currently limit the potential retreat of natural coastal habitat in response to sea level rise.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- Other lesser stressors include; a highly modified terrestrial margin, occasional management (relocation) of beach sand migrating to the Kaiteriteri estuary mouth, and disease risk to bathers and shellfish consumers from the Motueka River plume during high river flows.

Breaker and Honeymoon Bays

Issues	Monitoring
Duneland loss.	Beach/dune habitat mapping (10 yearly).
Margin squeeze.	Map catchment FC "hot spots" (5 yearly).
Modified terrestrial margin.	Monitor disease risk (shellfish).
Shellfish disease risk.	Rocky shore monitoring (5 yearly after baseline).
Biodiversity changes.	

5.1 TASMAN BAY - BEACHES, DUNES AND ROCKY SHORES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH/DUNE/ROCKY SHORE SITE: TAPU BAY TO OTUWHERO ESTUARY
DATE: (NOV 2010)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	

Stressor influence on habitat, uses and values

STRESSORS	Total Stressor Influence	Dune	Beach	Rock/Boulder	Cliff	Coastal Herbfield	Inshore water	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Natural Vegetation/Dunes	Seagrass	Birds	Fish	Other Biota
Fine Sediment	L						L									L	L
Nutrients/Eutrophication	L						L									L	L
Pathogens	M		M				M	M		M							
Toxicants	L																
Climate Change - Sea Level Rise	L	L	L		L	L			L				L	L	L		L
Climate Change - pH, temp	H	L	L				H								L	H	H
Spills (oil)	M		M				M	M	M	M	M		L	M	M	M	M
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation & dune overstabilisation	M	M	M						M				M		M		M
Harvesting living resources	L						L										
Algal blooms (from sea)	M						M			M						M	M
Seawalls, breakwaters etc	L	L	L				L		L				L		M		M
Invasive weeds/pests	L	L															
Vehicle damage																	
Loss of vegetated terrestrial margin	H	H	M						H				H		M		M
Animal/man disturbance	M	M	M						L				M		M		

Stressor influence on monitoring indicators/issues (D.=DISEASE)

Eutrophication: Chlorophyll-a in Water to Phytoplankton Blooms; Sedimentation: Muddiness to Macroinvertebrates; D.: Faecal Indicators; Toxins: Heavy Metals to Toxic algal blooms; Habitat Loss: Substrate to Sea Level.

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Benthic Microalgal Mats	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Macrophyte Loss	Macroinvertebrates	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates	Faecal Indicators	Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Substrate	Macrophytes (Seagrass)	Saltmarsh/Dunes	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment												L	L		L															
Nutrients/Eutrophication		L				L				L																				
Pathogens																	M												L	
Toxicants																		L	L											
Climate Change - Sea Level Rise																					L	L		L				L		L
Climate Change - pH, temp																						H			L	H	H	H	H	
Spills (oil)																									M	M	M	M	M	
Grazing of high value habitat																														
Freshwater abstraction																														
Reclamation & dune overstabilisation																							M	M			M			
Harvesting living resources																													L	
Algal blooms (from sea)																										M			M	
Seawalls, breakwaters etc																					L	L		L			L			
Invasive weeds/pests																					L	L		L			L			
Vehicle damage																														
Loss of vegetated terrestrial margin																					H	H		H			H			
Animal/man disturbance																									M					
PRIORITY INDICATORS FOR MONITORING																	M				H	H	H	H			H	H	H	

OVERALL VULNERABILITY RATING - TAPU BAY TO OTUWHERO ESTUARY

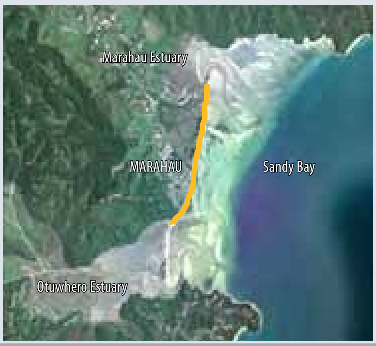
Human Use	H	High
Ecological Value	M	Moderate
Overall Stressor Influence	M	Moderate
OVERALL VULNERABILITY	M	Moderate
KEY ISSUES	Habitat Loss - margin squeeze, loss of dunes, loss of natural terrestrial margin, climate change.	

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Map catchment FC source "hot spots", 5 yearly. • Monitor disease risk (shellfish).

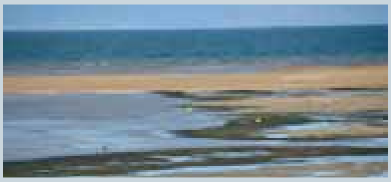
5.1 TASMAN BAY - BEACHES, DUNES AND ROCKY SHORES (CONTINUED)

OTUWHERO TO MARAHAU COASTLINE

Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	




Seawall at Marahau Beach


Seagrass beds, Marahau Beach


Pipis at Marahau

The 4.1km section of beach between Otuwhero Estuary and Marahau Estuary in Sandy Bay consists of a reflective upper beach and extensive intertidal sand flats and sand ridges. The beach is bordered by a mix of residential properties, seawalls (15% of the beach length), roading, grassland and native bush. It receives freshwater predominantly from the Otuwhero and Marahau river plumes. The beaches are heavily used and it is a popular tourist location and entry point to Abel Tasman National Park with high numbers of vehicles crossing the intertidal area relative to other parts of the coast. Coastal processes have caused some erosion at Marahau Beach, and subsequent heavy rock protection works have been constructed, out of character with the natural environment.

Uses and Values. High use - valued for its aesthetic appeal, sand beaches, shellfish, bathing, whitebaiting, fishing, boating, walking, access for ocean kayaks and scientific appeal. Public access is very good.

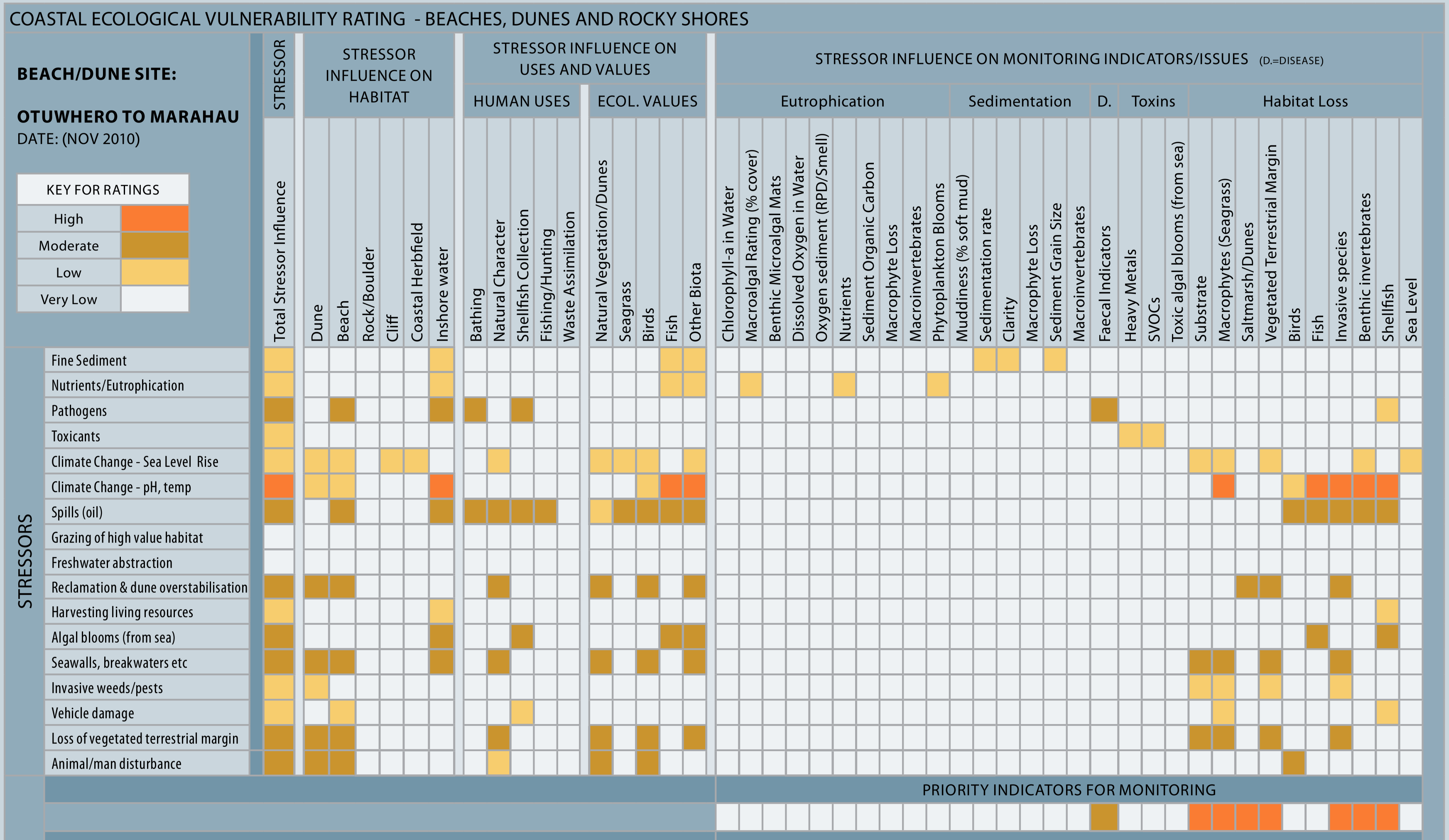
Ecological Values. Ecologically, the animal diversity of the inshore waters and beaches is expected to be high, but duneland is minimal (0.9ha - 800m length) and dominated by exotic plants. Extensive beds of high value seagrass (25ha) and shellfish beds (pipi and cockle) occur on the intertidal flats. Historically, most of the beaches had narrow areas of duneland at their upper margin. These have subsequently been lost or degraded. Banded dotterels and oystercatcher nest in the area. The stream mouth areas are important for whitebait spawning.

Issues and Stressors.

- **Margin Squeeze.** The presence of seawalls, roads, buildings are currently limiting the potential retreat of natural coastal habitat in response to sea level rise.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- Other lesser stressors include; a highly modified terrestrial margin, loss of duneland, disease risk to bathers and shellfish consumers from the Otuwhero and Marahau River plumes during high river flows, and intertidal vehicle use (e.g. launching and retrieval of water taxis and kayaks).


Marahau Beach near Tinline Bay

Issues	Monitoring
Margin squeeze and duneland loss.	Beach/dune habitat mapping (10 yearly).
Modified terrestrial margin.	Map catchment FC "hot spots" (5 yearly).
Shellfish disease risk.	Monitor disease risk (shellfish).
Biodiversity changes.	



OVERALL VULNERABILITY RATING - OTUWHERO TO MARAHAU ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Habitat Loss - climate change, margin squeeze, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Map catchment FC source "hot spots", 5 yearly.
- Monitor disease risk (shellfish).

5.1 TASMAN BAY - ESTUARIES

WAIMEA INLET

Estuary Type/Area	Tidal Lagoon/3,345ha
Intertidal/Subtidal	2,949ha/396ha
Catchment Area	913km^2
FW Inf ow	Mean annual 21m^3.s^{-1}
Saltmarsh, Seagrass	299ha, 21ha
Soft Mud	1,584ha
Macroalgae	32.8ha >50% cover
Dairy Cows	1645
SS Load	147 kt/yr
Nitrogen Load	222 t/yr
Faecal c. Load	4.39 x 10^{15}/yr
Landuse: 36% native forest, 33% exotic forest, 20% high producing pasture, 4% crop, 2%urban.	
Geology:	
Human Use	High
Ecological Value	Moderate
Stressors	Mod-High
ISSUES	
Muddiness	High
Eutrophication	Low
Disease Risk	High
Habitat Loss	High
Toxicity	Moderate
OVERALL VULNERABILITY	
Mod-High	


Photo: Google Earth

The ecological vulnerability of Waimea Inlet was assessed in detail in 2010 (Stevens and Robertson 2010). The results are summarised as follows: Waimea Inlet is a large (3,345ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with two tidal openings, two main basins, and several tidal arms. Catchment landuse is mixed with forest occupying 69% and prime pastoral 20%.

Uses and Values. High use. It is valued for its aesthetic appeal, assimilation of wastes, biodiversity, shellfish collection, bathing, duck shooting, 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 the estuary, located predominantly in the eastern basin near Saxton Island) and a small subtidal sponge-dominated community (by Rough Island). 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 83ha of saltmarsh has been reclaimed and developed. The invasive weed, *Spartina anglica*, occupied large areas of the estuary in the 1980's (40-50ha 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.

Issues and Stressors.

- **Excessive muddiness and elevated disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse (lower catchment) and exotic forestry (results in muddiness only), and to a lesser extent the Bells Island wastewater discharge. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Loss of high value saltmarsh/seagrass habitat** caused primarily by historical reclamations. In 2012 there was localised loss of seagrass from pipeline burial (Bells Island sewerage upgrade). Natural gravel supply to stream deltas is also being interrupted by retention structures (ponds or traps) that get cleaned out after floods reducing saltmarsh habitat and (short-term) protection against sea level rise. To maintain existing habitat in the face of impending sea level rise, inland migration of saltmarsh will need to be facilitated.
- **Shifts in biological communities** as a result of climate changes to sea pH and temperature.
- **Localised toxicity and eutrophication** at urban stream mouths caused by contaminated urban stormwater.
- Other lesser stressors include; a highly modified terrestrial margin, the presence of seawalls (limiting saltmarsh habitat and potential retreat in response to sea level rise), causeways and flapgates, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment and FC "hot spots" (5 yearly).
Elevated disease risk.	Model catchment SS and FC loads with BMP's in place.
Habitat loss.	Estuary habitat mapping (5yrly), fine scale monitoring (5 yearly after baseline), sedimentation rate (plates) annually.
Climate change.	Monitor river SS and FC loads (high and low flows) to determine annual loads.
Local eutrophication and toxicity.	Monitor shellfish and bathing disease risk.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

WAIMEA INLET
DATE: (DEC 2010)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	

STRESSOR; STRESSOR INFLUENCE ON HABITAT; STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
	STRESSOR	HABITAT							HUMAN USES					ECOL. VALUES				
Fine Sediment	H	H	H	H	H	H		H	H	H	H			H	H	H	H	H
Nutrients/Eutrophication	L	L	L	L		L		M						L	L			L
Pathogens	H	H						H	M		H							
Toxicants	M							M										M
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H												
Spills (oil)	M	M	M	M	M	M		M	M	M	M	M		M	M	M	M	M
Grazing of high value habitat																		
Freshwater abstraction	M																M	M
Reclamation/Drainage	H					H	H					H		H		H		
Harvesting living resources	M										M							
Algal blooms (from sea)	M	M														M	M	M
Seawalls, breakwaters etc	M					M	M							M				
Invasive weeds/pests	M					M	M							M				
Vehicle damage																		
Loss of vegetated terrestrial margin	H						H									H	H	H
Animal/man disturbance	M					M	M							M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

Eutrophication:

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms
Fine Sediment										
Nutrients/Eutrophication	L	L	L	L	L	L	L	L	L	L
Pathogens										
Toxicants										
Climate Change - Sea Level Rise										
Climate Change - pH, temp										H
Spills (oil)										
Grazing of high value habitat										
Freshwater abstraction										
Reclamation/Drainage										
Harvesting living resources										
Algal blooms (from sea)										
Seawalls, breakwaters etc										
Invasive weeds/pests										
Vehicle damage										
Loss of vegetated terrestrial margin										
Animal/man disturbance										
PRIORITY INDICATORS FOR MONITORING										

Sedimentation; D.; Toxins:

STRESSORS	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators (D.)	Heavy Metals	SVOCs	Toxic algal blooms (from sea)
Fine Sediment	H	H	H	H	H	H				
Nutrients/Eutrophication										
Pathogens							H			
Toxicants								M	M	
Climate Change - Sea Level Rise										
Climate Change - pH, temp										
Spills (oil)										
Grazing of high value habitat										
Freshwater abstraction										
Reclamation/Drainage										
Harvesting living resources										
Algal blooms (from sea)										M
Seawalls, breakwaters etc										
Invasive weeds/pests										
Vehicle damage										
Loss of vegetated terrestrial margin										
Animal/man disturbance										
PRIORITY INDICATORS FOR MONITORING	H	H	H	H	H	H	H			

Habitat Loss:

STRESSORS	Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	H	H	H					H	H	
Nutrients/Eutrophication										
Pathogens										
Toxicants								M		
Climate Change - Sea Level Rise										
Climate Change - pH, temp								H	H	
Spills (oil)	M	M	M		M	M	M	M	M	
Grazing of high value habitat										
Freshwater abstraction						M		M	M	
Reclamation/Drainage			H	H	H	H				
Harvesting living resources									M	
Algal blooms (from sea)									M	
Seawalls, breakwaters etc			M	M						
Invasive weeds/pests			M	M						
Vehicle damage										
Loss of vegetated terrestrial margin					H					
Animal/man disturbance				M	M					
PRIORITY INDICATORS FOR MONITORING	H	H	H	H	H	H		H	H	

OVERALL VULNERABILITY RATING - WAIMEA INLET

Human Use	High
Ecological Value	Moderate
Overall Stressor Influence	Mod-High
OVERALL VULNERABILITY	Mod-High
KEY ISSUES	Sedimentation, disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 5 years.
- Fine scale sediment monitoring every 5 years after 4yr baseline.
- Sedimentation rate monitoring annually.
- Shellfish and bathing disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

MOUTERE INLET/DELTA

Estuary Type/Area	Tidal Lagoon+Delta/1005ha
Intertidal/Subtidal	869ha/136ha
Catchment	182km^2
FW Inf ow	Mean annual 1-2m^3.s^{-1}
Saltmarsh, Seagrass	84ha, 1ha
Soft Mud	218ha
Macroalgae	Not measured
Dairy Cows	160
SS Loading	23.7kt/yr
Nitrogen Loading	88t/yr
Faecal c. Loading	3.4 x 10^{15}/yr
Landuse: 3% native forest, 34% exotic forest, 39% high producing pasture, 20% crop.	
Geology: post glacial alluvium.	
Human Use	High
Ecological Value	Moderate
Stressors	Mod-High
ISSUES	
Muddiness	High
Eutrophication	Low
Disease Risk	Moderate-High
Habitat Loss	High
Toxicity	Low
OVERALL VULNERABILITY	
Mod-High	

Port Motueka

Moutere Inlet is a moderate-sized (762ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with two tidal openings, one main basin, several tidal arms separated by causeways, and an extensive coastal tidal flat delta (243ha) located inshore of the Motueka sandspit (further details in Section on Port Motueka to Tapu Bay). Much of the sheltered tidal flat area inside the spit consists of soft mud, backed by the highly modified Motueka beachfront (seawalls, roads and houses). The catchment is fully developed and dominated by high producing pasture, cropping/horticulture and exotic forestry.

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

Ecological Values. Ecologically, habitat diversity is moderate but significant areas of high value habitat have been lost. Currently, saltmarsh occupies 8% of the estuary and seagrass 0.1%. Prior to 1947, saltmarsh was double the current area (Clark and Gillespie 2006). In addition, the estuary is excessively muddy (22% is soft mud), particularly the sheltered delta basin, and the natural vegetated margin has been lost and is now developed for grazing and horticulture (Clark et al. 2006). The inlet is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is important for birdlife. Toxicant indicators (heavy metals) are low (Gillespie and Clark 2006). In 2012, a $40k saltmarsh and terrestrial margin restoration project was undertaken, and a section of causeway removed following road realignment. This project continues in 2013.

Issues and Stressors.

- **Excessive muddiness and moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse and exotic forestry (latter results in muddiness only). Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Loss of high value saltmarsh/seagrass habitat and restricted flushing** caused by historical reclamations and causeway developments (the main highway cuts across several small embayments which open to the estuary through culverts). To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a highly modified terrestrial margin, the presence of seawalls and causeways (limiting saltmarsh habitat and potential retreat in response to sea level rise), localised eutrophication (macroalgal blooms) in poorly flushed lower estuary arms at times, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant). Quad bikes and ATVs are regularly used to access Jacketts Island. A "Muddy Buddy" fun run has been held annually for the past 3 years. The cause of elevated nutrients is primarily from catchment runoff but also from factory wastewater from 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.

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment and FC "hot spots" (5 yearly).
Moderate disease risk.	Model catchment SS and FC loads with BMP's in place.
Habitat loss.	Estuary habitat mapping (5 yearly), fine scale monitoring (5 yearly after baseline), sedimentation rate (plates) annually.
Climate change.	Monitor river SS and FC loads (high and low flows) to determine annual loads.
Local eutrophication and toxicity.	Monitor shellfish and bathing disease risk.

5.1 TASMAN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

MOUTERE INLET
DATE: (DEC 2010)

KEY FOR RATINGS	
High	H (orange)
Moderate	M (brown)
Low	L (yellow)
Very Low	(blank)

STRESSORS – Stressor, Habitat, Uses and Values

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Estuary Water	HABITAT: Estuary Unvegetated Substrate	HABITAT: Aquatic Macrophytes	HABITAT: Biogenic (living) Structures	HABITAT: Saltmarsh	HABITAT: Terrestrial Margin	HABITAT: Stream & River Mouths	HUMAN USES: Bathing	HUMAN USES: Natural Character	HUMAN USES: Shellfish Collection	HUMAN USES: Fishing/Hunting	HUMAN USES: Waste Assimilation	ECOL. VALUES: Saltmarsh	ECOL. VALUES: Seagrass	ECOL. VALUES: Birds	ECOL. VALUES: Fish	ECOL. VALUES: Other Biota
Fine Sediment	H	H	H	H	H	H		H	H	H	H			H	H	H	H	H
Nutrients/Eutrophication	L	L	L	L		L		M						L	L			L
Pathogens	H	H						H	M		H							
Toxicants	L							L										L
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H												
Spills (oil)	M	M	M	M	M	M		M	M	M	M	M		M	M	M	M	M
Grazing of high value habitat																		
Freshwater abstraction	L																L	L
Reclamation/Drainage	H					H	H					H		H		H		
Harvesting living resources	M										M							
Algal blooms (from sea)	M	M														M	M	M
Seawalls, breakwaters etc	H					H	H							H				
Invasive weeds/pests	M					M	M							M				
Vehicle damage																		
Loss of vegetated terrestrial margin	H						H									H	H	H
Animal/man disturbance	M					M	M							M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Eutrophication: Macroalgal Rating (% cover)	Eutrophication: Epiphyte abundance	Eutrophication: Dissolved Oxygen in Water	Eutrophication: Oxygen sediment (RPD/Smell)	Eutrophication: Nutrients	Eutrophication: Sediment Organic Carbon	Eutrophication: Seagrass Loss	Eutrophication: Macroinvertebrates AMBI	Eutrophication: Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation: Sedimentation rate	Sedimentation: Clarity	Sedimentation: Macrophyte Loss	Sedimentation: Sediment Grain Size	Sedimentation: Macroinvertebrates MUD	D.: Faecal Indicators	Toxins: Heavy Metals	Toxins: SVOCs	Toxins: Toxic algal blooms (from sea)	Habitat Loss: Substrate	Habitat Loss: Macrophytes (Seagrass)	Habitat Loss: Saltmarsh	Habitat Loss: Vegetated Terrestrial Margin	Habitat Loss: Birds	Habitat Loss: Fish	Habitat Loss: Invasive species	Habitat Loss: Benthic invertebrates	Habitat Loss: Shellfish	Habitat Loss: Sea Level
Fine Sediment											H	H	H	H	H	H					H	H	H					H	H	
Nutrients/Eutrophication	L	L	L	L	L	L	L	L	L	L																				
Pathogens																	H													
Toxicants																		L	L									L		
Climate Change - Sea Level Rise																														
Climate Change - pH, temp										H																		H	H	
Spills (oil)																					M	M	M		M	M	M	M	M	
Grazing of high value habitat																														
Freshwater abstraction																										L		L	L	
Reclamation/Drainage																							H	H	H	H				
Harvesting living resources																													M	
Algal blooms (from sea)																				M									M	
Seawalls, breakwaters etc																							H	H						
Invasive weeds/pests																							M	M						
Vehicle damage																														
Loss of vegetated terrestrial margin																									H					
Animal/man disturbance																								M	M					
PRIORITY INDICATORS FOR MONITORING											H	H	H	H	H	H	H				H	H	H	H	H	H		H	H	

OVERALL VULNERABILITY RATING - MOUTERE INLET

Human Use	High
Ecological Value	Moderate
Overall Stressor Influence	Mod-High
OVERALL VULNERABILITY	Mod-High
KEY ISSUES	Sedimentation, disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 5 years.
- Fine scale sediment monitoring every 5 years after 4 yr baseline.
- Sedimentation rate monitoring annually.
- Shellfish and bathing disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

MOTUEKA ESTUARY/ DELTA

Estuary Type/Area	Tidal River+Delta /760ha	
Intertidal/Subtidal	609ha/151ha	
Catchment	2,155km^2	
FW Inf ow	Mean annual 59m^3.s^{-1}	
Saltmarsh, Seagrass	63ha, 0ha	
Soft Mud	63ha	
Macroalgae	3.5ha	
Dairy Cows	5675	
SS Loading	702kt/yr	
Nitrogen Loading	548t/yr	
Faecal C. Loading	2.6 x 10^{15}/yr	
Landuse: 47% native forest, 29% exotic forest, 16% high producing pasture.		
Geology: post glacial alluvium.		
Human Use	High	
Ecological Value	Moderate	
Stressors	Moderate	
ISSUES		
Muddiness	Intertidal: Low	Subtidal: High
Eutrophication	Low	
Disease Risk	Moderate-High	
Habitat Loss	High	
Toxicity	Low	
OVERALL VULNERABILITY		
Estuary/Delta: Mod-High	Of shore Plume: High	

The Motueka Estuary consists of a short, narrow and shallow tidal river mouth estuary that discharges onto a broad delta (~700ha), with associated tidal lagoon estuaries located to the north (Riwaka 15ha) and south (Motueka 76ha). The river mouth estuary and delta has a high freshwater inflow and, as a consequence, is not very susceptible to having water and sediment quality problems. A series of islands and spits occupy the delta area and includes discharges from other smaller streams and rivers (e.g. Riwaka River). At low tide, most of the estuary/delta consists of exposed sandy or cobble tidal flats. Much of the Motueka catchment is forest, with pastoral use at 16%. The majority of the sediment and nutrient load from the river is discharged and settles into the subtidal plume area in Tasman Bay (Tuckey et al. 2006).

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, and moderate areas of saltmarsh (4.3% of estuary) and herbfield (3.5%) (Tuckey et al. 2004). However, the natural vegetated margin has been lost and is now developed for grazing. Also, since 1947 at least 33ha of salt-marsh has been drained and converted to pasture. Evidence also indicates a further loss of 200-300ha prior to 1947 (Tuckey et al. 2004). The estuary/delta is recognised as a valuable nursery area for marine and freshwater fish, is rich in shellfish, and a major feeding ground for wading birds.

Issues and Stressors.

- **Loss of high value saltmarsh habitat and upper estuary margin habitat** caused by historical reclamations and floodbanks. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Excessive muddiness** in offshore subtidal waters, caused primarily by catchment runoff from intensive landuse, exotic forestry and erosion-prone areas. The plume-affected seabed covers a significant area (at least 180km^2) in western Tasman Bay (Clement et al. 2010). A major storm in 2005, focused in the upper catchment, resulted in an estimated SS discharge of 161,000 tonnes into the Bay (Gillespie et al. 2011). Climate change (increased storms) is expected to exacerbate this issue.
- **Elevated Disease Risk**, particularly during high rainfall periods, as a result of faecal bacterial runoff from intensive pasture landuse, and to a much lesser extent the Motueka wastewater discharge. Disease risk from contaminated shellfish is the greatest risk. In addition, shellfish disease risk during high rainfall extends to offshore river plume areas.
- Other lesser stressors include; a highly modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness (offshore). Elevated disease risk. Habitat loss. Climate change.	Map catchment sediment and FC "hot spots" (5 yearly). Model catchment SS and FC loads with BMP's in place. Estuary habitat mapping (10 yearly), fine scale monitoring (5 yearly after baseline), sedimentation rate (plates) annually. Offshore river plume sediment monitoring; sedimentation rate (plates) annually. Monitor river SS and FC loads (high and low flows) to determine annual loads.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

MOTUEKA ESTUARY/DELTA
DATE: (DEC 2010)

KEY FOR RATINGS	
High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(white)

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
	STRESSOR	HABITAT							HUMAN USES					ECOL. VALUES				
Fine Sediment	Low	Low	Low	Low	Low	Low	Low	Low									Low	Low
Nutrients/Eutrophication	Low	Low	Low	Low		Low		Moderate						Low	Low			Low
Pathogens	Moderate	Moderate						Moderate	Moderate		Moderate							
Toxicants	Low							Low										Low
Climate Change - Sea Level Rise	Low			Low		Low								Low	Low	Low	Low	Low
Climate Change - pH, temp	High	High	High	High	High	High												
Spills (oil)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate
Grazing of high value habitat																		
Freshwater abstraction	Low																Low	Low
Reclamation/Drainage	High					High	High					High		High		High		
Harvesting living resources	Moderate										Moderate							
Algal blooms (from sea)	Moderate	Moderate														Moderate	Moderate	Moderate
Seawalls, breakwaters etc																		
Invasive weeds/pests	Moderate					Moderate	Moderate							Moderate				
Vehicle damage																		
Loss of vegetated terrestrial margin	High						High									High	High	High
Animal/man disturbance	Low					Low	Low							Low		Low		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators
	Eutrophication										Sedimentation						D.
Fine Sediment											Low						
Nutrients/Eutrophication	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low							
Pathogens																	Moderate
Toxicants																	
Climate Change - Sea Level Rise																	
Climate Change - pH, temp										High							
Spills (oil)																	
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation/Drainage																	
Harvesting living resources																	
Algal blooms (from sea)																	
Seawalls, breakwaters etc																	
Invasive weeds/pests																	
Vehicle damage																	
Loss of vegetated terrestrial margin																	
Animal/man disturbance																	
PRIORITY INDICATORS FOR MONITORING											High						

STRESSORS	Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
	Toxins			Habitat Loss									
Fine Sediment											High	High	
Nutrients/Eutrophication													
Pathogens													
Toxicants	Low	Low									Low		
Climate Change - Sea Level Rise													
Climate Change - pH, temp											High	High	
Spills (oil)				Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate	
Grazing of high value habitat													
Freshwater abstraction									Low		Low	Low	
Reclamation/Drainage						High	High	High	High				
Harvesting living resources												Moderate	
Algal blooms (from sea)			Moderate									Moderate	
Seawalls, breakwaters etc													
Invasive weeds/pests						Moderate	Moderate						
Vehicle damage													
Loss of vegetated terrestrial margin								High					
Animal/man disturbance							Low	Low					
PRIORITY INDICATORS FOR MONITORING				High	High	High	High	High	High		High	High	

OVERALL VULNERABILITY RATING - MOTUEKA ESTUARY/DELTA

Human Use	High
Ecological Value	Moderate
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Fine scale sediment monitoring every 5 years after 4 yr baseline.
- Sedimentation rate monitoring annually.
- Shellfish and bathing disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

5.1 TASMAN BAY - ESTUARIES (CONTINUED)

KAITERITERI ESTUARY

Estuary Type/Area	Tidal Lagoon/18ha
Intertidal/Subtidal	17ha/1ha
Catchment	4km^2
FW Inf ow	Mean annual 0.16m^3.s^{-1}
Saltmarsh, Seagrass	3ha, 0ha
Soft Mud	3ha
Macroalgae	0ha
Dairy Cows	?
SS Loading	0.6kt/yr
Nitrogen Loading	0.7t/yr
Faecal C. Loading	0.007 x 10^{15}/yr
Landuse: 30% native forest, 63% exotic forest, 7% high producing pasture.	
Geology: Separation Point granite.	
Human Use	High
Ecological Value	Moderate
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

The Kaiteriteri Estuary is small, shallow, well-flushed tidal lagoon estuary that has a small freshwater inflow and is enclosed between the beach and the surrounding erosion-prone hills. Sediments are dominated by sands but areas of soft mud (17% of the estuary) and gravels are also present. A remnant strip of mature black beech forest adjacent to the estuary is important visually and is representative of the region's original lowland/coastal podocarp-broadleaved forests. The campground area adjacent to the estuary has been highly modified. At low tide, most of the estuary consists of exposed muddy/sand tidal flats. Much of the estuary catchment is forest (primarily exotic), with intensive pastoral use at 7%.

Uses and Values. High use - valued for its aesthetic appeal, biodiversity, shellfish, bathing, whitebaiting, fishing, walking, and scientific appeal.

Ecological Values. Ecologically, habitat diversity is moderate with much of its intertidal vegetation intact and extensive remaining areas of saltmarsh (16.5% of estuary), although there is evidence of substantial historical losses of saltmarsh and wetland at the head of the estuary. Although 40% of the natural vegetated margin remains, pressure for future margin development for residential use is likely. The estuary is recognised as a valuable nursery area for marine and freshwater fish and is a feeding and roosting ground for wading birds.

Issues and Stressors.

- **Excessive muddiness** caused primarily by catchment runoff from a steep and erosion-prone catchment that includes exotic forestry and intensive landuse. Climate change (increased storms) is expected to exacerbate these issues.
- **Loss of high value saltmarsh habitat** caused by historical reclamations, sea-walls, and causeways. To maintain existing habitat in the face of impending sea level rise, inland migration of habitat will need to be facilitated.
- **Shifts in biological communities** as a result of climate changes to sea pH and temperature.
- **Moderate disease risk**, particularly during high rainfall periods, as a result of faecal bacterial runoff from intensive pasture landuse. Disease risk from contaminated shellfish is the greatest risk.
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and terrestrial weed growth.

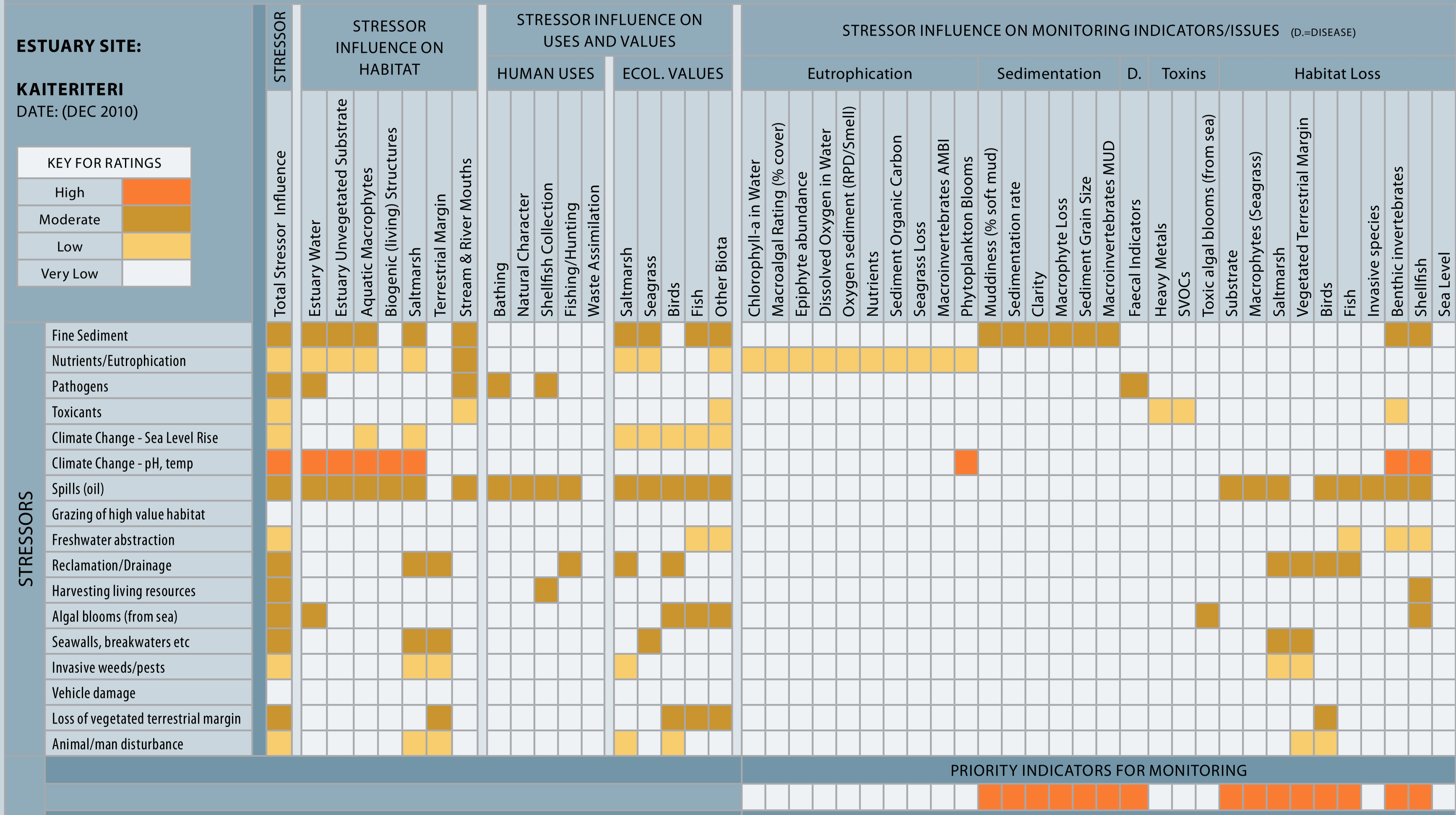
Lower Kaiteriteri Estuary

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment and FC "hot spots" (5 yearly).
Habitat loss.	Model catchment SS and FC loads with BMP's in place.
Climate change	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.
Disease risk.	

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

KAITERITERI
DATE: (DEC 2010)



OVERALL VULNERABILITY RATING - KAITERITERI ESTUARY

Human Use	High
Ecological Value	Moderate
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Climate change, historical reclamation, sedimentation, disease risk.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Sedimentation rate monitoring.
- Shellfish and bathing disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

NGAIO ESTUARY

Estuary Type/Area	Tidal Lagoon/3ha
Intertidal/Subtidal	3ha/0ha
Catchment	1km^2
FW Inf ow	Mean annual 0.010m^3.s^{-1}
Saltmarsh, Seagrass	3ha, 0ha
Soft Mud	0ha
Macroalgae	0ha.
Dairy Cows	0
SS Loading	0.046kt/yr
Nitrogen Loading	0.2t/yr
Faecal C. Loading	0.002 x 10^{15}/yr
Landuse: 15% native forest, 79% exotic forest, 5% pasture.	
Geology: Separation Point granite.	
Human Use	Low
Ecological Value	Moderate
Stressors	Low
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Low	

The Ngaio Estuary is small, shallow, well-flushed tidal river estuary that has a small freshwater inflow and is enclosed between the beach and the surrounding erosion-prone hills. Sediments are dominated by coarse sands and includes a large area of high tide flats covered in saltmarsh (*Juncus krausii*) vegetation. The estuary is split in two by a causeway providing access to a few residential properties. Much of the estuary catchment is forest (primarily exotic 79%), with pastoral use at 5%.

Uses and Values. Low use because of poor access - valued for its aesthetic appeal, biodiversity, and whitebaiting.

Ecological Values. Ecologically, habitat diversity is moderate with much of its intertidal vegetation intact, a very large area of saltmarsh (90% of estuary), and a small area of unvegetated intertidal flats, and a very low presence of soft muds. While much of the natural vegetated margin remains, some areas have been developed for grazing, and further losses during forest harvesting may occur in future. Approximately 30% of the upper estuary saltmarsh has been historically drained and converted to pasture. The estuary is recognised as important nursery area for marine and freshwater fish and birds.

Issues and Stressors.

- **Loss of high value saltmarsh habitat** caused by historical reclamations. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Shifts in biological communities** as a result of climate changes to sea pH and temperature.
- Other lesser stressors include; a partially modified terrestrial margin, and terrestrial weed growth.

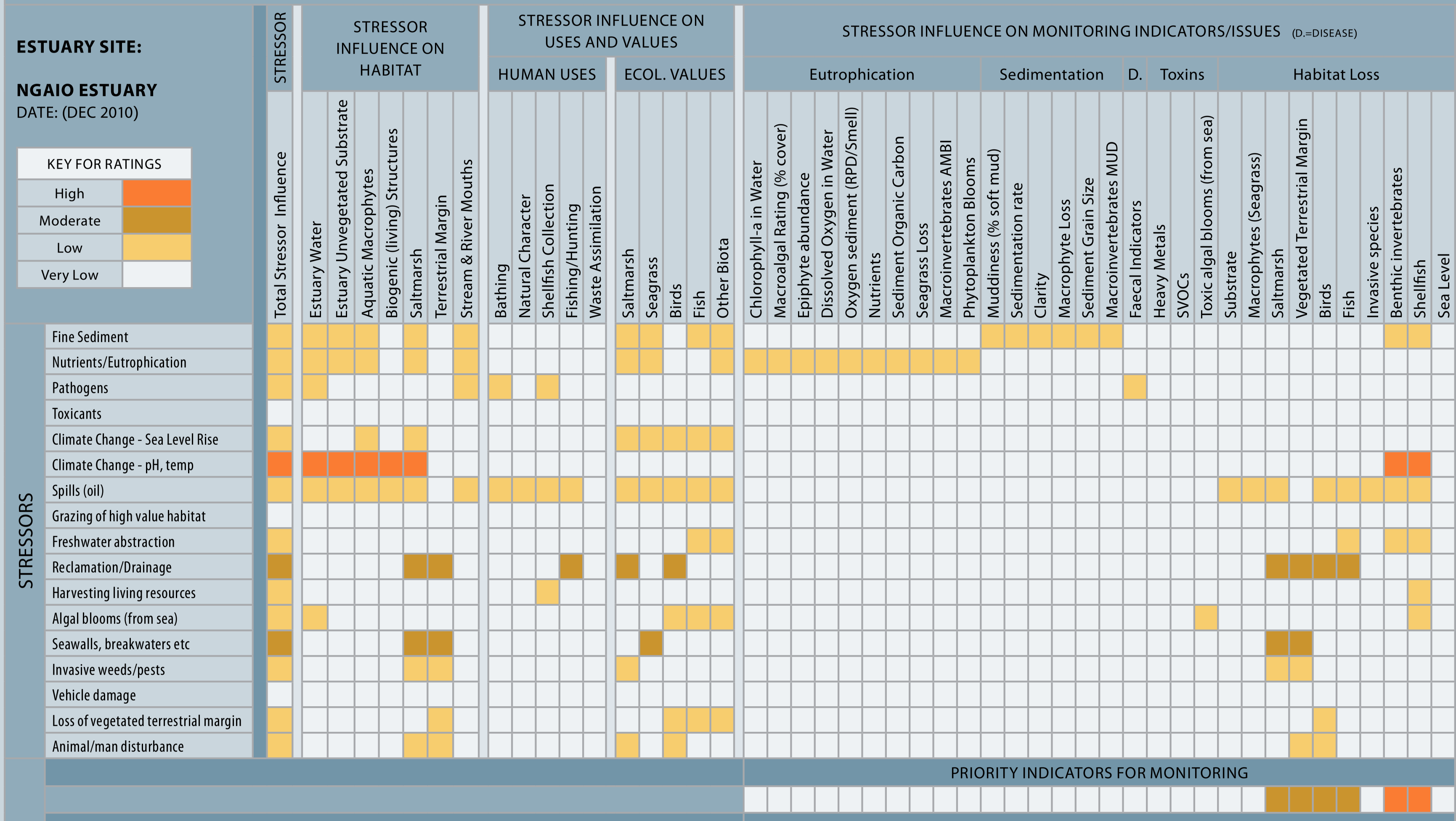
Issues	Monitoring/Investigations
Habitat loss. Climate change.	Estuary habitat mapping (10 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

NGAIO ESTUARY
DATE: (DEC 2010)

KEY FOR RATINGS	
High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(white)



OVERALL VULNERABILITY RATING - NGAIO ESTUARY

Human Use	Moderate
Ecological Value	Moderate
Overall Stressor Influence	Low
OVERALL VULNERABILITY	Low
KEY ISSUES	Climate change, historical reclamation, causeway.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years.

5.1 TASMAN BAY - ESTUARIES (CONTINUED)

OTUWHERO ESTUARY

Estuary Type/Area	Tidal Lagoon/95ha
Intertidal/Subtidal	87ha/8ha
Catchment	58km^2
FW Inf ow	Mean annual 2.8 m^3.s^{-1}
Saltmarsh, Seagrass	34ha, 1ha
Soft Mud	10ha
Macroalgae	0ha
Dairy Cows	?
SS Loading	24.2kt/yr
Nitrogen Loading	14t/yr
Faecal C. Loading	0.4 x 10^{15}/yr
Landuse: 28% native forest, 46% exotic forest,10% high producing pasture, 15% lo-producing pasture.	
Geology: granite.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Mod-High
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Otuwhero Estuary is a moderate-sized (95ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin, a small tidal arm, and a large freshwater influenced saltmarsh separated by a causeway. It has a double sandspit (700m long) largely vegetated in exotic weeds. Much of the estuary catchment is forest (primarily exotic 46%), with intensive pastoral use at 10%. The granite catchment is highly erodible and land disturbance has led to excessive sediment inputs to the estuary.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. On the inside of the sandspit near the mouth, a jetty and moorings cater for residents boats.

Ecological Values. Ecologically, habitat diversity is high and includes an community sequence including unvegetated tidal flats, saltmarsh, seagrass (on the delta area at the mouth), herbfields, freshwater wetland, and two forest remnants. However, significant areas of saltmarsh and natural vegetated margin have been lost. Currently, saltmarsh occupies 36% of the estuary whereas historically it was approximately 40-50% and much of the terrestrial margin is covered in pines or scrub. In addition, the estuary is excessively muddy (10% soft mud). The inlet is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Excessive muddiness and moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse and exotic forestry (sediment only). Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.
- **Loss of high value saltmarsh/seagrass habitat and restricted flushing** caused by historical reclamations, seawalls and causeway developments. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment and FC "hot spots" (5 yearly).
Moderate disease risk.	Model catchment SS and FC loads with BMP's in place.
Habitat loss.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.
Climate change.	

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

OTUWHERO ESTUARY
DATE: (DEC 2010)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	VL

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	H	H	H	H	H	H	VL	H	H	H	H	VL	VL	H	H	H	H	H
Nutrients/Eutrophication	L	L	L	L	VL	L	VL	L	VL	VL	VL	VL	VL	L	L	VL	VL	L
Pathogens	M	M	VL	VL	VL	VL	VL	M	M	VL	M	VL	VL	VL	VL	VL	VL	VL
Toxicants	L	VL	VL	VL	VL	VL	VL	L	VL	VL	VL	VL	VL	VL	VL	VL	VL	L
Climate Change - Sea Level Rise	L	VL	VL	L	VL	L	VL	VL	VL	VL	VL	VL	VL	L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Spills (oil)	M	M	M	M	M	M	VL	M	M	M	M	M	VL	M	M	M	M	M
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	L	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	L	L
Reclamation/Drainage	M	VL	VL	VL	VL	M	M	VL	VL	VL	VL	M	VL	M	VL	M	VL	VL
Harvesting living resources	M	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL	VL	VL	VL
Algal blooms (from sea)	M	M	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	M
Seawalls, breakwaters etc	M	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL
Invasive weeds/pests	M	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	M	VL	VL	VL	VL	VL	M	VL	VL	VL	VL	VL	VL	VL	VL	M	M	M
Animal/man disturbance	M	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL	M	VL	M	VL	VL

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	H	H	H	H	H	VL	VL	VL	VL	H	H	H	VL	VL	VL	VL	H	H	VL
Nutrients/Eutrophication	L	L	L	L	L	L	L	L	L	L	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Pathogens	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Toxicants	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	L	L	VL	VL	VL	VL	VL	VL	VL	VL	L	VL	VL
Climate Change - Sea Level Rise	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Climate Change - pH, temp	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	H	VL
Spills (oil)	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	M	VL	M	M	M	M	M	VL
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	L	VL	L	L	VL
Reclamation/Drainage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	M	M	VL	VL	VL	VL
Harvesting living resources	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL
Algal blooms (from sea)	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL	VL	VL	VL	VL	M	VL
Seawalls, breakwaters etc	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL
Invasive weeds/pests	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL	VL	VL	VL	VL
Animal/man disturbance	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL
PRIORITY INDICATORS FOR MONITORING											H	H	H	H	H	H	H				H	H	H	H	H	H		H	H	

OVERALL VULNERABILITY RATING - OTUWHERO ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Sedimentation, disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Sedimentation rate monitoring annually. • Map catchment sediment and FC source "hot spots" 5 yearly. • Model catchment SS and FC loads with BMP's in place.

5.1 TASMAN BAY - ESTUARIES (CONTINUED)

MARAHAU ESTUARY

Estuary Type/Area	Tidal River/37ha
Intertidal/Subtidal	35ha/2ha
Catchment	$31km^2$
FW Inf ow	Mean annual $1.4\ m^3.s^{-1}$
Saltmarsh, Seagrass	22ha, seagrass on delta
Soft Mud	1ha
Macroalgae	0ha
Dairy Cows	?
SS Loading	54.8kt/yr
Nitrogen Loading	6.4t/yr
Faecal C. Loading	0.6×10^{15}/yr
Landuse: 81% native forest, 11% exotic forest, 7% high producing pasture, 1% low producing pasture.	
Geology: granite.	
Human Use	High
Ecological Value	High
Stressors	Low
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Marahau Estuary is a moderate-sized (37ha), shallow, well-flushed, seawater-dominated, tidal river type estuary that is bordered by extensive saltmarsh flats (60% of estuary) and discharges to an extensive intertidal delta area. It has a sandspit on either side of the outlet. Much of the estuary catchment is forest (primarily native 81%), with intensive pastoral use at 7%. The granite catchment is highly erodible and land disturbance could lead to excessive sediment inputs to the estuary.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, whitebaiting, walking, and scientific appeal. A causeway has been built to facilitate foot access across the estuary to the southern entrance to Abel Tasman National Park.

Ecological Values. Ecologically, habitat diversity is high and includes a community sequence including unvegetated tidal flats, extensive saltmarsh (60% of estuary), seagrass (on the seaward delta in Sandy Bay), herbfields, and native forest remnants. However, significant areas of saltmarsh (approximately 30%) and natural vegetated margin have been lost and are now in pasture. The estuary is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Loss of high value saltmarsh/seagrass habitat and restricted flushing** caused by historical reclamations. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Potential for excessive muddiness** caused primarily by catchment runoff from intensive landuse and exotic forestry. Climate change (increased storms) is expected to exacerbate these issues.
- Other lesser stressors include; a modified terrestrial margin, high population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. iceplant).

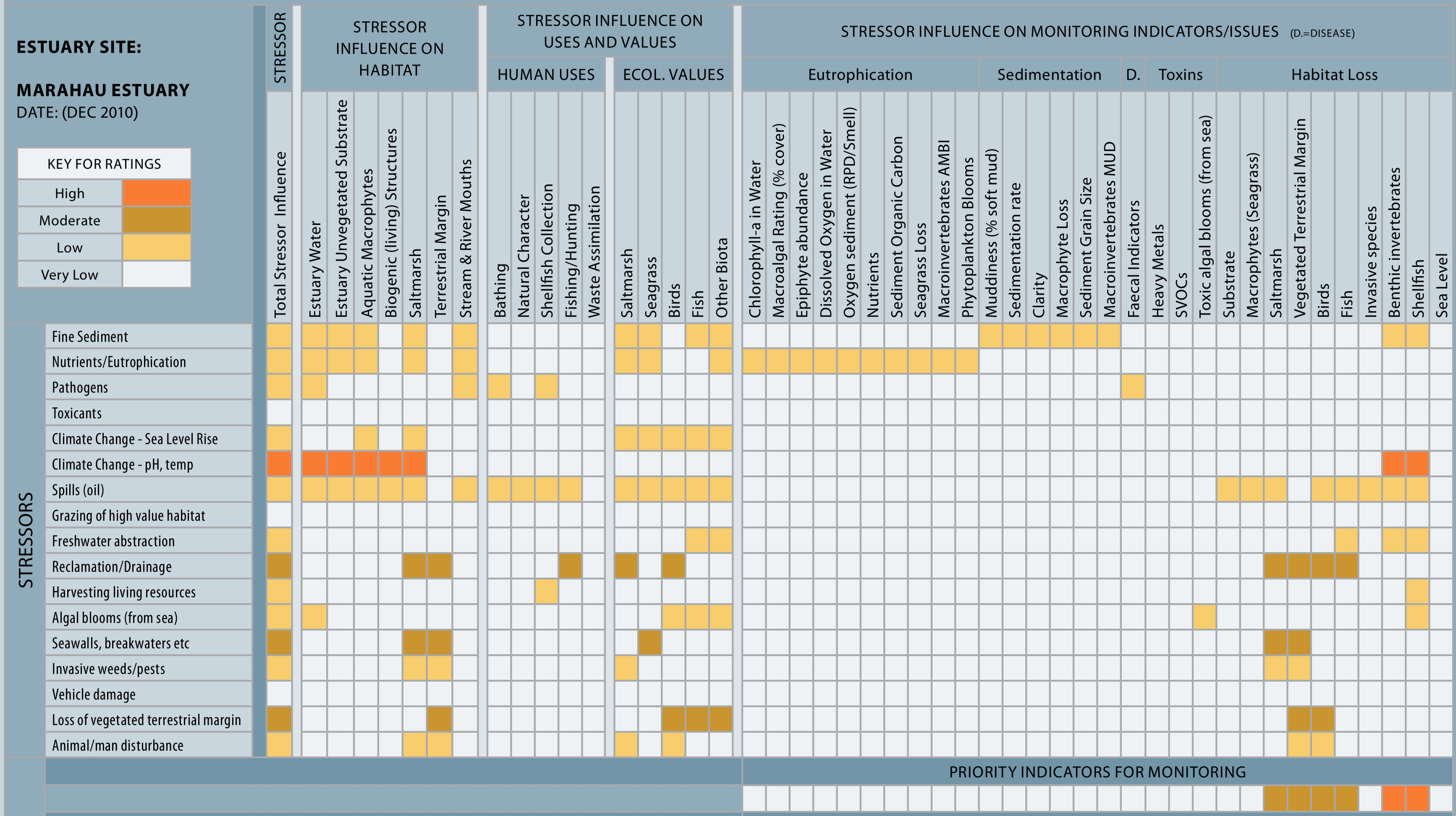
Issues	Monitoring/Investigations
Habitat loss.	Map catchment sediment "hot spots" (5 yearly).
Climate change.	Model catchment SS loads with BMP's in place.
Potential excessive muddiness.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.

5.1 TASMAN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

MARAHAU ESTUARY
DATE: (DEC 2010)



OVERALL VULNERABILITY RATING - MARAHAU ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Low
OVERALL VULNERABILITY	Low
KEY ISSUES	Climate change, terrestrial margin, historical reclamation.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Map catchment sediment source "hot spots", 5 yearly.

5.2 GOLDEN BAY - BEACHES, DUNES, ROCKY SHORES AND ESTUARIES

BEACH/DUNE/ROCKY SHORE

Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Low
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	High
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

The Golden Bay coastal section extends from Wainui Inlet to Puponga near Farewell Spit, and comprises 111km of estuary, 60km of beaches and 10km of rocky shore.

Terrestrial Margin. Farming and exotic plantations are the predominant land use, but coastal settlements occur throughout, and are most frequent between Pohara and Tata Beach. A few remnants of coastal podocarp forest and scrub occur at the mouth of the Takaka River, at Te Rae, and Waikato. Kahurangi National Park is a prominent feature of the catchments draining into Golden Bay, particularly north of the Takaka River mouth and more particularly between Collingwood and Farewell Spit.

Beach Types. Golden Bay has long stretches of sand or (less commonly) gravel beaches, mostly eroding and backed by low coastal terraces. They are primarily tide-dominated or tide-modified beaches with a short steep upper beach and extensive sandy tidal flats. Tata Beach is the exception, being a steep reflective wave-dominated beach without tidal flats. To the east, from Wainui Beach to the man-made Tarakohe Harbour, the beaches have coarse golden sand derived from erosion of hinterland granite rock. From Pohara to Puponga the beaches are extensive and dominated by pale, fine sands. Between Pakawau and Puponga extensive beds of seagrass and shellfish are common on the intertidal flats. Seagrass beds are also common in the Takaka River delta area. **Rocky Shores.** Rocky shores and reef areas are relatively uncommon except for the section between Wainui and Pohara which is dominated by limestone reefs, cliffs, towers and rock pedestals. Small sections of rocky shore (mudstones and calcareous siltstones) also exist at Paton's Rock/Rangihaeata, Onekaka, Tukurua, and Puponga.

Dunes. Duneland in Golden Bay is generally typified by a narrow low dune fringe of marram, lupin and gorse backing on to farmland and lifestyle blocks. At Wainui Beach, a small delta-shaped spit exists on the south-west side of the inlet and a long narrow spit, that is actively changing shape, on the north-east side. The dominant vegetation is marram, gorse and lupins. Ligar Bay and Tata Beach have small marram dominated foredunes, and a section of spinifex plantings at Tata Beach. Between Collingwood and Tarakohe some dunes are present, dominated by gorse, lupins and marram. Between Collingwood and Puponga, the dunes are narrow, but low dune ridges do extend inland (up to 1km in places) although introduced grasses and herbs have replaced most of the natural vegetation. Community plantings of native sand-binding duneland species (spinifex and pingao) have been undertaken, on a small scale, at many locations throughout Golden Bay (see GIS habitat maps in Appendix 4).

Uses and Values. Human use of the beach areas and dunes is high from both a tourist and local context. It is particularly valued for picnicking, swimming, walking, horse riding, surf-casting and shellfish collection. Public access is generally good to most areas. Scenic values are limited due the highly modified nature of the coastal margin environment.

Ecological Values. Animal diversity is expected to be moderately high throughout the beach and rocky shore areas. Sandy habitats are dominated by cockles, spionid polychaetes; pipis, tuatuas, amphipods, and isopods. Diversity is expected to be greatest at the west amongst the extensive seagrass beds (e.g. Dixon 2009). In the lower intertidal/shallow subtidal of limestone rocky shores, biota is dominated by the common kelp (*Ecklonia radiata*), foliose red algae, a low cover of coralline algae, gastropods (catseye *Turbo smaragdus* and Cook's turban *Cookia sulcata*) and the sea urchin *Evechinus chloroticus*. Duneland is highly modified and generally failing in its function as an essential part of the natural character of the coastal environment and an aesthetic buffer between the developed hinterland and the beach areas. Much of the area is important for birdlife.

Issues and Stressors.

- **Margin squeeze and dune overstabilisation** through development, exotic plantings (e.g. marram) and weed species.
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- **Shifts in biological communities** as a result of climate changes to sea pH and temperature.
- **Excessive disease risk** (especially during high rainfall periods) from intensively grazed (dairy, sheep, beef) catchments.
- Lesser stressors; population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss.

Issues	Monitoring
Margin squeeze and duneland loss. Modified terrestrial margin. Shellfish disease risk. Biodiversity changes.	Rocky shore (e.g. Wainui) and fine scale beach (e.g. Pakawau) -morphometry, invertebrates, grain size (5 yearly). Beach/dune habitat mapping (10 yearly). Map catchment FC "hot spots", 5 yearly. Monitor disease risk (shellfish).

5.2 GOLDEN BAY - BEACHES, DUNES AND ROCKY SHORES (CONT.)

BEACHES - WAINUI TO LIGAR BAY


Wainui Beach (golden sand with low tidal f ats)


Tata Beach (steep, coarse golden sand beach)


Ligar Bay beach (golden sand with low tidal f ats)

BEACHES - POHARA TO PATON'S ROCK


Pohara Beach at mid-tide (f ne pale sand with tidal f ats)


Beach in vicinity of Takaka River delta.


Paton's Rock Beach (f ne pale sand with tidal f ats)

BEACHES - PATON'S ROCK TO COLLINGWOOD


Onekaka Beach


Parapara Beach


Beach southeast of Collingwood

BEACHES - COLLINGWOOD TO PAKAWAU


Beach west of Collingwood


Pakawau Beach


Pakawau Beach

BEACHES - PAKAWAU TO PUPONGA


Beach west of Pakawau


Puponga Beach (sea grass beds on tidal f ats)


Puponga Beach (narrow eroding marram grass dune)

5.2 GOLDEN BAY - BEACHES, DUNES AND ROCKY SHORES (CONT.)

ROCKY SHORES - WAINUI TO LIGAR BAY (LIMESTONE ROCKS)


Abel Tasman Point (mussel farm buoys in foreground)


Rocky shore west side of Abel Tasman Point


Ligar Bay, rocky shore at eastern end

ROCKY SHORES - TARAKOHE (LIMESTONE ROCKS)


Rocky shores to east of Tarakohe Harbour


Man-made rocky wall, Tarakohe Harbour


Barnacles on rocks near Tarakohe Harbour

ROCKY SHORES - TARAKOHE TO PATON'S ROCK


Rangihaeta Head - east of Takaka River mouth


Bedrock, Onahau Beach


Patons Rock

ROCKY SHORES - PATON'S ROCK TO ONEKAKA


Rock pool, Paton's Rock


Platform rock, Onekaka


Mussels on rocks at Onekaka

ROCKY SHORES - TUKURUA TO PUPONGA


Tukurua Point


Artif cial rock wall - west of Ruataniwha Inlet


Puponga Point

5.2 GOLDEN BAY - BEACHES, DUNES AND ROCKY SHORES (CONT.)

DUNELAND- WAINUI TO LIGAR BAY


Marram, gorse, iceplant dunes, Wainui Beach


Spinifex plantings, Tata Beach


Ligar Bay marram, iceplant and spinifex

DUNELAND- POHARA


Marram dunes, Pohara Beach


Spinfex plantings, Pohara


Pohara: marram, f ax and iceplant.

DUNELAND- ONAHAU TO PATONS ROCK


Low eroding terrace at Onahau


Marram dunes on moving spit at Onahau


Patons Rock beach - marram and ice plant dunes

DUNELAND - PATON'S ROCK TO PARAPARA


Spinifex and pingao plantings, Paton's Rock


Marram dune fringe east of Parapara


Spinfex plantings, Pararpara

DUNELAND - PAKAWAU TO PUPONGA


Mix of marram, lupin and spinifex at Pakawau


Modif ed margin west of Pakawau


Narrow marram margin, Puponga

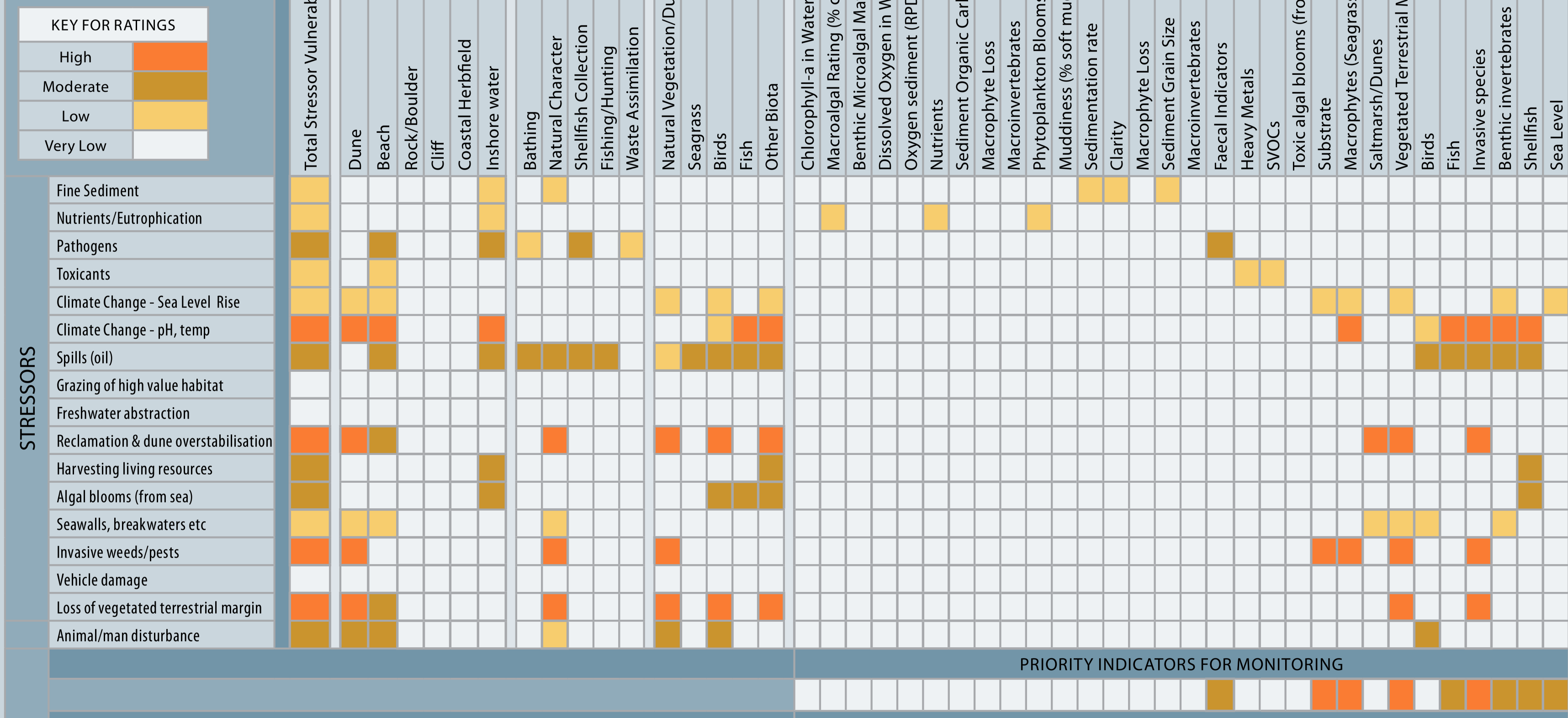
5.2 GOLDEN BAY - BEACHES, DUNES AND ROCKY SHORES (CONT.)

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH/DUNE/ROCKY SHORE SITE:

WAINUI INLET TO PORT PUPONGA

DATE: (MARCH 2011)



OVERALL VULNERABILITY RATING - GOLDEN BAY BEACHES/ROCKY SHORES

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate-High
KEY ISSUES	Habitat Loss - Loss of dunes, margin squeeze, disease risk (high rainfall), climate change, erosion, weeds.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Fine scale beach and rocky shore transect monitoring at several representative dissipative beach types and rocky shores in the region to monitor impacts of climate change.

5.2 GOLDEN BAY - ESTUARIES

WAINUI INLET

Estuary Type/Area	Tidal Lagoon/215ha
Intertidal/Subtidal	192ha/23ha
Catchment	$41km^2$
FW Inf ow	Mean annual $1m^3.s^{-1}$
Saltmarsh, Seagrass	41ha, 0ha
Soft Mud	24ha
Macroalgae	5ha
Dairy Cows	350
SS Loading	30kt/yr
Nitrogen Loading	17t/yr
Faecal C. Loading	0.19×10^{15}/yr
Landuse: 85% native forest, 5% exotic forest, 9% high producing pasture, 0% low producing pasture.	
Geology: granite.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Mod-High
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Wainui Inlet is a moderate-sized (215ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin, and a small tidal arm. It has a large sandspit (1,100m long) much of which (750m, ~8ha) is covered in exotic weeds, including marram. Much of the estuary catchment is regenerating native forest (85%), with intensive pastoral use at 9%. The granite catchment is highly erodible and land disturbance has led to excessive fine sediment inputs to the estuary.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. It is the northern entrance to Abel Tasman National Park. Evidence of early Maori occupation is found throughout the area.

Ecological Values. Ecologically, habitat diversity is high and includes unvegetated tidal flats, saltmarsh, and herbfields. However, significant areas of saltmarsh and natural vegetated margin have been lost. In addition, the estuary is excessively muddy (13% is soft mud). The inlet is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Excessive muddiness and moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse and an erosion prone catchment. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.
- **Loss of high value saltmarsh habitat** caused by historical reclamations and seawalls. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment and FC "hot spots" (5 yearly).
Moderate disease risk.	Model catchment SS and FC loads with BMP's in place.
Habitat loss.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.
Climate change.	

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

WAINUI INLET
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(white)

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
	STRESSOR	HABITAT							HUMAN USES					ECOL. VALUES				
Fine Sediment	High	High	High	High	High	High		High	High	High	High			High	High	High	High	High
Nutrients/Eutrophication	Low	Low	Low	Low		Low		Low						Low	Low			Low
Pathogens	Moderate	Moderate						Moderate	Moderate		Moderate							
Toxicants	Low							Low										Low
Climate Change - Sea Level Rise	Low			Low		Low								Low	Low	Low	Low	Low
Climate Change - pH, temp	High	High	High	High	High	High												
Spills (oil)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate
Grazing of high value habitat	Very Low																	
Freshwater abstraction	Low																Low	Low
Reclamation/Drainage	Moderate					Moderate	Moderate					Moderate		Moderate		Moderate		
Harvesting living resources	Moderate										Moderate							
Algal blooms (from sea)	Moderate	Moderate														Moderate	Moderate	Moderate
Seawalls, breakwaters etc	Moderate					Moderate	Moderate							Moderate				
Invasive weeds/pests	Moderate					Moderate	Moderate							Moderate				
Vehicle damage	Very Low																	
Loss of vegetated terrestrial margin	Moderate						Moderate									Moderate	Moderate	Moderate
Animal/man disturbance	Moderate					Moderate	Moderate							Moderate		Moderate		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

Eutrophication

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms
Fine Sediment										
Nutrients/Eutrophication	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pathogens										
Toxicants										
Climate Change - Sea Level Rise										
Climate Change - pH, temp										High
Spills (oil)										
Grazing of high value habitat										
Freshwater abstraction										
Reclamation/Drainage										
Harvesting living resources										
Algal blooms (from sea)										
Seawalls, breakwaters etc										
Invasive weeds/pests										
Vehicle damage										
Loss of vegetated terrestrial margin										
Animal/man disturbance										
PRIORITY INDICATORS FOR MONITORING										

Sedimentation / D. / Toxins

STRESSORS	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators	Heavy Metals	SVOCs	Toxic algal blooms (from sea)
Fine Sediment	High	High	High	High	High	High				
Nutrients/Eutrophication										
Pathogens							Moderate			
Toxicants								Low	Low	
Climate Change - Sea Level Rise										
Climate Change - pH, temp										
Spills (oil)										
Grazing of high value habitat										
Freshwater abstraction										
Reclamation/Drainage										
Harvesting living resources										
Algal blooms (from sea)										Moderate
Seawalls, breakwaters etc										
Invasive weeds/pests										
Vehicle damage										
Loss of vegetated terrestrial margin										
Animal/man disturbance										
PRIORITY INDICATORS FOR MONITORING	High	High	High	High	High	High	High			

Habitat Loss

STRESSORS	Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	High	High	High					High	High	
Nutrients/Eutrophication										
Pathogens										
Toxicants								Low		
Climate Change - Sea Level Rise										
Climate Change - pH, temp								High	High	
Spills (oil)	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate	
Grazing of high value habitat										
Freshwater abstraction						Low		Low	Low	
Reclamation/Drainage			Moderate	Moderate	Moderate	Moderate				
Harvesting living resources									Moderate	
Algal blooms (from sea)									Moderate	
Seawalls, breakwaters etc			Moderate	Moderate						
Invasive weeds/pests			Moderate	Moderate						
Vehicle damage										
Loss of vegetated terrestrial margin					Moderate					
Animal/man disturbance				Moderate	Moderate					
PRIORITY INDICATORS FOR MONITORING	High	High	High	High	High	High		High	High	

OVERALL VULNERABILITY RATING - WAINUI INLET

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Sedimentation, disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Sedimentation rate monitoring annually.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.

TATA BEACH ESTUARY

Estuary Type/Area	Tidal Lagoon /17ha
Intertidal/Subtidal	17ha/0ha
Catchment	3km^2
FW Inf ow	Mean annual 0.05 m^3.s^{-1}
Saltmarsh, Seagrass	2ha, 0.9ha
Soft Mud	6ha
Macroalgae	0ha
Dairy Cows	0
SS Loading	0.1kt/yr
Nitrogen Loading	0.6t/yr
Faecal C. Loading	0.025 x 10^{15}/yr
Landuse: 13% native forest, 60% exotic forest, 26% high producing pasture, 0% low producing pasture.	
Geology: granite.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	High
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Tata Beach Estuary is a small (17ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with a small amount of saltmarsh which discharges into Ligar Bay. Sediments are granite alluvium derived from the steep erodible hill country to the east. Much of the estuary catchment is forest (primarily native 81%), with intensive pastoral use at 7%. The granite catchment is highly erodible and land disturbance could lead to excessive sediment inputs to the estuary.

Uses and Values. High use. It is valued for its aesthetic appeal, its biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Evidence of early Maori occupation is found throughout the area.

Ecological Values. Ecologically, habitat diversity is moderate and includes unvegetated tidal flats, saltmarsh, seagrass, and herbfields. However, significant areas of saltmarsh and natural vegetated margin have been lost. A causeway for vehicle traf c cuts through saltmarsh habitat in the upper estuary and exotic plant growth is common around the margins, as is residential development. In addition, the estuary is excessively muddy (35% is soft mud). The estuary is recognised as a valuable nursery area for marine and freshwater fish, a shellfish resource, and important for birdlife.

Issues and Stressors.

- **Excessive muddiness** caused primarily by catchment runoff from intensive landuse and exotic forestry in erosion prone catchment. Moderate disease risk. Climate change (increased storms) is expected to exacerbate these issues.
- **Loss of high value saltmarsh habitat** caused by historical reclamations and causeways. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be encouraged.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).

Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment source “hot spots” (5 yearly).
Moderate disease risk.	Model catchment SS loads with BMP’s in place.
Habitat loss.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.
Climate change.	

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

TATA BEACH ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	

STRESSORS – Stressor influence on habitat, uses and values

STRESSORS	STRESSOR: Total Stressor Influence	STRESSOR INFLUENCE ON HABITAT: Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	STRESSOR INFLUENCE ON USES AND VALUES – HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	M	M	M	M		M		M						M	M		M	M
Nutrients/Eutrophication	L	L	L	L		L		M						L	L			L
Pathogens	M	M						M	M		M							
Toxicants	L							L										L
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H												
Spills (oil)	M	M	M	M	M	M		M	M	M	M	M		M	M	M	M	M
Grazing of high value habitat																		
Freshwater abstraction	L																L	L
Reclamation/Drainage	M					M	M					M		M		M		
Harvesting living resources	M										M							
Algal blooms (from sea)	M	M														M	M	M
Seawalls, breakwaters etc	M					M	M								M			
Invasive weeds/pests	L					L	L							L				
Vehicle damage																		
Loss of vegetated terrestrial margin	M						M									M	M	M
Animal/man disturbance	L					L	L							L		L		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	D.: Faecal Indicators
Fine Sediment											M	M	M	M	M	M	
Nutrients/Eutrophication	L	L	L	L	L	L	L	L	L	L							
Pathogens																	M
Toxicants																	
Climate Change - Sea Level Rise																	
Climate Change - pH, temp										H							
Spills (oil)																	
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation/Drainage																	
Harvesting living resources																	
Algal blooms (from sea)																	
Seawalls, breakwaters etc																	
Invasive weeds/pests																	
Vehicle damage																	
Loss of vegetated terrestrial margin																	
Animal/man disturbance																	
PRIORITY INDICATORS FOR MONITORING											H	H	H	H	H	H	H

STRESSORS	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment											M	M	
Nutrients/Eutrophication													
Pathogens													
Toxicants	L	L									L		
Climate Change - Sea Level Rise													
Climate Change - pH, temp											H	H	
Spills (oil)				M	M	M		M	M	M	M	M	
Grazing of high value habitat													
Freshwater abstraction									L		L	L	
Reclamation/Drainage						M	M	M	M				
Harvesting living resources												M	
Algal blooms (from sea)			M									M	
Seawalls, breakwaters etc						M	M						
Invasive weeds/pests						L	L						
Vehicle damage													
Loss of vegetated terrestrial margin								M					
Animal/man disturbance							L	L					
PRIORITY INDICATORS FOR MONITORING				H	H	H	H	H	H		H	H	

OVERALL VULNERABILITY RATING - TATA BEACH ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Muddiness, climate change, historical reclamation.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Sedimentation rate monitoring.
- Map catchment sediment source "hot spots" 5 yearly.
- Model catchment SS loads with BMP's in place.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

MOTUPIPI ESTUARY

Estuary Type/Area	Tidal Lagoon/169ha
Intertidal/Subtidal	157ha/12ha
Catchment	$41km^2$
FW Inf ow	Mean annual $2.2m^3.s^{-1}$
Saltmarsh, Seagrass	69ha, 2.5ha
Soft Mud	37ha
Macroalgae	3.6ha
Dairy Cows	2000
SS Loading	12.8 kt/yr
Nitrogen Loading	40.4 t/yr
Faecal C. Loading	1.6×10^{15}/yr
Landuse: 37% native forest, 8% exotic forest, 45% high producing pasture	
Geology: Complex; gravels, alluvium, mudstones, limestone.	
Human Use	High
Ecological Value	High
Stressors	Mod-High
ISSUES	
Muddiness	High
Eutrophication	Moderate-High
Disease Risk	Moderate-High
Habitat Loss	High
Toxicity	Low
OVERALL VULNERABILITY	
Mod-High	

Photo: Google Earth

Motupipi Estuary is a moderate-sized (169ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, and two main basins. The catchment is mostly developed and dominated by high producing pasture, native forest and exotic forestry. A sandspit extends west of the mouth and the majority of the margin is developed for intensive farming (Stevens and Robertson 2008).

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

Ecological Values. Ecologically, habitat diversity is moderate to high with much of its intertidal vegetation intact, extensive shellfish beds, large areas of saltmarsh (39% of estuary), and some seagrass (1.6% of estuary). However, the estuary is excessively muddy (22% soft mud) and the natural vegetated margin has been lost and developed for grazing. Also, since 1943 there has been a loss of 24ha 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. A causeway separates a small section of saltmarsh from the main estuary. Historically, the Takaka landfill was sited on the margin. 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 therefore experiences nuisance phytoplankton blooms when nutrient inputs are elevated (Robertson and Stevens 2008a). Heavy metals, used as an indicator of potential toxicants, were very low in the central estuary (Robertson and Stevens 2008b).

Issues and Stressors.

- **Excessive muddiness and elevated disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing at high tide, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Localised eutrophication** (algal blooms) in poorly flushed upper estuary arms at times. Areal nitrogen load to estuary exceeds recommended guideline of <50mgN/m²/d.
- **Loss of high value saltmarsh/seagrass habitat and restricted flushing** caused by historical reclamations and causeway developments. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a highly modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Excessive muddiness. Moderate-High disease risk. Habitat loss. Climate change Local eutrophication.	Map catchment sediment and FC "hot spots" (5 yearly). Model catchment SS and FC loads with BMP's in place. Estuary habitat mapping (5 yearly), fine scale monitoring (5 yearly after baseline), sedimentation rate (plates established in 2008) annually. Monitor river SS and FC loads (high and low flows) to determine annual loads. Monitor shellfish and bathing disease risk.

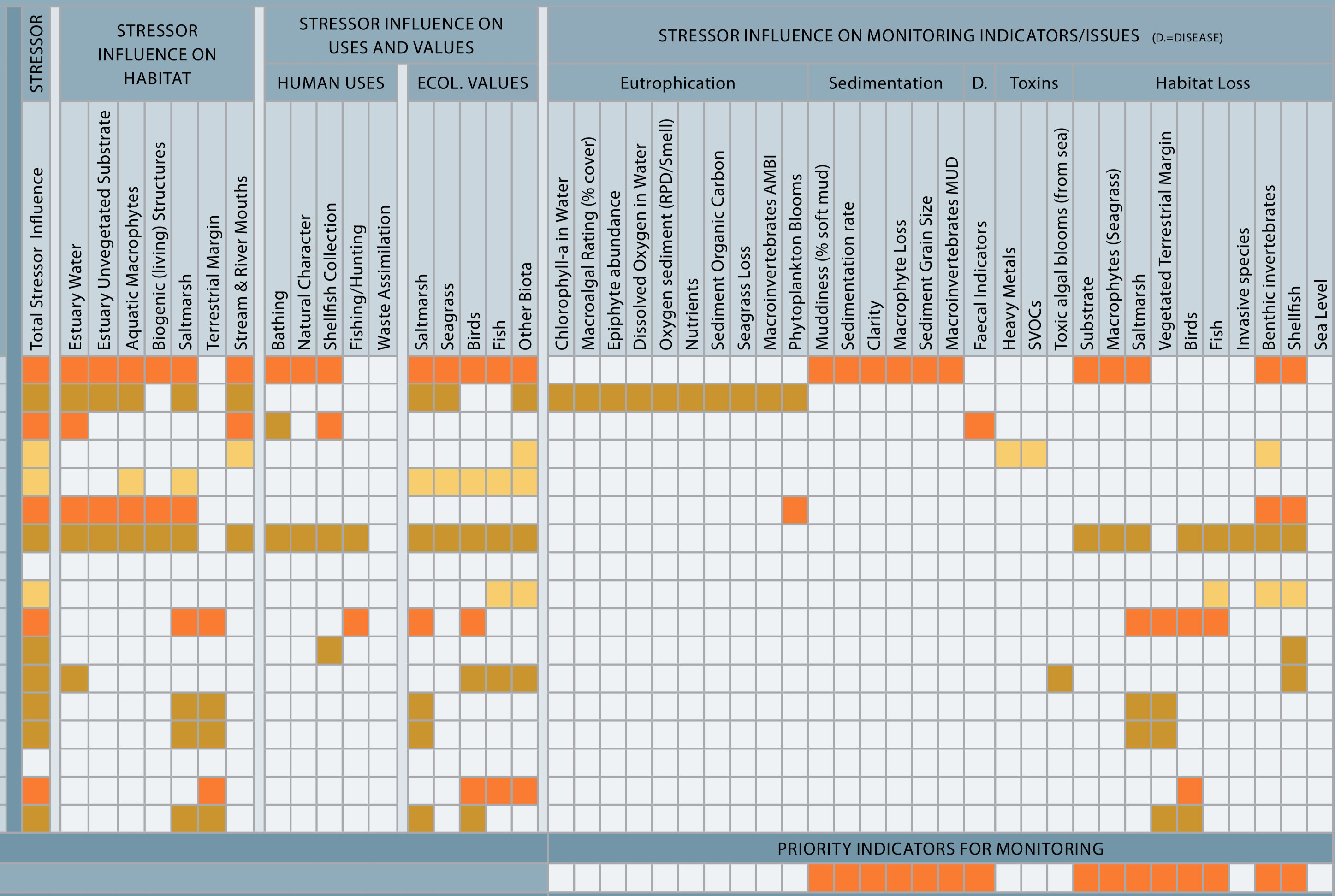
5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

MOTUPIPI ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS
- High
- Moderate
- Low
- Very Low



OVERALL VULNERABILITY RATING - MOTUPIPI ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Mod-High
OVERALL VULNERABILITY	Mod-High
KEY ISSUES	Sedimentation, disease risk, climate change, reclamation of high value habitat, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 5 years.
- Fine scale sediment monitoring every 5 years after 4 year baseline.
- Sedimentation rate monitoring annually.
- Shellfish and bathing disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

WAITAPU ESTUARY

Estuary Type/Area	Tidal Lagoon - 560ha
Intertidal/Subtidal	468ha/90ha
Catchment	873km^2
FW Inf ow	Mean annual 57m^3.s^{-1}
Saltmarsh, Seagrass	86ha, 15ha
Soft Mud	32ha
Macroalgae	0ha
Dairy Cows	7380
SS Loading	282kt/yr
Nitrogen Loading	464t/yr
Faecal C. Loading	5.1 x 10^{15}/yr
Landuse: 74% native forest, 3% exotic forest, 11% high producing pasture,2% low producing pasture.	
Geology: complex sedimentary rocks, limestone, granites, marble and schist.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Mod-High
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Waitapu Estuary is a complex tidal river, tidal lagoon and delta system (560ha) located at the mouth of the Takaka River and situated between Rangihaeata Head in the west to Soper's Hill in the east. High ground flanks the lagoon and delta, which is composed of paleozoic schists and tertiary sediments. The estuary complex is shallow, well-flushed, seawater-dominated, and has a large area of saltmarsh and extensive seagrass beds. The lagoon system to the east is relatively isolated from the main Takaka River flows. There are extensive sand dunes and spits to the north-east and northwest. The beach area is composed of fine sandy sediments. Much of the catchment is forest (primarily native 74%), with intensive pastoral use at 11%.

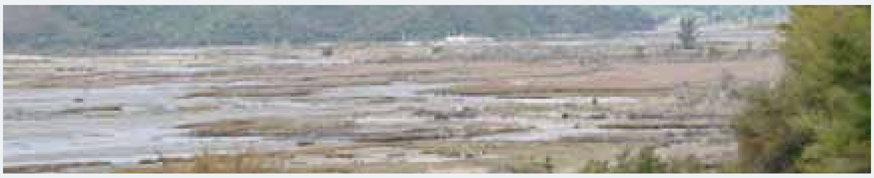
Uses and Values. High use. It is valued for its aesthetic appeal, its biodiversity, shell-fish collection, bathing, whitebaiting, fishing, boating, and scientific appeal. Waitapu is a locally significant fishing port. A small beach settlement is located at the base of Rangihaeata Head. Evidence of early Maori occupation is found in the area.

Ecological Values. Ecologically, habitat diversity is moderate and includes unvegetated tidal flats, saltmarsh, seagrass, and herbfields. A small stand of coastal totara forest grading into saltmarsh is present near the main river channel. However, significant areas of saltmarsh and natural vegetated margin have been lost. The majority of the margin is developed for farming. A causeway extends to the Waitapu wharf where a fish processing plant is established. A boat main-tenance area is a potential local source of heavy metal contaminants. The lagoon area is excessively muddy (26% is soft mud). In the early 1980's, the Catchment Board diverted the main flow of the Takaka River from its original channel towards Rangihaeata Head, to a direct route out to sea, through the construction of large stopbanks through the upper estuary. This has resulted in considerable die-off of mature vegetation in the area. Aerial photographs indicate several historic cause-ways and small reclamations have also been undertaken. The estuary is recognised as a valuable nursery area for marine and freshwater fish, a shellfish resource, and important for birdlife.

Issues and Stressors.

- **Excessive muddiness and moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse. Climate change (increased storms) is expected to exacerbate these issues. The estuary is gener-ally safe for bathing at high tide, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Loss of high value saltmarsh habitat** caused by small historical reclamations and causeways. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).

Other lesser stressors include; a modified terrestrial margin, margin encroachment (wildlife disturbance, predator introductions, habitat loss), weeds and invasive species (e.g. Pacific oyster, iceplant, gorse), and boat maintenance.



Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment source "hot spots" (5 yearly).
Moderate disease risk.	Model catchment SS loads with BMP's in place.
Habitat loss.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.
Climate change.	

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

WAITAPU ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS

High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(white)

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES (HUMAN USES; ECOL. VALUES)

STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	Moderate	Moderate	Moderate	Moderate		Moderate		Moderate						Moderate	Moderate		Moderate	Moderate
Nutrients/Eutrophication	Low	Low	Low	Low		Low		Moderate						Low	Low			Low
Pathogens	Moderate	Moderate						Moderate	Moderate		Moderate							
Toxicants	Low							Low										Low
Climate Change - Sea Level Rise	Low			Low		Low								Low	Low	Low	Low	Low
Climate Change - pH, temp	High	High	High	High	High	High												
Spills (oil)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate
Grazing of high value habitat																		
Freshwater abstraction	Low																Low	Low
Reclamation/Drainage	Moderate					Moderate	Moderate					Moderate		Moderate		Moderate		
Harvesting living resources	Low										Low							
Algal blooms (from sea)	Moderate	Moderate														Moderate	Moderate	Moderate
Seawalls, breakwaters etc	Moderate					Moderate	Moderate								Moderate			
Invasive weeds/pests	Moderate					Moderate	Moderate							Moderate				
Vehicle damage																		
Loss of vegetated terrestrial margin	Moderate						Moderate									Moderate	Moderate	Moderate
Animal/man disturbance	Low					Low	Low							Low		Low		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Chlorophyll-a in Water (Eutrophication)	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Muddiness (% soft mud) (Sedimentation)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators (D.)
Fine Sediment											Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	
Nutrients/Eutrophication	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low							
Pathogens																	Moderate
Toxicants																	
Climate Change - Sea Level Rise																	
Climate Change - pH, temp										High							
Spills (oil)																	
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation/Drainage																	
Harvesting living resources																	
Algal blooms (from sea)																	
Seawalls, breakwaters etc																	
Invasive weeds/pests																	
Vehicle damage																	
Loss of vegetated terrestrial margin																	
Animal/man disturbance																	
PRIORITY INDICATORS FOR MONITORING												Moderate					Moderate

STRESSORS	Heavy Metals (Toxins)	SVOCs	Toxic algal blooms (from sea)	Substrate (Habitat Loss)	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment											Moderate	Moderate	
Nutrients/Eutrophication													
Pathogens													
Toxicants	Low	Low									Low		
Climate Change - Sea Level Rise													
Climate Change - pH, temp											High	High	
Spills (oil)				Moderate	Moderate	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate	
Grazing of high value habitat													
Freshwater abstraction									Low		Low	Low	
Reclamation/Drainage						Moderate	Moderate	Moderate	Moderate				
Harvesting living resources												Low	
Algal blooms (from sea)			Moderate									Moderate	
Seawalls, breakwaters etc						Moderate	Moderate						
Invasive weeds/pests						Moderate	Moderate						
Vehicle damage													
Loss of vegetated terrestrial margin								Moderate					
Animal/man disturbance							Low	Low					
PRIORITY INDICATORS FOR MONITORING				Moderate	Moderate	Moderate	Moderate				High	High	

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Sedimentation rate monitoring annually.
- Shellfish disease risk monitoring.
- Map catchment sediment and FC source "hot spots" 5 yearly.
- Model catchment SS and FC loads with BMP's in place.
- Monitor input FC and SS loads.

OVERALL VULNERABILITY RATING - WAITAPU ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Muddiness, disease risk, climate change, historical reclamation.

ONAHAU ESTUARY

Estuary Type/Area	Tidal Lagoon-32ha
Intertidal/Subtidal	30ha/2ha
Catchment	22km^2
FW Inf ow	Mean annual 1.3m^3.s^{-1}
Saltmarsh, Seagrass	19ha, 0ha
Soft Mud	1ha
Macroalgae	0ha
Dairy Cows	455
SS Loading	1.1kt/yr
Nitrogen Loading	26t/yr
Faecal C. Loading	0.84 x 10^{15}/yr
Landuse: 63% native forest, 2% exotic forest, 33% high producing pasture, 1% low producing pasture.	
Geology: sedimentary rocks and granite.	
Human Use	Moderate
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
OVERALL VULNERABILITY	
Low-Moderate	

Onahau Estuary is a small (32ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin, a small tidal arm, and a very large area (19ha, 60%) in saltmarsh, that merges into freshwater wetland at the head of the estuary. A fringe of manuka surrounds much of the estuary, and much of the estuary catchment is regenerating native forest (63%), with intensive pastoral use at 33%. It has a sandspit which migrates and changes shape and is largely unvegetated. Over the last 5 years or so the spit has migrated approximately 120m landward, shortened in length by ~200m, lost 0.3ha of vegetation (scrub) to erosion, and reduced in overall area by ~80%.

Uses and Values. Moderate use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Evidence of early Maori occupation is found throughout the area.

Ecological Values. Ecologically, habitat diversity is high and includes unvegetated tidal flats, saltmarsh, and herbfields. The inlet is recognised as a valuable nursery area for marine and freshwater fish, a shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse in catchment. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.
- **Eutrophication**. Areal nitrogen load to estuary exceeds recommended guideline of <50mgN/m^2/d.
- **Erosion** of sandspit and adjacent beach margins.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not encouraged.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Moderate disease risk.	Map catchment FC source "hot spots" (5 yearly).
Margin loss.	Model catchment FC loads with BMP's in place.
Climate change.	Estuary habitat mapping (10 yearly).
Erosion of sand spit.	Macroalgal mapping (5 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

ONAHAU ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	VL

(Empty cells = Very Low)

STRESSORS	STRESSOR	STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES: HUMAN USES					ECOL. VALUES				
	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	M	M	M	M	M	M		M	M	M	M			M	M	M	M	M
Nutrients/Eutrophication	L	L	L	L		L		L						L	L			L
Pathogens	M	M						M	M		M							
Toxicants	L							L										L
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H												
Spills (oil)	M	M	M	M	M	M		M	M	M	M	M		M	M	M	M	M
Grazing of high value habitat	VL																	
Freshwater abstraction	L																L	L
Reclamation/Drainage	M					M	M					M		M		M		
Harvesting living resources	M										M							
Algal blooms (from sea)	M	M														M	M	M
Seawalls, breakwaters etc	M					M	M							M				
Invasive weeds/pests	M					M	M							M				
Vehicle damage	VL																	
Loss of vegetated terrestrial margin	M						M									M	M	M
Animal/man disturbance	M					M	M							M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)
Fine Sediment											M	M								
Nutrients/Eutrophication	L	M	L	L	L	M	L	L	L	L										
Pathogens																	M			
Toxicants																		L	L	
Climate Change - Sea Level Rise																				
Climate Change - pH, temp										H										
Spills (oil)																				
Grazing of high value habitat																				
Freshwater abstraction																				
Reclamation/Drainage																				
Harvesting living resources																				
Algal blooms (from sea)																				M
Seawalls, breakwaters etc																				
Invasive weeds/pests																				
Vehicle damage																				
Loss of vegetated terrestrial margin																				
Animal/man disturbance																				
PRIORITY INDICATORS FOR MONITORING		H									M	M					M			

STRESSORS	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	M	M	M					M	M	
Nutrients/Eutrophication										
Pathogens										
Toxicants								L		
Climate Change - Sea Level Rise										
Climate Change - pH, temp								H	H	
Spills (oil)	M	M	M		M	M	M	M	M	
Grazing of high value habitat										
Freshwater abstraction						L		L	L	
Reclamation/Drainage			M	M	M	M				
Harvesting living resources									M	
Algal blooms (from sea)									M	
Seawalls, breakwaters etc			M	M						
Invasive weeds/pests			M	M						
Vehicle damage										
Loss of vegetated terrestrial margin					M					
Animal/man disturbance				M	M					
PRIORITY INDICATORS FOR MONITORING	M	M	M	M	M	M		M	M	

OVERALL VULNERABILITY RATING - ONAHAU ESTUARY

Human Use	Moderate
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Low-Moderate
KEY ISSUES	Disease risk, climate change, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Macroalgal mapping 5 yearly.
- Map catchment FC source “hot spots” 5 yearly.
- Model catchment FC loads with BMP’s in place.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

Golden Bay has a number of very small tidal river estuaries and intermittently closed/open lagoons (ICOLs). Most are narrow, shallow and generally well-flushed. All have low tidal influence and little high value saltmarsh, shellfish or seagrass habitat. However, the mouths of such estuaries are expected to periodically constrict or close due to high seas. At such times they can become poorly flushed and water quality may deteriorate, particularly those with developed catchments where runoff of fine sediment, faecal bacteria and nutrients is elevated.

PUREMAHAIA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.1ha). Mouth generally open but potential to be constricted. Mean depth 0.5m (max 1.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in some areas. Floodgate present. Catchment - native forest (56%) and intensive pasture use (43%). 690 dairy cows in the 4km^2 catchment. Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin has been fenced and planted with trees and shrubs. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse and exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

BATTERY ROAD ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.3ha). Mouth always open but potential to be constricted. Mean depth 0.5m (max 1.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in some areas. Catchment (2km^2) dominated by intensive pasture use (96%) some of which is used for dairying. Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, and seagrass) but valued for fish and invertebrates. Saltmarsh (0.2ha) limited due to historical drainage and reclamation. Terrestrial margin modified by drainage and roading. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse and exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

GRANTS ROAD ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, intermittently closed/open lagoon/lake (ICOLL) estuary (0.2ha). Mouth mostly closed. Mean depth 0.5m (max 1.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in places. Stratified with low bottom dissolved oxygen and high salinity. Catchment (0.5km^2) - intensive pasture use (100%), mainly dairying. Low human use but valued for scenic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse which is exacerbated due to the mouth being predominantly closed.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

PARIWHAKAOHO ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.1ha). Mouth open with only limited potential to be constricted. Mean depth 0.5m (max 1.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in some areas. Catchment - native forest (77%) and intensive pasture use (17%). 420 dairy cows in the 15km^2 catchment. Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin fenced for grazing, and dominated by exotic trees and weeds. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse but mitigated by the low likelihood of the mouth being blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITES:

PUREMAHAIA, BATTERY ROAD, GRANTS ROAD, PARIWHAKAOHO
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	
Moderate	
Low	
Very Low	

STRESSORS	STRESSOR	STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES: HUMAN USES					ECOL. VALUES				
	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	Moderate	Moderate	Moderate	Moderate				Moderate									Moderate	Moderate
Nutrients/Eutrophication	Moderate	Moderate	Moderate	Moderate				Moderate									Moderate	Moderate
Pathogens	Moderate	Moderate						Moderate	Moderate									
Toxicants																		
Climate Change - Sea Level Rise	Low			Low		Low								Low	Low	Low	Low	Low
Climate Change - pH, temp	Low	Low	Low	Low	Low	Low												
Spills (oil)	Low	Low	Low	Low	Low	Low		Low	Low	Low	Low	Low		Low	Low	Low	Low	Low
Grazing of high value habitat																		
Freshwater abstraction	Low																Low	Low
Reclamation/Drainage	Low					Low	Low					Low		Low		Low		
Harvesting living resources	Low										Low							
Algal blooms (from sea)	Low	Low														Low	Low	Low
Seawalls, breakwaters etc																		
Invasive weeds/pests	Low					Low	Low							Low				
Vehicle damage																		
Loss of vegetated terrestrial margin	Low						Low									Low	Low	Low
Animal/man disturbance	Low					Low	Low							Low		Low		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD
Fine Sediment											Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Nutrients/Eutrophication	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate						
Pathogens																
Toxicants																
Climate Change - Sea Level Rise																
Climate Change - pH, temp																
Spills (oil)																
Grazing of high value habitat																
Freshwater abstraction																
Reclamation/Drainage																
Harvesting living resources																
Algal blooms (from sea)																
Seawalls, breakwaters etc																
Invasive weeds/pests																
Vehicle damage																
Loss of vegetated terrestrial margin																
Animal/man disturbance																
PRIORITY INDICATORS FOR MONITORING				Moderate	Moderate						Moderate					

STRESSORS	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment												Moderate		
Nutrients/Eutrophication												Moderate		
Pathogens	Moderate													
Toxicants														
Climate Change - Sea Level Rise														
Climate Change - pH, temp												Low	Low	
Spills (oil)					Low	Low	Low		Low	Low	Low	Low	Low	
Grazing of high value habitat														
Freshwater abstraction										Low		Low	Low	
Reclamation/Drainage							Low	Low	Low	Low				
Harvesting living resources													Low	
Algal blooms (from sea)				Low									Low	
Seawalls, breakwaters etc														
Invasive weeds/pests							Low	Low						
Vehicle damage														
Loss of vegetated terrestrial margin									Low					
Animal/man disturbance								Low	Low					
PRIORITY INDICATORS FOR MONITORING	Moderate													

OVERALL VULNERABILITY RATING - Puremahaia, Battery Road, Grants Road and Pariwhakaoho Estuaries

Human Use		Low
Ecological Value		Low
Overall Stressor Influence		Moderate
OVERALL VULNERABILITY		Low-Moderate
KEY ISSUES	Eutrophication, disease risk (bathing), muddiness.	

MONITORING RECOMMENDATIONS	
	• Broad scale habitat mapping every 10 years. • DO, % soft mud on bed, RPD when broad scale mapping.

ONEKAKA ESTUARY

Estuary Type/Area	Tidal Lagoon/23ha
Intertidal/Subtidal	21ha/2ha
Catchment	17km^2
FW Inf ow	Mean annual 0.65m^3.s^{-1}
Saltmarsh, Seagrass	5ha, 0ha
Soft Mud	0ha
Macroalgae	0ha
Dairy Cows	720
SS Loading	7.4kt/yr
Nitrogen Loading	18t/yr
Faecal C. Loading	0.7 x 10^{15}/yr
Landuse: 64% native forest, 4% exotic forest, 32% high producing pasture, 0% low producing pasture.	
Geology: mudstones and calcareous siltstones.	
Human Use	Moderate
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Photo: Google Earth

Onekaka Estuary is a small (23ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin, a small tidal arm near the mouth, and 5ha of saltmarsh. Gravels and cobbles are present at the inlet and upper estuary areas, but the majority of the estuary is firm muddy sands. A narrow fringe of bush surrounds much of the estuary and is flanked by pasture. It has small sandspits at the estuary entrance. Much of the estuary catchment is regenerating native forest (64%), with intensive pastoral use at 32%.

Uses and Values. Moderate use, mainly by locals. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Evidence of early Maori occupation is found throughout the area. Rich iron ore deposits attracted much attention in the early 1900's.

Ecological Values. Ecologically, habitat diversity is high and includes unvegetated tidal flats, saltmarsh, shellfish beds and herbfields. The inlet is recognised as a valuable nursery area for marine and freshwater fish (with diverse and rare freshwater fish communities), a shellfish resource, and is very important for birdlife. Land along the northern estuary shore has been modified by roading and an associated small causeway crosses the estuary near the northern spit. Excessive growths of green algae in the upper estuary indicate moderate nutrient enrichment.

Issues and Stressors.

- **Moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse in catchment. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.
- **Localised eutrophication** (algal blooms) in upper estuary at times. Areal nitrogen load to estuary exceeds recommended guideline of <50mgN/m^2/d.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not encouraged.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Moderate disease risk.	Map catchment FC and nutrient source "hot spots" (5 yearly).
Localised eutrophication.	Model catchment FC and nutrient loads with BMP's in place.
Margin loss.	Estuary habitat mapping (10 yearly).
Climate change.	Macroalgal mapping (5 yearly).

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

ONEKAKA ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	(blank)

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	M	M	M	M	M	M		M	M	M	M			M	M	M	M	M
Nutrients/Eutrophication	M	L	L	L		L		M						L	L			L
Pathogens	M	M						M	M		M							
Toxicants	L							L										L
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	H	H	H	H	H	H												
Spills (oil)	M	M	M	M	M	M		M	M	M	M	M		M	M	M	M	M
Grazing of high value habitat																		
Freshwater abstraction	L																L	L
Reclamation/Drainage	M					M	M					M		M		M		
Harvesting living resources	M										M							
Algal blooms (from sea)	M	M														M	M	M
Seawalls, breakwaters etc	M					M	M							M				
Invasive weeds/pests	M					M	M							M				
Vehicle damage																		
Loss of vegetated terrestrial margin	M						M									M	M	M
Animal/man disturbance	M					M	M							M		M		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	EUTROPHICATION: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	SEDIMENTATION: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	D.: Faecal Indicators
Fine Sediment											M	M					
Nutrients/Eutrophication	L	M	L	L	L	M	L	L	L	L							
Pathogens																	M
Toxicants																	
Climate Change - Sea Level Rise																	
Climate Change - pH, temp										H							
Spills (oil)																	
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation/Drainage																	
Harvesting living resources																	
Algal blooms (from sea)																	
Seawalls, breakwaters etc																	
Invasive weeds/pests																	
Vehicle damage																	
Loss of vegetated terrestrial margin																	
Animal/man disturbance																	
PRIORITY INDICATORS FOR MONITORING		H									M	M					M

STRESSORS	TOXINS: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	HABITAT LOSS: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment				M	M	M					M	M	
Nutrients/Eutrophication													
Pathogens													
Toxicants	L	L									L		
Climate Change - Sea Level Rise													
Climate Change - pH, temp											H	H	
Spills (oil)				M	M	M		M	M	M	M	M	
Grazing of high value habitat													
Freshwater abstraction									L		L	L	
Reclamation/Drainage						M	M	M	M				
Harvesting living resources												M	
Algal blooms (from sea)			M									M	
Seawalls, breakwaters etc						M	M						
Invasive weeds/pests						M	M						
Vehicle damage													
Loss of vegetated terrestrial margin								M					
Animal/man disturbance							M	M					
PRIORITY INDICATORS FOR MONITORING				M	M	M	M	M	M		H	H	

OVERALL VULNERABILITY RATING - ONEKAKA ESTUARY

Human Use	Moderate
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Low-Moderate
KEY ISSUES	Disease risk, local eutrophication, climate change, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Macroalgal mapping 5 yearly.
- Map catchment FC and nutrient source "hot spots" 5 yearly.
- Model catchment FC and nutrient loads with BMP's in place.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

Between Onekaka and Parapara, there are two small tidal river estuaries. These estuaries are narrow, shallow and generally well-flushed. Both have low tidal influence and little high value shellfish or seagrass habitat. Extensive areas of saltmarsh flank the Little Kaituna channel. However, the mouths of such estuaries are expected to periodically constrict or close due to high seas. At such times, they can become poorly flushed and water quality may deteriorate, particularly those with developed catchments where runoff of fine sediment, faecal bacteria and nutrients is elevated.

LITTLE KAITUNA ESTUARY

Human Use	Low
Ecological Value	High
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (6ha). Mouth generally open but potential to be constricted or closed. Mean depth 0.5m (max 1.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in places. Stratified with low bottom dissolved oxygen and high salinity. Saltmarsh very extensive (92% of estuary) and protected under a QEII covenant. Catchment - native forest (39%) and intensive pasture use (49%). 120 dairy cows in the 2km^2 catchment.

Human Use. Low human use but valued for whitebaiting and aesthetic beauty.

Ecological Values. Ecological value high (presence of high value saltmarsh and valued for fish and invertebrates. Terrestrial margin has been fenced and the majority in trees and shrubs.

Issues and Stressors.

- The main issue are intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse and exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

TUKURUA ESTUARY

Human Use	Low
Ecological Value	Moderate
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	High
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.1ha). Mouth usually open but potential to be constricted. Mean depth 0.5m. Clear water, mud, cobble, gravel bed. Sediments well-oxygenated. Catchment - native forest (83%) and intensive pasture use (10%). 50 dairy cows in catchment.

Human Use. High human use for swimming in peak holiday periods, and valued for whitebaiting and aesthetic beauty.

Ecological Values. Ecological value moderate (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish, invertebrates and bush fringing vegetation. Terrestrial margin has been fenced and is mainly bush-clad.

Issues and Stressors.

- The main issues are intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse, and/or septic tanks. Exacerbated if mouth is blocked or constricted.

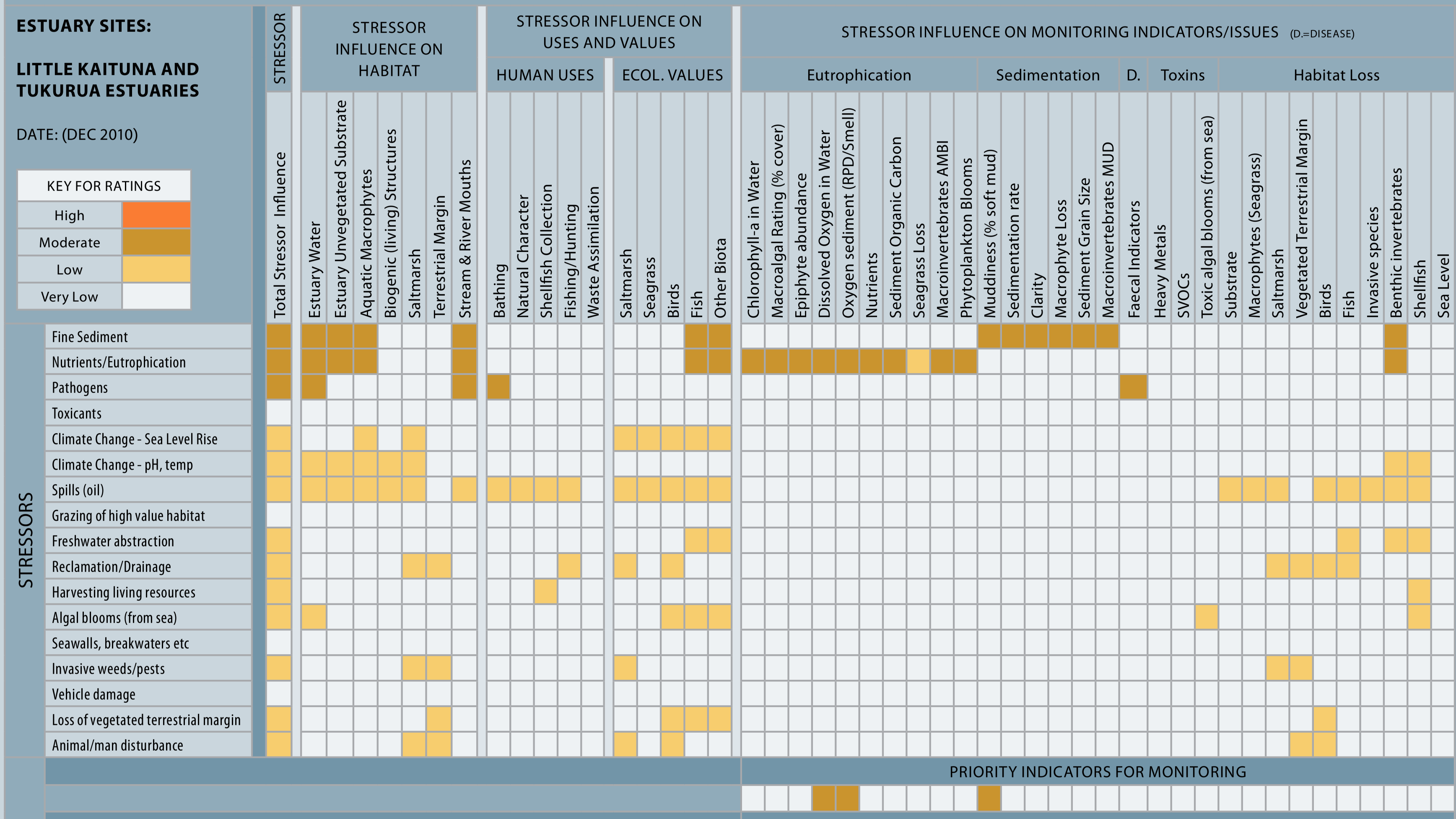
Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITES:

LITTLE KAITUNA AND TUKURUA ESTUARIES

DATE: (DEC 2010)



OVERALL VULNERABILITY RATING - Little Kaituna and Tukurua Estuaries

Human Use	Low
Ecological Value	Moderate-High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Eutrophication, disease risk (bathing), muddiness.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • DO, % soft mud on bed, RPD when broad scale mapping.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

PARAPARA ESTUARY

Estuary Type/Area	Tidal Lagoon/195ha
Intertidal/Subtidal	181ha/14ha
Catchment	42km^2
FW Inf ow	Mean annual 1.8m^3.s^{-1}
Saltmarsh, Seagrass	42ha, 1.1ha
Soft Mud	48ha
Macroalgae	0ha
Dairy Cows	?
SS Loading	17.8 kt/yr
Nitrogen Loading	14.8 t/yr
Faecal C. Loading	0.05 x 10^{15}/yr
Landuse: 96% native forest, 2% exotic forest, 1% high producing pasture	
Geology: mudstones and calcareous siltstones.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	High
Eutrophication	Low
Disease Risk	Moderate-High
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Photo: Google Earth

Parapara Estuary is a moderate-sized (195ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin and extensive saltmarsh and seagrass beds. A large embayment (22ha) is cut off from the main body of the estuary by a causeway (State Highway 60). The catchment is mostly undeveloped and dominated by native forest (96%) and exotic forestry (2%). Developed pasture is only 1% of the catchment. Sandspits to the north and south enclose the inlet from the open sea. On the northwest shore a limestone band is exposed and freshwater springs bubble up through the mudflats nearby.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Parapara has a small decrepit wharf that is used occasionally.

Ecological Values. Ecologically, habitat diversity is high with much of its intertidal vegetation intact, extensive shellfish beds, large areas of saltmarsh (21% of estuary), some seagrass (0.6% of estuary), rocky platforms and sand dune. However, the estuary is excessively muddy (25% soft mud), the southern end has been modified, and a causeway and roading cuts through the western area. The lagoon area upstream of the causeway is poorly flushed, through inadequate culvert drains, and consequently has excessive sedimentation and degraded habitat. The estuary is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife. Two potentially invasive mangroves trees have been planted in the Milnthorpe arm at the north of the estuary.

Issues and Stressors.

- **Excessive muddiness and elevated disease risk** (bathing and shellfish) caused primarily by catchment runoff (possibly historical). Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing at high tide, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Restricted flushing and sedimentation** caused by historical causeway developments.
- **Sea level rise.** To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant, mangroves).

Issues	Monitoring/Investigations
Excessive muddiness.	Map catchment sediment source "hot spots" (5 yearly).
Elevated disease risk.	Model catchment SS loads with BMP's in place.
Restricted flushing.	Estuary habitat mapping (10 yearly).
Climate change.	Sedimentation rate (plates) annually.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

PARAPARA ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS
High (H)
Moderate (M)
Low (L)
Very Low (VL)

STRESSOR / STRESSOR INFLUENCE ON HABITAT

STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths
Fine Sediment	H	H	H	H	H	H	VL	H
Nutrients/Eutrophication	L	L	L	L	VL	L	VL	L
Pathogens	M	M	VL	VL	VL	VL	VL	M
Toxicants	L	VL	VL	VL	VL	VL	VL	L
Climate Change - Sea Level Rise	L	VL	VL	L	VL	L	VL	VL
Climate Change - pH, temp	H	H	H	H	H	H	VL	VL
Spills (oil)	M	M	M	M	M	M	VL	M
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	L	VL	VL	VL	VL	VL	VL	VL
Reclamation/Drainage	H	VL	VL	VL	VL	H	H	VL
Harvesting living resources	M	VL	VL	VL	VL	VL	VL	VL
Algal blooms (from sea)	M	M	VL	VL	VL	VL	VL	VL
Seawalls, breakwaters etc	L	VL	VL	VL	VL	L	L	VL
Invasive weeds/pests	M	VL	VL	VL	VL	M	M	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	L	VL	VL	VL	VL	VL	L	VL
Animal/man disturbance	M	VL	VL	VL	VL	M	M	VL

STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	H	H	H	VL	VL	H	H	H	H	H
Nutrients/Eutrophication	VL	VL	VL	VL	VL	L	L	VL	VL	L
Pathogens	M	VL	M	VL	VL	VL	VL	VL	VL	VL
Toxicants	VL	VL	VL	VL	VL	VL	VL	VL	VL	L
Climate Change - Sea Level Rise	VL	VL	VL	VL	VL	L	L	L	L	L
Climate Change - pH, temp	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Spills (oil)	M	M	M	M	VL	M	M	M	M	M
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	VL	VL	VL	VL	VL	VL	VL	VL	L	L
Reclamation/Drainage	VL	VL	VL	H	VL	H	VL	H	VL	VL
Harvesting living resources	VL	VL	M	VL	VL	VL	VL	VL	VL	VL
Algal blooms (from sea)	VL	VL	VL	VL	VL	VL	VL	M	M	M
Seawalls, breakwaters etc	VL	VL	VL	VL	VL	L	VL	VL	VL	VL
Invasive weeds/pests	VL	VL	VL	VL	VL	M	VL	VL	VL	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	VL	VL	VL	VL	VL	VL	VL	L	L	L
Animal/man disturbance	VL	VL	VL	VL	VL	M	VL	M	VL	VL

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD
Fine Sediment	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	H	H	H	H	H
Nutrients/Eutrophication	L	L	L	L	L	L	L	L	L	L	VL	VL	VL	VL	VL	VL
Pathogens	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Toxicants	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Climate Change - Sea Level Rise	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Climate Change - pH, temp	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	VL	VL	VL	VL	VL	VL
Spills (oil)	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Reclamation/Drainage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Harvesting living resources	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Algal blooms (from sea)	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Seawalls, breakwaters etc	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Invasive weeds/pests	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Animal/man disturbance	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
PRIORITY INDICATORS FOR MONITORING											H	H				

STRESSORS	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	VL	VL	VL	VL	H	H	H	VL	VL	VL	VL	H	H	VL
Nutrients/Eutrophication	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Pathogens	M	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Toxicants	VL	L	L	VL	VL	VL	VL	VL	VL	VL	VL	L	VL	VL
Climate Change - Sea Level Rise	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Climate Change - pH, temp	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	H	H	VL
Spills (oil)	VL	VL	VL	VL	M	M	M	VL	M	M	M	M	M	VL
Grazing of high value habitat	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Freshwater abstraction	VL	VL	VL	VL	VL	VL	VL	VL	VL	L	VL	L	L	VL
Reclamation/Drainage	VL	VL	VL	VL	VL	VL	H	H	H	H	VL	VL	VL	VL
Harvesting living resources	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	M	VL
Algal blooms (from sea)	VL	VL	VL	M	VL	VL	VL	VL	VL	VL	VL	VL	M	VL
Seawalls, breakwaters etc	VL	VL	VL	VL	VL	VL	L	L	VL	VL	VL	VL	VL	VL
Invasive weeds/pests	VL	VL	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL	VL
Vehicle damage	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Loss of vegetated terrestrial margin	VL	VL	VL	VL	VL	VL	VL	VL	L	VL	VL	VL	VL	VL
Animal/man disturbance	VL	VL	VL	VL	VL	VL	VL	M	M	VL	VL	VL	VL	VL
PRIORITY INDICATORS FOR MONITORING					H	H	H	H	H	H				

OVERALL VULNERABILITY RATING - PARAPARA ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Sedimentation, disease risk, climate change, causeway restricting flushing.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Sedimentation rate monitoring annually.
- Map catchment sediment source "hot spots" 5 yearly.
- Model catchment SS loads with BMP's in place.

RUATANIWHA INLET

Estuary Type/Area	Tidal River with lagoon and delta/864ha
Intertidal	727ha
Catchment	$711km^2$
FW Inf ow	Mean annual $108m^3.s^{-1}$
Saltmarsh, Seagrass	121ha, 12ha
Soft Mud	89ha
Macroalgae	5ha
Dairy Cows	13300
SS Loading	336 kt/yr
Nitrogen Loading	483 t/yr
Faecal C. Loading	11×10^{15}/yr
Landuse: 78% native forest, 1% exotic forest, 12% high producing pasture	
Geology: mixed: granites, greywacke, sandstones and limestones.	
Human Use	High
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	High
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	

Ruataniwha Inlet is a moderate/large-sized (864ha), shallow, well-flushed, sea-water-dominated, tidal river type estuary with an associated extensive lagoon and delta. It has one tidal opening, one main basin and extensive saltmarsh and seagrass beds. 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 $108m^3.s^{-1}$). 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 catch-ment). The valley floor is relatively flat and is developed for agriculture (primarily dairying) - 12% of catchment area. Because the inlet is well flushed, 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.

Uses and Values. High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, duckshooting, fishing, boating, walking, and scientific appeal. A small commercial wharf is located at Collingwood.

Ecological Values. Ecologically, habitat diversity is high with much of its intertidal vegetation intact, extensive shellfish beds, large areas of saltmarsh (18% of estu-ary), some seagrass (1.7% of estuary), rocky platforms and sand dune. However, the estuary is excessively muddy (13% soft mud), and the natural vegetated margin has been mostly lost and developed for pasture (although some coastal forest exists along the western margin), and large parts of the estuary are bordered by roading (~5.5km). Also, since 1950 at least 50ha of saltmarsh has been drained and converted to pasture. The inlet is recognised 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).

Issues and Stressors.

- **Excessive disease risk** (bathing and shellfish) caused primarily by runoff from the intensively grazed lower catchment. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing at high tide, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Reduced flushing and sedimentation** caused by historical reclamations of saltmarsh areas.
- **Sea level rise.** To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Lesser stressors include; the presence of seawalls (road verge, northern and southern estuary), stormwater from Collingwood, and invasion of weeds and pests (e.g. Spartina, ice plant, 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.

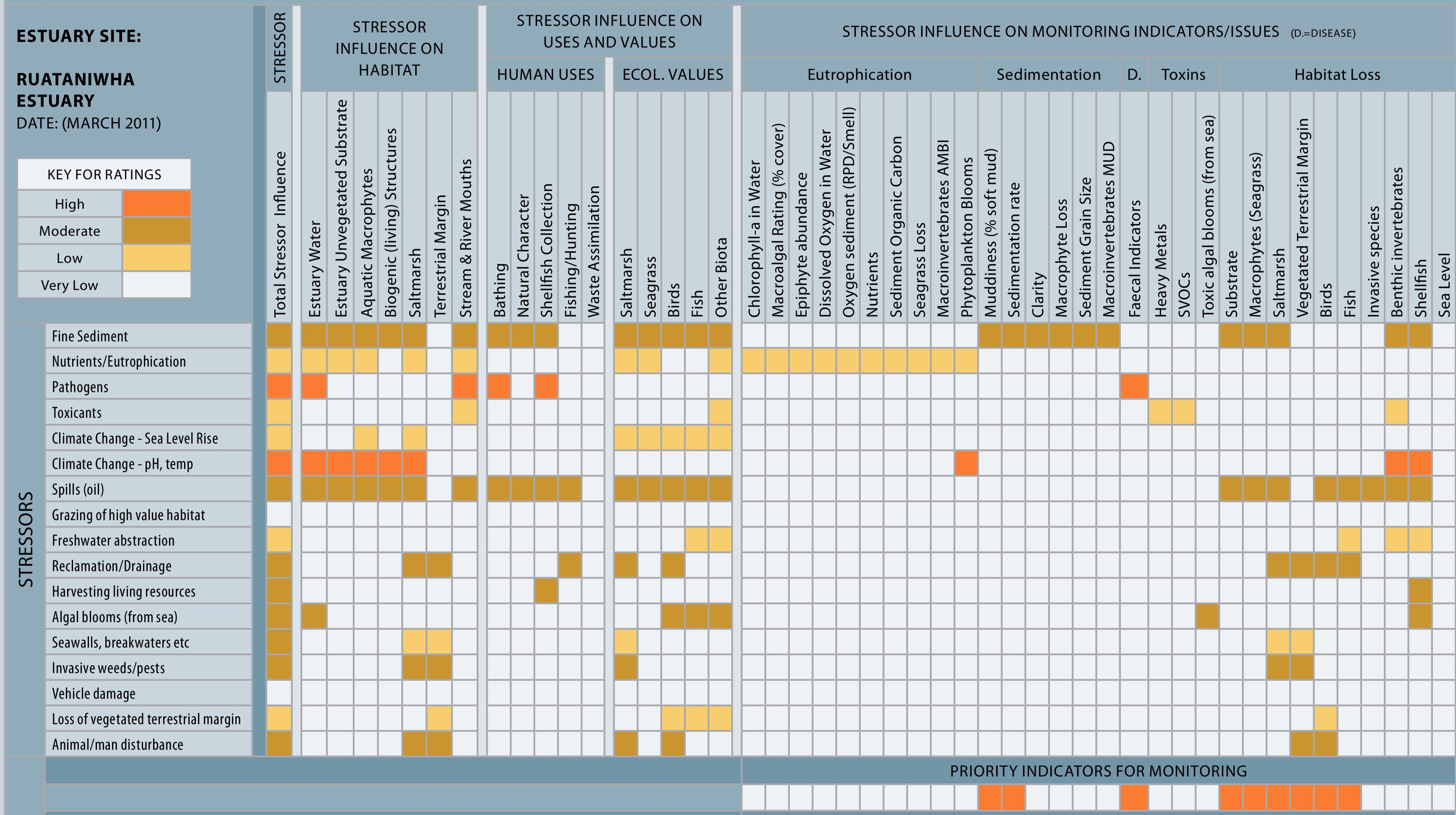
Issues	Monitoring/Investigations
Excessive disease risk.	Map catchment FC source “hot spots” (5 yearly).
Restricted flushing.	Model catchment FC loads with BMP’s in place.
Climate change.	Estuary habitat mapping (10 yearly).
	Fine scale monitoring (5 yearly after baseline).
	Sedimentation rate (plates) annually.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

RUATANIWHA ESTUARY

DATE: (MARCH 2011)



OVERALL VULNERABILITY RATING - RUATANIWHA ESTUARY

Human Use	High
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Moderate
KEY ISSUES	Disease risk, climate change, reclamations.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Fine scale monitoring 5 yearly.
- Sedimentation rate monitoring annually.
- Map catchment FC source "hot spots" 5 yearly.
- Model catchment FC loads with BMP's in place.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

WAIKATO ESTUARY

Estuary Type/Area	Tidal Lagoon/19ha
Intertidal/Subtidal	19ha/0ha
Catchment	$2km^2$
FW Inf ow	Mean annual $0.05m^3.s^{-1}$
Saltmarsh, Seagrass	11ha, 0ha
Soft Mud	0ha
Macroalgae	0ha
Dairy Cows	0
SS Loading	1.2kt/yr
Nitrogen Loading	1t/yr
Faecal C. Loading	0.043×10^{15}/yr
Landuse: 72% native forest, 2% exotic forest, 26% high producing pasture, 0% lo-producing pasture.	
Geology: sandstones, mudstones, schist.	
Human Use	Moderate
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
OVERALL VULNERABILITY	
Low-Moderate	

Waikato Estuary is a small (19ha), elongate, shallow, seawater-dominated, tidal lagoon type estuary with one tidal opening. The estuary has one well-flushed main basin to the north, a smaller, more poorly flushed arm to the south, and a large area of saltmarsh in both arms. Sandspits originate at the northern and southern ends of the estuary sheltering an area of mixed shell and sand, changing to mud at each end of the estuary. Both spits have been modified by housing, particularly the northern spit. The terrestrial margin is dominated by pastoral landuse and the spits by bush and weeds. Much of the estuary catchment is regenerating native forest (72%), with intensive pastoral use at 26%. A road extends centrally along the northern spit providing access to the beach and baches. A hard rock seawall exists along the outer edge of the northern spit and many other seawalls of various composition exist on the inner edge.

Uses and Values. Moderate use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. Evidence of early Maori occupation is found throughout the area.

Ecological Values. Ecologically, habitat diversity is high and includes unvegetated tidal flats, shellbank (unusual for Golden Bay), saltmarsh, and herbfields. Mature and regenerating coastal totara forest is also found on the northern spit. The inlet is recognised as a valuable nursery area for marine and freshwater fish, a shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Elevated disease risk** (bathing and shellfish) caused primarily by adjoining catchment runoff from intensive landuse. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.
- **Erosion** of sandspit and adjacent beach margins, and subsequent armouring.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, gorse, iceplant).

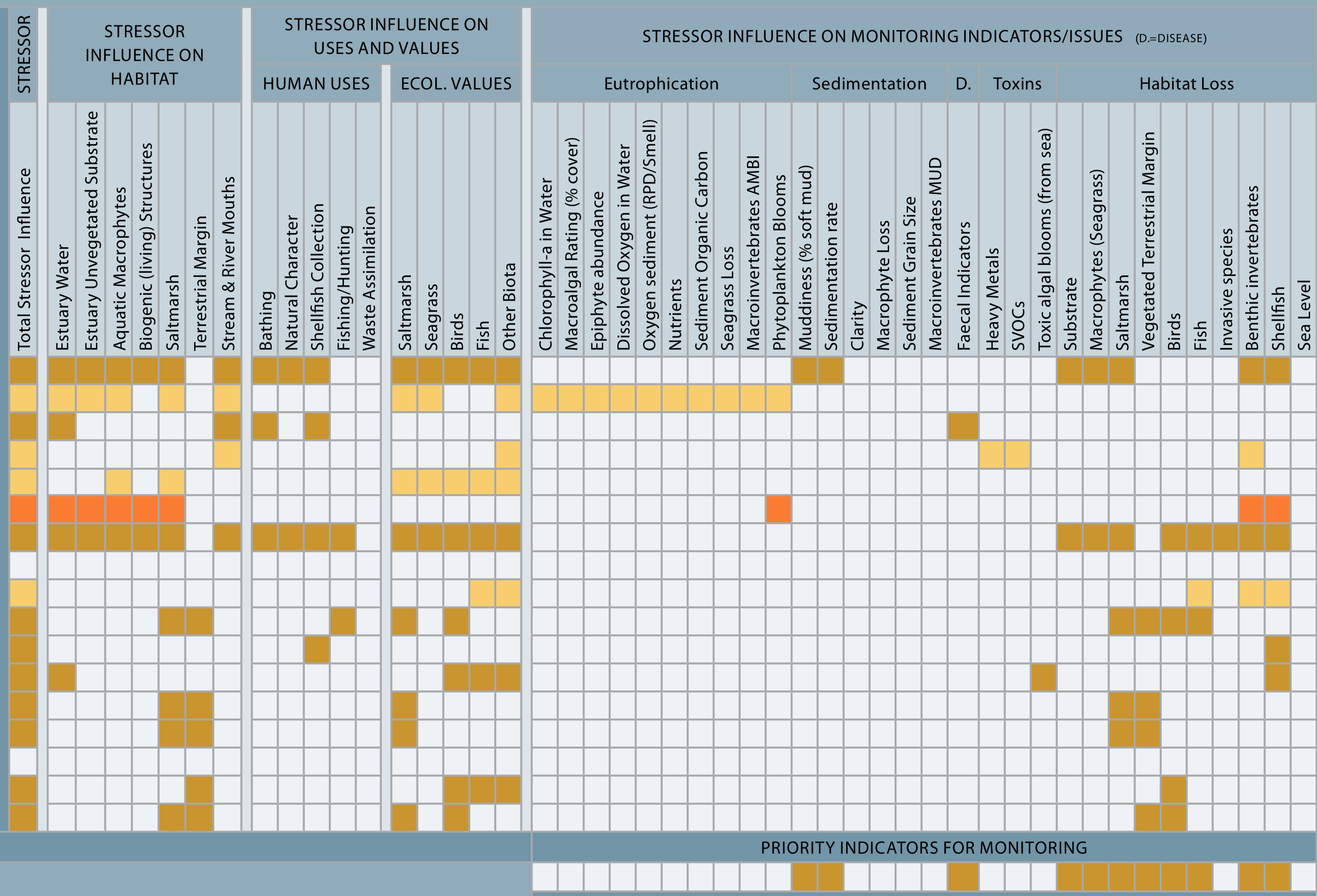
Issues	Monitoring/Investigations
Elevated disease risk.	Map catchment FC source "hot spots" (5 yearly).
Margin Loss.	Model catchment FC loads with BMP's in place.
Climate change.	Estuary habitat mapping (10 yearly).
Erosion of sand spit.	

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

WAIKATO ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	
Moderate	
Low	
Very Low	



OVERALL VULNERABILITY RATING - WAIKATO ESTUARY

Human Use	Moderate
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Low-Moderate
KEY ISSUES	Disease risk, climate change, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Map catchment FC source "hot spots" 5 yearly. • Model catchment FC loads with BMP's in place.

PAKAWAU INLET

Estuary Type/Area	Tidal Lagoon/65ha
Intertidal/Subtidal	65ha/0ha
Catchment	8km^2
FW Inf ow	Mean annual 0.15m^3.s^{-1}
Saltmarsh, Seagrass	31ha, 0.1ha
Soft Mud	10ha
Macroalgae	0ha
Dairy Cows	234
SS Loading	1.4kt/yr
Nitrogen Loading	3.3t/yr
Faecal C. Loading	0.082 x 10^{15}/yr
Landuse: 79% native forest, 11% exotic forest, 9% high producing pasture, 1% lo-producing pasture.	
Geology: sandstones, mudstones, schist.	
Human Use	Moderate
Ecological Value	High
Stressors	Moderate
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
OVERALL VULNERABILITY	
Moderate	


Photo: Google Earth


Drainage of the northern terrestrial margin.

Pakawau Inlet is a moderate-sized (65ha), shallow, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin and a large area of saltmarsh (48% of estuary). The seaward third of the estuary consists of gravel and cobbles with the remainder dominated by muddy sands. A wide band of saltmarsh extends around the western and southern edges backing into stands of manuka and raupo. A sandspit originates at the southern end and has been modified by farming and houses. The main road extends along the inner edge of the spit and a short bridge crosses the estuary at the mouth. The terrestrial margin is dominated by pastoral landuse and much of the estuary catchment is regenerating native forest (79%), exotic forest (11%) and intensive pastoral use at 9%. Recent land drainage and clearance of scrub surrounding the estuary was evident (photo lower left).

Uses and Values. Moderate use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, walking, and scientific appeal. Evidence of early Maori occupation is found throughout the area.

Ecological Values. Ecologically, habitat diversity is high and includes unvegetated tidal flats, saltmarsh, seagrass and herbfields. The lagoon area is excessively muddy (16% is soft mud). The inlet is recognised as a valuable nursery area for marine and freshwater fish, a shellfish resource, and is very important for birdlife.

Issues and Stressors.

- **Excessive muddiness and moderate disease risk** (bathing and shellfish) caused primarily by catchment runoff from intensive landuse. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing at high tide, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended.
- **Erosion** of sandspit and adjacent beach margins.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, gorse, iceplant).


Pakawau Estuary mouth.

Issues	Monitoring/Investigations
Moderate disease risk.	Map catchment FC and sediment source "hot spots" (5 yearly).
Margin Loss.	Model catchment FC and sediment loads with BMP's in place.
Climate change.	Estuary habitat mapping (10 yearly).
Muddiness.	

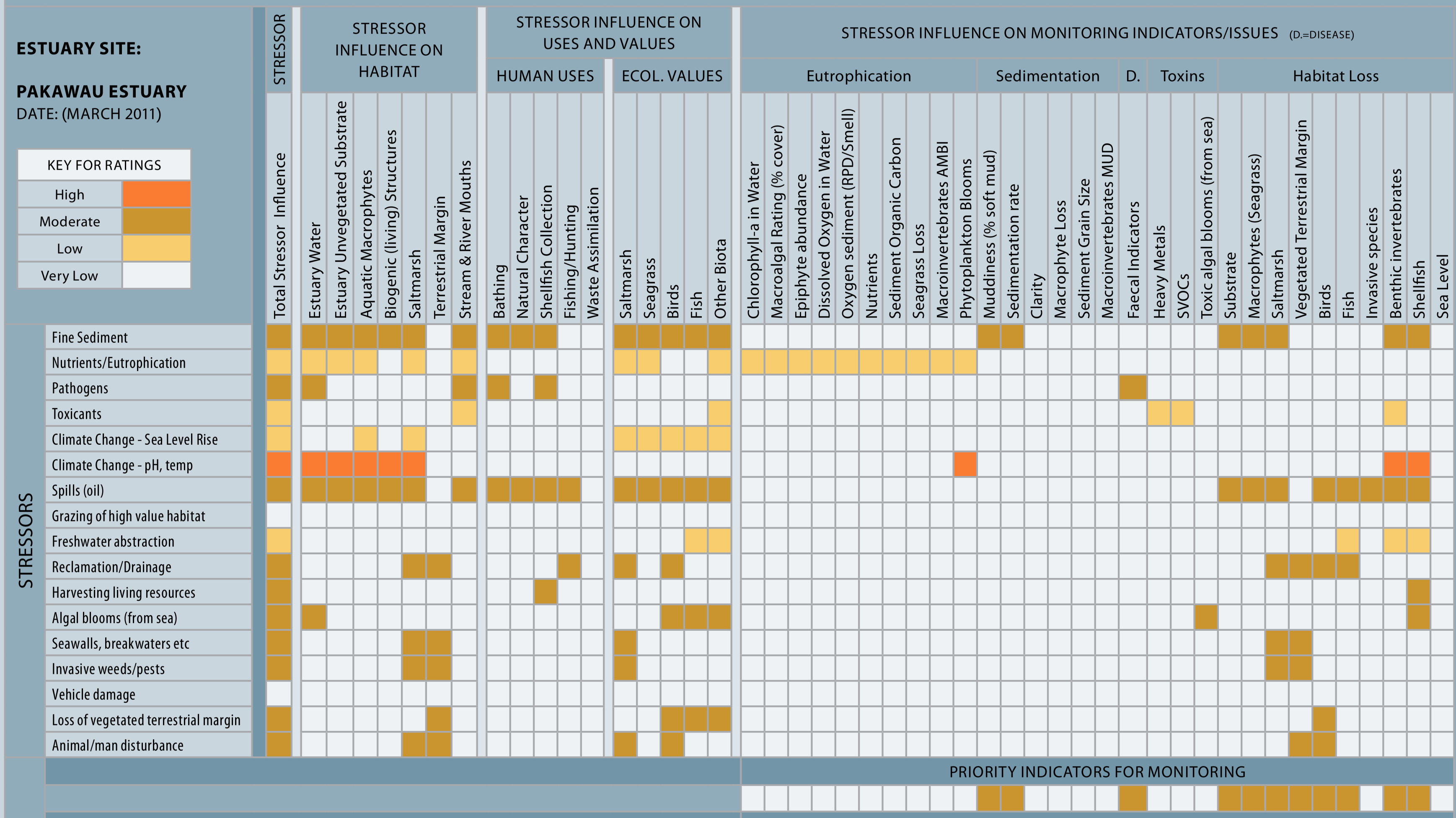
COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

PAKAWAU ESTUARY

DATE: (MARCH 2011)

KEY FOR RATINGS	
High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(pale grey)



OVERALL VULNERABILITY RATING - PAKAWAU ESTUARY

Human Use	Moderate
Ecological Value	High
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Low-Moderate
KEY ISSUES	Disease risk, muddiness, climate change, loss of natural terrestrial margin.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • Map catchment FC and sediment source "hot spots" 5 yearly. • Model catchment FC and sediment loads with BMP's in place.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

Between Pakawau and Puponga, the coastal plain narrows and gives rise to a number of small tidal river estuaries. These estuaries are narrow, shallow and generally well-flushed. All have low tidal influence and little high value saltmarsh, shellfish or seagrass habitat. However, the mouths of such estuaries are expected to periodically constrict or close due to high seas. At such times, they can become poorly flushed and water quality may deteriorate, particularly those with developed catchments where runoff of fine sediment, faecal bacteria and nutrients is elevated.

ONETAUA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (2.6ha). Mouth generally open but potential to be constricted. Mean depth 0.3m (max 0.5m). Clear water, mud, cobble, gravel bed. Sediments generally well-oxygenated. 2km^2 catchment - native forest (78%) and intensive pasture use (20%), mainly dairying. Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, and seagrass) but valued for fish and invertebrates and small area of saltmarsh (0.5ha). Terrestrial estuary margin dominated by road which separates estuary from surrounding land. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse, exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness	Estuary habitat mapping (10 yearly).

MATAKOTA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (2.4ha). Mouth generally open but potential to be constricted. Mean depth 0.3m (max 0.5m). Clear water, mud, cobble, gravel bed. Sediments anoxic in some areas. 1km^2 catchment - native forest (74%) and intensive pasture use (20%), mainly dairying. Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, and seagrass) but valued for fish and invertebrates. 1.2ha of saltmarsh present between beach dune and road. Terrestrial margin dominated by fenced pasture. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse, exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness	Estuary habitat mapping (10 yearly).

BILLY KING CREEK ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.6ha). Mouth mostly closed. Mean depth 0.5m (max 0.5m). Clear water, mud, cobble, gravel bed. Sediments generally well-oxygenated. 3km^2 catchment - native forest (89%) and intensive pasture use (11%) mostly dairying. Low human use but valued for scenic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, and seagrass) but valued for fish and invertebrates, saltmarsh (0.6ha) and adjacent delta area of coastal herbfields (3ha). Terrestrial margin is intensive pasture used for dairying. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse, exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

TAUPATA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Moderate
Eutrophication	Moderate
Disease Risk	Moderate
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Moderate

Small, tidal river estuary (0.4ha). Mouth generally open but potential to be constricted. Mean depth 0.3m (max 0.5m). Sediments generally well-oxygenated. Catchment - native forest (89%) and intensive pasture use (10%). 302 dairy cows in the 8km^2 catchment. Low human use but valued for aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates, and adjacent delta area with coastal rushland and herbfields. Terrestrial margin dominated by pasture and road which separates estuary from surrounding land. The main issue is from intermittent eutrophication, disease-risk and excessive muddiness caused by runoff from intensive pastoral landuse and exacerbated when mouth is blocked or constricted.

Issues	Monitoring
Intermittent eutrophication, disease-risk and excessive muddiness.	Estuary habitat mapping (10 yearly).

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITES:

ONETAUA, MATAKOTA, BILLY KING AND TAUPATA ESTUARIES

DATE: (MARCH 2011)

KEY FOR RATINGS	
High	
Moderate	
Low	
Very Low	

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	HUMAN USES: Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	ECOL. VALUES: Saltmarsh	Seagrass	Birds	Fish	Other Biota
Fine Sediment	M	M	M	M				M									M	M
Nutrients/Eutrophication	M	M	M	M				M									M	M
Pathogens	M	M						M	M									
Toxicants																		
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L
Climate Change - pH, temp	L	L	L	L	L	L												
Spills (oil)	L	L	L	L	L	L		L	L	L	L	L		L	L	L	L	L
Grazing of high value habitat																		
Freshwater abstraction	L																L	L
Reclamation/Drainage	L					L	L					L		L		L		
Harvesting living resources	L										L							
Algal blooms (from sea)	L	L														L	L	L
Seawalls, breakwaters etc																		
Invasive weeds/pests	L					L	L							L				
Vehicle damage																		
Loss of vegetated terrestrial margin	L						L									L	L	L
Animal/man disturbance	L					L	L							L		L		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD
Fine Sediment											M	M	M	M	M	M
Nutrients/Eutrophication	M	M	M	M	M	M	M	L	M	M						
Pathogens																
Toxicants																
Climate Change - Sea Level Rise																
Climate Change - pH, temp																
Spills (oil)																
Grazing of high value habitat																
Freshwater abstraction																
Reclamation/Drainage																
Harvesting living resources																
Algal blooms (from sea)																
Seawalls, breakwaters etc																
Invasive weeds/pests																
Vehicle damage																
Loss of vegetated terrestrial margin																
Animal/man disturbance																
PRIORITY INDICATORS FOR MONITORING				M	M						M					

STRESSORS	D.: Faecal Indicators	Toxins: Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Habitat Loss: Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment												M		
Nutrients/Eutrophication												M		
Pathogens	M													
Toxicants														
Climate Change - Sea Level Rise														
Climate Change - pH, temp												L	L	
Spills (oil)					L	L	L		L	L	L	L	L	
Grazing of high value habitat														
Freshwater abstraction										L		L	L	
Reclamation/Drainage							L	L	L	L				
Harvesting living resources													L	
Algal blooms (from sea)				L									L	
Seawalls, breakwaters etc														
Invasive weeds/pests							L	L						
Vehicle damage														
Loss of vegetated terrestrial margin									L					
Animal/man disturbance								L	L					
PRIORITY INDICATORS FOR MONITORING	M													

OVERALL VULNERABILITY RATING - Onetaua, Matakota, Billy King and Taupata Estuaries

Human Use	Low
Ecological Value	Low
Overall Stressor Influence	Moderate
OVERALL VULNERABILITY	Low-Moderate
KEY ISSUES	Eutrophication, disease risk (bathing), muddiness.

MONITORING RECOMMENDATIONS	
	• Broad scale habitat mapping every 10 years. • DO, % soft mud on bed, RPD when broad scale mapping.

5.2 GOLDEN BAY - ESTUARIES (CONTINUED)

PUPONGA INLET

Estuary Type/Area	Tidal River/33ha
Intertidal/Subtidal	32ha/1ha
Catchment	$5km^2$
FW Inf ow	Mean annual $0.2m^3.s^{-1}$
Saltmarsh, Seagrass	8ha, 15ha
Soft Mud	4ha
Macroalgae	0ha
Dairy Cows	0
SS Loading	0.3kt/yr
Nitrogen Loading	1.2t/yr
Faecal C. Loading	0.07×10^{15}/yr
Landuse: 88% native forest, 1% exotic forest,10% high producing pasture,0% lo-producing pasture.	
Geology: sandstones, mudstones.	
Human Use	Moderate
Ecological Value	High
Stressors	Low
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Moderate
Toxicity	Low
OVERALL VULNERABILITY	
Low	

Puponga Inlet is a moderate-sized (33ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary that is bordered by extensive saltmarsh and herbfield flats. It discharges through a narrow entrance to an extensive intertidal delta area dominated by seagrass. The entrance has a causeway and bridge across it (access to Farewell Spit), and a second causeway divides the southwest portion of the estuary (3ha). Sediments range from gravels and cobbles at the entrance, to muddy sand at the head, and soft muds towards the south. Much of the estuary catchment is forest (primarily native 88%), with intensive pastoral use at 10%. The estuary margin is regenerating coastal forest and manuka to the northeast, a flax/raupo swamp at the head and pasture to the west.

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

Ecological Values. Ecologically, habitat diversity is high and includes a community sequence including unvegetated tidal flats, saltmarsh, seagrass, herbfields, and native forest remnants. However, significant areas of the natural vegetated margin have been lost and the lagoon area is excessively muddy (11% is soft mud). The estuary is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife. Horse treking through the estuary is common.

Issues and Stressors.

- **Potential for excessive muddiness** if runoff from intensive landuse and exotic forestry is poorly managed. Climate change (increased storms) is expected to exacerbate these issues.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a modified terrestrial margin (particularly causeways), increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Issues	Monitoring/Investigations
Habitat Loss.	Map catchment sediment source "hot spots" (5 yearly).
Climate change.	Model catchment SS loads with BMP's in place.
Potential excessive muddiness.	Estuary habitat mapping (10 yearly), sedimentation rate (plates) annually.

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

PUPONGA ESTUARY
DATE: (MARCH 2011)

KEY FOR RATINGS	
High	(orange)
Moderate	(dark gold)
Low	(light yellow)
Very Low	(white)

STRESSORS	STRESSOR: Total Stressor Influence	HABITAT: Estuary Water	HABITAT: Estuary Unvegetated Substrate	HABITAT: Aquatic Macrophytes	HABITAT: Biogenic (living) Structures	HABITAT: Saltmarsh	HABITAT: Terrestrial Margin	HABITAT: Stream & River Mouths	HUMAN USES: Bathing	HUMAN USES: Natural Character	HUMAN USES: Shellfish Collection	HUMAN USES: Fishing/Hunting	HUMAN USES: Waste Assimilation	ECOL. VALUES: Saltmarsh	ECOL. VALUES: Seagrass	ECOL. VALUES: Birds	ECOL. VALUES: Fish	ECOL. VALUES: Other Biota
Fine Sediment	Moderate	Moderate	Moderate	Moderate		Moderate		Moderate						Moderate	Moderate		Moderate	Moderate
Nutrients/Eutrophication	Low	Low	Low	Low		Low		Low						Low	Low			Low
Pathogens	Low	Low						Low	Low		Low							
Toxicants																		
Climate Change - Sea Level Rise	Low			Low		Low								Low	Low	Low	Low	Low
Climate Change - pH, temp	High	High	High	High	High	High												
Spills (oil)	Low	Low	Low	Low	Low	Low		Low	Low	Low	Low	Low		Low	Low	Low	Low	Low
Grazing of high value habitat																		
Freshwater abstraction	Low																Low	Low
Reclamation/Drainage	Moderate					Moderate	Moderate					Moderate		Moderate		Moderate		
Harvesting living resources	Low										Low							
Algal blooms (from sea)	Low	Low														Low	Low	Low
Seawalls, breakwaters etc	Moderate					Moderate	Moderate								Moderate			
Invasive weeds/pests	Low					Low	Low							Low				
Vehicle damage																		
Loss of vegetated terrestrial margin	Moderate						Moderate									Moderate	Moderate	Moderate
Animal/man disturbance	Low					Low	Low							Low		Low		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Eutrophication: Chlorophyll-a in Water	Eutrophication: Macroalgal Rating (% cover)	Eutrophication: Epiphyte abundance	Eutrophication: Dissolved Oxygen in Water	Eutrophication: Oxygen sediment (RPD/Smell)	Eutrophication: Nutrients	Eutrophication: Sediment Organic Carbon	Eutrophication: Seagrass Loss	Eutrophication: Macroinvertebrates AMBI	Eutrophication: Phytoplankton Blooms	Sedimentation: Muddiness (% soft mud)	Sedimentation: Sedimentation rate	Sedimentation: Clarity	Sedimentation: Macrophyte Loss	Sedimentation: Sediment Grain Size	Sedimentation: Macroinvertebrates MUD
Fine Sediment											Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Nutrients/Eutrophication	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low						
Pathogens																
Toxicants																
Climate Change - Sea Level Rise																
Climate Change - pH, temp																
Spills (oil)																
Grazing of high value habitat																
Freshwater abstraction																
Reclamation/Drainage																
Harvesting living resources																
Algal blooms (from sea)																
Seawalls, breakwaters etc																
Invasive weeds/pests																
Vehicle damage																
Loss of vegetated terrestrial margin																
Animal/man disturbance																
PRIORITY INDICATORS FOR MONITORING												Moderate				

STRESSORS	D.: Faecal Indicators	Toxins: Heavy Metals	Toxins: SVOCs	Toxins: Toxic algal blooms (from sea)	Habitat Loss: Substrate	Habitat Loss: Macrophytes (Seagrass)	Habitat Loss: Saltmarsh	Habitat Loss: Vegetated Terrestrial Margin	Habitat Loss: Birds	Habitat Loss: Fish	Habitat Loss: Invasive species	Habitat Loss: Benthic invertebrates	Habitat Loss: Shellfish	Habitat Loss: Sea Level
Fine Sediment												Moderate	Moderate	
Nutrients/Eutrophication														
Pathogens	Low													
Toxicants														
Climate Change - Sea Level Rise														
Climate Change - pH, temp												High	High	
Spills (oil)					Low	Low	Low		Low	Low	Low	Low	Low	
Grazing of high value habitat														
Freshwater abstraction										Low		Low	Low	
Reclamation/Drainage							Moderate	Moderate	Moderate	Moderate				
Harvesting living resources													Low	
Algal blooms (from sea)				Low									Low	
Seawalls, breakwaters etc							Moderate	Moderate						
Invasive weeds/pests							Low	Low						
Vehicle damage														
Loss of vegetated terrestrial margin								Moderate	Moderate					
Animal/man disturbance								Low	Low					
PRIORITY INDICATORS FOR MONITORING							Moderate	Moderate	Moderate	Moderate		High	High	

OVERALL VULNERABILITY RATING - PUPONGA ESTUARY

Human Use	Moderate
Ecological Value	High
Overall Stressor Influence	Low
OVERALL VULNERABILITY	Low
KEY ISSUES	Muddiness, climate change, terrestrial margin.

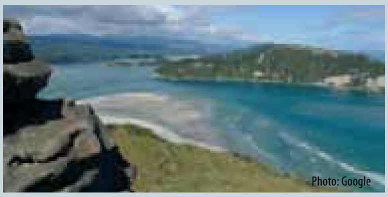
MONITORING RECOMMENDATIONS	
	• Broad scale habitat mapping every 10 years. • Map catchment sediment source "hot spots" 5 yearly.

5.3 WEST TASMAN - BEACHES, DUNES, ROCKY SHORES AND ESTUARIES

BEACH/DUNE/ROCKY SHORE SUMMARY

Human Use	Very Low
Ecological Value	High
Stressors	Very Low
ISSUES	
Muddiness	Very Low
Eutrophication	Very Low
Disease Risk	Very Low
Habitat Loss	Moderate
Toxicity	Very Low
OVERALL VULNERABILITY	
Low	

Wharariki Beach.



Fergusons Beach entrance to Whanganui Inlet.

Anatori Beach near river mouth.

The West Tasman section extends 208km from Fossil Point (near Farewell Spit) in the north to Kahurangi Point in the south, of which 136km is estuary, 29km rocky shore, and 42km beach. Human use is relatively low, except for land and water based recreation at Wharariki Beach. In other areas, fishing and shellfish collection are locally popular. Ecologically, values are high, particularly because of its diverse rocky shore, dune and beach habitats, and relatively low population pressure. Grassland (sheep and beef farming) dominates the rocky shore and beach margin (82%), with remaining areas predominantly in native forest and scrub. The coast includes 3 broad sections:

Fossil Point to Te Hapu. The 40km long northern section from Fossil Point in the north to Te Hapu in the south includes a dramatic cliffed coastline (~26km) of conglomerates and sandstones interrupted by several beaches (Davidson et al. 1993). The cliffs are backed by extensive pastoral (sheep and cattle) landuse, and scrub and some kanuka/broadleaf coastal forest. Extensive dune formations have locally buried low relief hills in some places, forming lakes and swamps, particularly around Lake Kaihoka, but are predominantly in pasture. The ~14km of beaches in this section, dominated by Wharariki, Greenhills, Nguroa and Kaihoka Bay, are all exposed, wave dominated types with medium sand. Dune vegetation along the backshores (~5km) is predominantly marram and lupins, but some pingao and spinifex is expected to be present. High, fine sand, unstable dunes extend 1km inland at Wharariki Beach. Many native herbfields are also present along the margins in these areas.

Te Hapu to Big River. This 28km long section is dominated by exposed, wave-dominated sandy beaches (26km) interspersed with complex rocky reefs and platforms, and some rocky headlands (2km). Buildup and erosion of sand over intertidal rock platforms is common. The area is relatively active and sand has been blown well inland across hill slopes (particularly south of Anatori River mouth), now largely grazed pasture, but patches of diverse coastal broad-leaved and podocarp forest remain on the sand veneer, interspersed with dune-slacks. Dune vegetation along the backshores (~12km) is predominantly marram and lupins, but pingao and spinifex is expected to be present. *Hebe elliptica* and other shrubs grow on the cliffs. In the section between Anatori and Big River, there is a broad sandy flattish beach, backed by a series of high active dunes, between which are some slacks, extending 700m inland. Vegetation is mainly lupins and grazed pasture with some shrubs and cabbage trees (Johnson 1992). Vehicles use beaches to access the coast south of Paturau.

Big River to Kahurangi Point. This 4km long southern section extends from the mouth of Big River to the Kahurangi Point and is dominated by large intertidal rock platforms cut across mudstone and sandstone (Davidson et al. 1993). Wide sand beaches alternate with partly buried rock platforms, and small lagoons impounded by sand bars. Exotic plants, primarily gorse, marram and other exotic weed species are present along the margin, and are backed by hills of either coastal broad-leaved and podocarp forest or pasture.

Issues and Stressors.

- **Dune overstabilisation and grazing.**
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- **Coastal erosion** is expected to increase in response to climate change induced sea level rise, increased storms and waves, and alterations to sediment transport systems.
- **Modified terrestrial margin.** The terrestrial margin is dominated by farmland.

Issues	Monitoring
Duneland overstabilisation. Coastal erosion. Modified terrestrial margin. Weeds.	Beach/dune habitat mapping (10 yearly). Fine scale monitoring at representative rocky (e.g. Paturau) and sandy shores (e.g. Kaihoka) in the region to monitor climate change impacts.

COASTAL ECOLOGICAL VULNERABILITY RATING - BEACHES, DUNES AND ROCKY SHORES

BEACH/DUNE/ROCKY SHORE SITES:

WEST TASMAN - FOSSIL POINT TO KAHURANGI POINT

DATE: (NOT VISITED)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	

STRESSOR / STRESSOR INFLUENCE ON HABITAT / STRESSOR INFLUENCE ON USES AND VALUES

STRESSORS	Total Stressor Vulnerability	Dune	Beach	Rock/Boulder	Cliff	Coastal Herbfield	Inshore water	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Natural Vegetation/Dunes	Seagrass	Birds	Fish	Other Biota
	STRESSOR	HABITAT						HUMAN USES					ECOL. VALUES				
Fine Sediment	L						L		L								
Nutrients/Eutrophication	L						L										
Pathogens	L		L				L	L		L		L					
Toxicants	L		L														
Climate Change - Sea Level Rise	L	L	L										L		L		L
Climate Change - pH, temp	H	H	H				H								L	H	H
Spills (oil)	L		L				L	L	L	L	L		L	L	L	L	L
Grazing of high value habitat																	
Freshwater abstraction																	
Reclamation & dune overstabilisation	M	M	M						M				M		M		M
Harvesting living resources	L						L										L
Algal blooms (from sea)	L						L								L	L	L
Seawalls, breakwaters etc	L	L	L						L								
Invasive weeds/pests	M	M							M				M				
Vehicle damage																	
Loss of vegetated terrestrial margin	M	M	M						M				M		M		M
Animal/man disturbance	L	L	L						L				L		L		

STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE)

STRESSORS	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Benthic Microalgal Mats	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Macrophyte Loss	Macroinvertebrates	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates	Faecal Indicators	Heavy Metals	SVOCs	Toxic algal blooms (from sea)
	Eutrophication										Sedimentation						D.	Toxins		
Fine Sediment												L	L		L					
Nutrients/Eutrophication		L				L				L										
Pathogens																	L			
Toxicants																		L	L	
Climate Change - Sea Level Rise																				
Climate Change - pH, temp																				
Spills (oil)																				
Grazing of high value habitat																				
Freshwater abstraction																				
Reclamation & dune overstabilisation																				
Harvesting living resources																				
Algal blooms (from sea)																				
Seawalls, breakwaters etc																				
Invasive weeds/pests																				
Vehicle damage																				
Loss of vegetated terrestrial margin																				
Animal/man disturbance																				
PRIORITY INDICATORS FOR MONITORING																				

STRESSORS	Substrate	Macrophytes (Seagrass)	Saltmarsh/Dunes	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
	Habitat Loss									
Fine Sediment										
Nutrients/Eutrophication										
Pathogens										
Toxicants										
Climate Change - Sea Level Rise	L	L		L				L		L
Climate Change - pH, temp		H			L	H	H	H	H	
Spills (oil)					L	L	L	L	L	
Grazing of high value habitat										
Freshwater abstraction										
Reclamation & dune overstabilisation			M	M			M			
Harvesting living resources									L	
Algal blooms (from sea)									L	
Seawalls, breakwaters etc			L	L	L			L		
Invasive weeds/pests	M	M		M			M			
Vehicle damage										
Loss of vegetated terrestrial margin				M			M			
Animal/man disturbance					L					
PRIORITY INDICATORS FOR MONITORING	M	M	M	M		M	H	M	M	M

OVERALL VULNERABILITY RATING - WEST TASMAN BEACHES/ROCKY SHORES

Human Use	L	Low
Ecological Value	H	High
Overall Stressor Influence	L	Low
OVERALL VULNERABILITY	L	Low-Moderate
KEY ISSUES	Habitat Loss - Dune overstabilisation, terrestrial margin development, climate change, erosion.	

MONITORING RECOMMENDATIONS	
	• Broad scale habitat mapping every 10 years. • Fine scale monitoring at representative rocky and sandy shores in the region to monitor impacts of climate change.

5.3 WEST TASMAN - ESTUARIES

ESTUARIES

Between Fossil Point and Kahurangi Point, the hilly terrain and wet climate produces a number of small and moderate sized tidal river estuaries (e.g. Anatori Estuary), and a large, relatively unmodified tidal lagoon estuary (Whanganui Inlet). Like the beaches of West Tasman, these estuaries were not visited for this survey, and consequently their vulnerability was assessed through the use of aerial photographs, available literature and past experience. This limited approach is used to identify priority areas for monitoring in the West Tasman region.

WHARARIKI ESTUARY

Human Use	Moderate
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (2.8ha). Mouth generally open but potential to be constricted. Mean depth 0.3m (max 0.5m). Clear water, sandy bed. Sediments generally well-oxygenated. 9km² catchment - native forest (78%) and intensive pasture use (21%). Moderate human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds and seagrass, but small area of saltmarsh) but valued for fish and invertebrates. Terrestrial margin mainly duneland. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

GREEN HILLS ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (4.4ha). Mouth generally open but potential to be constricted. Clear water, sandy bed. Sediments generally well-oxygenated. 8km² catchment - native forest (89%) and intensive pasture use (10%). Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds and seagrass, but small area of saltmarsh) but valued for fish and invertebrates. Terrestrial margin mainly mixed bush and pasture. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

NGUROA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (1.5ha). Mouth generally open but potential to be constricted. Clear water, sandy bed. Sediments generally well-oxygenated. 12km² catchment - native forest (67%) and intensive pasture use (27%). Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin mainly pasture and modified duneland. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

PATURAU ESTUARY

Human Use	Moderate
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

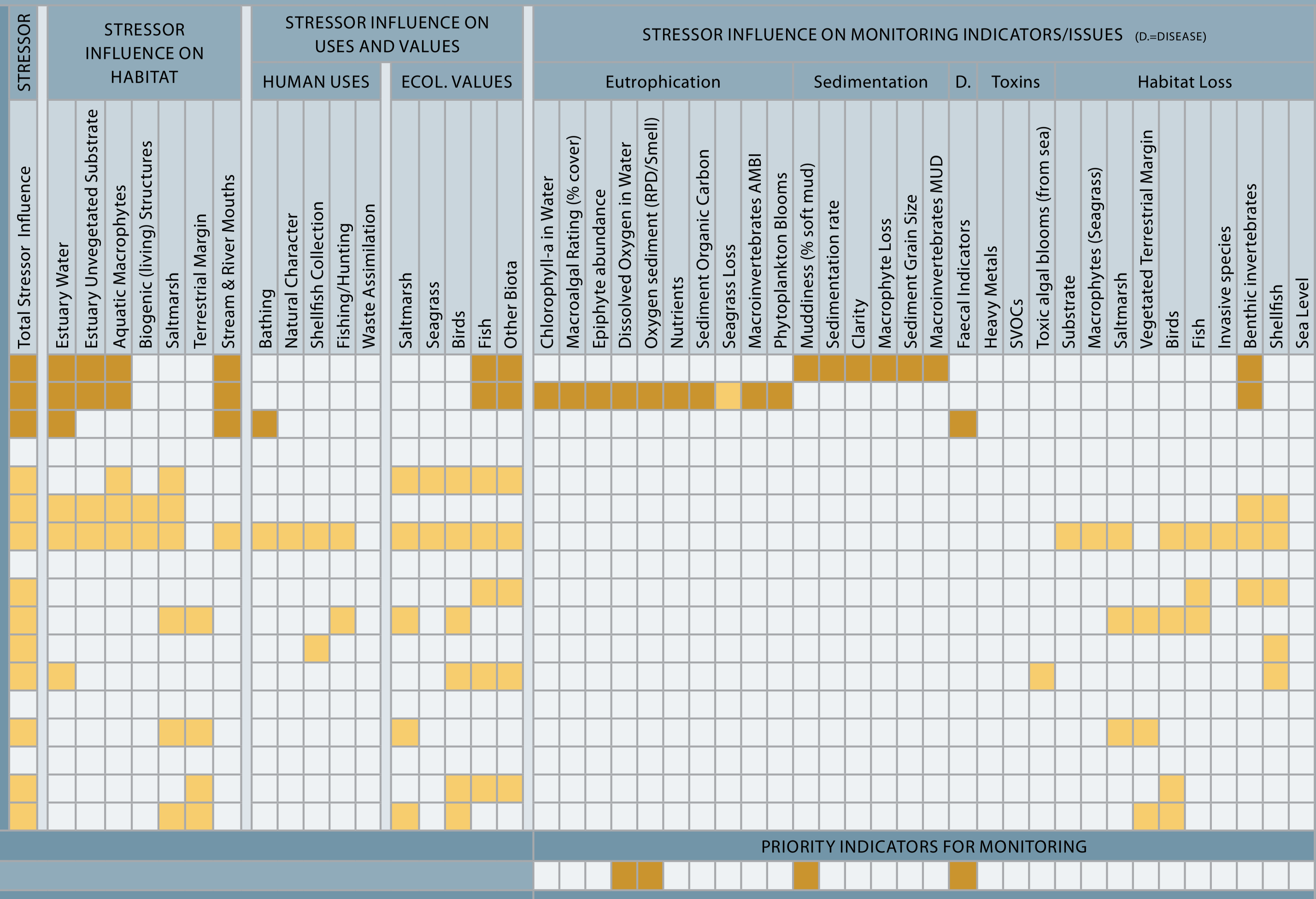
Moderate-sized, tidal river estuary (14ha). Mouth generally open. Clear water, gravel/cobble/sand bed. Sediments generally well-oxygenated. 77km² catchment - native forest (87%) and intensive pasture use (6%). Moderate human use but valued for whitebaiting, swimming, camping and aesthetic beauty. Ecological value moderate (absence of high value intertidal flats, shellfish beds, and seagrass but some saltmarsh) and valued for fish and invertebrates. Terrestrial margin mainly duneland. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITES:
Wharariki, Green Hills, Nguroa and Paturau
DATE: (NOT VISITED)

KEY FOR RATINGS	
High	
Moderate	
Low	
Very Low	



OVERALL VULNERABILITY RATING - Wharariki, Green Hills, Nguroa and Paturau Estuaries

Human Use	Low-Mod
Ecological Value	Low
Overall Stressor Influence	Low
OVERALL VULNERABILITY	Low
KEY ISSUES	Possible contamination from pastoral runoff.

MONITORING RECOMMENDATIONS	• Broad scale habitat mapping every 10 years. • DO, % soft mud on bed, RPD when broad scale mapping.

WHANGANUI INLET

Estuary Type/Area	Tidal River/2,748ha
Intertidal	1,979ha
Catchment	81km^2
FW Inf ow	Mean annual 6m^3.s^{-1}
Saltmarsh, Seagrass	96ha, 860ha
Soft Mud	110ha
Macroalgae	15ha
Dairy Cows	0
SS Loading	18.9kt/yr
Nitrogen Loading	35.6t/yr
Faecal C. Loading	0.77 x 10^{15}/yr
Landuse: 91% native forest, 3% exotic forest,6% high producing pasture,0% lo-producing pasture.	
Geology: Mixed: granites, greywacke, sandstones	
Human Use	High
Ecological Value	High
Stressors	Low
ISSUES	
Muddiness	Moderate
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
OVERALL VULNERABILITY	
Low	

Whanganui Inlet is a large (2748ha), relatively unmodified, shallow, well-flushed, seawater-dominated, tidal lagoon type estuary that is open to the sea via a narrow entrance mouth. The inlet is the third largest estuary of its type in the South Island and is located 19km southwest of Farewell Spit. It is fed by 4 main streams, Mangarakau Drain (mean flow 0.66m^3.s^{-1}), Mangarakau Stream (0.48m^3.s^{-1}), Wairoa River (0.16m^3.s^{-1}), and Muddy Creek (0.59m^3.s^{-1}) and a large number of 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. Much of the estuary catchment is forest (primarily native 91%), with intensive pastoral use at 6%. The estuary margin is coastal forest (53%), regenerating forest (30%) and pasture (17%). The road along the eastern estuary margin has resulted in numerous causeways restricting tidal flushing to many of the upper estuary arms.

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 and condition is high. It has almost all of its intertidal vegetation intact, large areas of seagrass (42% of estuary) and saltmarsh (5% of estuary), dunes, cliffs, islands, rock platforms, underwater reefs, and a well-vegetated terrestrial margin dominated by coastal forest (including kahikatea, pukatea, rata, beech, rimu and nikau palm). Approximately 30 species of marine fish use the inlet at some stage of their life history. It is an important breeding and nursery area for snapper, flatfish, kahawai and whitebait. It is also important for birdlife (particularly waders), and is connected to large areas of relatively unmodified wetland, freshwater streams and terrestrial vegetation.

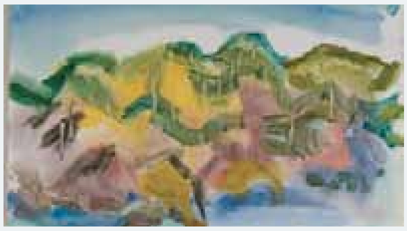
Issues and Stressors.

Whanganui Inlet has largely avoided permanent human impacts and consequently has few threats. The potential stressors identified are:

- **Potential for excessive muddiness** if runoff from intensive landuse or forest clearance is poorly managed. Climate change (increased storms) is expected to exacerbate these issues.
- **Loss of high value saltmarsh habitat** caused by impending sea level rise if inland migration of beds is not facilitated.
- **Changes in biological communities** as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).
- Other lesser stressors include; a partially modified terrestrial margin, presence of causeways, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant).

Whanganui Inlet (Photo Tristan Riley).

Seagrass beds, Whanganui Inlet (Photo Tristan Riley).



Whanganui Inlet (Doris Lusk, Hocken Collection)

Issues	Monitoring/Investigations
Potential habitat Loss.	Map catchment sediment source "hot spots" (5 yearly).
Climate change.	Estuary habitat mapping (10 yearly).
Potential excessive muddiness.	Fine scale monitoring (5 yearly after baseline).
	Sedimentation rate - plates (5 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITE:

WHANGANUI INLET
DATE: (NOT VISITED)

KEY FOR RATINGS	
High	H
Moderate	M
Low	L
Very Low	(blank)

	STRESSOR	STRESSOR INFLUENCE ON HABITAT							STRESSOR INFLUENCE ON USES AND VALUES: HUMAN USES					ECOL. VALUES					STRESSOR INFLUENCE ON MONITORING INDICATORS/ISSUES (D.=DISEASE): Eutrophication										Sedimentation						D.	Toxins			Habitat Loss									
STRESSORS	Total Stressor Influence	Estuary Water	Estuary Unvegetated Substrate	Aquatic Macrophytes	Biogenic (living) Structures	Saltmarsh	Terrestrial Margin	Stream & River Mouths	Bathing	Natural Character	Shellfish Collection	Fishing/Hunting	Waste Assimilation	Saltmarsh	Seagrass	Birds	Fish	Other Biota	Chlorophyll-a in Water	Macroalgal Rating (% cover)	Epiphyte abundance	Dissolved Oxygen in Water	Oxygen sediment (RPD/Smell)	Nutrients	Sediment Organic Carbon	Seagrass Loss	Macroinvertebrates AMBI	Phytoplankton Blooms	Muddiness (% soft mud)	Sedimentation rate	Clarity	Macrophyte Loss	Sediment Grain Size	Macroinvertebrates MUD	Faecal Indicators	Heavy Metals	SVOCs	Toxic algal blooms (from sea)	Substrate	Macrophytes (Seagrass)	Saltmarsh	Vegetated Terrestrial Margin	Birds	Fish	Invasive species	Benthic invertebrates	Shellfish	Sea Level
Fine Sediment	M	M	M	M		M		M						M	M		M	M											M	M	M	M	M	M												M	M	
Nutrients/Eutrophication	L	L	L	L		L		L						L	L			L	L	L	L	L	L	L	L	L	L	L																				
Pathogens	L	L						L	L		L																								L													
Toxicants																																																
Climate Change - Sea Level Rise	L			L		L								L	L	L	L	L																														
Climate Change - pH, temp	H	H	H	H	H	H																																								H	H	
Spills (oil)	L	L	L	L	L	L		L	L	L	L	L		L	L	L	L	L																					L	L	L		L	L	L	L	L	
Grazing of high value habitat																																																
Freshwater abstraction	L																L	L																										L		L	L	
Reclamation/Drainage	M					M	M					M		M		M																									M	M	M	M				
Harvesting living resources	L										L																																				L	
Algal blooms (from sea)	L	L														L	L	L																				L									L	
Seawalls, breakwaters etc	L					L	L							L	L																										L	L						
Invasive weeds/pests	L					L	L							L																											L	L						
Vehicle damage																																																
Loss of vegetated terrestrial margin	M						M									M	M	M																								M	M					
Animal/man disturbance	L					L	L							L		L																										L	L					
PRIORITY INDICATORS FOR MONITORING																														M											M	M	M	M		H	H	

OVERALL VULNERABILITY RATING - WHANGANUI INLET

Human Use	H	High
Ecological Value	H	High
Overall Stressor Influence	L	Low
OVERALL VULNERABILITY	L	Low
KEY ISSUES	Muddiness, climate change, terrestrial margin.	

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- Fine scale monitoring 5 yearly.
- Map catchment sediment source "hot spots" 5 yearly.
- Sedimentation rate (plates 5 yearly).

5.3 WEST TASMAN - ESTUARIES (CONTINUED)

SANDHILLS CREEK ESTUARY


Photo: Google Earth

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (3.3ha) that drains Lake Otuhie. Mouth generally open. Clear, humic-stained water, sandy bed. Sediments generally well-oxygenated. 38km² catchment - native forest (85%) and intensive pasture use (9%). Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin mainly duneland converted to pasture. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.


Photo: Google

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

ANATORI RIVER ESTUARY


Photo: Google Earth

Human Use	Moderate
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Moderate-sized, tidal river estuary (11.6ha). Mouth generally open. Clear water, gravel/cobble/sandy bed. Sediments generally well-oxygenated. 76km² catchment - native forest (97%) and intensive pasture use (1%). Moderate human use - valued for whitebaiting, fishing, swimming, camping and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin mainly bush and pasture. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.


Photo: Google

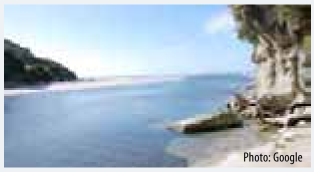


Photo: Google

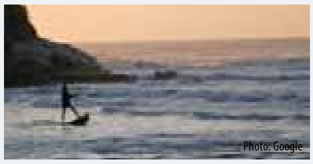


Photo: Google

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

TE RATA CREEK ESTUARY


Photo: Google Earth

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (6.2ha). Mouth generally open but potential to be constricted. Clear water, sandy bed. Sediments generally well-oxygenated. 57km² catchment - native forest (90%) and intensive pasture use (7%). Low human use but valued for whitebaiting and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds, saltmarsh and seagrass) but valued for fish and invertebrates. Terrestrial margin mainly duneland converted to pasture. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

TURIMAWIWI ESTUARY


Photo: Google Earth

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (14ha). Mouth generally open. Clear water, gravel/cobble/sand bed. Sediments generally well-oxygenated. 77km² catchment - native forest (87%) and intensive pasture use (6%). Low human use but valued for whitebaiting, swimming and aesthetic beauty. Ecological value low (absence of high value intertidal flats, shellfish beds and seagrass, but small area of saltmarsh) but valued for fish and invertebrates. Terrestrial margin mainly duneland converted to pasture. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary habitat mapping (10 yearly).

5.3 WEST TASMAN - ESTUARIES (CONTINUED)

ANAWEKA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Moderate-sized, tidal river estuary (64ha) - relatively deep. Mouth open. Clear, humic-stained water, gravel/cobble/sandy bed. Sediments generally well-oxygenated. 29km² catchment - native forest (85%) and intensive pasture use (9%). Low human use but valued for whitebaiting, fishing, and aesthetic beauty. Ecological value high - presence of high value intertidal flats, shellfish beds and saltmarsh, and valued for fish and invertebrates. Terrestrial margin mixed - duneland, pasture and bush. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

RAUKAWA ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Moderate-sized, tidal river estuary (11ha). Mouth generally open. Clear, humic-stained water, gravel/cobble/sandy bed. Sediments generally well-oxygenated. 7km² catchment - native forest (91%) and intensive pasture use (9%). Low human use but valued for whitebaiting, fishing, and aesthetic beauty. Ecological value moderate (absence of high value intertidal flats, shellfish beds and seagrass, but small area of saltmarsh) - valued for fish and invertebrates. Terrestrial margin mainly pasture, bush and dunes. No significant issues, except possible intermittent contamination (nutrients, faecal bacteria and sediment) from pasture runoff and stock in stream.

Issues	Monitoring
Possible contaminated pastoral runoff.	Estuary risk and habitat mapping (10 yearly).

BIG RIVER ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

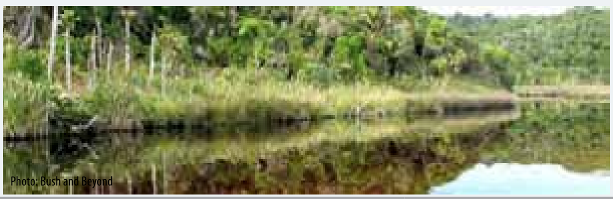
Moderate-sized, tidal river estuary (30ha) - relatively deep (>2m). Mouth open. Clear, humic-stained water. Bed varies from soft mud sands to granite gravels. Sediments generally well-oxygenated. 107km² catchment - native forest (79%) with minor area in intensive pasture near coast. Low human use but valued for whitebaiting, fishing, swimming and aesthetic beauty. Ecological value high - presence of high value intertidal flats, shellfish beds and saltmarsh, and valued for birds, fish and invertebrates. Terrestrial margin mixed - duneland, pasture and forest (95%). North-side of estuary bordered by sandspit, while the south is bordered by a marine terrace of siltstone. Issues, include weed growth (gorse, marram), and cattle damage.

Issues	Monitoring
Weed growth	Estuary risk and habitat mapping (10 yearly).

LAGOON CREEK ESTUARY

Human Use	Low
Ecological Value	Low
Stressors	
Muddiness	Low
Eutrophication	Low
Disease Risk	Low
Habitat Loss	Low
Toxicity	Low
VULNERABILITY	Low

Small, tidal river estuary (7ha). Mouth generally open. Clear, humic-stained-water, gravel/cobble/sand bed. Sediments generally well-oxygenated. 5km² catchment - native forest (90%) and intensive pasture use (1%). Low human use but valued for whitebaiting, aesthetic beauty, and pristine condition. Ecological value low (absence of high value intertidal flats, shellfish beds and seagrass, but small area of saltmarsh) but valued for fish and invertebrates. Terrestrial margin mainly duneland and forest. No significant issues, except weed growth (gorse and marram).



Issues	Monitoring
Weed growth	Estuary risk and habitat mapping (10 yearly).

COASTAL ECOLOGICAL VULNERABILITY RATING - ESTUARIES

ESTUARY SITES: Sandhills, Anatori, Te Rata, Turimawiwi, Anaweka, Raukawa, Big River, Lagoon Creek

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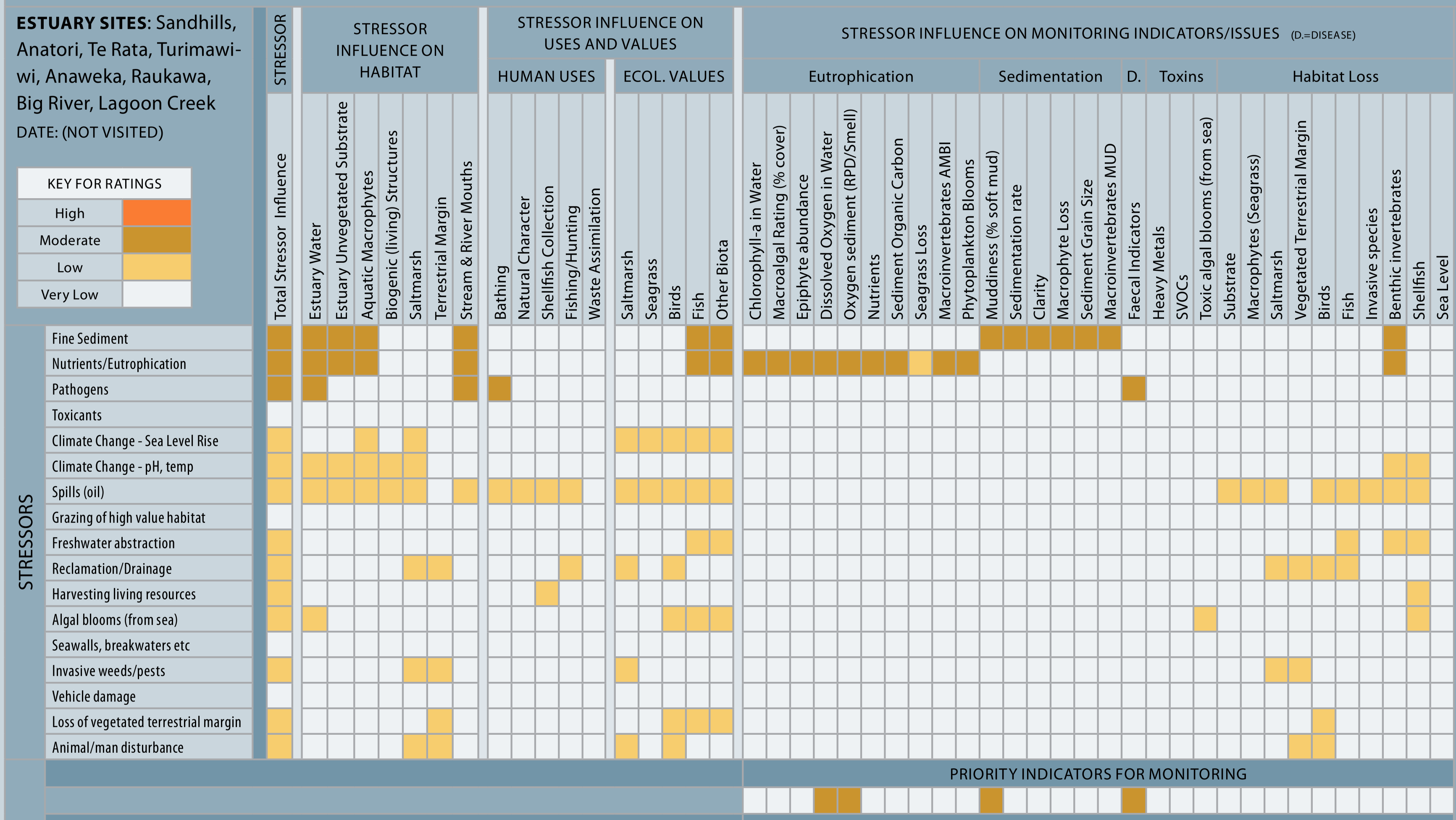


OVERALL VULNERABILITY RATING - Sandhills, Anatori, Te Rata, Turimawiwi, Anaweka, Raukawa, Big River, Lagoon Creek Estuaries

Human Use	Low-Mod
Ecological Value	Low
Overall Stressor Influence	Low
OVERALL VULNERABILITY	Low
KEY ISSUES	Possible contamination from pastoral runoff.

MONITORING RECOMMENDATIONS

- Broad scale habitat mapping every 10 years.
- DO, % soft mud on bed, RPD when broad scale mapping.

6. CONCLUSIONS

The habitat mapping study identified the Tasman Coast as an ecologically diverse region with a broad range of habitat types along the exposed west-facing shoreline in West Tasman, and the more sheltered north-facing coasts of Tasman and Golden Bays. It is a place of high biological diversity and high economic value. The health and productivity of the coastal habitats, including its extensive estuarine systems, is a cornerstone of the region's quality of life and vibrant economy, from recreational fishing to shellfish production to tourism. The major shoreline habitats of the region included: estuaries, beaches, dunes, rocky shores and terrestrial margin. Despite the high values of its coast, the vulnerability assessment identified a number of key issues as follows.

1. Excessive muddiness of estuaries and coastal waters

Although sedimentation is natural and provides a number of important functions (supplying nutrients, and buffering coastal erosion), environmental problems occur when the rate at which sediment is being transferred to, and deposited within, estuarine and coastal regions is increased. This has the potential to profoundly alter the structure and function of estuarine and embayment ecosystems.

The vulnerability assessment found that 50% of Tasman and Golden Bay estuaries were excessively muddy (greater than 10% of the estuary area filled with soft muds). Waimea was the most affected at 55% soft mud and Waitapu and Motupipi had approximately 25%. In addition, Tasman and Golden Bays are filling with mud which is degrading shellfish habitat and causing sedimentation problems in the bays and around rocky shores. Within the Tasman region, the major sources of sediment to the degraded estuaries and embayments were identified as intensive pastoral, urban and exotic forestry inputs.

2. Elevated disease risk in estuaries and embayments

The majority of Tasman's estuaries and beaches have a low risk of disease from bathing, except after heavy rain in the catchments, when there may also be an excessive disease risk associated with shellfish consumption. The major cause is faecal bacterial runoff from intensive pastoral farming, particularly dairying. Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the coastal environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks posed to humans through recreational contact and shellfish consumption, pathogen contamination can also cause economic losses due to closed commercial shellfish beds in the region.

3. Habitat loss through sea level rise

Sea level is predicted to increase up to 7mm/year or more in the next 100 years. A Coastal Vulnerability Index (CVI), used by the U.S. Geological Survey to evaluate the potential vulnerability of the U.S. coastline on a national scale to sea-level rise, was used to provide a preliminary evaluation for the Tasman region. In general, the CVI approach shows that the most vulnerable areas in Tasman will be shorelines that have soft sediments, low gradients, are eroding, exposed to strong wave action and have a low tidal range. Beaches, dunes, barrier islands, tidal wetlands, and estuarine systems are the most closely linked to sea level and therefore most vulnerable. Those that are exposed to large waves and have low tidal ranges are the most vulnerable. The West Tasman tidal river estuaries and the beaches and dunes between Paturau and Kahurangi, Wainui and Puponga, and Otuwhero to Marahau, all fit in the high to very high category. The majority of the other estuaries and beaches and dunes fit in the moderate category, with the Motueka Delta and the beaches between Tapu Bay and Otuwhero fitting in the low category. Vulnerability increases wherever barriers prevent the landward migration of coastal habitats in response to sea level rise.

6. CONCLUSIONS (CONTINUED)

The CVI approach only provides a relative regional vulnerability rating and not a description of the actual impact of sea level rise on each coastal section or habitat. It is therefore recommended that site-specific surveys be carried out in the high risk zones identified in order to provide a more comprehensive assessment of this key stressor.

4. Ecological change through sea temperature and acidity change

The assessment, based on Australian research, indicates that all shoreline habitats bathed by ocean waters in the Tasman region are at risk from increased ocean acidity and temperature induced by climate change. In SE Australia, where the most relevant research to NZ is being undertaken, the evidence indicates that future increases in temperature are likely to result in further range shifts of macroalgae and associated species, with range contractions and local extinctions to be expected for species that have their northern limits along the southern coastline. Changes are also expected from range expansions. While there is currently no evidence of changes attributable to non-temperature related climate impacts, potentially due to a lack of long-term observational data, experimental evidence suggests that ocean acidification will result in negative effects on calcifying algae and animals. The most vulnerable habitats in the Tasman region were identified as rocky shores and shallow subtidal reefs, and high biodiversity estuary and beach areas, particularly those where the intertidal area is large (i.e. most of the Tasman Bay and Golden Bay beaches, dunes and estuaries, and Whanganui Inlet in West Tasman).

5. Duneland loss through overstabilisation

Coastal sand dunes in good condition protect the coast from erosion, from sea level rise, provide specialised habitats for plants, birds and animals, provide us with a range of unique landforms, act as a filter for rain and groundwater and, if utilised wisely, provide recreational and living space. Within Tasman, the dune habitat mapping showed that approximately 30% of active duneland has been lost in the Tasman and Golden Bay areas since 1940 to overstabilisation. Overstabilisation of dunes has occurred through plantings of exotic forest, exotic sand-binding species (marram), development for pasture or residential developments, roading, and building seawalls. Of particular concern were areas of extensive dune overstabilisation, as at Rabbit Island (exotic forest), Motueka Spits, Jackett Island (exotic plantings and residential developments), and many spits and beach margins in Golden Bay (a mix of forest, marram, lupin, weeds and pasture e.g. Parapara to Collingwood, Puponga). However, there has also been a number of small-scale native dune plantings throughout the region (e.g. Parapara, Pohara, Collingwood) which all serve to support the likely success of any larger scale dune restoration programme for the region.

6. Saltmarsh loss through historical reclamation

The assessment found that ~30% of the saltmarsh in the Tasman and Golden Bay estuaries (excluding Abel Tasman and Farewell Spit areas) has been lost since 1900. Moutere and Ruataniwha estuaries have suffered the largest losses at 50% and 40% respectively. This reclamation of high value habitat has severely lowered the natural assimilative capacity of these estuaries which has led to increased sedimentation rates in tidal flat areas and low habitat quality. Saltmarsh is one of the most productive environments on earth, serves as an important nursery ground and wildlife habitat, and provides tremendous additional benefits for humans including flood and erosion control, water quality improvements, opportunities for recreation, and for atmospheric gas regulation - estuaries tend to be "carbon sinks," since carbon dioxide is absorbed in the photosynthesis carried out by the prolific plant growth. Tidal saltmarshes have the ability to respond rapidly to physical stressors, and their condition is often a dynamic balance between relative sea level rise, sediment supply and the frequency/duration of inundation. However, if sea level rises too much or too fast, or the sediment supply or inundation through flooding is excessive, then the balance can be upset and the saltmarsh is lost or its condition deteriorates. This balance varies between different types of estuaries but their response centres around how each reacts to sediment inputs and inundation (the latter is particularly important in face of predicted accelerated sea level rise through global warming). It also assumes that "natural evolution" of the coastline will be allowed to occur through erosion.

7. Loss of natural vegetated terrestrial margin buffer through development
Coastal shoreline habitats function best with a natural vegetated margin which acts as a buffer from development and "coastal squeeze". This buffer protects against introduced weeds and grasses, naturally filters sediment and nutrients, and provides valuable ecological habitat. The assessment found that 65% of the natural vegetated terrestrial 200m margin buffer that historically bordered Tasman and Golden Bay shorelines has been highly modified, mainly to intensive pastoral grazing, residential properties and forestry - modification often extending a long distance inland from the coast. Development within this coastal buffer margin results in decreased resilience of the coast in the face of physical forces, and reduced biodiversity, aesthetics, heritage and landscape values, and public access. Because coastal development is a major cause of natural margin loss, one way to manage change is to "setback" development a prescribed distance from the coast. Development setbacks inform property owners of the potential risk posed by coastal erosion, and are used to manage the location of new dwellings to ensure houses are safely located, avoiding the need for seawalls (Dahm & Gibberd 2009). Coastal setbacks can be calculated by a variety of methods (Scoullar 2010, Smith 2010), but most only consider hazards (particularly erosion and sea level rise) and ignore biodiversity and public access. Smith (2010) has recommended a 100m wide default setback for situations where detailed calculations have yet to be undertaken. In the current report, a 200m wide potential setback zone (terrestrial margin) has been mapped to ensure an adequate perception of current uses in this high value coastal margin zone.

8. Habitat loss through shoreline armouring (seawalls)
Currently, more than a 14% of all the shoreline around Tasman and Golden Bay (excluding Abel Tasman area) has shoreline armouring e.g. seawalls, causeways, stopbanks, reclamations. Seawalls, in particular, damage beach and estuary ecology, destroy dunes, and prevent natural migration of habitat landward in response to sea-level rise. On unarmoured shorelines, sand and gravel from eroding areas and river plumes are transported by waves and currents and ultimately supply sediment to form and maintain the beaches and spits of the region. These natural processes, important because they support vital functions like providing habitat for key species in the surf zone and intertidal areas of beaches, are compromised when shorelines are armoured.

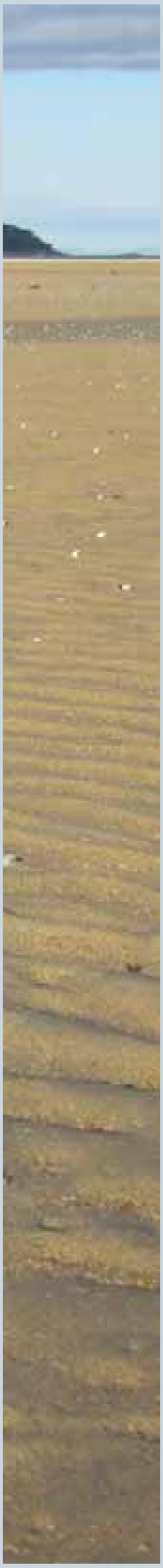
Currently, the largest proportion of beach that is armoured is at Ruby Bay (~55% of the beach), and the largest proportion of an estuary is Moutere Inlet (~43%). However, areas of beaches and estuaries are armoured throughout the Tasman region (e.g. Puponga, Collingwood, Marahau, Kina, Waimea). In the future, pressure to protect the Tasman coastline by artificial structures is expected to increase because of pressure to allow coastal development, associated defences against sea-level rise, combined with the greater predicted frequency of storms. Given the high value of Tasman's coastal ecosystems, it is recommended modification of natural shoreline processes be discouraged, and armouring in the region be reduced wherever possible, by locating new development to minimise the need for armouring, by strategically removing existing armouring where possible, or using "soft shore" designs for new and replacement armouring to reduce traditional hard armouring impacts.

In addition, there were a number of more minor stressors including: nutrient enrichment, harvesting, invasive species, off-road vehicles, human disturbance of wildlife, and grazing of high value habitats.

In order to address all these issues, a comprehensive monitoring programme has been proposed that includes a number of key indicators and pressures that reflect the overall vitality of the coast. Targets for each indicator, which if achieved will help restore the quality of the various coastal habitats to a better condition, would provide a focus for management efforts. The key indicators and the recommended monitoring plans are as follows:

7. RECOMMENDATIONS

MONITORING



ESTUARIES

1. High Vulnerability Estuaries

Monitor the long term condition of representative estuaries with highest biodiversity and risk to ecology.

- Broad scale habitat mapping of at-risk representative estuaries at 5 yearly intervals, all estuaries 10 yearly. Reason: To establish a baseline and to measure any change over time for extent of muddy habitat.
- Sedimentation rate monitoring using sediment plates placed in all moderate-large estuaries and measured annually. Reason: To establish a baseline and to measure any change over time for rate of mud deposition in representative habitat.
- Fine scale monitoring of representative high value estuaries (Waimea, Moutere, Motueka Delta, Motupipi, Ruataniwha, Whanganui), annual baseline for 3 years, then 5 yearly. Reason: To establish a baseline and to measure any change over time to physical, chemical and biological variables.
- Map catchment sediment, nutrient, and faecal bacteria source “hot spots” 5 yearly and model catchment loads with potential best management practices (BMPs) in place. Reason: To identify likely source areas and indicate the potential success of best management practices (BMPs) to guide planning and decision making.
- Monitor disease risk of shellfish and bathing waters near contaminated river plumes and urban stormwater discharges.

2. All Other Estuaries

- Monitor all other estuaries for long term change by repeating the broad scale synoptic monitoring (i.e. habitat mapping, sediment redox, depth, salinity, open/closed regime) and vulnerability assessment at 10 yearly intervals.

BEACHES AND DUNES

Long Term Beach and Dune Monitoring

- Broad scale mapping of the area of duneland, recording dominant sand-binding species, occurrence of weed species, and location of rare or threatened species, at 5 yearly intervals. Reason: To establish a baseline and to measure any change over time for extent and condition of dune habitat.
- Monitor long term condition of high biodiversity beaches. Fine scale monitoring of representative high value beaches bordered by dunes (e.g. Pakawau, Rabbit Island, Kaihoka). Establish annual baseline for 3 years, then 5 yearly. Reason: To establish a baseline and to measure any change over time to physical and biological variables.
- Broad scale mapping of the area of coastal seagrass from aerial photographs 5 yearly.
- Map the extent of coastal armouring 5 yearly.
- Identify the sources of the sand that feeds the dune systems in each area.

ROCKY SHORES

Monitor long term condition of high biodiversity rocky shores.

- Long term monitoring of the abundance and diversity of plants and animals (including indicator species) at three high diversity rocky shores (one in Tasman Bay, one in Golden Bay and one at West Tasman) using rapid assessment methods developed under the Marine Biodiversity and Climate Change Project (e.g. Hiscock 1996), and modified for NZ use e.g. Stevens and Robertson (2011). Establish annual baseline for 3 years, then 5 yearly. Reason: To establish a baseline and to measure any change over time to physical and biological variables.

200m TERRESTRIAL MARGIN BUFFER

Monitor long term condition of the 200m wide coastal terrestrial margin.

- Broad scale habitat mapping of the 200m wide terrestrial margin with particular emphasis on the extent of the natural vegetated terrestrial margin. Five yearly, where change is likely, and 10 yearly for other areas. Reason: To establish a baseline and to measure any change over time for extent of natural vegetated habitat.

7. RECOMMENDATIONS (CONTINUED)

MONITORING

In addition to the detailed monitoring reports, it is recommended the results for several key indicators that best reflect the vitality or condition of the coastal region be presented in Report Card format. These "Key Condition Indicators" will allow easy tracking of restoration success and achievement of any management targets.

"KEY CONDITION INDICATORS"

Indicator 1: Muddiness

Measure sedimentation rate in key estuaries.

Indicator 2: Eutrophication

Measure macroalgal cover annually in key estuaries.

Indicator 3: Disease Risk

Measure bathing and shellfish disease risk in estuaries and river plumes.

Indicator 4: Eelgrass

Measure eelgrass area in estuaries and beaches.

Indicator 5: Saltmarsh

Measure saltmarsh area in estuaries and delta areas.

Indicator 6: Duneland

Measure duneland area and condition in beach areas.

Indicator 7: Rocky Shores

Measure indicator species abundance in 3 representative rocky shore areas.

Indicator 8: Natural Vegetated 200m Terrestrial Margin

Measure area of natural vegetated terrestrial margin.

Indicator 9: Shoreline Armouring (Seawalls)

Measure length of shoreline armouring, type of armouring and sediment sources.

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BACKGROUND SUSCEPTIBILITY INFORMATION

Table A1. Background information to determine susceptibility of estuaries to catchment inputs of fine sediment.

Estuary Type, Shoreline Complexity	Estuary	*2 Flushing Potential (FW/EV) days	*4 Inter-tidal Soft mud (ha)	*3 SS g/ m^2/d	SS mm/yr	*1 Proposed High Susceptibility Sedi-mentation Trigger
PRISTINE - Tidal River plus delta in enclosed embayment	Freshwater	0.0426	2.0	0.2	0.062	<0.3 $g.m^{-2}.d^{-1}$. (<0.09mm/yr)
ICOLL (large)	Waituna	0.0085		0.2	0.060	< 0.6 $g.m^{-2}.d^{-1}$. (<0.2mm/yr)
Tidal Lagoon (Coastal embayments) - dominated by seawater influence.	Awarua	0.0003	0.0	0.0	0.000	< 0.6 $g.m^{-2}.d^{-1}$. (<0.2mm/yr)
	Bluff	0.0002	1.5	0.0	0.000	
	Westhaven	0.0063	110.0	0.5	0.152	
	Ohiwa	0.0064	547	0.1	0.031	
	Moutere	0.0086	92.0	0.0	0.005	
Tidal Lagoon (moderate freshwater influence, open basin)	Avon Heathcote	0.0186	69.0	1.2	0.354	< 3.2 $g.m^{-2}.d^{-1}$. (<1mm/yr)
	Nelson Haven	0.0115	89.0	1.6	0.476	
Tidal Lagoon (extensive low water subtidal areas upper estuary intertidal flats, mod. f/w influence)	Porirua Harbour	0.0134	3.0	7.3	2.222	< 3.2 $g.m^{-2}.d^{-1}$. (<1mm/yr)
Tidal Lagoon (shallow, extensive poorly flushed arms and upper estuary intertidal flats, moderate freshwater influence)	Motupipi	0.0135	36.0	9.1	2.760	< 3.2 $g.m^{-2}.d^{-1}$. (<1mm/yr)
	Waimea	0.0189	1541.0	10.9	3.327	
	Jacobs River	0.1373	120.0	18.3	5.556	
	New River	0.0550	570.0	10.1	3.069	
	Haldane	0.0755	20.0	2.0	0.607	
	Waikawa	0.0582	240.0	5.2	1.572	
	Kaipara Arm	0.0030	662	1.9	0.588	
Tidal River plus Moderate-sized Lagoon	Fortrose	1.3212	20.0	207.3	63.045	All Low Suscepti-bility
	Waiau	6.6725		708.0	215.347	
Tidal River plus delta in enclosed embayment	Havelock	0.1692	300.0	102.7	31.250	
Tidal River plus delta to open sea - some may have lagoon as well	Ruataniwha	0.4872	89.0	61.3	18.637	
	Motueka	0.3398	60.0	251.7	76.556	
	Takaka	0.3089		27.8	8.456	
Tidal River (moderate intertidal flats)	Porangahau	0.0952	33	154.5	46.997	
	Waimatuku	3.4560	0.5	33.4	10.167	
	Waikanae	0.8640	1.0	228.3	69.444	
Tidal River (one main channel, small intertidal flat area)	Wanganui	4.2174	24.0	3630.7	1104.344	
	Whareama	0.3402	100.0	465.5	141.593	
	Hutt	3.5712	5.0	1123.3	341.667	

*1 Based on estimated catchment sediment load (t/yr) and assuming all of load settles in estuary and is spread evenly throughout. This guideline is used to determine the boundary between High and Moderate Susceptibility. The Moderate to Low Susceptibility boundary is set at 50% of the Mod-High boundary.
*2 Flushing Potential = freshwater inflow (m3/d) divided by estuary volume (m3).
*3 Inputs based on CLUES model inputs (NIWA Clues model).
*4 Intertidal soft mud area from regional council, broad scale habitat mapping reports for each estuary.

Table A2. Faecal Coliform Inputs to NZ Estuaries and Disease Risk Rating.

Estuary	Areal FC Loading to Estuary	Risk Rating (based on Regional Council bathing season monitoring data)	
	Most Probable No. FC/m^2/day	Bathing Water	Shellfish Water
Waimea	213618	3	4
Freshwater	0	1	1
Awarua	9152	1	1
Avon Heathcote	282449	2	4
Jacobs River	3204887	3	4
New River	1743582	2	4
Hutt	7305689	3	4
Fortrose	16226892	3	4
Ruataniwha	390326	3	3
Havelock	534330	3	3
Porirua Arm	255183	3	
Pauatahanui Arm	288393	3	

* In relation to guideline criteria; 4 = often exceeds, 3 = occasionally exceeds, 2 = always less than, 1 = very low.

APPENDIX 1. ESTUARY CHARACTERISTICS

SOURCES OF INFORMATION

Catchment Area	CLUES Model	
Mean Freshwater Inflow	WRENZ or TDC	
No. Dairy Cows	TDC	
Mean Depth	Coastal Explorer, expert opinion of field estimate	
Catchment Dominant Rock Type	Qmap (provided by Jenny Eyles, TDC)	
Input Water Quality and Loads	CLUES	
Landuse	LCDB2 (2001)	
Spring Tidal Range	Coastal Explorer	
Geomorphology	Coastal Explorer or field estimate	
Erosion/Accretion Rate (m/yr)	Eric Verstappen estimates (TDC)	
Slope (%)	Coastal Explorer or field estimate, Eric Verstappen estimates (TDC)	
Rel. Sea Level Rise Rate (mm/yr)	Wratt et al. 2008 : 5-10mm/yr	
Mean Wave Height (m)	Coastal Explorer	
Mean Tidal Range	Coastal Explorer	
Key To Terms		
TR	Tidal River	
TL	Tidal Lagoon	
ICOLL	Intermittently Closed/Open Lagoon/Lake	
Landuse Categories		
NFS	Native forest-scrub	
EFS	Exotic forest-scrub	
HPP	High Producing Pasture	
LPP	Low Producing Pasture	
Urb	Urban/Artificial	
Crop	Crop	
Bare	Bare/Lightly vegetated	
Dominant Rock Type Abbreviations		
Arg=Argillite,	GSch=Greenschist	Sd=Sand
Bas=Basalt	Ls=Limestone	Sst=Sandstone
Dio=Diorite	Mel=Melange	Sch=Schist
Gab=Gabbro	Pt=Peat	Sltst=Siltstone
Grdio=Granodiorite	Pt=Peat	
Grv=Gravel	Qtzt=Quartzite	

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Waimea	Moutere Inlet/Delta	Mouteka Delta	Kaiteriteri
Catchment General	Estuary Type	TL (barrier island)	TL (barrier island)	TR	TL
	Catchment Area (km²)	913	182	2155	4
	Mean Freshwater Inflow (l/s)	21000	1500	58100	82
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	36, 33, 20/0, 2, 4, 4	3, 34, 39/0, 4, 20, 0	47, 28, 16/1, 0, 1, 6	30, 63, 7/0, 0, 0, 0
	Geology - dominant rock type	Sst Grv (Mel)	Grv (Grt)	Grv (Sst Grt Ls Arg)	Grt (Grv)
	No. Dairy Cows, Ha, Cows/Ha	1645, ?, ?	160, 64, 2.5	5675, ?, ?	
CLUES Model Estimates	N Load (t/y)	222.5	88.2	548.8	0.7
	TP (t/y)	38.0	6.8	126.1	0.3
	SS (kt/yr)	147.0	23.7	702.6	0.6
	E. coli load ($x10^{15}$/yr)	4.394	3.409	2.647	0.007
	Input mean TN (ug/l)	169	1331	158	95
	Input Mean TP (ug/l)	9.4	95	19	27
	N Areal Load (mg/m²/d)	18.2	24.0	197.8	11.0
	P Areal Load (mg/m²/d)	3.1	1.8	45.4	4.4
	SS Areal Load (g/m²/d)	12.0	6.5	253.2	9.1
	E. coli Areal Load ($FCx10^6/m^2$/d)	359929	929222	954023	112147
Consent Monitoring Data	Point Source N load (t/yr)	98.2			
	Point Source P load (t/yr)	28.1			
	Point Source SS load (t/yr)	134			
	Point Source E. coli. load ($Fcx10^{15}$/yr)	0.13			
	Point Source Toxicants (hi, mod, lo)	lo			
Estuary General	Estuary area (ha)	3345	1005	760	18
	Shoreline Length (km)	101	44	26	2
	Mean Depth at HW (m)	2.0	1.0	2.0	0.8
	Estuary Volume @ HW = mean depth x area = (m³)	66,890,200	10,050,000	15,205,800	136,501
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.026	0.013	0.674	0.098
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	SM	FMS	MS	FMS
Habitat Indicators	Intertidal area	2949	869	609	17
	Intertidal Soft mud (ha)	1584	218	63	3
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	299	84	63	3
	Seagrass Area (ha)	21.0	1.0		
	Macroalgae (ha with cover >20%)			3.5	
	Macroalgae (ha with cover >50%)	32.8	7.3		
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	0	15	17	41
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	63, 15, 11, 11	29, 14, 41, 1	48, 3, 31, 0	12, 40, 0, 0
	Chlor-a Benthic mg/m²	19			
	Mean Chlor-a surface water mg/m³				
	Dominant RPD Depth (cm)	1-3	1-3	5-10	3-5
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	3	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	4	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	13.7	9.5	13.7
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Waimea	Moutere Inlet/Delta	Mouteka Delta	Kaiteriteri
Sedimentation	Sedimentation Potential	Hi	Hi	Lo	Hi
	Sediment Existing Condition	Hi	Hi	Lo	Mod
	Overall Sediment Vulnerability Rating	Hi	Hi	Lo	Mod-Hi
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Mod	Mod	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Mod	Mod	V. Hi	Mod
	Overall Human Influence	Mod	Mod	V. Hi	Mod
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	Mod	High	Mod	Mod
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Mod	Lo	Lo	Lo
	Natural Sources	Mod	Lo	Mod	Lo
	Pesticides	Mod	Mod	Mod	Lo
	Overall Toxicant Rating	Mod	Lo-Mod	Lo-Mod	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	High	High	High	Mod
	Overall Probability of spill occurring	Mod-High	Mod-High	Mod-High	Mod-High
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod-High	Mod-High	Mod-High	Mod-High
Reclamation	Area of affected area as a %age of whole	Hi	Hi	Hi	Mod
	Ecological value of area prior to reclamation	Hi	Hi	Hi	Mod
	Overall Reclamation Vulnerability	Hi	Hi	Hi	Mod
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Hi	Mod	Mod	Lo
	Overall Vulnerability to FW Abstraction	Mod	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	Mod	Mod	Hi	Mod
	Proximity to Human Population Centres	Hi	Hi	Mod	Mod
	Overall Harvesting Vulnerability Rating	Mod-High	Mod-High	Mod-Hi	Mod
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Mod	Mod	Mod
	Overall Invasive Species Vulnerability Rating	Mod	Mod	Mod	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Waimea	Moutere Inlet/Delta	Mouteka Delta	Kaiteriteri
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Mod	Hi	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Mod	Hi	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Hi	Mod	Mod	Mod
	Proximity to Human Population Centres	Hi	Hi	Mod	Mod
	Access to vulnerable areas	Mod	Mod	Mod	Mod
	Overall Disturbance Vuln Rating	Mod-High	Mod-High	Mod	Mod
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Mod	Mod	Mod	Mod
	Seed Source up-current	Mod	Mod	Mod	Mod
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Hi	Hi	Hi	Hi
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Mod	Mod	Mod	Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Hi	Hi	Hi	Mod
	Overall Natural Terrestrial Margin Vulnerability	Hi	Hi	Hi	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Ngaio	Otuwhero	Marahau	Wainui
Catchment General	Estuary Type	TR	TL	TR	TL
	Catchment Area (km^2)	1	58	31	41
	Mean Freshwater Inflow (l/s)	33	2049	945	987
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	15, 79, 5/0, 2, 0, 0	28, 46, 10/15, 0, 0, 0	81, 11, 7/1, 0, 0, 0	85, 5, 9/0, 0, 0, 0
	Geology - dominant rock type	Grt (Grv)	Grt (Ls Gab Sch Gvl)	Grt (Grv)	Grt (Gab Grdio Grv)
	No. Dairy Cows, Ha, Cows/Ha				350, 140, 2.5
CLUES Model Estimates	N Load (t/y)	0.2	14.2	6.4	17.2
	TP (t/y)	0.089	3.0	2.1	3.9
	SS (kt/yr)	0.046	24.2	54.8	30.0
	E. coli load (x10^{15}/yr)	0.002	0.397	0.057	0.197
	Input mean TN (ug/l)	112	100	109	191
	Input Mean TP (ug/l)	47	17.6	19	21
	N Areal Load (mg/m^2/d)	19.6	40.9	46.8	21.9
	P Areal Load (mg/m^2/d)	8.7	8.6	15.1	4.9
	SS Areal Load (g/m^2/d)	4.5	69.7	403.1	38.1
	E. coli Areal Load (FCx10^6/m^2/d)	195657	1143399	416301	251146
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)				
Estuary General	Estuary area (ha)	3	95	37	215
	Shoreline Length (km)	1.1	8.0	4.3	8.4
	Mean Depth at HW (m)	0.3	0.8	0.5	1.5
	Estuary Volume @ HW = mean depth x area = (m^3)	7,001	713,841	186,147	3,230,285
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.120	0.337	0.618	0.052
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	FS	FMS	FS	FS
Habitat Indicators	Intertidal area	3	87	35	192
	Intertidal Soft mud (ha)	0	10	1	24
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	3	34	22	41
	Seagrass Area (ha)		1.0		
	Macroalgae (ha with cover >20%)				5.0
	Macroalgae (ha with cover >50%)				
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	93	84	37	43
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	0, 7, 0, 0	15, 0, 0, 0	63, 0, 0, 0	56, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	>10	5-10	>10	3-5
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	5	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	13.7	13.7	13.7
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Ngaio	Otuwhero	Marahau	Wainui
Sedimentation	Sedimentation Potential	Lo	Hi	Lo	Hi
	Sediment Existing Condition	Lo	Mod	Lo	Mod
	Overall Sediment Vulnerability Rating	Lo	Mod-Hi	Lo	Mod-Hi
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Mod	Mod	Mod	Mod
	Overall Human Influence	Mod	Mod	Mod	Mod
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	Mod	Mod	Mod	Mod
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	Mod	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	Mod	Hi	Hi	Hi
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Lo	Mod	Mod	Mod
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Mod	Mod	Mod
	Overall Invasive Species Vulnerability Rating	Mod	Mod	Mod	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Ngaio	Otuwhero	Marahau	Wainui
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Mod	Mod	Mod
	Proximity to Human Population Centres	Lo	Mod	Mod	Lo
	Access to vulnerable areas	Lo	Mod	Mod	Mod
	Overall Disturbance Vuln Rating	Lo	Mod	Mod	Mod
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Mod	Mod	Mod	Lo
	Seed Source up-current	Mod	Mod	Mod	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo-Mod	Lo-Mod	Lo-Mod	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Hi	Hi	Hi	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Mod	Mod	Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Lo	Lo	Mod	Mod
	Overall Natural Terrestrial Margin Vulnerability	Lo	Lo	Mod	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Ligar Tata	Motupipi	Waitapu	Takaka
Catchment General	Estuary Type	TL	TL	TL	TR
	Catchment Area (km^2)	3	41	4	869
	Mean Freshwater Inflow (l/s)	28	908	108	57000
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	13, 60, 26/0, 1, 0, 0	37, 8, 45/8, 2, 1, 0	5, 1, 81/0, 11, 2, 0	74, 3, 11/2, 0, 0, 10
	Geology - dominant rock type	Grt (Grv Sst)	LS Grv (Grdio Gab Sltst Sst)	Grv (Sst)	Arg Ls (Grv Mel Sltst Sst GSch)
	No. Dairy Cows, Ha, Cows/Ha		2000, 700, 2.9	700, 218, 3.2	6680, 2432, 2.7
CLUES Model Estimates	N Load (t/y)	0.6	40.4	7.8	456.7
	TP (t/y)	0.2	4.6	0.6	48.7
	SS (kt/yr)	0.1	12.8	0.4	281.8
	E. coli load (x10^{15}/yr)	0.025	1.589	0.087	5.029
	Input mean TN (ug/l)	250	714	1400	169
	Input Mean TP (ug/l)	60	53	164	9
	N Areal Load (mg/m^2/d)	9.4	65.5	17.7	284.4
	P Areal Load (mg/m^2/d)	3.3	7.5	1.4	30.3
	SS Areal Load (g/m^2/d)	1.6	20.7	0.9	175.5
	E. coli Areal Load (FCx10^6/m^2/d)	417711	2574847	198044	3131828
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	17	169	121	440
	Shoreline Length (km)	2.7	16.3	16.0	4.6
	Mean Depth at HW (m)	0.5	1.0	1.5	2.0
	Estuary Volume @ HW = mean depth x area = (m^3)	82,905	1,690,900	1,815,285	8,798,049
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.051	0.111	0.016	0.137
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	FMS	FMS	SMS	FS
Habitat Indicators	Intertidal area	17	157	112	356
	Intertidal Soft mud (ha)	6	37	32	0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	2	69	43	43
	Seagrass Area (ha)	0.9	2.5		15.1
	Macroalgae (ha with cover >20%)		3.6		
	Macroalgae (ha with cover >50%)		0.1		
	Gross Eutrophic Nuisance (ha)		0.20		
	Natural Terrestrial Margin (%)	35	22	23	56
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	53, 10, 0, 0	68, 3, 0, 0	77, 0, 0, 0	28, 16, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	3-5	5-10	1-3	5-10
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	3
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	5	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	13.7	13.7	10.6
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Ligar Tata	Motupipi	Waitapu	Takaka
Sedimentation	Sedimentation Potential	Lo	Hi	Lo	Lo
	Sediment Existing Condition	Hi	Hi	Hi	Lo
	Overall Sediment Vulnerability Rating	Mod	Hi	Mod	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Mod	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Lo	Mod	Mod	Hi
	Overall Human Influence	Lo	Mod	Mod	Hi
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Mod	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	Mod	High	Mod	High
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Mod	Lo	Mod
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo-Mod
Harvesting Living Resources	Presence of Harvestable Living Resource	Hi	Hi	Mod	Mod
	Proximity to Human Population Centres	Lo	Mod	Mod	Mod
	Overall Harvesting Vulnerability Rating	Mod	Mod-Hi	Mod	Mod
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Mod	Mod	Mod
	Overall Invasive Species Vulnerability Rating	Mod	Mod	Mod	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Ligar Tata	Motupipi	Waitapu	Takaka
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Mod	Mod	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Mod	Mod	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Mod	Mod	Mod
	Proximity to Human Population Centres	Mod	Mod	Mod	Mod
	Access to vulnerable areas	Mod	Mod	Mod	Mod
	Overall Disturbance Vuln Rating	Mod	Mod	Mod	Mod
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Mod	Hi	Hi	Lo
	Overall Natural Terrestrial Margin Vulnerability	Mod	Hi	Hi	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Onahau	Puremahaia	Battery Road	Grants Road
Catchment General	Estuary Type	TL	TR	TR	ICOLL (closed)
	Catchment Area (km^2)	22	4	2	0
	Mean Freshwater Inflow (l/s)	624	200	56	13
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	63, 2, 33/1, 2, 0, 0	56, 1, 43/0, 0, 0, 0	3, 1, 96/0, 0, 0, 0	0, 0, 100/0, 0 , 0
	Geology - dominant rock type	Grt Grv (Pt Sch)	Grv (Sch Grt)	Grv (Sltst Sst)	Grv (Sd)
	No. Dairy Cows, Ha, Cows/Ha	455, 205, 2.2	690, 320, 2.2		
CLUES Model Estimates	N Load (t/y)	26.4	5.6	4.6	0.1
	TP (t/y)	2.7	0.4	0.3	0.1
	SS (kt/yr)	1.1	0.3	0.1	0.0
	E. coli load (x10^{15}/yr)	0.849	0.328	0.279	0.076
	Input mean TN (ug/l)	640	642	1505	1489
	Input Mean TP (ug/l)	87	57	119	103
	N Areal Load (mg/m^2/d)	228.1	18983.6	4458.7	121.5
	P Areal Load (mg/m^2/d)	23.6	1475.4	334.5	97.9
	SS Areal Load (g/m^2/d)	9.2	1132.8	137.6	27.2
	E. coli Areal Load (FCx10^6/m^2/d)	7324958	1113600561	273167446	137816522
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	32	0.1	0.3	0.2
	Shoreline Length (km)	3.9	0.4	0.6	0.5
	Mean Depth at HW (m)	1.8	0.8	1.0	0.3
	Estuary Volume @ HW = mean depth x area = (m^3)	555,893	605	2,799	378
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.198	23.752	1.681	2.669
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	FMS	FS CF	FS CF	FS
Habitat Indicators	Intertidal area	30	0	0.2	0
	Intertidal Soft mud (ha)	1	0	0	0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	19	0	0	0
	Seagrass Area (ha)				
	Macroalgae (ha with cover >20%)				
	Macroalgae (ha with cover >50%)				
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	12	0	50	0
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	76, 12, 0, 0	100, 0, 0, 0	50, 0, 0, 0	100, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	1-3	5-10	3-5	1-3
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	5	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	13.7	13.7	13.7
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Onahau	Puremahaia	Battery Road	Grants Road
Sedimentation	Sedimentation Potential	Hi	Lo	Lo	Mod
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Mod	Lo	Lo	Lo-Mod
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Hi	Hi	Hi	Hi
	Overall Human Influence	Hi	Hi	Hi	Hi
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	High	High	High	High
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Mod	Mod	Mod	Mod
	Overall Vulnerability to FW Abstraction	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Harvesting Living Resources	Presence of Harvestable Living Resource	Mod	Lo	Lo	Lo
	Proximity to Human Population Centres	Mod	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Mod	Lo	Lo	Lo
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Mod	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Onahau	Puremahaia	Battery Road	Grants Road
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Mod	Lo	Lo	Lo
	Proximity to Human Population Centres	Mod	Lo	Lo	Lo
	Access to vulnerable areas	Mod	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Mod	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Hi	Hi	Mod	Hi
	Overall Natural Terrestrial Margin Vulnerability	Hi	Hi	Mod	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Pariwhakaoho	Onekaka	Little Kaituna	Tukurua
Catchment General	Estuary Type	TR	TL	TR	TR
	Catchment Area (km²)	15	17	2	5
	Mean Freshwater Inflow (l/s)	629	665	64	189
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	77, 5, 17/0, 0, 0, 1	64, 4, 32/0, 0, 0, 0	39, 11, 49/0, 0, 0, 0	83, 5, 10/1, 0, 0, 0
	Geology - dominant rock type	Sch Ls (Grv Sltst Sst)	Grv Sch (Sltst)	Grv (Sltst Sch)	Sltst Sch Sst (Grv Ls)
	No. Dairy Cows, Ha, Cows/Ha	420, 40, 10.5	720, 410, 1.8	120, 95, 1.3	50, 40, 1.3
CLUES Model Estimates	N Load (t/y)	11.8	17.7	2.4	2.3
	TP (t/y)	1.2	2.7	0.7	0.3
	SS (kt/yr)	9.6	7.4	0.7	2.0
	E. coli load ($x10^{15}$/yr)	0.408	0.666	0.048	0.029
	Input mean TN (ug/l)	348	367	570	195
	Input Mean TP (ug/l)	21	40	154	24
	N Areal Load (mg/m²/d)	13793.9	206.9	104.8	17570.1
	P Areal Load (mg/m²/d)	1403.9	32.1	31.8	2518.1
	SS Areal Load (g/m²/d)	11213.6	87.0	31.8	15443.2
	E. coli Areal Load ($FCx10^6$/m²/d)	477990189	7801473	2097317	220944879
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load ($Fcx10^{15}$/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	0.2	23	6	0
	Shoreline Length (km)	0.1	4.1	1.3	0.2
	Mean Depth at HW (m)	0.5	1.5	0.5	0.5
	Estuary Volume @ HW = mean depth x area = (m³)	1,168	350,661	31,456	179
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	45.242	0.156	0.171	88.573
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	CF	FMS	FMS	CF
Habitat Indicators	Intertidal area	0.2	21	6	0
	Intertidal Soft mud (ha)	0	0	0	0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	0	5	6	0
	Seagrass Area (ha)				
	Macroalgae (ha with cover >20%)				
	Macroalgae (ha with cover >50%)				
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	50	19	43	96
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	28, 0, 0, 0	75, 0, 0, 0	57, 0, 0, 0	0, 0, 0, 0
	Chlor-a Benthic mg/m²				
	Mean Chlor-a surface water mg/m³				
	Dominant RPD Depth (cm)	1-3	1-3	1-3	1-3
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	3	5	5	3
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	4	5	5	4
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	9.5	13.7	13.7	9.5
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Pariwhakaoho	Onekaka	Little Kaituna	Tukurua
Sedimentation	Sedimentation Potential	Lo	Hi	Hi	Lo
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Lo	Mod	Mod	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Hi	Hi	Hi	Hi
	Overall Human Influence	Hi	Hi	Hi	Hi
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	High	High	High	High
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Mod	Mod	Mod	Mod
	Overall Vulnerability to FW Abstraction	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Harvesting Living Resources	Presence of Harvestable Living Resource	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Lo	Lo	Lo	Lo
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Lo	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Pariwhakaoho	Onekaka	Little Kaituna	Tukurua
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Lo	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Lo	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Mod	Hi	Mod	Lo
	Overall Natural Terrestrial Margin Vulnerability	Mod	Hi	Mod	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Parapara	Ruataniwha	Waikato	Pakawau
Catchment General	Estuary Type	TL	TR	TL	TL
	Catchment Area (km^2)	42	711	2	8
	Mean Freshwater Inflow (l/s)	1777	80000	51	158
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	96, 2, 1/0, 0, 0, 0	78, 1, 12/0, 0, 0, 7	72, 2, 26/0, 0, 0, 0	79, 11, 9/1, 0, 0, 0
	Geology - dominant rock type	Arg (Gsch Sst)	Sst (Arg Grv Grt Sltst Grdio Bas Ls GSch)	Ls (Sltst Sst Grv)	Sst (Grv Grt)
	No. Dairy Cows, Ha, Cows/Ha		13300, 5000, 2.7		234, 180, 1.3
CLUES Model Estimates	N Load (t/y)	14.8	482.7	1.0	3.3
	TP (t/y)	1.3	67.8	0.8	0.6
	SS (kt/yr)	17.8	335.9	1.2	1.4
	E. coli load (x10^{15}/yr)	0.051	11.064	0.043	0.082
	Input mean TN (ug/l)	140	225	232	318
	Input Mean TP (ug/l)	7	11	41	30
	N Areal Load (mg/m^2/d)	20.8	193.3	14.5	13.9
	P Areal Load (mg/m^2/d)	1.8	27.2	10.9	2.7
	SS Areal Load (g/m^2/d)	25.0	134.6	17.5	6.0
	E. coli Areal Load (FCx10^6/m^2/d)	71496	4431667	618841	343971
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	195	864	19	65
	Shoreline Length (km)	13.2	26.0	4.1	4.4
	Mean Depth at HW (m)	1.8	2.3	0.5	1.2
	Estuary Volume @ HW = mean depth x area = (m^3)	3,513,627	15,732,000	95,760	780,697
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.042	0.577	0.044	0.016
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	FMS	FMS	FS	FMS
Habitat Indicators	Intertidal area	181	727	19	65
	Intertidal Soft mud (ha)	48	89	0	10
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	42	121	11	31
	Seagrass Area (ha)	1.1	11.9		0.1
	Macroalgae (ha with cover >20%)				
	Macroalgae (ha with cover >50%)				
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	82	8	38	14
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	12, 6, 0, 0	88, 2, 0, 0	62, 0, 0, 0	86, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	1-3	5-10	5-10	3-5
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	5	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	13.7	13.7	13.7
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Parapara	Ruataniwha	Waikato	Pakawau
Sedimentation	Sedimentation Potential	Hi	Mod	Hi	Hi
	Sediment Existing Condition	Hi	Mod	Lo	Mod
	Overall Sediment Vulnerability Rating	Hi	Mod	Mod	Mod-Hi
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Mod	Hi	Mod	Mod
	Overall Human Influence	Mod	Hi	Mod	Mod
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	Mod	High	Mod	Mod
	Shellfish Areal FC Loading Rating	Mod	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	Mod	Hi	Hi	Hi
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Lo	Lo	Lo	Lo
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Mod	Mod	Mod
	Overall Invasive Species Vulnerability Rating	Mod	Mod	Mod	Mod

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Parapara	Ruataniwha	Waikato	Pakawau
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Mod	Mod	Mod	Mod
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Mod	Mod	Mod	Mod
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Hi	Hi	Hi	Hi
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Hi	Hi	Hi	Hi
	Overall Disturbance Vuln Rating	Mod	Mod	Mod	Mod
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Lo	Hi	Mod	Hi
	Overall Natural Terrestrial Margin Vulnerability	Lo	Hi	Mod	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Onetaua	Matakota	Billy King Creek	Taupata
Catchment General	Estuary Type	TR	TR	TR	TR
	Catchment Area (km²)	2	1	3	8
	Mean Freshwater Inflow (l/s)	34	17	52	145
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	78, 3, 20/0, 0, 0, 0	74, 6, 20/0, 0, 0, 0	89, 0, 11/0, 0, 0, 0	89, 1, 10/0, 0, 0, 1
	Geology - dominant rock type	Sst (Grv)	Sst (Grv)	Sst (Grv)	Sst (Grv)
	No. Dairy Cows, Ha, Cows/Ha				302, 232, 1.3
CLUES Model Estimates	N Load (t/y)	0.9	0.2	1.5	3.1
	TP (t/y)	0.2	0.1	0.3	0.4
	SS (kt/yr)	0.3	0.1	0.5	1.1
	E. coli load ($x10^{15}$/yr)	0.023	0.013	0.018	0.042
	Input mean TN (ug/l)	434	291	560	455
	Input Mean TP (ug/l)	89	55	86	48
	N Areal Load ($mg/m^2/d$)	103.4	27.5	698.2	2380.3
	P Areal Load ($mg/m^2/d$)	23.5	6.5	129.5	298.6
	SS Areal Load ($g/m^2/d$)	32.6	14.7	220.1	826.5
	E. coli Areal Load ($FCx10^6/m^2/d$)	2708432	1416056	8409548	31839749
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load ($Fcx10^{15}$/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	2	2	1	0.4
	Shoreline Length (km)	0.2	0.8	0.2	0.2
	Mean Depth at HW (m)	0.5	0.5	0.5	0.5
	Estuary Volume @ HW = mean depth x area = (m^3)	11,744	12,421	2,908	1,804
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.243	0.108	1.502	6.753
	Spring Tidal Range MHW (m)	3.6	3.6	3.6	3.6
	Dominant sediment type	CF	CF	CF	CF
Habitat Indicators	Intertidal area	2	2	1	0
	Intertidal Soft mud (ha)	0	0	0	0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	0	1	1	0
	Seagrass Area (ha)				
	Macroalgae (ha with cover >20%)				
	Macroalgae (ha with cover >50%)				
	Gross Eutrophic Nuisance (ha)				
	Natural Terrestrial Margin (%)	100	19	5	22
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	0, 0, 0, 0	81, 0, 0, 0	93, 0, 0, 0	78, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	1-3	1-3	1-3	1-3
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	3	3	3	3
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	5	5	5
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	10.6	10.6	10.6	10.6
	Overall Sea Level Rise Vulnerability	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Onetaua	Matakota	Billy King Creek	Taupata
Sedimentation	Sedimentation Potential	Lo	Lo	Lo	Lo
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Lo	Lo	Lo	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Hi	Mod	Hi	Hi
	Overall Human Influence	Hi	Mod	Hi	Hi
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Disease Risk	Bathing Areal FC Loading Rating	High	High	High	High
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	High	High	High
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Lo	Lo	Lo	Lo
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Lo	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Onetaua	Matakota	Billy King Creek	Taupata
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Lo	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Lo	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Lo	Hi	Hi	Hi
	Overall Natural Terrestrial Margin Vulnerability	Lo	Hi	Hi	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Puponga	Wharariki	Green Hills	Nguroa
Catchment General	Estuary Type	TL	TR	TR	TR
	Catchment Area (km^2)	5	9	8	12
	Mean Freshwater Inflow (l/s)	90	165	146	211
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	88, 1, 10/0, 0, 0, 0	79, 0, 21/0, 0, 0, 0	89, 0, 10/0, 0, 0, 0	67, 4, 27/2, 0, 0, 1
	Geology - dominant rock type	Sst (Grv Pt)	Sst (Pt Sd)	Sst (Sd)	Sst (Sd Pt)
	No. Dairy Cows, Ha, Cows/Ha				
CLUES Model Estimates	N Load (t/y)	1.2	2.7	2.4	4.1
	TP (t/y)	0.2	0.5	0.4	1.8
	SS (kt/yr)	0.3	0.8	1.1	1.8
	E. coli load (x10^{15}/yr)	0.070	0.261	0.101	0.371
	Input mean TN (ug/l)	316	377	364	345
	Input Mean TP (ug/l)	40	61	39	106
	N Areal Load (mg/m^2/d)	10.4	263.8	150.0	743.1
	P Areal Load (mg/m^2/d)	1.3	53.3	21.8	323.4
	SS Areal Load (g/m^2/d)	2.6	77.4	68.1	331.9
	E. coli Areal Load (FCx10^6/m^2/d)	582969	25510763	6285181	67702283
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)				
Estuary General	Estuary area (ha)	33	2.8	4.4	1.5
	Shoreline Length (km)	4.9	1.8	1.0	1.0
	Mean Depth at HW (m)	1.5	1.5	1.0	1.5
	Estuary Volume @ HW = mean depth x area = (m^3)	489,934	42,000	44,000	22,500
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	0.034	0.330	0.649	0.791
	Spring Tidal Range MHW (m)	3.6	3.2	3.2	3.2
	Dominant sediment type	FMS	FS	FS	FS
Habitat Indicators	Intertidal area	32	2.1	2.1	0.5
	Intertidal Soft mud (ha)	4	0.0	0.0	0.0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	8	0.1	79.0	0.6
	Seagrass Area (ha)	15.0	0.0	0.0	
	Macroalgae (ha with cover >20%)		0.0	0.0	0.0
	Macroalgae (ha with cover >50%)		0.0	0.0	0.0
	Gross Eutrophic Nuisance (ha)		0.0	0.0	0.0
	Natural Terrestrial Margin (%)	66	45	62	0
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	30, 4, 0, 0	55, 0, 0, 0	38, 0, 0, 0	100, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)	3-5			
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	4	4	4
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	4	4	4
	f. Mean Tidal Range	3	3	3	3
	Physical CV = √{(a.b.c.d.e.f)/6}	13.7	24.5	24.5	24.5
	Overall Sea Level Rise Vulnerability	Lo	Hi	Hi	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Puponga	Wharariki	Green Hills	Nguroa
Sedimentation	Sedimentation Potential	Mod	Lo	Lo	Lo
	Sediment Existing Condition	Mod	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Mod	Lo	Lo	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Lo	Lo	Lo	Lo
	Overall Human Influence	Lo	Lo	Lo	Lo
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Hi	Hi	Hi	Hi
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo	Lo	Lo	Lo
Disease Risk	Bathing Areal FC Loading Rating	Mod	Mod	Mod	Hi
	Shellfish Areal FC Loading Rating	High	Mod	High	Hi
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	High	Mod	Mod	Mod
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	Mod	Lo	Lo	Lo
	Proximity to Human Population Centres	Mod	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Mod	Lo	Lo	Lo
Invasive Species	Pathway	Mod	Mod	Mod	Mod
	Existing Presence	Mod	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Mod	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Puponga	Wharariki	Green Hills	Nguroa
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Mod	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Mod	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Lo	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Lo	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	Hi	Hi	Hi	Hi
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Mod	Lo	Lo	Hi
	Overall Natural Terrestrial Margin Vulnerability	Mod	Lo	Lo	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Whanganui	Paturau	Sandhills Creek	Anatori
Catchment General	Estuary Type	TL	TR	TR	TR
	Catchment Area (km^2)	81	77	38	76
	Mean Freshwater Inflow (l/s)	2715	5112	1768	5001
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	91, 3, 6/0, 0, 0, 0	87, 0, 6/6, 0, 0, 0	85, 1, 9/2, 0, 0, 0	97, 0, 1/0, 0, 0, 2
	Geology - dominant rock type	Sst (Sch Grt	Sst (Arg Grv)	Sst (Arg Ls Sltst)	Sst (Arg Ls Sltst)
	No. Dairy Cows, Ha, Cows/Ha				
CLUES Model Estimates	N Load (t/y)	35.6	30.9	10.2	22.3
	TP (t/y)	5.3	5.9	1.5	3.1
	SS (kt/yr)	18.9	31.8	8.9	26.4
	E. coli load ($x10^{15}$/yr)	0.779	0.885	0.133	0.083
	Input mean TN (ug/l)	200	111	117	80
	Input Mean TP (ug/l)	15	14	13	8
	N Areal Load ($mg/m^2/d$)	3.5	591.6	844.8	527.1
	P Areal Load ($mg/m^2/d$)	0.5	113.1	122.1	73.7
	SS Areal Load ($g/m^2/d$)	1.9	609.8	740.1	624.2
	E. coli Areal Load ($FCx10^6/m^2/d$)	77627	16964843	11070154	1963155
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load ($Fcx10^{15}$/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	2748.0	14.3	3.3	11.6
	Shoreline Length (km)	104.2	3.0	0.8	2.4
	Mean Depth at HW (m)	1.2	1.8	1.5	2.0
	Estuary Volume @ HW = mean depth x area = (m^3)	32,426,400	250,250	49,500	232,000
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	1.591	2.568	3.000	3.241
	Spring Tidal Range MHW (m)	3.1	3.1	3.1	3.1
	Dominant sediment type	FMS	GF/CF	FS	GF/CF
Habitat Indicators	Intertidal area	1979.0	8.0000	1.9	6.6
	Intertidal Soft mud (ha)	110.0	0.0	0.0	0.0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	96.0	1.7	0.1	0.0
	Seagrass Area (ha)	860.0	0.0	0.0	0.0
	Macroalgae (ha with cover >20%)	15.0	0.0	0.0	0.0
	Macroalgae (ha with cover >50%)		0.0	0.0	0.0
	Gross Eutrophic Nuisance (ha)		0.0	0.0	0.0
	Natural Terrestrial Margin (%)	83	0	18	95
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	17, 0, 0, 0	100, 0, 0, 0	82, 0, 0, 0	7, 0, 0, 0
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)				
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	4	5	4
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	5	4	4	4
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	4	4	4
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	13.7	21.9	24.5	21.9
	Overall Sea Level Rise Vulnerability	Lo	Hi	Hi	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Whanganui	Paturau	Sandhills Creek	Anatori
Sedimentation	Sedimentation Potential	Mod	Lo	Lo	Lo
	Sediment Existing Condition	Mod	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Mod	Lo	Lo	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Lo	Hi	Lo	Lo
	Overall Human Influence	Lo	Hi	Lo	Lo
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	Mod	High	High	High
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo	Lo-Mod	Lo	Lo
Disease Risk	Bathing Areal FC Loading Rating	Mod	High	High	High
	Shellfish Areal FC Loading Rating	Mod	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	Mod	Mod	Mod	Mod
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	High	High	High	High
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Mod	Mod	Mod	Mod
Invasive Species	Pathway	Mod	Lo	Lo	Lo
	Existing Presence	Mod	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Mod	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Whanganui	Paturau	Sandhills Creek	Anatori
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Hi	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Lo	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Mod	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-High	Mod-High	Mod-High	Mod-High
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	High	High	High	High
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Lo	High	High	Lo
	Overall Natural Terrestrial Margin Vulnerability	Mod	High	High	High

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Te Rata Creek	Turimawiwi	Anaweka	Raukawa
Catchment General	Estuary Type	TR	TR	TR	TR
	Catchment Area (km²)	6	57	29	7
	Mean Freshwater Inflow (l/s)	223	4455	2348	333
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	57, 0, 41/0, 0, 0, 2	90, 0, 7/0, 0, 0, 2	94, 0, 2/0, 0, 0, 4	91, 0, 9/0, 0, 0, 0
	Geology - dominant rock type	Sltst Ls (Sst Pt)	Arg Sst Grt (Ls Sltst)	Grt (Arg Sst Ls)	Grt (Ls Sltst Sst)
	No. Dairy Cows, Ha, Cows/Ha				
CLUES Model Estimates	N Load (t/y)	1.8	19.7	9.9	2.0
	TP (t/y)	1.5	3.9	1.2	0.5
	SS (kt/yr)	2.0	17.0	2.1	2.1
	E. coli load ($x10^{15}$/yr)	0.238	0.337	0.039	0.034
	Input mean TN (ug/l)	125	89	80	87
	Input Mean TP (ug/l)	78	10	10	21
	N Areal Load (mg/m²/d)	286.5	868.8	42.0	49.0
	P Areal Load (mg/m²/d)	247.6	171.3	5.3	12.1
	SS Areal Load (g/m²/d)	328.1	749.3	8.9	52.9
	E. coli Areal Load ($FCx10^6/m^2/d$)	38407736	14888643	164553	861450
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load ($Fcx10^{15}$/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Estuary General	Estuary area (ha)	1.7	6.2	64.6	11.0
	Shoreline Length (km)	0.9	1.2	8.4	3.8
	Mean Depth at HW (m)	1.0	1.5	1.5	1.5
	Estuary Volume @ HW = mean depth x area = (m³)	17,000	93,000	969,000	164,250
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	1.102	7.659	0.401	0.170
	Spring Tidal Range MHW (m)	3.1	3.1	3.1	3.1
	Dominant sediment type	FS	FS	FS	FS
Habitat Indicators	Intertidal area	0.8	4.1	52.4	8.0
	Intertidal Soft mud (ha)	0.0	0.0	0.0	0.0
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	0.0	0.4	10.6	3.6
	Seagrass Area (ha)	0.0	0.0	0.0	0.0
	Macroalgae (ha with cover >20%)	0.0	0.0	0.0	0.0
	Macroalgae (ha with cover >50%)	0.0	0.0	0.0	0.0
	Gross Eutrophic Nuisance (ha)	0.0	0.0	0.0	0.0
	Natural Terrestrial Margin (%)	4	0	53	56
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	96, 0, 0, 0	100, 0, 0, 0	47, 0, 0, 0	44, 0, 0, 0
	Chlor-a Benthic mg/m²				
	Mean Chlor-a surface water mg/m³				
	Dominant RPD Depth (cm)				
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	4	4	4	4
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	4	4	4	4
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	24.5	24.5	24.5	24.5
	Overall Sea Level Rise Vulnerability	Hi	Hi	Hi	Hi

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Te Rata Creek	Turimawiwi	Anaweka	Raukawa
Sedimentation	Sedimentation Potential	Lo	Lo	Lo	Lo
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Lo	Lo	Lo	Lo
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo	Lo	Lo
	Macroalgae	Lo	Lo	Lo	Lo
	Epiphytes	Lo	Lo	Lo	Lo
	Overall Primary Symptoms	Lo	Lo	Lo	Lo
	DO in Water Column	Lo	Lo	Lo	Lo
	Gross Nuisance Conditions	Lo	Lo	Lo	Lo
	Sediment RPD	Lo	Lo	Lo	Lo
	Seagrass/Saltmarsh	Lo	Lo	Lo	Lo
	Harmful Algae	Lo	Lo	Lo	Lo
	Overall Secondary Symptoms	Lo	Lo	Lo	Lo
	Nitrogen (water) or N areal loading	Lo	Lo	Mod	Mod
	Overall Human Influence	Lo	Lo	Lo	Lo
	Dilution Potential	Lo	Lo	Lo	Lo
	Flushing Potential	High	High	High	High
	Overall Export Potential	Mod	Mod	Mod	Mod
	Overall Eutrophication Vulnerability Rating	Lo	Lo	Lo	Lo
Disease Risk	Bathing Areal FC Loading Rating	High	High	Mod	Mod
	Shellfish Areal FC Loading Rating	High	High	High	High
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicants	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spills	Proximity to offshore drilling platform	Mod	Mod	Mod	Mod
	Proximity to vessel path	Mod	Mod	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Mod	Mod
	Habitat Sensitivity	High	High	High	High
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-High	Mod-High	Mod-High	Mod-High
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
Reclamation	Area of affected area as a %age of whole	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to FW Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of Harvestable Living Resource	High	High	High	High
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Overall Harvesting Vulnerability Rating	Mod	Mod	Mod	Mod
Invasive Species	Pathway	Lo	Lo	Lo	Lo
	Existing Presence	Lo	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Lo	Lo	Lo	Lo

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Te Rata Creek	Turimawiwi	Anaweka	Raukawa
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vun. Rating	Lo	Lo	Lo	Lo
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo	Lo	Lo
	Presence of Damage	Lo	Lo	Lo	Lo
	Overall ORV Vuln Rating	Lo	Lo	Lo	Lo
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Lo	Lo	Lo
	Proximity to Human Population Centres	Lo	Lo	Lo	Lo
	Access to vulnerable areas	Lo	Lo	Lo	Lo
	Overall Disturbance Vuln Rating	Lo	Lo	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Lo	Lo	Lo	Lo
	Seed Source up-current	Lo	Lo	Lo	Lo
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo	Lo	Lo	Lo
	Presence of at-risk local species	Mod-High	Mod-High	Mod-High	Mod-High
	Presence of humans who eat shellfish/fish	Lo	Lo	Lo	Lo
	Overall Human Risk of Eating Infected Species.	High	High	High	High
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA	NA	NA
	Presence residential/industrial dwellings on duneland	NA	NA	NA	NA
	Presence of developed pasture on duneland	NA	NA	NA	NA
	Presence of seawalls in front of duneland	NA	NA	NA	NA
	Presence of marram/weeds on duneland	NA	NA	NA	NA
	Overall Dune Overstabilsation Vuln. Rating	NA	NA	NA	NA
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo	Lo	Lo
	Overall Grazing Vuln Rating	Lo	Lo	Lo	Lo
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	High	High	Mod	Mod
	Overall Natural Terrestrial Margin Vulnerability	High	High	High	High

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Category	Characteristic	Big River	Lagoon Creek		
Catchment General	Estuary Type	TR	TR		
	Catchment Area (km^2)	107	5		
	Mean Freshwater Inflow (l/s)	12169	220		
	Landuse (% NSF, ESF, HPP/LPP,Urb,Crop, Bare)	79, 0, 0/0, 0, 0, 20	99, 0, 1/0, 0, 0, 0		
	Geology - dominant rock type	Grt (Arg Ls)	Grt (Sst Ls)		
	No. Dairy Cows, Ha, Cows/Ha				
CLUES Model Estimates	N Load (t/y)	47.6	1.3		
	TP (t/y)	5.4	0.1		
	SS (kt/yr)	19.0	0.3		
	E. coli load ($x10^{15}$/yr)	0.378	0.005		
	Input mean TN (ug/l)	69	150		
	Input Mean TP (ug/l)	6	17		
	N Areal Load ($mg/m^2/d$)	434.7	52.7		
	P Areal Load ($mg/m^2/d$)	49.3	5.7		
	SS Areal Load ($g/m^2/d$)	173.2	12.3		
	E. coli Areal Load ($FCx10^6/m^2/d$)	3451324	212133		
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load ($Fcx10^{15}$/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo		
Estuary General	Estuary area (ha)	30.0	7.0		
	Shoreline Length (km)	5.6	2.1		
	Mean Depth at HW (m)	2.0	1.0		
	Estuary Volume @ HW = mean depth x area = (m^3)	600,000	70,000		
	Flushing Potential = FW(m3/d)/EV(m3) = (days)	2.766	0.264		
	Spring Tidal Range MHW (m)	3.0	3.0		
	Dominant sediment type	FS	FS		
Habitat Indicators	Intertidal area	10.2	5.1		
	Intertidal Soft mud (ha)	0.0	0.0		
	Subtidal Soft Mud (ha)				
	Saltmarsh Area (ha)	0.6	1		
	Seagrass Area (ha)	0.0	0.0		
	Macroalgae (ha with cover >20%)	0.0	0.0		
	Macroalgae (ha with cover >50%)	0.0	0.0		
	Gross Eutrophic Nuisance (ha)	0.0	0.0		
	Natural Terrestrial Margin (%)	95	96		
	Terrestrial Margin (% Gra, Resi, Hort, Indu)	5, 0, 0, 0	4, 0, 0, 0		
	Chlor-a Benthic mg/m^2				
	Mean Chlor-a surface water mg/m^3				
	Dominant RPD Depth (cm)				
VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5		
	b. Erosion/Accretion Rate (m/yr)	3	3		
	c. Slope (%)	4	4		
	d. Rel. Sea Level Rise Rate (mm/yr)	5	5		
	e. Mean Wave Height (m)	4	4		
	f. Mean Tidal Range	3	3		
	Physical CV = √{(a.b.c.d.e.f)/6}	24.5	24.5		
	Overall Sea Level Rise Vulnerability	Hi	Hi		

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Big River	Lagoon Creek		
Sedimentation	Sedimentation Potential	Lo	Lo		
	Sediment Existing Condition	Lo	Lo		
	Overall Sediment Vulnerability Rating	Lo	Lo		
Eutrophication	Phytoplankton - Chlorophyll - a	Lo	Lo		
	Macroalgae	Lo	Lo		
	Epiphytes	Lo	Lo		
	Overall Primary Symptoms	Lo	Lo		
	DO in Water Column	Lo	Lo		
	Gross Nuisance Conditions	Lo	Lo		
	Sediment RPD	Lo	Lo		
	Seagrass/Saltmarsh	Lo	Lo		
	Harmful Algae	Lo	Lo		
	Overall Secondary Symptoms	Lo	Lo		
	Nitrogen (water) or N areal loading	Lo	Mod		
	Overall Human Influence	Lo	Lo		
	Dilution Potential	Lo	Lo		
	Flushing Potential	Hi	Hi		
	Overall Export Potential	Mod	Mod		
	Overall Eutrophication Vulnerability Rating	Lo	Lo		
Disease Risk	Bathing Areal FC Loading Rating	Hi	Mod		
	Shellfish Areal FC Loading Rating	Hi	Hi		
	Timing of Disease Risk	Floods	Floods		
Toxicants	Urban Runoff Rating	Lo	Lo		
	Natural Sources	Lo	Lo		
	Pesticides	Lo	Lo		
	Overall Toxicant Rating	Lo	Lo		
Oil Spills	Proximity to offshore drilling platform	Mod	Mod		
	Proximity to vessel path	Mod	Mod		
	Proximity to land runoff source	Lo	Lo		
	Overall Probability of spill occurring	Mod	Mod		
	Habitat Sensitivity	High	High		
	Recovery Time	Mod	Mod		
	Overall Magnitude of Impact	Mod-High	Mod-High		
	Overall Oil Spill Vulnerability Rating	Mod	Mod		
Reclamation	Area of affected area as a %age of whole	Lo	Lo		
	Ecological value of area prior to reclamation	Lo	Lo		
	Overall Reclamation Vulnerability	Lo	Lo		
Freshwater Abstraction	Susceptibility	Lo	Lo		
	Magnitude	Lo	Lo		
	Overall Vulnerability to FW Abstraction	Lo	Lo		
Harvesting Living Resources	Presence of Harvestable Living Resource	Hi	Hi		
	Proximity to Human Population Centres	Lo	Lo		
	Overall Harvesting Vulnerability Rating	Mod	Mod		
Invasive Species	Pathway	Lo	Lo		
	Existing Presence	Lo	Lo		
	Overall Invasive Species Vulnerability Rating	Lo	Lo		

APPENDIX 1. ESTUARY CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Big River	Lagoon Creek		
Shoreline Armouring, Structures	Seawall/Breakwater/Causeway	Lo	Lo		
	Groyne	Lo	Lo		
	Exposure	Lo	Lo		
	Overall Structures Vun. Rating	Lo	Lo		
Vehicles on Beaches	Vehicles on Beaches, Dunes and Tidal Flats	Lo	Lo		
	Presence of Damage	Lo	Lo		
	Overall ORV Vuln Rating	Lo	Lo		
Wildlife Distur-bance	Presence of vulnerable wildlife	Lo	Lo		
	Proximity to Human Population Centres	Lo	Lo		
	Access to vulnerable areas	Lo	Lo		
	Overall Disturbance Vuln Rating	Lo	Lo		
Toxic Algal Blooms	Previous TABs	Lo	Lo		
	Seed Source local	Lo	Lo		
	Seed Source up-current	Lo	Lo		
	Conditions favourable for blooms	Lo-Mod	Lo-Mod		
	Overall Risk in Area	Lo	Lo		
	Presence of at-risk local species	Mod-Hi	Mod-Hi		
	Presence of humans who eat shellfish/fish	Lo	Lo		
	Overall Human Risk of Eating Infected Species.	Hi	Hi		
	Overall TAB Vuln. Rating	Lo-Mod	Lo-Mod		
Dune Overstabi-lisation	Presence of exotic forest on duneland	NA	NA		
	Presence residential/industrial dwellings on duneland	NA	NA		
	Presence of developed pasture on duneland	NA	NA		
	Presence of seawalls in front of duneland	NA	NA		
	Presence of marram/weeds on duneland	NA	NA		
	Overall Dune Overstabilsation Vuln. Rating	NA	NA		
Grazing	Presence of grazing animals in high value habitat.	Lo	Lo		
	Overall Grazing Vuln Rating	Lo	Lo		
Natural Terrestrial Margin	% non-natural cover of 200m wide margin	Lo	Lo		
	Overall Natural Terrestrial Margin Vulnerability	Hi	Hi		

APPENDIX 2. BEACH, DUNE AND ROCKY SHORE: CHARACTERISTICS AND VULNERABILITIES

SOURCES OF INFORMATION

Beach types	Coastal Explorer or Expert Opinion
Spring Tidal Range	Coastal Explorer
Geomorphology	Coastal Explorer or field estimate
Erosion/Accretion Rate (m/yr)	Eric Verstappen estimates (TDC)
Slope (%)	Coastal Explorer or field estimate
Rel. Sea Level Rise Rate (mm/yr)	Wratt et al 2008 : 5-10mm/yr
Mean Wave Height (m)	Coastal Explorer
Mean Tidal Range	Coastal Explorer
Key To terms	
WD LBT	Wave dominated longshore bar and trough
WD LTT	Wave dominated low tide terrace
WD TBR	Wave dominated tranverse bar and rip
UD	Ultra dissipative
R SF	Reflective + sand flats
R TSF	Reflective + tidal sand flats
R	Reflective
R LTT	Reflective + low tide terrace
Crop	Crop
Bare	Bare/Lightly vegetated

APPENDIX 2. BEACH, DUNE AND ROCKY SHORE CHARACTERISTICS & VULNERABILITIES

BEACH AND ROCKY SHORES		Rabbit Island	Ruby Bay - Jackett Is	Jackett Is - Tapu Bay	Tapu Bay - Otuwhero
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Beach and Rocky Shores Indicators	Total shoreline length (inc estuaries) (km)	8.4	15.3	7.7	9.0
	Beach Types	R LTT	R SF	R TSF	R
	Beach Length (km)	8.5	12.6	21.5	3.2
	Rocky Shore Length (m)	0	0	0	3.7
	Dominant Upper Beach Substrate	sand	cobble	cobble	sand
	Dominant Lower Beach Substrate	sand	cobble/sand	sand	sand
	Dominant Dune Vegetation (exotic/native)	E	E	E	E
	Native Dune Plantings (length, m)	800	0	0	0
	Dune Area (ha)	13.8	0	7.3	0.2
	Dune Length (km)	7.9	0	1.5	0.25
	Seawall Length (km)	0	2.2	0	0
	Natural Terrestrial Margin (% of margin)	0	13	26	43
	Saltmarsh Area (ha)	0	1	1.6	0.4
	Seagrass Area (ha)	0.0	1.8	12.3	0
	Macroalgae (ha with cover >20%)	Low	Low	Low	Low
	Macroalgae (ha with cover >50%)	Low	Low	Low	Low
	Intertidal Soft mud (ha)	0.0	0.0	0.0	0.0
	Subtidal Soft Mud (yes/no)	no	no	?	no
BEACH AND ROCKY SHORE VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	4	4	2
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	4	2	3	1
	d. Relative Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	12.2	7.7	9.5	3.9
Muddiness	Sedimentation Potential	Lo	Lo	Lo	Lo
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Lo	Lo	Lo	Lo
Eutrophication	Overall Eutrophication Vulnerability Rating	Lo-Mod	Lo	Lo	Lo
Disease Risk	Bathing Areal FC Loading Rating	Mod	Mod	Mod	Mod
	Shellfish Areal FC Loading Rating	Hi	Hi	Hi	Hi
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicant Risk	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Mod	Mod	Mod	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo-Mod	Lo-Mod	Lo-Mod	Lo
Oil Spill Risk	Proximity to offshore drilling platform	Mod	Mod	Mod	Mod
	Proximity to Vessel path	Hi	Hi	Hi	Hi
	Proximity to land runoff source	Hi	Mod	Lo	Lo
	Overall Probability of spill occurring	Hi	Mod-Hi	Mod	Mod
	Habitat Sensitivity	Mod	Mod	Mod	Hi
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod	Mod	Mod-Hi	Mod-Hi
	Overall Oil Spill Vulnerability Rating	Mod-Hi	Mod-Hi	Mod	Mod
	MNZ Relative Oil Spill Risk Rating	Mod Hi	Mod Hi	Mod	Mod

APPENDIX 2. BEACH, DUNE AND ROCKY SHORE CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Rabbit Island	Ruby Bay - Jackett Is	Jackett Is - Tapu Bay	Tapu Bay - Otuwhero
Reclamation	Area of affected area as a %age of whole estuary/beach/bay	Hi	Hi	Hi	Mod
	Ecological value of area prior to reclamation	Hi	Hi	Hi	Mod
	Overall Reclamation Vulnerability	Hi	Hi	Hi	Mod
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to Freshwater Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of harvestable living resource	Mod	Mod	Hi	Mod
	Proximity to human population centres	Hi	Mod	Mod	Mod
	Overall Harvesting Vulnerability Rating	Mod	Mod	Mod-High	Mod
Invasive Species	Pathway	Mod	Mod	Mod	Lo
	Existing Presence	Lo	Lo	Mod	Lo
	Overall Invasive Species Vulnerability Rating	Lo-Mod	Lo-Mod	Mod	Lo
Structure that Disrupt Sediment Transport	Seawall/Breakwater/Causeway	Lo	Hi	Mod	Lo
	Groyne	Lo	Lo	Hi	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vulnerability Rating	Lo	Hi	Hi	Lo
Off Road Vehicles	Vehicles on beaches, dunes and tidal flats	Lo	Lo	Lo	Lo
	Presence of damage	Lo	Lo	Lo	Lo
	Overall ORV Vulnerability Rating	Lo	Lo	Lo	Lo
Human/Animal Disturbance of Wildlife	Presence of vulnerable wildlife	Mod	Mod	Hi	Mod
	Proximity to human population centres	Hi	Hi	Mod	Mod
	Access to vulnerable areas	Mod	Mod	Mod	Lo
	Overall Disturbance Vulnerability Rating	Mod	Mod	Mod	Lo-Mod
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Mod	Mod	Mod	Mod
	Seed source up-current	Mod	Mod	Mod	Mod
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Hi	Hi	Hi	Hi
	Overall Human Risk of Eating Infected Species	Hi	Hi	Hi	Hi
	Overall TAB Vulnerability Rating	Mod	Mod	Mod	Mod
Dune Overstabilisation	Presence of exotic forest on duneland	Hi	Mod	Lo	Lo
	Presence of residential/industrial dwellings on duneland	Lo	Hi	Mod	Lo
	Presence of developed pasture on duneland	Lo	Lo	Lo	Lo
	Presence of seawalls in front of duneland	Lo	Hi	Mod	Lo
	Presence of marram/weeds on duneland	Hi	Mod	Mod	Lo
	Overall Dune Overstabilsation Vulnerability Rating	Hi	Hi	Mod	Lo
Grazing	Presence of grazing animals in high value habitat	Lo	Lo	Lo	Lo
	Overall Grazing Vulnerability Rating	Lo	Lo	Lo	Lo
Terrestrial Margin Development	% non-natural cover of 200m wide margin	Hi	Hi	Hi	Mod
	Overall Natural Terrestrial Margin Vulnerability	Hi	Hi	Hi	Mod

APPENDIX 2. BEACH, DUNE AND ROCKY SHORE CHARACTERISTICS & VULNERABILITIES

BEACH AND ROCKY SHORES		Otuwhero-Marahau	Wainui - Puponga	Wharariki-Paturau	Paturau-Kahurangi
Consent Monitoring Data	Point Source N load (t/yr)				
	Point Source P load (t/yr)				
	Point Source SS load (t/yr)				
	Point Source E. coli. load (Fcx10^{15}/yr)				
	Point Source Toxicants (hi, mod, lo)	lo	lo	lo	lo
Beach and Rocky Shores Indicators	Total shoreline length (inc estuaries) (km)	4.4	60.0	155.0	53.0
	Beach Types	R TSF	R, R LTT, R SF	WD TBR	WD LTT, LBT
	Beach Length (km)	4.4	50	20	22.3
	Rocky Shore Length (m)	0	10	26.7	2.3
	Dominant Upper Beach Substrate	sand	Sand	sand	sand
	Dominant Lower Beach Substrate	sand	Sand	sand	sand
	Dominant Dune Vegetation (exotic/native)	E	E	E	E
	Native Dune Plantings (length, m)	0	2500	0	0
	Dune Area (ha)	0.9	18.8	84.7	147.3
	Dune Length (km)	1	23.9	9.6	11.5
	Seawall Length (km)	0.6	5.1	0	0
	Natural Terrestrial Margin (% of margin)	75	39	0.5	1
	Saltmarsh Area (ha)	0	34.6	0	0
	Seagrass Area (ha)	25.3	1544	0	0
	Macroalgae (ha with cover >20%)	Low	Low	Low	Low
	Macroalgae (ha with cover >50%)	Low	Low	Low	Low
	Intertidal Soft mud (ha)	0.0	3.1	0.0	0.0
	Subtidal Soft Mud (yes/no)	no	yes	no	no
BEACH AND ROCKY SHORE VULNERABILITIES					
Sea Level Rise Vulnerability Assessment	a. Geomorphology	5	5	5	5
	b. Erosion/Accretion Rate (m/yr)	3	3	3	3
	c. Slope (%)	4	5	5	5
	d. Relative Sea Level Rise Rate (mm/yr)	5	5	5	5
	e. Mean Wave Height (m)	1	1	1	1
	f. Mean Tidal Range	3	3	3	3
	Physical CV = $\sqrt{(a.b.c.d.e.f)/6}$	12.2	13.7	13.7	13.7
Muddiness	Sedimentation Potential	Lo	Lo	Lo	Lo
	Sediment Existing Condition	Lo	Lo	Lo	Lo
	Overall Sediment Vulnerability Rating	Lo	Lo	Lo	Lo
Eutrophication	Overall Eutrophication Vulnerability Rating	Lo	Lo	Lo	Lo
Disease Risk	Bathing Areal FC Loading Rating	Mod	Mod	Lo	Lo
	Shellfish Areal FC Loading Rating	Mod	Mod	Lo	Lo
	Timing of Disease Risk	Floods	Floods	Floods	Floods
Toxicant Risk	Urban Runoff Rating	Lo	Lo	Lo	Lo
	Natural Sources	Lo	Lo	Lo	Lo
	Pesticides	Lo	Lo	Lo	Lo
	Overall Toxicant Rating	Lo	Lo	Lo	Lo
Oil Spill Risk	Proximity to offshore drilling platform	Mod	Mod	Mod	Mod
	Proximity to Vessel path	Hi	Hi	Mod	Mod
	Proximity to land runoff source	Lo	Lo	Lo	Lo
	Overall Probability of spill occurring	Mod	Mod	Lo	Lo
	Habitat Sensitivity	Hi	Hi	Hi	Hi
	Recovery Time	Mod	Mod	Mod	Mod
	Overall Magnitude of Impact	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Overall Oil Spill Vulnerability Rating	Mod	Mod	Mod	Mod
	MNZ Relative Oil Spill Risk Rating	Mod	Mod	Low	Low

APPENDIX 2. BEACH, DUNE AND ROCKY SHORE CHARACTERISTICS & VULNERABILITIES

Stressor	Subcomponent	Otuwhero-Marahau	Wainui - Puponga	Wharariki-Paturau	Paturau-Kahurangi
Reclamation	Area of affected area as a %age of whole estuary/beach/bay	Lo	Lo	Lo	Lo
	Ecological value of area prior to reclamation	Lo	Lo	Lo	Lo
	Overall Reclamation Vulnerability	Lo	Lo	Lo	Lo
Freshwater Abstraction	Susceptibility	Lo	Lo	Lo	Lo
	Magnitude	Lo	Lo	Lo	Lo
	Overall Vulnerability to Freshwater Abstraction	Lo	Lo	Lo	Lo
Harvesting Living Resources	Presence of harvestable living resource	Mod	Mod	Hi	Hi
	Proximity to human population centres	Mod	Mod	Lo	Lo
	Overall Harvesting Vulnerability Rating	Mod	Mod	Mod	Mod
Invasive Species	Pathway	Lo	Lo	Lo	Lo
	Existing Presence	Lo	Lo	Lo	Lo
	Overall Invasive Species Vulnerability Rating	Lo	Lo	Lo	Lo
Structure that Disrupt Sediment Transport	Seawall/Breakwater/Causeway	Mod	Mod	Lo	Lo
	Groyne	Lo	Lo	Lo	Lo
	Exposure	Lo	Lo	Lo	Lo
	Overall Structures Vulnerability Rating	Mod	Mod	Lo	Lo
Off Road Vehicles	Vehicles on beaches, dunes and tidal flats	Lo	Lo	Lo	Lo
	Presence of damage	Lo	Lo	Lo	Lo
	Overall ORV Vulnerability Rating	Lo	Lo	Lo	Lo
Human/Animal Disturbance of Wildlife	Presence of vulnerable wildlife	Hi	Hi	Hi	Hi
	Proximity to human population centres	Mod	Mod	Lo	Lo
	Access to vulnerable areas	Mod	Mod	Lo	Lo
	Overall Disturbance Vulnerability Rating	Mod	Mod	Lo	Lo
Toxic Algal Blooms	Previous TABs	Lo	Lo	Lo	Lo
	Seed Source local	Mod	Mod	Mod	Mod
	Seed source up-current	Mod	Mod	Mod	Mod
	Conditions favourable for blooms	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Overall Risk in Area	Lo-Mod	Lo-Mod	Lo-Mod	Lo-Mod
	Presence of at-risk local species	Mod-Hi	Mod-Hi	Mod-Hi	Mod-Hi
	Presence of humans who eat shellfish/fish	Hi	Hi	Lo	Lo
	Overall Human Risk of Eating Infected Species	Hi	Hi	Mod	Mod
	Overall TAB Vulnerability Rating	Mod	Mod	Mod	Mod
Dune Overstabilisation	Presence of exotic forest on duneland	Lo	Lo	Lo	Lo
	Presence of residential/industrial dwellings on duneland	Mod	Mod	Lo	Lo
	Presence of developed pasture on duneland	Lo	Hi	Mod	Mod
	Presence of seawalls in front of duneland	Mod	Mod	Lo	Lo
	Presence of marram/weeds on duneland	Mod	Hi	Hi	Hi
	Overall Dune Overstabilsation Vulnerability Rating	Mod	Mod-Hi	Mod	Mod
Grazing	Presence of grazing animals in high value habitat	Lo	Lo	Lo	Lo
	Overall Grazing Vulnerability Rating	Lo	Lo	Lo	Lo
Terrestrial Margin Development	% non-natural cover of 200m wide margin	Hi	Hi	Hi	Hi
	Overall Natural Terrestrial Margin Vulnerability	Hi	Hi	Hi	Hi

APPENDIX 3. BROAD SCALE HABITAT CLASSIFICATIONS

Forest: Woody vegetation in which the cover of trees and shrubs in the canopy is >80% and in which tree cover exceeds that of shrubs. Trees are woody plants ≥10 cm diameter at breast height (dbh). Tree ferns ≥cm dbh are treated as trees. Commonly sub-grouped into native, exotic or mixed forest.

Treeland: Cover of trees in the canopy is 20-80%. Trees are woody plants >10 cm dbh. Commonly sub-grouped into native, exotic or mixed treeland.

Scrub: Cover of shrubs and trees in the canopy is >80% and in which shrub cover exceeds that of trees (c.f. FOREST). Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed scrub.

Shrubland: Cover of shrubs in the canopy is 20-80%. Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed shrubland.

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

Duneland: Vegetated sand dunes in which the cover of vegetation in the canopy (commonly Spinifex, Pingao or Marram grass) is 20-100% and in which the vegetation cover exceeds that of any other growth form or bare ground.

Grassland: Vegetation in which the cover of grass (excluding tussock-grasses) in the canopy is 20-100%, and in which the grass cover exceeds that of any other growth form or bare ground.

Sedgeland: Vegetation in which the cover of sedges (excluding tussock-sedges and reed-forming sedges) in the canopy is 20-100% and in which the sedge cover exceeds that of any other growth form or bare ground. "Sedges have edges." Sedges vary from grass by feeling the stem. If the stem is f at or rounded, it's probably a grass or a reed, if the stem is clearly triangular, it's a sedge. Sedges include many species of Carex, Uncinia, and Scirpus.

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

Reedland: Vegetation in which the cover of reeds in the canopy is 20-100% and in which the reed cover exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either round and hollow – somewhat like a soda straw, or have a very spongy pith. Unlike grasses or sedges, reed f owers will each bear six tiny petal-like structures. Examples include Typha, Bolboschoenus, Scirpus lacutris, Eleocharis sphacelata, and Baumea articulata. Note, habitat maps in this report show a "Wetland" class overlay provided by TDC of areas within the 200m terrestrial margin that are dominated by freshwater plants.

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

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

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

Introduced weeds: Vegetation in which the cover of introduced weeds in the canopy is 20-100% and in which the weed cover exceeds that of any other growth form or bare ground.

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

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

Clif : A steep face of land which exceeds the area covered by any one class of plant growth-form. Clif s are named from the dominant substrate type when unvegetated or the leading plant species when plant cover is ≥1%.

Rock f eld: Land in which the area of residual rock exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

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

Cobble f eld: Land in which the area of unconsolidated cobbles (20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. Cobble f elds are named from the leading plant species when plant cover is ≥1%.

Gravel f eld: Land in which the area of unconsolidated gravel (2-20 mm diameter) exceeds the area covered by any one class of plant growth-form. Gravel f elds are named from the leading plant species when plant cover is ≥1%.

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

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

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

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

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

Very soft mud/sand: A mixture of mud and sand, the surface appears brown, and many have a black anaerobic layer below. When walking you'll sink >5 cm.

Cockle bed: Area that is dominated by both live and dead cockle shells.

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

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

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

Shell bank: Area that is dominated by dead shells.

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

APPENDIX 4. HABITAT MAPS

Location of numbered GIS maps of the Tasman coastline presented in Appendix 4. Maps show the dominant coastal substrate and vegetation layer. Additional detail is included in the broad scale GIS files that accompany this report, including seagrass beds and density, macroalgae, and subdominant vegetation.