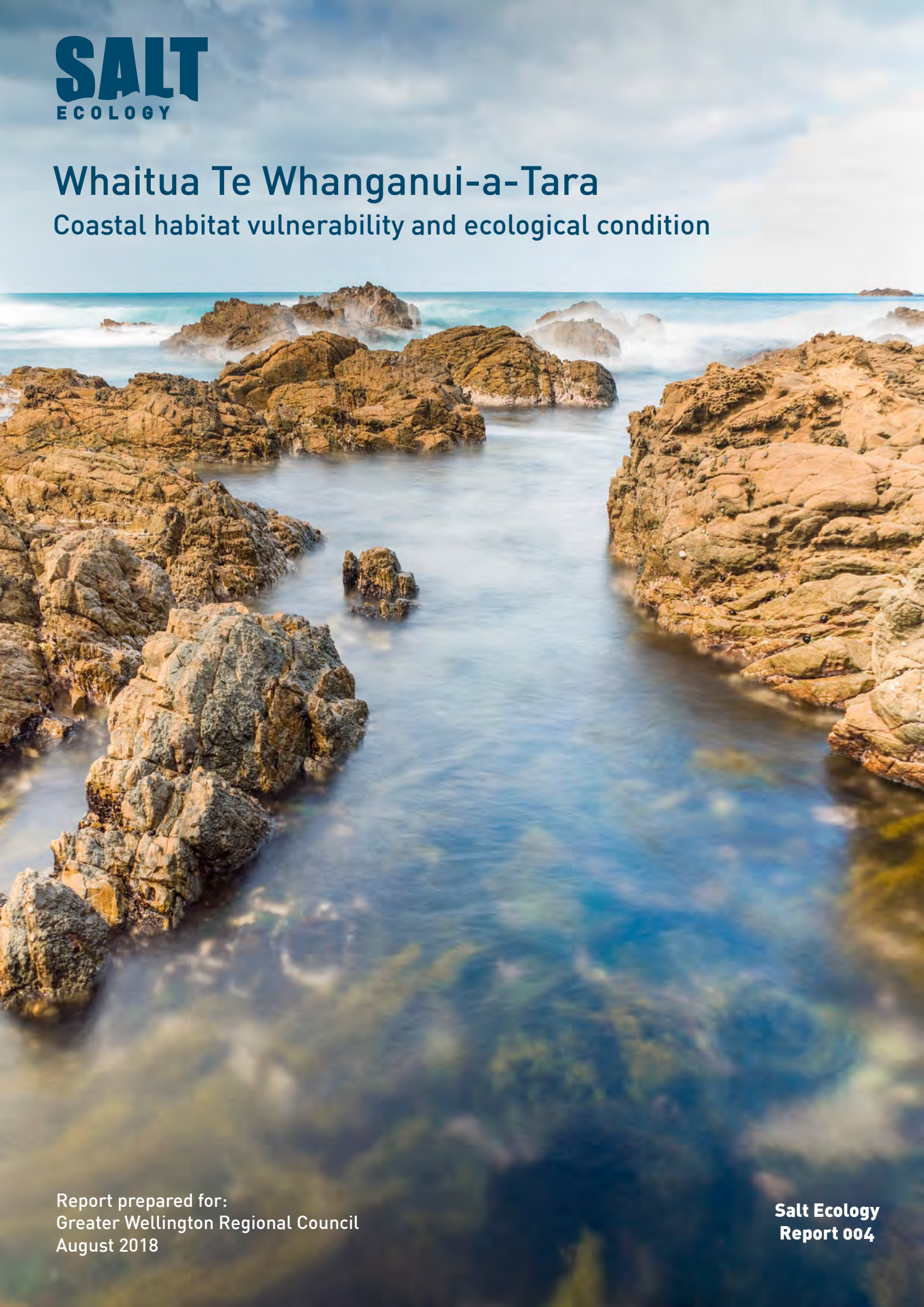
SALT ECOLOGY

Whaitua Te Whanganui-a-Tara

Coastal habitat vulnerability and ecological condition



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August 2018

Salt Ecology Report 004

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For the People
Mō ngā tāngata

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OVERVIEW

In order to support the effective monitoring and management of coastal and estuarine ecological features throughout the Wellington region, Greater Wellington Regional Council (GWRC) has previously commissioned investigations to characterise coastal and estuarine habitats and assess broad scale risks to these habitats from human activities. To support the current Wellington/Hutt whaitua process, this existing work has been reviewed and updated by quickly re-assessing the existing coastal habitat maps of the Wellington/Hutt whaitua and reviewing whether there were any obvious changes to stressors previously identified in relation to the three major coastal habitat types (rocky shores, sandy beaches and estuaries). The reassessment identified several minor changes where seawalls had been constructed or repaired, but overall confirmed that the type and impact of previously identified coastal stressors had not changed significantly over the past decade.

More detailed assessments of representative sandy beach, rocky shore and estuarine areas have been undertaken to characterise the general state of these important habitat features. McMurtrie and Brennan (2016) reported the community composition of Eastern Bays intertidal inner harbour sites was typical of rocky shore and beach habitat in the region. Stevens (2018a) found Petone Beach, Lyall Bay and Owhiro Bay to be in "very good" or "good" condition overall, and rocky shore sites representing a spectrum of wave exposures at Makara, Scorching Bay and Baring Head to be typical of "healthy" New Zealand rocky shores and similar to that described from previous surveys conducted at Flat Point on the Wairarapa coast (Stevens 2018b).

Assessments undertaken in Makara, Kaiwharawhara, Korokoro, Hutt and Wainuiomata estuaries provided updated habitat maps and detail on current condition. While estuaries are some of the most significantly modified coastal habitats in the whaitua, they retain high human use and ecological values because of their regional scarcity. Makara was in a relatively poor condition due to restricted flushing and elevated sediment and nutrient inputs. Kaiwharawhara, Korokoro, and Hutt estuaries were in a moderate ecological state, primarily maintained by high flushing but greatly modified by past channelisation. Wainuiomata Estuary was in good condition but is highly sensitive to sediment and nutrient inputs due to long periods of mouth closure. The relative rarity of estuarine habitat in the region, combined with extensive past modification, means remaining habitat is very important and should be protected from further degradation, and enhanced wherever possible.

1. INTRODUCTION

1.1 BACKGROUND

In order to support the effective monitoring and management of coastal and estuarine ecological features throughout the Wellington region, GWRC has previously commissioned investigations to characterise coastal and estuarine habitats, and assess broad scale risks to these habitats from human activities.

This work has provided overview reports on the habitat vulnerability and monitoring and management priorities for coastal ecological resources throughout the region including Kapiti coast (Otaki to Paekakariki), southwest coast (Paekakariki to Sinclair Head), south coast (Sinclair Head to Breaker Bay), Wellington Harbour (Breaker Bay to Baring Head), southeast coast (Baring Head to Cape Palliser), and Wairarapa coast (Cape Palliser to Owhanga). This work is summarised in various reports (e.g. Stevens et al. 2004, Stevens and Robertson 2006, Robertson and Stevens 2007a, 2007b, Stevens 2013) and identifies the major ecological issues present in terms of ecological habitat vulnerability. In addition, specific monitoring undertaken at a variety of sites throughout the region provides detailed information on the ecological response to existing stressors on beaches, rocky shores and estuaries (e.g. Stevens 2018a, 2018b, Stevens and O'Neill-Stevens 2017, Robertson and Stevens 2014, 2015, Stevens et al. 2004, 2006).

The vulnerability to common stressors is relatively well understood and preliminary approaches have been developed for use in NZ to rate both susceptibility (the extent an ecological community would be impacted if exposed to a stressor) and presence (likelihood of stressors) in a transparent and consistent manner (e.g. Robertson at al. 2016a, 2016b, Stevens and Robertson 2017). Such approaches are primarily

intended to enable different sites to be compared in a consistent manner, and to identify the main pressures impacting the habitat features present. However, there are obvious limitations in the methodology that need to be considered when using the outputs. For example, highly modified habitats often have a low susceptibility to some stressors because sensitive habitat features have already been lost e.g., a channelised estuary with all salt marsh removed is no longer sensitive to salt marsh loss. Similarly, a channelised estuary without settling basins may result in limited susceptibility to nuisance macroalgal blooms or mud accumulation, and assessments recording an absence of algal blooms or mud may falsely indicate estuary condition is better than it is in reality. The scores also do not highlight the potential for restoration, with meaningful ecological benefits often possible even from small improvements to highly modified habitats. Finally, the concept of "death by a thousand cuts" is also very important to consider in a regional context where even minor losses within an already significantly modified system can have disproportionately high consequences. As such, the assessment approach is best viewed as a screening tool to highlight key pressures and set priorities for further site specific analysis, with a high priority placed on the protection of remaining ecological features from further degradation or loss.

1.2 SCOPE

To support the current Wellington/Hutt whaitua process, Salt Ecology was commissioned in January 2018 to quickly re-assess the existing coastal habitat maps of the Wellington whaitua to determine if there were any obvious changes in either the stressors present or the previously assessed condition of three major coastal habitat types (rocky shores, sandy beaches and estuaries) over the past decade. The current work does not address coastal water quality or coastal dunes and is not a comprehensive re-assessment of stressor presence or ecological state. Instead it draws extensively from existing information, supplemented by brief field assessments undertaken in January 2018 along the wider coastline, as well as more detailed assessments of representative sandy beach, rocky shore and estuarine areas, to characterise the general state of these important habitat features. Specific beach studies were undertaken at Petone Beach, Lyall Bay and Owhiro Bay (Stevens 2018a) and rocky shores at Makara, Scorching Bay and Baring Head (Stevens 2018b). Makara, Kaiwharawhara, Korokoro, Hutt and Wainuiomata estuaries were synoptically surveyed to update broad scale habitat maps and to collect point in time water quality data (e.g. chl-a measures) to support the calculation of NZ Estuary Trophic Index (ETI) scores for each estuary.

1.3 REPORT STRUCTURE

The current report provides a high level summary of the methods used and information gathered as part of previous vulnerability assessments. It updates underpinning information used in the initial assessments where relevant (e.g. catchment sediment and nutrient load estimates), and incorporates synoptic field data. Recommendations are made where additional work is required to better characterise any identified changes.

Section 1 provides an introduction to the scope and structure of the study and background on the coastal habitats being assessed.

Section 2 describes the methods and criteria used for vulnerability assessments, habitat mapping, and the identification of monitoring recommendations.

Section 3 provides section by section summary of the coast describing characteristics, issues, values and uses, existing condition and susceptibility ratings. Subjective appraisal of the degree of modification, restoration potential, and overall value are also provided.

1.4 COASTAL HABITAT TYPES.

The major coastal habitat types found in the Wellington whaitua include rocky shores, beaches, estuaries, dunes and coastal waters.

1.4.1 Rocky Shores


Makara

The rocky shores can be divided into two main categories based on degree of exposure.

(1) Sheltered Rocky Shores

These occur within the relatively sheltered confines of Wellington Harbour. Rock types are

generally hard, with low susceptibility to weathering and have a characteristic and diverse ecology. Water clarity tends to be variable, depending primarily on catchment rainfall (particularly the Hutt River), as well as in response to fine sediment re-suspension from wind generated waves and water currents.

(2) Exposed Rocky Shores

The Southwest and South Wellington coasts are dominated by exposed, high-energy shores. They consist of hard greywacke type rocks with high biodiversity. Water is relatively clear and currents are generally strong. In some areas, reefs and headlands dampen wave impacts and dissipate the often significant wave energy.

1.4.2 Beaches

Scorching Bay

Beach type is an important determinant of beach ecology (Defeo and McLachlan 2005) with a generalised decrease in the number of species as beach slope and grain size increases. In addition, environmental gradients (e.g. wave exposure, salinity, grain size, sediment mobility) can cause asymmetries in the location and abundance of beach species. In the Wellington/Hutt whaitua there are three main beach types:

(1) Dissipative Beaches

Relatively flat and fronted by a wide zone in which waves dissipate much of their energy, dissipative beaches form under conditions of moderate tidal range, high wave energy and fine sand. Their sediments are well sorted (usually fine to medium sand), and they have weak rip currents with undertows. The tidal flat is at the extreme end of dissipative beaches. Compared with other beach types, dissipative or low energy beaches tend to have relatively high levels of primary production, diversity and biomass of macrofauna, are generally more regulated by biological interactions, and tend to be exporters of organic matter.

Petone Beach is a relatively narrow and largely dissipative beach due to the predominantly low energy wave environment within the harbour.

(2) Intermediate Beaches

Steeper than dissipative beaches but less steep than reflective beaches, intermediate beaches have very mobile sand and gravel sediments, and rip currents are common. They are characterised by plunging and spilling breakers in a relatively wide surf zone. Intermediate beaches are spatially and temporally the most dynamic (Wright and Short 1984) and zonation is generally highly dynamic and not sharply defined. Ecologically, they tend towards intermediate species richness with greatest species abundance and diversity in shallow subtidal areas with intertidal beach infauna often having high spatial and temporal variability.

Lyall Bay is the only example of this beach type in the Wellington/Hutt whaitua.

(3) Reflective Beaches

Reflective beaches generally comprise steep coarse sand, gravel or cobble sediments with steep beach faces reflecting breaking wave energy directly back to the sea. They have little or no surf zone and their ecological characteristics include low primary production, impoverished macrofauna with low species richness (mainly determined by physical features e.g. coarse and mobile sediments), with reliance on organic material imported from sea.

Steep, reflective beaches are the main type found on the exposed outer Wellington coastline (e.g. Owhiro Bay, Breaker Bay, Fitzroy Bay).

1.4.3 Estuaries

A simple definition for an estuary is the area seaward from an imaginary line closing a river mouth, to landward where ocean derived salts measure less than 0.5ppt during the period of average annual low flow (Madden et al. 2009). Within such a definition there are a range of different types of estuary that have been described in a comprehensive NZ typology by Hume (2016). This typology has been simplified in the ETI (see Robertson et al. 2016a,b) as follows:

(1) Shallow Intertidal Dominated Estuaries (SIDEs)

(2) Shallow, Short Residence time Tidal River (and adjoining lagoon) Estuaries (SSRTREs)

(3) Deeper Subtidal Dominated, longer residence time Estuaries (DSDEs)

Sub-types of SIDEs and SSRTREs are Intermittently Closed/Open Lake and Lagoon estuaries

(ICOLLs) whose mouths close for variable periods. These include small tidal river mouth estuaries which have a single channel that is often blocked near the coast by a sand or gravel barrier, which can create brackish lagoons on the river side when closed or restricted.

Susceptibility to key estuary stressors like eutrophication and fine sediment accurual is strongly influenced by specific physical modifying characteristics including dilution, flushing, residence time, depth, intertidal extent and mouth opening/closing regimes. Therefore the type of estuary and the scale of estuaries are important considerations in their assessment. For example, Wellington Harbour is classified as a DSDE type estuary but contains smaller SSRTRE estuaries that have different pressures and management needs. For the current work, the smaller estuary units have been used as they provide the most helpful guidance on stressors and management priorities.

1.4.4 Dunes

Island Bay

Dunes are not addressed as part of the current report but have been addressed previously. In a 1990 survey of the whole coast, no dune systems of outstanding value were identified (Partridge 1992), while remnant dunes are present in narrow strips at Titahi, Lyall, and Fitzroy Bays and Petone Beach. At most sites, the back dunes have been converted to pasture or developed for urban use, and the fore dunes are dominated by the introduced sand-binding grass, marram grass (*Ammophila arenaria*). However, most areas have also had significant replanting with native sand-binders spinifex (*Spinifex serceus*) and, to a lesser extent, pingao (*Desmoschoenus spiralis*).

1.4.5 Coastal Waters

GWRC monitoring of coastal water quality is limited and is not addressed as part of the current report. GWRC has recently established a monitoring buoy to collect continuous coastal water quality data for key indicators including chlorophyll-a, dissolved oxygen, turbidity, temperature, and salinity. Results from this data set will be reported on separately by GWRC in coming years.

1.5 KEY ISSUES AND INDICATORS

The most common stressors to NZ estuaries and coastlines are excessive inputs of fine muds, nutrients, pathogens (human disease risk), toxicants (e.g. stormwater, sewage or industrial discharges and spills), and habitat changes (e.g. habitat losses from reclamation, drainage, piping, land clearance, infrastructure or climate change related effects such as exacerbated coastal erosion from sea level rise and changing storm intensities). These stressors have variable influences depending on the receiving environments.

A detailed overview of such issues is presented in Robertson and Stevens (2012) along with a range of preliminary criteria applied to quickly rate the presence and ecological risk associated with identified stressors (see also Stevens 2013, Robertson et al. 2016b and Stevens and Robertson 2017 for additional criteria).

Table 1 lists a suite of common coastal and estuarine ecological stressors. This is not considered an exhaustive or ranked list, rather an overview of the key stressors likely to be encompassed by GWRC policy and management objectives.

Table 1. Common stressors impacting on ecological values and human use of the coastline.

Fine Sediment
Nutrients/Eutrophication
Human Disease Risk (pathogens)
Toxicants (Urban runoff, pesticides)
Spills (oil)
Coastal Erosion (Sea Level Rise)
Climate Change - pH, temp
Grazing of high value habitat
Freshwater abstraction
Reclamation/Drainage
Harvesting of living resources
Algal blooms (from sea)
Seawalls, breakwaters etc
Invasive weeds/pests
Vehicle damage
Loss of vegetated terrestrial margin
Animal/human disturbance of wildlife

Table 2 lists specific indicators commonly used to monitor the influence of stressors, grouped within over-arching issues associated with the most common issues addressed by council policy. These representative indicators provide much of the measured data used in undertaking ecological vulnerability assessments. The key stressors to beaches include habitat loss from sea level rise, sea walls, erosion, vehicles, human disturbance (including shellfish harvesting), discharges (stormwater and sewage) and human health issues from disease risk.

In contrast, rocky shores are more susceptible to human harvesting pressure and longer term climate change influences such as sea level rise or ocean acidification than they are to eutrophication or fine sediment, although the latter can still be a significant pressure.

In estuaries, the two most significant stressors on ecological condition are catchment inputs of nutrients (eutrophication) and fine sediment (muddiness). Eutrophication is a process driven by nutrient enrichment of water and sediment that results in excessive primary production of macroalgae and/or phytoplankton. Fine sediment causes a variery of problems including smothering, altered grain size, reduced clarity, lowered sediment oxygenation and pore water exchange, and increased concentrations of nutrients and toxicants because of their strong affinity to adsorb to fine sediments. The latter feature means the two issues of eutrophication and sediment muddiness are generally strongly interlinked with ecological degradation exacerbated when they occur together (e.g. muddy, nutrient-rich sediments leads to increased sediment bound nutrients, increased organic matter, reduced sediment oxygenation, elevated toxic sulphide levels and other toxicants).

Table 2. Dominant coastal issues and monitoring indicators commonly used to assess their influence.

Issue	Monitoring indicator
Eutrophication	Chlorophyll-a in water
	Macroalgal EQR
	Epiphyte abundance
	Dissolved oxygen in water
	Sediment oxygenation
	Nutrient concentrations
	Sediment organic carbon
	Seagrass/Macrophyte loss
	Benthic invertebrates
	Phytoplankton blooms
Fine sediment	Muddiness (extent)
	Sedimentation rate
	Sediment grain size
	Seagrass/Macrophyte loss
	Water clarity
	Benthic invertebrates
Human Disease Risk	Faecal Indicators
Toxicants	Heavy metals
	SVOCs
	Toxic marine algal blooms
Habitat Change	Substrate composition
	Seagrass/Macrophytes
	Saltmarsh extent
	Vegetated margin cover
	Birds
	Fish
	Invasive species
	Benthic invertebrates
	Harvestable shellfish
	Sea Level

2. METHODS

2.1 ECOLOGICAL VULNERABILITY ASSESSMENT

The Ecological Vulnerability Assessment (EVA) approach previously used in the region (Robertson and Stevens 2007a, 2007b) is based on an adaptation of a UNESCO methodology (UNESCO 2000) designed to be used by experts to represent how coastal ecosystems are likely to react to the effects of potential "stressors" (the causes of coastal issues, often human activities). The vulnerability of each estuary and coastal area to identified stressors was assessed using defined criteria to determine their potential influence, and combined with existing knowledge of the condition and ecological and human use values to determine the likely expression of problems (see Appendix 3). The EVA uses a combination of estuary physical characteristics, modelled estimates of nutrient, sediment and pathogen loads, monitoring results (collected using established tools such as the National Estuary Monitoring Protocol (NEMP) (Robertson et al. 2002), and assessment criteria from established risk assessment frameworks (e.g. Robertson and Stevens 2012, Stevens and Robertson 2017) and more recent tools like the NZ Estuary Trophic Index (ETI) (Robertson et al. 2016a,b).

Full details on the EVA approach and rating criteria are provided in Robertson and Stevens (2007, 2012, 2016), Stevens (2013) and Stevens and Robertson (2017) and are not repeated here.

For each defined coastal section (see Figure 1 overview map) (e.g. rocky shore, sandy beach or estuary) previous assessment results have been summarised to highlight the existing values of each area, identify the key stressors present, and rate the vulnerability to identified stressors. These summaries are presented in Section 3.

2.2 ASSESSMENT OF EXISTING DATA

Because existing habitat maps exist for most of the coastline in the Wellington/Hutt whaitua, and previous vulnerability assessments have been undertaken, for the purposes of the current study synoptic field assessments were undertaken to identify whether there had been any significant changes to habitat features or obvious changes to the coastal stressors present.

Rocky shore and beach features were assessed by driving or walking the wider coastline over a three day period to ground truth whether there were any significant changes to existing mapped features. Expert opinion was used to decide if there was any obvious change to the stressors present. These assessments were complimented by specific sandy beach and rocky shore studies reported separately in Stevens (2018a, 2018b).

For the five main estuaries in the whaitua (Makara, Kaiwharawhara, Korokoro, Hutt and Wainuiomata), more detailed assessments were undertaken reflecting their relatively high ecological sensitivity and value. Each estuary had existing mapping updated using methods based on the NEMP and ETI. Experienced scientists visited each estuary in January 2018 and mapped the primary habitat features on 1:3,000 colour aerial photos which were then digitised to produce GIS maps (ArcMAP 10.5) of dominant substrate, salt marsh, intertidal seagrass (*Zostera*), macroalgae, and vegetation/landuse in a 200m wide terrestrial margin strip. Estuary summary information and updated maps are included in Section 3.

Macroalgae, when present, was assessed using a 5 part multimetric index - the Opportunistic Macroalgal Blooming Tool (OMBT) - described in UK-WDF (2014). This integrated index provides a comprehensive measure of the combined influence of macroalgal growth and distribution.

Fine scale measurements were made of water quality using a hand held YSI meter (temperature, salinity, dissolved oxygen, pH) and Turner cyclops fluorometer (chlorophyll-a) and used with mapping results in the calculation of ETI scores for each estuary (data used in calculating the ETI are presented in Appendix 1).

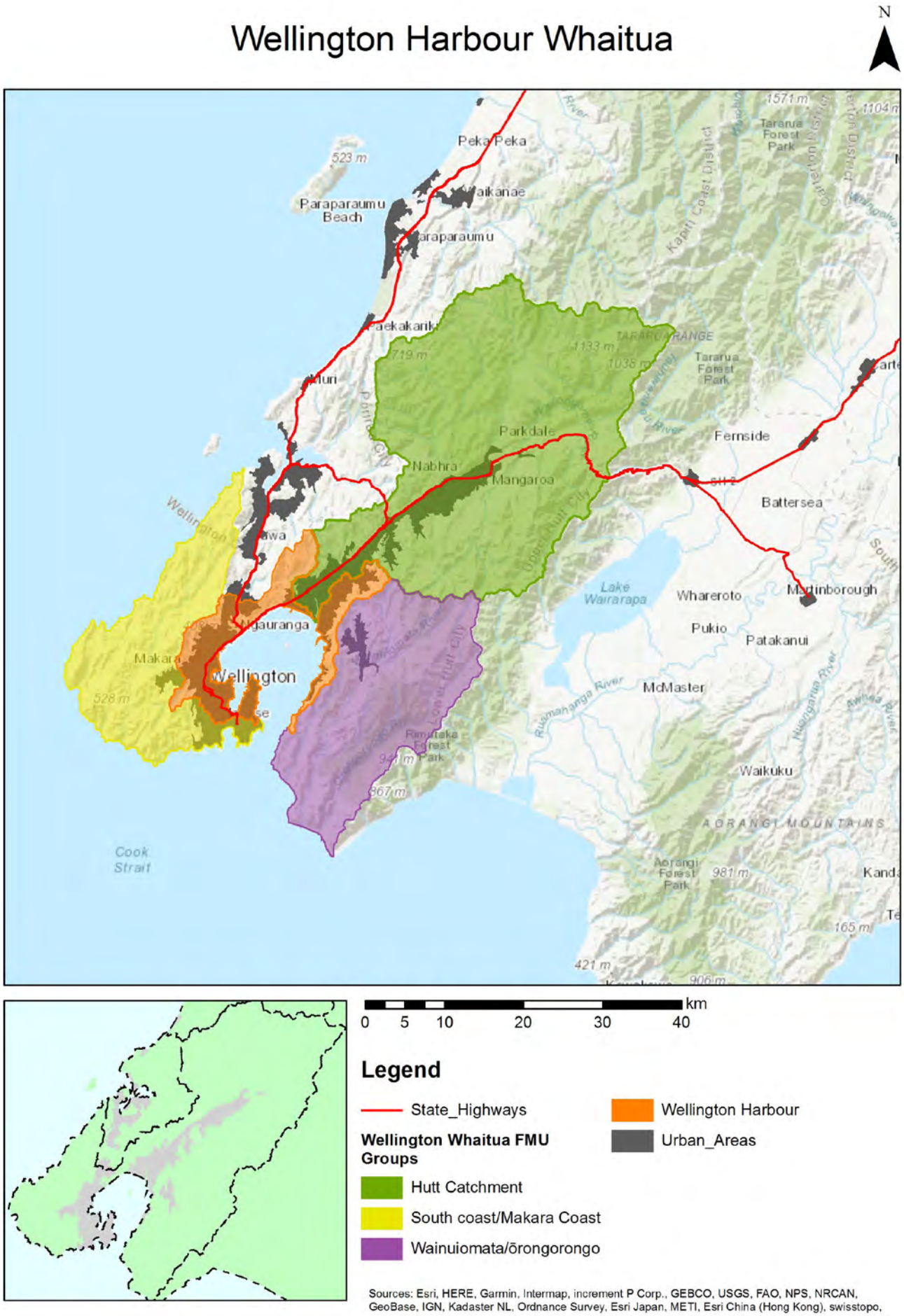


Figure 1. Overview map showing whaitua boundaries and areas covered in this report. Credit GWRC

3. RESULTS

3.1 SOUTHWEST COAST - NORTH OF MAKARA TO OWHIRO BAY

This area has not been ground-truthed by field surveys with assessments based primarily on aerial photographs. The southwest coast is relatively undeveloped. It is dominated by steep cliffs, hard rocky shores and reflective gravel and cobble beaches. Vegetation cover on the cliffs is sparse and land cover is dominated by pasture and regenerating scrub and forest cover. Localised hillside erosion appears relatively common, particularly on coastal cliff faces.

Southwest coast north of Makara.

Streams that discharge to the coast are generally small with stream mouth estuaries having small intertidal areas, little salt marsh and limited marine influence. Where gravel beaches restrict flows, freshwater backs up for relatively short periods to create small ephemeral freshwater-dominated estuaries characterised by low diversity. There are no notable salt marsh or dune areas except within the larger valleys like those of Makara Estuary.

Human Uses and Values

There is little land-based public access to much of the coast which limits public usage. Values include fishing, walking, surfing, shellfish collection, diving, and natural aesthetics.

Ecological Values

Exposed rocky shore and shallow subtidal reef habitats have high plant and animal biodiversity.

Beaches are steep with gravel and cobble substrate and hence are expected to have low biodiversity. Dune areas are generally narrow or non-existent. Estuaries are small and freshwater dominated.

Existing Condition

Existing condition of all habitat is expected to be "good" given its remoteness, and relatively low intensity grazing in the catchment. The pasture dominated catchment is likely to contribute elevated fine sediment compared to natural state conditions, and the past clearance of native cover means the terrestrial margin and any dune areas are likely to support exotic weeds and plants. There is likely to be localised depletion of some rocky habitat biota as a consequence of fishing/harvesting. Localised impacts to water quality and biota are expected near the Karori wastewater outfall.

ISSUES AND THREATS

- Climate change and human take threats to high biodiversity rocky shore habitat
- Weed invasions along terrestrial margin
- Coastal property development

Overarching Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Low	Low
Fine sediment	Moderate	Low
Human Disease Risk	Low	Low
Toxicants	Low	Low
Habitat Change	Low	Moderate
Overall Vulnerability	**Low**	

Presence of Stressors

The overall presence of stressors is rated "low". Localised stressors include human pressures on fish and shellfish stocks, and the Karori wastewater discharge. Eutrophication is unlikely to be a significant issue on the open coast. More widespread stressors are fine sediment inputs to the coast, habitat change as a consequence of climate change (sea level rise, sea temperature and pH), the presence of terrestrial weed/pest plants, offshore toxic algal blooms, and oil spills.

Susceptibility to Stressors

Susceptibility to stressors is rated "low". The coastline is well flushed and relatively remote, but is close to a large population centre and is a popular fishing and diving destination. Rocky shore and shallow subtidal reef habitat has the highest ecological and human use value and is most susceptible to human pressure through over-fishing. Long term changes in water quality (e.g. through climate change) are expected, and low probability but potentially high consequence impacts are possible e.g. oil spills, invasive pests and offshore algal blooms.

3.1.1 MAKARA ESTUARY

Makara Estuary is a small (7.5ha) "tidal river mouth" type estuary that has a large subtidal component and a constricted mouth which occasionally closes between the rocky headland and the steep (reflective) cobble/gravel/coarse sand beach (Figure 2). Its current condition is relatively degraded due to excessive inputs of sediment, poor sediment oxygenation in the lower estuary, and frequent blooms of nuisance algae. However, it has good potential for restoration and is a very under-represented habitat type on the southwest coast with a high priority for protection.

Makara Estuary showing mouth constricted with beach gravels.

The lower estuary comprises a shallow basin (average 1m deep) ~100m wide by 200m long, with a deeper main channel. The saltwater influence extends ~1.8km upstream but remains largely confined within incised river banks. Depths in the river channel are ~2-3m in the middle estuary. Subtidal substrate is dominated by soft anoxic muds and gravels in the lower estuary, with gravel and cobble present along the intertidal edge near the mouth, and sands and muds along river banks further upstream.

Low lying river flats support 2.5ha of estuarine salt marsh dominated by herbfields (glasswort, remuremu, shore primrose, bachelor's button) and rushland (sea rush and oioi), with stands of saltmarsh ribbonwood along the terrestrial fringe. Approximately 6ha of salt marsh is estimated to have been lost as a consequence of historical drainage and channelisation. These areas are now dominated by terrestrial grasses and weeds. An active community group has been replanting rushland in the lower estuary among a wider programme of restoration and conservation initiatives.

The native seagrass Horses' mane (*Ruppia* spp.)

MAKARA ESTUARY SUMMARY	
Estuary type / extent	Tidal River Mouth 7.5ha
Subtidal extent	3.2 ha (43%)
Mouth opening	Constricted, closes occasionally
Mean depth / Length	2 m / 1800m
Freshwater inflow	1.1 cumecs
Dominant substrate	Soft muds
Soft mud	1.3 ha (39%)
Salt marsh	2.5 ha (33%)
Macroalgae	0.75 ha, ~700g m^2
Seagrass	0 ha
Vegetated 200m margin	40%
Catchment area	149 km^2
Catchment geology	Greywacke, alluvium, peat, sand
Nitrogen loading	38.8 T/yr, 1416 mg/m^2/d
Phosphorus loading	8.3 T/yr, 304 mg/m^2/d
Sediment loading	16.8 KT/yr, 613g/m^2/d
E.coli loading	0.8 x10^{15}/yr
Land use	Native 3%,forestry 8%, pasture 67%, urban <1%
Dairy cows	0
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation.
NZ ETI score	0.59 Band C
Overall Condition	**Moderate**

ISSUES AND THREATS
• Elevated catchment sediment inputs
• Natural cycles of low to high water quality as mouth constriction varies
• Historical salt marsh drainage
• Ingress of terrestrial grasses, plants and weeds into salt marsh
• River bank erosion
• Human disturbance of wildlife

Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Moderate	Moderate
Fine sediment	Moderate	Moderate
Human Disease Risk	Moderate	Moderate
Toxicants	Low	Low
Habitat Change	Moderate	Moderate
Overall Vulnerability	**Moderate**	

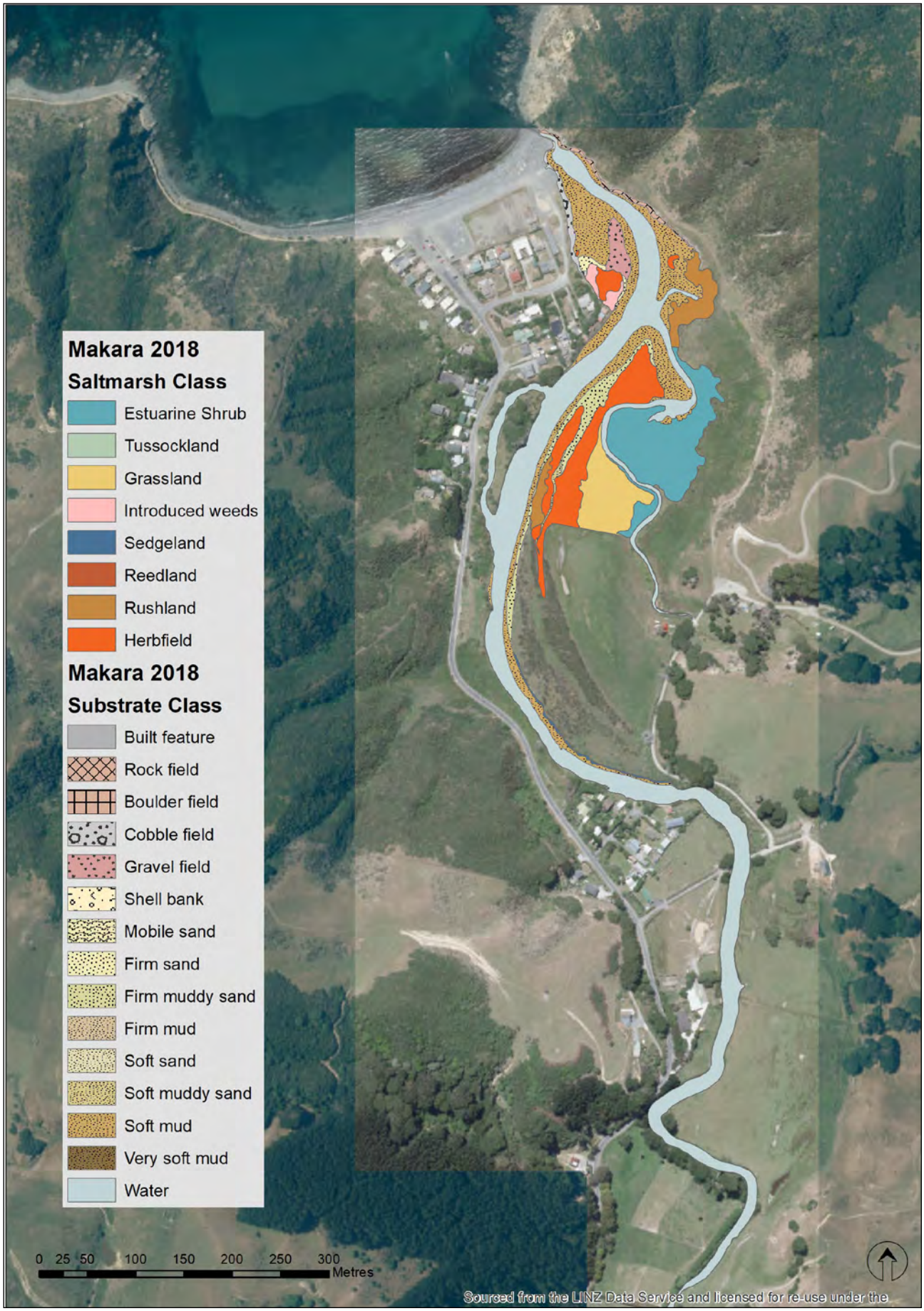


Figure 2. Makara Estuary showing extent and dominant substrate and salt marsh features.

is reported by Todd et al. (2016) to be abundant in the sub-tidal parts of the lagoon although this was not evident during the synoptic assessment undertaken in January 2018.

Reasonable habitat is considered to exist for whitebait spawning (Taylor and Kelly 2001, Taylor and Marshall 2016).

Mead and Haggitt (2013) monitored sediment deposition from 2012-2013 and reported very high rates of deposition in the lower estuary (20-57mm in 6 months). They noted the likely source was forest harvesting in combination with extreme weather events in the catchment. Although the deposition reported above is likely to be higher than long-term rates of deposition, it will have had significant adverse impacts on the ecology of the estuary.

Mead and Haggitt (2013) also present photographs showing regular and significant blooms of intertidal macroalgae (*Ulva*) in the lower estuary in 2007 and 2010, and the regular presence of smaller subtidal algal beds since 2002.

Makara Estuary macroalgal growth, Jan. 2018 - dense deposits in the lower estuary basin (top) and thin cover along the river edge in the middle estuary (bottom).

Algal growth dominated by *Ulva* spp. was widespread in January 2018. In the lower estuary basin, intertidal growths had moderate cover (~40%) and biomass (500-1000g/m^2) whereas further upstream cover was relatively high (80%) but biomass low (e.g. 30-50g/m^2). Lush subtidal growths were also present in the lower estuary. Sediment oxygenation beneath the dense beds of macroalgae was relatively poor (<0.5cm), bottom water dissolved oxygen was very low (~3mg/L), and reported sediment macrofauna (Mead and Haggitt 2013) indicates a very sparse community adapted to living in degraded sediment conditions.

Makara Estuary showing a thin layer of poorly oxygenated muddy surface sediments over oxygenated coarse gravels.

Human Uses and Values

Human use of the estuary is moderate. Makara Beach is a popular summer destination for sunbathers, picnickers, walkers and surfcasters. There is a sheltered boat ramp just inside the river mouth for small vessels, whitebaiting occurs during the season, and the estuary is a good site for bird watching.

The estuarine area is actively managed by 'Makaracarpas', a community group formed in 2006 and financially supported by a variety of organisations, both governmental and non-governmental. Along with GWRC, they have developed a Restoration Plan (Anstey 2007), and have taken responsibility for ecological weed and pest control and monitoring, fence construction and maintenance, restoration planting, monitoring of native fish, and regular rubbish removal. They are supported

by the local community and work in partnership with local landowners to rehabilitate parts of the estuarine system where stock have previously had access (Todd et al. 2016).

Makara Estuary restoration plantings of rushland (oioi) in the middle estuary .

Ecological Values

Ecologically, habitat diversity is moderate. The upstream channel has been modified, erosion prone areas reinforced with a variety of materials including concrete and tyres, there are limited areas of intertidal flats, salt marsh vegetation is significantly diminished from historical cover (~30% remaining) and weeds and terrestrial grasses are common. Despite such modification, the estuary retains regionally scarce and important habitat for native fish, tidal flat organisms, salt marsh, birds and terrestrial plants and animals.

Existing Condition

Much of the estuary is degraded, with impacts consistent with long-term (decadal) and persistent sedimentation. There is also evidence that dynamic, yet intermittent, natural events (e.g. storms/tidal inundation etc.) occasionally push marine macroalgae into the estuary where it subsequently gets trapped and decays (Haggitt and Mead (2015).

Salinities vary depending on the extent of tidal inflow. The water is generally clear and the sediments are soft sandy mud. However, surface sediments are anoxic (oxygen depleted) throughout much of the lower estuary basin.

Currently water quality in the stream is moderate (low nutrient and but elevated *E.coli* concentrations), reflecting the dominant landuse of high production pasture. Estimated nitrogen loadings are low-moderate. Because the estuary is relatively well flushed (although its mouth can block at times) its quality is expected to be similar to the river. Estuary sediment quality is likely to be good with regard to toxicants.

Presence of Stressors

The presence of stressors is expected to be "low-moderate".

Stressors include; water quality impacts from non-point discharges particularly sediment inputs, historical drainage, the presence of weed and pest plant species, stock grazing within salt marsh, and river bank erosion.

Susceptibility to Stressors

Susceptibility to stressors is expected to be moderate as although the estuary is generally well flushed, mouth constriction means sediment and nutrient inputs can accumulate in the lower estuary. This is compounded where marine algae washes into the estuary and it remains trapped and rots on the bottom. Stock access to salt marsh is relatively easily managed.

3.2 SOUTH COAST - OWHIRO BAY TO BREAKER BAY

Situated on the southern coast of Wellington City, this 21km section of the coast is exposed and bathed by relatively clear, clean waters. It consists of hard rocky shores and reefs (~69% of the shoreline) interspersed by a string of embayments (Owhiro, Island, Houghton, Lyall, Tarakena, Reef, Flax, Eve and Breaker Bays - see Figures 1 and 3). Gravel dominated beaches (~24% of the shoreline) are located at the head of most steep (reflective) bays with dumping waves. The inshore beach margin is narrow, with grasses, marram, flaxes and scrub species present. Above the vegetated margin there is usually a road, houses or steep cliffs. The exception to the above beach types is the much larger Lyall Bay, a sandy, low gradient (intermediate/dissipative) beach (~7% of the shore) with marram and pingao dunes, a rock wall at the western end, and backed by roads and houses.

Human Uses and Values

High Use. Swimming, fishing, scientific, boating, walking, picnics, scenic, surfing, shellfish, driving, diving.

Ecological Values

Exposed rocky shore and shallow subtidal reef habitats have high plant and animal biodiversity.

Most beaches are steep with gravel and cobble substrate and hence are expected to have low biodiversity. The exception is the more sheltered intermediate beach at Lyall Bay (see Stevens 2018a). Dune areas are infrequent and, when present, narrow. The Lyall Bay dune has been extensively revegetated. Stream mouth estuaries are present at most beaches but are very small, freshwater and gravel dominated, lack intertidal flats and saltmarsh, and are often piped or channelised.

The vegetated margin is managed, but in many areas is very narrow and supports a variety of weeds. There is a marine reserve at Island Bay.

Existing Condition

Existing condition of all habitat is expected to be "good" given its well flushed nature and the inclusion of part of the coast in the Taputeranga Marine Reserve. Exceptions are in localised areas where stormwater and treated wastewater discharge, and in particular cause exceedance of shellfish disease risk criteria (Lyall Bay, Moa Point/Tarakena Bay). Lyall Bay duneland is small but in good condition. The remaining vegetated areas between the road and the beaches and rocks have many weeds but are being actively managed. There is likely to be localised depletion of some rocky habitat biota as a consequence of fishing/harvesting. Localised impacts to water quality and biota are expected near the Moa Point wastewater outfall.

Presence of Stressors

The overall presence of stressors is rated "moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through stormwater and wastewater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, seawalls, and loss of natural upper beach berm/dunes.

ISSUES AND THREATS

- Climate change and human take threats to high biodiversity rocky shore habitat
- Wastewater discharges and overflows
- Weed invasions along terrestrial margin
- Coastal property development

Overarching Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Low	Low
Fine sediment	Low	Low
Human Disease Risk	Moderate	Moderate
Toxicants	Low	Low
Habitat Change	Moderate	Moderate
Overall Vulnerability	**Moderate**	

Susceptibility to Stressors

Susceptibility to stressors is expected to be "low-moderate" for the rock habitat, given that the area is well flushed, is spread over a large area and includes a marine reserve. The small area of dune and margin habitat makes it particularly susceptible to damage. The beaches have low susceptibility (exposed and well flushed).

Owhiro Bay

Houghton Bay

3.3 WELLINGTON HARBOUR

Wellington Harbour (Figure 3) is a large (8,900ha), relatively deep (10-30m deep), and sheltered sea-filled basin. It acts as a natural settling area so has a largely muddy bed, but is relatively well flushed by clean seawater on each tide. The inner harbour has three islands - Matiu/Somes, Mokopuna and Makaro/Ward Island. The harbour's intertidal margins (~67km) are mostly bedrock or seawalls (69%) with an almost unbroken stretch of modification extending from Seatoun to Eastborne.

Interspersed among this habitat are smaller areas of gravel dominated beaches near the harbour entrance (14%) and sand beaches (8%) located at Petone, Oriental Parade (reliant on imported sand), Lowry Bay and Days Bay. The vast majority of the natural stream estuaries to the harbour have been piped and modified with only the larger estuaries located at the mouth of the Hutt River, Korokoro Stream and Kaiwharawhara Stream remaining as significant open waterways, although these are also heavily modified. The scarcity of these remaining habitats places a high level of importance in maintaining and enhancing their ecological values.

Overall, the harbour has lost much of its previously extensive duneland, saltmarsh and tidal flat areas. Approximately half of the harbour margin has been modified (rip-rap seawalls flanking road and rail corridors), with large areas reclaimed in the Wellington commercial port area, at Kaiwharawhara, and at Seaview to the east of the Hutt River mouth. There are ~14,000 commercial shipping movements each year. Marinas are situated in southwest Evans Bay, west of Oriental Bay, and at Seaview. Outside the harbour entrance, the coastline is exposed, and dominated by rugged rocky coast interspersed with pocket beaches.

A summary of values are presented below followed by an overview of the broad sections of the coast, harbour and estuaries.

Human Uses and Values

High Use. Shipping, swimming, fishing, scientific, boating, walking, picnics, scenic, shellfish, driving, diving, windsurfing.

Ecological Values

Rocky Shore Habitat (intertidal and subtidal). The dominant shore type in the harbour, this supports a wide variety of animals (e.g. barnacles, mussels, sea stars, brittle stars, shield shells, crabs, limpets, chitons, snails, kina, and crayfish) and various seaweeds including the invasive kelp *Undaria*. The three islands in the harbour support several hundred little blue penguins that regularly traverse between nest sites on the islands and Cook Strait during the breeding season.

Beach Habitat. Sandy beach habitat is relatively rare and supports a wide variety of sand dwelling invertebrates (sandhoppers, pipi, polychaete worms). Small areas of seagrass are present in shallow subtidal areas in Lowry Bay. Steep gravel cobble beaches (e.g. Eastbourne, Camp Bay), tend to have less diversity due to the highly mobile sediments.

Oriental Bay is an eroding beach site maintained by the importation of coarse granite sands from Golden Bay.

ISSUES AND THREATS

- Climate change and human take threats to high biodiversity rocky shore habitat
- Stormwater discharges
- Wastewater overflows
- Weed invasions along terrestrial margin
- Coastal development and shoreline armouring

Overarching Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Low	Low
Fine sediment	Low	Low
Human Disease Risk	Moderate	Moderate
Toxicants	Moderate	Moderate
Habitat Change	High	Moderate
Overall Vulnerability	**Moderate**	

Figure 3. Location of sites in Wellington Harbour and on the south coast.

Dune/Vegetated Margin Habitat. This habitat has been the most affected by change in the harbour over time. Dunes and saltmarsh were common in the Petone/Hutt River estuary area but are now restricted to very small areas. The east side of the harbour between Eastbourne and Pencarrow Head retains the most unmodified coastal margin. Revegetation and shoreline management is currently being undertaken to improve this important buffering zone within the harbour but it is under constant pressure from coastal development.

Artificial Structure Habitat. The harbour includes a large area of habitat on artificial structures (predominantly seawalls) which is home to a wide variety of plants and animals.

Soft Sediment Habitat. This forms the bulk of the harbour floor and includes a high macroinvertebrate diversity dominated by polychaete worms, small crustaceans and molluscs.

Water Habitat. Plant and animal life in the harbour waters is dominated by microscopic phytoplankton, zooplankton, various fish species (spotties, wrasse, leatherjackets, yellow-eyed mullet, flounder, stargazers, stingrays) and occasionally whales, dolphins, seals and penguins.

Estuary Habitat. This is addressed in Sections 3.3.6-3.3.8.

Existing Condition

Water and Sediment Quality. Harbour waters are generally of good quality except in river plumes during rain events (particularly Hutt River) and near stormwater outfalls. Lowered water clarity, excessive sedimentation, faecal bacteria, nutrients and metals are the major impacts.

Biota. Harbour plants and animals have been affected by the large changes to the harbour following urbanisation, however, biodiversity is still high in the remaining habitats.

Stressors

Most of the coast has been modifed by the urban and industrial development of Wellington, Lower Hutt, Petone and Eastbourne and this has drastically altered the habitat values of the margin. The major stressors are:

Extensive seawalls.a Approximately half of the harbour margin has been modified (seawalls and roads).

Reclamations. Major sections of the harbour have been reclaimed in the Wellington dockyard area, at Kaiwharawhara, and at Seaview to the east of the Hutt River mouth. This has led to the loss of extensive saltmarsh and tidal flat areas.

Marinas. Marinas are in the southwest section of Evans Bay, Oriental Bay, and Seaview.

Point Source Discharges. Historically there were lots of discharges but the only point source discharges to the harbour at present are urban stormwater outfalls, which may, on occasion during very wet weather, include sewer overflows.

Nonpoint Source Discharges. The Hutt River discharges a large amount of sediment, nutrients, pathogens and possibly toxicants to the harbour.

Invasive Pests. The asian kelp *Undaria* is now common in the harbour.

Spills. Exposed to spills from ships, boats and road transport.

Susceptibility to Stressors

Because the harbour is relatively deep and sheltered, it acts as a natural settling basin for sediment, nutrients, pathogens and toxicants. However, it is also relatively well flushed with clean seawater each tide and so has a certain resilience to degradation. The muddy harbour bed habitat is most susceptible to toxins and organic build-up. The rocky habitat is extensive and relatively resilient, but is susceptible to toxins (e.g. toxic algal blooms), excessive sediment, invasive pests and collection for seafood.

A very brief summary of harbour coastal areas and biota is presented in the following sections. Additional detail is contained in Stevens et al. (2004), Stevens (2013), Overmars (2016) and McMurtrie and Brennan (2016).

3.3.1 SEATOUN TO KAU BAY

Overall Vulnerability	Moderate

Relatively sheltered and bathed by predominately clear, clean waters. It consists of a string of mainly urban embayments (Seatoun, Worser, Karaka, Scorching, Mahanga and Kau Bays) separated by hard rocky shores and reefs. The beaches are narrow, moderate gradient and a mix of sand and gravel. The inshore beach vegetated margin is either narrow or non-existent and dunes are rare. Above the vegetated margin there is usually a road and either houses or bush covered hills.

High Use. Swimming, fishing, boating, walking, picnics, scenic value, shellfish, driving, diving.

A significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an

expected moderate biodiversity of animals and plants. Biodiversity is expected to be low at the sand/gravel beaches. The duneland area is small (near Seatoun) and has been revegetated.

3.3.2 EVANS BAY

Overall Vulnerability	Moderate

Evans Bay is horseshoe shaped with rocky shores and contains many small embayments (Shelly, Kio, Weka, Balaena Little Karaka, and Shark Bays) running along each side. The beaches tend to be narrow rock/cobble, with a moderate gradient. Sand/gravel beaches are found at Hataitai, and Kio Bay. The inshore beach vegetated margin is either narrow or non-existent and dunes are absent. Above the vegetated margin there is usually a road, and buildings or road and bush covered hills. The head of the bay includes marina and wharf structures. Seawalls are common, particularly along the western (Greta Point) and southern (Cobham Drive) edges.

High use in some areas. Swimming, fishing, boating, walking, picnics, scenic value, driving, diving.

This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected moderate biodiversity of animals and plants. Offshore the sediments are muddy and fine sediments may have elevated metal and PAH levels. Biodiversity is expected to be moderate on the sheltered cobble/rock beaches. Where vegetated, the margin is primarily grass with trees.

3.3.3 ORIENTAL PARADE TO PETONE BEACH

Overall Vulnerability	Moderate

Represents a highly modified section of the coast, sheltered and bathed by relatively clear, clean waters (although urban stormwater runoff is significant). The area includes Oriental Bay (which has seawalls and an artificial coarse sand beach), a marina, the main port wharf facilities, Kaiwharawhara Estuary, and a long rip-rap seawall along the motorway between Kaiwharawhara and Petone Beach. The margin above high water is predominantly unvegetated e.g. road, railway, buildings, wharves.

High use in some areas. Shipping, swimming, fishing, boating, walking, picnics, scenic value, driving, diving.

Shoreline values are relatively low given the highly modified nature of the substrate and at times, water quality. However, they still provide habitat for a wide variety of plants and animals.

3.3.4 SEAVIEW TO ROBINSON BAY

Overall Vulnerability	Moderate

Consists of a string of mainly urban embayments (Sorrento, Lowry, York, Mahina, Sunshine, Days, Rona, Eastbourne, Robinson Bays), separated by hard rocky shores and reefs. The beaches are narrow, moderate gradient and a mix of sand, gravel and cobbles. The inshore beach vegetated margin is either narrow or nonexistent, and dunes are rare. Above the narrow and often weedy vegetated margin there is usually a road, then either houses or bush covered hills.

High Use. Swimming, fishing, boating, walking, picnics, scenic value, shellfish, diving.

This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected moderate biodiversity of animals and plants. Biodiversity is expected to be low at the sand/gravel beaches. The duneland area is small and has been revegetated. Seagrass beds are present intertidally and in the shallow subtidal zone of Lowry Bay. The majority of the upper shoreline has been protected with concrete or rip-rap seawalls, many of which are scheduled for replacement over the next several years (McMurtrie and Brennan 2016).

3.3.5 CAMP BAY TO PENCARROW HEAD

Overall Vulnerability	Low

A largely rural and uninhabited section along the eastern side near the entrance to Wellington Harbour. Camp Bay is a steep gravel cobble beach, with a small area of pingao dune field. A 6km stretch of isolated rocky shore extends from Camp Bay to Pencarrow Head. Treated wastewater from Hutt and Wainuiomata is discharged at Pencarrow Head.

Moderate use. Wastewater assimilation, fishing, boating, walking, scenic value, shellfish, diving.

This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected high-moderate biodiversity of animals and plants. Biodiversity is expected to be low within the sand/gravel beaches, but high above MHWS. The duneland area is small.

3.3.6 KAIWHARAWHARA ESTUARY

Overall Condition	Moderate

The Kaiwharawhara Estuary is a highly modified small "tidal river mouth" type estuary which drains into Wellington Harbour (Figure 4). The estuary is ~10m wide, 0.5-1m deep at high tide, and ~500m long. The scarcity of this habitat in the harbour makes if a high priority for protection and restoration.

Kaiwharawhara Estuary showing mouth with concrete seawalls and beach gravels.

The relatively small intertidal area is dominated by gravel and cobble substrate with a small gravel beach and tidal delta at the mouth. Its margins comprise vertical concrete channels and gabion baskets which support areas of terrestrial margin vegetation and some very small areas of riparian vegetation in the middle reach of the estuary. There is no salt marsh of any consequence and many exotic weed species are present. Large parts of the lower estuary are covered over by road and rail bridges.

Kaiwharawhara Estuary showing terrestrial vegetation and vertical estuary walls.

Extensive catchment work is currently underway to improve the upstream freshwater habitat and

KAIWHARAWHARA ESTUARY SUMMARY	
Estuary type / extent	Tidal River Mouth 0.65ha
Subtidal extent	0.3 ha (45%)
Mouth opening	Constricted, closes occasionally
Mean depth / Length	0.75m / 500m
FW inflow	0.3 cumecs
Dominant substrate	Gravel and cobble
Soft mud	0
Salt marsh	0
Macroalgae	0
Seagrass	0
Vegetated 200m margin	
Catchment area	17 km^2
Catchment geology	Greywacke
Nitrogen loading	9.2 T/yr, 3869 $mg/m^2/d$
Phosphorus loading	0.8 T/yr, 326 $mg/m^2/d$
Sediment loading	2.2 KT/yr, 914$g/m^2/d$
E.coli loading	0.4 $x10^{15}$/yr
Land use	Native 47%,forestry 6%, pasture 10%, urban 36%
Dairy cows	0
Uses/Values	Conservation, wildlife corridor, urban stormwater
NZ ETI score	0.09 Band A

ISSUES AND THREATS

- Industrial/urban stormwater
- Historical salt marsh drainage and reclamation
- Concrete channelisation of estuary
- Covering of lower reaches by road and rail corridors
- Development of port facilities near mouth
- Access restrictions

Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Moderate	Low
Fine sediment	Low	Low
Human Disease Risk	Moderate	Low
Toxicants	Moderate	Moderate
Habitat Change	High	Low
Overall Vulnerability	**Low**	

the estuary is a vital part of the connection between the sea and the upper catchment which includes the Zealandia wildlife scantuary.

Human Uses and Values

Human use of the estuary is low primarily because there is no direct or easy public assess to the estuary. It provides a limited aesthetic value but a number of community groups, supported by Wellington City Council, undertake planting, monitoring of pollutants and management of pest species in the estuary and catchment and Boffa Miskell (2011) undertook a project to look at restoration and access issues around the estuarine site. In December 2012, a Deed of Settlement was signed between Ngati Toa Rangitira and the Crown that recognises the role of Ngati Toa as kaitiaki of the coastal marine area of Wellington Harbour/Port Nicholson (Todd et al. 2016).

Ecological Values

Ecologically, habitat diversity is low given the modified upstream channel (vertical sided box culvert), dominance of coarse gravel and cobble substrate, and absence of salt marsh vegetation. Such conditions provide poor habitat for native fish, tidal flat organisms and birds, particularly in the covered sections of the lower estuary.

Eleven migratory native freshwater fish species have been found in the catchment and the estuary is a key part of a valued ecological corridor for birds and fish linking the harbour with the hills behind, however the estuary itself provides virtually no suitable fish spawning habitat due to an absence of riparian vegetation and high levels of shading in the lower estuary.

Kaiwharawhara Estuary showing shaded vertical estuary walls beneath the motorway over bridge.

Existing Condition

Salinities vary depending on the extent of tidal inflow. The water is generally clear and the sediments gravel and mud sediments are well oxygenated. Martin et al. (2017) report water quality as fair noting the presence of elevated E. coli, nitrate and upstream periphyton which reflects the dominant urban/native forest landuse.

Estimated nitrogen loadings are high, but within-estuary impacts are mitigated by the channelised nature of the estuary providing very good flushing. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Estuary sediment quality is expected to be moderate. Streambed sediment sampling carried out by GWRC in 2005 and 2006 found DDT exceeded ANZECC high trigger values (concentrations at which significant biological effects are likely to occur (Milne & Watts 2008), while Boffa Miskell Limited (2011) reported levels of both lead and zinc exceed sediment quality guidelines (Boffa Miskell Limited 2011).

Presence of Stressors

The presence of stressors is considered to be "moderate". Stressors include; concrete box channelling, loss of vegetated margins, change to water quality through urban stormwater discharges, and weed and pest invasions.

Susceptibility to Stressors

Because of the well flushed and already highly modified nature of the estuary, susceptibility to stressors is rated "low" despite the presence of elevated sediment toxicants and human disease risk.

Figure 4. Kaiwharawhara Estuary showing extent and dominant substrate features.

3.3.7 KORKORO ESTUARY

Overall Condition	Moderate

The Korokoro Estuary is a small "tidal river mouth" type estuary which drains into Wellington Harbour at the western end of Petone Beach (Figure 5). It has a small area of planted salt marsh vegetation (available for inanga spawning), and a gravel beach near the mouth provides some habitat for birds. The scarcity of this habitat in the harbour makes it a high priority for protection and restoration.

Upstream its margins are largely constrained by concrete culverts and channels as it passes under the Hutt motorway/rail corridor.

The upstream catchment is over 60% native bush.

Human Uses and Values

Human use of the estuary is moderate; primarily the lower reaches used for recreation, picnics, bathing, fishing, and walking dogs.

Ecological Values

Ecologically, habitat diversity is low, given the modified upstream channel, absence of tidal flats, and limited salt marsh vegetation. Where the stream flows through the Honiana Te Puni Local Purpose Reserve there are planted and maintained riparian strips consisting of oioi and wiwi backed by a mixture of toetoe, taupata, and flax. These areas appear suitable for inanga spawning and ten migratory native freshwater fish species have been found in the catchment (Todd et al. 2016) indicating that the estuary is an important migratory pathway. In the deeper parts of the stream, green algae (periphyton) forms mats on the stones. New Zealand spinach was recorded from the site by Borger (1996), and has been regularly monitored by DOC staff ever since. (Todd et al. 2016).

An assortment of birds, including gulls, variable oystercatchers, white-fronted terns and paradise shelducks are known to visit the area.

KOROKORO ESTUARY SUMMARY	
Estuary type / extent	Tidal River Mouth 0.29ha
Subtidal extent	0.15 ha (52%)
Mouth opening	Constricted, closes occasionally
Mean depth / Length	0.5m / 200m
FW inflow	0.3 cumecs
Dominant substrate	Gravel
Soft mud	0
Salt marsh	250m^2
Macroalgae	0
Seagrass	0
Vegetated 200m margin	~10%
Catchment area	16 km^2
Catchment geology	Greywacke, loess
Nitrogen loading	7.9 T/yr, 7509 mg/m^2/d
Phosphorus loading	1.3 T/yr, 1193 mg/m^2/d
Sediment loading	3.7 KT/yr, 3515g/m^2/d
E.coli loading	0.1 x10^{15}/yr
Land use	Native 64%,forestry 12%, pasture 21%, urban 2%
Dairy cows	0
Uses/Values	Swimming, picnics, conservation, urban stormwater, whitebait
NZ ETI score	0.16 Band A

ISSUES AND THREATS

- Industrial/urban stormwater
- Historical salt marsh drainage and reclamation
- Concrete channelisation of estuary
- Covering of lower reaches by road and rail corridors
- Wildlife disturbance
- Flood control (gravel extraction)

Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Low	Low
Fine sediment	Low	Low
Human Disease Risk	Low	Low
Toxicants	Low	Low
Habitat Change	High	Low
Overall Vulnerability	**Low**	

Figure 5. Korokoro Estuary showing extent and dominant substrate features.

Existing Condition

Salinities vary depending on the extent of tidal inflow but the estuary drains readily and is fresh-water dominated at low tide. Water is commonly clear and the gravel and mud sediments have little sign of anoxic conditions although organic matter does accumulate and rot in parts of the lower estuary. Stream water quality is expected to be relatively good reflecting the dominant native forest landuse, however in the lower reaches it passes through road and rail corridors and an industrial estate where stormwater contaminants may be present. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Estimated nutrient loadings are high although retention in the estuary is likely to be low due to high flushing.

The Honiana Te Puni Local Purpose Reserve is a privately owned foreshore reserve administered by Hutt City Council who are responsible for plantings, landscaping, and ecological weed and pest control.

Presence of Stressors

The presence of stressors is expected to be "low". Stressors include; concrete channels, loss of vegetated margins, weed and pest invasions, covering of the estuary by transport infrastructure, and flood conveyance works (GWRC has a consent to carry out gravel extraction in the stream to keep the channel clear). The presence of recreational beach visitors is likely to discourage bird roosting or nesting.

Susceptibility to Stressors

Susceptibility to stressors is considered "low" given that the area is well flushed, and already highly modified.

3.3.8 HUTT ESTUARY

Overall Condition	Moderate

The Hutt Estuary is a moderate-sized (15ha) "tidal river" estuary which drains into Wellington Harbour at the eastern end of Petone Beach (Figure 6). It has been extensively reclaimed and modified, and the banks clad with large rip rap (quarried boulders). Such substrate has low biodiversity and is unsuitable as inanga spawning substrate. However, where rip-rap is absent (two small areas, one near the Sladden Park boat ramp in Petone, and the other on the opposite bank along Opahu Stream), margin vegetation is present providing reasonable spawning habitat (Taylor and Kelly 2001). Salt marsh habitat was once extensive but, through reclamations, has been reduced to a small planted area on the western bank and along Moera Stream. The area of tidal flats has also been reduced (now approx. 0.5ha). The scarcity of this habitat in the harbour makes if a very high priority for protection and restoration.

Given the fundamental changes to the estuarine system's surrounding environment since the 1900s (Treadwell 1959), there has been a massive loss of habitat for wildlife. Despite this, the estuarine area is still an important ecosystem, particularly as an access corridor for migratory fish and birds. Common native species such as little black shags, white-faced herons and black swans regularly visit to forage. Rarer species such as red-billed gulls, Caspian terns, and variable oystercatchers will also congregate to feed at the mudflats in the western arm of the estuarine site. Thirteen migratory native freshwater fish species have been found in the catchment. Historically, Te Awa Kairangi /Hutt River has supported a large galaxiid population, and the estuarine ecosystem was an important inanga spawning ground. However, with the rock rip rap placed along the riverbanks, most of the suitable spawning habitat has been destroyed (Todd et al. 2016).

Human Uses and Values

Human use of the estuary is high. It is a local focal point, and paths run the length of the estuarine area on both banks, and are popular with walkers and joggers. Shandon Golf Course occupies the true right bank just upstream of the estuary bridge. The estuary is used for conservation, boating, bird watching, whitebaiting and fishing.

In December 2012 a Deed of Settlement was signed between Ngati Toa Rangitira and the Crown

HUTT ESTUARY SUMMARY	
Estuary type / extent	Tidal River Mouth 47.6ha
Subtidal extent	37.4 ha (79%)
Mouth opening	Constricted, closes occasionally
Mean depth / Length	1-3m / 3km
FW inflow	27.6 cumecs
Dominant substrate	Gravel and cobble
Soft mud	0.2 Ha
Salt marsh	0.5 Ha
Macroalgae	0
Seagrass	0
Vegetated 200m margin	<1%
Catchment area	149 km^2
Catchment geology	Greywacke, alluvium, peat, sand
Nitrogen loading	342.7 T/yr, 1973 $mg/m^2/d$
Phosphorus loading	56.2 T/yr, 323 $mg/m^2/d$
Sediment loading	143.6 KT/yr, 826$g/m^2/d$
E.coli loading	8.1 $x10^{15}$/yr
Land use	Native 67%,forestry 11%, pasture 13%, urban 6%
Dairy cows	0
Uses/Values	Fishing, swimming, picnics, conservation, boating, urban stormwater, whitebait, shellfish
NZ ETI score	0.54 Band C

ISSUES AND THREATS

- Industrial/urban stormwater
- Historical salt marsh drainage and reclamation (Loss of shallow wetland, tidal flat areas for water to spread, flap gates to prevent tidal flows)
- Concrete channelisation of estuary (Waiwhetu)
- Flood control (gravel extraction)
- Artificial rip rap estuary margins

Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	High	Moderate
Fine sediment	Low	Low
Human Disease Risk	Moderate	Moderate
Toxicants	Moderate	Moderate
Habitat Change	High	Low
Overall Vulnerability	**Moderate**	

Figure 6. Hutt Estuary showing extent and dominant substrate features.

that recognises the role of Ngati Toa as kaitiaki of the coastal marine area of Wellington Harbour (Port Nicholson). Te Atiawa maintains a strong interest in the management of the river, particularly the estuarine area, regarding it as a taonga. As such, they have advocated for the planting of native bush and restoration of wetlands on the river margins, and tighter restrictions on industrial discharge.

Ecological Values

Ecologically, habitat diversity is low, given the modified channel margins (straightened and armored), and the small area of tidal flats and salt marsh. A small patch of partially restored terrestrial saltmarsh vegetation is on the true right of the river, on the downstream side of the Waione Road Bridge, consisting of saltmarsh ribbonwood and taupata shrubs, along with tauhinu, toetoe, and ngaio. Te Mome and Moera streams have had restorative planting, including flax, umbrella sedge, wiwi, and searush.

Possible whitebait spawning habitat was identified in the Sladden Park boat ramp area, the bunded backwater of the lower Opahu Stream, and the Te Mome Stream (Taylor & Marshall 2016).

The estuarine system is a nursery area for juvenile flatfish, particularly black flounder (Stevens et al. 2004, and references therein). Kahawai, grey mullet, and other fish species found in the harbour also visit regularly to feed. Grey mullet have been observed spawning in the river in early spring (Todd et al. 2016).

Existing Condition

Although the river has frequent water quality problems, the intertidal estuarine sediments are in good health (Stevens et al. 2004; Robertson and Stevens 2010; Stevens & Robertson 2013, 2015b), with heavy metal levels well below those that might be expected. However, due to the nature of the catchment, contamination from urban stormwater and industrial sources remains a risk (Todd et al. 2016).

Because of its high volume, the Hutt River is the major contributor of nutrients, sediment and contaminants to the estuary and harbour. Salinities vary depending on the extent of tidal inflow. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Recent water quality monitoring in the Hutt River indicated relatively good conditions (low nutrient and *E.coli* concentrations), but was poor in the Waiwhetu Stream (Martin et al. 2017).

Upstream of the Waione Bridge, subtidal sediments in Hutt River are dominated by well oxygenated gravels, but in dredged areas downstream of the bridge where water is deeper, sediments are enriched, anoxic and have elevated concentrations of nutrients and some heavy metals including mercury, nickel and zinc (Stevens et al. 2016).

Presence of Stressors

The presence of stressors is "moderate". Stressors include; stormwater, rip rap margins, change to water quality through non-point discharges (esp. urban streams), historical drainage/reclamation, weed and pest invasions, tidal flap gates, harvesting (fish and shellfish), and dredging.

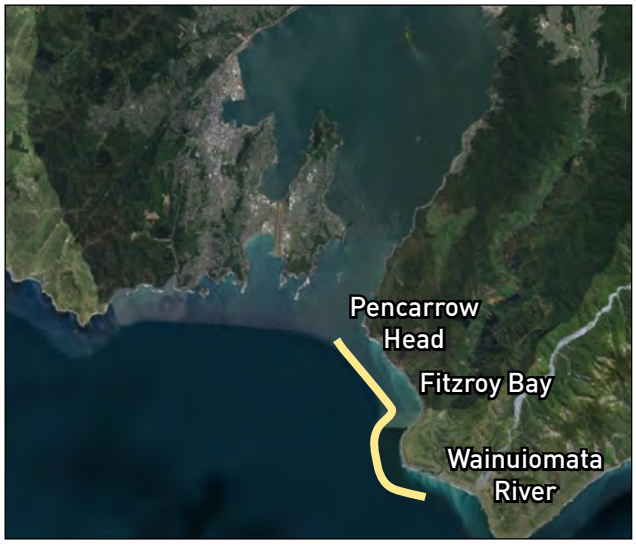
Opportunistic macroalgae is present throughout the intertidal area but not at nuisance levels, although it can be very extensive subtidally possibly due to catchment or localised nutrient inputs. Toxic algae are frequently reported in the Hutt River.

The nearby recreational water quality monitoring site (GWRC – Petone beach at kiosk) registered levels of *enterococci* which exceeded guidelines during the 2014/2015 summer bathing season (Keenan et al. 2015).

Susceptibility to Stressors

Susceptibility to stressors is considered "moderate" given that the area is well flushed and habitats already highly modified.

3.7 SOUTH COAST - PENCARROW HEAD TO WAINUIOMATA RIVER



The ~8km coastline from Pencarrow Head to Wainuiomata River is dominated by exposed, relatively wide, steep gravel beaches, with rocky reefs/outcrops and steep hillsides. Vegetation cover on the cliffs is relatively sparse and land cover is dominated by pasture and regenerating scrub and forest cover.

Streams that discharge to the coast are generally small and lack stream mouth estuaries. Two freshwater lakes are present east of Pencarrow Head (Lake Kohangapiripiri and Lake Kohangatera).

Human Uses and Values

Moderate use. There is limited direct road access to much of the coast which limits public usage. Values include wastewater assimilation, fishing, boating, walking, surfing, shellfish collection, diving, rock climbing, and natural aesthetics. Gravel is extracted from Fitzroy Bay.

Ecological Values

Exposed rocky shore and shallow subtidal reef habitats have moderate to high plant and animal biodiversity. Beaches are steep with gravel and cobble substrate and hence are expected to have low biodiversity. Dune areas are relatively extensive and diverse at Fitzroy Bay but include weed growth. Estuaries are small and freshwater dominated.

Existing Condition

Existing condition of all habitat is expected to be "good" given its remoteness, and relatively low intensity grazing in the catchment. The pasture dominated catchment is likely to contribute elevated fine sediment compared to natural state conditions, and the past clearance of native cover means the terrestrial margin and any dune areas support exotic weeds and plants. There is likely to be localised depletion of some rocky habitat biota as a consequence of fishing/harvesting. Localised impacts to water quality and biota are expected near the Pencarrow wastewater outfall.

Presence of Stressors

The overall presence of stressors is rated "low".

Localised stressors include human pressures on fish and shellfish stocks, and the Pencarrow wastewater discharge. Eutrophication is unlikely to be a significant issue on the open coast. More widespread stressors are fine sediment inputs to the coast, habitat change as a consequence of climate change (sea level rise, sea temperature and pH), the presence of terrestrial weed/pest plants, offshore toxic algal blooms, and oil spills.

Susceptibility to Stressors

Susceptibility to stressors is rated "low". The coastline is well flushed and relatively remote, but is close to a large population centre and is a popular fishing and diving destination. Rocky shore and shallow subtidal reef habitat has the highest ecological and human use value and is most susceptible to human pressure through over-fishing. Long term changes in water quality (e.g. through climate change) are expected, and low probability but potentially high consequence impacts are possible e.g. oil spills, invasive pests and offshore algal blooms.

ISSUES AND THREATS

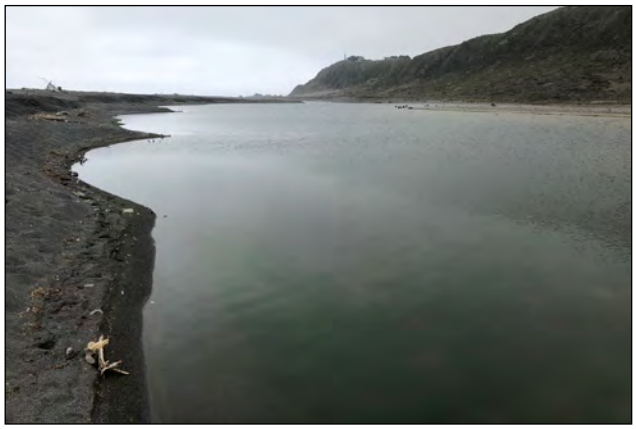
- Climate change and human take threats to high biodiversity rocky shore habitat
- Wastewater discharges
- Weed invasions along terrestrial margin

Overarching Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	Low	Low
Fine sediment	Low	Low
Human Disease Risk	Moderate	Low
Toxicants	Low	Low
Habitat Change	Low	Low
Overall Vulnerability	**Low**	

3.7.1 WAINUIOMATA ESTUARY

Overall Condition	Good

The Wainuiomata Estuary is a moderate-sized (6.7ha) "tidal river ICOLL" located on the south coast of Wellington (Figure 7). Todd et al. (2016) suggest the estuary be classified as a coastal lake as a series of historic earthquakes have raised the river mouth such that it is now several metres above the high tide line with a sand/gravel bar obstructing the mouth. While the mouth drains to the sea, at the time of sampling this was via seepage through beach gravels and not an open mouth. Measurements in January 2018 recorded salinities of ‹0.5ppt indicating freshwater dominance with the only saltwater influence likely to come from salt spray or from splashes over the bar during severe southerly storms. Eleven migratory native freshwater fish species in the catchment (Allibone et al. 2010) indicate that at times there is an open connection to the coast (as opposed to drainage through beach gravels).



Wainuiomata Estuary - coastal lake/lagoon behind elevated gravel berm.

Wainuiomata Estuary - low tide discharge to the coast through seepage into beach gravels.

In other respects, the river displays all the characteristics of a tidal river mouth estuary with a ~50m wide, elongate river basin that runs parallel to the coast for ~800m, separated from the sea

WAINUIOMATA ESTUARY SUMMARY	
Estuary type / extent	Coastal Lake 6.7ha
Subtidal extent	6.1 ha (100%)
Mouth opening	Closed, drains to ocean
Mean depth / Length	1m / 1km
FW inflow	4.0 cumecs
Dominant substrate	Gravel and cobble
Soft mud	0
Salt marsh	0
Macroalgae	0
Seagrass	0
Vegetated 200m margin	‹1%
Catchment area	213 km^2
Catchment geology	Greywacke
Nitrogen loading	65.7 T/yr, 2951 $mg/m^2/d$
Phosphorus loading	11.3 T/yr, 507 $mg/m^2/d$
Sediment loading	30.8 KT/yr, 1385 $g/m^2/d$
E.coli loading	1.5 $x10^{15}$/yr
Land use	Native 59%, pasture 31%, exotic forestry 6%, urban 4%
Dairy cows	0
Uses/Values	Fishing, picnics, conservation
NZ ETI score	0.14 Band A

ISSUES AND THREATS

- Water abstraction (reduced river flows)
- Weed invasions along terrestrial margin
- Historical land clearance for farming

Issue	Stressor Likelihood	Stressor Susceptibility
Eutrophication	High	High
Fine sediment	Low	High
Human Disease Risk	Low	Low
Toxicants	Low	Low
Habitat Change	Low	Low
Overall Vulnerability	**Moderate**	

Figure 7. Wainuiomata Estuary showing extent and dominant substrate features.

by a gravel berm.

Human Uses and Values

The area receives moderate recreational use, with some surfing and surf-casting activity on the adjacent beach. The river mouth is the access point for rock climbers using the popular boulders at Baring Head and Fitzroy Bay. Access is also via Baring Head by crossing the river mouth. The land around the river mouth and coastal dune forms part of the East Harbour Regional Park. Friends of Baring Head are assisting with weed control and carrying out intensive trapping of predators (hedehogs, mustelids, cats and possums) on the beaches surrounding the river mouth to protect ground-nesting birds such as banded dotterel. There are plans for a 'Big Coast' cycle route to be developed along the coast from the Wairarapa and up the Wainuiomata River (Todd et al. 2016).

Ecological Values

The estuary is dominated by gravel and sand with very little soft sediment habitat present due to the hard rock substrate in the catchment. Vegetation is scarce, patchy when present, and dominated by terrestrial plants with no evidence of salt marsh species. Combined with variable flows and salinities, the estuary is not expected to support a high diversity community. Aquatic vegetation reflects the freshwater dominance of the lagoon with conspicuous species being horse's mane weed (*Ruppia megacarpa*), pondweed (*Potamogeton crispus*) and water milfoils (*Myriophyllum triphyllum*)

Aquatic plants common in Wainuiomata River Estuary in Jan. 2018 (L to R: *Ruppia*, *Potamogeton* and *Myriophyllum*).

Existing Condition

Salinities appear consistently low and the mouth appears to remain closed for long periods. Under such conditions there is likely to be cyclical build ups of nutrients, organic matter and algal growth, reducing after flushing of the estuary under high flows. Martin et al. (2017) report good overall condition in the lower Wainuiomata River, although there are elevated concentrations of *E. coli* and periphyton.

Filamentous algae along the lagoon edge in Jan. 2018. Underlying sediments showed no signs of degradation.

Much of the catchment is within either the Rimutaka Forest Park or the GWRC managed Wanuiomata/Orongorongo Water Collection Area containing extensive areas of native forest and scrub draining the south-western part of the Rimutaka Range (Todd et al. 2016).

Presence of Stressors

The overall presence of stressors is rated "low" Water quality in the lower catchment is consistently rated as "fair" (e.g. Morar and Perrie 2013), although the river is still affected by stormwater contamination, occasional leakage from the Wainuiomata landfill, fertiliser runoff, and sedimentation. Predicted nutrient loads are high for a poorly flushed estuary. Toxic algal blooms are known to occur in the river during summer months (MacDonald and Joy 2009). Much of the western branch of the river is regulated by a series of dams for the purposes of metropolitan water supply and water abstraction (Wainuiomata Water Treatment Plant) can significantly reduce river flow. Reduced flows limit the flushing of the estuary and contribute to prolonged closure periods of the mouth.

Susceptibility to Stressors

Susceptibility to stressors is rated "moderate". Coastal lake and lagoon estuaries are highly sensitive to nutrient and sediment inputs due to the build up of concentrations over time, coupled with limited flushing and dilution.

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APPENDIX 1. INPUT DATA FOR THE ETI ONLINE CALCULATOR

NZ ETI Tool 1 Input details	Calculator Heading	Unit
Estuary Number	Est_no	
Estuary Name	Est_name	
Regional Council	Reg_Council	
Island	Island	
NZCHS geomorphic code	NZCHS_code	
NZCHS geomorphic class	NZCHS_class	
ETI Class	ETI_class	
Latitude	LAT	decimal degrees
Longitude	LON	decimal degrees
Freshwater inflow	Qf	m3/s
Annual river total nitrogen loading	TNriver	T/yr
Annual river total phosphorus loading	TPriver	T/yr
Volume	V	m3
Tidal Prism	P	m3
Return flow fraction	b	unitless
ACExR fitted exponent	A	unitless
ACExR fitted constant	B	unitless
Ratio NO3	R_NO3	unitless
Ratio DRP	R_DRP	unitless
Ocean salinity	OceanSalinity_mean	ppt
Ocean nitrate concentration	NOcean	mg/m3
Ocean DRP concentration	POcean	mg/m3
Intertidal area	Intertidal	%
Typical closure length	Tl	days
ICOE class	isICOE	one of: TRUE, FALSE
Closure length	closure_length	one of: days, months
Estuary Area	est_area_m2	m2
Mean depth	mean_depth	m
Tidal height	tidal_height	m
Estuary Area at low tide	LOWTIDEest_area_m2	m2
Mean depth at low tide	LOWTIDEmean_depth	m
Estuary volume at low tide	LOWTIDEvolume	m3

NZ ETI Tool 2 Input details		
Name of estuary	estuary_name	
Phytoplankton Biomass	CHLA	mg/m3
Macroalgal GNA	macroalgae_GNA_ha	ha
Macroalgal GNA/Estuary Area	macroalgae_GNA_percent	%
Opportunistic Macroalgae	macroalgae_EQR	OMBT EQR
Dissolved Oxygen (DO)	DO	mg/m3
Sediment Redox Potential (RP)	REDOX	mV
Total Organic Carbon (TOC)	TOC	%
Total Nitrogen (TN)	TN	mg/kg
Macroinvertebrates	AMBI	NZ AMBI
Area of soft mud	soft_mud	Proportion
Estuary type	estuary_type	
ICOE status	isICOE	TRUE/FALSE

APPENDIX 1. INPUT DATA FOR THE ETI ONLINE CALCULATOR

Input Value	Input Value	Input Value	Input Value	Input Value
171000	17100	1710	1740	1680
Hutt 2018	Korokoro 2018	Kaiwharawhara 2018	Makara 2018	Wainuiomata 2018
GWRC	GWRC	GWRC	GWRC	GWRC
North Island	North Island	North Island	North Island	North Island
				3C
Tidal river (unrestric	Tidal river (barrier b	Tidal river (unrestric	Tidal river (barrier b	Hapua-type lagoon (
SSRTRE	SSRTRE	SSRTRE	SSRTRE	COASTAL LAKE
-41.236477	-41.224458	-41.262067	-41.219103	-41.42716095
174.90034	174.864555	174.79106	174.714437	174.8746724
27.6	0.3	0.3	1.1	4
342.7	7.9	9.2	38.8	65.7
56.2	1.3	0.8	8.3	11.3
1190000	2900	4875	187500	67000
843000	2400	4150	155500	0
NA	NA	NA	NA	NA
0	0	0	0	-0.520003711
0	0	0	0	93.0492692
NA	NA	NA	NA	0.594568143
NA	NA	NA	NA	0.750082048
34.8	34.8	34.8	34.8	34.8
18.0	18.0	18.0	17.0	18.3
6.8	6.8	6.8	7.0	6.8
21.4	48.3	55.4	57.3	0
NA	NA	NA	NA	NA
FALSE	TRUE	FALSE	TRUE	TRUE
months	days	months	days	months
476000	2900	6500	75000	40514
2.5	1	0.75	2.5	1
1.034	1.034	1.034	0.659	1.098

Hutt (B) 2018	Korokoro 2018	Kaiwharawhara2018	Makara 2018	Wainuiomata 2018
5	3.5	1	5	1.5
NA	0	0		NA
NA	0	0		0
0.594	1	1	0.683	0.9
9	9	9.5	6	9
-200	50	50	-250	50
1	NA	NA	NA	NA
800	NA	NA	NA	NA
4.4	NA	NA	5.5	NA
0.024	0	0	0.39	NA
SSRTRE	SSRTRE	SSRTRE	SSRTRE	SSRTRE
FALSE	TRUE	FALSE	TRUE	TRUE

APPENDIX 2A. SUMMARY OF ESTUARY CONDITION

CONDITION RATING	1. Very Good	2. Good	3. Moderate	4. Poor

Ecosystem Value	Makara	Kaiwharawhara	Korokoro	Hutt	Wainuiomata
Site Area	G	P	P	VG	G
Ecological Integrity	P	P	P	P	VG
Plants and animals	M	G	G	M	G
Overall Ecosystem Value	**Mod**	**Mod**	**Mod**	**Mod**	**Good**

Ecological Condition	Makara	Kaiwharawhara	Korokoro	Hutt	Wainuiomata
Macroalgal EQR	G	VG	VG	M	VG
Phytoplankton biomass	G	VG	VG	VG	VG
Soft mud area	P	VG	VG	P	VG
Sediment mud content	P				VG
Macroinvertebrates	P	P	P	P	
Sediment total organic carbon				G	
Sediment total nitrogen				G	
Sediment oxygenation	P	M	M	G	VG
Intertidal GEZs	VG	VG	VG	VG	VG
Seagrass	P	P	P	P	G
Salt marsh	VG	P	P	P	P
Vegetated margin	M	P	P	P	VG
NZ ETI Score	M	VG	VG	M	VG
Overall Condition	**Mod**	**Mod**	**Mod**	**Mod**	**Good**

APPENDIX 2B. SUMMARY OF ESTUARY STRESSORS

RISK RATING	1. Very Low	2. Low	3. Moderate	4. High

Susceptibility (ETI Tool 1)	Makara	Kaiwharawhara	Korokoro	Hutt	Wainuiomata
Physical susceptibility	High	Moderate	Moderate	Moderate	High
N load susceptibility	Very High	Very High	Very High	Very High	Very High

Stressor Presence/Influence	Makara	Kaiwharawhara	Korokoro	Hutt	Wainuiomata
Human Use	M	VL	L	M	L
Ecological Value	H	L	L	H	M
Fine Sediment	H	L	L	M	L
Nutrients/Eutrophication	M	VL	VL	M	VL
Human Disease Risk (pathogens)	-	-	-	-	-
Toxicants (Urban runoff, pesticides)	M	H	H	H	VL
Spills (oil)	M	H	H	H	M
Coastal Erosion (Sea Level Rise)	-	-	-	-	-
Climate Change - pH, temp	-	-	-	-	-
Grazing of high value habitat	M	VL	VL	VL	M
Freshwater abstraction	L	VL	VL	L	H
Reclamation/Drainage	H	H	H	H	L
Harvesting of living resources	L	L	L	M	VL
Algal blooms (from sea)	L	VL	VL	L	VL
Seawalls, breakwaters etc	H	H	H	H	VL
Invasive weeds/pests	H	H	H	H	M
Vehicle damage	L	VL	VL	VL	VL
Animal/human disturbance of wildlife	M	M	M	H	L
Overall Vulnerability	**Mod**	**Low**	**Low**	**Mod**	**Mod**

APPENDIX 3A. CONDITION RATING ASSESSMENT CRITERIA

The following tables present criteria that can be used to assess key coastal and estuarine components in terms of their likely ecological value and condition (apply average of scores to derive an overall value). Further detail is included in the NEMP (Robertson et al. 2002) and the NZ ETI (Robertson et al. 2016a,b). The majority of these ratings are currently under review.

CONDITION RATING	1. Very Good	2. Good	3. Moderate	4. Poor
Ecosystem value				
Site area	›20ha	›5-20	0.5-5ha	‹0.5ha
Ecological integrity (% of site considered healthy & intact)	›75%	›50-75%	›25-50%	‹25%
Plants & Animals	Supports nationally endangered or vulnerable species (e.g. breeding colony) or part of known range for nationally critical species.	Supports species in serious or gradual decline (e.g. breeding colony) or known habitats for endangered or vulnerable species.	Supports endemic and non-threatened species (e.g. breeding colony) or known habitats for at risk or endemic species.	Habitat degraded and supports only non-threatened or migrant species
Ecological Condition (see Robertson et al. 2002, 2016a,b)				
Macroalgal EQR	0.8-1.0	0.6-‹0.8	0.4-‹0.6	0-‹0.4
Phytoplankton biomass (90th percentile measure of Chlorophyll-a)	‹5µg/L	5-10µg/L	›10-16µg/L	›16µg/L
Soft mud area (% of intertidal substrate ex. salt marsh)	‹1%	1-5%	›5-15%	›15%
Sediment Mud Content (% mud - worst 10% of estuary)	‹5%	5-10%	›10-25%	›25%
Macroinvertebrate Enrichment Index (NZ AMBI- worst 10% of estuary)	0-1.0 None to minor stress on benthic fauna	›1.0-2.5 Minor to moderate stress on fauna	›2.5-4.0 Moderate to high stress on fauna	›4.0 Persistent, high stress on benthic fauna
Sediment Total Organic Carbon (worst 10% of estuary)	‹0.5%	0.5-1.0%	›1.0-2.0%	›2.0%
Sediment Total Nitrogen (worst 10% of estuary)	‹250mg/kg	250-1000mg/kg	›1000-2000mg/kg	›2000mg/kg
Area of depleted sediment O_2 (aRPD depth ‹0.5cm or RPD@3cm below -150mV)	‹0.5ha or ‹1%	0.5-5ha or 1-5%	›5-20ha or ›5-10%	›20ha or ›10%
Gross Eutrophic Zones (ha or % of intertidal)	‹0.5ha or ‹1%	0.5-5ha or 1-5%	›5-20ha or ›5-10%	›20ha or ›10%
Seagrass - % decrease from measured baseline	‹5%	5-10%	›10-25%	›25%
Seagrass % decrease from estimated natural state cover	‹5%	5-10%	›10-25%	›25%
Salt marsh extent (% of intertidal)	›20%	›10-20%	›5-10%	‹5%
Percent cover of naturally vegetated 200m wide border	›80-100%	›50-80%	›25-50%	0-25%

APPENDIX 3B. RISK ASSESSMENT RATING CRITERIA

The following tables present criteria that can be used to assess key coastal and estuarine stressors in terms of the likely risk (apply average of scores to derive an overall value). Further detail is included in the ETI (Robertson et al. 2016a,b) in relation to estuary nutrient susceptibility. The majority of these ratings are currently under review.

RISK RATING	1. Very Low	2. Low	3. Moderate	4. High
Human Use				
No. of people involved	‹10/ year	0 - 50/year (‹30/day in summer)	›30/day in summer to ‹200/day.	›200/day (any time during year)
Social, Amenity & Recreation	Low to moderate local recreational use, community or amenity values.	Regionally significant seasonal recreational use, community or amenity values.	Regionally significant year round recreational use, community or amenity values.	Nationally significant seasonal, and year round regional, recreational use, community or amenity values.
Culture and Heritage	No special cultural importance. Some importance to individuals.	Some importance to hapu, iwi or the local community.	Important to hapu, iwi and the local community (e.g. important historical site).	Important to hapu, iwi and local community with some national significance (e.g. Mataitai or Taiapure).
Estuary Sediment Susceptibility (ETI screening value)				
Current State Sediment Load (CSSL)/Natural State Sediment Load (NSSL) ratio	CSSL = 1 to 1.1 x NSSL	CSSL = 1.1 to 2 x NSSL	CSSL = 2 to 5 x NSSL	CSSL ›5 x NSSL
Current Estuary Sediment Condition (ETI screening value)				
Area of soft mud	1%	›1-5%	›5-15%	›15%
Nutrients/Eutrophication (ETI score)				
NZ ETI Score	0-0.25	›0.25-0.5	›0.5-0.75	›0.75-1.0
Human Disease Risk (Pathogens)				
Vulnerability to Bathers	Areal Faecal coliform Loading (FC/m^2/day)	‹10,000	10,000 - 1 million	›1 million
Vulnerability to Shellfish Consumers	Areal Faecal coliform Loading (FC/m^2/day)	‹1,000	1,000-100,000	›100,000
Urban runoff / Contaminant spills				
Vulnerability to naturally occurring inputs of heavy metals	Unmodified catchment	Low urban or industrial development in catchment.	Moderate urban or industrial development in catchment.	Extensive urban or industrial development in catchment.
Pesticides				
Vulnerability to Pesticides	Receives runoff from unmodified catchments.	Runoff from significant areas of pastoral and forestry in catchment.	Runoff from small areas of intensive horticulture	Runoff from large areas of intensive horticulture, both historical and recent.

APPENDIX 3B. RISK ASSESSMENT RATING CRITERIA (CONTINUED)

RISK RATING	1. Very Low	2. Low	3. Moderate	4. High
Marine oil spill probability				
Proximity to offshore drilling platform	None	Low	Moderate	Within trajectory
Proximity to shipping/vessel route	Very low numbers of vessels	Recreational/commercial vessels present	Commercial port nearby	Large port nearby servicing oil tankers.
Proximity to land runoff source	Very remote	Semi-remote	Small communities nearby	Large town/city nearby
Marine oil spill consequences				
Habitat Sensitivity	Exposed coast, well flushed subtidal. Little potential to retain oil	Rip-rap man-made, subtidal embayment	Rocky shore, reef.	Salt marsh, tidal flats, sand/gravel beach, seagrass. High biodiversity habitats with potential to retain oil.
Recovery time or magnitude of impact	‹1yr or negligible	1-2yrs or slight	2-5yrs or moderate	›5yrs or severe/irreversible
Coastal Vulnerability Index (CVI) see Thieler and Hammar-Klose (1999)				
Coastal erosion/vulnerability to sea level rise	CVI ‹13.7	CVI 13.7 to 15	CVI ›15 to 17	CVI ›17
Grazing in High-value Habitat				
Presence and density of grazing animals	None	Few (‹1/ha)	Occasional (1-5/ha)	Common (›5/ha)
Freshwater Abstraction				
Magnitude	Zero	‹1% of mean flow	1-20% of base flow	›20% of base flow
Note: estuary susceptibility increases where mouth is constricted or close often, tidal lagoons or upper estuary are poorly flushed, estuary bottom water stratifies, or there is degraded water or sediment quality.				
Drainage and Reclamation				
Percentage or area affected	‹1%	1-5%	5-10%	›10%
Harvesting Living Resources				
Resource Presence	None	Low	Moderate	High
Proximity to human population	Very remote	Semi-remote	Small communities nearby	Large town/city nearby
Toxic Algal Blooms (TAB)				
Risk of TAB occurring	No previous TABs; no seed stock, unfavourable growth conditions.	No previous TABs; potential seed stock, favourable growth conditions.	Previous TABs; potential seed stock, favourable growth conditions.	Previous TABs; known seed stock, favourable growth conditions.
Risk to ecology if TAB occurred	No at-risk species (e.g. shellfish/fish)	Low abundance of at-risk species	Moderate abundance of at-risk species	High abundance of at-risk species
Risk to humans if TAB occurred	No human interaction (e.g. no human consumption)	Low human interaction	Moderate human interaction	High human interaction

APPENDIX 3B. RISK ASSESSMENT RATING CRITERIA (CONTINUED)

RISK RATING	1. Very Low	2. Low	3. Moderate	4. High
Structures (disruption to natural sediment transport)				
Seawall/Breakwater	Absent	Length of structure ‹1% of beach length.	Length of structure 1-10% of beach length.	Length of structure ›10% 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.
Invasive Species				
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.
Off-Road Vehicles				
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).
Human/Animal Disturbance of Wildlife				
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

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