THECATALYSTGROUP
planning and environment

STATE OF INDIGENOUS BIODIVERSITY AND INDIGENOUS ECOSYSTEMS IN THE WELLINGTON REGION

A COLLATION OF RECENT MONITORING AND REPORTING

NOVEMBER 2023

USE OF THIS REPORT

This report has been prepared by The Catalyst Group at the request of our client for the purposes for which they intended. Where we have relied on information from external sources, we have referenced these sources as appropriate and assumed them to be accurate. If you are unsure about interpretation of the content of this report, or its use beyond that for which the client intended, please get in touch with us at enquires@thecatalystgroup.co.nz

Please reference this report as:

Maseyk F, Parlato E 2023. State of indigenous biodiversity and indigenous ecosystems in the Wellington Region. A collation of recent monitoring and reporting. The Catalyst Group Report No. 2023/189 prepared for Greater Wellington Regional Council.

PREPARED BY:

Dr Fleur Maseyk, Dr Elizabeth Parlato

REVIEWED BY:

This report was peer reviewed by the following Greater Wellington Regional Council staff: Dr Roger Uys (Kaimātai Pūtaiao Matua Senior Terrestrial Ecologist), Dr Megan Melidonis (Kaimātai Moana Matua, Senior Environmental Scientist – Marine), Megan Oliver (Kaitohtohu Mātāmua Whai Māramatanga – Principal Advisor Knowledge), and Amanda Valois (Kaimātai Pūtaiao Matua, Senior Environmental Scientist).

REPORT NO:

2023/189

PREPARED FOR:

Greater Wellington Regional Council

ACKNOWLEDGEMENTS:

Greater Wellington Regional Council staff for provision of data and feedback on the draft report, particularly: Pam Guest, Roger Uys, Judith Chittock, Kim Norton, Megan Melodonis, Megan Oliver, and Amanda Valois.

This report is a compilation of existing monitoring and reporting, and as such draws heavily on information and data visualisation as presented by other authors. All attempts have been made to reference sources of all data and acknowledge original generators of graphics (including where these have been adapted here) throughout the report.

p. +64 6 358 6300

e. enquiries@thecatalystgroup.co.nz

a. Level 3, 31 George Street,

PO Box 362, Palmerston North

www.thecatalystgroup.co.nz

THECATALYSTGROUP
planning and environment

THE SITUATION AT A GLANCE

The Wellington Region encompasses a diversity of environments from mountains to sea across 813,140 ha of land, 786,700 ha of marine area, 12,300 km of rivers and streams, 500 km of coastline, 14 lakes and two harbours. The Region includes many nationally and internationally important features including the Taputeranga and Kāpiti marine reserves, part of the West Coast Marine Mammal Sanctuary, Mana Island and Waikanae scientific reserves, part of the Tararua Ranges, the Tararua and Remutaka forest parks, Zealandia Wildlife Sanctuary, and the Wairarapa Moana Ramsar Site.

The state and trend of indigenous biodiversity in the Wellington Region generally reflect both the legacy of historic loss and continued pressures from land use and management practices, development, and ubiquitous pressures from introduced invasive species. Continued effort from mana whenua, communities, landowners, and local and central government to protect and enhance indigenous biodiversity values, has resulted in some recovery (e.g., increase in kākā (*Nestor meridionalis*) and kererū (New Zealand pigeon, *Hemiphaga novaeseelandiae*) populations in Wellington City). However, the large proportion of the Region's resident species that are categorised as Regionally Threatened (85% of reptile species, 70% of bird species, 67% of indigenous fish species and 22% of indigenous vascular plant species) and the degree to which many indigenous ecosystems and habitats have been depleted (e.g., >95% loss of wetland habitat) means extensive restoration and conservation efforts will be required to shift indigenous ecosystems and species out of Threatened categories. Continued pressures from development and land use practices undermine restoration and enhancement efforts and are contrary to Greater Wellington Regional Council's (GWRC's) vision for indigenous biodiversity: Healthy ecosystems thrive in the Wellington region and provide habitat for native biodiversity (Greater Wellington Regional Council 2016).

States and trends across the terrestrial, freshwater and marine domains are summarised below to provide an overview of the current health of indigenous biodiversity and ecosystems in the Wellington Region, as informed by currently available information.

It is important to note that none of the monitoring data summarised here has been collected or interpreted within a mātauranga Māori framework. Integrating mātauranga Māori into GWRC's State of Environment (SOE) monitoring and reporting will be informed through the Council's mana whenua partnerships. Over time, GWRC's work to gather and share environmental information will be guided by the Kaipupuri taonga ki te ao whānui framework, a framework for caring for te taiao in the Wellington Region developed by Mauri Tūhono ki te Upoko o Te Ika a Māui working group (supported by GWRC).

Aspects of the terrestrial, freshwater, and marine domains that are relevant to indigenous biodiversity but are outside the scope of this report include freshwater and marine water quality state and trend across the Region, soil health and biodiversity, and outcomes from the many community and landowner-led initiatives to protect or enhance indigenous biodiversity throughout the Region. Other influences on indigenous biodiversity, such as air and climate, are also not included.

At a glance:

Threatened species:

- Many of the Region's assessed indigenous species are categorised as threatened with extinction or are at risk of becoming threatened (see Figure 7 for threat categories).

- Twenty-three nationally extant species (5 bird, 2 reptile, and 16 vascular plant taxa) are extirpated, that is, no longer occur in the Region.
- In the Wellington Region, more than 70% of indigenous species in reptile, bird, bat, and freshwater fish species groups are Regionally Threatened or At Risk of local extinction.
- Both remaining bat species are Threatened-Regionally Critical.
- Eighty-five percent (12 taxa) of the Region's resident indigenous reptile species are either Regionally Threatened (21%, 3 taxa) or At Risk (64%, 9 taxa) of local extinction.
- Sixty-nine percent (48 taxa) of the Region's resident indigenous bird species are either Regionally Threatened (63%, 44 taxa) or At Risk (6%, 4 taxa) of local extinction.
- Sixty-seven percent (14 taxa) of the Region's resident indigenous freshwater fish species are either Regionally Threatened (19%, 4 taxa) or At Risk (48%, 10 taxa) of local extinction.
- Twenty-two per cent (260 taxa) of the Region's indigenous vascular plant species are either Threatened (10%, 106 taxa) or At Risk (12%, 124 taxa) of local extinction.

Indigenous forest and scrubland health and extent:

- Nineteen distinct forest types have been identified in the Wellington Region, 11 (58%) of which are classified as Regionally Threatened (7 Critically Endangered, 3 Endangered and 1 Vulnerable).
- Historically, indigenous forests covered most of the Region but have been reduced to just over a quarter (27%) of the landcover.
- The majority of forest loss occurred in the lowlands, with predominantly upland forest types well represented in mountainous public conservation lands and regional parks.
- In more recent years, indigenous forest extent has remained relatively stable (<1% change between 1996 and 2018).
- Indigenous scrub covers 9% of the Region and has also remained stable (<1% change) over the period 1996 to 2018.
- Old growth forests in protected lands retain the greatest abundance of indigenous forest birds.
- Indigenous forest bird presence remained stable or declined in over half (59%) of the sites monitored across the region (2014–2016 & 2019–2022).
- Within Wellington City, encounter rates of indigenous and exotic bird species increased between 2011 and 2021. Kākā, kererū and tūī (*Prosthemadera novaeseelandiae*) have shown substantial increases within the city while pīpīwharauroa (shining cuckoo, *Chrysococcyx lucidus*) and tauhou (silvereye, *Zosterops lateralis*) have declined.
- Zealandia is having a measurable 'halo' effect on indigenous forest birds across the city, but this effect decreases rapidly beyond the Sanctuary as a result of mammalian predators such as rats (*Rattus* spp.), cats (*Felis catus*) and stoats (*Mustela erminea*).

Wetland health and extent:

- There has been a minor net increase in wetland extent in recent times (47.17ha over the period 2012-2018). This comprised 10 new wetlands, some of which were created to offset wetland loss as part of development. Although the total area increased, there was a decline in the number of wetlands, with a loss of 12 wetlands over the same period. It is important to recognise that (re)created wetlands do not have the same values as the wetlands that they replace, and the added extent only goes someway to offset the lost functionality.

- Wetland habitat >0.5 ha has been reduced to <3% of its former extent. Remaining wetlands are typically small in area. Just over 200 wetlands are scheduled in the Natural Resources Plan (NRP), 80% of which are <10 ha.
- Indigenous cover exceeded 75% in over half (58%) of wetland monitoring plots and exceeded 50% in a further 38% of plots (i.e., 96% of all plots are dominated by indigenous cover). Exotic species are not dominant but are reducing indigenous cover within wetland plots.
- Eight per cent (9 sites) of monitored wetlands were classed as 'excellent' using the Wetland Condition Index, with over three-quarters (76%) classed as 'good', 16% as 'moderate', and none classed as 'poor'.
- Surveys for the predator-sensitive, wetland-specialist pūweto (spotless crake, *Zapornia tabuensis*) detected pūweto at 69% (9) of the potential habitat sites surveyed between 2016 and 2020.

Duneland health and extent:

- There has been extensive loss of dunelands across New Zealand, and dunelands across the Wellington Region continue to be under pressure. Sea level rise is eroding the active foredunes and land use is encroaching on the stable back dunes.
- Active and stable dunelands and dune slack wetlands are classified as Threatened-Nationally Endangered ecosystems, while Inland Dunelands, as found around Lake Wairarapa, are ranked as Threatened-Nationally Critically Endangered ecosystems.
- Dunelands were dominated by exotic species (~69%), with exotics also dominating the vegetation cover (~64%) on average across 19 sites surveyed around the region.
- Nearly three-quarters (74%) of monitored duneland sites had a Duneland Condition Index score of between 10 and 15, which equates to 40–60% of the best possible score, reflecting the low scores across the majority of sites for two of the variables that contribute to the Index (buffering and indigenous cover dominance) and only moderate-poor scores for two other variables (indigenous bird dominance and indigenous cover dominance).

Naturally uncommon ecosystems:

- Naturally uncommon ecosystems (e.g., coastal turfs, ephemeral wetlands, shingle beaches) contribute disproportionately to national biodiversity and should be prioritised for protection.
- Nineteen naturally uncommon ecosystems are recognised in the Region, 14 (74%) of which are classified as Nationally Threatened.
- Little is known about contemporary trends of naturally uncommon ecosystems, except that coastal turfs are being lost to increased storm surge effects linked to sea level rise in the Region.

Freshwater:

Periphyton and benthic macroinvertebrate communities provide an overview of the region's freshwater ecosystem health.

Rivers

- The majority of Wellington rivers suffer from high (>30%) periphyton coverage at some times at the year. Periphyton blooms can have a significant impact on biodiversity by making the habitat unsuitable for many sensitive invertebrate and fish species. The potential impact of nuisance periphyton growth is reflected in the composition of benthic macroinvertebrate communities. Of the 45 monitored river sites, only just over a quarter meet the regional objective (in the Natural Resources Plan) for the Macroinvertebrate Community Index (MCI), demonstrating a region-wide impairment of macroinvertebrates. Nevertheless, invertebrate communities are likely, or very likely, improving at more sites than degrading, providing a hopeful outlook for macroinvertebrate recovery.

Lakes

- Of the 11 lakes and lagoons monitored across the region, most (n=9) have a high indigenous condition index, an indicator of indigenous biodiversity and extent of native vegetation within the lake. However, many lakes also score high in their invasive impact index due to the threat from invasive weeds.

Freshwater fish habitat

- There are at least 22 species of indigenous freshwater fish in the Region (67% of these are either Regionally Threatened or At Risk of local extinction).
- The species richness of fish communities within urban areas is generally fair or poor condition, with many urban stream sites having no native fish found. The diversity of fish species is influenced by the diversity of fish habitat available (particularly fish habitat cover and riparian shading).
- Eight sites in the beds of rivers and three lakes sites and their adjacent wetlands (Lake Onoke, Lake Wairarapa, and Parangarahu Lakes) provide significant habitat for indigenous birds. Lake Wairarapa (which forms part of the Wairarapa Moana Ramsar wetland site of international significance) is of particular importance, providing freshwater habitat for numerous Threatened and At Risk bird species.
- Three riverbed sites provide particularly significant habitat. These were a large site in the bed of the Opouawe River (and its tributaries) and a site in the Ruamāhanga River site. Both sites support regionally significant breeding populations of pohowera (banded dotterel (*Charadrius bicinctus*), and another site in the Ruamāhanga River supports the only breeding colony of tarāpuka (black-billed gull, *Chroicocephalus bulleri*) in the Wellington Region.

Marine and coastal:

- A total of 41 coastal sites were identified as providing habitat of significance for indigenous birds within the Region.

Estuarine

- Estuarine habitats are relatively rare in Wellington Region.
- Sedimentation poses a threat to habitat quality for estuarine biodiversity.
- In Te Awarua-o-Porirua Harbour there has been a steady increase in the spatial extent of mud-dominated sediment over the 12-year period between 2008 and 2020, most of which occurred in the eastern and northern areas of Pāuatahanui Inlet.
- The recent increases in sedimentation in Te Awarua-o-Porirua Harbour are likely due to land development in the catchment. Fine-scale intertidal monitoring conducted in Te Awanui-o-Porirua

Harbour has also shown signs of moderate enrichment of sediment in 2020, and while there has been some recovery from widespread deposition of soft muds recorded in intertidal areas of the northern Pāuatahanui Inlet, there had also been degradation in new areas.

- Annual sediment plate monitoring and trend assessment indicates that mean deposition rates of sediment over the 10-year and 5-year period from 2020/2021 within the Te Awarua-o-Porirua Harbour is rated 'poor'.
- The broad scale condition of nine Kāpiti Coast estuaries changed very little from 2007 to 2019, reflecting the already highly modified nature of these systems and historic loss of their vulnerable features due to development. With relatively large areas of salt marsh, the Waikanae, Waitohu and Ōtaki estuaries support higher biodiversity compared to the relatively low biodiversity at the other six sites due to the low diversity of substrate types and limited presence of salt marsh.
- Species richness and abundance have declined at Whareama Estuary between 2009 and 2022. These declines were associated with increases in sediment and mud content.
- Macroalgae growth (an indicator of estuary eutrophication) has improved for the Hutt Estuary from 'poor' in 2015 to 'moderate' in 2020. There was also an improvement in environmental quality status recorded for Te Awarua-a-Porirua Harbour, which shifted from 'moderate' to 'good'.
- The Waikanae Estuary and both inlets of Te Awarua-o-Porirua Harbour are notable for the diversity of Threatened and At risk bird species. These sites also provide important foraging and roosting habitat for migrant bird species.
- Mātātā (North Island fernbird, *Poodytes punctatus*), known from few sites in the Region, is found at Waikanae Estuary.
- Macrofauna species richness and abundance have declined over the last three intertidal estuarine surveys at all but one site within Te Awarua-o-Porirua Harbour.

Rocky intertidal

- Intertidal habitat is subject to sedimentation from land catchments, which can affect habitat quality for biodiversity in the intertidal zone.
- Species abundance varied across rocky shore zones, with habitat stability and rugosity and degree of wave and air exposure influencing species abundance. The taxa recorded at the Scorching Bay, Mākara, Baring Head, and Kāpiti and Mana Island sites are typical of healthy rocky shores of similar physical characteristics. Two years (2016, 2017) of baseline monitoring at Flat Point found a diverse, stable rocky shore community.
- In 2018, baseline assessments at Lyall and Ōwhiro bays and a survey at Petone Beach showed a low taxon richness and abundance. Monitoring at Peka Peka (2014, 2015) and Castlepoint (2014) beaches found invertebrate biota typical of the measured beach conditions.
- The foreshore habitats on Kāpiti and Mana Islands were of particular importance due to the high diversity of Threatened and At risk bird species present and for providing two of the largest areas of secure breeding habitat for kororā (little penguin, *Eudyptula minor*) in the Region.
- Similarly to estuarine and intertidal habitat, subtidal habitat for indigenous biodiversity is subject to degradation from sedimentation.
- Mud content of sediment can be a strong determinant of macrofaunal composition. Mud content in the subtidal zone within Pāuatahanui Inlet has been elevated (consistently rated 'poor') and increasing

at four of the five sampling sites since monitoring began in 2013. Mud content has also been increasing at the fifth site and this site is now also rated 'poor'.

- Sediment particle size in Te Awarua-o-Porirua Harbour and Te Whanganui-a-Tara (Wellington Harbour) in 2020 determined using wet sieving also showed eight of the ten samples in Te Awarua-o-Porirua Harbour to be predominantly muddy; and samples from all but one site at Te Whanganui-a-Tara were also predominantly muddy.
- The benthic ecology community within Te Awarua-o-Porirua Harbour (measured at five sites) shows that each of the sites are distinct from each other with little overlap in community composition. In contrast, the benthic ecology community within Te Whanganui-a-Tara (measure at 15 sites) had similar and overlapping community composition between all but one site.
- A relatively high abundance and diversity of macrofauna occurred in Te Awarua-o-Porirua Harbour including at the muddiest subtidal seafloor habitats.
- Using a Traits Based Index to reflect relative health status, three of the sites in Te Awarua-o-Porirua Harbour had a 'high' functional redundancy health score based on the 2020 monitoring data, one had an 'intermediate' score and one site was borderline between the 'intermediate' and 'low' health score.
- All but one of the Te Whanganui-a-Tara sites scored a 'high' functional redundancy health score (using the Traits Based Index) based on the 2020 monitoring data, and Trait Based Index scores were unexpectedly high given the very muddy subtidal seafloor habitats in the Harbour.
- Broadscale subtidal habitat mapping has been undertaken at the Hutt Estuary, Waikanae Estuary and Te Awarua-o-Porirua Harbour to document the key subtidal habitats and substrate types with a view of monitoring the changes to their areal extent over time. This mapping indicates there is a risk of adverse impacts due to loss and degradation of habitats.

Offshore

- Modelled reef fish species richness for subtidal reefs predicted species richness to be generally high in the Abel Bioregion to the north of Cape Terawhiti. In the Cook Bioregion (to the east of Cape Terawhiti), reef fish species richness was estimated to be lower, especially in Palliser Bay.
- Rhodolith beds are present to the east of Kāpiti Island. These are the only rhodolith beds known to occur in the lower North Island. Opportunistic invertebrate collections indicate high potential biodiversity associated with these beds.
- There are two seamounts in the Region's deep seas. Sampled benthic community composition was similar to other seamounts in New Zealand waters.
- The Region has 29 species of coral. All species are protected, with one species declining.

Protection:

- Nearly half a million hectares within the Region (land and sea, ~30% total area) is under some form of formal legal protection, mostly under the jurisdiction of central (Department of Conservation) or local government, with just over 1% (6716 ha) being private land covenanted with QEII National Trust.

Pressures:

- Impacts of invasive species (plants and animals) continue to be a major pressure and driver of declines in condition within indigenous habitats, and on species, across the Region.

Pest animals

- Possums (*Trichosurus vulpecula*) are absent or low at the vast majority of monitoring sites, with 45% (n = 21) of sites showing a decrease in possum density and 13% (n = 9) showing an increase in density over the five-year period between monitoring events (2014–2016 & 2019–22).
- Ungulates are absent or low at the vast majority of monitoring sites, with little change in density in the five-year period between monitoring events (2014–2016 and 2019–22). However, ungulates are supressing recovery of the understorey even when present in low numbers. Of particular concern is the evidence that ungulate presence is highest in the forest types with the least protection.
- Monitoring shows an increase of rat and mice (*Mus musculus*) presence at 50% and 60% of the eight monitoring Key Native Ecosystems (KNEs) respectively.

Pest plants

- There are 27 species (21 terrestrial, 6 aquatic) classified as pest plants affecting indigenous biodiversity and ecosystems in the Wellington Region.
- Infestations of four of these pest plant species are limited in distribution or density and are being managed under eradication programmes. The other plants are well established in the Region and are managed under control programmes.

Marine pests

- Te Whanganui-a-Tara is monitored for high-risk marine non-indigenous species. Surveys in Winter 2021 and Summer 2021–22 detected 12 previously recorded non-indigenous species but no main marine pests of concern (primary or secondary target species).

Land use

- Land use continues to impact on indigenous biodiversity. A total of 390 consents were granted over the period 2013–2016 impacting on streams, wetlands, coastal ecosystems, or (unspecified) vegetation.
- Provision for Significant Natural Areas (SNAs) is incomplete at a regional-level and inconsistent between district plans.
- A raft of activities that have the potential to have a detrimental impact on indigenous biodiversity are permitted within the Region's policy framework. The accumulative effect of these permitted activities is unknown.
- Flood protection works, maintenance of drainage networks, reclamation, and piping of streams, remain common practice and continue to have detrimental impacts on aquatic indigenous biodiversity.
- Earthworks associated with subdivision and infrastructure construction also continue to have detrimental impacts on aquatic (freshwater and marine) indigenous biodiversity. Non-compliance incidents are not insubstantial; GWRC's compliance database records show that between 2013 and 2023 there were 25 significant and 51 moderate non-compliance incidents associated with large earthworks and 35 significant non-compliance incidents associated with Roads of National Significance.
- Outcome monitoring of effects management (mitigation, offset, or compensation measures) implemented through the consenting process does not systematically occur (if at all). The effectiveness of these measures to adequately address adverse impacts on indigenous biodiversity cannot be determined.

Climate change

- Climate change will have impacts at all levels of indigenous biodiversity (species, habitat, and ecosystems) and across all domains (terrestrial, freshwater, and marine).
- Predicted temperature changes, rainfall patterns, increased frequency and intensity of storm events and droughts, increased fire risk, and exacerbated impacts of invasive species will influence species ranges and alter ecosystem functions.
- Ocean acidification, sea-level rise, increased frequency and intensity of extreme wave and storm surges, increased erosion, and wave exposure, and increasing sea temperatures as a result of climate change are predicted to detrimentally impact on marine species, ecosystems, and ecological function.

Summary

Globally, we are acknowledged to be in twin crises of biodiversity loss and climate change. Regionally, the effects of historic loss and ongoing pest, land use, economic, and climate change pressures, particularly in the marine domain, continue to undermine species, habitats, ecosystems, and the ecosystem processes that maintain them. Outside of a few exceptions, environmental management is failing to noticeably improve the extent and condition of the environment. Albeit at a slower rate than historically occurred, indigenous biodiversity is continuing to be lost and significantly more is needed to protect the environment and the services it provides.

The majority of resident species, in most groups that have been assessed, are Regionally Threatened or At Risk (Figure 1). Retention of these species is contingent on the recovery of the extent, connectivity, and condition of their habitat. Many of the ecosystems in the region are also nationally Threatened. This will continue to worsen if ecosystem processes (driven by the loss of ecosystem extent), connectivity, and condition, are not addressed. In addition to being essential for retaining indigenous biodiversity, the resilience found in healthy ecosystems is essential for supporting nature-based solutions to climate change to protect infrastructure, lives, and livelihoods. Resilience is built by reducing pressures (such as those from sedimentation and pest organisms) and by supporting ecosystem processes. Reinstating connectivity is essential for maintaining ecosystem processes and allowing the natural adjustment of habitats and ecosystems to the changing climate.

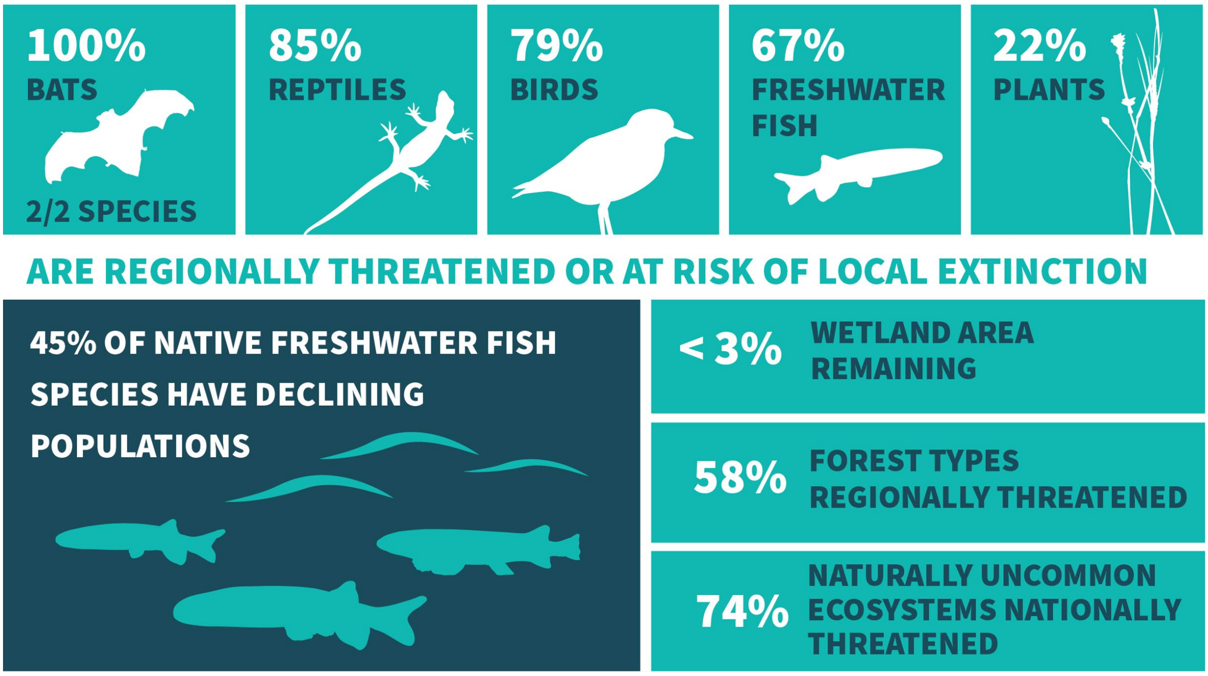

Figure 1: Threatened species and ecosystems in the Wellington Region.

TABLE OF CONTENTS

FRESHWATER INDIGENOUS BIODIVERSITY

COASTAL AND MARINE INDIGENOUS BIODIVERSITY

Tables

Figures

1. INTRODUCTION

Greater Wellington Regional Council (GWRC) undertakes State of the Environment (SOE) monitoring as a requirement under the Resource Management Act 1991 (RMA), and to:

- Observe and interpret impacts.
- Develop policies and plans and guide resource consent decisions.
- Convey information to the wider community.
- Inform biodiversity management.

SOE data is incorporated into the reporting on an annual basis (from 2014), and annual SOE data reports up to 2019 are publicly available from via GWRC's document library[1]. GWRC has now transitioned to online reporting of SOE data and information making the latest monitoring data available via an interactive interface[2], and via a static downloadable PDF document of the selected report. This is a valuable tool for decision-makers and members of the community to interact with data relevant to specific locations of interest to them and as a visual representation of the latest data of individual measures as a regional snapshot.

This report collates recent existing indigenous biodiversity data provided by GWRC across terrestrial, freshwater, and marine[3] domains[4] for the primary purposes of providing a contemporaneous overview for the Wellington Region in one report. In addition, this report provides high-level comment on current levels of formal protection and briefly discusses current and ongoing threats and pressures on indigenous biodiversity within the Region. The scope of this report does not extend to commentary on or evaluation of community conservation or landowner investment in the enhancement of indigenous biodiversity on their properties.

As a compilation, this document focusses on providing a 'general picture', the detailed data behind which can be found in the primary sources. The monitoring programme and sampling methods for each domain covered in this report are briefly described in Appendix 1, and further detailed in the relevant online report. Specific citations of published reports or online data sources are provided in footnotes and/or referenced as appropriate with full reference details provided at the end of this report.

It is important to note that this report utilises biophysical information collected by GWRC (or other agents) as part of the regional State of Environment (SOE) monitoring and reporting programme and does not include monitoring data collected or interpreted within a mātauranga Māori framework. Integrating mātauranga Māori into GWRC's indigenous biodiversity programmes, including monitoring and reporting on the state of Te Taiao will be informed by Mauri Tūhono, a proposed framework for caring for te Taiao in the Wellington Region developed by a collaborative group[5], supported by GWRC. Further work will involve GWRC and mana whenua working in partnership to establish and resource a kaitiaki indigenous biodiversity monitoring programme, as signalled within the Regional Policy Statement (RPS).

1 https://www.gw.govt.nz/document-library/?q=Publications.
2 https://www.gw.govt.nz/environment/environmental-data-and-information/.
3 Excluding water quality (freshwater or marine), although water quality is an important component of aquatic habitat and will be a strong influence on aquatic biodiversity.
4 Not all aspects of these domains are reported on (e.g., groundwater, surface water, soil), although they also support indigenous biodiversity. Additional domains (e.g., air, climate) are also outside the scope of this report although they too support indigenous biodiversity.
5 Mauri Tūhono ki te Upoko o te Ika Working Group.

2. THE WELLINGTON REGION

The Wellington Region –Te Upoko o te Ika a Maui – is the head of the fish that Maui fished up, creating the North Island. Other notable landmarks within the Region also reference the ika; Wellington Harbour and Lake Wairarapa being the eyes (Ngā Whatu o te Ika a Mauri); Palliser Bay the mouth (Te Waha o te Ika a Mauri) and Cape Palliser and Turakirae Head the jaws; the Remutaka, Tararua, and Ruahine ranges the spine. Archaeology records confirming Māori habitation in the Region are among the oldest[6] following human arrival in New Zealand ≈1280 A.D. (Wilmshurst et al. 2008).

The Wellington Region encompasses a diversity of environments across 813,140 ha of land (Statistics NZ), 786,700 ha of marine area, 12,300 km of rivers and streams, 500 km of coastline and 14 lakes. The Region spans the southern end of the North Island below a wandering line from Ōtaki, over the Tararua Range to the Owahanga River north of Castlepoint. GWRC manages approximately 50,000 ha of regional park and forests.

The Wellington Region, like the rest of New Zealand, has undergone a drastic transformation from its original state. Indigenous forest cover is predicted to have previously dominated land cover below the treeline, covering approximately 96% (782,000 ha) of the Region. This has been reduced to such an extent that many forest types are now classed as Regionally Threatened. Natural wetland habitat has similarly undergone extreme loss and is estimated to have been reduced to only <3% of its pre-human extent. The Region's harbours and estuaries have been degraded and historical land use change has resulted in the loss of considerable areas of high value coastal habitat. Most of the resident indigenous bat, bird, freshwater fish, and reptile species and 260 species of indigenous vascular plants are classified as Regionally Threatened or At Risk.

Introduced pest animal species and invasive plant species have had a huge impact on the Region's indigenous flora and fauna within all habitats and ecosystems. The suite of pest animals and plants have collectively led to declines in indigenous biodiversity due to the predation of eggs, chicks, reptiles, insects, seeds, loss of palatable plant species, grazing of understorey vegetation, competition for food and resources, and smothering and displacement of indigenous vegetation communities.

6 https://www.gw.govt.nz/your-region/

Some measures of indigenous biodiversity are showing encouraging indicators of improvement. For example, the North Island kākā[7] (*Nestor meridionalis*) once again now occurs in Wellington City and has recolonised many urban forests in the Wellington Region. The recolonisation of kākā and other forest bird species such as kākāriki (red-crowned parakeet[8], *Cyanoramphus novaezelandiae*), pōpokotea (whitehead, *Mohoua albicilla*), miromiro (tomtit, *Petroica macrocephala*), and korimako (bellbird, *Anthornis melanura*), likely from the Zealandia sanctuary or other areas subjected to sustained pest control (Innes et al. 2019). Although there is a measurable halo effect associated with Zealandia, the presence of predators (invasive mammals and domestic pets) outside of the predator-proof fence will continue to limit the ability of many indigenous species to re-establish self-sustaining populations beyond Zealandia (McArthur et al. 2020). Predator Free Wellington[9] supports and connects a growing number of community groups who are undertaking pest control in backyards or within public reserves throughout Wellington City. Findings from the Miramar Peninsula suggest that predator control has resulted in an increase in indigenous birds (McArthur 2023). GWRC and other agencies also continue to support rural landowners in activities to enhance indigenous biodiversity, including planting riparian margins, excluding livestock from wetlands and forest fragments, and undertaking pest control.

Despite these admirable efforts, the state of indigenous biodiversity in the Region remains such that it can be generally summarised as depleted, with many attributes remaining under threat and susceptible to the drivers of decline, which prevents or limits recovery potential. These drivers include the legacy of historic loss (fragmentation, interruption to trophic levels and food webs, disruptions to ecological connections, degrading feedback loops), ongoing impacts of urban development and land use and land management practices, and the ubiquitous threat from invasive pest plants and animals.

2.1 Land cover

Land cover change for the Wellington Region is reported using the three-tiered land cover classification used in the New Zealand Land Cover Database (LCDB)[10]. LCDB provides nationally consistent maps of land cover based on analysis of satellite imagery at specific points in time – currently 1996, 2001, 2008, and 2018. This enables evaluation of change over time on regional (and national) basis.

The LAWA (Land Air Water Aotearoa) website provides a summary of the land cover data from the LCDB for the Wellington Region. Land cover at 2018 for the Region is shown in Table 1, and change in land cover between 1996 and 2018 is shown in Table 2. Exotic grassland covered 44% of the Region in 2018 and forest a further 37%. Of the forest cover in 2018, nearly three-quarters (216,130 ha; 27% of the Region) was indigenous forest (Table 1). Indigenous forest cover remained relatively stable (<1% change) between 1996 and 2018, while exotic forest increased 34% (from 62,800 ha to 84,300 ha) over the same period. Artificial bare surfaces showed the greatest change in cover (+ 53%), followed by exotic forest (+ 34%), and cropping / horticulture (+ 15%) (Table 2).

7 At Risk – Recovering

8 At Risk – Relict

9 Predator Free Wellington is a charitable organisation that is supported by Wellington City Council, Greater Wellington Regional Council, NEXT Foundation, and Predator Free 2050 Ltd. https://www.pfw.org.nz/.

10 https://lris.scinfo.org.nz/layer/48423-lcdb-v41-deprecated-land-cover-database-version-41-mainland-new-zealand/.

Table 1: Land cover in Wellington Region (2018 figures) by LCDC land cover classes. Figures are provided for broad cover classes (grey shading) and medium cover classes where relevant. *Source*: LAWA website.[11]

Land Cover Class	Area	
	ha	Proportion of Region (%)
Forest	**300,426**	**37**
Indigenous forest	216,130	27
Exotic forest	84,296	10
Scrub/shrubland	**98,544**	**12**
Indigenous scrub / shrubland	74,020	9
Exotic scrub / shrubland	24,524	3
Grassland / other herbaceous vegetation	**367,692**	**45**
Tussock grassland	4,348	1
Exotic grassland	360,533	44
Other herbaceous vegetation	2,812	<1
Cropland	**8,194**	**1**
Cropping / horticulture	8,194	1
Urban / bare / lightly-vegetated surfaces	**27,129**	**3**
Natural bare / lightly-vegetated surfaces	5,153	1
Artificial bare surfaces	1,193	<1
Urban area	20,784	3
Water bodies	**11,154**	**1**
Water bodies	11,154	1

Table 2: Summary of land cover change in the Wellington Region between 1996 and 2018 by LCDB medium land cover classes. *Source*: Data obtained from LAWA website[12]

Land cover class (LCDB)	Area (ha in '000s)					
	1996	2001	2008	2012	2018	Change 1996–2018 (%)
Indigenous forest	215.9	215.2	215.2	215.5	216.1	<1%
Exotic forest	62.8	73.5	81.4	82.2	84.3	+ 34%
Indigenous scrub / shrubland	73.8	73.8	74.6	74.6	74.0	<1%
Exotic scrub / shrubland	26.5	25.9	25.7	25.7	24.5	- 8%
Tussock grassland	4.3	4.3	4.3	4.3	4.3	<1%

11 LAWA Land Air Water Aotearoa. https://www.lawa.org.nz/explore-data/land-cover/.
12 https://www.lawa.org.nz/explore-data/land-cover/.

Land cover class (LCDB)	Area (ha in '000s)					
	1996	2001	2008	2012	2018	Change 1996–2018 (%)
Exotic grassland	383.5	373.9	363.6	362.3	360.5	- 6%
Other herbaceous vegetation	2.8	2.8	2.8	2.8	2.8	- 1%
Cropping / horticulture	7.1	7.3	8.1	8.2	8.2	+ 15%
Natural bare / lightly-vegetated surfaces	5	5	5.1	5.1	5.15	+ 2%
Artificial bare surfaces	0.8	0.8	0.8	0.9	1.2	+ 53%
Urban area	19.5	19.5	20.4	20.5	20.8	+ 7%
Water bodies	11.1	11.1	11.1	11.1	11.2	+ 1%

2.2 Indigenous land cover

Prior to human occupation, the Wellington Region was almost completely (98% of the region) covered in indigenous forest (Ewers et al. 2006). Since the arrival of humans, and greatly accelerating once Europeans began to arrive in the Region in the early 19th Century, and especially following the arrival of the New Zealand Company settlers in 1839, the Region experienced a drastic transformation of the landscape.

Like elsewhere in Aotearoa New Zealand, the decline of indigenous vegetation cover in the Region has been non-random, with the greatest loss in areas most conducive to production of food, fibre, and settlement (i.e., the lowlands and coastal areas of the region) and least loss occurring in steeper hill country and mountainous areas least conducive to development (i.e., the Tararua Ranges). This is acutely illustrated (nationally and regionally) by the distributional patterns of the Threatened Environments Classification (Figure 2) which categorises land environments using a combination of LCDB and a national spatial database of protected areas. This analysis has been updated using 2012 data (Cieraad et al. 2015).

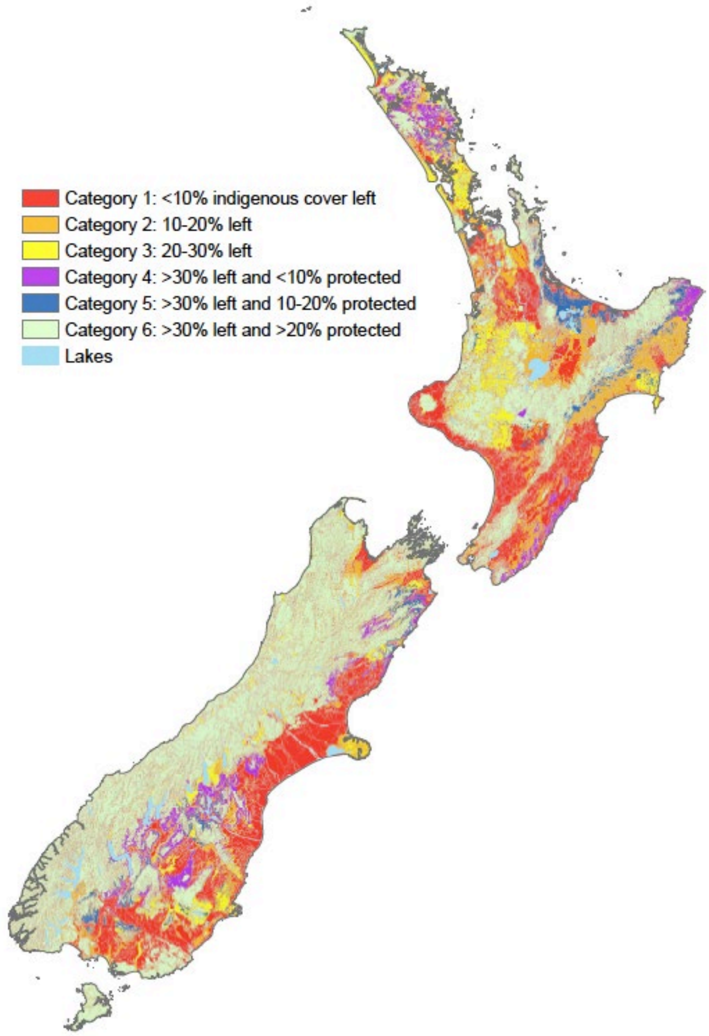

Figure 2: Threatened environment classification for New Zealand updated with 2012 data. *Source:* Cieraad et al. (2015).

2.2.1 Terrestrial ecosystems

The Wellington Region comprises diverse geology, landform, and climate. This has given rise to a corresponding diversity in ecosystems – Singers (2018) identifies 36 distinct ecosystems: 19 forest, 7 wetland, 1 cliff, 6 coastal, 2 alpine, and 1 braided river ecosystem types. The extent of the Region's terrestrial ecosystems has been drastically reduced from its original extent since human occupation in the Region (Figure 3).

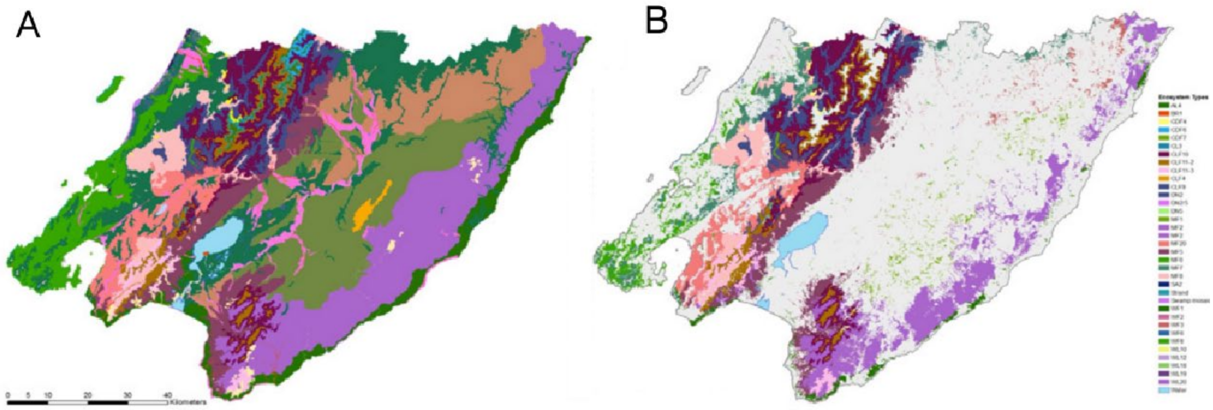

Figure 3: Historic (A) and current (B) extent of terrestrial ecosystems in the Wellington Region. Each colour denotes a unique ecosystem type. *Source*: Adapted from Singers et al. (2018).

The 19 indigenous forest types have been classified by regional threat status according to proportion (%) of former extent remaining. Over half (58%, n = 11) of the Region's forest ecosystems have been classified as regionally threatened (Figure 4, Table 3). Forest ecosystems which are Not threatened[13] are found within the stepper, mountainous areas of the Region, typically protected as public conservation land or council reserve. Distributional maps and detailed ecosystem descriptions are provided in Singers et al. (2018).

[13] Categories are as per Singers 2018, classified according to proportion (%) of former extent remaining, noting that these habitats are not immune to threats entirely.

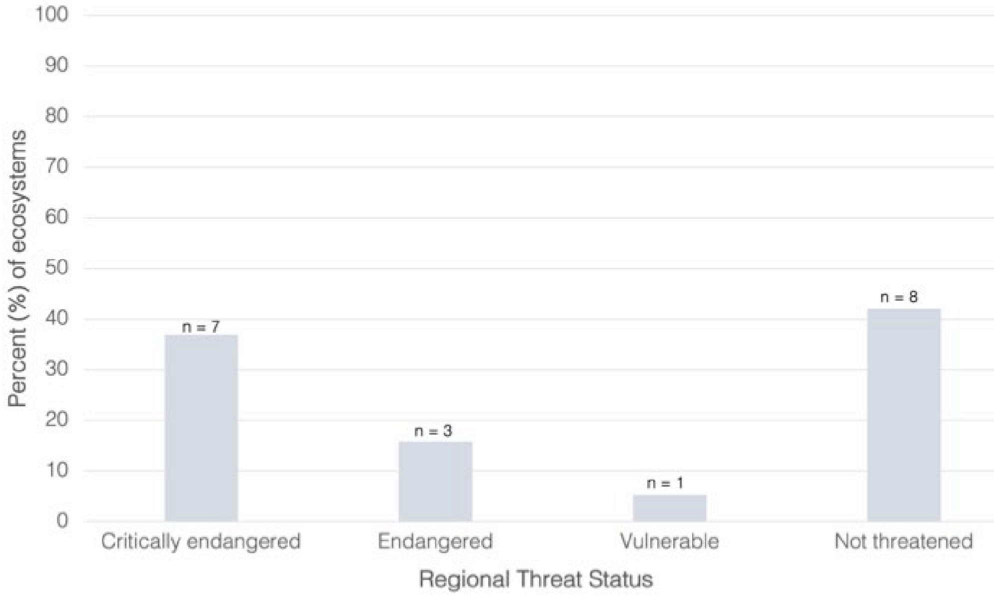

Figure 4: Summary of regional threat status of forest ecosystems in the Wellington Region (n = 19). *Source*: Data from Singers et al. 2018.

Table 3: Ecosystem types of the Wellington Region and regional threat status. Critically endangered = Less than 10% remaining; Endangered = Less than 30% remaining; Vulnerable = Less than 50% remaining; Not threatened = Greater than 50% remaining. *Source*: Data from Singers et al. 2018.

Ecosystem type and name	Proportion remaining	Regional threat status
WF1: Titoki, ngaio forest	3%	Critically endangered
WF2: Totara, matai, ribbonwood forest	3%	Critically endangered
WF3: Tawa, titoki, podocarp forest	3%	Critically endangered
WF6: Totara, matai, broadleaved forest [Dune Forest]	2%	Critically endangered
WF8: Kahikatea, pukatea forest	1%	Critically endangered
MF1: Totara, titoki forest	2%	Critically endangered
MF2: Rimu, matai, hinau forest[1]	16%	Endangered
MF5: Black beech forest[1]	47%	Vulnerable
MF6: Kohekohe, tawa forest	16%	Endangered
MF7: Tawa, kamahi, podocarp forest	22%	Endangered
MF8: Kamahi, broadleaved, podocarp forest	86%	Not threatened
MF20: Hard beech forest	51%	Not threatened
CLF4: Kahikatea, totara, matai forest	0.4%	Critically endangered
CLF9: Red beech, podocarp forest	95%	Not threatened
CLF10: Red beech, silver beech forest	93%	Not threatened

Ecosystem type and name	Proportion remaining	Regional threat status
CLF11: Silver beech forest	91%	Not threatened
CDF4: Hall's totara, pahautea, kamahi forest[2]	91%	Not threatened
CDF6: *Olearia, Pseudopanax, Dracophyllum* scrub [sub-alpine scrub]	>95%	Not threatened
CDF7: Mountain beech, silver beech, montane podocarp forest[2]	>95%	Not threatened

[1]MF2 and MF5 forms a mosaic in the Eastern Wairarapa.
[2]CDF4 is not threatened but is rare within the Wellington Region.

Wetland extent has been drastically reduced in the Wellington Region (Figure 5) and is predicted to have been reduced to 2.3% of its pre-European extent (Ausseil et al. 2008). These predictions of wetland extent are less likely to have detected wetlands less than 0.5 ha in extent, and certainly less likely to detect natural wetlands as small as 0.05 ha[14]. Therefore, the prediction of past loss applies particularly to larger (>0.5 ha) areas of natural wetland but based on what we do know of land cover change and land use practice (including the widespread alteration of hydrological regimes) it is reasonable to assume that smaller wetlands have undergone similar patterns of loss as larger wetlands.

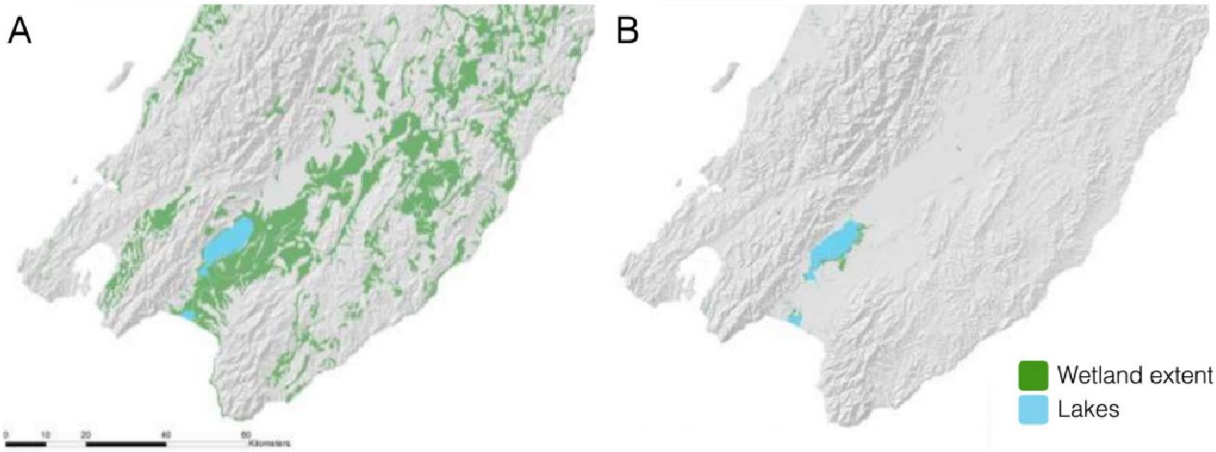

Figure 5: Historic (A) and current (B) wetland extent in the Wellington Region. *Source*: Adapted from Crisp 2018.

There has been a minor net increase in wetland extent in recent times (47.17 ha over the period 2012–2018). This comprised 10 new wetlands, some of which were created to offset wetland loss as part of development. Although the total area increased, there was a decline in the number of wetlands, with a loss of 12 wetlands over the same period. It is important to recognise that (re)created wetlands do not have the same values as the wetlands that they replace, and the added extent only goes someway to offset the lost functionality.

There are just over 200 natural wetlands that have been identified and scheduled in the NRP, of which 80% are <10 ha in extent (Crisp 2018).

14 As per new requirements of the National Policy Statement for Freshwater Management 2020.

The Wairarapa Moana ('sea of glistening water'), designated a Ramsar Site[15] in 2020, is the largest wetland complex in the southern part of the North Island. The Moana comprises a diverse complex of habitat types, including a freshwater lake (the second largest in the North Island), an estuarine lake (Onoke), freshwater swamps and marshes, seasonally intermittent marshes, ephemeral wetlands, coastal marshes, river and streams, and coastal shore habitats. More than fifty Threatened species of fauna and flora and a high diversity of migratory waterbird species are associated with the Wairarapa Moana. The area is culturally significant as a source of mahinga kai (Ramsar 2020).

2.2.2 Indigenous dominance

Monitoring of vegetation is conducted within the GWRC terrestrial biodiversity monitoring network (which utilises the national sampling grid established for the Land-use and Carbon Analysis System (LUCAS) programme, Figure 49 in Appendix 1). Nearly half (47%, *n* = 23) of the plots measured in the first monitoring cycle and 43% (*n* = 21) of the plots measured in the second monitoring cycle fall within the lowest range (0–20) of proportion of indigenous species (Figure 6). This is to be expected as just under a quarter (24%, *n* = 12) of the monitoring sites were located within indigenous dominated land cover[16].

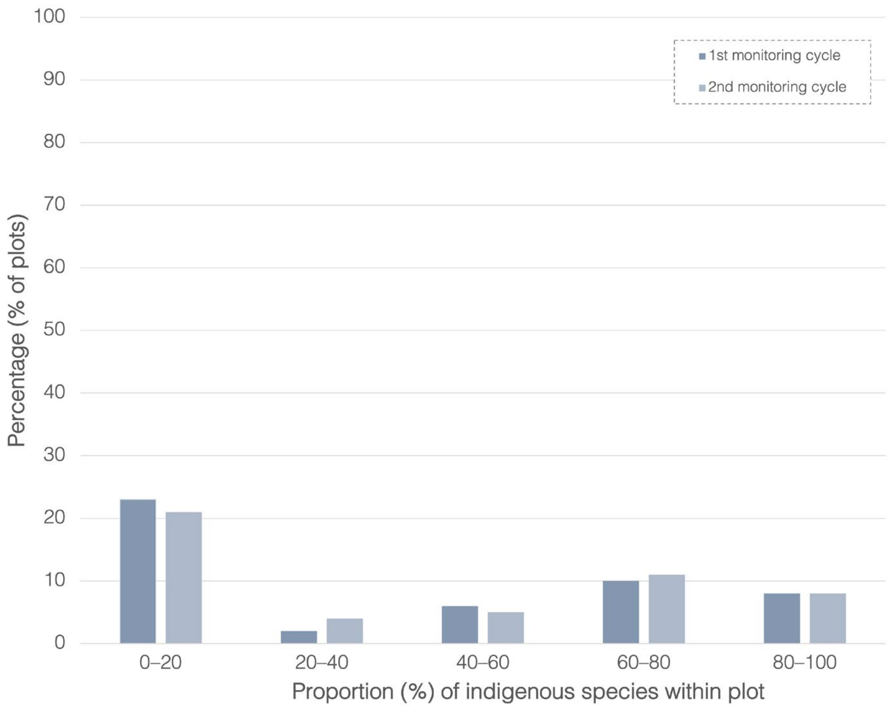

Figure 6: Indigenous vascular plant species as a proportion of total species recorded during the first (2014–2016) and second (2019–2021) monitoring cycles. *n* = 49. *Source:* Raw data obtained from GWRC Environmental Monitoring Portal.[17]

The aquatic ecosystems of the Wellington Region have also been reduced in condition and extent. This has occurred largely due to historical and ongoing adverse impacts of urban and rural development, and adverse impacts from surrounding land use and land management practices.

15 Ramsar wetlands are recognised as being of international significance, named for the town in Iran where the Convention on Wetlands of International Importance was signed in 1971.

16 That is, indigenous forestland, Indigenous scrubland, Other indigenous vegetation.

17 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/vegetation.html

2.2.3 Rare and naturally uncommon ecosystems

A total of 71 rare and naturally uncommon ecosystems have been identified in New Zealand and classified according to Threat status (Holdaway et al. 2012; Williams et al. 2007). Of these ecosystems, 29 are recognised in the Wellington Region; three quarters (76%; *n* = 22) are Threatened including 6 (21%) Critically Endangered, 11 (38%) Endangered, 5 (17%)) Vulnerable, while only a quarter (24% ; *n* = 7) are of Least Concern (Table 4).

Table 4: Threat status of rare and naturally uncommon ecosystems occurring in the Wellington Region. *Source*: GWRC pers. com. Threat categories follow Holdaway et al. (2012).

Critically Endangered	Endangered	Vulnerable	Least Concern
Cave entrances Coastal turfs Ephemeral wetlands Inland sand dunes Marine mammal haulouts Seabird burrowed soils	Active sand dunes Braided riverbeds Calcareous coastal cliffs Domed bogs (*Sporadanthus* spp.) Dune slacks Lagoons Seepages and flushes Shingle beaches Sink holes Stable sand dunes Stony beach ridges	Basic coastal cliffs Boulderfields of calcareous rocks Calcareous cliffs, scarps, and tors Estuaries Lake margins	Cliffs, scarps, and tors of acidic rocks Cloud forests Coastal cliffs on acidic rocks Coastal rock stacks Cushion bogs Subterranean river gravels Tarns

2.2 Regional conservation status of terrestrial flora and fauna

Methods have been developed to assess the regional conservation status of the indigenous terrestrial flora and fauna found within the Wellington Region (Crisp 2020a; 2020b; 2020c; Crisp et al. 2023). This evaluation builds off the New Zealand Threat Classification System (NZTCS, Townsend et al. 2008) and is a collaborative process with relevant experts. The regional threat classification categories are shown in Figure 7.

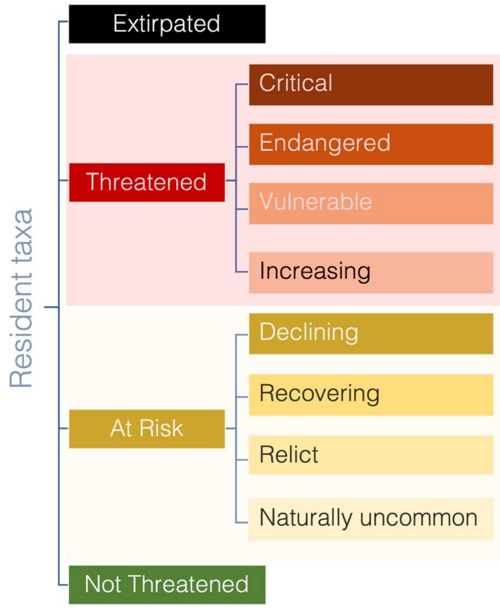

Figure 7: Regional Threat Classification System categories for the Wellington Region. The Extirpated category applies to indigenous species that are not extinct nationally, but which no longer exist in the wild within the Wellington Region. *Source*: Uys & Crisp 2023.

The Wellington Region supports a large number of Regionally Threatened or At Risk species. Of the Regionally Threatened terrestrial species, 63% are assessed as 'Regionally Critical' – the highest threat status. This includes both extant bat species, 30% (n = 16) of terrestrial bird species, 53% (n = 9) of coastal/marine bird species, 15% (n = 2) of reptile species, and 7% (n = 71) of vascular plant species occurring within the Wellington Region (Figure 8). A total of 24 species (1 bat, 5 bird, 2 reptile, and 16 vascular plant species) are extirpated from the Wellington Region.

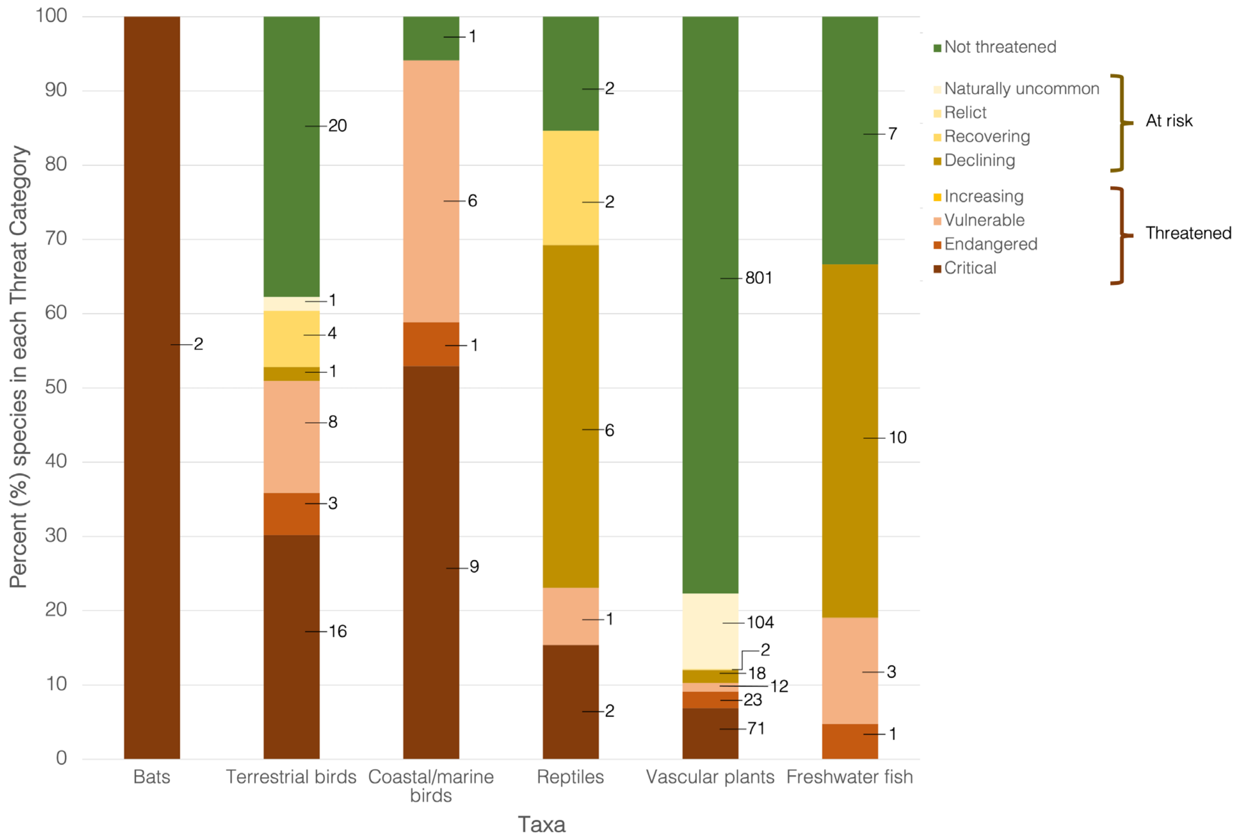

Figure 8: Percentage of extant resident species within each Regional Threat Category by taxa. Numerals next to bars are number of species in each regional threat category. Numbers for reptile species excludes tuatara (*Sphenodon punctatus*) which have been reintroduced to islands within the Wellington Region. *Source*: Uys 2023.

Of the Regionally Critical vascular plant species, 28% (*n* = 20) are found within forest/scrub habitat, 25% (*n* = 18) in coastal habitat, and 24% (*n* = 17) in wetland habitats (Figure 9).

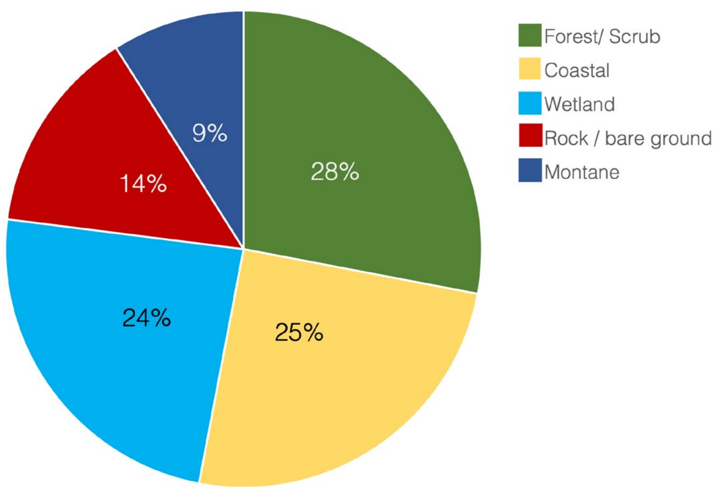

Figure 9: Percent of Regionally Critical vascular plant species (*n* = 71) by habitat type. *Source*: Uys & Crisp (2023).

2.3 Threats to indigenous biodiversity

The ongoing threats to and drivers of decline of indigenous biodiversity are many, layered, and interactive and will require carefully considered and cross-policy connections to address. Effort needs to be multi-directional with a focus on instigating, incentivising, and supporting activities that enhance and restore indigenous biodiversity across the Region alongside effort to prevent, disincentivise, and actively discourage activities that degrade and drive declines of indigenous biodiversity.

Statutory responsibilities for managing indigenous biodiversity across the Region are spread across GWRC (wetlands, rivers and lakes, and the coastal marine area including estuaries and harbours), territorial authorities (terrestrial biodiversity), and the Department of Conservation (species management and habitat within Public Conservation Land and Waters). This division of responsibility has manifested as gaps, tensions, and inconsistencies in the management and protection of indigenous biodiversity. Administrative boundaries and division of responsibilities has little relevance to ecological function at site or landscape scales. More coordinated and collaborative approaches between agencies (and mana whenua and communities) are being pursued, but these tensions are unlikely to be resolved quickly or completely.

Climate change will have impacts at all levels of indigenous biodiversity (species, habitat, and ecosystems) and across all domains (terrestrial, freshwater, and marine). Predicted temperature changes, rainfall patterns, increased frequency and intensity of storm events and droughts, increased fire risk, exacerbated impacts of invasive species (etc.) will influence species ranges and alter ecosystem functions. Ocean acidification, sea-level rise, increased frequency and intensity of extreme wave and storm surges, increased erosion, and wave exposure, and increasing sea temperatures as a result of climate change are predicted to detrimentally impact on marine species, ecosystems, and ecological function. There is little doubt that indigenous biodiversity and ecological function are vulnerable to and at risk from climate change impacts. However, indigenous biodiversity assets also provide an opportunity to increase the resilience[18] of landscapes. This will require recognising and managing within environmental limits and sustaining or enhancing indigenous biodiversity stocks to provide for a full range of ecosystem function and ecological integrity. Thus, indigenous biodiversity and ecological function is both at risk of further declines due to the impacts of climate change and provide an important tool for mitigating these impacts. Therefore, initiatives to address climate change challenges should go hand-in-glove with enhancement and restoration of indigenous species, habitats, and ecosystems.

Historic and contemporary landuse has been, and continues to be, a fundamental driver of modification, decline, and loss of indigenous biodiversity. The impact of permitted activities is difficult to quantify in the absence of policy effectiveness monitoring. However, the number of consents granted for activities that have the potential to detrimentally impact indigenous ecosystems provide an indication of the level of pressure on indigenous biodiversity from landuse. It can be assumed that where consents are granted (Table 3), any adverse effects of these activities that are more than minor will be adequately addressed via application of the effects management hierarchy, although determining the adequacy of effects management measures within consent conditions and therefore quantifying the impact of consented activities on indigenous biodiversity would be a considerable undertaking and one that is beyond the scope of GWRC's current indigenous biodiversity monitoring and reporting. In its place, compliance monitoring and reporting of consented activities can also be used as indication of pressure on indigenous biodiversity, particularly where non-compliance incidents relate to breaching of conditions placed on the consent to avoid or address adverse

18 The ability to withstand disturbances of greater severity (resistance) and the ability to recover from disturbances when they do impact.

effects on the environment. Since 2016[19], GWRC has undertaken 23 prosecutions, and issued 14 Infringement Notices and seven Advisory Notices (Table 5).

Table 5: Summary of consenting and enforcement action taken by GWRC between 2013 and 2023. ^Excludes consents for the purposes of harvest of exotic vegetation or control/removal of pest plant species, and consents for clearance of wetland vegetation (included in the wetland statistics), but includes consents granted for unspecified vegetation clearance. *See also Table 6. *Source*: Records provided by GWRC.

Biodiversity feature impacted	Number of resource consents granted (2013–2016)	Number of prosecutions taken (2016–April 2023)	Number of Infringement Notices issued (2016–April 2023)	Number of Advisory Notices issued (2016–April 2023)
Streams*	311	18	11	5
Wetlands	57	5	2	2
Coastal ecosystems	5	–	–	–
Vegetation^	17	–	1	0
Total:	390	23	14	7

2.3.1 Terrestrial indigenous biodiversity

Invasive species

While habitat loss is still occurring, the impacts of invasive species (plants and animals) continue to be a major pressure and driver of declines in condition within indigenous habitats, and on species, across the Region. Threats are further compounded when they impact on vulnerable and irreplaceable habitats. For example, GWRC monitoring has shown that pest animal species abundance is highest in the most threatened indigenous forests and even low populations of ungulate species are having a detrimental impact on plant species diversity (Crisp 2020d), Invasive species have an enormous impact on indigenous fauna through predation of individuals, competition for resources, or degradation of habitat. Pressures on indigenous biodiversity do not operate in isolation and detrimental impacts can be compounded and cyclical. For example, the alteration of hydrological regimes within wetlands due to surrounding land use practices can cause wetlands to become drier, changing plant compositions and providing greater opportunity for invasive plants to establish and further alter vegetation communities and habitat structure. A lack of sustained, strategic pest animal and plant control (for e.g., see Crisp 2020d) will result in ongoing losses in indigenous biodiversity and degradation of indigenous habitats and ecosystems. Where management ceases or is of inadequate intensity, populations of invasive species recover. Further, the impact of invasive species will be exacerbated by climate change (Macinnis-Ng et al. 2021). Therefore, invasive species should be considered an ongoing threat to indigenous biodiversity.

Land use activities

When considered against the continued declines in extent and condition of indigenous ecosystems, habitats, and species, it can be concluded that even consented, or permitted, activities contribute to the negative

[19] Enforcement data between the years 2013 and 2015 could not readily be extracted from GWRC's database.

pressures associated with land use and land management. Surrounding land use and particular management practices (e.g., application of fertilizer, grazing of wetlands and riparian margins or forest fragments, change in hydrological regimes) have detrimental impacts on indigenous biodiversity and ecological function. For example, through grazing indigenous plant species, trampling vegetation and compacting soils, changing nutrient levels and altering nutrient processes, changing species composition and reducing ground layer and understorey cover and composition, creating gaps and changed environmental conditions such that areas of indigenous habitat become more susceptible to other drivers of decline such as invasive animal and plant species and less resistant to natural pressures such as storm events or drought, contributing to cycles of decline.

Imperfect effects management instigated during the consenting process, including poorly designed and implemented mitigation measures and biodiversity offset or compensation packages create shortfalls or outright failures to address adverse impacts on indigenous biodiversity values due to development activities. The lack of compliance monitoring and reporting and/or enforcement exacerbates this risk.

Urbanisation

Subdivision and provision of infrastructure (particularly roads) associated with areas of settlement can directly impact on indigenous biodiversity through land conversion, and indirectly by (for example) facilitating the introduction of pest plant species into remaining areas of indigenous habitat (due to proximity to source), and predation of indigenous wildlife by domestic pets. Increased night sky brightness due to light pollution from urban areas has detrimental impacts on species and ecological areas in proximity (McNaughton et al. 2022). There will be ongoing challenges for the protection of indigenous biodiversity, soils, and habitats in meeting the need for new housing and infrastructure associated with a growing population.

2.3.2 Freshwater indigenous biodiversity

Fundamental pressures causing the decline of freshwater biodiversity include effects from surrounding land use and poor land management practices, as well as development pressures leading to loss of extent and quality of aquatic habitat (in urban, peri-urban, and rural environments). Introduced fish species and aquatic pest plant species also have detrimental impacts on freshwater habitats and biodiversity. The drivers of decline are contemporaneous and cumulative, and include:

Flood protection works and maintenance of drainage networks

It is a common practice in the Wellington Region to channelise, realign, and stop bank rivers to prevent river migration, increase the availability of floodplains upon which to develop infrastructure, and control flood risk (Guest et al. 2018). Such works alter the natural form of rivers, destabilise banks (contributing to sediment loading), and reduce diversity, availability, and quality of aquatic habitat.

Small streams are commonly referred to, and treated as, drains. This applies in both pastoral landscapes and urban areas. These waterways are frequently excavated to remove built-up sediment and aquatic plant growth that can affect the flow regime, water velocity, and drainage capacity. As in larger waterways, excavation degrades water quality and directly impacts aquatic plants and animals living in these smaller waterways. The homogenisation of the waterway features and characteristics, reduces habitat diversity and therefore reduces the diversity and abundance of aquatic species.

Efforts to improve practice when undertaking flood protection and drainage works are ongoing. However, there remains a tension between how these activities are conducted to project people and property and avoiding detrimental impacts on aquatic indigenous biodiversity and aquatic and riverbed habitat.

Reclamation and piping of streams

Reclamation and piping of streams to facilitate the transport of stormwater and increase the availability of developable area is still commonly practiced in the Wellington Region (Guest et al. 2018). This activity particularly impacts small headwaters. Aquatic habitat is homogenised (and therefore reduced in diversity and function) in terms of physical structure and flow and ecological connections are interrupted or completely severed (e.g., loss of riparian margins, interruption of fish passage). Therefore, detrimental impacts are experienced both up and downstream of a piped section of waterway and not just at the location of piped section.

Construction of structures in-stream which create barriers to fish passage

Physical structures in-stream (e.g., dams, weirs, culverts, fords etc.) can create barriers to fish, preventing them from moving between habitats and reaches of the waterway, or preventing migration between freshwater systems and marine systems as necessary to complete lifecycles. A study of fish barriers within Wellington City was conducted in 2019/2020, identifying and mapping 213 barriers, of which nearly three-quarters (72%, *n* = 154) were culverts (Davis n.d.). As noted above, piping of streams remains common practice, particularly in urban environments[20], resulting in the direct loss of freshwater habitat and aquatic biodiversity. Harrison (2019) concludes that fish barriers are also likely to be a major pressure influencing fish communities in Wellington's urban streams.

Surrounding land use

Surrounding land use and land management practices have significant impact on both riparian and in-stream values and aquatic species. For example, īnanga (*Galaxias maculatus*) spawning grounds are vulnerable to tramping by livestock in rural environments, mowing of riparian margins of urban streams, and flood management practices can result in īnanga mortality[21] (Taylor & Marshall 2016).

Heavy metals, nutrients, and other pollutants from surrounding land use continues to have a detrimental effect on the quality of aquatic habitat. Harrison (2019) found that macroinvertebrate communities declined where urban runoff was greatest, but pollutants are an ongoing issue in both rural and urban landscapes. The detrimental impact of nutrient loss from pastoral farming on water quality is well documented (e.g., Parliamentary Commissioner for the Environment 2015; Ministry for the Environment & StatsNZ 2022), and therefore the quality of aquatic habitat for aquatic indigenous biodiversity.

Invasive species

Introduced fish, invertebrate, and plant species pose a considerable threat to aquatic habitat and aquatic indigenous biodiversity by altering habitat, altering food webs, directly competing for resources, predation,

[20] For example, 12.79 km of stream within the Wellington Region was piped between the period 2003 and 2008; and over 2 kms of stream were piped for new subdivisions within special housing and urban growth (Guest et al. 2018).

[21] Taylor & Marshall (2016) also note the risk of fishing-induced declines of īnanga populations, although as the whitebait fishery is largely unmonitored it is difficult to fully understand the impact of the fishery on the īnanga populations.

and degrading ecological connections and functions. Thus, invasive species can exert multiple and interacting pressures on both habitat and species. For example, willow trees growing within riparian margins can negatively impact īnanga spawning grounds, and predators (e.g., rats) reduce egg numbers (Taylor & Marshall 2016). Riverbed-nesting bird species are also vulnerable to invasive pest species and would benefit from large-scale predator control along rivers known to support these species (Crisp 2020d).

Non-compliant land-use activities

GWRC's compliance records from April 2013 until April 2023 (Table 6) indicate that non-compliant land-use activities continue to adversely impact on freshwater biodiversity and cause ongoing declines. Over the past decade, non-compliance associated with large earthworks and reclamation in particular has remained relatively high. The GWRC records show that failure to comply with mitigation measures (such as riparian planting or appropriate use of sediment control devices) is not uncommon.

Table 6: Summary of non-compliance incidents between 2013 and 2023 impacting, or with the potential to impact, freshwater biodiversity. *Source*: GWRC Compliance records April 2013–April 2023.

Activity (GWRC compliance group)	Significant non-compliance (#)	Moderate non-compliance (#)	Ongoing investigations (#)	Comment
Bridges/culverts	0	5	2	Non-compliance incidents included perched culverts and failing to meet riparian planting conditions.
Coastal marine consents	0	3	1	Non-compliance incidents relating to fish being stranded and oil spill into a waterway. There have been no recorded incidents in this activity group since March 2018.
Large earthworks	25	51	0	Non-compliance incidents included: sediment discharge to waterways; insufficient or poorly placed Erosion and Sediment Control devices; failure to stabilise the site; and channel diversion shortfalls. The 25 significant non-compliance incidents all occurred between June 2021 and June 2022, and included earthworks beyond the consented area, unconsented reclamation, and concreting of stream length.
Reclamation	4	27	0	Non-compliance incidents included: discharge of sediment; failure to provide a planting plan; failure of mitigation (or offset) plantings; or failure to provide fish passage. Twenty-two (81%) of the moderate non-compliance incidents occurred before 2020. There have been no significant non-compliances reported since June 2015.
River works	3	20	7	Non-compliance incidents included: failure to provide fish passage; discharge of sediment; failure of mitigation planting; failure of stormwater diversion. Twelve (60%) of the moderate non-compliance incidents have occurred in the last five years (since 2018). All three of the significant non-compliance incidents are recent (since 2019).

Activity (GWRC compliance group)	Significant non-compliance (#)	Moderate non-compliance (#)	Ongoing investigations (#)	Comment
Roads of National Significance	35	0	2	Non-compliance incidents included: discharges of sediment; failure to follow Erosion and Sediment Control Plans (ESCP) and/or Site Specific Environmental Management Plans (SSEMP).

2.3.3 Marine and coastal indigenous biodiversity

The indigenous biodiversity and ecological values of the coastal environment are subject to detrimental impacts from a number of stressors including: coastal armouring, eutrophication from nutrient enrichment, smothering or turbidity effects from fine sediments; toxicants (urban runoff, pesticides); coastal erosion; sea level rise; climate change; livestock grazing; freshwater abstraction; reclamation/drainage; harvesting; algal blooms; seawalls, breakwaters etc.; invasive species; vehicles; habitat loss; human and animal disturbance of wildlife (Stevens 2018a). These pressures do not operate in isolation and have cumulative and compounding detrimental impacts. As well as these ongoing sources of disturbance, infrequent but potentially significant events (e.g., oil spills, harmful algal blooms) can also have catastrophic consequences (Forrest & Stevens 2019b).

The impacts of surrounding land use continue to be a driver of decline in the Region's coastal and marine environments. For example, the detrimental impact of sedimentation due to subdivision in the catchment and the construction of Transmission Gully is evident in the monitoring data from in Te Awarua-o-Porirua Harbour (Forrest et al. 2020; Rogers et al. 2021). Wellington Harbour continues to lose habitat as more is cribbed to provide for roading and other infrastructure (e.g., around Eastern Bays). Like freshwater and wetland habitat, estuaries are sensitive to eutrophication due to run off from surrounding and upstream land use. Excess nitrogen is utilised by opportunistic macroalgae enabling them to out-compete other seaweed species. This in turn leads to further declines in condition as at nuisance levels macroalgae can form dense mats which adversely impact underlying sediments and fauna, other algae, fish, birds, seagrass, and saltmarsh. Decaying macroalgae can also accumulate subtidally and on shorelines causing oxygen depletion and nuisance odours and conditions. The greater the macroalgal cover, biomass, persistence, and extent of entrainment within sediments, the greater the subsequent impacts (Stevens 2018).

Invasive marine species continue to have an impact on the Region's coastal and marine ecosystems. Asian kelp (*Undaria pinnatifida*) was first discovered in Te Whanganui-a-Tara in 1987 and is now found throughout the harbour and elsewhere in the Region's waters, including within the Taputeranga Marine Reserve. Undaria competes with native seaweeds. Other marine pests that have been found in Te Whanganui-a-Tara include *Sabella spallanzanii* (Mediterranean fanworm, subsequently eradicated), *Stictyosiphon soriferus* (a brown seaweed), and *Styela clava* (a sea squirt). [22] Te Whanganui-a-Tara is one of 12 High Risk Sites targeted for six-monthly surveys under the National Marine High Risk Site Surveillance programme[23] aimed at early detection of high-risk non-indigenous marine species. During the winter 2021 and summer 2021–2022 surveys none of the five primary or four secondary target species were detected in Te Whanganui-a-Tara, although 12 other non-indigenous taxa were detected in the harbour (Woods et al. 2022), illustrating that the establishment of invasive species is a current and ongoing threat.

22 https://www.doc.govt.nz/nature/habitats/marine/type-1-marine-protected-areas-marine-reserves/marine-reserve-report-cards/taputeranga-marine-reserve/marine-pests/

23 https://marinebiosecurity.org.nz/surveillance/

Climate change is already impacting on the Region's coastal and marine environment. Regional measurements of mean sea-level show a consistent increasing trend, which is most pronounced in Wellington. This is partly due to the concurrent occurrence of land subsidence (Ministry for the Environment & StatsNZ 2019). Species and habitat in intertidal, estuarine, rocky shore, duneland, coastal lake and wetland areas are particularly suspectable to impacts of sea level rise. The oceans surrounding New Zealand have warmed, with the strongest warming recorded off the Wairarapa Coast (Sutton & Bowen 2019). Increasing sea temperatures can affect growth and reproduction of marine species leading to cascading impacts through the food web.

2.4 Current protection of indigenous biodiversity in Wellington Region

2.4.1 Extent of land and sea under legal protection

Nearly half a million hectares within the Wellington Region (land and sea) is under some form of formal legal protection, mostly under the jurisdiction of central (Department of Conservation) or local government, with just over 1% (6716 ha) being private land covenanted with QEII National Trust (Table 7).

Two areas of Marine Reserve fall within the Wellington Region – the Taputeranga Marine Reserve (covering 855 ha of shoreline and coastal habitat on Wellington's south coast, between Lyall Bay and west of Ōwhiro Bay), and Kāpiti Marine Reserve (covering 2167 ha comprising two separate areas west and east of the island). In 2010[24], the West Coast North Island Marine Mammal Sanctuary was extended to the Taputeranga Marine Reserve, resulting in ~13%, (261,037 ha) of the Sanctuary falling within the Region.

Not all the areas (including that within Public Conservation Land, PCL) included within the protected areas data will be protected or managed for the purposes of indigenous biodiversity. For example, Greater Wellington Regional Council manages a regional network of 12 parks and forests for the purposes of recreation, water supply, scenic value, farming, forestry, and preservation of ecological and cultural values. Reserves managed by territorial authorities include playgrounds, amenity reserves, and recreational facilities. It is also unclear from the summary data whether the Life of Trees covenants or Landscape Protection Agreements managed by the QEII Trust (in full or part) targeted include indigenous biodiversity values. It is also likely that the Open Space Covenant data also includes covenants over properties for purposes other than protection of indigenous biodiversity. However, all reserves are included here for completeness; noting that non-indigenous dominated green space can provide habitat for indigenous species and ecological connectivity across urban and rural landscapes.

24 https://www.doc.govt.nz/nature/habitats/marine/other-marine-protection/west-coast-north-island/

Table 7: Summary of the land and sea within the Wellington Region under some form of formal legal protection. *As GWRC and DOC have overlapping responsibilities for Queen Elizabeth Park, the park (649 ha) is included only within the GWRC statistics. ^Two areas of PCL (Tararua Forest Park and Pukaha / Mount Bruce) span the boundary with Horizons Regional Council, only the area of PCL that falls within Greater Wellington's jurisdiction is included here. Likewise, only the extent of the West Coast North Island Marine Mammal Sanctuary that falls within the waters of the Wellington Region are included in the total Marine Reserve Area here.

Agency/Trust	Type/status	Number of protected areas	Total area (ha)
QEII National Trust	Landscape Protection Agreement	2	85
	Life of Trees Covenant	5	55
	Open Space Covenant	365	6546
	Property	1	30
	Subtotal:	*373*	*6716*
Department of Conservation^	Conservation Area	59	138,121
	Marginal Strip	55	317
	Reserve	276*	9530*
	Wildlife Area	1	32
	Marine Reserve	2	261,892
	Subtotal:	*393*	*409,892*
Greater Wellington Regional Council	Regional Park and Forest	20*	49,578*
Territorial Authorities	Council reserve	2837	26,404
	TOTAL:	3623	492,590

2.4.2 Provisions for Significant Natural Areas in District Plans

The RPS allocates the responsibility for the maintenance of indigenous biodiversity (excluding land within the coastal marine area, wetlands, and the beds of lakes and rivers, which is the responsibility of GWRC) to territorial authorities (city and district councils).

Section 6c of RMA requires that *the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna* are recognised and provided for as a matter of national importance. Policy 23 of the RPS directs that SNAs are to be identified within district (terrestrial SNAs) and regional (aquatic and wetland SNAs) plans. An area of indigenous vegetation or habitat is considered significant if it meets one or more of the criteria[25] as set out in Policy 23. Policy 24 of the RPS directs district and regional plans to include

25 Policy 23 includes criteria for representativeness, rarity, diversity ecological context, and tangata whenua values.

provisions to protect SNAs from inappropriate subdivision, use, and development but there is no regional[26] direction as to how SNAs are to be provided for. On a regional scale there is incomplete protection of identified SNAs (Table 8). Further, the application of ecological restoration and/or sustainability criteria when determining whether a site qualifies as an SNA (e.g., the City of Lower Hutt and Wairarapa Combined District Plans include these criteria) can further restrict the number of sites recognised as SNAs as these criteria bring in elements of condition and site management considerations which are inappropriate for responding to s6c RMA matters.

District Plans typically also include indigenous vegetation clearance provisions in the form of broad, relatively permissive rules (e.g., permitted clearance of kanuka, manuka, and tauhinu; clearance of maximum area(m^2)/time period and/or proportion (%) of total area of indigenous vegetation). This means continued loss of indigenous vegetation can occur without the requirement to address the effects of that loss. Further, any areas of indigenous vegetation or habitat that has not been identified and listed in a District Plan as an SNA will be subject to these generic provisions, meaning that areas that should be recognised as SNAs are vulnerable to loss.

[26] An Exposure Draft of the National Policy Statement for Indigenous Biodiversity (the third iteration of an NPS-IB) was released for feedback in 2022 but was not gazetted.

Table 8: Summary of provisions for Significant Natural Areas within the Regional and District Plans for the Wellington Region. Ticks (✓) = Yes; crosses (✗) = No; asterisks (❊) denotes partial response. ^Meeting Policy 24 requirements does not necessarily translate to full protection of SNAs as plans include exceptions and allows for discretion in decision-making. Avoidance policies are typically qualified (e.g., 'where practicable' e.g., Kāpiti Coast District Council). *Source*: Includes data provided by GWRC.

Plan	SNAs identified?	Policy 23 significance criteria used?	Assessment date	SNAs included in plan?	Policy 24 requirements meet?^	Comment
Natural Resources Plan for the Wellington Region 2022	✓	✓		✓	✓	❊ SNA identification is ongoing, and schedules will be updated as new information becomes available. Schedules of significant habitats for indigenous birds, sites with significant indigenous biodiversity values in the CMA, and habitats with significant indigenous biodiversity values in the CMA will be updated as part of the NRP Plan Change 1 (2023).
Kāpiti Coast District Plan 2021	✓	✓	–	✓	✓	–
Proposed Porirua District Plan 2020	✓	✓	2018	✓	✓	–
Proposed Wellington District Plan 2022	✓	✓	2016	❊	✓	❊ SNAs on private residential land have been excluded from the provisions of the plan. This represents 3% of the identified SNA sites
Upper Hutt City District Plan 2004	✓	✓	2018	✗	✗	Plan Change 48 Tiaki Taiao – Significant Natural Areas and Landscapes was paused after the release of the Draft NPS-IB in 2021. The draft chapter and overlay were less restrictive than the Draft NPS-IB.

Plan	SNAs identified?	Policy 23 significance criteria used?	Assessment date	SNAs included in plan?	Policy 24 requirements meet?^	Comment
						A Biodiversity Reference Group was established in 2020 and engagement with landowners has continued
City of Lower Hutt District Plan	❊	✗	?	❊	✗	❊ District Plan includes a schedule of sites of 'Significant Natural, Cultural, and Archaeological Resources' which are considered significant to the City, including for botanical, geological, or zoological reasons. The current list appears to be mostly areas on public land. In recent years, some further identification of SNAs (including on private land) was undertaken in preparation for a plan change to include SNAs in the District Plan. However, the District Plan Review Sub-committee resolved not to proceed with further work until the NPS-IB was gazetted
Wairarapa Combined District Plan 2011	❊	✗	–	❊	✓	❊ Only a sub-set of SNAs have been identified and included in the Operative WCDP. For example, only ten sites within Masterton District are included. The draft WCDP (2022) includes the same incomplete schedules of SNAs on public land.

2.4.3 Provisions for indigenous biodiversity protection within the Regional Natural Resources Plan

Under the RPS, GWRC is responsible for for developing objectives, policies, rules and/or methods in regional plans for the control of the use of land to maintain and enhance ecosystems in water bodies and coastal water. This includes land within the coastal marine area, wetlands, and the beds of lakes and rivers. Therefore, some protection of indigenous biodiversity occurs through implementation of the Natural Resources Plan (NRP). Specific activities that impact on certain aspects of indigenous biodiversity are provided for to varying degrees within the proposed NRP implemented via either regulatory or non-regulatory methods, and include policies to:

Avoid:

- Loss of extent and values of the beds of lakes and rivers and natural wetlands.
- Construction of new barriers impeding passage of fish and kōura species.
- (As far as practicable) the entrapment or stranding of fish, kōura, and kākahi.
- More than minor adverse effects on indigenous fish present in scheduled water bodies and habitats during spawning and migration times.

Protect and (where appropriate) restore:

- Scheduled ecosystems and habitats with significant biodiversity values (through application of the effects management hierarchy[27]).

Maintain or restore:

- Aquatic habitat diversity and quality; including where practicable connections between fragmented habitats.
- Critical habitat for indigenous species and indigenous birds; and avoid minimise or remedy adverse effects on aquatic species at critical life cycle periods.
- Riparian habitats.
- Values of natural wetlands.

Apply the effects management hierarchy to respond to adverse effects on:

- The coastal environment.
- Outstanding waterbodies.
- Scheduled ecosystems and habitats with significant biodiversity values.

Avoid, remedy, or mitigate:

- Adverse impacts on surface water bodies and the coastal marine area due to livestock access.

Use good management practice to manage:

- Earthworks, vegetation clearance, and plantation forestry harvesting activities that have the potential to result in significant accelerated erosion.

---

27 The effects management hierarchy describes the continuum of responses, applied in sequential order, and implemented to address adverse effects of an activity. The steps, in order of prior application are to avoid, then minimise, then remedy. More than minor residual adverse effects must be offset, or where an offset is not possible, compensated.

Encourage or promote:

- Encourage planting of appropriate riparian vegetation and control of pest plants and animals.
- Promote remediation to provide for passage of fish and kōura.

Restoring:

- Natural wetlands and constructing artificial wetlands to meet water quality, aquatic ecosystem health, and mahinga kai objectives.
- The ecological health and significant values of Te Awarua-o-Porirua Harbour, Wellington Harbour, and Wairarapa Moana.

In addition, the NRP recognises and includes provisions for Ngā Taonga Nui a Kiwa and sites with significant mana whenua values. Providing for these areas will also have benefits for indigenous biodiversity.

TERRESTRIAL INDIGENOUS BIODIVERSITY

3. RECENT CHANGES IN INDIGENOUS LAND COVER

A slight increase (161 ha) in the extent of total cover of indigenous land cover was recorded for the Wellington Region between 2012–2018 (MfE & StatsNZ 2022). Cover of 'indigenous forest' increased in this period by 658 ha (<1%, Table 2) while cover of 'indigenous scrub/shrubland' decreased by 618 ha. Extent of 'other herbaceous vegetation' also increased by 48 ha (Table 9). This very slight regional increase in indigenous land cover within Wellington Region sits against a backdrop of a national decrease of indigenous land cover by 12,869 ha between the same period.[28] Further, there are compositional and structure differences between recently revegetated areas and existing, more successionally advanced, or mature areas of indigenous vegetation such that they are not ecologically equitable.

Table 9: Change in indigenous vegetation cover (by vegetation class) between 2012 and 2018. *Source*: New Zealand Land Cover Database (LCDB5) as reported by StatsNZ[29]

Indigenous vegetation class (LCDB5)	2012 cover (hectares)	2018 cover (hectares)	Change (hectares)
Indigenous forest	215,472	216,130	658
Indigenous scrub/shrubland	74,637	74,019	-618
Natural bare/lightly-vegetated surfaces	5,080	5,153	73
Other herbaceous vegetation	2,764	2,812	48
Tussock grassland	4,348	4,348	0
Totals:	302,301	302,462	161

StatsNZ reported that freshwater wetland habitat increased by 47.2 ha in the Wellington Region between 2012–2018[30].

---

28 StatsNZ Indigenous land cover: https://www.stats.govt.nz/indicators/indigenous-land-cover

29 StatsNZ Indigenous land cover: https://www.stats.govt.nz/indicators/indigenous-land-cover

30 Stats NZ Wetland Area: https://www.stats.govt.nz/indicators/wetland-area/

4. FOREST AND SCRUB CONDITION

4.1 Indigenous dominance

Indigenous vegetation dominated in three-quarters ($n = 9$) of the monitoring sites within the regional terrestrial biodiversity monitoring network (see section 1.1 of Appendix 1) that fell within areas classed as either indigenous forestland or indigenous scrubland (Table 10).

Table 10: Proportion of indigenous species within monitoring plots within indigenous forestland or scrubland. Left of dotted line shows number of plots recorded in first monitoring cycle (2014–2016), right of dotted line shows number of plots recorded in second monitoring cycle (2019–2021). *Source:* Raw data obtained from GWRC monitoring portal.

Land cover	Proportion (%) range of indigenous species within plot									
	0–20		20–40		40–60		60–80		80–100	
Indigenous forestland ($n = 7$)	–	–	–	–	1	1	–	1	6	5
Indigenous scrubland ($n = 4$)	–	–	–	–	1	1	2	2	1	1

The indigenous vascular plant species richness (total number of species) was recorded within 49 monitoring plots (Table 41 in Appendix 1). There was no statistical difference ($p = 0.55$) of the mean number of indigenous species between the first and second monitoring cycles (Table 11).

Table 11: Total number of indigenous vascular plant species: Summary data from the first (2014–2016) and second (2019–2022) monitoring cycles. $n = 49$. $p = 0.553$. *Source:* GWRC Environmental Monitoring Portal.[31]

Summary statistic	First monitoring cycle	Second monitoring cycle
Range (min–max value)	0–77	0–86
Mode	2	0
Median	18	12
Average	22.67	22.18

The total number of indigenous species did not change between monitoring cycles across the majority (43%, $n = 21$) of plots, decreased within almost a third (31%, $n = 15$), and increased within 27% ($n = 13$) of plots (Figure 10).

[31] https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/vegetation.html

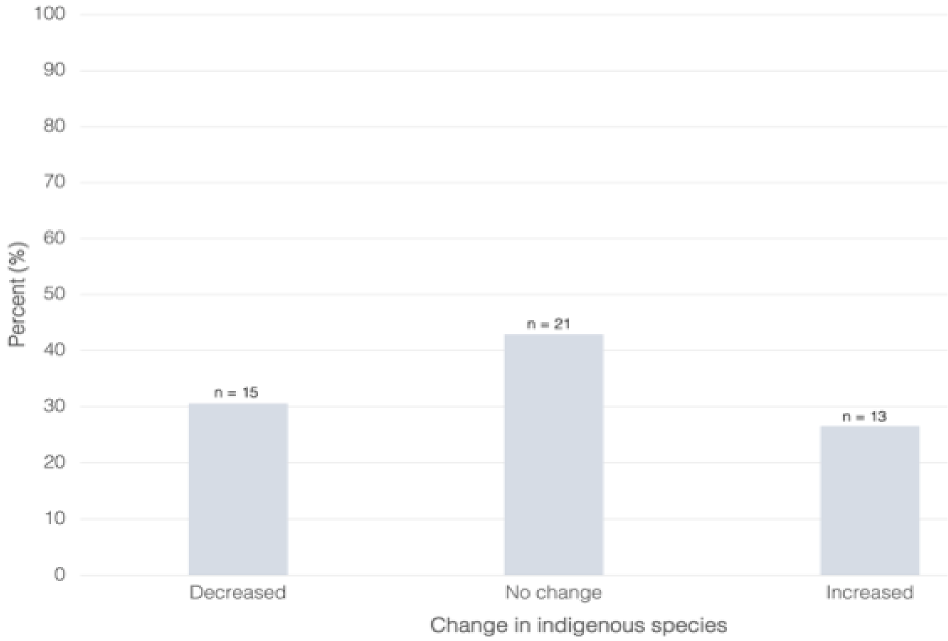

Figure 10: Change in indigenous vascular plant presence: Percentage of plots (n = 49) where the number of indigenous vascular plant species decreased, stayed the same, or increased between first (2014–2016) and second (2019–2022) monitoring rounds. A change in species number of 10% or greater is graphed as a change (increase or decrease). *Source*: GWRC Environmental Monitoring Portal.[32]

4.2 Condition and pressure

4.2.1 Possum presence

Possum density is measured within the GWRC terrestrial biodiversity monitoring network on a five-yearly cycle (see Appendix 1 for methods of possum monitoring). The proportion of monitoring sites within each density class (none, low, moderate, high) shifted between the two monitoring cycles with 'low' possum densities at 50% (*n* = 23) of sites in the first monitoring cycle, but only 28% (*n* = 13) of sites during the second monitoring cycle. The majority (59%; *n* = 27) of sites during the second cycle recorded no possums (Figure 11). Of the individual sites, only 13% (n = 9) showed an increase in possum density between the two monitoring cycles (Figure 12). Figure 13 further illustrates that possums are predominantly absent or at low density in monitoring results (noting the greater number of plots shown in Figure 13).

32 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/vegetation.html

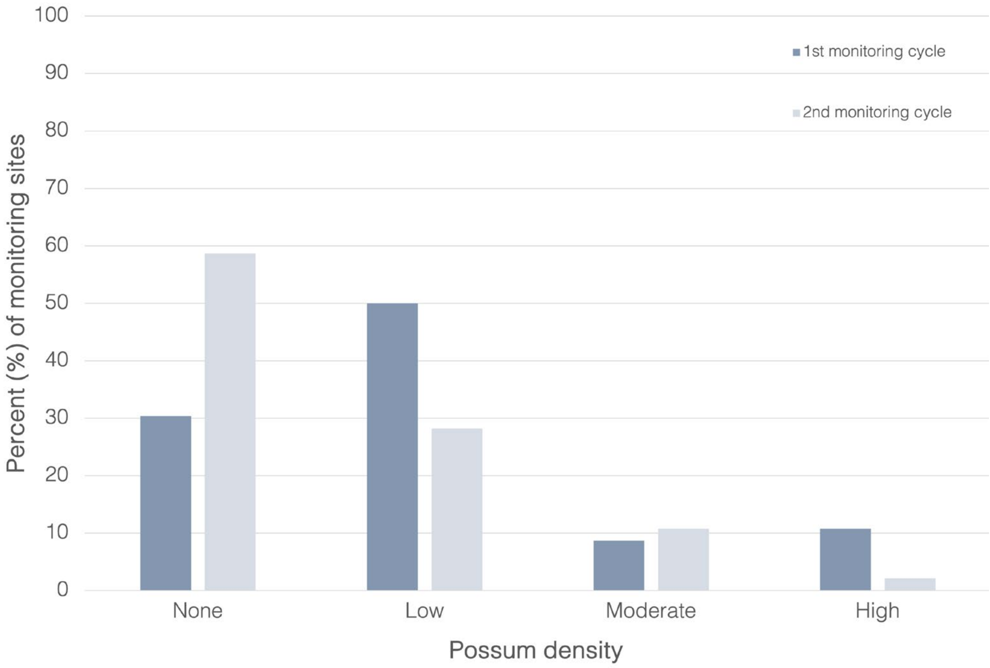

Figure 11: Number of monitoring sites within each possum density category recorded during first monitoring cycle (2014–2016) and the second monitoring cycle (2019–2022). Density: Low = <10%; Moderate = ≥10 <20%; High = ≥ 20%. *n* = 46. *Source:* Raw data obtained from GWRC Environmental Monitoring Portal.[33]

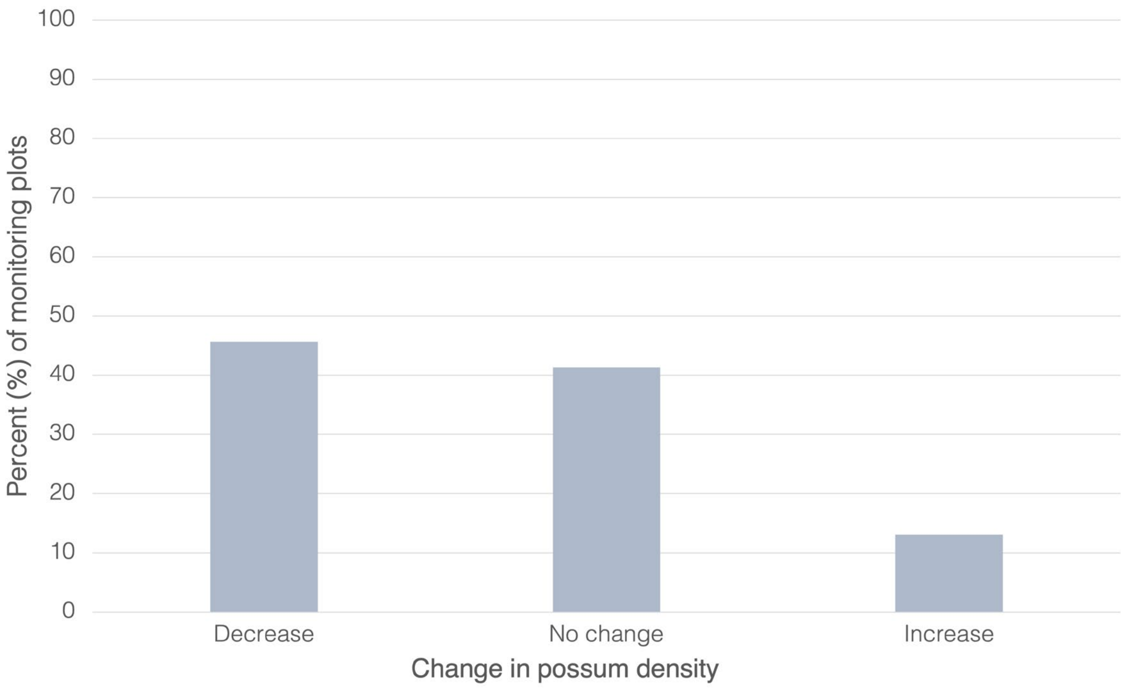

Figure 12: Change in possum density (proportion of monitoring plots) between first monitoring cycle (2014–2016) and the second monitoring cycle (2019–2022). *n* = 46. *Source*: Raw data obtained from GWRC Environmental Monitoring Portal.[34]

33 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/possums.html
34 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/possums.html

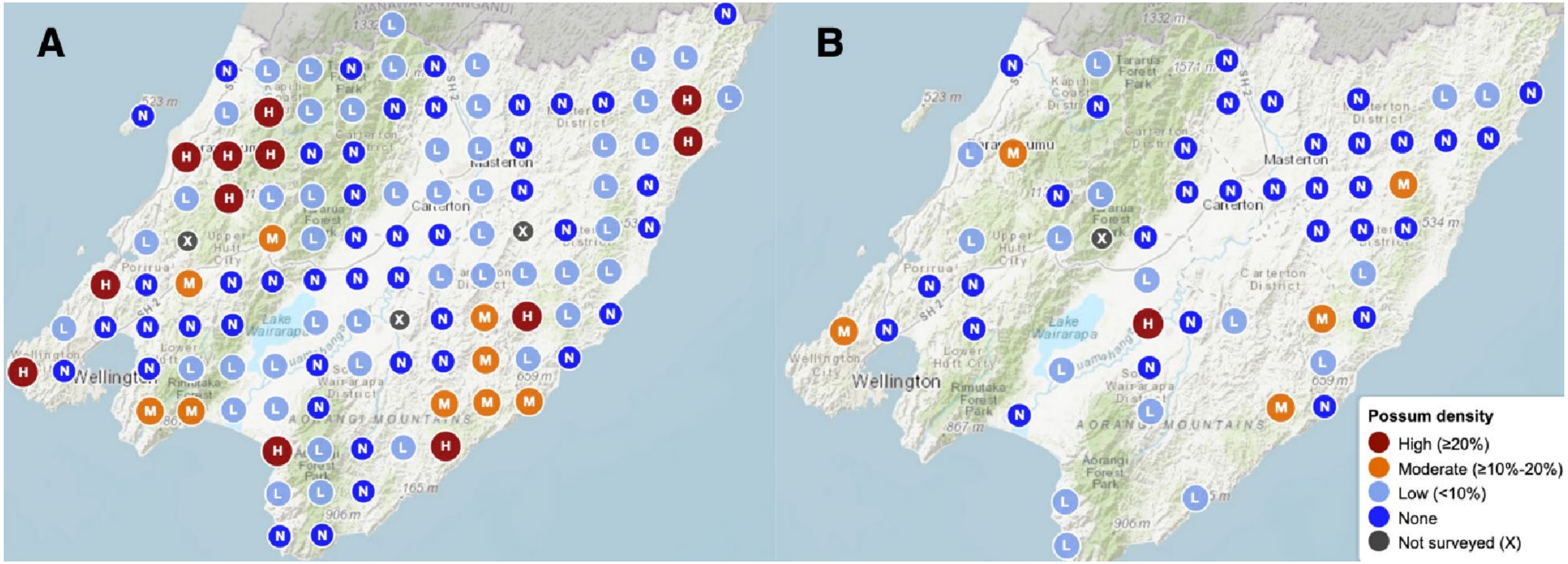

Figure 13: Possum density by monitoring plot. Panel A = first monitoring cycle (2014–2016); Panel B = second monitoring cycle (2019–2022). Gaps in the sampling grid could be for Lake Wairarapa, access being refused to some plots on private land, and plots being decommissioned. *Source*: Adapted from GWRC Environmental Monitoring Portal.[35]

35 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/possums.html

4.2.2 Ungulate presence

Ungulate density is measured within the GWRC terrestrial biodiversity monitoring network on a five-yearly cycle (see Appendix 1 for methods of ungulate monitoring). Ungulate presence was not detected at the majority of both the first (56%, $n = 28$) and the second (54%, $n = 27$) monitoring cycles, although high ungulate densities were recorded at 12% ($n = 6$) of monitoring sites during both cycles (Figure 14). Of the individual sites, the vast majority (86%, $n = 43$) showed no change in ungulate density between the two monitoring cycles (Figure 15). Figure 16 further illustrates that ungulates are predominantly absent or at low density in monitoring results (noting the greater number of plots shown in Figure 16).

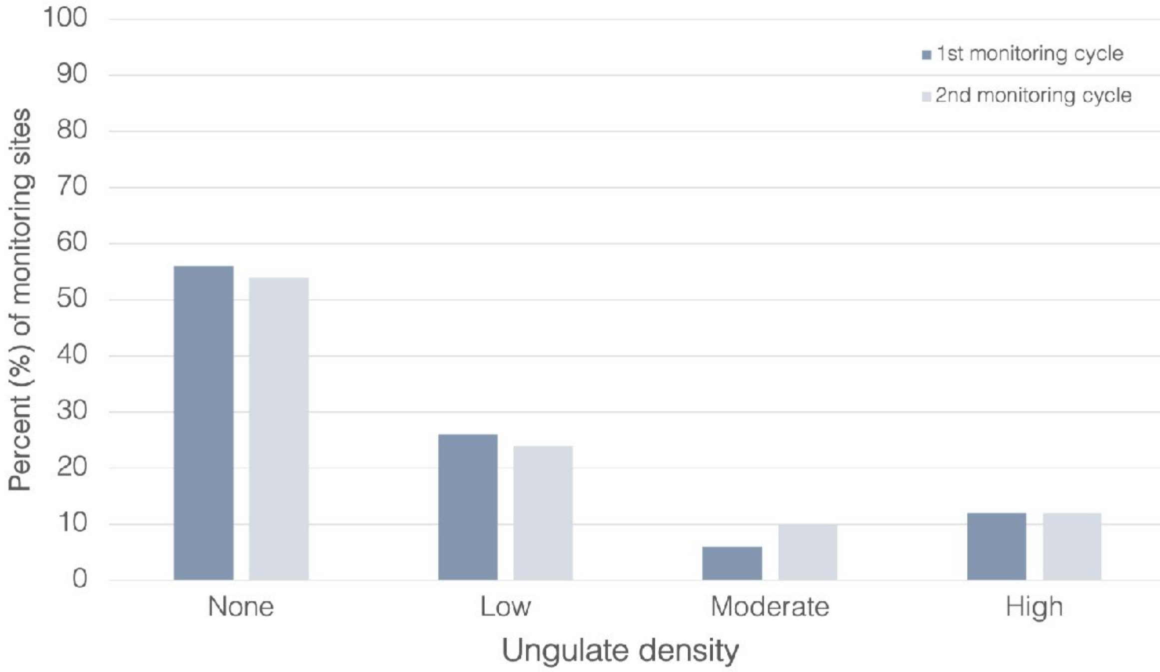

Figure 14: Number of monitoring sites within each ungulate (deer and goat) density category recorded during first monitoring cycle (2014–2016) and the second monitoring cycle (2019–2022). Density: Low = <10%; Moderate = ≥10 <20%; High = ≥ 20%. $n = 50$. *Source:* Raw data obtained from GWRC Environmental Monitoring Portal.[36]

36 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/ungulates-lagomorphs.html

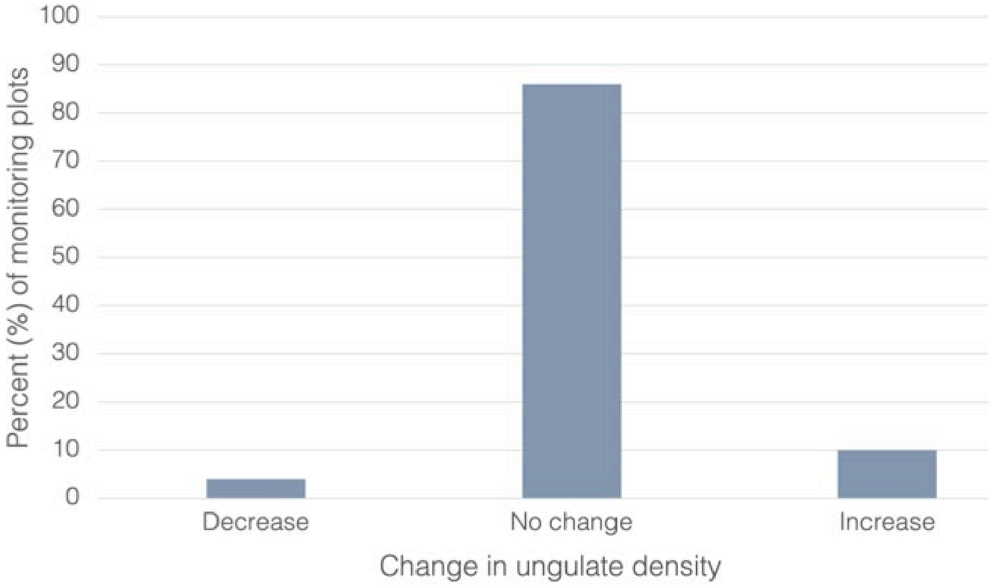

Figure 15: Change in ungulate (deer and goat) density (proportion of monitoring plots) between first monitoring cycle (2014–2016) and the second monitoring cycle (2019–2022). *n* = 50. *Source:* Raw data obtained from GWRC Environmental Monitoring Portal.[37]

Ungulates remain a concern, preventing the recovery of understory vegetation even in areas where they have been reduced to low population levels (Crisp 2020d). Of particular concern is the evidence that ungulate presence (as detected from pellets) is highest in the forest types with the least protection (Figure 17).

37 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/ungulates-lagomorphs.html

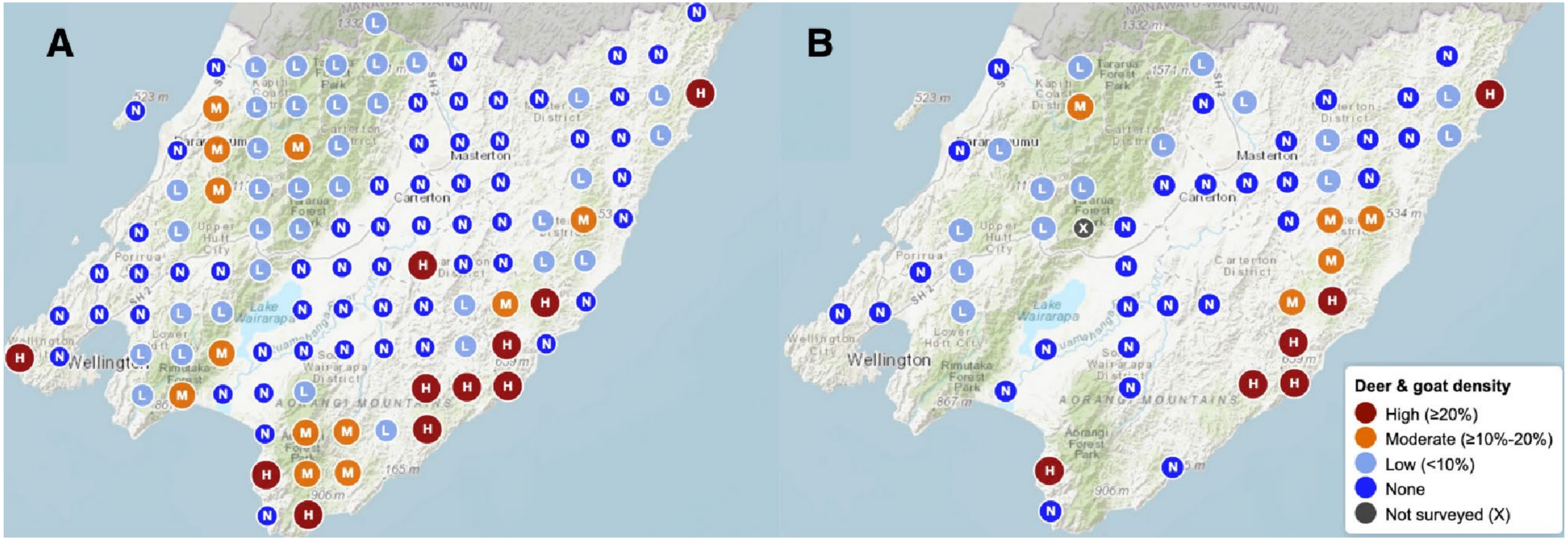

Figure 16: Ungulate (deer and goat) density by monitoring plot. Panel A = first monitoring cycle (2014–2016); Panel B = second monitoring cycle (2019–2022). Gaps in the sampling grid could be for Lake Wairarapa, access being refused to some plots on private land, and plots being decommissioned. *Source*: Adapted from GWRC Environmental Monitoring Portal. [38]

38 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/ungulates-lagomorphs.html

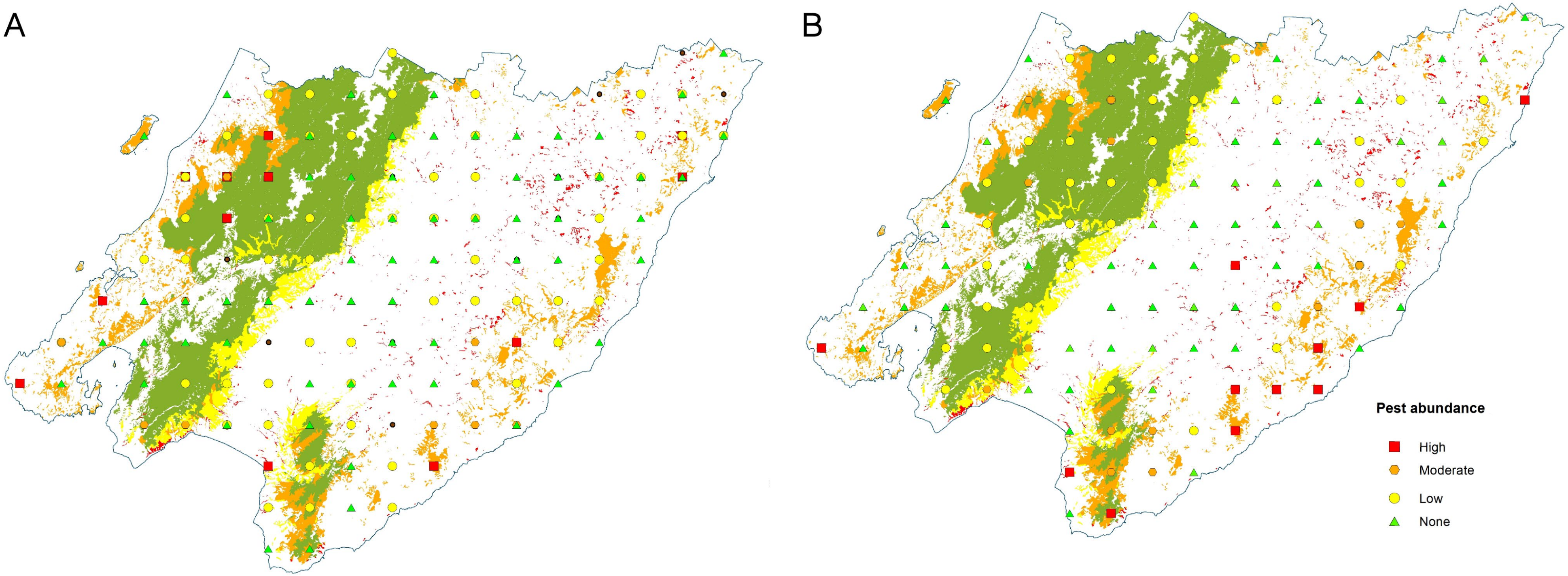

Figure 17: Remaining indigenous forest conservation status and pest animal abundance sampled between 2014 and 2019 across the Wellington Region. Panel A = possum abundance Panel B = ungulate abundance. Indigenous forest cover is shown by conservation status: green = Not Threatened; yellow = Vulnerable; orange = Endangered; red = Critically Endangered. Possum and ungulate frequency at terrestrial monitoring sites shown by coloured symbols: green triangles = None; yellow circles = Low (<10%); orange hexagon = Moderate (≥ 10%–20%); red square = High (≥ 20%). *Source:* Images provided by GWRC; data available in the Environmental Monitoring Portal.

4.2.3 Small mammal presence

Control of small mammals (rats, mice, mustelids, and hedgehogs) is conducted at most Key Native Ecosystem (KNE) sites throughout the Region. Regular monitoring of these small mammals within KNE sites is undertaken regularly, the purpose of which is to:

- Report on the effectiveness of small mammal control regimes in forest ecosystems.
- Gain a better understanding of small mammal population dynamics in coastal ecosystems.
- Provide a trigger for management to respond to changes in small mammal populations.
- Identify changes in small mammal populations over time.
- Compare the effectiveness of different control methods.

The small mammal monitoring programme is therefore used to report on the KNE programme as a whole, inform the management of individual KNE sites, and communicate outcomes of pest animal control. Long-term time series monitoring results for each site can be accessed from the GWRC Environmental Monitoring Portal[39].

The monitoring results from May 2023 are summarised in Table 12. The per cent tunnel tracking index (%TTI) for rats at East Harbour Northern Forest (both mainland island and non-treatment sites) showed a decreasing trend but was still outside the target range (5%). Rats at Wainuiomata/Orongorongo (both sites) and Queen Elizabeth Park were also outside the target range of 5% and 10%, respectively. Half of the sites showed an increasing rate of change in rat %TTI while 60% of sites did for mouse %TTI. The majority of sites (n = 7) where mustelid and hedgehogs were monitored showed a minimal rate of change with %TTI low at all sites, except for Baring Head which recorded a %TTI for hedgehogs of 17.1 (increasing rate of change) (Table 12).

Table 12: Key small mammal monitoring at eight Key Native Ecosystem (KNE) sites. %TTI = Percent tunnel tracking index; SE = Standard error for the mean %TTI. Shading shows gross rate of change of %TTI: Orange = Increasing (>10% change); Gold = Minimal (<±10% change); Pale Green = Decreasing (>-10% change). ^Denotes rat %TTI are outside of target range[40], all other sites are within target range for rat %TTI. Otari/Wilton's Bush has a single sample each monitor, and therefore no SE calculation. *Source*: Data from GWRC Environmental Monitoring Portal.[41]

KNE site (Date of last monitor)	Rat %TTI (SE)	Mouse %TTI (SE)	Mustelid %TTI (SE)	Hedgehog %TTI (SE)
Wainuiomata / Orongorongo Mainland Island (May 2023)	21.0 (4.1)^	3.0 (1.0)	0.0 (0.0)	0.0 (0.0)
Wainuiomata / Orongorongo Non-treatment area (May2023)	92.0 (3.7)^	0.0 (0.0)	2.6 (2.6)	0.0 (0.0)
East Harbour Northern Forest Mainland Island (May 2023)	24.0 (6.8)^	34.0 (9.3)	0.0 (0.0)	0.0 (0.0)

39 https://www.gw.govt.nz/annual-monitoring-reports/kne-small-mammal-monitoring/index.html.

40 5% for Wainuiomata Mainland Island and East Harbour Northern Forest Mainland Island; 10% for other KNE sites.

41 https://www.gw.govt.nz/annual-monitoring-reports/kne-small-mammal-monitoring/index.html

KNE site (Date of last monitor)	Rat %TTI (SE)	Mouse %TTI (SE)	Mustelid %TTI (SE)	Hedgehog %TTI (SE)
East Harbour Northern Forest Non-treatment area (May2023)	20.0 (4.5)^	10.0 (5.5)	0.0 (0.0)	0.0 (0.0)
Baring Head / Ōrua-pouanui (May 2023)	0.0 (0.0)	63.8 (10.8)	2.9 (2.9)	17.1 (8.1)
Belmont Korokoro (February 2023)	6.3 (6.3)	14.2 (5.2)	0.0 (0.0)	0.0 (0.0)
Queen Elizabeth Park (May 2023)	35.0 (35.0)^	60.0 (10.0)	–	–
Otari/Wilton's Bush (Western Wellington Forests) (February 2023)	3.3	26.7	0.0	0.0
Johnsonville Park (Western Wellington Forests) (February 2023)	0.0 (0.0)	15.0 (5)	–	–
Porirua Western Forests (February 2023)	3.3 (3.3)	13.3 (13.3)	–	–

Invasive lizards are also monitored at Baring Head / Ōrua-pouanui. The last monitor in February 2023 recorded a %TTI of 35.7 (SE 11.3) and a minimal (<±10%) rate of change.

5. WETLAND CONDITION

5.1 Wetland health monitoring programme

The wetland health monitoring programme has been designed to survey a total of 150 wetlands throughout the Region over a 5-year period. The whaitua framework developed by GWRC for freshwater planning was used in the sampling design, with 30 wetlands surveyed annually within each of whaitua as set out in Table 13.

Table 13: Wetland health monitoring programme.

Calendar year	Monitoring year	Whaitua
2016/2017	Year 1	Ruamāhanga
2017/2018	Year 2	Kāpiti Coast
2018/2019	Year 3	Te Awarua-o-Porirua and Te Whanganui-a-Tara
2019/2020	Year 4	Eastern Wairarapa
2020/2021	Year 5	Remaining wetlands (Ruamāhanga & Kāpiti Coast)

Results from the first four years (2017–2020) of the monitoring programme are presented here. As this was the first round of sampling, trend data is not yet available.

Wetland habitat was classified by dominant vegetation type, the most common (*n* = 29, 25%) was sedgeland, followed by reedland (*n* = 23, 19%), then shrubland dominated wetlands (*n* = 19, 16%) (Figure 18).

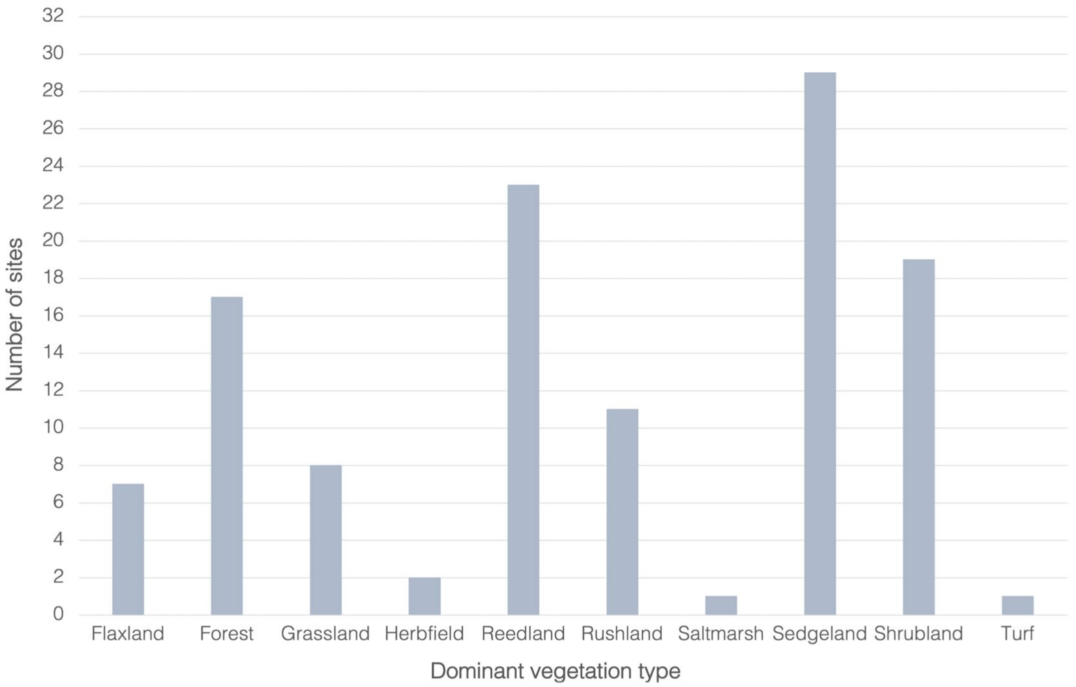

Figure 18: Number of wetland sites within each vegetation type. *n* = 118. *Source*: GWRC Environmental Monitoring Portal.[42]

5.1.1 Indigenous dominance

Vegetation composition was assessed within 5 x 5 m plots within each wetland site. A total of 208 plots were measured within the 118 wetland sites. The proportion (%) of indigenous cover exceeded 75% cover in 58% (*n* = 118) of the plots and exceeded 50% cover in a further 38% of plots. The proportion (%) of indigenous species exceeded 75% in 29% (*n* = 60) of plots and exceeded 50% in a further 71% of plots (Figure 19). This indicates that there are a number of small-statured exotic species that while not dominating the cover are decreasing the indigenous dominance.

42 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/index.html

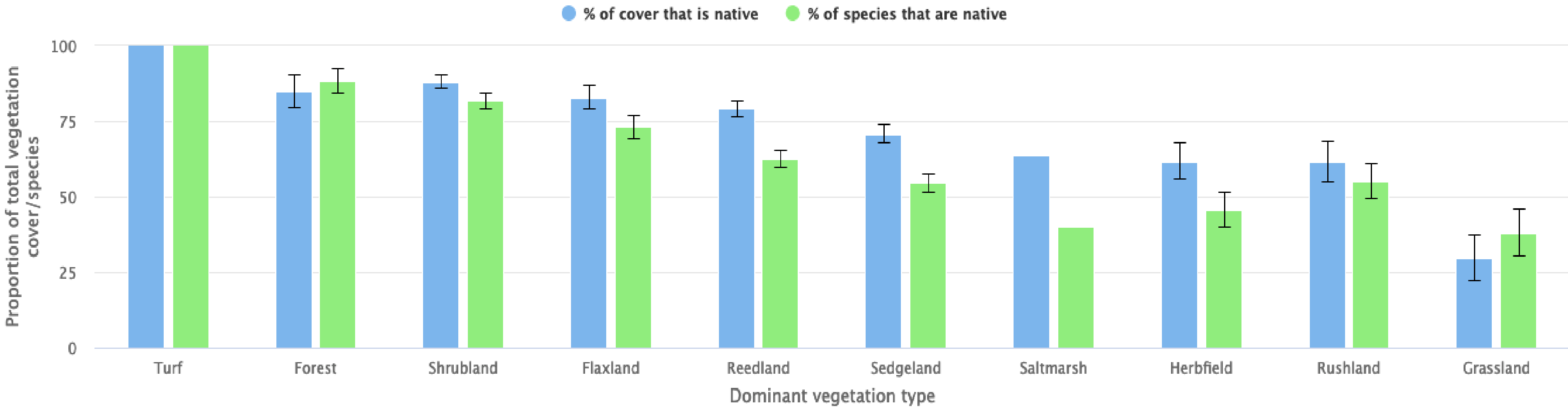

Figure 19: Mean proportion (%) of total vegetation cover (blue bars) and total species (green bars) that are indigenous by dominant wetland vegetation type. *n* = 208. *Source:* GWRC online environmental monitoring portal.[43]

43 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/wetland-health.html.

5.1.2 Condition and pressure

The Wetland Condition Index (WCI) combines scores of five equally weighted components of wetland health including hydrologic integrity; physicochemical parameters; ecosystem intactness; browsing/predation /harvesting; and dominance of indigenous plants. These components are summed together to give the WCI score (highest possible score being 25). The higher the WCI score the better the condition of the wetland site.

Wetland sites can be categorised into condition classes based on the WCI score for the site expressed as a proportion of the potential score. Class thresholds are:

Condition Class	Proportion (%) of possible Wetland Condition Index score
Poor	0–40
Moderate	40–60
Good	60–80
Excellent	80–100

Of the 118 wetland sites surveyed between 2017 and 2020, 8% (*n* = 9) of sites were classed as 'excellent'; 76% (*n* = 90) as 'good'; and 16% (*n* = 19) as 'moderate'. There were no sites that were classified as 'poor'.

The mean proportion (%) of best possible Wetland Condition Index score across the ten dominant vegetation types is shown in Figure 20.

Threats to wetland condition have been measured using the Wetland Pressure Index (WPI). Like the WCI, the WPI is also a composite index. The WPI combines measures of six factors of stressors and potential threats that exist in the landscape surrounding the wetland: presence of key undesirable species; modifications to catchment hydrology; precent catchment under introduced vegetation cover; water quality within the catchment; presence of pests; and animal access/grazing. These components are summed together to give the WPI score (highest possible score being 30). The higher the WPI score the greater the level of pressure on the wetland site.

For the wetlands surveyed between 2017 and 2020, nearly three-quarters (74%, *n* = 87) of sites have a WPI score that is greater than 50% of the highest possible score; indicating a high level of pressures within the catchments within which these sites are located. The mean proportion (%) of highest possible WPI score across the ten dominant vegetation types is shown in Figure 21.

A relationship is evident between WCI and WPI whereby the higher the WPI score (more pressures in the catchment) the lower the WCI score (Figure 22).

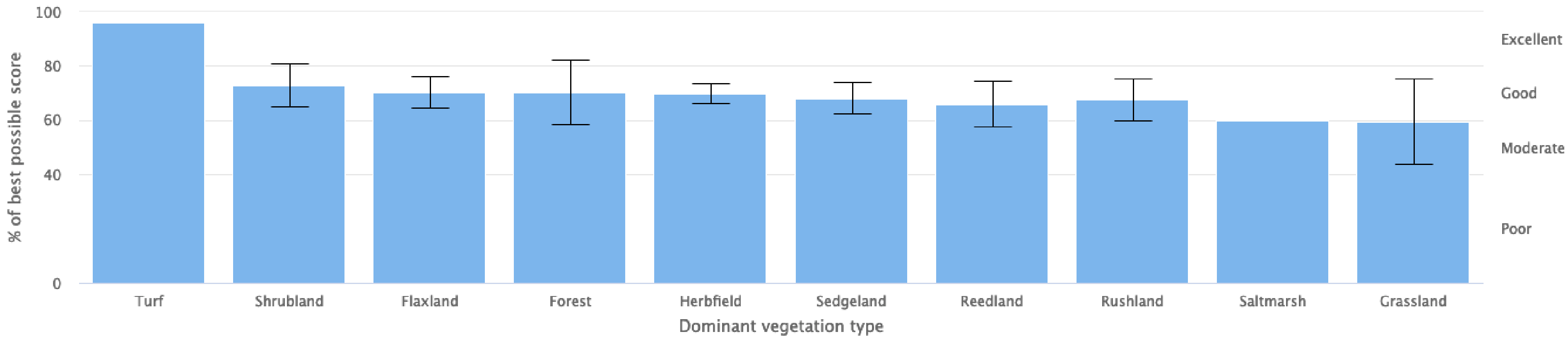

Figure 20: Mean proportion of best possible Wetland Condition Index score (left axis) and condition class (right axis). *n* = 118. *Source:* GWRC online environmental monitoring portal.[44]

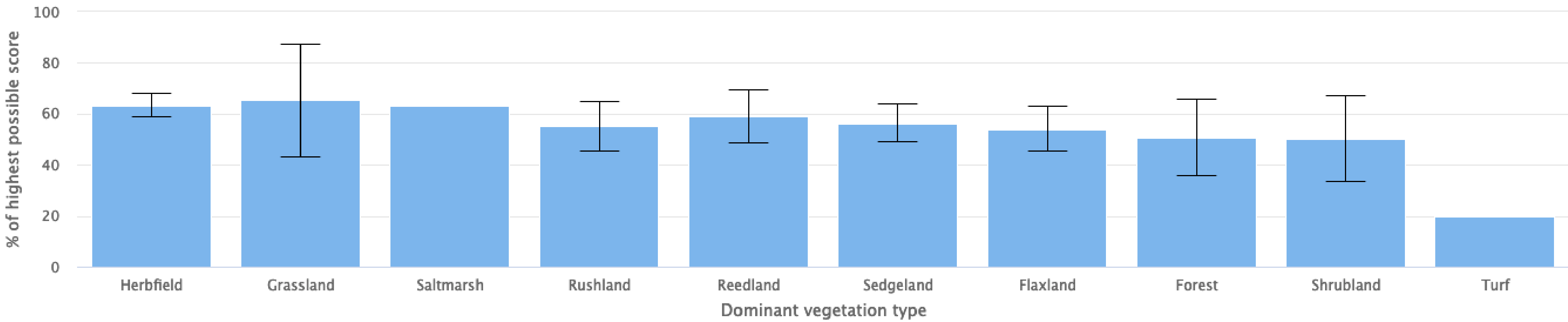

Figure 21: Mean proportion of highest possible Wetland Pressure Index score. *n* = 118. *Source:* GWRC online environmental monitoring portal.[13]

44 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/wetland-health.html.

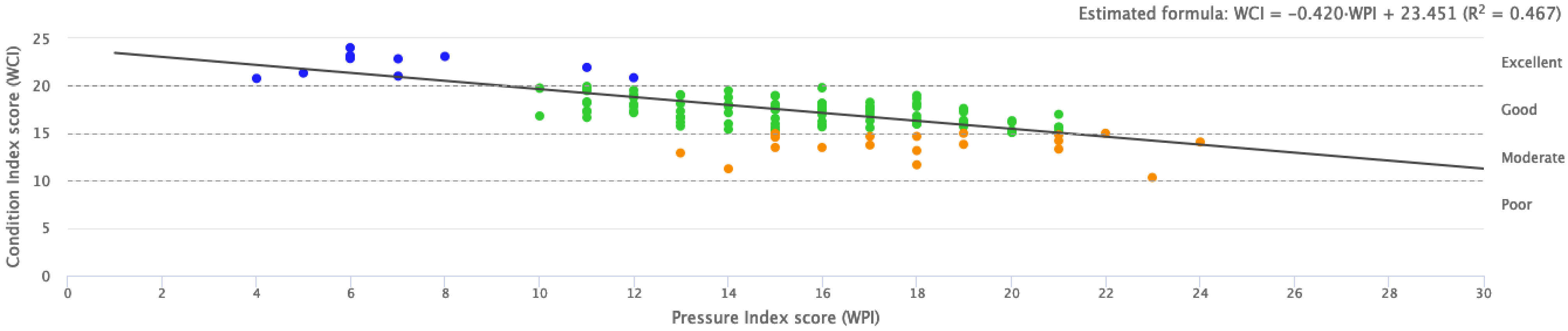

Figure 22: The relationship between Wetland Condition score and Pressure Index score. *n* = 118. Sites are coloured according to Condition class. Blue dots = Excellent; Green dots = Good; Orange dots = Moderate. Black line shows the estimated relationship between WCI and WPI. *Source:* GWRC online environmental monitoring portal.[45]

45 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/wetland-health.html.

6. DUNELAND CONDITION

There has been extensive loss of dunelands across New Zealand, and dunelands across the Wellington Region continue to be under pressure. Sea level rise is eroding the active foredunes and land use is encroaching on the stable back dunes.

Duneland is present in Titahi, Lyall, and Fitzroy Bays and Petone Beach, although the back dunes have typically been lost to development. The exotic sand-binding marram grass (*Ammophila arenaria*) is typically dominant on foredunes (Stevens 2018a).

Duneland monitoring occurred within 20 representative sites[46] of the 62 natural coastal dunelands remaining in the Region. Monitoring was conducted over a 5-year cycle as detailed in the 2017/22 Duneland health monitoring report[47]. A summary and location of monitoring plots is provided in Appendix 1.

6.1 Indigenous dominance

Across the 19 duneland monitoring sites sampled in 2022 the average proportion (%) of total species found across all monitoring sites that were indigenous was 31%, with an average of 1.5 indigenous species (Table 14).

Table 14: Mean number of indigenous species and proportion of total number of species that are indigenous within duneland monitoring plots. *n* = 19. Source: raw data sourced from GWRC online environmental monitoring portal.[48]

Management / agency	Mean number of indigenous species	Mean proportion (%) of total number of species that are indigenous
Department of Conservation	1.2	37
Key Native Ecosystem (GWRC)	1.3	31
Wellington City Council	4.6	26
Nil	1.4	47
Totals (mean of all plots):	1.5	31

In terms of total cover, just over a quarter (26%, *n* = 5) of all plots supported indigenous vegetation cover over more than 33% of the total plot, with indigenous vegetation cover reaching 50% of total cover in only one plot (Figure 23). Bare ground has been included as it is a natural and important characteristic of duneland habitat.

46 Within each monitoring sites, 1 m^2 quadrats were located 4 m apart along transects of varying lengths. The number of transects at each monitoring site also varied. Therefore, the total number of plots within each monitoring site varied.

47 https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/index.html.

48 https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/vegetation.html.

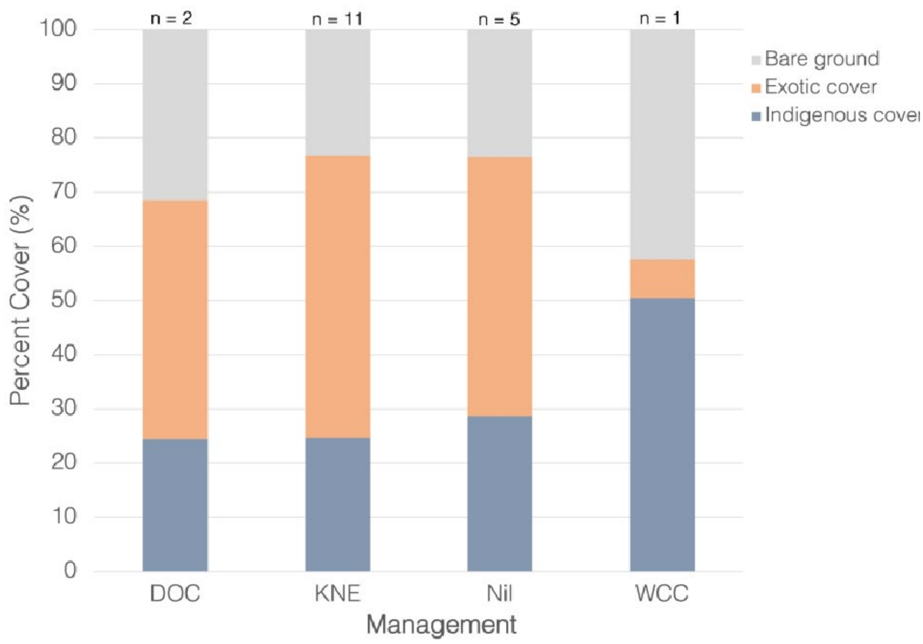

Figure 23: Mean cover across plots by management agency/programme. DOC = Department of Conservation; KNE =Key Native Ecosystem, managed by GWRC; Nil = no management; WCC = Wellington City Council. *n* = 19. *Source*: Raw data sourced from GWRC online Environmental Monitoring Portal.[49]

6.2 Overall duneland condition

Duneland condition is measured using a six-point condition index score, whereby 0 = poor and 5 = excellent. The score comprises five sub-components:

1. Indigenous cover dominance measured as the proportion (%) of total vascular plant species recorded that are indigenous.
2. Indigenous bird dominance measured as the proportion (%) of total number of bird species recorded that are indigenous.
3. Indigenous reptile dominance measured as the proportion (%) of total number of reptile species recorded that are indigenous.
4. Unnatural vegetation disturbance measures as the proportion (%) of the plot that is bare sand.
5. Buffering (the state of surrounding land cover) measured as a proportion (%) of land cover that is indigenous and proportion (%) of indigenous cover dominance).[50]

The sum of the sub-component scores gives an overall condition score for each plot; the Duneland Condition Index (DCI).

The majority of sites scored poorly for buffering (79%, *n* = 15) and indigenous cover dominance (95%, *n* = 18). Six sites (32%) were in 'excellent' condition as measured by vegetation disturbance. Nearly three-quarters (74%, *n* = 14) of sites had a DCI score between 10–15 (40–60% of the best possible score). None of the DCI scores were below 10 (Figure 24). All sites were in 'excellent' condition for indigenous reptile dominance (i.e.,

49 https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/vegetation.html.

50 The thresholds for scoring each of the sub-components is detailed in the methods section of the 2017/22 Duneland health monitoring report https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/methods.html.

all reptiles present were indigenous species). However, this is to be expected as only one invasive reptile is present in New Zealand (the plague skink (*Lampropholis delicata*)) which (to current knowledge) has not yet established breeding populations in the Region.

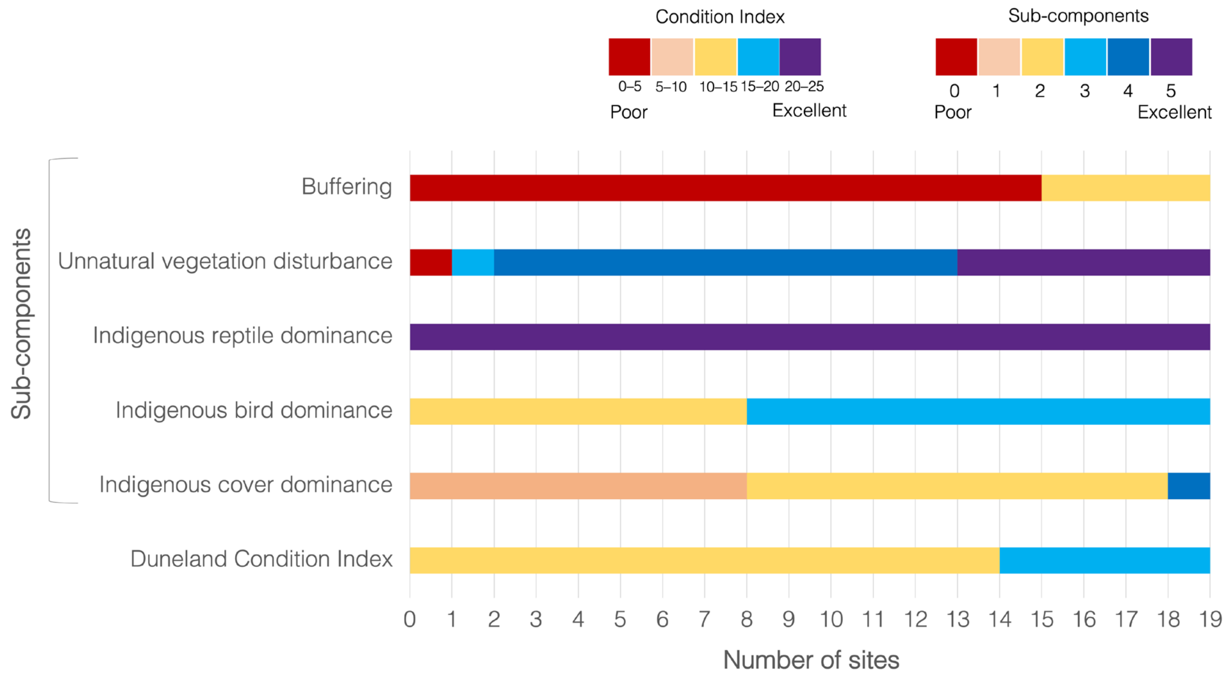

Figure 24: Overall duneland condition (indicated by Condition Index) and condition of the five sub-components which contribute to the Duneland Condition Index. *n* = 19. *Source*: raw data from GWRC environmental monitoring portal.[51]

Trend data is not available for duneland habitat in the Wellington Region as only one monitoring event has occurred to date.

51 https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/duneland-condition.html.

7. TERRESTRIAL AVIFAUNA

7.1 Forest avifauna

7.1.1 Regional monitoring network

Monitoring data shows that the old growth forests in protected lands (e.g., the main spine of the Tararua and Remutaka Ranges, Wainuiomata and Hutt Water Collection Area, Kaitoke Regional Park, Akatarawa and Pakuratahi Forests, and in the Eastern Wairarapa) retain the greatest abundance of indigenous forest bird species (Figure 25).

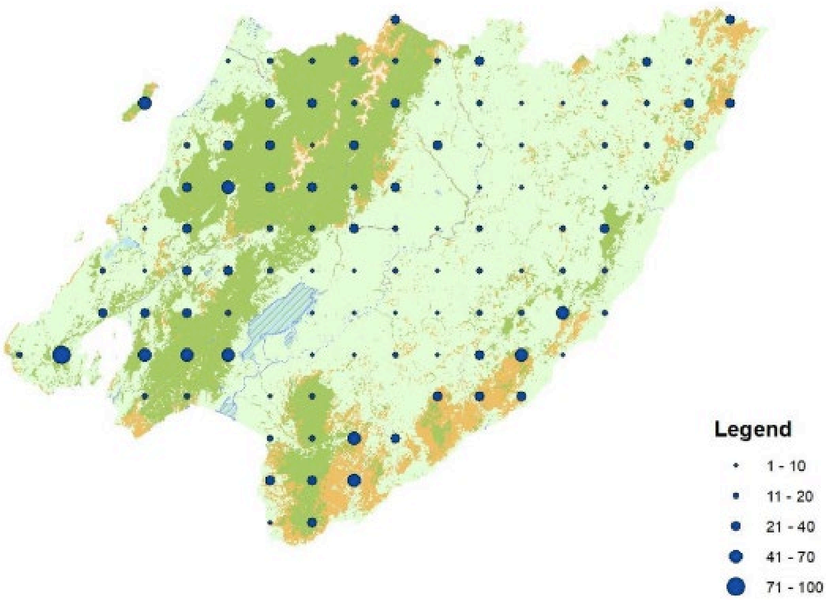

Figure 25: Indigenous bird abundance across the GWRC terrestrial biodiversity monitoring network. Dots indicate the number of individual birds counted in a total of 10 five-minute bird counts from five points sampled over two days at each site. *Source*: Crisp 2020d.

The indigenous forest bird species richness (total number of species) was recorded within 51 monitoring plots (Table 42 in Appendix 1). There was a statistical difference (p = 0.55) of the mean number of indigenous species between the first and second monitoring cycles (Table 15).

Table 15: Total number of indigenous forest bird species: Summary data from the first (2014–2016) and second (2019–2022) monitoring cycles. n = 51. p = 0.012. *Source*: Raw data obtained from GWRC Environmental Monitoring Portal.[52]

Summary statistic	First monitoring cycle	Second monitoring cycle
Range (min–max value)	2–12	0–12
Mode	6	8
Median	7	6
Average	7.3	6.3

52 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/birds.html

The total number of indigenous species increased between monitoring cycles across 41% (n = 21) of plots, remained the same across a third (33%, n = 17), and decreased within a quarter (25% (n = 13) of plots (Figure 26).

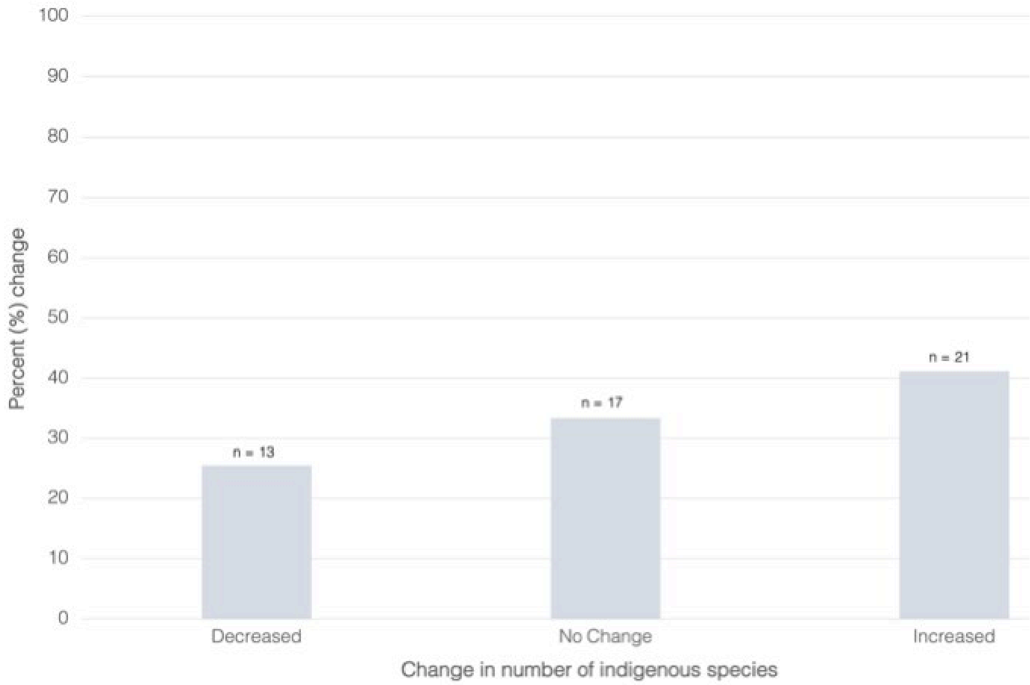

Figure 26: Change in indigenous forest bird presence: Percentage of plots (n = 51) where the number of indigenous forest bird species decreased, stayed the same, or increased between first (2014–2016) and second (2019–2022) monitoring rounds. A change in species number of 10% or greater is graphed as a change (increase or decrease). *Source*: Raw data obtained from GWRC Environmental Monitoring Portal.[53]

7.1.2 Wellington City

McArthur et al. (2022) undertook annual monitoring of birds at 100 bird count stations randomly established within forest habitat throughout the park and reserve network within Wellington City between 2011 and 2021 (see Figure 50 in Appendix 1 for location of stations). A five-minute bird count was carried out at each station on a fine, calm day in early November and early January of each year (total of two bird counts at each station each year). Data collection methods, modelling approach, and data analysis are detailed in McArthur et al. 2022.

A total of forty-eight bird species were detected during the ten years of monitoring of which 23 were typically found in indigenous forest habitats. The remaining species recorded were marine, coastal, or open country species. The majority (70%; n = 16) of these forest species were indigenous species. A further three indigenous species were reported by citizen scientists, bringing the total of regularly encountered indigenous species to 19 (McArthur et al. 2022).

Encounter rates of both indigenous and introduced species increased between 2011 and 2021 (Figure 27); indigenous species showed a 41% increase (from a mean of 4.9 to 6.9 (± 0.2 SE)) while introduced species increased by 34% (mean of 3.8 to 5.1 (± 0.2 SE)) in the same period (McArthur et al. 2022).

[53] https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/birds.html

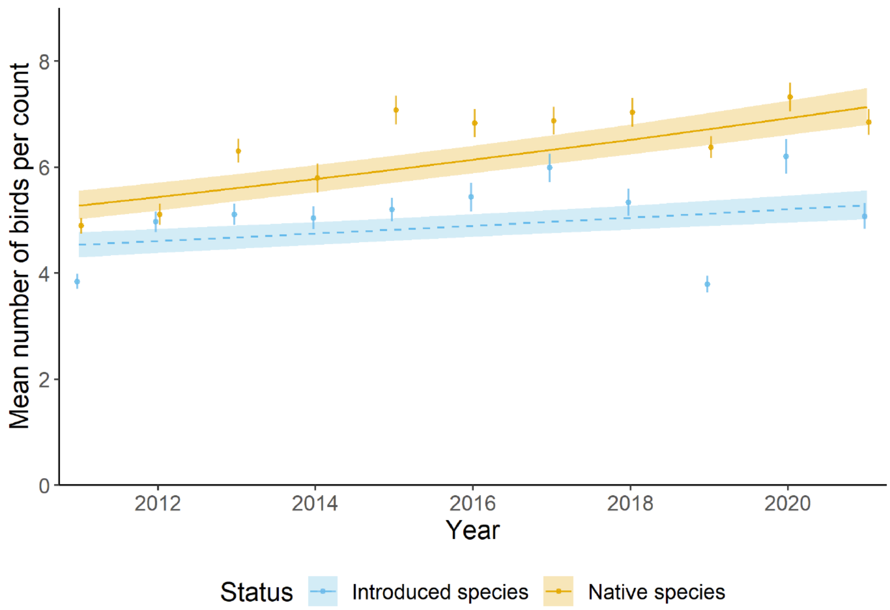

Figure 27: Trends in the mean number of indigenous and introduced birds encountered in Wellington City between 2011 and 2022. Individual data points (± SE) represent the mean number of species detected per count each year. Solid orange and dashed blue lines (± 95% CI) represent the modelled trend in the number of species recorded per count each year. *Source:* McArthur et al. 2022.

Of the 19 indigenous forest bird species recorded in Wellington City since 2011 five (26%) showed an increase, four (21%) showed no change, and two (10%) species showed a decline in encounter rates (Table 16). Kākā (270%), kereru (243%), tūī (74%), piwakawaka (fantail, Rhipidura fuliginosa) (37%) have shown substantial increases in abundance, while pīpīwharauroa and tauhou showed declines (35% and 8%, respectfully) (McArthur et al. 2022).

Table 16: Summary of population change trend for the 11 indigenous forest bird species detected on at least 55 occasions in Wellington City between 2011 and 2022. *Source*: Data from McArthur et al. 2022.

Species	Population trend		
	Increasing	No change	Decreasing
Kākā (*Nestor meridionalis*)	✓		
Kererū (*Hemiphaga novaeseelandiae*)	✓		
Tūī (*Prosthemadera novaeseelandiae*)	✓		
Pīwakawaka (fantail, *Rhipidura fuliginosa*)	✓		
Tīeke (NI Saddleback, *Philesturnus rufusater*)	✓		
Rioriro (Grey warbler, *Gerygone igata*)		✓	
Pōpokotea (Whitehead, *Mohoua albicilla*)		✓	
Kōtare (NZ kingfisher, *Todiramphus sanctus*)		✓	

Species	Population trend		
	Increasing	No change	Decreasing
Kākāriki (Red-crowned parakeet, *Cyanoramphus novaezelandiae*)		✓	
Pīpīwharauroa (Shining cuckoo, *Chrysococcyx lucidus*)			✓
Tauhou (Silvereye, *Zosterops lateralis*)			✓

McArthur et al. (2022) found that Zealandia was having a measurable 'halo' effect on indigenous forest bird species across Wellington City, although this effect decreases with distance from the sanctuary and several species (e.g., tieke, toutouwai (North Island robin, *Petroica longipes*) and pōpokotea (whitehead, *Mohoua albicilla*)) continue to have sparse and localised distributions and are largely confined to forest reserves immediately adjacent to Zealandia.

Annual counts and distribution data for every species of indigenous forest bird that has been observed in Wellington City outside of Zealandia since 2011 is provided in McArthur et al. 2022.

7.1.3 Miramar Peninsula

Between 2017 and 2022 a single five-minute bird count has been conducted at each of 84 stations on the Miramar Peninsula to monitor the response of local bird populations to pest control undertaken by Predator Free Wellington (see Figure 51 in Appendix 1 for location of stations).

A total of thirty-three bird species were detected during the five years of monitoring, twenty-two of which typically occupy terrestrial habitats. The remaining 11 species typically occupy marine, coastal, and freshwater habitats. Of the terrestrial bird species detected, just over a third (36%, 8 species) were native species indicating the bird community on Miramar Peninsula remains dominated by introduced species. An additional four native terrestrial species have been recorded by citizen scientists but have not yet been detected in five-minute bird counts. (McArthur 2023).

Encounter rates for native species showed a 71% increase (from a mean of 2.49 (±0.25 SE) to a mean of 4.26 (± 0.35 SE)) between 2017 and 2022 but a 23% decrease (from a mean of 13.38 (±0.77 SE) to a mean of 10.73 (±0.62 SE)) for introduced species over the same period (Figure 28).

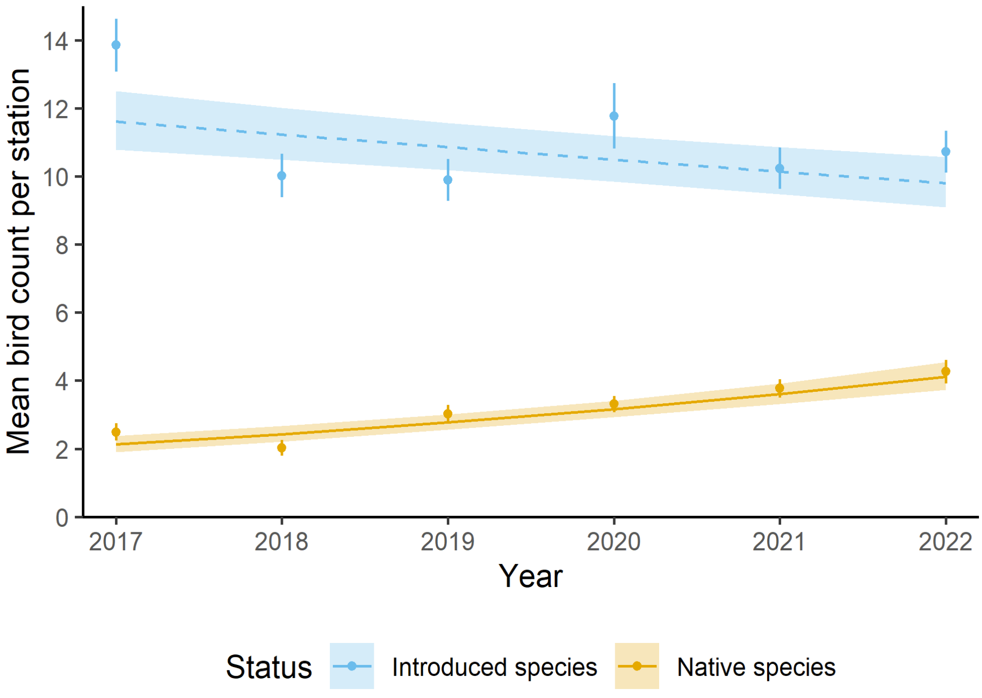

Figure 28: Trends in the mean number of indigenous and introduced birds encountered in Miramar Peninsula between 2015 and 2022. Individual data points (± SE) represent the mean number of species detected per count each year. Solid orange and dashed blue lines (± 95% CI) represent the modelled trend in the number of species recorded per count each year. *Source:* McArthur 2023.

Of the 4 most frequently encountered indigenous terrestrial bird species recorded on the Miramar Peninsula since 2017, three (75%) showed an increase and 1 (25%) showed no change in population trend (Table 17).

Table 17: Summary of population change trend for the 4 most frequently encountered indigenous forest bird species detected on Miramar Peninsula between 2017 and 2022. *Source*: McArthur 2023.

Species	Population trend		
	Increasing	No change	Decreasing
Pīwakawaka (fantail, *Rhipidura fuliginosa*)	✓		
Rioriro (Grey warbler, *Gerygone igata*)	✓		
Tūī (*Prosthemadera novaeseelandiae*)	✓		
Tauhou (Silvereye, *Zosterops lateralis*)		✓	

The increase in pīwakawaka and tūī recorded on Miramar Peninsula reflects the increase in these two species that has been recorded in parks and reserves throughout Wellington City (McArthur et al. 2023), likely due to predator control efforts across the City (and including the Peninsula). The increase in rioriro seen on Miramar Peninsula is likely to be attributable to local predator control efforts however, as this species has remained stable since 2011 elsewhere in Wellington City (McArthur 2023).

A history of the avifauna of Miramar Peninsula and encounter rates and trend data for all bird species encountered on the Peninsula between 2017 and 2022 is provided in McArthur (2023).

7.2 Wetland avifauna

A survey (see section 1.2.1 in Appendix 1) for the presence of pūweto and koitareke (marsh crake, *Porzana pusilla affinis*) was undertaken at a total of 13 wetland sites between 2016 and 2020 distributed across the five whaitua.

Pūweto were detected within all whaitua, at 69% (*n* = 9) of sites surveyed (Table 18). One individual Koitareke was detected at one site (in Kāpiti Coast whaitua).

Table 18: Pūweto detections across 13 wetland sites surveyed between 2016 and 2020.[54]

Whaitua (year surveyed) number of sites | number of plots | total area	Total number of individuals detected within Whaitua (number and percent of sites detected at)	Percent of total individuals detected across all sites *n* = 13
Eastern Wairarapa (2019/2020) 4 | 8 | 8 ha	5 (2, 50%)	15%
Kāpiti Coast (2017/2018) 3 | 19 | 152.5 ha	66 (3, 100%)	23%
Ruamāhanga (2016/2017) 3 | 7 | 37.4 ha	42 (2, 67%)	15%
Te Awarua-o-Porirua & Te Whanganui-o-Tara (2018/2019) 3 | 4 | 5.5 ha	27 (2, 67%)	15%

54 Raw data obtained from 2016/20 wetland health monitoring report accessed from https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/index.html.

FRESHWATER INDIGENOUS BIODIVERSITY

8. FRESHWATER HABITAT

8.1 River ecology

8.1.1 Macroinvertebrates

Several macroinvertebrate measures are used as indicators of the ecological health of the Region's waterways: the Macroinvertebrate Community Index (MCI) and Quantitative Macroinvertebrate Community Index (QMCI), Macroinvertebrate Average Score Per Metric (ASPM), and Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) taxa richness.

Of the 45 monitoring sites, less than 50% fall within the top two MCI Class or NOF State bands for QMCI & MCI, although 69% of sites fall within either and A or B NOF State band for APSM (Table 19).

Table 19: State data for macroinvertebrates for the 2021/22 monitoring period: Summary across MCI, QMCI, ASPM, and EPT taxa richness measures. Data presented as percentage of total monitoring sites within MCI Class (MCI), NOF State bands (QMCI & MCI and APSM) and percent cover range (EPT richness). *n* = 45.[55]

MCI			QMCI & MCI	APSM	% EPT Richness	
MCI Class	% of Sites	NOF State	% of Sites		% Range	% of Sites
A	13	A	13	29	60–80	13
B	31	B	22	40	40–60	51
C	47	C	31	18	20–40	24
D	9	D	33	13	0–20	11

Of the 45 monitored sites only just over a quarter (27%, *n* = 12) meet the NRP objective for MCI. For these sites the direction of change is indeterminate for 50% (*n* = 6) of sites over the 10-year trend period, but only 25% (*n* = 3) of sites over the 15-year trend period. Two sites (17%) are likely improving over both the 10-year and 15-year trend period, with an additional two sites very likely improving over the 15-year trend period. In contrast, nearly three-quarters (73%, *n* = 33) of monitored sites did not meet the NRP objectives for MCI. The trend is indeterminate at a third (*n* = 11) of sites over the 10-year trend period and 21% (*n* = 7) of sites over the 15-year trend period. More sites are likely or very likely improving than likely or very likely to be degrading over both 10-year and 15-year trend periods (Figure 29).

55 Raw data obtained from https://www.gw.govt.nz/annual-monitoring-reports/river-water-quality-and-ecology/ecology.html.

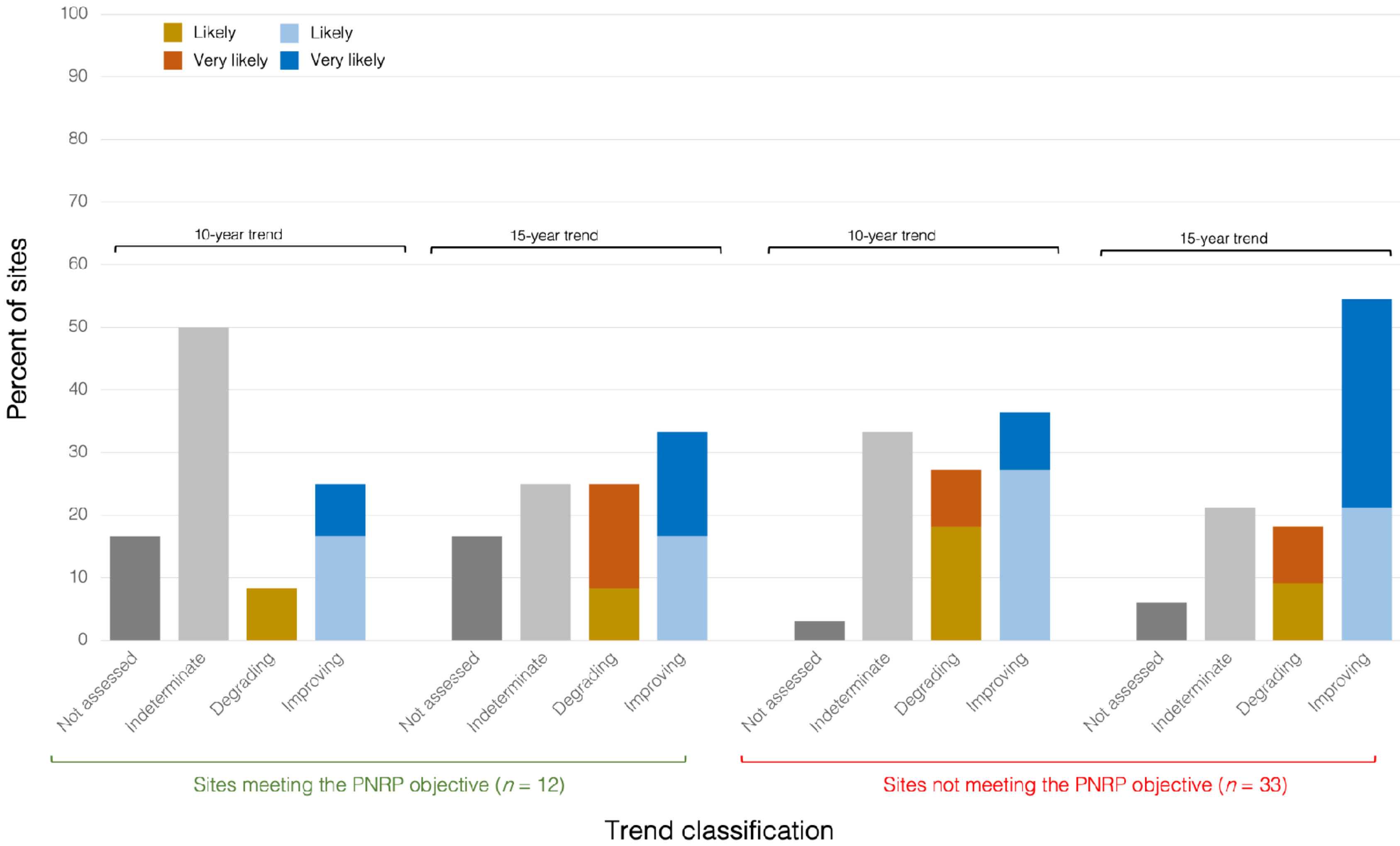

Figure 29: Trend analysis of Macroinvertebrate Community Index (MCI): Percentage of monitoring sites likely or very likely to be improving or degrading in MCI assessment over a 10-year and 15-year trend period, sites differentiated by whether they meet, or do not meet, the PNRP objective for MCI.[56]

56 Raw data extracted from https://www.gw.govt.nz/annual-monitoring-reports/river-water-quality-and-ecology/ecology.html.

8.1.2 Periphyton and cyanobacteria

The majority of sites (73%) fall within either NOF State Band C or D for periphyton biomass, although nearly a third of sites (32%) fell in the 0–20 % range for periphyton cover. Most sites (80%) fell in the 0-20% range for cyanobacteria cover (Table 20).

Table 20: State data for periphyton and cyanobacteria for the 2021/22 monitoring period. Summary of periphyton cover and biomass and cyanobacteria cover. Data presented as percentage of total monitoring sites within each NOF State bands for periphyton biomass and percent cover range for periphyton and cyanobacteria cover. *Source*: Raw data obtained from GWRC Environmental Monitoring Portal.[57]

Periphyton biomass		Periphyton cover		Cyanobacteria cover	
NOF State (8% or 17% of samples)	% of Sites (n = 15)	Max WCC (%)	% of Sites (n = 38)	Max cover (%)	% of Sites (n = 45)
A (n ≤ 50 mg/m^{3})	20	0–20	32	0–20	80
B (n > 50 mg/m^{3})	7	20–40	13	20–40	16
C (n > 120 mg/m^{3})	40	40–60	21	40–60	2
D (n > 200 mg/m^{3})	33	60–80	21	60–80	2
		80–100	13		

Trend data for periphyton and cyanobacteria is not available.

8.1.3 Habitat

A composite habitat score is used to indicate the availability of aquatic habitat at the regionally monitored sites. The score includes assessment of deposited sediment, invertebrate habitat diversity, invertebrate habitat abundance, fish cover diversity and abundance, hydraulic heterogeneity, bank erosion, bank vegetation, riparian width, and riparian shade. The habitat score is out of a maximum of 100, the higher the score the better quality the habitat.

Over half (57%) of the monitored sites had an overall habitat score of between 60 and 80 (out of 100), with a further 16% of sites scoring between 80 and 100 (Figure 30). The lowest habitat score was 29, the highest 98, and the median habitat score was 69.

57 https://www.gw.govt.nz/annual-monitoring-reports/river-water-quality-and-ecology/ecology.html.

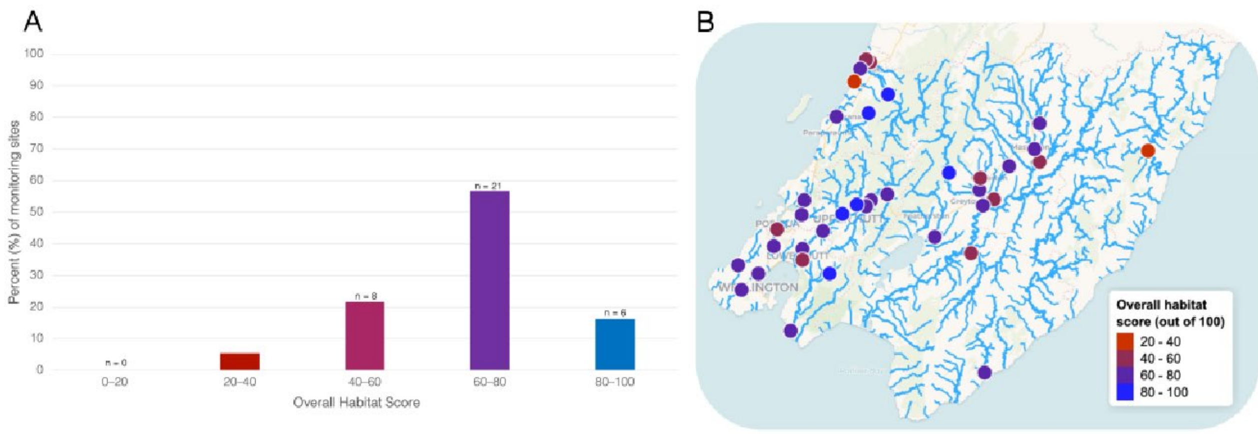

Figure 30: State of aquatic habitat for the 2021/22 monitoring period: Panel A shows percentage of total monitoring sites (n = 37) within each Overall Habitat Score range; Panel B shows the location of monitored sites and the Overall Habitat Score range for each monitoring site.[58]

Habitat condition was also sampled at 41 sites within urban stream catchments within Wellington City in either 2016/2017 (8 sites); 2017/2018 (24 sites) or 2018/2019 (14 sites).[59] Habitat scores ranged from Fair (33.5) to Excellent (94), with a median score of 73 (Good) (Harrison 2019). Just over half (51% n = 21) of sites were of Good quality with a Total Habitat Score falling between 70 and 90 (Figure 31).

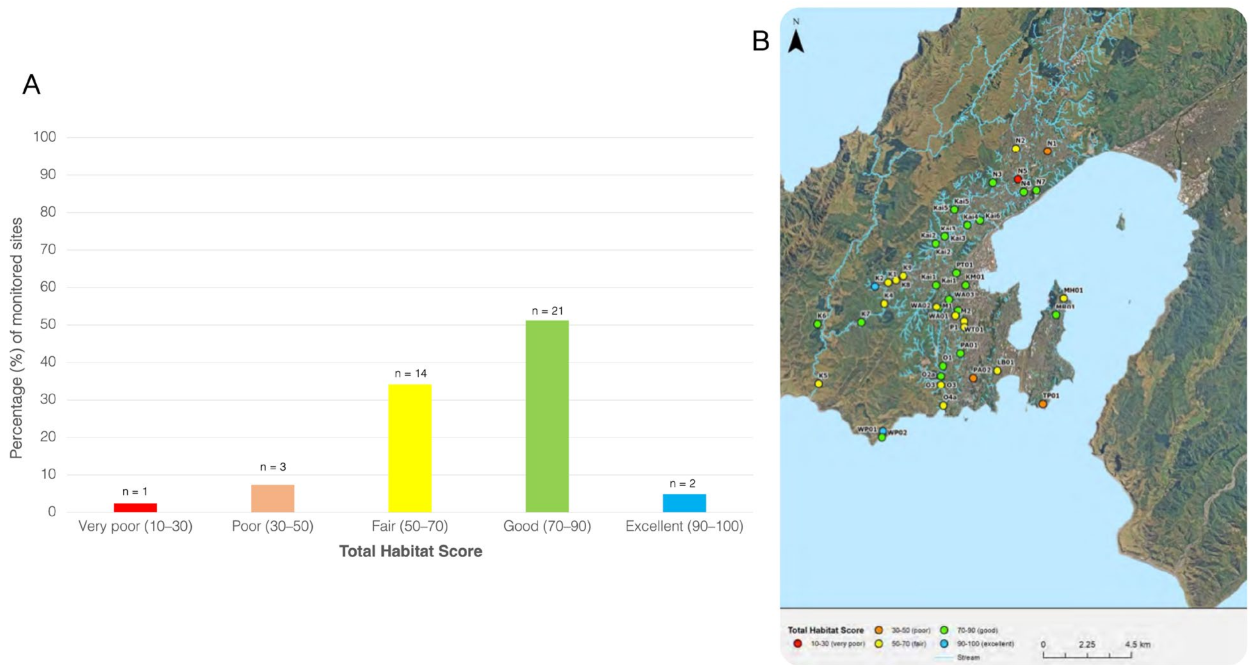

Figure 31: State of aquatic habitat (urban streams): Panel A shows percentage of total monitoring sites (n = 41) within each Total Habitat Score range and quality ranking; Panel B shows the location of monitored sites and the Total Habitat Score range for each site.[60]

58 Raw data and map obtained from https://www.gw.govt.nz/annual-monitoring-reports/river-water-quality-and-ecology/ecology.html.

59 Five sites were surveyed twice, once in 2016/2017 and once in 2017/2018.

60 Map sourced from Harrison (2019), raw data obtained from map.

8.2 Lake ecology

Indigenous dominance and invasive plant presence is measured in lakes using the LakeSPI method (Clayton & Edwards 2006) which includes three indices (Indigenous Condition, Invasive Impact, and Overall Condition)[61]. The Overall Condition Index is used to categorise lake condition as either Excellent, High, Moderate, or Poor.

The most recent LakeSPI monitoring was undertaken in 2019 (2 sites) and 2022 (9 sites). The data is summarised together here. Nearly a quarter (73%, *n* = 8) of surveyed lakes fall within the NOF Band B for Indigenous Condition. However, nearly three quarters of surveyed lakes fall within the NOP Bands C (60%, *n* = 6) or D (10%, *n* = 1) (Table 21).

Table 21: Summary of the Indigenous Condition index and Invasive Impact index of lake sites within the Wellington Region monitored in 2019 or 2022.

NOF State	Percent of sites (number of sites)	
	Indigenous Condition (*n* = 11)	Invasive Impact (*n* = 10)
A	9 (1)	0
B	73 (8)	30 (3)
C	0 (0)	60 (6)
D	18 (2)	10 (1)

Of the 11 lakes, nearly half (45%, *n* = 5) had an Overall Condition category of 'High', and over a quarter (25%, *n* = 3) had an Overall Condition of 'Moderate'. Only one (Lake Kohangatera, in Wainuiomata) was in an 'Excellent' Overall Condition (Table 22).

Table 22: Summary of the Overall Condition index of lake sites within the Wellington Region monitored in 2019 or 2022 (*n* = 11).

Overall Condition (% of maximum potential score)	Percent of sites (number of sites)
Excellent (>75)	9 (1)
High (>50–75)	45 (5)
Moderate (>20–50)	27 (3)
Poor (>0–20)	9% (1)
Non-vegetated (0)	9% (1)

61 See Appendix 1 for details on methods and attribute definitions.

9. FRESHWATER FAUNA

9.1 Freshwater species

At least 22 species of indigenous freshwater fish are known to occur in the freshwater ecosystems within the Region[62], over half (55%) of which are classified as Nationally Threatened. On a regional level 64% of these species are classified as Regionally Threatened or At Risk.

Freshwater fish were surveyed at a total of 45 plots across 12 monitoring sites. Surveys were conducted once at three sites within each Whaitua on a rolling basis from 2016/2017 to 2019/2020. The Te Awarua-o-Porirua and Te Whanganui-a-Tara Whaitua were combined, with three sites surveyed in 2018/2019. Ten freshwater fish species were detected during these surveys, half of which are listed Regionally Threatened (Regionally Vulnerable) or At Risk (Regionally Declining) (Table 23).

Table 23: Regional threat status for the ten freshwater fish species found during regional monitoring between 2016/2017 and 2019/2020. See Figure 7 for Regional Threat Classification System.

Species detected at monitoring sites	Regional threat status (Crisp et al. 2022)
Brown mudfish (*Neochanna apoda*)	Regionally Vulnerable
Dwarf galaxias (*Galaxias divergens*)	Regionally Declining
Īnanga (*Galaxias maculatus*)	
Longfin eel (*Anguilla dieffenbachii*)	
Giant bully (*Gobiomorphus gobioides*)	
Redfin bully (*Gobiomorphus huttoni*)	Regionally Not Threatened
Banded kōkopu (*Galaxias fasciatus*)	
Common bully (*Gobiomorphus cotidianus*)	
Shortfin eel (*Anguilla australis*)	
Upland bully (*Gobiomorphus aff. breviceps*)	

Only common bully and shortfin eel were detected within each of the four Whaitua (Figure 32).[63] Kōura (freshwater crayfish, *Paranephrops* species) were also detected within one site in the Ruamāhanga Whaitua, but the species was not recorded. The introduced Southern bell frog (*Litoria raniformis*) was also detected in the survey from one site in the Eastern Wairarapa Whaitua.

[62] Guest & Denton 2018.

[63] The estuarine species aua (mullet, *Aldrichetta* species) and estuarine triplefin (*Forsterygion nigripenne*, Not threatened) were also detected at one site within Te Awarua-o-Porirua Harbour & Te Whanganui-a-Tara Whaitua. Grey mullet is classified as Regionally Declining, yellow-eyed mullet as Not threatened. The species of mullet detected during the survey was not recorded.

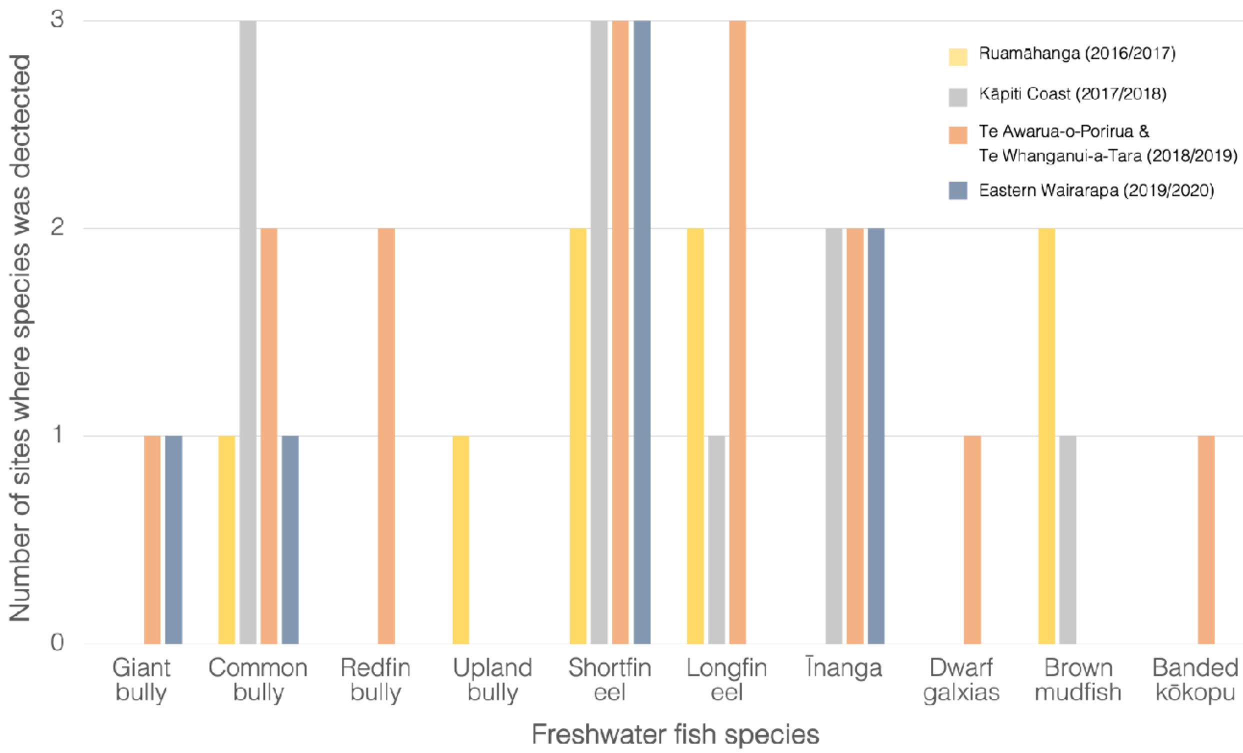

Figure 32: Freshwater fish species occupancy: Number of sites each species detected shown by Whaitua. Sampling effort as follows: Ruamāhanga: 7 plots across 3 sites, total plot area = 37.4 ha; Kāpiti Coast = 19 plots across 3 sites, total plot area = 152.5 ha; Te Awarua-o-Porirua & Te Whanganui-a-Tara: 13 plots across three sites, total plot area = 130.8 ha; Eastern Wairarapa: 6 plots across 3 sites, total plot area = 5.4 ha. Time period in brackets indicates the season survey was undertaken for each Whaitua. *Source*: Raw data sourced from GWRC Environmental Monitoring Portal[64].

Recently collected fish data is also available for urban catchments in Wellington City (Figure 33), collected between 2016 and 2019 (Harrison 2019). Longfin eel, banded kōkopu, kōura, and kōaro were the most commonly encountered species. Of the 19 species freshwater fish species present in urban streams in between 2016–2019, 63% were Regionally Threatened species.

64 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/faunal-survey.html

	RD	RNT	RNT	RV	RE	–	RD	RD	RNT	RNT	RNT	RD	RNT	–	–	RD	–	–	–
Catchment	Longfin eel	Shortfin eel	Banded kokopu	Giant kokopu	Shortjaw kokopu	Unidentified kokopu	Koaro	Inanga	Upland bully	Giant Bully	Redfin bully	Black flounder	Triplefin	Koura	Trout	Grey mullet	Unidentified eel	Unidentified galaxiid	Unidentified fish
Kaiwharawhara*	22	3	107	1		1				1	6	1	1	13			22		
Kumutoto			26				14												
Owhiro	54	15	15					7			14			3	2	1	1		
Karori	54	2	15	1			29		33					14	1		24		
Ngauranga	35	1	7				5	15						2			10		
Motoroa			5				6							2					
Lyall Bay	4	1	40											20					
Mahanga																	1		
Miramar		1	50											4					
Paikawakawa			12											22					
Pipitea	4		9				4							6			4		3
Te Poti														1			1		
Waimapihi			17				5							103				4	5
Waipapa	23	4	5	1	1		22							1				1	
Waitangi			6											28					
Wadestown	1		10																

Figure 33: Indigenous fish and kōura species present in urban stream catchments, Wellington City: Summary of species and number of individuals identified using electric fishing and spotlighting methods from 2016 to 2019. *Data from fishing conducted in 2018 and 2019. *Source*: Table extracted from Harrison 2019; annotated with Regional Threat Status: RE = Regionally Endangered; RV = Regionally Vulnerable; RD = Regionally Declining; RNT = Regionally Not Threatened (see Figure 7 for Regional Threat Classification System).

9.2 Freshwater habitats of significance for indigenous birds

A panel of ornithological experts identified freshwater sites within the Wellington Region that held significant biodiversity values for indigenous birds for the purposes of inclusion in the NRP (McArthur et al. 2015). Sites were identified based on species distribution and abundance data for Threatened and At risk species[65] and a set of criteria (McArthur et al. 2015) as follows:

- Rarity. The site provides habitat for ≥5% of the regional population of a Threatened or At risk species.
- Diversity. Four or more Threatened or At risk species are known to be resident at or regularly using the site.
- Ecological context. The site provides seasonal or core habitat for ≥33% of the regional population of a protected[66] (but not Threatened or At risk) species.

Eight sites in the beds of rivers and three lakes sites and their adjacent wetlands (Lake Onoke, Lake Wairarapa, and Parangarahu Lakes) were identified as providing habitat of significance for indigenous birds within the Wellington Region (Table 24).

Table 24: Summary of number of areas of meeting at least one of the sites of significance criteria, and therefore identified as a freshwater habitat of significance for indigenous birds. *Source*: Data from McArthur et al. 2015).

	Number of sites that meet criteria:					
	Rarity	Diversity	Ecological context	Rarity and Diversity	Rarity, Diversity, and Ecological context	Total
River habitats	1	4	0	3	0	8
Lake habitats	0	1	0	1	1	3

Lake Wairarapa (which forms part of the Wairarapa Moana Ramsar wetland site) was the only lake site to meet all three criteria, further illustrating the particular importance of the area for providing freshwater habitat for Threatened and At risk bird species (McArthur et al. 2015).

Three riverbed sites provided particularly significant habitat. These were a large site in bed of the Opouawe River (and its tributaries) and a site in the Ruamāhanga River site both of which support regionally significant breeding populations of banded dotterels, and another site in the Ruamāhanga River that supports the only breeding colony of black-billed gulls in the Wellington Region (McArthur et al. 2015).

65 Following the New Zealand Threat Classification threat classifications (Townsend et al. 2008) and as listed in Robertson et al. (2013).

66 Under the Wildlife Act 1953.

COASTAL AND MARINE INDIGENOUS BIODIVERSITY

A summary of the most recent (last ten years) coastal and marine monitoring conducted in the Wellington Region is provided in Table 25. Locations of the monitoring sites are shown in Figure 34.

Table 25: Summary of recent coastal monitoring in Wellington Region. Sampling locations, regime, and methods are detailed in the corresponding reference. The most recent reports of annual monitoring programmes are referenced here, for previous years see GWRC Environmental Monitoring Portal[67].

Location	Zone (number of monitoring sites)	Monitoring target	Frequency	Monitoring year	Reference
Te Awarua-o-Porirua Harbour	Subtidal (5)	Benthic community health; sediment quality	5-yearly (Fine scale)	2020	Cummings et al. 2021
	Intertidal (4)	Benthic community health; sediment quality	5-yearly (Fine scale)	2020	Forrest et al. 2020
	Intertidal (9) Subtidal (9)	Sedimentation	Annual	2020/2021	Roberts et al. 2021
	Bathymetric	Sediment movement	Ad-hoc	2019	Waller 2019
	Estuary	Habitat mapping; vegetation composition; macroalgae	5–10 yearly	2020	Stevens & Forrest 2020a
Te Whanganui-a-Tara Harbour	Subtidal (15)	Seafloor community health; sediment quality	5-yearly (Fine scale), 1 site annually	2020	Cummings et al. 2022
	Rocky shore (1)	Habitat characterisation	Targeted	2018	Stevens 2018c
Te Whanganui-a-Tara Whaitua estuaries	Estuary	Habitat maps; ecological condition	Targeted	2018	Stevens 2018a
Hutt Estuary	Intertidal (1)	Sedimentation	Annual	2020/2021	Roberts 2021a
	Intertidal	Macroalgal growth	Annual	2020	Stevens & Forrest 2020b
Waikanae Estuary	Intertidal (3)	Sedimentation	Annual	2020/2021	Roberts 2021b

67 https://www.gw.govt.nz/annual-monitoring-reports/coastal-water-quality-and-ecology/index.html.

Location	Zone (number of monitoring sites)	Monitoring target	Frequency	Monitoring year	Reference
Kāpiti Island	Rocky shore (3)	Habitat characterisation; Species presence	Targeted	2019	Forrest & Stevens 2019b
Mana Island	Rocky shore (1)		Targeted		
Castlepoint	Beach	Ecological condition	Targeted	2013/2014	Robertson & Stevens 2014
Peka Peka	Beach	Ecological condition	Targeted	2014/2015	Robertson & Stevens 2015
Paraparaumu Beach; Waikanae Beach	Beach	Ecological health; macrofaunal assemblage; species richness	Targeted	2019	Forrest & Stevens 2019a
Petone Beach; Lyall Bay; Owhiro Bay	Beach	Habitat characterisation; species richness	Targeted	2018	Stevens 2018b
Kāpiti Coast Whaitua estuaries	Estuarine (9)	Ecological condition	Targeted	2019	Stevens & Forrest 2019
Wairarapa estuaries	Estuarine (25)	Ecological condition	Targeted	2022	Roberts et al. 2023
Flat Head	Rocky shore (3)	Habitat characterisation, community composition	Targeted	2016/2017	Stevens & O'Neill-Stevens 2017
Baring Head	Rocky shore (1)	Habitat characterisation	Targeted	2018	Stevens 2018c
Mākara	Rocky shore (1)	Habitat characterisation	Targeted	2018	Stevens 2018c
	Estuary	Habitat maps; ecological condition	Targeted	2018	Stevens 2018a

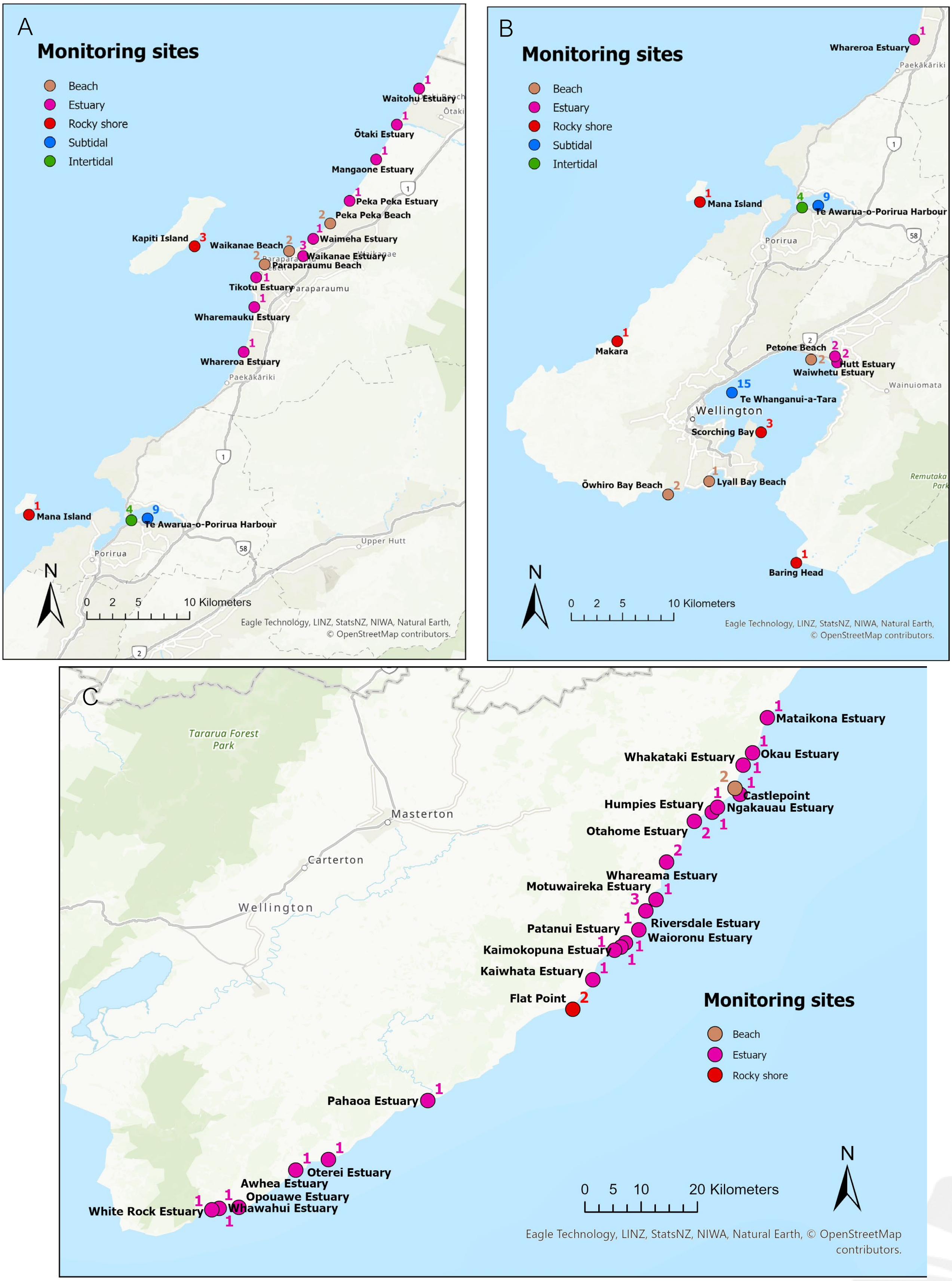

Figure 34: Locations of recent (past 10 years) coastal monitoring conducted on the west coast (A), south-west coast (B) and east coast (C) in the Wellington Region. The numbers shown represent the number of sites surveyed at each location. Sources listed in Table 25.

10. ESTUARINE HABITAT

Estuarine habitat is relatively rare in Wellington Region and has experienced extensive modification (Stevens 2018a), making it vulnerable to continued detrimental impact. GWRC has undertaken ecological condition monitoring of estuarine habitats following the National Estuary Monitoring Protocol (NEMP[68]) and annual monitoring of sediment indicators in the same estuaries, as well as other monitoring in estuarine habitat on occasion (see Table 25). The NEMP involves both broad-scale (undertaken every 5 to 10 years) to describe and map dominant habitat features (substrate and vegetation) within an estuary, and fine-scale (on a 5-yearly cycle) monitoring of benthic indicators including biological attributes (e.g., macrofauna) and physico-chemical characteristics (e.g., sediment mud content, trace metals, nutrients) (Forrest et al. 2020).

Estuary condition is assessed against condition ratings which have been established (or are developing) for each indicator to assign 'health status' (Table 26).

Table 26: Summary of condition ratings for estuarine health indicators AMBI = AZTI Marine Biotic Index; from Roberts et al. 2021 & Forrest et al. 2020.

Indicator	Unit	Very Good	Good	Fair	Poor
General indicators:[69]					
Sediment rate	mm/yr	<0.5	≥0.5 to < 1	≥1 to <2	≥2
Mud content	%	<5	5 to <10	10 to <25	≥25
aRPD	mm	≥50	20 to < 50	10 to <20	<10
AMBI	n/a	0 to 1.2	>1.2 to 3.3	>3.3 to 4.3	≥4.3

10.1 Mud extent

Sediment transects in Te Awarua-o-Porirua Harbour have been monitored annually since 2013 to track the spatial extent of mud-dominated sediment[70]. Since monitoring began, soft muds have extended towards the shoreline. The largest changes were recorded at Kakaho (380 m from starting baseline), Horokiri (75 m) sites (both in the Pāuatahanui Inlet, and at the Titahi (66 m) site in the Onepoto Inlet. The increase at Kakaho is consistent with the increased sediment accretion observed at both subtidal and intertidal Kakaho sites (Roberts et al. 2021).

Following widespread deposition of soft muds in the north and east of Pāuatahanui Inlet, in January 2020, mud extent in these areas of Te Awarua-o-Porirua Harbour was remapped in December of 2020. This showed a large decrease in the extent of mud elevated (25–50% mud) substrate (Table 27), indicating the large mud deposits previously recorded were remobilised sometime between January and December.

Table 27: Hectares of intertidal mud in the northern Pāuatahanui Inlet of Te Awarua-o-Porirua Harbour. *Source:* Roberts et al. 2021.

	Hectares (ha)	
	Jan-20	Dec-20

68 Robertson et al. 2002.
69 Ratings derived or modified as follows:
Sedimentation rate: Townsend & Lohrer 2015.; Mud content: Robertson et al. 2016a; aRPD: FGDC 2012; AMBI: Borja et al. 2000
70 See Figure 57 in Appendix 1 for transect locations.

Mud elevated (25–50% mud)	36.0	11.4
Mud-dominated (50–100% mud)	27.9	24.3
Total	63.9	35.7

However, Roberts et al. (2021) found that while there has been some intertidal recovery from widespread deposition of soft muds recorded in January of 2020, there had also been degradation in new areas and note that intertidal improvements likely reflect a degradation of subtidal areas.

Monitoring of nine Kāpiti estuaries in 2019 found that seven of the estuaries (Waitohu, Mangaone, Peka Peka, Waimeha, Tikotu, Wharemakau and Whareroa) had 0% intertidal soft mud extent (i.e., no areas with >25% mud). However, Waikanae and Ōtaki had 6% and 14% intertidal soft mud extent, respectively (Stevens and Forrest 2019).

Mud extent was also recorded for 25 estuaries along the Wairarapa coast in 2022. The extent of mud varied greatly, ranging from an absence of substrate with >50% mud content (14 estuaries) to ~60% of the estuary area with substrate containing >50% mud (Table 28).

Table 28: Mud extent at 25 Wairarapa coast estuaries monitored in 2022. ^Values missing for Otahome South as incorrectly recorded in draft report. *Source*: Data sourced from Roberts et al. (2023).

Estuary	Total area (ha)	Mud extent (>50% mud content)	
		Area (ha)	%
Mātaikona	12.5	0.2	2.1
Ōkau	1	0	0
Whakataki	3.9	0.02	1
Castlepoint	0.2	0	0
Ngākauau	4.3	0.04	1.4
Humpies	1	0.08	9.3
Otahome	1.9	0.4	29.2
Otahome South^	0.2	-	-
Whareama	74.4	10.7	53
Motuwaireka	6.5	0.1	3.1
Riversdale North	0.06	0	0
Riversdale Centre	0.04	0	0
Riversdale South	0.11	0	0
Waioronu	1.4	0	0
Patanui	1	0	0
Waikaraka	1.3	0.3	61.3
Kaimokopuna	1.6	0.1	7.6
Kaiwhata	4.1	0	0
Te Unu Unu (Flat Point)	0.4	0	0
Pāhāoa	24.5	0.1	0.9
Rerewhakaaitu	5	0	0
Ōterei	6.2	0.03	2.6
Āwhea	4	0.06	21.7
Āwheaiti	1	0	0

Estuary	Total area (ha)	Mud extent (>50% mud content) Area (ha)	%
Ōpouawe	12	0	0
Whawanui	8.4	0	0
White Rock	6.4	0	0

10.2 Opportunistic macroalgae

Intertidal opportunistic macroalgae growth is used as an indicator of estuary eutrophication and GWRC has undertaken annual monitoring in Hutt Estuary and Te Awarua-o-Porirua Harbour, as well as macroalgae monitoring in nine Kāpiti estuaries in 2019 and 25 Wairarapa coast estuaries in 2022. The environmental quality status has improved for the Hutt Estuary from 'poor' in 2015 to 'moderate' in 2020. There was also an improvement in environmental quality status recorded for Te Awarua-a-Porirua Harbour, which shifted from 'moderate' to 'good' (Table 29).

Table 29: Summary of change in EQR scores and environmental quality status for Hutt Estuary and Te Awarua-o-Porirua Harbour between 2015 and 2020. EQR = Ecological Quality Rating. *Source*: Stevens & Forrest 2020a (Te Awarua-o-Porirua Harbour), 2020b (Hutt Estuary).

	Hutt Estuary		Te Awarua-o-Porirua Harbour	
Year	EQR	Environmental quality status	EQR	Environmental quality status
2015	0.386	Poor	0.58	Moderate
2016	0.400	Poor	0.61	Good
2017	0.581	Moderate	0.55	Moderate
2018	0.594	Moderate	–	–
2020	0.424	Moderate	0.71	Good

Nuisance macroalgae (seaweeds) were present (low prevalence) at all sites across all years of the fine-scale monitoring sites within Te Awarua-o-Porirua Harbour sites, with the exception of 2020 when there was an apparent 'bloom' of a filamentous green mat-forming species near outer harbour at two of the sample sites (Forrest et al. 2020). Black anoxic sediment and dead cockles were evident under these macroalgal mats, indicating that the mats were detrimentally smothering the underlying sediments (Forrest et al. 2020).

The 2019 EQR score for all nine Kāpiti estuaries was 1 (Stevens and Forrest 2019) and all were therefore categorised as having a Very Good environmental quality status, indicating very little opportunistic macroalgae growth due to eutrophication across all sites.

No macroalgae were detected at any of the annual surveys undertaken at Whareama estuary between 2008 and 2016 or in a more recent survey in 2022. The other Wairarapa coast estuaries monitored in 2022 had no macroalgae cover >50%, except for Mātaikona Estuary where macroalgae cover >50% was recorded as present in 0.8% of the estuary (Roberts et al. 2023).

10.3 Intertidal habitat condition

10.3.1 Intertidal substrates

Approximately 265 ha of substrate in Te Awarua-o-Porirua Harbour was mapped in 2020 and found to be relatively heterogenous. The problematic (and biologically relevant) mud fraction covered ~45% (118.3 ha) (Table 30) of the tidal flat area. There has been a steady increase in the spatial extent of mud-dominated sediment over the 12-year period between 2008 and 2020, most of which occur in the eastern and northern areas of Pāuatahanui Inlet (Stevens & Forrest 2020a).

Table 30: Summary of the dominant intertidal substrates in Te Awarua-o-Porirua Harbour, 2020. *Source*: Stevens & Forrest 2020a.

Subclass	Dominant feature	Ha	%
Artificial	Artificial substrate	2.0	0.7
Bedrock	Rock field	4.9	1.8
Boulder/Cobble/Gravel	Boulder field	0.1	0.0
	Artificial boulder field	0.6	0.23
	Cobble field	4.2	1.6
	Artificial cobble field	0.1	0.05
	Gravel field	25.1	9.4
Sand (0-10% mud)	Mobile sand	10.1	3.8
	Firm sand	23.6	8.9
Muddy Sand (>10-25% mud)	Firm muddy sand	74.0	27.9
Muddy Sand (>25-50% mud)	Firm muddy sand	84.6	31.9
	Soft muddy sand	1.8	0.7
Sandy Mud (>50-90% mud)	Firm sandy mud	6.0	2.3
	Soft sandy mud	21.4	8.1
	Very soft sandy mud	4.5	1.7
Zootic	Shell bank	2.3	0.9
	Cocklebed	0.01	0.003
	Tubeworm reef	0.04	0.01
Total		**265.2**	**100**

10.3.2 Sedimentation

Rates of sedimentation deposition (mm/year) are monitored annually within the Onepoto and Pāuatahanui Inlets of Te Awarua-o-Porirua Harbour and the Hutt and Waikanae Estuaries (see Appendix 2).

Sediment plate monitoring[71] results are compared against estuarine condition ratings (Table 26). Adverse ecological effects are likely to occur when condition rating level is 'poor'.

Annual sediment plate monitoring and trend assessment indicates that mean deposition rates of sediment over the 10-year and 5-year period from 2020/2021 across all three sites is predominantly rate 'poor' (Table 31).

71 Methods are detailed in Roberts et al. 2021; Roberts 2021a, 2021b.

Table 31: Trend (10-year and 5-year) assessment of mean annual sedimentation rates measured using sedimentation plate monitoring at intertidal zones in the Wellington Region, from the 2020/2021 monitoring period. Shading indicates corresponding health status (as shown in Table 26). ^Sedimentation is measured at three sites in the Waikanae Estuary, but it is too early for trend assessment at two of the three sites. *Source:* Table adapted, and data sourced, from Roberts et al. 2021 (Te Awarua-o-Porirua Harbour); Roberts 2021a (Hutt Estuary); Roberts 2021b (Waikanae Estuary).

Site (Number of sampling sites)	10-year mean annual sedimentation rate (mm/y)	5-year mean annual sedimentation rate (mm/y)
Te Awarua-o-Porirua Harbour – Onepoto (3)	+2.5	+1.4
Te Awarua-o-Porirua Harbour – 'Pāuatahanui (6)	+1.0	+2.0
Hutt Estuary (1)	+3.1	+9.3
Waikanae Estuary (1^)	+12.9	+2.3

Te Awarua-o-Porirua Harbour has experienced ongoing and elevated sediment deposition, with recent increases in sedimentation in Te Awarua-o-Porirua Harbour likely due to land development in the catchment. Net deposition and net erosion within intertidal zones are spatially varied[72] within the two arms (Onepoto and Pāuatahanui) of the Harbour likely due to the influence of stream and stormwater outlets, the Harbour entrance, and large deposition events (Roberts et al. 2021). A bathymetric survey undertaken in 2019 also showed a positive trend in sedimentation in both the Onepoto and Pāuatahanui Inlets when compared to surveys conducted in 2014 and 2009 (Waller 2019).

The 10-year trend assessment of the sedimentation rate in the Hutt Estuary shows an initial period of erosion from 2012–2016, and steady accrual from 2016–2021. More recent sediment accrual has resulted in the increased mean sedimentation rate over the 5-year trend. The reasons for the temporal variance in erosion and accretion patterns are unclear, but may relate to altered catchment sediment inputs, or variability due to river flow conditions (Roberts 2021a).

Waikanae Estuary as experienced steady sediment accrual since 2010, although a brief period of erosion in 2017–2018 caused the rate of accrual to slow. The two monitoring sites within Waikanae Estuary for which trends in sedimentation rates cannot yet be assessed have experienced net accrual over the four years previous to the 2020 monitoring (Roberts 2021b).

Annual change in mean sediment depth relative to baseline is shown in Figure 35.

72 Mean annual change in sediment depth (mm/y ± SE) at intertidal sampling sites for the years 2009–2021 is detailed in the annual monitoring report (2020/; Figure 2, page 7.

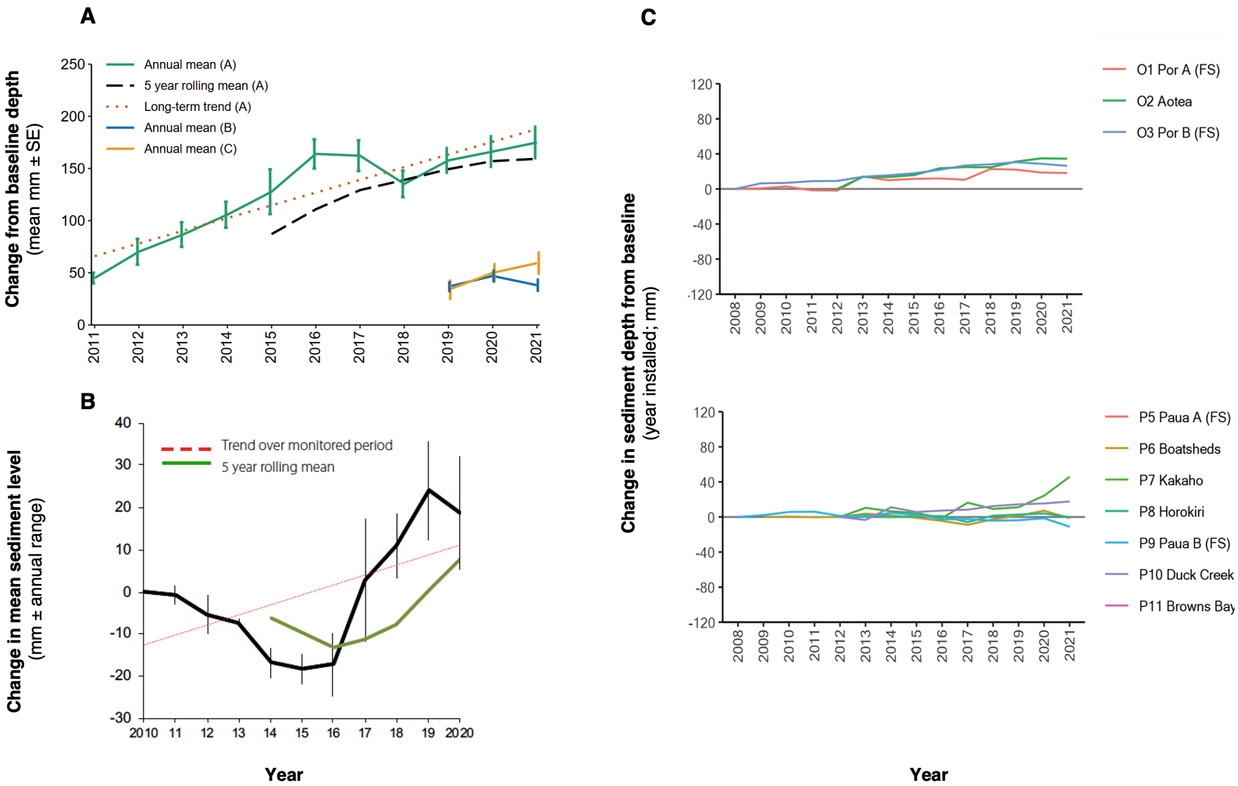

Figure 35: Change in sediment depth (mm) at intertidal zones over time within Waikanae (Panel A) and Hutt (Panel A) Estuaries and Te Awarua-o-Porirua Harbour (Panel C, top graph = Onepoto Inlet, bottom graph = Pāuatahanui Inlet) sampling sites. *Source:* Roberts 2021a & 2021b (Waikanae and Hutt Estuaries); Roberts et al. 2021 (Te Awarua-o-Porirua Harbour graphs).

Sedimentation rates have also been monitored annually from 2008-2016 at Whareama Estuary, and more recently in 2022. Sedimentation at Whareama Estuary showed a period of steady accrual between 2008 and 2016, followed by a small amount of net erosion from 2016 to 2022 (Figure 36). Net sediment accrual since over the 14 years since 2008 has been 6.8mm/yr and has an associated environmental condition rating of 'poor' (Forrest et al. 2023).

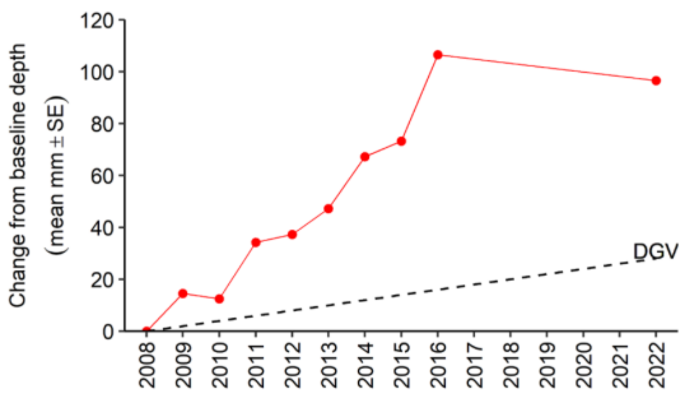

Figure 36: Mean change in sediment depth at Whareama Estuary (Site B) since the 2008 baseline. The dashed DGV lines represents accrual at the national Default Guideline Value of 2mm/yr. *Source*: Forrest et al. (2023).

10.3.3 Mud content and oxygenation

Of the ten sites within Te Awarua-o-Porirua harbour where sediment grain size was recorded in December 2020, the percentage of mud was rated 'very good' (*n* = 1) or 'good' (*n* = 6) at 70% of sites (Table 32). One site had a very high (67.3%) mud content, which was a significant increase on the previous monitoring period (Table 32, Figure 37) and corresponds with increased sediment deposition at the same sampling site (Rogers et al. 2021). Mud content (measured in 2021) at the three sampling sites in Waikanae Estuary and one site in the Hutt Estuary ranged between 11.3% and 21.0%, a condition rating of 'fair' for all four sites (Table 32). Mud content was high (58% and 79%) at two sampling sites at Whareama Estuary in 2022, giving a condition rating of 'poor' at both sites (Table 32).

Sediment oxygenation was visually assessed by measuring the apparent Redox Potential Discontinuity (aRPD) depth, being the depth at which sediments change in colour to grey/black. aRPD depths at all three sites located in the Onepoto Inlet of the Te Awarua-o-Porirua Harbour rated 'fair' (2 sites) or 'poor' (1 site). There was greater variability in aRPD depths within the Pāuatahanui Inlet of the Harbour with two sites rated as 'good', four sites rated as 'fair', and one site rated as 'poor'. The aRPD at Whareama Estuary was relatively shallow in 2022, especially at one site (mean depth ~4mm, rating 'poor'). At the other Whareama Estuary site the aRPD was deeper on average (~15 mm, rating 'fair') but was nonetheless highly variable within the site, being increasingly shallow from the land side (20-35mm, rating 'good') towards the estuary channel (5-10mm, rating 'poor'). aRPD depths at both the Waikanae and the Hutt Estuary monitoring sites rated as 'good' (Table 32).

Grain size and aRPD recorded for Te Awarua-o-Porirua Harbour are based on a single composite sample comprising 4 sub-samples collected from each site (Roberts et al. 20121). Grain size results from Waikanae and Hutt Estuaries are based on a single composite sample (Roberts 2021a, 2021b).

Table 32: Mud content and sediment oxygenation at intertidal zones in the Wellington Region. Shading indicates corresponding health status (as shown in Table 26). aRPD = Apparent Redox Potential Discontinuity. *Source:* Table adapted, and data sourced, from Roberts et al. 2021 (Te Awarua-o-Porirua Harbour); Roberts 2021a (Hutt Estuary); Roberts 2021b (Waikanae Estuary); Forrest et al. 2023 (Whareama Estuary).

Site	Monitoring period	Sampling site	% mud (g/100g dw)	aRPD depth (mm)
Te Awarua-o-Porirua Harbour	Dec-2020	O1 Por A(FS)	5.3	10
		O2 Aotea	6.2	8
		O3 Por B (FS)	8.1	15
		P5 Paua A (FS)	10.2	10
		P6 Boatsheds	11.8	8
		P7 Kakaho	67.3	30
		P8 Horokiri	5.6	10
		P9 Paua B (FS)	5.2	15
		P10 Duck Creek	2.9	17
		P11 Browns Bay	7.6	40
Waikanae Estuary	2021	A	11.3	40

Site	Monitoring period	Sampling site	% mud (g/100g dw)	aRPD depth (mm)
		B	13.7	20
		C	21.0	23
Hutt Estuary	2021	–	12.3	30
Whareama Estuary	2022	A	58	4
		B	79	15

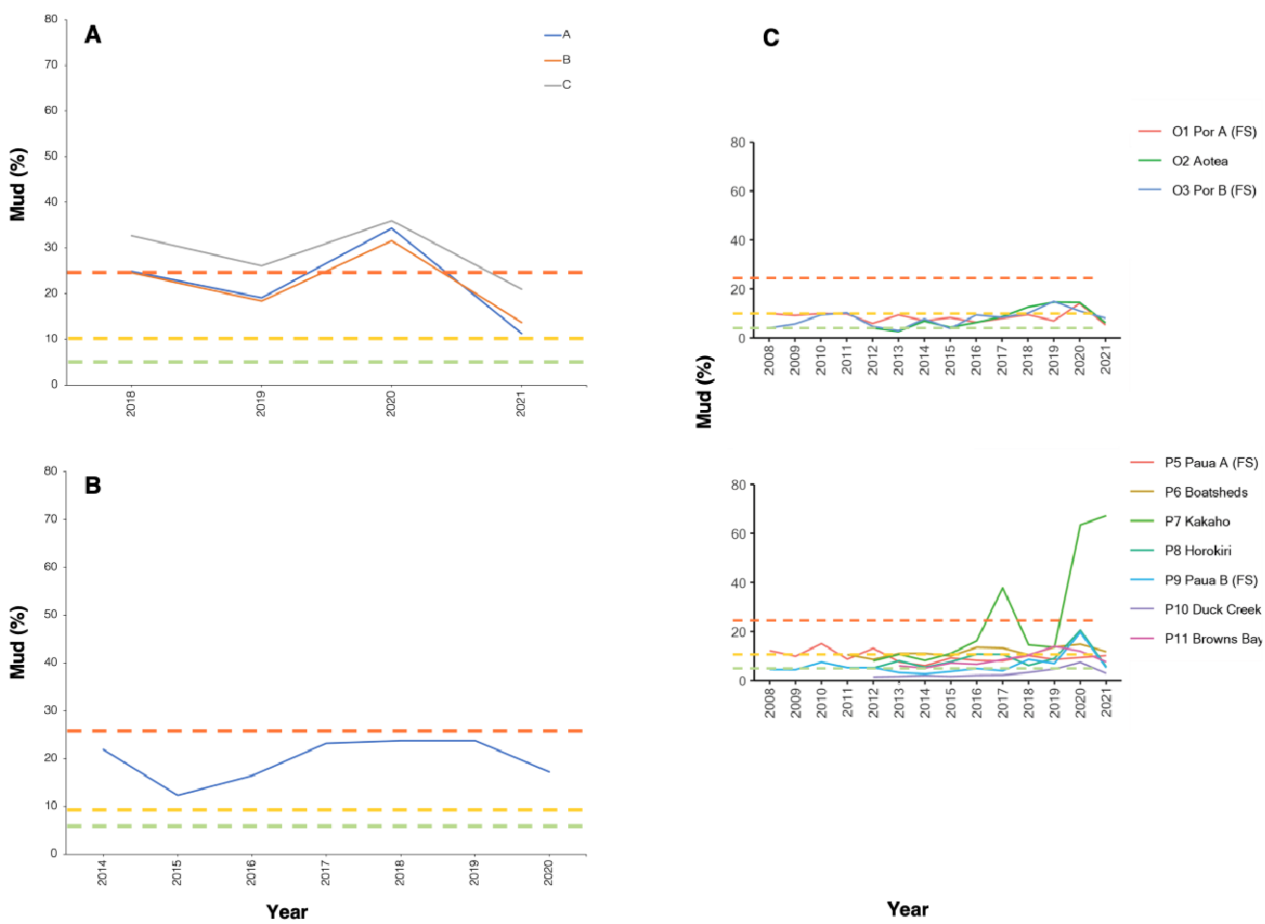

Figure 37: Change in mud content (%) at intertidal zones over time within Waikanae (Panel A) and Hutt (Panel A) Estuaries and Te Awarua-o-Porirua Harbour (Panel C, top graph = Onepoto Inlet, bottom graph = Pāuatahanui Inlet) sampling sites. Dashed lines correspond to lower threshold of condition bands (as shown in Table 26); Values below green dashed line = 'very good', above the green dashed line = 'good', above the yellow dashed line = 'fair', above the orange dashed line = 'poor'. Placement of condition band thresholds for Te Awarua-o-Porirua Harbour is indicative. 2021 results Te Awarua-o-Porirua Harbour refer to Dec-2020 monitoring. Results are based on a single composite sample. *Source:* Data for estuaries derived from Roberts 2021a & 2021b; Te Awarua-o-Porirua Harbour graphs sourced from Roberts et al. 2021, threshold lines added.

The mean sediment mud content values recorded at Whareama Estuary in 2022 were within the previous range recorded. Sampling over time has shown a slight overall trend for an increase in mud content at both sites since 2009/10 (Figure 38).

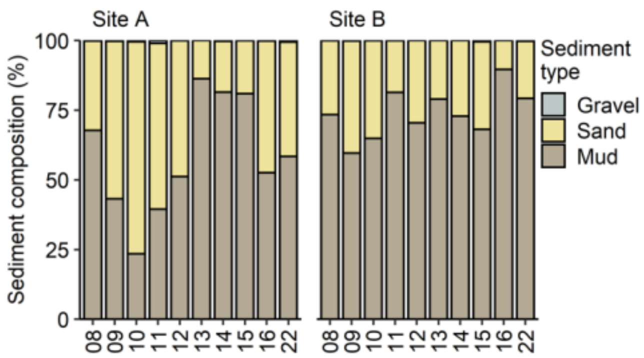

Figure 38: Percentage composition of mud, sand, and gravel over time at Whareama Estuary. *Source*: Forrest et al. 2023.

Fine-scale intertidal monitoring conducted in Te Awanui-o-Porirua Harbour has shown that in general, the depth to the aRPD transition has become shallower over time (Figure 39), with aRPD depths recorded in 2020 being similar to those recorded from the harbour-wide annual monitoring (Figure 37) for the same year, and showing signs of moderate enrichment of sediment in 2020 (Forrest et al. 2020). Mud content also showed similar trends between the fine-scale monitoring and the harbour-wide annual monitoring, ranging between 'very good' to 'fair' (Figure 39).

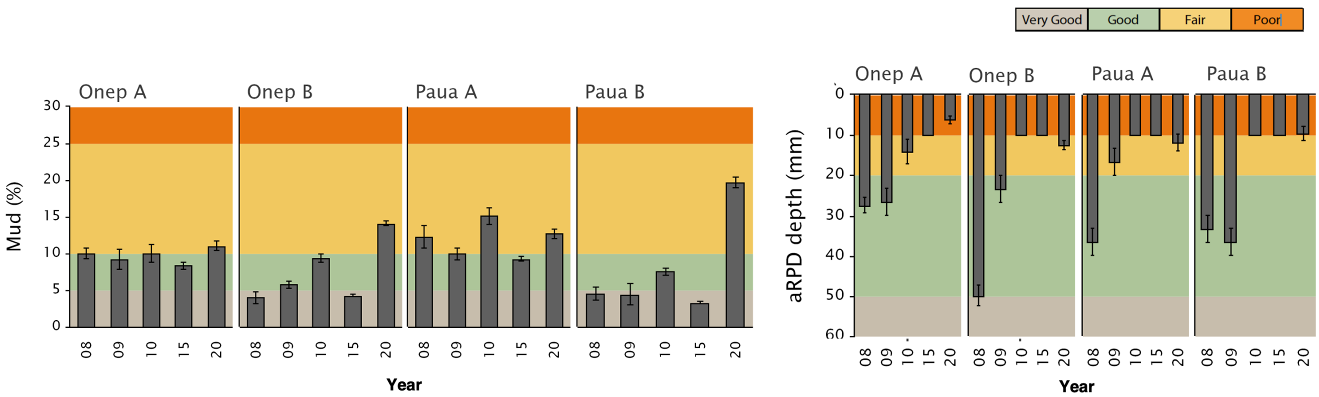

Figure 39: Mud content and aRPD depth in sediment recorded during fine-scale monitoring over five monitoring periods between 2008 and 2020 at Te Awanui-o-Porirua Harbour. Shading indicates corresponding health status (as shown in Table 26). *Source:* Adapted from Forrest et al. 2020.

Fine-scale monitoring at Whareama Estuary shows that while aRPD depth has been highly variable, in general the depth to the aRPD transition has become shallower over time (Figure 40).

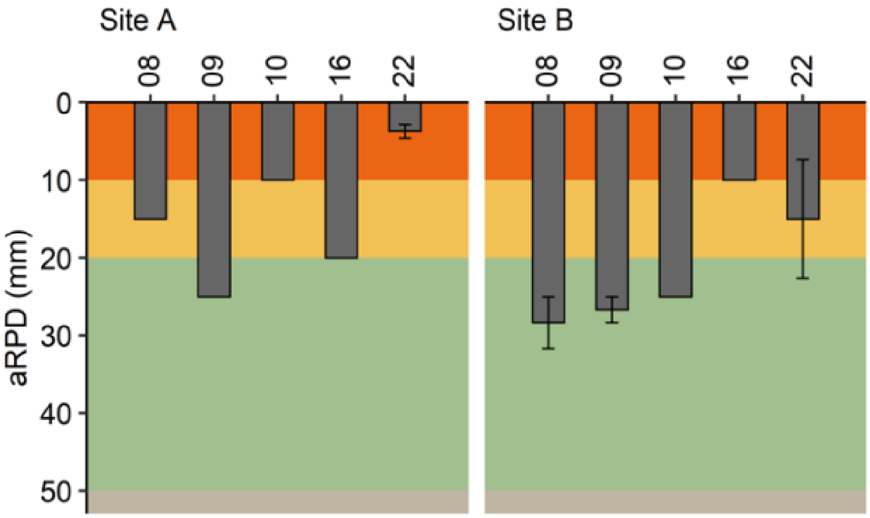

Figure 40: aRPD depth in sediment at Whareama Estuary over five monitoring periods between 2008 and 2022. Shading indicates corresponding health status (as shown in Table 26). *Source:* Forrest et al. 2023.

The aRPD depth was also measured at 8 of the 9 Kāpiti estuaries monitored in 2019 (Stevens and Forrest 2019). Five of the sites had aRPD condition ratings of 'good' and/or 'very good' (Waitohu, Ōtaki, Peka Peka, Wharemakau, Whareroa), whereas the other three sites had more variable ratings ranging from 'poor' to 'good' (Tikotu) or 'poor' to 'very good' (Waimeha, Waikanae) (Table 33).

Table 33: Sediment oxygenation (aRPD depth) recorded at Kāpiti estuaries in 2019. Shading indicates corresponding health status (as shown in Table 26). *Source:* Data sourced from Stevens and Forrest (2019).

Site	Estuary area (ha)	Sampling station	aRPD depth (mm)
Waitohu	11.2	Upper	100
		Dune	100
Ōtaki	19	TRB Otaki	NA
		N Lagoon	20
		S Lagoon	20
Mangaone	0.4	Upper Beach	NA
		Upstream	NA
Peka Peka	2.2	Upper Beach	100
		Upstream	100
Waimeha	3.6	Dune	100
		Bridge	2
		Waimeha	5
		Ngarara	5
		Upper beach	100
		Dune	100
Waikanae	37	Lagoon	3
		A	2
		Band	30
		C	100
		Main Band	5
Tikotu	0.4	Bridge	5
		Upstream	5
		Bridge	5
		Mouth	25
Wharemakau	0.55	Footbridge	30
		Road bridge	20
		Footbridge	30
		Mouth	80
Whareroa	0.9	Wall	50
		Bridge	100
		Upstream bridge	20

10.3.4 Benthic ecology

A total of 96 species or higher taxa were recorded in intertidal habitats in Te Awanui-o-Porirua Harbour across the five surveys (2008, 2009, 2010, 2015, 2020). Mean species richness was moderately high overall (12–24 species/core) but results from the 2020 survey were generally toward the lower end of the mean values recorded in previous years, and species richness has declined over the last three surveys at all but one site (Onep B). This pattern of decline is also reflected in species abundance (Forrest et al. 2020). These declines appear to be attributable to the increase in mud content (Forrest et al. 2020).

In contrast, AMBI[73] values recorded at Te Awanui-o-Porirua Harbour were within 'good' or 'very good' ecological condition ratings (Forrest et al. 2020).

Forrest et al. (2020) have shown that the 96 species recorded in intertidal habitat at Te Awanui-o-Porirua Harbour (total species across all sampling years), fall into 18 main taxonomic groups. However, only eight groups had a site-level abundance of ≥1% of the total in any one year. Polychaete worms were by far the most well-represented group, typically comprising around half of the taxa present and up to ~80% of the abundance. Bivalve shellfish also made a substantial contribution to site abundances but were represented by fewer species than gastropod snails. Other key groups represented at a lesser prevalence included small anemones, small shrimp-like amphipods, segmented worms (oligochaetes) and ribbon worms (nemerteans). The general compositional patterns across sampling sites and monitoring years, and contributions of the taxonomic groups to site richness and abundance is detailed in Forrest et al. 2020[74].

Forrest et al (2020) undertook analysis to determine the influence of sediment quality and sediment mud content on macrofaunal composition (between sites and years), finding that none of the variables associated with sediment quality and sediment mud content were strongly correlated with macrofaunal changes. However, when sampling sites were considered individually, Forrest et al. (2020) found that zones within sites were reasonably similar in macrofaunal composition but showed pronounced differences year to year. The data from 2020 appeared also showed differences between zones within sites, unlike other years. Forrest et al (2020) conclude that the most plausible driver of macrofaunal changes in 2020 at the upper estuary sites is the sediment mud content. However, Forrest et al. (2020) concluded that overall, much of the spatial and temporal variation in macrofauna assemblage cannot be explained by the environmental variables measured, indicating unknown drivers of observed variation.

Sediment core sampling at Whareama Estuary recorded 33 species (or higher taxa) over five surveys (2008, 2009, 2010, 2016, 2022). The species found were mainly hardy sediment-dwelling macrofauna. Macrofaunal richness and abundances were notably lower in the most recent 2016 and 2022 surveys. These declines in species richness and abundances were associated with increases in sediment mud content. AMBI scores were within 'fair' condition ratings for all sampling occasions, except for Site B in 2009, which was rated 'good' condition for AMBI (Forrest et al. 2023).

Smeagol climoi, a nationally threatened mollusc native to New Zealand, has been recorded on the Wellington South Coast.

---

73 The AMBI benthic index used worldwide has been strengthened for use in New Zealand through the integration of previously established, quantitative ecological group classifications through the computationally simple addition of a meaningful macrofaunal component (taxa richness), and through the derivation of classification- and breakpoint-based thresholds that delineated benthic condition along primary estuarine stressor gradients (in this case, sediment mud and total organic carbon contents). The latter was used to evaluate the applicability of existing AMBI condition bands, which were shown to accurately reflect benthic condition. (Roberts et al. 2016).

74 See for example, Section 4.5.2 and Figure 12 of Forrest et al. 2020.

10.4 Subtidal habitat condition

Subtidal habitat condition is monitored within the Onepoto and Pāuatahanui Inlets of Te Awarua-o-Porirua Harbour (see Appendix 2).

10.4.1 Sedimentation

Sedimentation within subtidal zones is monitored annually within the Onepoto and Pāuatahanui Inlets of Te Awarua-o-Porirua Harbour (see Figure 57 in Appendix 1). Annual sediment plate monitoring and trend assessment indicates that mean deposition rates of sediment over the 10-year and 5-year period from 2020/2021 within the Harbour is rated 'poor', with the exception of the 10-year mean annual rate in Onepoto inlet which corresponds to 'very good' (Table 34). This exception is primarily an artefact of the baseline commencing shortly after a large deposition event. Consequently, there was a rapid period of erosion that indicates a downward (improving) trend, but which does not capture the preceding deposition. If this had been captured, then the net trend would also be sediment deposition (Rogers et al. 2021). As with intertidal habitat, increases in sedimentation in Te Awarua-o-Porirua Harbour are likely due to land development in the catchment (Rogers et al. 2021). Mean annual change in sediment depth (mm/y ± SE) at subtidal sampling sites for the years 2009–2021 is detailed in the annual monitoring report (2020/2021).[75]

Table 34: Trend (10-year and 5-year) assessment of mean annual sedimentation rates measured using sedimentation plate monitoring at subtidal zones in Te Awarua-o-Porirua, from the 2020/2021 monitoring period. Shading indicates corresponding health status (as shown in Table 26). *Source*: Table adapted, and data sourced, from Roberts et al. 2021.

Zone (Number of sampling sites)	10-year mean annual sedimentation rate (mm/y)	5-year mean annual sedimentation rate (mm/y)
Onepoto Inlet (4)	-1.7	+7.3
Pāuatahanui Inlet (5)	+7.9	+8.3

Annual change in mean sediment depth relative to baseline is shown in Figure 41.

[75] Roberts et al. 2021; Figure 3, page 8.

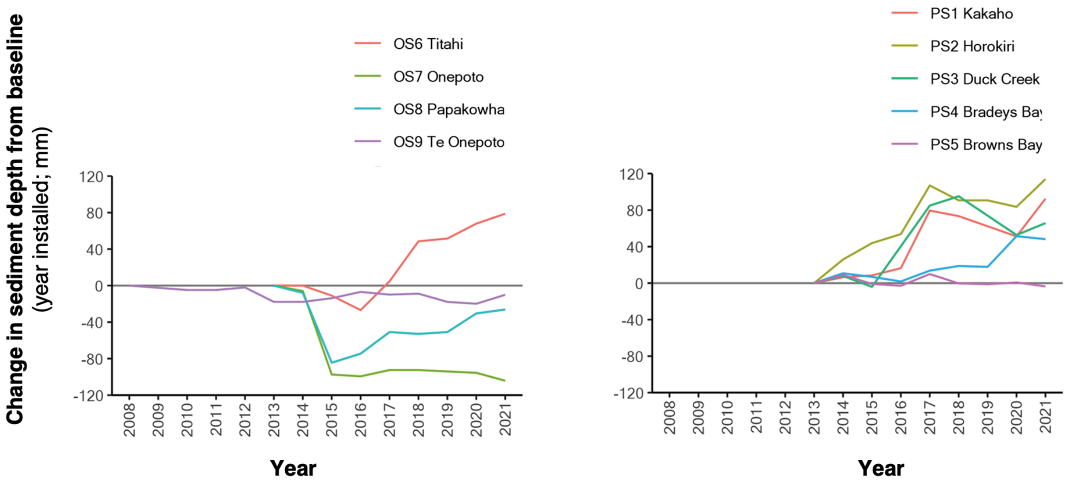

Figure 41: Change in sediment depth (mm) at subtidal monitoring sites over time within the Onepoto (left) and Pāuatahanui (right) Inlets in Te Awarua-o-Porirua Harbour. *Source:* Roberts et al. 2021.

10.4.2 Mud content and oxygenation

Of the nine sites within Te Awarua-o-Porirua Harbour where sediment grain size was recorded in December 2020, the percentage of mud was rated as 'poor' at 69% (*n* = 6) of sites, one site was rated 'fair', and two sites were rated 'good', (Table 35). Mud content in the subtidal zone within Pāuatahanui Inlet has been elevated (consistently rated 'poor') and increasing at four of the five sampling sites since monitoring began in 2013. The fifth site (Bradley's Bay) is a sandier site, but mud content has also been increasing here and this site is now also rated 'poor'. Mud content is lower in the subtidal zone within Onepoto Inlet, is more varied with only one site consistently rated as 'poor' since 2013 (Table 35, Figure 42).

Sediment oxygenation was visually assessed by measuring the apparent Redox Potential Discontinuity (aRPD) depth, being the depth at which sediments change in colour to grey/black. aRPD depths at all but one of the five sites in the Pāuatahanui Inlet rated 'poor', with the fifth site rating 'fair'. In contrast, two of the four sites in the Onepoto Inlet rated 'very good', one rated 'good', and the fourth site rated 'fair' for aRPD depth (Table 35).

Grain size and aRPD are based on single composite samples comprising 4 sub-samples collected from each site (Rogers et al. 2021).

Table 35: Mud content and sediment oxygenation at subtidal zones in Te Awarua-o-Porirua Harbour during the Dec-2020 monitoring period. Shading indicates corresponding health status (as shown in Table 26). aRPD = Apparent Redox Potential Discontinuity. Grain size and aRPD are based on a single composite sample comprising 4 sub-samples collected from each site. *Source:* Table adapted, and data sourced, from Roberts et al. 2021.

Site	Sampling site	% mud (g/100 g dw)	aRPD depth (mm)
Te Awarua-o-Porirua Harbour	OS6 Titahi	56.5	15
	OS7 Onepoto	12.5	>40
	OS8 Papakowhai	7.7	>150
	OS9 Te Onepoto	6.7	>150
	PS1 Kakaho	81.8	2
	PS2 Horokiwi	73.7	10
	PS3 Duck Creek	58.3	2
	PS4 Bradleys Bay	36.8	5
	PS5 Browns Bay	65.7	5

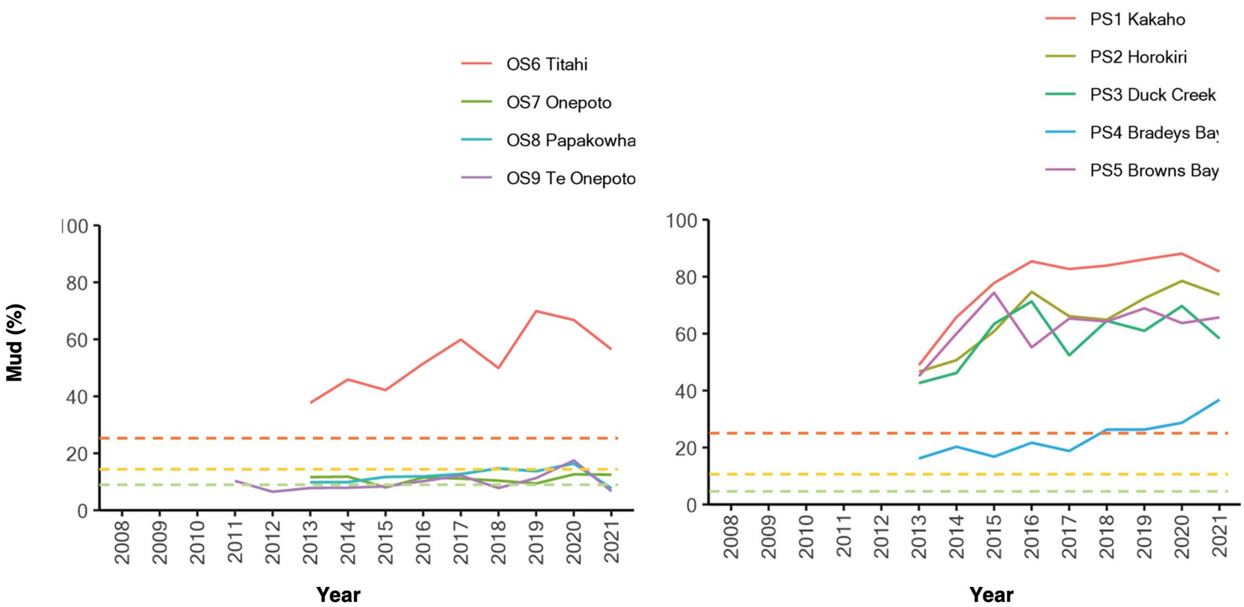

Figure 42: Change in subtidal mud content (%) Onepoto (left) and Pāuatahanui (right) Inlets in Te Awarua-o-Porirua Harbour. Dashed lines correspond to lower threshold of condition bands (as shown in Table 26); Values below green dashed line = Very good, above the green dashed line = Good, above the yellow dashed line = Fair, above the orange dashed line = Poor. Placement of condition band thresholds is indicative. *Source:* Roberts et al. 2021, threshold lines added.

Subtidal sediment samples were also collected from Te Awarua-o-Porirua Harbour (Cummings et al. 2021) and Te Whanganui-a-Tara (Cummings et al. 2022) in 2020[76] and sediment particle size determined using wet sieving.

Of the ten samples from Te Awarua-o-Porirua Harbour, eight were predominantly muddy with mud content ranging from 61%–97%. The remaining two sites were both a mix of mud and sand; 41% and 59% respectively at one site and 48% and 50% respectively at the other site (Cummings et al. 2021).

10.4.3 Benthic ecology

Subtidal sediment samples were collected from five subtidal sites in Te Awa-o-Porirua Harbour (Cummings et al. 2021) and 15 subtidal sites in Te Whanganui-a-Tara (Cummings et al 2022) in 2020.

The number of taxa was similar across sites in Te Awarua-o-Porirua Harbour (ranging from 14–18 on average) but the number of individuals was lower (106–185 per core) at the Pāuatahanui Arm than at the Onepoto Arm sites (where the number of individuals ranged from 297 and 239) (Figure 43). Species diversity (measured using the Shannon index (reflective of species richness and evenness[77]) was also higher at all the sites in the Pāuatahanui Arm (2.02, 2.03, 2.3) than at sites in the Onepoto Arm (1.66, 1.68) (Cummings et al. 2021).

One site in Te Whanganui-a-Tara (EB2) recorded substantially higher species diversity and numbers of individuals than the other 14 sites (Figure 43), which recorded from 14 to 22 taxa and from 40 to 124 individuals per core (average of 38 taxa and 315 individuals). The Shannon diversity index was very similar across all sites, ranging from 2.33 to 2.71 (Cummings et al. 2022).

[76] See Figure 61 and Figure 62, Appendix 1 for sampling locations. Methods are detailed in Cummings et al. 2021 (Te Awarua-o-Porirua Harbour) and Cummings et al. 2022 (Te Whanganui-a-Tara)

[77] Species richness is the number of species at each site and species evenness is the abundance of each species relative to total abundance.

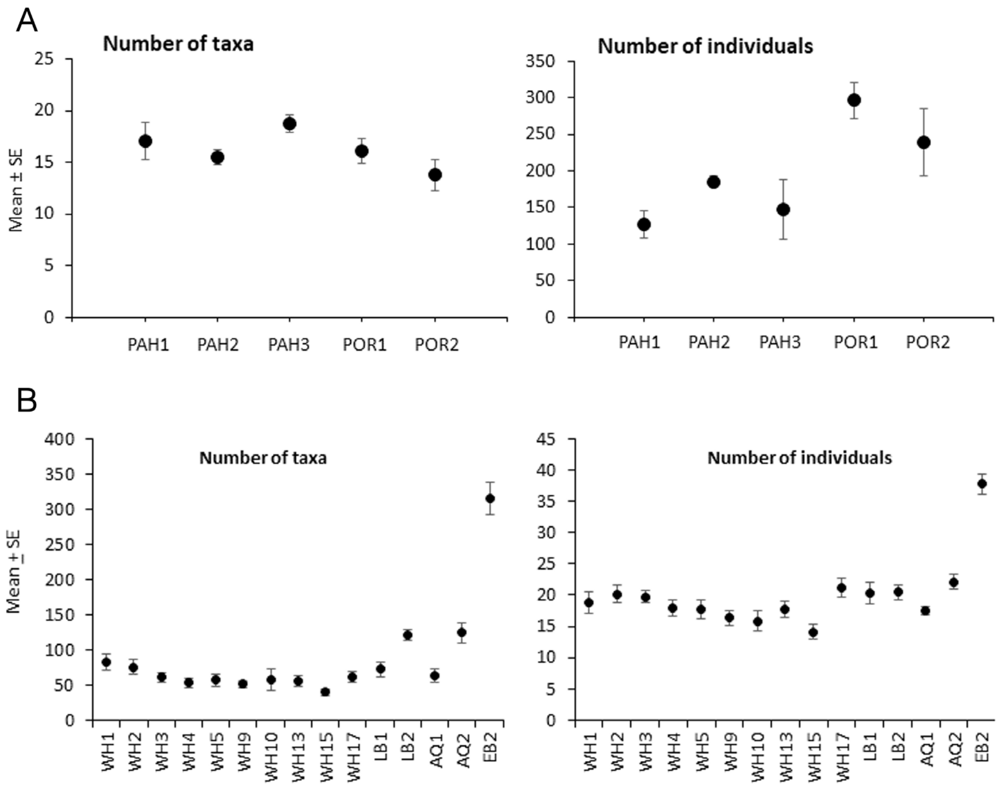

Figure 43: Total number of taxa and individuals found at each monitoring site in 2020. Panel A = Te Awarua-o-Porirua Harbour; Panel B = Te Whanganui-a-Tara. Values presented are mean (± SE) per 20 cm diam. core. *n* = 8. *Source:* Cummings et al. 2021; 2022).

The community composition and sediment characteristics of each site within Te Awarua-o-Porirua Harbour is detailed in Cummings et al. (2021), and at the 15 sites in Te Whanganui-a-Tara in Cummings et al. (2022). Analysis at Te Awarua-o-Porirua Harbour shows that each of the five sites are distinct from each other with little overlap in community composition. In contrast, within Te Whanganui-a-Tara 14 of the 15 sites had similar and overlapping community composition. The exception was Evans Bay site (EB2), the difference in the community composition at this site reflecting the greater number of taxa and individuals (Figure 43).

A comparison of benthic ecology over time shows that total number of taxa, individuals, and the Shannon diversity index track closely over time at each site in Te Awarua-o-Porirua Harbour, and also at each site it Te Whanganui-a-Tara, with the exception of the one site (Figure 44). The 2016 sampling results (Te Whanganui-a-Tara) are potentially due to the disturbance from storms and a major earthquake that occurred during sampling (Cummings et al. 2022).

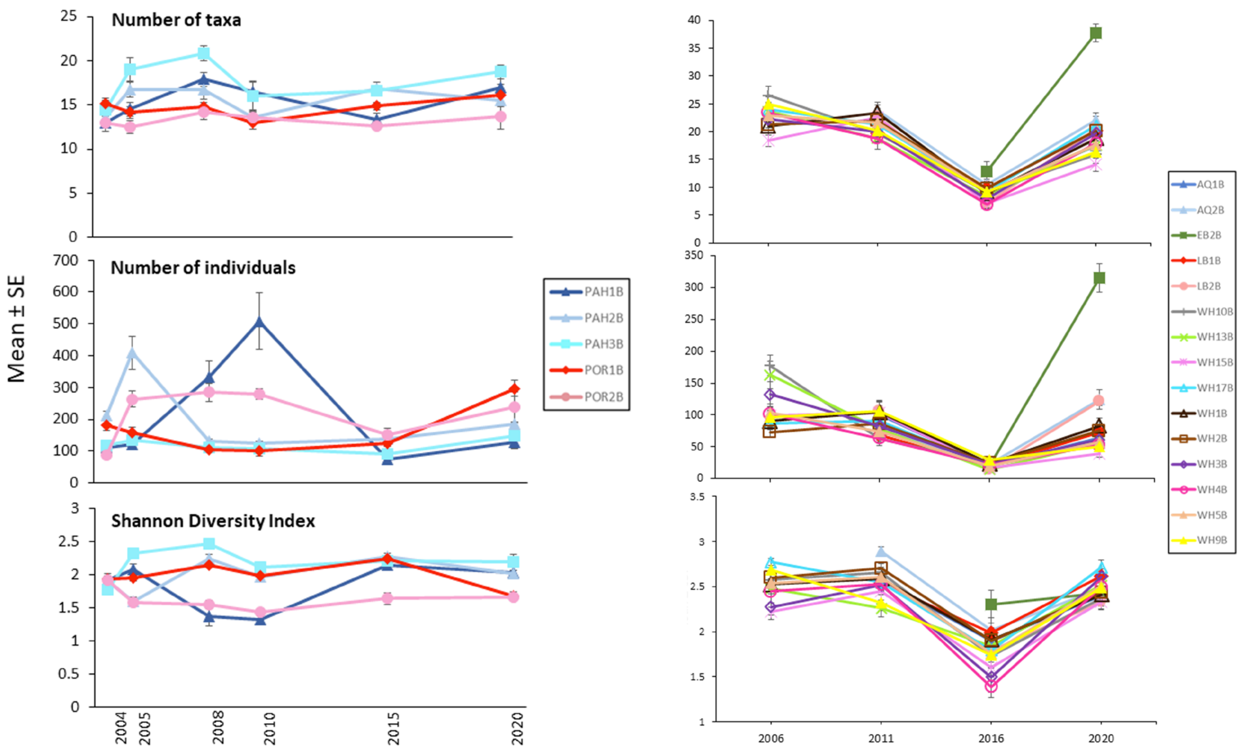

Figure 44: Total number of taxa (top), individuals (middle), and the Shannon diversity index (bottom) at each monitoring site across sampling occasions at Te Awarua-o-Porirua Harbour (left panel) and Te Whanganui-a-Tara (right panel). Values presented are mean (± SE) per 20 cm diam. core. *n* = 8. Note different y axis and different years of sampling events between harbours. *Source*: Cummings et al. 2021 (Te Awarua-o-Porirua Harbour); 2022 (Te Whanganui-a-Tara).

A Traits Based Index (TBI, Hewitt et al. 2012; Rodil et al. 2013) based on the sensitivities of different trait groups (that are likely to reflect ecosystem function) has been developed from intertidal estuarine data in the Auckland Region. Although not yet validated in the subtidal realm yet Cummings et al. (2021; 2022) have used it as an indication of the relative health status of the sites sampled in both Harbours. Three of the sites in Te Awarua-o-Porirua Harbour had a 'high' functional redundancy health score based on the 2020 monitoring data, one had an 'intermediate' score and one site was borderline between the 'intermediate' and 'low' health score. The health score did not change whether the condensed (i.e., some taxa have been amalgamated to a lower taxonomic level) or the full data set was analysed. All but one of the Te Whanganui-a-Tara sites scored a 'high' functional redundancy health score based on the 2020 monitoring data, although the one site that had an 'intermediate' health score based on the condensed data set also had a 'high' score when the full data set was analysed. The TBI scores for the condensed Te Whanganui-a-Tara data set were generally slightly higher than those generated using the full data set, which was unexpected because reduced taxa numbers tend to dampen TBI scores (Cummings et al. 2022).

Cummings et al. (2022) concluded that the benthic communities at each site within Te Whanganui-a-Tara generally diverse with reasonable abundances of bivalves, polychaetes and crustaceans and mixtures of functional types (large and small animals, suspension, and deposit feeders, etc.), were similar to each other, but did change over time, and noted the TBI scores were unexpectedly high given the very muddy subtidal seafloor habitats in the Harbour. Analysis of the correlation of sediment variables and community composition concluded that five-sediment associated variables explained 64% of the variation in benthic community composition at the Te Whanganui-a-Tara sites, including contaminants, total organic carbon, and coarse sand (Cummings et al. 2022).

A relatively high abundance and diversity of macrofauna occurred in Te Awarua-o-Porirua Harbour including at the muddiest subtidal seafloor habitats, where macrofauna were dominated by mud/enrichment tolerant species. TBI scores were also high at muddy sites, but not all muddy sites and high diversity and abundance did not always equate to a high TBI score, noting that the use of the TBI in subtidal realms is still be validated (Cummings et al. 2021). Analysis investigating the correlation between sediment variables and community composition found that different variables were influencing different sites and the strength of this variation also varied (Cummings et al. 2021). In general, Cummings et al. (2021) conclude that the two sites in the Onepoto Arm of the Harbour are in poorer health than the three sites in the Pāuatahanui Arm, largely due to metal contaminant and nutrient exceedances, although the benthic communities at these sites are reasonably diverse and the taxa present do not reflect a highly impacted site. Based on the temporal patterns which are similar across sites and the communities remaining distinct from each other, Cummings et al. (2021) conclude that the long-term pressures on the Harbour are general rather than localised in nature.

11. ROCKY SHORE

The rocky shores found within Wellington Region can be divided into the sheltered rocky shores (within the confines of Te Whanganui-a-Tara Harbour and exposed rocky shores found on the southwest and south coasts of the Region (Stevens 2018a).

Baseline assessment and characterisation of rocky shores in the Region were conducted at Scorching Bay, Mākara, and Baring Head in 2018 (Stevens 2018c), Flat Point in 2016 and 2017 (Stevens & O'Neill-Stevens 2017) and three sites on Kāpiti Island and one site on Mana Island in 2019 (Forrest & Stevens 2019b). Site locations are provided in Appendix 1 (Figure 64) and survey methods and detailed results[78] provided in Stevens (2018c), Stevens & O'Neill-Stevens (2017) and Forrest & Stevens (2019b).

The four locations of rocky shore on Kāpiti and Mana Islands and the Flat Point, Scorching Bay, Baring Head, and Mākara locations all provide physically complex habitats and support reasonably diverse intertidal assemblages, but species-poor supra-tidal zone. (Forrest & Stevens 2019b; Stevens & O'Neill-Stevens 2017; Stevens 2018).

11.1 Species richness and abundance

The abundance and diversity of conspicuous plants and animals was recorded using a semi-quantitative assessment method and categorising species abundance using 'SACFOR' ratings. Relative abundance of the main taxonomic groups across the shore zones and a full list scientific names and species data found at the Kāpiti and Mana Island sites is provided in Forrest & Stevens (2019b), those found at Flat Point in Stevens & O'Neill-Stevens (2017) and those found at Mākara, Baring Head, and Scorching Bay in Stevens 2018c.

Species abundance varied across rocky shore zones, with habitat stability and rugosity and degree of wave and air exposure influencing species abundance (Forrest & Stevens 2019b). The species and higher taxa recorded at the Kāpiti and Mana Island sites are typical of healthy rocky shores of similar physical

78 Including species composition and abundance patterns, similarity analysis of macrofaunal assemblages among sites and shore heights, and detailed schematics illustrating cross-sectional profile and general characteristics of the rocky shore habitat at the Kāpiti and Mana Island locations.

characteristics (Forrest & Stevens 2019b). The two years of monitoring at Flat Point found a diverse, stable rocky shore community (Stevens & O'Neill-Stevens 2017).

Species richness increased down the shore, with greatest species richness recorded in the low shore at Flat Point (Stevens & O'Neill-Stevens 2017) and on Kāpiti and Mana Islands (Forrest & Stevens 2019b) and in the mid-low tide zone at the Scorching Bay, Mākara, and Baring Head sites (Stevens 2018c).

12. SANDY BEACH

Cursory baseline assessment and characterisation of the beaches at Lyall and Ōwhiro Bays and a more comprehensive survey of Petone Beach was undertaken in 2018. The location of sampling transects and stations is provided in Appendix 1 (Figure 65 and Figure 66) and a summary of infaunal core sampling in Table 36. Sampling methods, raw data, and detailed analysis of sampling results are presented in Stevens (2018b).

Table 36: Summary of infaunal core sampling at Petone Beach, Lyall Bay, and Ōwhiro Bay, sampled in 2018. *Source*: Stevens 2018b.

	Sampling stratum	Petone Beach	Lyall Bay	Owhiro Bay
INTERTIDAL	No. of transects	2	1	1
	Stations per transect	6	6	6
	Samples per station	3	1	1
	Cores per sample	2	9	3
	Total samples (total cores)	36 (72)	6 (54)	6 (18)
SUBTIDAL	No. of transects	1	1	1
	Stations per transect	2	1	1
	Samples per station	1	1	1
	Cores per sample	3	3	3
	Total samples (total cores)	2 (6)	1 (3)	1 (3)

The three beaches had intertidal zones ranging from a relatively broad gently-sloping profile with predominantly sandy sediments at Petone, to a narrower, steeper, and predominantly gravel beach at Ōwhiro Bay. Lyall Bay was intermediate between these two. The three beaches also sat on a continuum of wave exposure, Petone Beach being relatively wave-sheltered, with wave exposure increasing at Lyall and again at Ōwhiro Bay. These different wave environments created different profiles with Ōwhiro Bay being steepest with the narrowest intertidal zone, Lyall Bay was wider and less steep, while Petone had the least steep beach profile (Stevens 2018b).

Petone Beach and Lyall Bay are backed by high undulating dune systems extending 5–10 m wide and ~1m high (Stephens 2018b). The invasive species marram grass dominates the sand dunes at Lyall Bay (where it has been planted), but both Lyall Bay and Petone Beach dune vegetation included extensive plantings of the indigenous sand-binding species spinifex and pingao. There were no visible biological growths or other obvious indicators of enrichment present at any of these three beaches.

Assessments of beach characteristics and infauna were also undertaken at Peka Peka Beach at two intertidal sites monitored in 2014 and 2015 (Robertson & Stevens 2015) and at Castlepoint Beach at two intertidal sites monitored in 2014 (Robertson & Stevens 2014). At both sites, two transects were established ~ 50m apart with six stations on each. Three replicate sediment cores were collected at each station. At Peka Peka Beach, the intertidal zone was ~120m wide and was steepest in the upper half, extending to a gradual slope in the lower section of the beach. The beach is backed by an undulating 2-3m high and 30-40 m wide dune system dominated by marram grass, tall fescue, and tree lupin, with a narrow (1-2 m wide) band of pale green spinifex at the seaward toe of the foredune. At Castlepoint Beach, the intertidal zone was 40-60 m wide and, similarly to Peka Peka, was steepest in the upper half extending to a gradual slope in the lower beach section. Castlepoint Beach was backed by an extensive, undulating 4 m high x 20-30 m wide dune system dominated by marram grass with scattered patches of tree lupin, pingao and spinifex also present.

12.1 Habitat condition

The AMBI biotic index (Borja et al. 2000) was used to calculate scores based on relative proportions of taxa according to their tolerance to organic enrichment. Condition ratings (Robertson 2016a; 2016b) were used to categorise the health status of the beach biota based on the AMBI scores, sediment mud content (%), and aRPD depth (cm) (Table 37).

The mud content (% of sediment) at all beaches was <2% (Table 37), and lowest at Ōwhiro Bay (maximum 0.3% mud) (Stephens 2018b) which equates to a condition rating of 'very good' for all sites. The aRPD depth (cm) also fell within the 'very good' condition rating for all five beaches (Table 37) as is typical of beaches with low mud content (Stephens 2018b) and indicating an absence of enrichment at the five beaches (consistent with the lack of biological growths).

Table 37: Values for mud content, aRPD depth and ABMI score calculated for infauna data for Petone Beach, Lyall Bay, and Ōwhiro Bay, sampled in 2018, and values for mud content and aRPD depth calculated for Peka Peka and Castlepoint Beaches, sampled in 2014 (both) and 2015 (Peka Peka). Shading shows condition ratings (see Table 26), Grey = 'very good'; Green = 'good'. ^AMBI scores for individual stations at Lyall Bay and Ōwhiro Bay did not meet operational criteria for index reliability, hence AMBI was calculated only for infauna data pooled within beach at these locations. AMBI scores were not calculated for Peka Peka or Castlepoint. *Source*: Data taken from Stevens 2018b, Robertson & Stevens 2015, and Robertson & Stevens 2014.

Indicator	Location				
	Petone Beach	Lyall Bay	Ōwhiro Bay	Peka Peka	Castlepoint
Mud content (%)	<2%	<2%	<2%	<2%	<2%
aRPD depth (cm)	>15	>15	>15	>15	>15
Biotic index AMBI (infauna pooled within each tidal elevation)^	1.5–1.88	–	–	–	–
Biotic index AMBI (infauna pooled within beach)	1.57	0.83	1.58	–	–

A cursory assessment was also conducted at Ōwhiro Bay for the potential presence of trace contaminants[79] due to an adjacent/upstream landfill but did not reveal any ecological significant concentrations (Stephens 2018b).

79 Conducted on additional composite samples, one taken from the upper 20 mm of sediment in the shallow subtidal zone at the end of sampling transect and the other from the Ōwhiro Bay Stream delta at low tide. The samples were analysed for total recoverable arsenic (As) and the trace metals Cd, Cr, Cu, Ni, Pb, Zn, and Hg).

12.2 Species richness and abundance

Infaunal assemblages at Petone Beach, Lyall Bay and Ōwhiro Bay showed a low taxon richness and abundance, only exceeding four species or taxa at one sampling station (subtidal station 7 at Petone Beach), and was especially poor across the mid-shore, as is typical of semi-exposed sandy beaches (Stephens 2018b). There were not consistent trends evident in richness values or abundance from the high shore to shallow subtidal (Figure 45). Distributional patterns of dominant species and higher taxa and similarity analysis (ordination biplots) are described in detail in Stephens (2018b).

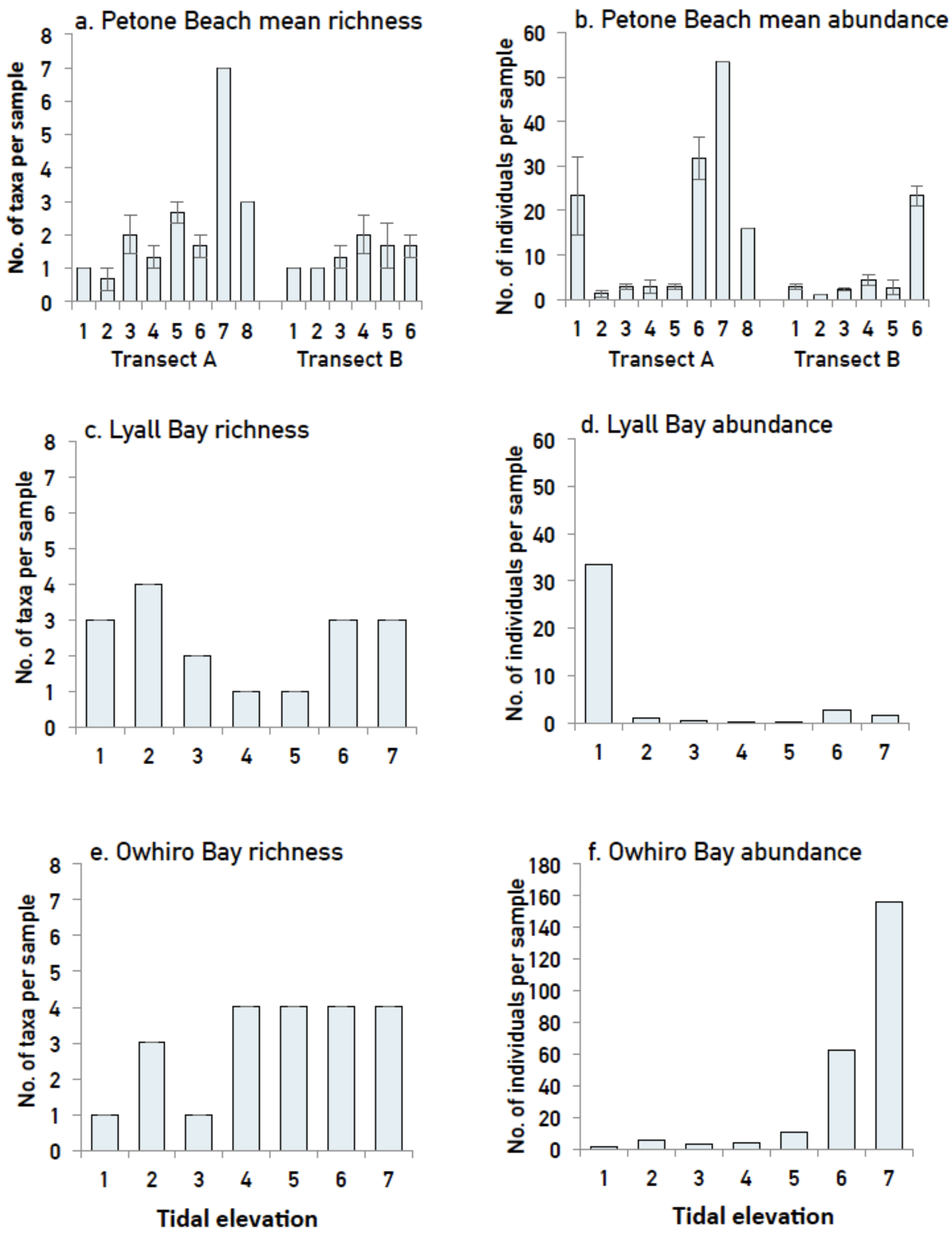

Figure 45: Taxon richness and abundance in composite core samples from sampled beaches, 2018. Petone Beach (panels a and b), Lyall Bay beach (panels c and d), and Ōwhiro Bay beach (panels e and f). Petone intertidal (1–6) bars show mean values (± SE) from replicate samples (*n* = 3). All abundances are scaled to cores numbers for Petone intertidal samples (*n* = 2) to facilitate comparison among stations and beaches. Note different abundance scales for Ōwhiro Bay (panel f). *Source*: Stevens 2018b.

Taxon richness and abundance Peka Peka Beach fell within the ranges observed at Petone, Lyall Bay and Ōwhiro Bay, with a mean of 3.8 species per core for Transect A and 5.1 for Transect B. The mean total abundance of macrofauna was 43/m^2 for Transect A and 68.5/m^2 for Transect B (Figure 46). The 2014 monitoring at Castlepoint Beach showed much lower species richness and abundance than Peka Peka than was previously recorded at Castlepoint (Figure 46).

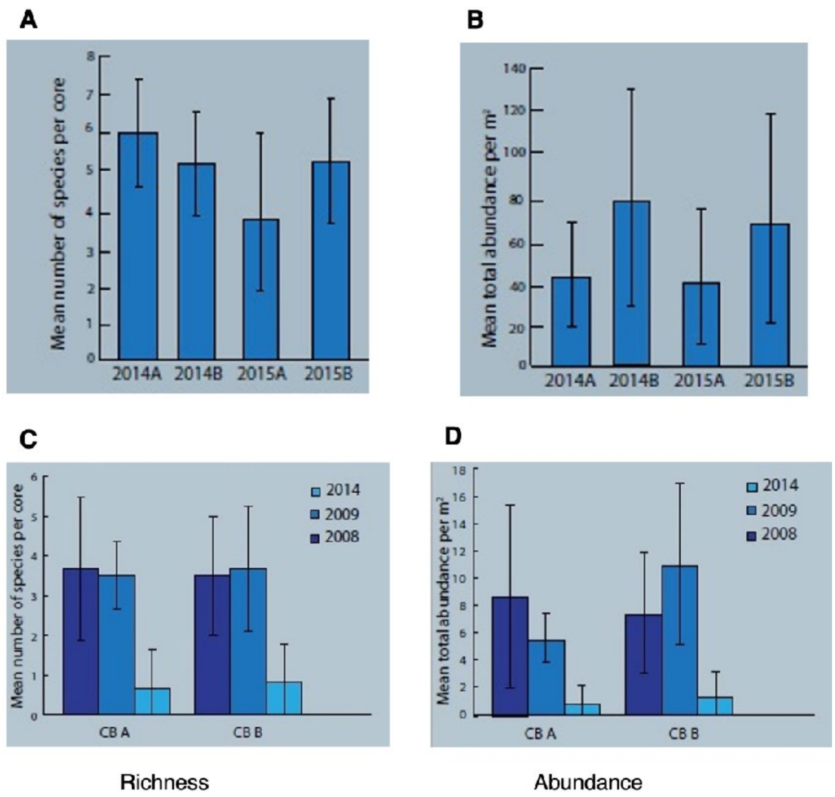

Figure 46: Species richness and abundance in composite core samples from Peka Peka Beach, 2014 and 2015 (panels A and B) and Castlepoint Beach, 2008, 2009 and 2014 (panels C and D). *Source*: Robertson & Stevens (2015) and Robertson & Stevens (2014).

Mean number of species per core was 0.7 for transect A and 0.8 for transect B. The mean total abundance was 0.8//m2 and 1.3/m2 for each transect, respectively. Given the presence of storm related changes to the beach, physical disturbance was identified as the likely primary cause of the reduced numbers of beach infauna recorded at Castlepoint in 2014 (Robertson & Stevens 2014).

13. OFFSHORE

13.1 Subtidal reefs

Subtidal rocky reefs occur along most shores in the Region, with the exception of the sandy beaches north of Paekakariki and in Palliser Bay (MacDiarmid et al. 2012). These reef habitats are divided into two bioregions (Shears et al. 2008). Reef habitat to the north of Cape Terawhiti lies within the Abel Bioregion and reef habitat to the east lies within the Cook Bioregion.

There have been no systematic surveys of reef biota over the whole of each bioregion (MacDiarmid et al. 2012). As such, it has not been possible to directly identify areas of particular significance for biodiversity.

Rather, reef fish species richness on shallow (<50 m) rocky reefs has been predicted using 15 environmental variables (Smith 2008). The most important variable for predicting abundance was sea surface temperature, followed by average wind fetch and salinity.

In the Abel Bioregion, reef fish species richness is predicted to be generally high especially around the more exposed headlands between Cape Terawhiti to Pipinui Point, the north-western and south-western headlands of Mana Island, and the southwestern tip of Kāpiti Island (Figure 47). Reef fish species richness is generally lower in the Cook Bioregion, especially in Palliser Bay (where there is little rocky reef habitat). The highest predicted reef fish species richness in this bioregion occurs to the west from Sinclair Head, at Baring Head, at Cape Palliser and around the major headlands northwards up the Wairarapa coast (Figure 47) (MacDiarmid et al. 2012).

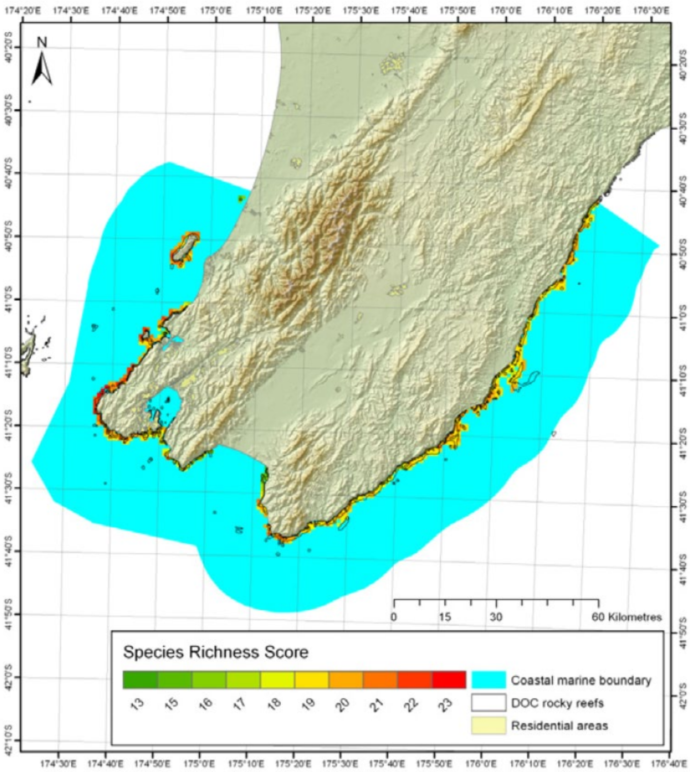

Figure 47: Predicted reef fish species richness in the Greater Wellington Region. Model output from Smith (2008). *Source*: MacDiarmid et al. (2012).

Kelp beds are known to support high biodiversity and occur on shallow (<50 m) rocky reefs in the Region (Nelson et al. 2021). Kelp species native to the Wellington Region are *Macrocystis pyrifera*, *Ecklonia radiata*, *Lessonia variegata* and *Durvillaea antarctica*. The structural complexity of kelp beds has been found to be positively associated with the abundance of reef fish species (Pérez-Matus and Shima 2010).

In 2017 a survey was carried out to map the distribution of *Macrocystis* beds in Te Whanganui-a-Tara compared to *Macrocystis* distribution recorded in 1990. The 2017 survey found that *Macrocystis* was no longer present at Evans Bay, at Point Halswell, on the southern side of Matiu Somes Island or at Aotea Quay (Nelson et al. 2021).

13.2 Rhodolith beds

Rhodolith beds are a unique ecosystem with high benthic biodiversity and that harbour high diversity and abundance of marine animals (Nelson et al. 2021). Rhodolith beds exist to the east of Kāpiti Island, and are the only ones known in the lower North Island. Complete characterisation of the Kāpiti Island rhodolith beds has not been undertaken, and there have been no surveys of the associated flora and fauna. However, opportunistic invertebrate collections indicate high potential biodiversity associated with these beds (Nelson et al. 2021).

13.3 Seamounts

There are two seamounts within GWRC's area of the territorial sea (Table 38) (Nelson et al. 2021). Seamount 516 has not been sampled for benthic biota. In 2010, benthic meio-macro- and mega-faunal communities were sampled on seamount 310 from the summit down to 1000 m on the southern side (Bowden et al. 2010). Faunal communities on the summit included sponges, gorgonians, asteroids, cidaroid echinoids, motile crinoids, natant decapods, holothuroids, pagurids and scorpaenid fish. The deeper samples found numerous burrows in muddy sand sediments and epifauna including asteroids, holothuroids, and *Stephanocyathus* sp. solitary corals. The benthic community composition was similar to other seamounts in the study (Nelson et al. 2021).

Table 38: Seamounts within the GWRC territorial sea area. *Source*: Nelson et al. (2021).

Registration #	Name	Latitude	Longitude	Peak depth (m)	Base depth (m)	Basal area (km^2)
310	N/A	-41.3252	176.1914	500	1016	17.00
516	Fisherman's Pinnacle	-41.067	174.6000	10	300	2.21

13.4 Corals

The Region has 29 species of coral (Figure 48). All of these species are protected, with one species (3%) recorded as declining.

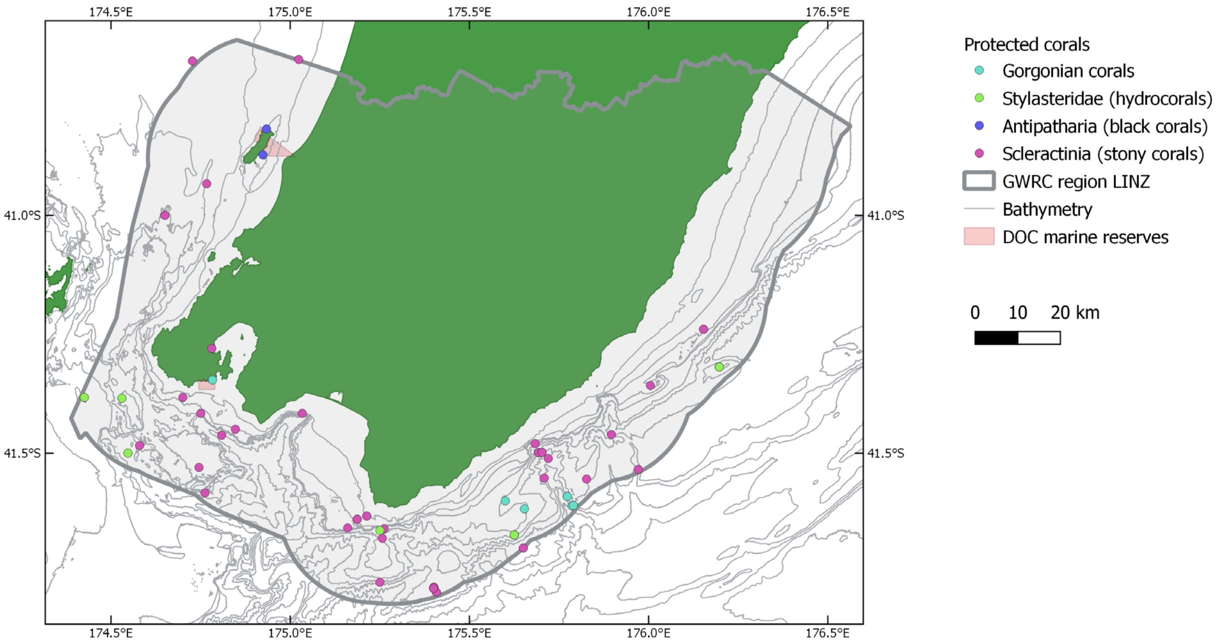

Figure 48: Location of corals identified in the Greater Wellington Region. *Source*: NIWA Invertebrate Collection.

14. COASTAL AND MARINE SPECIES

14.1 Coastal habitats of significance for indigenous bird species

A panel of ornithological experts identified coastal sites within the Wellington Region that held significant biodiversity values for indigenous birds for the purposes of inclusion in the NRP (McArthur et al. 2015). Sites were identified based on species distribution and abundance data for Threatened and At risk species[80] and a set of criteria (McArthur et al. 2015) as follows:

- Rarity. The site provides habitat for ≥5% of the regional population of a Threatened or At risk species.
- Diversity. Four or more Threatened or At risk species are known to be resident at or regularly using the site.
- Ecological context. The site provides seasonal or core habitat for ≥33% of the regional population of a protected[81] (but not Threatened or At risk) species.

A total of 41 coastal sites were identified as providing habitat of significance for indigenous birds within the Wellington Region (Table 39).

Table 39: Summary of number of areas of meeting at least one of the sites of significance criteria, and therefore identified as a coastal habitat of significance for indigenous birds. *Source*: Data from McArthur et al. 2015).

	Number of sites that meet criteria:					
	Rarity	Diversity	Ecological context	Rarity and Diversity	Rarity, Diversity, and Ecological context	Total
Coastal marine habitats	1	28	0	10	2	41

The foreshore habitats on Kāpiti and Mana Islands were of particular note due to the high diversity of Threatened and At risk species present and for providing two of the largest areas of secure breeding habitat for little penguins (*Eudyptula minor*) in the Wellington Region.

The Waikanae Estuary and both arms of Te Awarua-o-Porirua Harbour are also notable for the diversity of Threatened and At risk species present and provision of important foraging and roosting habitat for migrant species. Mātātā, known from only two sites in the Wellington Region, is found at Waikanae Estuary (McArthur et al. 2015).

Other coastal sites provide important habitat for large proportions of regional bird populations, including Riversdale Beach (only breeding population of tūturiwhatu (dotterel, *Charadrius obscurus*) in the Region), Onoke Spit (only breeding colony of taranui (Caspian tern, *Hydroprogne caspia*) in the lower North Island), Taputeranga Island (large proportion of regional population of matuku moana (reef heron, *Egretta sacra*), Castlepoint Reef (largest nesting colonies of tarāpunga (red-billed gull, *Larus novaehollandiae*) and tara (white-fronted tern, *Sterna striata*) (McArthur et al. 2015).

80 Following the New Zealand Threat Classification threat classifications (Townsend et al. 2008) and as listed in Robertson et al. (2013).

81 Under the Wildlife Act 1953.

REFERENCES

The following references can be downloaded from the document library on the Greater Wellington Regional Council website or accessed on the internet.

Ausseil A-GE, Gerbeaux P, Chadderton WL, Stephens T, Brown DJ, Leathwick J 2008. Wetland ecosystems of national importance for biodiversity: Criteria, methods and candidate list of nationally important inland wetlands. Landcare Research Contract Report LC0708/158 for the Department of Conservation.

Biggs BJF, Kilroy C 2000. Stream periphyton monitoring manual. Prepared for the Ministry for the Environment. NIWA.

Borja A, Franco J, Pérez V 2000. A Marine Biotic Index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin 40(12):1100–1114.

Bowden D, Tracey D, Mackay K, Chin C, Clark M 2010. Southern Hikurangi Margin: 14-29 April 2010. NIWA Voyage Report: 36.

Cieraad E, Walker S, Price R, Barringer J 2015. An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments. New Zealand Journal of Ecology 39(2):309–315.

Clapcott J 2015. National rapid habitat assessment protocol development for streams and rivers. Cawthron Institute Contract Report No. 2649 prepared for Northland Regional Council.

Clapcott J, Goodwin E 2014. Technical report of Macroinvertebrate Community Index predictions for the Wellington Region. Cawthron Institute Report No. 2503 prepared for Greater Wellington Regional Council.

Clarkson BR, Sorrell BK, Reeves PN, Champion PD, Partridge TR, Clarkson BD 2003. Handbook for monitoring wetland condition. Coordinated monitoring of New Zealand wetlands. A Ministry for the Environment Sustainable Management Fund Project (5105). Revised October 2004.

Clarkson BR, Hicks A, Robertson HA, Rance BD, Ledgard G 2013a. A monitoring approach for Southland's wetlands: Stage 1. Landcare Research contract report No. LC1722 prepared for Environment Southland.

Clarkson BR, Ausseil A-GE, Gerbeaux P 2013b. Wetland ecosystem services. In Dymond JR (Ed), Ecosystem services in New Zealand. Conditions and Trends. Lincoln, New Zealand: Manaaki Whenua Press.

Clayton J, Edwards T 2006. LakeSPI. A method for monitoring ecological condition in New Zealand lakes. Technical Report Version 2. NIWA report CRBV062.

Crisp P 2018. Statement of primary evidence of Dr Philippa Noel Crisp on behalf of Wellington Regional Council. Technical – Wetlands & Biodiversity. Before the Proposed Natural Resources Plan Hearings Panel in the matter of wetlands and submissions and further submissions set out in the s42A Officer Report.

Crisp P 2020a. Conservation status of lizard species in the Wellington Region. Greater Wellington Regional Council Publication No. WRC/ESCI-G-20/2.

Crisp P 2020b. Conservation status of indigenous vascular plant species in the Wellington Region. Greater Wellington Regional Council Publication No. GW/ESCI-G-20/20.

Crisp P 2020c. Conservation status of indigenous bird species in the Wellington Region. Greater Wellington Regional Council Publication No. GW/ESCI-G-20/75.

Crisp P 2020d. Priority biodiversity conservation actions for the Wellington Region – A think-piece. Greater Wellington Regional Council unpublished report.

Crisp P, Perrie A, Morar S, Royal C 2022. Conservation status of indigenous freshwater fish in the Wellington Region. Greater Wellington Regional Council Publication No. GW/ESCI-T-22/02. Greater Wellington Regional Council & Waiora Solutions Ltd.

Crisp P, O'Donnell C, Pryde M, Ryan J, Spearpoint O 2023. Conservation status of bat species in the Wellington Region. Greater Wellington Regional Council Publication No. GW/ESCI-G-23/01.

Cummings V, Halliday J, Olsen G, Hale R, Greenfield B, Hailes S, Hewitt J 2021.Te Awarua-o-Porirua Harbour subtidal sediment quality monitoring. Results from the 2020 survey. NIWA Client Report No 2021309WN prepared for Greater Wellington Regional Council.

Cummings V, Halliday J, Olsen G, Hale R, Greenfield B, Hailes S, Hewitt J 2022. Te Whanganui-a-Tara (Wellington Harbour) subtidal monitoring. Results from the 2020 survey. NIWA Client Report No 2021309WN prepared for Greater Wellington Regional Council.

Davis S. n.d. Fish passage barrier assessment in Wellington City.

Department of Conservation 2016. Field protocols for Tier 1 monitoring. Invasive mammal, bird, bat, RECCE surveys. Version 14. Inventory and monitoring toolbox DOCDM-826779.

Ewers RM, Kliskey AD, Walker S, Rutledge D, Harding JS, Didham RK 2006. Past and future trajectories of forest loss in New Zealand. Biological Conservation 133: 312–325.

FGDC 2012. Coastal and Marine Ecological Classification Standard Catalog of Units. Federal Geographic Data Committee FGDC-STD-018-2012.

Forrest BM, Stevens LM 2019a. Fine scale monitoring of Paraparaumu and Waikanae Beaches, Kāpiti Coast, Wellington. Salt Ecology Report 013, prepared for Greater Wellington Regional Council.

Forrest BM, Stevens LM 2019b. Kāpiti and Mana Island rocky short survey. Salt Ecology Report 020, prepared for Greater Wellington Regional Council.

Forrest BM, Stevens LM, Rabel H 2020. Fine scale intertidal monitoring of Te Awarua-o-Porirua Harbour. Salt Ecology Report 044, prepared for Greater Wellington Regional Council.

Forrest BM, Stevens LM, Roberts KL 2023. Fine scale intertidal monitoring of Whareama Estuary. Salt Ecology Report 098, prepared for Greater Wellington Regional Council.

Forsyth DM, Perry M, Moloney P, McKay M, Gormley AM, Warburton B, Sweetapple P, Dewhurst R 2018. Calibrating brushtail possum (*Trichosorus vulpecula*) occupancy and abundance index estimates form leg-hold traps, wax tags and chew cards in the Department of Conservation's Biodiversity and Monitoring Reporting System. New Zealand Journal of Ecology 42(2):179–191.

Greater Wellington Regional Council 2016. Greater Wellington Regional Council Biodiversity Strategy. Greater Wellington Regional Council publication number GW/BD-G-16/6.

Greenfield S 2016. Use of periphyton cover to estimate chlorophyll a concentration: Performance of Canterbury conversion factors in Wellington Region rivers. Greater Wellington Regional Council Publication No. GW/ESCI-T-16/90.

Guest P, Andrewartha H, Denton P 2018. Proposed Natural Resources Plan for the Wellington Region. Section 42A Hearing Report. Report on submissions and further submissions on the topic of beds of lakes and rivers. Prepared for Greater Wellington Regional Council for Hearing commencing 12 March 2018.

Guest P, Denton P 2018. Proposed Natural Resources Plan for the Wellington Region. Section 42A Hearing Report. Report on submissions and further submissions on the topic of wetlands and biodiversity. Prepared for Greater Wellington Regional Council for Hearing commencing 12 March 2018.

Harrison E 2019. Ecosystem health in Wellington City urban streams: Stage one summary report. GW/ESCI-T-19/123. Greater Wellington Regional Council.

Hewitt JE, Lohrer AM, Townsend M 2012. Health of estuarine soft-sediment habitats: Continued testing and refinement of state of the environment indicators. Auckland Council Technical Report TR2012/012.

Holdaway RJ, Wiser SK, Williams PA 2012. Status assessment of New Zealand's Naturally Uncommon Ecosystems. Conservation Biology 26(4):619–629.

Innes J, Fitzgerald N, Binny R, Byrom A, Pech R, Watts C, Gillies C, Maitland M, Campbell-Hunt C, Burns B 2019. New Zealand ecosanctuaries: types, attributes and outcomes. Journal of the Royal Society of New Zealand 49(3):370–393.

Larned S, Snelder T, Unwin M, McBridge G 2016. Water quality in New Zealand rivers: Current state and trends. New Zealand Journal of Marine and Freshwater Research 50(3):389–417.

Lee WG, Allen RB 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Landcare Research contract report LC144 prepared for Regional Councils' Biodiversity Monitoring Working Group.

MacDiarmid A, Nelson W, Gordon D, Bowden D, Mountjoy J, Lamarche G 2012. Sites of significance for indigenous marine biodiversity in the Wellington Region. NIWA Client Report No. WLG2012-19 prepared for Greater Wellington Regional Council.

Macinnis-Ng C, McIntosh AR, Monks JM, Waipara N, White RSA, Boudjelas S, Clark CD, Clearwater MJ, Curran TJ, Dickinson KJM, Nelson N, Perry GLW, Richardson SJ, Stanley MC, Peltzer DA 2021. Climate-change impacts exacerbate conservation threats in island systems: New Zealand as a case study. Frontiers in Ecology and the Environment 19(4):216–224.

Matheson F, Quinn J, Hickey C 2012. Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report. NIWA Client Report No: HAM2012-081 prepared for the Ministry of Science & Innovation Envirolink Fund.

McArthur N, Robertson H, Adams L, Small D 2015. A review of coastal and freshwater habitats of significance for indigenous birds in the Wellington Region. Greater Wellington Regional Council Publication No. GW/ESCI-T-14/68.

McArthur N 2023. State and trends in the diversity, abundance and distribution of terrestrial birds on Miramar Peninsula, Wellington. Client report prepared for Greater Wellington Regional Council, Wellington.

McArthur N, Flux I, Harvey A 2022. State and trends in the diversity, abundance and distribution of birds in Wellington City. Client report prepared for Greater Wellington Regional Council.

McNaughton EJ, Gaston KJ, Beggs JR, Jones DN, Stanley MC 2022. Areas of ecological importance are exposed to risk from urban sky glow: Auckland, Aotearoa-New Zealand as a case study. Urban Ecosystems 25:273–284.

Ministry for the Environment 2019. Essential Freshwater: Impact of existing periphyton and proposed dissolved inorganic nitrogen bottom lines. Wellington: Ministry for the Environment.

Ministry for the Environment, StatsNZ 2019. New Zealand's Environmental Reporting Series: Our Marine Environment 2019. ME 1468. Wellington: Ministry for the Environment & StatsNZ.

Ministry for the Environment, StatsNZ 2022. New Zealand's Environmental Reporting Series: Environment Aotearoa 2022. ME 1634. Wellington: Ministry for the Environment & StatsNZ.

Ministry for the Environment, Ministry of Health 2009. New Zealand Guidelines for Cyanobacteria in recreational fresh waters – Interim guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by Wood SA, Hamilton DP, Paul WJ, Safi KA, Williamson WM. Wellington: Ministry for the Environment.

Nelson WA, Bowden D, D'Archino R, MacDiarmid A, Mountjoy J, Peart R, Rowden A, Watson S 2021. Sites of significance for indigenous marine biodiversity in the Wellington Region – 2021 update. NIWA Client Report 2020351WN, prepared for Greater Wellington Regional Council.

Parliamentary Commissioner for the Environment 2015. Update report. Water quality in New Zealand: land use and nutrient pollution. Wellington: Parliamentary Commissioner for the Environment.

Pérez-Matus A, Shima J 2010. Disentangling the effects of macroalgae on the abundance of temperate reef fishes. Journal of Experimental Marine Biology and Ecology, 388: 1-10

Ramsar 2020. New Zealand. Wairarapa Moana Wetland. Ramsar Information Sheet for Site No. 2432. Accessed from https://rsis.ramsar.org/ris/2432.

Roberts K, 2021a. Hutt Estuary: 2020/21 Intertidal sediment monitoring summary. Salt Ecology Short Report 001, prepared for Greater Wellington Regional Council.

Roberts K, 2021b. Waikanae Estuary: 2020/21 Intertidal sediment monitoring summary. Salt Ecology Short Report 002, prepared for Greater Wellington Regional Council.

Roberts KL, Rabel H, Stevens LM 2021. Te Awarua-o-Porirua Harbour sediment plate monitoring 2020/2021. Salt Ecology Report No 061, prepared for Greater Wellington Regional Council.

Roberts KL, Stevens LM, Southwick M 2023. Wairarapa Coastal Habitats: Ecological Vulnerability Assessment. Salt Ecology Report 108, prepared for Greater Wellington Regional Council.

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

Robertson HA, Dowding JE, Elliott GP, Hitchmough RA, Miskelly CM, O'Donnell CJF, Powlesland RG, Sagar PM, Scofield RP, Taylor GA 2013. Conservation status of New Zealand birds, 2012. New Zealand Threat Classification Series 4. Wellington, New Zealand: Department of Conservation.

Robertson B, Stevens L 2014. Castlepoint Beach fine scale monitoring 2013/14. Wriggle Coastal Management Report, prepared for Greater Wellington Regional Council.

Robertson B, Stevens L 2015. Peka Peka Beach fine scale monitoring 2014/15. Wriggle Coastal Management Report, prepared for Greater Wellington Regional Council.

Robertson BM, Stevens L, Robertson B, Zeldis J, Green M, Madarasz-Smith A, Plew D, Storey R, Hume T, Oliver M 2016a. NZ Estuary Trophic Index Screening Tool 1: Determining eutrophication susceptibility using physical and nutrient load data. Prepared for Envirolink Tools Project: Estuarine Trophic Index, MBIE/NIWA Contract No: C01X1420.

Robertson BP, Gardner JPA, Savage CS, Robertson BM, Stevens LM 2016. Optimising a widely-used coastal health index through quantitative ecological group classifications and associated thresholds. Ecological Indicators 69:595–605.

Robertson BM, Stevens L, Robertson B, Zeldis J, Green M, Madarasz-Smith A, Plew D, Storey R, Hume T, Oliver M 2016b. NZ Estuary Trophic Index Screening Tool 2: Determining monitoring indicators and assessing estuary trophic state. Prepared for Envirolink Tools Project: Estuarine Trophic Index MBIE/NIWA Contract No: C01X1420.

Rodil IF, Lohrer AM, Hewitt JE, Townsend M, Thrush SF, Carbines M 2013. Tracking environmental stress gradients using three biotic integrity indices: advantages of a locally-developed traits-based approach. Ecological Indicators 34: 560–570.

Shears NT, Smith F, Babcock RC, Duffy CA, Villouta E 2008. Evaluation of Biogeographic Classification Schemes for Conservation Planning: Application to New Zealand's Coastal Marine Environment. Conservation Biology 22: 467–481.

Singers N, Crisp P, Spearpoint O 2018. Forest ecosystems of the Wellington Region. GW/ESCI-G-18-164. Greater Wellington Regional Council.

Smith ANH 2008. Predicting the distribution and relative abundance of fishes on shallow subtidal reefs around New Zealand. NIWA Client Report No. WLG2008-9.

Snelder TH, Moore C, Kilroy C 2019. Nutrient concentration targets to achieve periphyton biomass objectives incorporating uncertainties. Journal of the American Water Resources Association JAWRA-19-0032-P.

Stark JK, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR 2001. Protocols for sampling macroinvertebrates in wadeable streams. Sustainable Management Fund Contract No. 5103 prepared for the Ministry for the Environment. New Zealand Macroinvertebrates Working Group Report No. 1.

Stevens LM, Forrest BM 2019. Kāpiti Whaitua. Review of estuary ecological condition and habitat vulnerability. Salt Ecology Report 028, prepared for Greater Wellington Regional Council.

Stevens LM, Forrest BM 2020a. Broad scale intertidal habitat mapping of Te Awarua-o-Porirua Harbour. Salt Ecology Report 050, prepared for Greater Wellington Regional Council.

Stevens LM, Forrest BM 2020b. Hutt Estuary intertidal macroalgal monitoring. January 2020. Salt Ecology Report 055, prepared for Greater Wellington Regional Council.

Stevens LM, O'Neill-Stevens S 2017. Flat Point 2017 fine scale rocky shore monitoring. Wriggle Coastal Management Report, prepared for Greater Wellington Regional Council.

Stevens LM 2018a. Waitua Te Whanganui-a-Tara. Coastal habitat and vulnerability and ecological condition. Salt Ecology Report 004, prepared for Greater Wellington Regional Council.

Stevens LM 2018b. Fine scale monitoring of Petone Beach, Lyall Bay and Owhiro Bay, Wellington. Salt Ecology Report 007, prepared for Greater Wellington Regional Council.

Stevens LM 2018c. Rocky shore monitoring of Scorching Bay, Makara, and Baring Head, Wellington. Salt Ecology Report 008, prepared for Greater Wellington Regional Council.

Sutton PJH, Bowen M 2019. Ocean temperature change around New Zealand over the last 36 years. New Zealand Journal of Marine and Freshwater Research 53(3):305–326.

Taylor M, Marshall W 2016. Inanga spawning habitat quality, remediation and management in the Wellington Region. Aquatic Ecology Ltd. Report No. 138 prepared for Greater Wellington Regional Council, Wairarapa Moana Wetlands Group, Porirua City Council, and Wellington City Council.

Townsend AJ, de Lange PJ, Duffy AJ, Miskelly CM, Molloy J, Norton DA 2008. New Zealand Threat Classification System manual. Department of Conservation.

Townsend M, Lohrer D 2015. ANZECC Guidance for estuary sedimentation. NIWA Client Report Number HAM2015-096, prepared for Ministry for the Environment.

Uys R 2019. Terrestrial ecology State of the Environment monitoring programme. Annual data report 2018/2019. GW/ESCI-T-19/133. Greater Wellington Regional Council.

Uys R, Crisp P 2023. On the conservation status of species in the Wellington Region. Presentation to the Wellington Branch Royal Forest and Bird Society 2 March 2023. Greater Wellington Regional Council.

Verburg P, Hamill K, Unwin M, Abell J 2010. Lake water quality in New Zealand 2010: Status and trends. NIWA Client Report No. HAM2010-107 prepared for Ministry for the Environment.

Waller et al. 2019. Porirua Harbour bathymetric survey 2019: Report of survey. Discovery Marine Ltd Ref: 1902, prepared for Greater Wellington Regional Council.

Williams PA, Wiser SK, Clarkson BR, Stanley MC 2007. New Zealand's historically rare terrestrial ecosystems set in a physical and physiognomic framework. New Zealand Journal of Ecology 31(2):119–128.

Wilmshurst JM, Anderson AJ, Higham TFG, Worthy TH 2008. Dating the late prehistoric dispersal of Polynesians to New Zealand using the commensal Pacific rat. PNAS 105(22):7676–7680.

Woods C, Seaward K, Rodgers LP, Buckthought D, Carter M, Middleton C, Olsen L, Smith M 2022. National Marine High Risk Site Surveillance. Annual synopsis report for all High Risk Sites 2021–22 (SOW23030). Biosecurity New Zealand Technical Paper No. 2022/09. Prepared for the Ministry of Primary Industries. Wellington: New Zealand Government.

APPENDIX ONE:
INDIGENOUS BIODIVERSITY MONITORING PROGRAMMES – SAMPLING REGIMES

The following material is included here to provide brief context for the data presented in this report. It is sourced directly from GWRC's online Environmental Monitoring Portal and associated downloadable reports. Further information should be requested directly from GWRC's Science Team.

1. TERRESTRIAL BIODIVERSITY MONITORING PROGRAMME

1.1 Monitoring network

The SOE monitoring programme for terrestrial biodiversity is implemented using the nationally agreed monitoring framework (Lee & Allen 2011) that comprises ten indicators of components[82] of 'ecological integrity' and which incorporates the Driver-Pressure-State-Impact-Response (DPSIR) Model (Table 40).

Table 40: Components ecological integrity and monitoring indictors used within the regional council terrestrial biodiversity monitoring framework and relationship to DPSIR Model. Indicators 9 and 10 are included within the framework to enable measurement of community involvement in the protection of indigenous biodiversity. Adapted from Lee & Allen (2011) and Uys (2019).

Indicator	DPSIR	Ecological integrity
State and condition		
1. Land area under indigenous vegetation	State	Environmental representation
2. Biodiversity condition	State	Environmental representation Species occupancy
Threats and pressures		
3. Weeds and animal pests	Pressure; Impact	Indigenous dominance
4. Habitat loss	Driver; Pressure; Impact	Environmental representation Indigenous dominance
5. Climate change	Driver	Environmental representation
Effectiveness of policy and management		
6. Biodiversity protection	Impact; Response	Environmental representation Species occupancy
7. Pest management	State; Response	Indigenous dominance
8. Ecosystem services	State	Environmental representation
Community engagement		
9. Protection and restoration	Response	n/a
10. Weed and pest control	Response	n/a

82 Species occupancy (to avoid extinctions); Indigenous dominance (to maintain natural ecological processes); Environmental representation (to maintain a 'full range of ecosystems') (Lee & Allen 2011).

Standardised measures (e.g., land cover, vegetation structure and composition, distribution, and abundance etc.) are used to monitor each indicator, some of which can be measured remotely or using existing data, while others require in-field data collection.

GWRC uses the national 8 km x 8 km Land Use and Carbon Accounting System (LUCAS) monitoring grid for their in-field terrestrial indigenous biodiversity monitoring programme. The LUCAS programme was established by the Ministry for the Environment (MfE) in 2005 for the purposes of Kyoto Protocol reporting and the grid is now also used by the Department of Conservation (DOC) for their Tier1 Biodiversity Monitoring and Reporting System. A total of 126 grid points (sampling plots) fall within the Wellington Region, 50 of which are monitored by MfE and DOC while GWRC aims to monitor the remaining 76 plots over a five-year period (Figure 49).

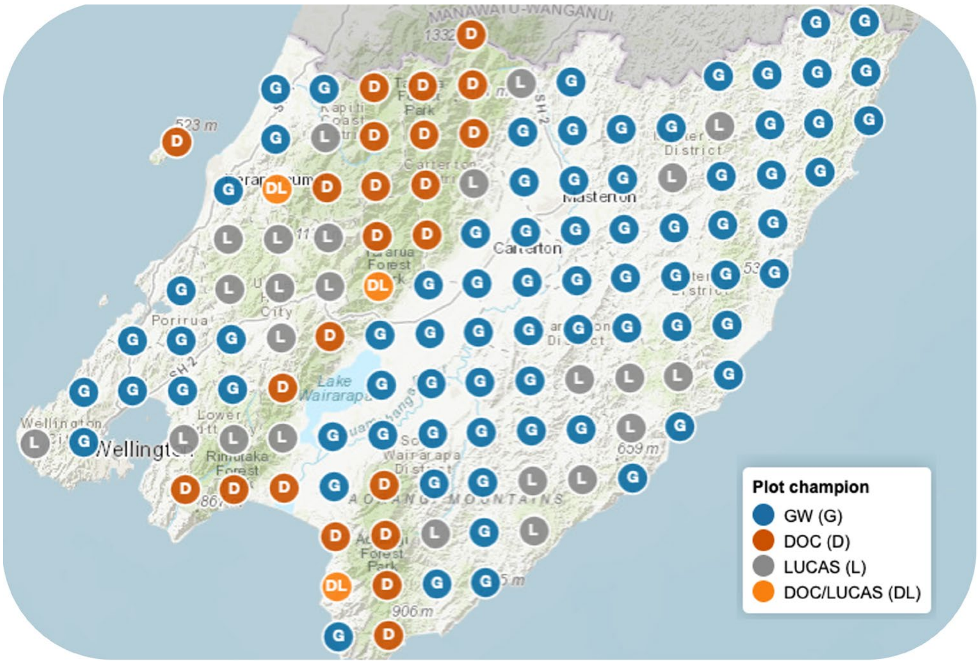

Figure 49: Terrestrial ecology monitoring locations showing plot champions. Source: GWRC online environmental monitoring portal: https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/index.html.

The objectives of GWRC's terrestrial biodiversity field[83] monitoring are to determine:

1. The state and trend of vegetation and bird community richness, structure, and composition.
2. The pressure of plant and animal pests based on their regional distribution and local abundance.
3. The effectiveness of pest management based on the abundance (richness, basal area, and density) of indigenous plants susceptible to introduced herbivores and the abundance of indigenous bird guilds (frugivores, insectivores, and ground dwelling) that are susceptible to introduced herbivores and carnivores.[84]

---

83 Noting that in-field data collection sits within the wider national ecological integrity monitoring framework.

84 https://www.gw.govt.nz/annual-monitoring-reports/terrestrial-ecology/index.html.

1.1.1 Indigenous vascular plant species

Table 41: Number of monitoring plots within each land cover class and year of monitoring of indigenous vascular plant species. Years 1–3 = 1st monitoring cycle; Years 6–8 = 2nd monitoring cycle.

Land cover	Monitoring Years				Total
	1 and 6	2 and 7	2 and 8	3 and 8	
Exotic forestland	4	2		2	8
Exotic grassland	7	8		10	25
Exotic scrubland		1			1
Indigenous forestland	3	2	1	1	7
Indigenous scrubland	2			2	4
Natural bare ground	1				1
Other indigenous vegetation			1		1
Urban		1			1
Water, snow, and ice				1	1
Total	17	14	2	16	49

1.1.2 Bird monitoring

The number of monitoring plots within the regional terrestrial biodiversity monitoring network where bird presence was recorded is shown in Table 42.

Table 42: Number of monitoring plots within each land cover class and year of monitoring of bird presence. Years 1–3 = 1st monitoring cycle; Years 6–8 = 2nd monitoring cycle.

Land cover	Monitoring Years				Total
	1 and 6	2 and 6	2 and 7	3 and 8	
Exotic forestland	4		2	2	8
Exotic grassland	7		8	10	25
Exotic scrubland			1		1
Indigenous forestland	3	1	3	2	9
Indigenous scrubland	2			2	4
Natural bare ground	1				1
Other indigenous vegetation			1		1
Urban			1		1
Water, snow, and ice				1	1
Total	17	1	16	17	51

The location of five-minute bird count stations across the Wellington City park and reserve network is shown in Figure 50 and across Miramar Peninsula in Figure 51.

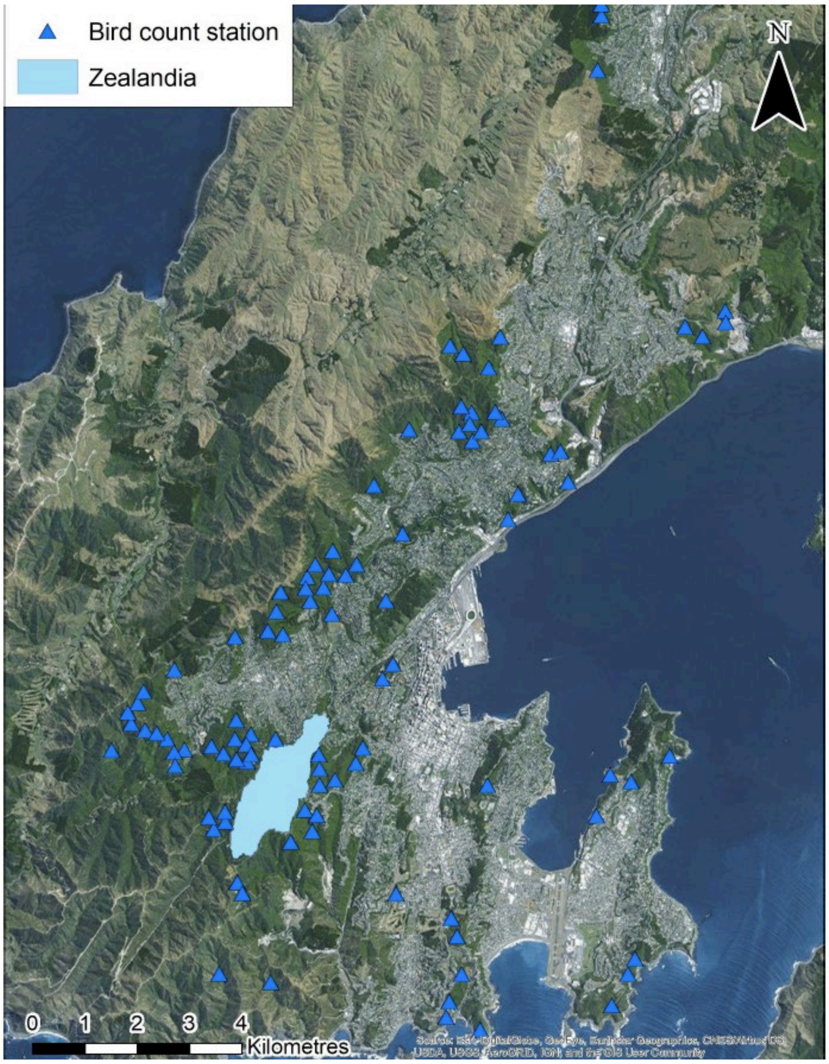

Figure 50: Location of five-minute bird count stations within Wellington City surveyed annually between 2011 and 2021. *Source*: McArthur et al. 2022.

Figure 51: Location of five-minute bird count stations across Miramar Peninsula surveyed annually between 2017 and 2022. *Source*: McArthur 2023.

1.1.3 Possum monitoring

Possum monitoring transects (each 200 m long) were laid out at 45° angles from each of the corners of the 20 m x 20 m vegetation plot (Figure 52). Ten chew cards were placed on trees or 5 mm aluminium rods 20 cm–30 cm above the ground, starting 20 m from the corner of the plot and spaced at 20 m intervals along each of these four possum monitoring transects (i.e., 40 cards per site). The chew cards were constructed from a 9 cm x 18 cm rectangle made of 3mm white plastic coreflute, loaded with aniseed flavoured possum dough. In accordance with the DOC protocol, cards were left out for one dry night and the bite marks on cards identified to determine the relative abundance of pests (Department of Conservation 2016). Initially, DOC used leg-hold traps for possum monitoring. These were however not an option in production landscapes where livestock may be injured. DOC converted to chew cards at all sites in the second season as these were considered easier to deploy (Forsyth et al. 2015).

GWRC used wax tags for possum monitoring in its first two seasons of monitoring but included chew cards from its second season. GWRC then discontinued using wax tags and continued with chew cards in its third season. The wax tags were not placed on the lines off the corners of the vegetation plot as per the protocol but were run as four lines of ten wax tags each, spaced at 20 m intervals, in the nearest wooded areas. Wax tag lines were not sampled if there were no wooded areas close by, and fewer lines were sampled if there was not enough wooded area in which to establish all four lines. The chew cards were used in all habitats. Although used primarily to monitor possums, the chew cards also recorded the presence of rats and mice.

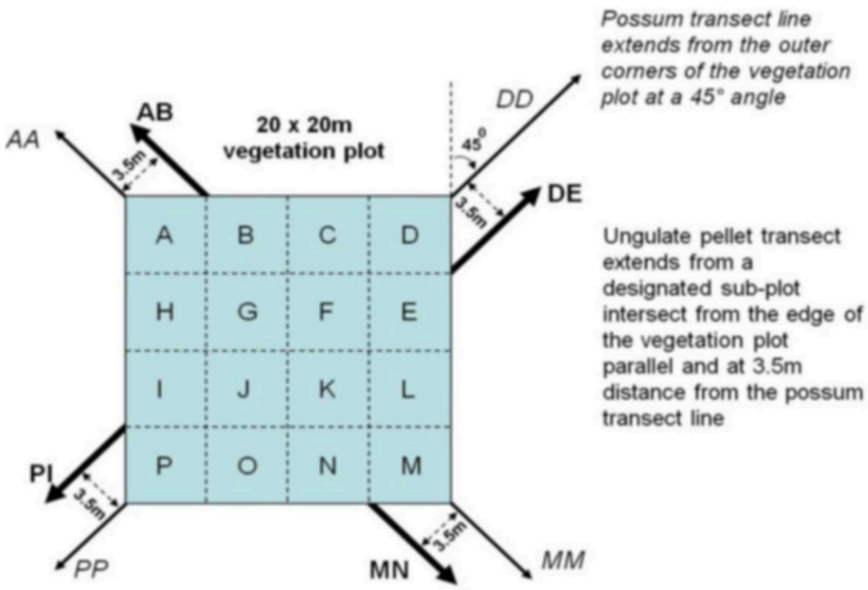

Figure 52: Location of possum transect lines in relation to ungulate pellet transects and the vegetation plot layout.

1.1.4 Ungulate monitoring

Ungulate pellet density transects (each 150 m long) were established parallel to the possum monitoring transects off the corners of the vegetation plot, spaced 3.5 m apart. The ungulate pellet density transects started at the next sub-plot corner clockwise around the vegetation plot from the possum monitoring transect (Figure 52). Each line consisted of 30 quadrats, spaced at 5m intervals (i.e., 120 quadrats per site). Each quadrat had a 1m radius (3 m^2) in which all ungulate dung pellets were recorded. Nested within the centre of this 1m radius quadrat was an inner subquadrant with a 0.18 m radius (0.1 m^2) in which all hare and rabbit pellets were counted. In the first season the GWRC sampling team realised that they could not reliably distinguish deer and goat pellets, so these were combined in the monitoring results described here (Department of Conservation 2016). Unlike the DOC sampling teams that surveyed primarily in natural landscapes, the GWRC sampling team sampled extensively in livestock production landscapes. Consequently, the GWRC sampling team found it necessary to record livestock dung and pellets separately to that of deer and goats, while these were combined in the ungulate counts by DOC.

1.2 Wetland monitoring programme

There are 211 wetlands scheduled in the proposed Natural Resources Plan, 150 of which are included in the wetland health monitoring programme (Figure 53). The first round of sampling will be completed in the 2020/2021 year.

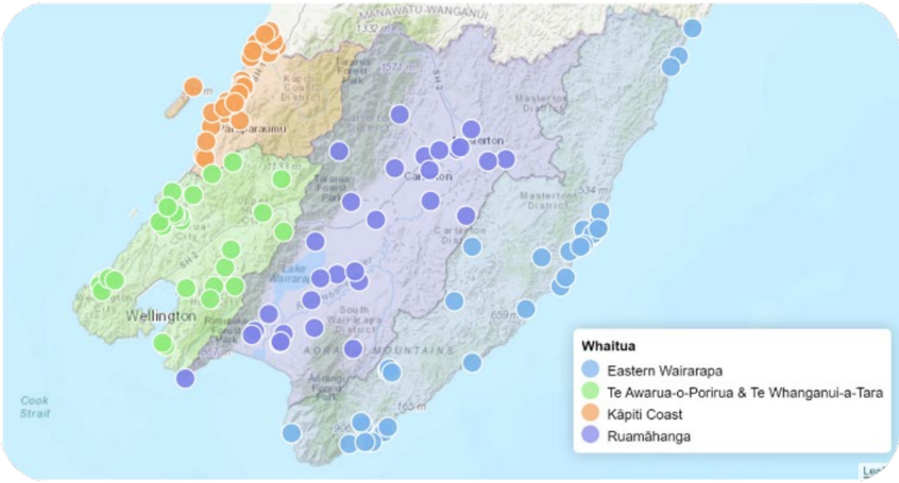

Figure 53: Location of the wetland health monitoring sites 2017–2020, coloured by Whaitua. *Source*: GWRC Environmental Monitoring Portal.[85]

Wetland monitoring followed Clarkson et al. (2003), with adaptations from Clarkson et al. (2013a & 2013b). The following indices/attributes were surveyed:

- Wetland Condition Index
- Wetland Pressure Index
- Vegetation composition

The Wetland Condition Index is a composite index that uses indicators of the following components of wetland health:

- Hydrologic integrity
- Physiochemical parameters
- Ecosystem intactness
- Browsing/predation/harvesting
- Dominance of indigenous plants

Assessments were made at both the wetland scale and at a more detailed plot level. A Wetland Pressure Index was also scored at the landscape scale for each wetland.
The vegetation composition was sampled in 5m x 5m plots randomly located off a sampling grid in all plant communities covering > 20% of the terrestrial area of the wetland.

1.2.1 Wetland fauna

Sampling of birds and fish was conducted in spring. Gee-minnow traps (3 mm mesh) and fine-mesh fyke nets with exclusion chambers were set overnight and retrieved at first light to minimise hypoxia risk. Up to five fyke nets and 10 Gee-minnow traps were deployed at each site where accessibility allowed. Species, numbers, and size classes were recorded for fish. All fish were released alive at their capture location.

Wetland birds were surveyed from the margins of each wetland using playback calls for spotless and marsh crake. Surveys were conducted between 3pm and midnight, and in the morning starting 1 hour after midnight. Listening for bittern calls took place between 3am and 1 hour after sunrise. Recording devices were also left

85 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/index.html

at each wetland for 4–6 weeks and were pre-set to record bird call for 4 hours at dusk and 2 hours before dawn. Species, number, and location were recorded for wetland birds.

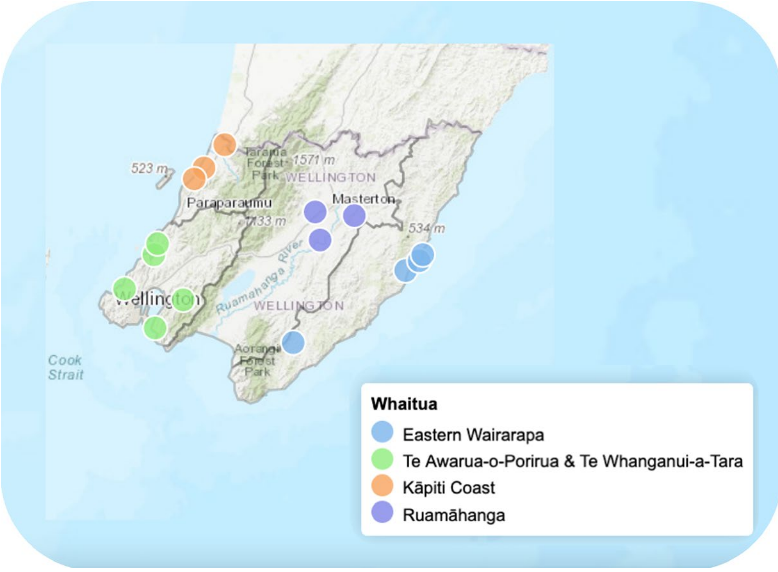

Figure 54: Location of the wetland avifauna monitoring sites 2017–2020, coloured by Whaitua. *Source*: GWRC Environmental Monitoring Portal.[86]

1.3 Duneland biodiversity monitoring programme

Table 43: Number of monitoring plots by land tenure and management regime surveyed on a 5-year cycle as part of Greater Wellington Regional Council's terrestrial biodiversity monitoring programme.

Management programme / Administrative agency	Number of plots
Key Native Ecosystem (KNE) programme / Greater Wellington Regional Council	11
Unmanaged	5
Regional Park / Greater Wellington Regional Council	1
Public Conservation Land / Department of Conservation	2
Wellington City Council	1
Total:	20

86 https://www.gw.govt.nz/annual-monitoring-reports/wetland-health/faunal-survey.html.

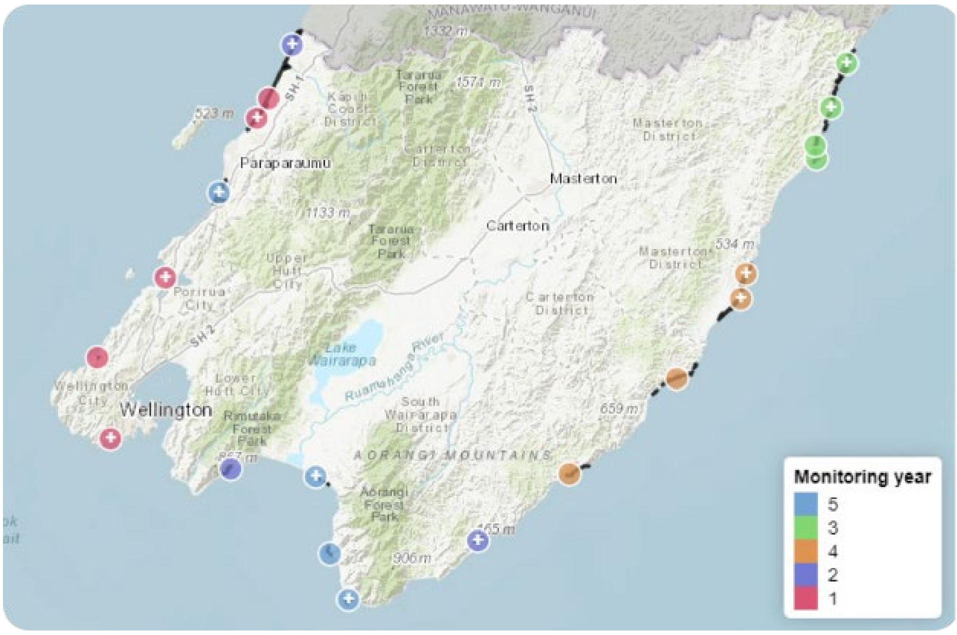

Figure 55: Location of duneland monitoring sites within the Wellington Region. Duneland is depicted by black outlines, circles show location of monitoring sites, coloured according to monitoring year. Year 1 = 2016/2017, Year 5 = 2021/22. Plus signs (+) within circles depict Key Native Ecosystem sites. Source: GWRC online environmental monitoring portal: https://www.gw.govt.nz/annual-monitoring-reports/duneland-health/index.html.

2 FRESHWATER BIODIVERSITY MONITORING PROGRAMME

2.1 Macroinvertebrates

Macroinvertebrates play a central role in stream ecosystems by feeding on periphyton (algae), macrophytes, dead leaves and wood, or each other. They are extremely important for processing terrestrial and aquatic organic matter, and in turn, are an important food source for animals further up the food chain, such as wading birds and fish. When the insects become adults, they leave the water and become food for animals such as birds, bats, spiders, etc.

The Macroinvertebrate Community Index (MCI) is based on the presence or absence of invertebrate species (taxa) with different tolerances/sensitivities to organic pollution and nutrient enrichment. For this reason it is regularly used as an indicator of river or stream ecosystem health.

2.1.1 Sampling

A single macroinvertebrate sample is collected at RWQE water sampling sites during summer/early autumn. The timing of sampling is determined at random, although macroinvertebrate sampling is, where practicable, avoided within two weeks of any flood event (flood events are defined as flows greater than three times the median river flow).

Samples are collected with the use of a kick-net (0.5 mm mesh size) following Protocol C1 of the national macroinvertebrate sampling protocols (Stark et al. 2001) for the 39 sites with hard substrate (in riffle habitat) and Protocol C2 for the 7 sites with a soft substrate. All samples are processed in accordance with Protocol P2 (Stark et al. 2001).

2.1.2 Benchmarking

Macroinvertebrate Community Index (MCI) scores are assessed against quality classes recommended for the Greater Wellington Region and Greater Wellington Natural Resources Plan (NRP) plan outcomes (Clapcott and Goodwin, 2014).

These thresholds have been developed based on regional data for six Freshwater Ecosystems of New Zealand (FENZ)[87] river classes and were defined from statistical distributions of data from a mix of:

- Observed reference sites.
- Modelled 'reference' conditions using reaches with land use restrictions that indicate low disturbance.
- All contemporary observed sites.
- All modelled contemporary conditions.

Limits for MCI class and NRP outcomes in the table below refer to the latest three-year median MCI score.

87 https://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/

River class	MCI Score quality class				NRP Outcomes	
	D	C	B	A	All rivers	Significant rivers
1 (Steep, hard sedimentary)	< 110	110–120	120–130	≥ 130	≥ 120	≥ 130
2 (Mid–gradient, coastal and hard sedimentary)	< 80	80–105	105–130	≥ 130	≥ 105	≥ 130
3 (Mid–gradient, soft sedimentary)	< 80	80–105	105–130	≥ 130	≥ 105	≥ 130
4 (Lowland, large, draining ranges)	< 90	90–110	110–130	≥ 130	≥ 110	≥ 130
5 (Lowland, large, draining plains and eastern Wairarapa)	< 80	80–100	100–120	≥ 120	≥ 100	≥ 120
6 (Lowland, small)	< 80	80–100	100–120	≥ 120	≥ 100	≥ 1

2.1.3 Model Estimates

This regional specific model estimated MCI score based on land cover and environmental variables such as slope, geology, climate. Model performance diagnostics indicated a very good predictive model, with 95th percent confidence intervals of < 29 MCI units, and effectively no bias (< 0.1 MCI unit). More details of the data and model development can be read in section 2.1.1 of Clapcott & Goodwin (2014).

2.2 Periphyton and cyanobacteria

Periphyton is algae/slime that attaches to hard surfaces such as rocks and tree roots in freshwater environments. It is an important food source for invertebrates and some fish, and can absorb contaminants from water (e.g., nitrate, ammonia, phosphorus, and metals). However, too much of it can limit the food sources and/or habitat of macroinvertebrates (e.g., insects, snails, and worms), affect the ability of fish to find food, and cause harmful water quality effects such as daily fluctuations in dissolved oxygen and pH (acidity). Periphyton blooms can also be visually unappealing and can make access to streams difficult (slippery).

Cyanobacteria (commonly known as blue-green algae) are photosynthetic prokaryotic organisms that are integral parts of many terrestrial and aquatic ecosystems. In aquatic environments, under favourable conditions, cyanobacterial cells can multiply and form planktonic (suspended in the water column) blooms or dense benthic (attached to the substrate) mats. An increasing number of cyanobacterial species are known to include toxin-producing strains. These natural toxins, known as cyanotoxins, are a threat to humans and animals when consumed in drinking water or by contact during recreational activities. The mechanisms of toxicity for cyanotoxins are very diverse, ranging from acute unspecified intoxication symptoms (e.g., rapid onset of nausea and diarrhoea), to gastroenteritis and other specific effects, such as hepatotoxicity (liver damage) and possibly carcinogenesis (MfE & MoH 2009).

2.2.1 Sampling

Formal periphyton & cyanobacteria assessments are limited to the 39 RWQE sites with hard substrates.

2.2.2 Monthly assessment of visible streambed cover

Periphyton cover is determined by estimating the percentage of mat (>1 mm thick), cyanobacterial mat (>1 mm thick) and filamentous (>2 cm long) periphyton present on the stream or riverbed. Note that cover of mat and cyanobacterial mat-periphyton are mutually exclusive (i.e., cyanobacterial mat cover >1 mm thick will be counted as separate from mat-periphyton). A total of 20 observations are taken at each site from two transects of ten observations, or, if the stream or river is not wide enough or too swift to wade across more than half of the river's width, four transects of five observations. Each observation is typically made with an underwater viewer and covers an approximate area of a 30 cm diameter circle.

Visible streambed periphyton cover assessments are carried out equally in both run and riffle-type habitats if these are present at a sampling site/reach.

2.2.3 Monthly assessment of biomass

Periphyton samples for quantitative biomass assessments (chlorophyll a) are collected on a monthly basis. During 2021/22, chlorophyll a samples were collected from 17 of the 39 RWQE sites with hard substrates. Sampling protocols involved collecting samples from a run habitat and following modified versions of quantitative methods 1b (QM-1b) and 3 (QM-3) as outlined by Biggs and Kilroy (2000). This involves pooling periphyton samples from 10 rocks into a single composite sample for analysis (see Greenfield (2016) for further details).

2.2.4 Benchmarking

Monthly observations of percent streambed periphyton cover (filamentous and mat-forming periphyton) are compared against the periphyton composite cover guidelines (Matheson et al. 2012). The threshold for nuisance mat cover is twice that for filamentous periphyton cover, so the periphyton weighted composite cover (WCC) can be defined as filamentous periphyton cover + (mat periphyton cover / 2) with a nuisance guideline of ≥ 30%.

Results for periphyton biomass are rated against the Ministry for the Environment (MfE) National Objectives Framework (NOF) guidelines. See the National Policy Statement for Freshwater Management (NPS-FM) document for more information.

2.2.5 Model estimates

Periphyton biomass state has been estimated for each river reach by comparing modelled median total nitrogen (TN) and dissolved reactive phosphorus (DRP) concentrations from Larned et al. (2017) to DRP thresholds in Snelder et al. (2019) and revised TN thresholds in MfE (2019).

These nutrient thresholds relate to each NOF state where increasing levels of estimated TN and DRP (see nutrients model estimates above where TN is modelled using the same approach) correspond to higher risk of increased periphyton biomass. In the case that TN and DRP thresholds estimated different periphyton states for the same river reach the higher risk state has been used.

2.4 Habitat quality

Habitat assessments are undertaken annually at RWQE sites during summer/early autumn when invertebrates samples are collected following the updated methods outlined in Clapcott (2015). This assessment provides an indication of the condition of the physical habitat and its ability to support stream biota, and incorporates the following variables: deposited sediment cover, invertebrate habitat abundance and diversity, fish habitat abundance and diversity, hydraulic heterogeneity, bank erosion and vegetation, and riparian width and shade. Each category is scored between 1 ('poor') and 10 ('excellent'). Summation of individual scores provides an overall total habitat quality score for each site (lowest and highest possible scores are 10 and 100, respectively).

This methodology was developed with a focus on wadeable hard-bottomed streams (Clapcott, 2015) and hence its applicability to other stream/river types has not been explored.

2.5 Lake ecological condition

Submerged aquatic plant communities are assessed using the nationally accepted LakeSPI (Submerged Plant Index) methodology developed by Clayton and Edwards (2006). This involves scuba divers assessing 11 metrics over a 2 m wide transect from the shore to the deepest vegetation limit at several sites which are representative of the lake.

The first LakeSPI surveys were carried out in autumn 2011 and are intended to be repeated at five-yearly intervals except where more frequent surveys are warranted.

Application of the LakeSPI method results in three indices expressed as a percentage of expected pristine state:

- An indigenous condition index (i.e., the diversity and quality of the indigenous flora);
- An invasive condition index (i.e., the degree of impact by invasive weed species); and
- An overall LakeSPI index that synthesises components of both the indigenous condition and invasive condition indices to provide an overall indication of lake ecological condition.

The LakeSPI index is used to place the lake vegetation into one of five categories of lake condition listed in the table below (Verburg et al. 2010):

Lake ecological condition	LakeSPI index (% of expected pristine state)
Non-vegetated	0
Poor	>0-20
Moderate	>20-50
High	>50-75
Excellent	>75

Each sub-component condition index is also rated against National Policy Statement for Freshwater Management 2020 NOF guidelines:

Attribute state	Indigenous Condition index	Invasive Impact index
A	>75	0*
B	>50 and ≤75	>1 and ≤25
C	>20 and ≤50	>25 and ≤90
National bottom line	20	90
D	≤20	>90

**Note Invasive Impact index scores for non-vegetated lakes are not included in the A band.*

In 2011 assessments of ecological condition, based on submerged macrophyte community structure and composition, were introduced for Lakes Kohangapiripiri, Kohangatera and Pounui. Assessments of macrophyte communities, termed LakeSPI (Submerged Plant Indicator) have since been expanded to other lakes and lagoons in the Wellington Region: Bartons Lagoon, Boggy Pond, Lake Nganoke, Lake Ngarara, Lake Waiorongomai, Matthews Lagoon and Turners Lagoon. LakeSPI assessments are planned to occur every three-five years.

The monitoring network is shown in Figure 56.

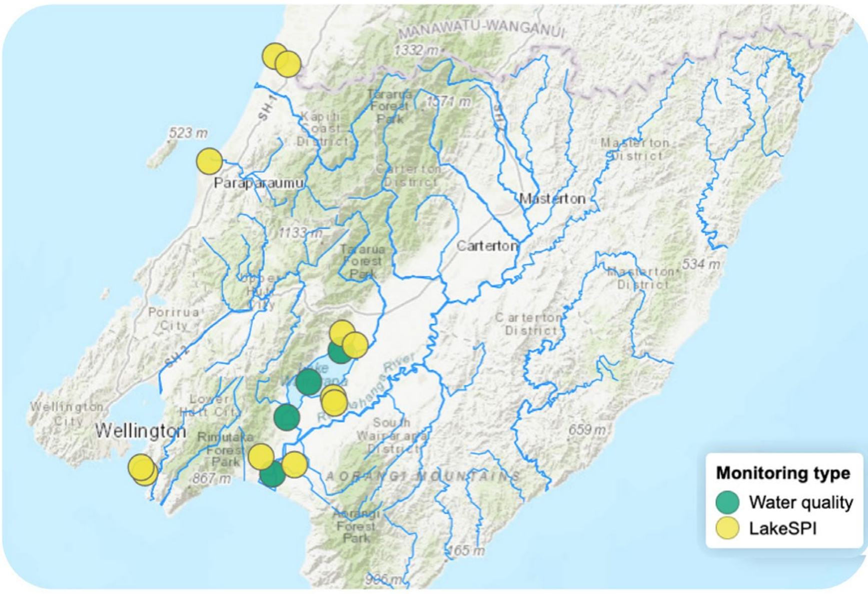

Figure 56: Location of the 2021/22 lake water quality and ecology monitoring sites. For the purposes of this report only the LakeSPI plots are of relevance. *Source*: GWRC Environmental Monitoring Portal[88].

88 https://www.gw.govt.nz/annual-monitoring-reports/lake-water-quality-and-ecology/index.html.

3 Coastal and marine monitoring programme

3.1 Annual sediment monitoring

Annual sediment monitoring is conducted in Te Awarua-o-Porirua Harbour (Figure 57) as part of GWRC's ongoing work monitoring and management catchment sediment inputs to the harbour. The monitoring involves measuring sedimentation at nine intertidal and nine subtidal sites, assessing changes in sediment mud content, and visually assessing sediment redox status (oxygenation). In addition, changes in the spatial extent of mud-dominated sediment is measured on six fixed transects adjacent to subtidal sites. Monitoring methods are detailed in Rogers et al. 2021.

Since 2010, Greater Wellington Regional Council has undertaken annual State of the Environment (SOE) monitoring of sediment indicators in the Hutt and Waikanae estuaries to assess trends in the deposition rate, mud content, and oxygenation of intertidal sediments. In the Hutt Estuary, monitoring (comprising four buried sediment plates) is conducted at the only remaining intertidal site in the lower estuary, while monitoring is conducted at three sites in the Waikanae Estuary (Figure 58). Monitoring methods are detailed in Rogers 2021a (Waikanae Estuary) and Rogers 2021b (Hutt Estuary).

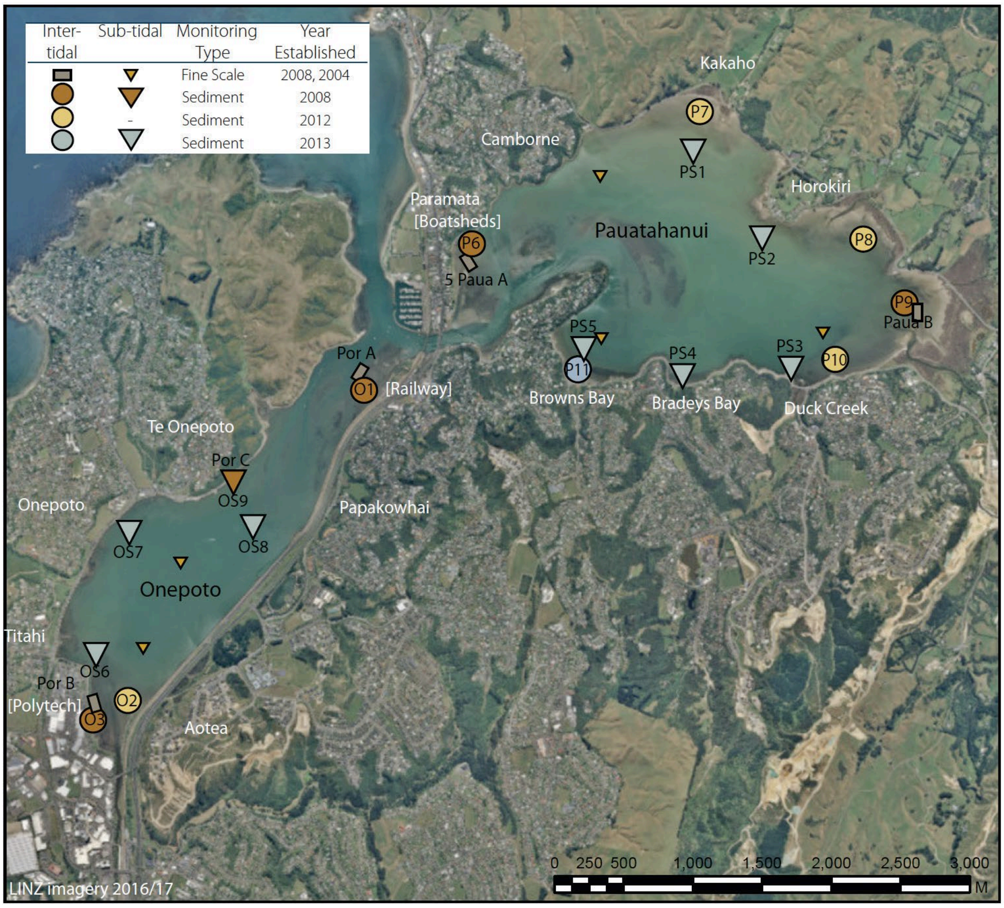

Figure 57: Location of the monitoring sites in the Onepoto and Pāuatahanui Inlets in Te Awarua-o-Porirua Harbour. Buried sediment plate sites indicated with alphanumeric sequence and circles (intertidal) and large triangles (subtidal). 'Fine scale' monitoring sites indicated by rectangles (intertidal) and small triangles (subtidal). *Source*: Roberts et al. 2021.

Figure 58: Location of the monitoring sites in the Hutt (left) and Waikanae (right) Estuaries. *Source:* Roberts 2021a, 2021b.

3.1.1 Sediment transects

The location of sediment transects in Te Awarua-o-Porirua Harbour is shown in Figure 59. Transect coordinates are provided in Roberts et al. 2021.

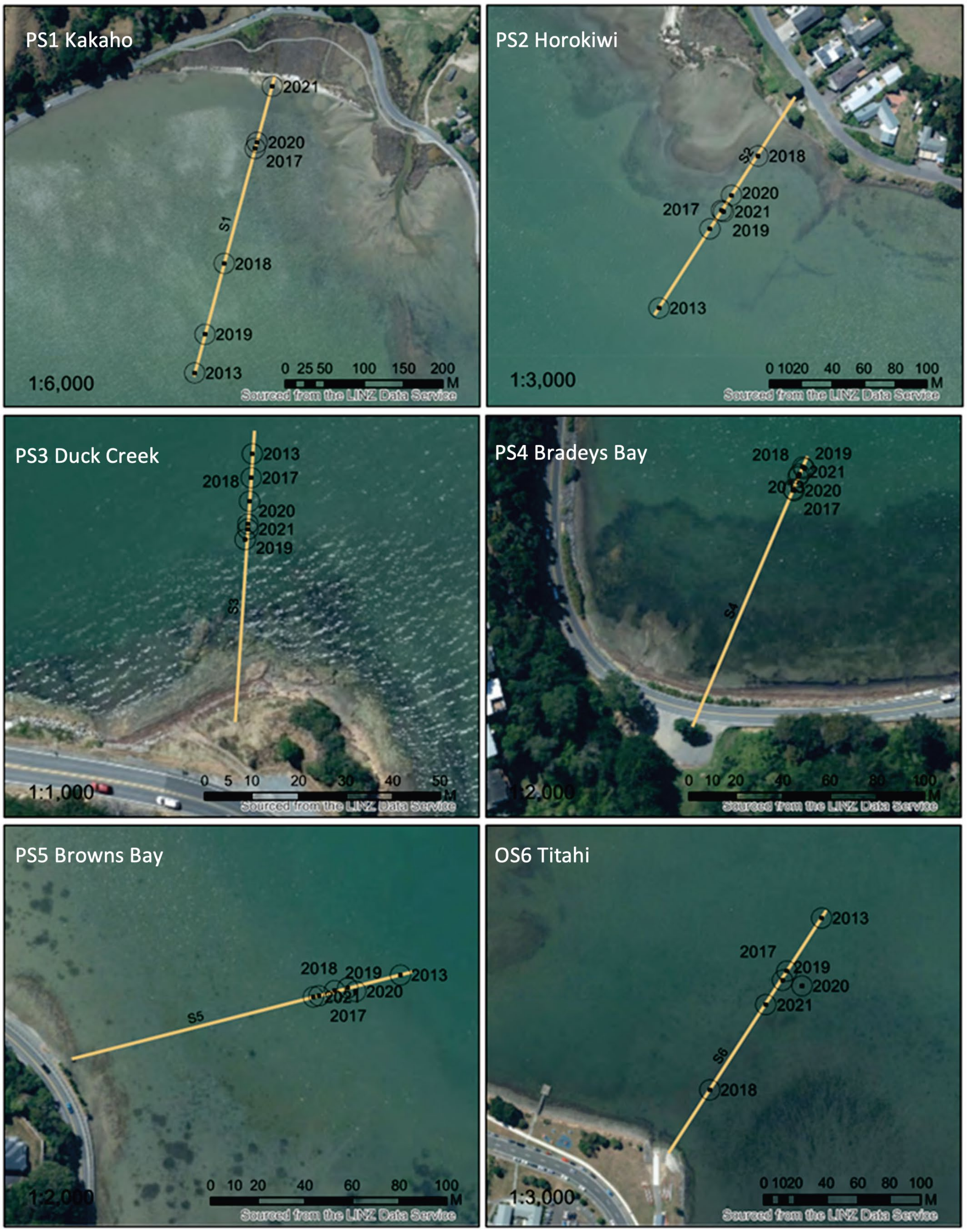

Figure 59: Location of the sediment transects in Te Awarua-o-Porirua Harbour showing the distance from subtidal plate sites to where soft mud transitions to finer sediments closer to the shoreline (2013, 2017, 2018, 2019 and 2021). *Source:* Roberts et al. 2021.

3.2 Fine-scale intertidal monitoring

Four fine scale sites (two in each inlet) were first established in Te Awarua-o-Porirua Harbour in January 2008 (Figure 60). Sites are largely unvegetated, except for patches of seagrass at one of the Onepoto sites (Onep A). Each monitoring site is 30 x 60 cm and has 'sediment plates' for sedimentation monitoring installed at one end. Each site is divided into a 3 x 4 grid of 12 plots and benthic indicators sampled in ten of these plots. Indicators, sampling methods, and GPS locations of plots are detailed in Forrest et al. 2020.

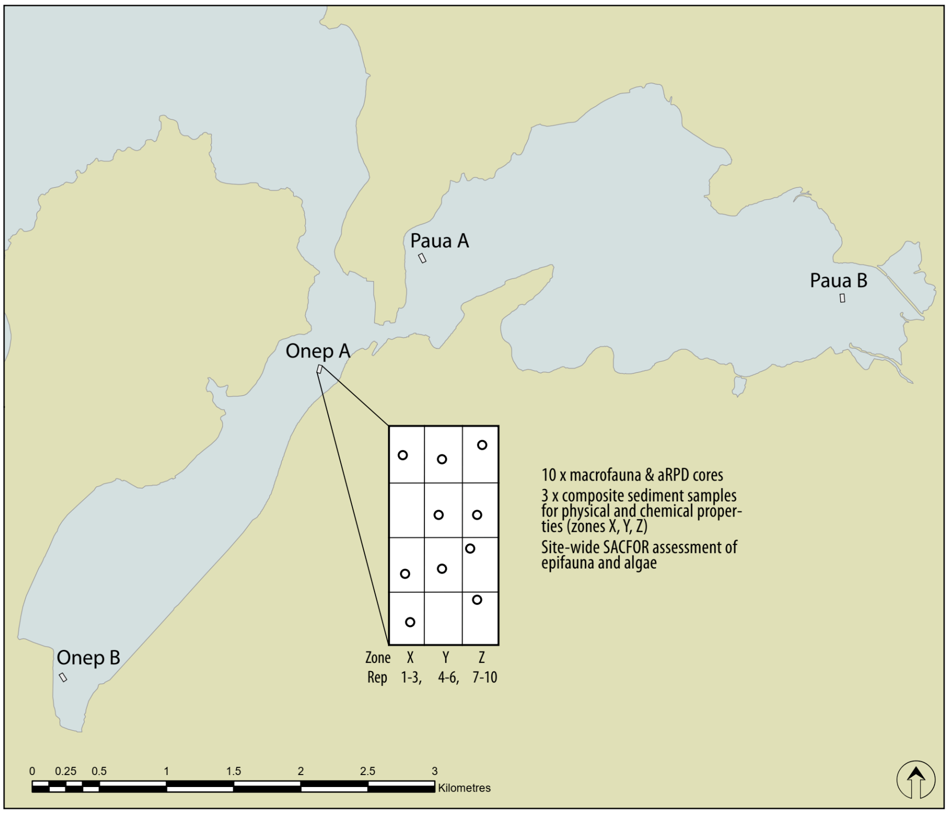

Figure 60: Location of fine-scale monitoring sites in the Onepoto and Pāuatahanui Inlets, Te Awarua-o-Porirua Harbour showing the schematic of sampling design. *Source*: Forrest et al. 2020.

3.3 Subtidal benthic ecology monitoring

Subtidal sediment samples were collected by divers from five sites in Te Awarua-o-Porirua Harbour on the 12 and 20 November 2020 (Figure 61), and from 15 sites in Te Whanganui-a-Tara on the 2 and 26 November 2020 (Figure 62). Details of site position and sampling method are provided in Cummings et al. 2021 (Te Awarua-o-Porirua Harbour) and 2020 (Te Whanganui-a-Tara).

The schematic of subtidal sampling is shown in Figure 63.

Figure 61: Map of locations of subtidal sites in Te Awarua-o-Porirua Harbour sampled in 2020. *Source:* Cummings et al. 2021.

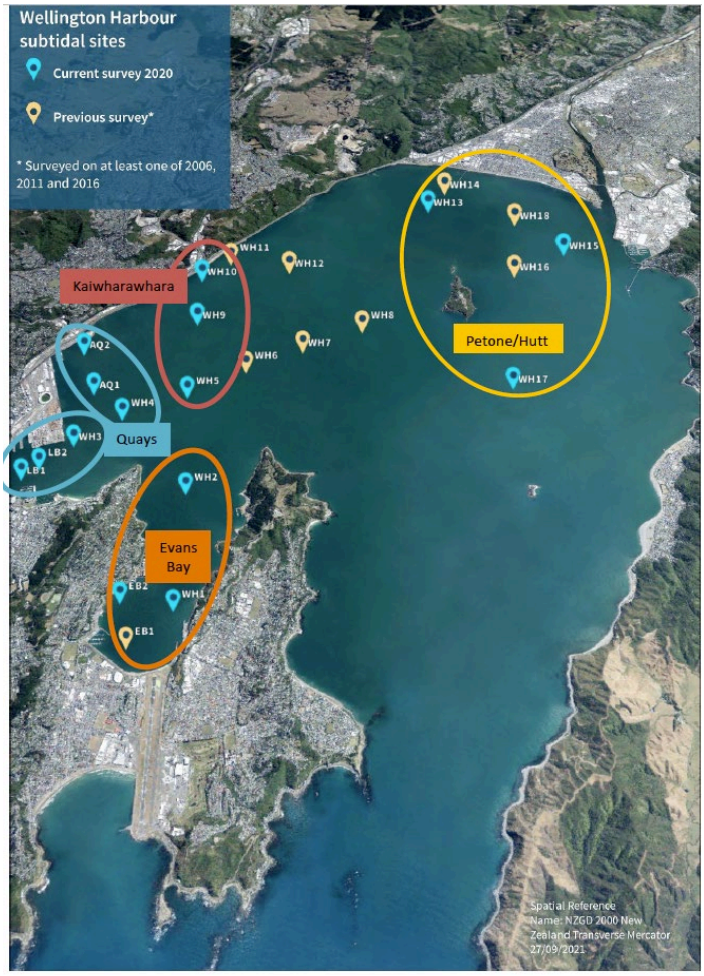

Figure 62: Map of Wellington Harbour subtidal sites sampled in 2020 (blue markers). Sites depicted by blue markers were surveyed in 2020 and sites depicted by yellow shading were surveyed in previous years (but were not resurveyed in 2020). The current sites have been grouped by location into Evans Bay (EB2, WH1, WH2), the Quays (southern grouping of LB1, LB2, WH3; northern grouping of WH4, AQ1, AQ2), Kaiwharawhara (WH5, WH9, WH10), and Petone/Hutt (WH13, WH15, WH17). *Source:* Cummings et al. 2022.

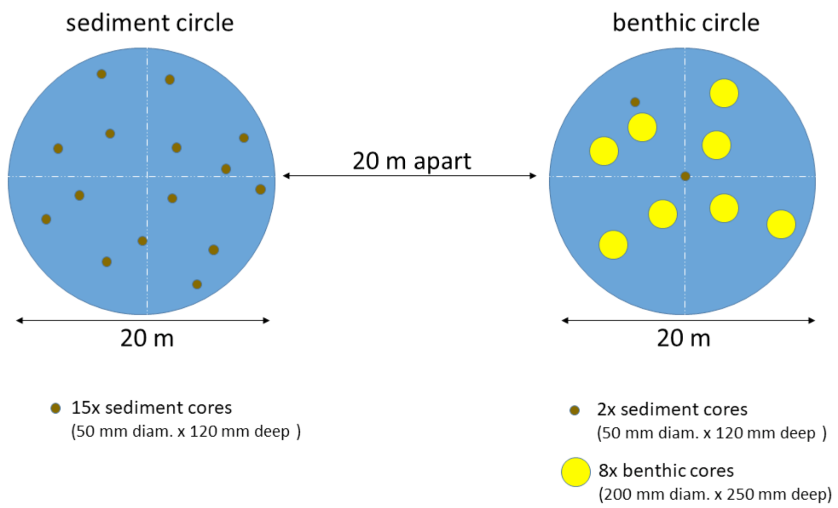

Figure 63: Schematic of subtidal sampling methodology followed for collection of sediment and benthic faunal samples from Te Awarua-o-Porirua Harbour and Te Whanganui-a-Tara. *Source:* Cummings et al. 2021; 2022.

3.4 Rocky shore baseline assessment

The location of the rocky shore sites where baseline assessment and characterisation has been conducted is provided in Figure 64. Location of sampling areas and details of sampling methods are provided in Forrest & Stevens 2019b, Stevens 2018 and Stevens & O'Neill-Stevens 2017.

Figure 64: Location of rocky shore baseline assessment and characterisation surveys conducted in 2019 on Kāpiti and Mana Islands (upper left panel), in 2018 at Mākara, Scorching Bay, and Baring Head (upper right panel) and in 2016/17 at Flat Point (lower panel). *Source*: Forrest & Stevens 2019b; Stevens 2018; Stevens & O'Neill-Stevens 2017.

3.5 Sandy beach monitoring

The location of the sandy beach sites where baseline assessment and characterisation has been conducted is provided in Figure 65 and Figure 66. Details of sampling methods are provided in Stevens 2018b, Robertson & Stevens 2014 and Robertson & Stevens 2015.

Figure 65: Location of sandy beach baseline assessment and characterisation survey transects and stations (2018) at Petone Beach (top), Lyall Bay (middle), and Ōwhiro Bay (bottom). *Source:* Stevens 2018b.

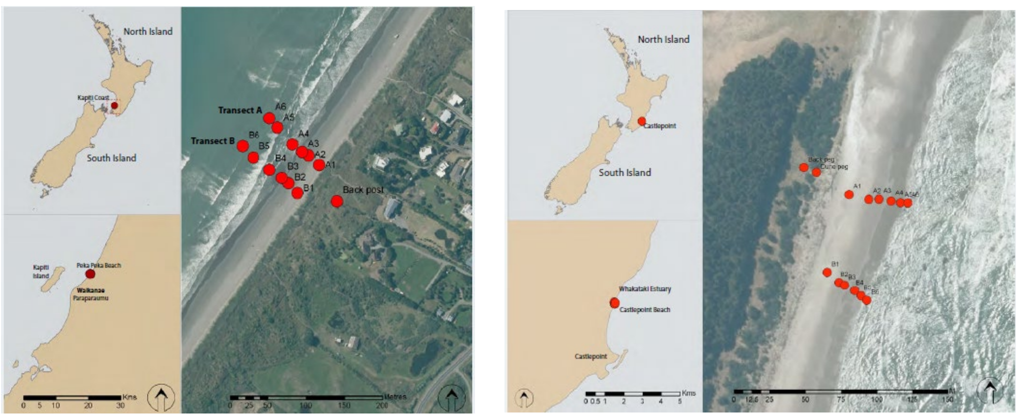

Figure 66: Location of sandy beach baseline assessment and characterisation survey transects and stations at Peka Peka Beach in 2014/15 (left panel) and Castlepoint Beach in 2014 (right panel). *Source:* Robertson & Stevens 2015, Robertson & Stevens 2014.

THECATALYSTGROUP
planning and environment

p. +64 6 358 6300

e. enquiries@thecatalystgroup.co.nz

a. Level 3, 31 George Street,

PO Box 362, Palmerston North

www.thecatalystgroup.co.nz