Te Whanganui-a-Tara monitoring

Greater Wellington
Te Pane Matua Taiao

Contents

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For the latest available results go to the GW environmental data hub.

Overview

Te Whanganui-a-Tara (Wellington Harbour) is a nationally significant harbour and port environment valued for the range of biodiverse habitats, species, and ecosystem goods and services it provides. Like other coastal environments surrounded by urban areas, the harbour receives inputs of sediment, nutrients, and other contaminants from the surrounding catchments.

Such contaminants have the potential to adversely impact on the health and function of its ecosystem.

Why monitor sediments in estuaries and harbours?

- There is a lot of human activity in and around our harbours and it is Greater Wellington's job to understand how the activities of people are affecting the marine environment. This will allow us to manage our activities so that we can minimise our impacts through more environmentally conscious actions.
- Sediments are of particular interest as contaminants (such as heavy metals from zinc roofs, copper from vehicle brake pads, carcinogenic hydrocarbons emitted during combustion) stick easily to fine muddy particles.
- Sediments also smother marine life and plant communities living on the seafloor. Mapping the extent of muddy areas and the content of mud within marine and estuarine sediment allows us to better understand the effects mud is having on our precious estuarine ecosystems such as shellfish and seagrass beds.
- Since contamination affects the health of the animal communities living within our marine ecosystems, we analyse samples from the very top layer of harbour sediments to understand whether selected sites within our harbours are becoming more contaminated or whether they are improving over time.

We currently monitor deposition rate, mud content, and oxygenation of intertidal sediments at one site in the Te Awa Kairangi (Hutt River) lower estuary and have been doing so since 2010. Periodically we also monitor macroalgae in this system. Additionally, three buoys have continuously monitored inner harbour water quality and wave data.

Subtidal sediment surveys are one of the big pieces of monitoring work that we release every four to five years for our main harbours within the Greater Wellington Region. Together with habitat mapping, this information allows us to assess the health of our marine and estuarine invertebrate communities which are indicators of overall ecosystem health.

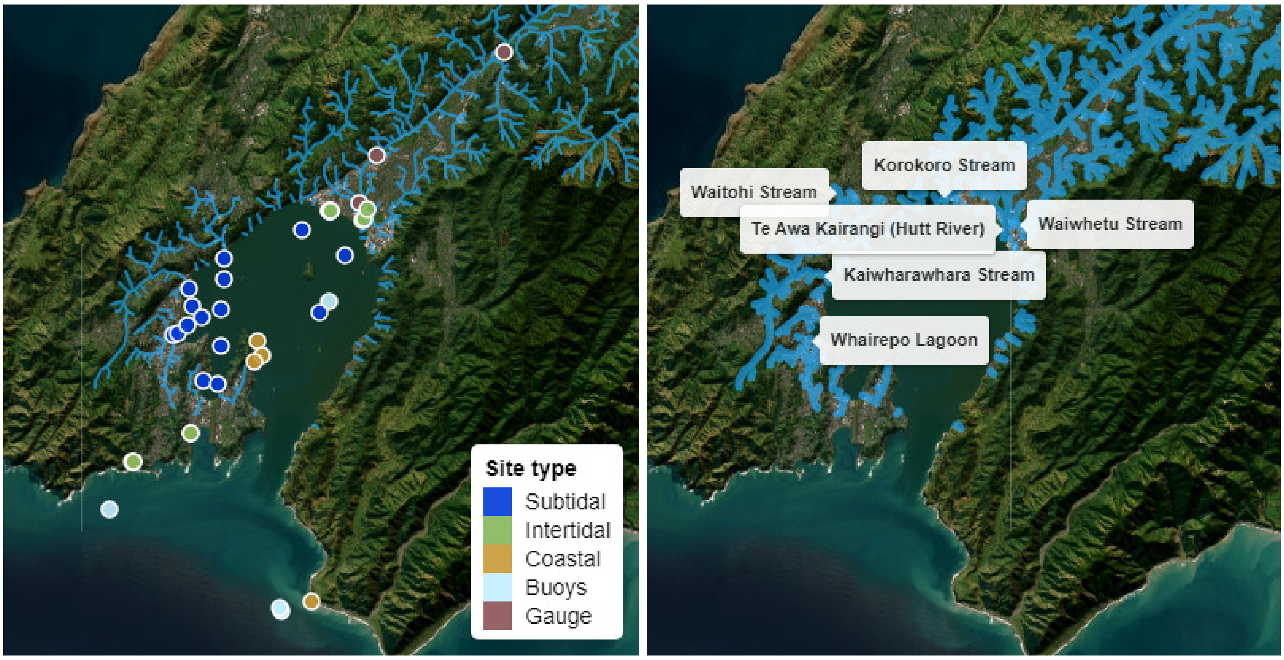

Figure 1: Te Whanganui-a-Tara monitoring sites and the main stream/creek inputs flowing into the harbour. Note that sites and indicators vary across the sampling period.

Methods

Full details of methods and guideline comparisons are accessible in coastal monitoring reports.

Habitat surveys describe and map estuaries according to dominant habitat features combining aerial photography, detailed ground truthing, and Geographic Information System (GIS) data. Changes in the position, size, or type of dominant habitats are monitored over time by repeating the mapping exercise every five years. Once an estuary has been classified according to its main habitats and their condition, representative habitats can be selected and targeted for sediment quality and ecological monitoring.

The environmental characteristics assessed in fine scale surveys include biological attributes (e.g. number of animals) and physical and chemical characteristics (e.g. sediment mud content, metals, nutrients) to assess ecological condition. We also measure the amount of sediment depositing in the harbour using plates buried below the soft sediment in intertidal and subtidal areas to tell us where and how much mud is settling. Results across all years are assessed using estuarine health metrics or condition ratings, which are used to assign one of four 'health status' bands (e.g. poor, fair, good, very good) to track changes over time. These data are used to make informed environmental management decisions to protect and improve the resilience of Te Whanganui-a-Tara Harbour.

Annual executive summaries

2022/23

Sedimentation rate annual survey

Sedimentation in Te Awa Kairangi (Hutt River) estuary has been variable since monitoring began, with large deposition and erosion events recorded between 2011 and 2023 (Stevens 2023). Over the past 10 years there has been an overall trend of moderate deposition, with net erosion recorded over the past five years. The sediment mud content has also been variable but has been trending downwards since 2019, while the moderately shallow and variable aRPD depth has been improving at the same time. This tentatively suggests an improvement in sediment condition, although because of the variable sediment deposition and erosion, only tolerant species of infauna are likely to be able to survive on the intertidal flats. It is also noted that while recent years indicate a period of erosion and an improvement in sediment condition, most fine sediment from catchment sources is likely to deposit in subtidal basin areas which are not monitored.

2021/22

Sedimentation rate annual survey

Mean sedimentation rates in Te Awa Kairangi (Hutt River) estuary over the past five- and 10-years corresponded to a condition rating of ‘poor’. The long-term calculation showed sedimentation of 2.6 mm/year, while that of the five-year mean was 3.5 mm/year. Sediment oxygenation reduced from ‘good’ to ‘fair’ since the previous year, while mean sediment mud content remained ‘fair’ but increased from 12.3% to 17.4% (Stevens 2022). These results indicate the intertidal estuary flats remain under pressure from sediment deposition. They reinforce previous recommendations to assess and manage fine sediment inputs to the estuary, noting that most fine sediment is likely to deposit in subtidal basin areas which are not currently monitored.

2020/21

Sedimentation rate annual survey

Mean sedimentation rates over the past five and 10 years corresponded to a condition rating of ‘poor’. The long-term calculation showed sedimentation of 3.1 mm/year, while the five-year mean increased to 9.3 mm/year due to consistent sediment accrual since 2016. Sediment oxygenation was ‘good’ and mean sediment mud content was ‘fair’ (12.3%), almost the lowest value recorded during the monitoring programme (Roberts 2021).

The sedimentation rate over the past 10 years shows an overall trend of deposition, which has increased over the last five years. Most recent sediment accrual is sand dominated with a relatively low mud content, comparable to previous years. Sediment movement and deposition is variable due primarily to the influence of stream inputs and flows but also due to dredging in the lower Te Awa Kairangi (Hutt River).

Environmental health fine scale subtidal survey

Some of the ways that contaminants may enter our harbours is via point source discharges such as stormwater, river systems, or in water runoff during rainfall events. In Te Whanganui-a-Tara (Wellington) Harbour our monitoring sites are strategically placed in areas of high activity such as operational quays, and near rivers that discharge large volumes of potentially sediment and nutrient laden water into our coastal environment. We also have monitoring sites towards the centre of the Harbour, which act as control or less impacted sites as they are located in deeper water away from major sources of contaminants.

The November 2020 sediment survey of Te Whanganui-a-Tara Harbour showed that bottom sediments were very muddy (69-96% mud) at 14 of the 15 subtidal sites sampled. Only southern Evans Bay was found to be mostly sandy. Most heavy metals measured (arsenic, cadmium, chromium, nickel) and total PAHs were below safe guidelines at all sites, while the site near the entrance of the Te Awa Kairangi (Hutt River) as well as the one near Matiu (Somes) Island did not exceed guidelines for any of the chemical contaminants measured. Lead and mercury, two of the most toxic heavy metals, concerningly exceeded guidelines at all other sites. Zinc and copper were also above guideline concentrations in eastern Evans Bay, and in and around Lambton Basin, while sites near Aotea Quay were approaching exceedance concentrations for copper. Should these sediments be disturbed, toxic contaminants may be released from the mud, possibly killing marine life. The benthic communities at each site were generally diverse with reasonable abundances of bivalves, polychaete worms and crustaceans, mixtures of functional types (e.g., suspension feeders, deposit feeders), and an assortment of disturbance tolerant and sensitive species. This shows that a healthy infaunal community is managing to persist despite pollution and sedimentation pressures. Southern Evans Bay was again clearly different with an abundance of seafloor animals (average 38 taxa and 315 individuals per sample) as opposed to other areas of the Harbour which hosted a smaller variety of species and fewer animals (between 14 and 22 taxa and 40-124 individuals per sample). The Hutt River site had the lowest diversity and abundance.

We do not yet have sufficient data to accurately identify trends over time; however, it is apparent that contamination within Wellington Harbour sediments remains of high concern.

2019/20

Sedimentation rate annual survey

The sedimentation rate in the Te Awa Kairangi (Hutt River) Estuary over the past 10 years shows an overall trend of deposition and a relatively consistent elevated mud content. There has been an overall mean sedimentation rate of +1.9mm/year across the 10 years of monitoring, with a rolling mean over the past five years of 7.4mm/year, a condition rating of ‘poor’ (Stevens 2020).

Sediment oxygenation is ‘fair’, mostly as a result of bioturbation (crabs, cockles and worms in surface sediments creating voids that allow air and water to transfer oxygen to underlying sediments). The estuary flats remain under pressure from sediment impacts related to poor water clarity and the muddy intertidal substrates support mostly mud tolerant species.

A ‘moderate’ macroalgal Ecological Quality Rating reflects the widespread presence but generally low biomass and absence of entrainment of intertidal macroalgae in the estuary, with growths not causing significantly degraded intertidal sediment conditions. However, the artificial rock walls that replace natural intertidal estuarine habitat tend to result in an overestimate of habitat health. Regular flushing of the estuary is also likely to remove macroalgae from intertidal areas and limit the development of rotting macroalgae and poorly oxygenated sediments to very localised areas on intertidal flats. Indeed, there is ongoing evidence of significant subtidal impacts from excessive nutrient-driven macroalgae growth. The consistent widespread cover of opportunistic green macroalgae throughout the intertidal estuary strongly suggests that elevated catchment nutrient inputs from water column, sediment and groundwater sources are driving the observed growths (Stevens & Forrest 2020).

Sedimentation

Sediment (particularly muddy sediments) discharged into rivers, streams and harbours can negatively impact a range of values, including ecosystem health and the way people use water for recreational, cultural and spiritual purposes.

The main habitats monitored are unvegetated sediments (e.g. mud and sand areas) and areas vegetated with salt marsh and seagrass. Degraded habitat is a major contributor to reduced aquatic ecosystem health.

Sedimentation rate

The depth of sediment overlying concrete pavers buried at discrete sites provides an indicator of estuary sedimentation. The map shows monitoring site (circles) annual sedimentation over a rolling five year period and the whole harbour average of these values (shaded region). Positive values indicate where there has been sediment deposition (accumulation) and negative values indicate erosion. See Stevens 2022 for technical methods, data tables, and further information

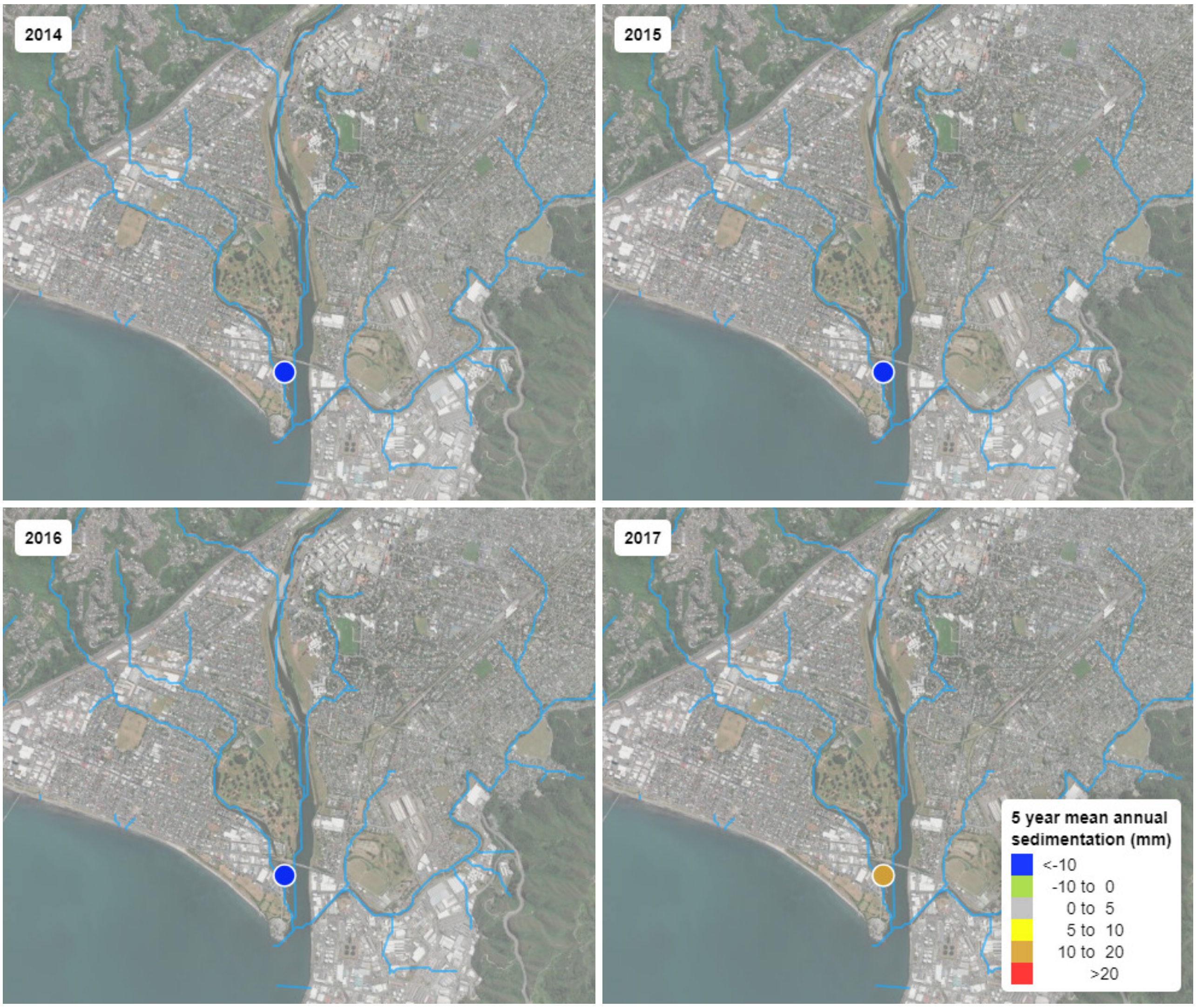

Figure 2: Five year mean annual sedimentation (mm) results for the periods ending 2014 to 2017.

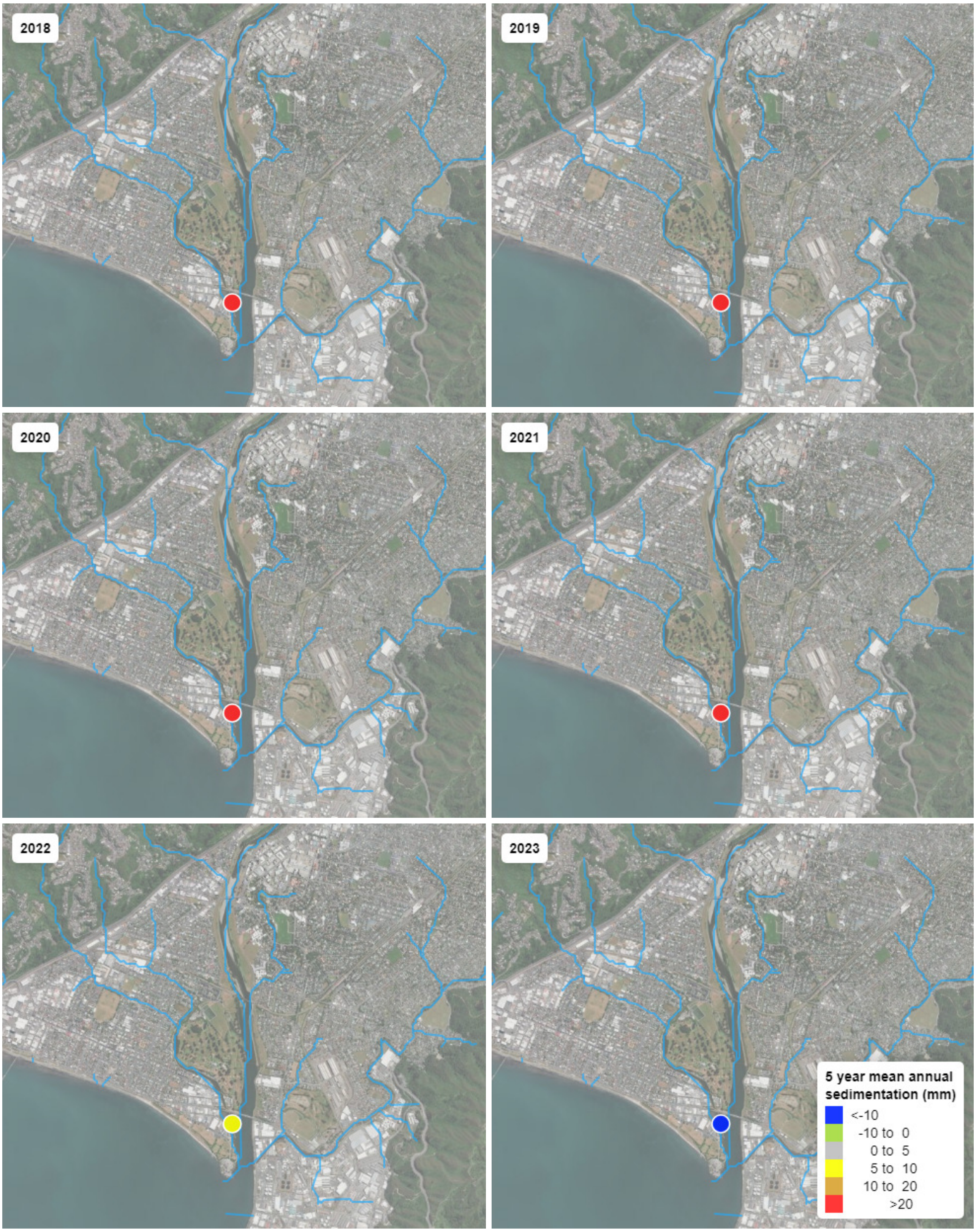

Figure 3: Five year mean annual sedimentation rate (mm) results for the periods ending 2018 to 2023

Mud content

At discrete fine scale and sedimentation monitoring sites, mud content is determined from laboratory analysis of surface sediment samples, and results are rated against thresholds derived from the New Zealand Estuary Trophic Index. A sample mud content of 25% is considered the threshold above which significant ecological changes in associated macroinvertebrate communities can occur. See Stevens 2018a, Cummings et al. 2021 and Stevens 2022 for technical methods, data tables, and further information

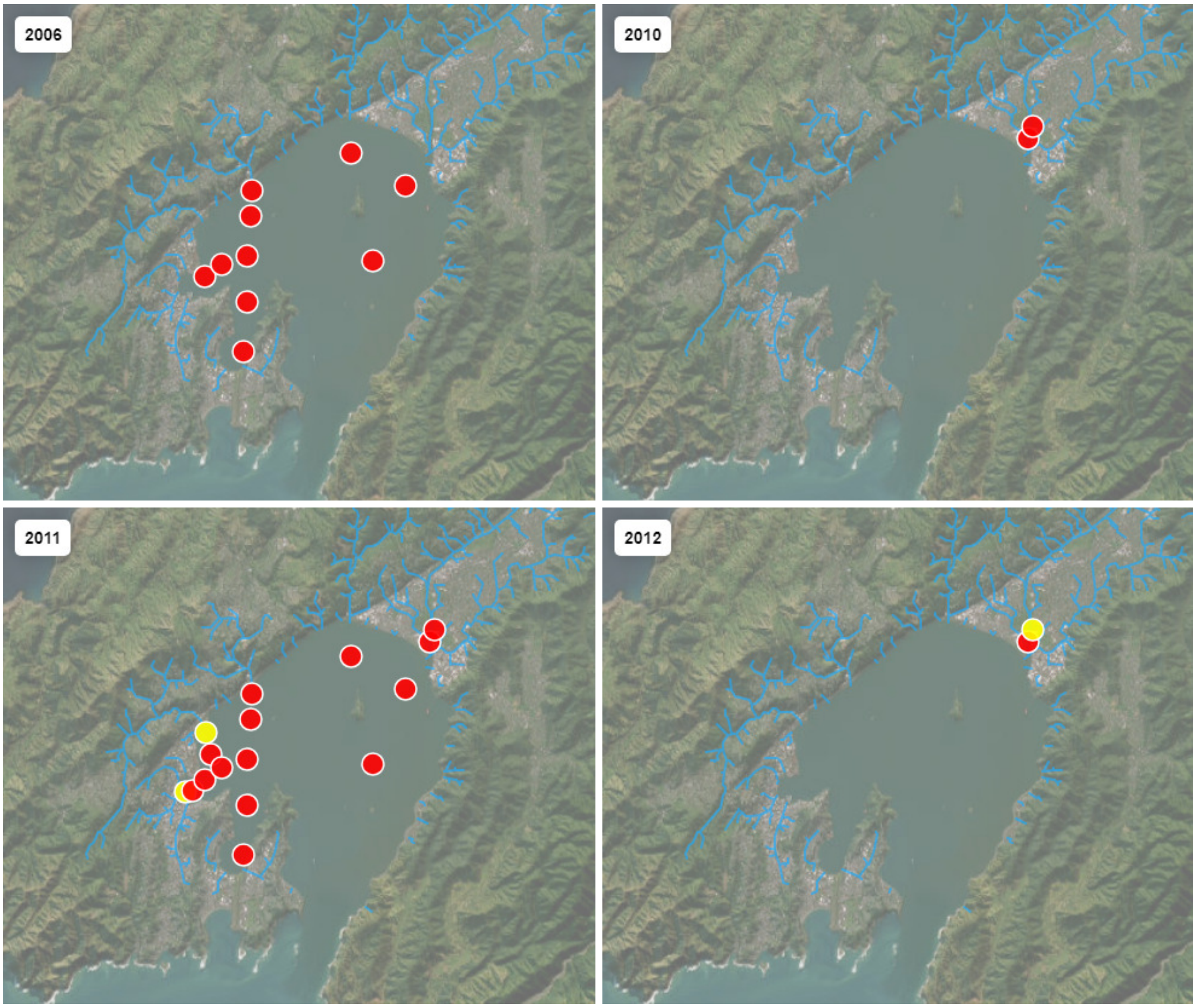

Figure 4: Mud content (%) ratings for 2006 and 2010 to 2012.

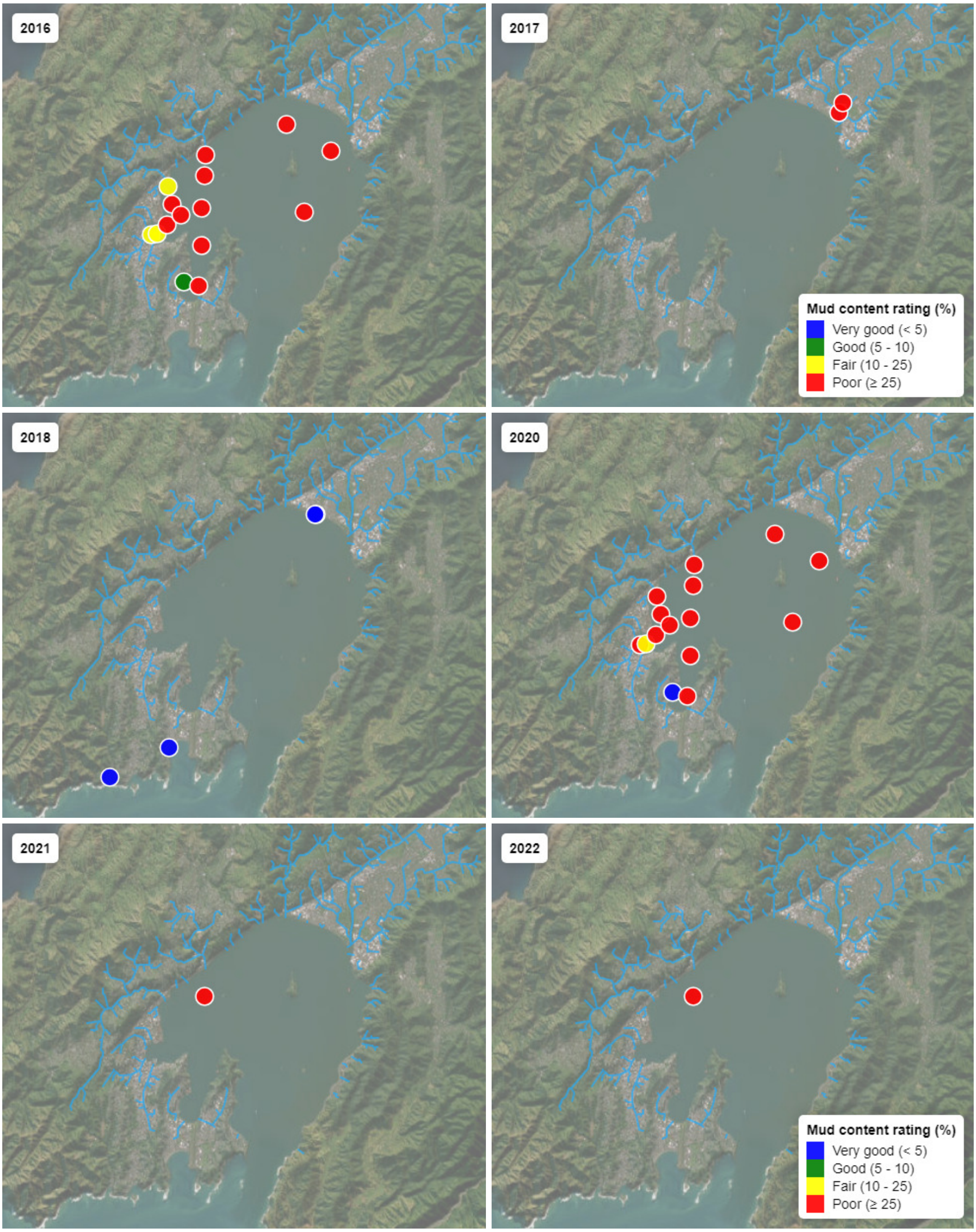

Figure 5: Mud content (%) ratings for 2016 to 2017, 2018 and 2020 to 2022.

Habitat

The main habitats monitored are unvegetated sediments (e.g. mud and sand areas) and areas vegetated with salt marsh and seagrass. Degraded habitat is a major contributor to reduced aquatic ecosystem health.

Substrate type

In terms of estuarine health, a key broad scale focus is on understanding the spatial extent and temporal change in mud-dominated sediment (>50% mud content) across intertidal areas. See Stevens et al. 2016 for technical methods, data tables, and further information

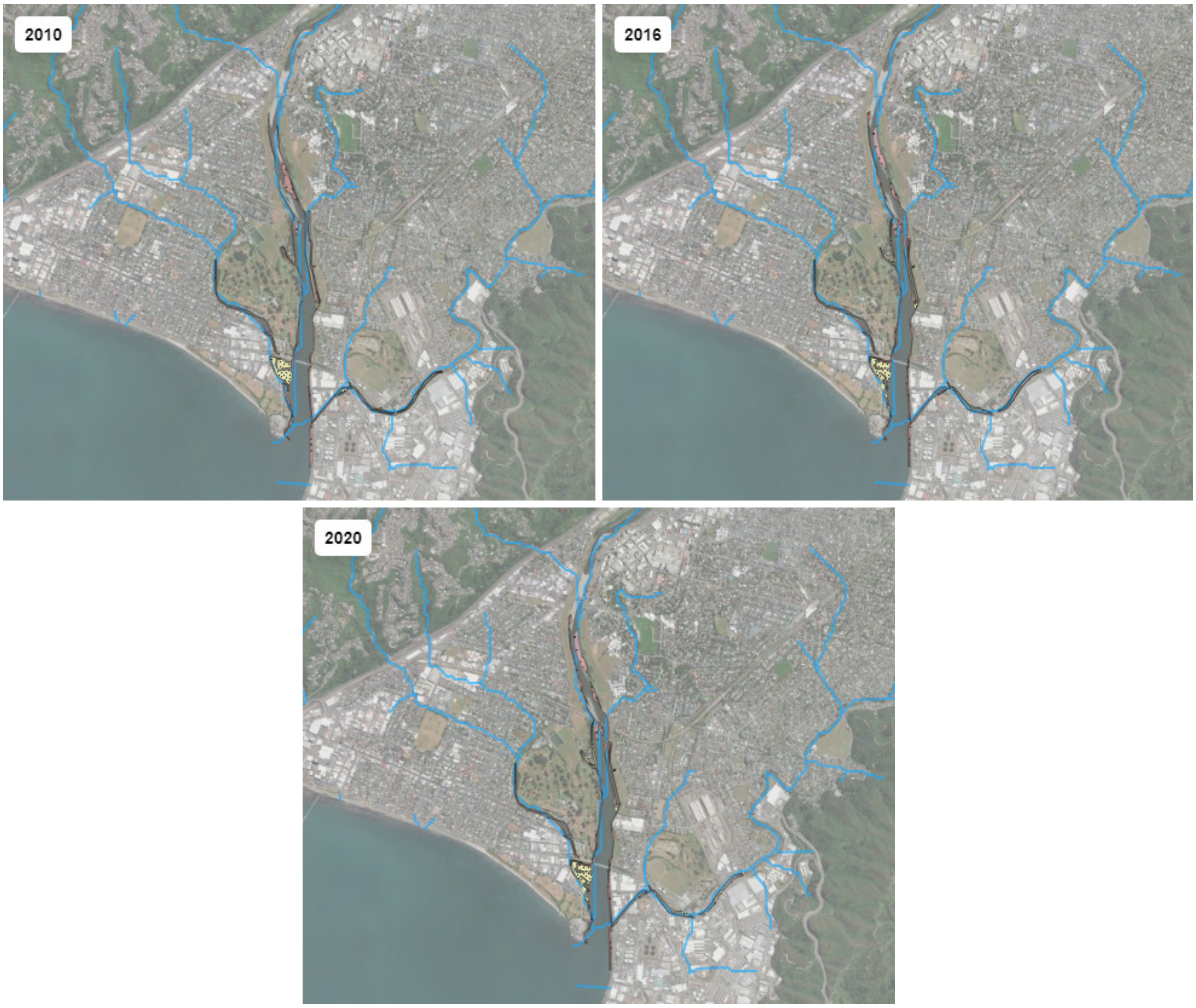

Figure 6: Broad scale substrate mapping results for 2010, 2016, and 2020.

Indigenous biodiversity

Our native plants and animals (indigenous biodiversity) are unique, and essential to supporting healthy ecosystems, communities and wellbeing. The Natural Resources Plan for the Wellington region identifies the following sites with significant indigenous biodiversity values (SIBVs) in the Te Whanganui-a-Tara coastal marine area. See GW 2023 for technical methods, data tables, and further information

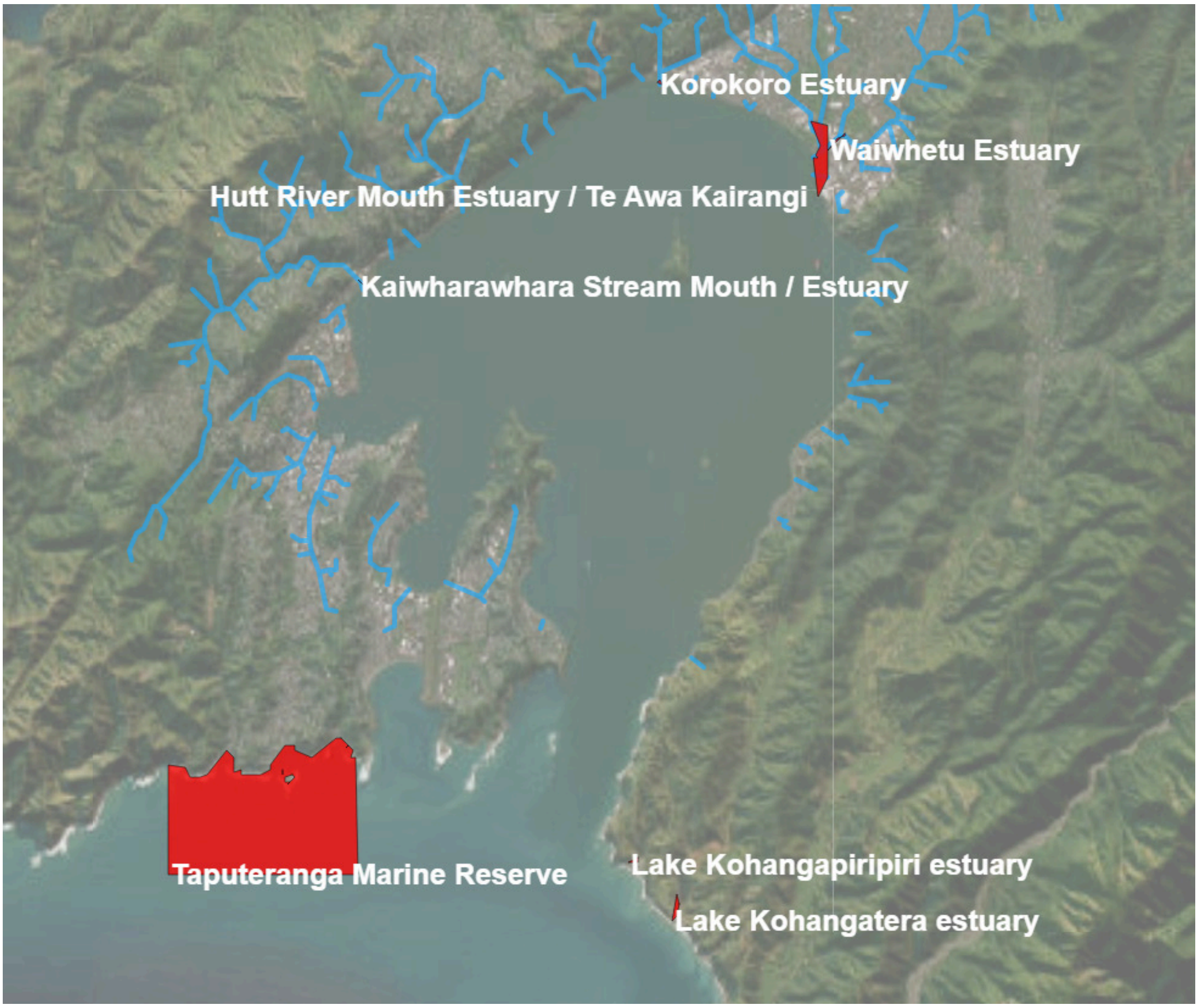

Figure 7: Significant indigenous biodiversity value areas identified in the Wellington Region Natural Resources Plan.

Reef mapping

Characterisation and mapping of shallow animal-dominated habitats (<30 m depth) in the Wellington Region. See Micaroni et al. 2023 for technical methods, data tables, and further information

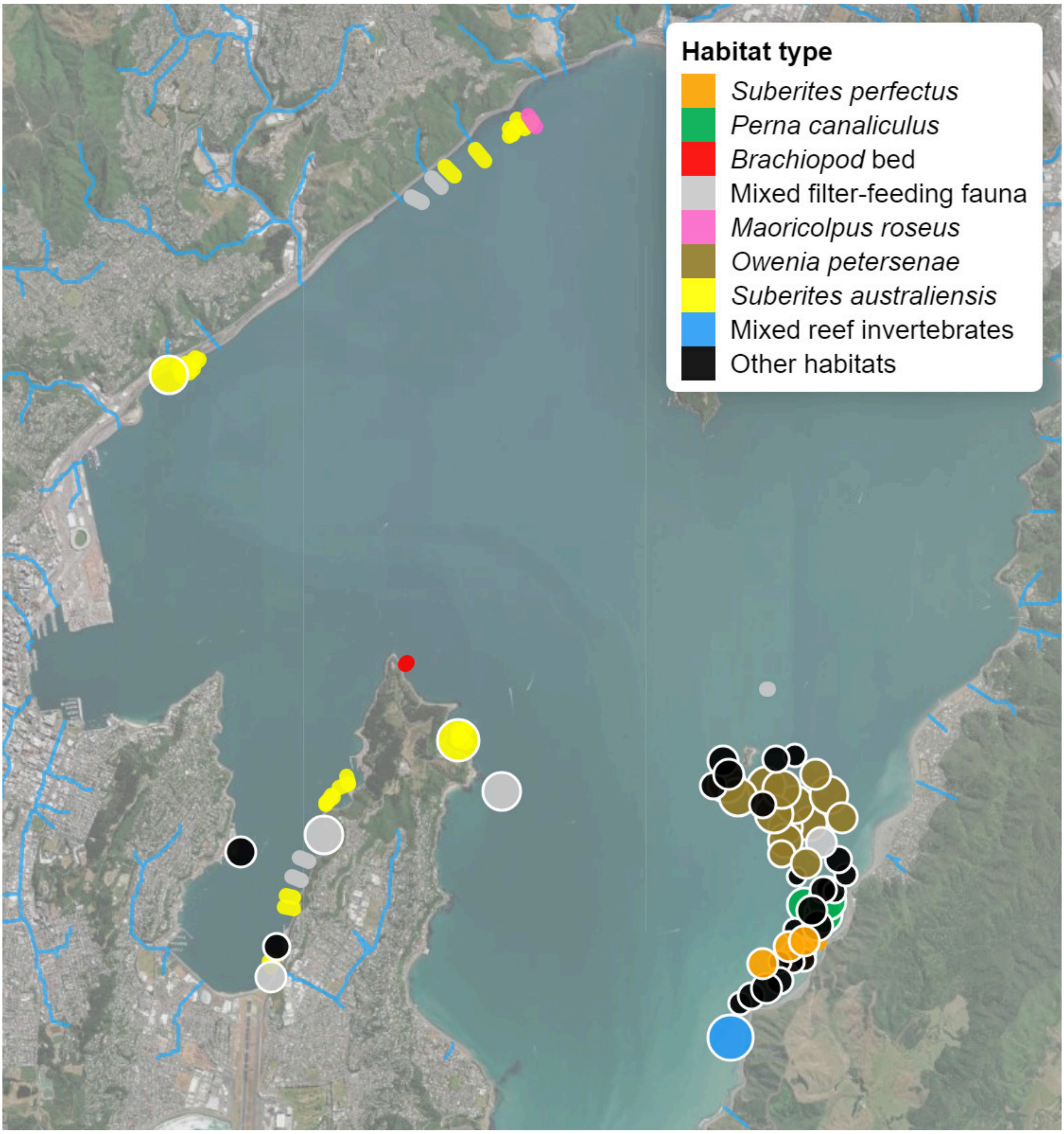

Figure 8: Reef mapping results for 2021 to 2023. Sample locations are denoted by circles and their radius scaled by respective habitat quality scores (1-10).

Macroinvertebrates

Macroinvertebrates, also known as macrofauna, are the animals living on top of or within the sediment. The abundance, composition and diversity of macrofauna are commonly-used indicators of estuarine health.

Marine Biotic Index (AMBI)

The AZTI's Marine Biotic Index (AMBI) is one of several marine biotic indices that assesses estuarine health based on the types and numbers of macrofauna and their known tolerances to environmental stress. Lower AMBI values generally indicate better ecological conditions. Values are rated against thresholds derived from the New Zealand Estuary Trophic Index. See Stevens & Robertson 2012 and Stevens 2022 for technical methods, data tables, and further information

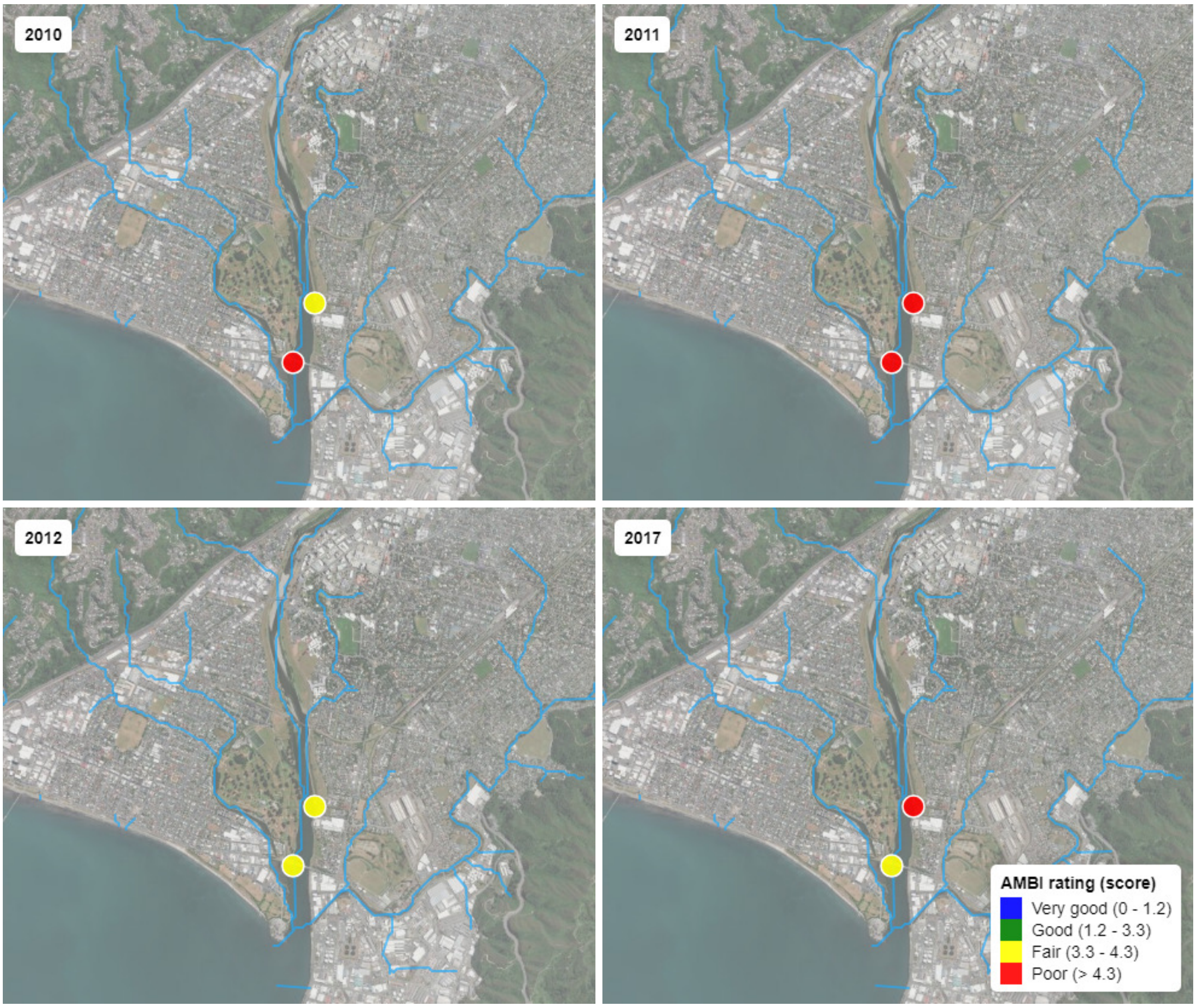

Figure 9: Macroinvertebrate AMBI ratings for 2010 to 2012, and 2017.

Benthic Health Model (BHM)

Benthic health models have been developed to track the health of New Zealand estuarine benthic communities in response to two key coastal stressors: sedimentation and heavy metal contamination. The mapped results below indicate the impact of heavy metal contamination on the benthic health of Te Whanganui-a-Tara relative to other estuarine sites in New Zealand. See Cummings et al. 2021 for technical methods, data tables, and further information

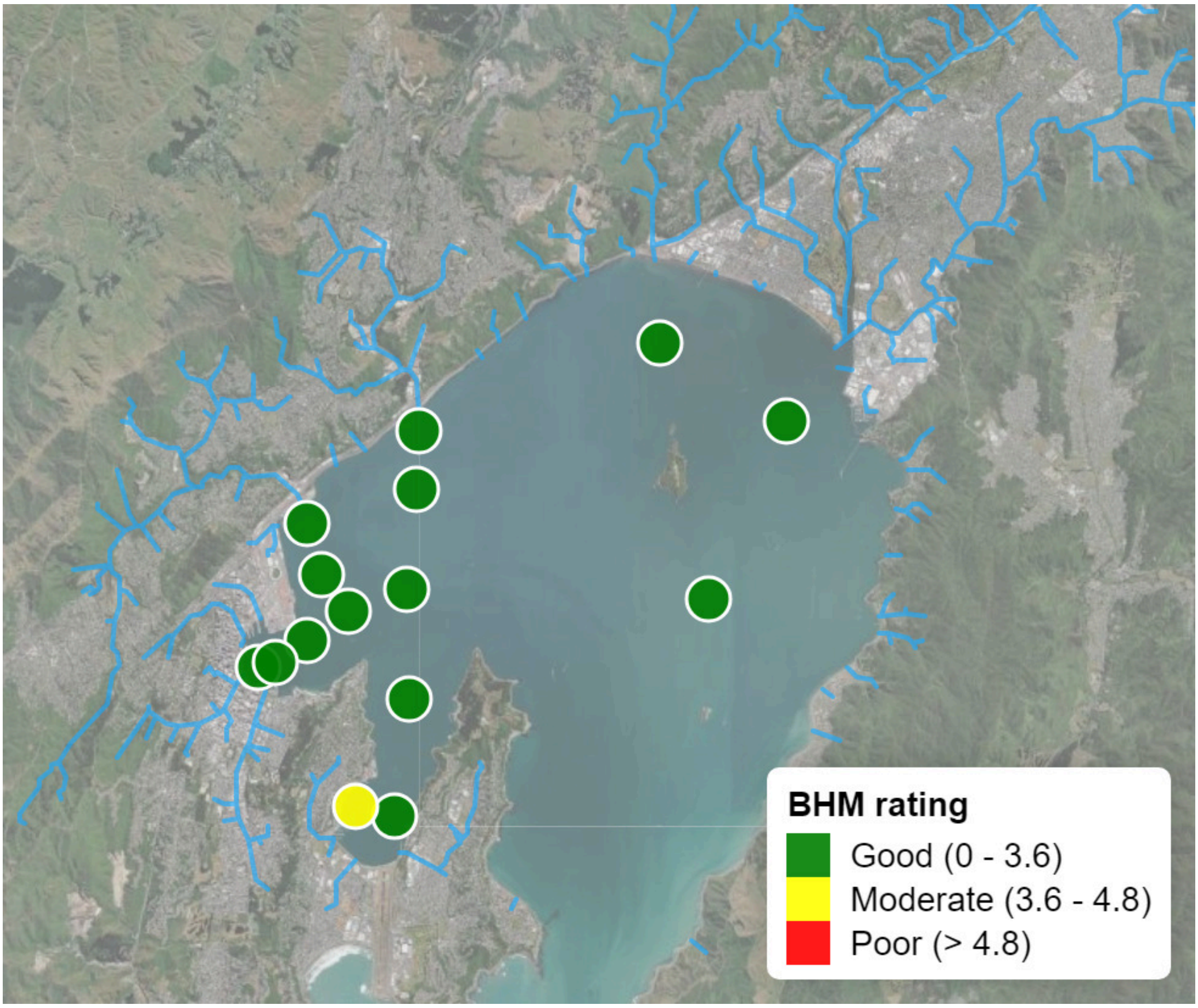

Figure 10: Macroinvertebrate BHM ratings for 2020.

Traits Based Index (TBI)

Benthic ecology status can be assessed using a Traits-based index (TBI) that indicate the levels of community functional redundancy and the degree of site degradation. See Cummings et al. 2021 for technical methods, data tables, and further information

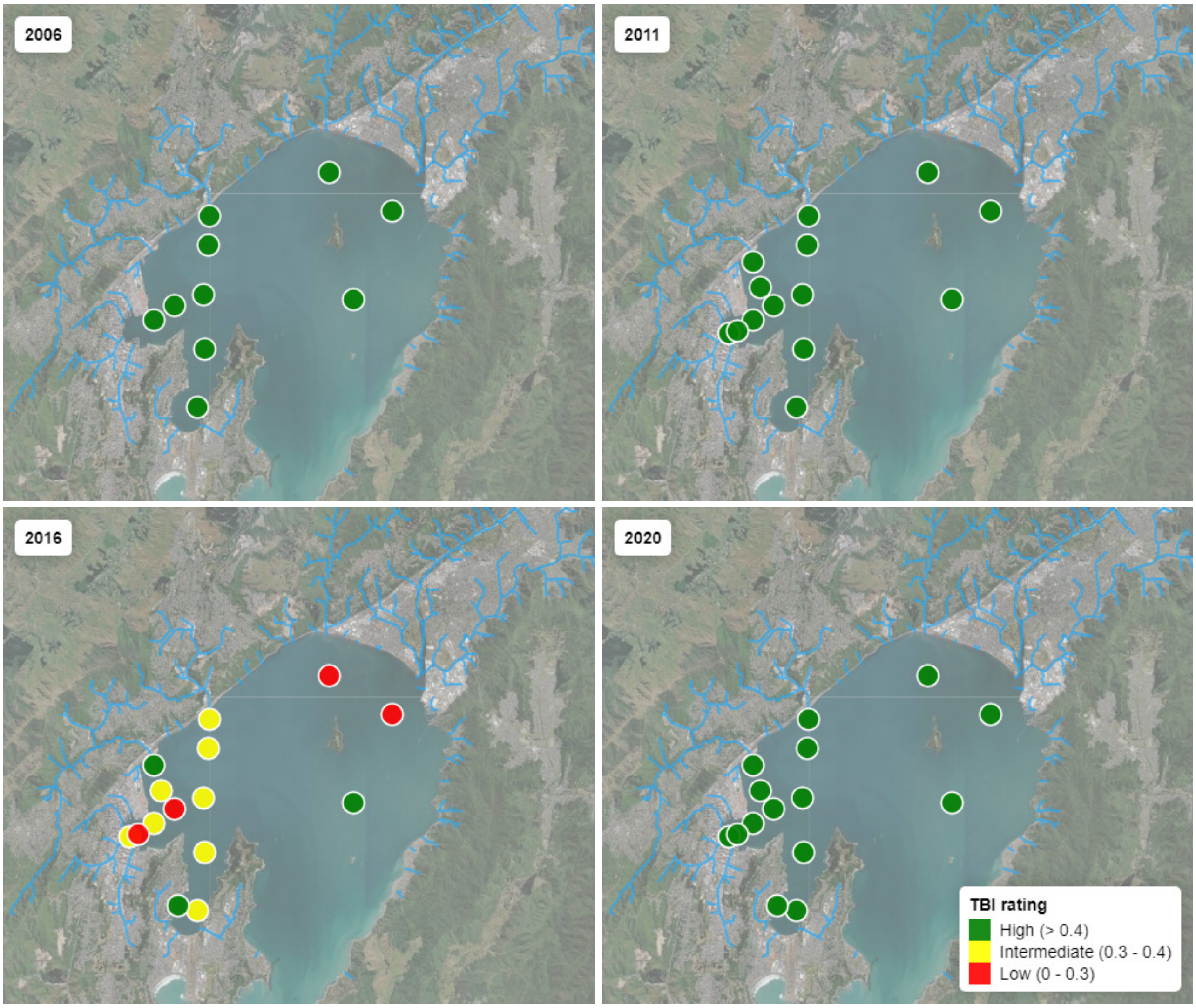

Figure 11: Macroinvertebrate TBI ratings for 2006, 2011, 2016, and 2020.

Species richness

Species richness is measured by counting the number of different species of invertebrates present in a sample. High richness can indicate greater diversity. Note that different surveys use varying sample sizes and taxonomic classifications. See Stevens & Robertson 2012, Stevens 2018a, Stevens 2018b and Stevens 2022 for technical methods, data tables, and further information

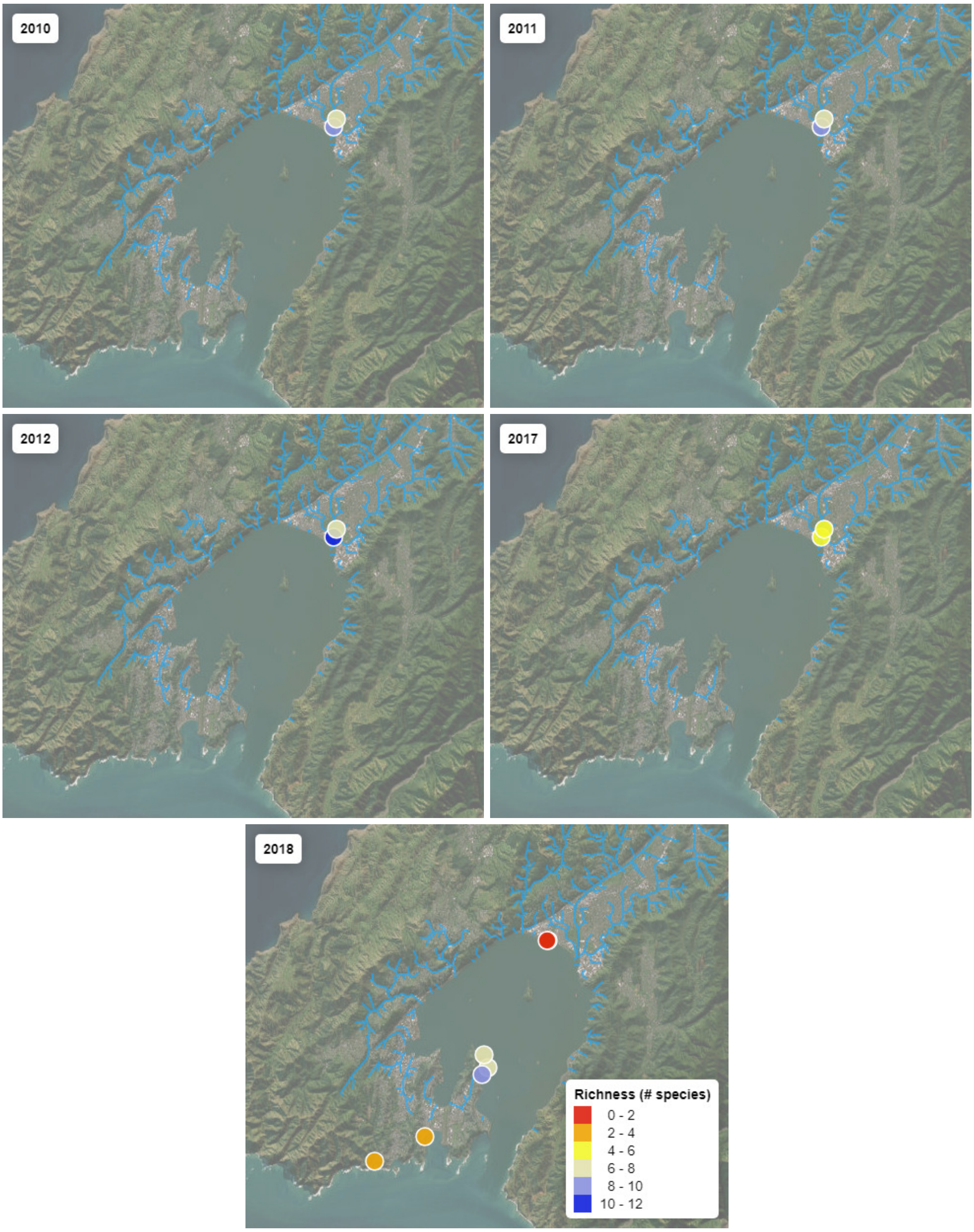

Figure 12: Macroinvertebrate AMBI ratings for 2010 to 2012 and 2017 to 2018.

Nutrient enrichment

When an estuary or coastal environment becomes over-enriched with nutrients excessive growths of algae can occur (eutrophication). These include growths of ‘opportunistic’ macroalgae such as the red seaweed *Gracilaria chilensis*, and blooms of potential harmful phytoplankton (microscopic algae that drift in water currents), which can include species that release biotoxins.

Macroalgae

Opportunistic macroalgal blooms are a primary consequence of estuary eutrophication (nutrient enrichment). Macroalgal blooms can deprive seagrass beds of light, causing their decline, while decaying macroalgae can accumulate subtidally and on shorelines causing oxygen depletion and associated nuisance odours in the sediments beneath. The main problem species in New Zealand are the red seaweed *Gracilaria chilensis* and the bright green *Ulva*. In Porirua Harbour over recent years, there has also been an increased prevalence of the filamentous green mat-forming species *Chaetomorpha ligustica*. See Stevens & Forrest 2020 for technical methods, data tables, and further information

Figure 13: Broad scale macroalgal mapping results for 2010 and 2011.

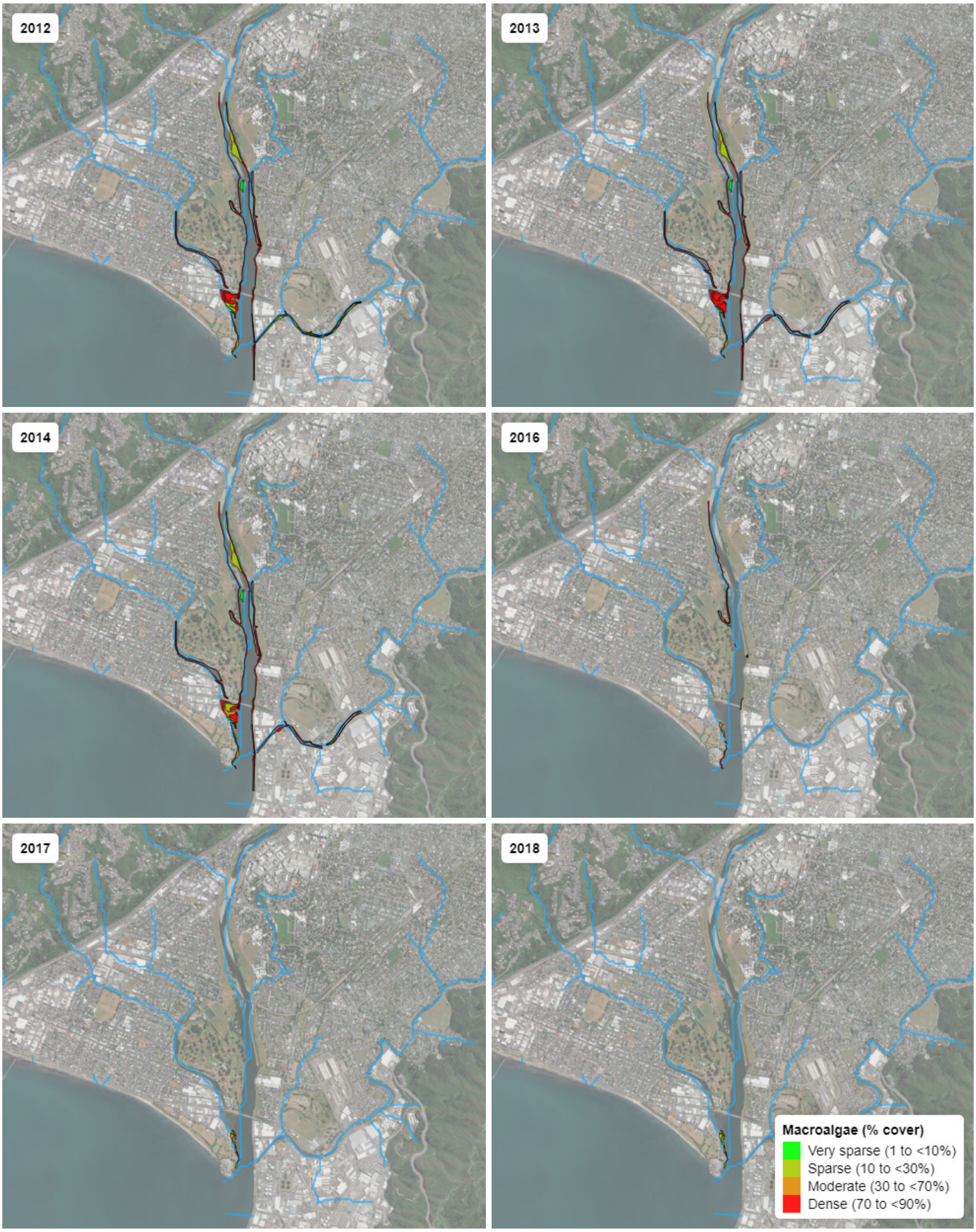

Figure 14: Broad scale macroalgal mapping results for 2012 to 2014 and 2016 to 2018.

Sediment oxygenation

The apparent Redox Potential Discontinuity (aRPD) is a time-integrated measure of the enrichment state of sediments according to the visual transition between brown oxygenated surface sediments and deeper less oxygenated grey/black sediments. The aRPD usually occurs closer to the sediment surface as organic matter loading increases. Values are rated against thresholds modified from those presented in the New Zealand Estuary Trophic Index. See Stevens & Robertson 2012, Cummings et al. 2021 and Stevens 2022 for technical methods, data tables, and further information

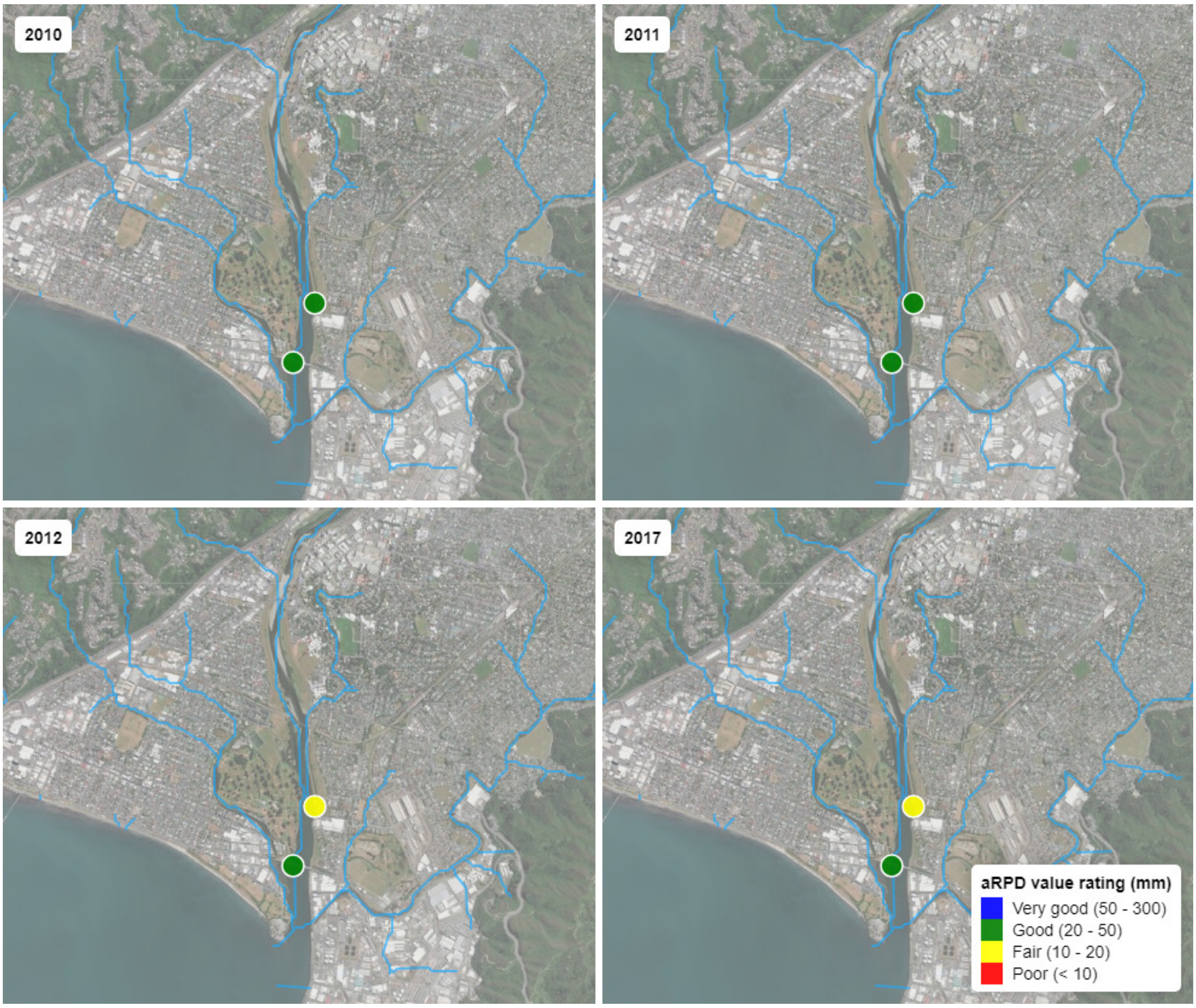

Figure 15: Sediment oxygenation aRPD (mm) condition rating results for 2008 to 2011.

Total Organic Carbon

Total Organic Carbon (TOC) is a measure of the organic content of sediments, which is associated with their enrichment status. Sediments with a high TOC (>1-2%) often display symptoms that indicate excessive enrichment, including reduced oxygenation. Values are rated against thresholds derived from the New Zealand Estuary Trophic Index (ETI). See Stevens & Robertson 2012, Cummings et al. 2021 and Stevens 2022 for technical methods, data tables, and further information

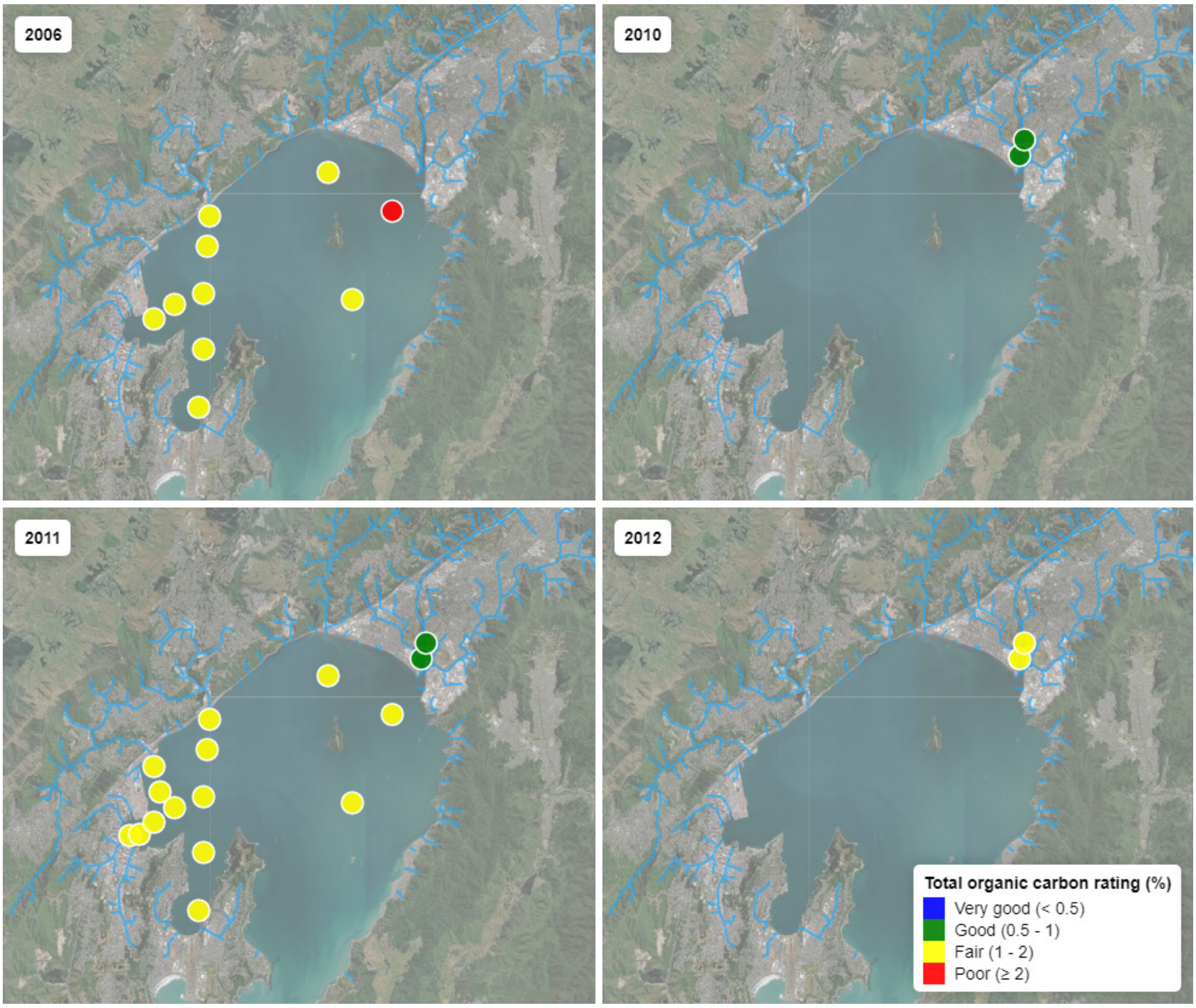

Figure 16: Total organic carbon (%) ratings for 2006, and 2010 to 2012.

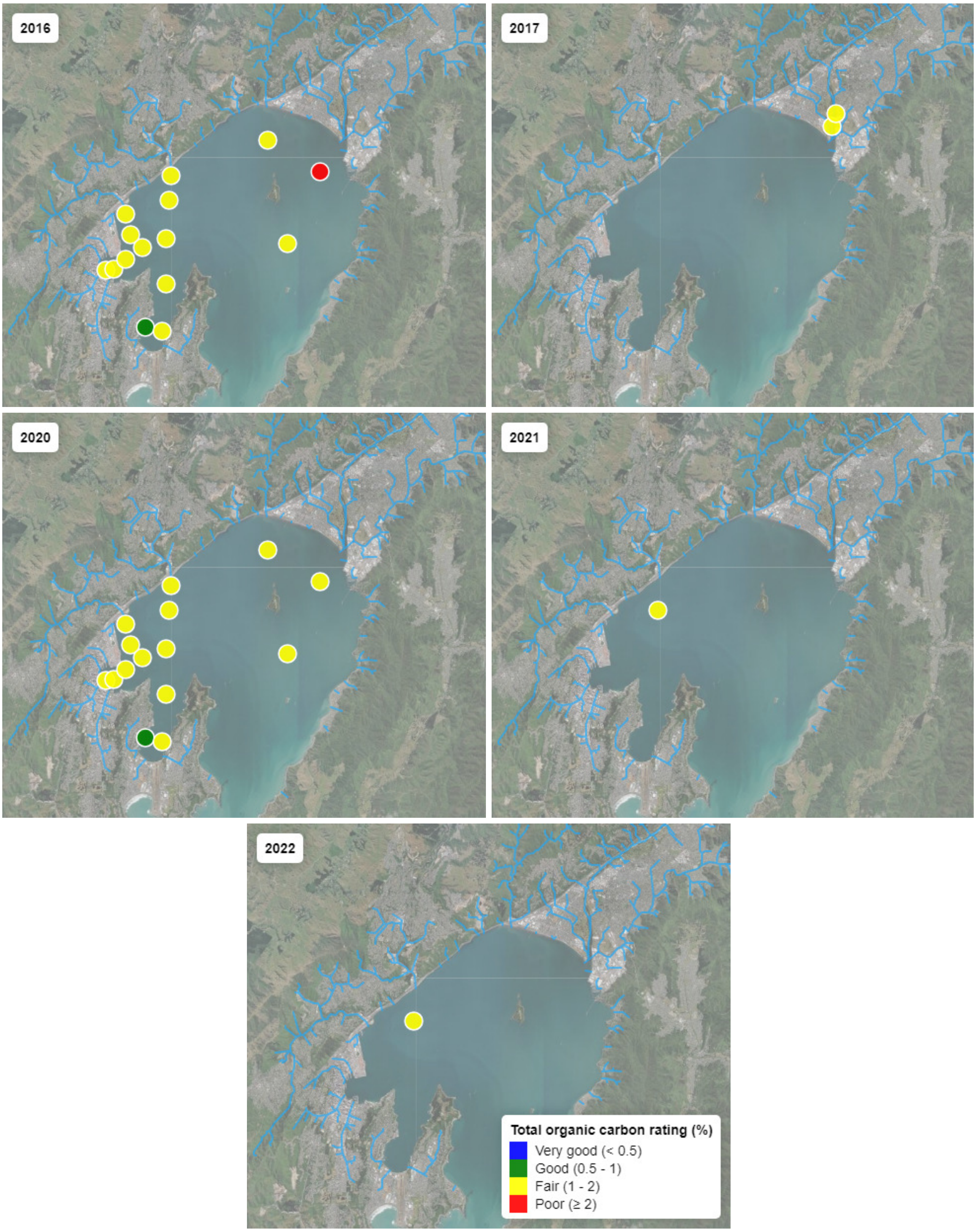

Figure 17: Total organic carbon (%) ratings for 2016 to 2017 and 2020 to 2022.

Total Nitrogen

Nitrogen is a key nutrient for plant and algae growth in estuarine and marine environments. Total nitrogen in sediments is an indicator of their trophic status and potential for algal blooms or other symptoms of excessive enrichment. Values are rated against thresholds derived from the New Zealand Estuarine Trophic Index (ETI). See Stevens & Robertson 2012 and Stevens 2022 for technical methods, data tables, and further information

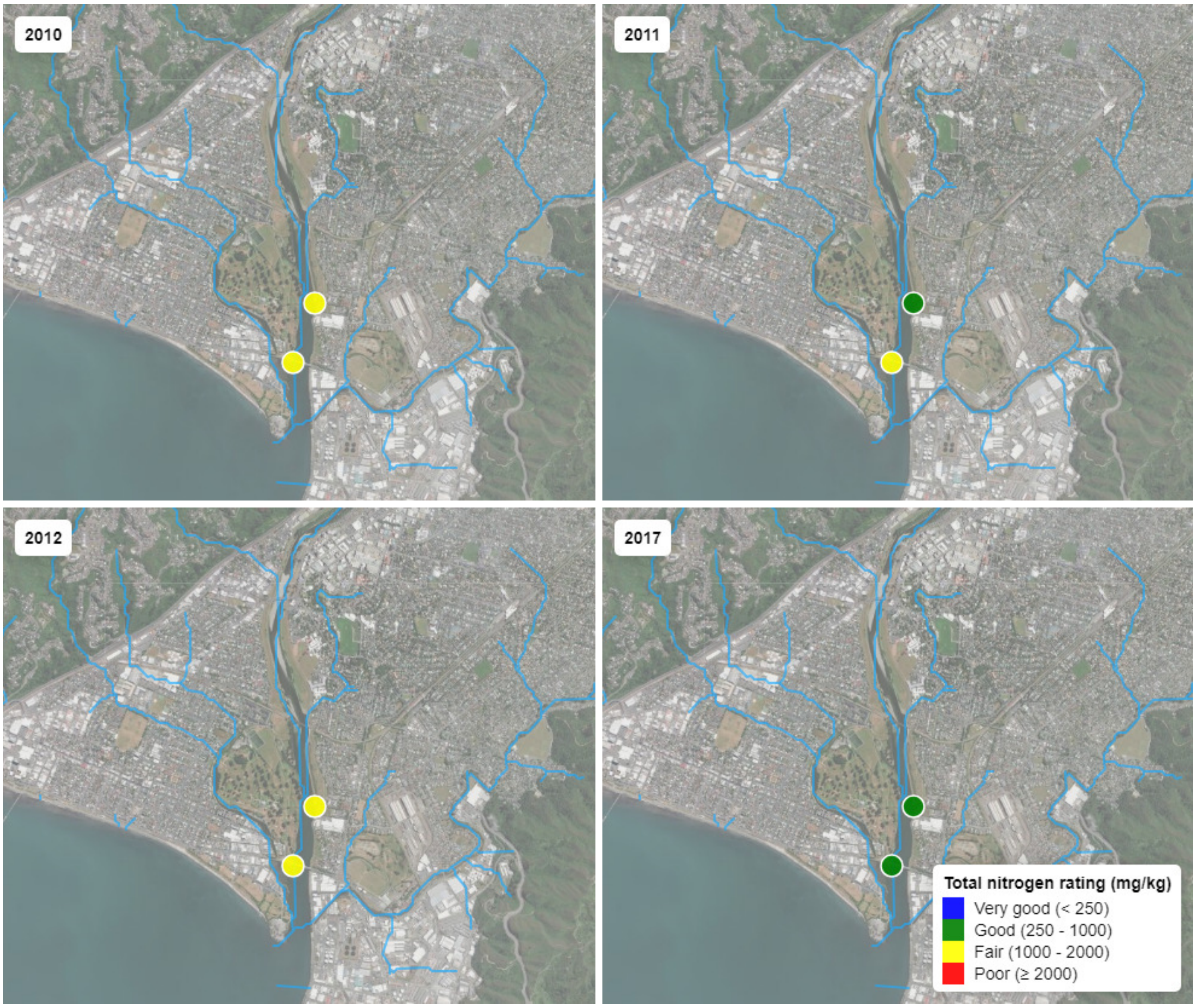

Figure 18: Total nitrogen (mg/kg) ratings for 2010 to 2012, and 2017.

Metal contaminants

Some metals, when in high concentrations, can have toxic effects on aquatic life in both a dissolved state and when attached to sediment particles. Zinc and copper in particular are often used as proxies for the suite of other potential urban contaminants (e.g. polycyclic aromatic hydrocarbons, plasticisers) or legacy contaminants such as the historic pesticide DDT. These types of contaminants often end up in estuaries via stormwater runoff. Copper is approximately 5 to 10 times more toxic to aquatic life than zinc, but generally occurs in lower concentrations.

Values are rated against thresholds derived from the New Zealand Estuary Trophic Index (ETI), which in turn are scaled relative to 2018 Australia and New Zealand Guidelines (ANZG) for sediment quality. Ratings of “good” and “very good” correspond to ‘safe’ values that are less than ANZG (2018) default guidelines, while “fair” corresponds to values between the default and high-guideline values, reflecting “possible” ecological effects. “Poor” sites exceed the high-guideline value.

See Stevens & Robertson 2012, Stevens 2018a, Cummings et al. 2021 and Stevens 2022 for technical methods, data tables, and further information

Zinc

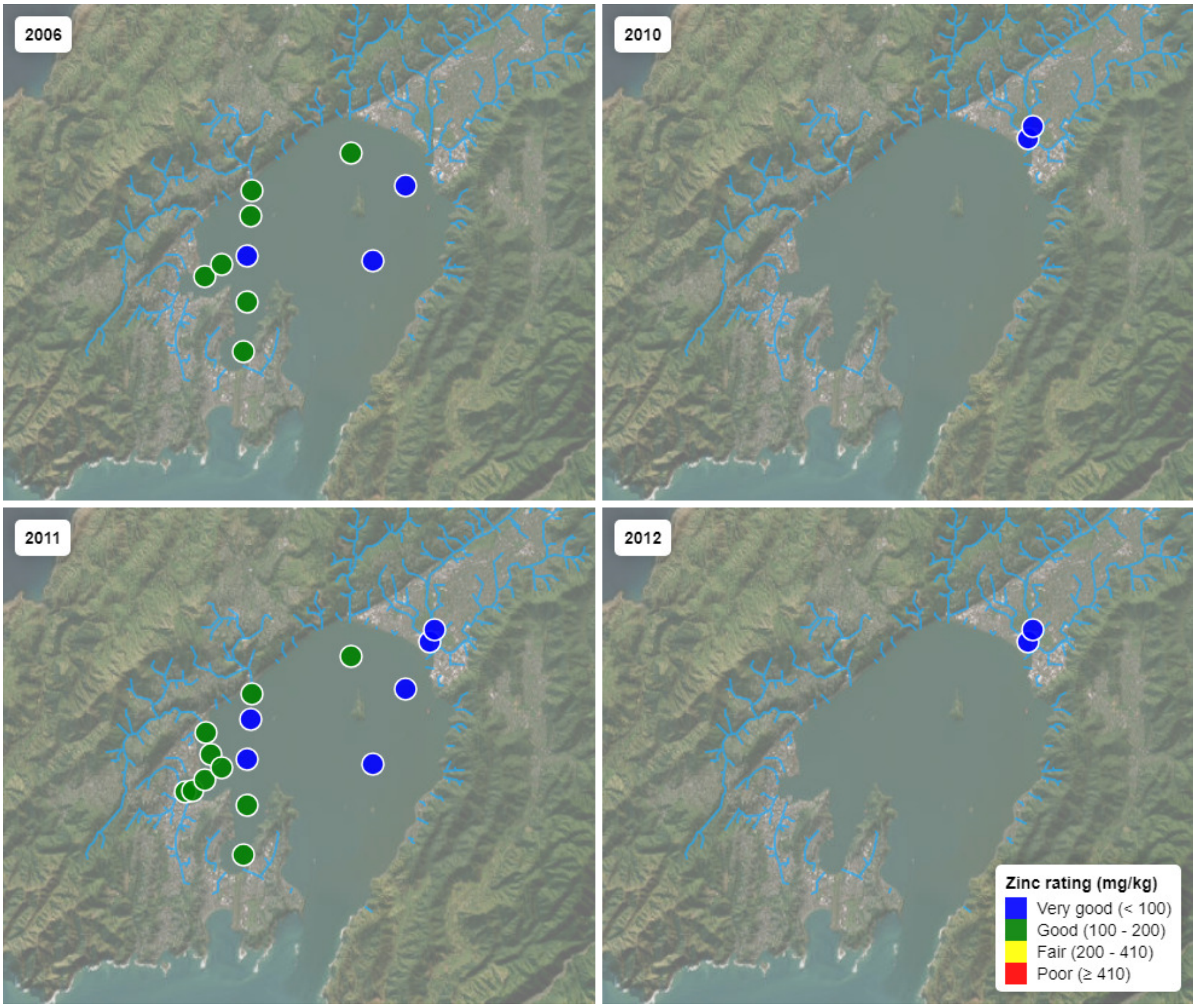

Figure 19: Zinc (mg/kg) ratings for 2006, and 2010 to 2012.

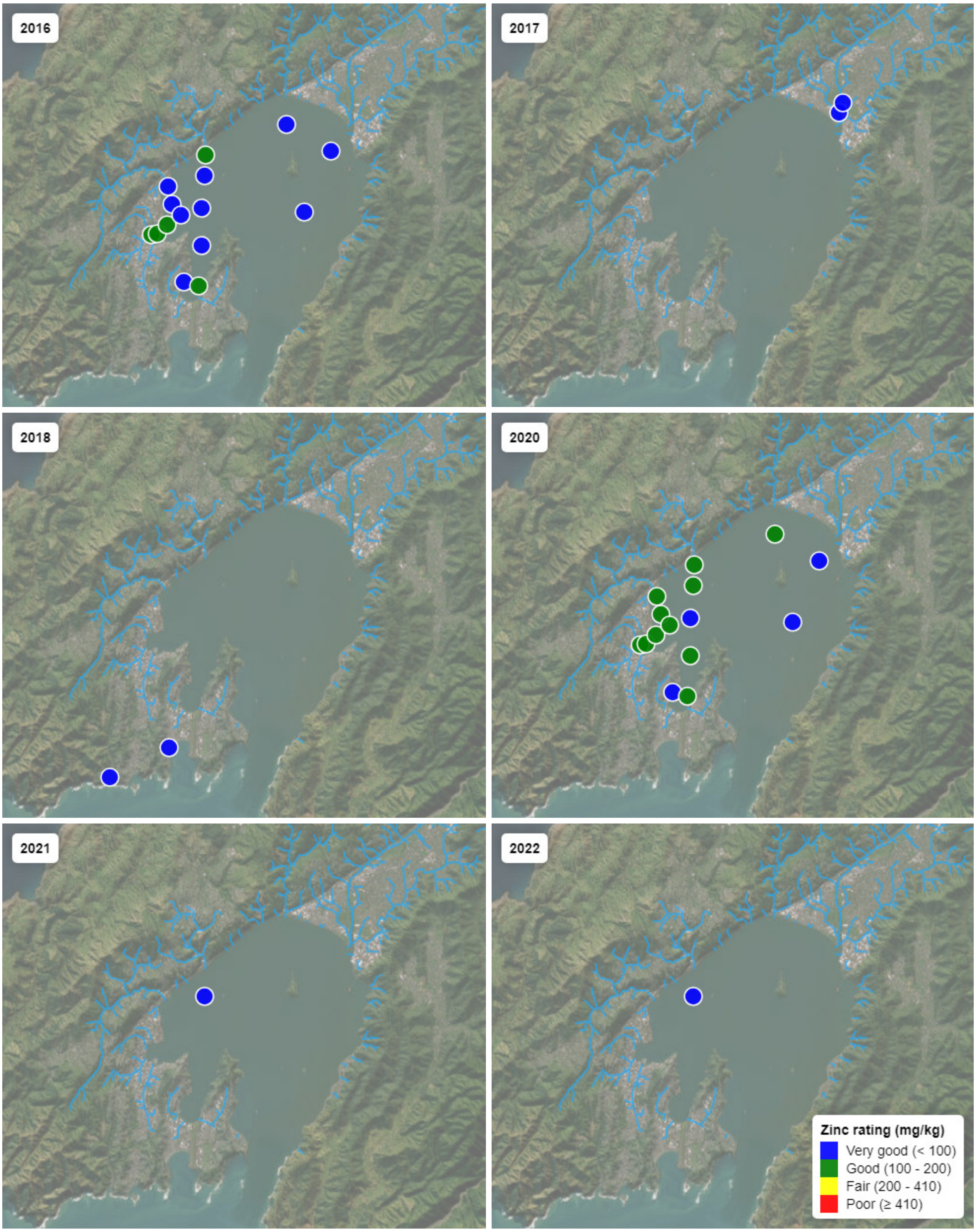

Figure 20: Zinc (mg/kg) ratings for 2016 to 2018, and 2020 to 2022.

Copper

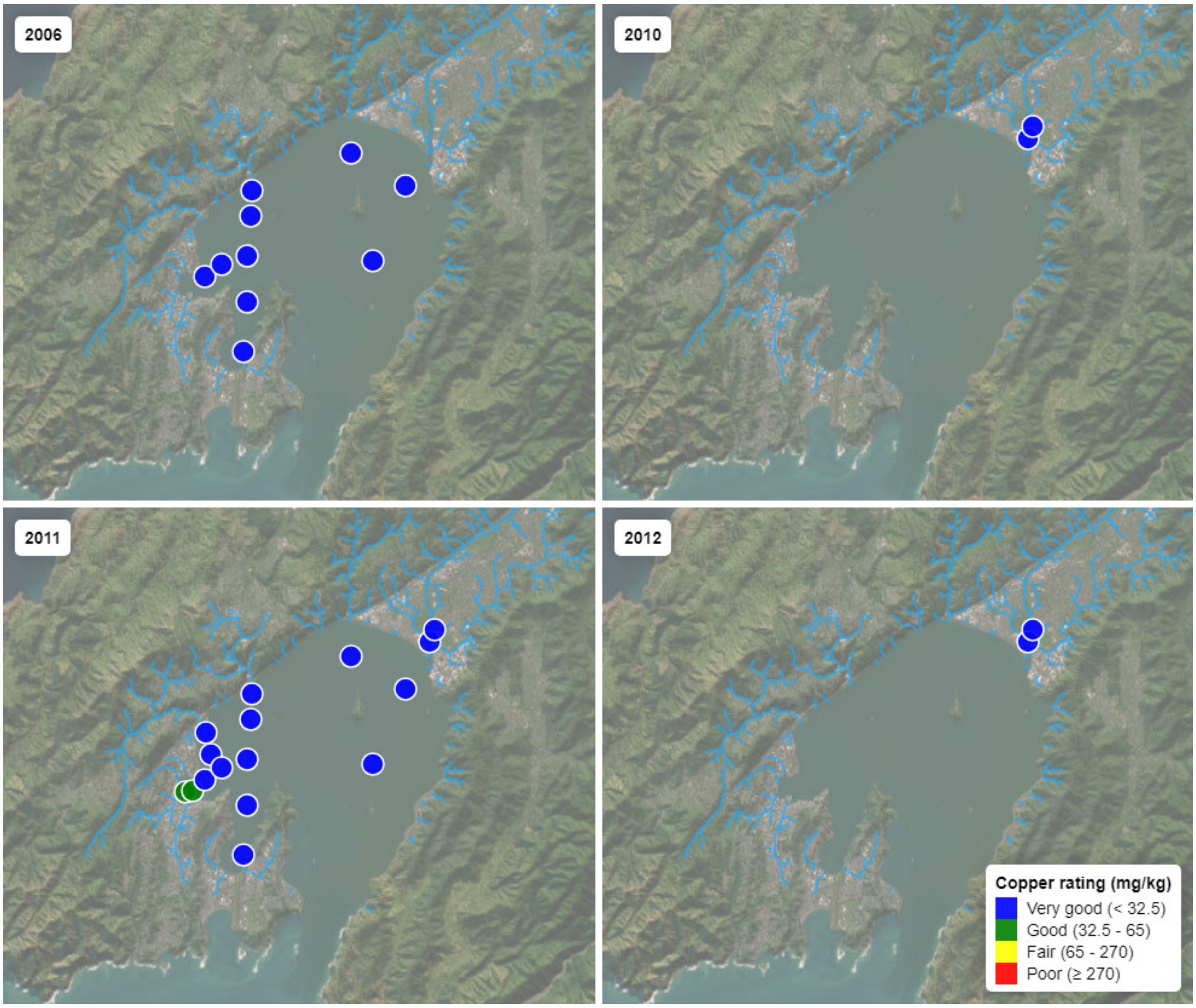

Figure 21: Copper (mg/kg) ratings for 2006, and 2010 to 2012.

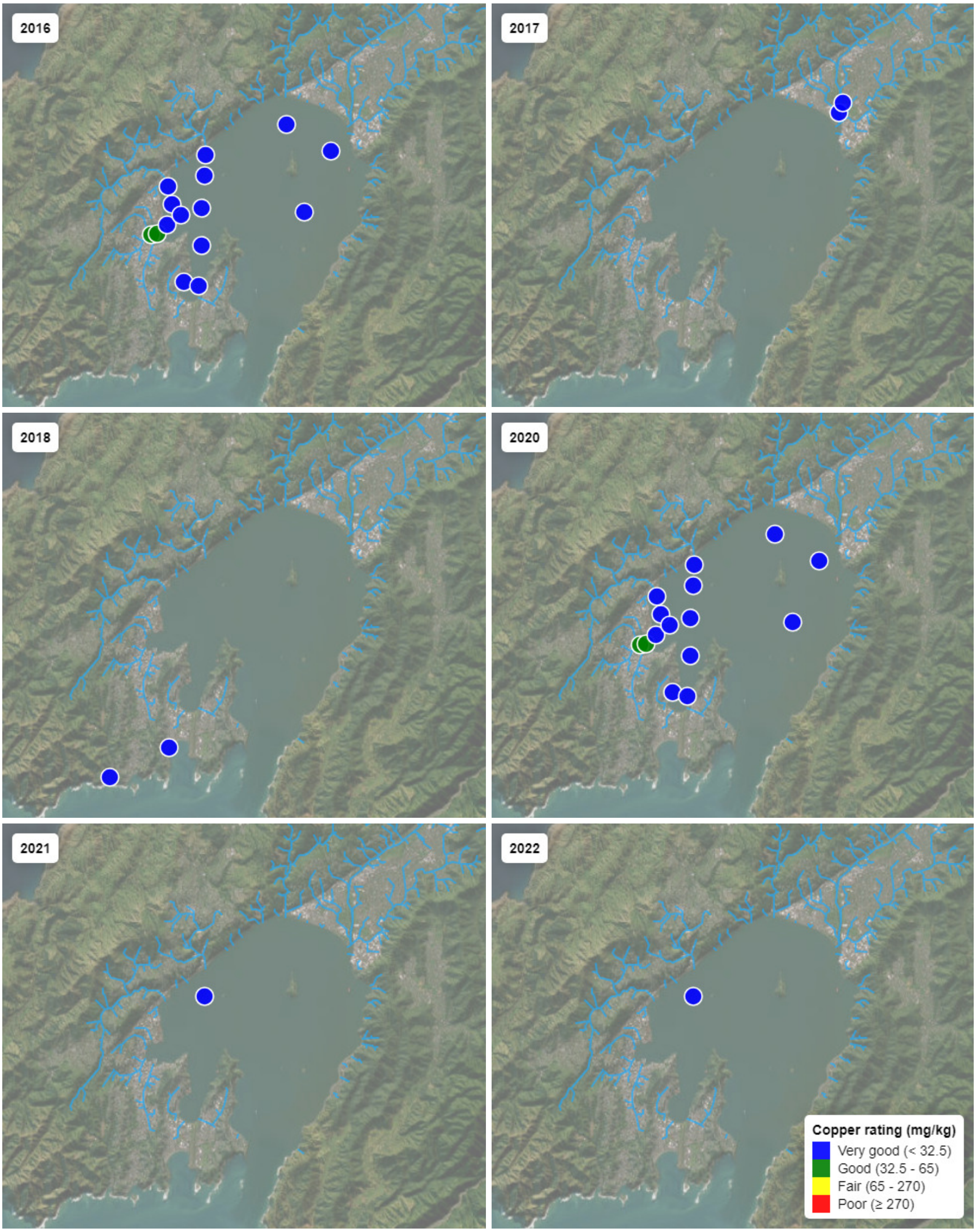

Figure 22: Copper (mg/kg) ratings for 2016 to 2018, and 2020 to 2022.

Water quality

Integrated buoy observations

Wellington Regional Integrated Buoy Observations (WRIBO) has been monitoring Te Whanganui-a-Tara/Wellington Harbour for the period 13 July 2017 to 11 July 2022. Measurements are obtained at 1, 5, and 10 m depths below the water surface.

Key processes in Wellington Harbour include river influence and tidal flows as measured by the Acoustic Doppler Current Profiler (ADCP). Results indicate that river plumes flowing from the Hutt River are generally less than 5 m thick and persist for at least five days after peak discharge. Interestingly, sediment transport may be modified for weeks to months after an event. Data have also indicated that events occur during all seasons.

Most recent data are available at the GW live data viewer. Note that gaps in the data are due to periods of repair and maintenance where either the whole WRIBO array or instruments attached to the array were removed from the water for instrument calibration or replacement.

In the figure captions, **WRIBO** data refers to continuous telemetered readings from the coastal buoy. **Te Awa Kairangi (Hutt River) flow, turbidity and rainfall** (Taita Gorge, Melling Bridge and Shandon Golf Club) are continuously monitored using telemetered instrumentation permanently installed onsite. See the overview map for locations of sampling sites.

- Ocean turbidity, measured in Nephelometric Turbidity Units (NTU), is produced by particles suspended in the water column which decreases sea water clarity and can impair water quality for aquatic and human life. Optical backscatter β(650nm), shown per metre-angle (/m/sr), is another measure of particles present in seawater, which can include sediment, organic matter and microorganisms.
- Chlorophyll a biomass, presented in milligrams per cubic meter (mg/m^3), indicates the amount of phytoplankton present in the water. Very high Coloured Dissolved Organic Matter (CDOM) readings, displayed in parts per billion (ppb), can reduce sea water clarity and inhibit phytoplankton growth.
- Dissolved oxygen data are presented in micrograms per litre (µ/L) with concentrations typically decreasing with an increase in nutrients and organic matter (e.g. from urban stormwater, sewage discharges, and rural runoff from farmland). Excessive algae growth and decay in response to increasing nutrients can significantly affect the amount of dissolved oxygen available to organisms.
- The temperature and salinity (saltiness) of marine waters are used to calculate density, which plays an important role in determining where water flows and where species are distributed.
- Water temperature varies with depth and was measured from the surface buoy down to mid-water (10 m), which allows us to identify sharp thermoclines or uniform conditions.

- Ocean values of salinity are typically around 35 psu. Decreases in salinity indicate the presence of river water in Te Whanganui-a-Tara/Wellington Harbour. At times salinity observations, presented in practical salinity units (psu), decrease to around 20 psu after large amounts of rainfall.

Turbidity

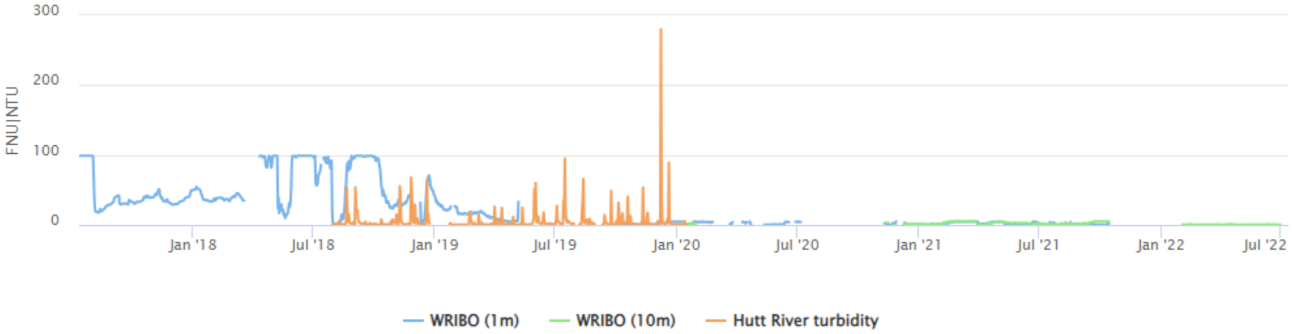

Figure 23: WRIBO & Hutt river daily average turbidity measurements (FNU & NTU). Note that telemetered and discrete measurements at WRIBO and those taken at the Hutt River are displayed in different units, NTU and FNU respectively, but these units are essentially the same in value (1 NTU ≈ 1 FNU). Additionally, WRIBO turbidity measurements are device constrained to less than 100 NTU while actual values could be higher.

Hutt River flow

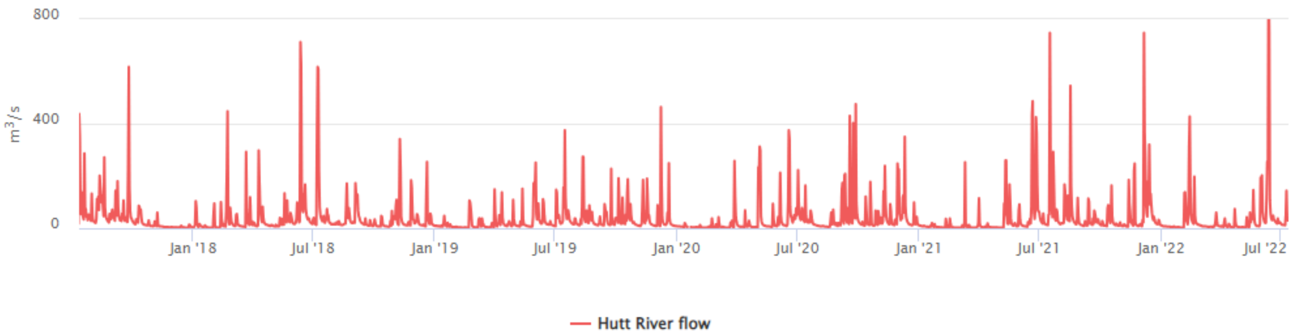

Figure 24: Hutt river daily average flow (m^3/s).

Chlorophyll a biomass

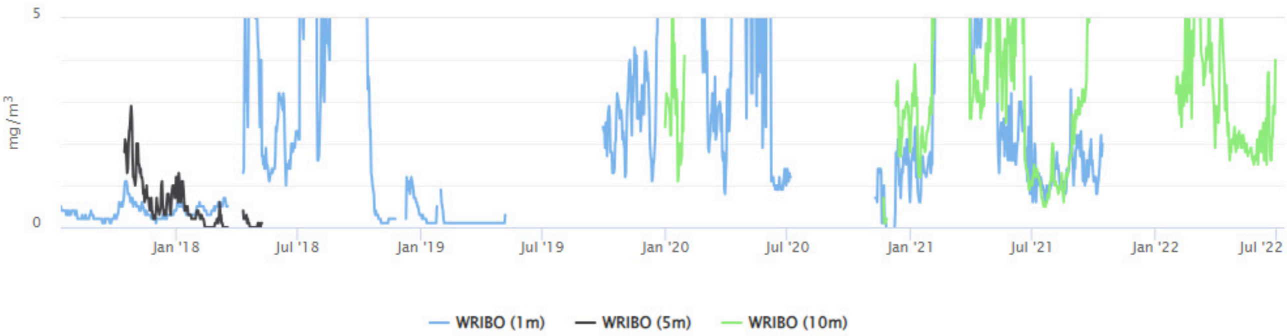

Figure 25: WRIBO daily average Chlorophyll a (mg/m^3). Note that only data between zero and five mg/m^3 are shown. Higher values could be observed but are typically less reliable from ocean water quality sensors.

Coloured dissolved organic matter (CDOM)

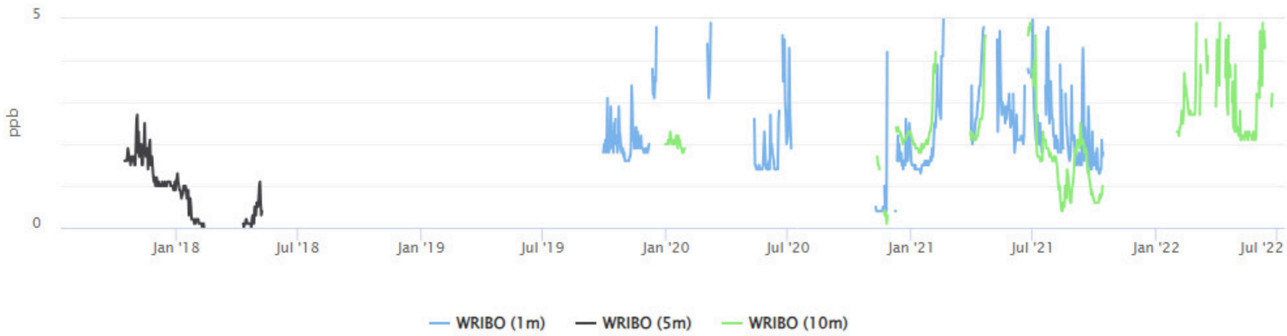

Figure 26: WRIBO daily average coloured dissolved organic matter (ppb). Note that only data between zero and five ppb are shown. Higher values could be observed but are typically less reliable from ocean water quality sensors.

Dissolved oxygen concentration

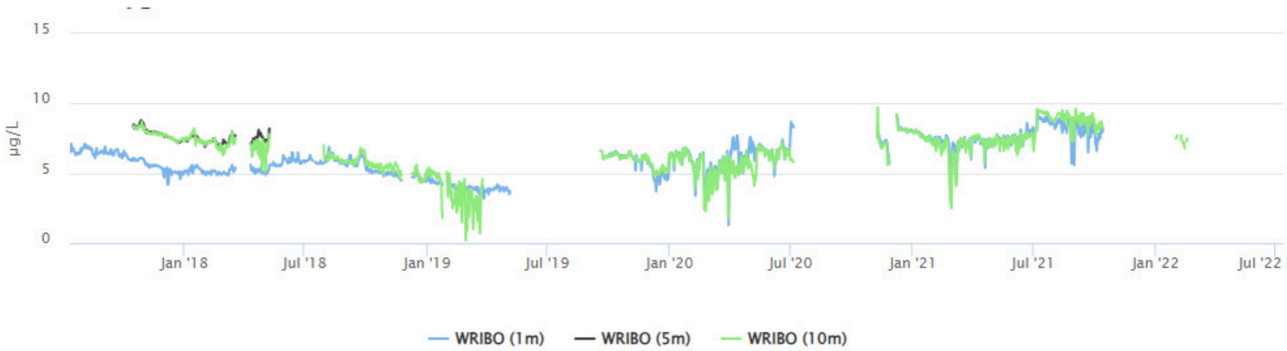

Figure 27: WRIBO daily average dissolved oxygen concentration (µg/L)

Salinity

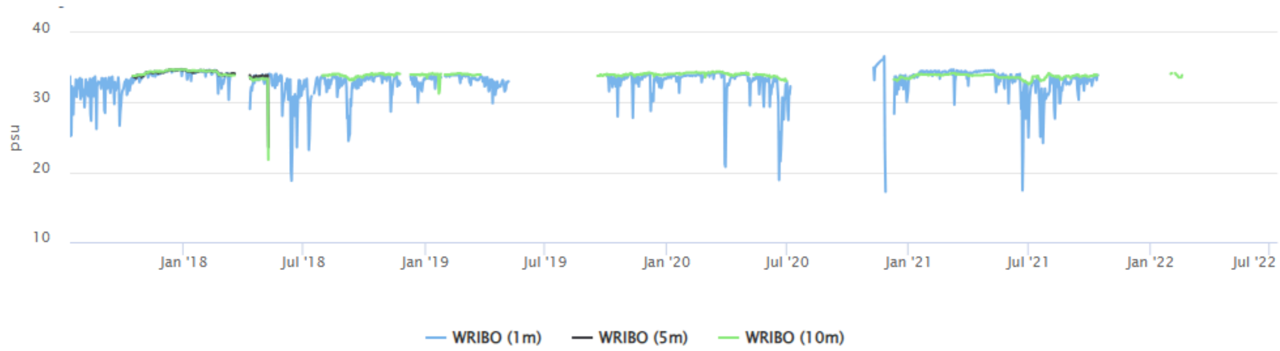

Figure 28: WRIBO daily average salinity (PSU).

Water temperature

Figure 29: WRIBO daily average water temperature (°C)

Hutt River rainfall

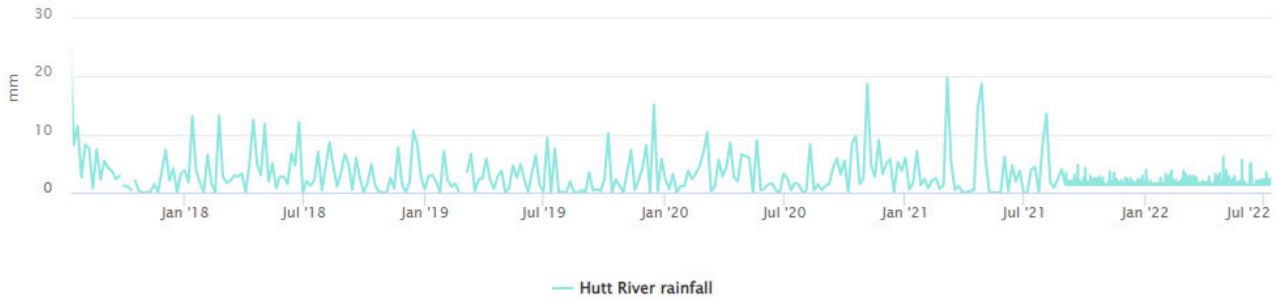

Figure 30: Hutt river daily total rainfall (mm)

Wind speed and direction

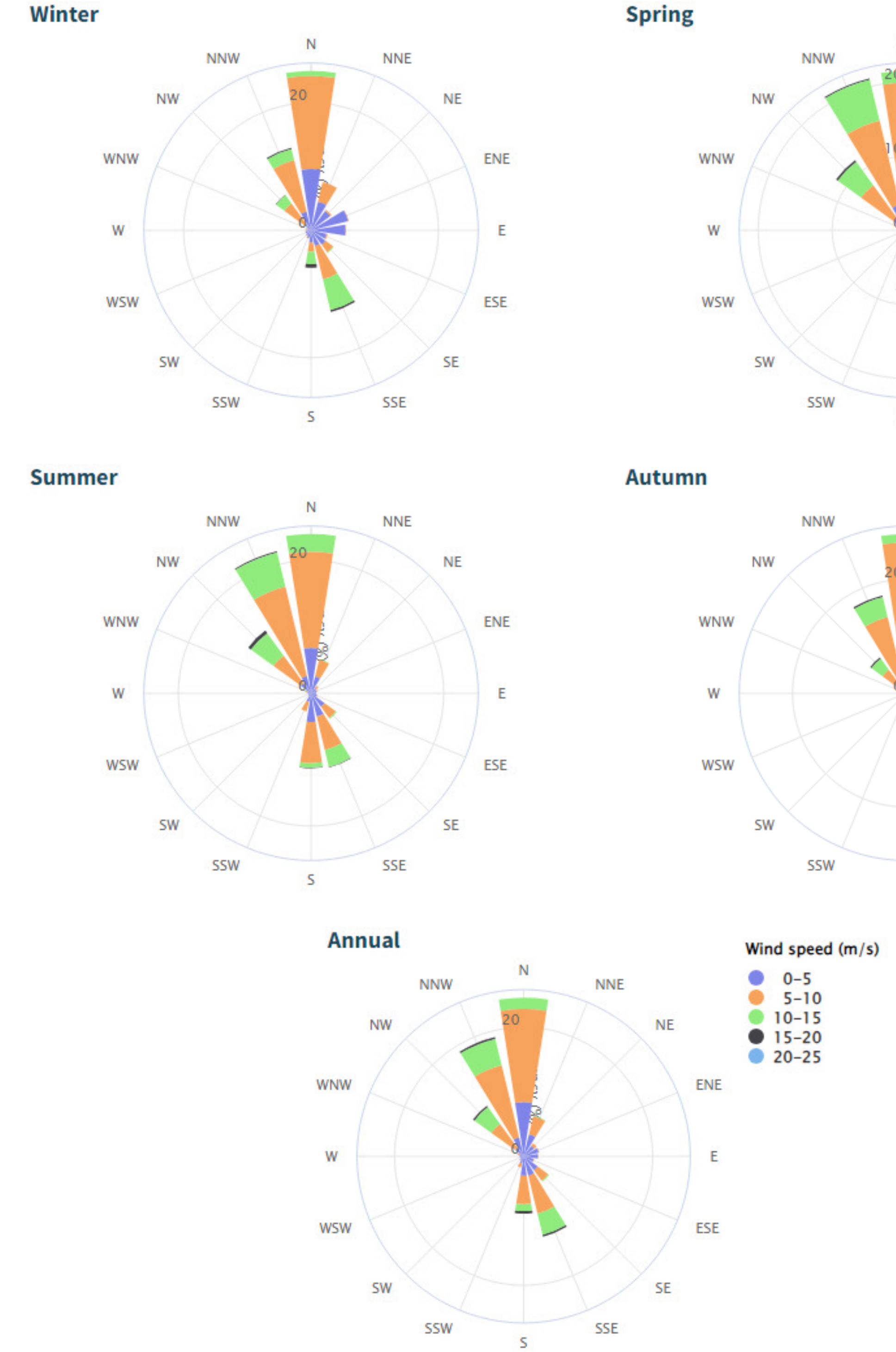

Figure 31: Average wind speed and direction in different seasons from 2017 to 2022.

Water current speed and direction

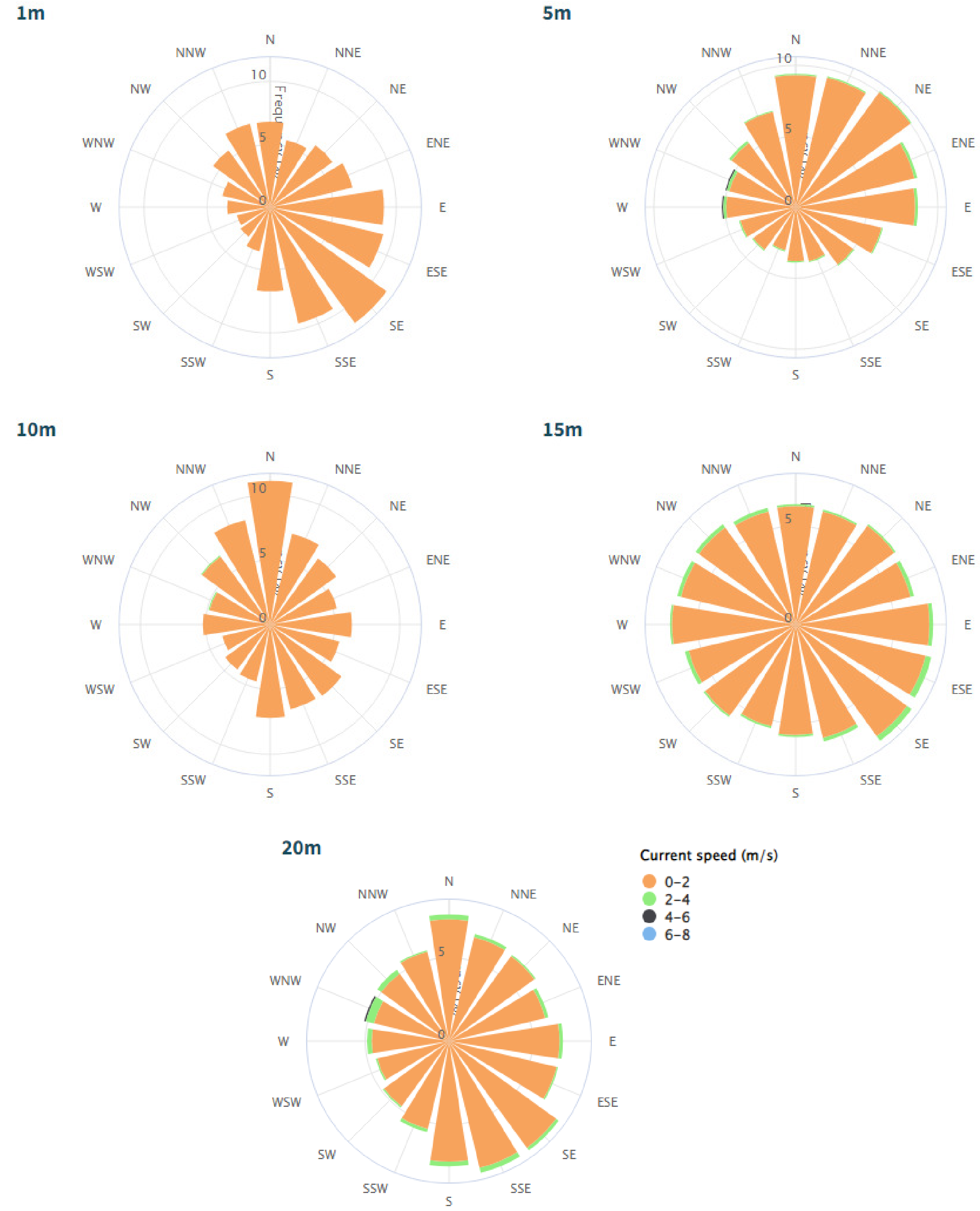

Figure 32: Average water current speed and direction at different metres below sea level from 2017 to 2022.

Waves

Three waverider buoys have been monitoring Te Whanganui-a-Tara/Wellington Harbour since 09 June 2020 with the charts below summarising key monitoring variables. Most recent data for each buoy are available through the GW live data viewer:

- Taputeranga Marine Reserve Wave Buoy
- Wellington Harbour at Baring Head Wave Buoy (North (A))
- Wellington Harbour at Baring Head Wave Buoy (South (B))

Water temperature

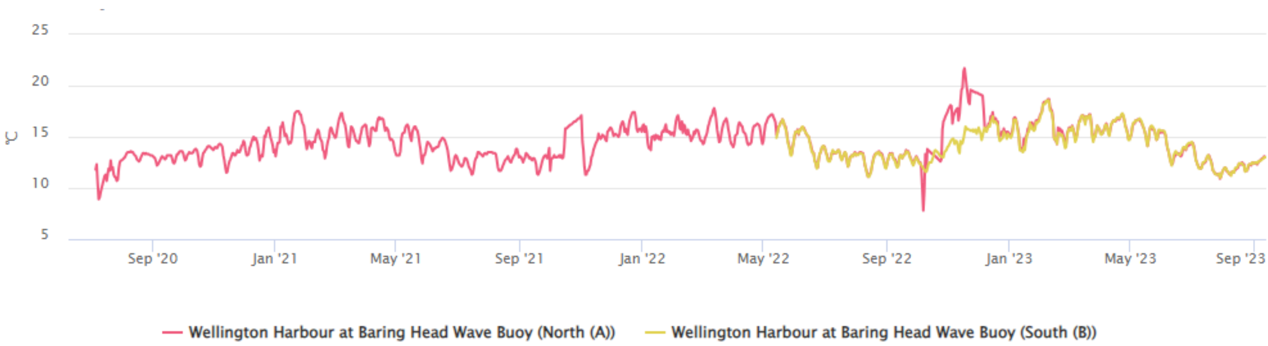

Figure 33: Waverider daily average water temperature (°C)

Wave height

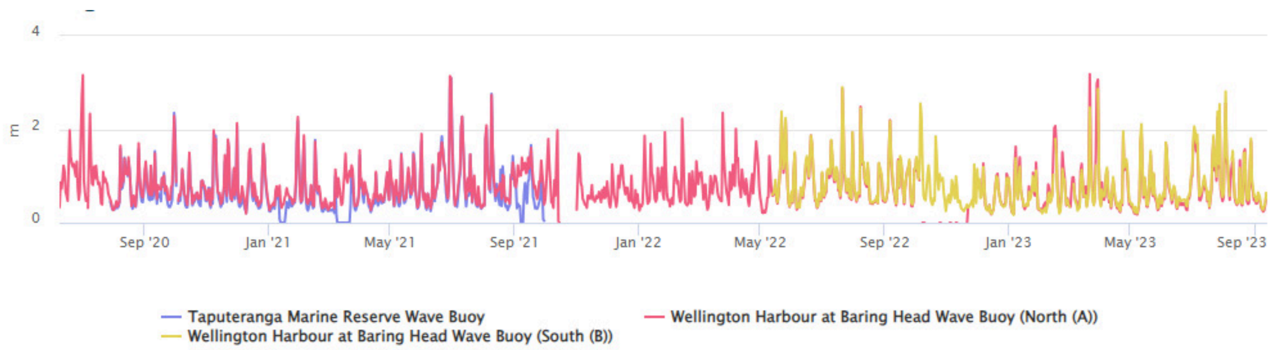

Figure 34: Waverider daily average wave height (m)

Wave direction

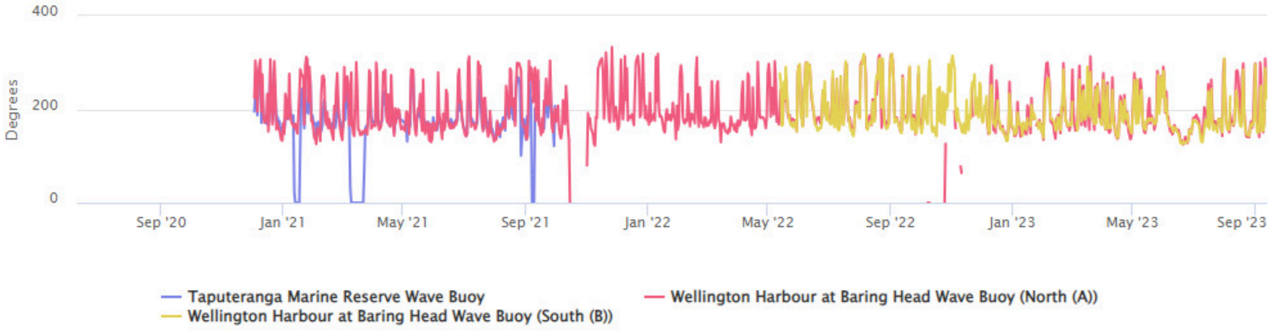

Figure 35: Waverider daily average wave direction (degrees)

Resources

Te Whaitua te Whanganui-a-Tara Implementation Programme

Sea Level Rise Mapping

Land, Air, Water Aotearoa (LAWA) – Estuaries

Recreational Water Quality Monitoring Programme

River Water Quality & Ecology Monitoring Programme

Groundwater Quality Monitoring Programme

Wellington Regional Integrated Buoy Observations instrument (WRIBO) Monitoring

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Stevens L. 2023. Hutt Estuary Sediment Plate Monitoring Report – January 2023. Salt Ecology Report 029, prepared for Greater Wellington Regional Council, June 2023. 2p.

Appendix: Data tables

Check the methods and relevant results section above for links to references and more information on the data summaries presented below. Also, please note the disclaimer before using any of these data.

Sedimentation rate

Table A1.1: Annual and 5-year mean sedimentation change (mm) results.

Year	Annual change	5-year change
2010	0.00	
2011	-0.75	
2012	-4.75	
2013	-2.00	
2014	-9.25	-16.75
2015	-1.50	-17.50
2016	1.00	-11.75
2017	20.00	10.25
2018	8.25	27.75
2019	13.00	42.25
2020	-5.25	36.00
2021	9.50	25.50
2022	-8.25	9.00
2023	-11.75	-15.75

Mud content

Table A1.2: Mud content (%) ratings summary.

Location	Year	Rating	Avg. Mud %	No. sites
Hutt estuary	2010	Poor	43.2	2
Hutt estuary	2011	Poor	38.8	2
Hutt estuary	2012	Poor	25.6	2
Hutt estuary	2017	Poor	30.6	2
Sandy beaches	2018	Very good	1.1	4
Subtidal	2006	Poor	63.0	10
Subtidal	2011	Poor	58.1	14
Subtidal	2016	Poor	54.6	15
Subtidal	2020	Poor	55.3	15
Subtidal	2021	Poor	94.2	1
Subtidal	2022	Poor	98.0	1

Substrate type

Table A1.3: Total area (ha) of each substrate type across years.

Substrate type	2010	2016	2020
Artificial		0.0	0.1
Boulder/Cobble/Gravel	6.5	6.5	6.5
Rock field	0.0	0.0	
Sand-dominated sediment (≤50% mud)	2.6	3.0	3.0
Mud-dominated sediment (>50% mud)	0.5	0.2	0.2
Saltmarsh	0.1	0.2	

Indigenous biodiversity

Table A1.4: Significant indigenous biodiversity value areas identified in the Wellington Region Natural Resources Plan.

Area	Values
Kaiwharawhara Stream Mouth / Estuary	Kaiwharawhara Estuary provides habitat, specifically passage to and from the catchment, for 7 threatened indigenous fish species: longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, īnanga, redfin bully, bluegill bully
Korokoro Estuary	Korokoro Estuary provides seasonal or core habitat for six threatened indigenous fish species: longfin eel, giant kokopu, koaro, īnanga, redfin bully and bluegill bully
Hutt River Mouth Estuary / Te Awa Kairangi	This site provides habitat for threatened indigenous fish - longfin eel, giant kōkopu, kōaro, īnanga, redfin bully, bluegill bully, lamprey; a nursery for juvenile flatfish; nationally significant habitat for the polychaete *Boccardiella magniovar*
Waiwhetu Estuary	Waiwhetu Estuary provides seasonal or core habitat for four threatened indigenous fish species: longfin eel, giant kōkopu, kōaro and īnanga
Taputeranga Marine Reserve	It protects a unique and richly varied mixture of warm, cold, temperate, and subantarctic fauna and flora. The area is representative of the North Cook Strait bioregion's habitats and ecosystems
Lake Kohangapiripiri estuary	Lake Kohangapiripiri is on rare occasion open to the sea and there are various Threatened or At Risk plant species present in the estuarine system. Other plants of interest are also present. Provides habitat for threatened indigenous fish species.
Lake Kohangatera estuary	Lake Kohangatera is periodically open to the sea and there are various Threatened or At Risk plant species present in the estuarine system. Other plants of interest are also present. Provides habitat for six threatened indigenous fish species.

Reef mapping

Table A1.5: Average habitat quality scores by area.

biota	SW	SE	NW
Suberites perfectus		5.8 (6)	
Perna canaliculus		6.6 (4)	
Brachiopod bed	7.5 (1)		
Mixed filter-feeding fauna	6.3 (5)	5.8 (2)	7.0 (2)
Maoricolpus roseus			6.0 (1)
Owenia petersenae		5.9 (14)	
Suberites australiensis	7.2 (13)		7.0 (12)
Mixed reef invertebrates		8.5 (1)	
Other habitats	4.5 (2)	3.7 (22)	

Marine Biotic Index (AMBI)

Table A1.6: Macroinvertebrate AMBI ratings summary.

Location	Year	Rating	Avg. AMBI score	No. sites
Hutt estuary	2010	Poor	4.4	2
Hutt estuary	2011	Poor	4.5	2
Hutt estuary	2012	Fair	4.0	2
Hutt estuary	2017	Fair	4.3	2

Benthic Health Model (BHM)

Table A1.7: Macroinvertebrate BHM ratings summary.

Year	Rating	Avg. BHM	No. sites
2020	Good	3.1	15

Traits Based Index (TBI)

Table A1.8: Macroinvertebrate TBI ratings summary.

Year	Rating	Avg. TBI	No. sites
2006	High	0.6	10
2011	High	0.6	14
2016	Intermediate	0.4	15
2020	High	0.6	15

Species richness

Table A1.9: Macroinvertebrate AMBI ratings summary.

Location	Year	Avg. richness	No. sites
Hutt-Well	2010	8	2
Hutt-Well	2011	8	2
Hutt-Well	2012	9	2
Hutt-Well	2017	5	2
Ōwhiro Bay	2018	3	1
Baring Head	2018	6	1
Lyall Bay	2018	2	1
Petone Beach	2018	2	2
Scorching Bay	2018	8	3

Macroalgae

Table A1.10: Total area (ha) of macroalgae in each % cover group across years.

Year	Very sparse (1 to <10%)	Sparse (10 to <30%)	Moderate (30 to <70%)	Dense (70 to <90%)
2010	1.7	2.8	1.1	4.1
2011	1.6	3.3	0.7	4.0
2012	0.7	3.3	0.6	5.1
2013	0.8	1.7	0.5	6.0
2014	0.8	2.3	1.3	4.7
2016			0.7	0.5
2017		0.2	0.3	0.0
2018		0.5	0.1	0.0

Sediment oxygenation

Table A1.11: Sediment oxygenation aRPD (mm) condition rating results summary.

Location	Year	Rating	Avg. aRPD mm	No. sites
Hutt estuary	2010	Good	33	2
Hutt estuary	2011	Good	33	2
Hutt estuary	2012	Fair	15	2
Hutt estuary	2017	Fair	15	2

Total Organic Carbon

Table A1.12: Total organic carbon (%) ratings summary.

Location	Year	Rating	Avg. TOC %	No. sites
Hutt estuary	2010	Good	0.81	2
Hutt estuary	2011	Good	0.79	2
Hutt estuary	2012	Fair	1.12	2
Hutt estuary	2017	Fair	1.05	2
Subtidal	2006	Fair	1.63	10
Subtidal	2011	Fair	1.52	14
Subtidal	2016	Fair	1.44	15
Subtidal	2020	Fair	1.41	15
Subtidal	2021	Fair	1.41	1
Subtidal	2022	Fair	1.36	1

Total Nitrogen

Table A1.13: Total nitrogen (mg/kg) ratings summary.

Location	Year	Rating	Avg. TN mg/kg	No. sites
Hutt estuary	2010	Fair	1,312	2
Hutt estuary	2011	Fair	1,067	2
Hutt estuary	2012	Fair	1,150	2
Hutt estuary	2017	Good	800	2

Zinc

Table A1.14: Zinc (mg/kg) ratings summary.

Location	Year	Rating	Avg. Zn mg/kg	No. sites
Hutt estuary	2010	Very good	65.3	2
Hutt estuary	2011	Very good	63.2	2
Hutt estuary	2012	Very good	73.0	2
Hutt estuary	2017	Very good	69.9	2
Sandy beaches	2018	Very good	84.0	2
Subtidal	2006	Good	108.9	10
Subtidal	2011	Good	105.8	14
Subtidal	2016	Very good	97.4	15
Subtidal	2020	Good	106.8	15
Subtidal	2021	Very good	99.6	1
Subtidal	2022	Very good	96.4	1

Copper

Table A1.15: Copper (mg/kg) ratings summary.

Location	Year	Rating	Avg. Cu mg/kg	No. sites
Hutt estuary	2010	Very good	9.0	2
Hutt estuary	2011	Very good	8.9	2
Hutt estuary	2012	Very good	10.3	2
Hutt estuary	2017	Very good	11.8	2
Sandy beaches	2018	Very good	8.5	2
Subtidal	2006	Very good	19.3	10
Subtidal	2011	Very good	19.9	14
Subtidal	2016	Very good	20.4	15
Subtidal	2020	Very good	19.7	15
Subtidal	2021	Very good	13.2	1
Subtidal	2022	Very good	12.8	1

Water quality

Table A1.16: Water quality summaries for Hutt River, WRIBO and Waverider Buoys. Note that measurements at WRIBO and those taken at the Hutt River are displayed in different units, NTU and FNU respectively, but these units are essentially the same in value (1 NTU ≈ 1 FNU). CDOM = coloured dissolved organic matter.

Site	Flow (m^3/s)	Turbidity (NTU|FNU)	Rainfall (mm)	Chlorophyll *a* (mg/m^3)	Water temperature (°C)	Dissolved oxygen (µg/L)	Salinity (PSU)	CDOM (ppb)
Hutt River	23.7	5.7	0.1					
WRIBO at 1m		20.9		5.6	14.7	6.6	33.0	4.4
WRIBO at 5m				0.7	17.2	7.6	34.2	2.9
WRIBO at 10m		2.2		6.2	14.9	7.0	33.2	4.3
Baring Head N					14.4			
Baring Head S					14.3			

Wind direction & speed

Table A1.17: WRIBO wind direction and speed summaries for different seasons.

Season	Speed (m/s)	Direction
Winter	5.4	NNE
Spring	6.1	N
Summer	6.9	NNW
Autumn	6.6	N
All	6.3	N

Current direction & speed

Table A1.18: WRIBO water currents direction and speed summaries at different depths below sea level.

Depth (m)	Speed (m/s)	Direction
1	0.1	E
5	0.3	NE
10	0.1	NNE
15	0.5	E
20	0.6	ESE
All	0.3	ENE

Wind direction & speed

Table A1.19: WRIBO wind direction and speed summary.

Site	Height (m)	Direction
Taputeranga Marine Reserve	0.7	S
Baring Head North A	0.8	S
Baring Head South B	0.8	S