Habitat Mapping and Sediment Characterisation of Matakana River Estuary, 2026

Orlando Lam-Gordillo, Sarah Hailes, Kelly Carter, Reuben Hattingh

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Cockle beds in Matakana Estuary. Photograph by Kelly Carter, Earth Sciences New Zealand.

Earth Sciences New Zealand

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Prepared for Auckland Council

April 2026

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Cover photo: Cockle beds in Matakana Estuary. [Kelly Carter, Earth Sciences New Zealand]

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Executive summary

Estuaries are among the most productive environments on earth. However, at the interface of land and sea they face many pressures, particularly as the receiving environment for run-off from different land uses and direct discharges. Mapping of habitats within estuaries is an important step in understanding the biodiversity values and ecological functions of an estuary, to help inform management decisions related both to the estuary and to the catchment surrounding it.

A rapid habitat assessment technique that has been developed, tested, and applied previously in several estuaries across New Zealand, and shown to be accurate, was carried out in Matakana Estuary on the east coast of the Auckland region.

This report documents the application of that assessment, providing a detailed description of the methods used and the resulting habitat classification. This report also describes the sedimentary conditions of the top 2 cm of sediment (i.e., sediment chlorophyll a, phaeopigments, organic matter content, and particle size distribution) across 60 sampling sites in Matakana Estuary. A short literature review on the environmental information available for Matakana Estuary was performed and a summary of the findings is presented in this report.

The rapid habitat mapping identified 11 habitat classes across Matakana Estuary. Mangroves, High Density Burrows, and Mounds and Pits were the habitat classes that covered most of the area surveyed within the estuary. A relatively large spatial extent of Seagrass habitat was recorded in the lower section of the estuary, yet the structural characteristics of the seagrass meadow suggest a deteriorated condition. High Density Cockles, High Density Crabs and Cockles, and High Density Oysters covered a small proportion of the total surveyed area (<6%) within Matakana Estuary.

Chlorophyll a and phaeopigments concentrations were consistently low across Matakana Estuary, suggesting no clear symptoms of eutrophication at a system-wide scale. However, localised high concentrations of Chlorophyll a and phaeopigments near freshwater entry points were identified.

Organic matter and mud content in the sediments across Matakana Estuary were also higher near freshwater inputs and in the poorly flushed northern reaches of the estuary. The lowest OM and mud content were recorded in the middle and lower portions of estuary, closer to the mouth.

This report presents the first rapid habitat assessment of Matakana Estuary, generating information on the extents of intertidal habitats that contribute to ecosystem functioning that can be used to inform catchment management planning. The standardised methods used to survey Matakana enabled the identification of habitat types and conditions present at the time of the survey and can be repeated in the future. Thus, the baseline provided by the 2026 survey supports efforts to detect habitat change over the longer-term and informed management under increasing human and climate pressures.

1 Background

Estuarine ecosystems (interfaces between rivers and the sea) are among the most productive environments on Earth (Thrush et al. 2013; Douglas et al. 2019). Their unique mixing of freshwater and saltwater creates a dynamic mosaic of habitats such as mudflats, saltmarshes, mangroves, seagrass meadows, and tidal channels (Thrush et al. 2021; Lam-Gordillo et al. 2024b). These habitats support high biodiversity, providing nursery grounds for fish, feeding areas for migratory birds, and essential ecological functions like nutrient cycling and shoreline stabilization (Thrush et al. 2021; Bulmer et al. 2024). Beyond their ecological value, estuaries underpin cultural identity, recreation, and commercial fisheries, making them vital to both nature and society (Cloern et al. 2016; Thrush et al. 2021).

Despite their importance, estuaries are facing escalating pressures. Urbanization, agriculture, industrial discharges, and dredging all degrade water quality and disturb sediment regimes (Lotze et al. 2006; Cloern et al. 2016). Excess nutrients from land runoff can trigger eutrophication, harmful algal blooms, and hypoxia, while habitat fragmentation reduces ecological connectivity (Lohrer et al. 2004; Lohrer et al. 2012; Cloern et al. 2016). Climate change compounds these issues, with sea-level rise, ocean warming, and increased storm intensity further stressing estuarine communities and threatening their natural resilience (Lam-Gordillo et al. 2024c; Lam-Gordillo et al. 2025). The cumulative effect of these stressors is a decline in ecological health, with many estuaries experiencing losses in biodiversity, reduced water quality, and diminished ecosystem functioning and services.

Mapping habitats within estuaries is crucial for understanding and protecting these systems. Accurate habitat maps reveal the spatial distribution of key ecological features, helping scientists detect changes over time, identify vulnerable areas, and assess the impacts of human activities. For resource managers, these maps guide marine spatial planning, restoration prioritization, and policy development ensuring that the interventions are targeted and effective. Ultimately, habitat mapping provides the foundational knowledge needed to safeguard estuarine ecosystems and maintain the essential services they provide to humankind.

Matakana Estuary is the lower tidal reach of the Matakana River, situated on the east coast within the northern Auckland Region of New Zealand. This estuarine system represents an intersection of terrestrial, freshwater, and marine environments, supporting a diverse mosaic of habitats characteristic of northern New Zealand estuaries. These habitats include mangrove forests, seagrass meadows, and soft-sediment intertidal flats, each contributing uniquely to the ecological functioning and productivity of the system.

Despite its potential importance, scientific research in Matakana Estuary remains relatively limited. In particular, there is a notable lack of detailed studies examining intertidal habitats. As a result, the full extent of the ecological resources and processes within this estuary is not well understood. This knowledge gap is especially important in the context of ongoing environmental change, including coastal development, sedimentation, and climate-driven stressors, which may disproportionately affect intertidal habitats. Expanding research efforts in Matakana Estuary would therefore be valuable for improving our understanding of its ecological dynamics, informing conservation and management strategies, and ensuring the long-term sustainability of this important coastal ecosystem.

In January 2026, Auckland Council (AC) contracted Earth Sciences New Zealand (ESNZ, formerly NIWA) to perform a rapid habitat mapping (RHM) assessment of intertidal areas in Matakana Estuary. The RHM assessment was previously carried out in other estuaries across the Waikato and Bay of Plenty regions, and in Okura Estuary in 2024, proving to be an effective assessment technique for differentiating habitats associated with the provision of ecosystem goods and services. Furthermore, RHM has also been conducted by Auckland Council in Ōrewa, Pūhoi and Waiwera in 2025 and 2026.

This report documents the application of RHM assessment methodology for the first time in Matakana Estuary, to enable the identification of habitats related to ecosystem goods and services and as a temporal snapshot for comparison with future mapping efforts to detect change in the intertidal areas of Matakana Estuary. This report includes:

- A short description of the methodologies (i.e., equipment and field techniques) used for mapping the estuary.
- A description of the habitat classes identified in Matakana Estuary.
- A map showing the spatial distribution of the habitat classes across Matakana Estuary.
- A visual assessment of the sedimentary conditions across Matakana Estuary.
- A compilation and summary of the environmental information available to date for Matakana Estuary.
- Comments on the habitat classes found in Matakana Estuary and their potential linkage to ecosystem functions and services.

In addition to this report, GIS shape files of habitats and the accompanying metadata have been provided to AC.

2 Methods

2.1 Habitat mapping

The RHM assessment was developed to quickly and accurately distinguish among various intertidal habitat types present within estuaries based on features linked to estuarine ecosystem functions and services. This approach has been applied in several New Zealand estuaries (Needham et al. 2013; Lam-Gordillo et al. 2023; Lam-Gordillo et al. 2024a; Lam-Gordillo et al. 2024b) and has proven effective for classifying intertidal estuarine habitats.

2.1.1 Field equipment

The field equipment used for rapid habitat assessments included handheld Global Positioning System (GPS) units, cameras, quadrats, and trowels. GPS units were essential for recording boundary tracks, waypoints, habitat classifications, and field notes at precise locations (1-3 m under optimal conditions). Quadrats (0.25 m^2) and trowels were used to assess specific habitat types by placing the quadrat on the sediment surface and scraping or digging into the substrate to identify key features characteristic of each habitat (e.g., number of shellfish of a given size that are present). Photographs were taken of the sediment/habitat type by each assessor for habitat validation and cross-checking purposes; but also, of the surrounding area (e.g., adjacent shore and catchment).

2.1.2 Field techniques

The field methods followed the approaches described by Needham et al. (2013) and refined by Lam-Gordillo et al. (2023) and Lam-Gordillo et al. (2024a). In summary, a combination of methods was used to rapidly and efficiently survey large intertidal flats. Transects were walked in a zig-zag pattern to maximise area coverage, with changes (or consistencies) in habitat type verified by multiple team members and recorded using GPS waypoints. In long, narrow bays, a fan-shaped search pattern (i.e., where each field worker walked outward from a central point) was employed to further increase coverage.

Some habitat types exhibited clear, well-defined boundaries (e.g., raised sand banks, rock platforms, emergent vegetation). Where feasible, these boundaries were walked in full. For large or difficult-to-access habitats (such as dense mangrove or pneumatophore zones), only a representative portion of the perimeter was walked, with GPS waypoints, track logs, and field notes used to later confirm boundaries against aerial imagery. Photographs were taken throughout to document habitat characteristics and to support consistent identification across this and future surveys.

2.1.3 Habitat classification

The habitat classification used for Matakana Estuary followed the framework outlined in Lam-Gordillo et al. (2023), Lam-Gordillo et al. (2024a), and Lam-Gordillo et al. (2024b) to ensure consistency and comparability with previous work. A total of eleven habitat classes were identified, grouped into three main categories. Flora-defined habitats included Mangroves (*Avicennia marina*) and Pneumatophores. Fauna-defined habitats comprised High Density Burrows (crustacean burrows), High Density Cockles (*Austrovenus stutchburyi*), High Density Crabs and Cockles, High Density Oysters, Low Density Deposit Feeders, Low Fauna, and Mounds and Pits. The final habitat class was Mud stone/Rocky Reef (Table 2-1).

Table 2-1: Summary table of the habitat classification for Flora and Fauna groups used in this study.

Habitat Type	Qualifying information
HD Burrows	≥10 crustacean burrows of ≥20 mm aperture in a 0.25 m^2 quadrat. Repeated, randomly thrown quadrats (n=3 to 5) must yield the same density.
HD Cockles	≥10 individuals sized ≥20 mm shell length per 15 x 15 cm area, armoured shells >15 mm shell length where the entire sediment surface is covered shell to shell; or >3 individuals sized ≥40 mm shell length per 15 x 15 cm area. Typically, with a fine layer of associated shell hash.
HD Crabs and Cockles	Both at densities to qualify for their respective habitat categories (above).
HD Oyster	Covering greater than 80% of the 0.25 m^2 quadrat. Must be repeatable over an area >10m in one dimension.
HD Tube worms	Covering greater than 80% of the 0.25 m2 quadrat. Must be repeatable over an area >10 m in one dimension.
LD Deposit Feeders	Low to medium density of mainly deposit feeding fauna.
Low Fauna	Sparse fauna often in densities lower than 1 ind. 0.25 m^2 quadrat.
Mangroves	Adult plants greater than 10 m^2 in spatial extent.
Mounds and Pits	Similar to LD deposit feeder category but with noticeable surface topography. Burrows and mounds range from <1 to 4 per 0.25 m^2 quadrat.
Mud stone / Rocky reef	Areas dominated by sedimentary rock, with a thin covering of soft sediment or areas where exposed or submerged rock outcrops were present.
Pneumatophores	Border of the adult plants protruding laterally >5 m.
Seagrass	Dense vegetation spanning more than 10 m^2.

2.1.4 Habitat map digitalisation

In order to create the Matakana habitat map, all tracks and waypoints were downloaded from the GPS units and compiled into a single dataset. These data were overlaid, colour-coded, and exported as a .kmz file for use in Google Earth and ArcGIS Pro. Field photographs were batch-processed into thumbnail formats and geotagged in Google Earth using the GeoSetter freeware. This information, combined with written field notes, formed the basis for map creation in ArcGIS Pro.

Polygons were generated using the "Create Polygon" tool, which allows users to trace GPS tracks and delineate habitat boundaries. Habitat boundaries were defined using four primary information sources: (1) GPS waypoints and tracks collected in the field, (2) high-resolution aerial imagery, (3) geotagged field photographs, and (4) written notes linked to GPS locations. In areas where zig-zag or fan-shaped survey methods were used to cover broad intertidal flats, differences in community structure between transects were evaluated and then used to visually interpolate boundaries between them. Waypoints, imagery, photographs, and visible physical features all contributed to the precise placement of each boundary.

2.2 Sediment sampling

Three sedimentary variables known to indicate sediment condition were measured. The three variables assessed were sediment chlorophyll-a (Chl-a), sediment organic matter content (OM), and the percentage of silt–clay (i.e., Mud) in the sediment (% dry weight < 63 µm). Following standard regional protocols (Drylie, 2021), one replicate of sediment samples for Chl-a, OM, and grain size were collected at each of the 60 sampling sites across Matakana Estuary (Figure 2-1, Table A-1) using a small PCV corer (26 mm diameter, 20 mm deep core). Sediment from six small cores was amalgamated per replicate to encompass localised variability.

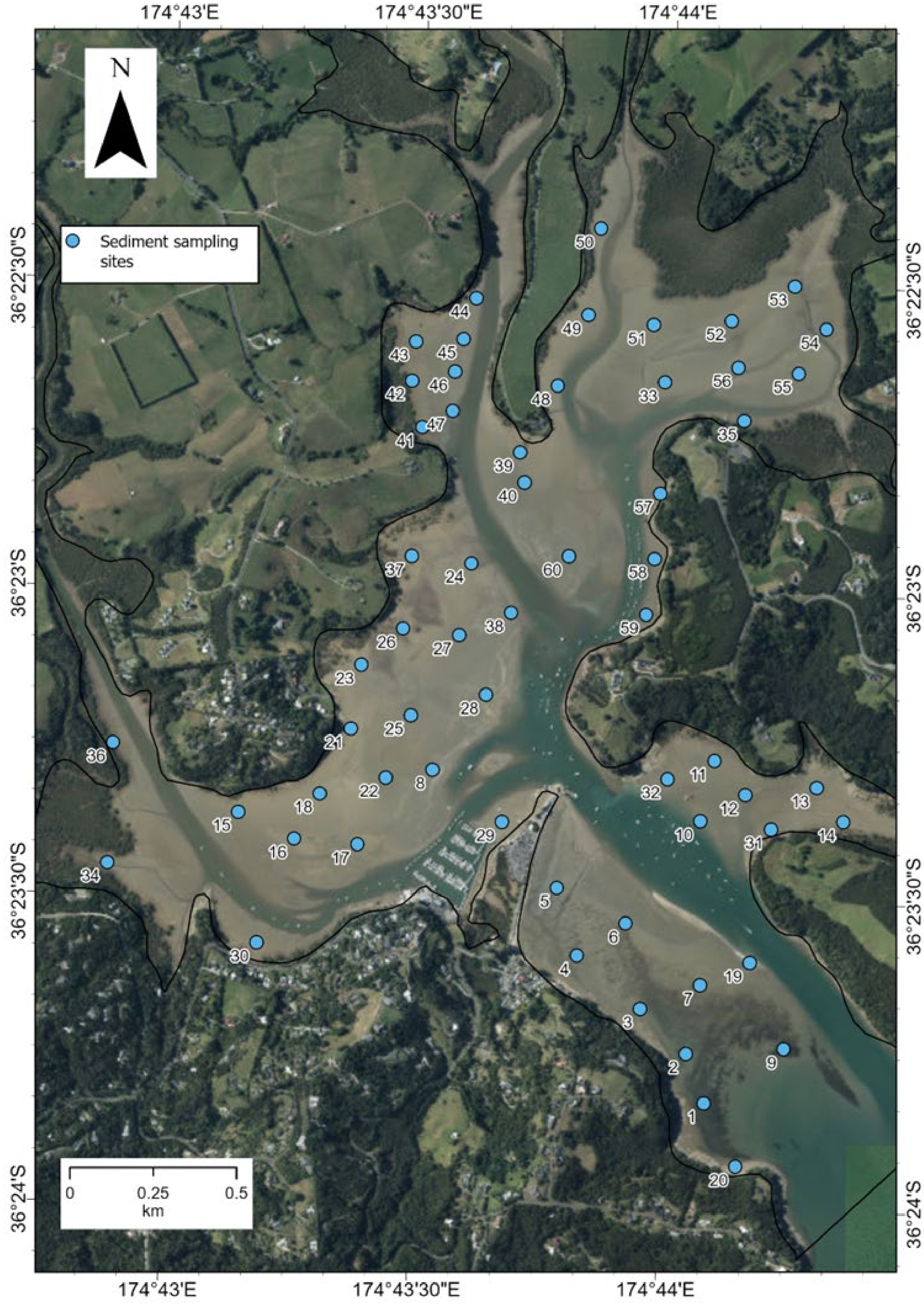

Figure 2-1: Map of Matakana Estuary, New Zealand, showing the 60 sediment sampling sites. Black line represents the estuary boundary. Imagery and estuarine boundary were retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

2.2.1 Laboratory analysis

Prior to the laboratory analysis, each small core was homogenized and sub-sampled for analysis of Chl-a, OM, and grain size. Chl-a was extracted from freeze dried sediments by boiling in 90% ethanol. The extract was measured spectrophotometrically, and an acidification step was included to separate degradation products (phaeophytin) from Chl-a (Sartory, 1982). Organic matter content was determined by drying the sediment at 60°C for 48 h and then combusting it at 400°C for 5.5 h, with OM expressed as percent dry weight lost on ignition. For sediment grain size, samples were homogenised and then digested in ~ 9% hydrogen peroxide until frothing ceases. Samples were wet sieved through 2000 µm, 500 µm, 250 µm, 125 µm, and 63 µm mesh sieves. Pipette analysis was used to separate the <63 µm fraction into >3.9 µm and ≤3.9 µm. All fractions are then dried at 60°C until a constant weight is achieved (fractions are weighed at ~ 40 h and then again at 48 h) to obtain the percentage weight of gravel/shell hash (>2000 µm), coarse sand (500–2000 µm), medium sand (250–500 µm), fine sand (125–250 µm), very fine sand (62.5–125 µm), silt (3.9–62.5 µm) and clay (≤3.9 µm).

2.2.2 Data analysis

Sedimentary conditions were visually analysed to elucidate trends in sediment condition throughout Matakana Estuary. Point values and interpolated measured values based on an Inverse Distance Weighting (IDW) method were used to create maps for Chl-a, Phaeopigments, OM, and Mud content (percent of sediment particles <63 µm) using ArcGIS PRO v.3.3 software.

2.3 Matakana Estuary environmental data review

To compile and summarise the environmental data available for Matakana Estuary, a literature review was conducted using the databases SCOPUS (Elsevier; elsevier.com), Web of Science (WoS, Thompson Reuters; webofknowledge.com), and Google Scholar (https://scholar.google.com/). The literature searches were performed using a combination of the following terms: “Matakana Estuary”, “Matakana”, “environmental”, “environmental variable(s)”, “New Zealand”, in the fields of ‘Article title, Abstract, Keywords’ for SCOPUS, in ‘topics’ (Article title, Abstract, Author, Keywords and Keywords plus) for WoS, and in the search box in Google Scholar. Additionally, we searched in grey literature across institutional libraries (Auckland Council, ESNZ) for potential local reports. This search resulted in nine published studies, which were assessed and all the relevant environmental information was extracted and summarised.

3 Results

3.1 Habitat mapping

Eleven distinct habitat classes were identified in Matakana Estuary (Table 3-1, Figure 3-1). The largest area of the estuary was dominated by Mangroves (32.6%), followed by HD Burrows (25.4%), Mounds and Pits (14.6%), and LD Deposit feeders (9.2%) habitats (Table 3-1). HD Cockles and Seagrass habitats covered ~5% of the total surveyed habitat each (5.8% and 5.4%, respectively), while the combined HD Crabs and Cockles and HD Oysters habitats covered less than 1% of the surveyed area in Matakana Estuary (Table 3-1). The upper section of the estuary (i.e., northern - close to river inputs) was mainly covered by Mangroves and HD Burrows habitats, while the lower (i.e., southern – close to the estuary mouth) section of the estuary was covered by LD Deposit Feeders and a extensive Seagrass habitat (Figure 3-1). Despite the relatively large expanse of Seagrass habitat in outer Matakana Estuary, the seagrass was characterised by short, thin blades, lacking the longer and more robust growth typically associated with healthy seagrass meadows. Much of the vegetation appeared brown-green in colour. Furthermore, due to the easy public access to the area and the firm substrate, it is likely that frequent trampling by visitors contributes to the condition observed (Figure 3-2). Mounds and Pits habitat was identified in several sections of the estuary and often associated with HD Burrows habitat. HD Cockles habitat was identified in the middle section of the estuary and closer to the channels (Figure 3-1). Long sections close to shore were covered by Mud stone habitat, while HD Oysters habitat was identified in localised areas in the middle of the estuary and within the Mud stone habitat (Figure 3-1).

Table 3-1: Summary table showing the total area and percentage of area covered by each habitat in Matakana Estuary in 2026.

Habitat	Area (m^2)	Area (Ha)	Area (km^2)	Area (%)
HD Burrows	799 642	79.96	0.7996	25.4
HD Cockles	182 895	18.29	0.1829	5.8
HD Crabs and Cockles	2 208	0.22	0.0022	0.1
HD Oysters	1 700	0.17	0.0017	0.1
LD Deposit feeders	289 092	28.91	0.2891	9.2
Low fauna	65 884	6.59	0.0659	2.1
Mangroves	1 026 790	102.68	1.268	32.7
Mounds and Pits	461 507	46.15	0.4615	14.7
Mud stone / Rocky reef	101 354	10.14	0.1014	3.2
Pneumatophores	40 829	4.08	0.0408	1.3
Seagrass	170 751	17.08	0.1708	5.4

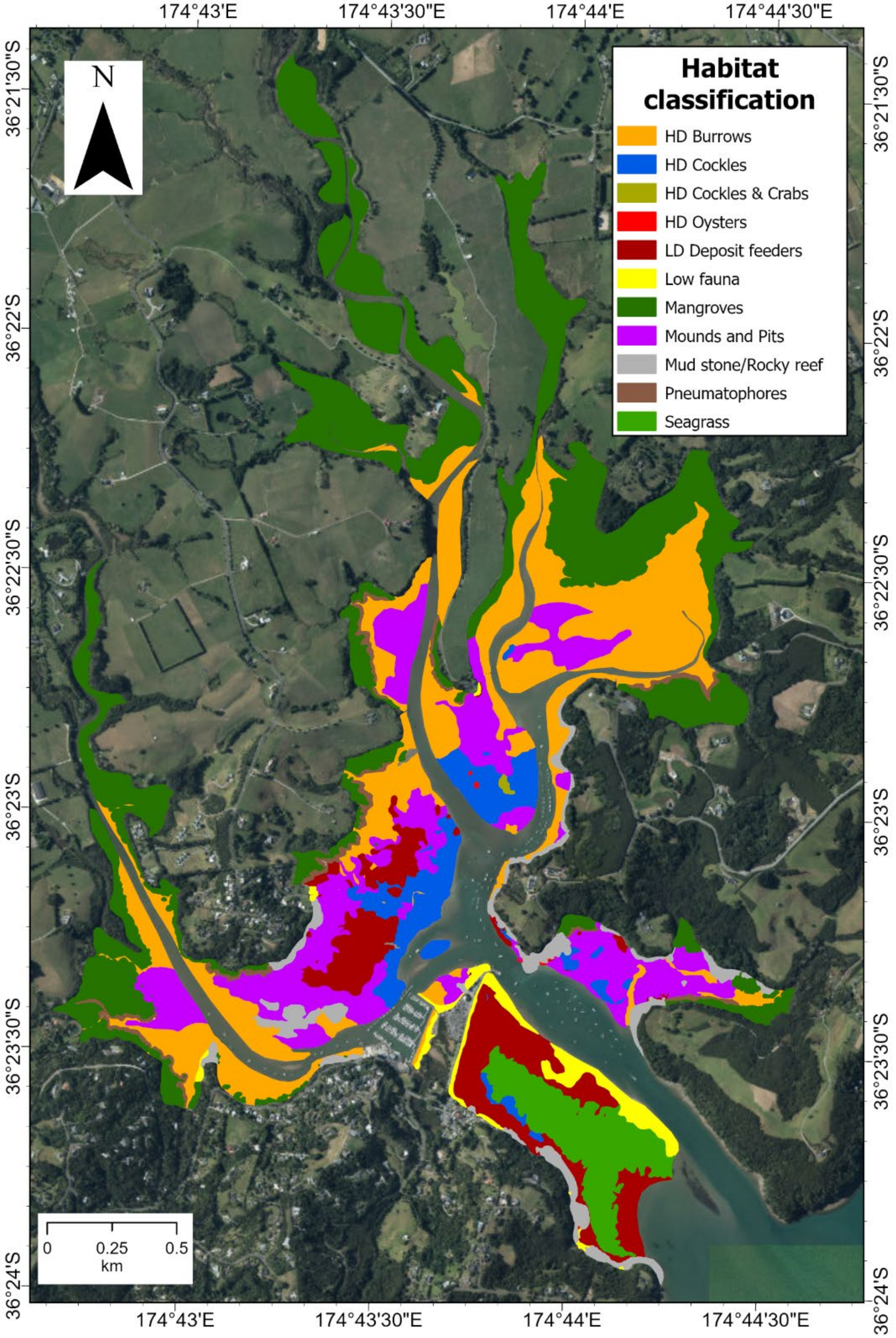

Figure 3-1: Habitats mapped in Matakana Estuary in 2026. The eleven habitat classes are presented in different colours. Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

Figure 3-2: Seagrass sample collected while performing the rapid habitat mapping at Matakana estuary in January 2026.

3.2 Sedimentary conditions across Matakana Estuary

3.2.1 Chlorophyll-*a* in sediment

Overall, chlorophyll-a (Chl-a) was low across the entire estuary, which suggested no symptoms of eutrophication (Figure 3-3). The highest Chl-a concentrations were recorded close to a freshwater entry point in the west side of the estuary, with the highest concentrations of Chl-a recorded at Site 36. In contrast, most of the lowest concentrations of Chl-a were identified at the middle section of the estuary, close to estuary mouth, and across the seagrass habitat (Figure 3-3).

Phaeopigments (Phaeo), i.e., the degradation product of algal chlorophyll pigments, followed a similar pattern as Chl-a, showing high concentration values in the vicinity of freshwater entry point in west side of the estuary, but also at Sites 28, 60, 10, and 53 (Figure 3-4). Concentrations of Phaeo were generally relatively low throughout Matakana Estuary, revealing the absence of decaying algal material in most areas of the estuary. Low concentrations of Phaeo were identified in the middle section of the estuary, which aligned with patterns in Chl-a concentration (Figure 3-4).

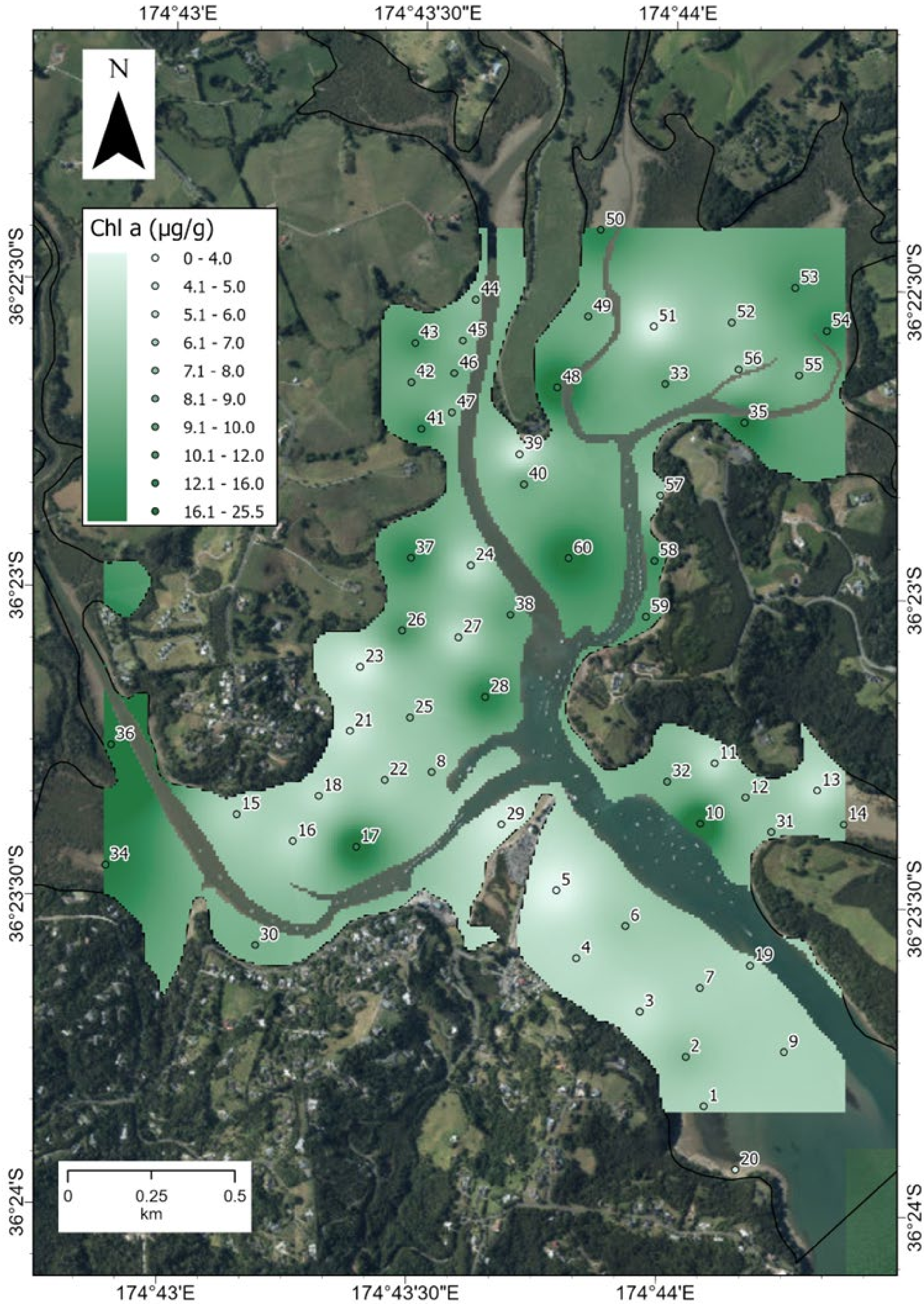

Figure 3-3: Map of Chlorophyll-a (Chl-a) content in sediments across Matakana Estuary. Map shows point values (concentrations in µg/g), with interpolation between points based on an Inverse Distance Weighted (IDW) interpolation method. Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

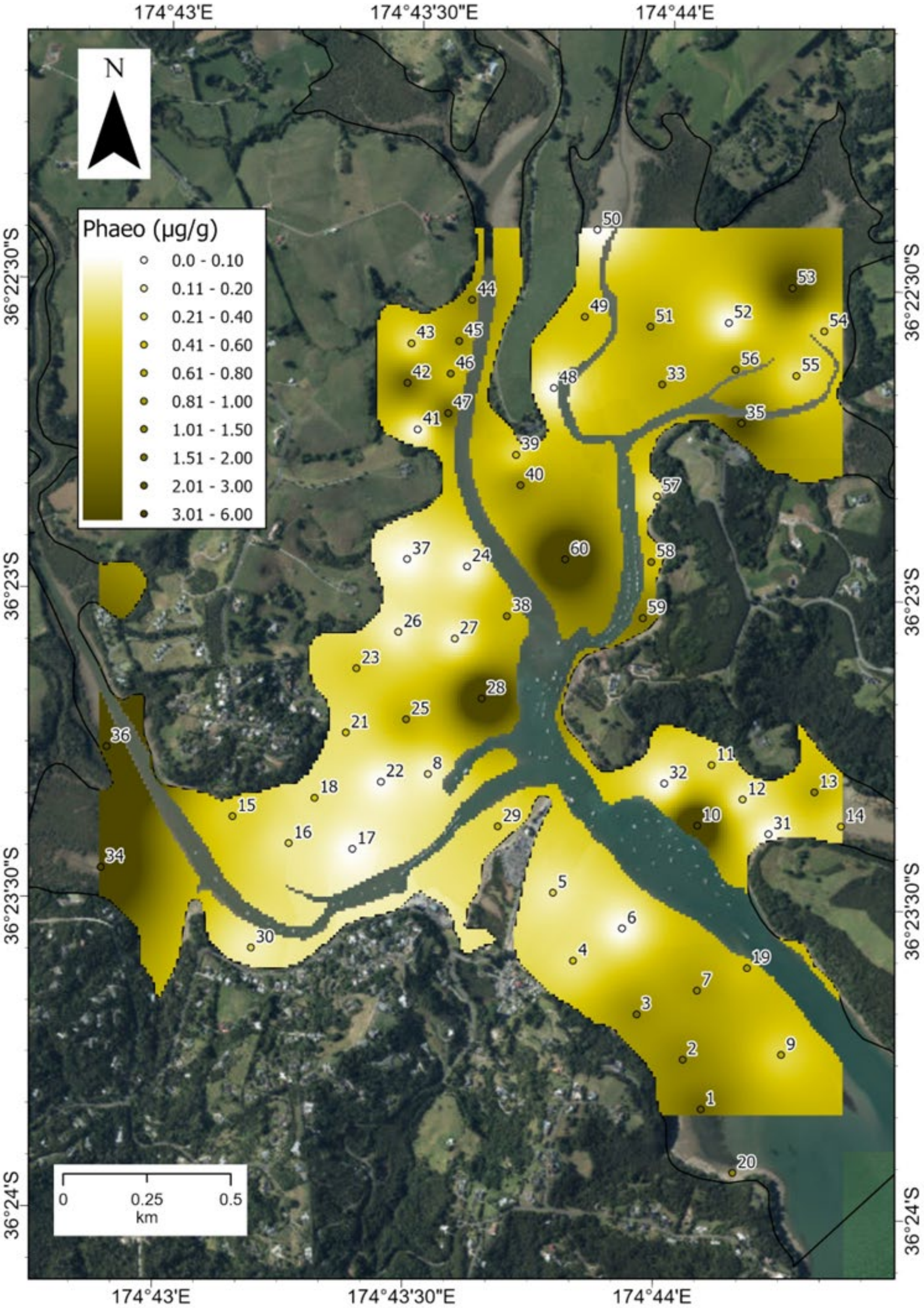

Figure 3-4: Map of Phaeopigment (Phaeo) content in sediments across Matakana Estuary. Map shows point values (concentrations in µg/g), with interpolation between points based on an Inverse Distance Weighted (IDW) interpolation method. Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

3.2.2 Sediment organic matter content

Organic matter content was >1% in almost all sites (49/60) sampled across Matakana Estuary (Figure 3-5). The highest content of organic matter in sediment were identified closer to freshwater inputs, in the west side of the estuary at Sites 36 (6.0%) and 34 (5.6%), and in the northern section of the estuary at Sites 53, 54, 35, and 44-47 (Figure 3-5). This could reflect higher rates of organic matter deposition via land inputs and consequently higher organic matter content in sediment. Similar to Chl-a and Phaeo, the lowest content of organic matter was identified in the middle section of the estuary and in areas close to mouth of the estuary (Figure 3-5).

3.2.3 Sediment grain size

Sediment grain size was variable across Matakana Estuary (Figure 3-6, Table A-2). Overall, Matakana sediments were characterised as fine sand to very fine sand. Medium to very fine sand sediments dominated the areas close to the mouth of the estuary (2% to >3%). In the middle section of the estuary, fine sediments were prominent, while sediments with high concentrations of silt were found in the poorly flushed inner and upper reaches of the estuary, i.e., in the northern section of the estuary at Sites 51, 39, and 35 (Figure 3-6, Table A-2). Mud content in sediment (i.e., silt + clay) exhibited a pattern different to that of Chl-a and Phaeo, and more similar to that of OM, i.e., higher mud content in the innermost (northern) section of Matakana Estuary (Figure 3-7, Table A-2). Low sediment mud content (<1%) was found in areas close to the mouth of Matakana Estuary and some areas in the middle section of the estuary (Figure 3-7, Table A-2).

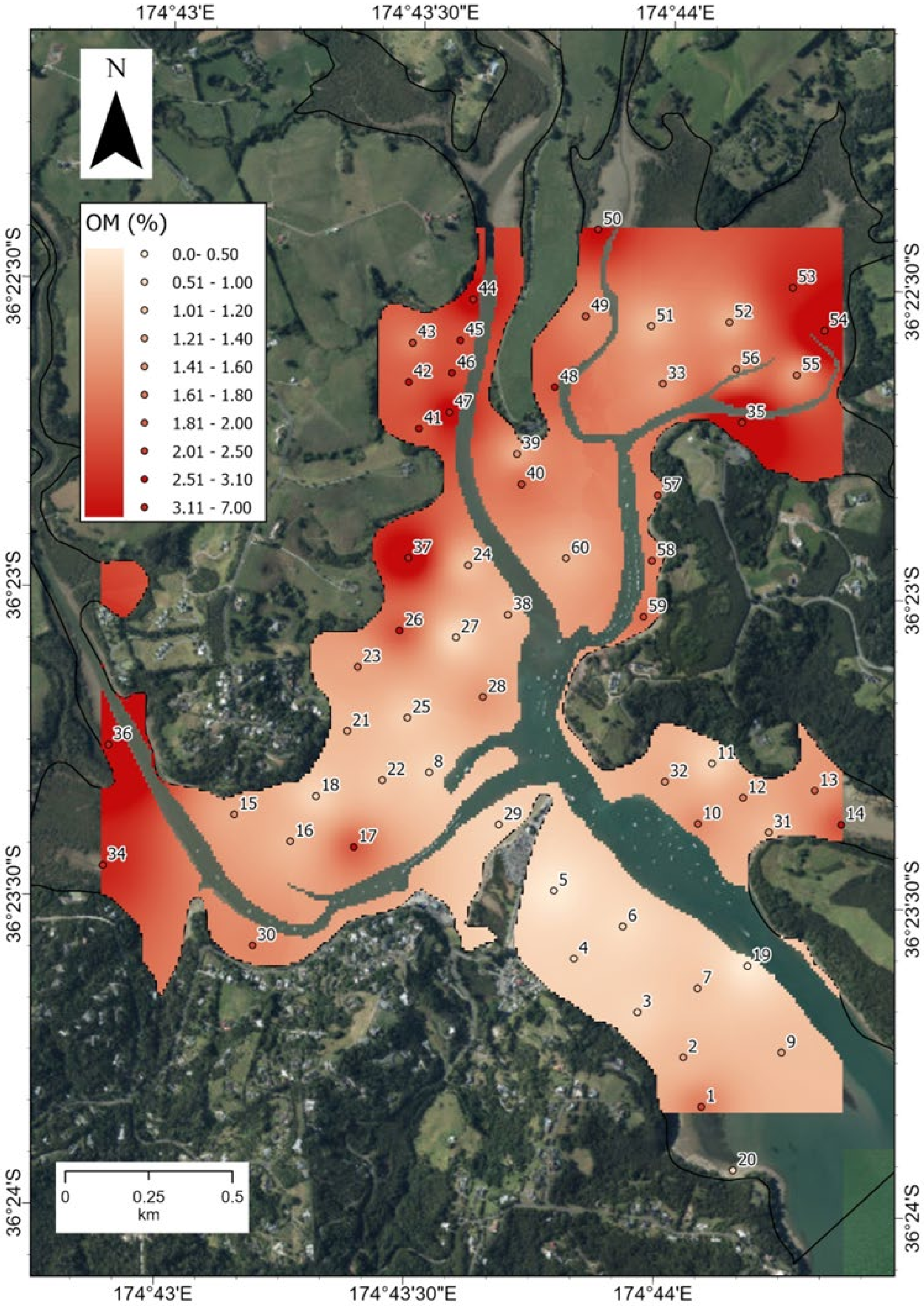

Figure 3-5: Map of organic matter content in sediment (OM %) across Matakana Estuary. Map shows point values (concentrations in µg/g), with interpolation between points based on an Inverse Distance Weighted (IDW) interpolation method. Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

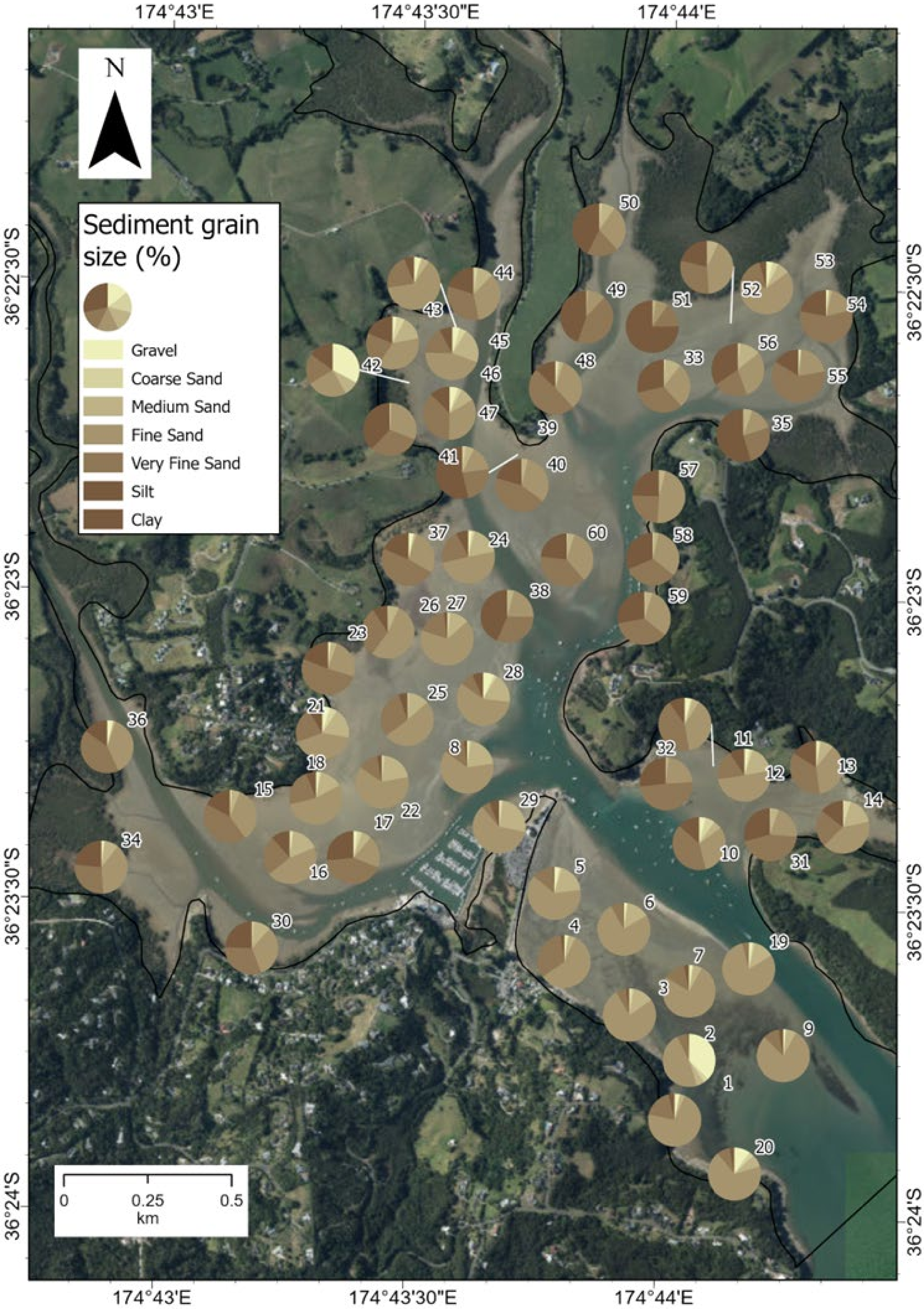

Figure 3-6: Map of sediment grain size (%) in Matakana Estuary. Map shows the distribution of grain size classes at individual sites using pie charts. Gravel/shell hash (>2000 µm), coarse sand (500–2000 µm), medium sand (250–500 µm), fine sand (125–250 µm), very fine sand (62.5–125 µm), silt (3.9–62.5 µm) and clay (≤3.9 µm). Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

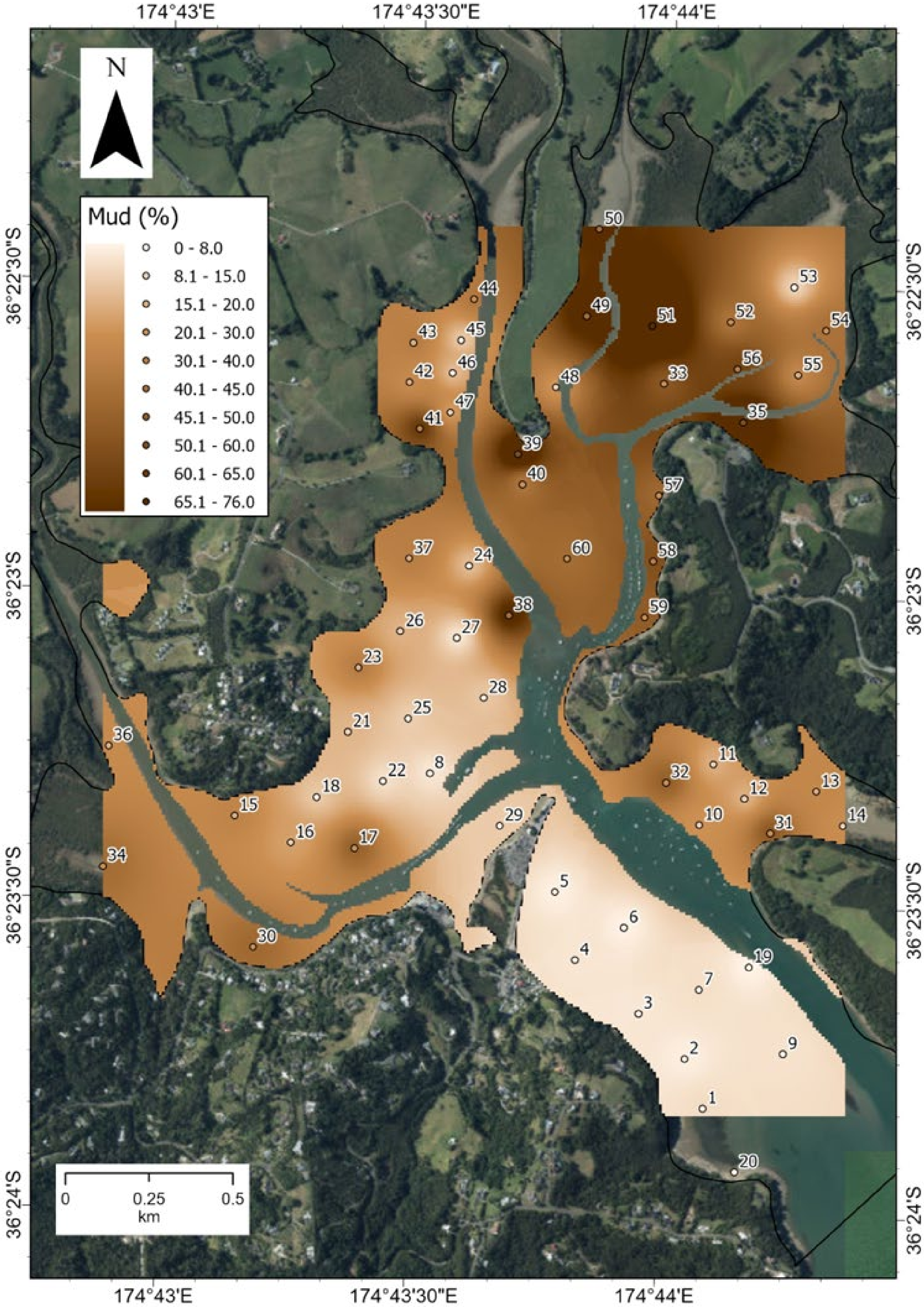

Figure 3-7: Map of mud matter content in sediment (%, silt+clay) across Matakana Estuary. Map shows point values (concentrations in µg/g), with interpolation between points based on an Inverse Distance Weighted (IDW) interpolation method. Imagery was retrieved from Land Information New Zealand (https://data.linz.govt.nz/).

3.3 Matakana Estuary environmental data review

Our literature review yielded nine publications related to the study of Matakana Estuary (Table 3-2). The main environmental variables assessed were tides, water quality (in Matakana River), benthic communities, estuarine geomorphological characteristics, and nutrient concentrations in the water column (Table 3-2).

Matakana Estuary is a tidally influenced coastal system, where marine and freshwater inputs interact to shape sediment transport, salinity gradients, and ecological communities. Matakana Estuary has a mean tidal range of approximately 2 m. In addition, it experiences seiches (standing wave oscillations with periods of around one hour) that are superimposed on the regular tidal signal. The average tidal excursion (i.e., the distance a water parcel travels during a single tidal cycle) is ≤ 3 km (Harris 1993; Hume et al. 2016). The primary freshwater input into Matakana Estuary is the Matakana River, which has been influenced by rural land use (Auckland Regional Council, 2007; Lockie and Neale 2014; Ingley and Groom 2025). In Matakana River, the mean dissolved oxygen recorded was 87.3%, 16.0 °C, pH of 7.5, and 2.2 g/m^3 of suspended solids (Auckland Regional Council 2007; Lockie and Neale 2014). Low to moderate concentrations of nutrients and low concentrations of metals were reported for the Matakana River (Auckland Regional Council 2007; Lockie and Neale 2014; Ingley and Groom 2025). In 2020, Matakana River was classified with fair water quality (66.7 WQI), decreasing from a good water quality (83.1 WQI) reported in 2016 (Auckland Regional Council 2007; Lockie and Neale 2014; Herzig et al. 2024; Ingley and Groom 2025). The most recent assessment showed that the water quality for the Matakana River indicate mixed ecological condition (Ingley and Groom, 2025). Site-specific classifications revealed that dissolved inorganic nitrogen (DIN) and visual clarity were in the A-band state, while dissolved reactive phosphorus (DRP) was in the B-band state. In contrast, microbial water quality was considerably poorer, with Escherichia coli classified in the E-band state (Ingley and Groom 2025). Long-term trend analysis (7-year record) indicates generally declining water quality, with likely increasing concentrations of nitrogen and phosphorus species, alongside deteriorating trends in clarity-related variables, including reduced visual clarity and increasing turbidity and suspended sediment concentrations (Ingley and Groom 2025).

Sedimentary habitats in Matakana Estuary have been reported predominantly as fine sands to mud, presumably due to a combination of relatively weak tidal currents and elevated sediment input into the estuary (Chiaroni et al. 2008; Swales et al. 2009). Previous studies also reported that the majority of the communities in Matakana Estuary were dominated by the little neck clam *Austrovenus stutchburyi*, and that the muddier sediments were comparable with those found in the neighbouring Mahurangi Estuary to the south (Chiaroni et al. 2008; de Juan and Hewitt 2011). Mangrove habitats have been documented in Matakana Estuary. In 2009, mangrove habitats occupied 68% of their potential habitat with medium to low likelihood of mangrove seedling establishment, i.e., medium to low likelihood of large-scale mangrove habitat-extension during the next century (Swales et al. 2009).

Overall, the results of the rapid habitat mapping and sediment sampling are broadly consistent with previously reported environmental patterns for Matakana Estuary. Chlorophyll a and phaeopigment concentrations were generally low across the estuary, supporting earlier reports of low to moderate nutrient conditions in the Matakana River system. However, localized increases near freshwater inputs indicate areas of potential land-use influence not resolved in previous studies.

Similarly, organic matter and mud content were generally low to moderate, with fine sediment accumulation restricted to freshwater-influenced and poorly flushed upper estuary areas, refining earlier descriptions of more broadly distributed muddy sediments. The dominance of sandy sediments in the middle and lower estuary is consistent with previous interpretations of relatively weak tidal energy and sediment transport dynamics, while the mapped distribution of mangroves aligns with documented mangrove presence and expansion in the system. In addition, the relatively large extent of seagrass recorded in the lower estuary is consistent with its known presence in the system, although observed structural characteristics suggest a deteriorated condition not previously well documented at this spatial scale.

Table 3-2: Summary table showing the outcomes of the literature review of the environmental information available for Matakana Estuary.

Id	Title	Author and publication year	Publisher	Type of publication	Environmental variable
1	Hauraki Gulf Tideways: Elements of their natural sciences	(Harris, 1993)	University of Auckland Leigh Marine Laboratory	Book	Tides
2	State of the Environment Monitoring: River & Stream Water Quality Data Report	(Auckland Regional Council, 2007)	Auckland Regional Council	Report	Water quality data for Matakana River
3	Benthic Marine Habitats and Communities of Kawau Bay	(Chiaroni et al. 2008)	Auckland Regional Council	Report	Benthic marine habitats and communities
4	Potential Future Changes in Mangrove-Habitat in Auckland’s East-Coast Estuaries	(Swales et al. 2009)	Auckland Regional Council	Report	Mangrove habitats
5	Relative importance of local biotic and environmental factors versus regional factors in driving macrobenthic species richness in intertidal areas	(de Juan and Hewitt, 2011)	Marine Ecology Progress Series	Journal article	Intertidal communities of Kawau Bay (including Matakana estuary)
6	A classification of New Zealand's coastal hydrosystems	(Hume et al. 2016)	NIWA	Report	Tidal volume, intertidal area, catchment area, shoreline, geomorphic class

Id	Title	Author and publication year	Publisher	Type of publication	Environmental variable
7	State of the environment monitoring: river water quality annual report 2013	(Lockie and Neale, 2014)	Auckland Council	Report	Water quality data for Matakana River
8	River water quality in Tāmaki Makaurau / Auckland 2020 annual reporting and National Policy Statement for Freshwater Management current state assessment	(Ingley and Groom, 2025)	Auckland Council	Report	Land use, water quality, and nutrients of Matakana River and catchment
9	From mountains to the sea: values and science for an informed kaitiaki/guardian – land	(Herzig et al. 2024)	Landcare Research	Report	Nutrients
10	River water quality current state and trends in Tāmaki Makaurau / Auckland to 2024	(Ingley and Groom, 2025)	Auckland Council	Report	Land use, water quality, and nutrients of Matakana River and catchment

4 Final remarks

Estuarine ecosystems have undergone substantial transformation as a result of intensifying anthropogenic pressures. These changes are becoming more frequent and impacts more obvious at a variety of scales. Among the most pervasive drivers of change in North Island estuaries are elevated sediment inputs from surrounding catchments, as a result of land-use modifications such as deforestation, expansion of pastoral agriculture, and urban development combined with more frequent, long-term (i.e., days of consistent heavy rain) and severe weather events. These pressures are further compounded by broader environmental stressors, including climate change and sea-level rise, which together alter sediment dynamics, hydrology, and habitat structure. Such changes can lead to shifts in the distribution, extent, and ecological functioning of key estuarine habitats.

In light of the potential for estuarine change in response to environmental pressures, we carried out the rapid habitat mapping assessment across Matakana Estuary aimed at systematically identifying, delineating, and classifying intertidal habitats. This approach provides a spatially explicit understanding of habitat composition and distribution, forming a critical baseline for monitoring environmental change and informing future conservation and management efforts.

Habitat maps are essential tools for characterising the distribution and diversity of natural resources within a given area. By providing a spatially explicit representation of habitat types, they enable a clearer understanding of the ecological composition and structure of a system. In estuarine environments, where habitats are highly dynamic and often heterogeneous, such maps are particularly valuable for capturing patterns that may not be evident from point-based observations alone.

Our rapid habitat mapping identified 11 different habitat classes, showing that Mangroves, HD Burrows, and Mounds and Pits were the largest habitats across Matakana Estuary. The habitat heterogeneity observed across Matakana Estuary reflects potential spatial gradients in environmental conditions, consistent with patterns commonly reported for temperate river dominated estuaries. The differentiated separation between upper and lower estuary habitats suggested that hydrodynamic regime, sediment characteristics, and freshwater influence could be playing key roles in determining the distribution of the various intertidal habitats.

The upper (i.e., northern) section of the estuary, situated close to freshwater inputs, was characterised by a high percentage of mud in the sediments and elevated organic matter (OM) content. These conditions, alongside reduced hydrodynamic energy, are favourable for mangrove establishment and infaunal burrowing organisms such as crabs, explaining the extensive coverage of Mangroves and HD Burrows in this section of the estuary. The frequent co-occurrence of Mounds and Pits habitat with HD Burrows further supports the interpretation of a transitioning area (related to increases in mud content) in the estuary, where bioturbation is a major driver of sediment structure with potential important implications for nutrient cycling and sediment stability.

In contrast, the lower (i.e., southern) section of the estuary, closer to the mouth, was characterised by LD Deposit Feeders, Low fauna, and a large area of Seagrass habitat. This pattern likely reflects the higher rates of tidal flushing in this section of the estuary, the predominantly fine to very fine sandy sediments, and the improved water clarity, all of which are favourable for seagrass growth.

Such conditions are generally conducive to seagrass persistence by maintaining sediment stability while limiting excessive organic accumulation. This interpretation is supported by the low Chl-a and Phaeo concentrations observed in this zone, which indicate limited phytoplankton biomass and low levels of algal degradation. Furthermore, seagrass meadows are well known for their capacity to stabilise sediments and enhance biodiversity, and their concentration in the lower estuary suggests that hydrodynamic exposure and sediment conditions there fall within suitable thresholds for establishment and persistence.

Despite the relatively large spatial extent of seagrass recorded, the structural characteristics of the meadow suggest a deteriorated condition. The prevalence of short, thin blades and the brown-green coloration of the vegetation are indicative of physiological stress and reduced growth. These characteristics are often associated with light limitation, physical disturbance, or suboptimal nutrient and sediment conditions. Given the low Chl-a and Phaeo concentrations across the seagrass habitat, light limitation due to phytoplankton blooms is unlikely to be a primary driver, however, reduced light availability may still occur intermittently due to fine sediment resuspension in areas of very fine sediments and higher hydrodynamic exposure (Zabarte-Maeztu et al. 2020; Zabarte-Maeztu et al. 2021). In contrast, the generally low mud content suggests that prolonged smothering or persistent sediment deposition is unlikely to be a dominant stressor in these areas. Instead, physical disturbance could be a plausible contributing factor. In Matakana Estuary, the firm substrate and ease of public access could potentially exacerbate physical damage through trampling, which can directly break shoots, compact sediments, and reduce seagrass meadow resilience over time. Chronic, small-scale disturbance of this nature may not immediately reduce seagrass extent, but it can significantly impair meadow health, productivity, and recovery capacity (Eckrich and Holmquist 2000; Rossi et al. 2007 ; Zabarte-Maeztu et al. 2020).

Across Matakana Estuary, Chl-a concentrations were consistently low, indicating no clear symptoms of eutrophication at a system-wide scale. Localised high concentrations of Chl-a and Phaeo near freshwater entry points on the western side potentially reflect catchment-derived nutrient and organic inputs combined with reduced flushing in these areas. However, these increases were spatially constrained, and the generally low Phaeo concentrations throughout the estuary indicate limited accumulation of decaying algal material.

Organic matter content in sediments exceeded 1% at most sites, with highest values recorded also near freshwater inputs and in the poorly flushed northern reaches of the estuary. Elevated OM at these locations is consistent with enhanced deposition of land-derived organic material and reduced resuspension. In contrast, the lowest OM content occurred in the middle and lower estuary, particularly near the mouth, where stronger tidal exchange promotes sediment winnowing and organic matter export. The spatial pattern of OM closely mirrored that of mud content, underscoring the strong coupling between sediment grain size, depositional environment, and organic matter accumulation.

Soft- and hard-bottom bivalve habitats, including HD Cockles, HD Crabs and Cockles, and HD Oysters, covered only a small proportion of the total surveyed area (<6%) within Matakana Estuary. The limited extent and localised distribution of these habitats may reflect constraints imposed by sediment type, food availability, or historical disturbance. HD Cockles were primarily located in the middle estuary and closer to channels, suggesting a preference for areas with moderate current velocities that enhance food delivery while limiting fine sediment accumulation.

Similarly, HD Oysters were confined to discrete patches within Mud stone habitat, highlighting the importance of suitable hard substrate for oyster attachment and persistence. Collectively, the habitat distribution observed in Matakana Estuary points to an ecosystem shaped by strong physical gradients and subject to ongoing anthropogenic pressure. While seagrass remains spatially extensive, its degraded appearance may be reflective of reduced ecosystem function and resilience. Our results suggest that Matakana Estuary is not experiencing chronic nutrient enrichment, although certain locations, specifically in the upper section of the estuary, may be periodically influenced by terrestrial inputs, with consequences including high mud and organic matter accumulation. These findings highlight the importance of management actions that address both large-scale environmental drivers and localised human disturbances, particularly in accessible intertidal areas. Maintaining and improving habitat condition will be critical for preserving the ecological functions and services provided by the estuary.

Finally, this study documents the first application of a rapid habitat assessment technique in Matakana Estuary, providing a robust baseline for characterising intertidal habitats and their associated ecosystem goods and services. The approach enables rapid, spatially explicit identification of key habitat types and condition indicators, offering a practical and repeatable framework for future monitoring. Importantly, the standardised nature of the method allows direct comparison with subsequent mapping efforts, facilitating the detection of temporal change in habitat extent and condition across the intertidal zone. As coastal systems such as Matakana Estuary are increasingly subject to both anthropogenic pressure and climate-driven change, the establishment of this baseline represents a valuable foundation for long-term assessment, adaptive management, and informed conservation planning.

Furthermore, we suggest that the ability of habitat maps to provide static representations of ecological patterns, could be boosted by integrating them into recent published flexible spatial data frameworks and dynamic decision-support tools (Lam-Gordillo et al. 2026). Building on approaches such as the flexible spatial framework, habitat maps can be transformed into multi-layered, interoperable datasets that capture not only ecological states but also the distribution and intensity of anthropogenic stressors. By structuring habitat information alongside principles such as ecosystem function, vulnerability, and degradation, these maps can evolve into analytical platforms capable of identifying priority areas for conservation, restoration, and management. Embedding habitat maps within flexible frameworks allows for iterative updates as new data become available, supports the incorporation of local and Indigenous knowledge, and enables scenario testing under different environmental or management conditions. Ultimately, advancing habitat maps in this way shifts them from descriptive tools to predictive and decision-oriented systems, enhancing their utility in adaptive management and improving outcomes for complex ecosystems such as estuaries.

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Appendix A

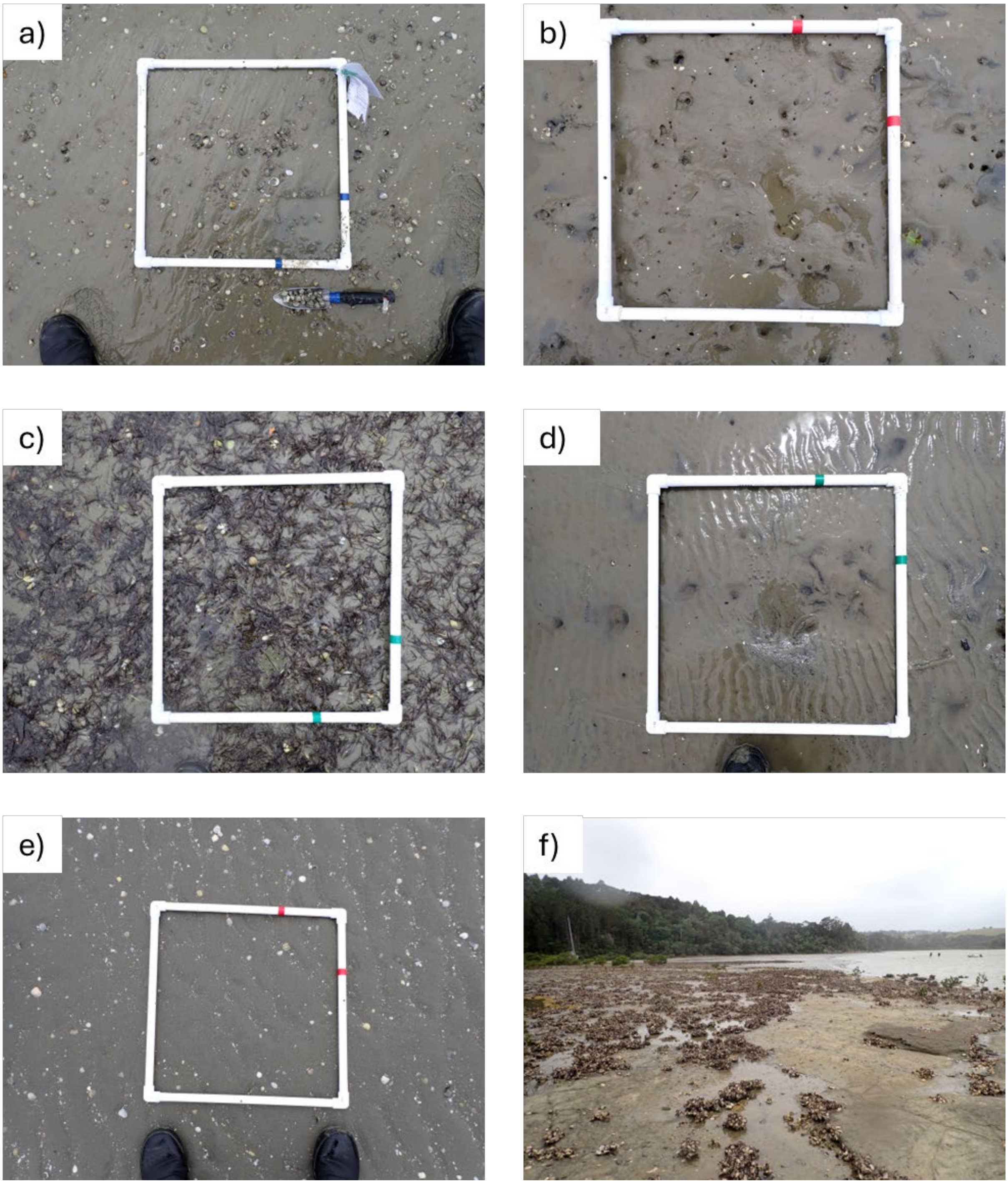

Figure A-1: Examples of the habitats found in Matakana Estuary during the 2026 mapping. a) HD Cockles, b) HD Burrows, c) Seagrass, d) Mounds and Pits, e) LD Deposit Feeders, f) Mud stone and on top HD Oysters.

Table A-1: Summary table showing the names and IDs of the 60 sediment sampling sites in Matakana Estuary.

Latitude	Longitude	Name	ID
-36.397086	174.734851	Sediment #1	1
-36.39576	174.734212	Sediment #2	2
-36.394561	174.732658	Sediment #3	3
-36.393154	174.730512	Site new #4	4
-36.391328	174.729799	Sediment #5	5
-36.39226	174.732128	Sediment #6	6
-36.393893	174.734655	Sediment #7	7
-36.388195	174.725572	Site old #8	8
-36.395587	174.737492	Sediment #9	9
-36.389457	174.734567	Sediment #10	10
-36.387821	174.734999	Sediment #11	11
-36.38873	174.736053	Sediment #12	12
-36.388503	174.738438	Sediment #13	13
-36.389409	174.739342	Sediment #14	14
-36.389422	174.719099	Sediment #15	15
-36.390121	174.720988	Sediment #16	16
-36.390245	174.723104	Sediment #17	17
-36.388884	174.721824	Sediment #18	18
-36.393267	174.7363	Site old #19	19
-36.398788	174.735941	Site old #20	20
-36.387118	174.722821	Sediment #21	21
-36.388423	174.724014	Sediment #22	22
-36.385383	174.723137	Sediment #23	23
-36.382588	174.726754	Site old #24	24
-36.386731	174.724817	Sediment #25	25
-36.384384	174.72451	Sediment #26	26
-36.384538	174.726389	Sediment #27	27
-36.386138	174.727323	Sediment #28	28
-36.38957	174.727931	Sediment #29	29
-36.392951	174.719787	Site new #30	30
-36.38965	174.73693	Site old #31	31
-36.388333	174.733438	Site old #32	32
-36.3776	174.733128	Site old #33	33
-36.390845	174.714745	Sediment #34	34

Latitude	Longitude	Name	ID
-36.378606	174.735791	Site old #35	35
-36.387599	174.714867	Sediment #36	36
-36.382421	174.724755	Sediment #37	37
-36.383907	174.728114	Sediment #38	38
-36.379559	174.728319	Sediment #39	39
-36.380376	174.72848	Site new #40	40
-36.378928	174.725032	Sediment #41	41
-36.37767	174.724663	Sediment #42	42
-36.376606	174.724775	Sediment #43	43
-36.375408	174.726769	Sediment #44	44
-36.376525	174.726358	Sediment #45	45
-36.377409	174.726098	Sediment #46	46
-36.37847	174.726036	Sediment #47	47
-36.377743	174.729533	Sediment #48	48
-36.375816	174.730524	Sediment #49	49
-36.373467	174.730894	Sediment #50	50
-36.376049	174.732714	Sediment #51	51
-36.375907	174.735316	Sediment #52	52
-36.37494	174.737408	Sediment #53	53
-36.376093	174.738489	Sediment #54	54
-36.377303	174.737593	Sediment #55	55
-36.377164	174.735575	Sediment #56	56
-36.380611	174.733031	Sediment #57	57
-36.38238	174.732872	Sediment #58	58
-36.383896	174.732623	Sediment #59	59
-36.382353	174.730016	Sediment #60	60

Table A-2: Sedimentary conditions recorded in Matakana Estuary. Chl-a: Chlorophyll a (µg/g), Phaoepigments: Phaeo (µg/g), gravel/shell hash (>2000 µm), coarse sand (500–2000 µm), medium sand (250–500 µm), fine sand (125–250 µm), very fine sand (62.5–125 µm), silt (3.9–62.5 µm) and clay (≤3.9 µm), Mud: silt + clay (%), OM: organic matter content in sediment (%).

Site	Chl-a	Phaeo	Gravel	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Mud	OM
1	6.49	2.19	3.11	0.18	2.98	71.99	18.10	1.74	1.91	3.65	2.16
2	8.12	1.80	37.51	3.01	4.72	47.23	6.40	0.26	0.86	1.12	1.34
3	5.05	1.64	0.87	1.71	12.72	76.40	6.18	0.87	1.25	2.12	0.92
4	5.64	0.41	2.27	0.57	4.24	57.90	32.76	1.13	1.13	2.26	0.93
5	3.15	0.27	2.96	1.41	18.65	62.88	13.16	0.31	0.62	0.94	0.55
6	7.13	0.00	1.62	0.83	13.74	75.65	7.50	0.11	0.55	0.66	0.78
7	6.36	1.48	2.03	0.54	5.40	75.67	13.13	1.08	2.16	3.24	1.15
8	7.42	0.14	1.24	1.15	20.28	62.36	12.93	0.64	1.39	2.04	0.93
9	6.53	0.63	1.30	0.69	6.07	79.52	9.66	1.18	1.58	2.76	1.28
10	16.59	4.03	3.78	5.83	5.45	31.02	40.33	8.46	5.13	13.58	1.93
11	5.12	0.55	3.75	0.96	4.33	38.27	42.99	6.81	2.89	9.70	0.93
12	7.74	0.21	3.06	1.95	16.98	50.40	18.25	4.93	4.42	9.35	1.62
13	4.90	1.21	1.80	1.04	7.77	37.36	35.85	12.70	3.48	16.18	1.81
14	8.60	0.56	0.47	4.14	16.91	40.99	22.94	9.44	5.10	14.55	2.68
15	6.07	0.73	0.73	0.32	5.07	34.07	42.62	15.04	2.15	17.19	1.54
16	5.55	0.34	1.42	0.74	16.63	45.51	24.21	7.73	3.77	11.50	1.34
17	14.99	0.00	2.34	2.84	6.14	19.53	42.58	20.86	5.72	26.58	2.56
18	5.45	0.42	2.42	1.15	13.59	54.19	22.52	4.33	1.80	6.13	0.91
19	6.13	0.96	2.11	1.33	12.83	79.59	3.67	0.00	0.46	0.46	0.55
20	4.11	1.06	9.49	3.09	7.86	68.82	7.84	1.62	1.27	2.90	0.97
21	4.52	0.46	4.86	4.48	18.48	41.57	21.78	5.25	3.59	8.84	1.32
22	6.29	0.00	0.49	1.08	20.24	62.76	12.43	1.65	1.35	2.99	1.12
23	3.79	0.76	1.46	0.30	3.64	24.22	51.19	15.39	3.79	19.19	1.62
24	5.37	0.03	2.40	1.50	17.93	49.60	20.83	5.06	2.68	7.74	1.22
25	7.39	1.21	0.19	0.83	12.58	50.98	29.95	2.88	2.58	5.45	1.01
26	11.66	0.14	0.47	0.19	6.15	52.96	31.01	4.35	4.87	9.22	2.65
27	5.38	0.10	0.60	1.12	11.47	67.13	17.53	0.92	1.23	2.15	0.80
28	13.42	3.68	6.64	1.89	18.25	57.81	8.86	3.27	3.27	6.55	1.79
29	4.24	0.63	0.78	1.38	25.97	60.66	5.11	2.96	3.14	6.10	0.95
30	9.20	0.26	0.13	1.13	10.53	32.30	31.47	17.12	7.31	24.43	2.03
31	7.60	0.00	0.18	0.16	4.88	21.02	44.70	19.46	9.60	29.06	1.31

Site	Chl-a	Phaeo	Gravel	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Mud	OM
32	9.12	0.00	0.00	0.13	1.64	22.26	49.21	15.78	10.98	26.76	1.53
33	10.10	1.26	0.10	1.04	9.52	27.78	32.72	22.39	6.44	28.83	1.69
34	13.85	3.29	1.58	0.40	8.47	38.39	27.87	17.97	5.31	23.28	3.26
35	14.15	2.65	0.01	0.40	4.99	14.55	25.55	48.87	5.63	54.50	5.62
36	25.11	5.80	3.45	0.37	1.24	37.96	41.90	11.05	4.04	15.09	6.07
37	13.22	0.00	3.15	0.18	1.61	28.12	48.29	13.58	5.06	18.64	4.24
38	10.56	1.09	0.00	0.27	3.80	21.20	31.11	38.21	5.41	43.62	1.33
39	4.23	0.58	0.10	1.70	5.63	15.35	23.37	44.62	9.25	53.87	1.51
40	9.75	1.65	0.09	0.30	3.24	31.80	44.02	16.50	4.06	20.56	2.35
41	12.37	0.02	0.07	0.22	0.54	30.15	30.99	31.54	6.49	38.03	2.63
42	9.65	2.23	32.43	0.83	8.57	24.53	18.47	12.58	2.59	15.17	2.50
43	11.93	0.41	2.59	5.08	14.14	37.13	22.17	12.70	6.19	18.89	2.03
44	8.01	1.72	0.29	2.24	9.76	34.51	32.94	14.07	6.18	20.26	3.83
45	8.53	1.57	4.12	0.88	4.54	63.03	21.35	2.95	3.13	6.08	2.67
46	9.65	1.00	4.50	4.21	21.59	45.11	16.80	4.50	3.27	7.77	2.76
47	8.26	2.22	5.06	2.35	9.12	33.84	37.21	7.16	5.25	12.42	3.87
48	15.37	0.00	1.03	1.30	2.35	33.54	48.93	7.77	5.08	12.85	2.58
49	9.56	0.97	0.00	0.11	0.97	10.62	43.69	40.00	4.60	44.61	1.90
50	13.02	0.00	0.00	1.46	8.33	28.60	18.87	36.87	5.87	42.73	3.58
51	3.75	1.32	0.00	0.17	2.02	7.70	14.83	68.39	6.89	75.28	1.35
52	7.39	0.00	0.00	0.29	6.84	41.85	29.85	13.06	8.12	21.18	1.45
53	11.80	2.86	3.88	3.55	7.36	64.72	15.85	2.13	2.51	4.64	3.25
54	13.00	0.57	1.41	0.24	1.98	17.45	56.92	18.33	3.67	22.00	5.24
55	8.94	0.45	1.08	0.20	0.57	20.39	61.61	10.31	5.85	16.15	1.69
56	7.22	1.44	0.22	1.22	12.76	30.23	20.98	31.30	3.28	34.58	1.78
57	7.16	0.32	0.06	0.21	3.83	46.94	24.45	22.28	2.23	24.50	2.02
58	12.01	1.00	0.41	0.19	2.81	32.08	33.13	27.09	4.29	31.39	2.10
59	11.48	1.99	0.01	0.52	4.33	30.92	36.19	19.01	9.02	28.03	2.30
60	14.94	3.86	0.23	0.33	4.13	34.02	38.16	15.33	7.80	23.13	1.37