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Intertidal habitat mapping for ecosystem goods and services: Tairua harbour

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Executive Summary

In January 2013, Waikato Regional Council (WRC) contracted the National Institute of Water and Atmospheric Research (NIWA), to develop rapid assessment techniques for mapping of intertidal habitats associated with the provision of ecosystem goods and services. Assessment techniques were trialled and implemented for the intertidal area of the Tairua estuary with the view of providing:

- Descriptions of habitat types that may be linked to levels of ecosystem goods and services.
- Descriptions of the techniques involved in differentiating and mapping habitats, and an analysis of the precision and accuracy/validity of the methods.

This report documents the evolution of the methodology and a proof of concept using Tairua estuary as a test case to build a habitat map. The goal is to generate precursor maps that will facilitate the mapping of ecosystem goods and services in the near future.

The rapid habitat assessment was designed to divide the intertidal area into specific habitats that could be differentiated based upon their potential to influence ecosystem goods and services. These habitats included flora (seagrass, mangroves and their pneumatophores, and thick algal mats) and fauna (tubeworm mats, pipi beds, cockle beds, mud snails (*Amphibola*), oysters, wedge shells (*Macomona*), crustacean burrows, and a background of deposit feeders) as well as descriptions of sediment (e.g., shell-hash, ankle deep mud, and coarse and fine rippled sands.

Handheld global positioning systems (GPS) were used to demark boundaries between habitats, which were defined based on densities or assemblages of organisms observed using quadrats (surface traits) and spades (subsurface factors). Geo-referenced photographs were also collected for each habitat type. Accuracy of the GPS varied from 1-5 m which was within the degree of error anticipated. Coordinates obtained by the cameras varied from the corresponding GPS unit by 19±6m. Post processing data involved all spatial information being interpreted into a GIS based habitat map.

This report includes two habitat maps of the Tairua Estuary. The first map was developed during the initial assessment documented in this report. The second is a revised version following modification of the habitat categories that occurred during the mapping of other Coromandel estuaries and harbours reported in Needham et al. (2013).

1 Introduction

In January 2013, Waikato Regional Council (WRC) contracted the National Institute of Water and Atmospheric Research (NIWA), to develop rapid assessment techniques for mapping of intertidal habitats associated with the provision of ecosystem goods and services. Ecosystem goods and services are defined as 'the direct and indirect benefits that humankind receives or values from natural or semi-natural habitats' and include the provision of food and raw materials, waste treatment, processing and storage, disturbance prevention, sediment retention, water filtration and regulation, nutrient regulation, gas and climate regulation, habitat structure and cultural services such as spiritual heritage and leisure and recreation (Townsend et al. 2010).

Assessment techniques were to be trialled and implemented for the intertidal area of the Tairua estuary with the view of providing:

- Descriptions of habitat types that may be linked to levels of ecosystem goods and services.
- Descriptions of the techniques involved in differentiating and mapping habitats, and an analysis of the precision and accuracy/validity of the methods.

This report documents the evolution of the methodology and a proof of concept using Tairua estuary as a test case to build a habitat map. The goal is to generate precursor maps that will facilitate the mapping of ecosystem goods and services in the near future.

2 Methods

This field based rapid habitat assessment was designed to divide the intertidal area into specific habitats that could be differentiated based upon their potential to influence ecosystem goods and services. Handheld global positioning systems (GPS) were used to demark boundaries between habitats, which were defined based on densities or assemblages of organisms observed using quadrats (surface traits) and spades (subsurface factors). Geo-referenced photographs were also collected for each habitat type. Post processing of data involved all spatial information being interpreted into a GIS based habitat map.

2.1 Derivation of habitat types

The first step in this process was to consider the various habitat types typical of NZ estuaries and harbours and focus on those where the implicit links to services are well known. As the primary goal was to provide a rapid assessment technique, we used the most prevalent habitat type across New Zealand's estuaries as a baseline. This habitat type happened to be a moderately bioturbated, deposit feeder dominated, muddy sand or sandy mud habitat. Deviances from this baseline would be noted as the presence of other habitat types. The focus of the habitat classification did not necessarily reflect the whole community structure but instead was based on the relative dominance of organisms that influence services. The habitat types developed to date are shown in Table 1, below. Qualifying information was compiled both prior to and during field work.

Table 1: Derived habitats and a non-exhaustive illustration of their links to goods and services provision.

Habitat Type	Implicit Service Links
Flora	
Seagrass	Primary production. Habitat structure. Sediment stability & retention.
Mangroves	Primary production. Carbon sequestration. Gas and climate regulation. Disturbance prevention. Sediment stability & retention. Habitat structure.
Pneumatophores	Nutrient cycling.

Habitat Type	Implicit Service Links
Fauna	**Goods/Services**
Tube worm mats	Sediment stability.
Cockle or Pipi beds	Productivity – links to food source. Cultural harvesting. Waste treatment, processing and storage. Carbon sequestration.
Amphibola crenata	Cultural harvesting.
Oysters	Biogenic habitat provision. Cultural harvesting, food. Sediment stability & retention.
Macomona liliana (indicated from feeding track patterns on sediment surface)	Sediment stability. Nutrient cycling.
Crustacean burrows Mud, sand, sand with gravel	Links to services are mediated by sediment type: Sediment stability/instability. Nutrient recycling Waste treatment, processing and storage
Mounds and holes	Nutrient cycling. Sediment stability. Waste treatment, processing and storage
Other - sediments	
Shell-hash	Biogenic habitat provision. Carbon sequestration. Gas and climate regulation. Waste cycling.
Mud > ankle deep	Nutrient recycling Sediment stability
Coarse Sand	Coarse sands with low biota may low service potential.

2.2 Pre-field work information

Due to their excellent image resolution during low tide periods, Google earth images were used as reference in the planning phase to form strategies on how to best rapidly assess the intertidal area.

Information owned and made available to us by WRC included extensive shellfish and sediment survey data conducted in Tairua estuary (Felsing and Giles 2010), used for initial planning and intended cross referencing of sediment classifications. WRC fund a monitoring programme examining the vegetation of Coromandel estuaries (Graeme, 1997, 1998a, b, 1999, 2010). Therefore it was deemed unnecessary to repeat monitoring of these habitats. Having said this, it was agreed that in areas of high abundance, or at the meeting of two distinct vegetation types (e.g., seagrass and mangroves), the boundary, or a portion thereof, would be walked to further verify accuracy and precision of our GPS marks relative to WRAPS 2012 photographs and secondarily, to note any major shifts (through comparison of polygons) since 2008 when the last vegetation survey took place.

2.3 Field-gear

The principle pieces of equipment used in the field were cameras and GPS units. The GPSs were Garmin GPSMAP 78SC which gave the ability to mark waypoints and describe the habitat features or attributes at a specific location and also to record track boundaries, used to demarcate the edges of habitat patches. The cameras used were the Fujifilm FinePix XP150, which provided high resolution images (14 MP) and were GPS capable to Geotag photos facilitating post analysis. Other gear included 0.25m^2 quadrats, trowels, stakes and 2cm dia. sediment corers (see section 3.2).

2.4 Field techniques

A mixture of techniques was used to cover the area required in the given time frame of this rapid assessment. On each day, each group of 2 (or more) individuals targeted a specific area of the estuary, ensuring maximum coverage over the 3 day field trip. At the initiation of mapping, visual inspection of the sediment surface in the immediate area was conducted. Each pair moved through the area until changes in the surface traits were observed (see section 3.2 for details).

Clearly defined boundaries between habitats were often apparent for a number of the defined habitat types (for example, raised banks of shell rich sediments, vegetation). Where practicable, patch boundaries were walked in their entirety. Where extensive habitat regions existed (e.g., mangroves, seagrass) a section of the perimeter was walked (noted by GPS waypoints) so that this could be referenced to both the WRAPS 2012 aerial photos and existing GIS vegetation layers. Where boundaries were not as easily defined (for example between high density bioturbation and medium levels of bioturbation), the perceived boundary was temporarily marked with stakes, then adjusted where necessary (see section 3.2) prior to walking the boundary to create a GPS track line. Similarly in areas where wide, expansive patches existed, two individuals walked the perimeter in opposite directions until they came together. Patches <10 m in their longest dimension were not noted on their own, due to the accuracy of the GPS units, but were amalgamated in to the description of the surrounding area. Such information will be used to better define the habitat categories and their specific characteristics.

Photographs were taken to collate information on different habitat characteristics and to cross reference each habitat type to ensure repeatability. Each photo was taken at approximately 5 m or more from the boundary between habitats to try and ensure more accurate geo-referencing by the camera.

2.5 Sediment particle size

Sediment samples were collected in a number of locations where a transition between sediment types (namely, from sand to mud) were observed. During the first day, a technique, whereby samples were collected along a transect crossing the sediment gradient was devised to better identify transition areas. Sediment was collected using a 2 cm dia. corer to a depth of 2 cm and placed in a labelled container. This was photographed inside a representative quadrat and a waypoint marked. Samples were frozen as soon as was practicable. Sediment samples were collected to provide some qualifying information on what our specified categories meant in terms of their granulometry (i.e., to ensure that our muddy category was more muddy than the muddy sand or sand etc.,) and to identify the range of fine sediment (%) attributed to our 'muddy > ankle deep' classification as other factors such as permeability and porosity may influence the 'sinkability'. The sediment data is not presented in this report.

3 Precision obtained in field

3.1 Instruments

At the beginning of each day, all GPS and cameras were taken to a single known reference location (in this case, the northern side of the pedestrian bridge near Pepe inlet) where a waypoint and photo were taken on each unit. As accuracy is dependent on the number of satellites available at any given time, this positioning enabled us to offset any differences observed in daily measurements and boundaries. Coordinates obtained by the 3 GPS units varied between being within 1m on one day to 3 – 5 m difference on the second day which is within the degree of error anticipated (manufacturers quote ± 5 m).

Coordinates obtained by the cameras varied from the corresponding GPS unit by 19±6m. The smallest deviation was 7 m and the largest was 26 m.

3.2 Habitat decisions

Generally there were few problems with assigning habitat types in the field (Table 2). For visible aspects (e.g., holes, tube worm mats), a 50 x 50 cm quadrat was thrown randomly. If the quadrat was considered representative of the surrounding area it was used to define the habitat. If the area immediately next to the thrown quadrat appeared to have notably higher or lower densities, additional quadrats were thrown until a consensus could be found. Similarly, for the non-visible aspects of our classifications, two randomly placed 15 x 15 cm areas were dug to a depth of approximately 10 cm and the habitats assessed. Additional 15 x 15 cm areas were dug until a consensus could be found.

Assigning habitats to categories was relatively simple, except for heavily bioturbated habitats (which we hadn't previously defined) and ankle deep mud (which was always heavily bioturbated). The solution was to add several categories - heavily bioturbated mud (with sediment samples), heavily bioturbated muddy sand, heavily bioturbated sand, moderately bioturbated muddy sand and moderately bioturbated sand. Another bioturbated habitat of gravel and pebbles was observed in the upper reaches of both Pepe inlet and Paku bay. This was often overlying a firm, clean sand and had large numbers of crustacean burrows. This was given a separate habitat classification.

Some mottling of the sediment surface was noted in some sandy areas. These areas were explored subsurface, but did not yield any notable fauna (Figure 1). Therefore this was amalgamated in to the 'sand with no mud' category. However photos and waypoints in locations where this occurred were collected in case it is a common feature in estuaries that will be sampled in the future.

Figure 1: Sediment mottling observed across areas some sandy areas in Tairua.

Near the head of the estuary, large expanses of highly gravelly coarse sand were observed. Although low in biota, this was kept as a separate classification as it was distinct from other sediments in the estuary and from our default sediment type.

Although transition areas at boundaries between two habitats will exist to some degree (likely within out ± 5 m error margin), few are likely to form species matrices whereby they become a habitat in their own right. One exception, not seen in Tairua, is that of tube mat/cockle matrices. If this is observed in other estuaries a new category will be created.

Table 2: Habitat types and their definitions.

Habitat Type	Qualifying Information	Found	Map legend code
Flora			
Seagrass	Of sufficient density and extent to be considered a seagrass bed. Note of sediment beneath seagrass (mud or sand)	yes	12
Mangroves	Adult plants	yes	14
Pneumatophores	Juvenile structures, generally extending out from mangrove areas.	yes	3

Habitat Type	Qualifying Information	Found	Map legend code
Fauna			
Tube worm mats	High density	no	-
Pipi beds	High density	no	-
Cockle beds	high density >4 sized >20mm ind. in a 15 x 15 cm area	yes	11
Amphibola crenata	High density, ≥10 ind. $0.25m^{-2}$ quadrat.	yes	6
Oysters	high density, >80% of the 0.25 m^2 quadrat.	yes	10
Macomona liliana (indicated from feeding track patterns on sediment surface)	High density, ≥4 individuals sized ≥30 mm (shell length) in a 15 x 15 cm area Moderate density	yes yes	9
Crustacean burrows Mud, sand, sand with gravel	High density, ≥10 burrows of ≥20 mm aperture in a 0.25 m^2 quadrat Moderate density	yes yes	2 (sand),5 (mud), 7 (sand and gravel) 8
Mounds and holes	Collections of bioturbating fauna	yes	15
Other - sediments			
Shell-hash	High density shell-hash on the sediment surface	yes	1
Mud > ankle deep	Defined as mud, where sinking to ankle depth 13-15 cm or greater. Texture is smooth when rubbed between fingers, i.e., low percentage of sand and coarser grains.	Yes but only found with high bioturbatio n in Tairua	5
Coarse Sand and fine sand (ripples)	No fine grains felt when rubbed between fingers.	yes	16, 4
Muddy sand (or sandy mud) dominated by deposit feeders	Default background sediment	yes	17

Although likely to be somewhat ephemeral, the presence of thick algal mats was also noted in some places (map code 0).

3.3 Habitat perimeters

For areas where repeat GPS tracks (see Figure 2 for examples) were collected, the distance was divided into 5 sectors and for each sector a maximum and minimum divergence was calculated. These were then averaged to produce an average difference and a standard deviation of the maximum divergences also calculated (See Table 3). Average differences were within the precision of the GPS coordinates and generally less than 5m.

Two habitat patches were mapped by 2 people. The first patch was a shell bank mosaic with sand (expected to reasonably difficult to decide on where the edges were); the area of the patch was reported as 43 x 58 m and 48 x 67 m by the two observers, respectively (Fig 2a). The major difference appeared to be generated by the definition of the seaward edge. The second patch was a mud habitat and the two estimates were 50 x 15.7 m versus 52 x 17 m (Fig 2b). One part of the edge of a seagrass patch had also been repeated by 2 people (Fig. 2c) with a maximum difference <3 m).

Table 3: The average difference and a standard deviation of the maximum divergences between repeat tracks.

	Average	St deviation of maximum div.
Sand	1.6	1.7
Mud	1.4	1.3
Shell	2.7	4.1
bioturbated	2.5	1.3
bioturbated	2.1	5.9
Macomona	2.4	1.4

When comparing seagrass patch boundaries between previous vegetation surveys (2008) and the polygons we created (2013), some differences were observed in patch size. Much of the difference, however, appears to be genuine expansion in seagrass patch area, given the concordance of WRAPS 2012 and 2013 with the current assessment. All perimeter boundaries aligned well with the photographs with <2 m error in all cases (i.e., well within the GPS error margin). Interestingly, all seagrass patches show some expansion over the 5 year period except for in Pepe inlet, where seagrass shoots were covered by a layer of slightly muddy sand which made them near indistinguishable from the sediment surface.

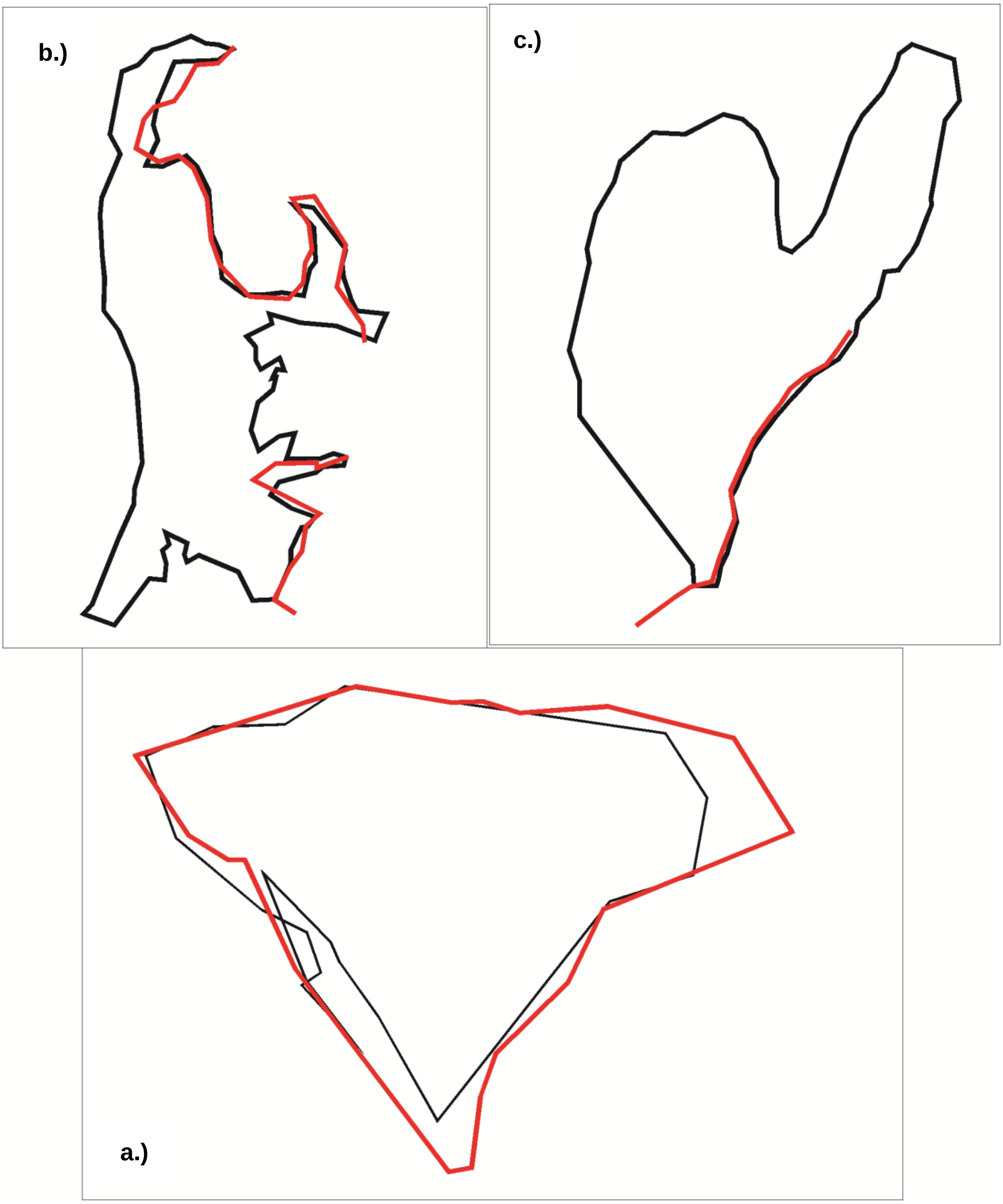

Figure 2: Examples of two individual's GPS tracks (indicated by the difference in colour) and interpretation of boundary edges for a.) a shell bank mosaic, b.) a mud habitat and c.) a seagrass patch.

Figure 3: Example seagrass boundary shifts a) pink line denotes the boundary walked with a GPS handset; b) yellow polygon (this study) overlain with 2008 ground truthed polygon (denoted by bright blue line); c) dual tracks walked at the edges of a different patch of seagrass; d) most recent polygon of the patch shown in c) (this study) in yellow with 2008 polygon boundaries denoted by the bright blue line.

4 Habitat Map

To create the habitat map, all GPS units were downloaded using Garmin Basecamp software where all tracks and waypoints were compiled in to one file, overlaid and colour coded. All data was transposed in to a .kmz file suitable for use in Google Earth. All photographs (see appendix for example habitat images), were batch processed to thumbnail size and imported to Google Earth using GeoSetter freeware. This information, alongside written notes were used to interpret the map in to GIS.

Polygons were created using the trace function where complete loops of a patch had been completed. Where a seaward boundary had been walked, the Hauraki Gulf intertidal extent 2013 layer (courtesy of WRC, AC) was overlaid and the boundary traced. It should also be noted that this polygon did not always match our observations at the channel edge perfectly, with some of our mapped areas appearing sub-tidal when using this layer. Where this occurred, the underlying WRAPS (2012) photograph was used to define the water's edge. A copy of the Hauraki Gulf intertidal extent 2013 layer was also modified to create our default sediment type which filled in any areas where other documented habitat types did not exist.

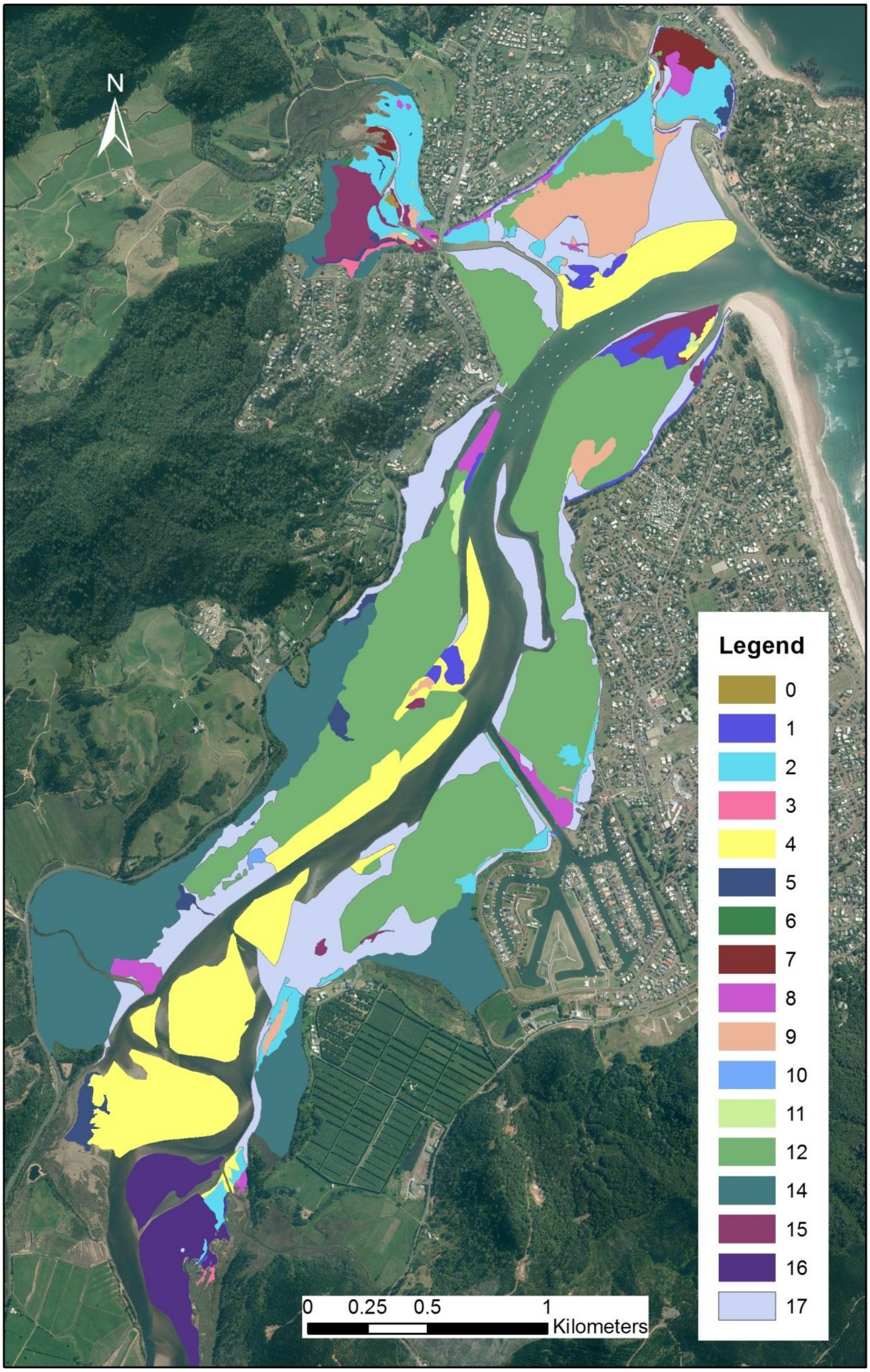

Figure 4: The Tairua estuary habitat map. Legend descriptors are given in Table 2.

5 Recommendations

GPS units should be checked against each other and a verified point at the beginning and end of each day, and at least once during the intervening period (particularly if steep hilly terrain in the surrounding catchment is likely to interfere with GPS satellite coverage). If more information is collected on these changes, it may prove possible to post-correct to minimise erroneous differences.

While the cameras provide useful information about the habitat, unless they are turned off between pictures and/or the time stamp recorded, they cannot be used to tag the picture to the GPS unit track. As each photo has a sequential number, this can be marked with a waypoint as a back-up geo-reference. As surveys progress, the need for extensive photography will lessen as the use of images is primarily for habitat identification and verification.

6 Tairua Habitat Map Updated

Following the development and trial of the rapid assessment technique for mapping intertidal habitats in Tairua Harbour, Waikato Regional Council commissioned NIWA to apply this to a further thirteen intertidal areas within the Waikato Region (Otahu River, Whangamata Harbour, Wharekawa Harbour, Purangi River, Whitianga Harbour, Whangapoua Harbour, Kennedy Bay, Waikawau Bay, Port Charles, Colville Bay, Coromandel Harbour, Te Kouma Harbour and Manaia Harbour). Further adaptations and revisions of habitat categories were made during this process and are documented in Needham et al. (2013). Figure 5 presents the revised Tairua habitat map, consistent with the other Waikato estuaries and harbours.

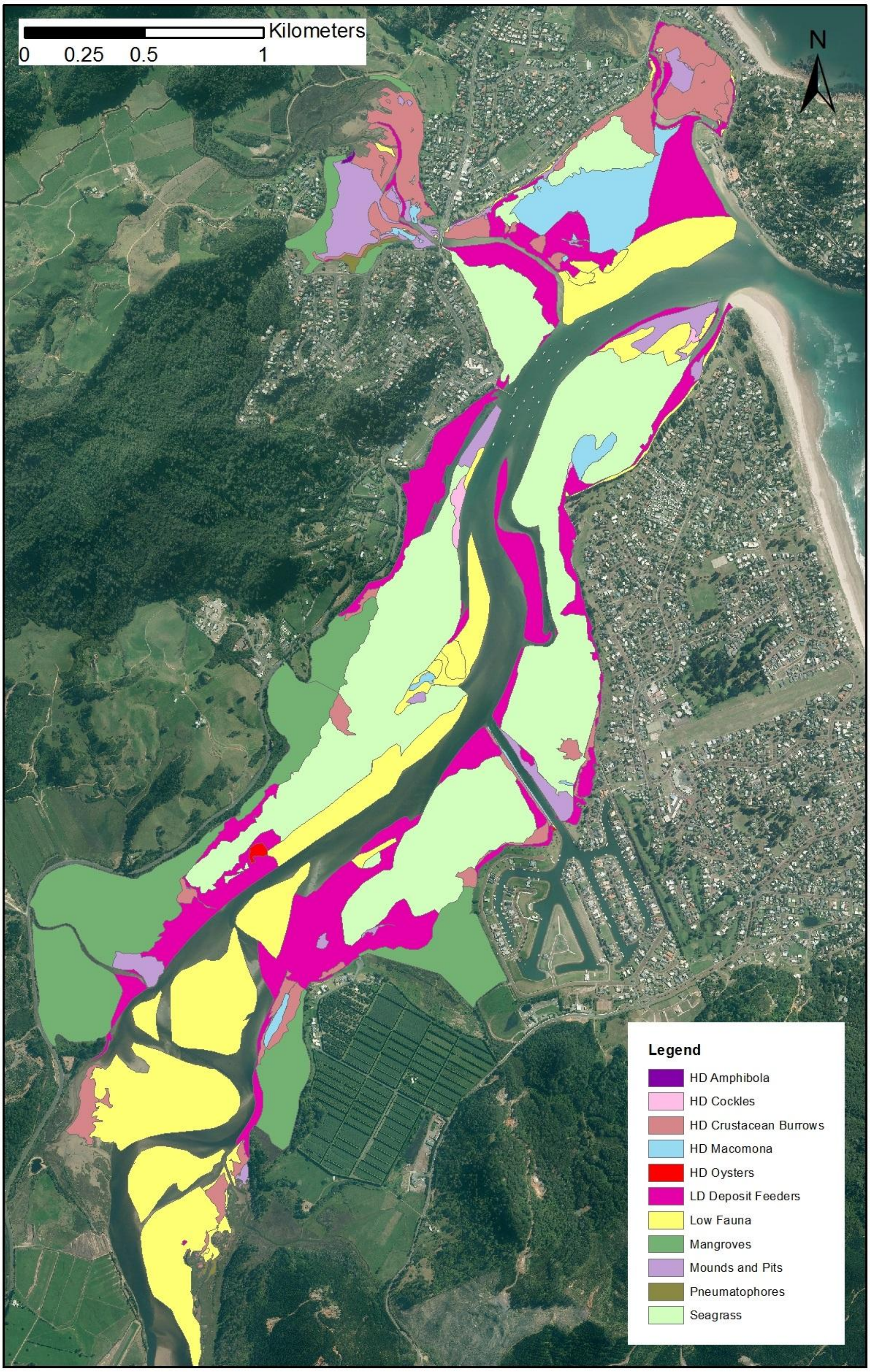

Figure 5: The Tairua estuary habitat map updated, following the refinements.

7 Acknowledgements

We would like to thank Professor Roman Zajac for technical development and assistance in the field.

8 References

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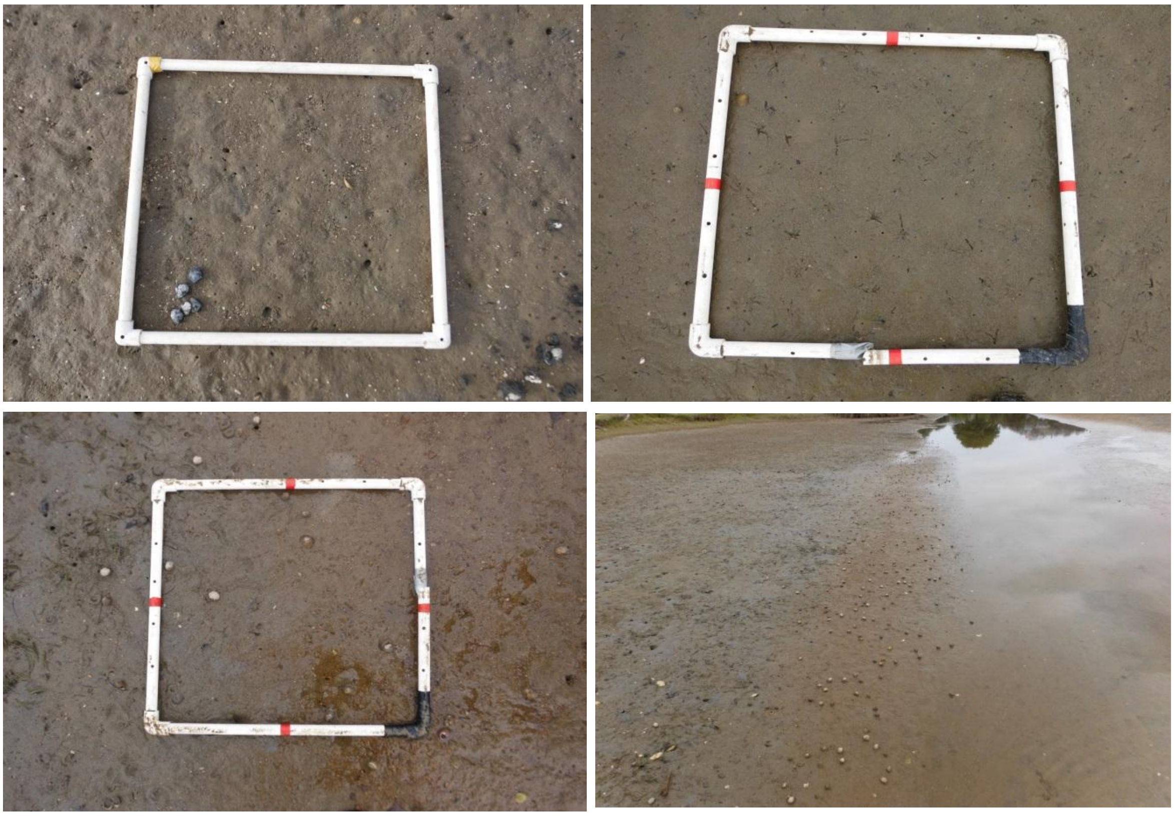
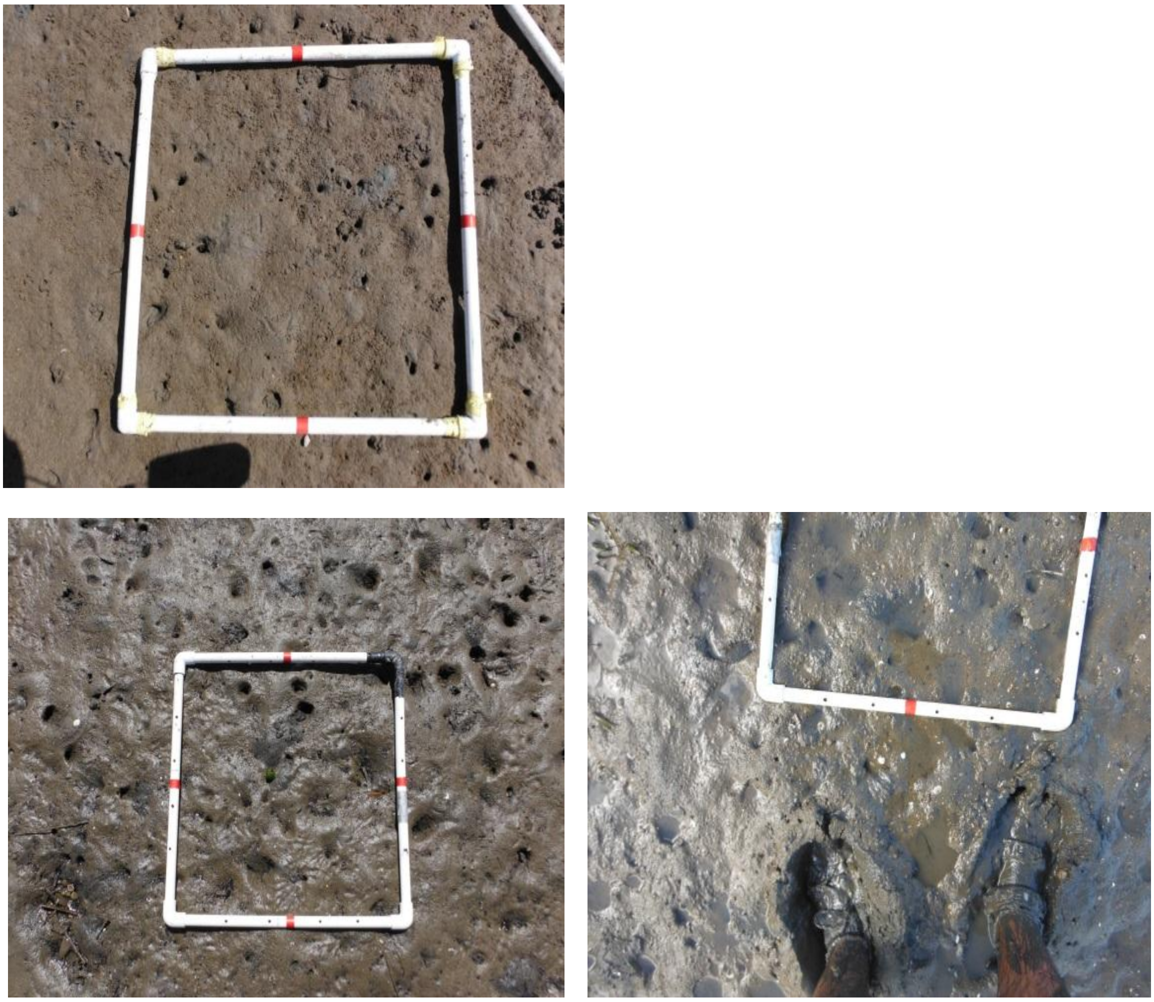
Appendix A

Images of shell rich sediments (top) and medium crustacean burrowing in sand (below).

Images of coarse sand and gravel with crab burrows (top) and high density oyster shells (below).



Top images show *Macomona* tracks at high (left) and medium (right) densities. Images below show *Amphibola*.



Top image showing crab burrows in sand. Images below show crab burrows in sandy mud (left) and mud (right).