

# 2011 Mangrove abundance in the Bay of Plenty



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NEW ZEALAND

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Cover Photo:  
Mangrove stand north of Motuotu Island, Ōhiwa killed by a hailstorm  
on 11 May 2009 (photograph by Stephen Park 14 December 2014).



## Acknowledgements

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Heather McKenzie is acknowledged for her work on mangrove mapping and preparation of the figures relating to hail damaged mangrove areas in Ōhiwa Harbour. Rob Donald and Rob Win are thanked for reviewing the report.



## Executive summary

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Results of 2011 mapping of mangroves throughout the entire Bay of Plenty have been analysed to provide information on abundance and trends. In Tauranga Harbour the total abundance of mangroves has continued to increase from 623 canopy ha in 2003 to 811 in 2011. At the time of mapping not all consented mangrove clearance had occurred which would reduce that total by 24 ha, hence still a long-term increase. If no mangrove removal had taken place, the 2011 mangrove canopy cover would have been around 895 ha.

In the sub-estuaries of Tauranga Harbour, increases in mangrove abundance has occurred from 1943 up to 1999 and then more recently areas such as Te Puna and Waikaraka Estuary and north of Tanners Point have shown a decline in abundance. In all cases this has been due to mangrove removal. There are also areas with low catchment sediment and nutrient inputs and no mangrove removal such as Hunter Creek and Bluegum Bay that have shown significant long-term increase in mangrove abundance up to 2011.

Ōhiwa Harbour has recorded a drop in mangrove abundance from 118.8 canopy ha in 2007 to 99.0 in 2011. This drop was due to the impact of a severe hailstorm on 11 May 2009 which killed off 25 canopy ha (43.5 ha total extent) of mature mangrove stands. This loss represented around 20% of the harbour population.

Throughout the remaining smaller estuaries of the Bay of Plenty there are very few mangroves. The highest abundance is in Waihi Estuary which has shown an increase from 1.43 canopy ha in 2003 to 4.77 ha in 2011.

Investigation of potential saltmarsh displacement by mangrove colonisation indicates that for the period 2003 to 2011 at the four sites studied, very little is occurring. Displacement appears to be limited to the edges of saltmarsh vegetation (mainly rushes) and perceived displacement is mainly due to infilling of bare habitat by mangroves. It was also observed that drainage and other impacts to the saltmarsh areas results in enhanced colonisation of mangroves into the saltmarsh areas.

Seagrass displacement by mangrove colonisation was also investigated by comparing the overlap between the 1959 seagrass extents in Tauranga Harbour and the 2011 mangrove extents. Results showed a total of 52 ha of overlap. Of this it was estimated that around 30 ha may be displacement of seagrass from suitable habitat. This would represent a loss of 0.68% of the total 1959 seagrass extent compared to 38% loss that has occurred as a result of declining environmental quality or habitat loss.





# Contents

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|  |     |
|--|-----|
| <b>Acknowledgements</b>                        | i   |
| <b>Executive summary</b>                       | iii |
| <b>Part 1: Introduction</b>                    | 1   |
| 1.1 Purpose                                    | 1   |
| 1.2 Scope                                      | 1   |
| 1.3 Background                                 | 1   |
| <b>Part 2: Location and methods</b>            | 3   |
| <b>Part 3: Results</b>                         | 5   |
| 3.1 Mangrove abundance                         | 5   |
| 3.2 Storm damage to mangroves in Ōhiwa Harbour | 10  |
| 3.3 Saltmarsh displacement by mangroves        | 11  |
| 3.4 Seagrass displacement by mangroves         | 15  |
| <b>Part 4: References</b>                      | 17  |
| <b>Appendix 1 – Mangrove mapping protocol</b>  | 21  |



# Part 1: Introduction

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## 1.1 Purpose

The purpose of this study is to provide mapping of mangrove extents throughout the Bay of Plenty and assessment of trends and changes over time. In particular the mapping provides:

- Monitoring data to meet Bay of Plenty Regional Council's legislative obligations to monitor the state of the environment under the Resource Management Act.
- Information to assist management of the Bay of Plenty harbour ecosystems.

## 1.2 Scope

This report focuses on use of mapping of mangrove extents based on aerial photography delivered as part of the regional digital aerial mosaic (RDAM) programme for the Bay of Plenty. Specifically it will provide:

- Accurate estimates of mangrove abundance in 2011 for the entire Bay of Plenty.
- An accurate estimate of rates of change over time in estuaries or sub-estuaries throughout the Bay of Plenty where historic extent information is available.
- Assessment of mangrove colonisation of saltmarsh and seagrass habitat.

## 1.3 Background

### 1.3.1 Mangroves

New Zealand has a single temperate species of mangrove, the grey mangrove or Manawa (*Avicennia marina* subsp. *australasica*) which occurs widely overseas. Within New Zealand its distribution is limited to the north of the North Island extending south to 38°05' at Kawhia Harbour on the west coast and 38°03' at Ōhiwa Harbour on the east coast. In the far south of the range the plants grow as low-spreading shrubs reaching around 1 m in height, while further north in Tauranga Harbour they grow to around 2.5 m. In the more northern harbours mangroves can grow up to 5 m or more. Within estuaries mangroves occupy a tidal range from MHWS (Swales et al. 2007) down to mean sea level (MSL) (Park 2004, Swales et al. 2009) in ideal conditions.

### 1.3.2 Bay of Plenty coastline

The Bay of Plenty is located on the northeast coast of the North Island, New Zealand and has 258 km of exposed coastline stretching from Waihi in the northwest of the region to Lottin Point in the east. There are a number of coastal inlets and nearly all can be classed as estuaries. Larger inlets tend to be barrier enclosed estuaries while there are a number of smaller river mouth estuaries.

## **Tauranga Harbour**

Tauranga Harbour is the largest estuarine inlet in the region being impounded by a barrier island (Matakana Island) and two barrier tombolos, Mount Maunganui at the southern entrance and Bowentown to the north (Healy and Kirk 1981). The harbour is shallow and covers an area of 201 km<sup>2</sup> with 66% of its total area being intertidal. It has three main basins with the largest being the northern and southern basins (separated at low tide) and the smaller Town Reach basin in the far south. At mean high water the northern basin has a volume of approximately 178 million m<sup>3</sup> and the southern basin a volume of 278 million m<sup>3</sup>. There are more than 20 small sub-estuaries around the harbour.

The total harbour catchment covers an area of approximately 1,300 km<sup>2</sup> and is well developed with extensive horticultural and agricultural use. The northern harbour basin has a catchment area of 270 km<sup>2</sup> and a mean freshwater inflow of 4.1 m<sup>3</sup>/s or 0.1% of the harbour volume per tidal cycle. The southern catchment has a total area of 1,030 km<sup>2</sup> and a mean freshwater inflow of 30.5 m<sup>3</sup>/s which is 0.48% of the harbour volume per tidal cycle.

## **Ōhiwa Harbour**

Ōhiwa Harbour is a 26.4 km<sup>2</sup> estuarine lagoon enclosed by the Ōhope and Ōhiwa barrier spits. It is shallow with 83% of its area being exposed sand and mudflats at low tide. The harbour has a very low volume compared to the spring tidal compartment and is dominated by tidal currents. Residence time of water in the harbour is low and estimated to be 1-2 tidal cycles. The Nukuhou River with a median flow of 0.98 m<sup>3</sup>/s is the main freshwater inflow to the harbour.

## **Other estuaries**

The larger of the remaining Bay of Plenty estuaries are all barrier enclosed and include Waihi Estuary covering 2.4 km<sup>2</sup> most of which dries at low tide. The main freshwater inflow is the Pongakawa Stream with a median flow of 4.6 m<sup>3</sup>/s. Maketū Estuary covers 2.3 km<sup>2</sup> and is very shallow with extensive tidal flats. It is the former outlet for the Kaituna River and currently receives only 100,000 m<sup>3</sup> per tidal cycle of the river flow. Whakatāne and Waiotahi Estuaries cover around 1.3 km<sup>2</sup> and 1.0 km<sup>2</sup> with small areas of intertidal flats influenced by river flow. The remaining estuaries are smaller again and tend to be river mouth estuaries with a very high river influence.

## Part 2: Location and methods

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Mangrove mapping for the whole of the Bay of Plenty region was carried out using 2011 aerial photography. This includes all estuaries extending from the northern end of Tauranga Harbour along the coast to Whangaparaoa River near Cape Runaway in the east. The 2011 aerial photography comprised a digital tiled mosaic of the whole region. Resolution of photography (flown at 13,000 feet) was 25 cm pixels over the areas covering the estuaries. Some estuary areas near the open coast have additional photography at 12.5 cm pixel resolution. Spatial registration accuracy of 2011 aerial photography is +/- 0.50 m for >90% of coverage.

Mapping was done using GIS software (ArcMap 10.2) to create data sets (polygons) classified (5 classes) according to the density of mangrove canopy coverage in any areas they occur. To ensure consistent accuracy of mapping at a scale of 1:500, a protocol was used to guide the mapping process (see Appendix 1). All mapping was essentially a desktop mapping exercise with little or no ground truth surveys.



## Part 3: Results

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### 3.1 Mangrove abundance

#### 3.1.1 Tauranga Harbour

Total canopy cover of mangroves throughout all of Tauranga Harbour for 2011 is 811 ha. At the time the aerial photography was flown around 84 ha of consented mature mangrove removal had recently taken place. Then soon after the aerial photography was flown a further 24 ha of consented mature mangrove removal took place. If no mangrove removal had taken place the 2011 mangrove canopy cover would have been around 895 ha.

Table 1 below provides a comparison between the 2011 cover and historic extents. Figure 1 shows the total Tauranga Harbour mangrove canopy cover over time in graphical form. Despite consented removals taking place the overall trend for Tauranga Harbour has shown a marked increase in mangrove canopy cover.

*Table 1 Total mangrove canopy cover (ha) in Tauranga Harbour for years in which mapping has been done up to 2011.*

| Year | Canopy cover (ha) |
|------|-------------------|
| 1943 | 240               |
| 1974 | 375               |
| 1991 | 521               |
| 2003 | 623               |
| 2011 | 811               |

In Figure 2 (a – h) below, selected areas of Tauranga Harbour (Tanners Point-north, Tuapiro Estuary, Bluegum Bay, Te Puna Estuary, Waikaraka Estuary, Hunters Creek, Waimapu Estuary and Welcome Bay) have time series of mangrove canopy graphed to show changes that have taken place. The Tanners Point-north area, Te Puna Estuary and Waikaraka Estuary, all show recent reduction in mangrove canopy cover as a result of consented mangrove removal. Some areas such as Waimapu Estuary were mapped just before consented mangrove removal took place or was completed, hence may now have little or no long-term increase. The Hunters Creek and Bluegum Bay areas are examples of trends for locations that have lower sediment inputs from surrounding catchments and where there has been no consented mangrove clearance. All sites shown in Figure 2 display a similar long-term trend of increase up to 1999 as shown for total mangrove cover in Figure 1.

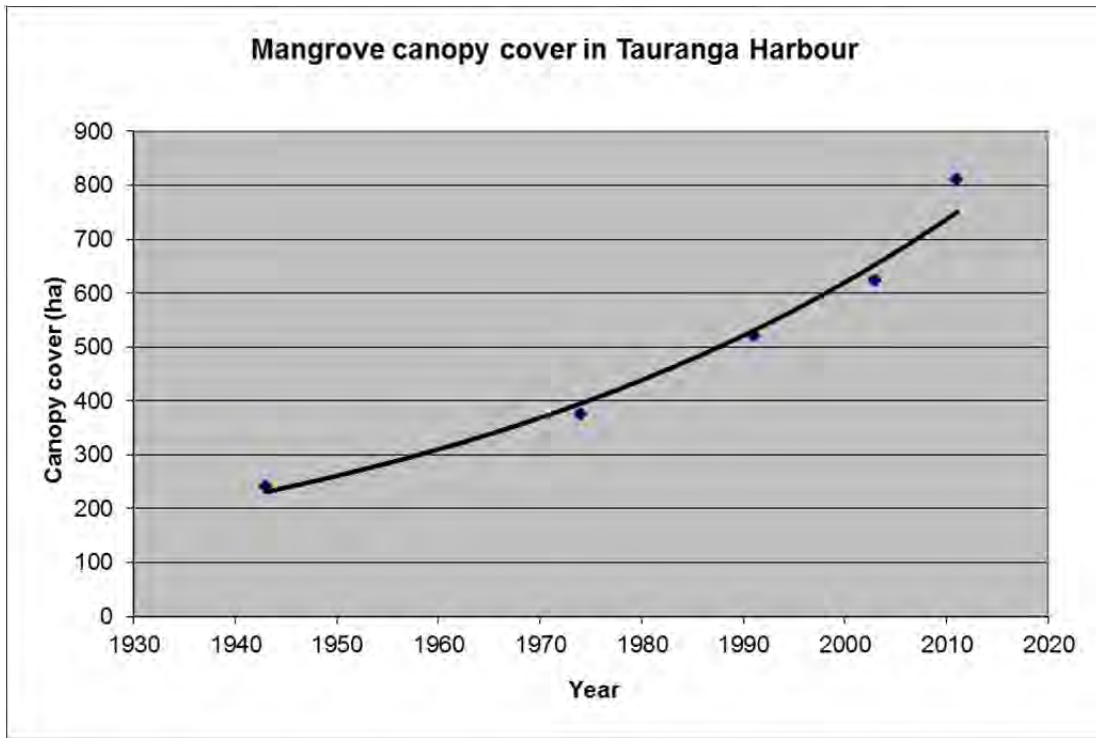
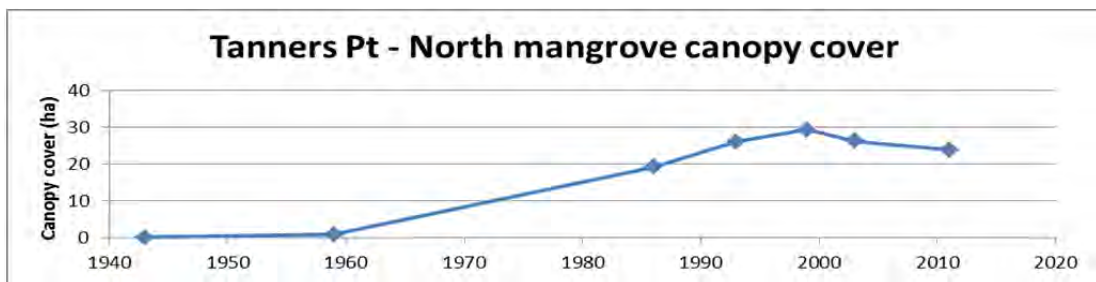
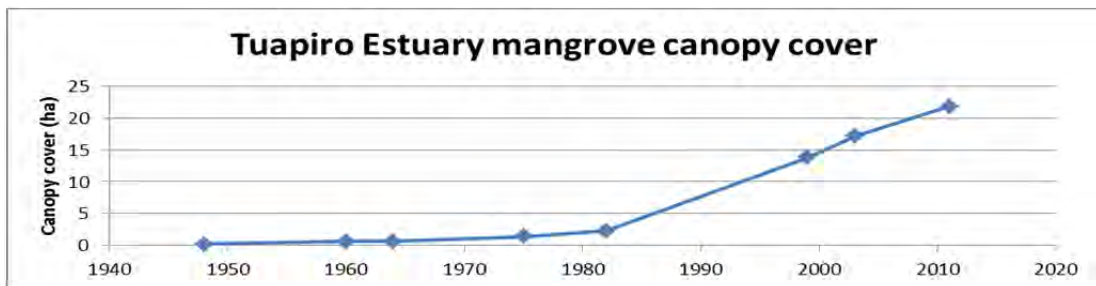


Figure 1 Mangrove canopy cover (ha) in Tauranga Harbour from 1943 up to 2011.

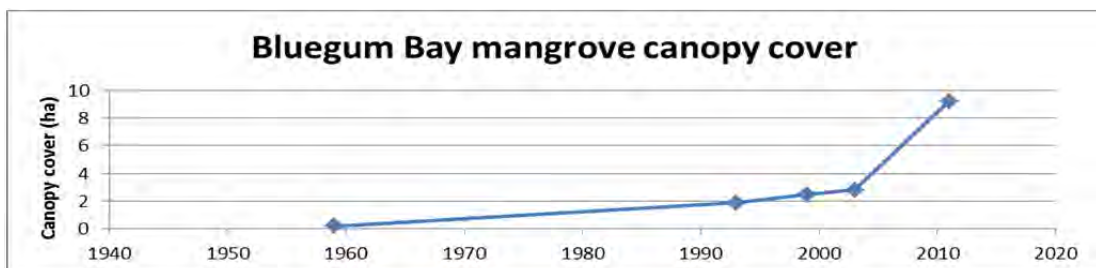
(a)



(b)

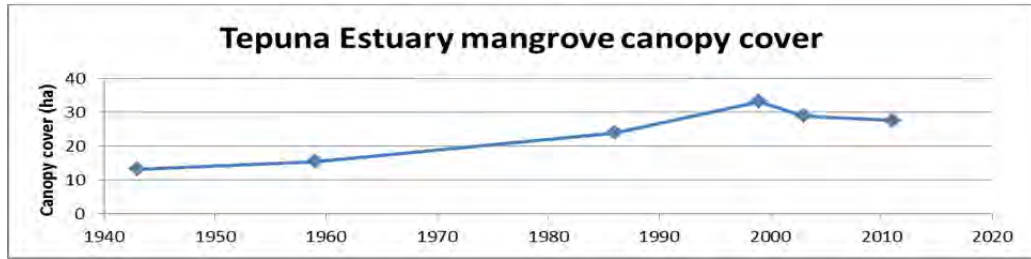


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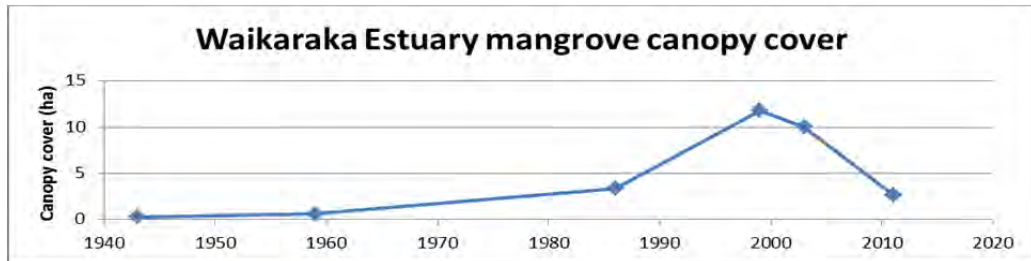




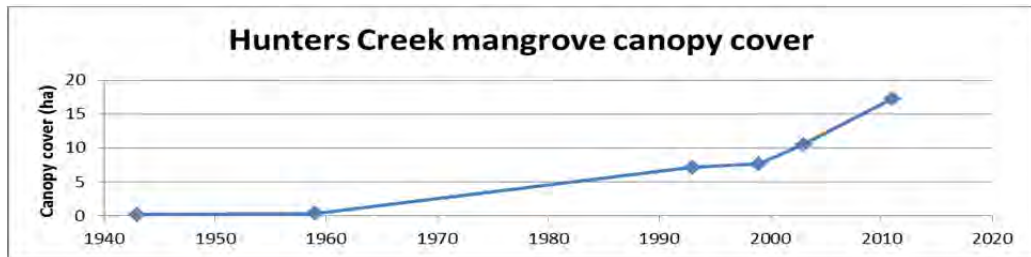
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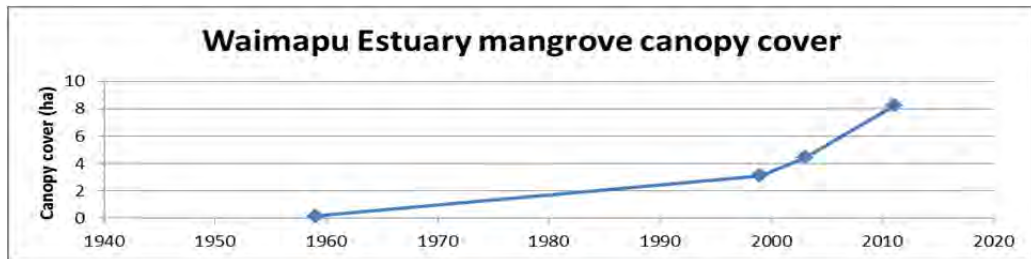
(e)



(f)



(g)



(h)

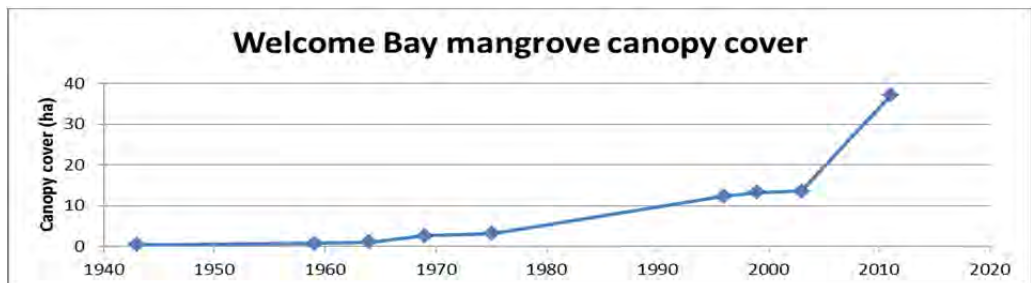


Figure 2 (a-h) Mangrove canopy cover (ha) in a selection of estuaries or smaller geographic locations within Tauranga Harbour up until 2011.

### 3.1.2 Ōhiwa Harbour

The historic and 2011 mangrove canopy cover in Ōhiwa Harbour over time is shown in Table 2 below with the same data presented graphically in Figure 3 and spatially in Figure 4. As a general long-term trend, the pattern of change is very similar to that seen in Tauranga Harbour, with a marked increase since the first mapping results of the 1945 abundance. Part of the variability seen in the 1992 - 2007 mapping results is due to differences in the assessment methodologies. The decrease seen from 2007 - 2011 is due to the impact of a severe hailstorm that occurred on 11 May 2009. Section 3.2 below provides more information on the impacts of that storm.

Table 2 Total mangrove canopy cover (ha) in Ōhiwa Harbour for years in which mapping has been done up to 2011.

| Year | Canopy cover (ha) |
|------|-------------------|
| 1945 | 20.6              |
| 1992 | 91.1              |
| 2003 | 90.8              |
| 2007 | 118.8             |
| 2011 | 99.0              |

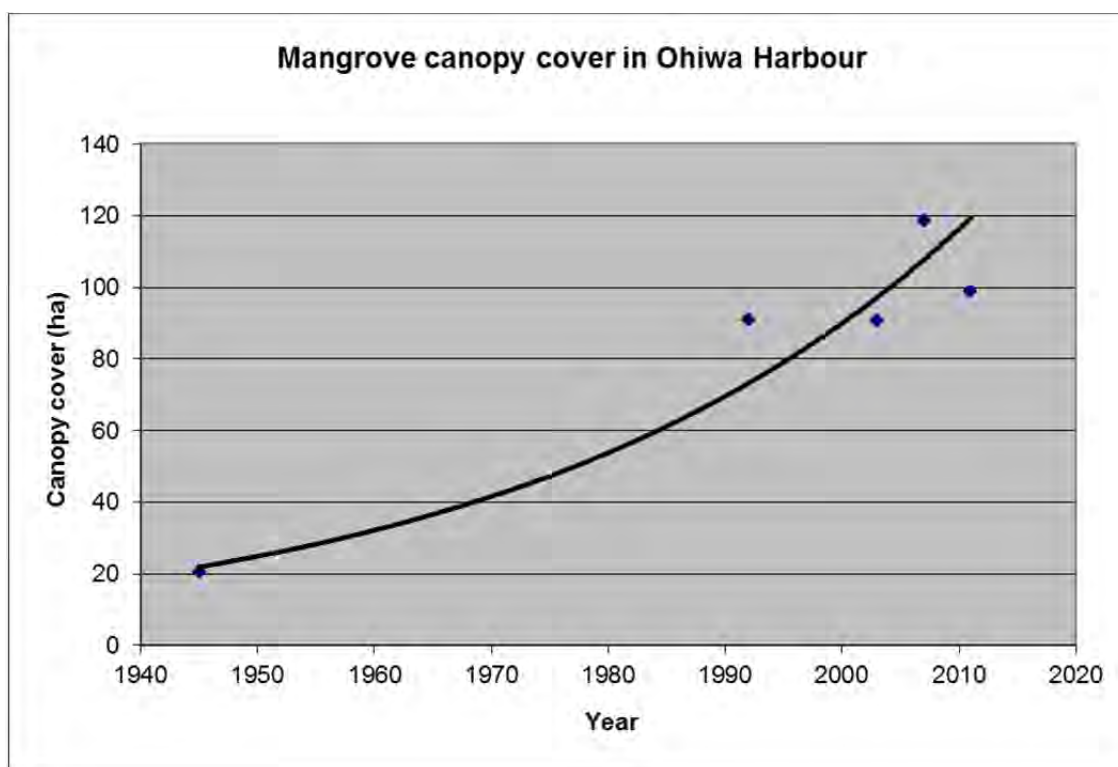


Figure 3 Mangrove canopy cover (ha) in Ōhiwa Harbour from 1945 up to 2011.

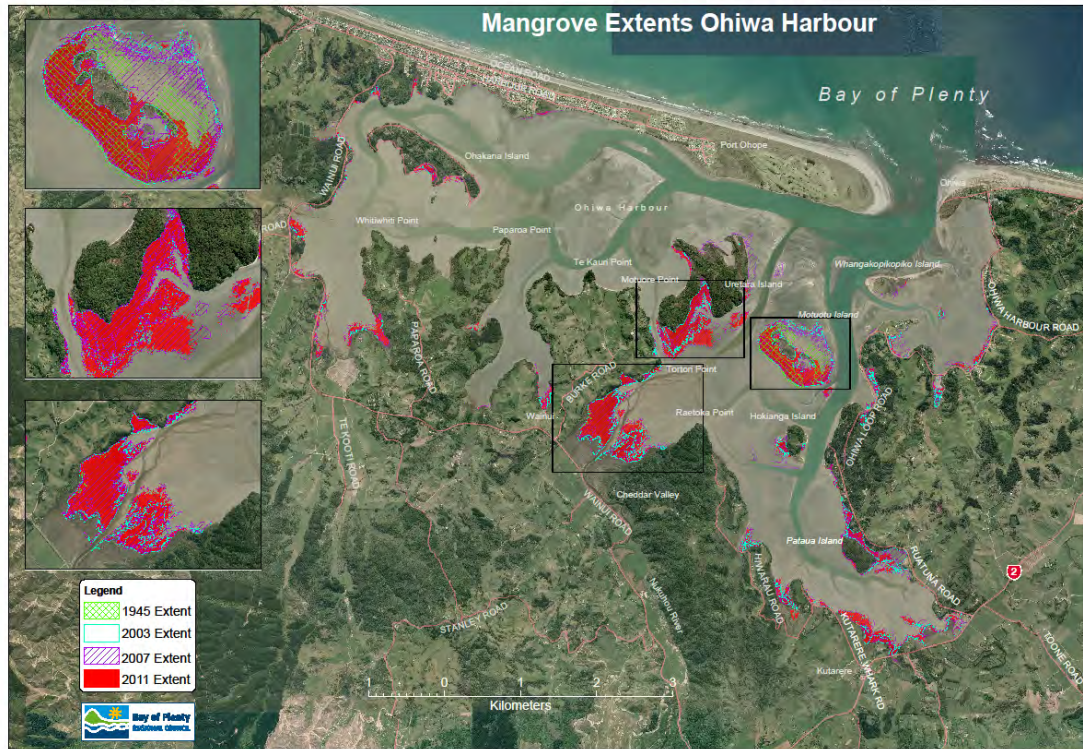


Figure 4 Mangrove spatial extents in Ōhiwa Harbour from 1945 up to 2011 with insets showing the Motuotu Island, Uretara Island and Nukuhou River Mouth areas.

### 3.1.3 Other estuaries/areas of Bay of Plenty

There are very few mangroves in the smaller estuaries of the Bay of Plenty, particularly as they become increasingly river-flow dominated. Maketu (2.3 km<sup>2</sup>) Estuary has historically had mangroves present at low abundance and mapping based on 2003 aerial photography recorded 0.3 ha. In the 2011 mapping there were no mangroves present which is due to illegal removal of both mature and seedling plants.

Waihi Estuary (2.4 km<sup>2</sup>) historically also had low abundance of mangroves. In 2003 mapping recorded 1.43 ha of mangrove canopy cover and in 2011 there was a marked increase with 4.77 ha.

In the remaining small riverine estuaries there is very little suitable habitat for mangroves and no populations of significance have been noted or mapped. In the Waiaua River Estuary located around 9 km to the east of Ōpōtiki, a small number of mature plants were present (1990s) in the eastern arm. However, these plants appear to have been lost as a result of storms washing sand over the beach spit and filling in the estuary arm.



### 3.2 Storm damage to mangroves in Ōhiwa Harbour

On 11 May 2009 a particularly severe hailstorm hit Ōhiwa Harbour which resulted in the localised extermination of mature mangrove stands in the central to eastern area of the harbour. Initially there was uncertainty as to what caused the mangroves to die as the hailstorm was followed by a fortnight of very hard frost. Investigation showed that the sole mechanism of plant death was due to the initial hailstorm alone. The hail effectively damaged the plants so badly that it destroyed all apical growing points on the plants which do not have the capacity to sprout new buds from any point on the trunk or branches.

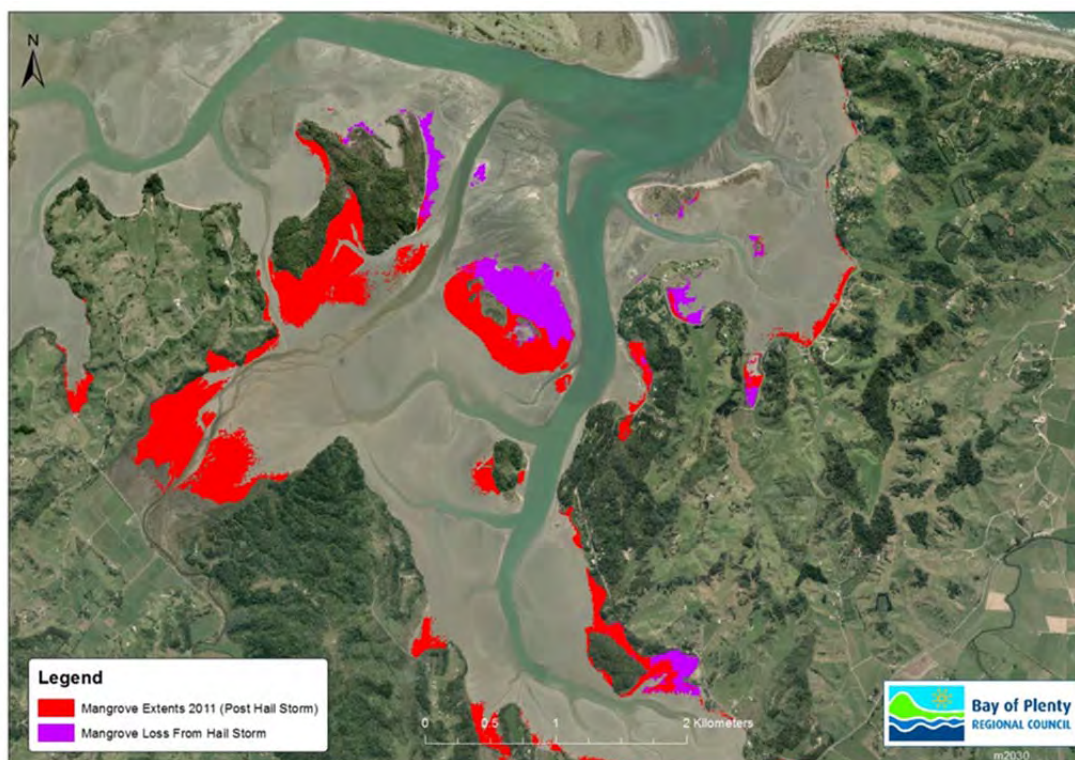


Figure 4 Areas of mature mangrove stands in Ōhiwa Harbour in 2011 (red) and the areas lost (purple) due to the hailstorm of 11 May 2009.

Spatial analysis of the areas of mangrove stands lost (as shown in Figure 4) shows that 43.5 ha of mature mangrove stands were affected. The canopy area lost was around 25 ha which accounts for the reduction in the total mangrove canopy abundance between 2007 and 2011 for Ōhiwa Harbour. In terms of the total mangrove abundance in Ōhiwa Harbour the storm effectively removed 20% of the mangrove population. The largest area of mangroves affected was on the north side of Motuotu Island and the photograph in Figure 5 shows part of that area.



*Figure 5* Area of mature mangrove stand on the north side of Motuotu Island, Ōhiwa Harbour, killed in the hailstorm of 11 May 2009.

### 3.3 **Saltmarsh displacement by mangroves**

Concerns have been expressed by numerous people or community groups over time on the issue of perceived potential saltmarsh displacement by mangroves. In an ecological sense, it would normally be the other way around with very gradual displacement of mangroves by saltmarsh as a result of natural succession. Usually vegetation sequences shift seaward as estuaries in-fill with sediment, if sea level is static. Over the last decade sea level rise in the Bay of Plenty has been close to 3 mm/year meaning that unless sedimentation rates exceed that same level, mangroves will be pushed into the saltmarsh areas. The areas affected if displacement does occur would be limited to the zone around and below mean high water level. Saltmarsh tends to occupy a zone that extends above that level to which mangroves can grow; hence overlap of the two habitats is only partial.

To help understand what is actually happening in Tauranga Harbour, four sites in the southern harbour were selected and the saltmarsh mapped with a high degree of accuracy from 2003 aerial photography. The later 2011 mangrove extents have been compared to the 2003 saltmarsh extents to determine where and how much overlap or potential displacement has taken place.



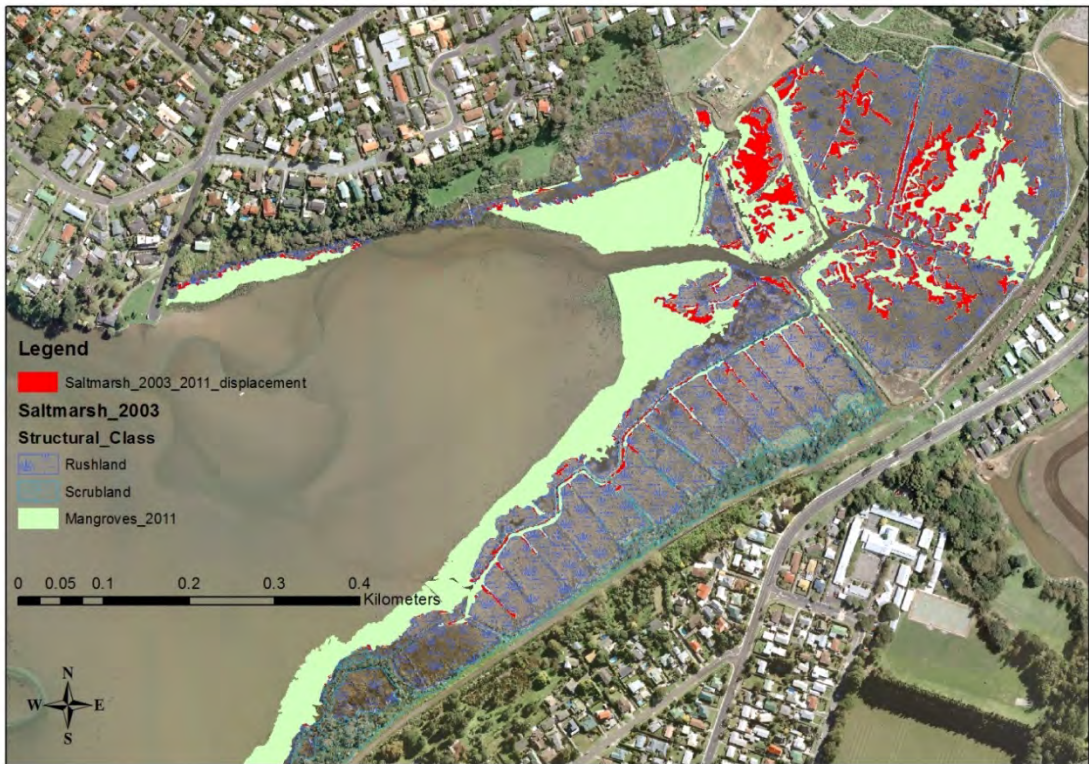


Figure 6 *Matua wetland area showing 2011 mangrove and 2003 saltmarsh vegetation extents and area potentially displaced by mangroves.*

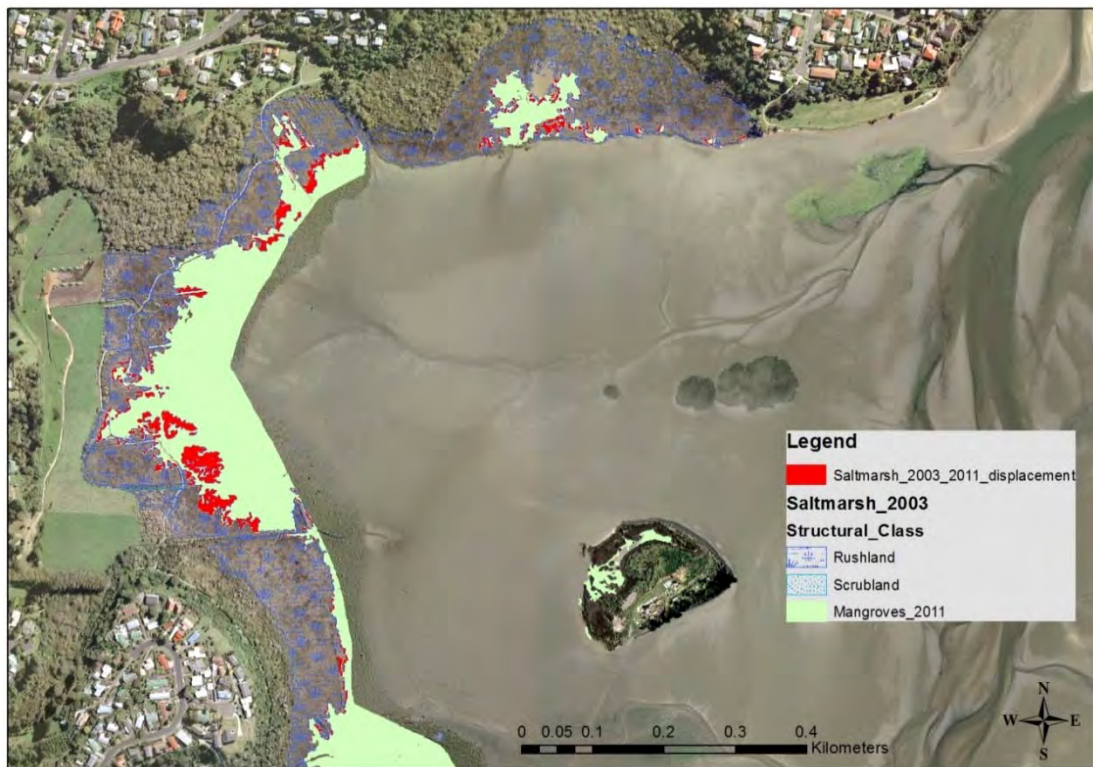


Figure 7 *Waikareao Estuary wetland area showing 2011 mangrove and 2003 saltmarsh vegetation extents and area potentially displaced by mangroves.*





Figure 8 Waimapu Estuary wetland area showing 2011 mangrove and 2003 saltmarsh vegetation extents and area potentially displaced by mangroves.



Figure 9 Close up of area in Matua wetland in 2003 showing low density of saltmarsh (rushes) vegetation.





*Figure 10 Close up of area in Matua wetland in 2011 showing low density of saltmarsh (rushes) vegetation still present but with extensive in-fill by mangroves.*

Results of spatial mapping analysis show that between 2003 and 2011 there is some overlap of saltmarsh by mangroves as seen in Figures 6 to 8 above. However, most of the larger areas of overlap occur because the mapping techniques are based on recording the dominant vegetation cover type and do not mean that the saltmarsh has been overgrown and displaced. An example from the Matua wetland is provided for the largest area of potential displacement (largest red area) shown in Figure 6. This area is shown at high resolution in Figure 9 where it can be seen that the density of saltmarsh vegetation is very low in 2003. In Figure 10 the same area is shown for the 2011 photography and although the area is now dominated by mangroves it can be seen that the saltmarsh vegetation present in 2003 is largely still present.

In Waikareao Estuary there is another example of the need to interpret the changes carefully for the largest area of overlap or potential displacement. In this case the saltmarsh vegetation (rushes) had extensively died back and the mangroves are simply colonising the bare habitat.

In-filling of bare habitat is the dominant process of mangrove colonisation occurring in areas of saltmarsh as shown by the example for Matua wetland in Figure 10. Figures 6 – 8 also highlight that most potential displacement is occurring in a very narrow band (1-2 m) on the external margins of saltmarsh vegetation. The figures also show that where there are drainage channels in the saltmarsh, then tides are carrying mangrove propagules (seeds) further into the saltmarsh than would otherwise occur in healthy intact habitat.



### 3.4 Seagrass displacement by mangroves

Potential loss of seagrass beds in Tauranga Harbour due to colonisation by mangroves was investigated by analysing the spatial overlap of the 1959 seagrass extents with the 2011 mangrove extents. Potential habitat overlap is limited as seagrass beds reach the same upper tidal height as mangroves but extend down into the subtidal zone, whereas mangroves occur from mid tide to mean high tide. Hence the tidal zone in which overlap can occur is limited to the upper half of the tidal range.

Results from the spatial analysis show that for the whole of Tauranga Harbour, there is a total area of 52 ha where mangroves now occupy areas formerly occupied by seagrass beds in 1959. The area of the harbour where the largest overlap was recorded is the mid upper harbour (Figure 11) with around 20 ha. It is likely that in this area, most of the overlap represents displacement of seagrass beds by mangrove colonisation.

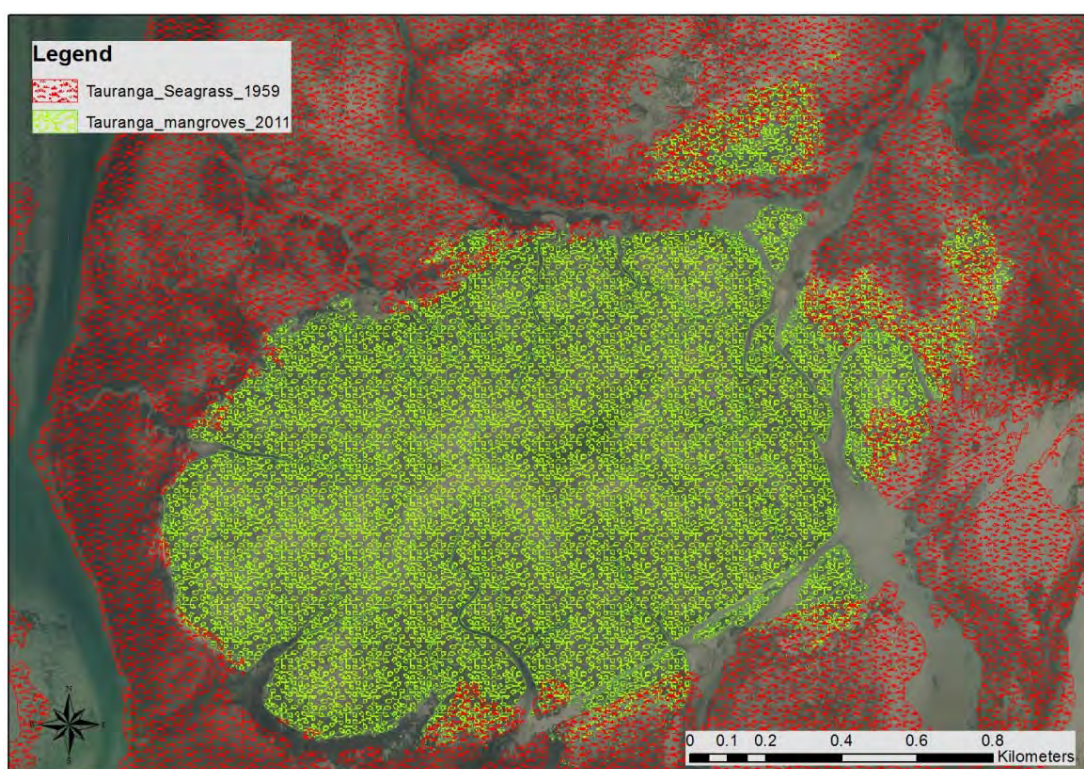


Figure 11 Example showing areas of overlap between the historic 1959 extents of seagrass and 2011 mangroves in the mid upper area of Tauranga Harbour between Matahui Peninsula and Matakana Island.

The next largest area of overlap occurred in Rangataua Bay near the Waitao Stream mouth (Figure 12) with around 13 ha of overlap. In this area the seagrass had disappeared before the mangroves colonised the area as a result of sediment and nutrient inputs which have also made the habitat more favourable for mangrove growth.

Of the 52 ha of overlap recorded between the 1959 seagrass extents and 2011 mangrove extents, it is hard to precisely identify just how much is due to mangrove displacement rather than changing distributions. An estimate of 30 ha is likely to be close to the amount of real mangrove displacement that has occurred over the 52 year period. To put this into context, between 1959 and 2011 1,679 ha (38%) of the seagrass beds have been lost. The 30 ha estimate for mangrove displacement represents 0.68% loss of the 1959 seagrass beds.

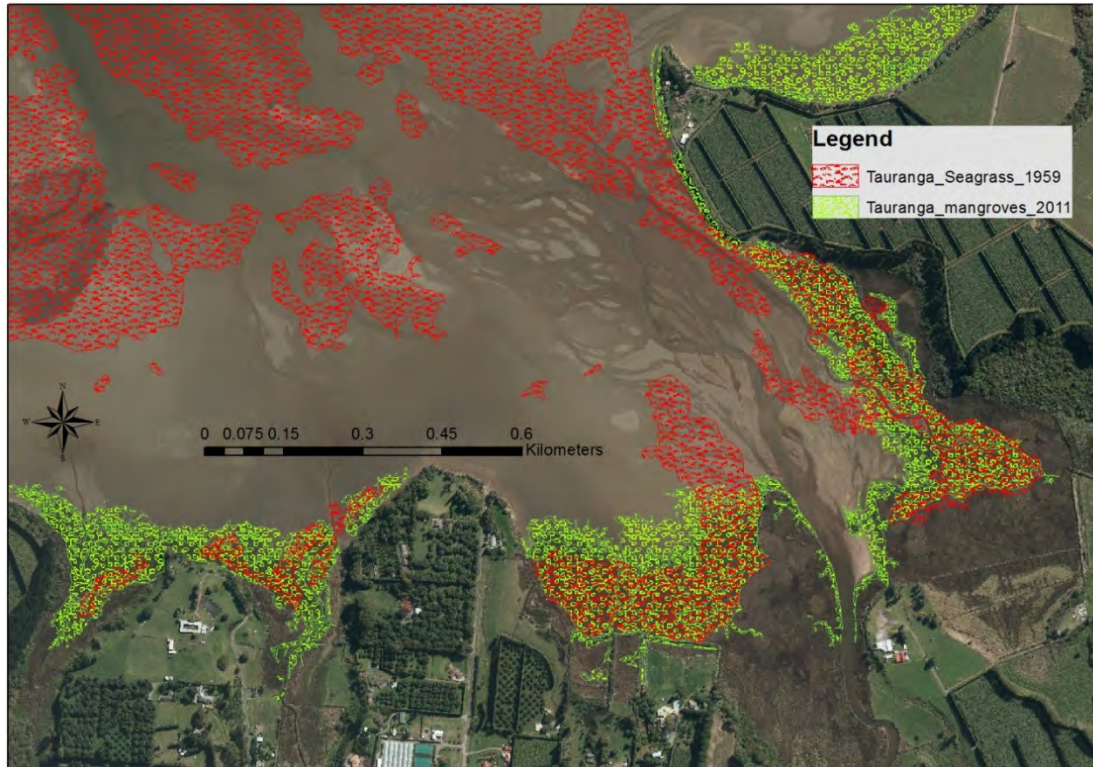


Figure 12 Example showing areas of overlap between the historic 1959 extents of seagrass and 2011 mangroves in the Rangataua Bay area of Tauranga Harbour near the Waitao Stream Mouth.

## Part 4: References

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# **Appendices**

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# Appendix 1 – Mangrove mapping protocol

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## Mangrove mapping protocol – NERMN

Spatial mapping of mangroves for the purpose of regional monitoring (NERMN) throughout the Bay of Plenty should be done every five years using the five-yearly supply of digital orthorectified aerial photography as a mosaicked RDAM with 25 cm pixel resolution.

Mapping using GIS software shall have a defined attribute table using the classification parameters from previous extent mapping as held in our corporate SDE database. Parameters cover the appropriate hydrological and vegetative classes to ensure that the mapping can be included in any general biodiversity database or assessments.

To enable accurate comparison of mangrove extent change over time, polygons are mapped according to the density (canopy cover) of mangroves in an area. These density classes are 0-24.99 (24), 25-49.99 (49), 50-74.99 (74), 75-99.99 (99) and 100% (100) cover.

Mapping is to be done at a minimum working scale of 1:500 and the accuracy of the finished work will be suitable for publication at scales of 1:5,000 or greater. To provide guidance on the expected accuracy of the work the following should be followed:

- Where larger mangroves (1.5 m x 1.5 m or bigger) occur as isolated plants around 10 m or more from other mangroves, they should be mapped as a polygon showing their canopy extent and classified at 100% cover. If part of a loose aggregation of mangroves (may include smaller mangroves), then map polygon tightly around perimeter excluding as much empty area as can be reasonably done and classify density accordingly.
- In large contiguous areas of mangroves at varying density the mangroves should be mapped to define areas of similar density as per the density classes. The minimum area of mangroves mapped by a polygon into a defined density class should be at least 25 m<sup>2</sup> (i.e 5 m x 5 m) if within 10 m of larger areas or aggregations of smaller areas/plants. Areas smaller than this will just be included into larger polygon areas with an appropriate overall density classification as above.
- Small mangroves down to 0.25 m x 0.25 m (0.25 m<sup>2</sup>) are to be included in mapping where they occur as aggregations. However, if individual plants occur at distances of around 20 m or more from other mangroves, then they are not mapped.
- In areas of small mangroves which are hard to positively identify, ground truth verification should be made. Some coastal areas have 12.5 cm pixel resolution photography available and this can be used as a reference to confirm whether mangroves are present.