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Bay of Plenty Maritime Wetlands Database

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Cover Photo: Wetland sequence in Blue Gum Bay, Tauranga Harbour 1991.

Executive Summary

Wetland vegetation surveys, digital mapping, database design, data capture have now been completed for nearly all the maritime wetland within the Bay of Plenty region. In addition an estimation of historic wetland from aerial photography has been mapped for Tauranga and Ohiwa Harbours at a 1:10,000 scale. The information and database form an important tool for managing and assessing these ecosystems. In particular the surveys and data can provide both spatial and quality assessments for areas of special importance with formal protection in the Regional Coastal Environment Plan. It can also provide baseline data allowing assessment of ecosystem impacts and change in general that may link to the success or otherwise of environmental plans and management.

An initial analysis of both the areas of wetland types according to the national classification and the quality of those areas has been presented to indicate potential utility of the database. Tauranga Harbour contains over 80% of the region's palustrine and estuarine wetlands while Ohiwa Harbour has around 12%. While some of the smaller estuaries such as Opotiki only contain a small proportion of the region's total wetland, they are important in that vegetation is different and represents the bulk of some vegetation structural classes.

An example of wetland quality based on Tauranga Harbour showed that some vegetation types suffered more from weed infestion or human impacts than others. For example, the sedgeland growth form was heavily impacted by weeds while shrublands, which are largely mangroves, were not. This can obviously highlight vegetation types or areas that may be in need of management to maintain their current values.

Included in the mapping work from aerial photos was an assessment of seagrass meadows in Ohiwa Harbour for 1945 and 1996. Results showed a 27% reduction in areas over this period, which is similar to the result previously reported for the whole of Tauranga Harbour. The geographical pattern of loss was also similar to that of Tauranga Harbour, which strongly implicates the same causal factors of sediment and nutrient impacts.

Both Tauranga and Ohiwa Harbour now have an assessment of historic and recent mangrove abundance. Mangrove expansion has been high with an additional 280ha and 70ha or 220% and 440% increase respectively for each harbour between 1943/45 and 1991/2. Sediment input to these areas is the most likely cause and is an issue that Environment B·O·P is addressing in a holistic management approach. The extent of estuarine wetland in both harbours between an 1840 estimate and 1991/2 has shown an increase. However, if the expansion of the total area covered by all densities of mangroves is taken into account, then mangroves can account for all the increase alone. In addition, provisional figures for the amount of estuarine saltmarsh lost by reclamation in the same period represents over half the current area now present throughout the whole region. Overall the results show that major dynamic changes are occurring in the estuarine ecosystems over these longer periods of time.

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Chapter 1: Introduction

1.1 Scope

This report presents an overview of Bay of Plenty maritime wetlands and Environment B·O·P's methods for monitoring those wetlands. Summary data are presented based on detailed vegetation mapping work initially undertaken from 1991 up until 1999. A detailed description of the database developed for this monitoring work is provided along with limitations of the data and future sampling methodology. A historic assessment of Tauranga and Ohiwa Harbour wetlands and changes since then provides a case example of impacts on these ecosystems.

The maritime wetland database provides an important tool with which Environment B·O·P can address its responsibilities under the Resource Management Act (1991). In particular the sustainable management principals set out in Part II (section 5) and directives to monitor the state of the environment as set out in Part IV (section 35; 1 and 2a, section 30; 1a). In addition the database provides a detailed spatial backdrop supporting the ecological habitat zoning evaluations and designations set out in Environment B·O·P's "Proposed Bay of Plenty Regional Coastal Environment Plan".

1.2 Background

Wetlands are important ecosystems that often support endangered or threatened species of flora and fauna. Throughout New Zealand freshwater wetlands in particular have been severely diminished in extent. In the Bay of Plenty only around 10% of the original freshwater wetlands remain. Estuarine wetlands on harbour margins may have faired a little better but provisional figures (Environment B·O·P unpublished data) indicate that at least 1,400 hectares of this habitat has been reclaimed within the coastal marine area of the Bay of Plenty.

The maritime wetlands database is an integrated Geographic Information System based on vegetation mapping and assessment, which utilises the recently developed national classification framework (Ward *et al*. 1999). Comparison of extent and identification of unique vegetation associations poorly represented at the national level will be possible once data from other regions is available. Both freshwater ("palustrine") and "estuarine" systems around the harbour margins are included in the database. Palustrine wetlands were included where these ecosystems are either contiguous with the harbour margin, tidally influenced or within several meters elevation of the mean high water spring tide mark. Not all wetlands within the region have been captured, but for the estuarine component the mapping is at least 99% complete. Current areas omitted include very

small river or stream mouths generally measuring less than 0.1 km^2 in extent with little or no salt tolerant vegetation. Areas completely covered include; Tauranga Harbour, Ohiwa Harbour, Maketu Estuary, Waihi Estuary, Whakatane Estuary, Waiotahi Estuary, Opotiki Estuary and Waiaua Estuary (see Figure 1.1).

To provide information of a useful nature with which to effectively manage the regions maritime wetlands a database/monitoring programme needs to provide data both in spatial context and in terms of its composition and quality. If both aspects are covered in an appropriate fashion then it is possible to follow these ecosystems through time and highlight any detrimental changes.

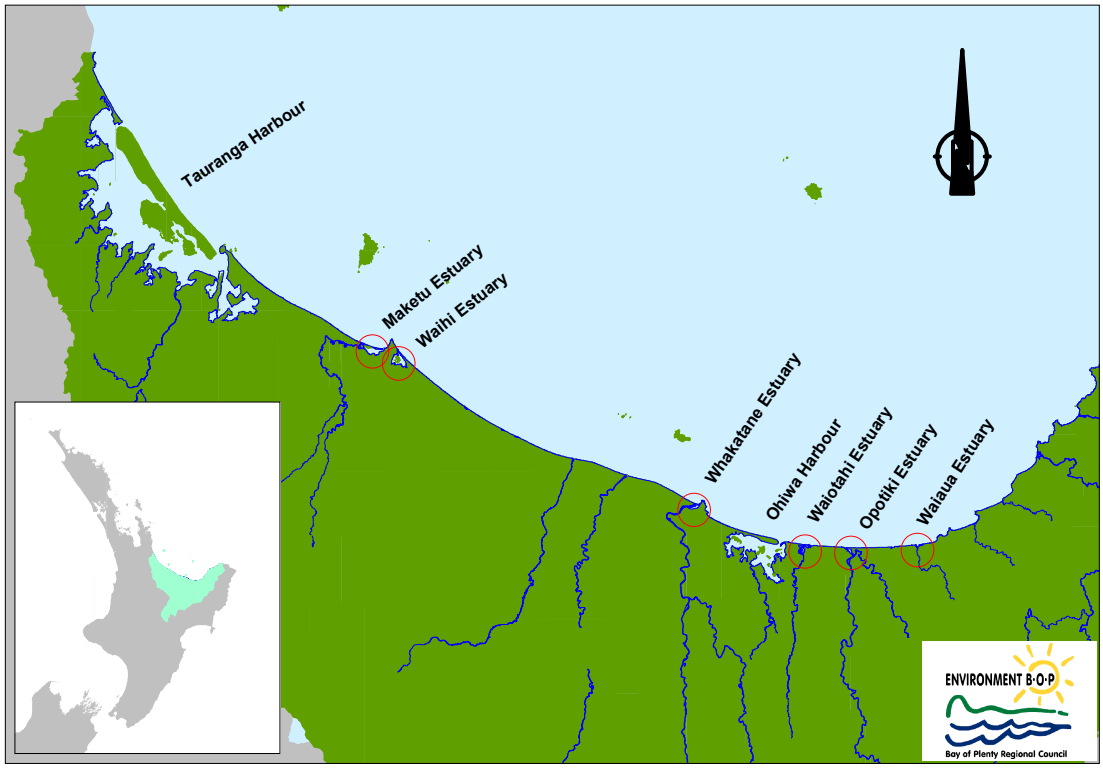

Figure 1.1 Location of harbours and estuaries in which wetland vegetation surveys have been undertaken within the Bay of Plenty.

Chapter 2: Methods

Environment B·O·P's maritime wetland data has been collected between 1991 and 1999 before the outcomes of the MfE funded project to develop a consistent approach on monitoring wetlands. However, it was always intended that the data collection would be detailed enough to retrospectively slot into a national classification system. To date there are still many aspects of assessing the quality of wetlands that require standardising at a national level. These will need to be adopted in the future as agreement on methods and indicators are reached.

An outline of the national classification system and methods used by Environment B·O·P in mapping the regions maritime wetland is set out below.

2.1 National Classification

Environment B·O·P's maritime wetland database has been developed to be consistent with the national classification system (Ward *et al*. 1999) which is the outcome of a Ministry for the Environment SMF funded project. This hierarchical system will allow for co-ordinated monitoring and consistency in reporting wetlands throughout New Zealand. It will also provide a platform in which comparison and determination of commonality or rarity at the national level will be possible.

The national classification consists of the following levels relevant to the maritime database:

Level I **Hydrosystem** – hydrological setting, either:

Estuarin*e* (alternating saline and freshwater) or

Palustrine (vegetation emergent over freshwater, not including floating plants)

Level IA **Subsystem** – flow regime

Level II **Wetland class** – take into account substrate, pH, chemistry.

Estuarine – includes: saltmarsh, seagrass meadows, algal flat, mudflat, sandflat.

Palustrine – includes: marsh, swamp, fen, bog, flush and seep.

Level IIA **Wetland form** – land form

Level III **Structural Class** – biotic structure

Classes at this level are well established and best applied to wetland vegetation where the dominant structural growth form of the plant species determines the class. The proposed classification system is not so easily determined or established for habitats dominated by faunal communities, especially in the marine environment. The diagnostic criteria for vegetation structural classes and definitions of growth form follow the system developed by Atkinson (1985). Examples of classes include ***scrub, fernland, grassland, sedgeland, rushland, reedland and herbfield***. A full account of determining and applying these classes is contained in either Ward *et al*. (1999) or Atkinson (1985).

Level IV **Dominant cover** – the dominant species present. e.g. Zostera, Avicennia, Typha, Carex etc.

2.2 1991-93 Survey Methods

Between 1991 and 1993 both Tauranga and Ohiwa Harbour maritime wetlands were mapped using consultants engaged by Environment B·O·P's planning department. Mapping of vegetation was done at a scale of 1:10,000. Colour aerial photographs were used as a base on which the initial mapping of distinct vegetation units could be plotted in conjunction with ground verification. Vegetation units and description followed the system of Atkinson (1985) which is the basis of the national classification at the structural level.

The vegetation in each mapping unit was assessed for the semiquantitative representation of the species present. To record the presence of these species a code for the many different assemblages of plants were created. However, these codes are not consistent between Tauranga and Ohiwa Harbours. Information in the form of a ranked assessment of the level of weed, pest and human impact was made for each area. For Tauranga Harbour a large number of vegetation plots were surveyed in detail. The location of these plots was recorded on the survey forms with a standard map reference (ie accurate to $\pm$ 100m).

An assessment was made of the representative mosaics and sequences of the vegetation units being mapped. Criteria for this followed the ranking system of Shaw with regard to criteria proposed by Myers *et al*. (1987). Two categories of significant vegetation were used for Tauranga Harbour while three were used for Ohiwa Harbour. A more detailed description of the methods can be found in Beadel (1992,1993). After completion of all field mapping and assessment the results were mapped as a series of A1 hardcopies.

2.3 1998-99 Survey Methods

Over this period the maritime marsh areas in Maketu Estuary, Waihi Estuary, Whakatane Estuary, Waiotahi Estuary, Opotiki Estuary and Waiaua Estuary were surveyed and mapped. Recording of vegetation units followed essentially the same procedure as for the 1991-93 surveys. Major differences were the recording of species

in each vegetation unit as an individual code and density rank. Assessment of significant areas of vegetation was not made nor was any vegetation plot surveys done.

2.4 Historic Wetlands

Environment B·O·P has region wide database coverage of historic wetland (1840) within the Bay of Plenty. However, these maps are at a coarse scale of 1:250,000 and do not have a consistent level of detail throughout the region. Because of this they are not suitable for making comparison of historic changes in wetland extent against the 1991 and 1992 surveys of Tauranga and Ohiwa Harbours. To enable analyses of wetland losses within these regions a 1:10,000 mapping exercise was under taken.

Since historic mapping can only be based on aerial photography without any ground truth validation, assessment of attribute data was generally limited. Classification was assessed only to level II of the national systems (i.e. saltmarsh and marsh/swamp) with the exception of mangroves, which were assessed down to level IV. The 1945 aerial photographs (1:15,000 scale) are the oldest available that cover the whole of the harbour catchments and form the basis of the mapping. By this date much of the freshwater wetland had already been cleared but is still discernible by the poor state of pasture and drainage networks. Hence it is possible to map reasonably accurately what was obviously wetland before human intervention.

2.5 Digital Mapping

Survey maps and data from all surveys were captured digitally on Environment B·O·P's computer network using MapInfo version 4.5. A region wide 1996 aerial photo mosaic available on the GIS system was used as a spatial reference layer against which to digitise map line work for 1991/2 surveys. All the individual prints covering complex wetland areas were re-scanned and registered to improve image resolution.

2.5.1 Scale and Resolution

The original resolution of the 1996 aerial photography was 1:15,000. These prints were scanned in grey scale to provide a minimum resolution of 1-meter pixel size when the electronic files were viewed on screen. Minimum scale for mapping was 1:10,000.

2.5.2 Image Registration

I/RAS C software was used to register rectify and mosaic the scanned photography. This method will not achieve ortho-rectification (systematic removal of camera lens distortion in the photos). The areas being mapped were obviously flat so distortion due to varying terrain elevation was not a problem. Positional accuracy from rectification of photos depends on the degree of overlap between photos and the number of quality registration points.

Generally each photo was registered with between 12-15 known points. Most points were derived from DCDB data with some from known geographical points. Overall the final product has a minimal positional accuracy of $\pm$ 10 m for 90% of the imagery.

2.5.3 Line Work

Line work from the hard copy maps was digitised on-screen using the 1996 photography to show and map the vegetation unit boundaries. In cases where the survey area had changed in relation to the 1996 photo mosaic, the most relevant photography available was registered as a reference layer. Vegetation unit boundaries have an accuracy well within $\pm$ 3m for defining the margins of these areas.

2.6 Database Structure and Development

Environment B·O·P's maritime wetland database consists of an MS Access relational database with key attribute data linked to the spatial mapping components residing in MapInfo. The database layout shown in Figure 2.1 is founded on the national classification system and incorporates aspects of wetland quality assessment and species abundance making it suitable as a management information tool. The database has also been developed with the intention that it forms a standard with which any future survey will be based upon.

One component of the Atkinson system not incorporated into the database is recording of the species status in relation to whether it forms part of a canopy/subcanopy/ground cover complex. This was done for simplicity of the database structure and means that in an area in which there is a canopy and complete ground cover the total species cover for that area may add up to well over a 100%. The species table in the database provides information not only indicating a species structural class but also additional information such as common names, family, rarity, habitat etc.

When incorporating the historic survey data a number of assumptions had to be made and corrections applied. These are laid out below for each survey and use of the data must take into account the limitations that arise implicit with these assumptions.

2.6.1 1991-92 Data for Tauranga and Ohiwa Harbours

Although the vegetation in these two surveys was assessed in a semiquantitative manner the use of composite codes to record the presence of species meant that the reliability of the data was severely diminished. To highlight the problems and how the data was dealt with the following example is provided.

One area of Tauranga Harbour, wetland vegetation was coded as having 20-50% cover for each of the following; C/W, CWM, Lsc, W and WM. These codes represent vegetation that includes the following:

C/W – represents cabbage tree and willow as the dominant species with which there could be a number of less abundant species of shrubs, grasses sedges etc.

CWM – is as above but also includes manuka as an abundant species.

Lsc – represents manuka scrub, which generally has in association a highly variable under storey of less abundant species.

W – represents willow forest with which a number of less abundant shrubs grasses, sedges etc may occur.

WM – is described as being the same as C/W but with the dominant species being willow and manuka.

In assessing the presence of species represented by these codes it is obvious that willow, manuka and cabbage trees definitely occur at the site. There is no definable level of certainty as to whether any of the other species that might occur in this area actually are present. Having regard to this, the database incorporates the vegetation that is almost certain to be there, while not registering the rarer less abundant species. A text field has been incorporated into the database containing the original codes and hence providing a way of indicating what else might have been there.

In the Tauranga Harbour survey, but not the Ohiwa Harbour survey, a number of vegetation plots were surveyed. Because the location of these plots were only recorded to the nearest 100m it will not be possible to re-survey them. Such plots would have other wise allowed for very sensitive monitoring of compositional/quality changes over time. As a result it is not worth recording the plot information in the database. However, the database does note the presence of a vegetation plot within a unit of mapped vegetation and the data on species occurrence has been used to represent the whole of that area. Hence where a vegetation unit is shown as having a plot survey the list of species present is usually more extensive than those having dominant species gleaned from the use of composite codes.

Abundance data for a large proportion of the vegetation mapping units in both Tauranga and Ohiwa Harbours varies from that shown on the original hard copy maps. These should no longer be used. This possibly occurred because the notation with which density was recorded made it easy to make mistakes. The densities of all mapping units were rechecked and corrected using the aerial photographs.

Although the mapping of Tauranga and Ohiwa Harbour generally conformed to the national classification system, a small percentage of vegetation units (<2%) included more than one hydrosystem (i.e. estuarine and palustrine). These areas were classified according to the dominant hydrosystem. The same was also true for structural class although at this level there will always be some variation as to where a vegetation boundary should be made.

2.6.2 1999 Surveys

Data incorporation into the database for these surveys was relatively straightforward. Vegetation mapping units were drawn as to follow changes in hydrosystems and plant structural class if well defined. All species abundance in each area were individually recorded and entered into the database.

2.6.3 Future Survey Methods

Future survey methods will be similar to those used in the past. The required attribute data will define the manner in which mapping is conducted (i.e. to closely follow obvious classification boundaries) and the information recorded. Any monitoring methods or indicators developed as national standards will be adopted. The minimum mapping scale should always be 1:10,000 and if feasible 1:5,000.

At the 1:10,000 scale mapping, pixel resolution of scanned images should be a minimum of 1m and GPS points recorded to improve registration accuracy. In areas of mosaic vegetation types including more than one structural class, obvious features/structural class areas greater than around 10m in width/breadth should always be mapped separately. Areas of readily identifiable wetland vegetation down to a size of 5m should also be mapped. At 1:5000 pixel resolution and vegetation features mapped will be proportionately finer.

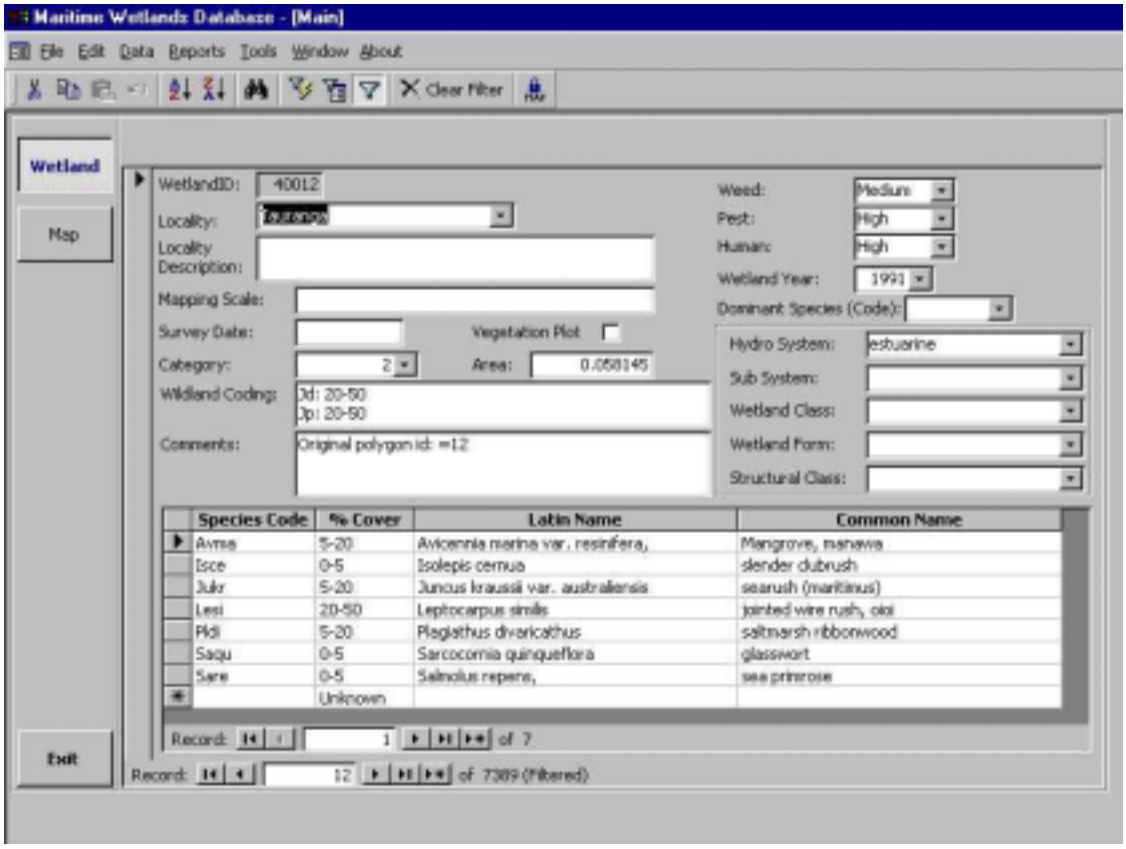

Figure 2.1 Maritime wetland database main form layout.

Detailed vegetation plots (10x10m) should also be surveyed in selected representative vegetation throughout the region. In these surveys the individual species abundance should be recorded as a percentage cover. Location of these plots need an accurate (<1m) GPS reference recorded so that the exact same area can be surveyed again at any time.

Chapter 3: Summary of results

3.1 Overview of Maritime Wetlands in the Bay of Plenty

The following summaries of wetland vegetation for the Bay of Plenty Region provide a comprehensive overview of wetland abundance and type. Summaries of palustrine wetland only relate to the areas around harbour margins that met the criteria defined in the survey/mapping methods. There are other palustrine wetlands within the region that are not included and hence summaries are not complete region wide totals. The estuarine wetlands summary includes mangroves but not seagrass meadows. Seagrass meadows are reported for Ohiwa Harbour separately and have previously been reported for Tauranga Harbour (Park 1999a, 1999b). Table 3.1 below shows the relative abundance of estuarine and palustrine wetlands in the region by harbour/estuary.

Table 3.1 Area and relative abundance of estuarine and palustrine wetland in the Bay of Plenty harbours and estuaries

Harbour	Estuarine		Palustrine	
	Area ha	%	Area ha	%
Tauranga	1839.60	80.0	469.03	83.1
Maketu	14.32	0.6	7.64	1.4
Waihi	78.93	3.4	0.88	0.2
Whakatane	21.38	0.9	13.36	2.4
Ohiwa	293.23	12.7	65.35	11.6
Waiotahi	18.70	0.8	2.04	0.4
Opotiki	17.89	0.8	3.12	0.6
Waiaua	16.36	0.7	3.88	0.7
Region total	**2300.40**		**564.6**	

Tauranga Harbour contains over 80% of the regions estuarine and associated palustrine wetlands. In combination with Ohiwa Harbour the figure is over 95% highlighting the importance of these two areas. Table 3.2 below provides a summary of all maritime wetland area for the Bay of Plenty by the structural classification of vegetation (ie the dominant growth form).

Table 3.2 Area of maritime wetland in the Bay of Plenty by dominant vegetation growth form

	Estuarine		Palustrine	
Structural class	**Area ha**	**%**	**Area ha**	**%**
Rushland	1147.0	49.9	73.1	12.9
Shrubland	1046.4	45.6	86.2	15.3
Sedgeland	68.6	3.0	20.5	3.6
Reedland	21.1	0.9	43.4	7.7
Herbfield	7.1	0.3	0	0.0
Grassland	7.0	0.3	4.6	0.8
Treeland	0	0.0	160.2	28.4
Scrub	0	0.0	123.6	21.9
Forest	0	0.0	36.5	6.5
Fernland	0	0.0	13.6	2.4
Flaxland	0	0.0	2.9	0.5

In estuarine areas of wetland, the rush growth form is clearly predominant within the Bay of Plenty region accounting for half of all the areas surveyed. Within the shrub growth form category over half of the area is due to the presence of mangroves. In the palustrine wetland areas, dominance shifts to tree and shrub growth forms. Manuka is one of the most common species in these wetlands but in some areas willow is becoming very common in what would have originally been rush/reed/sedge type wetlands.

Tables 3.3 to 3.6 provide a detailed breakdown of the area and percent cover of vegetation in each harbour by growth form structural class. Tables 3.3 and 3.4 show the relative percentage of vegetation for each structural class within that harbour as a whole while 3.5 and 3.6 show the proportion of each structural class within the whole region occurring in each harbour.

Table 3.3 Estuarine wetland areas (ha) and percent composition by harbour and vegetation structural class

	Tauranga		Maketu		Waihi		Whakatane		Ohiwa		Opotiki		Waiotahi		Waiaua	
Structural class																
	Area	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**
Rushland	905.7	49.3	8.8	61.7	66.0	83.6	11.5	53.9	123.1	42.0	4.0	22.4	17.0	90.6	10.9	66.5
Shrubland	870.1	47.4	0.1	0.2	12.8	16.2	0	0.0	162.8	55.6	0	0.0	0.1	0.5	0	0.0
Sedgeland	57.1	3.1	0	0.0	0.2	0.2	6.5	30.4	4.6	1.6	0.1	0.3	0.1	0.4	0.1	0.2
Reedland	0.1	0.0	5.5	38.1	0	0.0	0	0.0	0.5	0.2	13.8	77.3	0	0.0	1.2	7.3
Herbfield	1.4	0.1	0	0.0	0	0.0	3.4	15.7	1.8	0.6	0	0.0	0.6	3.4	0	0.0
Grassland	1.4	0.1	0	0.0	0	0.0	0	0.0	0.4	0.1	0	0.0	1.0	5.1	4.3	26.0
Totals	**1835.8**		**14.3**		**78.9**		**21.4**		**293.2**		**17.9**		**18.7**		**16.4**	

Table 3.4 Palustrine wetland areas (ha) and percent composition by harbour and vegetation structural class.

	Tauranga		Maketu		Waihi		Whakatane		Ohiwa		Opotiki		Waiotahi		Waiaua	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Rushland	62.7	13.4	6.5	85.2	0	0.0	1.7	12.4	0	0.0	0.3	8.0	2.0	100.0	0	0
Shrubland	64.3	13.7	0	0.0	0	0.0	0	0.0	21.9	33.5	0	0.0	0	0.0	0	0
Sedgeland	5.1	1.1	0	0.0	0	0.0	1.1	8.2	14.3	21.9	0	0.0	0	0.0	0	0
Scrub	109.7	23.4	0	0.0	0	0.0	0	0.0	14.6	22.3	0	0.0	0	0.0	0	0
Reedland	23.4	5.0	0	0.0	0.9	100.0	6.1	45.4	6.2	9.5	2.9	92.0	0	0.0	3.9	100
Grassland	0	0.0	0	0.0	0	0.0	4.6	34.1	0	0.0	0	0.0	0	0.0	0	0
Fernland	12.5	2.7	1.1	14.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Flaxland	2.9	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Treeland	151.9	32.4	0	0.0	0	0.0	0	0.0	8.3	12.7	0	0.0	0	0.0	0	0
Forest	36.5	7.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Totals	469.0		7.6		0.9		13.4		65.4		3.1		2.0		3.9	

Table 3.5 Percentage of the regions total estuarine wetland in each harbour by vegetation structural class

Structural class	Tauranga	Maketu	Waihi	Whakatane	Ohiwa	Opotiki	Waiotahi	Waiaua
	%	%	%	%	%	%	%	%
Rushland	79.0	0.8	5.8	1.0	10.7	0.3	1.5	0.9
Shrubland	83.2	0.0	1.2	0.0	15.6	0.0	0.0	0.0
Sedgeland	83.3	0.0	0.2	9.5	6.8	0.1	0.1	0.0
Reedland	0.7	25.8	0.0	0.0	2.5	65.4	0.0	5.6
Herbfield	19.0	0.0	0.0	47.1	25.1	0.0	8.8	0.0
Grassland	20.5	0.0	0.0	0.0	5.1	0.0	13.6	60.8

Table 3.6 Percentage of the regions total palustrine wetland in each harbour by vegetation structural class

Structural class	Tauranga	Maketu	Waihi	Whakatane	Ohiwa	Opotiki	Waiotahi	Waiaua
	%	%	%	%	%	%	%	%
Rushland	85.7	8.9	0.0	2.3	0.0	0.3	2.8	0.0
Shrubland	74.6	0.0	0.0	0.0	25.4	0.0	0.0	0.0
Sedgeland	24.9	0.0	0.0	5.3	69.8	0.0	0.0	0.0
Scrub	88.3	0.0	0.0	0.0	11.7	0.0	0.0	0.0
Reedland	54.0	0.0	2.0	14.0	14.4	6.6	0.0	9.0
Grassland	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Fernland	91.7	8.3	0.0	0.0	0.0	0.0	0.0	0.0
Flaxland	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Treeland	94.8	0.0	0.0	0.0	5.2	0.0	0.0	0.0
Forest	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

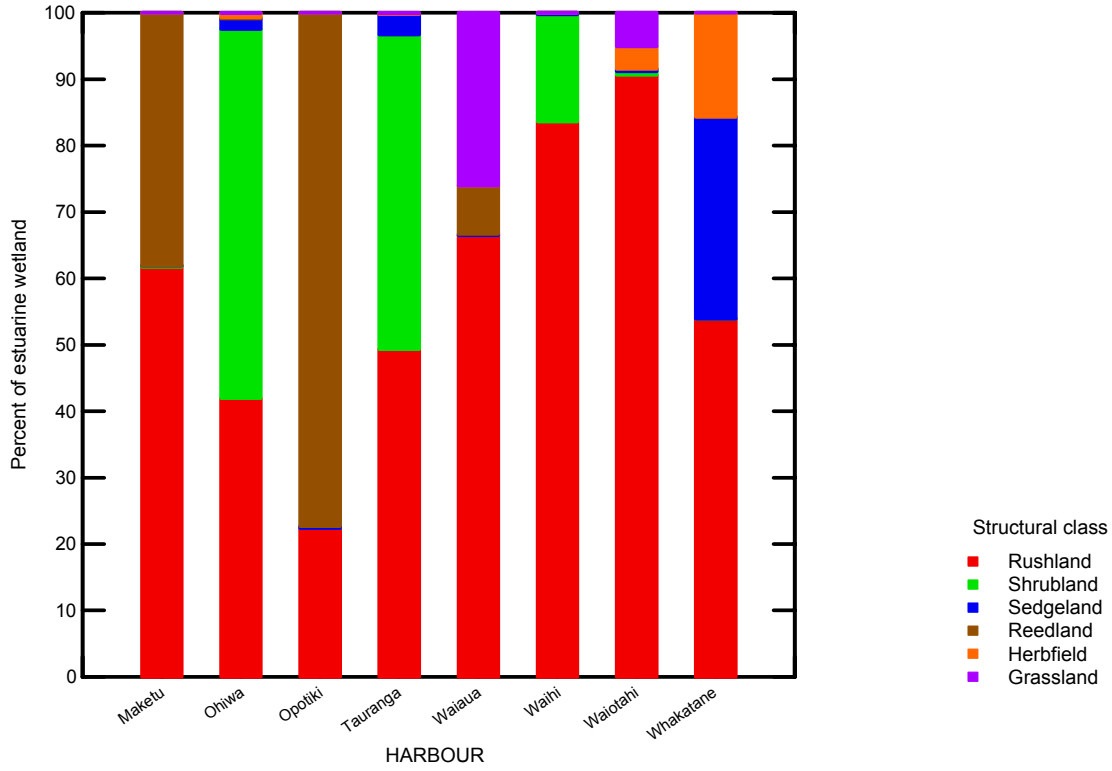

Figure 3.1 Proportion of vegetation growth form recorded within each harbour for the estuarine wetland

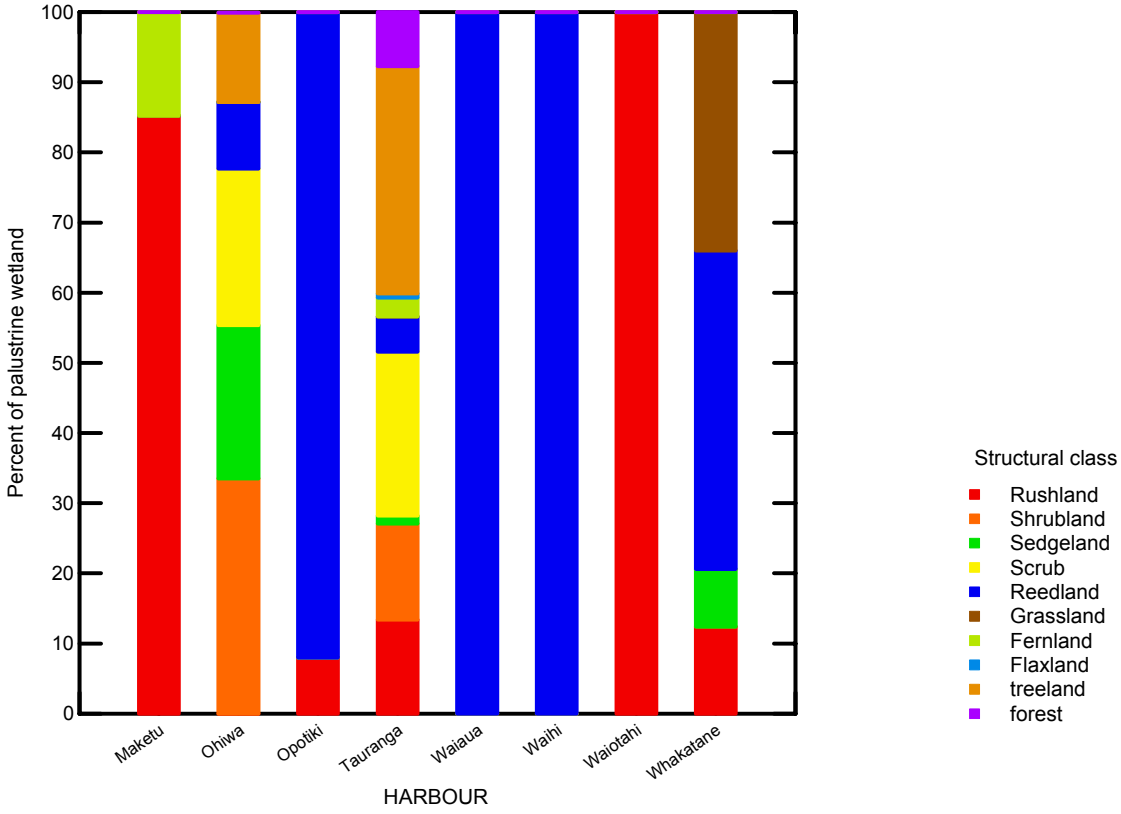

Figure 3.2 Proportion of vegetation growth form recorded within each harbour for the palustrine wetland

In both the estuarine and palustrine vegetation growth form classes shown in Tables 3.3 and 3.4 there is considerable variation in the proportion of vegetation types between the different areas. Opotiki, which has the largest amount of fresh water inflow relative to the size of the estuary, has the highest relative abundance of reed growth form both within the estuarine and palustrine classes of wetland. Figures 3.1 and 3.2 show graphically the percentage of each growth form, for estuarine and palustrine wetland respectively, within each harbour.

Tables 3.5 and 3.6 show a similar pattern of results to Tables 3.3 and 3.4. Despite the majority of wetland vegetation being present in Tauranga Harbour some areas such as the Opotiki Estuary still represent the greatest area of estuarine reedland within the Bay of Plenty. Some other growth forms such as the estuarine herbfields have very few areas in which this vegetation was both present over a large enough area and dominant enough to receive this classification. The herbfield species are reasonably common in amongst different growth form classes in areas like Tauranga Harbour which appears to have an under representation of this structural class.

3.2 Application of Quality Attributes

A number of attributes within the maritime wetland database describe the quality of the vegetation mapped. For both Tauranga and Ohiwa Harbours a ranking of the wetland areas was made in terms of its quality and representative nature, especially for consideration of gaining some form of protection and management to ensure their future sustainability.

Table 3.7 Area (ha) of estuarine wetland in Tauranga and Ohiwa Harbours that has a value ranking for each category by vegetation structural class

	Ohiwa				Tauranga		
	Cat 1	**Cat 2**	**Cat 3**	**None**	**Cat 1**	**Cat 2**	**None**
Rushland	55.7	3.3	4.4	59.7	144.2	208.12	553.36
Shrubland	143.9	4.4	1.38	13.2	387.79	221.05	261.25
Sedgeland	0.0	0.0	0	4.6	4.92	3.11	49.1
Reedland	0.0	0.0	0	0.5	0	0	0.1
Herbfield	0.0	0.0	0	1.8	0.06	0.01	0.7
Grassland	0.0	0.0	0	0.4	0.78	0	0.7

Category 1 (Cat 1) is the highest ranking of a wetland area and the "none" column in Table 3.7 above is the area that has not been deemed worthy of ranking as a representative, high quality area in Cat 1 – 3. The sedge growth form class is one type of wetland that appears under represented in areas deemed worthy of protection. In Ohiwa Harbour the shrubland growth form has 88% of this area included in Category 1 ranking. In both Tauranga and Ohiwa Harbours over half of the shrubland structural class comprises of low diversity mangrove areas. Figure 3.3 shows the relative percentages of vegetation structural class ranked into each category for both Tauranga and Ohiwa Harbours combined.

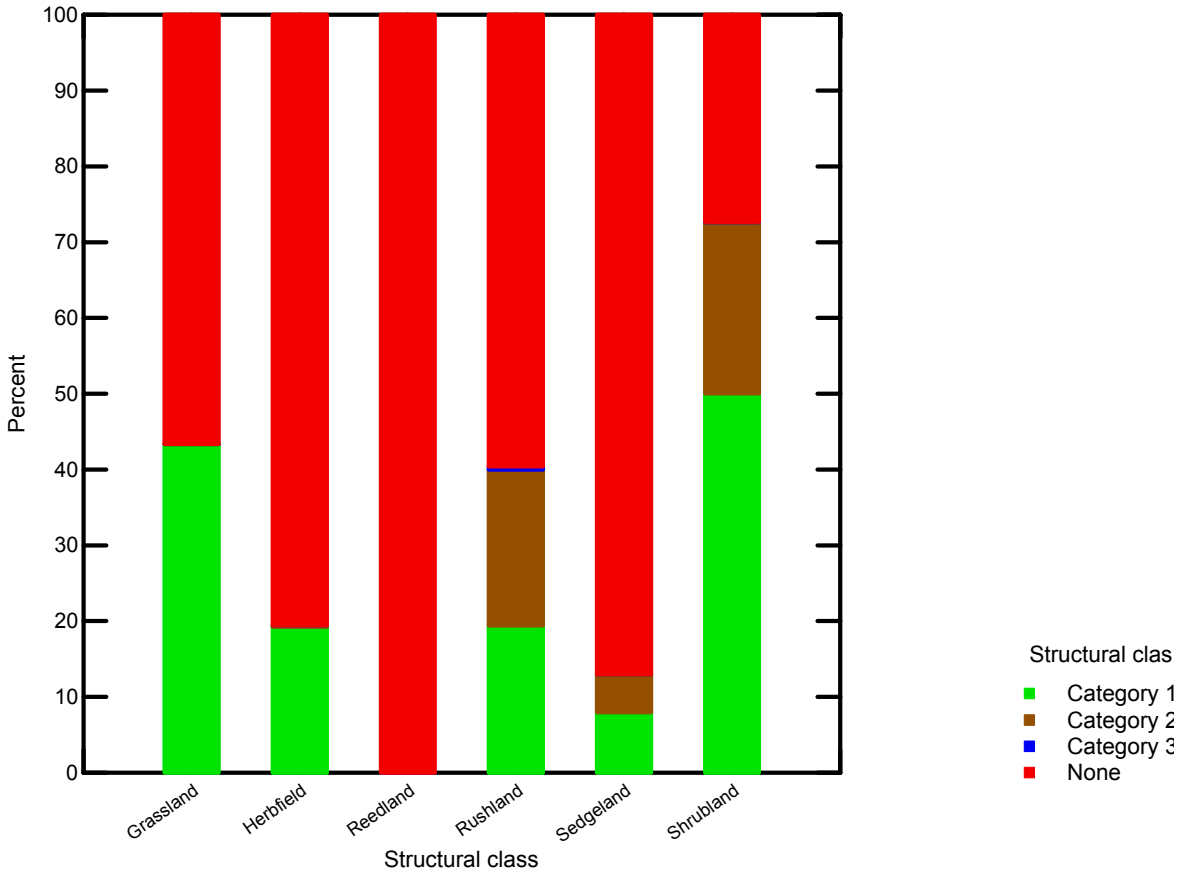

Figure 3.3 Percentage of estuarine wetland from Tauranga and Ohiwa Harbours combined receiving a value ranking by vegetation structural class

A similar analysis has been performed on the Tauranga Harbour estuarine wetland areas. Each of the mapped areas was evaluated and given a ranking of weed, pest and human impacts. The results are shown in Table 3.8 below and provided in Figures 3.4 and 3.5 as a relative percentage of each vegetation structural class.

Table 3.8 Area (ha) of Tauranga Harbour estuarine wetland as ranked by weed and pest impact by vegetation structural class

	Weeds				Human			
	None	**Low**	**Med**	**High**	**None**	**Low**	**Med**	**High**
Rushland	300.2	300.3	110.7	181.8	202.9	169.5	160.4	360.3
Shrubland	824.3	28.6	5.5	12.6	482.5	315	35.8	36.8
Sedgeland	8.7	1.5	39.9	6.9	7.1	40.2	3.8	6.0
Reedland	0.1	0.0	0	0.0	0.1	0	0.0	0.0
Herbfield	0.2	0.7	0.4	0.0	0.3	1.1	0.0	0.0
Grassland	0.8	0.2	0.5	0.0	0.8	0.7	0	0.0

Sedgeland and herbfield appear to suffer the most degradation from both weed and human impacts. This could also be one of the reasons why sedgeland appeared to be under represented in areas placed in categories for protection. Knowing that mangroves comprise over half the shrubland areas also explains why there is so little weed problems but note that they don't escape so well from human impact.

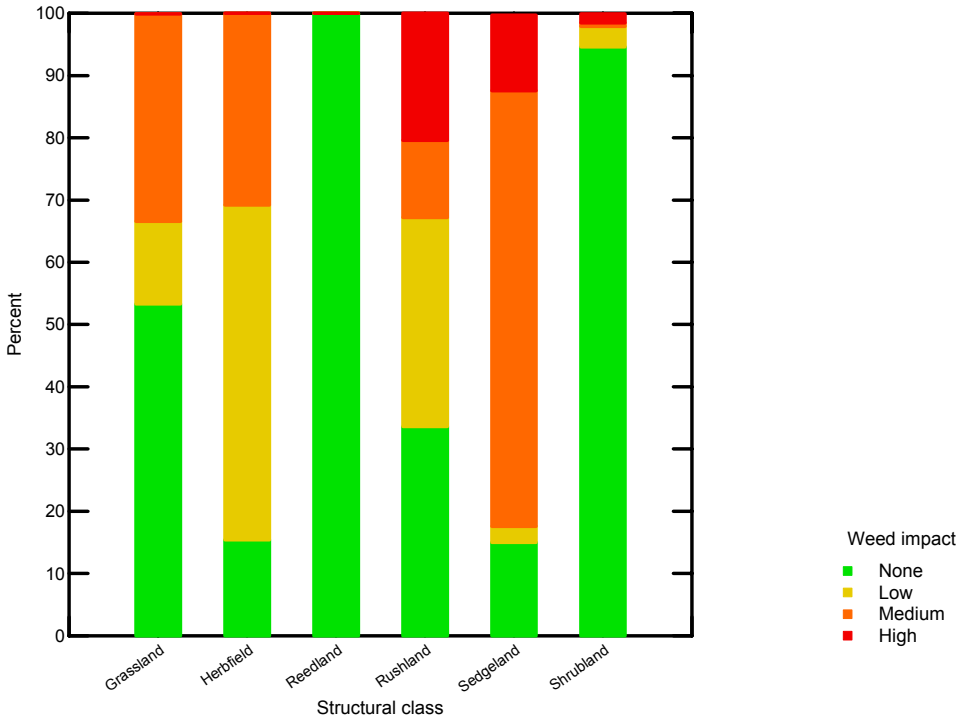

Figure 3.4 *Percentage of each vegetation structural class impacted by weeds for Tauranga Harbour estuarine wetland*

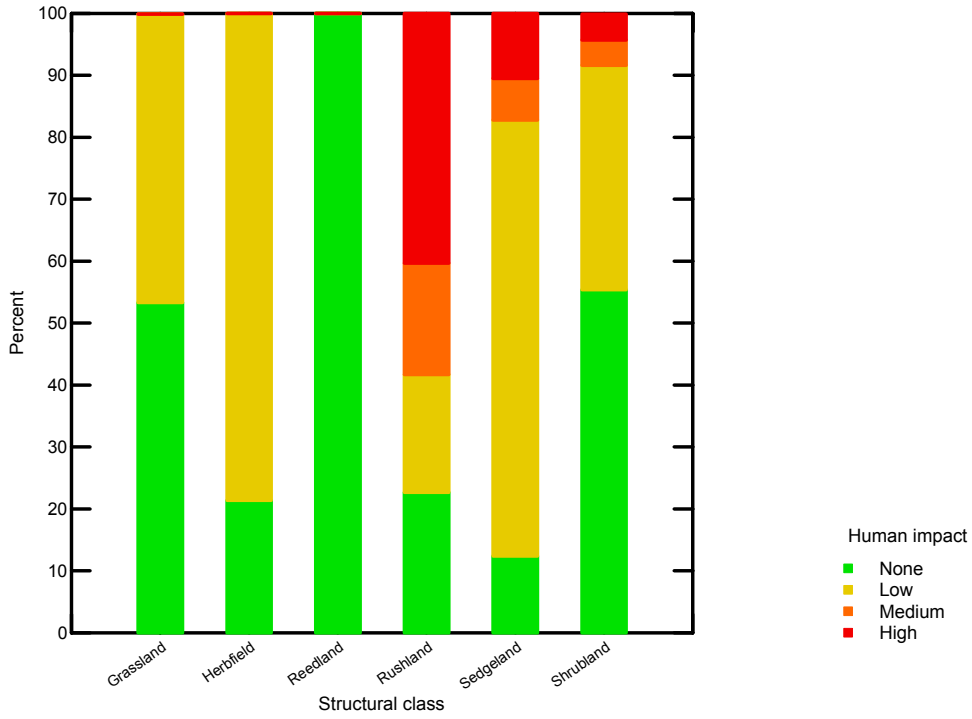

Figure 3.5 *Percentage of each vegetation structural class impacted by humans for Tauranga Harbour estuarine wetland*

3.3 Temporal changes in Tauranga Harbour

The changes in palustrine and estuarine wetland extent in Tauranga Habour have been mapped at a consistent scale of 1:10,000 for the years of 1840 and 1991. The 1840 estimate of wetland extent is a commonly used base to provide figures on vegetation types present in the absence of European modification. The areas of these wetlands and the extent of change are provided in Table 3.9 below.

Table 3.9 Area (ha) of palustrine and estuarine wetland vegetation in Tauranga Harbour for 1840 and 1991 and the extent of change

	1840	1991	%change
Estuarine wetland	1,575.7	1,839.7	+16.8
Palustrine wetland	3,001.6	469.0	-84.4

Extent of estuarine vegetation has increased since 1840. A major component of this increase is however due to the increase in mangroves. More detail on these changes is provided below. The extent of palustrine wetland around the harbour margins has shown a marked reduction with only 15.6% of this wetland type remaining. Most of the palustrine wetland drainage had already occurred by 1945 and nearly all of this was converted to agricultural uses.

The mapping of seagrass meadows in Tauranga Harbour for the years of 1959 and 1996 has previously been reported (Park 1999a, Park1999b). Results showed that over the 37-year period, seagrass had declined by 34% on average for the whole harbour. The pattern of loss correlated to sediment and nutrient inflows from the larger harbour catchments. In the northern harbour with its relatively smaller catchment area the average loss was only 10% while in the southern harbour it was 55%. In the sheltered western sub-estuaries the figure climbed to 69% average loss.

Mangrove distribution has also been mapped at several different points in time for Tauranga Harbour. Table 3.10 below provides the estimates of actual area covered.

Table 3.10 Area of mangroves (ha) in Tauranga Harbour

	1943	1974	1991
Total area mapped	341	535	707
Area of mangroves	240	375	521

The total area of mangrove for each year in Table 3.10 above has been recorded in different ways. The 1974 data comes from Bioresearches (1976) and consisted of 63 ha of dense and 471 ha of sparse mangrove. The 1991 data is density ranked into four classes and the "total area mapped" is the maximum of each class multiplied by the mapped areas. In the table, the "area of mangroves" is then the estimate of actual coverage area of mangroves for all different densities converted to 100% cover. For the 1991 data this is simply the density class mid point multiplied by the area and for the other two years a conversion factor of 0.7.

On the basis of the above treatment of mapping and estimating the 100% mangrove coverage, the rate of change over time is following an exponential increase. Since 1943 the area of mangroves has shown an average increase of between 50-60% every thirty years for the harbour as a whole.

3.4 Temporal changes in Ohiwa Harbour

The areas of palustrine and estuarine wetland and seagrass meadow have been mapped in Ohiwa Harbour for the years of 1945 and 1992. As with Tauranga Harbour estimates of the 1840 wetland extent have been made. The results of all these habitat assessments are provided in Table 3.11 below.

Table 3.11 Area (ha) of palustrine, estuarine, mangrove and seagrass wetland in Ohiwa Harbour and the percent change over time

	1840	1945	1992	% change
Palustrine	556.8	-	63.5	-88.6
Estuarine	181.0	-	293.1	+61.9
Mangrove	-	20.6	91.1	+442.2
Seagrass	-	120.7	88.3	-26.8

The area of seagrass and mangrove cover in Table 3.11 is the absolute 100% coverage value based on mid-point conversion of density classes mapped for both these habitats. As in Tauranga Harbour, the area of seagrass is declining while the mangroves are expanding. The rate of mangrove increase appears to be higher than in Tauranga Harbour while the rate of seagrass decline appears to be similar. The large loss of palustrine wetland is also similar in magnitude to Tauranga Harbour and the same reasons apply. The estimated extent of wetland in Ohiwa Harbour for 1840 is shown in Figure 3.5 and the 1992 survey results in Figure 3.6. The 1945 and 1996 distribution of seagrass meadows in Ohiwa Harbour is shown in Figure 3.7.

Increases in the estuarine wetland since 1840 can be attributed to the increase in the area of mangroves. The total area mapped as different densities of mangroves went from 28.4 to 234.4 ha from 1945 to 1992. A large proportion (around half) of this 200 ha increase will not include other saltmarsh vegetation and could easily account for all of the observed increase in estuarine wetland.

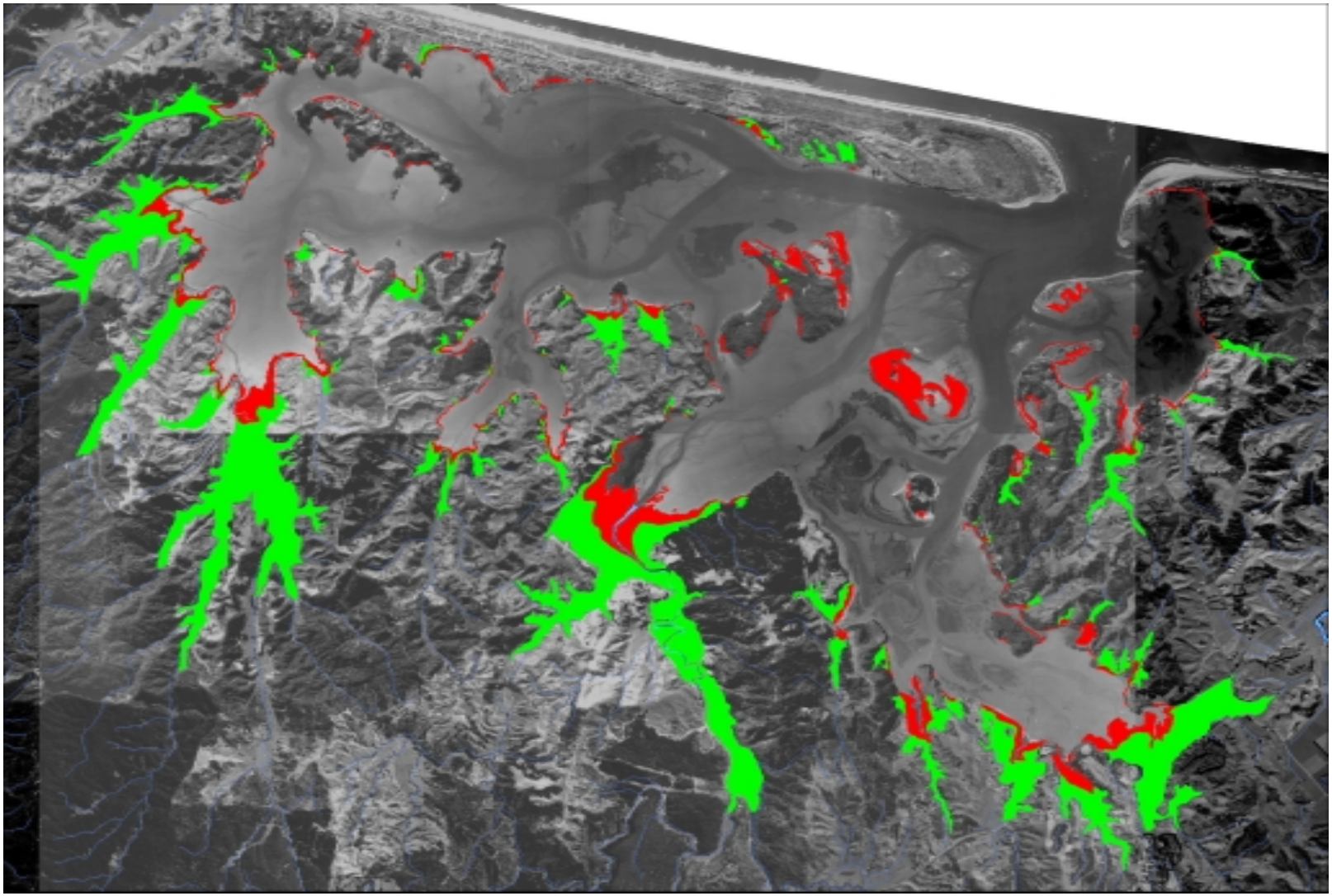

Figure 3.5 Ohiwa Harbour palustrine (green) and Estuarine (red) wetland cover estimates for 1840

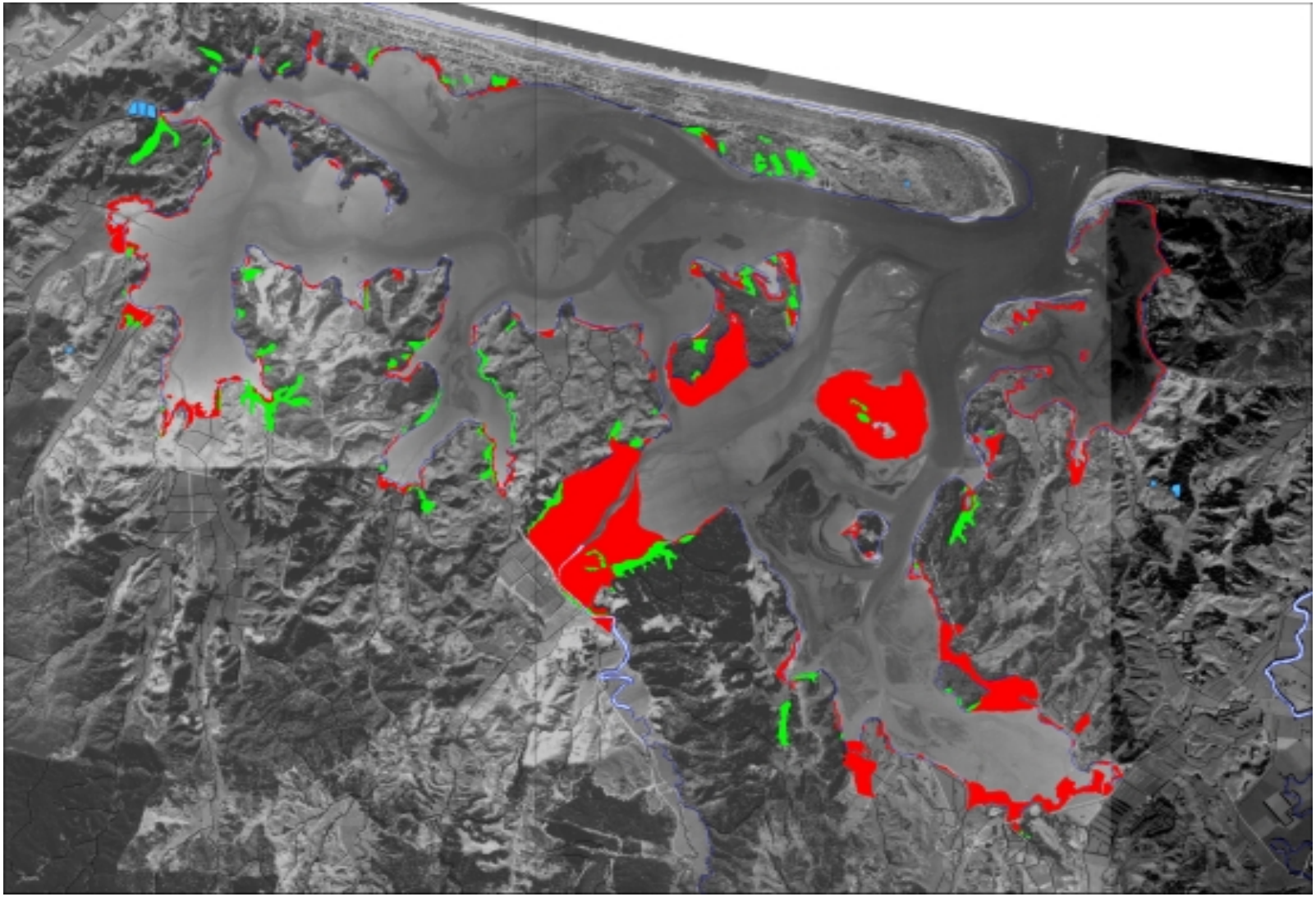

Figure 3.6 Ohiwa Harbour palustrine (green) and Estuarine (red) wetland cover for 1992.

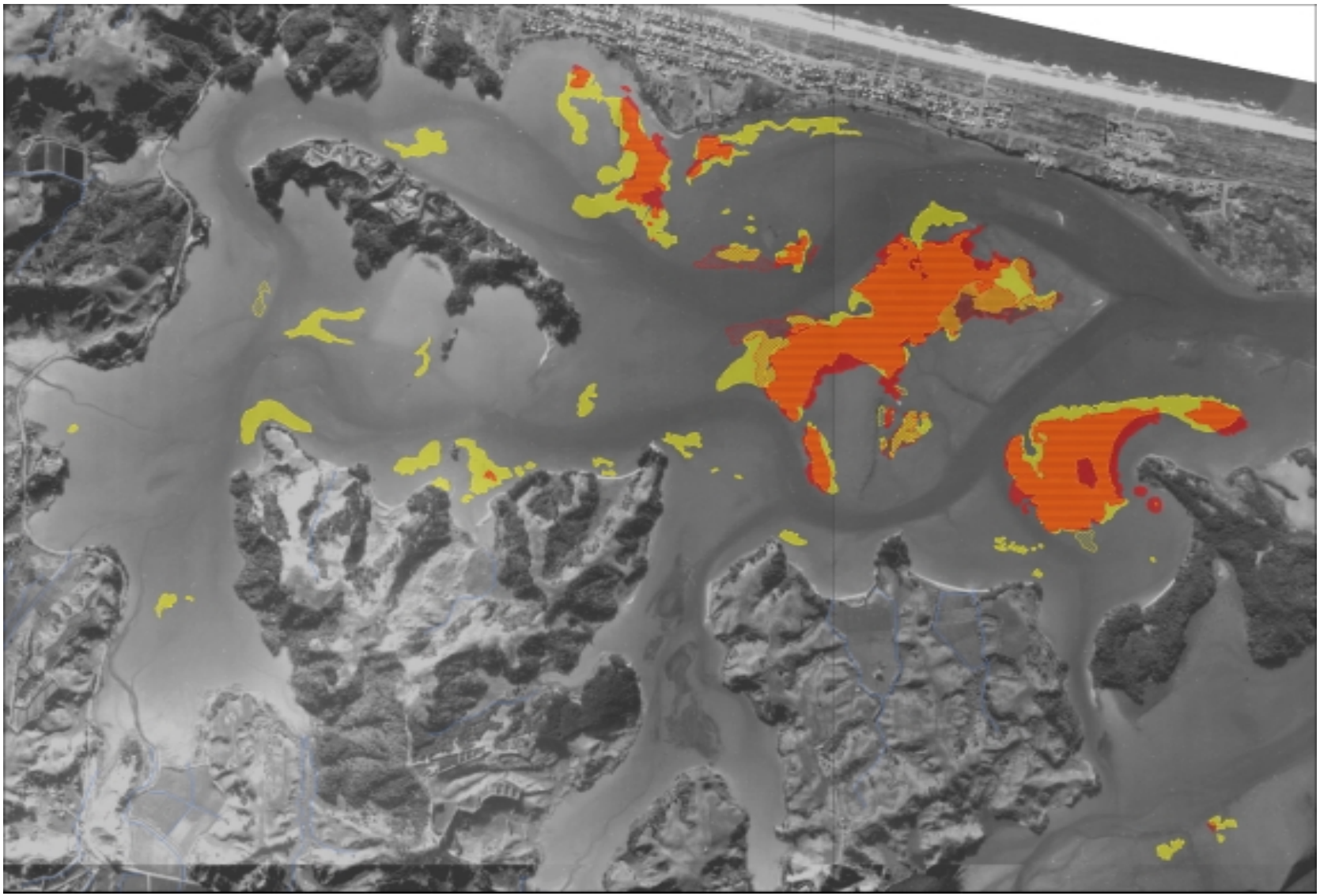

Figure 3.7 Seagrass meadow in Ohiwa Harbour in 1945 (yellow) and 1992 (red)

Chapter 4: Discussion

The results presented in this report represent only an initial analysis of the information contained in the database at the coarsest levels of detail. It is only intended that the results should display some of the utility the new system is capable of providing for environmental management purposes. There is a great deal more analysis that can be gained from the data. This could include such analysis as the abundance and dominance of species present in particular areas. The output of such data could also be used in multivariate analysis to look at community similarities and classification, ordination etc. Currently a detailed analysis of Tauranga and Ohiwa Harbours would not be appropriate because of the loss of information from the surveys on the less abundant plant species in each area.

Even with the results presented, some important aspects of the mapped areas have already emerged. One example is the difference of habitat (species and vegetation structural class) found in the different estuaries. Opotiki Estuary for instance has most of the regions estuarine reedland. Another is the under representation of the sedgeland structural growth form in areas categorised as habitat worthy of protection. Analysis of the data also showed that this most likely stemmed from the fact that sedgeland had one of the highest overall levels of weed impact. If this trend was followed throughout the country, sedgeland could by virtue of neglect become a rare and degraded habitat type.

From the point of view of the already established areas receiving some form of environmental protection by way of the "Proposed Bay of Plenty Regional Coastal Environment Plan" it is now possible to look up the vegetation types that exist there. The detailed mapping will also allow an easier assessment of whether protected maritime wetlands have been impacted. This includes baseline assessments of the impacts of weed, pests and human interference. It is not adequate to simply define the area of a wetland at different points in time and say that nothing has changed. If an area of high quality wetland is grazed and invaded by weeds it is likely that it would then have little wildlife, botanical or intrinsic values due to its poor state. The database allows both the spatial and quality assessment of change over time. The current quality assessment that has been used is poor and needs to be more rigorous and repeatable with well-defined criteria. This is one area that the national wetlands group is hoping to standardise and would be adopted for this region's wetland surveys.

The data presented on extent of wetland change over time has shown several consistent trends emerging for both Tauranga and Ohiwa Harbours. The decline in seagrass for Ohiwa Harbour is similar to the rates previously reported for Tauranga Harbour. Analyses of the patterns of seagrass loss in Tauranga Harbour correlated significantly with sediment and nutrient inputs. The same factors are likely to be responsible for the pattern observed in Ohiwa Harbour. The greatest loss of seagrass is in the upper reaches of the harbour closer to the sediment and nutrient inputs.

While detrimental to seagrass beds, sediment and nutrient inputs are the main factor behind the observed increase of mangroves in both harbours. Both the increase in substrate height and the addition of mud and nutrient to sandy shores will encourage mangrove colonisation in previously marginal areas. The rate of mangrove increase appears to be higher in Ohiwa Harbour although the actual area of additional mangroves is only 60 ha compared to Tauranga Harbour with 280 ha for the same period. It is possible that being smaller, Ohiwa Harbour has proportionately more habitat suitable for colonisation. A large proportion of Tauranga Harbour is very exposed or too deep at high tide for mangroves to survive.

Another factor commonly suggested, as a possible cause for the rapid spread of mangroves is climate change. The Ohiwa harbour mangroves are at the southern limit of the species and the main effect of temperature is that they do not reach much more than 1-2m in height. While it is unclear whether the small change in average temperature has had an influence, many northern harbours and estuaries where this factor is irrelevant, have shown similar increases.

A considerable proportion of Environment B·O·P's environmental management is linked to reducing nutrient and sediment inputs to estuarine areas and hence mangrove increase or seagrass loss. Approaches to this are holistic in nature and start back on the land at the source of the problem and use a large spectrum of tools from education through to regulation and enforcement.

One common factor accounting for the most significant loss of estuarine wetland in all Bay of Plenty harbours and estuaries has been the reclamation of these areas, especially for agricultural use. Table 4.1 below shows the areas lost and of most interest is the saltmarsh component. In total over 1,400 ha have been reclaimed which represents a 60% loss of this habitat type throughout the region as a whole. Most reclamation occurred in the early to mid 19th century with very little now occurring. Some of these areas may be able to be rehabilitated but the majority of reclamation is likely to be permanent.

Table 4.1 Provisional figures for the area (ha) of habitat reclaimed from the coastal marine area in the Bay of Plenty

Harbour	Saltmarsh	bare intertidal	subtidal
Tauranga	693.4	179.7	45.7
Ohiwa	73.9	10.4	0.0
Maketu	107.5	0.8	0.0
Waihi	403.6	0.0	0.0
Whakatane	38.1	20.0	0.2
Waiotahi	72.5	0.5	0.0
Opotiki	43.9	0.1	3.3
BOP Total (ha)	1,432.9	211.5	49.2

References

Atkinson, I.A.E. 1985: Derivation of mapping units for an ecological survey of Tongariro National Park North Island, New Zealand. New Zealand Journal of Botany, 23:361-378.

Baker, M.F. & Larcombe, M.F. 1976: Aspects of the biology of Tauranga Harbour. Prepared for the Bay of Plenty Catchment Commission and Regional Water Board by Bioresearches Ltd.

Beadel, S.M. 1992: The coastal environment plan – Tauranga Harbour wetland vegetation. Prepared for the Bay of Plenty Regional Council by Wildlands Consultants Ltd, Rotorua.

Beadel, S.M. 1993: The coastal environment plan – Ohiwa Harbour indigenous vegetation. Prepared for the Bay of Plenty Regional Council by Wildlands Consultants Ltd, Rotorua.

Myers, S.C., Park, G.N., Overmars, F.B. 1987: A guidebook for the rapid ecological survey of natural areas. New Zealand biological resources centre publication No. 6. Department of Conservation, Wellington.

Park, S.G. 1999a: Changes in abundance of seagrass in southern Tauranga Harbour. Environmental Report 1999/12. Environment B·O·P, PO Box 364, Whakatane.

Park, S.G. 1999b: Changes in abundance of seagrass (Zostera spp.) in Tauranga Harbour from 1959-96. Environmental Report 1999/30. Environment B·O·P, PO Box 364, Whakatane.

Shaw, W.B. In press: Botanical ranking of nature conservation. Department of Conservation, Wellington.

Ward, J.C. & Lambie, J.S. 1999: Monitoring changes in wetland extent: An environmental performance indicator for wetlands. Coordinated monitoring of New Zealand wetlands. A Ministry for the Environment SMF funded project. Final Report – Project Phase One. Contributing authors: Clarkson, B.D., Clarkson, B.R., Denyer, K., Gerbeaux, P., Harmsworth, G., Johnston, P.N., Partridge, T.R., Richmond, C., Smith, S. & Wilde R.H.

Appendices

Appendix I Wetland Survey Sheet

Appendix I – Wetland Survey Sheet

Environment BOP Wetland survey record sheet

Surveyed by:

Date:	**ID #:**	**Mapping scale:**
Location:	**Hydrosystem:**	**Sub-system:**
Wetland class:	**Structural class:**	**Dominant cover:**

Quality	None	Low	Medium	High	Type of impact ie species/activity
Pests					
Weeds					
Human					

Naturalness Very high / High / Moderate / low

Special features

IUCN "at risk species":
"Local" species:
Threatened communities:
Other (e.g. distributional thresholds):

Species cover present in area

					Physiognomy		Plant tier	
Species	0-5%	5-20%	20-50%	>50%	ie sedge/fern	Ground	Mid	canopy

General comments: