Preliminary Assessment of the Environmental Status of the Nelson Haven

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Preliminary Assessment of the Environmental Status of the Nelson Haven

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EXECUTIVE SUMMARY

Nelson City Council requested advice and assistance in compilation and evaluation of background information required for follow up determination of the degree of modification of the condition/health of the Nelson Haven. This information was required as a basis for future incorporation of Nelson Haven into the overall State of the Environment (SOE) monitoring framework for the region. The work was funded by the Foundation for Research Science and Technology through Envirolink NLCC18.

The present report provides:

(1) A compilation of background information relevant to the ecological condition of the Nelson Haven,

(2) Digitised historical vegetation maps of the Nelson Haven (1840, 1931 and 1985), and

(3) A preliminary Decision Matrix (DM) ranking of the ecological status and values of the Nelson Haven.

The Nelson Haven, including the intertidal habitats contained within it, is a defining feature of the city of Nelson. During the past 160 years, however, the Haven and the contributing catchment have been subjected to developmental changes that are likely to have affected estuary condition with resulting alteration of the functional integrity of the intertidal ecosystem. Potential major contributors to changes in estuary condition include:

- Opening of a new entrance channel through the Boulder Bank in 1906,
- Infilling/draining of intertidal and adjoining freshwater wetland habitats,
- Development and maintenance of port and marina infrastructure and operations,
- Hardening of intertidal margins (*e.g.* through roading, flood control *etc.*),
- Historical operation of two refuse disposal sites on reclaimed land along the southeast (landward) margin of the estuary,
- Urban, industrial and residential development with associated storm water discharges,
- Alterations in catchment land use characteristics, and
- Introduction and spread of Pacific oyster.

The present ecological state of intertidal habitats and the degree to which alteration of estuary functional integrity has occurred in response to the above perturbations has not been thoroughly assessed. Due to the considerable values attached to the Nelson Haven ecosystem, it is critical that a baseline is established describing its present ecological state as a basis for long-term SOE monitoring. Estuary-wide, broad-scale habitat mapping and fine-scale assessment of individual reference sites, according to the standardised methods set out in Cawthron's 2002 environmental monitoring protocol, are recommended. In addition to providing a means of updating historical information and assessing past changes in estuary characteristics, this would enable comparison with other estuaries in the region, and serve as a point-in-time baseline for future monitoring. Additional evaluation of estuarine water quality and shellfish faecal indicator concentrations would provide better understanding of the relationships with catchment inflows and potential sources of contamination. In conjunction with SOE

monitoring, it is recommended that scoring of the appended estuary DM spreadsheet be revised with community/iwi input and periodically updated to provide a working document for prioritising estuary management requirements.

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1. INTRODUCTION

Through a Ministry for the Environment Sustainable Management Fund (SMF) grant, with support from 11 councils throughout New Zealand, Cawthron Institute (Cawthron) developed a standardised protocol for the assessment and monitoring of New Zealand estuaries (Robertson *et al*. 2002). The resulting Estuary Monitoring Protocol (EMP) recommends that a preliminary characterisation and assessment is carried out for each estuary considered for inclusion in a regional State of the Environment (SOE) management plan.

The EMP has been implemented within a series of estuaries on the western side of Tasman Bay and in Golden Bay. A long-term objective of the Nelson City and Tasman District Councils is to incorporate all significant estuaries within the Nelson Bays into a coordinated SOE monitoring programme through implementation of the EMP. The Nelson City Council is considering inclusion of a number of estuaries in eastern Tasman Bay into this programme. The Nelson Haven (Figure 1) is one of the estuaries considered for inclusion.

Figure 1. Map of the Nelson Haven.

The Nelson City Council seeks advice and assistance in compilation and evaluation of background information required for determination of the degree of modification of the condition/health of the Nelson Haven. This information is required in summary form as a basis for future incorporation of the Nelson Haven into the overall SOE monitoring framework for the region. The work was funded by the Foundation for Research Science and Technology through Envirolink NLCC18.

This report focuses on the intertidal component of the estuary extending northeast from the tidal opening to Tasman Bay with only brief reference to the primarily subtidal Port Nelson region. The report provides:

(1) A compilation of background information relevant to the ecological condition of the Nelson Haven,

(2) Digitised historical vegetation maps of the Nelson Haven (1840, 1931 and 1985), and

(3) A preliminary ranking of the ecological status and values of the Nelson Haven.

2. METHODS

The assessment was undertaken in three steps as described in the following sections.

2.1. Summary of estuary characteristics

Background information was compiled from the general literature, data held by the Nelson City Council, the former Nelson Catchment and Regional Water Board and Cawthron's previous research and monitoring experience involving the estuary. It was organised into the broad categories described in the EMP (Part B, Appendix A). The information was briefly summarised and evaluated in relation to estuary condition.

2.2. Historical vegetation maps

Historical vegetation maps of the intertidal zone of the Nelson Haven (1840, 1931 and 1985) were converted to digital format using Arcmap 9.0 GIS software. The areas of major vegetation types were then calculated using the software. The 1840 vegetation cover was estimated from available photographs and anecdotal description. The 1931 comparison was taken from mapping results published by Davies (1931). The 1985 comparison was based on field investigation (L Mackenzie and P Gillespie, Cawthron, unpub.) and available photographic records. The resulting maps were approximate only, and intended to demonstrate major changes in the ecological structure of the estuary.

2.3. Decision matrix

The final step of the assessment was to prepare a flexible tool, the 'Decision Matrix' (DM), to give a rapid, broad overview of the condition/status of the estuary. The DM format was modified from that presented by Robertson *et al*. 2002. The revised spreadsheet uses three general categories of factors; a) existing estuary physical characteristics, b) natural character and resource values/uses, and c) characteristics that indicate an existing adverse impact. Each of the various factors was assigned a score (or rating), a weighting (multiplier) and tabulated to arrive at an overall numerical assessment. The scores provided in this report were based on the authors' perspective only and are meant to provide context for engagement/consultation to achieve a broader outlook (*e.g.* from the community, iwi and various environmental interest groups). The DM scores can be re-evaluated periodically to assess changes reflecting new information (*e.g*. monitoring results) and/or changing values. This framework can also be used to assess the present DM scores in the context of historical information (*e.g.* photographic records, reports, anecdotal perceptions) in order to determine whether changes in the various assessment factors indicate improvement, stability or degradation of estuary condition. Local knowledge can be particularly valuable by way of providing a reality check to the assigned scores and identifying changes over time that may influence interpretation.

2.4. Utility of the preliminary assessment

Once other estuaries have been similarly assessed, review of the assembled information and application of the DM will enable prioritisation of efforts within a regional coastal management strategy. By ranking estuaries within a region, based on the combination of these factors, they can be evaluated in comparative terms, enabling a risk-based approach for deciding which estuaries require the most urgent consideration for more detailed assessment and monitoring.

In completing the DM for estuaries in a particular region, it is envisaged that managers will:

(1) Become more familiar with their estuaries,

(2) Identify knowledge gaps concerning their estuaries,

(3) Identify the significant values associated with their estuaries,

(4) Identify potential threats to estuarine values,

(5) Prioritise estuary monitoring requirements based on the perceived condition, potential threats, and significant values (*e.g.* ecological, cultural, recreational, economic).

3. RESULTS AND DISCUSSION

3.1. Estuary characteristics

3.1.1. *Location, size and estuary type*

Nelson Haven (Figure 1) is a bar-built, fluvial erosion estuary, approximately 1300 ha in area, at the southern end of Tasman Bay. It is enclosed by a narrow strip of land along its eastern arm, referred to as the Nelson Boulder Bank.

3.1.2. *Morphology and hydrology*

The 13.5 km Boulder Bank that separates Nelson Haven from Tasman Bay varies in width from approximately 10-55 m at high tide. The seaward entrance to the Haven was originally around the southwest side of Haulashore Island, however an artificial opening (The Cut) was created through a low point of the Boulder Bank in 1906 to achieve a more direct access route. The estuary opens to Port Nelson and Tasman Bay at its southwestern end with tidal flats and drainage channels extending northeast from Port Nelson into an elongated intertidal embayment. Due to its shallow configuration and large tidal range (from a minimum of <1.2 m during neap tides to >4.2 m during spring tides), the upper estuary is nearly completely drained with each ebb flow resulting in near-complete exchange with the returning tide. Subtidal regions of the lower marina and harbour would be less efficiently flushed, however the volume of the tidal compartment and calculated flushing estimates were not available. The main freshwater discharge to the Inlet is the Maitai River (mean flow ~3.5 m^3/s at the river mouth) however minor contributions derive from a number of smaller streams, numerous stormwater discharges and direct runoff from hills to the southeast. During normal flows, significant reduction in the salinity is confined to surface waters of the upper inflow channels; *e.g.* reductions to 15‰ at the Nelson Marina at low tide (Updegraff *et al*. 1977). During large to extreme events, flows in the vicinity of 300 to 450 m^3/s may be achieved. This would likely result in significant salinity reduction throughout the Haven and extending into Tasman Bay.

3.1.3. *Seabed and general ecological characteristics*

Dominant features of the intertidal seabed of the Nelson Haven are extensive sand flats with significant coverage of eelgrass (*Zostera* sp.), macroalgae (*e.g. Ulva* sp. and *Gracillaria* sp.) and glasswort (*Sarcocornia quinqueflora*). Small remnant areas of rushland, primarily searush (*Juncus kraussii*) still persist in the upper estuary. Although depositional zones result in the accumulation of fine-grained sediments in some locations, the extent of mudflat coverage is not known. Earlier ecological descriptions (Davies 1931; Gillespie & MacKenzie 1990) suggest that tidal currents were sufficient to promote the export of fine-grained sediments from most regions.

A brief description of animal life in the Haven by Davies (1931) indicated a generally sparse abundance at that time. Cockles (*Chione stutchburyi*), of generally small size, were present within eelgrass beds. Although animal communities within the Haven have not been described in detail, they are likely to be comparable, in general terms, to those found in other Tasman Bay estuaries (Gillespie *et al*. 2006; Gillespie *et al*. 2007).

3.1.4. Human occupation

Based on archaeological evidence and oral history, the Nelson region may have been first settled as early as the 12th century (Sheridan 2007). Information provided in two volumes describing an account of the history of Maori of Nelson and Marlborough (Mitchell & Mitchell 2004, 2007) suggests that population densities have been generally low but variable in the vicinity of the estuary. Prior to the arrival of the first European settlers in early 1842, the Maori population in the Nelson Region was reduced to about 600. This was a result of the Tainui Taranaki incursions of the late 1820s and 1830s. Maori re-establishment proceeded in the region along with the growing European communities.

A recent estimate of the resident population within the Maitai and Nelson Haven catchments (provided by NCC), based on the 2006 Statistics New Zealand census, is 11,658. If we add the Nelson North and Port and Tahunanui populations, the total estimate would be 14,347.

3.1.5. Catchment characteristics

3.1.5.1. Area

The total land area draining to the Nelson Haven through the Maitai River catchment is approximately 91 km^2 (data provided by NCC). An additional area of about 12 ha outside the Maitai catchment boundary drains directly into the Haven through Nelson urban, industrial, and residential lands.

3.1.5.2. Geology and soils

The geology of the Nelson region, including the Maitai catchment (Rattenbury *et al*. 1998), is extremely complex and will not be discussed in detail here.

The Nelson Boulder Bank, that forms the seaward boundary of the Haven, is a unique geological feature that has been under construction through natural processes since the Pleistocene age some 10,000 years ago. This physical barrier dictates the geo-morphological, and consequently the ecological, structure of the estuary. It is composed of granodiorite pebbles, cobbles and boulders up to 0.8 m in diameter. The boulders originate from The Glen, to the northeast, and are graded in size and rounded as they are transported toward Nelson via wave energy and the Tasman Bay long shore current.

A number of geological formations to the west of the Waimea Fault (Johnston 1981) contribute to the complexity of the substrata of the Nelson Haven. These include the Brook Street volcanics and the Grampian, Kaka, Groom Creek, Drumduan, Botanical Hill, Marybank and Wakapuaka formations. The "Nelson Mineral Belt", or Dun Mountain ophiolite belt (Johnston 1981), is a prominent upper catchment feature that is of major importance to the chemical composition of Nelson Haven sediments.

According to Chittenden *et al* (1966), the main soil types of lower catchment areas bordering the Haven are the Sunny Hill Complex (moderate fertility), Wakatu Hill Soils (high fertility) and Waimea Clay Loam (high fertility, flood plain/low terrace soils). Waimea Clay Loam soils also extend up through the lower Maitai River flood plain. Steepland soils further inland include the Atawhai Steepland Complex (low to moderate fertility), Whangamoa Steepland Soils (moderate to low fertility) and Dun Steepland Soils (very low fertility). The latter soil type is a product of the Dun Mountain ophiolite belt containing large amounts of serpentine and dunite. Consequently it can contain potentially phytotoxic levels of nickel and chromium. Erosional sediment loads transported downstream during rainfall events can have a significant effect on the mineralogy of Nelson Haven sediments however the biological significance of this is unknown.

3.1.5.3. Land use

A breakdown of the land use classification of the Maitai River catchment as of 2002 (Figure 2, Table 1) shows the dominance of 54% native forest cover (including 9% manuka/kanuka) with a significant coverage of managed exotic forestry (27%) and smaller areas of gorse and broom (6%) and low and high producing grassland (4%). Not included in the breakdown were urban and residential areas, roughly estimated to be 1170 ha, that drain directly into the Haven through stormwater drains and small, intermittent stream flows.

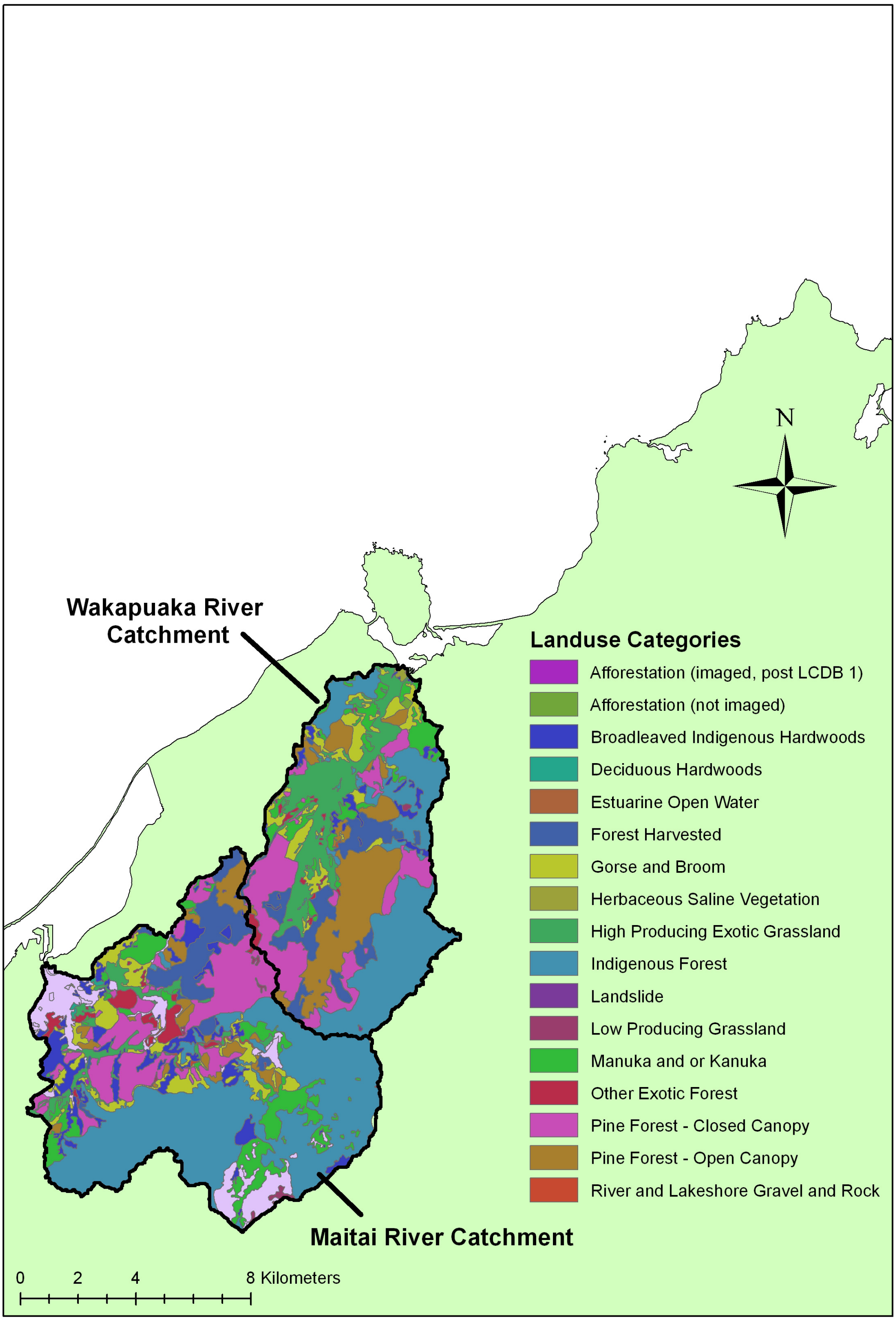

Figure 2. Land use classification map for the Maitai and Wakapuaka River catchments (data extracted from Landsat 7 satellite imagery, 2001-2).

Table 1. Land use classification of the Maitai River catchment excluding estuary habitat (data extracted from Landsat 7 satellite imagery, 2001-2).

Land Use name	Area (ha)	Area %
Afforestation (imaged, post LCDB 1)	2.0	0.0
Alpine Gravel and Rock	4.2	0.0
Broadleaved Indigenous Hardwoods	694.9	7.6
Built-up Area	274.8	3.0
Deciduous Hardwoods	15.2	0.2
Forest Harvested	576.1	6.3
Gorse and Broom	563.2	6.2
High Producing Exotic Grassland	314.9	3.4
Indigenous Forest	3441.9	37.7
Lake and Pond	34.3	0.4
Landslide	0.8	0.0
Low Producing Grassland	57.6	0.6
Manuka and or Kanuka	809.1	8.9
Mixed Exotic Shrubland	9.8	0.1
Other Exotic Forest	210.8	2.3
Pine Forest - Closed Canopy	1272.1	13.9
Pine Forest - Open Canopy	387.0	4.2
River	3.7	0.0
River and Lakeshore Gravel and Rock	25.0	0.3
Surface Mine	10.5	0.1
Tall Tussock Grassland	291. 7	3.2
Transport Infrastructure	16.2	0.2
Urban Parkland/ Open Space	109.1	1.2
Total catchment area	9137.0	100.0

3.1.6. *Estuary values and uses*

- *Cultural/historical*

The long history of Maori occupation, with numerous temporary pre-European settlements in the region of the Haven, lend to its spiritual, cultural and archaeological values. Historic value also derives from its early European visitations, selection of the site for settlement by the New Zealand Land Company and early Maori/European relations. Nelson Haven was a primary attractant which drew the two cultures together.

- *Geological*

The Nelson Boulder Bank is listed as a landform of "international importance" containing distinctive biological communities (Davidson *et al*. 1990). The significance of the Boulder Bank cannot be entirely separated from that of the adjoining estuary because their values (*e.g*. wildlife and bird habitat *etc*.) are largely integral.

- *Ecological*

The Haven is noted as important feeding and roosting habitat for wading birds, including large numbers of summer migrants and some rare and threatened species (Bell 1986). Although the considerable ecological values of the Haven have been reduced over the years due to various developments/modifications, they continue to nourish the coastal food web of Tasman Bay through the tide-mediated export of dissolved and particulate organic materials and the estuary-sea exchange of biota. Central intertidal habitats may still contain the largest areas of eelgrass meadow in Tasman Bay estuaries, and these are considered to possess particularly high biodiversity values. The estuary also provides protected habitat for a variety of fish species. For example it functions as a nursery area and feeding ground for a number of commercial species (*e.g*. snapper, flounder, kahawai) and a freshwater↔sea migratory link (*e.g*. for whitebait, yellow-eyed mullet, brown trout). Anecdotal evidence indicates that the Haven supports particularly large numbers of juvenile snapper, probably owing to its large area of eelgrass habitat (see Section 2.2).

- *Recreational*

Convenient access to the protected waters of the estuary provides for a wide range of recreational uses (*e.g*. kayaking, boating, windsurfing, fishing, swimming *etc*.).

- *Aesthetic*

The coastal outlook of the Haven with its aesthetic attributes contributes greatly to the character of Nelson and dictates land values of the surrounding hillsides.

- *Wastewater treatment*

A site reclaimed from the pre-existing intertidal zone of the Haven is used for Nelson's Wakapuaka wastewater oxidation pond treatment facility. The effluent is discharged into Tasman Bay through an ocean outfall.

- *Solid waste disposal*

During the 1940s and 1950s a refuse disposal site was located at the Haven end of Para Para Road. This site was later replaced with another site on reclaimed estuary habitat bordering the landward (Atawhai) side of the Haven. The Atawhai facility was closed in 1987 and subsequently covered and redeveloped as part of the presently existing Miyazu Gardens.

- *Shipping*

As the only Tasman Bay estuary that retains a sufficient depth of water to accommodate shipping activities, the Haven provides a high-value commercial port and marina facility for the region.

3.1.7. Water and sediment quality

A preliminary assessment of a suite of estuary water quality characteristics in the Nelson Haven (Updegraff *et al*. 1977) indicated slight nutrient enrichment and elevated faecal indicator bacteria (FIB) concentrations attributable to dairy farm run-off at the northeast end of the estuary. It was concluded that, although a number of potential nutrient sources existed, the high flushing rate and mixing with oceanic waters prevented development of eutrophic (over-enriched) conditions. FIB concentrations were sufficiently high, however, to impact on values related to harvesting of shellfish for human consumption.
Decreased water quality characteristics were reported for the lower Maitai River during a survey carried out during 1977 by Spencer & Ramsay (1978) who reported a large increase in nitrogen concentrations where the Maitai River passed through Nelson. Wilkinson (2007)

summarised surface water quality in the Nelson region, 2000-2007. He reported poor water quality in the lower Maitai River and some of its tributaries (*i.e*. The Brook, Sharland Creek and Groom Creek). Primary concerns were high FIB, nutrient and suspended sediment concentrations. Although rapid dilution and tidal flushing of fresh water inflows is likely to reduce effects to the coastal environment, it is not possible to rule out periodic (event related) or long-term cumulative effects without implementation of appropriate estuary monitoring.

Wastewater from the city of Nelson is piped across the Haven to the Wakapuaka oxidation ponds at the northeast end of the estuary. After treatment, the effluent is discharged through the Boulder Bank into Tasman Bay via a 320 m outfall (commissioned 1979). Since direct discharge without further land application represents a particular conflict with iwi values, development of an additional wetland treatment step is planned. Occasional failures of the waste-water reticulation system have resulted in raw sewage being discharged into the Haven or into contributing stormwater systems. Although these are infrequent and dealt with as quickly as possible with an accompanying media release, public concerns about the perceived level of faecal contamination still hinder recreational usage. Similar risks are associated with a fisheries outfall that pumps organic fish processing wastes across the Haven and through the Boulder Bank into Tasman Bay through a 350 m outfall (commissioned 1982), however no leaks have thus far been reported.

Port Nelson Limited (PNL) undertakes regular dredging of the seabed in order to maintain adequate depths for shipping channels, berths and marinas. Maintenance dredging has been undertaken for this purpose over a period of many years. An average volume of about 40,000 m^3 is removed from the harbour annually. Additional dredging (*e.g.* marina development and expansion, gravel extraction, seabed regrading) is carried out periodically (Roberts 1994; Sneddon & Barter 2007). All of these activities result in the introduction of fine-grained sediments into the water column. Some of these are carried into the inner arm of the Haven and potentially deposited within the intertidal zone. Some of the sediments are taken from areas that may be contaminated to various degrees due to Port activities or urban/residential sources (Bennett 2006). Sources of contaminated sediments also arise from tributary streams that discharge into the Haven. Barter & Frisk (2001) reported elevated concentrations of some contaminants in sediments of the lower Maitai River, the Brook and Oldham Creek. Thus there is a risk that contaminants could accumulate in depositional regions of the Haven. Although monitoring investigations (*e.g.* Sneddon 2005; Conwell 2007; Sneddon & Barter 2007) are able to assess the localised impacts of individual sources and predict the likely implications regarding the greater estuary environment, it is difficult to address the potential long-term cumulative effects of multiple sources. To accomplish this would require long-term estuary monitoring.

3.1.8. Exotic plant and animal species

The Nelson Haven opens to Port Nelson, a significant harbour receiving national and international shipping traffic. It is a major outlet for forestry and horticulture products and it is New Zealand's primary fishing port. Ship maintenance, repair and refitting are important activities in Port Nelson and a 510-berth marina provides moorings for recreational and some commercial vessels. The presence of a large variety of artificial substrates in the form of wharf pilings, mooring lines and various types of fill, provide potential settlement sites for introduced plant and animal species. Thus the natural character and biodiversity of the estuary is at particular risk of invasion by exotic species transported by incoming shipping. In spite of this risk, little information was found describing the present biodiversity status of the estuary apart from investigations for detection and surveillance of particular species thought to be of high risk within the Nelson Bays region (*e.g*. the Asian kelp, *Undaria pinnitifida*, which was first detected in Port Nelson during 1997). Other potential invaders include the sea squirts, *Didemnum vexillum* and *Styella clava* and a variety of bryozoans and ascidians.

An invasion by an exotic bivalve, the Pacific oyster (*Crassostrea gigas*), was reported in the Nelson region during the early 1980s (Bull 1981). Although, since that time, fluctuating populations of Pacific oyster have established at upper intertidal levels along the southeast shore, it is not known to what extent other areas of the estuary have been colonised, and the ecological implications have not been investigated. .

3.2. Historical vegetation maps

The total area of the estuary (at high water spring tide) was estimated to be 17, 15 and 13 km^2 for the years, 1840, 1931 and 1985 respectively, indicating an approximately 24% decrease due to infilling, drainage and flood control. Historical vegetation maps for the same years (Figures 3 and 4) show corresponding changes in intertidal vegetation coverage. The classifications used in the maps refer to dominant vegetation types, however in most cases a mix of species was actually present. For example "Juncus" habitat would have included searush (*Juncus kraussii*) and jointed wirerush (*Leptocarpus similis*), and "Ulva" habitat would have included sea lettuce (*Ulva* sp.) and a variety of other macroalgal species.

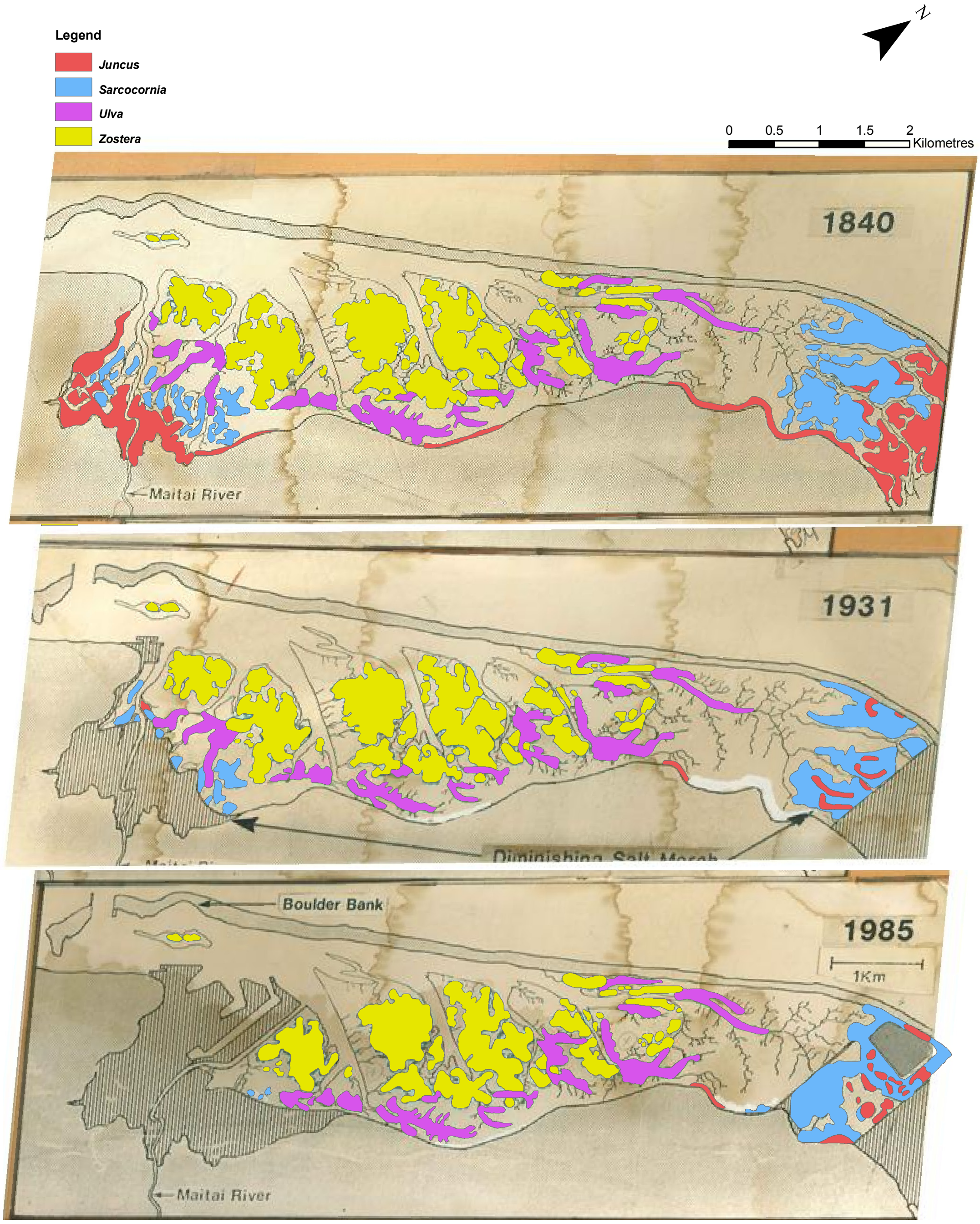

Figure 3. Historical vegetation maps of the Nelson haven.

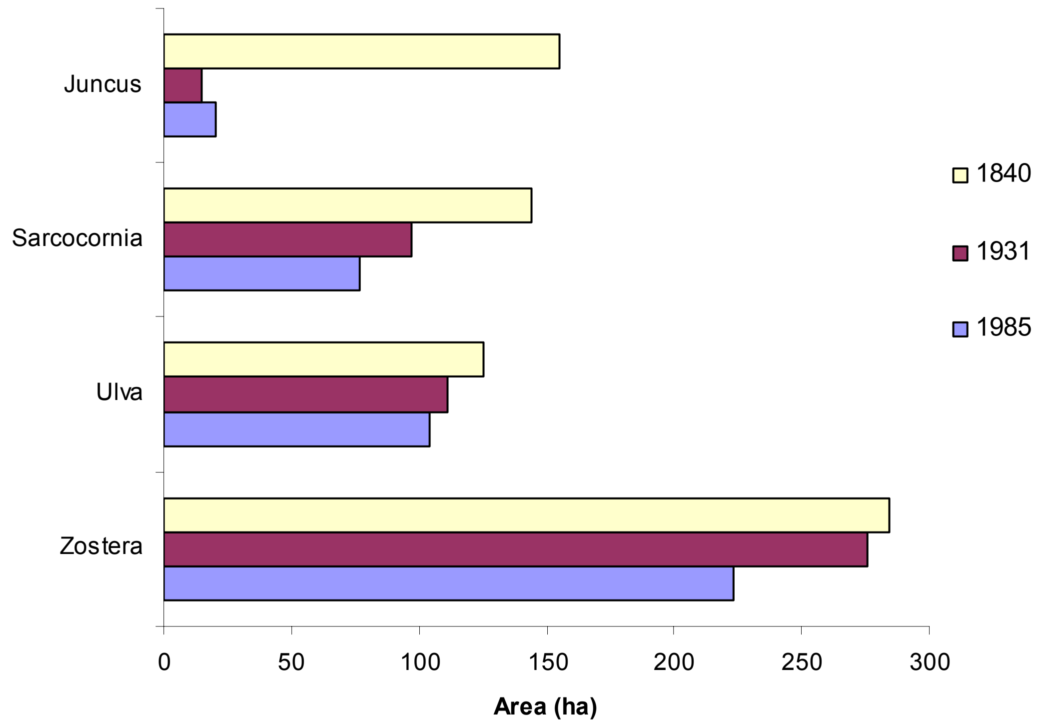

Figure 4. Estimated vegetation area coverage in the Nelson Haven, 1840, 1931 and 1985.

A 135 ha (87%) loss of peripheral rushland habitat occurred between 1840 and 1985. Most of this was associated with infilling/development of coastal wetlands of the lower Maitai River and restriction of tidal flooding to the upper estuary tidal flats. Over the same time period, reductions of 67 ha (47%) in *Sarcocornia* (herbfield) habitat, and 61 ha (21%) in *Zostera* (eelgrass) habitat, occurred. Eelgrass habitat comprised a relatively high proportion of the estuary compared to the other major vegetation types. As of the 1986 estimate, a considerably larger area of eelgrass was still present in the Haven (223 ha, 17%) than typically noted for other Tasman Bay estuaries. For example, the much larger Waimea Inlet, to the west, supports only 21 ha (<1%) of eelgrass meadow (Clark *et al*. 2006) while Delaware Inlet, to the east, supports only 8.4 ha (2.5%) of eelgrass meadow (Gillespie 2008). Because eelgrass meadows are recognised as having high ecological and biodiversity values, they may therefore represent a particularly high-value feature of the Nelson Haven. In order to confirm this, information would be required describing eelgrass biomass and the ecological composition of the associated communities.

Additional transparencies of the Haven, outlining eelgrass and sea lettuce coverage only, were prepared in 1979 and 1980 by the Nelson Catchment and Regional Water Board to assess the effects of a further Maitai reclamation and dredging of a redefined river channel. Although, based on a preliminary visual comparison, there appears to have been no major changes between 1980 and 1985, these maps are held by the Nelson City Council and could be included in future historical comparisons.

3.3. Estuary (Decision Matrix) ranking

The Decision Matrix (DM) spreadsheet appended to this report has been scored solely from the author's perspective. It is intended that these scores provide an example only, and that the DM be used as a tool by estuary managers to engage with stakeholders and prioritise monitoring requirements for the Nelson Haven by comparison with other estuaries in the Nelson Bays region. A similar ranking exercise, carried out for Delaware Inlet, is described in Gillespie (2008).

4. ECOSYSTEM CONDITION

The Nelson Haven, and the intertidal habitats within, is well recognised as a defining feature of the city of Nelson. Although substantially modified, the Haven continues to provide substantial ecosystem services for the region.

During the past 160 years, the Haven and its contributing catchment have been subjected to developmental changes that are likely to have had significant effects on the functional integrity of the intertidal estuarine environment. Potential contributors to changes in estuary condition include:

- Opening of a new entrance channel through the Boulder Bank,
- Infilling/draining of intertidal and adjoining freshwater wetland habitats,
- Development and maintenance of port and marina infrastructure and operations,
- Hardening of intertidal margins (*e.g.* through roading, flood control *etc*.),
- Urban, industrial and residential development with associated stormwater discharges,
- Historical operation of two refuse disposal sites on reclaimed land along the southeast (landward) margin of the estuary,
- Alterations in catchment land use characteristics, and
- Introduction and spread of Pacific oyster.

The present ecological state of intertidal habitats and the degree to which alteration of estuary functional integrity has occurred in response to the above perturbations has not been thoroughly assessed.

5. RECOMMENDATIONS

Due to the considerable values attached to the Nelson Haven ecosystem, it is critical that a baseline is established describing its present ecological state as a basis for long-term SOE monitoring. Estuary-wide, broad-scale habitat mapping and fine-scale assessment of individual reference sites, according to the methods set out in the EMP, are recommended. In addition to providing a means of updating historical information and assessing past changes in estuary characteristics, this would enable comparison with other estuaries in the region and serve as a point-in-time baseline for future monitoring. Additional evaluation of estuarine water and sediment quality and shellfish faecal indicator concentrations would provide better understanding of the relationships with catchment inflows and potential sources of contamination.

In conjunction with SOE monitoring, it is recommended that scoring of the appended estuary DM spreadsheet be revised with community/iwi input and periodically updated to provide a working document for prioritising estuary management requirements.

6. ACKNOWLEDGMENTS

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Nelson City Council
Paul Sheldon for providing relevant information from NCC records.
Ian Tyler, for calculation of the approximate population density of the catchment.

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Tasman District Council
Martin Doyle for estimates of Maitai River flow discharges to Nelson Haven.

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8. APPENDICES

Appendix 1. Estuary decision matrix spreadsheet for the Nelson Haven

	NELSON HAVEN	DECISION MATRIX FOR PRIORITISING ESTUARIES FOR STATE OF ENVIRONMENT MONITORING							
	Estuary Assessment Factor	**Explanation**	**Scoring Schedule**	***Preliminary Scoring***			***Consultative Scoring***		
A. Existing Estuary Physical Characteristics				**Score**	**Weighting factor**	**Total**	**Score**	**Weighting factor**	**Total**
1	Area of estuary (ha)	Value of an estuary increases with the area of the resource.	1 = <500 ha, 2 = 500-2500 ha, 3 =>2500 ha.	2	3	6			
2	Area of the estuary catchment	Estuaries with large catchment areas draining into them will be at greatest risk of land use effects.	1 = <100 km^2, 2 = 100-500 km^2, 3 = >500 km^2	1	3	3			
3	Flushing time (days)	Flushing time is the average period during which a quantity of freshwater derived from a stream or seepage remains in the estuary. The very well-flushed estuaries will be least at risk from build-up of contaminants.	1 = < 3 days, 2 = 3-10 days, 3 = >10 days	1	3	3			
4	Freshwater input (litres/s)/Area of estuary (ha) ratio	Estuaries with a high FW inflow/Area ratio have a large freshwater influence resulting in higher risk of catchment-related impacts.	1 = <10, 2 = 10-100, 3 = >100.	3	4	12			
B. Natural Character and Values									
5	Wetland and wildlife status	Estuaries are often important habitat for coastal fisheries and international migratory birds, and may be recognised as having significant conservation value. Estuaries with high wetland and wildlife status have a high perceived value and may have been assigned a regulatory status.	1 = low, 2 = medium, 3 = high wetland and wildlife status	3	5	15			
6	Recreational use	An estuary can be a significant social resource, used for water sports, food gathering, sightseeing, *etc.*	1 = low utilisation for recreation, 2 = moderate, 3 = high utilisation for recreation	3	5	15			
7	Cultural signifcance	The values of tangata whenua, including the issue of mana whenua (customary authority) may be significant to an estuary. Estuaries may have a high cultural value if they are or were a traditional food-gathering site, papa taakoro or of other cultural importance.	1 = low perceived cultural significance, 2 = medium, 3 = high perceived cultural significance	3	5	15			
8	Commercial use	An estuary can be a commercial resource with economic importance (*e.g* . for shellfish/fish harvesting, aquaculture, ecotourism, waste disposal *etc.*)	1 = low commerical use, 2 = moderate, 3 = high commercial use	2	2	4			
9	Perceived value by the communities in the region	Estuaries may have high aesthetic and amenity value to surrounding residential communites. They may also be important for education, tourism, or significant to the communities' natural character or identity.	1 = low perceived value by communities, 2 = medium, 3 = high perceived value by communities	3	5	15			
10	Diversity of intertidal habitat	Estuaries with the broadest array of intertidal habitats have the greatest potential for high intertidal biodiversity and therefore have greatest ecological value to a region. Habitats include: rushes, reeds, seagrasses, tussocks, herbfields, scrub, rock, cobble, gravel, mobile sand, sand, shell, muddy sand, soft muds, shellfish beds, sabellid beds.	1 = limited array of habitats, 2 = moderate array of habitats, 3 = most common habitats present and in good condition	2	5	10			
11	Extent of fish/shellfish resources	Occurrence of fish and shellfish resources in or near an estuary enhances its value. A drop in abundance and diversity could result from a deterioration in estuarine function.	1 = low or no fish and shellfish resources, 2 = medium abundance/diversity, 3 = High abundance and/or diversity	2	5	10			
12	Scientific investigation/education	Scientific understanding and community awareness are essential for managing estuaries sustainably. Some estuaries may provide useful study locations (*e.g* . due to location, estuary type, existing impacts, pristine qualities, *etc* .).	1 = low, 2 = medium, 3 = high scientific/educational value.	3	5	15			
13	Estuary effects on land prices	Lands surrounding estuaries are often sought after for residential or industrial development and can therefore demand higher prices.	1 = little or no effect on land prices, 2 = moderate effect, 3 = strong effect	3	5	15			
C. Characteristics that Indicate an existing or potential adverse impact									
14	Proportion of urban/Industrial landuse in the estuary catchment	Modified catchments are likely to pose greatest risk of impact to an estuary. Urban and industrial contaminants include heavy metals, nutrients, organochloride pesticides *etc.*	1 = low , 2 = medium, 3 =high extent of urban/industrial landuse	2	5	10			
15	Proportion of agricultural landuse in the estuary catchment	Modified catchments are likely to pose greatest risk to each estuary from contaminant entry. Agricultural run-off has been attributed to increased sedimentation, nutrients and contaminants in estuaries.	1 = low , 2 = medium, 3 = high extent of agricultural landuse	1	3	3			
16	Proportion of exotic forest landuse in the estuary catchment	Modified catchments are likely to pose greatest risk to each estuary from contaminant entry. Exotic forestry can impact on estuaries by causing increased erosion of the catchment and increased sedimentation in the estuary.	1 = low , 2 = medium, 3 = high extent of exotic forest landuse	3	3	9			
17	Proportion of modified to unmodified estuary catchment	The least modified catchments are likely to pose least risk to an estuary from contaminant entry.	1 = low, 2 = medium, 3 = high extent of unmodified catchment	2	3	6			
18	Estuary margin alteration (*e.g.* reclamation)	Estuaries where margins have been altered and/or reclamation has been undertaken have less value and a decreased ability to assimilate contaminant entry and increased erosion and sedimentation processes.	1 = low, 2 = medium, 3 = high extent of margin alteration	3	5	15			
19	Point Source effluents	Presence of point source discharges of wastewater (municipal, industrial and/or agricultural) into an estuary pose a high risk of contaminant entry.	1 = very low or no discharges, 2 = moderate discharges, 3 = extensive discharges.	2	5	10			
20	Aquaculture Licences	Presence of aquaculture activities in an estuary provides a greater risk of contaminant entry and other impacts (*e.g.* biosecurity risk and impingement on the natural and aesthetic values of an estuary).	1 = none existing and no known potential, 2 = none existing but potential for future development, 3 = existing aquaculture licences .	1	1	1			
21	Extent of risk of accidental spills	Accidental spillage of hazardous wastes (*e.g* . oil) lowers values in an estuary.	1 = low risk, 2 = medium risk, 3 = high risk of accidental spills	3	3	9			
22	Percentage of intertidal area comprised of soft mud	Estuaries with a high proportion of muddy habitat are likely more prone to sedimentation effects.	1 = <5%, 2 = 5-20%, 3 = >20%	2	4	8			
23	Reduction of vegetated habitat	Estuaries where vegetated (*e.g.* saltmarsh, sea grass, mangrove, *etc* .) habitats have been reduced or reclaimed have lower ecolgical value, fewer feeding and nursery habitat for animal species, and a decreased ability to assimilate contaminant and sediment entry. These habitats act as coastal buffers.	1 = Habitat extent unaltered, 2 = moderately reduced, 3 = severely reduced	3	5	15			
24	Extent of nuisance macro and micro-algal blooms	Excessive macrolgal (seaweed) growth (*e.g. Ulva* sp.) indicate nutrient enrichment. This can have widespread adverse ecological and aesthetic effects.	1 = no incidence , 2 = occasional incidence, 3 = frequent incidence and/or large areas of nuisance macroalgae	2	4	8			
25	Extent of invasive species	Occurrence of exotic invasive species can threaten the natural character and biodiversity of an estuary (*e.g.* Pacific oyster, *Spartina* sp.)	1 = no known invasive species, 2 = low colonisation of invasive species, 3 = large colonisation of invasive species	2	5	10			
26	Extent of modification of estuary hydrodynamic characteristics	The hydrodynamic processes of an estuary can be altered by gravel or sand extraction, roading, reclamation and structures, creating modified water circulation patterns, increased sedimentation, less flushing and an increase in contaminant loading.	1 = Zero to low, 2 = moderate, 3 = large extent of modification of hydrodynamic characteristics	3	5	15			
27	Extent of water clarity problems	Widespread water clarity problems (*e.g.* after heavy rain and/or wind events) lower the perceived value of an estuary, have an adverse social effect and adversely effect aquatic ecosystems.	1 = zero or rare , 2 = occasional, 3 = frequent water clarity problems	2	3	6			
28	Extent of faecal contamination problems	Widespread faecal contamination problems lower estuary values. Problems are indicated by high faecal coliforms and enterococci in the water column and shellfish, illness or perceived health risk.	1 =zero or rare, 2 = moderate, 3 = high faecal contamination problems	2	3	6			
29	Extent of nuisance odour problems	Nuisance odour problems, (e.g. from effluent, decomposing macroalgae, anaerobic sediments, *etc.)* lower estuary values.	1 = zero or rare, 2 = occasional, 3 = frequent nuisance odour problems	2	5	10			
30	Extent of toxicity problems	Widespread sediment contamination (*e.g.* metals, organics, sulphide, ammonia) lower estuary values. Toxicity problems can occur in the water and/or sediment, and may have extensive adverse effects for the biological communities.	1 = zero or low, 2 = moderate, 3 = high incidence or extent of toxicity problems	1	3	3			
31	Solid waste/litter	The presence of solid waste (*e.g.* refuse/litter) lowers estuary values.	1 = zero or low, 2 = medium 3 = high occurrence of solid waste	2	2	4			
	Total Score	**Notes: (1). This estuary is evaluated partly according to the existing degree of modification/adverse impact. The higher the final score the higher the priority for SOE monitoring and/or management intervention. (2). Where there was insufficient information to confidently assign a score, the value was entered in red.**				**286**			

Appendix 2. CD-ROM containing a working version of the historical vegetation maps