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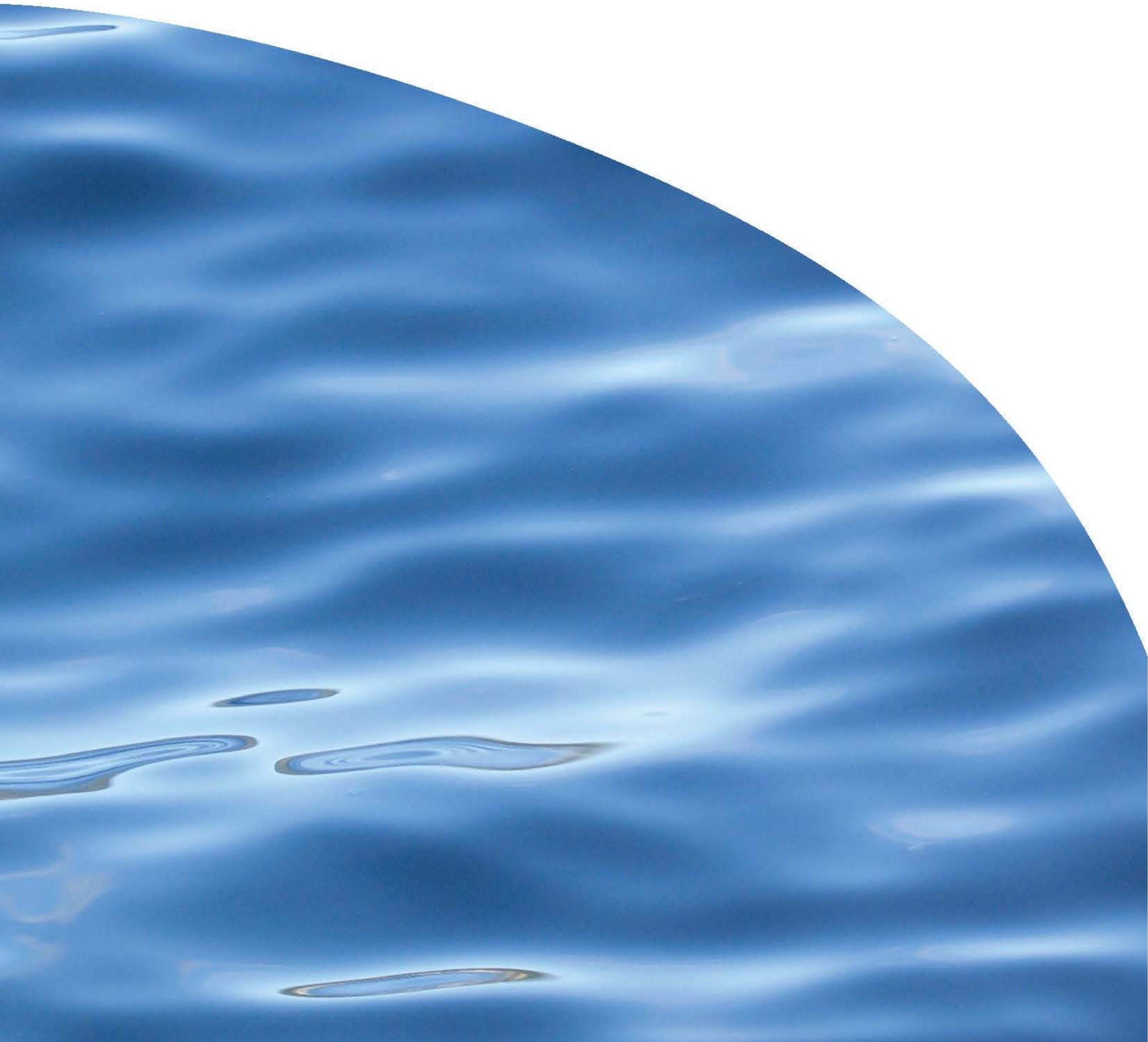
PRELIMINARY ASSESSMENT OF THE ENVIRONMENTAL STATUS OF THE WHANGAMOA INLET, NELSON



PRELIMINARY ASSESSMENT OF THE ENVIRONMENTAL STATUS OF THE WHANGAMOA INLET, NELSON

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Prepared for Nelson City Council, funded through Envirolink (1418-NLCC76)

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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 Whangamoa Inlet. This information was required as a basis for future incorporation of Whangamoa Inlet into the overall state of the environment (SOE) monitoring framework for estuaries in the region.

The present report provides:

1. A compilation of existing background information relevant to assessing the ecological condition of Whangamoa Inlet
2. A preliminary decision matrix ranking of the ecological status and values of Whangamoa Inlet
3. Identification of critical information gaps indicating the need for further investigation,
4. Recommendations for follow-up baseline investigation of estuary health.

Existing information describing estuary characteristics, although limited, suggests that Whangamoa Inlet remains in a relatively pristine condition compared to other estuaries within Tasman Bay that have been more thoroughly investigated.

The present ecological state of intertidal habitats and the degree to which alteration of estuary functional integrity has occurred in response to upper estuary perturbations and catchment land use activities, although likely minor, has not been thoroughly assessed. Due to the considerable values associated with the relatively unmodified state of the intertidal environment, it is critical that a baseline be established describing the presently existing ecological state of the Inlet. Estuary-wide, broad-scale habitat mapping and fine-scale assessment of individual reference sites are recommended. These investigations should be carried out in accordance with the standardised estuary monitoring protocol previously implemented for other Tasman Bay estuaries. This would enable a regional comparison of estuary condition and serve as a point-in-time baseline for future monitoring.

Additional evaluation of estuarine water and shellfish faecal indicator bacteria concentrations would provide better understanding of the relationships with catchment inflows and potential sources of contamination.

Preliminary scoring of an estuary decision matrix spreadsheet (appended to this report) indicates a high priority for further investigation. Numerous gaps were identified in the available information required to build a better understanding of estuary health / condition and the associated risks. In conjunction with SOE monitoring, it is recommended that scoring of the estuary decision matrix be reviewed and revised with community / iwi input and periodically updated to provide a working document for prioritising estuary management requirements.

Considering the 'assumed' relatively pristine condition of the Inlet and the associated high values attached, a collaborative management approach including major stakeholders would seem highly appropriate. Historical Māori interests in the region of the Whangamoa River mouth suggest a potential for integration of science-based indicators with iwi cultural indicators for future monitoring of intertidal Inlet habitats.

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1. INTRODUCTION

Through a Ministry for the Environment Sustainable Management Fund 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) has been implemented in more than 40 New Zealand estuaries including six major estuaries within the Nelson bays.

The protocol 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 framework. A long-term objective of the Nelson City and Tasman District councils is to incorporate all significant estuaries within the Nelson Bays into such a framework through implementation of the EMP. The Nelson City Council has previously initiated SOE monitoring of the Nelson Haven and Delaware Inlet. Whangamoa Inlet (Figure 1) is a significant estuary located ~8.5 km to the southwest of Cape Souci and is under consideration for inclusion in the Nelson bays SOE monitoring framework.

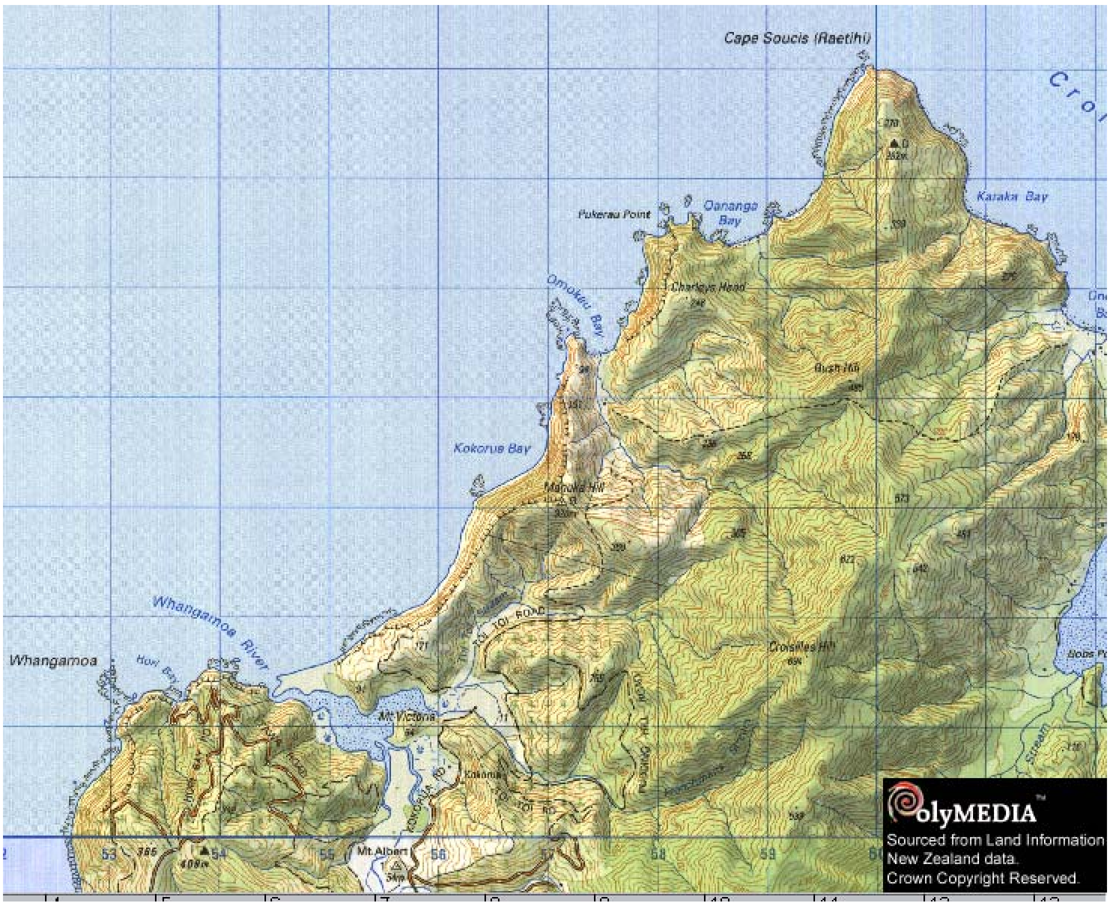

Figure 1. Location map of Whangamoa Inlet, Nelson region.

The Nelson City Council seeks advice and assistance in compilation and evaluation of background information required for determining the degree of modification of the condition / health of Whangamoa Inlet. This information is required in summary form as a basis for decisions regarding future incorporation of the Inlet into a coordinated SOE monitoring framework for the region. The work was funded by the Ministry of Science and Innovation through Envirolink 1418-NLCC76.

This report focuses on the intertidal component of the estuary and general characteristics of the surrounding lands, stream inflows and the Whangamoa River catchment. The report provides:

1. A compilation of existing background information relevant to assessing the ecological condition of Whangamoa Inlet.
2. A preliminary decision matrix ranking of the ecological status and values of Whangamoa Inlet.
3. Identification of critical information gaps indicating the need for further investigation.
4. Recommendations for follow-up baseline investigation of estuary health.

2. METHODS

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

2.1. Summary of estuary characteristics

Background information was compiled from the general literature, references held by the Nelson City Council and the Department of Conservation and personal observations during a site visit (25 October 2012). The information was organised into the broad categories described in the EMP (Part B, Appendix A), briefly summarised and evaluated in relation to estuary condition.

2.2. Estuary decision matrix

The final step of the preliminary assessment was to prepare a flexible tool, a 'decision matrix', to give a rapid, broad overview of estuary characteristics and values based on existing information. This was done to enable prioritisation of the Inlet for SoE monitoring in the context of other estuaries in the region. The decision matrix format was modified from that presented by Robertson *et al*. 2002 in order to score the Inlet according to values based on pristine qualities as opposed to values lost or reduced due to human influences. The revised matrix uses three general categories of factors:

1. Estuary physical characteristics
2. Natural character and resource values / uses
3. Characteristics that indicate a pristine ecological condition with respect to potential adverse impacts.

Each of the various factors was assigned a score (or rating), a weighting (multiplier) and tabulated to arrive at an overall numerical assessment of the priority for monitoring compared to other estuaries in the region. The scores provided in this report were based on the limited information available and the author's 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 decision matrix 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 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.

2.2.1. *Utility of the decision matrix assessment*

Because other estuaries in the region have been similarly assessed, review of the assembled information and application of the decision matrix will enable prioritisation of efforts within a regional coastal management strategy. Ranking estuaries within a region enables a risk-based approach for deciding which estuaries require the most urgent consideration for more detailed assessment and monitoring.

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

- become more familiar with their estuaries
- identify knowledge gaps concerning their estuaries
- identify significant values associated with their estuaries
- identify potential threats to estuarine values
- 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

Whangamoa Inlet (Figure 2) is a bar-built, fluvial erosion estuary on the eastern side of Tasman Bay. It is located between Delaware Inlet and Cape Souci and covers an intertidal area of ~120 ha.

Figure 2. Aerial view of Whangamoa Inlet (2011). Image Google Maps — ©2013 Google.

3.1.2. Morphology and hydrology

The Inlet is surrounded by steep hills and enclosed by a ridge of land along its northern side which extends to a sand spit tidal barrier with a narrow opening to Tasman Bay (Figure 3).

Figure 3. Outer Whangamoa Inlet, view overlooking sand spit barrier.

The volume of the tidal compartment of the Inlet has not been estimated to date. However, due to its broad, shallow configuration and the >4 m tidal range of Tasman Bay, the Inlet is largely drained with the ebbing tide resulting in a near-complete flushing with each tidal return. Based on the existing circulation patterns of Tasman Bay (Tuckey *et al.* 2006) the return of water back into the estuary with the rising tide would be expected to be minimal.

The main freshwater inflow to the estuary is the Whangamoa River (mean flow < 3 m^3/s) and minor contributions derive from the Frenchmans and Toitoi streams and a number of smaller localised streams. In view of this, freshwater contributions to the tidal compartment would be expected to be small except during high rainfall (storm-affected) periods. Salinities of ~30-35 psu would likely be characteristic throughout most of the Inlet. Exceptions would be localised regions around river / stream inflow channels where salinities would be expected to fluctuate widely with the state of the tide. During major flood events, significant salinity reduction would be expected throughout the Inlet and surface waters surrounding the outlet to Tasman Bay.

Water quality in the Whangamoa River and tributaries is classed as excellent or very good (Wilkenson 2013); however, there is some concern that a recent slight increase in nitrate concentrations may have resulted from earlier forest harvesting activities and decomposition of residual logging slash over the past decade (NCC 2012).

3.1.3. Seabed and general ecological characteristics

With the exception of possible grazing effects along estuary borders and some loss of land-sea connectivity due to small reductions of adjoining freshwater wetland areas (*e.g*. stream diversion for flood control and access tracks bisecting small inflow streams), the intertidal seabed of Whangamoa Inlet appears to be relatively unmodified. It is characterised by extensive sand and mud flats that support the production of microalgae (*e.g*. diatoms) and macroalgae (*e.g. Ulva* sp., *Gracillaria* sp., *Gelidium* sp.). Eelgrass (*Zostera* sp.) meadows are expected to be present in limited areas adjacent to tidal drainage channels at mid to low tide elevations. Although the area coverage of eelgrass in the Inlet is presently unknown, it is generally recognised as a potentially ecologically important habitat (Hemmings & Duarte 2000). Upper intertidal regions (Figure 4) contain intact stands of mixed salt marsh species (*e.g*. *Juncus krousii, Leptocarpus similis, Sarcocornia quinqueflora;* providing a natural progression from freshwater wetlands (Figure 5) and fringing terrestrial vegetation.

Figure 4. Upper estuary salt marsh vegetation.

Figure 5. Freshwater wetland (raupō marsh) bordering north eastern arm of Whangamoa Inlet.

3.1.4. Catchment characteristics

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 describes the history of Māori settlement throughout the Nelson / Marlborough region (Mitchell & Mitchell 2004, 2007). Due to limited access through the Whangamoa Valley and the generally steep terrain within the catchment, population pressures affecting the estuary have remained low. There is vehicle access to the estuary through a privately owned 4WD track, however public access is presently at the discretion of the land owners.

The 2006 Statistics NZ census lists the resident population of the entire Whangamoa region as 870 with 309 households.

Area

The total land area draining to the Inlet through the Whangamoa River catchment is 8,410 ha (Table 1) however this does not include the immediate estuary surrounds which would possibly increase the total catchment area by a few hundred hectares.

Geology

The geology of the Nelson region, including the Whangamoa catchment (Rattenbury *et al.* 1998), is extremely complex and will not be discussed in detail here. The catchment drains the Bryant and Whangamoa ranges by the Collins River, Graham Stream, Denker Creek and numerous smaller tributaries. It is likely that the catchment is interconnected with mineral-bearing substrata within the Nelson / Marlborough region. For example the Whangamoa fault runs through the Dun Mountain–Maitai mineral-rich terrane (Rattenbury *et al.* 1998). This suggests that Whangamoa Inlet sediments may contain naturally high concentrations of metals such as nickel, chromium and copper, however analyses have not been carried out to assess this.

Land use

The western side of the Inlet is largely comprised of regenerating scrubland with exotic forestry covering higher elevations. Much of the eastern side has been developed for agriculture (*i.e.* pasture) with some remaining areas of shrubs (Figure 6).

Figure 6. Pasture and shrub land bordering intertidal habitat.

Bordering farmlands drain into the intertidal zone either directly *via* diffuse runoff or indirectly through storm water flows and small, intermittent streams. Some areas are grazed down to the estuary margin and there is evidence of storm-generated erosional input of sediment (Figure 7)

Figure 7. Frenchmans Stream flowing into freshwater wetland on eastern margin of Whangamoa Inlet. Note erosion from recent storm event.

The sand spit bordering the Inlet to the north (see photo in Figure 3) has historically been used for grazing of cattle and sheep but has now been excluded from farming practices.

Land use within the Whangamoa catchment (Figure 8, Table 1) is dominated by indigenous forest (~51%) located largely in steeper peripheral regions of the catchment and exotic forest (~45%) located more centrally within the catchment. Small areas of exotic grasses border sections of the lower River. In the mid-catchment, the valley floor has been developed for farming but the valley sides and ridges are still mainly in native forest or in plantation forest. The land use in the lower catchment is also dominated by production forest, with only the valley bottom and lower slopes developed for farming and lifestyle blocks.

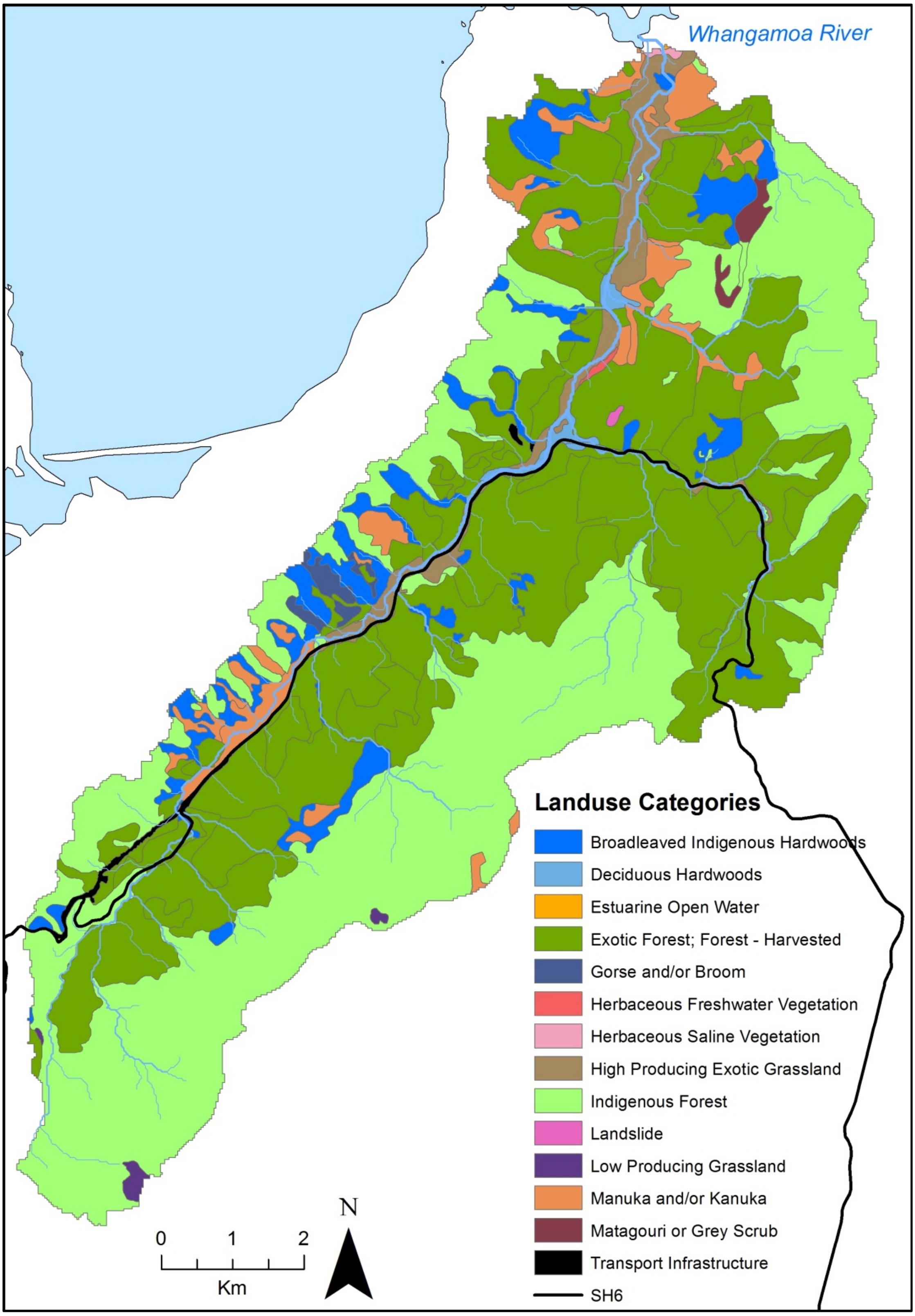

Figure 8. Land use classification map for the Whangamoa River catchment (data extracted from New Zealand's Landcover Database v3.0 (LCDB3 released at July 2012).

Table 1. Land use classification of the Whangamoa River catchment excluding estuary intertidal habitat (data extracted from New Zealand's Landcover Database v3.0 (LCDB3 released at July 2012).

Land use category	M^2	Ha
Broadleaved indigenous hardwoods	4,806,628	480.7
Deciduous hardwoods	463,909	46.4
Estuarine open water	5,403	0.5
Exotic forest	30,273,413	3,027.3
Forest — harvested	6,687,592	668.8
Gorse and / or broom	438,988	43.9
Herbaceous freshwater vegetation	50,293	5.0
Herbaceous saline vegetation	45,128	4.5
High producing exotic grassland	2,596,588	259.7
Indigenous forest	34,270,232	3,427.0
Landslide	36,062	3.6
Low producing grassland	178,611	17.9
Manuka and / or kanuka	3,641,728	364.2
Matagouri or grey scrub	337,703	33.8
Transport infrastructure	270,977	27.1
Total catchment area		8,410.3

3.1.5. Estuary values

Cultural / historical

The long history of Māori occupation in the region lends to the spiritual, cultural and archaeological values of the Inlet and surrounding lands. Numerous culturally significant archaeological sites exist along the sandspit, river mouth and Inlet vicinity (Davidson & Preece 1994, Bagley 1985). Historic argillite quarries in the upper Whangamoa catchment provided raw materials for tool development for Māori. The Whangamoa Spit is considered a site of major archaeological significance as the least disturbed of pre-European river mouth Māori settlements in Tasman Bay (Appendix 4 in Lindsay 2012). Fish and shellfish resources contained in the Inlet represent a potentially stable source of kai moana in comparison to that available from many other estuaries in Tasman Bay. However, information describing the suitability of shellfish resources for human consumption has not been reported. Although water quality in the Whangamoa River is classed as high (see Section 3.2.2) agricultural sources of faecal bacteria along estuary margins may be impacting on shellfish quality.

Ecological

The Inlet is considered by the Department of Conservation (DOC) to be of national importance as habitat for a variety of rare (*e.g*. variable oystercatcher) and threatened (*e.g*. banded rail, banded dotterel) bird species (Davidson & Preece 1994).
The Whangamoa sand spit, also known as the Kokoroa sand spit (shown in Figure 3), has been gazetted as a scientific reserve (NZ Gazette 2011). The spit includes a coastal dune system containing a variety of native and exotic grasses and shrubs. It is considered a significant ecological site that remains relatively undeveloped compared to other river mouth dune systems (Lindsay 2012) and still contains remnant populations of a variety of regionally threatened plant species (*e.g*. spinifex and pīngao). A dune restoration programme with community involvement is presently being undertaken by the DOC and the Nelson City Council to control exotic plant species and reinstate pre-existing native communities.

A collaborative (DOC, iwi, land owners and Nelson / Marlborough Fish & Game) wetland restoration / management plan pertaining to shoreline regions along the northeast and southwest arms of the Inlet is presently under discussion (pers. comm. R Gaskell, DOC).

Inlet intertidal biological communities, although they have not previously been described, potentially represent important contributions to coastal biodiversity and productivity in the region. The relatively unmodified estuarine habitats provide linkage with remaining freshwater wetland habitats acting as a buffer for catchment discharges (*e.g*. nutrients, sediments, contaminants). Although the river flow is relatively small, tidal flushing of the productive estuary habitats would likely contribute to nourishment of the food web within the surrounding marine ecosystem.

Recreational

Recreational use of the estuary is limited by the lack of public access from land. Land access is presently at the land owners' discretion, however seaward access is available *via* boat. Thus recreational usage is probably low but fish (*e.g*. whitebait) and shellfish (*e.g*. cockle) resources are likely present that would represent high 'potential' recreational, as well as the previously discussed cultural (kai moana), value.

The relatively intact progression of habitats (from terrestrial→freshwater wetland→coastal wetland→offshore marine) is rare amongst the estuaries bordering Tasman Bay. This likely provides unimpeded migratory routes for a variety of recreationally important fish species that use estuary habitats for protective cover, feeding and / or reproduction (*e.g*. whitebait, sea run brown trout, kahawai, flounder, eels) and other species that indirectly affect recreational usage (*e.g*. yellow-eyed mullet, smelt).

3.1.6. Water and sediment quality

No information is presently available describing water and sediment quality in Whangamoa Inlet. However, with the possible exception of some faecal bacterial contamination from agricultural sources, it is expected to be relatively pristine, reflecting the high water quality of the Whangamoa River (see Section 3.1.2).

3.1.7. Exotic plant and animal species

Records of a number of common invasive plant and animal species established along estuary supra littoral margins are provided by Davidson *et al*. (1994) and Lindsay (2012). However, little information was found describing exotic species within the intertidal compartment of the estuary.

An invasion by an exotic bivalve, the Pacific oyster (*Crassostrea gigas*), was reported in the Nelson region during the early 1980s (Bull 1981). Since that time, fluctuating populations of Pacific oyster have established at upper intertidal levels of many Tasman Bay estuaries; however, it is not known to what extent Whangamoa Inlet has been colonised, and the ecological implications have not been investigated.

Estimation of any potential risks of the spread of exotic species within the estuary will require a detailed inventory of presently existing biological communities.

3.2. Estuary (decision matrix) ranking

The decision matrix (Appendix 1) has been scored solely from the author's perspective. It is intended that these scores provide an example only, and that the matrix be used by estuary managers as a tool to engage with stakeholders and prioritise monitoring requirements for Whangamoa Inlet by comparison with other estuaries in the Nelson bays region. Similar rankings have been carried out for Delaware Inlet (score 280, Gillespie 2009a) and the Nelson Haven (score 286, Gillespie 2009b). Our preliminary scoring of 303 for the Whangamoa Inlet decision matrix indicates a high priority for monitoring largely due to its relatively pristine condition.

4. ECOSYSTEM CONDITION

The present ecological state of Whangamoa Inlet has not been thoroughly assessed; however, the functional integrity of the estuarine system appears to be relatively intact by comparison to other significant estuaries in Tasman Bay.

Agricultural development and flood control in the vicinity of upper estuary stream inflows appear to have had some effect on freshwater wetland habitats with potential follow-on effects on adjoining coastal wetlands.

The degree of adverse effects of physical disturbance, nutrient enrichment and / or faecal contamination from stock grazing along wetland margins has not been assessed as yet. These effects are likely to be minor at the present time although they represent a potential future risk.

Catchment land use appears to have resulted in only minor nutrient enrichment generated from forest harvesting activities and agricultural and life style blocks; however, erosional sediment discharge may have had a significant historical effect on substrate characteristics of intertidal habitats.

The possibility that catchment mineral belt sources of elevated metals have affected the biological composition of intertidal sediments has not been assessed.

5. RECOMMENDATIONS

Due to the considerable values attached to the Whangamoa Inlet ecosystem, it is recommended that a baseline describing its present ecological state be established 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. This would enable comparison with other estuaries in the region and serve as a point-in-time backdrop for future monitoring. Additional evaluation of estuarine water quality and shellfish faecal indicator bacteria concentrations would provide better understanding of the relationships with catchment inflows and potential sources of contamination.

Preliminary evaluation of the appended Whangamoa Inlet decision matrix indicates a high priority for monitoring. In conjunction with SOE monitoring, it is recommended that the decision matrix be reviewed / revised periodically with community / iwi input to provide a working document for updating estuary management requirements.

Considering the ‘assumed’ relatively pristine condition of the Inlet by comparison to other Tasman Bay estuaries and the associated high values attached, a collaborative management approach including major stakeholders would seem highly appropriate. Due to the historical significance of the region to Māori, iwi consultation with regard to future management of the Inlet would be critical.

There is strong potential for two-way benefits (and additional insight) through coordination of estuary SOE surveys and iwi monitoring initiatives. Through a separate Envirolink grant (NLCC 27), Walker (2009) has encouraged the development and implementation of a suite of iwi estuarine indicators designed to improve articulation of Māori cultural values and foster increased iwi participation in the environmental management of coastal habitats. Integration of sites and cross-referencing of the results of parallel scientific and cultural monitoring programmes within Whangamoa Inlet (and other Tasman Bay estuaries) would increase the spatial coverage of intertidal habitats in a synergistic manner thereby increasing the interpretive value of both. With further development, a multi-stakeholders approach could be implemented as a model for improved management of coastal environments in New Zealand.

6. ACKNOWLEDGEMENTS

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- Paul Sheldon (Tasman District Council) for preliminary discussions and coordinating input from the Nelson City Council staff.
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- Department of Conservation Nelson Branch staff, Andrew Baxter, Simon Moore and Roger Gaskell for access to relevant reports / information.
- Kati Doehring for providing the land-use map shown in Figure 8.

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8. APPENDICES

Appendix 1. Estuary decision matrix for Whangamoa Inlet.

	WHANGAMOA INLET	**DECISION MATRIX FOR PRIORITISING ESTUARIES FOR STATE OF ENVIRONMENT MONITORING**							
	Estuary Assessment Factor	**Explanation**		***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.	1	2	2			
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.	1	4	4			
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	2-a	3	6			
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	1-b	3	3			
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-c	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	3	5	15			
11	Extent of fish/shellfish resources	Occurrence of fish and shellfish resources in or near an estuary enhance its value. A drop in abundance and diversity could result from a deterioration of estuarine function.	1 = low , 2 = medium, 3 = High abundance and/or diversity of fish and shellfish resources	3	5	15			
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/education 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, 2 = moderate effect, 3 = strong effect on land prices	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 = high , 2 = medium, 3 =low extent of urban/industrial landuse	3	5	15			
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 = high , 2 = medium, 3 =low extent of agricultural landuse	2	3	6			
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 = high , 2 = medium, 3 =low extent of exotic forest landuse	1	3	3			
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 = high , 2 = medium, 3 =low extent of unmodified catchment	3	4	12			
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 = high , 2 = medium, 3 =low extent of margin alteration	3	4	12			
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 = extensive discharges, 2 = moderate discharges, 3 = very low or no discharges.	3	5	15			
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 = existing aquaculture licences, 2 = none existing but potential for future development, 3 = none existing and no known potential .	2	3	6			
21	Extent of risk of accidental spills	Accidental spillage of hazardous wastes (*e.g*. oil) lowers values in an estuary.	1 = high risk, 2 = medium risk, 3 = low 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% mud habitat.	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 = severely reduced, 2 = moderately reduced, 3 = unaltered saline wetland habitat.	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 = frequent incidence and/or large areas, 2 = occasional incidence, 3 = no incidence of nuisance macroalgae.	3	4	12			
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 = large colonisation of invasive species, 2 = low colonisation of invasive species, 3 = no known 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 = frequent, 2 = occasional, 3 = zero or rare 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 = high, 2 = moderate, 3 = zero or rare 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 = frequent, 2 = occasional, 3 = zero or rare nuisance odour problems.	3	3	9			
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 = high, 2 = moderate, 3 = zero or low incidence or extent of toxicity problems.	3	3	9			
31	Solid waste/litter	The presence of solid waste (*e.g.* refuse/litter) lowers estuary values.	1 = high, 2 = medium, 3 = zero or low occurrence of solid waste.	3	3	9			
	Total Score	**Notes: (1). In this estuary, monitoring priority is placed on pristine rather than modified characteristics. 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.**				**303**			

a Presently low use but high potential.
b Unknown potential.
c Few local residents but high value regionally.