

Habitats and Ecological Values of the Hokianga,

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1.0 Introduction

1.1 Background

This report presents ecological information on particular aspects of Hokianga Harbour, Northland.

The environmental aspects investigated during the present study included:

1.0 Existing information

Intertidal habitat description and mapping

Preliminary intertidal values and their evaluation

4.0 Human impacts on ecological values

- nutrient enrichment
- toxic substances
- loss of estuarine habitats
- causeways
- introduced predators and domestic animals
- stock damage of estuarine fringe vegetation
- weeds and introduced species
- fire

5.0 Ecological issues and management recommendations

- tidal flow and sediment transport
- disturbance to wildlife

- *Spartina*
- disturbance or loss of estuarine and freshwater habitats
- introduction of contaminants
- restoration or protection of peripheral habitats
- protection of marginal vegetation from stock
- creation of high tide bird roosts
- predator and possum control around wetland margins
- promotion of estuary education, tourism and landscape values
- legal protection of further areas

6.0 Protection mechanisms and recommendations

- Legislation options for the intertidal and subtidal environment
- Concepts for the protection of the ecological values of Hokianga Harbour

1.0 Existing Ecological Information

1.1 *Hokianga Harbour*

A variety of reports have been produced that outline values and threat in Hokianga Harbour. They are in brief summary:

- 1) Davis and Bellingham (1984) stated that Hokianga Harbour was some 15,414 ha in size making it the fourth largest harbour in New Zealand. The Harbour is a drowned river valley draining a catchment of 156,302 ha. Main rivers entering the Harbour are the Manganuka, Waipapa-Waihau and the Waima-Taheke. Smaller rivers include the Tapuwae, Whakarapa, Omania, Orira and the Whirinaki. There are numerous small streams and creeks that enter the Harbour. The authors listed and discussed the range of bird species and the areas that they utilised in the Harbour. The authors also attached a habitat map outlining the major vegetation and substratum types.
- 2) McLay (1976) stated that the tidal flow was the factor that predominantly influenced water circulation in the Harbour and not freshwater inflows.
- 3) The authors of the Coastal Wetland Inventory (Volume 2) stated that the Harbour was 11,500 ha in size with approximately 2,900 ha supporting mangroves. The authors stated that during the 1930's as depression relief work large areas of the Harbour was reclaimed. In addition, between 1979 and 1984, large areas of the Harbour were illegally reclaimed.
- 4) In a Ministry of Agriculture and Fisheries publication investigating marine reserve options in the Auckland region the authors stated that the upper Hokianga Harbour supported some of the finest large mangroves in New Zealand.
- 5) Ogle (1992) stated in a report on the wildlife values of Northland that *Spartina* was abundant on particular mud-flat areas in the Harbour.
- 6) In the Hokianga Harbour Plan Preliminary Draft (Hokianga County Council, 1985) the authors stated that there were two water quality problems in the Harbour (1) excessive siltation and water discolouration from accelerated erosion and (2) bacterial and viral pollution as a result of poor sewage disposal practices and surface runoff from pastoral land. These authors stated that changes to sewage reticulation schemes should improve the

situation particularly in the Rawene area.

1.2 Coastal Resource Inventory

Shaw and Maingay in the Department of Conservation Coastal Resource Inventory (1990) summarised the ecological values of Hokianga Harbour and listed the threats and human modification. They rated the harbour as internationally important on the grounds that the wetlands were important to a range of birds including migratory species. The authors also stated that the pleistocene dunes, coastal forest remnants and archaeological sites were of national importance.

Other ecological values listed in the report included:

- a band of saltmarsh and mangrove vegetation around extensive areas of the Harbour;
- in particular areas of the harbour saltmarsh and mangrove are contiguous with freshwater wetlands;
- the Harbour is important to a variety of bird species many of which are status species; and
- the South Head supports the only known population of and undescribed species of *Hebe*.

The authors stated that there were two Scenic Reserves located adjacent to the Harbour at Tapuwae and Mangataipa and a Historic Reserve located at the South Head.

The authors stated that threats to the Harbour included the exotic cord grass *Spartina*, stock grazing and trampling of saltmarsh, sediment deposition and turbidity derived from erosion in the catchments, and reduced water quality from effluent and pastoral run-off.

2.0 HABITAT DESCRIPTION AND MAPPING

2.1 Methodology

All fieldwork was conducted from 4th to 8th June 2001. Major intertidal habitats and substratum types were mapped onto 1:15,000 colour aerial photographs. Major vegetation types and habitat groups were mapped directly onto the aerials.

A variety of methods were used to map habitat and substrata. These methods included:

- a boat was used to survey the main and secondary channels;
- many of the tidal flats and areas behind the mangroves were investigated on foot. In particular areas the adjacent hills were climbed in order to gain an elevated view of the tidal areas; and
- most of the roads and farm tracks around the Harbour were visited by vehicle in

order that an elevated view of tidal areas would be obtained.

Features that were mapped included:

- tidal boundaries of the harbour (i.e. the point where estuarine or tidal plants and substratum were replaced by freshwater or terrestrial habitats). This boundary was mapped as the upstream penetration of marine habitats as well as the Harbour edge extent of marine habitats.
- major substratum types were mapped. The substratum types were based on visual and textural characteristics and were largely based on Wentworth parameters; and
- intertidal plant species were recorded at distinct monospecific polygons or as a groups of species. In the case of areas with a variety of species the species were listed in order of dominance.

Other features that were noted during the investigation were:

- dominant conspicuous epibenthic (surface dwelling) intertidal macroinvertebrates were recorded from particular sites and habitats within the Harbour;
- a list of conspicuous human related impacts was compiled;
- brief notes on adjacent terrestrial plant cover were taken; and
- brief notes on the presence of pest or weed species within the harbour were collected.

It is important to note that habitat and vegetation maps do not show small-scale variations in sediment type or vegetation patterns. For example, at the 1:15000 scale it was often impossible to separate distinct plant or substratum types often found in close association. Vegetation and/or substratum types often formed mosaics. In these cases, the mosaic was displayed as a group of species or substratum types depicted in the order of their relative abundance (i.e. the first species in the list is dominant with subsequent species representing declining abundance).

Due to the time of year when mapping occurred it was difficult to differentiate between vegetation stands dominated by *Spartina alterniflora* and *Leptocarpus similis*. This was due to *Spartina* having an autumn red hue that was difficult to separate from the colour and texture of *L. similis*. The inability to differentiate the difference between these species occurred even at relatively close range (i.e. 30 m) increased the possibility of underestimating the extent and area covered by *Spartina*.

The quality of the aerial photographs available during the present study was relatively poor. It is therefore recommended that should better quality aerial photographs be flown in the future (i.e. at low altitude, around midday, in summer at low tide), the mapped information collected during the present study be reassessed. It is probable that better separation of habitats and resolution of habitats and substratum could be achieved using better quality photographs.

2.2 RESULTS

2.2.1 Intertidal habitats and substratum types

During the present study, a total of 12 intertidal habitats and substratum types were recognised from intertidal Hokianga Harbour. No survey of the subtidal habitats was conducted during the present study.

Freshwater wetland habitats such as *Scirpus fluviatilis* and raupo (*Typha orientalis*) stands were observed around the Harbour, particularly in the heads of the river arms, but were not mapped as part of the present study. Davis and Bellingham (1994) mapped 246 ha of reclaimed harbour habitats. Historic reclamations were not mapped as part of the present study.

Bedrock (R)

Bedrock substratum was defined as solid rock substratum. Bedrock was located in the lower and central Harbour, particularly around and adjacent to headlands.

Boulder (B)

Rocks greater than 256 mm in size. These substrata were most often recorded from the central and lower Harbour along the main channel edges.

Cobble (C)

Rocks from 64 mm to 256 mm size. This substrata was most often recorded in association with boulder and pebble substrata and was observed from the central and lower Harbour along the main channel edges.

Pebble (P)

Rock material from 4 mm to 64 mm in size. This substrata was most often recorded in association with boulder and cobble substrata and was observed from the central and lower Harbour along the main channel edges.

Coarse sand (CS)

Coarse sand was defined as substrata from 0.5 mm to 4 mm particle size. This material was recorded from particular locations in the harbour as long and narrow raised banks often located near the head of relatively wide bays located along the main channel of the Harbour. These areas appear to have been formed by a combination of wave and tidal current action. The sand sedge (*Carex pumila*) was often recorded in association with these sandbanks.

Sand (S)

Sand was defined as 0.25 mm to 0.5 mm particle size. This substratum was relatively widespread in the lower Harbour, particularly on the northern shoreline.

Fine Sand (FS)

Fine sand was defined as particles < 0.25 mm. These tidal flats appear similar to mud flats, but were distinguished by a granular texture and their ability to support the weight of an adult human. This substratum often formed extensive tidal flats located in the central Harbour.

Mud (M)

Mud was defined as constituting a combination of silts and clays (< 0.063 mm in diameter). This habitat is easily recognised by a glutinous appearance and black anaerobic layer relatively close to the surface. Intertidal mud areas were relatively widespread in the Harbour arms, backwaters and bays free from the influence of strong tidal currents.

Native Rushes (*Juncus maritimus* (J), *Leptocarpus similis* (L))

Two rush species (*Juncus maritimus*, *Leptocarpus similis*) were the most common salt marsh plant species observed within the Harbour. Rushes were observed as either a relatively narrow strip around the Harbour edges or formed expansive beds particularly in the arms of the upper Harbour. No marine sedge salt marsh species (e.g. *Schoenoplectus pungens*) were observed from the Harbour during the present investigation.

Cord grass (*Spartina alterniflora*, *Spartina anglica* (Sp) beds

Spartina alterniflora was relatively widespread within the central and upper Harbour. In these areas it was recorded as distinct patches (i.e. < 100 m²) or was recorded as extensive beds. One patch of *S. anglica* was recorded from within the Harbour during the present investigation.

Herbfield (*Selliera radicans* (Se) and *Samolus repens* (Sa)

Herbfields were defined as areas of low lying salt marsh species. Turfing or herb fields habitats were relatively rare within the Harbour and were usually restricted to isolated patches at a relatively high tidal height. Herbfields were dominated by remuremu (*Selliera radicans*), sea primrose (*Samolus repens*), glasswort (*Sarcocornia quinqueflora* (Sq)), button weed (*Cotula coronopifolia*), bucks-horn plantain (*Plantago coronopus* (Pl)), sedge (*Isolepis prolifa* (Is)), and sea celery (*Apium* “white denticle”). The introduced *Paspalum vaginatum* was also recorded from the Harbour during the present study.

Mangrove (Mn)

The mangrove (*Avicennia marina* var. *resinitera*) was observed as mature trees along the main and secondary channel edges and as small or stunted trees growing away from the channel edges. These smaller mangroves often formed lower density stands compared to the trees growing adjacent to the main channels.

2.2.2 Invertebrate communities

Notes were collected on the presence/absence of dominant conspicuous epibenthic (surface dwelling) intertidal macroinvertebrates from ten sites around the Harbour (Table 1). A variety of habitats, tidal heights and locations were investigated.

Table 1 Locations where notes on dominant surface dwelling macroinvertebrates were collected.

Site no.	Site name	Substrata/habitat	Tidal height
1	Kohukahu	Mudflat, pebbles	High
2	Waima River	Salt marsh	High
3	Ohuri	Salt marsh, herbfield	High
4	Otawhiti	Fine sand	Middle
5	Otawhiti	Mangrove	High

6	Kauwhara Point	Boulder, cobble	Middle
7	Kauwhara Point	Rock	Low
8	Te Mata Point	Fine sand	Middle-low
9	Te Karaka	Rock	Low
10	Te Motu Island	Rock	High

A variety of dominant macroinvertebrate species were recorded from Hokianga Harbour. Both marine and estuarine species were recorded from the Harbour. Species regarded as truly marine were recorded penetrating into the harbour to at least Onoke some 12 km from the entrance. Examples of these species included the paddle weed (*Ecklonia radiata*), wide and narrow flapjack (*Capophyllum flexuosum* and *C. maschallocarpum*), topshells (*Melagraphia aethiops*, *Diloma substrata*), oyster borer (*Lepsiella scobina*) and cats eye snail (*Turbo smaragdus*). Truly estuarine species were also recorded from though out the harbour (eg. mudflat whelk, *Cominella glandiformis*; cockle, *Austrovenus stutchburri*; mudflat snail, *Amphibola crenulata*; estuarine snail, *Potamopyrgus estuarinus*).

Table 2 Species list of dominant conspicuous surface dwelling invertebrates. Numbers refer to: 1 = occasional, 2 = common, 3 = abundant or zone forming.

Species	Common name	Sample site									
		1	2	3	4	5	6	7	8	9	10
MOLLUSCA											
<i>Amphibola crenata</i>		2	2	2	2	3			2		2
<i>Atrina zelandica</i>									1		1
<i>Austrovenus stutchburyi</i>					2				1		1
<i>Crassostrea gigas</i>		1	2	2	1	3	1	2	1	1	1
<i>Cominella glandiformis</i>					2	2			2		2
<i>Diloma subrostrata</i>							2	2		2	
<i>Lepsiella scobina</i>							2	1			
<i>Melagraphia aethiops</i>							2	3		2	
<i>Pecten novaezelandiae</i>									1		1
<i>Perna canaliculus</i>								1			
<i>Potamopyrgus estuarinus</i>		2	3	2							
<i>Triostrea lutaria</i>								1			
<i>Turbo smaragdus</i>								1		1	
<i>Zeacumantus</i> sp.					2				1		1
CRUSTACEA											
<i>Elminius modestus</i>							3	1			
<i>Helice crassa</i>		3	3	3							
<i>Hemigrapsus edwardsii</i>							2	1		1	
<i>Leptograpsus variegatus</i>							2				
<i>Macrophthalmus hirtipes</i>					2				1		1
<i>Pagurus</i> spp								1		1	

ECHINODERMATA

<i>Coscinasterias calamaris</i>	1	1
<i>Fellaster zelandiae</i>	2	2

ALGAE

<i>Carpophyllum flexuosum</i>	1	1
<i>Carpophyllum maschalocarpum</i>	1	
<i>Hormosira banksii</i>	1	
<i>Ecklonia radiata</i>	2	2
<i>Rhodomenia sp.</i>	1	1

2.2.3 Areas of Particular Importance to Birds

As part of the present study, areas important to birds were identified and described. A variety of wildlife habitats are known from Hokianga Harbour. Each habitat is utilised by a variety of bird communities.

The range of habitats have been summarised as follows:

- open tidally flooded mud and sand flats;
- beaches;
- sand dunes;
- cobble, boulder and rock;
- native rush-lands and peripheral shrubs;
- *Spartina* grassland;
- permanent water;
- shallow water (< 0.5 m depth);
- deep water (> 0.5 m depth);
- peripheral trees;
- tidal freshwater vegetation;
- native herb-field;
- artificial structures; and
- islands.

Open tidally flooded mud and sand flats

This feeding habitat is utilised by a variety of wading bird species including regularly observed species such as banded dotterel, pied stilt, godwit and ducks and less frequent visitors such as lesser knot and wrybill. These mud and sand flat areas support invertebrates including shellfish (e.g. cockles), snails, crabs and worms that provide a staple food for many different wader bird species.

Large areas of sand flat occur in the lower Harbour (i.e. Onoke to the entrance), while large areas of mudflat occur in the central and upper Harbour. According to Davis and Bellingham (1984) some separation in species utilisation between sand flats of the lower Harbour and the mudflats in the central and upper Harbour occur. For example, waders excluding stilts and herons tended to utilise the sand flats of the lower Harbour.

Beaches

Relatively large areas of beach habitat is located between the northern entrance to Waitapu. These areas are important to roosting waders such as New Zealand dotterel, wrybill and banded dotterel.

Sand dunes

Extensive dune areas are located at the north head of the Harbour. These areas are used as breeding sites by variable oystercatcher, black-backed gull and New Zealand dotterel.

Native rush-lands and peripheral scrubs

There are extensive *Juncus maritimus* and *Leptocarpus similis* saltmarsh habitats in the upper Harbour and at the heads of many of the river arms. In particular areas the saltmarsh grades into ribbonwood (*Plagianthus divaricatus*), raupo (*Typha orientalis*), native vine (*Muehlenbeckia complexa*) and other small hardy shrubs such as manuka, kanuka and coprosma. These salt marsh areas are utilised by banded rail, Australasian bittern, fernbird, spotless crane and marsh crane.

Peripheral scrub areas above spring tide represent important roosting and nesting habitat for species such as banded rail. A concentration of banded rail activity was recorded from rushland habitat in close proximity to this habitat by Davis and Bellingham (1984).

***Spartina* grassland**

Spartina grassland represents a favoured habitat of pukeko where these birds feed on the grass stems. Ducks will loaf in mud areas adjacent to *Spartina* and will sometimes feed or rest in the water amongst the grass as the tide rises. Herons, banded rail and other birds feed on bare mud adjacent to the *Spartina*, but not within the grassland itself.

Permanent water

This habitat is described as a combination of substratum types covered by permanent water. A large part of the Harbour, from its entrance to the heads of river arms are dominated by this habitat type. These areas are used chiefly by waterfowl (ducks and swans), foraging shags and loafing gulls.

Shallow water (<0.5 m depth)

Shallow water channels and pools were widespread in the estuary forming a mobile habitat altering according to state of the tide. Birds using this habitat move according to the tide (i.e. in depths suitable for dabbling, wading or up-ending). Depending on the depth and state of tide this zone also provides foraging areas for herons, ducks, gulls, terns and waders.

Deep water (>0.5 m depth)

Deeper offshore water areas and tidal areas covered by appreciable water depth were utilised by shags, terns and gannets foraging for small estuarine fish species such as yellow-eyed mullet and bait-fish such as anchovies, garfish or pilchards. Gulls may also feed in such areas, while swans and ducks loaf in this zone in secluded portions of the estuary

Peripheral trees

Trees located around the edge of the Harbour are utilised by species such as shags and kingfisher for resting or for spotting their prey. Terrestrial bird also utilised this habitat.

Tidal freshwater vegetation

At the head of particular river arms are tidal freshwater habitats. These areas are dominated by freshwater species, but occasionally become inundated by large tides. In this habitat, plant species such as flax and raupo were often observed. A wide range of birds use these areas, including pukeko, bittern, crakes, and ducks.

Native herb-field

Herb field habitat was located in low gradient high tide areas and are dominated by small low lying estuarine plants such as *Selliera radicans* and *Samolus repens*. This habitat was relatively rare in Hokianga Harbour. In particular estuaries in New Zealand this habitat is utilised by small wading bird species such as banded dotterel (Davidson and Brown 2000). It is unknown whether this habitat is used by small wading birds in Hokianga Harbour.

Artificial structures (eg. wharfs, jetties)

These structures are located at a variety of locations around the Harbour (e.g. Opononi, Rawene, Omapere, Kohukahu). Artificial structures are used by several shag species, Caspian tern and gulls as roost sites.

Islands

Small islands are located at various locations around the Harbour. For example, the island offshore of Koutu Point is utilised as a breeding site by red-billed gull and white-fronted tern.

2.2.4 Terrestrial vegetation

In New Zealand, terrestrial vegetation around estuaries and harbours has often been removed and replaced by farmland, forestry, towns or industry (Knox 1986). As a result many terrestrial species have been eliminated from the coast or have suffered greatly reduced ranges (Davidson and Moffat 1990). This modification in the Nelson area for example has meant that species such as manatu *Plagianthus betulinus*, kahikatea, and mistletoes such as *Ileostylus micranthus* are relatively rare from the coastal fringe (Davidson *et al.*, 1995).

Much of the terrestrial environment around the Harbour is dominated by pasture, forestry or early regeneration kanuka/pasture. There are, however, areas of mature forest or lowland swamp forest. Davis and Bellingham (1984) for example, recorded populations of mistletoes (*Korthalsella salicornioides* and *Tupia antarctica*) in swamp forest on the Waohau River. Mistletoe species have virtually disappeared from many areas in New Zealand due to possum damage. In northern Marlborough, two sites in the inner Pelorus are the only known sites in northern Marlborough for *K. clavata*. Mistletoes find refuge in swampy or estuarine areas as the wet muddy nature of the substrate deters possums from entering and eating these palatable species.

Prior to infilling of Harbour margins, fresh water or brackish swamp vegetation would have been considerably more extensive than it is at present. Species such as flax, raupo, sedges, shrubs such as kanuka, manuka, *Coprosma* species, *Hebe* species, and larger trees such as kahikatea (white pine) would have been dominant plants.

Largest areas of mature coastal forest exist on the hillside on the southern side of Tapuwae River arm, around much of Wharekauere arm, at isolated areas on the southern hillsides in the Waima River arm, and in the northern Mangamuka River arm. These forests were not surveyed as part of the present investigation, but appear to be dominated by regenerating podocarp forest.

3.0 HARBOUR VALUES AND EVALUATION

3.1 Comparison with Other Estuarine Areas in New Zealand

In order that ecological, scientific and conservation values of Hokianga Harbour can be evaluated, the existing information for the Harbour should be compared with other areas in New Zealand. The following chapter summarises the existing information known for the area and attempts to compare these data with other areas in New Zealand.

Macroinvertebrates

The abundance and distribution of number of invertebrate species has not been thoroughly investigated for Hokianga Harbour. During the present study only records of dominant species were collected from particular locations around the Harbour. No comparison of the macroinvertebrate faun is therefore possible with other areas in New Zealand.

Based on preliminary observations, it is clear, however, that the Harbour supports a wide range of invertebrates from truly marine to truly estuarine species. It is expected that this phenomenon will result in a relatively extensive list of invertebrate species that inhabit the Harbour.

Birds

Davis and Bellingham (1984) produced a list of water bird species recorded from Hokianga Harbour. The number of water birds from Hokianga Harbour has been compared with other New Zealand estuaries and harbours in Table 3.

The number of water birds recorded from Hokianga Harbour is moderate to high compared to many of the large estuaries and Harbours in New Zealand. The number of water birds recorded from Hokianga Harbour was high compared the largest estuary in the Marlborough Sounds (Kaituna Estuary) and Pauatahanui Inlet near Wellington. The number of water birds from Hokianga Harbour was comparable to the number recorded in Kaipara Harbour by Veitch (1979).

Table 3 Number of water bird species recorded from Hokianga Harbour compared to other estuaries and harbours in New Zealand.

Estuary/Harbour	Number of waterbirds	Source of information
Hokianga Harbour (Northland)	39	Davis and Bellingham 1984
Kaituna Estuary (Pelorus)	36	Davidson and Brown 2000
Kaipara Harbour (Northland)	42	Veitch, 1979
Pauatahanui Inlet (Wellington)	30	Healy, 1980
Whanganui Inlet (Nelson)	42	Davidson, 1990
Waimea Inlet (Nelson)	50	Davidson and Moffat, 1990

Wairau (Vernon Lagoons)(Blenheim)	56	Knox, 1983
Avon-Heathcote Estuary (Christchurch)	53	Holdaway, 1983

The ecological value of Hokianga Harbour for particular birds should be considered at the national and in some cases international level. Many species cannot survive in one location or one habitat, and often make use of widely separate and diverse habitats. As examples, black swans banded at Lake Ellesmere, Caspian terns banded near Nelson and red-billed gulls banded on the Kaikoura coast have been seen in the Kaituna Estuary in the Marlborough Sounds (Davidson and Brown 2000). Most other species, including international migrant waders, travel considerable distances to make use of feeding and roosting habitats in Hokianga Harbour.

Freshwater and marine fish

No survey of marine or freshwater fish has been conducted in Hokianga Harbour or the catchments of the Harbour.

3.2 Estuary Evaluation

Evaluation of whole Harbour

A comprehensive evaluation of the ecological values of Hokianga Harbour is not possible as there is insufficient data to establish its representativeness compared to other estuarine and Harbours in New Zealand.

A preliminary evaluation has, however, been attempted as part of the present study. It is important to consider that this evaluation will change as more data on Hokianga Harbour is collected in the future. The preliminary values of Hokianga Harbour have been compared to values recorded for estuarine areas that have been evaluated previously using the same methodology (Table 4). The evaluation methodology was developed during an ecological study of Waimea Inlet in consultation with Professor Knox (Davidson and Moffat, 1990). A summary of the criteria have been included in Appendix 1. Most other estuarine areas used in the present evaluation fit the criteria outlined by the Davidson and Moffat (1990) as they have been fully investigated (Knox and Kilner, 1973; Knox *et.al.*, 1977; Davidson and Moffat, 1990; Davidson, 1990, 1992) or partially investigated as for Havelock Estuary (Davidson and Brown, 2000).

On ecological and scientific grounds, Whanganui Inlet clearly ranked highest of the South Island estuaries investigated (Table 4). Whanganui Inlet is a large inlet located on the north-west coast of the South Island. It is regarded as one of the most natural estuarine areas in New Zealand (Davidson 1990). In contrast, Parapara Inlet located in Golden Bay is a relatively small estuary surrounded by farmland and areas of low density dwellings. This small estuary was the lowest ranked estuarine area investigated. Hokianga Harbour scored well for the pollution status, size, and the potential number of marine fish and invertebrates (Table 4). The Harbour ranked relatively poorly for the state of the adjacent terrestrial vegetation, and number of vascular intertidal species. The Harbour may be upgraded in the future as more ecological information is collected or as a result of estuary restoration.

Table 4 Evaluation of Havelock Estuary and Kaituna complex compared with five other South Island estuaries.

Criteria	Hokianga	Kaituna	Abel Tasman	Whanganui Inlet	Waimea Inlet	Parapara Inlet	Avon-Heathcote
1. Representativeness in region	54	80	80	80	80	27	80
2. State of estuary	60	40	60	60	40	40	40
3. Pollution status	45	45	60	60	30	45	15
4. State of terrestrial vegetation	15	30	45	45	15	30	15
5. State of salt marsh vegetation	45	45	60	60	45	45	30
6. Size of intertidal and subtidal areas	40	24	16	40	40	24	32
7. Number of invertebrate species	32*	8	8	40	32	16	32
8. Number of waterbird species	16	16	16	24	24	8	32
9. Number of marine fish species	40*	10*	10	40	40	30	40
10. Maximum cockle density	24*	40	8	32	40	24	40
11. Number tidal vascular plant species	10*	10*	15	10	20	15	20
Total	381	348	378	491	406	304	376
Percentage	68%	62%	68%	88%	73%	54%	67%

* note: area has not been comprehensively surveyed and may therefore increase or decrease in value.

Evaluation and definition of major parts of Hokianga Harbour

Insufficient information on the ecological values of Hokianga Harbour exist to enable the parts of the Harbour to be evaluated. As part of the present study, however, there were sufficient observations made to enable a preliminary division of the harbour into three major areas. These were:

- A) Lower Harbour (Entrance to Te Karaka/Onoke)
- B) Middle Harbour (Te Karaka/Onoke to Matawhera)
- C) Upper Harbour (Matawhera extending into Harbour)

Lower Harbour

Characterised by relatively high salinity oceanic water, presence of particular truly marine invertebrate and algae species, soft substratum dominated by sands, numerous areas of boulder and rock, strong tidal currents, low water turbidity and relatively short water residence times.

Middle Harbour

Transitional area between outer and inner Harbours areas. Characterised by soft substratum dominated by fine sand and mud, moderate size river arms with mangrove forest, mudflats and moderate to small areas of salt marsh, moderate to strong tidal currents in main channels, occasional true marine species but fauna dominated by estuarine species.

Upper Harbour

Characterised by relatively low salinity estuarine water, presence of only true estuarine invertebrate and algae species, soft substratum dominated by silt and clays, strong tidal currents in particular areas, numerous backwaters and lengthy river arms, relatively long water residence times, high water turbidity, large areas of high tidal flats, mangrove and salt marsh habitats.

3.3 *Spartina* values

Hokianga Harbour supports beds of the introduced cord grass *Spartina*. Relatively large beds were observed in the upper Harbour, while isolated pockets or patches were observed in the middle and lower Harbour. Davis and Bellingham (1984) calculated that 22 ha of the Harbour were vegetated in *Spartina*/salt marsh mixes. *Spartina* was introduced into a variety of estuaries throughout New Zealand, but has been eradicated from many in recent years (eg. Waimea Inlet and Whanganui Inlet in the Nelson region).

Spartina represents a source of productivity to Hokianga Harbour and potentially to the adjacent outer coast (Knox 1986). This positive contribution is, however, outweighed by its adverse impact on the Harbour habitats. For example, it represents little or no value to wading birds and instead represents a loss of wader feeding habitat. It may therefore reduce biodiversity within the estuary. Few wetland birds utilize *Spartina* beds, though many will feed around its margins. Pukeko are the exception, with birds using the *Spartina* beds as a feeding source or refuge. It is probable that pukeko is the only estuarine bird to benefit from *Spartina* habitat. White-faced heron and mallard duck may rest or forage along the channel sides against *Spartina* beds, but do not depend or necessarily benefit from the *Spartina*. *Spartina* may also increase the rate of infilling resulting in premature change to habitats and their associated species.

4.0 HUMAN IMPACTS ON ECOLOGICAL VALUES

4.1 Nutrient enrichment

Surface sediments from most of the estuary were relatively aerobic with no obvious areas characterised by anaerobic conditions due to artificial enrichment. These observations suggest that the Harbour has not been highly enriched from human related activities.

Sources of human derived nutrient entering the Hokianga Harbour include:

- run off from adjacent farms, particularly dairy/cattle lots;
- enrichment entering the Harbour from a variety of human activities occurring in the catchments;
- discharge of the adjacent sewage treatment ponds; and
- stormwater from adjacent townships.

No large-scale point source discharges of nutrient rich effluent entering the Harbour were identified during the present study.

4.2 Toxic substances

Potential sources for these substances include:

- leachate from any rubbish dumps (active or closed);
- stormwater run-off from townships;
- boat cleaning activities;
- accidental spillages (road or townships); and
- light industrial activities.

No data on the levels of contaminants were sourced during the present study.

4.3 Loss of intertidal habitats

Substantial areas of Hokianga Harbour have been permanently lost through infilling and drainage, causeway construction, while modification to the Harbour values occurs through stock grazing, illegal rubbish dumping, and clearance of estuarine fringing vegetation. Davis and Bellingham (1984) reported that 246 ha of Harbour had been lost to drainage and infilling. Causeways have cut off and altered upper tidal reaches of the Harbour and caused loss or alteration of saline-freshwater zones and saltmarsh to lowland forest vegetation. Probable bird roosting areas and high tide feeding areas have also been lost as a result of these causeways. The proximity of roads to the estuary may also result in road kills of marsh birds.

4.4 Introduced predators and domestic animals

Footprints of cats, dogs and probably ferrets have been observed within and on the periphery of the Harbour habitats during the present study. These species and other predators such as stoats and rats are well-known hunters of bird species and will prey upon any nest, chick or adult birds that they can locate and catch. Domestic pets such as cats and dogs may also result in adverse impacts on nesting or roosting birds through disturbance, aversion or predation. This is particularly the case for those wildlife species that utilise the fringes of the estuary or modified sites (i.e. areas most accessible to such predators). Such species include the banded rail and marsh crake (roosting and nesting), ducks and swans (nesting), and a variety of waders, gulls and terns during high tide roosting activities.

4.5 Stock damage of estuarine fringe vegetation

Stock damage in intertidal vegetated habitats can result in reduced population densities, reduced community diversity compared to areas free from cattle grazing (Andresen *et al.* 1990). Particular areas around the Hokianga Harbour margins remain accessible to domestic stock, particularly in the upper Harbour along the river arms.

4.6 Weeds

Introduced weeds have aggressively colonised some fringe areas in Hokianga Harbour, particularly those areas where the natural vegetation has been modified and disturbed.

4.7 Fire

Fire is a threat to fringe and saltmarsh/rushland areas inhabited by banded rail and other marsh species.

5.0 Ecological Issues and Management Recommendations

Estuarine areas in New Zealand are often the scenes of human related activities that can result in modification or the lowering of estuarine values (Knox 1986). As a result, some estuaries and harbours or parts of these marine habitats close to human habitation often have relatively low ecological, scientific and/or conservation values (e.g. Manukau Harbour, southern shoreline of Waimea Inlet, Nelson). The following sections outlines various issues or activities that can lower ecological values and outline management recommendations that aim to maintain or improve the ecological values of Hokianga Harbour.

5.1 Tidal flow and sediment transport

Tidal flushing and sediment transport in the Harbour has undoubtedly been modified by the *Spartina* infestation, road causeways and infilling of Harbour arms. Restricted flows can result in increased rates of fine sediment deposition. This process results in a change to habitat structure and species assemblages (Knox 1986). Alteration of freshwater flow regimes may result in a change in salt marsh community composition, which may in turn influence species such as banded rail dependent on particular plant species for their survival.

Recommendation 1

It is therefore recommended that any future developments within or immediately adjacent to the Harbour do not unduly interfere with tidal flushing, sediment transport and salinity regimes.

5.2 Disturbance of wildlife

Wildlife is vulnerable to disturbance from human activity, particularly in areas close to human habitation. Such activities may be either long term or short term (i.e. related to a particular time of year or during particular stages of any development). At present most intertidal values are relatively isolated from human disturbance (e.g. salt marsh).

Recommendation 2

On the basis that particular human disturbance can have a negative impact on birds, it is recommended that human related activities such as development (e.g. subdivision) or tourist activities be undertaken in consideration of wildlife values of the Harbour.

5.3 *Spartina*

Spartina can spread considerable distance by means of relocation of vegetative material or from fertile seeds. It is recommended that for any activity that may disturb *Spartina*, all care be taken to minimise the spread of this species.

Spartina can spread within the Harbour if left unchecked. If left it spread it will replace intertidal flats utilised by waders as feeding habitat. *Spartina* beds may also increase the rate of sediment build up within tidal areas (Knox 1986). Eradication of *Spartina* has been successful in the Nelson/Marlborough region (e.g Waimea Inlet, Whanganui Inlet, Abel Tasman Estuaries). Based on considerations that *Spartina*:

- will spread if left unchecked;
- will reduce wader feeding habitat; and
- will probably result in reduced diversity and abundance of invertebrates compared with tidal mudflat habitat.

It is recommended that *Spartina* be eradicated from the Harbour.

A variety of issues related to the removal of large areas of *Spartina* should be addressed prior to eradication on a large scale. These include:

- the fate of sediment released following the vegetative decay of *Spartina* stems and root structures;
- the effect of sprays on the local environment.

Recommendation 3

Based on the negative impacts that *Spartina* has on intertidal values, it is recommended that the status of *Spartina* be upgraded and be included in the total control or progressive control plant pest lists in any future review of the Councils Plant Pest Management Strategy.

5.4 Disturbance or loss of estuarine and freshwater habitats

Activities that have historically occurred in and around the edges of estuaries have often led to modification or permanent loss of estuarine habitat. Areas most vulnerable are high tide fringe or edge vegetation often impacted by drainage, stock access, vegetation clearance or stop-banking and infilling.

Recommendation 4

Estuary edges have historically been the areas where ecological degradation occurs. It is recommended that:

- permanent loss of estuarine habitat be minimised or eliminated;
- fringe vegetation be protected by appropriate options including fencing, land covenant, purchase or voluntary agreement of the landowner;
- where practicable, land owners be encouraged to fence stream edges in an effort to exclude stock; and
- road culverts that inhibit freshwater fish passage be modified to allow for fish migrations.

5.5 Introduction of contaminants

Introduction of contaminants into estuarine environments occurs from a variety of sources. These can include outside fill material used for roading, port development or illegal dumping may contain contaminants above those regarded as acceptable (refer NOAA, USEPA, ANZECC, MfE for appropriate standards). Industry effluent, treated sewage and leachates from the landfill may introduce contaminants into the estuary.

Recommendation 5

Estuaries and harbours tend to accumulate contaminants (Knox 1986). It is therefore recommended that any potential sources of contamination to the estuary be managed to minimise or terminate contamination and where appropriate such sources should be monitored on a thorough and regular basis.

5.6 Restoration or protection of peripheral habitats

Habitats that should be considered as appropriate for protection, restoration or enhancement include fringe shrub-lands and forest immediately adjacent to salt-marsh vegetation and tidal freshwater margins of the rivers and estuarine margins. Any restoration should include weed control and replanting to create an intact vegetation sequence from estuarine wetland to freshwater wetland and forest. Potential for such restoration exists in many areas around the estuary.

Recommendation 6

Peripheral estuarine habitats represent important ecological habitats. These areas are often lost in many estuaries and harbours of New Zealand. It is recommended that peripheral areas around the Harbour should be identified and measures to protect, improve or enhance these areas be outlined and where appropriate be implemented.

5.7 Protection of marginal vegetation from stock access using fencing

Stock access to estuarine and freshwater habitats results in a lowering of ecological values. During the present investigation stock were observed feeding and wandering in saltmarsh habitat.

Recommendation 7

Fencing of estuarine or fringe vegetation and freshwater riparian zones to inhibit stock access is recommended.

5.8 Predator and possum control around wetland margins

Periodic or long-term control of predators and possum would be time-consuming and costly, but would benefit wetland plant species and should be considered in regional pest control strategies. Localised control within a small portion of the wetland may benefit particular species eg banded rail nesting sites.

Recommendation 9

Due to the relatively high plant values and the presence of marsh bird species in particular areas, it is recommended that control of predators and should be considered in regional pest control strategies

5.9 Promotion of education, tourism and landscape values of the area

Many people consider wetlands to be wastelands of mud, whereas they are actually some of the most productive ecosystems known, and have downstream value for important commercial and recreational fisheries as well as high value for wildlife (Knox 1986). Raising public appreciation and awareness of the Harbour through options such as a walking tracks, with opportunities to view an excellent variety of wildlife at reasonably close range or local education programmes would help improve this attitude. Possibilities exist for interpretation and educational signs to further promote a positive image of the estuary and its values.

Recommendation 10

Estuaries are often poorly understood by many New Zealanders. It is recommended that opportunities to promote the Harbours values should be identified and where appropriate implemented.

5.10 Legal protection of further areas

There are few areas of land adjacent to the Harbour that are protected and administered by the Department of Conservation. Formal protection through appropriate mechanisms (e.g. purchase, covenant) of land adjacent to the Harbour would improve catchment control and therefore help protect the Harbour values.

Recommendation 11

If the opportunity arises purchase or assist with covenants on adjacent land with ecological values. Areas of particular value include adjacent wetlands, forested hillsides and intertidal habitats under private ownership.

6.0 Protection mechanisms and recommendations

The Hokianga Harbour is the fourth largest harbour in New Zealand. It supports relatively high ecological, scientific and conservation values (Davis and Bellingham 1984, DoC 1990). In New Zealand and overseas, estuaries and harbours represent one of the most impacted marine areas (Knox 1986, Smith 1986, Stoffers *et al.*, 1986, Roper *et al.*, 1988). This is not surprising as these environments often have the concentrations of urban and industrial development. As a result there has been a gradual decline in estuarine and harbour ecological values in New Zealand. It is therefore timely that the Department of Conservation is currently investigating options for protecting the ecological values of the Harbour.

6.1 Legislation for the intertidal and subtidal environment

There exists a wide range of legislative mechanisms to protect areas of New Zealand. Many are not appropriate for marine areas as they often do not apply to areas of foreshore and seabed. The following legislation has been applied to areas of New Zealand foreshore and seabed environments. This list is not exhaustive but covers many of the most appropriate or successful mechanisms used to protect marine areas in New Zealand.

6.1.1 Marine Reserves Act 1971

Marine reserves are areas of the seabed, foreshore and waters set aside under the Marine Reserves Act 1971 (Department of Conservation 2000). They are established by an Order in Council made by the Governor General following a statutory process. The objectives are to manage areas for the scientific study of marine life, preserve the natural state, preserve and protect marine life and to allow for public access and entry subject to conditions and restrictions necessary for the preservation and protection of marine life.

In New Zealand all existing marine reserves are no-take (Davidson 2001). This means that extraction of animals, plants or minerals are not permitted. Access by the public and passive activities such as diving, swimming and boating are permitted. Examples of marine reserves in New Zealand are: Tonga Island Marine Reserve, Poor Knights Marine Reserve, Pohatu Marine Reserve.

6.1.2 Wildlife Act 1977

A principal purpose of the Wildlife Act 1953 is to protect land or water (foreshore and seabed) that provides a haven for any classes of wildlife or possesses important wildlife habitat not otherwise protected.

Wildlife Management Reserve

Under the Wildlife Act 1953, a wildlife management reserve can be applied to land including areas of seabed and foreshore. They are established by proclamation by the Governor General subject to such conditions specified in the proclamation.

This legislation can restrict and control entry as appropriate, but generally allows for the taking of game. It can also allow for human manipulation for optimum management. The features protected within any wildlife management reserve would be detailed in the proclamation. For example, for the Westhaven Wildlife Management Reserve fishing, gathering of kina, netting of whitebait, hunting of acclimatised waterfowl and movement of stock by adjacent landowners are allowed. The primary purpose of that area was to protect the estuarine habitats from activities such as infilling, aquaculture and fishing methods that damage the benthos.

Wildlife Sanctuary or Reserve

Under the Wildlife Act 1953, a wildlife sanctuary or reserve can be applied to land including areas of seabed and foreshore that are considered especially susceptible to damage or disturbance by uncontrolled public entry; or outstanding ecosystems, geology of physiological features and/or species available primarily for scientific or other similar purposes.

This legislation is most often applied to areas where the ecological/scientific values are very high and would be threatened by uncontrolled public access (e.g. Stephens Island in the Marlborough Sounds).

6.1.3 Reserves Act 1977

A principal purpose of the Reserves Act 1977 is to protect land or water possessing indigenous flora and fauna or natural features that are of special interest in terms of rarity, scientific interest or importance, or uniqueness. The primary objectives are to preserve the area in a natural state, preserve possessing indigenous flora and fauna or natural features, exterminate exotic flora and fauna and permit entry under controls that protect and preserve the flora and fauna in a natural state.

The disadvantage with this legislation in terms of marine areas is that it covers land and foreshore down to mean low water spring, but not seabed. Therefore channels and subtidal areas of Hokianga Harbour could not be protected using this legislation.

6.1.4 National Parks Act 1980

A principal purpose of the National Parks Act 1980 is to protect land or water possessing indigenous flora and fauna, ecological, geological, archaeological or historical features of special significance. The primary objectives are to preserve the special features intact with the minimum human interference and to permit entry only for activities compatible with the purpose for which the area was set aside.

The disadvantage with this legislation is that it covers land and foreshore down to mean low water spring, but not seabed. Therefore channels and subtidal areas of Hokianga Harbour could not be protected using this legislation.

6.1.5 Fisheries Act 1996

The purpose of the Fisheries Act 1996 is to provide for the utilisation of fisheries resources while ensuring sustainability (Ministry of Fisheries 1991). In the Fisheries Act, "utilisation" means conserving, using, enhancing, and developing fisheries resources to enable people to provide for their social, economic and cultural wellbeing. "Ensuring sustainability" means: maintaining the potential of fisheries resources to meet reasonably foreseeable needs of future generations; and avoiding, remedying or mitigating and adverse effects of fishing on the aquatic environment.

Marine Park

Provide for a range of activities in a marine area under specific guidelines or restrictions. These restrictions can apply to some or all activities such as fishing, mining, transport or recreational activities. Examples of these areas are Tawharanui Marine Park (Hauaki Gulf) and Mimiwhangata Marine Park (Northland).

Taiapure

Established in areas traditionally important to iwi or hapu and recognises their special needs relating to the area. A taiapure is managed by a committee that may include both Maori and non-Maori members who are nominated by the local Maori community. Commercial fishing may occur within a taiapure. The committee may recommend to the Minister regulation to recognise and provide for

customary food gathering or to manage other fishing in the taiapure. Anyone may fish in a taiapure. Examples are Palliser Bay, Maketu and Karitane (East Otago).

Mataitai

Mataitai reserves are areas that are identified traditional fishing grounds and where tangata whenua have a special relationship (Ministry of Fisheries 1991). They have a special status under the Fisheries Act to recognise and provide for non-commercial customary food gathering by Maori. Both Maori and non-Maori may fish in mataitai reserves, but they are managed by a Maori Committee or kaitiaki who can make by-laws restricting or prohibiting the taking of fish, aquatic life or seaweed in the reserve, if they consider this necessary for sustainable management. An example includes Rapaki (Lyttleton Harbour).

6.2 Concepts for the protection of the ecological values of Hokianga Harbour

The following section outlines concepts and considerations for the management of all or parts of Hokianga Harbour.

6.2.1 Protection versus human use

Estuarine and Harbour areas in New Zealand and worldwide are traditionally areas of high human activity and use. They are areas where people live, work and play. They are areas that people often build a close personal association. Management of Hokianga Harbour is no different and its management is a complex issue. It is therefore critical that options for its protection take into account the wide range of existing human activities, aspirations and cultural issues. These need to be placed in perspective with the variety of ecological values and their location in the Harbour. In this regard there will always be areas of agreement and conflict between human use of the Harbour and the protection of its ecological, scientific or conservation values.

Protection recommendation 1:

The Department of Conservation should carefully assess the reasons for protection (i.e. to protect all species, to protect the habitat of species, to protect particular species or their habitats, to protect species in vulnerable stages of their life history). Once the reasons for protection have been determined it will become more clear what protection mechanism/s will achieve the objective/s. Once the reasons for protection have been determined they should be placed into context with other issues in the Harbour. There needs to be: (a) assessment of the ecological/conservation values of the area/s under consideration; (b) assessment of existing human use/s of the area, and (c) assessment of existing human activities that compromise ecological values and the objectives of the protection mechanism.

6.2.2 Protection mechanisms and options

There are a wide variety of protection mechanisms that can be applied to marine areas. Some mechanisms extend over both intertidal and subtidal habitats, while others apply only to intertidal areas. Any successful protection of Hokianga Harbour will be involve lengthy public discussion and debate and ultimately be a compromise between human use and protection of ecological values.

Protection recommendation 2:

The Department of Conservation should formulate a package of protection options for public consideration. The public should be involved from the earliest point possible.

6.2.3 Protection of ecological habitats

Davis and Bellingham (1984) stated that Hokianga Harbour was 15,466 ha in size and comprised 9,909 ha or 64 % permanent water. The remaining 36 % or 5557 ha was intertidal comprising vegetation and a variety of substratum types. The species inhabiting subtidal and intertidal areas support both resident and temporary species. Many species that visit the Harbour take advantage of food and shelter at all or particular parts of their life history (e.g. snapper, eastern bar-tailed godwit), while many resident species form part of the food chain.

Protection recommendation 3:

Protection of subtidal and/or intertidal areas should prioritise areas that are important habitat for important resident and visiting species (e.g. sand flats for feeding waders, banded rail habitat).

Davis and Bellingham (1984) stated that 3053 ha or 55 % of the intertidal was covered by vegetation such as mangrove and salt marsh species. This represents a large source of primary productivity to the Harbour (Knox 1986). The food chain in estuarine areas is based on a detrital system that is largely driven by the breakdown of vegetative material (Knox 1986).

Protection recommendation 4:

Protection of intertidal areas should incorporate area of primary production such as mangrove and saltmarsh.

6.2.4 Protection of the whole Harbour versus protection of parts of the Harbour

Protection of the whole Harbour under one management regime would be preferable from an ecological perspective, but the intensity of human use and activities around and within the Harbour will influence the success of protection and its type and extent. One option to protect the entire Harbour would be to use a variety of protection mechanisms in different areas taking into regard human use and ecological values. At Whanganui Inlet (north-west Nelson) part of the estuary is protected by a marine reserve, while the remainder and majority of the area is protected under a Wildlife Management Reserve.

Protection recommendation 5:

Protection of the whole harbour should be considered ecologically preferable. The mechanism to achieve overall protection and the level of protection will therefore vary as a result. The type of protection should consider ecological values and human use.

6.2.5 Area by area and intertidal versus subtidal

Some of the marine protection mechanisms listed in section 6.1 do not extend beyond low water. Management of intertidal and subtidal areas using these protection mechanisms would therefore

separate the management of marine habitats in the Harbour. For example an intertidal area could be managed under the Reserves Act and the adjacent subtidal area under the Marine Reserves Act. Different types of legislation often have different purposes and therefore may not always be compatible. For example a Wildlife Management Reserve could permit waterfowl hunting but the discharging of a firearm into or within a Marine Reserve is not permitted. Similarly a recreational fishing may be permitted in a Wildlife Management Reserve, but not in a Marine Reserve, therefore migrating fish may be captures as they leave or before they enter a marine reserve.

Protection recommendation 6:

Proposed protection mechanisms should be compatible and consider ecological values, the aims of protection and human use.

6.3 Protection options for Hokianga Harbour

The following potential options for protection of all or parts of Hokianga Harbour are the view of Davidson Environmental Ltd and not necessarily those of the Department of Conservation, local residents, recreational or commercial fishers or iwi.

Marine Reserve

A marine reserve protects all life within its boundaries and a variety of studies within New Zealand and overseas have documented a recovery of fish due to removal of fishing (Bell, 1983; McCormack and Choat, 1987; Buxton and Smale, 1989, Bennett and Atwood, 1991; MacDiarmid and Breen, 1993; Cole *et al.*, 1990; Kelly *et al.*, 2000; Willis *et al.*, 2000; Davidson 2001; Davidson *et al.*, in press). It does not protect animals that move outside its boundaries through spill-over (Cole *et al.*, 2000), migration, or movement. Depending on the size and location of a marine reserve within the Harbour a marine reserve would protect a range of resident species. It could also provide refuge for migratory species that inhabit areas in the harbour where they are vulnerable to fishing or hunting. For example a marine reserve located in a mangrove area would protect mullet in the channels where they are concentrated and vulnerable to netting. A marine reserve located near the Harbour entrance would incorporate reef habitat and therefore would protect particular resident reef fish species. Fish moving into and out of the Harbour would not be protected by a small marine reserve. A marine reserve imposed over the entire Harbour would protect fish while they were concentrated and more vulnerable to fishing within the Harbour compared to outside the Harbour. It is possible, however, that fish congregate outside the Harbour entrance where they would be available to fishing. Protection of the whole Harbour as a marine reserve may also require consideration of the entrance and immediate offshore environment in order to more fully protect fish.

It is unlikely that a marine reserve over the entire Harbour would be accepted by the public as the area is regarded by locals and visitors as an important fishery.

Protection example 1:

Protection of particular areas that are important to fish species or areas where they are vulnerable to a disproportionate level of fishing. According to Davis and Bellingham (1984) there are 1576 ha of mangrove forest. These forests have extensive tidal channels that are used by mullet to access feeding areas. Some or all of these areas could for example be protected as a marine reserve.

Protection example 2:

There are isolated reef habitats located within the main reach of the Harbour, however, the largest single area is located from the southern head to Opononi (approximately 5 km). This area is subjected to relatively strong tidal currents and is permanently subtidal. This subtidal area has not been surveyed, but it probably supports a variety of resident reef fish species. Apart from periods when migrating fish would be located temporarily within it, this type of marine reserve would only protect resident reef fish species. It would, however, protect a the benthic community dominated by relatively sessile or immobile species such as crustaceans, molluscs, echinoderms, algae, sponges and smaller fish such as triplefins. This are has relatively good water visibility and at particular times of the tide could be studied by science divers to determine the impact of reservation.

Wildlife Management Reserve

A Wildlife Management Reserve would protect the intertidal and subtidal habitats, but could allow for many existing human uses such as fishing and water-fowl hunting. For this reason it is often seen as beneficial top the local community as it keeps the Harbour the same, but allows for traditional activities that do not damage the habitat to occur.

Protection example 3:

A Wildlife Management Reserve implemented over the entire inlet would protect all intertidal and subtidal habitats from activities such as marine farming, reclamation and substrate extraction. Should this option be selected it is recommended that the reserve accommodate traditional activities such as water-fowl hunting and recreational fishing.

Protection example 4:

A Wildlife Management Reserve could be implemented in conjunction with one or more smaller marine reserve areas. Marine reserve areas would have specific ecological goals and objective such as protection of fish or sensitive marsh birds.

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APPENDIX 1 Estuarine Evaluation (From Davidson and Moffat, 1990)

Schemes for ranking terrestrial habitats (Spect et. al., 1974; Ratcliffe, 1977; Wright, 1977; Imboden, 1978; Park and Walls, 1978; Ogle, 1982; Myers et. al., 1987), wetlands (Morgan, 1982; Angel and Hayes, 1983; Pressey, 1985; Davis, 1987) and lagoons (Barnes, 1989) have been developed in response to a growing need for conservation input into environmental management. These evaluation methods are not directly applicable to estuarine systems, and a system for the evaluation of whole estuaries and parts of estuaries has not been previously developed for use in New Zealand. Two methods for the assessment of estuarine environments are therefore proposed in this section.

The first method evaluates the total estuary, while the second method deals with specific areas within the estuary. The criteria are based on either modified terrestrial criteria or directly on estuarine values. Information of this type, as well as being descriptive, allows estuarine systems to be assessed on conservation grounds. Evaluation is, therefore, an important tool for developing estuarine management guidelines.

Evaluation of an Estuary

Criteria used are:

1. Representativeness/uniqueness of the estuary, compared with other estuaries in the region. Representativeness/uniqueness may be classified using flora, fauna, vegetation and/or geological and physical data. In the Nelson Marlborough area, Waimea Inlet was classified as unique, principally because of the diversity and rarity of the flora and fauna and on the physical structure of the estuary.
2. The state of the estuary. This is an assessment of the degree to which the estuary has been physically modified from its pristine through minor or localised modification to major modification and habitat loss.
3. Pollution status of an estuary. This may range from no pollution through minor effluent discharge in localised areas to nutrient enrichment influencing large areas of estuary.
4. Degree of modification of the terrestrial surrounding the estuary. Intact terrestrial vegetation scores highly, while farmed, industrial or stop-banked estuarine margins rank lowly.
5. State and degree of intact salt marsh vegetation.
6. Size of the estuary. Large estuaries are rare in New Zealand: only ten are larger than 2000 ha (McLay, 1976). Approximately 68 % of estuaries in this country are less than 500 ha in size.
7. Total number of invertebrate species in the estuary.
8. Number of water bird species present in the estuary for all or part of the year.
9. Number of fish species living, visiting or migrating through the estuary at some stage of their life history.
10. Maximum density of cockles recorded from the estuary.
11. Number of intertidal vascular plant species present. Values above 20 species is considered high, while less than ten species is regarded as low.

This evaluation, therefore, incorporates scientific and subjective assessments and requires that a full biological study be undertaken before all criteria can be accurately answered. Small or limited biological surveys would give lower scores than could be achieved with a large survey and can not therefore be used with any confidence.

Evaluation of an Estuary as One Unit.

CRITERION 1

Representativeness/uniqueness of estuary compared with other estuaries in ecological region:

- (a) Unique, only one of its kinds in ecological region.
- (b) One of the few estuaries/harbours of its kind in ecological region.
- (c) Typical of many estuaries/harbours in ecological region.

CRITERION 2

State of Estuary:

- (a) Pristine condition.
- (b) Minor development or modification in localised areas.
- (c) Significant areas of estuary modified.
- (d) Extensive development of the estuary/harbour.

CRITERION 3

Pollution status:

- (a) Pristine condition.
- (b) Minor pollution in localised areas.
- (c) Significant areas of estuary/harbour polluted.
- (d) Extensive pollution of estuary/harbour.

CRITERION 4

State of terrestrial vegetation:

- (a) Original terrestrial vegetation intact.
- (b) Some areas of original zonation present, or under present regeneration.
- (c) Little or no buffering vegetation, <50% of land farmed or developed.
- (d) >50% of land adjacent to estuary/harbour developed into urban areas, industrial development or farming.

CRITERION 5

State of salt marsh vegetation:

- (a) Original salt marsh vegetation around >90% of the estuary/harbour.
- (b) Significant areas of salt marsh vegetation intact.
- (c) Small areas of original salt marsh intact.
- (d) Remaining salt marsh modified.

CRITERION 6

Size of intertidal and subtidal areas:

- (a) >2000 hectares
- (b) 1001-1999 hectares
- (c) 501-1000 hectares
- (d) 100-500 hectares
- (e) <100 hectares

CRITERION 7

Number of invertebrate species recorded from estuary/harbour:

- (a) >125
- (b) 101-125

- (c) 76-100
- (d) 50-75
- (e) <50

CRITERION 8

Number of waterbird species recorded from estuary/harbour:

- (a) >60
- (b) 51-60
- (c) 41-50
- (d) 30-40
- (e) <30

CRITERION 9

Number of marine fish species:

- (a) >36
- (b) 26-35
- (c) 15-25
- (d) <15

CRITERION 10

Maximum recorded density of cockles (per m²):

- (a) >3000
- (b) 2000-3000
- (c) 1000-2000
- (d) 500-1000
- (e) <500

CRITERION 11

Number of intertidal vascular plant species:

- (a) >20
- (b) 15-20
- (c) 10-14
- (d) <10