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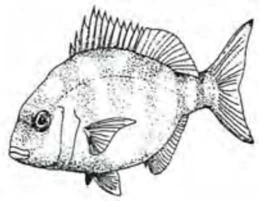


Specialists in:
Marine, and Freshwater Research, Survey and Monitoring

A report on the ecology of Havelock Estuary,

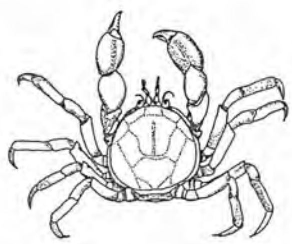
Pelorus Sound, Marlborough Sounds

Research, Survey and Monitoring Report Number 342

A report prepared for:

Marlborough District Council
P.O. Box 443
Blenheim

By:
Robert J. Davidson and Derek A. Brown



JULY, 2000

Bibliographic reference:
Davidson, R. J.; Brown D. A. 2000. A report on the ecology of Havelock Estuary, Pelorus Sound, Marlborough Sounds. Prepared by Davidson Environmental Limited for Marlborough District Council. Survey and Monitoring Report No. 342.

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July, 2000

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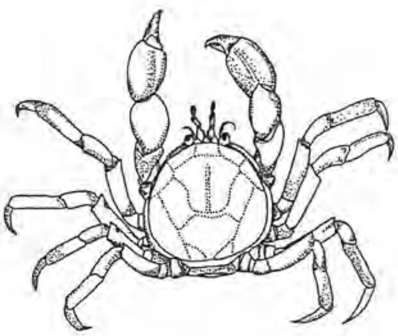

JULY, 2000

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Acknowledgments

We would like to thank all the people who assisted with field work or supported the project with advise They are Rhys Barrier (freshwater), Andrew Baxter (pier review), Mike Hawes (weeds and pests), Colin Rattcliff (aerial photographs) and Maria (shellfish sampling).

We would especially like to thank Carol Mills from the MDC who produced as set of excellent figures for the report.

This study was made possible through the enthusiasm of Linda Neame (MDC). The project was funded by the Marlborough District Council. The Department of Conservation assisted by funding an set of colour aerial photographs and provided expert advise and assistance.

1.0 Introduction

1.1 Background

This report presents ecological resource information on Havelock Estuary, Marlborough Sounds.

Environmental issues investigated during the present study included:

A) Existing information

- oxidation pond discharge
- Havelock refuse station and retired landfill
- Sanfords (South Island) discharge
- Port Havelock development and dredging
- Estuarine ecological information

B) New information

- map displaying areas of particular interest
- invertebrates (hardshore communities, shellfish density and sizes)
- freshwater fishes
- birds

C) Estuarine values and evaluation

- comparison with other estuarine areas in New Zealand
- estuary evaluation
- *Spartina* values
- bird habitats

D) 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

E) 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

1.2 Havelock Estuary

The estuarine areas around Havelock comprise two parts often referred to as Kaituna Estuary or Pelorus Estuary. For the purposes of this study we have called pooled these considered these two areas as parts of the wider Havelock Estuary (Figure 1).

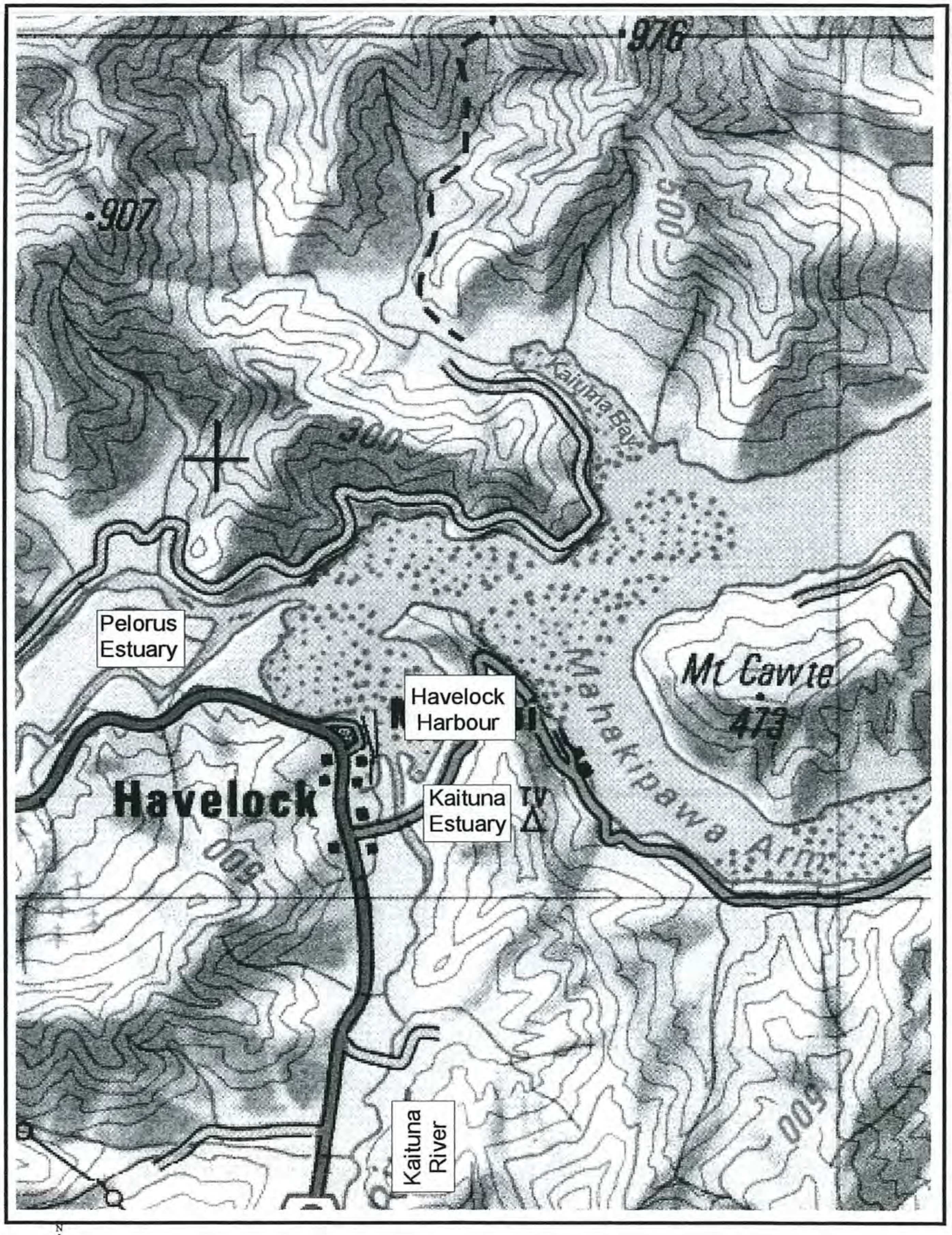
The Havelock Estuary is located at the inner-most part of Pelorus Sound adjacent to the township of Havelock. The Estuary is part of the largest complex of estuarine habitats located in the Marlborough Sounds (i.e. ecologically has strong links with values in Mahikapawa Arm and Kaiuma Bay)(Figure 2). The Havelock Estuary part of this complex receives freshwater and sediments from two rivers (Pelorus and Kaituna) as well as from many smaller streams. At low tide, the Pelorus and Kaituna estuarine deltas are linked by the main harbour entrance channel. This estuarine expanse of >500 ha of intertidal salt marsh and mud-flat habitats is surrounded by typical Marlborough Sounds hill country.

1.3 Existing Ecological Information

Davidson *et al.*, (1995), recognised a variety conservation values for the Havelock Estuary. These included: the threatened (Bell, 1986) (vulnerable in New Zealand, but extends its range outside New Zealand) banded rail (*Rallus philippensis assimilis*) present and breeding (Elliott, 1990). The threatened (vulnerable in New Zealand, but extends its range outside New Zealand)(Bell 1986) Australasian bittern is present in low numbers. The intertidal wetlands were considered of importance to a wide variety of wetland birds including large numbers of oystercatcher, black swan, ducks, heron and shags. The vulnerable black-fronted tern (*Sterna albostriata*), and the Caspian tern (*Hydroprogne caspia*) (status is vulnerable in New Zealand, but its range extends outside New Zealand) frequent these areas in non-breeding seasons. Large numbers of pukeko (*Porphyrio porphyrio*) breed in this area.

The authors stated that Havelock Estuary is the largest wetland complex in the Marlborough Sounds and contains the majority of species typically found in the Sounds estuaries. The authors ranked the estuary as nationally important due to the presence of the threatened breeding banded rail (Bell, 1986; Elliott, 1990) and regionally important as one of the single largest salt marsh areas in the Nelson/Marlborough region (see Appendix 6 for site record form in Davidson *et al.*, 1995).

Figure 1. Location of Havelock Estuary



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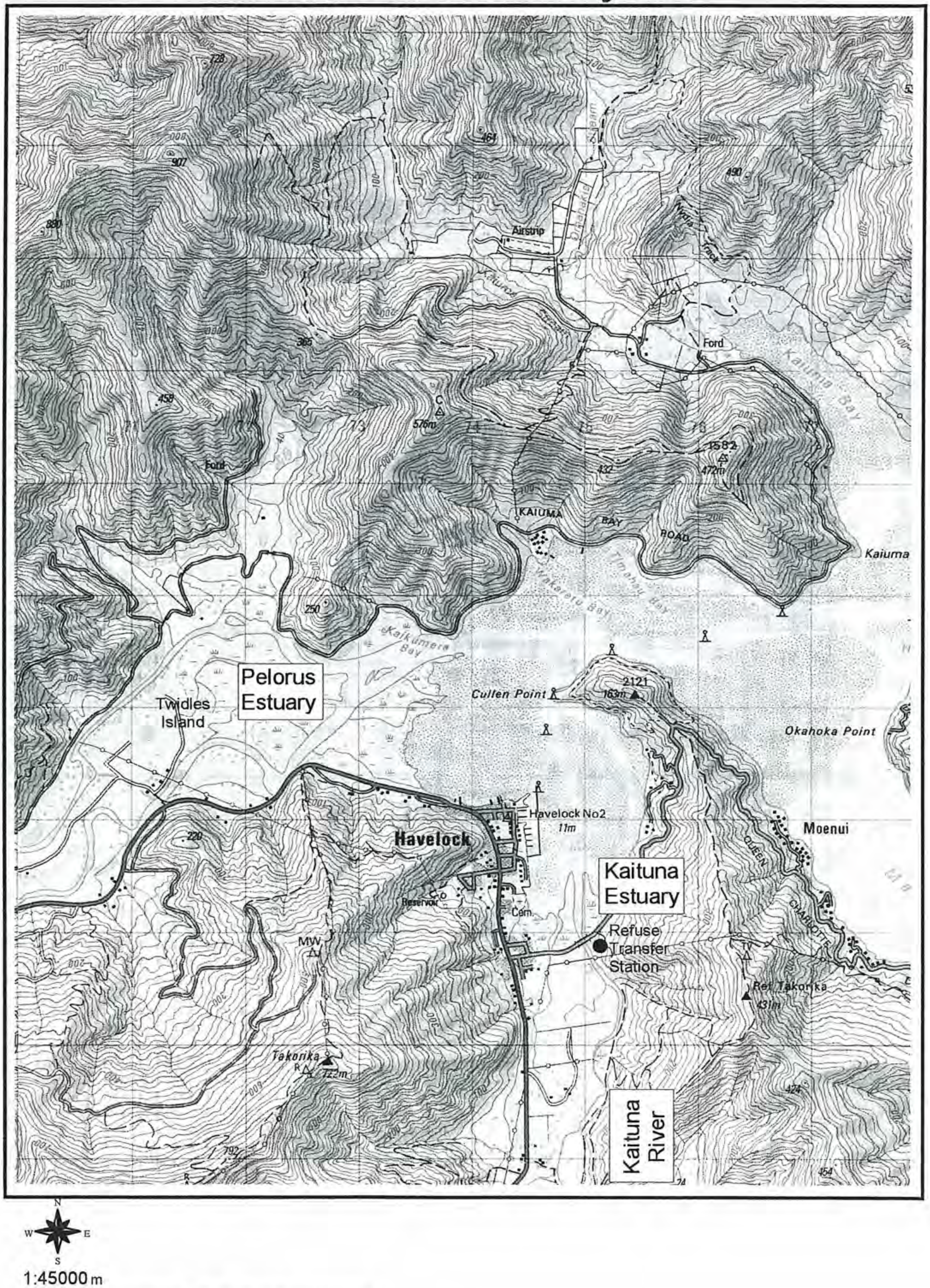
Produced on Marlborough District Council GIS.

Figure 2. Locations cited within the Havelock Estuary area



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The Pelorus estuary complex including Havelock Estuary were rated as being of moderate to high value by The Wildlife Service report on Sites of Special Wildlife Interest (SSWI) produced in 1983. This rank was primarily due to its large size, importance to a range of wildlife species and its relatively unmodified state.

Knox (1982) reported from a study investigating primary production and energy pathways that in a period of less than 50 years, *Spartina* had transformed 80 ha of mudflat into vegetated channel edge and flat habitat. Knox (1982) also reported that total animal diversity was low within the salt marsh, but suggested that the channels between salt marsh acted as a nursery for seven species of fish including flounder, mullet, and whitebait. Knox (1986) modelled the Kaituna marsh-estuarine ecosystem and stated that it captured the essential features of the *Spartina* ecosystem.

In chapter 10 of the Havelock Planning Study (1986) B. Cash stated the wetland was important to wildlife. He suggested that the wildlife values had been substantially changed due to the infestation of *Spartina*. Cash (1986) mapped the extent of native rush (94.4 ha) and the introduced *Spartina* (49 ha) within Havelock Estuary.

1.4 Proposed Resource Management Plan

The proposed Marlborough Sounds Resource Management Plan recognises the Havelock Estuary as having ecological values (see ecology map 3 of Volume 3 maps).

2.0 Methodology

All fieldwork was carried as part of the present study was out between October 1998 and February 2000. Sediment, contaminant, shellfish and soft and hard shore invertebrate sample sites are displayed in Figures 3 and 5, while other sites where contaminant levels were compared have been displayed in Figure 4.

2.1 Ecological

Invertebrate communities

Both epibenthic intertidal macroinvertebrates were investigated from samples collected from rocky shore substrata within the estuary (Table 1). This habitat was targeted during the present study as:

- no data existed for this habitat and
- data for other hard shores exist from the Marlborough Sounds allowing a comparison.

Table 1 Intertidal shellfish and hard shore invertebrate sample sites

Site no.	Site name	Substrata	Tidal height
R1	Cullen Point (north)	Boulders	Low to mid
R2	Cullen Point (middle)	Boulder	Low to mid
R3	Cullen Point (south)	Boulders	Low to mid
S1	Western main harbour channel	Sand	Low
S2	Western main harbour channel	Mud	Low
S3	Western main harbour channel	Sandy mud	Low
S4	North Pelorus channel	River silt	Low
S5	North Pelorus channel	Mud/oyster bed	Low
S6	South Pelorus channel	Mud	Low
S7	Eastern main harbour channel	Sand	Low
S8	Western main harbour channel	Sandy mud	Low
S9	Eastern main harbour channel	Sandy mud	Low

Cobble and small boulders of a size from 300 mm to 400 mm length were sampled from three sites during the present investigation (Figure 5). Each boulder was placed on a white tray and the animals living under the rock and on the rock surface were counted or recorded as present. This methodology was used as it allowed direct comparison with data collected by Davidson 1997, 1998) collected from Queen Charlotte Sound and Tory Channel.

Cockles, pipis and wedge shells were sampled from a variety of sites throughout the estuary (Table 1). Core samples were passed through a 4 mm aperture sieve. Cockles were measured from the umbo to the posterior edge (see Davidson and Moffat 1990, Davidson 1990, Davidson 1992), while pipi and wedge shells were measured across the maximum width.

Freshwater values

Freshwater fish were sampled on the 4th November 1999 using electric fishing and spotlighting techniques (Figure 6, Table 2). Where possible an area of 25 m^2 was sampled using standard qualitative methods. Apart from whitebait species, all fish were identified to a species level.

Table 2 Freshwater fish sample sites.

Site no	Sample site	Method	Area surveyed	Stream size
1	Kaiuma River	Electric	25 m^2	11 m wide
2	Wakaretu Bay stream	Electric	25 m^2	1.5 m wide
3	Kaiuma Bay Road (unnamed east)	Electric	25 m^2	3-5 m wide
4	Kaiuma Bay Rd (unnamed middle)	Electric	25 m^2	1 m wide
5	Kaiuma Bay Road (unnamed west)	Electric/spotlight	25 m^2	3-5 m wide
6	Havelock causeway (west)	Electric	15 m^2	1-1.5 m wide
7	Havelock water supply stream	Electric	25 m^2	2-3 m wide

Figure 3. Location of contaminant sample sites

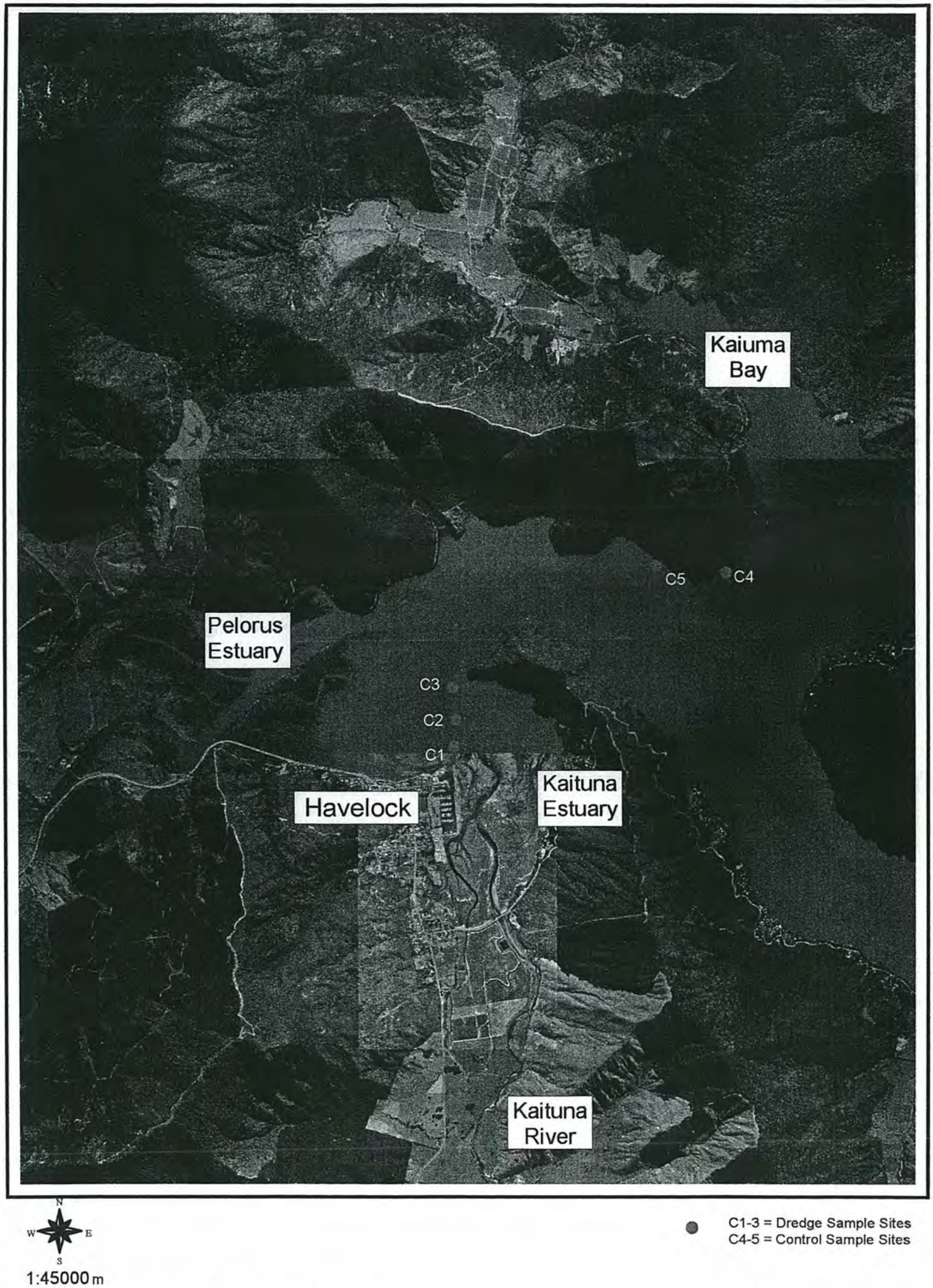

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Figure 4. Location of other contaminant values in New Zealand

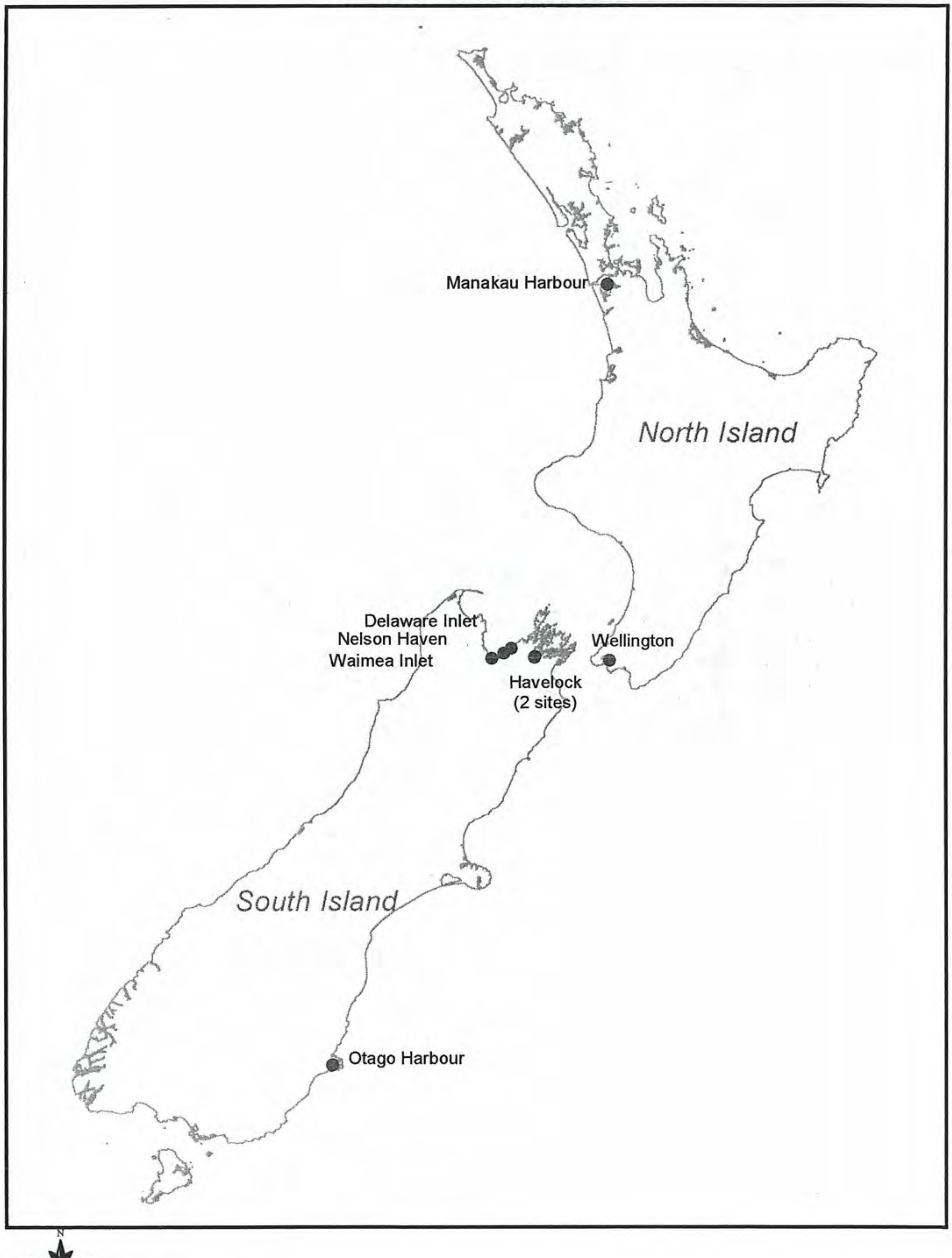

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Figure 5. Location of invertebrate sample sites

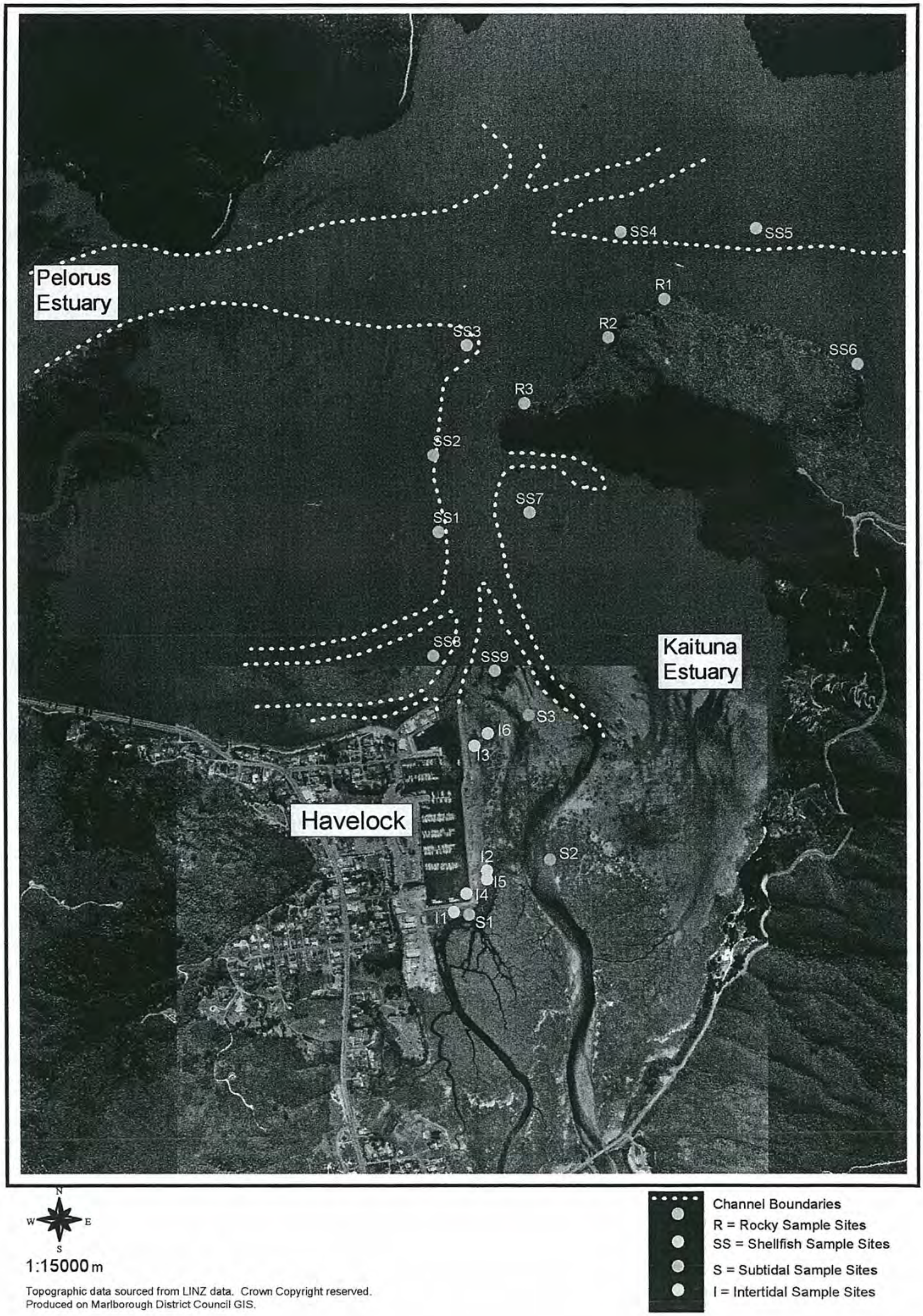
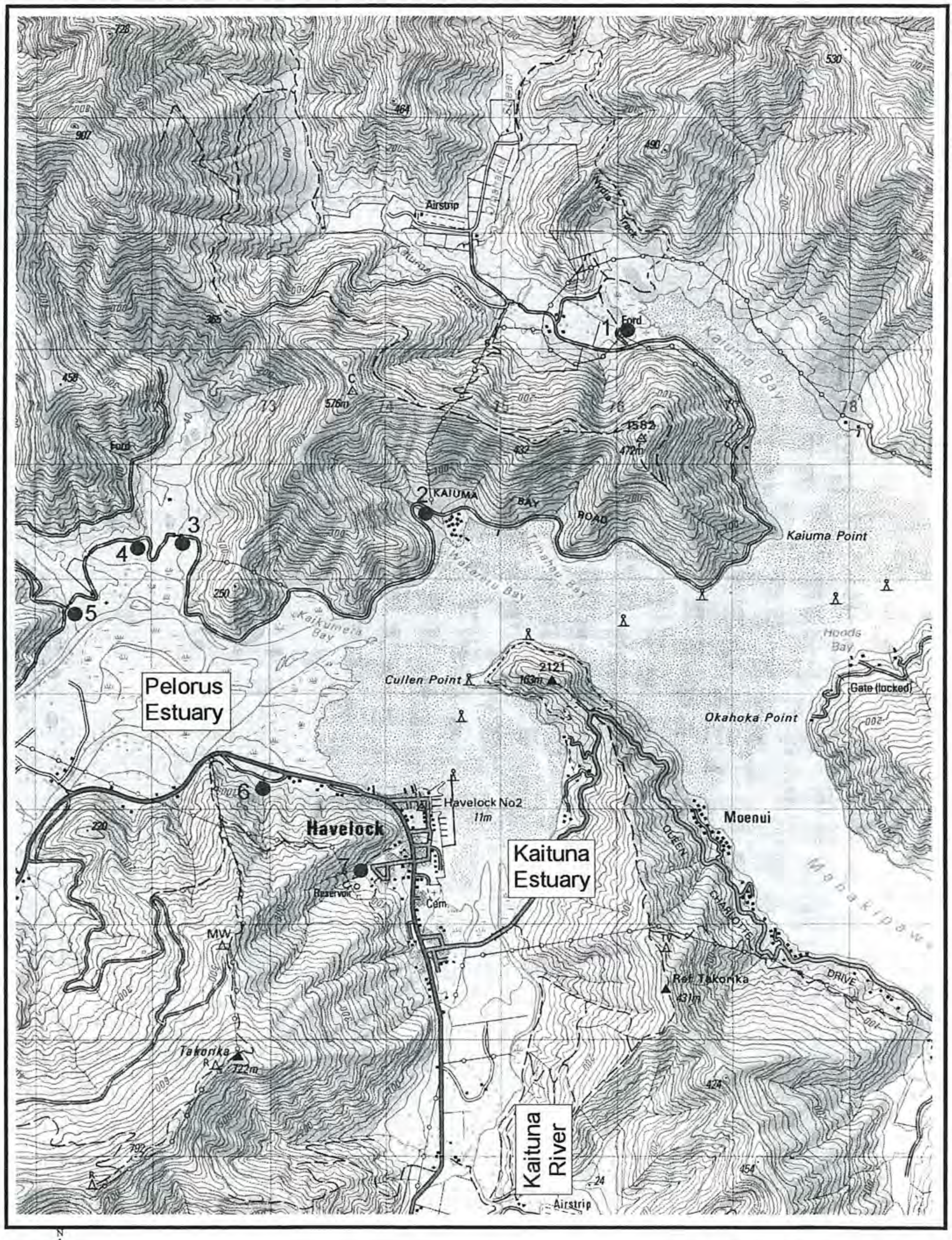


Figure 6. Location of freshwater fish sample sites



● 1-7 Freshwater fish sample sites

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Wildlife Values

Information on bird use for the inner Marlborough Sounds has been collected from April 1987 to February 1992 (38 counts) and from 1998 to 2000 (14 counts). Further anecdotal observations of areas adjacent to Havelock marina were made on a average of once-weekly basis between 1994 and 2000. These data have included a three year, once-monthly count of all such areas from Whatamango Bay near Picton across to and including the Pelorus wetlands, from April 1987 to March 1990 (D. Brown, unpublished reports DoC file SUR 012, Picton). Regular visits to the inner Sounds wetlands since that comprehensive survey have added to the information base for the purposes of this report (D. Brown, unpublished data).

It should be noted that counts of particular bird species presented in the present study were conservative. Not all areas of the wetlands are visible from the four vantage points used to count birds in the present study (Figure 7). Counts of large flocks tended to result in conservative numbers when precise counts could not be made due to logistical constraints. Further, birds that may use the wetlands may often be either out of sight, utilising an adjacent area of wetland or even visiting nearby farmland for roosting or feeding. The use of the same four vantage points for all counts has enabled comparison over season and year.

3.0 Results

3.1 Existing information

3.1.1 Oxidation ponds

Roan, P. 1992: Ecological impact of the Havelock oxidation pond discharge on the Kaituna Estuary. Prepared for the Marlborough District Council by Cawthron Institute.

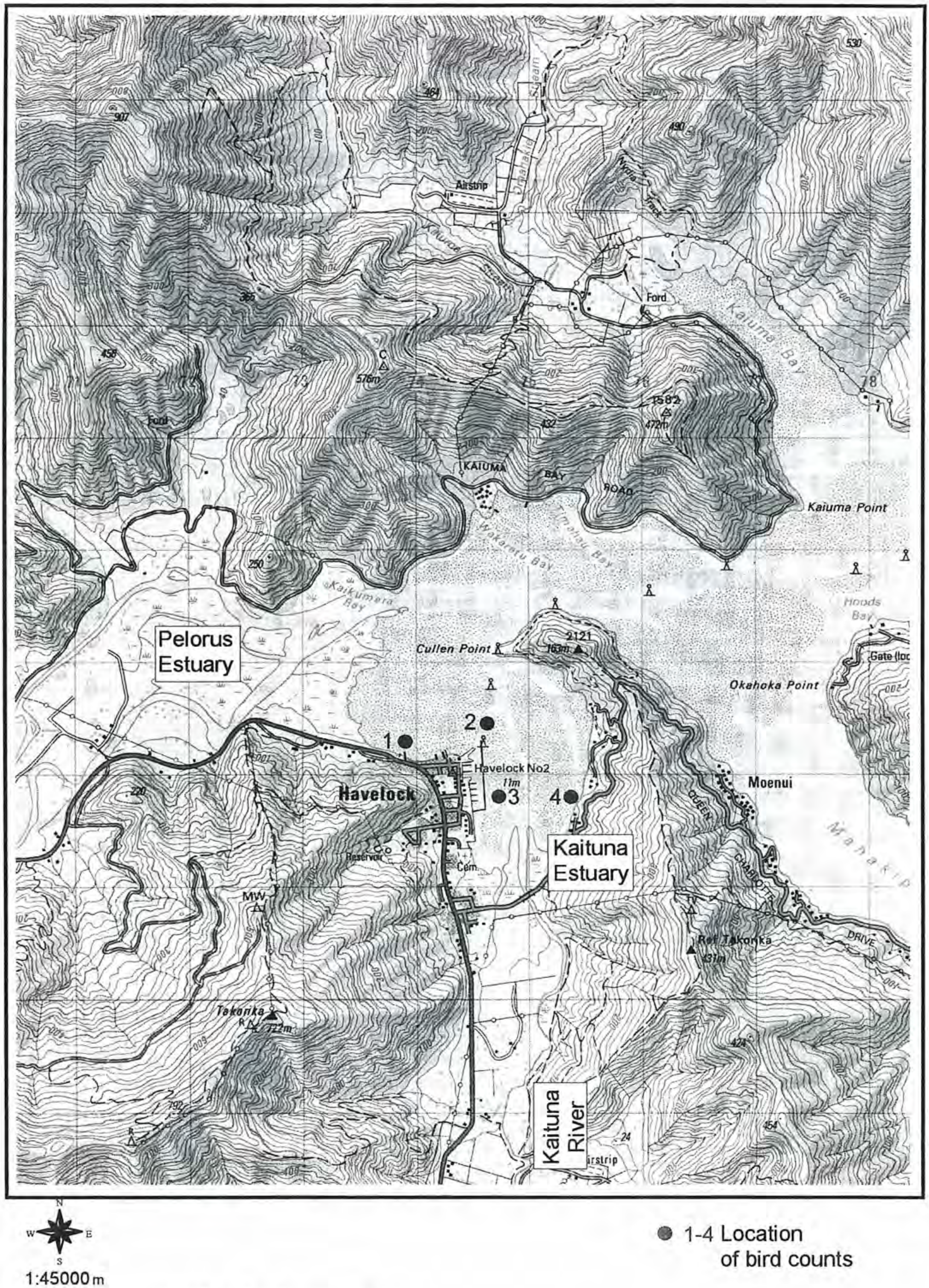
Forrest, B. 1995: Ecological effects of Havelock sewage discharge (second monitoring survey, February 1995). Prepared for the Marlborough District Council by Cawthron Institute. Report No. 296.

Shearer, K. 1997: Ecological effects of Havelock sewage discharge (third monitoring survey, February 1997). Prepared for the Marlborough District Council by Cawthron Institute. Report No. 402

These reports represent the monitoring requirement as part of the authorisation to discharge treated sewage from Havelock township into Kaituna Estuary (discharge permit MLB 900069). Monitoring consisted of eight benthic community and sediment samples collected from the true left bank of the Kaituna River channel at a variety of distances above (10 m, 50 m and 200 m) below the discharge point (10 m, 50 m, 250 m and 500 m) and at the outfall itself.

Results from benthic monitoring studies suggested that the pond discharge did not alter numbers of bottom dwelling invertebrate species present and had a variable impact on the densities of animals. One species of midge (*Chironomus* sp.) exhibited elevated densities at the outfall, 10 m above the

Figure 7. Location of bird counts



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outfall and up to 250 m downstream of the outfall (Roan 1992). This result combined with the observation that sediments within this zone contained a flocculent surface layer with generally more anaerobic conditions than observed from other sites provide an indication of some localised enrichment due to the discharge. Roan (1992) stated that this enrichment appeared relatively mild and did not make sediments unsuitable for invertebrate life. Forrest (1995) and Shearer (1997) concluded that the discharge had an effect at the outfall and at a site 10 m distance from the outfall, but not at sites 50 m or more away and that the results supported mild enrichment.

3.1.2 Havelock refuse transfer station

Royds Consulting, 1994: Resource Consent application and assessment of effects on the environment: Havelock Landfill. Prepared for Marlborough District Council.

Marlborough District Council 1995: Management Plan for the Havelock Landfill. MDC file U941158

Marlborough District Council 1996: Annual landfill monitoring report. MDC file U941158.

Stevens, L. 1996: Review of 1996 landfill monitoring. Prepared for Marlborough District Council by Cawthron Institute.

Stevens, L. 1997: Review of Marlborough District Council landform monitoring conditions. Prepared for Marlborough District Council by Cawthron Institute.

Marlborough District Council 1997: Annual landfill monitoring review. MDC file U941158.

Marlborough District Council 1997: Havelock refuse disposal site: application for a replacement Resource Consent. MDC file U941158.

Stevens, L. 1997 Preliminary assessment of leachate effects from the Havelock Landfill. Prepared for Marlborough District Council by Cawthron Institute. Report No. 430.

The Marlborough District Council provides refuse disposal facilities at a site located immediately east of the Kaituna River causeway. The landfill operated for approximately 50 years (Stevens 1996). Up until March 1996, the site operated as a landfill. Since December 1996 the site has operated as a refuse transfer station. The old landfill has been sealed, solid sump collectors installed and the landfill face landscaped. In a report by Royds Consulting (1994) the consultants stated that the effects of leachate and stormwater discharges upon the quality of the Kaituna River were anticipated to be low based on the nature of the river and the presence of the sewage discharge on the opposite side of the river. The report recommends closure of the landfill including covering using low permeability materials, landscaping and ongoing monitoring of the site.

Annual monitoring of a range of contaminants occurs at the Havelock transfer station. Stevens (1996) reported elevated levels of particular contaminants that could have a significant adverse effect on aquatic ecosystems and suggested a variety of actions including further investigation of contaminant sources. In a MDC management plan review (1997) problems associated with the landfill meeting consents conditions were identified.

Stevens (1997) reported leachate exceeded ANZECC guideline values for zinc, iron, copper, ammonia, dissolved oxygen and pH on several monitoring occasions. The author stated that the levels of leachate were, however, small in volume compared to Kaituna River where significant dilution was likely to occur. Stevens (1997) concluded that based on available monitoring tests, leachate discharges were unlikely to have caused significant adverse effects in the receiving environment. Their investigation of macrofauna found no indication of adverse effects directly attributable to the leachate discharge.

3.1.3 Sanford SI factory

Roan, P. 1993: Preliminary ecological assessment of a mussel processing effluent discharge to Havelock Estuary. Prepared for Sanford South Island Ltd. by Cawthron Institute.

Forrest, B. 1994: Ecological effects of a mussel processing effluent discharge to Havelock Estuary. Sampling design and results. Prepared for Sanford South Island Ltd. by Cawthron Institute. Report No. 254.

Tonkin and Taylor, 1995a: Mussel processing plant washwater discharge: assessment of ecological impacts. Prepared for Sanfords South Island Ltd.

Tonkin and Taylor, 1995b: Havelock mussel processors: preliminary evaluation of wastewater treatment options. Prepared for Sanfords South Island Ltd.

Royds Consulting, 1995: Review of proposals for wastewater treatment and disposal. Prepared for Sanfords South Island Ltd.

Forrest, B. 1995: Havelock mussel processing discharge: ecological effects of existing and proposed discharge regimes. Prepared for Sanford South Island Ltd. by Cawthron Institute. Report No. 299.

Marlborough District Council 1996: Monitoring report: Sanfords South Island Ltd. Prepared by Marlborough District Council. File U930695.

Robinson, A. 1997: Assessment of Sanfords discharge on bacterial levels of the Havelock Estuary.

Davidson, R. J. 1999: Effects monitoring in relation to Sanford effluent discharge into Havelock Estuary, Pelorus Sound. Prepared by Davidson Environmental Limited for Sanford (South Island) Ltd. Survey and Monitoring Report No. 198.

Sanford (South Island) Ltd hold a Resource Consent to discharge mussel processing and wash down water to the Havelock Estuary. As part of their consent they have been required to monitor a variety of parameters including dilution and dispersion of effluent, the impact of the discharge on water quality and its impact on the estuarine biota.

Tonkin and Taylor (1995) reported that dispersion studies indicated that the critical period in relation to effluent dilution in the receiving environment was around low water. Over the incoming and outgoing tides effluent was rapidly dispersed into the wider estuary.

A variety of studies investigating the impact of the discharge on water quality and the biota (Roan 1993, Forrest 1995, Davidson 1999). In summary, visual effects were localised and apparent as a slight milky appearance and a surface scum extending up to 30 m to 40 m from the discharge. Water quality samples collected at low water suggested that oxygen was not depleted and temperature was not affected outside a small zone around the outfall. Forrest (1995) stated that the discharge had a discernible organic enrichment effect within approximately 25m distance of the discharge, but the sediment were still inhabitable to estuarine biota although reduced within 10 m of the outfall. Forrest (1995) suggested a mixing zone of 50 m radius from the discharge, beyond which the author expected the discharge would meet the requirements of Section 107 of the Resource Management Act (1991). Forrest (1995) stated that the exception would be elevated levels of indicator bacteria that would occur in the shellfish outside the 50 m mixing zone, but were likely to occur regardless of the Sanford discharge because of the high background inputs.

Robinson (1997) sampled bacterial levels in the waters both above and below the outfall. The author stated that:

- bacterial levels were influenced by contaminated water from the Kaituna River;
- all samples taken at the outfall were well within the Shellfish Gathering Guidelines; and
- all samples met the 1992 MfE Bathing Guidelines of a Designated Bathing Beach.

3.1.4 Port Havelock

Davidson, R. J.; Brown, D. A. 1998: Ecological report on Kaituna Estuary in relation to proposed dredging and marine development, Havelock (final report). Prepared for Port Marlborough NZ Ltd by Davidson Environmental Ltd. Report no. 154.

Davidson and Brown (1998) collected contaminant samples from a variety of sites in the main shipping channel and from control areas (Figure 3). The authors compared values from Havelock Estuary with other values collected from the Nelson/Marlborough region and New Zealand (Figure 4).

Heavy metals (lead, zinc, chromium, cadmium, mercury, copper)

Heavy metal concentrations recorded by Davidson and Brown (1998) were low compared to values recorded from sediment collected from areas adjacent to large urban development (e.g. Manukau, Wellington Harbour, Otago Harbour)(Table 3). Concentrations of metals levels were consistently lower from the shipping channel than from the control sites near the confluence of the Pelorus River and Estuary. The authors suggested that this probably reflected sediment size (i.e. substratum being finer at the control sites), and the influence of the Pelorus catchment versus the Havelock township catchment.

Within the shipping channel, values for all but nickel were well below guideline levels for heavy metals (Table 3). Nickel ER-M (effects range medium, see Table 3) values were exceeded at two of the shipping channel sites and at both controls. Values increased with increasing distance from the marina suggesting that the source of nickel was not the marina but rather related to the Pelorus catchment where nickel and chromium occur in mineral deposits in the Dunn Mountain area. This phenomenon is apparent for the chromium values recorded from the two control sites which had relatively high levels for New Zealand (Table 3).

Values for metals often indicative of pollution in New Zealand and overseas (zinc, lead and cadmium), were well below the NOOA recommended guideline levels (Table 3).

Anti-fouling substances

Davidson and Brown (1998) sampled monobutyl tin oxide, dibutyl tin oxide and tributyl tin oxide levels from each of composite shipping channel and control samples. The authors found that levels were below the detection level of the analysis procedure. No trends between control and impact sites related to proximity to the potential source of anti-fouling substances were recorded during the present study.

Nb. No samples have been collected adjacent to the slipway located to the west of the Sanford processing factory.

Table 3 Concentrations of heavy metals in sediments collected from Havelock dredge zone, Havelock controls, Waimeą Inlet (Nelson Catchment Board 1983, Nelson/Marlborough regional Council 1991), Delaware Inlet and Nelson Haven (Smith 1986), Manukau Harbour (Roper et al 1988), Wellington Harbour (Stoffers et al. 1986) and Otago Harbour (Roberston and Ryder 1995).

Contaminants	Locations									
	NOOA1 ER-L	NOOA1 ER-M	Havelock dredge	Havelock controls	Waimea Inlet	Delaware Inlet	Nelson Haven	Wellingt on	Manukau Harbour	Otago Harbour
Copper	70	390	13-16	22-29	4.3-18.4	12-30	9	68	10-90	3-132
Cadmium	5	9	<0.2	<0.2	<0.05	<0.2	<0.2	-	0.02-0.25	0.8-38
Chromium	80	145	39-57	120-170	18-80	24-25	34	91	-	1.8-1750
Lead	35	110	<2-5	3-5	3.2-18	0.2-4.7	0.5	183	9-58	1.4-250
Mercury	0.15	1.3	0.03-0.07	0.06-0.07	0.01-.133	0.2-0.8	0.4	-	-	-
Nickel	30	50	28-42	83-130	63-107	17-28	34	21	11-16	9-34
Zinc	120	170	48-52	63-71	19-129	64-88	38	249	85-285	5.5-188

1 The guideline levels selected for assessment of significance of marine sediments contamination are the United States Oceanic and Atmospheric Administration Apparent Effects Threshold Concentration: ER-L (effects low range) = concentrations above which adverse effects are predicted among sensitive life stages, ER-M (effects range medium) = concentration above which adverse effects are predicted among most species.

Total petroleum hydrocarbons

Davidson and Brown (1998) compared total petroleum hydrocarbon levels from the shipping channel adjacent to the marina and control sites located distant to any potential point sources of petroleum products. The authors recorded comparable levels with no trend related to proximity to the marina.

3.1.5 Kaituna ecological information

Knox, G. A. 1982: The ecology of the Kaituna marsh, Pelorus Sound with special reference to the introduced cord grass, Spartina. Soil and Water Vol. 16 (2), pp 32-36.

Havelock Planning Study Team, 1983: Havelock Planning Study. Prepared for the United Marlborough Council. 87 p.

Knox G.A. 1986. Estuarine Ecosystems: a systems approach. CRC Press Inc., Florida. Vol. I and II.

Davidson, R. J.; Brown, D. A. 1998: Ecological report on Kaituna Estuary in relation to proposed dredging and marine development, Havelock (final report). Prepared for Port Marlborough NZ Ltd by Davidson Environmental Ltd. Report no. 154.

3.1.5.1 Sediments

Davidson and Brown (1998) collected sediment cores to a depth of 30 cm from the shipping lane and control sites. Authors reported that sediments in the shipping lane were dominated by sands of various size classes, each with a component of fine and very fine sand. The average size of particles increased with increasing distance from the marina entrance, for example, sediments were dominated by sand and coarse sand at a site adjacent to the Kaituna River channel. The depth of the redox or anaerobic layer increased with the increase in particle size. The anaerobic layer was approximately 13 cm deep at a site closest to the marina, 18 cm some 350 m from the marina and was not detected within the surface 30 cm approximately 600 m distant to the marina entrance.

3.1.5.2 Substrata, habitats and mapping

Knox (1982) identified a variety of primary productivity components of the estuarine system. Davidson and Brown (1998) described nine intertidal and three subtidal habitats from Havelock Estuary. The authors mapped these onto 1:10000 scale aerial photographs taken in December 1993 and displayed in their report.

Intertidal Substratum and Habitat Types

Habitats and substrata were based on those identified by Davidson and Brown (1998).

Cobbles, Pebbles and Coarse Sand

Small cobbles, pebbles and coarser sands were common in eastern intertidal areas adjacent to the Pelorus River Channel. These coarser substrata are obviously carried into and deposited onto the estuarine flats by the Pelorus River.

Fine Sand with Coarse Sand and Gravel

Fine sand with a component of coarse sand and pebbles were widespread in estuarine areas, particularly in areas adjacent to the Kaituna and Pelorus Rivers. The coarser material is probably deposited onto the intertidal flats during flood events.

Fine Sand

Fine sand flats physically appear similar to mud, however, fine sand is distinguished by a granular texture and its ability to support the weight of an adult human. These areas were located in areas away from the influence of the Kaituna and Pelorus Rivers.

Mud

Mud constitutes a combination of silts and clays < 0.063 mm in diameter. This habitat is easily recognised by a glutinous appearance and black anaerobic layer close to the surface. Intertidal mud areas were restricted to backwater areas free from the influence of strong tidal currents and rivers.

Zostera novazelandica (eelgrass)

Eelgrass was relatively uncommon within the estuary. Eelgrass was located in and adjacent to secondary and tertiary channels between areas colonised by salt marsh vegetation.

Ruppia sp. (Horse mane weed)

Beds of *Ruppia* were observed in small channels adjacent to the main causeway west of Havelock.

Native Rushes, Sedge and Herb Field

Two rush species (*Juncus maritimus, Leptocarpus similis*) and were the most abundant vascular plants observed within the estuary. These expansive beds were largely restricted to the heads of both main estuary arms. The sedge (*Schoenoplectus pungens*) was recorded from the Kaituna River above the road bridge estuary during the present investigation. Turf or herb fields were rare within the estuary and when present, were dominated by remuremu (*Selliera radicans*), button weed (*Cotula coronopifolia*) and bucks-horn plantain (*Plantago coronopus*). Glasswort (*Sarcocornia quinqueflora*) and native 'celery' *Apium australe* were recorded in the estuary, but were uncommon.

Cord grass (*Spartina* sp.) beds

Spartina was widespread within the estuary and dominated channel edges and sand-flats seaward of the large native rush beds in both Pelorus and Kaituna Estuary arms. Largest areas of *Spartina* were observed in the Kaituna arm of the estuary.

Boulders and Bedrock

Boulders and bedrock substrata were located adjacent to the marine channel at Cullen Point.

Subtidal Substratum and Habitat Types

Mud

Mud was recognised by a glutinous non-granular appearance. This substratum was restricted to backwater channels located within the estuary.

Sand Mix

Sand mix is primarily composed of sand with various proportions of broken and dead shell and pebbles. Sand mix was located in the main river channels and the marina access channel out to channel marker No. 5 (north-east of Cullen Point). In general, channel substrata increased in size with increasing distance from the marina entrance.

Gravels

Gravels composed of small cobbles, pebbles and coarse sands were observed in the main channel east of where the main Pelorus River combines with the Kaituna Channel.

3.1.5.3 Estuarine vegetation

The area that *Spartina* and native rushes occupied within Kaituna Estuary was compared between the 1986 report (Havelock Planning Study, 1986) and the December 1993 colour aerial photograph used by Davidson and Brown (1998)(Table 4). Results from field observations suggested that the area of estuary occupied by *Spartina* alongside the State Highway 6 causeway has declined perhaps due to an expansion of native rush habitat (ie 10.7 ha of *Spartina* in 1986 compared to 5.4 ha in 1993). Results also showed that in the Kaituna arm of the estuary, *Spartina* had increased its coverage by approximately 9 ha. This increase had primarily occurred adjacent to the eastern mole. The estimated total area covered by *Spartina* in December 1993 was 58.5 ha compared to 54 ha in 1986 (Table 4).

Table 4 Summary of area occupied by *Spartina* and native rushes in 1986 (Havelock study, 1986) and 1993 (Davidson and Brown 1998).

Habitat	Area	Area (ha) (Havelock study, 1986)	Area (ha) (Dec 1993 photo)
Spartina	Kaituna	32.5	42.0
Spartina	Pelorus	21.5	16.5
Spartina	**Total**	**54.0**	**58.5**
Native rushes	Kaituna	13.4	17.5
Native rushes	Pelorus	90.8	163.6
Native rushes	**Total**	**104.2**	**181.1**

3.1.5.4 Macroinvertebrates

Davidson and Brown (1998) sampled invertebrates from three sites and from three habitats: *Spartina*, intertidal flats and subtidal channels. A list of species recorded from core samples and observations was displayed in their Appendix 1.

Each sample site was located within one of three area types: 1) within the proposed reclamation associated with dredge spoil disposal; 2) within the area proposed for future port development (Option D); and 3) from the areas outside any proposed development of port facilities. Data from these core samples are displayed according to habitat type in their Appendix 1 (*Spartina*), Appendix 2 (intertidal flats) and Appendix 3 (subtidal channels).

Invertebrate communities

Davidson and Brown (1998) reported that the invertebrate community showed no variation with respect to the three sample treatments (dredge zone, marina zone and estuary proper). The assemblage of species recorded from each habitat also showed considerable similarity (Appendix 2, 3, 4 in Davidson and Brown 1998). Notable differences between habitats ware the higher number of the estuarine snails (*P. estuarinus*) recorded from the *Spartina* samples (average 19,500 to 30,000 individuals per m^2, see their Appendix 2). The high numbers of the estuarine snail resulted in high mean invertebrate values for *Spartina* samples compared to intertidal and subtidal samples.

1. *Spartina*
   A total of 12 macroinvertebrate species were recorded in core samples collected from this estuarine vegetation habitat. The mean number of species per core sample ranged between 3.3 to 4 species (Table 5). The estuarine snail (*P. estuarinus*) was recorded from all core samples in high densities, while an unidentified amphipod and the mud crab (*Helice crassa*) were recorded from 66% and 44% of samples respectively. Shellfish species were absent of uncommon from *Spartina* samples.

2. Intertidal Estuary Flats
   A total of 12 invertebrate species were recorded from intertidal sand flat core samples. The mean number of species per core sample ranged between 5 to 6.7 species (Table 5). The fauna was dominated by molluscs (6 taxa), followed by crustaceans (4 taxa), polychaetes (1 taxa) and one sipinculid. Mud flat snail (*Amphibola crenata*) was recorded from all samples, while the cockle (*Austrovenus stutchburyi*) was recorded from all but one sample. The estuarine snail (*P. estuarinus*) was recorded from all but two core samples, while the mud crab (*H. crassa*) and rag worm (*Nicon aestuariensis*) were recorded from over 50% of samples.

3. Subtidal channels
   A total of 15 invertebrate species were recorded in core samples collected from estuarine channels. The mean number of species per core sample ranged between 3 to 5.7 species (Table 5). The fauna was dominated by molluscs (9 taxa), followed by crustaceans (4 taxa), polychaetes (2 taxa) and one sipinculid. The estuarine snail (*P. estuarinus*) was recorded from all but one sample, while an unidentified amphipod was recorded from 56% of samples. Pipi (*Paphies australis*) were common from the three cores collected from the main Kaituna River channel site with densities recorded between 113 to 5885 individuals

per m^{-2}.

Table 5 Core sample summary data for Havelock Estuary. Values represent numbers per m^2.

Treatment	Site number	Total no. species	Mean no. species (SE)	Mean no. Individuals	SE
Spartina	I1	8	4.0 (0)	2468.5	2436.2
	I2	6	3.3 (0.3)	2539.8	2484.3
	I3	6	3.3 (0.3)	5014.4	4961.8
Intertidal sand flat	I4	7	5.0 (1.0)	760	669.5
	I5	11	6.7 (0.66)	73.6	20.4
	I6	8	6.7 (0.66)	172	66.2
Subtidal Channel	S1	5	3.0 (0.58)	312.9	169.2
	S2	9	5.7 (0.33)	624.2	391.0
	S3	12	5.3 (1.45)	43.6	11.9

Bird Communities

Davidson and Brown (1998) recorded a total of 32 birds from the Havelock Estuary (see Appendix 8 in Davidson and Brown 1998). The authors stated the presence of birds recognised as "threatened" by Molloy and Davis (1994) or Bell (1983) was of particular note. Of these important species, only the banded rail were known to breed in the area. They stated that the Australasian bittern may, however, breed in the upper reaches of the Pelorus arm of the estuary. Black-fronted tern and Caspian tern, "threatened" species, were often seen feeding and roosting on the mudflat and shallow sub-tidal habitats. They were present for much of the year but returned to breed on braided river systems (black-fronted terns) or sandy or shingle beaches (Caspian terns). The authors reported up to 45 Caspian terns and 17 black-fronted terns known to roost on the eastern mole, making it a non-breeding habitat of some importance to these species. White-fronted terns breed further out in the Sounds, but disperse to areas such as the Pelorus wetlands in the non-breeding periods. Up to 25 individuals of this species have been seen feeding or roosting in the Havelock Estuary.

Davidson and Brown (1998) recognised other "threatened" species such as the variable oystercatcher, banded dotterel, white heron and royal spoonbill as occasional visitors. Variable oystercatchers breed in the outer sounds, but move inward to make use of intertidal mud habitats in winter (Brown, pers obs). Banded dotterel were more common in the area historically, but preferred habitat of firmer, upper-tidal mudflats and saltmarsh meadows were not particularly common due to the nature of the wetland (ie. lack of this habitat type).

Davidson and Brown (1998) stated that the Pelorus wetland complex including Havelock Estuary was import to wading bird species such as stilts, herons and oystercatchers. The extensive areas of tidally exposed open mudflats provide good foraging habitat for these species, and attract internationally and locally migratory birds. A prominent feature of the wetlands was the abundance of the strikingly marked South Island pied oystercatcher. This species breed on braided South Island rivers with up to 350 of these birds spending much of the year from December to August in the Pelorus wetlands. Similarly up to 100 pied stilts, 35 spur-winged plover and 23 white-faced heron have been observed, though many of these birds may breed in the local area.

Surprisingly few international migrants use the wetland, perhaps due to it's relative isolation from larger wader habitats (such as Farewell Spit or Lake Ellesmere) and their linking flight-paths. Up to 17 eastern bar-tailed godwit have been recorded, and it is likely though not yet observed that other relatively common migrants such as knot and golden plover may occasionally use the area. The lack of a secure and relatively undisturbed roost site may dissuade longer-term stays. Godwit and other northern hemisphere wading birds are present from September to March, returning to the northern hemisphere to breed in their summer.

Davidson and Brown (1998) stated that the Pelorus wetlands were also significant as a waterfowl habitat, with an abundance of ducks and swans present. Up to 85 black swans were present year-round with some breeding occurring locally, but the majority breeding at other colony sites. Mallards, grey ducks and hybrids were numerous, with over 200 seen on many occasions and the actual population likely to be much higher than this due to their use of secluded loafing spots. The New Zealand shoveler duck is more transient but the wetland supports at times up to 120 of this species, while the paradise shelduck is present in similar numbers on or in fields adjacent to the wetland.

Davidson and Brown (1998) recognised a variety of areas they considered of particular importance to birds in Havelock Estuary. These areas included:

- the upper *Juncus maritimus* salt marsh, adjacent estuary fringe vegetation and freshwater inflows are critical for breeding populations of banded rail (south western Kaituna arm, western Pelorus arm);
- intertidal sand flats are important to feeding wader species;
- high tide wader roost sites located along the outer portion of the eastern marina mole.

4.0 New Information

4.1 Invertebrates

Hard shore communities

A total of seven species of macroinvertebrate were recorded from 18 replicates collected from 3 sites north of Cullen Point (Figure 5, Table 6). On average from 3.8 and 4.2 species were recorded from each sample site in Havelock Estuary. In comparison Davidson (1998) recorded from 8.4 to 10.75 species from rocks in the northern entrance to Queen Charlotte Sound. These results suggest that the number of species and their abundance in Havelock Estuary were relatively low compared with Queen Charlotte Sound. This may be due to the relatively low salinities that occur in Havelock for relatively prolonged periods. This phenomenon may exclude many species that are common under rocks in other areas of the Marlborough Sounds (e.g. *Diloma nigerima, Risellopsis varia, Melagraphia aethiops, Turbo smaragdus, Petrolisthes elongatus*).

Table 6 Pooled hard shore rock data collected from Havelock Estuary. Numbers represent mean per cobble sample (standard error).

Species		Rock site 1	Rock site 2	Rock site 3
Elminius modestus	Estuarine barnacle	Common	Common	Common
Cominella glandiformis	Mudflat whelk	0	0	0.6 (0.6)
Littorina unifasciata	Periwinkle	0	69 (14.8)	2 (0.68)
Crassostrea gigas	Pacific oyster	12.8 (4.7)	3.16 (1.6)	6.5 (1.7)
Xenostrobus pulex	Black mussel	9.2 (3.9)	1.33 (0.95)	0.83 (0.54)
Helice crassa	Mud crab	1.83 (0.75)	0.33 (0.21)	0
Leptograpsis variegatus	Shore crab	0	0.16 (0.16)	0
Amphipoda sp.	Hopper	Occasional	Occasional	Occasional
Mean no of species		3.8 (0.3)	4.16 (0.3)	4.17 (0.3)

Shellfish

Cockle, pipi and wedge shell were sampled from 9 sites located at varying distances along the main shipping channel from Havelock marina (Figure 5, Tables 7 and 8). Raw shellfish data have been presented in Appendix 1.

Cockle density varied between sample sites. Highest densities were recorded from sites close to channel confluence areas where tidal currents were strongest. No cockles were recorded in areas where river flood deposits occurred (i.e. site S4). Cockle densities were high at sites S2, S3 and S6, however, cockles size at all sites was low with few cockles reaching 30 mm (Figure 8). Small average cockle size was also recorded by Davidson 1992 in Whanganui Inlet. The reason for this phenomenon is unknown but may be related to salinity or high turbidity in Havelock Estuary following large flood events.

Pipis were recorded from eight of the nine sample sites (Table 7). Densities were low at most sites and their average size was also low. Adult pipis were recorded by Davidson and Brown (1998 in the main channel north-east of Cullen Point. Wedge shells were relatively uncommon being recorded from one of the nine sample sites (i.e. S9).

Table 7 Number of cockles within each size class averaged from three cores collected at each site.

Size class	Sample sites									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	All
5-9 mm		10			1	5	1	1	6	24
10-14 mm	1	48	2		1	11			3	66
15-19 mm	3	59	17		5	35	1	1		121
20-24 mm		37	26		3	30	6	1	1	104
25-29 mm		3	26		2	19	5			55
30-34 mm			1		1	2				4
Total number	4	157	72	0	13	83	13	3	10	374
Mean size (mm)	15.7	17.9	22.2		18.8	19.5	22	15	10.6	17.7
Mean density m^{-2}	226	8884	4074	0	736	4697	736	170	566	2232

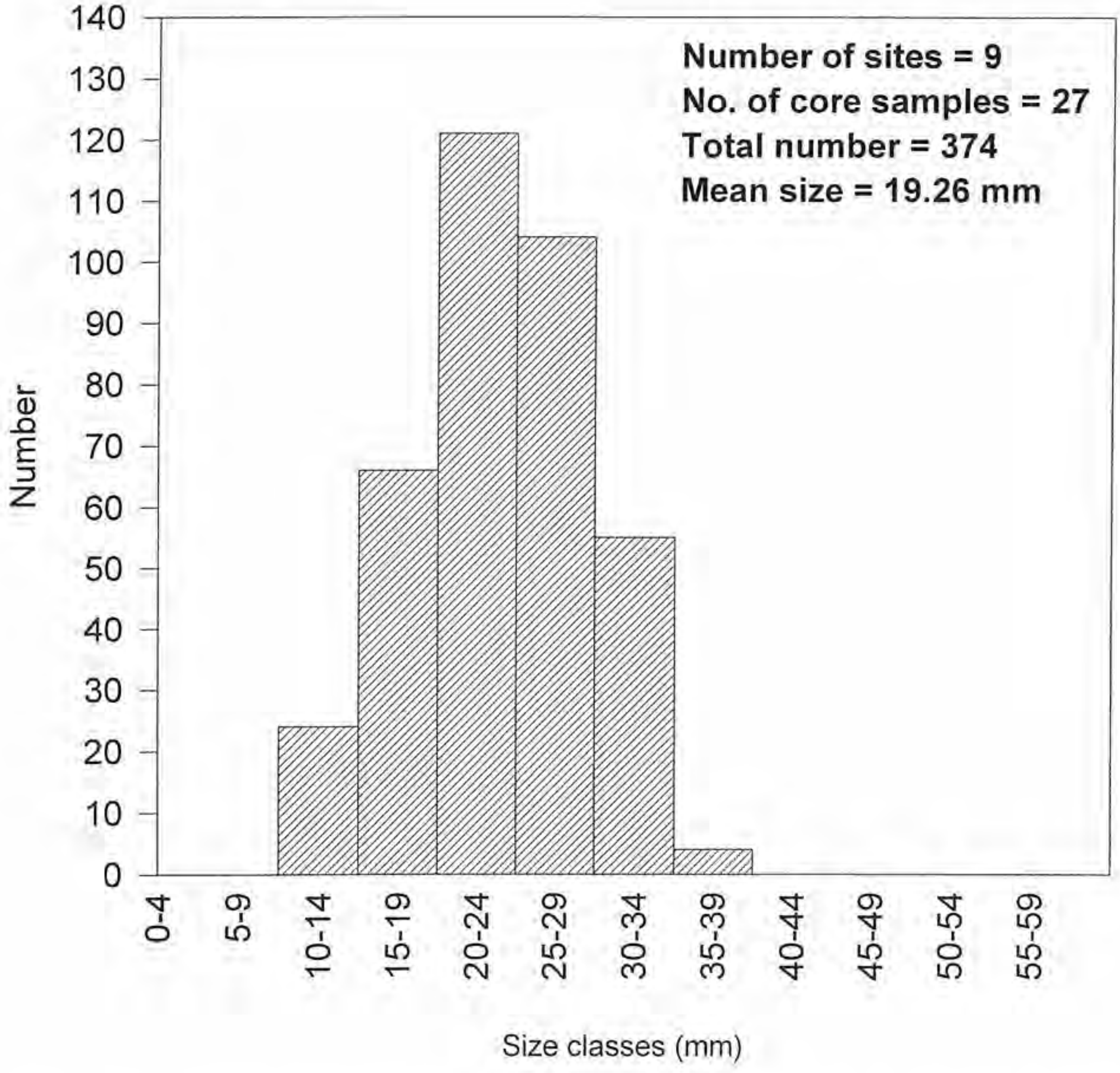


Figure 8 Cockle size classes from pooled sample sites in Havelock Estuary.

Cockle1.spw

Table 8 Number of pipis within each size class averaged from three cores collected at each site.

Size class	Sample sites								
	S1	S2	S3	S4	S5	S6	S7	S8	S9	All
5-9 mm	0	2	18	0	0	0	7	0	3	
10-14 mm	0	3	21	0	1	1	6	0	1	
15-19 mm	0		0	0	0	0	0	0		
20-24 mm	0		0	0	0	2	0	0		
25-29 mm	0		1	0	0	2	0	0		
30-34 mm	0		0	0	0	1	0	0		
Total number	0	5	40	0	1	6	13	0	4	3.7
Mean size (mm)		10.6	10.1		14	23.3	10.0		10.25	13.0
Mean density m^{-2}	0	283	2263	0	56	340	736	0	226	434

4.2 Freshwater fish

Seven freshwater streams and small rivers were sampled during the present investigation (Table 9, Figure 6). All but one of the sample sites were located in a stream < 4 m wide. Two other rivers enter the estuary, but were not sampled during the present investigation (ie. Pelorus and Kaituna Rivers).

Table 9 Description of the freshwater fish sample sites around Havelock Estuary.

Site no	Sample site	Width	Catchment	Fish cover	Modifications
1	Kaiuma River	11m	Bush, farmed flats	Poor	Stopbank, channel alignment
2	Wakaretu Bay stream	1 m	Bush	Good	Road culvert inhibiting passage
3	Kaiuma Bay Road (east)	3 m	Bush, farmed flats	Moderate	One bank fenced
4	Kaiuma Bay Rd (middle)	0.4 m	Farmed hillside, bush lower reach	Good	Cattle pugging
5	Kaiuma Bay Road (west)	4 m	Bush, farmed flats	Good	Some erosion protection
6	Havelock causeway (west)	0.5 m	Bush	Good	Some vegetation removal
7	Havelock water supply	1.2 m	Bush, houses lower reach	Moderate	Water abstraction

A total of seven species of freshwater fish (six native and one introduced) were recorded from sample sites flowing into Havelock Estuary (Table 10). Only one species has a recognised conservation status (ie. banded kokopu: Category C third priority threatened species). Banded kokopu was recorded from two small streams during the present study. In 1995, banded kokopu (*Galaxias fasciatus*) had been recorded from 18 river systems at 25 sites in the Marlborough District (Allibone 1995).

Another eight species (seven native and one introduced) are may pass through Havelock Estuary on their way to upstream habitats particularly in the tributaries of the Pelorus, Rai and Wakamarina Rivers. One Category A species (short-jawed kokopu) is known from the Wakamarina catchment.

Species that may pass through Havelock Estuary inlcude:

Short jawed kokopu (*Galaxias postvectus*): Category A;
Koaro (*Galaxias brevipinnis*): Category C;
Lamprey (*Geotria australis*): Category M;
Torrentfish (*Cheimarrichyths fosteri*);
Giant bully (*Gobiomorphus gobioides*);
Blue gilledbully (*Gobiomorphus hubbsi);*
Red finned bully (*Gobiomorphus huttoni);*
Rainbow trout (*Oncorhynchus mykiss*): Introduced

Table 10 Fish recorded from sample sites around Havelock Estuary.

Site no	Sample site	Banded kokopu	Inanga	Common bully	Upland bully	Long eel	Short eel	Brown trout
	Conservation status	C						
1	Kaiuma River			32		1		
2	Wakaretu Bay stream	2		1		1		
3	Kaiuma Bay Road (east)		2	11		1		2
4	Kaiuma Bay Rd (middle)		30+	10		6		
5	Kaiuma Bay Road (west)		1	12	2			1
6	Havelock causeway (west)	1	1	3		1		
7	Havelock water supply	C				1	1	

Overall, the small streams that enter Havelock Estuary have good water clarity and quality as they drain upper catchments clad in native forest. In the low reaches some of the streams pass through freshwater tidal wetland habitats (eg. Kaiuma Bay stream east and middle). Many of the streams have intact native vegetation along their margins providing good cover important to many native fish species. In general, these streams have low levels of modification from human related activities.

4.3 Birds

A total of 36 species of wetland birds have been recorded from sites surveyed the estuary (Figure 7, Appendix 2), and 32 of these were observed during the present study. Several of these are recognised as being "threatened" in the most up to date threatened species classifications (Molloy and Davis, 1994).

The area remains of some importance to a number of threatened species. The present study has largely confirmed previous records of bird species and relative abundance, but has increased the known maximum population of several threatened species including black-fronted, white-fronted and Caspian terns.

Of the 21 species (actually 23 but mallard and grey duck counts were lumped together as they are indistinguishable from a distance, and the same applies for red-billed and black-billed gulls) recorded in the formal counts, eight showed an increase in mean numbers seen per count. Ten species showed a decline and three were stable. However all changes with the exception of black-backed gull were within normal margins of error.

Overall the total number of birds seen per count changed little, dropping from a mean of 267 in 1987-1992 to 253 in the present study. The difference was due to the drop in numbers of black-backed gull since the refuse dump closed. Virtually all other species showed a remarkable stability in mean numbers observed. This indicates that the estuary's values for birdlife has changed little in the last 10 or so years.

Royal spoonbill have appeared relatively recently in the estuary, with up to five birds being infrequently observed in the last few years. There appears to be plentiful habitat for this species and they are likely to increase in numbers, in line with an increasing population nation-wide. They are, however, susceptible to human disturbance and tend to occur only in areas well away from human activity. The one high tide roost available located at the marina mole is probably disturbed too often for these birds to feel secure.

The banded rail is an uncommon species in the South Island, with a total population of perhaps only 100 pairs of birds, mainly in the Nelson area. Although formerly recognised as a 'threatened' species, the latest Department of Conservation classification has lowered it's ranking. Due to the rails rarity in the South Island and the fact that the Havelock Estuary is one of the largest single habitats for them, the presence of a breeding population of banded rail here is of considerable ecological value. Marlborough Sounds' wetlands have an estimated 10 pairs of banded rail (Elliott, 1990) of which most are found in the greater Pelorus wetland complex. This species is not found elsewhere in Marlborough, and its survival in the province is undoubtedly linked to the retention of suitable habitat in the core Havelock Estuary.

This present study confirmed the continued presence of this species with a comparable quantity and distribution to that reported by Elliott (1990). Banded rail are present in both the Pelorus and Kaituna Arms of the estuary, and as part of a linked population birds also exist in adjacent wetland areas such as Kaiuma Bay, Mahakipawa Arm, and the Grove Arm of Queen Charlotte Sound.

During this survey fresh remains of seven swan nests were found on the eastern side of the estuary, in Kaikumera Bay and the true left of the Pelorus River, indicating a small resident breeding population. At least five broods of cygnets confirmed this nesting was successful. More nesting almost certainly occurred as nests are often well concealed and not all areas were covered.

Mallards and mallard/grey duck hybrids were numerous, while grey ducks were rarely seen. Over 200 mallards were seen on many occasions and the actual population is likely to be much higher than that recorded due to their frequent use of secluded loafing spots. The New Zealand shoveler duck is more transient, but the wetland supported up to 120 individuals of this species, while the paradise shelduck was present on or in fields adjacent to the wetland (Table 11). This species only occasionally feed or roosted in estuarine areas. Grey teal were an occasional visitor in small flocks. The Pelorus wetlands are known to be popular with local hunters during the game-bird season with up to 40 hunters using the wetland or adjacent land each year (Brown pers. obs.).

The secretive rush-inhabiting marsh crake has been recorded from Kaikumera Bay within the Pelorus estuary by Elliott (1990) and in the same location during this study. It is a small and secretive bird and may also exist elsewhere in the estuary. Potentially suitable habitat exists for another swampland species the fernbird, but this species has not been recently recorded.

The wetlands are also a sizeable and important habitat for a variety of other species including four species of shag, three species of gull, kingfisher, harrier and pukeko.

A new record for the estuary was a sighting, in January 2000, of a black stilt hybrid. Black stilts are a Category A threatened species, but occasionally interbreed with the common pied stilts. The individual seen was almost entirely black with small white markings on the face and chest, indicating it was genetically mostly 'black' rather than 'pied' (i.e., one parent was most likely a pure-bred black stilt and the other parent itself a hybrid).

This survey confirmed that few changes had occurred in relation to bird usage of the area since the 1987-1990 counts. Populations of many species appeared relatively stable over this period. Any changes are largely thought to reflect seasonal breeding success or chance events rather than any appreciable increase or decline in numbers.

Some changes that were noted include:

- A drop in the population of black-backed gulls. This was probably due to the conversion of the open refuse dump to a transfer station. The gulls are naturally now more widely dispersed over the wetland, while in the past gulls tended to congregate around the refuse dump. Any drop in numbers is not considered a concern, as the population now better reflects a more natural level, and the environmental effects of the change to a transfer station are otherwise strongly beneficial to estuary ecology. Small groups of grey teal have been seen in recent years during winter months. This species was not observed in the surveys from 1987 to 1990. This result may reflect a gradual increase in population of this species nation-wide or chance observations of this highly mobile and transient species.

- An increase in the maximum number observed on any given day for four important species, with 53 black-fronted tern (a category B threatened species), 44 white-fronted tern (category C), 60 Caspian Tern (category O), and 375 South Island pied oystercatcher being seen during the current study.

- Four species added to the list of known birds confirmed as present in the estuary complex (i.e.marsh crake, gannet, cattle egret and grey teal)

- a sighting of a black stilt and a pied stilt hybrid.

Table 11 Summary of monthly bird counts from Pelorus-Kaituna Estuaries, Nov 1986 - Feb 1992 (38 counts), and 1998-2000 (14 counts).

Species	Low Count	High Count	Mean 86-92	Mean 98-00	Comments and Seasonal Trends
black swan	0	185	16	17	seasonally high in winter
mallard / grey duck	0	400	59	53	throughout year but numbers peak in winter
paradise shelduck	0	10	<1	5	more common on adjacent farmland
NZ shoveler	0	120	9	19	mainly present in non-breeding seasons
grey teal	0	20	0	2	not seen 1986-1992, present in recent winters
black-backed gull	0	500	39	9	highest counts in autumn
black/red-billed gulls	0	165	35	42	lesser numbers in spring
white-fronted tern	0	25(44)	3	3	most numerous late summer /autumn
Caspian tern	0	60	8	6	seasonally high in autumn
black-fronted tern	0	53	2	7	seasonally high in late summer / autumn
pied shag	0	2	<1	<1	occasional visitor in low numbers
little shag	0	21	5	4	present throughout year
little black shag	0	12	<1	2	transient small flocks
black shag	0	8 (11)	2	<1	small numbers throughout year
white-faced heron	0	30	8	5	more common in summer
kingfisher	0	9	1	<1	absent over summer
spur-winged plover	0	35	1	<1	common on surrounding farmland
pied stilt	0	100	17	11	most numerous late summer / autumn
godwit	0	17	2	<1	most numerous late summer / autumn
pied oystercatcher	0	350 (375)	59	66	most numerous late summer / autumn
variable oystercatcher	0	3	<1	<1	winter visitor from the outer sounds
Mean - all birds counted			267	253	
		(x) indicates a count outside formal counts			

Nb. also seen but not counted: pukeko, harrier, pipit, welcome swallow, introduced passerines, feral pigeons, feral goose
seen outside formal counts: Canada goose, gannet, spoonbill, cattle egret, white heron, banded dotterel
unlikely to be seen on counts but known to be present: banded rail, marsh crake, bittern

Seasonality of birds

There was a strong seasonal pattern exhibited by many bird species using the estuary. The high productivity means that it was extensively used for feeding, but for many species suitable nesting habitat was either absent or limited. Many species therefore leave the estuary for the duration of their respective breeding seasons. As a result, total bird numbers was lowest during the spring breeding season, and although this trend was pronounced, it was probably further exacerbated by the secretive nature and wide dispersal of the remaining birds during their nesting activities in Havelock Estuary. Total numbers of birds was highest in autumn and winter as birds (and their progeny) returned to make use of the productive feeding grounds of the estuary.

A prime example of wader seasonality was demonstrated by South Island pied oystercatchers, that peaked in autumn (i.e. up to 375 birds present) with lowest numbers recorded in spring when only a low number of non-breeding birds (perhaps immature birds) remained. Oystercatchers breed on braided river bed systems of the eastern South Island. Pied stilt, black-fronted tern and black-billed gulls also nest in similar braided river habitat and follow the same seasonal pattern. Caspian tern, white-fronted tern and red-billed gulls nest on the coasts, but also display the same seasonal pattern. Internationally migrant waders such as godwit were present only in summer and early autumn, before returning to Siberia and other northern hemisphere locations to breed.

Ducks favour secluded areas for nesting and appear to disperse widely from the estuary to undertake this activity. Peak duck numbers occurred in winter when flocks congregated following breeding. Some swans were, however, present in the estuary all year-round. Relatively low numbers of swans breed in the wetland with most breeding at large colonial nesting locations such as Lake Ellesmere. Highest numbers of this species occurred in winter months within the estuary.

Kingfishers also exhibited a pronounced seasonality, being almost completely absent in summer months, breeding and feeding inland in forests and along riverbanks. These birds returned to the estuary for the winter months. White-faced heron exhibited the reverse trend occuring in highest numbers during the spring breeding season. This species nested in tall trees surrounding the estuary. This species utilize the estuary regularly as a feeding habitat. No distinct seasonal trend was obvious for shags.

Areas of Particular Importance to Birds

As part of the present study, areas important to birds were identified and described in full. A variety of wildlife habitats can be found in the Pelorus wetlands. Each habitat is utilised by a different bird community. The range of habitats have been summarised as follows:

- open tidally flooded mudflats;
- native rush-lands;
- *Spartina* grassland;
- river channels;
- shallow water (less than 0.5 m depth);
- deep water (greater than 0.5 m depth);
- peripheral shrubs and trees;
- tidal freshwater vegetation;

- native herb field zone;
- marina eastern mole; and
- artificial or modified areas (e.g. marina)

Open tidally flooded mudflats

This habitat represents a vital feeding area for many wading bird species including oystercatchers, pied stilt, godwit and herons, as well as dabbling ducks. Banded rail feed in mud flats close to rush cover. These mudflat areas support invertebrates including shellfish (e.g. cockle and pipi), snails, crabs and worms that all provide a staple food for many different bird species. This habitat type virtually disappears at higher tides, being replaced by shallow water used in a different way by different species.

Native rush-lands

There are extensive *Juncus maritimus* rushlands in the upper tidal zone of the estuary, utilised by banded rail and marsh crake. These areas represent a major habitat for these species and are represented by a small and vulnerable population in Marlborough. Other native rushes and sedges such as the jointed rush (*Leptocarpus similis*) and the triangle sedge (*Schoenoplectus pungens*) are also present in the estuary, but are not used by these species.

Salt marsh habitat also provides habitat for marsh crake and bittern, particularly on the margins of pooled water and tidal channels. The rushlands on higher ground provide nesting habitat for these species plus black swan, harrier and duck species.

***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.

River Channels

This habitat is described as a combination of pebble, gravel, sand and mud substrata covered by permanent water. Largest channels are the main Pelorus River, its' flood channel adjacent to SH6 and the Kaituna River. These areas are used chiefly by waterfowl (ducks and swans), foraging shags and loafing gulls. Large tree trunks and stumps brought down rivers in storm events forming important roost sites particularly during high spring tides for a range of species of shags, ducks, herons and the pukeko.

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 dpeths suitable for dabbling, wading or up-ending). This zone forms feeding habitat for swans, particularly where their food such as native eel grass (*Zostera*), horse mane weed (*Ruppia*) and mats of filamentous green algae occur. 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 utilized by shags, terns and occasionally by 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 shrubs and trees

Particular areas around high tide margins of the estuary support saltmarsh ribbonwood (*Plagianthus divaricatus),* native vine (*Muehlenbeckia complexa)* and other small hardy shrubs such as manuka, kanuka, coastal tree daisy (*Olearia solandri*), and coprosma (*Coprosma propinqua* and *Coprosma robusta)*. Remnants or regenerating stands are mapou, totara, kowhai, mahoe and ribbonwood were also present on higher ground. These peripheral 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. Extensive rush-land distant to this habitat, although appearing suitable, was poorly utilised by these birds.

Species such as shags and kingfisher use trees around the estuary margins for resting or for kingfisher, for spotting their prey. Terrestrial bird species such as tui, bellbird, silvereye, grey warbler and morepork also utilised such habitat.

Tidal freshwater vegetation

The edges of the tidal Kaituna and Pelorus Rivers grade from freshwater to saline water with increasing penetration into the estuary. In this transition zone, plant species such as flax, toetoe and raupo were often found. A wide range of birds use these areas, including pukeko, bittern, crakes, and ducks.

The fresh water habitat was used by many bird species for bathing and drinking with many saline-tolerant bird species dependant on some freshwater. In some locations small remnants of riparian forest and shrub-land remain at or near the upper limits of saline water tidal intrusion. Such vegetation communities are now relatively rare in New Zealand.

Native herb field

Herb field habitat was located in low gradient high tide areas often dominated by small low lying estuarine plants such as *Selliera radicans* and *Samolus repens*. This habitat was relatively rare in Havelock Estuary. Small areas of this habitat were located along the eastern mole of the marina and on the banks of the lower Pelorus River. These zones are favoured by small wading bird species such as banded dotterel and pipit. Historically this habitat would have represented mid- to high-tide roost sites and loafing spots for wading birds and waterfowl.

Marina eastern mole

The eastern mole of the Havelock marina is the most important high tide bird roost for many bird species using Havelock Estuary. It is the only site within the current estuarine area available for birds roosting when they are unable to feed at high tide. An alternative site is available in pasture, on the opposite side of the Queen Charlotte Drive causeway. These roost sites are used by waders, terns and gulls as they avoid areas in close proximity to dense vegetation providing predator cover.

The current site can at best be described as barely satisfactory due to repeated human disturbance from activities associated with the port. Any enhancement of a roost site will benefit the birds and may encourage greater use of the estuary by migrant waders and sensitive species such as Royal spoonbill. The mole represents a congregation area for many species at high tide and the birds are visually conspicuous representing an educational or tourist opportunity.

Artificial or modified sites (eg. marina)

The deeper water of the marina is used by several shag species. Shags and gulls utilise the numerous artificial roost sites offered by wharf piles and railings.

4.4 Terrestrial vegetation

In New Zealand, terrestrial vegetation around estuaries has been removed and replaced by farmland towns or industry (Knox 1986). Many species have been eliminated or greatly reduced in range (Davidson and Moffat 1990). This modification in the Nelson area has meant that species such as manatu *Plagianthus betulinus*, kahikatea, and mistletoes such as *Ileostylus micranthus* are relatively rare from around estuarine areas. In Havelock Estuary pockets of adjacent terrestrial vegetation remain.

On the western side of the Pelorus River and the bottom end of Twidles Island the wetland complex has healthy populations of two rare mistletoes *Korthalsella salicornioides* and *K. lindsayi*. Both have been recorded in the neighbouring Kaiuma Bay wetland, but not from the Pelorus prior to this study. The Pelorus and Kaiuma Bay sites are the only known sites in northern Marlborough (north of the Wairau River) for *K. clavata*. Another mistletoe *Ileostylus micranthus* was located in a localised area on Twidles Island and was previously known to occur in a localised but abundant population amongst farmland willows immediately adjacent to the wetland. Such mistletoes find refuge in estuarine areas as the wet muddy nature of the substrate deters possums from entering and eating these palatable species.

Prior to infilling of estuarine margins, fresh water or brackish swamp vegetation would have been more common than today. Species such as flax, raupo, Carex sedges, toetoe with shrubs such as *Olearia solandri*, manuka, *Coprosma* species, *Hebe* species, and larger trees such as kahikatea (white pine), wineberry, and possibly swamp maire would have been dominant plants. Remnant patches of this vegetation occur on higher ground around the estuary. Totara and mapou are not normally associated with wetlands, but were relatively common in this area. Totara was relatively common large tree with remnant patches of forest, though its' current abundance may reflect the lower stock palatability compared with other species such as ribbonwood or kahikatea.

5.0 ESTUARINE VALUES AND EVALUATION

5.1 Comparison with Other Estuarine Areas in New Zealand

Macroinvertebrates

The number of invertebrate species recorded from Havelock Estuary were compared with other New Zealand estuaries Table 6 in Davidson and Brown (1998). The location of the other estuarine areas used in this comparison have been displayed in Figure 9 in the present report. The number of macroinvertebrates recorded from Havelock Estuary was relatively low compared with other estuaries in the Nelson/Marlborough region. Only the Wairau River Estuary and Vernon Lagoons exhibited a lower diversity of benthic invertebrates. Studies of estuaries in the Nelson area suggest that estuary size, substrate, salinity and diversity of habitat contribute to the density and diversity of benthic invertebrates (Davidson and Moffat, 1990; Davidson 1990, 1992). Observations made during the present study suggest that salinity may be the most important environmental variable influencing the number of invertebrates in Havelock Estuary. The estuary receives a relatively large freshwater input particularly from the Pelorus River that would lower the salinity, particularly during flood or elevated flow events. This lowering of salinity would be compounded due the considerable separation between the estuary and the open sea. Gibbs *et al.* (1991) showed that water residence times were relatively long in particular bays in Pelorus Sound (ie. up to 13 day turn over period). Although no data has been collected from inner Pelorus Sound, it is probable that salinity may be reduced for long periods of time due the long distance between the ocean and the estuary. It is therefore not surprising that the range of invertebrate species recorded from Havelock Estuary was considerably lower than has been recorded from large well flushed estuaries directly connected to the open sea (e.g. Waimea Inlet, 3455 ha and Whanganui Inlet, 2744 ha).

Davidson and Brown (1998) reported that all of the major estuarine feeding types were represented in the intertidal areas. Typical of estuaries, detritivores (deposit feeders) dominated the invertebrate fauna with six taxa. Suspension feeders were represented by five taxa, while carnivores were represented by three taxa, followed by herbivores with one limpet. The dominance of detritivores in the Kaituna Estuary was consistent with findings for other estuaries in the Nelson region and throughout the world.

Density data for common benthic invertebrates recorded from estuaries around the Nelson/Marlborough area and New Zealand have been presented in Table 12. Maximum densities of benthic invertebrates recorded from Havelock Estuary were comparable to values recorded from productive estuaries in the Nelson area. For example, densities of mud flat snail (*A. crenata*), estuarine snail (*P. estuarinus*) and pipi (*P. australis*) were moderate to high compared to other large estuaries (Table 12). Values for nereid worms, cockle (*A. stutchburyi*) and nut shell (*Nucula hartiviana*) were relatively low, but may have been a reflection of the relatively small range of habitats sampled during the present study, rather than an indication of low productivity. Similarly, the wedge shell (*Tellina liliana*), top shell (*Diloma subrostrata*) and spire shells (*Zeacumantus lutulentus, Z. subcarinatus*) were not recorded from core samples collected during the present study.

TABLE 12: Maximum densities (per square metre) of selected species from Kaituna and other New Zealand estuaries.

	Kaituna Estuary	Abel Tasman Estuaries	Whanganui Inlet	Waimea Inlet	Moutere Inlet	Parapara Inlet	Wairau River Estuary	Avon-Heathcote Estuary	Ahuriri Estuary
Bivalves									
Austrovenus stutchburyi	8884	1234	2524	3168	1347	1426	1340	3050	7270
Paphies australis	5885+	3531	815	3530+	4494	-	452	2547*	present
Tellina liliana	-	249	283	815	419	230	-	1337*	730
Nucula hartvigiana	170	-	1958	1268	226	present	-	-	NA
Gastropods									
Amphibola crenata	509	40	215	532	68	230	129	977*	580
Diloma subrostrata	-	40	127	170	79	63	-	1146*	360
Potamopyrgus estuarinus	35086	4957	3656	23450	present	present	10449	884000	2500
Zeacumantus lutulentus	-	-	260	147	226	150	-	-	740
Zeacumantus subcarinatus	-	11	962	-	11	-	-	18000*	NA
Polychaetes									
Capitellidae	-	-	45	4674	691	50	12040	36584*	present
Nereidae	170	170	555	509	464	230	602	1350*	present
Decapods									
Helice crassa	57	113	71	328	430	180	516	250*	420
Hemigrapsus crenulatus	-	747	57	566	260	present	-	255*	present
Macropthalmus hirtipes	-	-	23	102	215	-	516	250*	present

* Jones, 1983
\+ Subtidal record

Birds

Davidson and Brown (1998) compared the number of water bird species recorded from the Havelock Estuary with the number documented from other New Zealand estuaries in Table 13 (see Figure 9 for other locations). The number of water birds recorded from Havelock Estuary was low compared to many of the larger estuaries in New Zealand, but was high compared to the two of the largest estuarine areas in the Marlborough Sounds (i.e. Anakiwa and Whatamango).

Table 13 Number of water bird species recorded from Pelorus Estuary complex compared to other estuaries in New Zealand.

Estuary	Number of waterbirds	Source of information
Kaituna Estuary	36	Present study
Anakiwa Estuary	26	D. Brown unpublished
Whatamango Estuary	21	D. Brown unpublished
Whanganui Inlet	42	Davidson, 1990
Waimea Inlet	50	Davidson and Moffat, 1990
Wairau (Vernon Lagoon)	56	Knox, 1983
Avon-Heathcote Estuary	53	Holdaway, 1983
Kaipara Harbour	42	Veitch, 1979
Pauatahanui Inlet	30	Healy, 1980

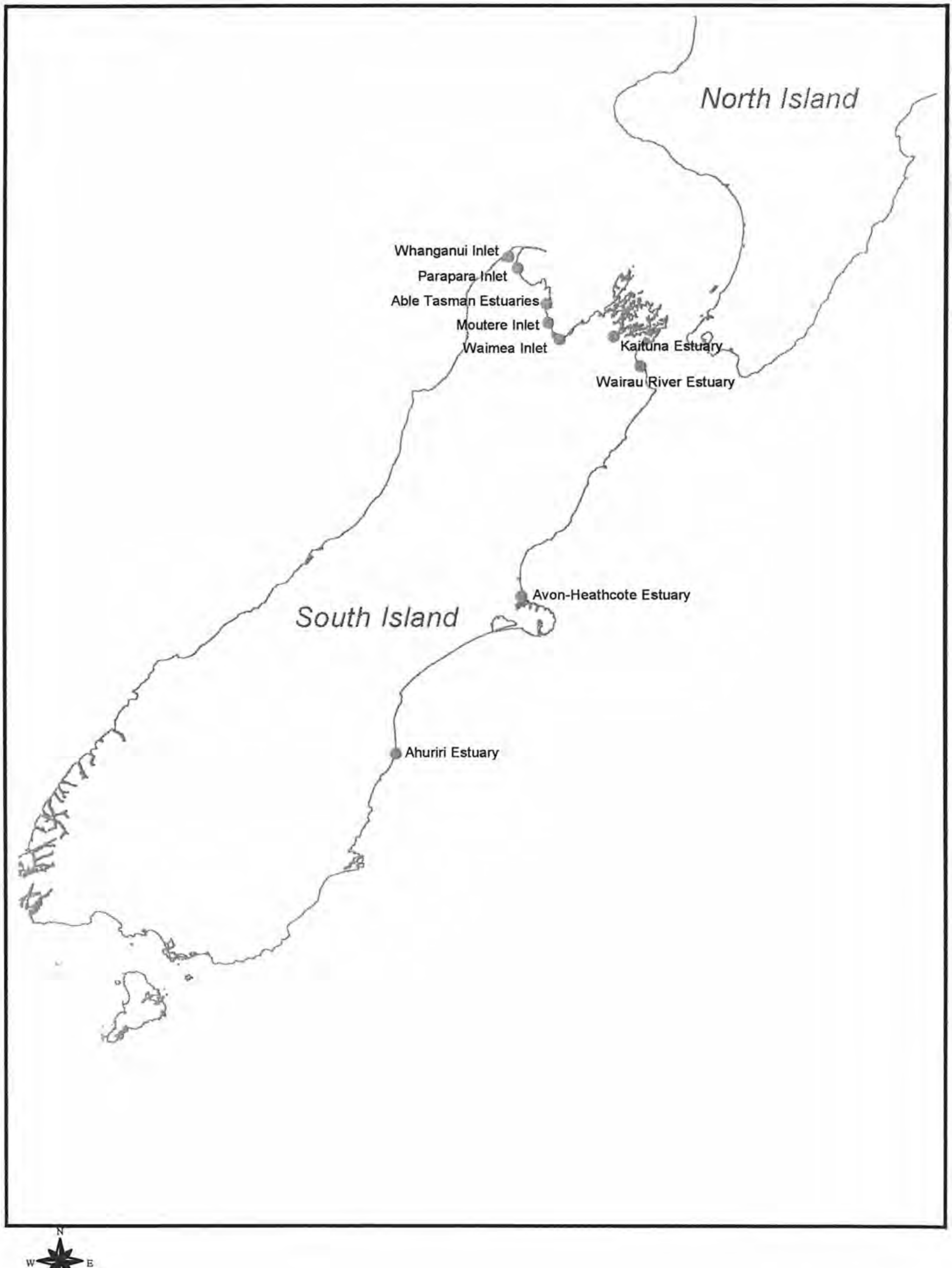
The value of the estuary is not only for its stand-alone value, but as part of a national and in some cases global linkage of bird habitats. Many species cannot survive in one location or habitat alone, and make use of often widely separate and diverse habitats. As examples, black swans banded at Lake Ellesmere, Caspian terns banded near Nelson and red-billed gulls banded on the Kaikoura coast have been seen in the Kaituna Estuary. Most other species, including international migrant waders, travel considerable distances to make use of the wetland.

5.2 Estuary Evaluation

Ecological values for Havelock Estuary have been compared to values recorded for five other South Island estuarine areas in Table 14. The evaluation methodology was developed during an ecological study of Waimea Inlet (Davidson and Moffat, 1990). Estuaries used in the present evaluation fit the criteria outlined by the Davidson and Moffat (1990). The ecological values for each estuary used in the present evaluation have been fully investigated (Knox and Kilner, 1973; Knox *et.al.*, 1977; Davidson and Moffat, 1990; Davidson, 1990, 1992).

On ecological and scientific grounds, Whanganui Inlet clearly ranked highest of the South Island estuaries investigated with Havelock Estuary ranking fifth out of six estuarine areas used in the comparison. Parapara Inlet, Golden Bay was the lowest ranked estuary of the six (Table 14). Havelock Estuary scored well for representativeness as it is the largest and ecologically most important estuary in the Marlborough Sounds. Havelock Estuary received moderate scores for pollution status, degree of modification, and state of estuarine vegetation. The estuary may be

Figure 9. Location of other South Island estuaries



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Produced on Marlborough District Council GIS.

TABLE 14 **Evaluation of Kaituna complex five other South Island estuaries.**

Criteria	Kaituna	Abel Tasman	Whanganui Inlet	Waimea Inlet	Parapara Inlet	Avon- Heathcote
1. Representativeness in region	80	80	80	80	27	80
2. State of estuary	40	60	60	40	40	40
3. Pollution status	45	60	60	30	45	15
4. State of terrestrial vegetation	30	45	45	15	30	15
5. State of salt marsh vegetation	45	60	60	45	45	30
6. Size of intertidal and subtidal areas	24	16	60	60	24	36
7. Number of invertebrate species	8	8	40	32	16	32
8. Number of waterbird species	16	16	24	24	8	32
9. Number of fish species	10*	10	40	40	30	40
10. Maximum cockle density	40	8	32	40	24	40
11. Number of intertidal vascular plant species	10*	15	10	20	15	20
Total	348	378	511	426	304	380
Percentage	62%	68%	91%	76%	54%	68%

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

upgraded in the future as more ecological information on the estuary is collected or as a result of estuary restoration.

Areas with high ecological value were predominantly located on the Pelorus side of the Havelock Estuary. Here, large areas of tidal flats represent large feeding area for wading birds, while an extensive native salt marsh habitat covered much of the higher tidal areas. Of particular note were areas of salt marsh fringed by tidal and freshwater wetland.

5.3 *Spartina* values

The Havelock Estuary supports extensive beds of *Spartina anglica*. This species is fertile and was a result of chromosome doubling of *Spartina townsendii* (Edgar and Connor (2000). *Spartina* was introduced into a variety of estuaries throughout New Zealand, but has been eradicated ffrom many in recent years (e.g. Waimea Inlet, Whanganui Inlet).

Spartina represents a source of productivity to Havelock Estuary and probably the wider Pelorus Sound (Knox 1986). This positive contribution is, however, outweighed by its adverse impact on the estuary. 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 numerous 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 in Havelock Estuary. White-faced heron and mallard duck are often observed resting or foraging along the channel sides against *Spartina* beds in this area, but do not depend or necessarily benefit from the *Spartina*. *Spartina* may also increase the rate of infilling of the estuary resulting in premature change to habitats and their associated species.

5.4 Bird habitats

Roost sites located along the eastern mole of the Harbour represent the areas of highest value to wader bird species. Most waders use areas towards the end of the mole, but on occasion, waders use areas adjacent to the marina log handling area. The eastern mole roost sites represent the only high tide roosts for wading birds located within the estuary. Herb field habitat represents a relatively uncommon habitat in the estuary and is important to small wading bird species such as banded dotterel and pipit.

Marginal vegetation including ribbonwood (*Plagianthus divaricatus),* native vine (*Muehlenbeckia complexa)* and other small hardy shrubs such as manuka, kanuka, coastal tree daisy (*Olearia solandri)*, and coprosma's (*Coprosma propinqua* and *Coprosma robusta)* represent important roosting and nesting habitat for species such as banded rail. Particular areas of *Juncus maritimus* rushland located in the upper tidal zone of the estuary represent habitat for marsh birds, particularly banded rail.

6.0 HUMAN IMPACTS ON ECOLOGICAL VALUES

6.1 Nutrient enrichment

Known and localised areas of nutrient enrichment have been documented from the oxidation pond outlet and from Sanfords discharge outlet. No pollution indicating polychaetes (*Capitella capitata* and *Heteromastides filiformis*), nematodes or dense beds of macroalgae such as *Ulva* sp., *Enteromorpha* sp. or *Gracilaria* sp. were recorded or observed during the present investigation of the wider estuary. Apart from isolated backwater areas, surface sediments from most of the estuary were relatively aerobic. These results suggest that the estuary has not been significantly enriched.

Sources of human derived nutrient entering the Havelock Estuary included:

- run off from farms entering the estuary directly or via rivers and streams;
- discharge of the Havelock sewage treatment ponds via the Kaituna River;
- stormwater from Havelock township;
- discharge of effluent from Havelock industry (e.g. Sanford (South Island) Ltd.).

No large-scale point source discharges of nutrient rich effluent enter the Havelock Estuary.

6.2 Toxic substances

Results from contaminant samples suggest that particular contaminants are either absent or enter the estuary in relatively low concentrations. Potential sources for these substances include:

- leachate from the closed rubbish dump;
- stormwater run-off from Havelock township;
- slipway activities;
- marina activities (eg accidental spillages);
- port activities including boat hull cleaning; and
- industrial activities.

6.3 Loss of estuarine habitats

Substantial areas of Havelock Estuary have been permanently lost through port development (past and proposed in the future), causeway construction, infilling and drainage, while modification to the estuarine values occurs through stock grazing, rubbish dumping, bark accumulation from log handling activities and clearance of estuarine fringing vegetation. Substantial habitat modifications have included the construction of road causeways to the north-west of Havelock, and reclamations and dredging related to the Port development. It should be noted that the proposed development of the Havelock marina development would result in loss of *Spartina* beds, stream channels and some mudflat habitat (see Davidson and Brown 1998).

6.4 Causeways

Loss of considerable estuarine, edge and terrestrial vegetation has occurred due to construction of causeways around Havelock Estuary. These have included the construction of causeways across the head of the Kaituna side of the estuary (i.e. the Queen Charlotte Drive) and the eastern side of the Pelorus side of the estuary (i.e. State Highway 6). These causeways have cut off and altered upper tidal reaches of the estuary 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.

6.5 Introduced predators and domestic animals

Footprints of ferrets, cats and dogs have been observed within and on the periphery of the estuarine 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. The proximity of high concentrations of 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.

6.6 Stock damage of estuarine fringe vegetation

Stock damage in estuaries can result in reduced population densities, reduced species richness and suppressed invertebrate community diversity compared to areas free from cattle grazing (Andresen et al. 1990).

Many areas around the Havelock Estuary margins remain accessible to domestic stock, particularly in the western estuary. Some areas have been fenced, though periodic flooding makes fencing a difficult though not impossible solution.

6.7 Weeds (gorse, wattle, heath, honeysuckle, broom)

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

See chapter 5.3 for *Spartina anglica* impacts.

6.8 Fire

On at least one occasion in the past a major fire has spread into the estuary from a non-permitted fire on neighbouring farmland. This fire temporarily destroyed extensive areas of rushland inhabited by banded rail and other marsh species.

7.0 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 1866). As a result, some estuaries or parts of estuaries close to human habitation often have relatively low ecological, scientific and/or conservation values (e.g. Manukau Harbour, southern shoreline of Waimea Inlet). The following sections outline various issues or activities that can lower ecological values and outline management recommendations that aim to maintain or improve the ecological values of Havelock Estuary.

7.1 Tidal flow and sediment transport

Tidal flushing and sediment transport in the Kaituna side of the estuary has undoubtedly been modified by the *Spartina* infestation, road causeways and existing port development. Restricted flows appear to have resulted in deposition of fine sediment. 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 estuary do not unduly interfere with tidal flushing, sediment transport and salinity regimes.

7.2 Disturbance of wildlife

Wildlife is vulnerable to disturbance from human activity, particularly in areas close to human habitation or in recreational areas (e.g. dog exercise areas). Such activities may be either long term or short term (i.e. related to a particular time of year or during particular stages of a development). At present most estuarine values are relatively isolated from human disturbance (e.g. salt marsh), however, the roost sites located on the northern parts of the eastern mole are subjected to regular human, vehicle and dog activity.

Recommendation 2
On the basis that particular human disturbance can have a negative impact on roosting birds, it is recommended that vehicle access to the eastern mole be closed and that signs be installed requesting that dogs be exercised under control in consideration of wildlife values.

7.3 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 is spreading within the estuary and is replacing intertidal flats utilised by waders as feeding habitat. *Spartina* beds may be increasing the rate of sediment build up within the estuary

(Knox 1986). Eradication of *Spartina* has occurred from all other previously infested areas in the Nelson/Marlborough region (e.g Waimea Inlet, Whanganui Inlet, Abel Tasman Estuaries). The Havelock Estuary remains the largest *Spartina* infestation in the northern South Island. Based on considerations that *Spartina*:

- will continue to spread;
- will reduce wader feeding habitat;
- will probably result in reduced diversity and abundance of invertebrates compared with tidal mudflat habitat;

it is therefore recommended that *Spartina* be eradicated from the estuary and inner Pelorus Sound.

A variety of issues related to the removal of large areas of *Spartina* should be addressed for Havelock Estuary 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 and the marine farming industry (ie. the effect on phytoplankton in Pelorus Sound).

Recommendation 3
Based on the negative impacts that *Spartina* has on estuarine 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 Regional Plant Pest Management Strategy (MDC, 1996)

7.4 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;
- road culverts that inhibit freshwater fish passage be modified to allow for fish migrations;

7.5 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 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 be monitored on a thorough and regular basis.

7.6 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. A key candidate is located on the western side of the Pelorus River and the lower end of 'Twidles Island' (Figure 2). This area contains the most extensive and least modified wetland shrubland-forest located in Havelock Estuary. Options for this area include fencing, weed control, a return to natural drainage (i.e. removal or alteration of man-made drainage), replanting of native species, or purchase for reservation.

Other important areas suitable for riparian restoration include boundaries with residential properties in the western Kaituna arm, along road or esplanade reserve on the eastern side of the Kaituna arm, the eastern side of the Kaituna River, swampy pasture/drainage channels inland of the Queen Charlotte Drive causeway, and area of saltmarsh communities isolated from the estuary by the SH6 causeways.

Recommendation 6
Peripheral estuarine habitats represent important ecological habitats. These areas are often lost in many estuaries of New Zealand. It is recommended that peripheral areas in Havelock Estuary be identified and measures to protect, improve or enhance these area be outlined and where appropriate be implemented. Recommendations by Davidson and Brown (1998) to plant areas around the edges of Havelock Estuary should be supported.

7.7 Protection of marginal vegetation from stock access using fencing

At the bottom end of Twidles Island the Department of Conservation has established some fencing, but stock intrude into estuarine and riparian zones of the Pelorus and to a lesser degree the Kaituna Rivers.

Recommendation 7
Stock access to estuarine and freshwater habitats results in a lowering of ecological values. Fencing of estuarine or fringe vegetation from estuarine and freshwater riparian zones is recommended to inhibit stock access.

7.8 Creation of high tide bird roosts

Remedial action relating to a proposed extension to the Port Marlborough marina in Havelock was recommended by Davidson and Brown (1998). Exclusion of all vehicle traffic (including trail bikes) from the outer section of the marina mole was also recommended, as well as formation of a low-lying shellbank or 'island' slightly off-shore from the mole as a high-tide bird roost. These actions would all improve the habitat for birds in Havelock Estuary.

Recommendation 8
Measures to enhance bird roosting habitats recommended by Davidson and Brown (1998) be supported.

7.9 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 in particular areas of Hacelock Estuary, it is recommended that control of predators and should be considered in regional pest control strategies

7.10 Promotion of estuary 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). A balanced development scheme such as that promoted for the Havelock marina expansion (see Davidson and Brown 1998), would provide opportunities to change such prevalent attitudes. The proposal includes mitigation options such as a walking track along landscaped areas, with opportunities to view an excellent variety of wildlife (including swans, oystercatchers, herons and terns) at reasonably close range. 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 estuaries and Havelock Estuary in particular should be identified and where appropriate implemented.

7.11 Legal protection of further areas

An area of the Pelorus Estuary has been designated a Wildlife Management Reserve. Other areas in the estuary also warrant formal protection. These areas include:

- The wider Havelock Estuary outside of the designated port and marina zones; and
- Intertidal habitats at Kaiuma Bay and Mahakipawa Arm

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Appendix 1 Number of cockles recorded within each size class. Data collected in February 2000.

	Sites																											
Size	1a	1b	1c	2a	2b	2c	3a	3b	3c	4a	4b	4c	5a	5b	5c	6a	6b	6c	7a	7b	7c	8a	8b	8c	9a	9b	9c	Total
5mm-9mm	0	0	0	4	0	6	0	0	0	0	0	0	1	0	0	2	0	3	0	0	1	0	0	1	4	1	1	24
10mm-14mm	0	1	0	24	0	24	0	1	1	0	0	0	1	0	0	3	6	2	0	0	0	0	0	0	0	3	0	66
15mm-19mm	0	0	3	26	4	29	2	6	9	0	0	0	1	2	2	4	16	15	0	1	0	1	0	0	0	0	0	121
20mm-24mm	0	0	0	12	1	24	7	7	12	0	0	0	1	1	1	5	9	16	1	4	1	0	0	1	1	0	0	104
25mm-29mm	0	0	0	3	0	0	11	11	4	0	0	0	1	1	0	7	7	5	2	1	2	0	0	0	0	0	0	55
30mm-34mm	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	4
Total	0	1	3	69	5	83	20	26	26	0	0	0	5	4	4	22	38	42	3	6	4	1	0	2	5	4	1	374

APPENDIX 2 Bird species recorded from Kaituna Estuary

Category B - second highest priority rating for species conservation:

Black-fronted tern	*Sterna albostriata* -	resident non-breeding

Category C - third highest priority rating for species conservation:

White-fronted tern	*Sterna striata*	resident non-breeding
Variable oystercatcher	*Haemotopus unicolor*	occasional visitor
Banded dotterel	*Charadrius bicinctus*	rare visitor

Category O - threatened in NZ but secure elsewhere in the world:

Australasian bittern	*Botaurus stellaris*	resident
White heron	*Egretta alba modesta*	very rare visitor
Royal spoonbill	*Platelea leucorodia*	rare visitor
Caspian tern	*Hydroprogne caspia*	resident non-breeding

Other species:

Australasian gannet	*Morus serrator*	rare visitor
Black shag	*Phalacrocorax carbo*	resident
Little black shag	*P. sulcirostris*	regular visitor
Pied shag	*P. varius*	resident
Little shag	*P. melanoleucos*	resident
White-faced heron	*Ardea novaehollandiae*	resident
Cattle egret	*Bulbulcis ibis*	rare visitor
Black swan	*Cygnus atratus*	resident
Canada goose	*Branta canadensis*	rare visitor
Paradise shelduck	*Tadorna variegata*	resident
Mallard	*Anas platyrhynchos*	resident
Grey duck	*A. superciliosa*	resident
NZ shoveler	*A. rhynchotis*	resident
Grey teal	*A. gracilis*	occasional visitor
Harrier	*Circus approximans*	resident
Banded rail	*Rallus phillipensis*	resident (threatened in Bell 1983)
Marsh crake	*Porzana pusilla*	resident
Pukeko	*Porphyrio porphyrio*	resident
Pied oystercatcher	*Haemotopus ostralegus*	resident non-breeder
Spur-winged plover	Vanellus miles novaehollandiae	resident
Bar-tailed godwit	*Limosa lapponica*	migratory visitor
Pied stilt	*Himantopus himantopus*	resident
Black-backed gull	*Larus dominicanus*	resident
Red-billed gull	*L. novaehollandiae scopulinus*	resident
Black-billed gull	*L. bulleri*	resident
Kingfisher	*Halcyon sancta*	resident non-breeder
Welcome swallow	*Hirundo tahitica neoxena*	resident
Pipit	*Anthus novaeseelandiae*	resident/regular visitor

APPENDIX 3: Macroinvertebrates recorded from Kaituna Estuary.
Habitats: Sp = *Spartina*, In = Interidal sand flat, Sub = Subtidal, R = Rock

Feeding type: C = Carnivore; D = Detritus; H = Herbivore; Sus = Suspension; Scav = Scavenger

Invertebrate	Common Name	Feeding Group	Habitat
Phylum Sipunculida (Acorn worms)			
Unidentified sp.		D	In
Class Gastropoda (Univalve molluscs)			
Amphibola crenata	Mudflat snail	D	In/Sp/Sub
Cominella glandiformis	Mudflat whelk	C	In
Notoacmea helmsii	Limpet	H	In
Ophicardellus costellaris	Snail	D	Sp
Potamopyrgus estuarinus	Estuarine snail	D	Sp/In/Sub
Class Pelecypoda (Bilvalves)			
Austrovenus stutchburyi	Cockle	Sus	In/Sub
Crassostrea gigas	Pacific oyster	Sus	In/R
Nucula hartvigiana	Nut shell	Sus	In/Sub
Paphies australis	Pipi	Sus	Sub/Sp
Xenostrobus pulex	Little black mussel	Sus	Sp/Sub
Class Polychaeta (Marine worms)			
Family Nereidae			
Nicon aestuariensis	Rag worm	C	In/Sp/Sub
Family Pectinariidae			
Pectinaria australis	Sand mason worm	Sus	Sub
Order Cirripedia (Barnacles)			
Elminius modestus	Estuarine barnacle	Sus	Rock
Order Amphipoda (Sand Hoppers)			
Unidentified sp. # 1			Sp/In
Unidentified sp. # 2			Sp/In
Unidentified sp. # 3			Sub
Order Isopoda (Sea lice)			
Unidentified sp.			Sub/In
Order Decepoda			
Halicarcinus whitei	Spider crab	C	In/Sub/Sp
Helice crassa	Mud crab	D	Sp/In/Rck
Leptograpsus varigatus	Shore crab	C	Rck
Class Insecta			
Dipteran larvae sp. # 1	Larval fly	D	Sp.

APPENDIX 3: Macroinvertebrates recorded from Kaituna Estuary.
Habitats: Sp = *Spartina*, In = Interidal sand flat, Sub = Subtidal, R = Rock

Feeding type: C = Carnivore; D = Detritus; H = Herbivore; Sus = Suspension; Scav = Scavenger

Invertebrate	Common Name	Feeding Group	Habitat
Phylum Sipunculida (Acorn worms)			
Unidentified sp.		D	In
Class Gastropoda (Univalve molluscs)			
Amphibola crenata	Mudflat snail	D	In/Sp/Sub
Cominella glandiformis	Mudflat whelk	C	In
Notoacmea helmsii	Limpet	H	In
Ophicardellus costellaris	Snail	D	Sp
Potamopyrgus estuarinus	Estuarine snail	D	Sp/In/Sub
Class Pelecypoda (Bilvalves)			
Austrovenus stutchburyi	Cockle	Sus	In/Sub
Crassostrea gigas	Pacific oyster	Sus	In/R
Nucula hartvigiana	Nut shell	Sus	In/Sub
Paphies australis	Pipi	Sus	Sub/Sp
Xenostrobus pulex	Little black mussel	Sus	Sp/Sub
Class Polychaeta (Marine worms)			
Family Nereidae			
Nicon aestuariensis	Rag worm	C	In/Sp/Sub
Family Pectinariidae			
Pectinaria australis	Sand mason worm	Sus	Sub
Order Cirripedia (Barnacles)			
Elminius modestus	Estuarine barnacle	Sus	Rock
Order Amphipoda (Sand Hoppers)			
Unidentified sp. # 1			Sp/In
Unidentified sp. # 2			Sp/In
Unidentified sp. # 3			Sub
Order Isopoda (Sea lice)			
Unidentified sp.			Sub/In
Order Decepoda			
Halicarcinus whitei	Spider crab	C	In/Sub/Sp
Helice crassa	Mud crab	D	Sp/In/Rck
Leptograpsus varigatus	Shore crab	C	Rck
Class Insecta			
Dipteran larvae sp. # 1	Larval fly	D	Sp.