A REPORT ON THE ECOLOGY OF THE KARAMEA / OTUMAHANA ESTUARY, WEST COAST, NEW ZEALAND.

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SUMMARY

Estuaries are widely recognised as highly productive wetland ecosystems, of which many are significantly threatened by human activities. Of the nine tidal flat estuaries on the West Coast, few have been closely studied, and equally few are protected in reserves. Covering 400 ha, the Karamea/Otumahana Estuary is the second largest estuary in the region, and was surveyed and mapped over the summer of 1991-2. The estuary contains seven main habitat types based on sediment texture and saltmarsh plant communities. These support a large number of indigenous animals, including at least 20 species of invertebrates, __ species of fish, and __ species of birds.

__ intertidal plant species were also identified from the estuary. The good water quality, the diversity of habitats and food sources, and the relative closeness to the enormous sandflats of Farewell Spit, are all fundamental to the richness of the estuary's fauna. The Otumahana Estuary is the southern limit on New Zealand's west coast for an intertidal mollusc (the bubble shell, *Haminoea zelandiae*) and a saltmarsh plant (the glasswort, *Sarcocornia quinqueflora*).

Human activities in and around the estuary often depend on the quality of the estuary, but also have diminished that quality in some instances. Fishing, whitebaiting, cockling, waterfowl shooting and birdwatching occur in the estuary. However, the estuary's margins, which are particularly important for maintaining these activities and the estuary itself, are mostly modified by land clearance, drainage and farming.

It is recommended that the estuary be managed to maintain its essential natural qualities...

1. INTRODUCTION

1.1 ESTUARIES

Definition of (tidal flat) estuaries
Importance of estuaries generally???

1.1.1 THE IMPORTANCE OF ESTUARY MARGINS

1.2 WEST COAST ESTUARIES

The West Coast Region is generally regarded as including the coastline from Kahurangi Point in the north, to Awarua Point in the south. These boundaries are recognised in most national government agencies (including the Department of Conservation and MAFFish), and also by regional and local governments. Within this 600 km of coastline are approximately 10 major tidal flat estuaries, and at least 28 other tidal estuarine and lagoonal systems (McLay,1976). Although the Department of Conservation maintains an inventory of Wetlands of Ecological and Representative Importance (called the WERI Database), there have been very few detailed ecological studies of the West Coast's estuaries. Okarito Lagoon (Knox et al, 19__) and Blaketown Lagoon (Knox et al, 19__) are the only estuaries that have been studied in any real detail.

Estuary	Total Area (ha)	Saltmarsh area (ha)	Mudflat area (ha)	Cockle bed area (ha)		
Oparara	110					
Karamea/ Otumahana	400					
Orowaiti	240					
Buller River mouth	125					
Okari	400					
Blaketown	25					
Saltwater	850					
Okarito	3240					
Three Mile	110					
Okuru	132					
TOTAL	5632					

Only three of the West Coast's ten tidal flat estuaries have any significant degree of physical protection by way of marginal buffer strips, and/or legal environmental protection (viz. Saltwater Lagoon Scenic Reserve, Okarito Lagoon Wildlife Management Reserve, and Three Mile Lagoon within Westland National Park) and these are all within 30 kilometres of each other. Furthermore, the three are all within two adjacent districts (Harihari and Waiho) of the same ecological region (Whataroa), as defined by McEwen (19__). They are therefore not likely to represent the full range of estuarine habitat types on the West Coast. Development around some of the West Coast's less protected estuaries has already degraded many important estuarine habitats. It is therefore important to identify the character and important features of the region's estuaries, and if necessary to ensure that these features are adequately protected from unnatural disturbances.

1.3 OBJECTIVES

The study set out to achieve the following objectives:

1. map vegetation, substrates, structures and land use within and adjacent to the estuary;
2. obtain baseline biological information on vegetation, invertebrates, fishes and birds;
3. relate invertebrate species composition to habitat type and assess the accuracy of predicting species composition in non-sampled areas;
4. identify biologically important areas and features in the estuary;
5. identify threats to the estuary and suggest possible solutions; and
6. make recommendations for the management of the estuary.

The methods used in this study, and the structure of this report, closely follow those of the survey of Waimea Inlet by Davidson and Moffat (1990). That survey is now recognised by the Department of Conservation as a benchmark for estuary survey techniques in New Zealand.

2. KARAMEA/OTUMAHANA ESTUARY

Approximately 6 000 years ago, post glacial sea levels rose to the present day levels. Since then, the sea levels have fluctuated above and below this level by +0.6m and -0.4m (Gibb, 1986). During this period, sediments were transported by littoral drift predominantly from the south, and by rivers such as the Karamea. Huge volumes of sand were reworked by sea waves and deposited as beach ridges and sand dunes to form a sand plain 29 km long by up to 4.5 km wide. This large flat expanse of land is the Karamea Plain, stretching from Kohaihai River in the north to Little Wanganui River in the south.

South of Karamea River, the rapid progradation of the coast created a lowlying depression that was progressively blocked off from the Tasman Sea by the formation of a sand ridge and dune along its western edge. This depression is now regularly flushed by every tide and has evolved into what is now known as the Otumahana Estuary. Together with the adjacent estuarine area of the Karamea River it covers 400 ha, making it the largest estuarine system in the Buller District and the third largest on the West Coast, behind Okarito and Saltwater Lagoons. The Karamea/Otumahana Estuary is the largest of the only two tidal flat estuaries that occur along the 160 km of coastline between Whanganui Inlet and Orowaiti Estuary (the other being the nearby 110 ha Oparara Estuary). It lies within the Karamea Ecological District, which is part of the North West Nelson Ecological Region (BRC, 19).

[FIGURE 1: MAP OF KARAMEA/OTUMAHANA ESTUARY, 1:15 000. With location map, scale bar, place names, roads & buildings, estuary outline, channels, saltmarsh area,]

The Karamea/Otumahana Estuary is shown in Figure 1. It is a shallow bar-built estuary, measuring approximately 5.5 km north to south by 1.2 km east to west. It is open to the Tasman Sea at its northwestern corner, and is also fed by the Karamea River in the north and Granite Creek in the south. The sea enters this large tidal compartment twice daily, raising the water level by between ___ and ___ metres above low tide level. From this, it is estimated that as much as ______ cubic metres of water enter the estuary on each spring tide. At low tides, most of the estuary is left exposed, with only the river channels remaining underwater.

The Karamea River is the largest source of freshwater entering the estuary. The river mostly flows straight out to sea through the Karamea Estuary, but significant volumes of freshwater flow south into the Otumahana Estuary during high tides and flood events. Normal flows into the estuary are approximately __ cumecs, while flood events of ____ cumecs have been recorded. Baker's Creek flows into the northern end of the estuary, and is the main overflow channel for flood events in the Karamea River.

Granite Creek flows into the southern end of the Otumahana Estuary, from the Kongahu Swamp which extends further to the south. The creek is tidally influenced, with saltmarsh plants and animals penetrating its lower reaches. Kongahu Swamp is the largest coastal swamp habitat in Westland (Morse, 1981), but has been extensively modified by drainage and other agricultural activity. Some __ other small streams also enter the estuary.

The estuary is a very dynamic system, as can be seen in the diagrams in Figures 2a and 2b. These outlines and channel configurations are drawn from air photos of the estuary taken in 19__ and 1988 respectively. Parts of the estuary margins have eroded while other parts have aggraded. The channels within the estuary have also changed considerably. Some of these changes are due to land development such as drainage, but some (particularly near the mouth of the estuary) are natural changes caused by the dynamic action of flowing water and waves on the movement of the sandy and muddy sediments.

[FIGURE 2a AND 2b: ESTUARY OUTLINE AND CHANNEL CONFIGURATIONS,

19__ & 1988; 1:15 000]

There is some evidence to suggest that the bed of this estuary, and perhaps a larger portion of the Karamea Plain, has dropped in elevation in historical times (A Quince, pers. comm. 1993). Old farm fences that were presumably once on dry land can be found running through parts of the estuary flats, having been inundated by the tides as the land has slumped. The widespread erosion of the coastline between the Karamea and Little Wanganui Rivers may also be explained as an adjustment to a change in relative sea level caused by slumping of the seabed and coastal land. Such a drop in elevation may have been caused by the 19?? Murchison earthquake and other seismic activity.

Archaeological evidence suggests that the estuary and the surrounding land has been used by the human inhabitants of the Karamea coastal plain for the past ___ years. It has become a prime site for fishing, whitebaiting, waterfowl shooting and shellfish gathering, as well as non-extractive activities such as bird-watching and boating. During this long period of occupation, the estuary has been significantly modified, most obviously due to the draining of the swampy margins and development of these areas for stock grazing. Today, much of the estuary's margin bears little resemblance to its condition prior to human arrival.

Despite the modification, the Karamea/Otumahana Estuary is regarded as an area of high conservation value (Morse, 1981). A comprehensive ecological survey of the estuary is therefore considered important before more ecologically important areas within and around the estuary are lost. This report investigates the ecology of the Karamea/Otumahana Estuary and outlines a set of conservation guidelines for future management. It is hoped that the report will be of particular use for educational and scientific purposes.

Modification of the estuary has occurred right around its margins. The most obvious impact has been from agricultural activities. The Karamea coastal plain has undergone extensive land drainage and clearance of the original vegetation, in order to convert it to grazing pasture. The inherent quality of the soils has enabled the subsequent development of some of the best quality dairy farming land on the West Coast. As well as modifying the estuary's catchments, these activities have encroached into the margins of the estuary itself, and parts of the estuary have suffered as a result. Floodgating and excavation of estuary channels to further improve drainage of the adjacent land has had additional impacts on the estuary.

5. HABITATS AND HABITAT MAPPING

Within estuaries, many physical and biological factors interact to form unique estuarine areas or habitats. Each habitat type is associated with a community consisting of particular plants and animals. Each community is able to cope with a particular set of environmental constraints.

Recognition and mapping of the main habitats in the Karamea/ Otumahana Estuary (this chapter) and determination of characteristic flora and fauna associated with each habitat type (Section 4) forms the basis of the report.

5.1 HABITAT TYPES

This section describes the major habitat types in the Karamea/Otumahana Estuary. Each habitat type was recognised using either physical factors (eg. substrate type, tidal height, salinity), or biological features such as the presence and abundance of certain plants and animals. Using the combination of physical and biological features, seven basic habitat types were recognised in the estuary.

1. Mobile sand
   Mobile sand in the estuary is recognised by the granular beach sand appearance and the usually rippled surface layer. Mobile sand is continually being moved by strong tidal currents and often forms bars and beaches.

2. Fine sand flats
   Fine sand flats are mud-like in appearance, but are granular when rubbed between the fingers, and solid enough to support an adult's weight without sinking more than 1-2 cm. Fine sand may have a thin layer of silt on the surface, making identification from a distance impossible.

3. Mudflats
   Mudflats below the high tide level appear brown on the surface with a black anaerobic layer below. Most mudflat areas in the Karamea/Otumahana Estuary are composed of thick glutinous silt and clay which, when rubbed between the fingers appears soft and non-granular. Small pebbles or shell material provide attachment for agar weed (*Gracilaria* sp.).

4. 'Gravel' flats
   Granite Creek, and to a lesser extent the Karamea River, carry significant volumes of fine granitic gravel into the estuary. Soon after entering the quiet waters of the estuary, this gravel is dropped out of the bedload and settles on the estuary bed near the river outlets to form broad flats (or deltas) that fan out from the mouths and channels. The gravel is often mixed with fine sands encroaching from the flats further out in the estuary, so that the 'gravel' flats are in fact composed of a mixture of sediment sizes.

5. *Samolus* herbfields
   The sea primrose (*Samolus repens*) is located in the high tide zone of the Karamea/Otumahana Estuary. It is often found along with other small herbs such as glasswort (*Sarcocornia quinqueflora*) and remuremu (*Selliera radicans*). These plants grow on all substrate types present in the high tide zone. It was noted (R. Davidson, pers comm. 1993) that some of the herbfield species collected in this survey from the Karamea/

Otumahana Estuary were unusually large; the reason for this is not known.

6. <u>Saltmarsh of native sedges and rushes</u>
Two rushes (*Juncus maritimus* and *Leptocarpus similis*) and one sedge (*Schoenoplectus pungens*) were mapped in the estuary. Each of these species is easily distinguished and are most often located near freshwater input and around the margins of the estuary.

7. <u>Subtidal and river channels</u>
Subtidal and river channels are tidally influenced areas permanently covered by water. Due to the relatively high flow velocities in these channels, the sediments are usually in the coarser range of sizes (fine sand to gravel).

All of these habitat types except for the 'gravel' flats and *Samolus* herbfields are derived from Davidson and Moffat (1990). Five habitat types that were found in that study (viz. eelgrass beds, pebbles and cobbles, highshore flats, glasswort beds, and *Spartina* beds) were absent from the Karamea/Otumahana Estuary, or were of too small an area to be mapped.

5.2 HABITAT AND VEGETATION MAPS
The distributions of the major habitats and vegetated areas in the Karamea/Otumahana Estuary were determined using aerial photographs flown in 1988 on a low tide and enlarged to approximately 1:7000. Habitats were field verified and marked on the photos. The final habitat map is produced in Figure 3 at a scale of 1:15 000, and shows the distribution of sediments and vegetation types in the estuary. From this map it can be seen that the estuary comprises a complex mosaic of habitats.

[FIGURE 3: HABITATS OF THE KARAMEA/OTUMAHANA ESTUARY; 1:7 000]

5.2.1 Distribution of Sediments
Sediments in estuaries are moved and deposited by the flows of water caused by tides and rivers. They are brought into the estuary from the relatively strong and turbulent flows from the rivers, streams and sea. The largest particles (sands and gravels) tend to drop out of suspension soon after entering the relatively calm water of the estuary. Water flows within the estuary are greatly reduced away from the main channels, and by the presence of saltmarsh vegetation. The smallest sediment particles (clays and silts) are held in suspension in the water, but if they happen to reach a place where the flow velocities are low enough, these particles settle on the estuary bottom. The middle size particles (fine sands) tend to fall out of suspension where the flows are moderate. As a result, the distribution of sediments in the estuary tends to reflect the pattern of water flow.

Nevertheless, sediments do not simply enter the estuary and settle on the bed, never to move again. Estuaries are "dynamic sediment traps", in which there is a continual flow of sediments into and out of the system. The distribution of sediments that you see at any one moment is merely a "snapshot" of a very mobile system. Pethick (1984) notes that:

> "A common misconception about tidal mudflats and marshes is that they are formed in coastal backwaters where they form a sort of dumping ground for the detritus collected on open coasts and transported into those sheltered bays. Thus these backwaters are supposed to fill with mud and constitute only an ephemeral coastal landform.
>
> This is, of course, not so. Tidal landforms are not areas of quiet water, they receive enormous discharges and tidal currents twice a day and their morphology is adapted to these energy inputs."

Figure 4 shows, at a scale of 1:______, the distribution of sediments in the Karamea/Otumahana Estuary. The pattern of deposition described above is apparent in this map.

[FIGURE 4: SEDIMENTS OF THE KARAMEA/OTUMAHANA ESTUARY, 1:15 000]

Gravel and mobile sand beds occur where coarse sediments are deposited near the mouths of the major river channels and the mouths of the estuary that lead to the sea. The type of coarse sediment at each of these places is determined by the type supplied by the current. That is, the Karamea River and the sea discharge mostly sand-sized particles into the estuary, while Granite Creek mostly discharges coarser gravel particles. This process is indicated in the types of coarse material that are found at each of these estuary mouths, and is known as the 'Source Area Effect'.

The estuary channel that drains Granite Creek has been dredged in past times, and the dredged gravel has been piled up into a long mound or 'bund' running alongside the channel. As well as deepening the channel and changing the immediate area from a tidal flat to a mound covered in pasture grasses, this has had significant effects on the composition of the substrate in the vicinity. The bund has enclosed and sheltered a tidal area at the southern end of the estuary that has - probably as a consequence - turned into a mudflat. The dredging has also brought underlying gravel to the surface to be washed further out into the estuary. The encroachment of gravel across the estuary surface has therefore probably been increased by past excavation activities in the channel leading out of Granite Creek.

Mudflats occur where the small-sized clays and silts are concentrated. They tend to be in some of the more sheltered pockets of the estuary away from the mouths, in places where the water currents are weak. These areas are mostly around the margins of the southern half of the estuary. Some of the areas of saltmarsh vegetation shown on the map are also on a muddy substrate, since the vegetation 'traps' the finer sediments by reducing the strength of the tidal currents.

Fine sand flats occur where the current flows are moderate, and this includes much of the southern half of the estuary, particularly away from the sheltered margins and the mouth of Granite Creek. Smaller areas of fine sand flats also occur in the northern portion of the estuary. A large proportion of the saltmarsh vegetation grows on a fine sand substrate.

5.2.2. Saltmarsh Habitats

Pethick describes saltmarshes as follows:

> "Saltmarshes are vegetated mudflats [and sandflats], and yet their form and the processes which act upon them are quite distinct. Marsh surfaces are much higher, relative to mean tide level, than mudflats and consequently are flooded much less frequently, in most cases only by the highest spring tides. The tidal currents which flow over the marsh surfaces are much weaker than those on mudflats. ...The major differences between marsh and mudflat are produced by the vegetation which covers the marsh surface and by the intricate creek network which covers most marshlands."

As the upper mudflats build higher with fresh accumulations of fine sediment so the tidal flooding decreases, leaving the mudflat more exposed and allowing vegetation to colonise. The flats are initially colonised by mid-tide herbfield species such as *Samolus* and *Selliera*, which help to accumulate more sediment and cause the marsh to grow in height. This in turn allows many more competitive species (such as rushes and sedges) to colonise the flat and progressively raise the surface level, developing a sequence or succession of plant communities over time and, to a lesser extent, over the width of the marsh. Young marshes (0-100 years) may build up by as much as 10cm/year, but over long time intervals the accretion rates show a gradual decrease as the surface rises in height. Pethick (1981) has found that saltmarsh surfaces which are flooded to a depth of 0.8m on the highest tides of the year have almost zero accretion rates and become stable at this level.

5.3 AREA OF EACH HABITAT

Habitat areas were calculated using a planimeter and dot-grids, and the results are presented in Table 1. Biologically important plant species are also included in the table.

The largest habitat in the estuary is _____ (__ ha), followed by ________. Vegetation is dominated by the saltmarsh rushes *Juncus maritimus* and *Leptocarpus similis* (__ha) and *Samolus repens* (__ha). Native estuarine vegetation covers ___ha or ___% of the total estuary.

6. FLORA AND FAUNA

6.1 INVERTEBRATES

6.1.1 Sampling methods and analyses

Invertebrates were sampled from __ sites in the Karamea/Otumahana Estuary in the summer of 1991-92 (Table 2; Figure 3). Sample sites were restricted to the major habitat types in the estuary. Each habitat type except the subtidal habitat was sampled at least once. It should be noted however that the extent of invertebrate sampling was limited by the time available, thus giving the analysis that follows a degree of uncertainty. To fulfill statistical requirements, each habitat type would need to be sampled at a minimum of four sites. It is recommended that this be done if the opportunity arises.

At each site, five random core samples (15 cm in diameter and 15 cm deep) were collected and immediately sieved. Samples of predominantly mud/silt were passed through 0.5 mm mesh, while samples containing coarse substrates were sieved through 1.0 mm mesh. Material remaining in the sieve was placed in labelled plastic containers, and stored in 80% isopropyl alcohol (IPA) within 10 hours of collection. Organisms were sorted from the samples, identified and counted. For molluscs, numbers of reasonably intact shells were counted, since it was impractical to count only the live specimens. Occurrences of species from each habitat type were recorded, and estimates of average density per square metre were derived.

Macroinvertebrates within five random quadrats (250 x 250 mm) were also counted and recorded at each site. Approximately 5 minutes at each site, and also while moving between sites, was spent searching for rare or widely distributed invertebrates. Their presence and approximate abundance were noted.

In order to get an impression of the distributions of the larger invertebrates within the estuary, an additional sampling design was carried out. The metric NZMS260 map grid was transferred as accurately as possible on to a 1:7000 scale air photo of the estuary and a 200 metre grid over the whole of the estuary was developed from this. Sampling sites were placed at each grid point, and by this means the 100? sampling sites shown in Figure 5 were selected. At each sampling site, five random quadrats (250mm x 250mm) were sampled. The numbers of large invertebrates (cockles, crabholes, snails) were counted and the lengths of all cockles were measured.

__ additional sites were sampled only for cockles, using the quadrat method only, and were counted and measured.

[FIGURE 5: INVERTEBRATE SAMPLING LOCATIONS, 1:15 000]

<u>Cockle sampling</u>
Cockles (*Austrovenus stutchburyi*) collected from benthic invertebrate core samples and from the grid sampling by the quadrat method were counted and measured (Appendix _).

6.1.2 Invertebrate fauna

Twenty invertebrate species were recorded from the Karamea / Otumahana Estuary (Table 3). The Mollusca ('shellfish') were represented by ten species (seven univalves; three bivalves), the Polychaeta ('worms') by 1+ species, and the Crustacea (crabs, etc.) by 5+ species. Representatives of ____, ______ and _____ were also recorded from the estuary.

The species diversity of this estuary is considerably less than the 112 invertebrate species that were found by Davidson and Moffat (1991) to inhabit Waimea Inlet. The likely reasons for this are:

1/ this estuary is much smaller (600ha vs. 3455ha);

2/ fewer major habitat types occur here (7 vs. 10), and in particular, there are no 'effectively immobile' (ie. bedrock, boulder, or pebble/cobble) habitats in the Karamea/Otumahana Estuary. Such habitats tend to support an entirely different fauna than the more common mobile sediment substrates; 32 of the Waimea Inlet species predominated solely on pebble/cobble habitats.

3/ this survey was less detailed, and may have overlooked a greater number of species.

TABLE 3. Species list of benthic invertebrates from the Karamea/Otumahana Estuary

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In the following list, the locality type in which each animal occurred most frequently is recorded as:

R = Rushes/sedges
G = Gravel
M = Mud
F = Fine sand
S = Subtidal

Feeding type is recorded as:

C = Carnivore
H = Herbivore
Sc = Scavenger
D = Detritus feeder
Su = Suspension feeder

Phylum Mollusca (molluscs)
Class Gastropoda (univalve molluscs)

Amphibola crenata	Mudflat snail	D	M
Cominella glandiformis	Mudflat whelk	C	M
Diloma subrostrata	Mudflat topshell	H	M
Haminoea zelandiae	Bubble shell	D,C	M
Notoacmea sp.	Estuarine limpet	H	
Ophicardellus costellaris	A snail	H,D	
Potamopyrgus estuarinus	Estuarine snail	D	

Class Pelecypoda (bivalve molluscs)

Austrovenus stutchburyi	Cockle	Su	F
Paphies australis	Pipi	Su	S?
Tellina liliana	Wedge shell	D	F?

Phylum Annelida (segmented worms)
Class Polychaeta
SEDENTARIA

Family Pectinariidae (sand mason worms)			
Pectinaria australis		D	M̄
Phylum Arthropoda			
Class Cirripedia (barnacles)			
Elminius modestus	Estuarine barnacle	Su	F
Class Malacostraca			
Order Amphipoda (sand hoppers)			
Order Isopoda (sea lice)			
Order Decapoda (decapods)			
Halicarcinus	Spider crab	C	S?
Helice crassa	Mud crab	D	F?
Hemigrapsus crenulatus	Hairy handed crab	C	F?
Macropthalmus hirtipes	Stalk eyed crab	D	F?
Class Insecta (insects)			

6.1.3. Habitats and associated invertebrate communities.

Within each of the six habitat types identified in the estuary (see Section), a characteristic group of invertebrates were recognised.

1. Mobile sand
2. Fine sand flats
3. Mudflats
4. 'Gravel' flats
5. Native sedges and rushes - large numbers of *Potamopyrgus estuarinus*, along with *Amphibola crenata*, polychaete worms, amphipods
6. Subtidal and river channels - these were not properly surveyed, although a few species were incidentally identified from this habitat type. Other New Zealand estuary studies suggest that dominant invertebrate species are likely to be pipi, swimming crabs and polychaete worms.

....

6.1.3 Invertebrates of particular interest

The following section describes the general biology and special features of the invertebrate species found in the Karamea/Otumahana Estuary, and outlines their distribution within the estuary. Drawings and further descriptions of the species listed here can be found in the handbook "Animals of the Estuary Shore" by Malcolm Jones.

MOLLUSCA (Gastropoda):

<u>Mudflat snail (*Amphibola crenata*)</u>

The mudflat snail is the most widely distributed mollusc in the Karamea/Otumahana Estuary, and reaches densities of ___ per sq. m ... The snail prefers mud substrates and is absent from mobile sand flats. It feeds on micro-organisms and organic detritus in the surface layer of estuarine sediments, leaving a characteristic trail of egested mud.

Estuarine snail *(Potamopyrgus estuarinus)*
This small brown snail (less than 6mm) occurs in the upper-tidal the estuary, and feeds on microscopic plants growing on the bed surface. They are most abundant on moist surfaces, particularly mudflats, channel margins, and sedge/rush beds. In the Karamea/Otumahana Estuary, they were found to reach densities of up to 7200 per sq. m in *Juncus* rush beds (**check this**).

Mudflat topshell *(Diloma subrostrata)*
This topshell occurs predominantly among the cockle beds on the mid-tidal fine sand flats. The snail feeds on microalgae and macroalgae.

Mudflat whelk *(Cominella glandiformis)*
This occurs predominantly among the cockle beds on the mid-tidal fine sand flats. The whelk feeds on dead shellfish. It actively seeks prey with its sensitive proboscis.

Bubble shell *(Haminoea zelandiae)*
Morton and Miller (19__, p543) have this to say about the bubble shells:

> "The most characteristic gastropods of the *Zostera* shore, and of soft, low tidal muds, are those opisthobranchs known as Bullomorpha. The forerunners of the naked sea slugs, they are, however, much more primitive in retaining a spiral shell, thin and smooth and with an involuted or sunken spire that has procured for the group the name of 'bubble shells'. The most numerous species is *Haminoea zelandiae*, its depressed and slug-like body being greyish black and flecked with brown. The shell is fragile and globular, horny brown or almost transparent, being partly covered from view by fleshy parapodia. In front of it lies a fleshy head shield, hard within from the presence of a box-like gizzard lined with shelly plates. *Haminoea* creeps about with its broad foot beneath the shelter of *Zostera* leaves, or buries itself in the soft surface mud. Its spawn is easily recognised and often to be found upon *Zostera* beds, forming a sausage-shaped jelly mass with a fine string of small yellow eggs spiralling closely through it."

This gastropod was found in only one location in the Karamea/Otumahana Estuary, congregated on a small area of low-tidal mud adjacent to the main channel draining the southern portion of the estuary. Egg masses were also present there, mostly attached to driftwood and cockle shells. The species may occur elsewhere in the estuary, since they can be easily overlooked, and empty shells were frequently found washed up on the eastern margins of the estuary. Nevertheless, their preferred habitats as described above are not common in this estuary and *Haminoea* is not likely to be widespread here. The Karamea/Otumahana Estuary is now significant as the southern known limit of this species on the West Coast, it having previously been found only as far south as Whanganui Inlet (Bruce Marshall, National Museum, pers. comm. 1992). It is known to occur only as far south as ________ on the east coast of the South Island, and also occurs at a slightly lower latitude in Waimea Inlet, near Nelson.

(Ophicardelus)
This mollusc resembles the estuarine snail, but grows to a larger size (__mm). It was found mainly in rush beds, usually on the bed surface or attached to the plant stems.

MOLLUSCA (Pelecypoda):
Cockle (*Austrovenus stutchburyi*)
Cockles are perhaps the most ecologically important molluscs in New Zealand estuaries. They are relatively large shellfish, and often occur as extensive beds across the mud and fine sand flats. Cockles filter microscopic food particles when they are covered by water around high tide. In many places, people collect cockles for food, but the extent of this activity in the Karamea area is not known. They are a major food source for wading birds such as oystercatchers, godwits and knots. In the Karamea/Otumahana Estuary, they were found to reach densities of up to ___ per sq. m.

Wedge shell (*Tellina liliana*)

Pipi (*Paphies australis*)

POLYCHAETA:
Sand mason worm (*Pectinaria australis*)
This worm has the peculiar habit of constructing and occupying narrow conical tubes up to __mm long, made of grains of fine sand. They were found during the survey in only a few small areas, on low tidal mudflats near the estuary outlet.

CRUSTACEA:
Estuarine barnacle (*Elminius modestus*)
Small aggregations of this small barnacle were commonly found attached to the shells of cockles that lay above the bed surface. They also occur on the larger (less mobile) bits of driftwood.

Mud crab (*Helice crassa*)
The mud crab constructs burrows in many parts of the estuary, but favours the moderately moist mid-tide surfaces where it can burrow down to the water table, thus creating a wet retreat for itself to occupy at low tide. At high tide, the Ocrabs forage the estuary bed for detrital food particles.

Hairy handed crab (*Hemigrapsus crenulatus*)

Stalk-eyed mud crab (*Macropthalmus hirtipes*)

NOTE:
The following two sections (6.1.4 and 6.1.5) are extracted from Davidson and Moffat, 1990; pp46-51.

6.1.4 Cockle distribution, abundance and size

The cockle is an important member of the estuarine community because:

1. It supports a traditional recreational fishery and has

recently become part of New Zealand's commercial shell fishery;

2. It is an animal of wide distribution in areas subject to increasing environmental pressure and may be valuable as an indicator species;
3. It is representative of a niche common to most estuarine systems and the importance of the role of occupants in this niche has been stressed many times (Stephenson, 1981).
4. It is an important food source for many other species, including birds such as oystercatchers and godwits, and fish such as mullet and flounder.

Several environmental factors influence the distribution, abundance and size of cockles. The most important factors are exposure time (ie. height on the shore), sediment composition (mud, silt, clay) and salinity.

In several different localities in the South Island a positive relationship between cockle size and period of immersion has been observed (Larcombe, 1971). Stephenson (1981) found that cockles are generally restricted to shores below the lowest high water neap. It is thought that a minimum time of immersion per tide determines the upper limit of cockle habitation. **In the present study, cockle density and size declined towards the upper tidal levels of the estuary. (CHECK THIS)**

Substrate type is important to the many benthic organisms in estuaries, especially filter feeders. Cockles cannot survive if they are buried or exposed, nor can they survive in areas where fine sediments clog the gills and interfere with feeding and respiration. Many workers have reported that suspension feeders are abundant in well-sorted fine-grained deposits, but that the abundance of cockles decreases as the silt-clay content increases. In the Karamea/Otumahana Estuary, cockle density was highest from _________.

Voller (1973) found that in salinities less than 18%, cockles would not feed, and if subjected to salinities of 4% or lower for protracted periods, death would result. The distribution of cockles over most of the Karamea/Otumahana Estuary suggests that salinity is **not?** a limiting factor. **or** Further work on salinity distributions needs to be done to determine whether this is the case in the K/O Estuary.

Cockles were absent from certain habitats in the Karamea/Otumahana Estuary. Mobile sand and 'gravel' flats are unsuitable habitats due to the strong currents and the unstable surfaces in which they would live. They were recorded in low densities from the river channels where salinities would be low and the bed somewhat unstable. They are also absent from high shore habitats including native rushes, sedges and *Samolus* herbfields.

In the K/O Estuary, the highest densities of cockles occur _______. In these beds, cockle densities of up to ___ per square metre were recorded.

6.1.5 Factors influencing invertebrate distribution

Physical factors have the greatest influence on the distribution of the fauna within an estuary. The most important of these are salinity, substrate type and tidal height and exposure (Knox, 1983).

Salinity

Salinity grades from freshwater in the Karamea River and Granite Creek (<0.5 parts per thousand) to seawter at the estuary mouth (35-37 ppt). In general, estuaries have low invertbrate diversities compared with open coast environments. This is largely due to the inability of many species to tolerate the daily changes in salinity that occur in all estuaries (Barnes, 1984).

Very few freshwater invertebrate species survive in salinities in excess of 5ppt and few marine species are found in salinities of less than 18 ppt. There are therfore three groups of benthic estuarine invertebrates. The first type are the marine species which penetrate into the estuary from the sea. In the Karamea/Otumahana Estuary, marine dwelling invertbrates include the .... . The second group are freshwater species such as the tubificad oligochaete worms which may be found within the estuary. The last group are the truly estuaine inhabitants, which are able to tolerate a wider range of salinities that is however different for each species. Invertebrates which tolerate the widest salinity range are distributed over much of the estuary, and includes the estuarine snail *Potamopyrgus estuarinus*, the mud crab *Helice crassa*, the mud snail *Amphibola crenata*, and nereid polychaetes. Estuarine species less tolerant of low salinities are found closer to the outlet, including the pipi *Paphies australis*, wedge shell *Tellina liliana*, and the stalk-eyed mud crab *Macropthalmus hirtipes*.

Substrate

Many species cannot tolerate certain substrate conditions, such as mobile beds that make living on the surface difficult, or fine sediments that inhibit respiration or filter feeding. The distribution of benthic invertebrates in the estuary is therefore greatly affected by the distribution of sediments that is described and explained in Section 5.2.1. For example, *Tellina* (Fig.__: picture of Tellina) is a deep-burrowing shellfish that can tolerate changes in the bed level, and prefers the cleaner water of the sand flats for respiration and filtering: it is most commonly found on the regularly flooded fine sand flats near the estuary mouth.

Tidal height and exposure

Many estuarine invertebrates are not able to survive exposure to air for any great length of time, while others prefer to be exposed for most of the tidal cycle (Knox, 1983). The elevation of the bed in relation to the tide is therefore an important environmental factor affecting the distribution of invertebrates.

In the Karamea/Otumahana Estuary, ____.

6.2 FISH

Some __% of New Zealand's native fish species are diadromous, moving between fresh and salt water at some stage of their lives. Estuaries are therefore vital to almost all of our "freshwater" fish and a good proportion of our commercial fish species.

No work was done in the present survey on the fish fauna of the Karamea/Otumahana Estuary. However, some data exist on the species occuring in the catchments that feed the estuary, and the knowledge of local residents provides some information on the species that occur there.

6.3 BIRDS

6.4 ESTUARINE AND TERRESTRIAL VEGETATION

Specimens of most of the plants in the estuary, and some of the species around the margins, were collected in 1993 by A Quince and prepared for herbarium records.

A total of 3 algae and ?29? vascular plant species were recorded from the intertidal zone of the Karamea/Otumahana Estuary (Table). The most common vascular plants in the estuary are the sea rush, the jointed rush and the sea primrose.

TABLE 3. Species list of intertidal and saltmarsh plants recorded from the Karamea/Otumahana Estuary

---

Phylum Phycophyta (Algae)
Class Chlorophyaceae (green algae)

.	*Enteromorpha* sp.	

Class Rhodophyceae (red algae)

	Gelidium	
	Gracilaria sp.	Agar weed

Phylum Spermatophyta
Class Angiospermae (seed plants)

.	*Apium prostratum* agg.	
.	?*Callitriche*	
.	*Calystegia soldanella*	Sand convolvulus
.	*Carex pumila*	
.	?*Cotula coronopifolia*	
.	*Cyperus*	
.	✓*Isolepis cernua*	
.	*Isolepis nodosa*	
.	*Juncus articulatus*	
.	✓*Juncus maritimus* ssp. *australiensis*	Sea rush
.	*Juncus ?australis*	
.	✓*Juncus* sp.	
.	*Leptinella* ?'mediana'	

- *Leptocarpus similis* Jointed rush
- *Lilaeopsis rutimana*
- *Muelenbeckia ?complexa x australis*
- *Myriophyllum ?pedunculatum*
- *?Oplismenis*
- *Plantago coronopus*
- *Pyrrosia eleagnifolia*
- *Rorippa nasturtium aquaticum* Watercress
- *Ruppia ?polycarpa*
- *Samolus repens* Sea primrose
- *Sarcocornia quiqueflora* Glasswort
- *Scheonoplectus pungens*
- *Selliera radicans* Remuremu
- *Triglochin striata*
- *Typha orientalis* Raupo
- *Zostera muelleri* Eel grass

6.4.1 Plants of particular interest

Sea rush (*Juncus maritimus*)

Jointed wire rush (*Leptocarpus similis*)

(*Samolus repens*)

Eel grass (*Zostera*)

Gracilaria sp.

Glasswort (*Sarcocornia quinqueflora*)
The Karamea / Otumahana Estuary was found during the survey to represent the southern known limit of this species on New Zealand's western coast, it having previously been recorded only as far south as the Oparara Estuary (Dave Norton, Canterbury University School of Forestry, pers. comm. 1992). It occurs on the east coast at least as far south as ___ (___). This species is frequent on the drier fine sand flats around the high tide margins of the Karamea/Otumahana Estuary, usually amongst *Samolus* herbfields and on the margins of sedge/rush beds. It is most common on the inner margins of the estuary spit and the western margins of the islands within the Otumahana Estuary **(check this)**.

7. AREAS OF PARTICULAR ECOLOGICAL IMPORTANCE
This section discusses the ecological significance of the estuary and some of its component parts. They are listed in an approximate order of significance, based on the evaluation method developed by Davidson, and recounted in Appendix __. The accompanying maps for each area type indicate the approximate distribution of these habitats within the Karamea/Otumahana Estuary, at a scale of 1:50 000.
[MAP FOR EACH SECTION, SHOWING THE APPROX. LOCATIONS OF EACH; 1:50 000]

7.1 Whole estuary
The estuary as a whole is of great importance for a number of reasons. It is the larger of the only two intertidal

estuarine flats in the northern Buller area.

7.2 Main cockle beds
The main cockle bed on the Karamea/Otumahana Estuary is located near the western margins of the Otumahana Estuary, with smaller beds near the northern and eastern margins (Figure __). As discussed in Section __, cockle beds are ecologically significant areas of estuaries, not least because they are important feeding areas for wading birds and probably fish.

Evaluation Ranking: **Score**
(1) Importance of flora, fauna and habitats
(2) Representativeness/uniqueness within estuary
(3) Representativeness/uniqueness within Conservancy
(4) Biological and physiological state of margins
(5) State of surrounding terrestrial vegetation

7.3 Mudflats
Mudflats are the

7.4 Estuary channels
Estuary channels are the primary link between the sea and the rivers, and are the only part of the estuary that remains continually underwater. They are therefore of vital importance to the many fish that occupy or move through the estuary. Fish species that spend most of their time within the estuary use the channels as a refuge during low tide after feeding on the flats when the tide is high. Flounder and grey mullet are the most common of such species.

7.5 Highshore roosts
Some areas at or above the high tide level are used daily by wading birds as roosting sites during high tides. The mobile sand flats near the mouth of the estuary are probably the most significant of these habitats, with many wading birds being observed there during the study.

7.6 Saltmarsh habitat
Saltmarsh is a major feature of estuaries, supporting a characteristic range of plant and animal species that are closely adapted to the brackish water and fine mobile sediments.

Saltmarsh habitat is perhaps the most vulnerable of all estuarine habitats in New Zealand and worldwide, since they tend to occur around the margins of estuaries, where the effects of land development are greatest.

7.7 Glasswort habitat
Since the Karamea/Otumahana Estuary is the southern limit for glasswort on New Zealand's west coast, the protection of the species and its habitat here are of some importance. Species limits are significant as areas where the potential for genetic evolution and range expansion of species are greatest. As such, they are important to the biodiversity of natural ecosystems.

7.8 Raupo habitat?

~~**7.9 Bubble shell habitat**~~

As with the glasswort habitat (7.7), the protection of this area as the southern west coast limit for this species is important to maintain its potential for genetic evolution and range expansion.

7.10 Low tide mudflat habitat, western mudflat area.
Low-tide mudflats are an uncommon feature in the Karamea/Otumahana Estuary, with only one significant area being recorded. This habitat supports a rich invertebrate fauna, including some species that were rare or absent elsewhere in the estuary (eg. *Pectinaria*, *Gracilaria*).

7.11 Whitebait spawning sites

7.12 Marginal coastal forest - southern end, eastern margin?
Most of the indigenous sand-dune forest that once surrounded the Karamea/Otumahana Estuary has been lost through land development, and only two significant patches of marginal forest remain.

8 HUMAN USE OF THE ESTUARY

Estuaries are extremely vulnerable to human impact (Knox, 1980, 1986; Barnes, 1984). Estuaries most at risk lie close to populated areas where pollution from surface water runoff, point discharges and rubbish dumping can occur. Land use requirements for agricultural, industrial, domestic and recreational purposes are also high. The ecological values of the Karamea/Otumahana Estuary have suffered as a result of some such impacts. This section discusses human impacts and uses of the Karamea/Otumahana Estuary.

8.1 Land tenure

Figure __ shows the cadastral boundaries in and adjacent to the Karamea/Otumahana Estuary, and the current owners of the land. Most of the estuary is Crown land below MHWM, administered by the Department of Conservation under the Land Act, and managed by the West Coast Regional Council under the Resource Management Act (1991). Parts of the estuary and its margins are in freehold title currently owned mostly by local farmers and residents. Ownership of the land below MHWM allows the landowner to (???graze stock,...???), provided that such activities comply with the operative New Zealand Coastal Policy Statement and Regional Coastal Plan. At present, there are large areas of the estuary in private ownership that have not been significantly altered.

8.2 Farm development and drainage

Most of the land adjoining the Karamea/Otumahana Estuary is developed for agriculture. Dairy cattle are farmed on most of the pasture areas,

Grazing, trampling, dairy shed effluent, pasture runoff of nutrients, drainage of wetlands upstream of, within and adjacent to the estuary, conversion of margins to pasture, channel and tidal current modifications,

8.3 Pollution and nutrient input

Pollution has perhaps the greatest impact of all human activities on New Zealand's estuaries. Estuaries are at the downstream end of the water cycle, being the ultimate recipient of any incremental pollution of rivers as well as any direct discharges from outfalls and runoff from activities occurring on adjoining land.

Agricultural runoff from adjoining land is probably the most significant source of pollution in the Karamea/Otumahana Estuary. However, no studies are known to have investigated the water quality or nutrient levels in the estuary.

8.4 Infilling of intertidal areas
The main road linking Karamea with the

8.4 Harvesting of species
incl. duckshooting, cockling, fishing, whitebaiting,

8.5 Vehicle and boat access

8.6 Birdwatching

8.7 Weeds and adventive plant species
The introduced cord grass *Spartina*, has not been recorded in the Karamea/Otumahana Estuary, but it is known to occur (and is periodically controlled) in the nearby Oparara Estuary. (marram & Spartina, pasture grasses, gorse).

9 MANAGEMENT RECOMMENDATIONS FOR THE ESTUARY

Work towards ensuring protection of the estuary and its margins

Reduce the runoff of agricultural pollutants from adjoining land.

Survey the estuary saltmarsh vegetation for the presence of *Spartina*, at least once a year.

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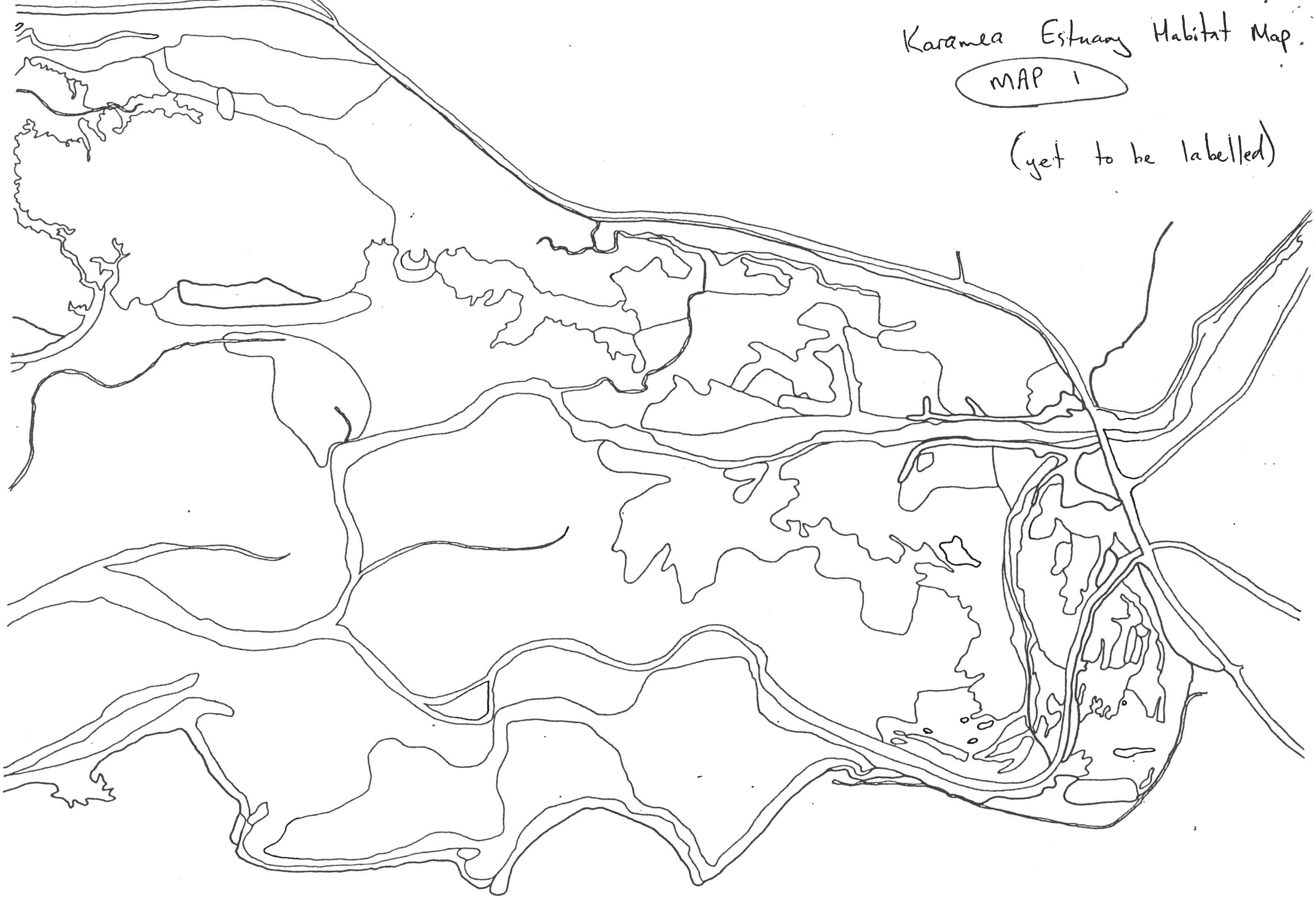
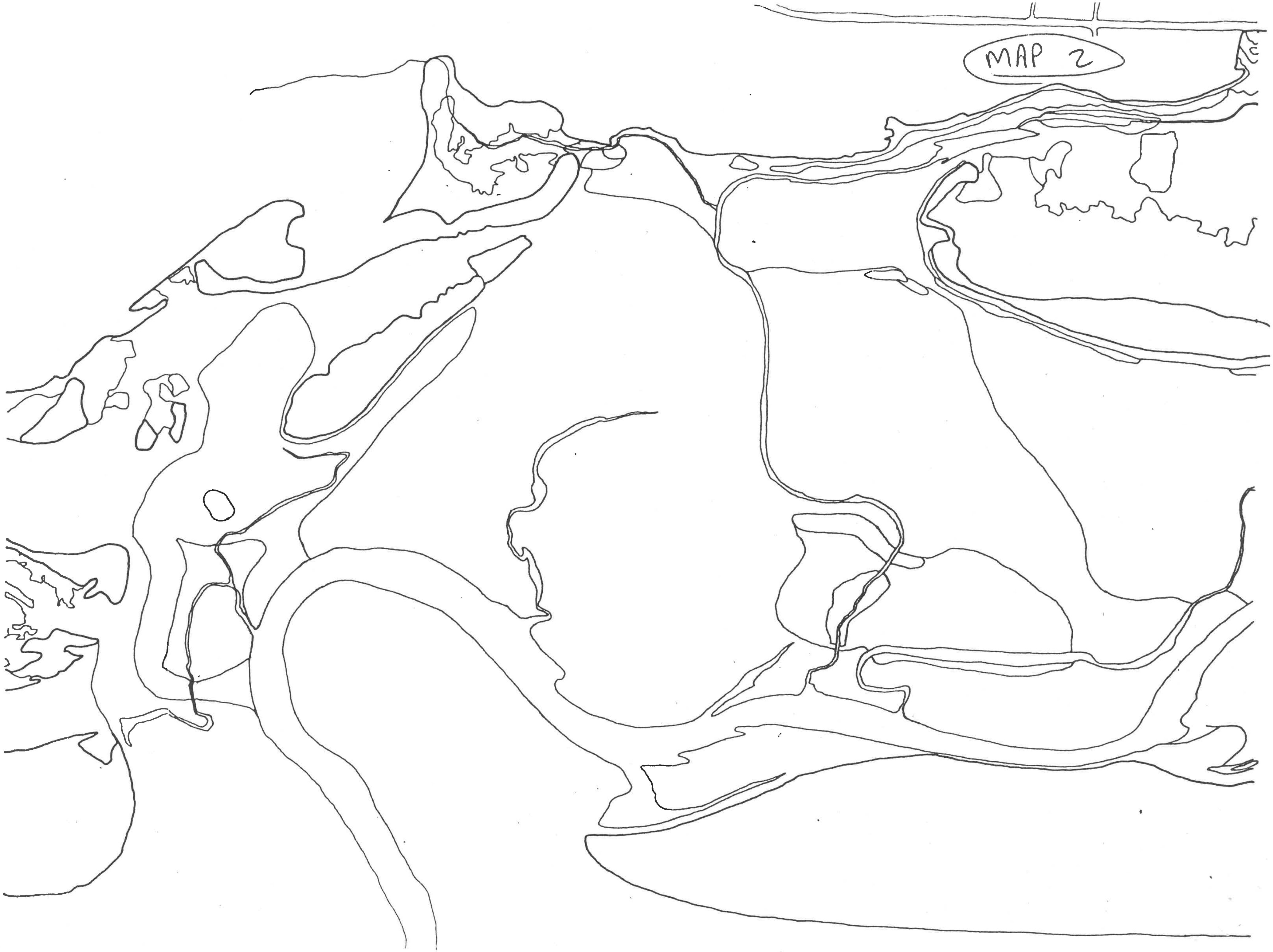
Shannel Courtney, Botanist, Department of Conservation, Nelson; for identification of plants.

Karamea Estuary Habitat Map.

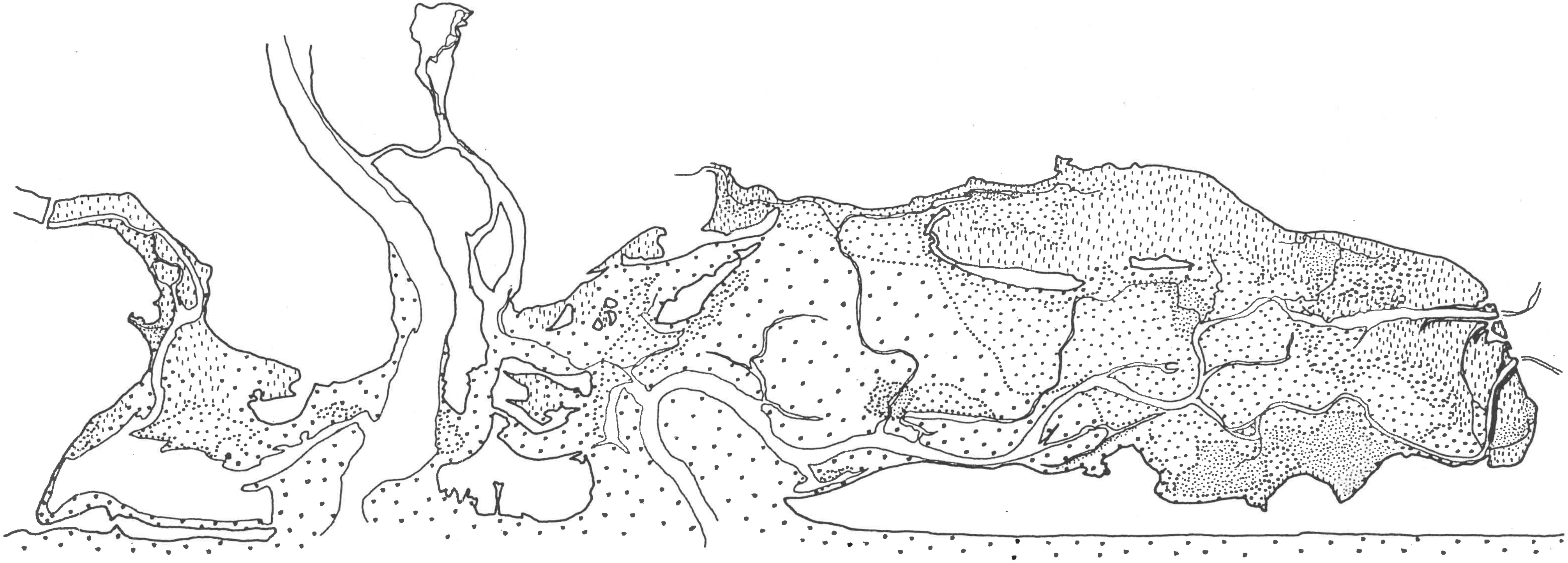
MAP 1

(yet to be labelled)




MAP 2


MAP 3



Substrate types of Karamea Estuary.

Saltmarsh

Course sand.

Fine sand

Mud

Gravel

HABITAT TYPES.

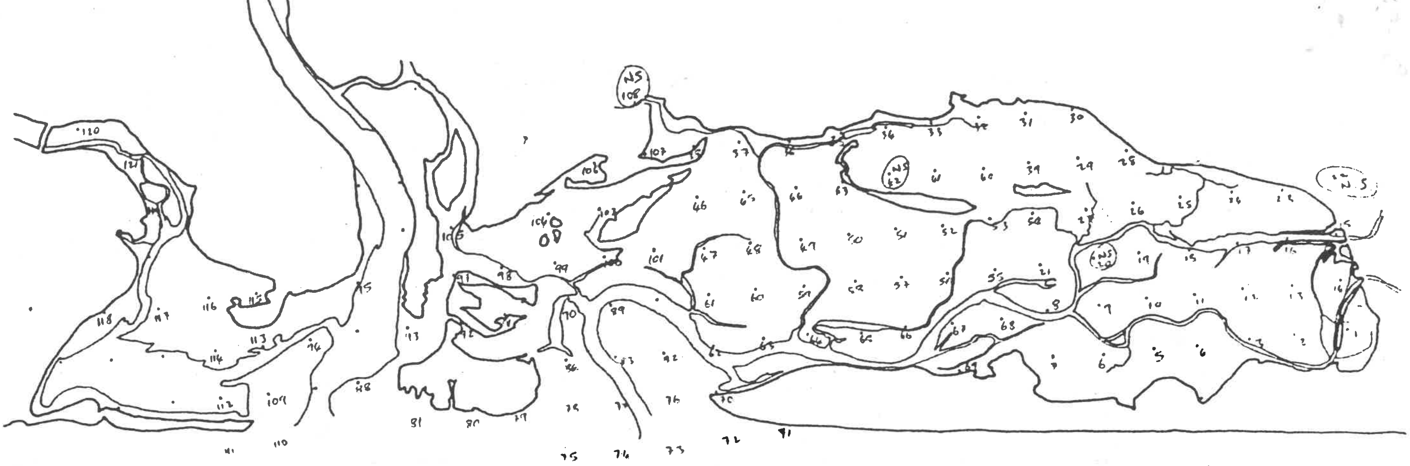
Figure

i) Habitat types recorded at each grid point sampled (N=97)

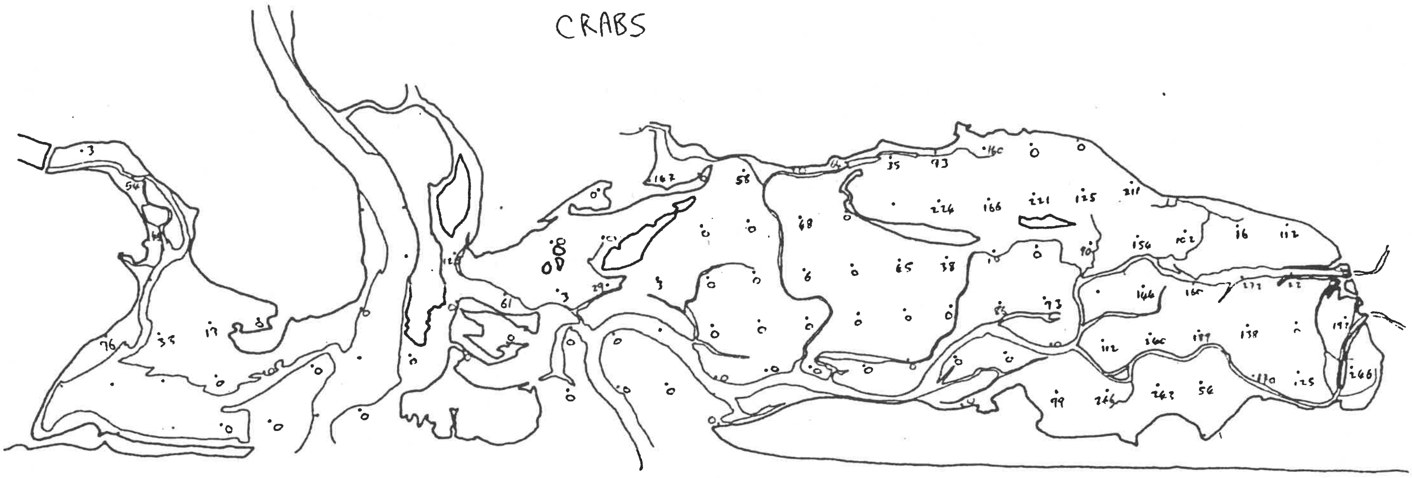
- C = coarse sand 41
- F = fine sand 29
- M = mud 7
- J = Juncus 7
- L = Leptocarpus 2
- Sa = Samolus 2
- G = gravel 2
- P = pasture 4
- ? = not recorded 2
- Ra = Raupo 1

NB. unlabelled grid points were not [illegible] surveyed.

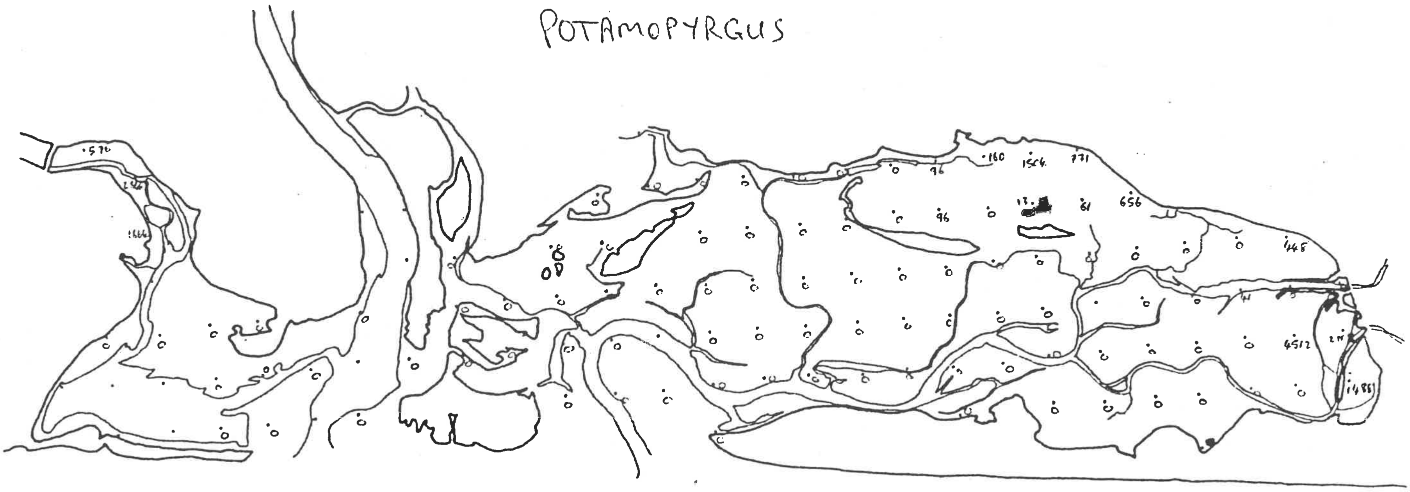
SITE NUMBERS



CRABS



POTAMOPYRGUS



AMPHIBOLA