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RESOURCE DEVELOPMENTS IN THE COASTAL ZONE:
A STUDY OF PLANNING AND MANAGEMENT FOR
THE WEST COAST, SOUTH ISLAND

Presented in partial fulfilment of
the requirements for the Degree
of
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in the
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by

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"Et quidem naturali jure communia sunt omnium haec, aer, aqua profundus, et mare et per hoc littora maris" — By natural law itself these things are the common property of all: air running water, the sea, and with it the shores of the sea.

Justinian, *Institutes*, Lib. II, Ch. 1, s.1
ABSTRACT

Coastal zone management problems have been the focus of many conferences, seminars, and publications in recent years. In spite of the attention given to providing information and guidance for decision making, it has been suggested that the present coastal zone management approach in New Zealand remains inappropriate to the character and use of the zone. To address this issue, the existing management approach is examined to identify the types of problems that have arisen. This study discusses the West Coast of the South Island, New Zealand, as an example of an area where significant developments within the coastal zone may be proposed. An examination of the information available for coastal zone management on the West Coast provides the basis for identifying issues and conflicts that have resulted from the existing management approach. A generalised model of the planning and decision making process is developed, which provides a framework for examining the coastal system and assessing the adequacy of the present management approach.

The study incorporates an examination of the physical system on the West Coast, resource developments in the area, and institutional aspects of coastal zone management. This examination is used to draw attention to general inadequacies in the existing management approach, particularly those relating to uncertainties and institutional arrangements. An approach to coastal zone planning and management is developed, that addresses specific problems and uncertainties, with particular reference to the West Coast.

This approach is based on an understanding of the interactions between the physical system, resource uses, and institutional aspects of the coastal zone. Management uncertainties can be dealt with by the use of incremental decisions where existing information is inadequate or by gathering further information. A system of monitoring and evaluation to provide feedback to the decision making process is essential.

The existing framework for coastal zone management in New Zealand is shown to have several deficiencies. These deficiencies are related to an inadequate information base, existing jurisdictional boundaries, and fragmented policies and management directives. It is concluded that the resolution of these problems requires measures designed to provide guidelines for achieving management objectives, coordination between management agencies, and means of developing and implementing management responses.
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CHAPTER ONE

INTRODUCTION

1.1 PROBLEM STATEMENT AND STUDY OBJECTIVES

The West Coast United Council periodically receives proposals for resource developments within the coastal zone. The problem is that there does not appear to be an adequate basis for making management decisions regarding these proposals that is appropriate to the characteristics of the coastal zone resource.

Knowledge of the physical processes at present operating in the coastal zone of the West Coast is limited. In addition, the interactions between the physical system and uses of the coastal zone resources are not clear, producing uncertainties surrounding the effects that each has on the other. Knowledge of possible future resource characteristics, such as the scale and location, is at present unclear (for example, Ilmenite sand mining; alluvial gold mining or dredging; gravel extraction; port, commercial and residential developments). Uncertainties surround the possible cumulative effects of these resource uses; that is, the total effect of resource developments may exceed the sum of the effects of the individual developments. This may be viewed as a form of synergy.

Under the conditions described above decisions concerning management of the coastal zone are likely to be made without full knowledge of the consequences. Yet it may not be possible to delay many of these decisions until full knowledge is available. In the face of uncertainties relating to natural processes, use of the resources of the coastal zone, and the interactions between the two, how well is the existing management approach equipped to deal with these problems? If it is inadequate, how can appropriate management strategies for the coastal zone be developed?

In order to address these questions, two major objectives of the study were decided on:

1. To isolate management concerns, specific problems and uncertainties that need to be addressed in coastal zone
planning and management, with particular reference to the West Coast and the present management approach.

2. To present an approach to coastal zone management for the West Coast that accommodates uncertainties in planning and management decisions, within an overall framework for coastal zone management.

This study presents an examination of existing coastal zone management problems, focussing on the West Coast of the South Island, New Zealand. The West Coast was chosen as an example of an area where few studies relating to physical processes or management have been undertaken, but for which significant developments affecting the coastal zone may be proposed in the near future.

A study of the West Coast, therefore, provides the basis for the identification of management problems and an examination of the adequacy of the existing management approach to deal with these issues.

The existing coastal zone management approach in New Zealand has received much attention in recent years. A number of conferences and publications have focussed on management problems and their resolution (see for example, New Zealand Institute of Surveyors, 1972; Morton et al., 1973; New Zealand Institute of Engineers, 1974; Knox, 1977; Ministry of Transport, 1980; and Commission for the Environment, 1982). Despite this attention and changes to relevant legislation (for example, the Town and Country Planning Act 1977), it is argued by many (Lello, 1980; Morton, 1980; Healey, 1980; Willis, 1982) that present management of the coastal zone remains inappropriate and that progress in formulating appropriate strategies has been both slow and ineffective.

Underlying these statements is a view that the coastal zone presents special problems for management that are not addressed adequately by existing legislation and management systems. In order to demonstrate whether or not there is an exceptional character to coastal zone problems, requiring special management responses, it seems essential to first explore specific problems under the existing management approach.
1.2 STUDY APPROACH

The approach taken in this study is based on a generalised model of the planning and decision making process (Ackley, Centre for Resource Management, pers. comm. 1983). This model provides a framework for viewing how the coastal system operates and the adequacy of the management approach that is applied to this system.

Traditional management incorporates a number of functions including planning, organising, direction, control and innovation (Dale, 1973). A broader view of management is needed, however, when considering management of natural resources. O'Riordan (1971) defines resource management as a process of decision making for resource allocation over space and time, involving judgement of needs, aspirations and preferences, within the framework of managerial, technological and administrative alternatives. Emphasis is given to flexibility, the avoidance of environmental disasters, and the maximisation of net social welfare over time.

But no one, of course, can handle the management functions capably unless he is conversant with what he is managing (Dale, 1973 p.9, author's emphasis).

This initial requirement of management, a survey of the existing situation, is the first step in the planning process and is also the first phase of this study.

Coastal resources management is based on an understanding of the ecological interdependence of coastal resources and an analysis of the sectoral responsibilities regarding management decisions (Ditton et al., 1977). The next two chapters present information relating to the operation of the physical system to which management is applied, and the resource uses that are present or proposed within the coastal zone. Specific reference is made to the West Coast although examples relevant to the discussion are drawn from other areas of New Zealand. Institutional aspects of coastal zone management are discussed in Chapter 4 with reference to the physical system and resource uses described in Chapters 2 and 3. Interactions between these three aspects of coastal resources management are outlined in Chapter 5 as an overall view of the coastal zone. Specific management problems and uncertainties posed by these interactions are examined, as is the adequacy of the existing management approach.
In dealing with these issues. In Chapter 6 an approach to coastal zone management for the West Coast is presented and involves an appropriate consideration of the information outlined in the preceding chapters. Conclusions from the study are presented in Chapter 7.
CHAPTER TWO

THE COASTAL SYSTEM

2.1 INTRODUCTION

This chapter presents a discussion of the operation of the resource, in this case the coastal zone of the West Coast. Emphasis is placed on the physical characteristics of the system that present important considerations for management.

The West Coast is an area where knowledge of the physical processes operating in the coastal zone is limited. Resource developments that may have a significant impact on the coastal zone may be proposed in the near future. It is, therefore, useful to examine existing knowledge regarding the physical system in order to determine the likely effects of resource developments and to analyse the adequacy of the existing management approach in dealing with these interactions. The latter aspects are dealt with in subsequent chapters.

The time constraints of this study have meant that it was not possible to gather any field data. The discussion, therefore, is based on a literature review to summarise existing knowledge of the physical processes operating in the coastal zone of the West Coast.

By way of introducing the physical system of the West Coast, it is useful to first describe the major components of the system and how they operate. This discussion leads to an examination of the specific components of the coastal system of the West Coast beginning with an analysis of the influence that oceanic circulation off the South Island's West Coast has on the more variable coastal currents. Together with a consideration of wave characteristics, sediment characteristics and sources, this information leads to an examination of the factors influencing sediment transport within the coastal zone. These factors are primarily responsible for the development and features of the coastal zone. Resource developments that affect any one or more of these factors will result in some response that may alter the balance between these factors, expressed by the form and features of the coast.
2.2 COASTAL ZONE PROCESSES

The coastal zone can be broadly defined as the zone of interaction between the hydrosphere, lithosphere and atmosphere (Zenkovich, 1967). It is the zone where major ocean currents, variable coastal currents, tidal movements and waves, produced by the interaction of the oceans and atmosphere meet the land. A broad definition of the coastal zone is necessary in order to encompass not only the narrow strip of the shore, but also the adjacent areas of land and water where the impact of activities may be evident or where developments may impinge on the other areas.

The major influence of the land is through the input of sediments from river basins and the erosion of areas directly bordering the coast. In addition, the land surface influences the characteristics of waves approaching the coast and serves to absorb their energy. The main components of the system, therefore, are:

- the hydrodynamics of the coastal zone as a whole and particularly energy transformation and water movement by wave action;
- the processes of transport and deposition resulting from these movements; and,
- the development and features of the coastal zone related to the physical character of the land and sediment characteristics (Zenkovich, 1967).

The interactions between these components give rise to the particular characteristics of a given coastline, including features such as headlands, cliffs, estuaries, beaches and dunes.

Beaches are the most common features of many coastlines and represent depositional landforms, as opposed to erosional landforms such as marine cliffs or shore platforms. A beach can be defined as a three-dimensional accumulation of unconsolidated sediment, resting on some basement, around the limit of wave action (King, 1972; Kirk, 1979a). This definition emphasises the dynamic nature of beaches, with the form and position of the beach at any particular point in time being an expression of the processes controlling the supply, transfer, and loss of sediments (Kirk, 1979a).

The inter-relationships between the components of a beach system
result in dynamic adjustments of the whole system to changes in one or more components (King, 1972; Healey, 1980). Removal of material from one component, such as the foreshore or dune will result in readjustment of the entire beach system in an attempt to restore the sediment balance. Coastal stability may be reduced not only at the site of removal but also in downdrift areas where the supply of material is reduced (Kirk, 1979a). In order to avoid reductions in coastal stability a knowledge of the beach sediment budget is needed - where is the material coming from, at what rate, and how much can be removed in a given time without resulting in a sediment deficit? (Figure 2.1).

Beach systems that are formed between distinct boundaries such as headlands are termed coastal compartments. These segments of a coast may, however, be significantly influenced by inputs, transfers and losses of sediments to and from other parts of the coast through longshore transport. It follows, therefore, that a characterisation of the sediment inputs, transfers and losses for a segment of coast (a sediment budget) is best conducted on a regional scale.

Waves are the principal cause of most shoreline changes. These changes depend on the characteristics of the waves approaching the shore and the duration for which a particular wave type acts on the shore. The characteristics of waves (height, length, and period) are determined by the fetch distance, wind velocity, duration of the wind, and the distance the wave travels after leaving the generating area (Coastal Engineering Research Centre, 1977).

There are two main types of wave that affect beaches: sea waves and swell waves. Sea waves are produced during storm conditions and are characteristically short, steep waves. Where a storm occurs close to a coast and the winds are blowing toward the shore, the waves reaching the shore will be similar in form to the sea waves when they are first generated. Generally, these short steep waves will cause erosion on a beach (Figure 2.2). Swell waves are those that have been generated a great distance offshore and are characteristically long, low waves since the short steep components have been eliminated over the distance travelled. Swell waves will, generally, cause accretion of a beach (Figure 2.2).
Aims: (a) where does beach material come from? (b) what happens to it within compartment? (c) how and where does it leave a compartment? (d) what are the amounts of material involved in the above?

Figure 2.1: A sediment budget model.

Longshore Movement

Beach material

From Cliffs
Wind

From River

From Cliffs

In situ addition - biogenous material

Submarine Canyon (Loss)

Onshore Offshore

Longshore Movement

KEY
 additions
 losses

Additions, input, sources - rivers, cliffs, onshore, longshore, in situ, wind.

Transfers - Onshore, alongshore, wind.

Losses, output - offshore, longshore, wind (inshore).
The important characteristics of breaking waves affecting the transport of sediments near a beach are their height, period, and direction. Waves affect sediment transport in the nearshore zone by initiating sediment motion and generating currents that may transport sediment that is set in motion. The quantity of sand distributed by breaking waves is determined to a large extent by the wave height. Sediment transport in an on-offshore direction is mainly influenced by wave steepness, sediment size and the slope of the beach. The direction of wave approach and wave energy are the most important influences on the direction and rate of sediment transport in a longshore direction (Coastal Engineering Research Centre, 1977).
2.3 OCEANIC CIRCULATION OFF THE WEST COAST

Although oceanic circulation does not have a direct influence on the processes that define the character of a given coastline, it is an important influence on the pattern of circulation closer inshore. Inshore circulation, tidal movements and wave action are the major factors governing the transportation of sediments in coastal water. Current speed determines the potential for sediment transport.

Oceanic circulation in the Tasman Sea west of New Zealand is generally weak. A broad east flowing current, fed by an inflow from the west, appears to be controlled by the bottom topography (Stanton, 1976). The broad submarine Challenger Plateau, rising to 500 metres depth, forms a major obstruction to circulation, causing the east flowing current in the Tasman to flow south-east from the Plateau. This flow divides somewhere west of the South Island, with a portion of the flow continuing north as the Tasman Current and the other portion flowing south around the south coast of New Zealand (Figure 2.3).

Closer inshore, the Westland Current flows north-east along the north-west coast of the South Island. The Southland Current begins as a south-westward flow around Jackson Head (Brodie, 1960; Garner, 1961; Heath, 1969). The northern limit of the Westland Current is variable (Brodie, 1960). The inshore zone tends to enter Cook Strait around Farewell Spit, but strong southerly winds reduce this component and extend the current to the north (Figure 2.3).

Studies of current flows west of the South Island suggest that the Westland Current is driven by prevailing winds from the south-west quarter (Stanton, 1976; Heath, 1969). During periods of little wind the Westland Current is replaced by a weak south-westerly coastal current. Stanton (1976) suggests that during calms the weak south-westerly flow is produced in response to geostrophic circulation, but that this flow is reversed by a stronger wind-driven component during periods of south-westerly winds. To the south, the wind-driven component is not sufficient to reverse the strongly developed Southland Current.

Heath (1973) made direct current measurements for a single point
Figure 2.3: Oceanic circulation off the West Coast.

in time to provide a basis for further current measurements. Between Cape Foulwind and Jackson Head the subsurface flow was mainly tidal with a maximum speed of 1.36 m.s\(^{-1}\) although mean flows were much weaker and typically less than 0.5 m.s\(^{-1}\) (Heath, 1973), but this makes no account for variations in tidal flow or the effect of local winds. The potential for sediment transport as a result of these flows is discussed in section 2.6.1.

2.4 THE WEST COAST WAVE ENVIRONMENT

The westerly winds predominating between latitudes 30°S and 70°S are the major force generating waves affecting much of the New Zealand coast. Because of large fetch distances, the duration of wind is the major limiting factor in wave generation (Reid, 1981). The prevailing winds and fetch distances result in a high energy wave climate especially on the south and west coasts of New Zealand.

2.4.1 Wave Characteristics

Despite limitations due to the short period of observations and the subjectivity of visual observations, Pickrill and Mitchell (1979) were able to make some preliminary generalisations about the ocean wave characteristics around New Zealand.

Deep water wave records from oil rigs off the New Zealand coast are the most reliable as extensive refraction of most waves near the coast causes changes in wave height, direction and, to some extent, wave period. The dominant direction of wave approach to New Zealand's West Coast is from the west through the southwest.

Mangin (1973) found waves at Westport approached mainly from the north-west. Due to the configuration of the coast around Westport, however, and the resulting effects of refraction, these waves are likely to have a deep water approach anywhere between south-west and north.

Ocean wave heights are likely to be much greater than wave heights in coastal water as waves reaching the coast have usually lost many of the smaller components of their height. Mean wave heights
recorded are between 2.2 m and 2.8 m (Pickrill and Mitchell, 1979). Mean wave heights observed from the shore are typically half those recorded in deep water. Those recorded by Mangin (1973) at Westport were 0.9 m, but due to the amount of refraction around Cape Foulwind, mean wave heights at the shore for much of the rest of the West Coast of the South Island may be higher.

Wave period is less affected by wave refraction than height and direction. Wave periods at the coast are, however, longer than in the open ocean, possibly due to the attenuation of shorter period waves by the time they reach the coast.

Deep water wave periods off the West Coast are typically between 6-9 seconds, and rarely exceed 12 seconds. Mean wave period from shore-based records ranged between 8.3 and 12.8 seconds, while few waves with periods greater than 16 seconds or shorter than 7 seconds were recorded.

Collection of wave data over long periods of time has been limited, but both offshore and shore-based visual observations suggest that there is no seasonal pattern in wave height, period, steepness or direction (Pickrill and Mitchell, 1979; Mangin, 1973). The wave climate on the West Coast is dominated by storm events and the passage of low pressure cyclonic weather systems may produce a short period cyclicity. Low pressure systems move eastwards across the Tasman Sea, often with a quasi-cyclic rhythmic pattern of fairly constant interval (5-11 days). The low pressure systems are generally associated with strong winds, ideal for wave generation, while the intervening high pressure anticyclones are generally associated with low wind speeds, less able to generate waves.

A relationship between the timing of low pressure systems and greater wave heights on the West Coast of New Zealand has been shown to exist (Pickrill and Mitchell, 1979 p.514). To some extent at least the quasi-cyclic weather patterns experienced on the West Coast (and over most of New Zealand) are reflected in the wave climate.

2.4.2 The Wave Climate

Deep water waves off the West Coast are characteristically approaching
from the south-west through to west, with a height of 1.0-3.0 metres and a period of 6-8 seconds. On entering shallow water the deep water waves are transformed to a 0.5-1.5 metre high wave with a period of 9-12 seconds, when observed from the beach (Pickrill and Mitchell, 1979).

The steep and narrow continental shelf off the West Coast means that little wave energy is lost due to friction with the bottom, and that waves approaching at an angle to the coast may not be refracted completely. Since the shoreline is generally oriented in a south south-west to north north-east direction, incomplete refraction of waves approaching from the south-west through west will result in a component of the wave energy being directed alongshore in a north north-east direction.

Waves may also be generated by storms to the north-west. Mangin (1973) found the dominant direction of wave approach at Westport to be from this direction, although the effects of refraction in this area mean that the waves were likely to be approaching from anywhere between south-west and north. Despite this, where waves approaching from the north-west are not completely refracted they may result in a longshore current to the south south-west.

The direction of net longshore transport in the nearshore zone may not be dominantly to the north. Recent work at Point Elizabeth near Greymouth has shown that there is no dominant direction of net longshore transport in that area (Pfahlert, 1984). The direction of longshore movements appears more related to the weather systems generating the waves. If there is a sequence of storms to the south-west or west then the direction of wave approach is likely to result in a strong northward drift, while if frequent storms occur to the north-west the reverse may be true.

Since the West Coast of the South Island is on the margin of the zone of strongest westerly winds, waves travelling from this zone to the West Coast are generally higher than those reaching other parts of the New Zealand coast (Davies, 1972). In addition, the West Coast is to the lee of the unlimited fetch zone of the Tasman Sea. Waves reaching this coast are generally higher and steeper than elsewhere around New Zealand. Since the energy of waves
is proportional to the wave length and the square of the wave height, wave energy increases rapidly with an increase in wave height (King, 1972). The combination of waves of greater than average height (and energy) and steep waves generated by storms near the coast mean that there is a great potential for erosion along much of the West Coast.

Swell waves originating from the south and west and storm waves from the Tasman Sea do not travel a great distance to the West Coast and, therefore, are likely to be of shorter period, higher, and steeper: characteristics that promote sediment movement and erosion. The relationship between wave conditions and the passage of weather systems across the Tasman Sea results in a wave climate that is characterised by locally generated storm waves interrupting swell waves generated by storm centres to the west and south. The frequent passage of storm systems and the difficulties in predicting their timing and position off the West Coast mean that changes in wave conditions may be abrupt.

2.5 SEDIMENT CHARACTERISTICS AND SEDIMENT SOURCES

Sources of sediments on the West Coast may be inferred from a discussion of sediment characteristics, distribution and the processes operating historically and under present day conditions. The various zones referred to in the discussion are depicted in Figure 2.4.

2.5.1 Offshore Sediments

For most of the continental shelf off the West Coast there is a sequence of seaward fining of sediments (Figure 2.5). Coarse sands dominate the littoral zone grading into fine sand, muddy sand (50-90% sand), sandy mud (10-50% sand), and finally mud (less than 10% sand) at depths of 40-125 metres (Carter, 1980). Coarser sediments occur again toward the edge of the shelf. The coarser sediments of the outer shelf are due to the presence of relict sands and the possible influence of greater hydraulic turbulence (Carter, 1980; van der Linden, 1969). Mud blankets large areas of the continental shelf except shallow banks and the nearshore surf zone (Carter and Heath, 1975). Gravel is not a major constituent of the sediments although significant deposits of gravel occur in
Figure 2.4: Beach profile - related terms.

Source: Coastal Engineering Research Centre, 1977
Figure 1.1.
Figure 2.5: Dominant offshore terrigenous sediments - West Coast

the Kahurangi Shoals (van der Linden, 1969).

Analyses of subsurface core samples indicate increasing coarseness of sediments and increasing quantities of gravel with depth (Norris, 1972; Carter, 1980). Much of the offshore sediments accumulated during the Pleistocene and Holocene transgressions. The muds overlying the coarser sediments are interpreted as having accumulated during the last 6500 years, once sea level had reached its present level (Norris, 1972; Carter, 1980; Gibb, 1979).

2.5.2 Nearshore and Beach Sediments
Sediments in the nearshore zone and in beaches on the West Coast range from fine sands to gravels. Many beaches have characteristic mixtures of sand and gravel (see for example, Mangin, 1973). Coarse sand is the dominant sediment of the nearshore and beach deposits.

Because of the interactions, due to wave action, there may be a continual interchange of sand between the beach system and the nearshore zone. It is, therefore, assumed that the nearshore zone contains sediments similar to those of adjacent beaches. Unlike sand, gravel is not so readily transported and movement of gravel is most likely confined to the surf zone and foreshore. Once beyond a critical depth, gravel is unlikely to be redeposited on the shore as water motion will be insufficient to initiate transport.

Mud is conspicuously absent from nearshore and beach sediments. Very fine particle sizes may be readily suspended in the high energy nearshore zone and are then readily transported offshore or alongshore.

2.5.3 Sediment Sources
Mineralogically, the offshore, nearshore and beach sand deposits are a quartz-mica-feldspar association, derived from the granites, gneisses and schists of the Southern Alps (van der Linden, 1969; Carter, 1980). Processes occurring during the Pleistocene and Holocene have concentrated minerals in beach and dune deposits (Carter, 1980).

Numerous rivers and streams of steep gradient drain westward
from the Southern Alps, carrying enormous quantities of sediment (Table 2.1). The high yields have been shown to be predominantly a function of the high rainfall of the region, provided catchments are relatively undisturbed by man (Griffiths, 1981).

Table 2.1: Suspended sediment yields for South Island West Coast rivers.

<table>
<thead>
<tr>
<th>River Name</th>
<th>Basin Area (km²)</th>
<th>Basin specific annual suspended yield (tonnes km⁻² yr⁻¹)</th>
<th>Load delivered to ocean annually (tonnes yr⁻¹ x 10⁶)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karamea</td>
<td>1242</td>
<td>325</td>
<td>0.404</td>
</tr>
<tr>
<td>Mokihinui</td>
<td>752</td>
<td>3830</td>
<td>2.88</td>
</tr>
<tr>
<td>Buller</td>
<td>6484</td>
<td>270</td>
<td>1.75</td>
</tr>
<tr>
<td>Grey</td>
<td>3948</td>
<td>787</td>
<td>3.11</td>
</tr>
<tr>
<td>Taramakau</td>
<td>1005</td>
<td>9877</td>
<td>9.93</td>
</tr>
<tr>
<td>Hokitika</td>
<td>1069</td>
<td>17070/448/16080</td>
<td>12.0</td>
</tr>
<tr>
<td>Haast</td>
<td>1349</td>
<td>12736</td>
<td>17.2</td>
</tr>
<tr>
<td>Kapitea to</td>
<td>11292</td>
<td>14903/1062</td>
<td>80.1</td>
</tr>
<tr>
<td>Mackenzie</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Griffiths and Glasby, in prep., Table 1.

Much of the mud in surficial offshore deposits is derived from river sources. It has been suggested that the sediment input in this area exceeds the sorting capacity of the hydraulic regime existing on the shelf, resulting in the accumulation of mud (Carter and Heath, 1975). Mud entering the sea may flocculate out and accumulate near the shore but is easily resuspended by wave action. Once resuspended the mud is readily transported by the prevailing water movements (Carter and Heath, 1975).

2.6 SEDIMENT TRANSPORT IN THE COASTAL ZONE

A number of factors, including ocean currents, tides and waves, contribute to sediment transport in the marine environment. The forces producing sediment movement may be more concentrated in the nearshore zone, so that the greatest amount of sediment transport probably occurs in this zone. Despite this, sediment transport does occur seawards of the nearshore zone, in a zone termed the offshore zone. Sediment transport is conveniently discussed by reference to these two zones.
2.6.1 Offshore Zone

Within this zone sediment movement is influenced mainly by the mean circulation, tides and waves. Direct measurements of mean circulation off the West Coast show that it is generally too weak to produce movement of even the finest sediments (Heath, 1973; Carter and Heath, 1975). Tidal flows are too weak to move sediment on the open shelf, but velocities may be significant in areas where tidal flow is constricted, as in Cook and Foveaux Straits. Waves produce a resultant water movement at the bottom. In the case of waves recorded off western New Zealand, this movement is not of sufficient velocity to initiate movement of bed sediments at the water depths of the wave records (90-175 metres). At shallower depths, water velocities at the bottom, produced by waves would be greater and sediment may be transported.

Only in a few isolated positions do the individual components of water motion mentioned above have enough strength to move bed sediments by themselves. For sediment transport to occur the strengths of the components need to be combined. Bed sediments off the West Coast consist mainly of fine and medium sands with critical velocities for transport in excess of about 35-40 cm.s\(^{-1}\) (Carter and Heath, 1975). The Westland Current has low mean velocities of between 1.3 and 9.6 cm.s\(^{-1}\) while tidal flows are up to 51 cm.s\(^{-1}\) at the surface (Carter and Heath, 1975).

Available measurements of waves and storm induced currents suggest that storms are capable of disturbing bottom sediments over much of the continental shelf. Because of the oscillatory nature of water motion induced by waves, the principal effect of waves is to disturb sediment rather than transport it. Once in suspension most sediments are easily transported.

The inferred direction of bed sediment transport is to the north north-east, coinciding with the direction of the Westland Current. The main forces producing sediment transport are tides, waves and storm driven currents. Maximum sediment transport would occur when south-westerly storms are coincident with peak tidal flow and the mean circulation, both of which are in a north north-east direction.
2.6.2 Nearshore Zone

Sediment transport in the nearshore zone can be divided into movements in an onshore-offshore direction and movements in an alongshore direction. This distinction is, however, arbitrary as at any moment sediment transport is likely to be in a number of directions with both on-offshore and alongshore components.

Significant amounts of material are likely to be transported in an on-offshore direction, primarily as a result of wave action. As mentioned, mud is easily transported offshore and gravel is not easily transported once in deep water. Most of the sediment transfer in an on-offshore direction will involve sand movements in response to changes in wave characteristics and beach conditions.

Longshore transport results from the disturbance of sediment by breaking waves and the transfer of this sediment by the component of wave force directed alongshore. Greater angles of approach and higher wave energy result in greater amounts of sediment being disturbed and transported (Coastal Engineering Research Centre, 1977).

Within the nearshore zone, sediment transport usually occurs as a combination of bedload transport and suspended load transport. The distinction between sediment moving on the bottom and sediment moving in suspension is once again arbitrary as individual grains may move in both manners.

The dominant direction of longshore transport in the nearshore zone of the West Coast may possibly be to the north as most waves approach from the west through to south-west. Wherever these waves are not completely refracted by passing over shallow water before reaching the coast, some component of the wave energy will be directed alongshore in a north north-east direction. Despite this, Mangin (1973) has shown the influence of Cape Foulwind in refracting waves approaching the Karamea Bight. The resultant waves approach the shore predominantly from the north-west and produce longshore transport to both the north and south. In addition, Pfahlert (1984) has shown the longshore transport direction to vary considerably in the vicinity of Point Elizabeth (see section 2.3.5). In contrast, other researchers have inferred that northward
transport of sediment was dominant (Furkert, 1947; van der Linden, 1969; Carter and Heath, 1975).

Furkert (1947) calculated that the growth of Farewell Spit during the Quaternary has been due to the addition of around 4.5 million $\text{m}^3\text{yr}^{-1}$. From this evidence and calculations of the supply of sediment from West Coast rivers and deposition and erosion measured in the vicinity of Westport Harbour, Furkert concluded that sediment transport past Westport Harbour was of the order of 5 million $\text{m}^3\text{yr}^{-1}$.

It appears from the literature that Furkert's estimates have generally been accepted without question, although there have been no studies at Farewell Spit or elsewhere on the West Coast that clearly demonstrate a net northward movement of this quantity of sediment.

2.7 DEVELOPMENT OF A SEDIMENT BUDGET

The procedure for obtaining a littorial sediment budget for a stretch of coast consists of assessing the sedimentary contributions (credits) and losses (debts) and equating these to the net gain or loss (balance of sediments) within given boundaries.

For the purposes of this study, the area included is that portion of the West Coast from Jackson Bay in the south to Farewell Spit in the north.

Within this area the major sediment contribution is assumed to be from the numerous rivers of high sediment yield draining the Southern Alps. Griffiths and Glasby (in prep.) calculate that the total sediment yield from rivers between Jackson Bay and Farewell Spit is in the order of $130 \pm 26 \times 10^6$ tonnes per year ($98 \pm 20 \times 10^6 \text{m}^3\text{yr}^{-1}$ using a conversion of $1,33$ tonnes per $\text{m}^3$). Coastal erosion may be a significant contributor of material to the sediment budget. For example, an area of coast 10 kilometres long, eroding at a rate of two metres per year could be expected to contribute approximately $20,000 \text{m}^3\text{yr}^{-1}$ or more. It appears that a significant proportion of the coastline on the West Coast is naturally eroding at average rates of up to eight metres per year (Gibb, 1978). Other possible
sources are:
- cliff erosion, onshore transport, longshore transport into the area, wind transport, in situ biogenous and hydrogenous deposition, and man.

Although sand may be continually transferred between beach systems and the nearshore zone, mud, which is the dominant surface sediment further offshore, is conspicuously absent (see section 2.5). It can be assumed from this evidence that onshore transport of sediments from the continental shelf is minimal. The offshore areas appear to act more as sinks for the finer sediments reaching the coast.

Cliff erosion may contribute some material in certain localities (Mangin, 1973). Longshore transport in from the south is assumed to be minimal due to the strong Southland Current flowing south from Jackson Bay (Brodie, 1960; Heath, 1969). Other contributions from sources such as wind transport and in situ deposition are likely to be minor in comparison to the quantities of sediment supplied by the rivers.

Within the area, the major transfers in the offshore and littoral zones have been described. The assumption that material is transported predominantly in a northward direction appears to be an oversimplification of the various transfers occurring.

Sediment sinks identified to date are the continental shelf of western New Zealand and possibly Farewell Spit and Cook Strait. Little reliable data is available on the amounts of sediment being deposited in each of these sediment sinks.

Although a reasonable estimate of the quantity of sediment supply is available, the lack of data available on the quantities of sediment transfers and losses means that what happens to this material within the area and where it goes is uncertain. As a result, there is no clear knowledge of the overall balance or imbalance of sediment supply and loss on the West Coast. The implication is that it becomes difficult to determine long term trends in coastal stability. It is also difficult to predict the likely effects of various resource developments on the systems state of balance.
2.8 COASTAL EROSION AND ACCRETION

Rates of coastal erosion and accretion around the New Zealand coastline studied by Gibb (1978) show a dominance of erosion of the coastline between Jacksons Bay and Karamea.

Rates of erosion and accretion may have a significant effect on developments located close to the present shoreline. Developments with an expected lifetime of more than 10 years are likely to be affected by rates of $1.0 \text{ m. yr}^{-1}$ or greater. For the purposes of this study, therefore, mean rates of erosion or accretion greater than $1.0 \text{ m. yr}^{-1}$ are assumed to be significant.

Areas of significant erosion are:
- Jacksons Bay, Bruce Bay, Hunts Beach, Waitaha, the coastline north of the Grey River mouth to Rapahoe, the Barrytown flats, Nine Mile Beach, Fairdown, Waimangaroa, Jones Creek, Little Wanganui and Te Namu (Figure 2.6).

Areas of significant accretion are:
- The coastline immediately south of the Grey River mouth, Canoe Creek lagoon on the Barrytown flats, Carters Beach, North Beach, Karamea and Farewell Spit (Figure 2.6).

Coastal erosion problems may be caused by a variety of complex factors, both natural and man induced. Erosion is, however, always the result of a deficit in the beach sediment budget. For this reason a careful consideration needs to be given to the natural sediment transfers occurring and to how these will be affected by developments in the coastal zone.

A major problem with the use of average rates for erosion or accretion is that they may disguise important short term changes in the sediment balance on beaches along the coastline. In addition, large areas of the coastline were not included in the study by Gibb (1978).
Figure 2.6: Areas of significant erosion and accretion - West Coast.

Source: Compiled from Gibb, 1978.
2.9 CONCLUSIONS

There are certain features of the coastal zone of the West Coast that are important when considering proposed resource uses within that zone. These features and their implications are summarised here.

The coastal zone of the West Coast is characterised by large inputs of sediments from the rivers and streams draining the Southern Alps and seaward ranges. Developments within these catchment areas that influence the quantity and type of sediments delivered to the coast are likely to have implications for sediment transport and deposition within the coastal zone.

The numerous beaches along the West Coast are predominantly composed of coarse sands. Fine sands, gravels and mixtures of sand and gravel also occur. This material is readily transported by wave action which is generated mainly by west and south-west winds. There is a high potential for sediment transport in both an onshore and alongshore direction due to the incidence of high energy, steep waves and the angle at which these may approach the shore. These processes are readily affected by activities that influence wave characteristics and sediment transport, or disturb the natural form of the beach system. Examples of such activities are the erection of structures within the nearshore zone and the destruction or modification of dune systems.

The overall balance or imbalance of the sediment supply and loss within the West Coast coastal system is unknown at present. This is due to the difficulty of determining the quantities of sediment transfers and losses. As a result, it becomes difficult to predict the effects that resource developments influencing sediment inputs, transfers or losses will have on the overall balance of the system.

It has been noted that a significant portion of the coastline is affected by erosion, suggesting a predominant erosional trend for the area. Activities or developments located close to the foreshore may be affected by erosion in the future. There is also a potential for erosion to increase in areas where the natural beach system is disturbed or where transfers of material supplying the beach
are interrupted.

Resource developments within the coastal zone of the West Coast should involve recognition of the dynamic nature of the physical processes operating in that zone. Planning for, and management of, resource developments needs to be based on an understanding of the physical processes, described in this chapter, and the impacts that are likely to result. In Chapter 3 the features of resource uses within the coastal zone are discussed to highlight management issues related to their location.
CHAPTER THREE

RESOURCE USES IN THE COASTAL ZONE

3.1 INTRODUCTION

The major uses of the coastal zone of the West Coast that are likely to present problems for the management of the resource are outlined in this chapter. Features of the resource use that have presented problems in the past or that are likely to in the future are discussed. Considerations important in the management of resource uses are discussed and will be developed in subsequent chapters.

The wide range of uses of the coastal zone include port and harbour developments, coastal subdivision, effluent disposal, mining, agriculture, and recreation; all of which affect the resource in some way. The development of these various uses has led to conflict and to problems related to their location in a dynamic environment.

3.2 MINERALS AND MINING

3.2.1 Aggregate Extraction

The recovery of aggregate is dependant on market conditions, especially demand. Because of low market prices and the high costs of transportation, aggregate extraction usually occurs close to the area of use. Despite its low market value, the total monetary value of aggregate exceeds that of any other mineral produced in New Zealand.

There are two main types of aggregate sources: \textit{in situ} hard rock, and unconsolidated sediment produced by the natural breakdown of parent material. \textit{In situ} hard rock is extracted by quarrying operations and can be considered a non-renewable (stock) resource as it is limited by the stock or quantity available. Unconsolidated material occurs in river channels and terraces, beaches and offshore deposits and can be considered a renewable (flow) resource as it is continually replenished by erosion processes. In some instances, however, the supply of material to beach and offshore sources may have ceased, and in all cases the rates and quantity of supply may vary in space and time.
On the West Coast, some aggregate is extracted from quarries but the bulk is removed from rivers and river terraces. Material suitable for metal aggregates (gravel particles or larger) is transported predominantly as bedload within a river system. Griffiths (1979, 1981) has shown sediment yields for South Island West Coast rivers to be very high (see section 2.5.3). In considering the large quantities of sediment supplied by the rivers, at first glance it may appear that little planning or management is required. An important feature of renewable resources, however, is that although they are virtually unlimited in the duration of supply, they are limited by the quantity available per unit of time (Ehrlich et al., 1977). If the rate of extraction exceeds the rate of supply over a prolonged period of time, then the resource may be exhausted or irreversibly damaged. Sustainable use of a renewable resource requires that the rate of extraction is maintained at or below the rate of replacement. Sediment supply within river systems is characterised by important variations in space and time. If aggregate is to be treated as a renewable resource then the implications of these variations for the rate of extraction should be considered.

Annual sediment yields from catchment areas draining steep mountain lands usually vary by an order of magnitude or more about mean values (Hayward, 1979). These variations in sediment yield are related to variations in stream flow and sediment supply. Estimates of the contribution of bedload to total sediment yield may vary from as low as 1% to greater than 40%, depending on catchment size, geological and geomorphic factors, flood magnitude, and climate. Griffiths and Glasby (in prep.) suggest that bedload ranges from 2-5% of the suspended sediment yield. It should be noted that at times bedload may account for a much more significant portion of sediment yield, such as when coarse material armouring the stream bed has been reduced. The greater portion of bedload may be produced by infrequent flood events of high magnitude (Hayward, 1979). Griffiths (1981) shows, however, that for South Island rivers generally, the greater portion of suspended sediment is moved by flood events smaller than the mean annual flood. Larger events are so infrequent that overall they carry a smaller proportion of total suspended sediment yield.

From this discussion it is noted that sediment movement (bedload
and suspended load) is episodic. For most of the time the greater portion of sediment is held in storage at some point within the fluvial system, either in the catchment area or on the bed and banks of the river channel. Sediment stored temporarily in the fluvial system forms part of a potential supply to downstream components of the system and to coastal and/or offshore areas. Continued extraction from one site results in a 'hole' in the longitudinal profile of the river. This 'hole' may act as a sediment trap causing reduced sediment supply to downstream areas, or it may induce deepening of the river channel upstream as an adjustment to the lower, temporary base level produced by the hole. Extensive or prolonged extraction, therefore, requires amounts of sediment that are surplus to the requirements of stability in the river system and in coastal or other storage areas.

Aggregate extraction from beaches is widespread along the West Coast and has a long history. Most extraction operations are located close to the major population centres at Hokitika, Greymouth, and Westport, although other areas may be exploited for local requirements. Although a licence is required for sand and shingle extraction below mean high water mark (MHWM), the Ministry of Transport acknowledges that illegal operations do occur. For example, sand and gravel has been removed from Hokitika Beach for a considerable period of time without a licence having been granted. Periods of beach erosion have threatened the commercial area of Hokitika while there has been no assessment of the relationship between the beach sediment budget and the quantity of material extracted.

Offshore exploitation of sands and gravels appears unlikely on the West Coast since aggregate materials are readily available from river and beach sources, and because of the increased costs of production. In other areas of New Zealand, sand and gravel is extracted from offshore deposits in water depths usually less than 30 metres. The technology used for offshore sand and gravel extraction is similar to that which would probably be used for offshore mining of minerals such as gold and is discussed in section 3.2.2.

3.2.2 Gold Mining
Large areas of low grade alluvial gold bearing deposits occur
on the West Coast. At the height of the gold dredging boom in
the early 1900's, 63 dredges worked in catchment areas, lagoons,
and dune systems in the West Coast area. The only large scale
dredging operation in recent times (the Kaniere gold dredge on
the Taramakau River) ceased operation early in 1982. Proposals
to recommence dredging operations on the Grey River with a new
dredge have been unsuccessful to date (Wallace, 1984a). An application
for a mining licence to dredge the Mikonui River south of Ross
has been approved in principle, but cost changes and lower gold
prices since the original feasibility study may mean that the operation
is commercially unattractive, at least at the present (Wallace,
1984c).

The escalation of gold prices on the world market in recent years
has meant that many of the previously uneconomic placer gold
deposits may now become economic. This price escalation has stimulated
expenditure in exploration and prospecting for gold and applications
for exploration, prospecting, and mining licences covering alluvial
areas on the West Coast increased dramatically in the early 1980's.

At present, all gold production in the South Island comes from
small to medium scale operations using earthmoving machinery or
hand methods to work streams, terrace gravels or beach sands.
A typical low grade alluvial deposit requires the extraction and
processing of more than 1000 m³ per day. In several catchments
on the West Coast there are a large number of small scale operations
and little is known about the cumulative effect of these activities
on catchment processes, or of the environmental effects of small
scale mining in general.

Gold in the beach sands may be typically of a smaller size than
the other mineral constituents (Williams, 1974). The concentration
of surface gold-leads in the beach sands is dependant on suitable
conditions arising from the interaction of the tides, nearshore
currents, and wave characteristics. If the beach sands are mined
for other economic minerals in the future, such as ilmenite, then
gold is likely to be an attractive by-product.

The major areas of interest in offshore gold in New Zealand are
the drowned river valleys off land areas that have provided significant
discoveries in the past, namely the West Coast of the South Island, Foveaux Strait, Otago, and the Coromandel Peninsula. Erosion of these areas during glaciation may have resulted in accumulation of detrital gold in what are now submerged beach sands and river valleys. Conzinc Riotinto Australia (CRA) Exploration Pty Limited have exploration licences covering some 1,000 km² off the West Coast and Southland, where they have been searching for submerged river channels and beaches.

If offshore extraction of material proceeds, it is likely to involve one of two main types of suction dredging - anchor dredging which involves a stationary dredge excavating pits, or trailer dredging which utilises a moving dredge. Below water depths of around 35 metres jet assistance may be utilised. In offshore areas the placer deposit is likely to be overlain by other sediments (Carter, 1980). The technology required to explore for offshore gold is expensive and physical conditions such as strong winds and waves may disrupt operations. Gillie and Kirk (1980) outline four possible areas of direct impact from offshore mining; bathymetric changes, particle size changes, suspension of fine sediments, and coastal erosion.

Bathymetric changes are determined by the extent and thickness of the deposit being mined, the method of mining, and the mobility of the material in the vicinity of the site.

Particle size changes can be significant if material beneath the deposit being removed is of a different size class. Off the West Coast, sediment sizes generally increase with depth below the seabed (see section 2.5.1) and particle size changes will depend on the type of material removed (for example, relict sand deposits in the case of offshore gold mining).

Suspension of fine sediments is likely to be significant in the case of deposits overlain by mud. Suspension can result from the action of the suction pipe on the seabed or from discharge at the surface from collection vessels. Fine material is easily redispersed and the greatest impact is likely to be related to biological effects of disturbance of the material and the density of the discharge plume (Gillie and Kirk, 1980; Padan, 1977). Fine material may also be redeposited in unfavourable areas such as navigation channels.
Coastal erosion may be caused by four main mechanisms:

1. slumping of the beach profile drawing material offshore;
2. changes in wave refraction influencing longshore transport as a result of changes in bathymetry;
3. reduced protection from wave attack due to the removal of offshore bars or banks; and
4. the removal of material normally part of the on-offshore sediment transport budget (Gillie and Kirk, 1980; Padan, 1977).

Accordingly, offshore mining operations should be excluded from nearshore areas to avoid interaction with the processes affecting shoreline stability.

3.2.3 Ilmenite Sand Mining

Within the coastal zone of the West Coast between Karamea and Jacksons Bay (a distance of approximately 400 kilometres) there is estimated to be over 1000 million tonnes of potentially valuable beach sands (Nicholson et al., 1958; Nicholson, 1967). These sands comprise dune systems behind the present shoreline and also a series of Pleistocene and Recent shorelines inland at heights up to a maximum of 152 metres above present sea level (Nicholson, 1967). A range of potentially valuable minerals can be extracted from the sands including ilmenite, magnetite, zircon, monazite, gold, scheelite, rutile, uranothorite, zirconium, and cassiterite.

The percentage content of many of the minerals in the sands are mostly low but are significant in comparison to those from profitable mining operations overseas (Nicholson, 1967). Apart from gold, none of these minerals are being commercially recovered at present. Ironsand deposits may also occur offshore as relict beaches but are covered with modern sediments and it is unlikely that modern shelf currents are actively concentrating heavy minerals (Carter, 1980). Offshore sands are not likely to be commercially exploited for the minerals described, except perhaps for gold, because of the high cost of prospecting and mining.

Together, two major companies hold prospecting licences for the most significant ilmenite deposits on the West Coast. Fletcher-Challenge Limited, in a joint venture with Amax Exploration (N.Z.) Inc. and Mineral Resources (N.Z.) Ltd., have conditional approval
to prospect on 1862 hectares of the Barrytown flats. CRA Exploration Pty Limited, in conjunction with Buller Minerals Ltd., have applications covering over 13,040 hectares around Westport and Cape Foulwind in addition to a licence covering the nearshore zone off Nine Mile Beach.

In combination, the prospecting licences of these two major companies cover the greater portion of Quaternary beach deposits in the stretch of coast between the Barrytown flats and the Waimangaroa River mouth (Figure 3.1). If a mining licence is approved for one of the areas adjoining the foreshore, or in the nearshore zone, then there are likely to be major implications for sediment transfers and shoreline stability.

Eventual mining of the Barrytown flats, if the resource is proved economic in a commercial sense, would probably be by the means of a cutter suction dredge. A dredge has already worked the area for gold up until the 1940's. The dredge would need to work in a pond approximately 225-375 metres in length and would move approximately 50 metres per week. Sand would be delivered to a trommel screen for the concentration of the minerals at the rate of 40 m$^3$.hr$^{-1}$. The area of land disturbed at any one time is likely to be less than 20 hectares with reject sand and soil being used for restoration. Approximately 37 hectares would be mined each year, giving a lifetime for the mining operation of around 50 years (total area of prospecting licence is 1862 ha). The approximate annual output from the mining is presented in Table 3.1.

Table 3.1: Potential output from mining of the Barrytown Flats.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Annual Output (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilmenite</td>
<td>225,000</td>
</tr>
<tr>
<td>Magnetite</td>
<td>15,000</td>
</tr>
<tr>
<td>Monazite</td>
<td>4,500</td>
</tr>
<tr>
<td>Rutile</td>
<td>2,200</td>
</tr>
<tr>
<td>Zircon</td>
<td>9,000</td>
</tr>
<tr>
<td>Gold</td>
<td>130 kg</td>
</tr>
</tbody>
</table>

Figure 3.1: Major ilmenite prospecting areas.

Source: Compiled from Bowen, 1964 and NZMS 261B sheets K 29 and 30.
Originally, the ilmenite was to be processed into synthetic rutile for titanium metal production, but studies undertaken by the Industrial Processing Division of the Department of Scientific and Industrial Research for Fletcher-Challenge now favour the production of a titanium dioxide pigment.

3.3 PORT DEVELOPMENTS - CHANGING COASTAL GEOMETRY

Changes in shore geometry will lead to responses in the beach system which are often undesirable. Perhaps the most significant changes to shoreline geometry are those associated with the construction of port facilities.

Typical structures used in port developments are jetties or breakwaters which are designed to confine an entrance channel to a particular location and to prevent accumulation of material in the channel. Despite being effective in achieving those results, structures protruding from a natural shoreline can have other effects. Where material transported as littoral drift is interrupted by a solid structure the material will accumulate on the updrift side, while the downdrift region is starved of sediment supply and may begin to erode. Solid structures also influence diffraction and changes to shoreline geometry resulting from the accumulation or erosion of material will influence wave refraction. These influences may cause either concentration or dissipation of wave energy leading to further problems of erosion or accretion.

On the east coast of the South Island, the port of Timaru exemplifies many of these problems as a result of a net drift in a northward direction. On average 60,000 m$^3$.yr$^{-1}$ of material has accumulated on the southern side of the harbour breakwater, resulting in an area of around 80 hectares. Immediately to the north of the harbour, fine sediments have accumulated in Caroline Bay, while further north the gravel beaches, particularly at Washdyke, have been eroding rapidly (Kirk, 1982).

Many of New Zealand's secondary ports are located at the mouths of rivers rather than in natural harbours. Changing coastal geometry causes problems that are aggravated by changes to the river mouth
bar and the system by which material, travelling alongshore, bypasses the river channel.

Port developments at Westport and Greymouth on the West Coast exemplify the problems associated with location at the mouths of major rivers. Waves from the west and south-west are refracted around Cape Foulwind to approach Westport from the northwest (Mangin, 1973).

The entrance to Westport Harbour was confined by two main breakwaters and river training walls between 1886 and 1900 (Simpson and Fyson, 1971). Various extensions and raisings of the breakwaters were carried out between 1906 and 1916 when the harbour entrance was 110 metres seaward of the original entrance and the west breakwater extended 60 metres further than the east breakwater. Following construction of the harbour works, Carters Beach to the west accreted at average rates of 8.2 m yr\(^{-1}\) from 1895-1928 and 7.6 m yr\(^{-1}\) from 1928-1944 (Furkert, 1947). Accretion has continued since that date (Figure 3.2). Immediately to the east of the harbour there was a short period of erosion but this was rapidly reversed and the area has been accreting since then at a rate faster than to the south at Carters Beach (Gibb, 1978). Further east, active erosion has been occurring at least since the period of harbour construction. Furkert (1947) calculated that between 1890 and 1945, 1.25 million m\(^3\) yr\(^{-1}\) had accumulated about the harbour works and as a result of their construction.

The existence of a bar at the entrance to the harbour, formed by the interaction of waves, river, and tidal flow, has necessitated dredging since 1904. Dredging inside the harbour has also been conducted since 1910. There have been numerous problems with the operation of a dredge, not the least of which was the fact that the dredge could not cope with the large amount of material to be removed, including large logs. In 1963, with the imminent retirement of the dredge, a scheme to extend and narrow the breakwaters was approved. Breakwater extension was completed by 1967 and at first it was hoped that the narrowing of the entrance would be enough to maintain water depths. More recently, however, the harbour authority has become concerned again with the decreasing water depths, as this is restricting cement vessels from loading to capacity.
Figure 3.2: Coastal changes at Westport, Southern Karamea Bight.

A. 1885 shoreline
B. 1973 shoreline

Source: Mangin, 1973, Figure 38.
3.4 RESIDENTIAL - COMMERCIAL DEVELOPMENTS

Residential and commercial developments in the coastal zone have frequently proceeded without any knowledge of the shoreline dynamics and all too often they have been threatened by coastal erosion.

One of the fundamental causes of erosion threatening coastal developments has been the failure to recognise that dune systems, and particularly the foredune, are important reservoirs of coastal sediments that act as buffers during storm events by releasing sand to the beach system and dissipating wave energy. Changes to a beach profile that result from variations in wave conditions and sediment supply, therefore, mean that the position of mean high water mark commonly shifts a distance of between 15 and 30 metres (Healey, 1980). Where the foredune is destroyed or modified, the capacity to resist erosion is reduced and where developments are located on dune formations they are likely to be threatened by storm events from time to time.

At Omaha Beach in Northland, the frontal dune was destroyed and replaced by a near-vertical sea-wall. Solid structures of this type often accentuate beach erosion by reflecting storm waves and promoting scour of the beach in front of the sea-wall (Figure 3.3). Consequently, storms destroyed the sea-wall at Omaha and an extensive and costly programme of groyne construction renourishment of the beach, and rebuilding of the frontal dune has been undertaken.

Failure to consider long term persistent erosion patterns and the migration and erosion of river mouths is a further cause of developments being threatened by erosion (see Healey, 1980 and Forbis, 1974 for examples).

Although the West Coast is not subject to the extreme pressures of subdivision and development to the same degree as experienced in the northern half of the North Island and around major population centres on the coastline, there are still many examples of problems caused by coastal erosion. Rates of coastal erosion and accretion studied by Gibb (1978) show a dominance of erosion along the West Coast.
Figure 3.3: Progressive erosion around a near vertical sea-wall of the type constructed at Omaha Beach.

Source: Healey, 1980, Figure 14.3.
At Hokitika, the town commercial district is located in a hollow immediately landward of the foredune. There has been considerable concern expressed by residents about the effect of erosion and salt water overtopping of the foredune. A brief examination of the history of the site shows that there have been periods of both erosion and accretion, suggesting that fluctuations in the shoreline position may simply be the result of storm events rather than a long term trend. Detailed study may, however, show that despite short term periods of accretion the overall trend at the site is one of erosion.

Erosion of the foredune along the beach at Punakaiki settlement has occurred during the last few years, causing some alarm amongst residents. Most recently the foredune has been rebuilding and the beach system appears in a state of recovery. It is difficult to associate the erosion with any one causal factor such as increased storm events and periods of erosion or accretion may occur again at any time.

The examples above serve to illustrate two main points regarding the siting of developments in the coastal zone. First, where developments are proposed close to the coast, detailed knowledge of the coastal dynamics are needed, and developments should always be located some distance landward to preserve the buffering capabilities of the foredune. Second, where developments exist close to the coast that appear threatened by erosion, it should first be ascertained whether the erosion is due to short term storm events or is part of a long term trend.

3.5 CONCLUSIONS

This chapter has examined features of some of the major resource uses of the coastal zone, with specific reference to the West Coast. Emphasis has been given to interactions between the physical system and resource uses with the aim of presenting considerations that are important in the management of resource uses.

Mineral extraction operations may have a marked effect on sediment budget characteristics, especially the supply of material to the
coastal zone. The extraction of aggregate and gold from catchment areas may affect the storage of sediments and supply of material to coastal areas. Operations that remove material from beach and coastal areas are likely to have a more direct impact on coastal stability. Offshore developments will have the greatest impact where they are located within the nearshore zone or only a short distance offshore.

Port developments illustrate the types of shoreline changes induced by structures that intercept the transport of sediment in the coastal zone. Where sediment transfers are interrupted, erosion of downdrift areas will usually result.

The most common response to the threat of erosion has been the building of protective structures such as groynes, sea-walls or other barriers. Many of these structures have failed to solve the erosion problem due to poor design or construction. Where structures are effective they frequently require costly and extensive maintenance. As a result, they should only be resorted to as a final effort and only when they are based on a detailed knowledge of the shore processes affecting that portion of the coast. The siting of resource developments in the coastal zone should involve a recognition of the buffering capabilities of dune systems and both short and long-term variations in shoreline position.

In the next chapter, institutional aspects applying to the coastal zone are discussed. Institutional arrangements define the basis of the management approach that is applied to the coastal zone resource and the various resource uses. This discussion of institutions is used as a basis for assessing the adequacy of the existing management approach in dealing with the important management considerations developed in this chapter and Chapter 2.
CHAPTER FOUR

INSTITUTIONAL ASPECTS OF THE COASTAL ZONE

4.1 INTRODUCTION

In this chapter institutional aspects related to the coastal zone are described using a framework for viewing how property rights are constrained by institutional arrangements. The notions of property rights and the free market allocation of resources as they affect coastal zone policy and management are discussed. This involves a consideration of those institutional aspects needing recognition in a management framework. These aspects will be considered again when a framework for planning and management is presented in Chapter 6.

The emphasis of the remainder of the chapter is on legislation and the responsibilities of management agencies. Coastal planning and management policy is examined as a current expression of the social goals for management of the coastal zone. Existing policy and legislation provide the basis for the existing management approach that is applied to the coastal zone. As there exists a multitude of acts applying to the coastal zone and since numerous agencies have responsibilities for different aspects of management, the discussion aims only at presenting the main points relevant to this study.

Although institutions have been variously defined (Ciriacy-Wantrup, 1969; Schmid, 1972; Fox, 1976) the term is used here to refer to the elements of the social, economic and political systems that order the relationships among individuals in society. This broad definition of institutions includes laws, regulations, various resource control and management agencies, traditions, moral and ethical judgements, and customary or accepted practices. Institutions act as constraints on the property rights that apply to a particular resource.
4.2 PROPERTY RIGHTS

Property rights specify the proper relationships among people with respect to the use of things, and the penalties for violation of those proper relationships (Randall, 1981 p.148).

The set of property rights applying to a particular resource will influence the structure and distribution of incentives that guide economic decisions. These decisions will ultimately affect the allocation and use of the resource under consideration.

Where property rights to a resource are not defined or poorly defined, conflict may arise between users while penalties for the violation of rights will not be enforced. This situation is likely to result in mis-management of the resource and can be compared to the 'tragedy of the commons' described by Hardin (1969). Every system of property rights should define the object of these rights, the holder of the rights who is accountable for obligations under that right, and some source of authority which legitimates or gives social approval to the assignment of the rights (Burch, 1976). Resource allocation will be determined by the nature of the property object (resource), the holder of the rights to the resource, and the means of authority used to enforce the property right.

There are two main groupings of property: public and private, and two main types of property rights: public and private. Different combinations of these rights and holders of the rights give rise to four possible mechanisms for allocation of the resource (Table 4.1). Private rights to private property are allocated by the market, public rights to private property are allocated by tradition, private rights to public property are allocated by regulation, while legislation decides the allocation of public rights to public property.

There are also situations in which the resource owner delegates control to another agency, as in the case of some minerals in New Zealand, which are owned by the Crown with control delegated to the Ministry of Energy (Mines Division). Within the coastal zone legislation provides for control of both public and private use.
Table 4.1: Mechanisms of allocation of rights to property.

<table>
<thead>
<tr>
<th>Private Rights</th>
<th>Public Rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Property</td>
<td>Market</td>
</tr>
<tr>
<td>Public Property</td>
<td>Regulation</td>
</tr>
</tbody>
</table>

Source: Burch, 1976 p. 79

4.2.1 Property Rights in the Coastal Zone

As a resource, the coastal zone has a number of characteristics which are relevant to the discussion of property rights to the resource. First, the coastal zone is unique in that it is the only zone where the three spheres (land, sea, air) meet and interact. Second, it has a diversity of physical and biological characteristics. Third, it is a finite resource of limited length, so that only a certain level and number of uses may be allocated within a given stretch of coast. Finally, the coastal zone is vulnerable to changes due to the complexity of interactions. Any disturbance to one part of the system is likely to produce local variations as well as affect other parts of the system.

A variety of property rights to the coastal zone in New Zealand have been distributed through a number of mechanisms. A large portion of the coastal zone is held in public ownership by the state including the 20 metre strip of esplanade reserve (where it exists), the continental shelf, and offshore waters. Private rights to the public property may be specified or vested in private individuals by the Crown. For example, the rights to minerals in offshore areas may be vested in private mining companies although the Crown's interests persist in the form of conditions placed on the mining licence and the collection of royalties for the minerals.

There are also large areas of land within the coastal zone held under private ownership. The set of private rights to private land may be restricted by the granting of some public rights, as is the case with land use zoning. Public property on land also exists, mainly in the form of the esplanade reserves, National Parks and Reserves, and State Forest areas, which are controlled by regulations.
Legislation and regulation should reflect societal interest so that public property is managed in a manner that is most consistent with that demanded by society. Private ownership of a resource is more likely to result in management that diverges from societal ideals. Although the market is an efficient means of allocating private goods and ensuring that private property gravitates to the highest value use, there are situations in which free market outcomes are inefficient (Randall, 1981). This has been termed 'market failure' or 'market imperfection' and typically involves the attenuation of property rights and/or pricing inefficiencies. Where the free market system results in a socially undesirable allocation or use of the resource, some form of public intervention is necessary. Intervention may involve agreements with the owner of the rights, policy inducements, regulatory controls, or compulsory taking (Albee and Storey, 1973).

Agreements and policy inducements may not have a long-lasting influence and there is little opportunity for restitution of damage. For these reasons, a set of public rights to private property, enforced through regulations, provides an effective means of ensuring that the resource is managed in a way that is consistent with societal goals. This is especially true since the outright purchase of land areas at 'fair market value' may be prohibitive in cost terms and involves complicated legal proceedings (United Nations Department of International Economic and Social Affairs, 1982).

The land-water edge is thus characterised by an interlocking web of specific individual concerns and diffuse social and ecological interests. Yet the economic and legal regimes regulating man's activities in this zone were historically intended to protect and serve only the interests of individuals in their dealings with each other, and have not always been well-suited to maximise the broader social welfare. Part of this welfare is the opportunity for the general public to have access to and enjoy the unique features of the shoreline...This indicates that traditional institutional arrangements entrusted with the allocation of scarce coastal resources have been incapable of striking a socially-optimal balance, not only between conservation and development, but also between private and public use (Ducsik, 1974 p.5).

4.2.2 Market Inefficiencies
One possible cause of inefficiency in resource allocation through market mechanisms is the existence of externalities. Externalities
arise where management of one activity causes costs or benefits to be imposed on other activities that are not accounted for by the market. In this way externalities result in an allocation that may be inconsistent with the social value of the resource being exchanged.

In practice many externalities remain in existence because of high transactions costs, or because of legal constraints. For example, building a structure on the foreshore that intercepts longshore transport of sand, causing erosion of property downdrift, can be thought of as an externality. High transactions costs in defining some form of compensation, and legal restraints such as proof of responsibility, may result in the externality not being accounted for. A further example of an externality is the residential development of an area that was popular for public recreational pursuits, resulting in the imposition of social costs to those unable to use the resource after development.

Ducsik (1974) outlines two reasons for market failure in the allocation of resources within the coastal zone. The first is a result of the difficulties in estimating, in price terms, the economic value of public use of the coastal zone (for example, the value of a scenic view or sand beach). The second is that the coastal zone has characteristics of a "res communus" resource - one that is held in common ownership. Common ownership applies to such features as aesthetics, physical composition and ecological diversity within the coastal zone. The implication is that in the absence of an efficient assessment of the value of public use, the coastal zone is overcommitted to uses for which there is some means of value-expressions, such as market price. Examples of uses for which market values are obtainable are usually capital intensive developments such as industry, housing, and commerce.

An improved specification of property rights may result in a greater portion of the social costs of developments in the coastal zone being accounted for in decisions made by the private sector. The achievement of an optimal policy will involve the balancing of marginal social benefit with marginal social costs.
4.3 A FRAMEWORK FOR INSTITUTIONAL ANALYSIS

Institutions are aimed at directing, controlling, restraining, or otherwise influencing the activities of individuals in the pursuit of social goals. This is achieved through restricting individual freedom by limiting the harm an individual can impose on others, and at the same time enhancing freedom by protecting individuals from the harm imposed by others. In simple terms, institutions define 'the rules of the game' and the structure of incentives that influence individual actions (Randall, 1981). Consequently, institutional arrangements affect the attainment of social goals, and influence the distribution of benefits and costs of resource use.

Institutions can be conceptualised as part of a three level hierarchy of decision systems (Ciriarcy-Wantrup, 1969). The highest (policy) level involves policy decisions that describe a broad statement of purpose and the goals or ends that are desired. The second (institutional) level sets out the institutional arrangements that influence decision making on the lower level. Legislation and regulation are important components of the institutional level as they establish the responsibilities of various management agencies and specify the allocation of public property rights. The lower (operational) level of the decision making hierarchy is the level at which management agencies make decisions in accord with the constraints imposed from the higher levels.

Each of the three levels of the hierarchy can be analysed in terms of the structure, functioning and performance of the decision systems (Schmid, 1972). In the following sections of this chapter, the structure, functioning, and performance of coastal zone management in New Zealand is discussed in relation to the three levels of the decision hierarchy. This involves a discussion of coastal zone policy and its administration on a regional and local level, together with a brief description of the legislation applying to coastal zone management.

4.4 COASTAL ZONE POLICY AND MANAGEMENT AGENCIES

If institutional arrangements are to control, direct or otherwise
influence activities in the pursuit of societal goals, then those goals must be explicitly stated. Where various management agencies are responsible for different aspects, the policies and goals of those agencies must be compatible and coordinated in an effort to fulfil the primary goals: those of over-riding importance. These primary goals should guide the formulation of the more specific goals and objectives of the management agencies. In the case of publicly owned resources (discussed in section 4.2) society will seek an acceptable mix of institutional arrangements for deciding on resource use. These arrangements will determine how resources should be allocated, what goods and services are to be produced, and how they are to be distributed in space and time. Without an acceptable set of social goals and effective mechanisms for achieving those goals, resource allocation decisions will lead to conflict and debate among opposing interest groups. Although conflict in resource allocation decisions may seldom be avoided, it can be reduced if societal goals are stated in a manner that clearly defines the relationships between resources and their desired use.

This section focusses on the expressed goals of coastal zone management, as reflected in policy, and the coordination and compatibility of the responsibilities of the major management agencies.

4.4.1 National Policy

Present national policy on the use of coastal land is contained within a statement made by the Minister of Works and Development in August 1974. This policy is used by government when exercising its legislative powers or when allocating finance (Ministry of Works and Development, 1979). The basic elements of the policy are as follows:

a) Recognition that coastal land is a resource of national importance, but of fixed quantity.

b) Provision should be made for as wide a variety of both active and passive recreational opportunity and experience as the coast is able to offer, now and in the future.

c) The retention in "sufficient quantity" of the native coastal flora and fauna in its natural state, as well as some "unique" and "typical" areas of coastal scenery.

d) Establishment of a pattern of future land use that clearly
defines land for urban development and land that should be prohibited from such development.

e) Ensuring that any development of coastal land for urban and holiday purposes is in sympathy with the landscape and natural features of the site.

f) Recognition that the stability of large areas of coastal land is dependant on the stability of sand dunes and that high levels of recreational use should not be permitted on unstable dune areas (Minister of Works and Development, 1974).

The provisions of the Town and Country Planning Act 1977 are supposed to provide the opportunity for more effective and coordinated planning to deal with all issues related to the coastal zone. There are, however, several other acts of parliament which contain some implicit policies.

The Ministry of Transport represents the Crown as owner of foreshores and the seabed. Under the Harbours Act 1950, the Ministry of Transport has the responsibility of approving structures and works. It also has several policies relating to mining, dredging, sand and shingle extraction, structures, reclamations, and other developments especially in relation to erosion and public access and enjoyment of coastal lands (Ministry of Transport, 1983).


The Ministry of Agriculture and Fisheries administers the Fisheries Act 1983 and the Minister has the power to impose constraints on developments under the Mining Act 1971.

The Department of Lands and Survey has the major responsibility for the purchase of reserve lands, and since 1966 has been undertaking a national survey of coastal reserves. The Minister of Lands can impose conditions on mining proposals for land administered by the Department.
National Policy related to planning and management of the coastal zone is fragmented in nature. Despite the attempt to control coastal land use under the Town and Country Planning Act 1977, the complex nature of interactions in the coastal zone means that many other national policies have some applications to this area.

4.4.2 Regional and Local Administration

In essence the Town and Country Planning Act 1977 is designed to provide the link between central government policy and the responsibilities of territorial and local authorities. The establishment of Regional and Maritime Planning Authorities provides the opportunity for the implementation of national policy for the coastal zone at a regional level and coordination of local management functions. Many local authorities have, through district scheme planning, implemented policies to deal with residential developments, erosion and the relationship between land and water uses. Despite this, many issues such as the use of foreshores and estuaries, port developments, mineral extraction, and recreational uses have not received full attention (Ministry of Works and Development, 1979).

National policy provides little explicit guidance for the resolution of problems in Regional and District Planning Schemes. Interaction of planning and management is hindered by the limited coverage of marine areas by Maritime Planning Schemes and the constraints of limited expertise and resources for the extension of regional planning areas beyond the land boundary. Although planning schemes must have regard to the principles and objectives expressed in the Soil Conservation and Rivers Control Act 1941 and the Water and Soil Conservation Act 1967, there are other acts which do not apply (for example the Mining Act 1971). Planning and management of resource use either side of the foreshore boundary, in essence, remain divorced.

The range of administrative options available to plan and manage areas above and below MHWM adds to the confusion and conflict. For example, depending on the circumstances, areas below MHWM may be administered under a range of statutes (including the Harbours Act 1950, Town and Country Planning Act 1977, Marine Farming Act 1971, Mining Act 1971, and Fisheries Act 1983), and through a range of mechanisms (such as ad hoc management plans, grants
of control, extension of regional planning boundaries, district schemes, maritime planning and existing licensing procedures) (Ministry of Works and Development, 1979).

Given that much planning and management of the coastal zone is undertaken at a local level, there needs to be a clearer definition of the role of various central and local government agencies. Local and regional authorities appear to have neither the expertise nor the resources to effectively plan and manage the coastal zone on their own. Central government has the expertise and the resources but these are scattered amongst many departments and agencies. Nowhere is there a clear outline of overall societal goals for the management of the coastal zone. Before guidance and assistance in planning and management can be dispersed from central government to the local level, a common set of goals should be clearly stated in a form which encompasses all the aspects of the coastal zone that need planning and management, and which are at present dispersed.

4.5 FEATURES OF THE LEGISLATION APPLYING TO THE COASTAL ZONE

Legislation for the regulation and management of activities in the coastal zone is abundant. Around 40 Acts of Parliament exist, applying to either land, water, or both (Figure 4.1). No clear boundary exists between those acts applying to land areas and those applying to the sea. The range of aspects covered by the legislation results in the planning and management of different aspects of the coastal zone being the responsibility of a number of government departments, territorial authorities and non-governmental organisations.

Since there is no single act clearly setting out the legal arrangements and responsibilities for coastal zone planning and management in New Zealand, it is not surprising that this is conducted in a virtually identical fashion to land use planning inland. The following sections briefly describe the main acts applying to planning and management of the resources of the coastal zone, and the responsibilities of the administering agencies. No attempt is made to provide a detailed survey of the legislation covering coastal zone planning and management, due to the complexity of such a task. Hopefully, the brief mention of the major acts relevant to this study will avoid some of the
Figure 4.1: Legislative administration of the coastal environment.

**EXCLUSIVE ECONOMIC ZONE**
- 200 nautical miles

**TERRITORIAL SEA**
- 12 nautical miles

**INTERNAL WATERS**
- width varies

**FORESHORE**
- L W M M H W M
- Baseline for Sea Boundaries
- Baseline for Land Boundaries

**TIDAL RANGE**
- I W M

**FOSSILS**

**TERRACES**

**SELLIFS**

**SAND DUNES**

**BEACH RIDGES**

**CONTINENTAL SHELF**

**CONTINENTAL CRUST**

**OCEANIC BOUNDARY**

**Fisheries Act 1982**
- Petroleum Act 1937
- Marine Pollution Act 1974
- Marine Mammals Protection Act 1974
- National Development Act 1979

**Territorial Sea and Exclusive Economic Zone Act 1977**

**Continental Shelf Act 1964**

**Submarine Cables and Pipelines Protection Act 1966**

**Marine Farming Act 1971**
- Marine Reserves Act 1971

**Crown Grants Act 1908**
- Harbours Act 1950
- Health Act 1956
- Post Office Act 1959
- Water and Soil Conservation Act 1967
- NZ Ports Authority Act 1968
- Electricity Act 1968

**Mining Act 1971**
- Antiquities Act 1975
- Town and Country Planning Act 1977
- Coal Mines Act 1979
- Litter Act 1979
- Historic Places Act 1980
- Public Works Act 1981

**Land Drainage Act 1908**
- River Board Act 1908
- Soil Conservation and Rivers Control Act 1941
- Land Act 1948
- Wildlife Act 1953
- Maori Affairs Act 1953
- Civil Aviation Act 1964
- Reserves Act 1977
- National Parks Act 1980
- NZ Railways Corporation Act 1981

**Sand Drift Act 1908**
- Swamp Drainage Act 1915
- Native Plants Protection Act 1934
- Forests Act 1949
- Iron and Steel Industry Act 1959
- Civil Defence Act 1962
- Local Government Act 1974
- Forest and Rural Fires Act 1977

Source: Adapted from Ministry of Works and Development, 1979.
confusion and conflict that surrounds the interpretation and administration of the numerous acts.

4.5.1 Town and Country Planning Act 1977

The Town and Country Planning Act 1977 is the principal legislative act controlling land use in New Zealand, and is the only act covering the coastal zone which is not restricted to a specific activity or sectional interest. Responsibility for planning is delegated to the regional and local territorial authorities. This jurisdiction is implemented through Regional, District, and Maritime Planning Schemes which are prepared by Regional (United) Councils, local Councils, and Maritime Planning Authorities respectively. The purpose of such schemes as described in section 4(1) of the act is:

...the wise use and management of the resources and the direction and control of development of the region, district or area in such a way as will most effectively promote and safeguard health, safety and convenience, and the economic, cultural, social and general welfare of the people, and the amenities of every part of the region, district or area (Town and Country Planning Act, 1977).

Control of development and the provision of recreational facilities and access is achieved by way of zoning procedures. Usually the boundaries of territorial local authorities extend only to MHWM but in some cases they may cover tidal areas and beyond. Maritime Planning Schemes will normally extend only from MHWM to the limit of the territorial sea (12 miles). To date only four Maritime Planning areas have been established and it is likely that only small areas of specific conflict over use will be designated as Maritime Planning areas in the future.

Regional Planning Schemes may extend out to the 12 mile limit and both District and Maritime Planning Schemes must comply with the Regional Planning Scheme. The 1973 amendment to the 1953 Town and Country Planning Act set out matters of national importance to be provided for in the preparation, implementation, and administration of District Schemes. These matters were included in the rewritten 1977 Act and extended to Regional and Maritime Schemes under section 3, which includes:

The preservation of the natural character of the coastal environment and margins of lakes and rivers and the protection of them from unnecessary subdivision and development (Town and Country Planning Act 1977, section 3(1)(c)).
4.5.2 **Soil Conservation and Rivers Control Act 1941**

This act was established primarily to control soil erosion and establish flood control. The National Water and Soil Conservation Authority has the power to take land or restrict land use in an area to control soil erosion and flooding. Catchment Boards were also set up under the act with rating powers and the responsibility of implementing the functions of the act. Licences for private contractors to extract sand and gravel from rivers are administered by Catchment Boards who may also control licences for sand and gravel extraction from Crown owned river-beds.

4.5.3 **Water and Soil Conservation Act 1967**

This act constitutes the National Water and Soil Conservation Authority (now enlarged to include the dissolved Water Resource Council and Soil Conservation and Rivers Control Council) and Regional Water Boards. Under the act the National Water and Soil Conservation Authority has, as part of its functions:

To examine problems concerning, and make plans in respect of...
The control of erosion on the banks of rivers, the shores of lakes, and the seashore;...(section 14(3)a(ii)), and;
To exercise, in relation to erosion, accretion, and pollution in estuaries and on the sea front and in all other places within the outer limits of the territorial sea of New Zealand, all the functions and powers conferred by or under the Soil Conservation and Rivers Control Act 1941, as if those functions and powers extended to the said estuaries, sea front, and places (section 14(3)e, Water and Soil Conservation Act 1967).

In a draft amendment to the Water and Soil Conservation Act, the suggested functions and powers of the National Water and Soil Conservation Authority under the two main acts have been amalgamated (Anon. 1984).

4.5.4 **Harbours Act 1950**

The Harbours Act (1950) gives Harbour Boards jurisdiction over specific areas of coast. Within their defined area, Harbour Boards have the responsibility of the administration, control, and management of harbours, and the overall control of coastal foreshores, seabed, and navigable rivers and lakes.

A Harbour Board may licence the removal of stone, shingle, sand, boulders, silt, mud, shell, or other material from the foreshore, harbour bed, lake or navigable river which is vested in the Crown,
but only with the consent of the Minister of Fisheries. Licences for the removal of material granted under any other act except the Petroleum Act 1937 and the Iron and Steel Industry Act 1959, may not be granted without the consent of the Ministry of Transport. At present the Ministry of Transport is implementing measures to bring licencing of sand and shingle removal under the control of the Mining Act 1971. Reclamations are only approved under the authority of a special Act of Parliament, although reclamations less than four hectares in size, that will not interfere with navigation and which is for "the benefit of the public" (section 175), may be authorised by the Governor General through an Order in Council (Wells, 1984).

Harbour Boards are not required to produce either a management plan or development plan for the areas under their jurisdiction, but must always comply with the policies and conditions set out in Regional Planning Schemes and with the regulations of the Ministry of Transport. Where a Maritime Planning Area is set up entirely within the jurisdictional area of a Harbour Board, the Board will be appointed as the Maritime Planning Authority, unless it declines. Conflicts may arise between port developments and the objectives of maritime planning, and few Harbour Boards have planning experience appropriate to the management of maritime resources on a regional scale.

4.5.5 Mining Act 1971
This act applies to the mining of Crown owned minerals and excludes coal, iron sands, petroleum and geothermal energy. Gold and silver are deemed to be the property of the Crown on or under the surface of any land within New Zealand's territorial limits. All other minerals not on Crown land can be licensed under a number of other acts (Wells, 1984). Where Crown land has been sold since the commencement of the act, the Crown retains ownership of any minerals and the right to prospect for and mine those minerals.

Subject to the written consent of the appropriate Minister, all Crown land is open to mining through licences granted by the Minister of Energy. Mining privileges for (a) any part of the foreshore, being the area between high water ordinary spring tide (HWOS) and low water ordinary spring tide (LWOS), or; (b) any part of the seabed between LWOS and the seaward limit of the territorial
sea, cannot be issued unless the written consent of the Minister of Transport acting in concurrence with the Minister of Agriculture and Fisheries has been obtained (Mining Act 1971, section 27(1)). Before mining of private land is approved, the written consent of the owner and occupier and the owner of any minerals is required. If consent is refused, the land (except for certain classes) may be declared open for mining by an Order in Council, following specified procedures (Mining Act 1971, section 27(1)).

Conditions may be imposed on a mining licence at any time by the Minister of Energy. Where the mining technique specified will disturb the surface of the land, the Minister of Energy, on the advice of the appropriate Commissioner of Crown Lands and Catchment Board or Commission, may impose conditions for the purpose of: preventing destruction of the land surface; providing for the restoration of the land surface; preventing any conflict with the purposes of the Soil Conservation and Rivers Control Act 1941, as far as is reasonably practicable. The Town and Country Planning Act 1977, except for provisions relating to the Planning Tribunal, does not apply to the Mining Act.

All applications for a mining privilege must be accompanied by an Environmental Impact Assessment. In the case of large scale, or high impact mining proposals, an Environmental Impact Report may be required under the Environmental Protection and Enhancement Procedures administered by the Commission for the Environment (for example, the Grey River dredging proposal or offshore dredging or mining). Recently, however, there has been increasing concern at the pressure that the Mines Division of the Ministry of Energy is under in processing a huge number of mining privilege applications, and the ability to adequately assess the environmental impacts of the proposals (Wallace, 1984d).

4.5.6 Iron and Steel Industry Act 1959

The purpose of this act is to provide for the iron and steel industry in New Zealand. Under the act, the right to prospect for and mine ironsands in three areas is vested in the Crown (Iron and Steel Industry Act 1959, section 3(1)). The three ironsands areas designated at present are: from the Kaipara Harbour to the Whangaehu River (North Island, west coast); from the Karamea River to the Haast
River (South Island, west coast); and Waitapu Survey District (Nelson Land District). The first two areas include all land from MHWM to three miles inland.

The Mining Act 1971 does not apply to the mining of ironsands within ironsands areas. The right to prospect or mine for ironsands in these areas can be authorised to any person or company by the Minister of Energy, on such terms and conditions as the Minister thinks fit. Land within these areas may be taken for mining purposes and compensation paid (Iron and Steel Industry Act 1959, sections 7 and 8). With respect to tidal lands, mining privileges require the written consent of the Minister of Transport, who may impose conditions to protect any land in the area or adjacent to it from erosion or other damage (Iron and Steel Industry Act 1959, section 11). Provisions for land rehabilitation under the act are few and only of a very general nature.

4.5.7 Continental Shelf Act 1964
This act is administered by the Ministry of Foreign Affairs to control the exploration and exploitation of the continental shelf of New Zealand. The right to explore and exploit the shelf is vested in the Crown. Licences for the prospecting and mining of minerals of a specified type in a specified area of the continental shelf, subject to conditions, are granted by the Minister of Energy (Continental Shelf Act 1964, section 5).

4.5.8 Other Acts
Numerous other acts have applications to coastal zone planning and management. Since a large portion of coastal land is in some form of Crown ownership, the provisions of the Land Act 1948, Forests Act 1949, National Parks Act 1980, Reserves Act 1977, and Wildlife Act 1953 may apply. The Public Works Act 1981 makes provision for the taking of land for the purposes of 'public works' undertaken either by the Crown or a local authority (for example a Harbour Board or a Council). Where land is subject to erosion, under the Local Government Amendment Act 1979 a Council may either refuse building permits or grant a building permit for the erection of a non-permanent structure (Local Government Amendment Act 1979, section 641, amended 1980).
4.6 CONCLUSIONS

This chapter began with an examination of the concept of property rights to illustrate how rights are specified and how they relate to ownership off the coastal zone. Latter sections discussed policy relating to planning and management and examined existing legislation pertaining to the coastal zone.

Although large areas of land within the coastal zone are held in public ownership and administered by government agencies, much of the land is privately owned. Private ownership of coastal resources may result in a socially undesirable allocation or use of the resource and the imposition of negative externalities. Since the coastal zone has characteristics of a publicly owned resource, adjustments to the specification of rights to the resource may be used to achieve greater recognition of the social costs of developments.

National policy affecting coastal zone management is not clearly defined and deals primarily with residential developments and recreational activities. Other policies relating to land and water use that are relevant to coastal zone management have been defined in a number of acts or by separate management agencies. Little guidance is given to regional and local authorities in implementing Planning Schemes and management actions.

There is an abundance of legislation applying to the coastal zone. Boundaries between these acts are not clearly set out and the range of administrative options leads to confusion and conflict. As a result, the planning and management of activities on land and water are not well integrated.

In the chapters to follow, these institutional arrangements will be considered in conjunction with aspects of the physical system and resource uses (discussed in Chapters 2 and 3) in order to develop an approach to coastal zone management that is consistent with their characteristics.
CHAPTER FIVE

INTERACTIONS WITHIN THE COASTAL ZONE AND MANAGEMENT ISSUES

5.1 INTRODUCTION

This chapter aims to describe interactions between the physical processes, resource uses and institutional arrangements within the coastal zone. These interactions are used to illustrate the considerations that are necessary in developing an approach to coastal zone management. Emphasis is placed on presenting what information and knowledge is necessary for appropriate management and where there are shortfalls in current information and knowledge.

Specific problems and management issues can be described as arising from two main sources. First are those problems and issues arising from the physical character of the coastal zone and interactions with resource developments. These are discussed in section 5.2. Second are those originating from institutional aspects and the management regime applied to the resource, which are discussed in section 5.3.

Consideration is also given to uncertainties present in the characterisation of the coastal zone. Because time is needed to collect and analyse additional information and knowledge, it is necessary to isolate management concerns, specific problems, and uncertainties that need to be accounted for in the management process.

Information is drawn from Chapters 2, 3 and 4 to present an overall view of the coastal zone. In terms of the generalised model of the planning and decision making process, information presented in this chapter can be viewed as an analysis of the inventory data discussed in Chapters 2, 3 and 4. The remaining steps in the model form part of the discussion presented in Chapter 6.
5.2 RESOURCE CHARACTER AND DEVELOPMENT ISSUES

5.2.1 Mining Impacts

Many aggregate extraction operations at present may have little consideration for the implications for the coastal zone as the effects are not readily linked to the extraction operation. This problem is related to a lack of knowledge and information, and a narrow view of managing river basins without consideration of the implications for 'downstream' impacts. Where a river system provides a significant amount of material to the coastal sediment budget aggregate extraction should be carefully managed to ensure that the supply is not altered in a manner that could lead to a shortfall in the coastal sediment budget.

Removal of sand or shingle from beaches has a more direct effect on the coastal sediment budget and may alter beach profiles and dune stability. Sand and shingle extraction licences granted under the Harbours Act 1950 (see section 4.5.4) require favourable technical reports and are not granted in erosion-prone areas. In many cases, however, there are no data relating to the sediment budget balance of an area and so licences are likely to be approved where there is no evidence to suggest that erosion could result. Licences may be suspended if problems such as accelerated erosion become evident (Ministry of Transport, 1980) but usually by the time such effects are noticeable efforts to reverse the erosion may be difficult and costly.

A further complication arises where unlicensed extraction is occurring as the amount of material removed and the effect this has on the sediment budget is difficult to determine (see section 3.2).

The impact that goldmining may have on catchment systems and the supply of sediments to the coast is unknown. Sediments that may normally be supplied to downstream areas may be removed from river beds and terraces by goldmining operations and dumped as tailings outside of the active river channel. The disturbance due to the use of dredging machinery may increase the proportion of fine sediments transported by rivers. The cumulative effect of numerous operations in one catchment is also unknown.

Mining of beach sands for ilmenite may have important implications for the stability of coastal areas. The areas of interest for ilmenite
sand mining include large accumulations of sand between the present shoreline and the coastal uplands. The importance of these dune areas as buffers against storms and as reservoirs of material to be supplied during periods of erosion has already been mentioned. Current prospecting licences for ilmenite sands cover areas right out to MHWM and beyond (see section 3.2.5). If future mining is permitted out to this point then the stability of large areas of coastline may be affected as the natural dune systems are disturbed.

Fletcher Challenge Limited are evaluating a world scale titanium dioxide pigment plant producing 100,000 tonnes per annum. The plant is likely to be located near Charleston to utilise the local coal and limestone resource. A total of around 400 people would be employed in the various stages of production; the mineral dressing of the Barrytown sands, open cast mining of Charlestown coal, and operation of the titanium pigment plant (Bryce, Fletcher Challenge Ltd., pers. comm. 1984).

5.2.2 Engineering Structures
The design of engineering structures requires detailed information on wave characteristics and sediment transport in the nearshore zone. Building of structures without this knowledge can lead to unforeseen complications and may only add to the problem rather than solve it. The difficulties of obtaining finance often mean that inadequate structures are built that do not meet minimum requirements to deal with the problem. There is no formal evaluation of the effectiveness of structures and little provision is made for their maintenance. Consequently, structures may be built that are ineffective. Where no provision is made for maintenance, structures that may have been effective frequently become inadequate and visually unattractive.

Construction and maintenance guidelines that should be followed for any shore protection works are outlined by the Coastal Engineering Research Centre. These guidelines list six rules, as follows:

1. Provide adequate protection for the toe of the structure to prevent undermining;
2. Secure both ends of the protection works against erosion at the flanks;
3. Check the foundation conditions of any structure;
4. Use individual blocks of material that are heavy and dense enough to withstand movement due to wave action;  
5. Build the structure high enough to prevent waves overtopping;  
6. Ensure that voids between individual pieces of protection material are small enough to prevent underlying material from being washed out by waves.

5.3 INSTITUTIONAL ARRANGEMENTS AND ORGANISATIONAL ISSUES

Many problems in coastal zone management arise from institutional arrangements and the nature of the existing management approach. These may be related to specific responses to problems arising from the physical character of the resource or to broader organisational aspects of existing management systems. Examples of the former include planning responses to coastal hazards and regulations applying to resource uses. Examples of the latter are the abundance of legislation, problems of coordination between agencies, and the level at which planning and management is applied.

5.3.1 Planning Responses to Coastal Erosion Hazards

Recent responses to coastal erosion hazards have involved controls on development implemented through zoning procedures. Where developments are proposed in an area, demarcation of an appropriate coastal construction set-back line may be an appropriate management tool to avoid the problems of erosion (United Nations Department of International Economic and Social Affairs, 1982).

In New Zealand this concept has been applied in the form of 'Development Set-back' (Healey, 1980) and 'Coastal Hazard Zoning' (Gibb, 1982). Where they are applied to existing coastal developments, however, the demarcation of construction set-back lines may have detrimental social and possibly economic consequences (Chung, 1984). Kirk (1979b) outlines the concept of a 'buffer zone' which includes a guide to development set-back, but also outlines other management objectives such as dune management and sand conservation. This concept is seen as a more positive management tool in that it encourages activities that promote foreshore stability.

The various techniques for assessing construction set-back limits
rely on historical data. This data may be inadequate in terms of the length of the record and/or the accuracy of predicting future trends in erosion or accretion with any confidence (Chung, 1984).

Average rates of erosion may disguise short-term changes in the beach sediment balance such as those due to the effects of storm events. Short-term changes in the position of the shoreline may be greater than those shown by average rates of erosion or accretion. Knowledge of beach responses to short-term events such as storms is, therefore, needed in addition to that presented by average rates on longer-term erosion or accretion.

Construction set-back limits are implemented through District Planning Schemes and building permits may be refused under section 641 of the Local Government Act 1974. Unfortunately, section 641 does not deal with other aspects of land use besides residential building developments. Under the act there are no controls on other land use practices that may lead to erosion, such as dune removal, and no controls on other land uses that may be affected by coastal erosion (that is developments not involving buildings).

5.3.2 Controls on Mining

Licencing for the removal of sand, gravel or other aggregate is in the hands of various bodies depending on the location. Catchment boards administer most licences for extraction from river systems, harbour boards, and the Ministry of Transport administer foreshore areas and the seabed below MHWM although this control is at present being transferred to Mines Division, Ministry of Energy. Most other mining licences are administered by Mines Division. This raises the issue of coordination between the agencies to ensure that adequate information is available for decision making. Licensing also needs to be conducted in a consistent manner for all areas, so that the cumulative effects of extraction operations are evaluated rather than just their effects within a single jurisdictional area.

Furthermore, under the Iron and Steel Industry Act 1959, there are few provisions for land restoration. Under the Mining Act 1971 conditions may be imposed to ensure that the land surface is restored (see section 4.2.5) but the provisions of the Iron and Steel Industry Act 1959 are far more general in nature.
5.3.3 Property Rights

Property rights of individuals and groups are more easily defined for land resources than for water resources. Rights to the use of land resources are traded as economic goods and although some rights to the use and ownership of water resources may be defined (for example, through the granting of water rights) they do not exist to the extent that they do for land resources. Divergent or incompatible uses of the land resource may respond to market-allocation mechanisms and can often be controlled by institutional constraints such as zoning. Since ownership rights to water resources are customarily held by society as a whole (res communus) the potential for the effects of externalities is greater. Where externalities are transmitted by the water body, these market inefficiencies cannot be reduced by control and allocation of land use alone (Harrison, 1978).

The declaration of the coastal environment as a matter of national importance (Town and Country Planning Act 1977, section 3c) implies that some form of common ownership applies to the land resources as well as to the water resources of the coastal zone. Management of the coastal zone as a res communus resource could involve not only the reduction of market inefficiencies but the imposition of an allocation system that replaces the market (Harrison, 1978). If such a management system were imposed, then the information used in decision making would be of critical importance.

Private property within the coastal zone is interrelated with the resource held in communal ownership. Decisions made by private individuals on the use of their property have the potential to impact on the res communus resource. It has been argued that many problems in coastal planning and management, particularly at a local level, arise because of a deep founded belief in the rights of private owners and the value of land as a market commodity (Lello, 1980). Ditton et al. (1977) point out a failure on the behalf of local government agencies to recognise that resources in common ownership are of greater than local concern.

The interrelationships of natural coastal systems frequently extend beyond local planning boundaries, creating jurisdictional and coordination problems. In accordance with this, it seems appropriate that coastal
zone management is based at a regional level under agencies with jurisdictional control over entire natural systems, including both land and water resources. The nature of the ownership of the resource, however, implies that there is also a national dimension to management. These points are discussed further in Chapter 6.

5.3.4 Legislation and Agency Coordination Issues

The numerous acts covering various aspects of management related to the coastal zone have a range of jurisdictional limits. Most planning and management in the coastal zone is undertaken in a sectional fashion with institutional arrangements related to individual functional units within the coastal zone. Since these functional units (for example water, land covered by the sea, harbours and estuaries, and the land above sea level) may be more easily identified than some overall definition of the 'coastal zone', management may be more effectively aimed at the individual functional units. It may be argued, therefore, that fragmentation of management per se is not a significant problem, but rather the lack of coordination between existing institutional arrangements and management agencies (Harrison, 1978).

The need for coordination of existing management policies and the functions of various management agencies was expressed as a major concern at the 1984 Coastal Zone Management Seminar (Lands and Survey Department, in prep.). The need to examine existing policies for the management of the coastal zone and to frame these in some overall policy statement is significant. Such a statement should incorporate a recognition of societal goals for the management of the coastal zone.

Regional planning boundaries may be set at a scale that can be compatible with the natural processes operating in the coastal zone. Maritime planning covers only management of the marine resource and has been established only in a few critical areas. Harbour boards will normally have responsibility for maritime planning although they seldom have planning expertise related to maritime planning beyond port boundaries. Regional planning may have a wider coverage, but few Regional or United Councils have the resources or the expertise to extend planning beyond the limits of the land. At present central government provides little guidance for Regional,
local, and Maritime Planning Authorities in making day-to-day management decisions. Existing policy related to coastal zone management is fragmented and emphasises residential and recreational developments. Little consideration is given to policies for other developments or to providing specific guidelines for the implementation of these policies at the regional and local level.

An alternative system of 'regional' management exists in the form of government and ad hoc agencies responsible for the planning and management of 'functional' units within the coastal zone (for example, Ministry of Transport, Ministry of Agriculture and Fisheries, Department of Lands and Survey and Catchment Boards. One Catchment Board covers virtually the whole of the West Coast area. A management system based on sectional agencies would, however, need to be highly coordinated: a situation which does not exist at present.

Financial resources and the provision of personnel and expertise are also inadequate. Government allocation of funds for the purchase of coastal land for preservation purposes has been insufficient and local authorities are frequently forced to approve developments in order to increase their revenue from rates. Many local and regional authorities do not have adequate access to expertise or personnel trained in matters applicable to coastal zone management. The complexity of interactions within the coastal zone and the resolution of management problems requires technical training and expertise in a variety of disciplines. There is a need for an increased number of trained personnel to be based at the regional and local decision making levels, in conjunction with the provision of more technical and financial support from central government.

5.4 UNCERTAINTIES IN INTERACTIONS

Present knowledge of the physical processes operating on the West Coast and the possible impacts of resource developments is limited. In addition, important information on resource, technical socio-economic, and institutional aspects may be lacking. One implication of this incomplete information and knowledge is that it leads to uncertainty about the nature and significance of past events and future actions (Radford, 1977; Rowe, 1977). Uncertainty leads to the
possibility that the outcome of a particular decision may be different from that estimated at the time the decision is made.

In choosing between decisions or courses of action, the presence of uncertainty adds the dimension of risk: the possibility of an unfavourable outcome from the decision. As decisions become more complex, the outcomes more uncertain, and the possible consequences more unfavourable, the need to employ some means of analysing uncertainty and risk becomes more compelling.

The first step in an analysis of uncertainty and the resultant risk should be an identification of the factors contributing to uncertainty. Analysis of the sources of uncertainty will assist in defining which uncertainties contribute the most risk to the decision making process. It will also help to define what information is critical to the decision process and lead to the gathering of further data where this is found to be necessary.

In relation to coastal zone management, three main sources of uncertainty can be identified. These are the following:

1. Uncertainties about the operation of physical processes and the nature of physical events;
2. Uncertainties surrounding the impacts of resource developments in the coastal zone such as mining, engineering structures; and,
3. Uncertainties relating to institutional arrangements for coastal zone management including such things as social responses, coordination of management and the question of who decides.

The following sections discuss these sources of uncertainty in more detail, defining information that is likely to be important in coastal zone management decisions. Specific examples from the West Coast are used to support the discussion.

5.4.1 Knowledge of Physical Processes and Events

Some processes are easily defined and observed, such as the flood and ebb of tides. Others are far less predictable (for example, the effects of storms). Physical studies have provided a general understanding of how waves are formed and propagated by storm events but it is difficult to predict exactly when and where storms
will occur, the size and energy of the waves formed, and how they will affect the coastline.

The characteristics and energy of waves reaching the shore have implications for the transport of material in either a longshore or on-offshore direction. The situation on the West Coast appears to be one of either northward or southward drift depending on the direction of currents due to winds and the direction of wave approach (see section 2.6.2). Given that these conditions vary considerably and that it is difficult to predict the duration of either northward or southward drift, the amount and direction of net longshore transport is uncertain.

The effects of storm waves are also related to the existing condition of the beach on which they act (Short, 1980). Where erosion or accretion is occurring it may be difficult to determine whether the erosion is due to natural causes or is man induced, through for example, a reduction in sediment supply by damming a river or removal of sand from a beach. Prediction of the timing and location of storms and the magnitude of the consequences is, therefore, a complex task.

Uncertainty also surrounds the determination of the sources and quantities of material being supplied to the coastal zone. On the West Coast, rivers transport approximately $98 \times 10^6 \text{ m}^3\text{ yr}^{-1}$ to the coast but this figure is only accurate to within plus or minus 20%. The amount of sediment supplied by erosion of parts of the coast is also uncertain as it is difficult to quantify the exact volume of material involved for large lengths of the coast. The amount is also likely to vary considerably in time and space.

Knowledge of the quantities of material supply, transfer, and loss is, therefore, fundamental to an understanding of how physical events relate to the responses of the coastal environment. Even if the amounts of sediment supplied to the West Coast could be accurately quantified, there could still be uncertainty about the quantities in transfer.

Accumulation of material against an artificial structure, such as the jetties at Westport Harbour may not provide an accurate picture
of how much material is in transfer as significant quantities of material may bypass the harbour entrance. The identification and quantification of sediment sinks may be incomplete. For example, it is difficult to quantify the amount of material that may be transported into Cook Strait or north to be deposited in the Taranaki Bight or further offshore.

5.4.2 The Impact of Resource Developments

Any development in the dynamic coastal zone is liable to have highly uncertain impacts. In the case of problems arising from physical processes (for example, coastal erosion or sedimentation in harbours) initial uncertainty arises over what the response should be. If some form of engineering response is considered, just what type of structure should be built? How will it affect the physical processes and will it solve the problem?

Many resource developments or responses to problems in the coastal environment involve the building of structures. Unlike many other areas of engineering work, coastal engineering does not have a well defined design coding. Although general principles can be applied, such as those outlined in the Shore Protection Manual (Coastal Engineering Research Centre, 1977), there remains uncertainty about the exact form a structure should take and what its affects will be. Thus, a structure that works well in one situation may not work in another.

A further problem involving uncertainty is how to determine what the effect of physical processes on a development will be. Many structures have failed because they have not been able to withstand the physical forces acting on them. In many cases structures have failed to solve the problem they were designed to deal with or have created other unforeseen problems.

All these uncertainties surrounding the impact of resource developments are related to the operation of the physical system. Consideration of resource developments should recognise that the coastal zone is a dynamic process-response system. Knowledge of the physical system will assist in reducing the uncertainties surrounding the impacts of resource developments. If a detailed sediment budget can be developed for an area of coast then developments can be
more readily assessed in terms of their impact on the sediment budget. These impacts may then be compared with other considerations, such as economic, technical, and institutional aspects relating to the development, in order to identify the trade-offs between the different aspects (see section 6.3.6).

5.4.3 Institutional Arrangements for Management

Under existing institutional arrangements uncertainty arises over who has control over the various aspects of coastal zone management. In considering a single resource development proposal it may be necessary to gain consents from a number of agencies. This uncertainty is in part due to the sectional nature of present management and the resultant difficulties in determining responsibilities.

Where controls are imposed on resource developments, there may be uncertainty relating to their acceptance. Although social acceptance of controls is a logical prerequisite, few arrangements are likely to meet with total acceptance. It may be necessary to impose controls on a certain type of development in order to protect some general aspect of societal well-being. In doing so the controls may be unacceptable to some groups or individuals within society. The uncertainty of social acceptance can be reduced by ensuring public participation in the process of determining goals for the management of the resource and in deciding on what controls are to be implemented.

Even if responsibilities are adequately defined and societal goals specify that some control on a resource use is desirable, uncertainty can still arise over how best to deal with problems. This may be related to uncertainty surrounding the different costs and benefits of alternative management options. Where damage to a resource resulting from a particular use is easily identifiable, the costs of such damage and the benefits from different control measures may be uncertain.

Management decisions will normally involve trade-offs (for example, between acceptability and social goals or between costs and benefits or alternative actions). This leads to problems over 'who decides' and what is the 'best' decision?
5.5 CONCLUSIONS

This chapter has discussed interactions between physical processes, resource uses and institutional arrangements in the coastal zone with a view to illustrating important concerns for management. These interactions, together with uncertainties arising from information constraints, are important considerations in developing a framework for coastal zone management. For this reason, it is useful to highlight the management problems and uncertainties needing consideration before an appropriate framework for coastal zone management is developed in Chapter 6.

A detailed description of the operation of the physical system is essential for effective planning and management. This is particularly true when dealing with a dynamic environment such as the coastal zone. Present information describing processes affecting change is lacking for the West Coast. A sediment budget approach could be used to provide information for a more integrated management of activities affecting the coastal zone. Specific process-response relationships need to be identified in order to isolate the impacts of resource developments.

Existing responses to coastal erosion hazards present problems of social acceptance and, in the case of engineering structures, frequently fail to solve the problem. Planning responses may be suitable where no developments exist at present, although they are not an absolute solution to problems where existing developments are located. Planning responses implemented under the Local Government Act 1974, only deal with buildings and not other forms of land use.

Coordination of the functions of the various management agencies presents a further problem. Sectional management through a number of agencies, however well it is performed, cannot hope to achieve a maximum or optimal efficiency because of the lack of communication and interaction between the agencies. A more holistic view of management is needed to define common goals and coordinate responsibilities. At present there is no overall definition of which activities are permitted under certain circumstances and which ones are not (for example, zoning of land uses may differ between counties). Mining
activities are to a large extent excluded from Town and Country Planning procedures but there appears to be a case for the exclusion of mining from the coastal zone where there are likely to be severe detrimental consequences. Present management is not adequately suited to the regional inter-relationships of the natural system or to the res communus (communal ownership) nature of the coastal zone resource.

Goals for the management of the resource are fragmented through the legislation and are not clearly defined. Goal setting should provide a basis for decision making and should recognise social needs and the enhancement of social well-being.

Uncertainties present complex problems for decision making and management. Specific uncertainties in information about physical processes lead to difficulties in determining appropriate management responses. These include the timing, magnitude and affects of storms, resultant movement of material, sediment budget parameters, and whether or not erosion or accretion will occur. Resource developments involve uncertainties about the impact of structures or extractive resource uses such as mining, the effectiveness of attempts to combat natural processes, and the effects of physical processes on developments. Because of the relationship between developments and the physical event system and sediment budget, information about the operation of the physical system is likely to reduce uncertainty relating to resource developments. Institutional uncertainties are associated with the nature and acceptance of controls, an unclear definition of responsibilities, and decisions on how to deal with problems. Information about the physical system and resource uses provides a basis for management and uncertainties in these areas will produce corresponding uncertainties in management.
CHAPTER SIX

APPROACHES TO COASTAL ZONE MANAGEMENT -
A STUDY OF THE WEST COAST

6.1 INTRODUCTION

The previous chapters have described physical processes and resource uses in the coastal zone of the West Coast, discussed institutional aspects, and highlighted important interactions between these aspects and management issues that arise from them. Uncertainty was shown to be implicit in many management issues. Effective planning and management, that which operates so as to achieve the desired effect, should account for all of these factors.

The aim of this chapter is to present an approach to coastal zone management on the West Coast. This involves a brief discussion of several approaches to coastal zone management that may be taken by a management agency such as the West Coast United Council. A consideration of the merits and inadequacies of the various options is made with reference to the discussion presented in earlier chapters. This leads to the development of an approach to management that incorporates guidelines for management in the coastal zone of the West Coast. Since management decisions will always involve some degree of uncertainty, an attempt is made to incorporate means of dealing with uncertainties within the management approach. A broader national framework for management is presented at the end of the chapter. The implications of the suggested management approach for present policy and management are considered in the concluding chapter.

6.2 APPROACHES TO COASTAL ZONE MANAGEMENT

There are two general approaches to coastal zone management: those that are reactionary and those that are anticipatory. Reactionary approaches involve responses to management problems or to development proposals as they arise. Anticipatory approaches involve assessing the general characteristics of both the resource and possible development proposals, and providing guidelines for management that take account
Dealing with specific management problems as they arise has several shortcomings which are exemplified by a number of past responses to problems in the coastal zone. First, solutions to problems that have arisen are often costly. This is nearly always true in the case of engineering structures that are built to protect residential and commercial developments located immediately landward of the foreshore. The costly restoration programme undertaken at Omaha Beach in Northland illustrates this point (Healey, 1980). In other cases the cost of erecting and maintaining a protective structure may exceed the value of the assets that it is designed to protect.

Second, it may not be possible to solve problems outright or to restore the conditions that originally existed. Protective structures such as groynes, sea-walls, and breakwaters frequently fail to solve the problem and often lead to undesirable secondary effects such as erosion of adjacent areas (see sections 3.3 and 3.4). In the case of mineral extraction affecting the coastal zone it may not be possible to completely restore the form and character of the area once problems become evident or once mining has ceased.

Finally, a reactionary approach fails to recognise that many problems may be avoided if careful consideration is given to the character of the resource and the developments that are proposed.

Instead of dealing with problems as they arise, a management agency may react to specific proposals for development in the coastal zone. This could involve an assessment of the interactions between the resource and the proposed development in order to evaluate the likely impacts. An approach that involves responses to specific proposals is an improvement on reacting to problems as they appear, but it is still reactionary. This type of approach still fails to incorporate a consideration of the dynamic nature of the coastal zone and the likely interactions prior to a specific development proposal being put forward.

A more satisfactory approach involves a general characterisation of the resources of the coastal zone and anticipation of likely
resource developments. This approach requires an understanding of the character and dynamics of the coastal zone. Specific guidelines for resource developments may then be proposed in accordance with the character and functioning of the system. The guidelines for management could include a statement of those aspects that must be considered in planning for resource developments. This will help to ensure that proposals meet desired management objectives and will assist in avoiding management problems that result from poorly considered proposals.

6.3 AN APPROACH TO COASTAL ZONE PLANNING AND MANAGEMENT FOR THE WEST COAST

6.3.1 The Present Management Approach
The proposed section one of the West Coast Regional Planning Scheme outlines objectives and policies related to community viability population, employment, services, the environment and resource developments. These policies are to be expanded, elaborated and added to in later sections of the Regional Planning Scheme (West Coast United Council, 1981). The scheme does not outline any specific objectives or policies related to the coastal environment or to resource developments within the coastal zone.

In the absence of reference to objectives for the management of the coastal environment in the Regional Planning Scheme, the present management approach applied to the coastal zone of the West Coast relies on responses to specific management problems and development proposals. It is, therefore, a reactionary approach. Individual management agencies will respond to problems that arise within their own jurisdictional or management areas.

The problem, therefore, is that where developments or alternative courses of action to solve single problems are considered independently, the overall result obtained by aggregating the individual impacts may be undesirable. This results from a failure to consider the

1. One semantic difficulty is that the definitions of policies, goals, and objectives commonly used differ from the definitions in section 6.3.3. Notwithstanding this, any hierarchical definition of policies, goals and objectives may be used, provided that it is clear what is meant by each term.
net effect of a series of low level decisions, or the failure to address the overall problem at a higher level in the decision making hierarchy. This process and the problems it creates for economic decision making has been termed the 'tyranny of small decisions' by Kahn (1966). Odum (1982) outlines the relevance of this concept to environmental problems, pointing out that many environmental problems result from a series of small decisions rather than a conscious decision to effect environmental degradation.

The existence of numerous agencies that plan and manage individual functional units within the coastal zone could result in these types of decision being made. For example, on the West Coast, individual decisions that are made regarding developments within catchment areas, on the foreshore, or offshore, could result in a major alteration to the sediment budget balance. The individual impact of each decision may be slight but the cumulative effect on coastal stability may be significant.

6.3.2. An Alternative Approach
In order to avoid the problems associated with a reactionary approach, present management of the coastal zone of the West Coast needs to be altered to be more anticipatory in nature. One means of recognising the cumulative effects of developments is to adopt a holistic approach to planning and management that examines the inter-relationships amongst alternative development proposals. Regional planning provides a mechanism for a coordinated approach to resource management on a regional scale.

The general features of a sediment budget model were discussed in section 2.2 and are illustrated in Figure 2.1. A sediment budget model can be used as a framework around which planning and decision making can be applied. The significance of using a sediment budget is that it draws attention to the functioning of the whole coastal system. It is thus a convenient basis from which managers can identify the likely impacts of a proposed development on the whole system.

Much of the discussion presented in the following sections is common to conventional planning practice. For the purposes of managing the coastal zone of the West Coast, however, the procedures and
processes outlined here should be adopted in relation to the features of the physical system as represented in the sediment budget model.

The planning process is a rigorous and systematic procedure for following motivations, such as the pursuit of goals or the identification of a problem. The process has a number of basic steps that provide the decision maker with the information required to make a reasoned choice. The various steps of the planning and decision making model are as follows:

1. Preliminary Definition of Goals and Objectives, or Identification of the Problem: these form the basis on which management decisions will be made.

2. Inventory: a survey of the existing situation with respect to a resource, social needs or whatever, aimed at clarification of the problem or goal.

3. Analysis of Inventory Data: should provide a refined definition of goals and objectives or the problem to be addressed. Forms the basis for step 4.

4. Identification of Alternative Courses of Action: the expected consequence of each course of action suggested, should be outlined.

5. Choice: choice of the best, optimum or preferred alternative is made.

6. Plan for Action: a detailed design of the activities, tasks, responsibilities, and sequence of actions.

7. Implementation: implementation of the plan for action.

8. Monitoring and Evaluation: measures of performance are made to ensure that the plan is implemented in accordance with the policies and goals adopted, and the success of the plan is evaluated.

These steps are aimed at transforming, over some period of time, what is perceived to be a less desirable situation into one that is more desirable from the decision makers viewpoint (Radford, 1977).

Although each step leads logically to the next, the process is also characterised by feedback (Figure 6.1). At any time new information may be provided, which may lead to a redefinition of the analysis.

In the following sections the planning and decision making model is used to provide the basis of an anticipatory approach to management of the coastal zone of the West Coast.
Figure 6.1: Conceptual model of the planning and decision making process.

Problem definition
Initial Definition of Goals and Objectives

Data gathering and Inventory of existing situation

Analysis of Inventory Data
- Redefinition of problem/goals and objectives
- Adequacy of information

Identify Alternative Courses of Action
(including do nothing option)
Outline consequences of each alternative

Choice of Preferred Alternative and Plan for Action - tasks, responsibilities, sequence

Implementation of Plan

Monitoring and Evaluation
- performance of management actions
- success of plan
- achievement of objectives
6.3.3 Definition of Policy, Goals and Objectives
The first step in any planning process should be the definition of the 'ends' that are to be sought and the means of achieving those ends. These desired 'ends' can then serve as a basis for management decisions and define the criteria for the assessment of management actions.

Policy, goals and objectives provide a hierarchy of purpose and detail that determine desired ends and means. Policy generally involves a broad statement of purpose reflecting societal values and can be thought of as a guiding philosophy or set of guiding principles (Ackley, Centre for Resource Management, pers. comm. 1983). Goals define the specific ends that it is desired to achieve from pursuit of a policy, while objectives describe the means by which goals are to be achieved and are, therefore, capable of both attainment and measurement (Young, 1966).

In order to avoid a reactionary approach to resource management, guidelines for development are necessary. Within the coastal zone of the West Coast a sediment-budgeting approach can be used as one means of determining the cumulative impacts of alternative development proposals. All development proposals should consider the impact on the various elements of the sediment budget:

- whether sediment supply from land, within the littoral zone, or offshore is affected (for example, by mineral extraction operations);
- whether sediment transfers are disturbed (as in the case of structures located in the nearshore zone); and,
- whether sediment storage and loss functions are modified.

The aggregate impact of developments should also be evaluated in terms of other management goals and objectives defined in the planning scheme related to social and economic factors.

6.3.4 Inventory and Analysis of the Existing Situation
A basic inventory of the coastal zone and its characteristics is an essential basis for management. The aim of such an inventory would be to:

1. Identify the various coastal resources and evaluate their sensitivity and vulnerability;
2. Provide an understanding of coastal systems in order
to forecast their response to developments; and,

3. To explain the causes of negative impacts and identify appropriate responses to these problems (Amir, 1983).

In addition to providing benchmark data for measuring and evaluating development impacts, the inventory would also provide a basis for monitoring long-term changes (United Nations Department of International Economic and Social Affairs, 1982).

The objectives of a coastal zone management policy should be related to specific problems identified by the inventory. Where areas that are in need of special protection from development are identified, then the objective should be a means for providing protection to these areas. The inventory will, therefore, provide a basis for the identification of areas on the coastal zone suitable for different developments and determination of the intensity of use acceptable in these (Amir, 1983; United Nations Department of International Economic and Social Affairs, 1982).

A broad and flexible definition of the coastal zone is needed to include not only maritime waters and land adjacent to the shoreline, but also the adjacent areas where the impact of activities may become evident or where the cause of problems originates. Decisions over various courses of action and development proposals can then be made in terms of the impact on the resources and the achievement of stated objectives. Decisions may be implemented through the use of specific management tools including zoning, construction set-back lines, preservation of sensitive areas, and restrictions and controls on developments.

Zoning can be used to control the location of developments and provide buffers between various resource uses. Construction set-back lines and preservation of sensitive areas would ensure that developments were excluded from areas susceptible to erosion or vulnerable to changes induced by developments. Where developments are implemented, restrictions and controls may need to be imposed in order to meet management objectives.

6.3.5 Identification and Analysis of Alternative Courses of Action

All proposals for resource development within the coastal zone should identify the available alternatives. The analysis of the inventory
data should identify where problems are likely to arise from certain types of resource development, such as the location of buildings adjacent to the foreshore or the extraction of material from beach systems.

Different problems identified by an analysis of the inventory data will require different courses of action for resolution. The courses of action will depend on whether the problem is due to natural physical processes, resource use and developments, institutional arrangements or combinations of these. For a problem arising from natural erosion, alternative courses of action may be to build some type of engineering structure, attempt to correct a deficit in the sediment budget through beach nourishment, implement some planning response restricting developments in the area, or do nothing.

Where a resource development is proposed, such as mining within the coastal zone, alternative courses of action may relate to the technology to be used, the scale of the development, the spatial extent of the development, and means of avoiding or reducing environmental impacts. In addition, there may be alternative institutional arrangements applying to the management of the resource development.

The expected consequences of each alternative course of action should be outlined in all appraisals. These consequences can be evaluated in terms of the goals or objectives for the management of the resource expressed in the Regional Planning Scheme. The consequences of each alternative should, therefore, be expressed in a manner that is consistent with the stated management objectives.

The impacts of various development alternatives may be either tangible (easily measured in monetary or other quantifiable terms) or intangible (not readily measured in monetary or other quantifiable terms). Tangible impacts can be analysed using methods such as cost-benefit analysis or input-output analysis but these techniques have a number of shortcomings when attempting to account for intangible impacts. These shortcomings are related to the difficulties of expressing consequences in some common unit.

A range of intangible impacts such as reduced environmental quality or aesthetics are non-linear in certain cases. For example, the
erosion that may be caused by the removal of sand or gravel from a beach may be negligible up to a certain rate of extraction. Above that rate of extraction, however, the system may not be able to absorb the impact and severe erosion may result. It is, therefore, important to identify impacts that are non-linear and define the limit at which environmental change becomes significant.

Coastal zone management problems involve uncertainties, multiple objectives, and deal with a dynamic environment. Consequently, the use of quantitative analytical methods for determining an optimal solution is not applicable. A procedure for analysing alternatives in terms of their feasibility or desirability in view of stated goals and objectives is more desirable. This procedure, termed feasibility analysis, will not necessarily define the 'best' or optimal alternative but allows a choice between alternatives based on criteria set out in the stated management objectives (Albee and Storey, 1973).

Feasibility analysis involves testing or analysing alternatives in terms of their economic, engineering, political, financial, and social feasibility or desirability (Albee and Storey, 1973). Economic feasibility is frequently tested using cost-benefit analysis which should consider all relevant social costs and benefits from a development (see United Nations Department of International Economic and Social Affairs, 1983 pp.14-17). The engineering feasibility of an alternative should determine whether a structure can be built and how well it will solve the problem (for example, design and building of a sea-wall or breakwater). An alternative should also be politically feasible, in other words it must have political support and be capable of implementation within the existing political and institutional structures. Financial feasibility relates to whether an alternative can be adequately financed. As an example, a structure for the protection of an area of coast may be feasible in economic, engineering and political terms but the costs of construction and maintenance may exceed available finance, or the value of the asset that it is to protect. Finally, an alternative must be socially feasible implying a certain level of social acceptance.

One approach that may be useful in evaluating how alternatives meet desired objectives is the "goals-achievement matrix" (goals
here are the equivalent of objectives defined in section 6.3.3) developed by Hill (1968). This approach is an extension of cost-benefit analysis in which the costs and benefits are defined either quantitatively or qualitatively, in terms of their achievement of specific goals (objectives). Thus, progress toward a specified goal is entered as a benefit while departures from goals are entered as costs. However, there are difficulties in determining relative weights for different objectives and groups, and a separate matrix is needed for each alternative plan (Albee and Storey, 1973).

Despite the simplifications and some difficulties in application, a generalised matrix approach to decision making involving multiple objectives may be useful conceptually (see for example, Albee and Storey, 1973; Anderson et al., in prep.)

Information about the effects of each alternative and their contribution to the various objectives is presented in a matrix form. The matrix allows the ordering of information and can be used as both a checklist to ensure that all factors have been considered and as a means of summarising and comparing the information about each of the alternatives. In this way the consequences of each alternative are presented in a manner which allows an assessment of the implications of each available choice. Since all the information is not likely to be quantitative, the evaluation of the matrix and the set of alternatives will require the exercise of judgement.

6.3.6 Choice Between Alternatives
The evaluation of alternatives leads to the selection of an alternative to deal with the problem or a development proposal that is compatible with the guidelines set out under management objectives. Unless one alternative is 'optimal' in that it is the best alternative for meeting each objective, there will be some degree of trade-off between the attainment of objectives. As a result, it is necessary to determine preferences or means of weighting the objectives.

Where a matrix has been used to represent the alternatives and their consequences, the trade-offs between the attainment of the various objectives should be relatively clear. The implications of choosing one alternative ahead of the others can be determined from an evaluation of the consequences of each alternative, allowing some judgement of whether choices are 'good' or 'bad'. The trade-offs
between objectives will need to be considered each time a decision between a set of alternatives is made. In this way it may be possible to determine estimates of the relative importance of the objectives, if the decision makers' choices are consistent over time.

6.3.7 Plan for Action
A plan for action or strategy involves a detailed design of the activities, tasks, and responsibilities of management and definition of their timing and sequence. The interactions between the various elements of the coastal zone and complexity of management problems mean that any such plan will be composed of many elements. Such a plan should involve means of dealing with the range of existing management problems and methods to ensure that future developments and resource allocations within the coastal zone are consistent with management objectives. A plan can, therefore, be defined as an organised set of specific decisions to meet a set of objectives within a given time horizon.

The essence of a good plan or strategy is cooperation and coordination in implementing the complete set of actions. As a result of this, adoption of only a portion of the strategy will be ineffective.

The chain of command and the details of management responsibilities are essential for a plan or strategy to be effective. Coordination of management techniques and decision making is a major step in avoiding the tyranny of small decisions described in section 6.3.1. Institutional aspects, therefore, become an important consideration in the development of a workable plan for action.

Management plans developed by separate agencies should be coordinated in a manner that ensures their compatibility with an overall management strategy. Various government departments, local and regional authorities, and ad hoc agencies responsible for management within the West Coast region should act in accordance with each other. Regional planning provides a mechanism for the overall coordination of planning and management, but only where the boundaries incorporate both land and water areas (see sections 4.4.2 and 6.5.2).
6.3.8 Implementation

Institutional aspects are also very important when implementing management actions. A management agency must have a clear authority to implement actions and should receive guidance on the direction that a plan or programme is to take. If this authority does not exist there may be delays or conflicts in implementing management actions. Guidance and direction are needed to avoid misinterpretation and to ensure that action leads to the desired results.

Management agencies require adequate resources (including finance, personnel, and expertise) to be available for implementation of actions. The provision of adequate resources will assist in reducing the tendency for agencies to treat existing programmes as being of greater priority. The lack of available resources for coastal zone management at a regional and local level is a particularly strong constraint on implementing actions.

A further problem with implementation may arise where decisions are not made at the appropriate level of authority. In other words there may be a number of clearance points or steps in the approval of actions. A clear chain of command that delegates authority to the various levels of management should be outlined to avoid decisions having to be referred back to higher levels of management for approval.

6.3.9 Monitoring and Evaluation

The final step in the planning and decision making process involves monitoring the outcomes of management actions and evaluating these in terms of the objectives of the plan or strategy. Monitoring and evaluation provide information on how a management system is performing. Essentially this information provides feedback to the earlier steps in the planning and decision making model in a continuous manner. For example, it may be found that a plan that has been implemented is inadequate in meeting the defined objectives, therefore, other alternatives can be considered or further controls introduced. Monitoring and evaluation may also identify new problems that need to be dealt with.

At present there is no agency with a clear mandate for the monitoring and evaluation of the effectiveness of planning and management
of the coastal zone. Monitoring and evaluation of the coastal environment of the West Coast should involve monitoring of physical changes in the system, the impacts of developments, and evaluation of the effectiveness of management actions. Catchment Boards and Regional Water Boards frequently undertake investigations related to problems in the coastal zone in addition to their management functions in catchment areas. Since one Catchment Board is responsible for virtually the whole of the West Coast region, it may be appropriate for this agency to undertake monitoring functions in conjunction with other agencies such as the Regional Planning Authority and government departments.

The cost of obtaining data may place restrictions on monitoring and evaluation as well as other aspects of the management process. This constraint means that the selection of data requirements is critical. There is usually a tendency to rely on data that is easy to obtain or easy to quantify, ignoring that which is difficult to quantify or qualitative in nature. This does not, however, ensure that the most useful data is obtained. Important variables may be overlooked for a number of reasons. These include the difficulty in quantifying variables, ignorance or lack of knowledge, and uncertainties with regard to the system. Much of the data that is easily obtained may also be irrelevant or of little use to the problem being considered.

6.3.10 A Generalised Approach to Coastal Zone Planning and Management

The planning and decision making model outlined suggests a general approach to coastal zone management for the West Coast region (Figure 6.2). The approach involves first, defining the goals and objectives of management in order to define the basis on which decisions will be made. Second, an inventory of the existing situation provides the basis for evaluating alternative resource uses and management problems. Third, choices are made between these alternatives, involving an evaluation of alternative management techniques for achieving the desired result in terms of the goals and objectives that are being pursued. Finally, monitoring and evaluation of the actions that are implemented provides the means for assessing how well the management objectives have been met.

It is important to recognise that the approach does not involve a single step-wise procedure. Instead it is a continual process
Figure 6.2: Conceptual framework of a generalised approach to coastal zone planning and management for the West Coast.

Data Gathering and Inventory of Existing Situation
- Coastal Resources (sensitivity and vulnerability to change)
- Understanding of Coastal System (e.g. sediment budget)
- Sources of negative impacts
- Identification of sensitive areas

National Policy, Goals and Objectives for Coastal Zone Management (Legislation)

Analysis of Inventory Data
- Identification of specific problems
- Definition of Goals and Objectives
  - Related to problems identified
  - Constrained by National Policy, goals, objectives
  - Adequacy of information?

Identify Alternative Courses of Action
- Zoning
- Preservation of sensitive areas
- Restrictions and controls on developments
- Construction set-back limits
- Location of developments

Selection of Preferred Alternatives
- Specification of management actions
- Responsibilities of agencies

Monitoring and Evaluation
- Sensitive areas
- Development impacts
- Coastal system responses

Need further information for Decision Making
of verification through feedback from the monitoring and evaluation phase. This allows modification of plans and management techniques, pursuit of new objectives, further feedback and so on. It should also be recognised that the steps of the model are not in a strict sequence and several phases may be undertaken at once. For example, the analysis of the inventory data or the evaluation of alternatives may be useful in defining additional objectives and identifying further problems.

6.4 DECISION MAKING APPROACHES UNDER UNCERTAINTY

In Chapter 5 uncertainties surrounding knowledge of the physical system, resource uses and institutional aspects were shown to have important implications for management. It is important to consider how uncertainties can be dealt with within the overall management approach. A brief account of the concept of uncertainty and techniques for analysing uncertainty and assessing risk is presented in Appendix I. The discussion here centres on means of accounting for uncertainties in the decision making process.

In a quantitative approach to decision making, rational managers will choose the best or 'optimal' alternative. This approach involves balancing the various costs, benefits and uncertainties in a way that is likely to lead to the most desirable result. Where the uncertainties are not easily quantified, however, the approach will be more dependant on the decision makers' judgement. The lack of easily quantifiable data means that this is likely to be the case in many coastal zone management decisions.

In practice, therefore, decision makers may be constrained by a lack of important information affecting the decision. For example, a lack of information relating to the sediment budget for the West Coast creates difficulties in determining the likely impact of developments (see section 2.7). Other constraints that may influence decision making are a lack of time or pressure to make quick decisions and the possibility of overlooking alternatives. These limitations restrict the capabilities of determining an optimal decision and result in 'satisficing' solutions. Satisficing is a term used to describe decision making aimed at identifying and selecting a satisfactory alternative (as opposed to the best one) that will achieve a minimally
acceptable solution. This approach recognises the 'bounded rationality' of decision making in which decision makers will make the most rational decision limited by their inadequate information and their ability to use this information (Simon, 1957).

Besides ignoring the possibility of determining better feasible alternatives, however, the satisficing approach may also involve poor decisions for the solution of complex problems and is more likely to lead to wrong or 'bad' decisions where there is a large degree of uncertainty involved. The motivation for dealing explicitly with uncertainty in decisions, therefore, becomes more urgent as decisions get larger and more complex, outcomes become more uncertain, and the possible consequences and their implications more unfavourable.

The value of dealing explicitly with uncertainty in the decision making process is that it is more likely to prevent bad decisions being made. This does not, of course, ensure that all decisions will have favourable outcomes. Where an analysis of uncertainty is made, the decision approach should be iterative and adaptive to incorporate new information as it becomes available. The approach should also be flexible so that the responses to the decision problem can be adjusted.

Methods for reducing uncertainty in decision making include emphasising short-term decisions, creating an effective feedback mechanism for the modification of management actions, and emphasising decisions and actions that involve a sequence of steps (Radford, 1977). This approach is similar to the incremental strategy described by Braybrook and Lindblom (1963). The strategy involves concentrating on courses of action that result in incremental changes to the present situation. As each action is implemented, the decision is re-evaluated to assess the effects and the decision may then be altered if the objectives are not being met or if the objectives themselves have altered.

The basic criticism of this approach is that it does not adequately allow for innovative or fundamental decisions to be made. In addition it requires the availability of time to provide for the adaptive adjustments to be implemented and evaluated. Although an accumulation of small decisions may lead to a fundamental decision, there is
no guidance or direction for these decisions. The approach is also very reminiscent of the 'tyranny of small decisions' described in section 6.3.1. These criticisms led Etzioni (1967) to develop an approach that incorporates elements of both fundamental and incremental decision making.

Although the criticisms are valid, where uncertainty is involved decision makers are more likely to favour incremental decisions. This is especially true where the consequences of a fundamental decision that is incorrect or 'bad' are extremely unfavourable. The incremental approach also provides a convenient means of implementing decisions that need to be made on the information available, while further information is being collected and analysed.

6.5 AN APPROPRIATE FRAMEWORK FOR MANAGEMENT

The planning and decision making model describes a useful approach for decisions relating to coastal zone management on the West Coast. In order to ensure consistency and coordination between the various levels and agencies involved in management, it is necessary to consider an overall or national framework for the management of the coastal zone resource. This overall framework should define national management policies, goals and objectives, provide legislative guidelines, identify the appropriate levels of management, define linkages between management agencies, and outline various tools appropriate to achieving the desired objectives.

6.5.1 National Policy, Goals and Objectives

Present national coastal policy in New Zealand has a strong emphasis on guiding urban and residential development in the coastal zone and on providing for recreational opportunities (see section 4.4.1). Little recognition is given to other developments affecting the coastal zone or to integrating other national policies or legislation affecting resource use and development. A national coastal policy should be consistent with and form part of the overall policies and goals guiding the development of the nation (United Nations Department of International Economic and Social Affairs, 1982).

Goals defining the ends to which coastal zone management aspires, and objectives for the achievement of those goals must be outlined
in support of the policy. These goals and objectives may already be defined in existing legislation or other policies relating to the coastal zone. The complexity of interactions within the coastal zone means that individual sectoral policies need to be coordinated under a single coastal management policy to avoid differences and conflicts (United Nations Department of International Economic and Social Affairs, 1982). An evaluation and rationalisation of existing policies, goals and objectives relating to the coastal zone would be an effective first step in developing a consistent management framework.

6.5.2 Appropriate Governmental Level of Management

A variety of jurisdictional levels exist at present including local and regional authorities, Catchment Boards and government departments. All are involved in planning and management at either the regional or national levels. These different agencies and institutions administer and implement the provisions of numerous single-purpose laws, often resulting in overlapping jurisdictions, confusion and conflict. Management actions are largely single-purpose or piecemeal as a result. The character of the coastal zone dictates that there will be many interactions between management actions, so that a wide range of elements should be considered within a systematic approach (United Nations Department of International Economic and Social Affairs, 1982). In regard to this view, local and regional management agencies need guidelines for the incorporation of actions consistent with national goals and objectives.

The incorporation of planning and management at the regional and local level within a national framework requires coordination between local authorities and regional agencies responsible for management. This problem is intensified by the inadequate provision of expertise, finance and technical support at many levels. Appropriate institutional arrangements for coastal zone management require actions related to scientific, economic and political functions. The traditional functional management of government departments and the tendency for local authorities to overlook wider concerns present problems for the achievement of appropriate institutional arrangements. There are three mechanisms possible for the restructuring of governmental management; first, expanding or refining the mandate of an existing
department; second, the creation of a new department; or third, the formation of a coordinating body to oversee and delegate functions to existing agencies (United Nations Department of International Economic and Social Affairs, 1982).

Expanding the mandate of an existing department would be a complex and difficult task. The large number of agencies involved, the various interactions between them, and the frequent overlapping of statutory responsibilities mean that it may be difficult to expand the functions of one agency to incorporate the wide range of activities involved. This solution would not necessarily ensure coordination between all agencies and interests in coastal zone management.

The creation of a new department with responsibilities for coastal zone management would involve problems related to the cost and time necessary for establishment and the organisation of functions within the existing system. If a new Ministry of the Environment was to be proposed, with responsibilities for environmental management, then it could possibly include a coastal management section. Despite this, the problem of coordination of the existing functions of other agencies would remain.

The third option involves the formation of a coordinating body to oversee and delegate functions to existing agencies. Since coastal management has made substantial progress in New Zealand already, despite its problems and inadequacies, the coordination of existing functions appears to be the most desirable and easily implemented possibility. Within this possibility, the existing functions of agencies could be expanded, reduced, maintained or clarified to facilitate the coordination needed.

Essentially, the functional management of government departments would remain (i.e. the Ministry of Agriculture and Fisheries controlling fisheries management; Lands and Survey controlling reserve management; Ministry of Transport responsible for harbours, transport and navigation). Responsibility for day-to-day management, including responsibility for foreshore management, would be in the hands of regional and local planning authorities who would receive guidance from the coordinating authority. Catchment Boards and Regional Water Boards could have an extended responsibility for collection of physical data related
to coastal conditions, maintaining water quality management functions
and the support of the National Water and Soil Conservation Authority
and the activities of the Ministry of Works. Evaluation of major
development proposals would remain the function of the Commission
for the Environment under the Environmental Protection and Enhancement
Procedures. The coordinating authority would be responsible for
monitoring the functions of all the management agencies involved
with guidance provided where goals and objectives are not being met.

The coastal zone cannot, however, be considered as a single planning
unit. Disaggregation of the management of different sections of the
coast should be based on natural boundaries such as those between
different geomorphological or biological units (Amir, 1983). This
presents a problem in that divisions may not coincide with existing
governmental boundaries. This problem may be overcome to a large
degree by the coordination of activities to ensure compatibility
between the management of adjoining natural areas. Furthermore,
in determining the appropriate level of planning and management,
the relevant area of externalities or spill-over effects should be
examined in order to determine at what level they are best managed
(Albee and Storey, 1973). Where externalities affect the public
at large, these problems should be dealt with by national planning
and management, while those affecting only local communities are
best managed at the local level. Further disaggregation of the
coastal zone into different natural resource categories (Estuaries,
beaches, nearshore zone, bluffs...) is necessary for the analysis
of the impacts of different activities within each of those categories

The coastal zone remains governed by the general legal regime applied
to all areas including legislation governing land use, town and country
planning, and resource development (United Nations Department of
International Economic and Social Affairs, 1982). Although a comprehensive
process for land planning exists in New Zealand, the coastal zone
is not treated in a manner which recognises the special characteristics
of the area (for example, there is no overall control governing
the use of coastal waters and the seabed). The provisions of the
various acts covering land and water use such as the Town and
Country Planning Act 1977, the Harbours Act 1950, and the Mining
Act 1971 are not integrated together.
This emphasises the need for providing horizontal linkages between the different agencies and institutions responsible for the administration of these laws.

Generally, a coastal zone management programme could be implemented under the existing legislation and within the structure provided by the Town and Country Planning Act 1977. However, this structure needs to be strengthened through the provision of better coordination and the implementation of management actions to meet specified societal goals and objectives within an overall policy for the management of the coastal zone. Integrated management requires linkages between information collection and analysis, economic and environmental evaluation of various development alternatives, and public input (United Nations Department of International Economic and Social Affairs, 1982).
CHAPTER SEVEN

CONCLUSIONS

This study has explored specific problems of coastal zone management that exist under the present management approach. The West Coast of the South Island was used to illustrate these problems and to examine the adequacy of the existing management approach in dealing with these issues.

The objectives of the study were:

1. To isolate management concerns, specific problems and uncertainties that need to be addressed in coastal zone planning and management, with particular reference to the West Coast and the present management approach; and,

2. To present an approach to coastal zone management for the West Coast that accommodates uncertainties in planning and management decisions within an overall framework for coastal zone management.

An investigation of the physical system of the West Coast, developments that are present or proposed in the coastal zone, and the institutional aspects of management facilitated an analysis of the existing management approach. A generalized model of the planning and decision making process was used as a framework for examining the coastal system. This framework was then used as the basis for developing an anticipatory approach to coastal planning and management applicable to the West Coast of the South Island.

Features of the coastal zone of the West Coast that have implications for resource developments and management are:

- the large input of sediments from rivers;
- the high potential for sediment transport in the nearshore zone;
- the lack of knowledge on the balance between sediment supply and loss in the zone; and
- the prevalence of erosion and potential for this to increase.
Resource uses within the coastal zone of the West Coast should involve a recognition of the dynamic nature of the physical processes operating in that zone. Planning and management of resource uses needs to be based on an understanding of the physical system and an assessment of how resource developments will impact upon that system. The most significant developments are likely to be those that affect the supply of material to the coast or which intercept sediment transport. Protective engineering structures should be assessed in terms of their ability to overcome problems and the cost-effectiveness of the protection they offer. The natural buffering capabilities of the beach and dune system should be encouraged and account taken of variations in the shoreline position.

The coastal zone has characteristics of a publicly owned resource. Property rights to the resource should be assigned in a manner that brings private use more into line with societal goals for the management of the resource. Present policy for the management of the coastal zone is poorly defined and provides little guidance for management at the regional and local levels. The abundance of legislation relevant to management of the coastal zone needs further integration to ensure consistency between activities on land and water.

Specific problems and management issues were identified as arising from either the physical character of the coastal zone and interactions with resource developments, or from institutional aspects and the existing management approach. Several deficiencies in the present management approach were identified. These are related to inadequacies in information and knowledge, producing uncertainties over the interactions between the physical system and resource developments, and to deficiencies of the existing institutional arrangements for management.

Coastal resources management should be based on an understanding of the physical nature of the system and the development of management approaches in accordance with those characteristics. Decision makers need basic information about the physical system. Information is also needed on the types of development that place demands on coastal resources. Questions may then be asked about the impact of developments and management can be directed towards these problems.
The approach suggested for the management of the coastal zone of the West Coast is an anticipatory approach involving an understanding of the character and functioning of the coastal system and the general nature of developments that are likely in the zone.

A sediment budget model forms a convenient framework for assessing development proposals, around which planning and decision making can be applied. This would allow a coordinated approach to management on a regional scale that avoids the problems associated with decisions made independently.

Goals and objectives for the management of the West Coast coastal environment need to be clearly defined in the Regional Planning Scheme. These would provide a basis for management decisions which can be made by adopting the procedures of the planning and decision making model framed around the sediment budget model.

Uncertainties may be dealt with through a system of identifying and gathering information that is established as being important for management decision making. Where this information is not available, decisions that are made should be of an incremental nature. A feedback mechanism that assesses the quality and performance of these decisions is essential in order to incorporate new information into future decision making. The explicit consideration of uncertainties in the decision making process is an effective means of reducing the likelihood of unfavourable outcomes from decisions.

Management of the coastal zone of the West Coast as a publicly owned resource should involve a hierarchy of decision systems from the national through to the local level. Decisions made at the lower levels of the hierarchy should be in accordance with policy decisions at the highest level. In order for this to be so, guidelines for decision making need to be provided with a clear delegation of authority to the various levels of the hierarchy.

A general framework for coastal zone management exists in New Zealand in the form of town and country planning procedures. Yet this framework has a number of deficiencies, not the least
of which are the inadequacy of the information base, the inappropriateness of existing boundaries, and the fragmentation of policies and management directives. The resolution of these deficiencies requires the following measures:

- A clear definition of national policy for the coastal zone and development of management goals and objectives;
- Guidance on the means of achieving those objectives at the regional and local level;
- Better coordination between existing management agencies;
- The establishment of a national agency responsible for the direction, coordination, and evaluation of coastal zone management.
- Research and development of tools for coastal zone management.

The implementation of these measures has several implications for existing policy, legislation, and management. A national policy for the coastal zone should draw on existing policy statements expressed in various laws and be based on input from management agencies, interest groups, and the general public. Existing legislation should be examined to identify where linkages are needed and to ensure compatibility of the management goals. The specific management functions of the various agencies may be altered in order to define responsibilities and to coordinate actions.
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APPENDIX I

ACCOUNT OF UNCERTAINTIES IN INFORMATION AND KNOWLEDGE

An analysis of the uncertainties involved is an important consideration for decisions based on incomplete information and knowledge. The various sources of uncertainty in coastal zone management decisions were described in section 5.3. These uncertainties were associated with physical processes, the impacts of resource developments, and institutional aspects of management. Uncertainties present complex problems for decision making, requiring the determination of appropriate management responses.

This appendix discusses means of analysing uncertainty in decision making. The discussion is based on a consideration of the concepts of uncertainty and risk and the processes for their assessment presented by Kilby et al. (1984).

The Concept of Uncertainty
If uncertainty arises from possession of only limited amounts of information and knowledge, then the level of uncertainty will depend on the amount of information and knowledge available. There are two types of information about an event, giving rise to two types of uncertainty. First, absence of information relating to the identity of variables that influence or determine an event leads to what is termed descriptive uncertainty. Second, measurement uncertainty arises where there is a lack of information relating to the specific values of each of the variables (Rowe, 1977).

In relation to the coastal zone, descriptive uncertainty may surround the determination of the variables influencing erosion of a section of coastline or the identification of sediment sources and sinks. Where all the variables can be identified (for example, all the sediment sources and sinks) then measurement uncertainty may exist as to the specific values of the variables (for example the quantities of sediment involved may not be precise or may vary over time).

Uncertainty can also arise in defining the set of alternatives, and this leads to uncertainty related to the set of possible consequences. Even where all the alternatives can be specified there may still
be uncertainty surrounding the consequences of each alternative. For example, if all the alternative means of shore protection for a particular area of coast could be identified, the effects that each alternative would have on the physical processes and how effective they will be in solving the problem may be unclear. The complexity of interactions within the coastal environment means that the consequences of resource development may be difficult to identify, so that potential adverse impacts are hard to specify.

**Analysing Uncertainty**

Uncertainties can be dealt with using an analytical process that involves three phases: developing the set of alternatives; modelling to quantify the relationships between alternatives and their consequences; and, choosing between the alternatives. Graphical or tabular representations such as decision diagrams may be used to provide a structure for decision making under uncertainty. A decision diagram may be analysed using sequential analysis (Holloway, 1979), where probabilities can be assigned to each outcome, and some performance measure corresponding to each sequence of decisions and outcomes is available.

In practice, probabilities may be assigned by either subjective or objective methods (for example, using informed guesses, data from past experience, or statistical estimates of the likelihood of the occurrence of an event). Frequently it is not possible to assign probabilities on the basis of data from past experience or repeated simulation of an uncertain event. This is most likely to be the case in determining the probability of events in a dynamic environment such as the coastal zone of the West Coast. Subjective probability distributions may be developed on the basis of an expert's intuition or judgement to allow the explicit incorporation of uncertainty into mathematical modelling or analytical techniques. However, there is a large degree of uncertainty associated with subjective estimates and the results of analyses based on these should be viewed cautiously. Decision theory does, however, offer several approaches to choosing between alternatives in these situations, based on criteria relating to attitudes toward risk.

In a decision problem involving uncertainty, the choice of an alternative may still be difficult even if a model can be developed to describe the decision problem completely. A simple expression of the decision
maker's preference, based on an assessment of the consequences of each alternative, is usually inadequate as the decision maker cannot be sure which outcome will result from the alternative chosen (Holloway, 1979).

A direct choice between alternatives may be made using some intuitive process, and this may be simplified where one alternative dominates others (Kilby et al., 1984). For complex decisions, however, this may not be adequate as it is difficult to consider all the factors important to a decision at once. Where probabilities can be assigned, methods of assessing the probability distributions or comparing how alternatives meet some level of aspiration can be used (see Holloway, 1979).

When faced with an uncertain situation where possible outcomes are known, but for which probabilities cannot be assigned, the decision maker can use an approach consistent with his/her attitude to risk. Where the decision maker has a 'risk-loving' or optimistic attitude the alternative with the maximum possible gains can be chosen, irrespective of the possible losses (this is known as the 'maximax' criterion). If the attitude of the decision maker is 'risk-averse' or pessimistic the alternative with the greatest minimum gains can be chosen, although the possibility of large gains may be foregone (the 'maximin' criterion). It is generally accepted that society is either risk-neutral or risk-averse and decisions affecting the welfare of society should, therefore, apply the 'maximin' criterion, resulting in a conservative bias (Cooper, 1981).

The irreversibility of environmental impacts has important implications for the evaluation of resource developments in the coastal zone due to the uncertainty concerning future demands for use of coastal resources. In evaluating impacts that are essentially irreversible, at least in economic terms, the problem lies in determining optimum levels of development that result in irreversible damage. There will be uncertainty surrounding the benefits of environmental preservation but information about these benefits is likely to increase with time. An example of this could be the destruction of the buffering capabilities of a coastal dune system, resulting in erosion that involves prohibitive economic costs to control. Information about the benefits of maintaining the protective capabilities of the dune
system is likely to increase with time especially if developments are contemplated in the inland area. Arrow and Fisher (1974) demonstrate that the prospect of greater future certainty about the magnitude of the costs of environmental damage mean that it is optimal to hold back developments that are likely to result in irreversible impacts.

Methods for Assessing Risk in Decisions

There are two main analytical procedures for characterising and evaluating variables that influence the risks involved in decision making and for assessing how various alternatives contribute to the attainment of specified societal goals. These methods are first, sensitivity analysis and second, risk simulation.

In decisions involving uncertainty decision makers will normally use the best estimates available for all the variables involved, unless the decision can be delayed until more or better information is available. These estimates are likely to be somewhat subjective, however, involving at least some element of the decision maker’s judgement (Radford, 1977). Sensitivity analysis is a method for examining the effect that changes in the estimate of a variable have on the outcomes of the analysis. If some measure of the performance of an alternative is used, then sensitivity analysis can provide information on how the performance varies with changes in the estimates of variables.

If changes in an estimate have little effect on the analysis then the decision is relatively independent of the accuracy of that estimate. If changes result in significant variations of the performance measure or the result of the analysis, then the uncertainty associated with the estimate of the variable is likely to be an important consideration in the decision. Sensitivity analysis is, therefore, an effective means of identifying which variables contribute most to the risk (i.e. the likelihood of an unfavourable outcome) involved in the decision.

Risk simulation involves the use of random samples of the estimates of variables to obtain an idea of how the performance measure or result of a decision varies, thus indicating the risk involved. The random samples are made from probability distributions for
the variables, which are based on past data or determined subjectively where data is not available. An estimate for each variable is obtained from the random sample and used in the analysis of the alternative. The distributions are sampled repeatedly to provide numerous calculations of the performance or result of the analysis. This allows a complete probability distribution of the result of the analysis which can then be evaluated in terms of the decision maker's goals or objectives.
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