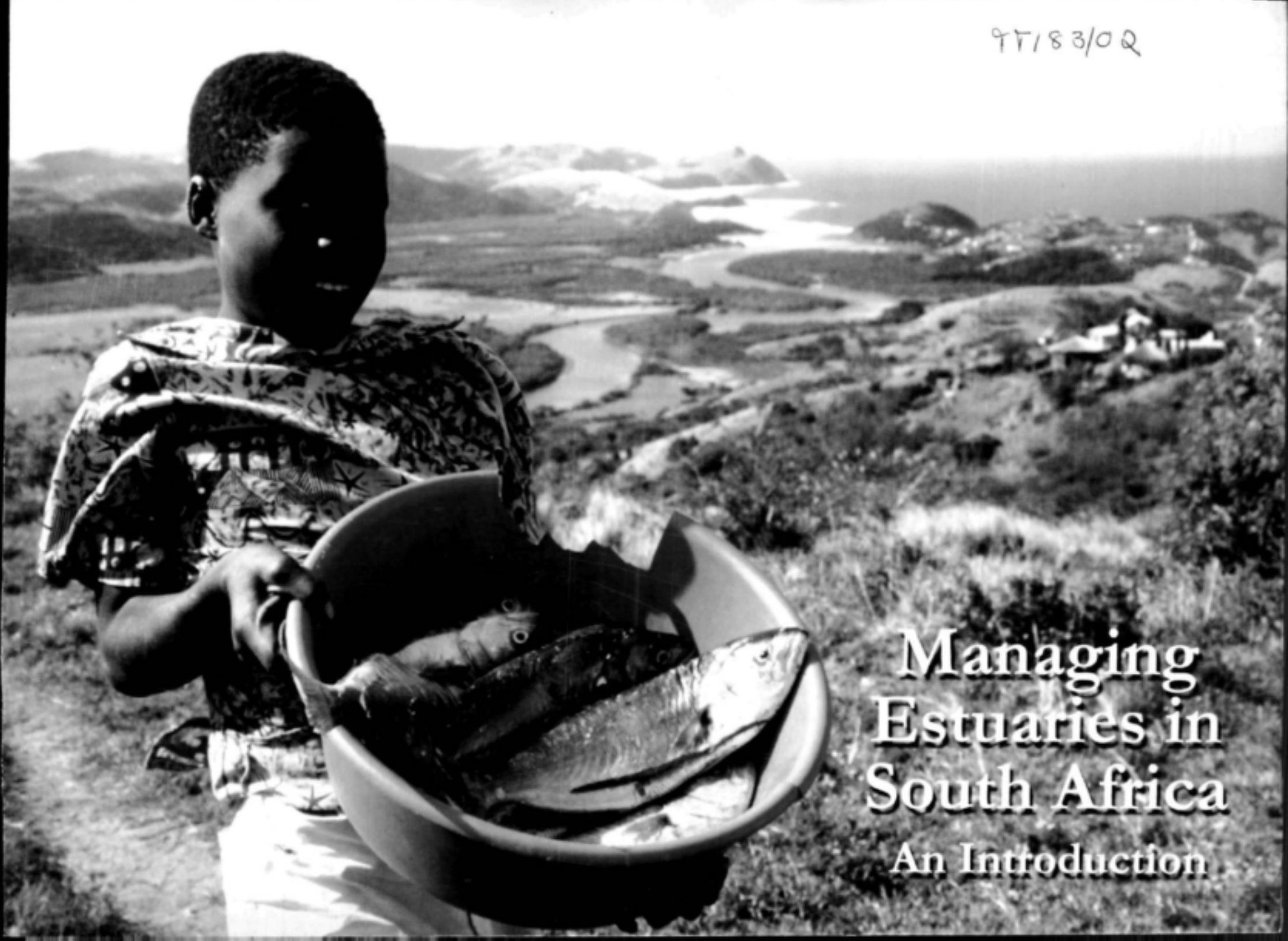

Managing Estuaries in South Africa

An Introduction

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Funders

Water Research Commission

Department of Environmental Affairs and Tourism

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FOREWORD

There are more than two hundred estuaries in South Africa and at almost every one decisions on resource use are being made daily at the local level. It is at this level that the unique properties of each estuary and the interests of constituents can be most effectively incorporated into planning that seeks to promote equitable, efficient and sustainable use of goods and services. South African environmental policy and legislation acknowledges the imperative of participatory management and makes provision for structures to be set up at local level in order to achieve this.

As the pressures on the coastal zone increase, so too does the complexity of the decisions shaping use of resources. Those charged with making these decisions will have to be well informed, which is why this introduction to estuary management is so important. It meets two real needs at a time when coastal zone policy and legislation has been revised. First, it will provide readers with a good basic understanding of estuaries and their management. Second, it will give readers the confidence necessary to engage estuary management and expand their knowledge and understanding.

The future of our estuaries is largely in the hands of those whose livelihoods depend on their viability. For the first time policy and legislation acknowledges their importance. Now they must champion the cause of coastal management.

Mr Mohammed Valli Moosa
Minister of Environmental Affairs and Tourism

ACKNOWLEDGEMENTS

Photographs and Illustrations:
Front Cover: Hugh Tyrrell
Map of South Africa: Arjoon Singh, CSIR
The design element that appears on all pages is based on a photograph by Janine Adams

Layout:
The layout of the book was done by The Blue Box.

ISBN: 0-620-28089-1

Acknowledgements:
The editors of the handbook would like to thank the following people for their helpful advice and comments on various drafts of the handbook: Mike Kidd, Lesley McGwynne, Craig Daniel, D Langmann, Dirk Roux, Noqobo Gcwabe, and the members of the Water Research Commission Steering Committee: Dr SA Mitchell, Ms APM Oelofse, Mr DG Hay, Mr P Viljoen, Dr DE Malan, Dr D van Driel, Mrs B Weston, Prof AK Whitfield and Mr TD Harrision. The editors would also like to thank Duncan Hay, Gail Knox-Davies and Amanda Xaba for the extensive assistance they provided throughout the production of the handbook.

Suggested citation
For the entire book:
Breen CM and McKenzie M (eds), 2001. Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

For a specific chapter:
Breen CM, 2001. Introduction in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

Mander M, 2001. The Value of Estuaries in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

Whitfield A, 2001. Structure and Functioning in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

Van Driel D and Breen CM, 2001. Influence of Human Activities in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

Dent M and Breen CM, 2001. Becoming Involved Estuary Management in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.

Breen CM, Harrison T & Quinn N, 2001. Assessing the State of an Estuary in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg
McKenzie M, 2001. Policy and Law in Breen CM and McKenzie M (eds) Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg

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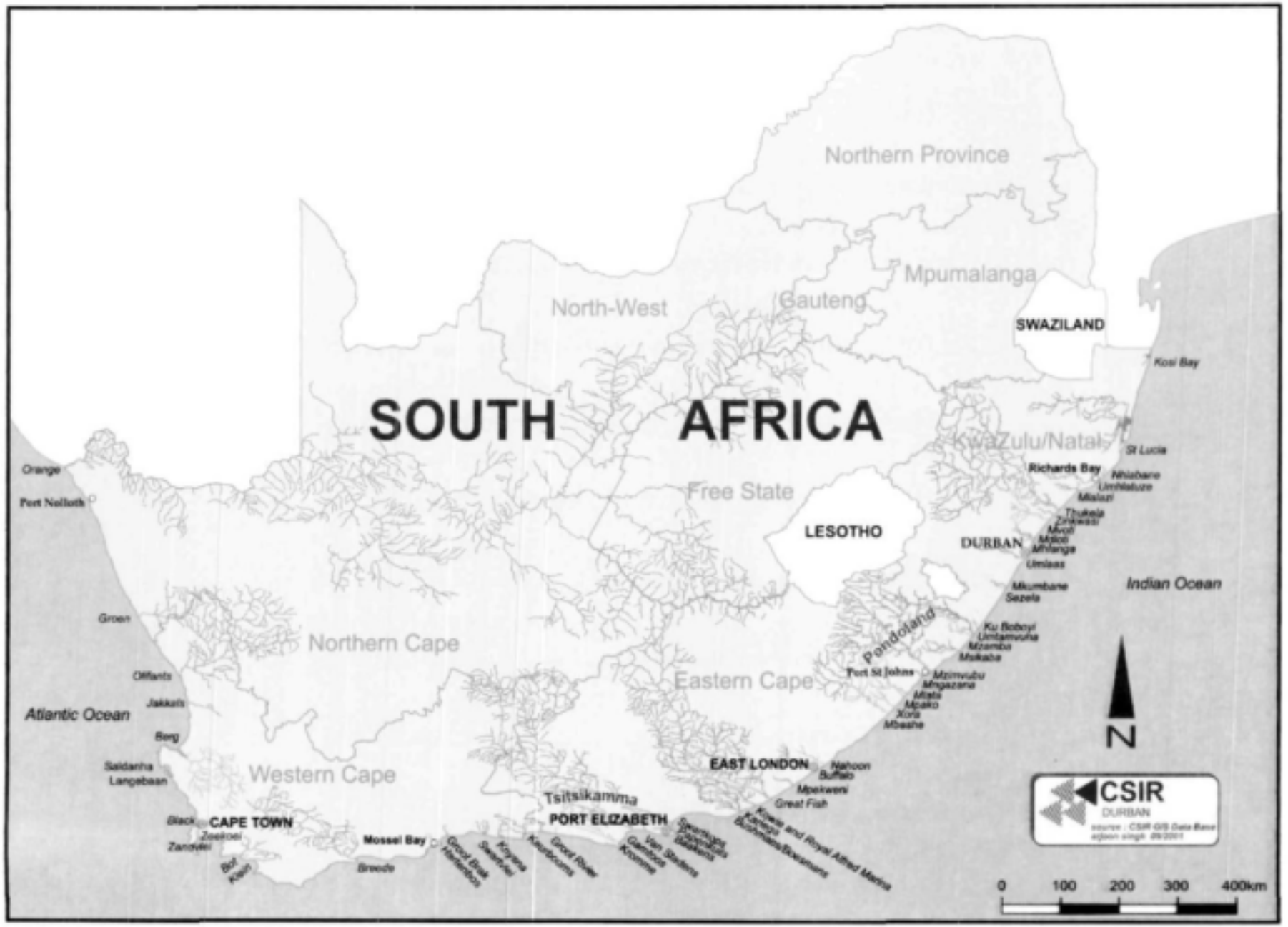
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Northern Province
Mpumalanga
North-West
Gauteng
SWAZILAND
Kosi Bay
KwaZulu/Natal
St Lucia
Richards Bay
Nhlabane
Umhlatuze
Mlalazi
Thukela
Zinkwasi
Mvoti
Mdloti
Mhlanga
Umlaas
DURBAN
Mkumbane
Sezela
Indian Ocean
Free State
LESOTHO
Orange
Port Nolloth
Groen
Northern Cape
Ku Bobnyi
Umtamvuna
Mzimbo
Mtakaba
Pondoland
Port St Johns
Mzimvubu
Mngazana
Mtata
Mpako
Xora
Mbashe
Eastern Cape
Olifants
Jakkals
Atlantic Ocean
Berg
Saldanha
Langebaan
Western Cape
EAST LONDON
Nahoon
Buffalo
Mpekweni
Great Fish
Tsitsikamma
PORT ELIZABETH
Kowie and Royal Alfred Marina
Black
CAPE TOWN
Zoetkoei
Zandvlei
Bot
Klein
Mossel Bay
Breede
Great Brak
Hartenbos
Kingna
Swartkops
Great River
Kleinbrak
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Chapter One - Introduction

When we pause to reflect we quickly appreciate that fresh water is intricately woven into every aspect of our daily lives. Whether it be household use, mining, agricultural production, manufacturing, working or recreation; everything uses water either directly or indirectly. Fresh water is both an essential and a scarce resource; and because South Africa is not well supplied with fresh water we are increasingly aware of the importance of efficient and sustainable use of our water resources. More and more effort is being directed towards recycling and reduction of wastage.

It is not unusual to hear people say that fresh water flowing into the sea is 'a waste of water'. These are value judgements based on perceptions that water flowing into the sea creates little or no value, whereas the same water used in other ways would create much more value. Since estuaries arise where rivers discharge fresh water into the sea they must form the focus for debate around whether fresh water flowing into the sea creates value or is simply a waste of a precious resource. Chapter 2 addresses this specifically.

Estuaries, just like any other natural system, provide goods and services useful to society. The value we ascribe to estuaries reflects the costs and benefits we experience from the use of these goods and services. Value, therefore, changes in response to the way we use and abuse estuaries. We cherish and look after things we value and we abuse those that we perceive to have little or no value. Value is not founded only on material benefits. Intangible benefits, particularly spiritual benefits, and issues such as morality are important contributors to assessment of value.

Our world is continuously changing in response to natural factors and in response to the way in which we live. These changes are particularly reflected in estuaries because they are the final stage in river systems draining the landscape. It is important that we learn to appreciate the value of estuaries and that we act wisely to manage them for sustainable use. It is the responsibility of every individual to act wisely and to promote sustainable use.

The purpose of this book is to promote the wise and sustainable use of all estuaries. It is premised on the belief that informed people will act wisely and seek to protect our heritage for future generations. We have endeavoured to produce an informative, readable introduction to estuaries and estuary management. We hope that the book will help people to converse with each other, and that through such conversations they will come to appreciate the value of estuaries and gain the insight and wisdom necessary to work together to promote sustainable use.

This is an introductory text. It is a starter kit for those who know little about estuaries and those who may have experience in one aspect and would like to start to learn about others. It is intended to help those who wish to contribute constructively to achieving sustainable use of estuaries and who need to gain sufficient confidence to engage others in conversation about estuary management. Six subjects are addressed: the value of estuaries, structure and functioning, influence of human activities, becoming involved in estuary management, assessing the state of an estuary and policy and legislation. Once you have read the book you should be able to go out and make a difference!

KEY ISSUES

- We look after things we value
- Estuaries provide a wide range of useful goods and services
- Many goods and services are free - so we do not value them
- The way in which we use goods and services can lead to conflict

The Nahoon Estuary
(Picture - Janine Adams)

WHY DO WE NEED ESTUARIES?

Estuaries are focal points for community and business activities along the coast as they provide us with a wide range of opportunities and benefits. They are an important location for cultural and recreation activities for both coastal residents and visiting tourists. Millions of households make use of estuaries every year here in South Africa. People live on properties close to estuaries to enjoy the attractive setting. They visit estuaries for fishing, water sports, and for cultural outings. Many people rely on productive estuaries as a source of food, such as fish, for household subsistence.

Not only do estuaries enhance the quality of life for households, but they also provide numerous opportunities for jobs and income generation. Many businesses rely on estuaries to perform functions which have economic value, such as providing a nursery for marine fish and crustaceans, for transport or for a place to provide facilities for tourists, which in turn helps to support businesses and jobs in the coastal region.

Local government benefits by generating substantial rate revenue from higher rates that result from elevated property values next to estuaries. More rate revenue means more services can be supplied to coastal communities.

In addition to the more direct benefits of estuaries, there are also many other benefits that are supplied with little or no cost to the users of estuaries. For example, the ability of estuaries to control or reduce flooding, and to improve the quality of water provides major benefits to coastal communities. These benefits ensure that other economic activities such as estuary tourism are maintained at a minimal cost to the local council.

As a consequence of these benefits, coastal communities, tourists and local governments on the coast depend on estuaries. For example, where would the Durban, Knysna, Veldrif, and Kosi communities be without estuaries at their backdoors; or how would their economies look if the estuaries were only capable of providing half the current quantity of benefits? Because estuaries are natural features the opportunities they offer are free. Free goods and services are seldom accorded their proper value and are thus commonly abused.

WHAT DO WE USE ESTUARIES FOR?

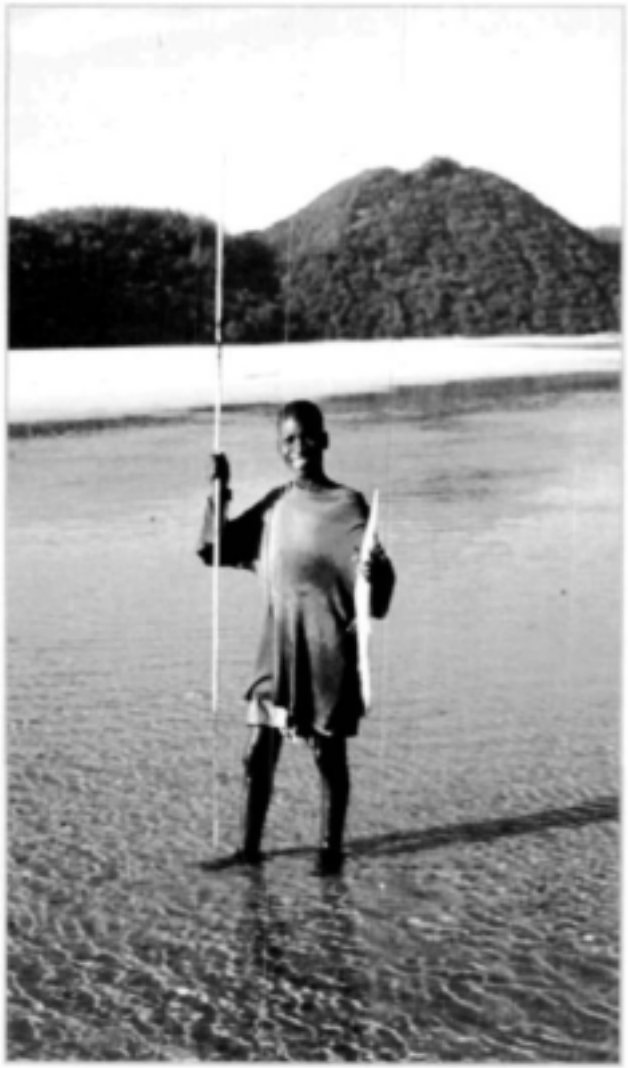
The properties of and processes occurring in and around estuaries provide options for use i.e. goods and services. Each different type of land use or resource use activity that:

- surrounds an estuary;
- may be located up-stream from an estuary; and
- may be in the sea in close proximity to the estuary

demands a range of natural resources, or goods and services from estuaries. For example, local households and tourists can directly use estuary goods such as fish, plant fibres and bait. Estuary processes provide services such as waste treatment, floodwater control, erosion control and nutrient cycling that can be used by local councils, property owners and fishing businesses.

Estuary goods and services are just like any other goods and services that may be bought, except that the estuary provides these to users through the functioning of the estuary ecosystem (Chapter 3). These goods and services can be used both directly and indirectly, or they can be left as an option for future use. Importantly, most of these estuary services are not usually purchased even though people regularly use them.

Examples of ecosystem goods and services	Examples
Refugia and migratory corridors	Fish and crustacean nurseries and roosts for migratory birds.
Disturbance regulation	Flood control, drought recovery and refuges from natural and human induced catastrophic events (e.g. oil spills).
Water supply and regulation	Water supply to marine environment and water for mariculture.
Sediment supply and regulation	Creation and maintenance of beaches, sand bars and sand banks.
Erosion control and mangroves.	Prevention of soil loss by estuary vegetation, and by capturing soil in reedbeds
Soil formation	Accumulation of sediment and organic material on floodplains and in mangroves.
Nutrient supply and cycling	Nutrient supply, nitrogen fixation and nutrient cycling through food chains.
Waste treatment	Breaking down of waste and detoxifying pollution.
Food and bait production	Production (natural and cultivated) of fish, crustaceans and worms.
Raw materials	Harvesting of craftwork and house-building materials.
Genetic resources	Genes for mariculture, ornamental species and fibre.
Nature appreciation	Providing access to estuaries and associated wildlife for viewing and walking.
Sport fishing	Estuary flyfishing, estuary and inshore conventional fishing.
Water sports	Swimming, sailing, canoeing, skiing, jetskiing and kayaking.
Scenic views	Residential houses, flats and offices with scenic views.
Transport services	Marinas, harbours and skiboat launching.
Cultural	Aesthetic, educational, research, spiritual, intrinsic and scientific values of estuary ecosystems.



Traditional Fishing in the Kosi Estuary
(Picture - Alan Whitfield)

HOW VALUABLE ARE ESTUARIES?

Each of the estuary goods and services described on the previous page has value. Importantly, value can take different forms, including monetary value and non-monetary value. Some of these values are financial.

For example, an attractive estuary such as Knysna generates higher property prices for the surrounding property owners, due to the views they have of the estuary or due to the close proximity of the attractive recreational environment. Let us say that 400 houses have a greater value of 10% that is attributable to the estuary, and that the average price per house is R300 000, then the estuary contributes about R12 million to local property values.

A study by Lamberth and Turpie (2001) estimated that the value of estuaries to the South African fishing community was R951 million (in 1997 prices) or R1.162 billion at current prices. This is made up of the value of the estuary fisheries (R433 million in 1997 prices) and the value of the estuary dependant fisheries in the inshore marine environment (R518 million in 1997 prices). The bulk of these values are generated by recreational fishing.

A study of the value of the estuary fisheries between the Kromme and Great Fish estuaries (Pradervand, 1998) showed that over a two year period, 1995 to 1997:

- 7 900 people participated in fishing activities;
- 40% of the people involved earned less that R30 000 a year;
- 560 boats were used;
- R37 million was invested in capital equipment; and
- R11 million a year was invested in running costs.

A study (based on the values of estuaries in international studies) estimated that Durban Bay contributed approximately R150 million each year in terms of incomes generated and cost savings made from 'free' services (e.g. water treatment).

This shows that many people from a wide range of sectors of society benefit from estuaries, and that a significant amount of money is invested in the local economy, far exceeding the value of the fish caught.

Apart from the financial value of estuaries, the economy also benefits from healthy estuaries.

For example, in a fishing town such as St Lucia, several hundred jobs are created through meeting the variety of needs of local people and visitors using the estuary.

In other estuaries, such as those along the Pondoland and northern KwaZulu-Natal coasts, subsistence households living around estuaries are able to harvest fish for feeding their families. Such resources have immense value to communities as they form both an income source and also provide option values. For example, the estuary provides an option for exploitation or a safety net in events such as unemployment and crop failure. This provides important social benefits such as household independence. Access to these resources in times of need reduces the burden borne by society.

Estuaries do not exist in isolation from the coastal landscape. It has been estimated that each year the coastal zone contributes R168 billion to the South African economy. It is imperative that we invest in maintaining the ecosystems that support this economy.

A further value is the intrinsic value. For many people, the presence of an estuary may provide value even if they do not use it. The intense national and international public reaction to the proposed dune mining of St Lucia clearly exhibits the non-use values which people may have. People opposed mining because they valued the system even though they may seldom, if ever, visit it and benefit from its goods and services.

Tourism development at the mouth of the Xora Estuary
(Picture - Bruce Mann)

HOW DO ESTUARIES SUPPLY US WITH GOODS AND SERVICES?

Each estuary consists of a number of different habitats, including, for example, the water column, salt marshes, intertidal banks and reedbeds. Each habitat is a product of the physical features and the biological features. The combination of these features generates the potential of each estuary to supply goods and services (Chapter 3). The processes of how estuaries produce goods and services for coastal communities are shown on the adjacent page.

To see how a process works, begin on the left hand side of the diagram. Here the combination of large scale regional processes, such as the flows of water, nutrient, energy and matter, interact to generate a cluster of habitats within an estuary.

For example in the Keurbooms estuary the interaction of regional processes results in the formation of large sandbanks. Within these sandbanks bacteria cover every grain of sand and large numbers of burrowing animals live in the sand. The breakdown of organic material, waste and pollution in the estuary by the bacteria provides a waste management service that ensures that the Plettenberg Bay community has safe water for recreation activities. The burrowing animals on the other hand provide food for fish, thereby increasing fishing opportunities in the estuary and the adjoining ocean. These goods and services in turn provide value to communities, either in the form of money or other benefits, such as spiritual well being.

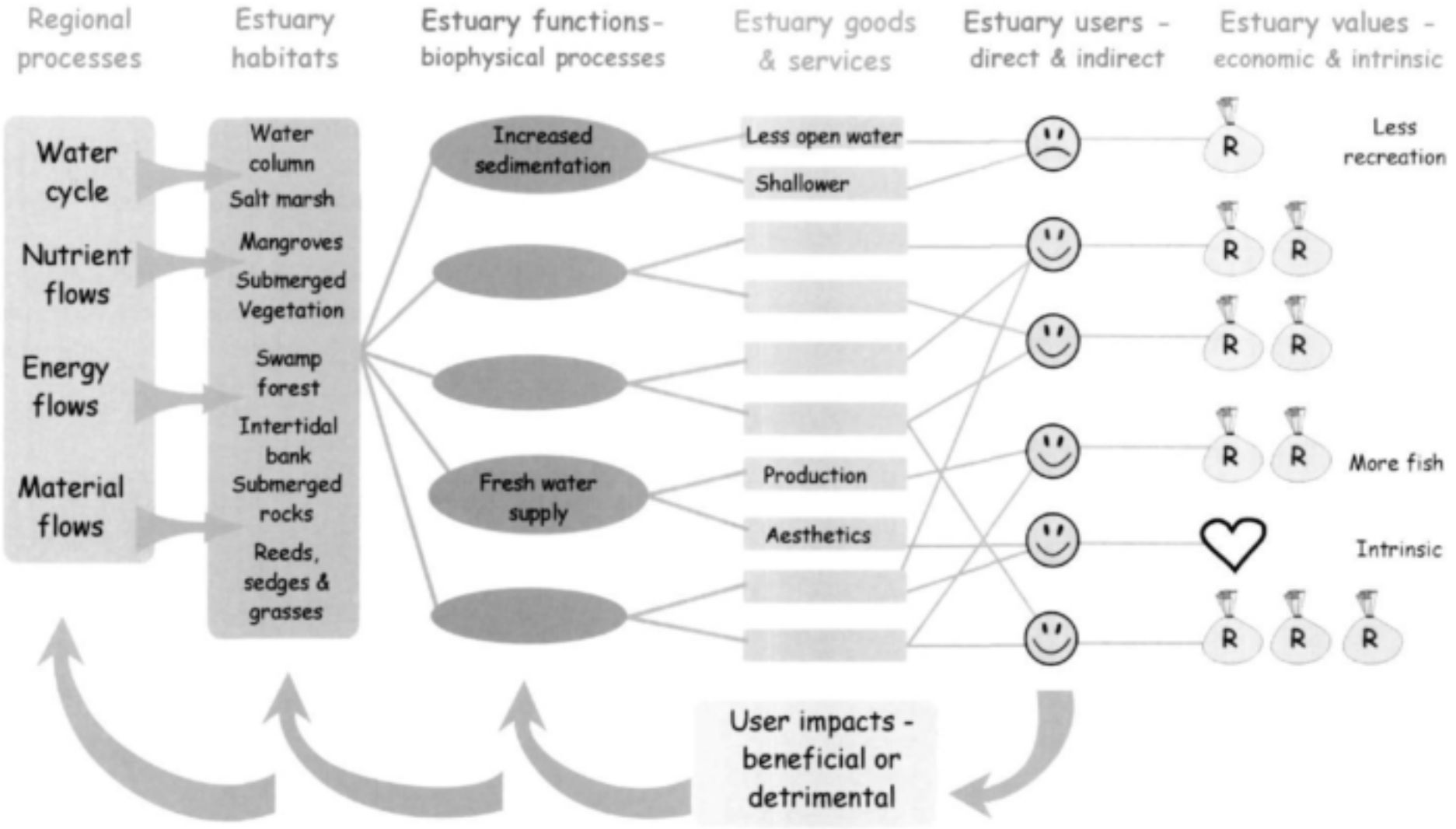
It is important to appreciate that humans are part of these processes; not only do we make use of the services supplied by estuaries, but the way we use the services influences the entire process. The impacts of human use on the system can be both positive and negative (Chapter 4). Being part of the process has serious implications, because intensity of use by one group or person influences the quantity and quality of services provided by the estuary, thereby having impacts on the welfare of many other users.

Two examples illustrate this;

- the construction of the Royal Alfred Marina on the Kowie River has altered the pattern of the tidal currents thereby contributing to sediment accumulation in the main channel and restricting navigation; and
- the dam on the Kromme River has dramatically decreased the supply of fresh water to the estuary to such an extent it has lost much of its productivity.

So, whilst the marina and dam have brought benefits to some, these have been at costs to others. Remedial action (dredging in the Kowie and release of freshwater to the Kromme) brings further costs and benefits to different sectors of society.

This serves to illustrate why we should strive to understand the likely consequences of our actions (Chapter 4) and why we should commit to managing the impacts to achieve equitable distribution of costs and benefits to society.



Examples of how regional processes alter habitats, estuary processes and goods and services. This affects users and, consequently how much people value estuaries (Illustration: Myles Mander).

WHY SHOULD WE MANAGE ESTUARIES?

People use estuaries with an intention of improving their wellbeing. For example we use estuaries for food production, fishing, recreation, property developments (marinas), transport and storm water control. All these result in greater wellbeing. However, there are also a number of unintended results that arise through the use of estuary goods and services (Chapter 4). For example, we can generate pollution, decrease biodiversity, increase sedimentation and decrease the size of the estuary. These unintended results all reduce the overall capability of the estuary to continue to supply the desired services. In many cases, the people who bear the costs of a negative impact, such as water pollution, may not be the group that causes the impact. This implies that we influence the lives of other people through the way we use estuaries.

So, this means that to optimise the benefits of using an estuary, we don't need to manage the estuary as much as we need to manage people's use of the goods and services provided to the estuary (e.g. freshwater) and by the estuary. We need to try to limit conflicting uses, where one use reduces the opportunities of other users; and we need to try to increase the number of complementary uses.

The concept of managing an estuary is no different from managing road use. We share a resource (the road surface and traffic lights) and using it requires very specific behaviour, which includes respect for the resource (the road) and respect for other users. Failure to do so results in costs to everyone, while respect promotes great benefits to all the users. Estuaries are no different.

ESTUARIES AS AN ASSET

Estuaries are an asset just like any other service infrastructure. Local governments have asset registers with all manner of built infrastructure listed, and they also have an accompanying maintenance programme. However, estuaries are seldom considered as a local government asset, even though they may generate considerable rates and other revenue for local government. Because of the failure to appreciate the value, little gets spent on management. This is equivalent to not viewing one's car as an asset, and not bothering to service it.

Estuaries should be regarded as assets and should be managed to maintain their value. The failure to do so can have major cost implications for local governments. Consider the consequences to places such as Knysna and St Lucia should the estuary cease to deliver a quality experience to tourists and residents.

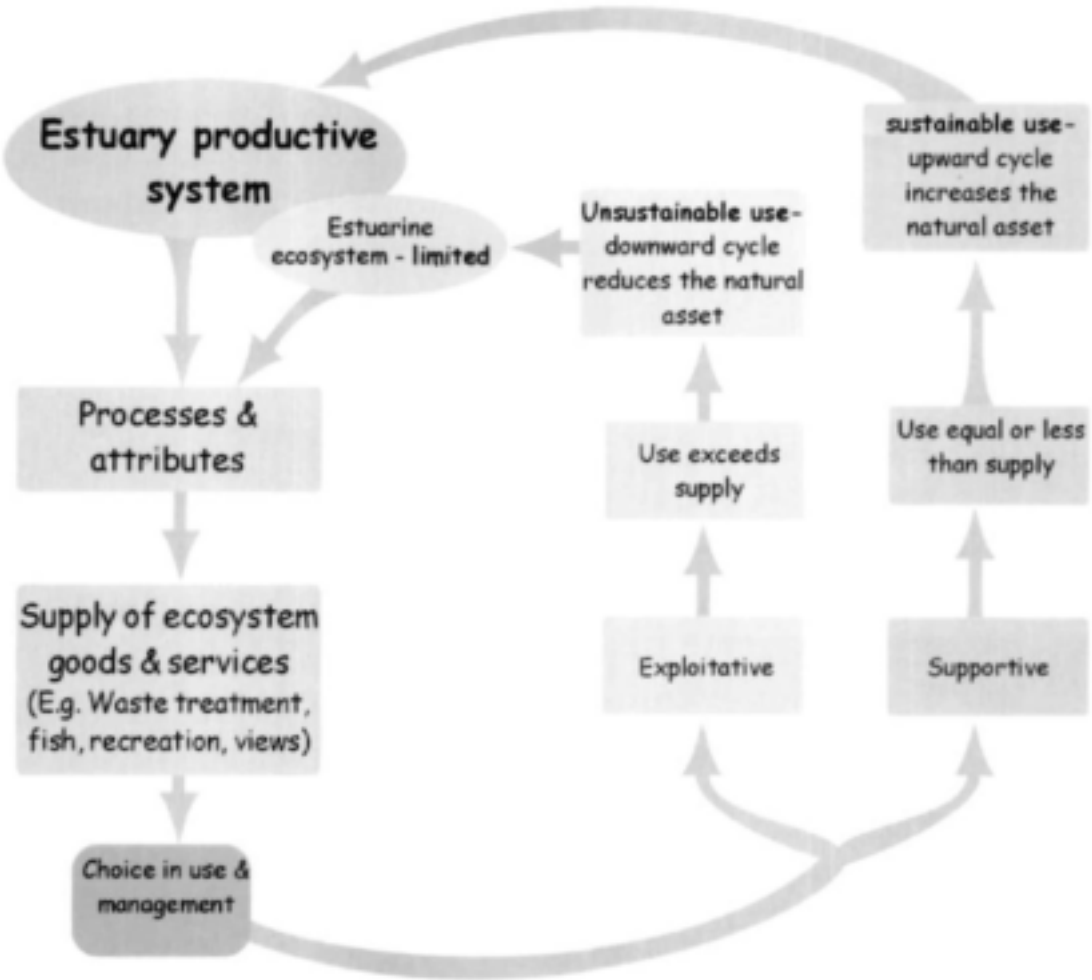
One may even question the legitimacy of not investing in management of estuaries, given that the goods and services they supply increases local expenditure and property values, which directly increase the rates paid to local government.

Estuaries provide diverse goods and services
(Picture: Margaret McKenzie)

THE NEED TO BALANCE THE USE OF ESTUARIES WITH THEIR ABILITY TO SUPPLY SERVICES

The use of estuaries needs to be balanced with their ability to supply goods and services. Not only do we need to manage conflicting uses as discussed previously, but we also need to ensure that the demands placed on estuaries can be met by the ecosystem. The diagram shows how our choice and intensity of use will influence the ability of the estuary to continue to supply services. If demand exceeds supply we will reduce future wellbeing. On the other hand, if we demand resources that are equal to or less than supply, the estuary will continue to supply goods and services in the long term.

Importantly, this should not be viewed as a constraint to economic development, but should rather be seen as opportunity to diversify the economy. By focusing on a wide range of complementary and sustainable uses, the greatest benefits can be generated for the greatest number of people by an estuary at minimised cost to society.



This diagram shows how choices of resource use, management and investment can either promote or reduce estuary asset value through the associated delivery of goods and services to communities.
(Illustration: Myles Mander)

KEY ISSUES

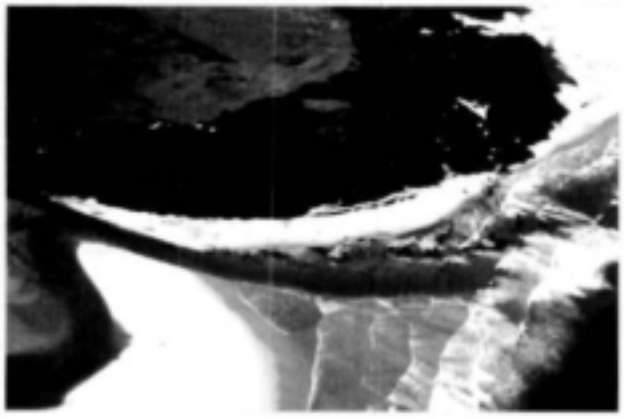
Fresh water is necessary for healthy estuaries

Healthy estuaries have active exchange with the sea

We have a wide variety of estuaries

Understand and appreciate change that occurs naturally in estuaries

Altering one component of an estuary alters all others



The permanently open Kariega Estuary
(Picture: Alan Whitfield)

WHAT IS AN ESTUARY?

Estuaries form where a river meets the sea. They are that portion of a river system, which has, or can have, interaction with the sea. Unlike estuaries elsewhere, most South African estuaries are prone to closure by sand bars which block off the mouth for varying lengths of time. During this closed phase direct interaction with the sea ceases but, as water within the estuary is derived from both the river and sea, they still fit the definition above.

NOT ALL ESTUARIES ARE THE SAME

Permanently open estuaries

(e.g. Breede, Swartkops and Mlalazi)

These are usually quite large systems with a perennial river and/or strong tidal exchange with the sea. Under low river flow conditions tidal exchange is sufficient to keep the mouth open. The sea is the dominant influence on the estuary, but during floods river influence is evident right down to the mouth. Permanently open estuaries have been known to close briefly during droughts but under normal conditions they do not close.

Temporarily closed/open estuaries

(e.g. Groen, van Stadens and Mhlanga)

Approximately 70% of South African estuaries fall into this category. These estuaries are often closed for many months each year and sometimes for more than a year at a time. Temporarily closed/open estuaries usually have small catchments and limited penetration by tidal waters when they are open. Mouth opening events usually occur after periods of high rainfall. River flow and tidal exchange are not sufficient to keep the mouth open. During very high seas, marine water sometimes washes over the sand bar at the mouth and 'tops up' the estuary on the other side.

River mouths

(e.g. Orange, Mzimvubu and Thukela)

All rivers flowing into the sea have a river mouth. The categorisation river mouth estuary reflects properties other than the presence of a mouth. These estuaries are usually permanently open to the sea. The river, not the sea, dominates the physical processes within these estuaries. Penetration of marine water upstream is limited by river flow and, in some systems, penetration may even be confined to the lower reaches for much of the year. When high river flows occur, the mixing zone between freshwater and seawater can be pushed offshore and marine water is not able to enter the estuary.

Estuarine lakes

(e.g. Swartvlei, St Lucia and Kosi)

These occur where a coastal lake is connected to the sea by a channel of varying length and width. The mouth of an estuarine lake can be either permanently or temporarily open. Salinity levels vary in both space and time and they largely reflect the balance between freshwater and sea water inflow into the lake, as well as evaporation from the lake surface. Because they are usually large and shallow, water temperatures in these systems are more related to solar heating on their surfaces than to the influence of the temperature of either rivers or the sea.

Estuarine bays

(e.g. Durban Bay, Knysna and Richards Bay)

These estuaries have wide mouths with strong tidal exchange resulting in a continuously open mouth, and the regular replacement of marine water in the lower and middle reaches. Even under high river flow conditions, seawater salinities persist in the bottom waters of the lower reaches as the less dense fresh water flows over the more dense sea water. Water temperatures in an estuarine bay are more strongly influenced by the sea than the river. These marine dominated systems are sometimes dredged to improve their value as harbours for large ships.

HOW LARGE ARE OUR ESTUARIES?

Our estuaries are small by world standards. We have in the region of 260 functional estuaries and together they are smaller than the Chesapeake Bay system on the eastern seaboard of the United States of America. Southern African estuaries range in size from the huge Lake St Lucia (32 500 hectares) to the tiny Mkumbane Estuary (0.3 hectares), with catchments as large as 852 000 square kilometres (Orange River Estuary) or as small as four square kilometres (Ku-Boboyi Estuary). The majority of South African estuaries have surface areas smaller than 50 hectares. Water depths are also highly variable and range from less than one metre in many small temporarily open/closed estuaries to more than 10 metres in some of the larger estuarine lakes and bays.

HOW OLD ARE OUR ESTUARIES?

Virtually all of our present day estuaries are only a few thousand years old and originated when a rising sea level at the end of the last northern hemisphere ice age drowned the adjacent river valleys. This process is illustrated in the Msikaba Estuary where a 35m high waterfall, one kilometre upstream from the mouth, was inundated by the sea within the last 10 000 years. Although estuaries have existed for millions of years in South Africa, those which we currently see along our coast are temporary features which will change with future rising or falling sea levels.

Build up of marine sediment temporarily closes this estuary mouth (Picture: Bruce Mann)

The Mzimvubu Estuary is a 'River Mouth' type of estuary (Picture: Bruce Mann)

Fresh water and sea water do not mix easily
(Picture: Kevin Weerts, Zinkwazi Estuary)

PHYSICAL PROCESSES

Tidal exchange

Incoming (flood) tides force sea water into estuaries raising the water level. Water levels near the mouth decrease more quickly than higher up on the outflowing (ebb) tides. The difference in water level can result in strong outflowing currents. In large estuaries (e.g. Knynsa) tidal exchange helps keep the mouth open.

Deposition and removal of sediments

Deposition and removal of sediments are very important processes. Erosion, when sea level was lower than at present, created the physical form of the estuary and cycles of deposition and removal of sediments modified this. Rivers bring in sediment from the land and during floods they scour sediment out. In addition wind and coastal currents transport marine sediment into and out of estuaries. When river flow is low the river and incoming tides may bring in more sediments than outflowing tides can remove, this causes the mouth of the estuary to shallow or close. Deposited sediments are stabilised by plant growth, which increases resistance to erosion.

The supply of sediments to estuaries is very variable from both the land and the sea. Most estuaries of KwaZulu-Natal receive high loads from land and sea so they are greatly modified by sediment accumulation. By contrast the estuaries along the Tsitsitkamma coast are much less modified by sediment deposition. Estuaries change continuously as sediments accumulate and then are scoured out to sea, returning the estuary to an earlier condition.

Mixing of fresh and sea water

Fresh water is less dense (lighter) than sea water. Consequently, fresh water flowing into an estuary can flow over the top of sea water in the estuary, particularly if the river water is warm relative to the sea water. The layering of different densities is most strongly developed in deep parts of the estuary where mixing processes are weak.

CHEMICAL PROCESSES

The ability of an estuary to support plants and animals depends largely on the physical and chemical characteristics of the water column and sediments. Typically estuaries exhibit a mix of river and sea water and of material brought down by the river and transported in and out by the sea. This mix is modified by the growth, death and decay of organisms living in the estuary, and by alternating processes of sediment deposition and

resuspension which trap or release nutrients and toxic materials. The result is a unique chemical environment, which is highly variable in time and space and which can change suddenly. There are usually marked salinity differences between the upper and lower parts of an estuary and this salinity gradient is an important determinant of biological processes. Rivers transporting large sediment loads can reduce the clarity of the water. This can also occur when dissolved organic matter in river water is mixed with sea water. The resulting particulate material is a very important food source for estuary animals.

Turbidity reduces light penetration and determines the depth at which photosynthesis can take place. By reducing visibility it also makes it easier for small animals to escape from predators.

BIOLOGICAL PROCESSES

The success of organisms inhabiting estuaries is linked to physical and chemical processes. Many organisms (e.g. prawns, crabs and some fish) have to spend time at sea to complete their life cycles and movement in and out estuaries promotes exchange of genetic material. The seasons and cycles of the moon commonly determine when these movements occur, so when and how long the mouth is open are important. The chemical composition of water flowing out to sea provides cues that orientate animals so they can enter or return to estuaries.

Organisms respond to changing conditions. Changes in salinity, nutrient content of the water and sediment deposition favour some species over others so that sequential change of species (succession) results. Floods, flushing and scouring can reinstate earlier conditions favouring formerly successful species. These cycles occur over periods of days, in the case of microscopic plants and animals, to many years, in the case of large plants such as reeds and mangroves.

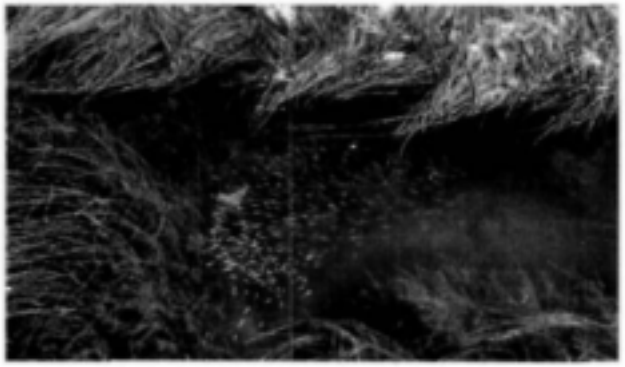
The productivity of estuaries relates closely to nutrient-rich material transported by rivers. Rooted plants, which capture solar energy (photosynthesis), and burrowing animals enable nutrients and energy to enter the food web through which they are transferred by growth, death and decay, grazing and predation.

HUMAN PROCESSES

Estuary condition reflects human behaviour in the catchment, in the sea and in the estuary (Chapter 4). Land and water use patterns result in less and less river water and more and more sediment and waste products reaching estuaries. Activities along the coast can change wind and sea currents, altering patterns of sand transport and deposition. Harvesting marine and estuarine organisms also decreases populations in estuaries.

The construction of causeways and jetties, and activities such as power boating alter the patterns of deposition and erosion in estuaries. Together with other activities such as trampling, digging for bait, and over-fishing they reduce populations, disrupt behaviour patterns and destroy habitats. The nature and character of estuaries is also greatly affected by development within the catchment and by activities occurring on the estuary. Managing how people use estuary goods and services (Chapter 5) lies at the heart of achieving sustainable, complementary use.

The compounding effects of these pressures are acknowledged in recently revised policies and legislation (Chapter 7).



An eelgrass bed, with juvenile fish sheltering among the leaves (Picture: Alan Whitfield)

Algae along the shore decomposes to provide an important food source in estuaries (Picture: Janine Adams)

A salt marsh showing distinct zonation of species (Picture: Janine Adams)

VARIETY & DISTRIBUTION OF PLANTS

Plants living in estuaries vary from large trees (e.g. mangroves) to tiny algae floating in the water. Each species has special requirements, which determine where they live, resulting in species zonation up and down the estuary, in the intertidal area and in the water column. Changing conditions also determine when they come and go (succession). Estuary type, sediment distribution and properties, and water temperature are important determinants of distribution and, since similar conditions may occur in estuaries, many species are widely distributed.

TYPES OF PLANTS

There are six different plant community types that are found in South African estuaries.

Small algae (microalgae)

Individual microalgae are seldom visible to the naked eye. On mud, sand and bigger plants large populations of these organisms give surfaces a green or brown tinge. Large populations in the water column greatly restrict light penetration and water appears green, brown or red. Growth responds quickly to availability of nutrients, and microalgae in the water column (phytoplankton) are good indicators of nutrient status and pollution. Phytoplankton produce oxygen during photosynthesis but, when dense populations start to die, decay can consume so much oxygen that fish and other organisms are killed.

Large algae (macroalgae)

These plants are not distinguished into roots, stems and leaves although some may have root-like structures attaching them to various surfaces. Large algae are present in almost all estuaries and comprise two main groups, those with a thread-like (filamentous) form and those that are firmly attached and have a leafy (thalloid) form.

Seaweed varieties are more common than fresh water algae and occur mainly in the lower reaches where salinities are highest. Some filamentous algae occur in the lower and middle reaches where dense growths can smother rooted plants.

Submersed large plants (macrophytes)

These rooted plants have stems and leaves, which may reach the water surface. Some species (e.g. eelgrass) can survive desiccation during exposure at low tides and, whilst able to survive strong tidal currents, whole beds can be washed out during floods. Flowering and fertilisation occurs both above and under water.

Eelgrass beds are widespread in the lower reaches of larger estuaries but they are replaced by other species in the upper reaches where salinities are lower and water currents less strong.

Submerged macrophyte beds are important habitats for other organisms living in estuaries (e.g. fish).

Salt marshes

These develop at high elevations (e.g. flood plains) in estuaries and are more prevalent in the lower and middle reaches. Salt marshes are flooded daily (at high tide) or less frequently, but the soil is always saline.

Few species can tolerate these conditions and species diversity is low. One or two species dominate and may include grasses (e.g. cord grass) and fleshy plants (e.g. soutbossie), some with jointed stems (e.g. glassworts).

Salt marshes are important habitats. They provide protection for certain invertebrates (eg. crabs) and a source of organic litter which sustains many species.

Mangroves

These are trees and shrubs that grow in tidal and saline coastal areas. They occur neutrally in parts of our warm estuaries from the Kosi system to the Kei Estuary. Those south of the Kei have been introduced.

High tides submerge their aerial roots and lower stems but they can be exposed for several hours at low tide. They are intolerant of prolonged flooding with either fresh or saline water that covers their roots because this restricts exchange of gases, especially oxygen. The stems and roots provide large surface areas for colonisation by small organisms, which, together with leaf litter, supply energy and nutrients for other species.

Mangrove wood is durable and is used for building material. Because of the limited extent of mangrove swamps in South Africa harvesting needs to be conducted in a sensitive manner.

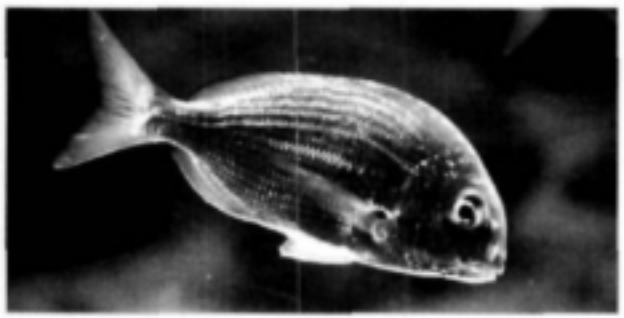
Reeds and sedges

The presence of these species in estuaries usually indicates fresh or brak (slightly saline) water conditions. Reeds and sedges occur extensively in the middle and upper reaches, while the common reed may extend into the lower reaches, especially in temporarily closed systems or where fresh water seepages occur. During droughts and periods of high salinity they die back, only recovering after floods have flushed away the saline water.

Reed and sedge beds are particularly important sources of energy and nutrients during the fresh water phase of some estuaries, because they replace those plant species that flourish under saline conditions. They are also important in subsistence economies, providing materials for craftwork (e.g. rushes and sedges) and construction (e.g. reeds).

Mangrove poles ready for use in construction
(Picture: Janine Adams)

The mud prawn, a popular bait organism and food item for carnivorous fish (Picture: Alan Whitfield)



The Cape stumpnose, a species that relies on estuaries for the juvenile life stages (Picture: Alan Whitfield)

White pelicans and white-breasted cormorants – fish eating birds that frequent many estuaries (Picture: Alan Whitfield)

VARIETY & DISTRIBUTION OF ANIMALS

Large animals (hippos and crocodiles) were formerly widespread but nowadays their presence is largely restricted to estuaries in conserved areas. Nowadays size varies from large fish (kob and leervis) to microscopic animals inhabiting the water column and sediments. Species tend to be widespread within two broad zones defined largely by temperature. These two zones merge along the former Transkei coast.

Animals differ from plants in that they are able to move and many actively seek favourable conditions in estuaries. Salinity, type of substratum (rock, sand, mud), and presence of other species (e.g. submerged plants) influences the distribution and abundance of individual species. Generally the diversity of marine species decline up the estuary and the diversity of fresh water species decline towards the mouth. There are few truly estuarine species and estuaries have lower species diversity, but higher abundance, than adjacent fresh water and marine systems.

TYPES OF ANIMALS

Invertebrates

These are all those animals (e.g. crabs and worms) which do not have a backbone Some, known as benthic species, live on (e.g. crown crab and sand shrimp) or in the sediment (e.g. bloodworm and sand prawn). Others, known as nektonic species, swim actively in the water column (e.g. swimming prawn). The two groups are not rigidly separated as the larval stages of many benthic species spend time in the water column, thus allowing them to establish in areas different from parent populations. Small nekton (zooplankton), barely visible to the naked eye, can be abundant and may move down and settle on the sediment during daylight hours.

Benthic species aerate and release nutrients from sediments through burrowing and water pumping. Invertebrates are very important processors of living and dead plant material, making energy and nutrients available to other species.

Fishes

The fishes found in South African estuaries can be divided into five main groups depending on their origin, biological adaptation to estuarine conditions and their degree of dependence on estuaries for survival. The dominant group are marine species that breed at sea and whose juveniles show varying degrees of dependence on estuaries as nursery areas. The second most important group comprises truly estuarine species,

which breed within estuaries and spend all or most of their lives within these systems. The third group comprises freshwater species for which the degree of penetration into estuaries is determined by salinity tolerance. The fourth group comprises marine species, which 'stray' into estuaries, usually occurring in the lower reaches, and are not dependent on estuaries. The final group comprises the anguillid eels, which use estuaries as a conduit between the sea and river. The larval eels swim through estuaries during their upstream migration, finally returning along the same path on their way to the marine environment where spawning occurs.

Estuaries are important nursery areas for juvenile marine fish. Diet varies among species. Some feed directly on plant material (e.g. stumpnose) others (e.g. mullet) feed on fine living and dead particulate material and some (e.g. grunter and kob) are carnivorous feeding on other animal species. Diet can change as species mature.

Birds

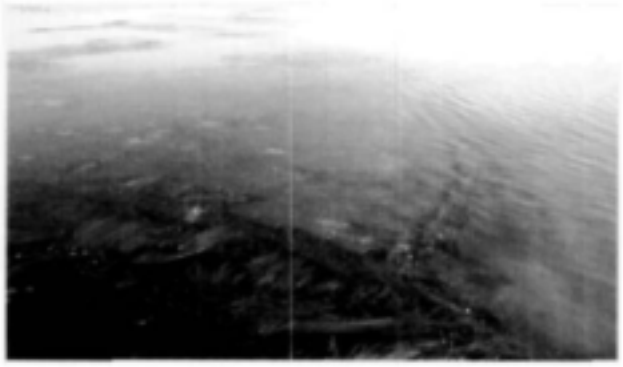
The variety of food resources and habitats provides opportunities for a diversity of bird species. Waders, waterfowl, kingfishers, cormorants, gulls, terns, egrets and herons may be found in and around estuaries. Birds are often the most conspicuous animals on the tidal flats, moving from one area to another as conditions (such as tide) change. Three major groups may be recognised on the basis of diet; those feeding primarily on vegetation (e.g. redknobbed coot), those feeding mainly on invertebrates (e.g. greeen shank) and those that feed primarily on fish (e.g. fish eagle and cormorant).

There are more bird species found at east coast estuaries than at the west coast estuaries. This is largely due to the diversity of wading birds found at east coast estuaries, most of which are sedentary, fish eating species. On the west coast bird densities tend to be higher and the dominant species are migratory, invertebrate feeders.

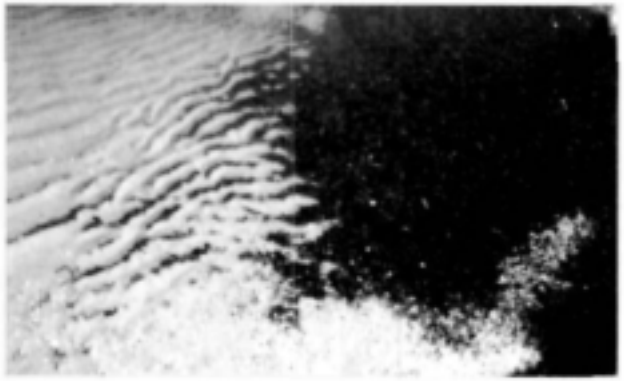
Palearctic waders (those which migrate seasonally to and from northern areas e.g. Europe) vary markedly in their preferences between tidally influenced estuaries and lagoons and fresh water coastal lakes. Most Palearctic waders are restricted to tidal habitats (e.g. grey plovers) and decrease in abundance progressively around the coast from west to east.

Other vertebrates

Prior to the advent of the rifle, the top predator in most large subtropical estuaries along KwaZulu-Natal coast was the Nile crocodile. Today this reptile is predominantly confined to protected estuarine lakes such as St Lucia and Kosi, where even humans have to be careful not to become a prey item in its varied diet. Other predatory vertebrates, which make use of South African estuaries, but are seldom seen because of their shyness, include two species of otter and the water mongoose. The most widespread large mammal associated with our estuarine systems was the hippo. However, this species was eliminated from all estuaries between the Western Cape and Lake St Lucia where several hundred individuals survive today. The hippo is an important transporter of terrestrial plant material into adjacent water bodies in the form of dung, and one can only guess at the impact of the loss of these large herbivores on the food webs in Eastern and Western Cape estuaries.



Extensive beds of eelgrass (Zostera), an important plant in many estuaries (Picture: Ricky Taylor)



Detritus (broken down plant and animal material) the primary food source of most invertebrates and fishes in estuaries (Picture: Alan Whitfield)

ESTUARY FOOD WEB

Food webs in estuaries are structured around producers, decomposers and consumers. Plants containing green pigment (chlorophyll) dominate the producers. They are able to use light energy, nutrients and water in growth (photosynthesis). The large primary producers (aquatic macrophytes) in estuaries are generally not directly consumed. Instead they supply material which decays and is broken down by micro-organisms, particularly bacteria and fungi. The fine particles of organic material which result (detritus) are then consumed by a variety of species including invertebrates (e.g. prawns) and fish (e.g. mullet) which are collectively referred to as detritovores. Microalgae in the water column may be directly consumed by components of the zooplankton (primary consumer), but a large proportion of the microalgae population also undergoes processing to detritus before passing on through the food web.

Food webs in estuaries are complicated by their connections to fresh water systems, which are in turn strongly connected to land systems, and to marine systems. These sources augment detritus originating within the estuary. Much of the detritus accumulates on the surface of the mud where it is consumed by benthic organisms, which live in or on the substratum. These include above surface filter feeders (bivalves such as mussels and clams), sub-surface filter feeders (e.g. mud prawns), crabs, which feed selectively on larger particles, and worms, which ingest mud to extract nutritive substances.

Invertebrates are dominant amongst the organisms that consume detritus (primary consumers). They provide food for secondary consumers (e.g. predatory fish) and ultimately tertiary consumers (e.g. predatory birds and man). Detritus forms the main food base for almost all estuarine animal life and the abundance of this resource is the primary reason for the high productivity of these systems.

SUSTAINING FOOD WEBS

Food webs in estuaries are constructed around a diversity of plants and animals and linkages to fresh water and marine systems. If the productivity of estuaries is to be sustained then both the diversity and linkages have to be maintained. The diversity of plants and animals in an estuary is determined by a variety of factors including the size of the system, the variety of habitats present, the position of the estuary along the coast, the

nature of the mouth, the salinity and the temperature.

BIOGEOGRAPHY AND BIODIVERSITY

Perhaps the most important factor, which influences plant and animal diversity in South African estuaries, is biogeography. There are three main biogeographic regions on the subcontinent; the subtropical zone between Kosi and Mbashe estuaries, the warm-temperate zone between the Mbashe Estuary and Cape Point, and the cool-temperate zone between Cape Point and the Orange River. The biodiversity of estuaries in the cool-temperate zone is considerably lower than in the warm-temperate zone, with the subtropical estuaries having the highest species diversity of plants and animals on the subcontinent.

Despite the increase in biodiversity from the south western to the north eastern part of the country, the proportion of endemic species is much higher in the south than the north. Therefore estuaries in the temperate zones have a major role to play in terms of providing a sanctuary to plants and animals that are found on the subcontinent and nowhere else in the world.

The linkages to fresh water and marine systems are strongly influenced by human activities, particularly those which alter the pattern of fresh water supply to estuaries. Policy and legislation (Chapter 7) make provision for meeting these requirements but we can, nevertheless, anticipate long term changes in the supplies of sediment, nutrients and detritus to estauries (Chapter 4).

Simplified Estuary Food Web (Illustration: Lauren Glennie)

KEY ISSUES

- Human actions are the most pervasive agents of change
- Focus on managing human behaviour
- Think not what benefit I can gain, but what costs my actions will generate for others
- Beware of creeping development. Principles once compromised are difficult to re-establish

Impounding rivers and abstracting water threaten functioning of estuaries. Releases of water can help to maintain healthy estuaries (Picture: Janine Adams)

INTRODUCTION

Management seeks to regulate human behaviour so that the consequences of particular human activities are desirable, or at least acceptable, to society. If we are to manage for desirable outcomes we must be able to foresee the likely consequences of human activities which impinge on estuaries. The purpose of this chapter is to enable readers to anticipate and start to evaluate the probable influences of human activities.

Estuaries are indirectly influenced by human activities occurring away from the estuary, on land and in the sea, and they are directly influenced by human activities occurring within the bounds of the estuary. All human activities that may impinge on estuaries are regulated and it is, therefore, possible to manage the influence they have on estuaries. Legislation (Chapter7) requires that the environmental consequences of development proposals are adequately considered. Proponents of development and rehabilitation (e.g. dredging) actions must have approval, from the relevant provincial department responsible for environmental affairs. The Environmental Impact Assessment (EIA) process for seeking approval for a project is described in Chapter 7.

CONSEQUENCES OF ACTIVITIES IN THE CATCHMENT

Supply of fresh water decreases

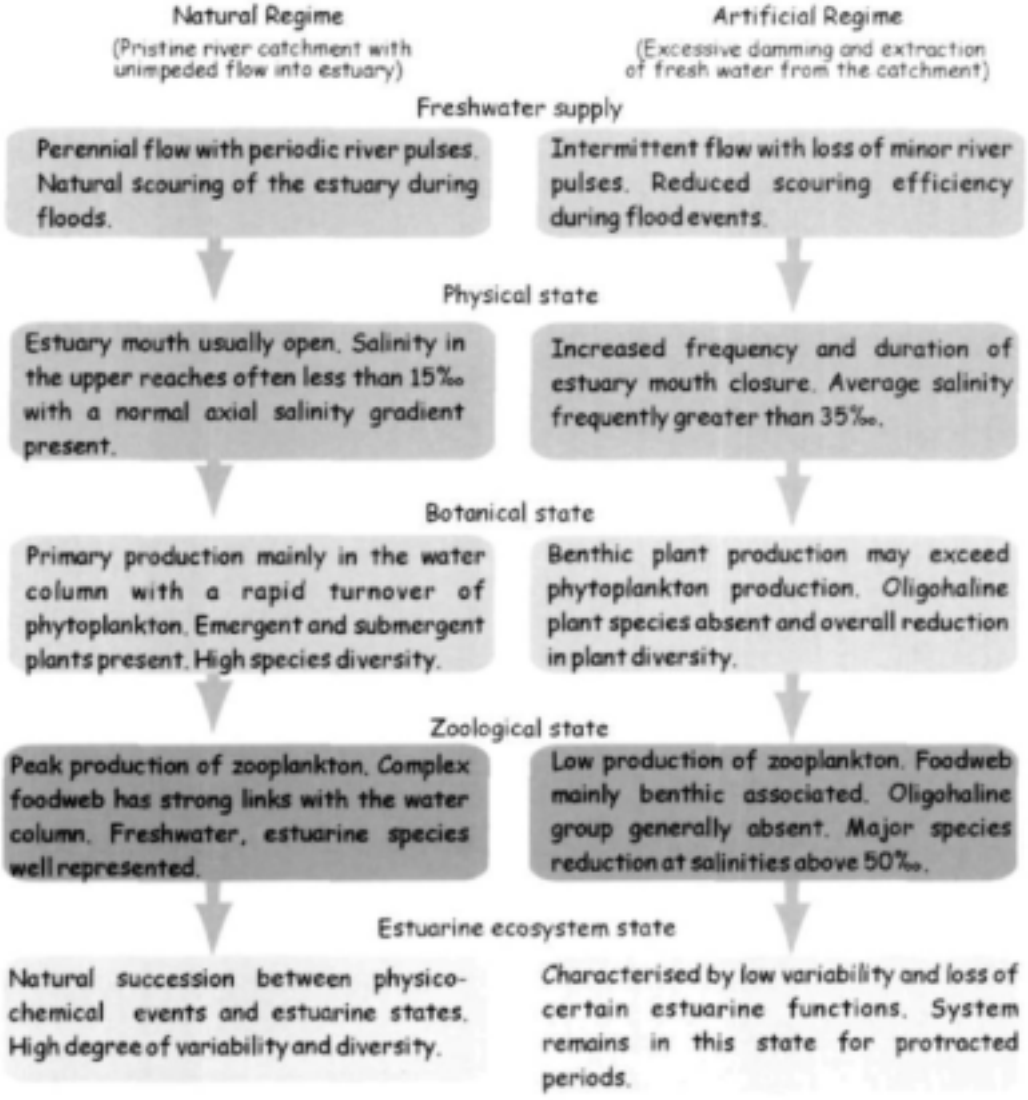
Fresh water is an increasingly scarce resource in South Africa. The continually rising 'need' for fresh water is satisfied through managing supply and demand. Supply is improved by managing land use activities (e.g. afforestation) which reduce stream flow, by increasing storage and transferring water from one catchment to another. Demand is managed through a combination of regulating water use and allocation (Chapter 5). Legislation (Chapter 7) makes provision for allocation of water to sustain people and the structure and functioning of rivers and estuaries. Only after this requirement has been satisfied can the remaining water be allocated for other uses.

Storage and abstraction have two important consequences for estuaries, the amount of fresh water reaching estuaries is reduced, and the pattern of supply (volume and flow) changes. Estuaries require a continuous supply of fresh water to maintain salinity gradients (Chapter 3). Where base water flow ceases estuaries may assume characteristics of the sea (e.g. Kromme Estuary), or exhibit reversed salinity gradients with highest salinity in the upper reaches (e.g. St. Lucia

Estuary). Periodically elevated water flows are usually required to keep the mouth open and flood events scour estuaries after periods of gradual infilling with river-borne and marine sediment.

Dams are usually of such a size that they exert their greatest influences on small and intermediate flood events, and on base flow, both of which are critical for maintenance of estuary structure and functioning. Their effects can be particularly severe for estuaries in small catchments with many small impoundments (e.g. farm dams). Large (infrequent) floods overtop dam walls and are not usually attenuated to any significant degree.

Releases of water from impoundments can be used to maintain ecosystem integrity and satisfy the legal requirements for the environmental reserve. This is achieved by establishing an estuary management system which incorporates monitoring the condition of the estuary and linking this into the operating rules for releases from the impoundment. Whilst this may be relatively easy to achieve where large dams have been constructed to permit such releases, it is more difficult to achieve where there are numerous dams and weirs which have not been constructed to provide the required releases of water.



The diagram above (taken from Whitfield, 1998) illustrates the impact of the reduction of freshwater supply on an estuary (Illustration: Lauren Glennie)

The Mfolozi river discharging silt laden water into the sea just south of the St Lucia System (Picture: Caroline Fox)

The Tukela Estuary showing sediment deposition (Picture: Janine Adams)

Sediment load changes

The balance between the supply of sediment to estuaries and its removal from estuaries is a very important determinant of the ability of an estuary to produce goods and services useful to people. If we change this balance we can radically alter the value we place on an estuary (Chapter 2).

Because the gradient (slope) of rivers usually decreases near the sea, river flow rate slows down and sediment is deposited; the estuary is infilled and its attributes change (Chapter 6), most usually reducing its value to users.

River flow transports sediment to the estuary and high flows (floods) remove it to the sea. Growing demand for fresh water has required construction of dams. These store water by capturing flow. There are fewer and fewer flows of sufficient size to remove the sediment from the estuaries. Only the very big floods pass down the river and scour out accumulated sediment; and nowadays these usually also bring lots of sediment with them.

Many estuaries require river flow to remove marine sediment washing through the mouth. As more and more water is stored and used in the catchment, there is less and less available to help the ebb tide remove marine sediment. Estuary mouths close more frequently and stay closed for longer.

The government has now made provision for water to be allocated to protect estuary structure and function (the Environmental Reserve, Chapter 7). Because the rate of supply of sediment has increased and the natural processes that remove sediment have been weakened, it may be impossible to achieve a desired balance without active intervention. Dredging has been used for many years to remove sediment from estuaries (later in this Chapter). Because it is costly alternative methods which enhance the ability of the ebb tide to resuspend and scour out deposited material are being sought.

Sand deposited in the upper reaches of the Mdloti Estuary is removed for construction (Picture: Kevin Weerts)

Water quality deteriorates

Apart from being essential for life, water is a medium for transporting material in suspended (e.g. soil particles) and dissolved (e.g. nutrients) states. Consequently, every human activity affects the quality of water either directly or indirectly. Agricultural, industrial and urban activities elevate the loads of suspended and dissolved substances in water. The Department of Water Affairs and Forestry has established guidelines (standards) as a mechanism for managing water quality. Activities, such as waste water treatment, that may threaten water quality require authorisation and monitoring (Chapters 6 and 7). Failure to meet the conditions of authorisation may result in prosecution.

Water draining the landscape transports these suspended and dissolved materials to estuaries where they may accumulate with undesirable physical, chemical and biological consequences. Suspended particles increase turbidity that changes both the quantity and quality of light penetrating the water column. This decreases the depth at which plants can grow and reduces productivity. Turbidity also reduces visibility and predation. Where fresh water and sea water mix the properties of particles change, causing them to precipitate so that those parts of estuaries with high salinities tend to have clear water. Sediment particles carry with them adsorbed nutrients that support plant growth and toxic substances such as pesticides and heavy metals (e.g. mercury and copper). If sediments contain sufficient organic material, microbial activity may deplete oxygen and create conditions that cause toxic substances to be released into the water.

Human activities tend to elevate concentrations of dissolved inorganic and organic substances in river water. These materials derive from 'point sources,' such as industry or sewage outfalls, and from 'diffuse sources' such as urban and agricultural run off. Point sources of pollution are more easily regulated than diffuse sources. Enrichment of river water with non-toxic inorganic substances (e.g. sodium) is not usually problematic for estuaries. Elevated levels of phosphorus and nitrogen, particularly from sewage treatment plants or septic tanks, boosts plant growth (Chapter 3). Algae are usually the quickest to respond and dense growths can develop and smother submerged rooted species. Occasionally growths may become so dense that oxygen in the water is depleted and animals die in large numbers.

Although human disease causing organisms do not normally survive for long in saline parts of estuaries, they can survive long enough to cause serious health problems. When wastes and untreated sewage enter estuaries risk of infection is elevated.

Under exceptional circumstances sea water entering estuaries can impair water quality. The most likely causes are pollutants (e.g. oil) and 'blooms' of toxic microalgae.

Oil spill covering the intertidal area at the chemical berth at Richards Bay (Picture: Ricky Taylor)

A train bridge built across the mouth of the Mkomazi Estuary (Picture: Dirk van Driel)

The weir at the head of the Kowie Estuary has a fish ladder to enable fish to migrate upstream (Picture: Anton Bok)

A bulkhead built on the bank of the Kariega Estuary to provide parking (Picture: Margaret McKenzie)

CONSEQUENCES OF ACTIVITIES ON AND AROUND ESTAURIES

Encroaching structures

Estuaries provide benefits to society (Chapter 2) but they are also barriers to movement. Structures of various types facilitate movement and enable us to access goods and services. Where and how they are constructed determines their impact on estuary structure and functioning. With few exceptions, the State owns most of the property below the high water mark. Consequently, such developments are regulated (Chapter 7).

Wiers and Causeways

Weirs are constructed at the head of estuaries to store fresh water (e.g. Nhlabane Estuary). They restrict intrusion of saline water and unless constructed with 'fish ladders' they become barriers to migration (Chapter 3). Abstraction of river water during periods of low flow may prevent fresh water reaching the estuary. Water levels in estuaries may be stabilised with weirs constructed near the mouth (e.g. Jakkals Estuary and Sandvlei). These restrict biological exchange with the sea; tidal flushing is reduced and stored water may become fresh; and nutrients, pollutants and sediment may accumulate.

Causeways are constructed to facilitate movement across estuaries. They are designed to allow exchange of water through culverts or by overtopping but, because they restrict movement of saline water upstream, they can decrease the size of estuaries. Commonly the foundations for the culverts are elevated so that the causeway acts as a low weir (Zeekoei and Jefferys Bay Estuaries). The closer the causeway to the mouth the more pronounced the consequences.

Bridges and embankments

Estuaries are in a continuous state of change as they respond to wide variations in river (e.g. floods and scouring) and sea (e.g. tides and storms) processes. All bridges and embankments alter hydraulic conditions thereby modifying patterns of flow, sedimentation and scouring. Because bridges and embankments are designed as permanent structures they disrupt water moving down estuaries and by changing the speed and direction of water flow (tidal and river), they alter the patterns of erosion and sedimentation both upstream and downstream. When constructed near the mouth they can stabilise the position of the mouth, interfering with the natural processes. It can also result in reduction in the area of the estuary (e.g. Swartkops Estuary). Potentially

adverse impacts may be minimised by reducing embankments to a minimum and elevating bridges to allow flood events to pass through unrestricted.

Bulkheads and channelisation

Channel meandering and switching are natural processes in estuaries on flat coastal plains. Development has not always taken cognisance of these processes, or of water levels associated with infrequent floods and storms, and as a result developments can be threatened by erosion. Legislation that regulates risky development (Chapter 7) is more strictly applied these days.

To protect developments at risk bulkheads, walls that are infilled on the landward side, are used to stabilise against erosion (e.g. Great Brak Estuary). They may also be constructed to facilitate access to an estuary by vehicles (e.g. Swartkops Estuary) and for boats. Gently sloping intertidal areas with soft substrates are commonly replaced with vertical walls constructed with solid material. The fauna and flora associated with habitats created by encroaching structures are quite different from fauna and flora associated with soft substrates (Chapter 3).

Channelisation occurs where bulkheads are constructed on both sides of an estuary. This is done to achieve one or more of the following conditions: the position of the channel is stabilised (e.g. Kowie Estuary); hydraulic resistance is reduced so that floods pass quickly out to sea thereby reducing inland flooding (e.g. Umlaas Estuary); pollutants are rapidly discharged into the sea; mouths are kept open and deep by confining and speeding up flows into and out of the estuary (e.g. Kowie Estuary). When carried out on a large scale channelisation permits construction of deep water harbours (e.g. Buffalo Estuary).

There is a complete range of variation from isolated bulkheads to complete channels in which sides and bottom are consolidated. The impacts vary accordingly. In some cases (e.g. Black and Papenkuils estuaries) estuarine habitats no longer exist and in others (e.g. Durban Bay) they are more typical of marine than estuarine habitats. When bulkheads extend out to sea to provide safe harbours the longshore transport of sand can be interrupted, causing beaches to erode.

Jetties

Jetties are walkways constructed on pylons. When they do not protrude too far into estuaries they have relatively little influence on the hydrodynamics of estuaries, although they can alter local patterns of erosion and sedimentation. Three common consequences of jetty construction are obstruction of boats, which can be hazardous at night; disruption of the natural character of the shoreline; and the 'privatisation' of public property so that access to the estuary and passage along its shore is illegally restricted. Written authorisation is required for the construction of jetties.

Boat house and jetty located on the Mngazana Estuary (Picture: Margaret McKenzie)

The harbour at Port Elizabeth on the canalised Baakens Estuary (Picture: Dirk van Driel)

The Port Alfred harbour on the Kowie Estuary provides moorings for boats used at sea and in the estuary (Picture: Dirk van Driel)

Encroaching structures continued
Harbours

Estuaries are favoured locations for harbour development because their natural physical features provide for maximum storm protection. Harbour construction and maintenance transforms estuaries, changing their physical form, water quality and ecological structure and functioning.

Harbours such as Durban and Richards Bay have lost most of their estuary properties and now function as extensions of the sea. Small remnants of estuarine conditions may persist where ground water seeps into the harbour (e.g. Saldanha) or when streams and rivers still flow into the harbour (e.g. Durban). In the planning and construction of Richards Bay harbour a part of the estuarine bay was cut off from the harbour development with an embankment which incorporated control gates to enable fresh water to be released into the harbour. A 'new mouth' was opened to maintain contact between the Umhlathuze River and the sea. Now all river borne sediment is trapped in the 'new estuary' and a vast mud bank is forming dramatically altering the condition of the estuary.

South African harbours are naturally shallow and need to be constantly dredged. This disrupts the habitat of benthic organisms (Chapter 3), and may release toxic substances into the water. Dredged material is usually dumped at sea.

Cargo handling (e.g. coal and iron ore), industrial operations (e.g. aluminium smelting and fish processing) and on-ship processes (e.g. refurbishment and maintenance) make it difficult to maintain high standards of water quality in harbours.

Despite losing much of their estuarine character, deep-water harbours are ecologically important. The small functioning estuarine components provide contact between populations of organisms up and down the coast thereby facilitating exchange of genetic material. Harbours also provide habitats that are important in the life cycles of marine organisms.

Marinas

Marinas are constructed to provide a lifestyle that is closely related to water. They, therefore, bring development and the associated activities into close contact with the aquatic system. The result is a completely transformed and unnatural landscape with significant ongoing impacts. The requirement for association with water is met by

developing waterways (canals) through low lying parts of the estuary (e.g. salt marshes at the Royal Alfred Marina) or adjacent low lying ground. Constructions are secured from erosion and flooding by stabilising canals with bulkheads and by using spoil to elevate stands.

The waterways can increase the shallow water component of estuary habitat suitable for macroalgae and rooted plants, and small animals (fish and invertebrates). The extent to which this happens is largely dependent upon the maintenance of adequate connection to the estuary to ensure acceptable flushing and water quality. Marinas can increase the tidal prism providing flushing and enhancing removal of marine sediment at the mouth. The hydraulic resistance in channels, and 'blind' channels can restrict flushing causing stagnant water conditions to develop. In some situations (e.g. Royal Alfred Marina) the design of the waterways enables increasing amounts of water to bypass the original course, significantly altering natural patterns of erosion and sedimentation in the canals and estuary. The consequences may be favourable for some and unfavourable for others.

The necessity for maintaining conditions suitable for boat traffic commonly requires that waterways are dredged and cleared of growth of aquatic plants. Both of these activities reduce the potential benefits associated with the extension of shallow water habitat.

Marinas increase and focus human activities on and adjacent to parts of estuaries. Deterioration of water quality is an inevitable consequence associated with the development of adjoining domestic properties (e.g. seepage of fertilisers and septic tank effluent), commercial properties (e.g. boat supplies, maintenance and refurbishment) and recreational activities (oil spills and waste discharge). Many of these sources of pollution are difficult to effectively control because of their diffuse nature.

Marinas typically privatise what were public assets. In so doing they reapportion rights, costs and benefits in ways which are not clearly evident. Consequently they become controversial.

Boats at Fanies Island, St Lucia
(Picture: Caroline Fox)

The breakwater at Laaiplek Estuary (Picture: CSIR)

Dredged spoil being discharged onto the beach at St Lucia (Picture: Ricky Taylor)

Dredger at the mouth of the St Lucia Estuary (Picture: Bruce Mann)

Dredging

Accumulated sediment in estuaries may only be removed (dredged) with authorisation of the appropriate government department concerned with environmental affairs or, in the case of sandwinning, with the Department of Minerals and Energy.

Although dredging mimics natural scouring it is a very disruptive process because of its impact on the sites from which material is removed and on those where spoil is disposed of. The costs and benefits of dredging should be considered carefully before decisions are taken. Under natural conditions sediments generally accumulate slowly and organisms are able to accommodate the changes in level and composition that arise.

Sudden erosion events are commonly associated with infrequent large floods. As with dredging, they are very disruptive of the physical and chemical environment. Recovery after dredging varies. It can be quick but it can also be very slow with some sites at St. Lucia showing little recovery after twenty years. This is partly attributable to a change in the physical structure of sediment remaining behind. Where coarse material is preferentially removed the fine unconsolidated material that remains forms an unsuitable habitat for benthic organisms.

Spoil dredged from deep water harbours can usually be disposed of at sea, where the adverse effects are minimised. In estuaries, however, the high costs of pump dredging usually restrict spoil disposal to adjoining land or into the surf zone (e.g. St Lucia and Royal Alfred Marina). Land and surf disposals are unsightly and can smother existing flora and fauna. Disposal on land can lead to salinisation of soil and seepage and release of toxic substances adsorbed onto dumped spoil.

Dredging attempts to establish and maintain a condition that is inconsistent with the processes shaping estuary structure and functioning, particularly when these have been modified by human activities. With the exception of sandwinning, dredging does not produce saleable products; rather it incurs the double costs of dredging and disposal which increase as spoil has to be pumped or transported greater distances. Under natural conditions river and tidal flow remove sediment to sea.

Harvesting living resources

Permits, issued in accordance with the Marine Living Resources Act (Chapter 7), regulate who may harvest a resource and how, when, where and how much may be harvested. Subsistence users are not exempt from permitting.

Estuary plant resources are seldom harvested or removed in South Africa. Exceptions are dense growths of submersed macrophytes that impede water circulation and boat traffic (e.g. marina waterways) and mangroves that have slow growing resistant timber suitable for construction (e.g. Mngazana Estuary) and building fish traps (e.g. Kosi Estuary). Since the overall productivity of estuaries is largely founded on plants (Chapter 3) their removal can have unexpected outcomes. For example, filter-feeding worms associated with the plant *Potamogeton pectinatus* in Sandvlei contribute very significantly to water clarity. Worm populations in Marina da Gama may, at times, filter a volume of water equivalent to that in the marina in about twenty-six hours.

Several species of invertebrate, particularly the mud and sand prawns, are harvested for bait. The physical effects of trampling and harvesting (digging and pumping) are considered to be more harmful than the reduction in standing stocks. Even when bait collecting is intense only a small portion of the population is harvested although the size of individuals remaining decreases. Scavengers (e.g. gulls) may take significant numbers of individuals after disturbance. Recovery from disturbance is slow with evidence persisting beyond eighteen months. Harvesting easily depletes populations of species such as the bloodworm and razorclam.

Many of the species harvested for consumption from estuaries (e.g. crabs, swimming prawns and fishes) require a marine phase for development (Chapter 3). Harvesting at sea can, therefore, also affect populations in estuaries. Over-exploitation has been considered the cause of declining commercial and recreational catches of the white steenbras, which used to be important in catches in the Swartkops and Sandvlei estuaries. The elf (shad), which was also abundant in these estuaries in the past, has now all but disappeared. It has only been through regulation of exploitation that populations of these species are recovering in the open sea.

Recreational anglers target preferred species such as the spotted grunter and the dusky kob. If numbers of anglers continue to grow and catches are not controlled one can envisage severely depleted estuary resources. The complex interdependence of physical, chemical and biological processes is such that an integrated, holistic approach is required when managing to remedy perceived problems with the harvesting of living resources

Fishing kraals at Kosi Bay Estuary (Picture: Bruce Mann)

Ncema, a rush that grows in estuaries, is valued in craftwork (Picture: Ricky Taylor)

Estuary mouth breaching

Artificial opening of estuary mouths is controlled by legislation (The Sea-Shore Act, 21 of 1935 and Section 21 of the National Water Act, 36 of 1998) and by local regulations. The natural tendency for estuaries to close (Chapter 3) is exacerbated by water flow modification and reduction so that closure occurs more frequently and for longer periods. High water levels disrupt access, flood dwellings and agricultural land, and may prevent proper operation of septic tanks and storm water discharges. These provide the principal motivations for opening the mouth.

The decision on when to open the estuary can be contentious. Local authorities and property owners prefer to open the mouth at relatively low water levels. Those concerned about maintaining ecological integrity prefer to open the mouth when water levels are high. A trade off between these two positions has to be made as artificial breaching can have serious long term consequences.

Strong outflows are the principal mechanism for removing sand transported into estuaries by flood tides. The higher the water level at the time of breaching the greater the scour, particularly if this is timed to coincide with a period of high river inflow caused by either rainfall or a release from an upstream impoundment (e.g. Groot Brak Estuary). At small estuaries which can easily close at neap tide, breaching 3 to 4 days before springtide will result in good tidal exchange at the next springtide. Ineffective scouring results in marine sand moving further and further into the estuary (4km in Klein Rivier at Hermanus).

Good scour lengthens the period of contact between the estuary and the sea. This improves prospects for successful breeding and recruitment of estuary fauna that have an obligate marine requirement (Chapter 3).

To simulate natural cycles as closely as possible breaching should occur in late winter/early spring. When the mouth is breached sudden lowering of the water level can have dramatic consequences as large parts of the basin become exposed with high mortalities of vegetation and associated fauna. Recovery can be very slow with waterbirds taking up to three years to return to pre-breaching populations in the highly modified Bot River system.

The National Water Act (Chapter 7) espouses an integrated approach to water resources (including habitat) management. Regulations are, however, site specific. Local guidelines for breaching have been established in some places. At Swartvlei the breaching level has been set at two metres above mean sea level, but this can be altered under situations of high risk (high lake level with rain). A level of just over two metres has been set for the Klein River Estuary. At Groot Brak a checklist of condition assessments informs decisions about mouth breaching and release of fresh water from the Wolwedans Dam (Chapter 6.)

Peripheral development and recreation

The impacts of development occurring around or away from an estuary can be profound. A distant upstream impoundment (e.g. the Wolwedans Dam on the Great Brak River) or local urban development affect the structure, functioning and sense of place associated with the estuary. Most major developments, such as construction of sewage works, are subject to environmental impact assessments and to authorisation from national and/or provincial government. Municipal councils largely control local urban expansion and environmental impact assessments, although

always desirable, are not always a requirement. The result is that 'creeping development' within the visual catchment of estuaries gradually erodes the natural character of these systems.

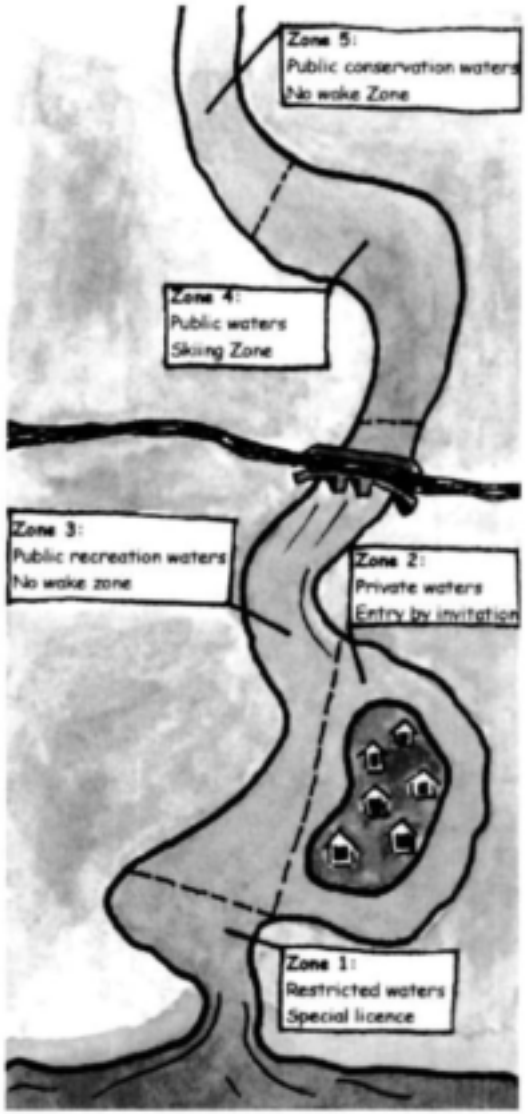
Local councils are required to construct Integrated Development Plans, and to update them regularly. Because the goods and services society derives from estuaries (e.g. fish, storm water discharge and recreation) are free, normally requiring little or no financial investment, they are commonly undervalued. This causes them not to be given appropriate consideration in development planning. Effective management (Chapter 5) is a pre-requisite for regulating the undesired consequences of peripheral development.

Estuaries provide a range of opportunities for recreation. These vary in accordance with the type of estuary and its condition at any time. Because of their location at the interface of land and sea the conditions change over short time scales (e.g. tidal cycles), medium time scales (e.g. seasonal) and long term (e.g. episodic flood events). Conditions also change up and down the estuary creating conditions favourable for some activities and not others.

Recreational activities are not always compatible. Equitable access to opportunities is achieved by defining which activities may occur when and where (zoning space and time for use). Transparency is facilitated by establishing common goals through a participative process (Chapter 5).

Regulating the extent of use within the defined spatial and temporal zones safeguards the quality of recreational experience. This is commonly referred to as the carrying capacity. These can also vary in time and space allowing for natural cycles (e.g. waterfowl breeding) and human cycles (e.g. annual regattas).

Successful recreation management requires clearly articulated policies, goals and practices that have public support (Chapter 5).



An example of recreational zoning
(Illustration: Lauren Glennie)

KEY ISSUES

- Impaired estuaries become a costly burden and a source of conflict
- The quality of interactions between people determines success
- Do not underestimate the challenge of management
- Grasp the opportunity and accept responsibility
- Trust, loyalty, pride and commitment are necessary
- Develop and maintain an estuary management plan

The challenge of managing the Mtentu estuary is conserving the natural beauty and at the same time providing benefits to the local community
(Picture: Margaret McKenzie)

WHY MANAGE ESTUARIES?

In a healthy state, estuaries continuously provide a variety of goods and services valued by society (Chapter 2). Mostly, these (e.g. fish and recreational opportunities) arise at little or no cost. However, in an unhealthy state (e.g. when polluted), estuaries become a costly burden as ongoing remedial action is required to achieve acceptable conditions. Maintaining a healthy state requires continuous intervention in order to regulate the consequences of human activities (Chapter 4) and to adapt use to changing needs and circumstances.

Because different users have different requirements they do not always share a common view of what constitutes a healthy estuary; or how it should be managed. Differences can be resolved only where all user groups strive to appreciate and accommodate the reasonable needs of all. All interested parties need to collaborate to manage use of estuaries for the greatest sustainable benefit for society. Who are these parties and how do they organise and operate to achieve their vision of a healthy estuary? The South African Constitution and supporting legislation promotes public participation in management of natural resources.

CO-OPERATIVE GOVERNANCE

Estuaries are public assets for which the elected government has ultimate responsibility. The intention of government is to promote partnerships in management between the regulators (government at all levels) and the regulated, the people who make use of the goods and services of, in this case, estuaries. The strength of such a partnership reflects the extent to which estuary stakeholders are able to contribute constructively to envisioning and attaining the preferred state of the estuary. The stakeholders need to be organised and recognised by government if they are to exert meaningful influence. Constitution of estuary management forums provides an organisational entity with which government can engage.

Estuary management forums may be formally constituted (e.g. as a sub-committee of a local authority; or as part of a coastal forum) or they can be citizens' action groups. Whatever their form they should strive to represent a meaningful constituency and should promote sound planning and management of the estuary and its surrounds. They should also contribute to monitoring and regular reporting. These cannot be achieved until the forum has linkages with other parties and engages constructive communication with them.

COASTAL MANAGEMENT INSTITUTIONS

The White Paper for Sustainable Coastal Development sets out an institutional framework for coastal management in South Africa. The institutional framework is described below.

National Coastal Management Sub-committee

At a national level the White Paper recommends the establishment of a Coastal Management Sub-committee of the Committee for Environmental Co-ordination. This sub-committee, chaired by the Department of Environmental Affairs and Tourism's Marine and Coastal Management Chief Directorate, is responsible for co-ordinating the implementation of the national coastal policy.

Provincial coastal working groups

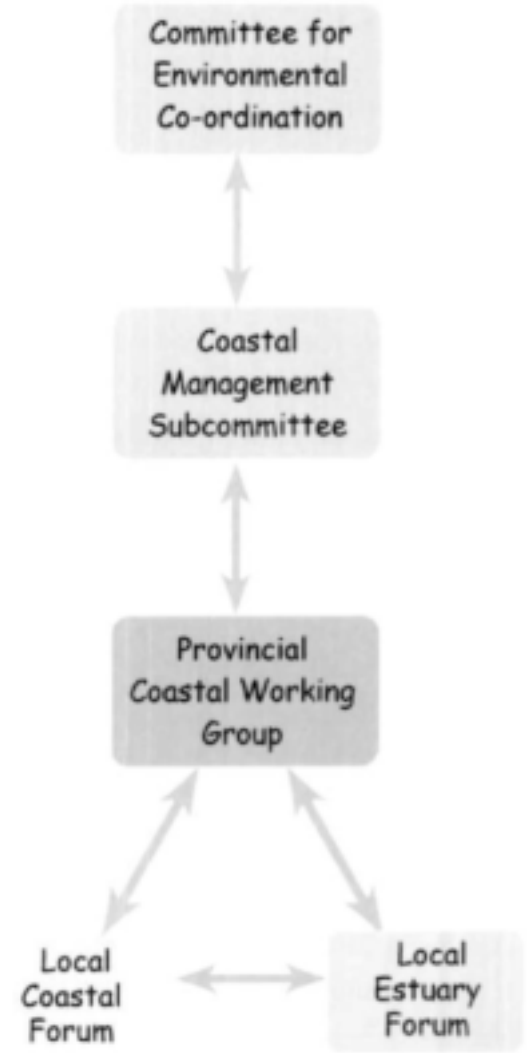
The White Paper also recommends that provincial coastal working groups be established in each of the coastal provinces. These working groups will report to the coastal management sub-committee. The purposes of coastal working groups are to advise the provincial department with responsibility for coastal management and to facilitate dialogue, co-operation, co-ordination and integration between coastal role-players.

Local coastal forums

In the long term the policy aims to establish local coastal forums throughout the coast. These will facilitate dialogues between local coastal role-players and advise local authorities. They could also become involved in management and decision making regarding coastal resources, including estuaries.

Estuary management forums

An estuary management interest group or forum provides a structure for people with common interests, the estuary and a shared vision of what it should be like, to engage and contribute to planning and management at the local level. The linkages through coastal forums and working groups to the national coastal management sub-committee provide for integration so that local actions contribute to attainment of national objectives. It goes without saying that such a forum or interest group would have little legitimacy if it did not foster participation, so as to adequately reflect the diversity of opinions and perspectives surrounding the use of estuaries.



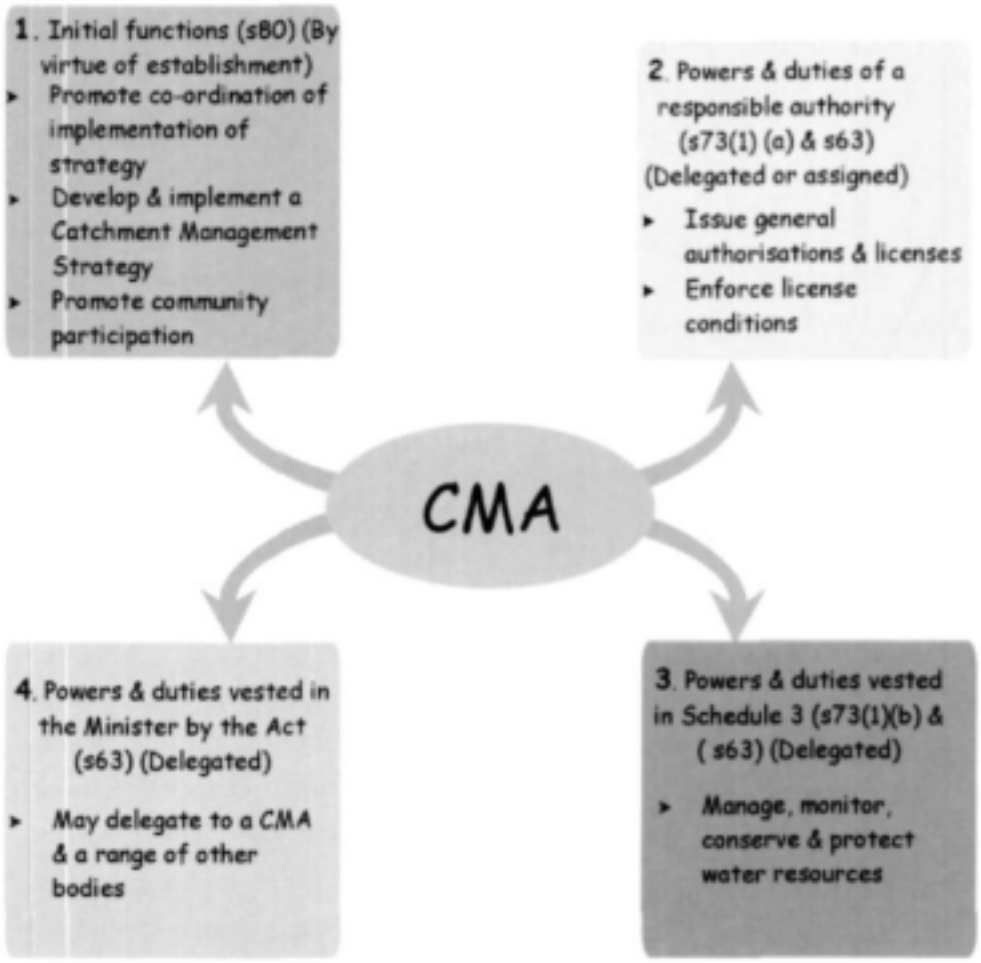
Coastal Management Institutions
(Illustration: Lauren Glennie)

WATER MANAGEMENT INSTITUTIONS

The National Water Act establishes a number of water management institutions that have roles to play in the management of estuaries. The various institutions are described below.

Catchment Management Agencies

Nineteen water management areas have been designated. For each of them there will be a Catchment Management Agency (CMA) answerable to a Board appointed by the minister and whose membership must be broadly representative. A CMA manages water resources within its water management area. Amongst other requirements (Figure) it must develop and implement a catchment management strategy for the water resources that is in harmony with the National Water Resource Strategy. This must also be done in a manner that secures cooperation and agreement from stakeholders and interested persons. Because of the size of water management areas, and the complexity of achieving equitable and efficient use, statutory and non-statutory bodies assist in the process. CMAs are funded from water use charges. A catchment management strategy and a water allocation plan would be incomplete if estuaries were not addressed specifically.



Powers, functions and duties of the Catchment Management Agencies (Illustration: Lauren Glennie)

Water User Associations

Water User Associations (WUAs) are statutory bodies which may be established for any form of water use including:

- taking and using water for irrigation purposes on a commercial or subsistence scale and supply of water for domestic, industrial and municipal use;
- stream flow reduction activities (e.g. afforestation);
- treatment of effluent and waste and its disposal;
- control of the use of water for recreational and/or environmental purposes.

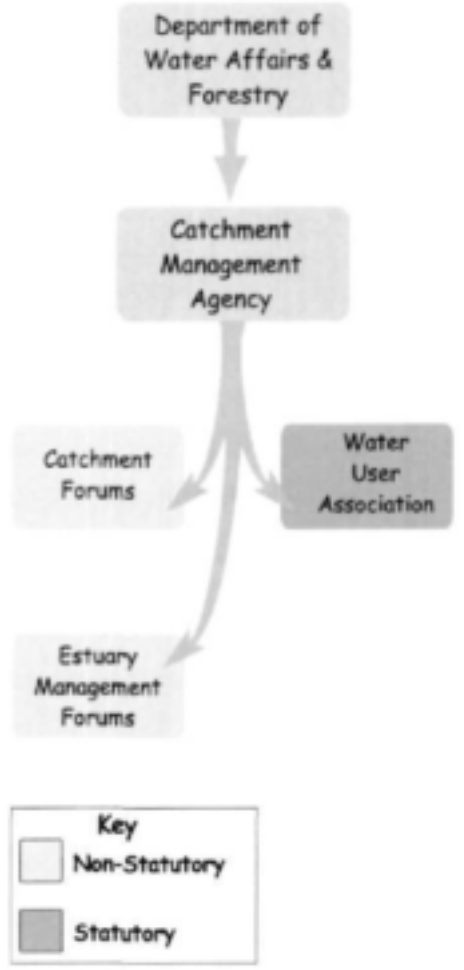
A WUA is a body corporate with a management committee directly accountable to its members and broadly accountable to the minister or to the CMA, if the minister has delegated responsibility. The CMA is the key water resource management institution in a water management area. WUAs assist in the implementation of the catchment management strategy at a local level.

The broad role of a WUA is to enable people within a community to pool their resources (money, human resources and expertise) to more effectively carry out water related activities. Members will benefit from addressing local needs and priorities. WUAs will normally be funded through water use charges levied on members. Establishment of a WUA is only possible if members are able to pay for or raise the operation and maintenance costs of any capital works and for the full administrative costs.

Catchment forums

The National Water Act places considerable emphasis on public participation and cooperative governance. It is desirable, therefore, that stakeholders who share a common interest or concern, or who have interests in a particular area, should be able to develop and articulate their interests and concerns in an orderly and constructive manner. This would enable stakeholders to participate actively in cooperative governance.

Interest groups or forums of this type commonly emerge spontaneously. Some endure indefinitely whereas others arise around an issue and disappear once the issue is resolved. These organisations are the most active centres of participation by civil society in governance at local levels. Without these local people have little power to influence planning and actions which affect them. Because these forums are established by civil society to serve their own interests, they are non statutory. Their management structures are accountable to their members and they are self funded.



Water Management Institutions
(Illustration: Lauren Glennie)

Management process

We live in a world of continuing change because we strive to change the way things are and because nature is never constant. Our ability to foresee change and adapt our actions timeously determines whether we set and achieve realistic goals. Management, therefore, is a continuing, self-informing process in which a conscious attempt is made to prepare for change (strategic adaptive management).

Strategic adaptive management requires that we define a preferred state (condition) for the estuary. This is a state we could reasonably expect to achieve and maintain given present circumstances, our perceptions of changes which lie ahead, and our ability and capacity to influence the direction and form of change. As we implement actions to achieve our preferred state, and as the effects of other people's actions in the catchments (land and sea) become evident, it will be necessary to reassess the realism of our preferred state.

Estuaries provide a stream of diverse goods and services (Chapter 2) for people with quite different interests. As individuals and groups strive to maximise their benefit, different views on the preferred state of the estuary usually arise. These different views have to be reconciled so that actions can be aligned and become mutually supportive in promoting attainment of preferred state. Management must be a participative, transparent process supported with information and technology.

Vision

The starting point for the management process is construction of a shared vision of the preferred state. A vision is a mental picture of something. This picture could be of how the estuary will look in years to come.

For a vision to have a guiding effect on the actions of many people those people must share the vision so that their actions can be aligned to the same target. Once expectations and actions are aligned conflicts are reduced and visits to the estuary become enjoyable and safe for all.

It is easier to achieve consensus around general principles than around specifics touching individual interests. A shared vision is therefore founded on common values (including ethics and morality) held by the stakeholders. It is the most generalised statement of intent. Despite this, it is extremely important, serving as a rallying point and a reference standard against which the more defined statements of intent (goals and objectives) must be aligned.

Goals

If the vision is thought of as the guiding star the goals are some of the major milestones that the stakeholders need to work towards en route to that star (vision). The goals are phrased in more specific terms than the vision but in more general terms than the objectives.

The key words in the vision statement can be used to develop the goals. This ensures that the goals support attainment of the shared vision. Goals are precise statements of what stakeholders intend to achieve.

They must be realistically achievable given prevailing circumstances, likely future scenarios and the resources (expertise, technology and financial) which can be mobilised. Because circumstances change continuously, goals should also be achievable within a defined period that is related to the capacity we have to effect and/or regulate change.

Objectives

Objectives are smaller milestones along the path towards the goals. Ideally each goal should be supported by 3 to 5 objectives with time horizons of 6 months to a year to achieve. The objectives are phrased in specific terms. It is tempting to establish more goals and objectives than we are able to engage effectively. Failure to engage them leads to frustration and disillusionment and, ultimately the collapse of the management process.

Proposing and implementing actions

The next step is to decide on which actions should be implemented. Actions are the most detailed level of activity specified in the plan. Actions are documented in very specific terms, even to the point of who must do them, when and with what resources. They have a time horizon of weeks or months.

Monitoring the consequences of actions

If we implement an action successfully the probable outcome is that we will achieve our objective; if we achieve our objectives we should achieve our goal; if we achieve our goals we would be promoting attainment of our vision. If we do not measure the consequences of the actions we implement, and those which we fail to implement, we have no way of learning and enhancing our wisdom about estuary structure, functioning and use. At best we may continue to make the same mistake and waste resources, at worst we may implement actions which move us increasingly further from our vision.

Auditing progress

Unless we can measure progress towards attaining an objective, there is no point in having it. This requires us to establish indicators that we can measure at appropriate intervals and end locations (Chapter 6). We must also periodically conduct a comprehensive analysis (an audit) so that we can assess progress towards attaining the vision.

The estuary management planning process (Illustration: Lauren Glennie)

Estuary stakeholders engaging in estuary management discussions and planning
(Pictures: Margaret McKenzie and Charles Breen)

PROPERTIES OF SUCCESSFUL MANAGEMENT

Integration

Estuaries are complex in their structure and functioning (Chapter 3), in the way goods and services are used (Chapter 2) and in the cascading effects of disturbance (natural and human: Chapter 4). In addition, estuaries are, in most cases, state property and as such are viewed as public assets over which civil society (local, national and even global) is able to exert influence. It is inconceivable that such interrelated systems can be divided into discrete compartments that are managed in isolation from one another. We have to accept the complex interelatedness of estuaries and learn to manage accordingly.

Integration has more to do with how we do things than with what we do. It requires us to focus on the bigger picture, the greater good, and to align what we do with it. Consequently, if we are practising integration we strive to identify and do what needs to be done rather than to persuade others to let us do what we want to do.

Integration is not easy and it does not happen naturally, but it is an essential ingredient for success. We have to work at it to make it happen.

Access to goods and services

The South African Constitution, supported by legislation, makes provision for equitable access to the benefits and sharing of costs associated with the use of resources, including estuaries. Since supply may not satisfy demand and not all uses are compatible (Chapter 2), resources have to be allocated through a participative, transparent and equitable process. Interactions between people lie at the heart of equitable allocations, which result in safe, efficient and sustainable use as required by law (Chapter 7). Because estuaries require an assured supply of fresh water that derives at a distance from the estuary, negotiations have also to engage people in the catchment.

In complex and uncertain circumstances, such as surround the use of estuaries, absolute rights to goods and services are exceptionally difficult to establish. Conflicting parties therefore generally decide to negotiate access and use in terms of their interests, but still within the parameters of the law.

Interest based bargaining and aligning of uses does not mean the removal of tension and functional conflict between parties. The tension

and conflict should centre on issues and not people, and should be managed to improve understanding and support responsible practices.

Influence and relationships

Legislation (Chapter 7) requires co-operative governance and this applies to management of water resources, rivers and estuaries. Neither the state nor any other single body will be able to succeed in managing estuaries or catchments by command and control or by coercion and reward. No single body has jurisdiction over all the components of the system that affect the state and functioning of catchments and the estuaries which they feed.

The complexity of forces of change deriving from the land, the sea and the estuary, with its diverse users, creates conditions for conflict and confusion. Estuary management, consequently, has as much to do with managing the interactions between people as it has with managing the impact of their activities.

The implications of this are profound because decisions on estuary management will reflect the extent of influence one has, and the strength of relationships between individuals and organisations. Building relationships and influence are essential skills in the new approach to managing the use of resources. The purpose of expanding influence and building relationships is to help others promote their interests and achieve their goals whilst addressing personal and own organisation interests and goals.

Relationships founded on trust are a prerequisite for managing complex systems whether they are estuaries, cities or oil refineries.

Knowledge

We cannot harness experience and anticipate the future unless we manage knowledge. Experience and knowledge are personal; they are attributes of individuals. Until we share them we cannot benefit from the store of knowledge we have, and the speed with which we develop the insight necessary to manage in a changing world is retarded. The technology for communication, particularly computers, has advanced much more rapidly than has our communication behaviour. It is now possible to share experience and knowledge and to develop new insights in a collective way such that widely separated organisations and individuals can co-operate for the common good. This can be achieved with a culture of knowledge sharing in which due attention is directed towards building and sustaining relationships.

We make decisions in order to influence the future. Since the future is unknown and unknowable, our decisions are always founded on our wisdom (experience, knowledge and insight). As the future unfolds we have to evaluate our assumptions and thereby generate new wisdom.

Estuary stakeholders engaging in estuary management discussions and planning (Picture: Margaret McKenzie)

KEY ISSUES

- Manage for the future rather than the present
- Strive to keep options open
- Set measurable, achievable goals and audit progress
- Share information and knowledge
- Support the national requirements for environmental reporting
- Act on monitoring information

Researchers monitoring fish in the Mtata Estuary
(Picture: Alan Whitfield)

WHY MONITOR ESTUARIES?

Monitoring is a means to an end. It comprises the actions we take on a regular basis in order to determine whether we are progressing towards meeting our objectives, goals and vision. Because it is purposeful, monitoring must be tailored to develop the understanding and to supply the information required for decision making. Every monitoring action should have a clear purpose and a defined target. Because monitoring incurs ongoing cost it can turn out to be very expensive. The design and operation of monitoring programmes should be considered carefully to ensure affordability and effectiveness in decision making.

National Water Act

Monitoring is required by legislation. The National Water Act specifies in Section 137 (1) that the Minister of Water Affairs and Forestry must establish national monitoring systems; and Section 139 (1) requires establishment of national information systems, such as a system to monitor the quantity and quality of all water resources. It also specifies that the information from such systems should be generally accessible to water users and the general public. Section 145 (2) goes further, mandating the minister to establish early warning systems for risks posed by various events including deterioration of water quality.

Provision is made in the Act for designating estuaries into Ecological Management Classes that reflect the preferred, achievable ecological state. This enables determination of the amount and quality of fresh water required to sustain an estuary in the defined ecological state. The most pristine (least disturbed) state is designated Class A and the most degraded and requiring rehabilitation is Class D. The class establishes the target and a monitoring programme designed to enable us to check that the necessary procedures, practices, time frames, resources and targets are being followed and achieved.

White Paper for Sustainable Coastal Development

The National Department of Environmental Affairs and Tourism is the lead department for coastal development. The White Paper for Sustainable Coastal Development in South Africa states that 'Each provincial lead department will assist, in the short term, in investigating the needs and current capacity of their province in terms of monitoring, in consultation with ...role players who currently are, or could in the future be,

involved in monitoring initiatives.' In the medium term in order to meet their requirements for State of the Environment and Agenda 21 reporting, they will develop guidelines for monitoring, and set standards, norms and coastal performance indicators. It is further stated that "A focus should be on monitoring the priority issues identified for implementation, for example protected areas, estuary management or coastal tourism, leisure and recreation."

The intention in the longer term is that "Over time, the capacity of local authorities to undertake monitoring will be developed, together with stakeholder groupings and local coastal forums where appropriate." In order to be able to do this the national Department of Environmental Affairs and Tourism, working with provincial lead departments, will develop a coastal information and decision system to assist coastal managers at national, provincial and local levels.

Development Facilitation Act

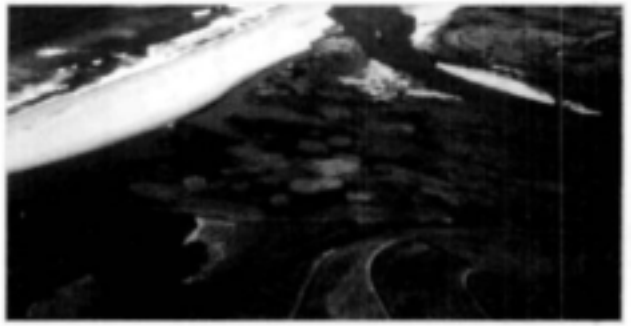
This Act (67 of 1995) requires that 'Land Development Objectives' should be developed by every local authority in provinces where the Act has been adopted. These objectives must address, amongst other things, how the environment will be used in a sustainable way and how natural resources should be optimally used. To achieve management that promotes optimal sustainable use of natural resources local authorities that have jurisdiction over estuaries, should consider their estuaries and their current state in the formulation of Land Development Objectives.

Local Government Transition Act

Act 209 of 1993 requires municipalities to draw up Integrated Development Plans. These are defined as a plan aimed at the integrated development and management of the area of jurisdiction. Municipalities are required to regularly monitor and assess their performances against their plans. Estuaries would form an integral part of such plans where they occur within the area of jurisdiction.

Implications

Policy and legislation make provision for cooperative governance (Chapter 7). Civil society, if properly organised, is able to engage government, at various levels, in order to establish the preferred ecological state (Class) and to monitor and support its attainment.



It is important to define and strive to maintain a preferred ecological state – Mvoti Estuary (Picture: Charles Breen)

Andrew Lucas from the Department of Water Affairs and Forestry sampling the upper reaches of the Mzamba Estuary for cholera (Picture: Margaret McKenzie)

DECIDING WHAT TO MONITOR

The purpose of monitoring is to enable society to establish whether actual state conforms with preferred state (the management class) and if necessary, to identify and implement remedial actions.

The apportionment of benefits and costs deriving from the estuary (Chapter 2) shapes individual and societal perceptions of whether actual state conforms with preferred state. It is the reapportionment of benefits and costs that one strives to achieve when directing change towards the state enunciated by the shared vision, goals and objectives (Chapter 5). It is, therefore, essential to establish and monitor the delivery of goods and services and how costs and benefits are apportioned (Box 1 in Figure opposite).

The extent and manner in which goods and services are used determines the impact use has on the structure and functioning of the estuary; in other words on its state. It is necessary to define the uses and describe and measure the impacts arising from these uses (Box 2 in Figure). By monitoring these one is able to identify causal factors modifying structure and functioning. Regulating use (how much, when and where) enables us to mitigate the impacts so that use does not detract from achieving the preferred state defined by the vision, goals and objectives.

The goods and services an estuary can supply sustainably reflect its physical, chemical and biological attributes (Box 3 in Figure). For example the size and shape of the water surface and depth determine what sorts of craft can be used and how many may be accommodated at any time. This, in turn, determines the types of activities that can occur and thereby who gains which benefit from the system. People, who do not engage in some of these activities and are therefore not beneficiaries, may bear costs (e.g. noise pollution) or disruption of other activities for which they are beneficiaries (e.g. bird watching). Monitoring attributes, which have a tangible link to use, enables us to establish causal links with both impacts and perceptions of users. This improves cost effectiveness and efficiency of monitoring.

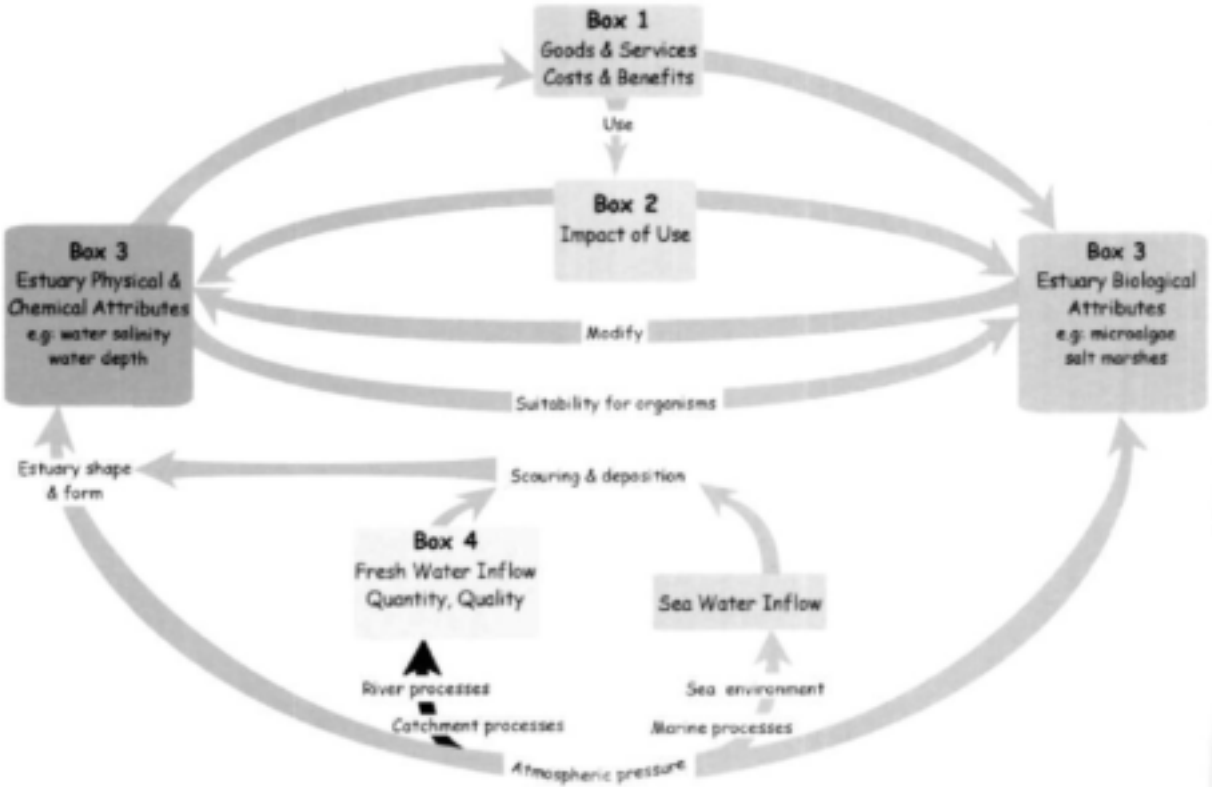
Attributes which have links to use are not always the most suitable indicators of the 'health' of an estuary. For example salinity (Chapter 3) and aquatic plants may have little direct relevance to use, but they are important indicators (vital signs) of the suitability of the estuary for biota (salinity) and of production potential (aquatic plants). Circumspection is necessary when choosing indicators to ensure that the information gathered can inform decision making, and that monitoring is affordable. Composite indicators, which can assist, are considered later.

The legal requirement of the National Water Act (Chapter 7) to supply the environmental reserve (Box 4 in Figure) makes it imperative that the quality, quantity and timing of fresh water flows to the estuary are monitored. When choosing which physical, chemical and biological attributes should be monitored it is necessary to also consider how these respond to and reflect both fresh water and sea water inflow.

Estuaries change continuously in response to what we do to them and to forces, such as climate, over which we have little influence. Monitoring should, therefore, enable us to distinguish between background changes and those superimposed on estuaries by human pressures, which are amenable to control. Failure to make this distinction causes us to attempt to confine change to narrow limits, instead of allowing for natural fluctuation in state.

Deviation is inevitable and it is necessary to distinguish between acceptable and unacceptable deviation from the reference state ie. the management class set by the Department of of Water Affairs and Forestry in consultation with stakeholders. Change should be allowed to occur until it reaches a level (threshold) at which we feel there is cause for concern and reason to consider corrective action. It is necessary to acknowledge that natural forces may ultimately result in a state different from that which is currently perceived to be desirable.

People are not always aware of the consequences of their actions. Tracks across a saltmarsh at Knysna
(Picture: Janine Adams)



MAKING MONITORING WORK

Monitoring is useful if it helps us make better decisions. If we link it to decision-making in a two way process, information and emerging understanding are fed into decision making, and monitoring receives feedback, then it can be reorganised and restructured to accommodate strategic adaptive management (Chapter 5). Monitoring is as much concerned with communication as it is with measurement. A structured approach is necessary to promote cost effectiveness and indicators should be carefully selected after considering at least the points in the adjacent table.

Examples illustrating the application of this system for monitoring are set out on the following pages.

- what are we trying to assess? Examples are the environmental water reserve; ecosystem health; distribution of costs and benefits and aesthetic quality;
- which indexes will we measure? We need to identify those which are easiest to measure yet which will give us the necessary insight;
- what standards and/or targets have been established for the indicator?;
- why are we monitoring? We must specify whether it is a legal requirement and/or to improve understanding;
- for whom is monitoring being conducted? It could be one or more of government departments, local authorities and civil organisations;
- where are the indicators to be measured? Estuaries are very variable in space and time. Locations of sampling sites must be clearly defined;
- when must samples be taken? This may vary from the time of day, through seasonal changes which arise slowly or infrequently (large floods) over many years;
- how will the indicator be measured? The techniques to be used for sampling, measuring and analysis must be stated;
- who will be responsible for providing the resources (personnel, equipment and finance) for conducting the sampling and analysis and for interpretation and reporting?;
- in what format and with what frequency is reporting required?;
- who must prepare the reports and to whom should they be submitted?;
- what sort of decision responses are anticipated and who is responsible for them?;
- who should receive feedback and who is responsible for this?;
- should the monitoring programme require revision, who is responsible for ensuring that this happens and that the revised system is implemented?;

Example 1: For a particular estuary, stakeholders have agreed that the natural indigenous character of the estuary should predominate within the skyline for the middle and upper reaches of the estuary.

What are we trying to assess?	Landscape change.
Which indicator will we measure?	1. Visible[1] physical development 2. Visible vegetation transformation (structure and composition).
What standards and/or targets have been established for the indicator?	1. Visible physical development: a visible physical development with at least a medium degree of incompatibility will be considered to be cause for concern. 2. Visible vegetation transformation: a visible vegetation transformation with at least a medium degree of inappropriate transformation will be considered to be cause for concern.
Why are we monitoring?	We are monitoring to ensure that the natural character of the estuary predominates within the skyline for the middle and upper reaches of the estuary.
For whom is monitoring being conducted?	For the estuary management forum, for the planning authority, for the Provincial agriculture and environment departments.
Where are the indicators to be measured?	Within the visual basin of the middle and upper reaches of the estuary.
When must samples be taken?	Monthly, within the first week.
How will the indicator be measured?	1. All development proposals which may impact on the visual catchment will be scrutinised. 2. Visible physical development: Any visible physical development will be noted and rated for degree of obtrusiveness (score between 1 and 10)[2] 3. Visible vegetation transformation: Any visible vegetation transformation will be noted and rated for degree of obtrusiveness (score between 1 and 10)[2]. If a cause for the vegetation transformation is discernible it should also be noted.
Who will be responsible for providing the resources?	The estuary management forum.
In what format and with what frequency is reporting required?	Monthly situation report. When visible physical development and vegetation transformation are noted, a report will be compiled that notes all incidents recorded, their score and their approximate location (where possible the identification and ownership of the plot of land concerned will be recorded).
Who must prepare the reports and to whom should they be submitted?	A designated member of the estuary management forum will undertake the monitoring and prepare the reports. The reports will be submitted to the estuary management forum. When there is concern the reports will be submitted to relevant authorities.
What sort of decision responses are anticipated and who is responsible for them?	Where an incident has scored 5 or more, a designated member of the estuary management forum will investigate further. If the physical development or vegetation transformation was the result of an illegal action a formal complaint will be made to the relevant authorities and requests for legal sanction will be made. If the cause of the physical development or vegetation transformation was legally sanctioned, the rationale for the decision to sanction the event will be investigated and, where appropriate, submissions will be made to the authority concerned to change its policy. The estuary management forum should endorse any action taken.
Who should receive feedback and who is responsible for this?	The estuary management forum will receive feedback from the designated member of the forum.
Should the monitoring programme require revision, who is responsible?	The estuary management forum will review the monitoring programme on annual basis and implement revisions if required.

1 In this context visible means anything that can be seen from a boat on the estuary

2 A score of 1 will indicate that something is visible, but is compatible with the natural character of the estuary. A score of 10 will indicate very high visibility and total incompatibility with the natural character. A score of 5 or above should be considered to require action.

Example 2: For a particular estuary, stakeholders have agreed that breaching of the mouth should be managed to optimise the balance between protection of infrastructure and maintenance of biodiversity.

What are we trying to assess?	Risk to infrastructure and biodiversity.
Which indicators will we measure?	1. Water level 2. Mouth condition 3. Water Quality 4. Salinity 5. Fish death
What standards and/or targets have been established for the indicator?	1. Water level: less than +2 MSL. 2. Mouth condition: open or closed. 3. Water quality: bad smell/excessive algal growth, coliform bacteria less than 1000 per ml. 4. Salinity: more than 7 and less than 40 parts per thousand. 5. Fish deaths: gaping at surface and/or deaths.
Why are we monitoring?	We are monitoring to determine when to breach the mouth.
For whom is monitoring being conducted?	For the estuary management forum, for the local council, the Catchment Management Agency, the Departments of Water Affairs and Forestry and Land Affairs.
Where are the indicators to be measured?	Water level at the gauging station on the bridge; mouth condition at mouth; water quality, salinity and fish deaths at three stations: first bridge, the wreck and Jim's jetty.
When must samples be taken?	Monthly in the second week and daily for a week after breaching.
How will the indicators be measured?	1. Water level: from the gauging plate. 2. Mouth condition: visually. 3. Water quality: subsurface samples for analysis by Analytical Services Department; algae and smell by direct observation. 4. Fish deaths : direct observation and counts of dead fish over 20m of shoreline at each site. 5. Month : record.
Who will be responsible for providing the resources?	Municipality: staff, boat and transport; heavy equipment and operator to breach mouth. Department of Health: water quality, equipment and analysis. Estuary Management Forum: supervision of breaching and collation of results and reporting.
In what format and with what frequency is reporting requested?	Monthly, within two weeks of sampling and one month after breaching. In the format agreed with the Department of Water Affairs and Forestry.
Who must prepare the reports and to whom should they be submitted?	The designated member of the Estuary Management Forum. Reports to be submitted to Town Clerk, Department of Water Affairs and Forestry and Provincial Environment Affairs Department.
What sorts of decision responses are anticipated and who is responsible for them?	1. A decision on whether or not to breach the mouth, with a record of the decision. 2. A decision on release of water from the Amanzi impoundment upstream. 3. Authorisation and instructions for breaching and release of water. 4. Instructions to designated forum members to supervise.
Who should receive feedback and who is responsible for this?	The designated member of the forum will report back to the Catchment Management Agency, municipality, Department of Water Affairs, the Provincial Environment Affairs Department and the forum.
Should the monitoring programme require revision, who is responsible?	The estuary management forum will review monitoring as it relates to mouth breaching at least once a year, and will be responsible for ensuring that, if necessary, a revised monitoring programme is developed with, and adopted by stakeholders.

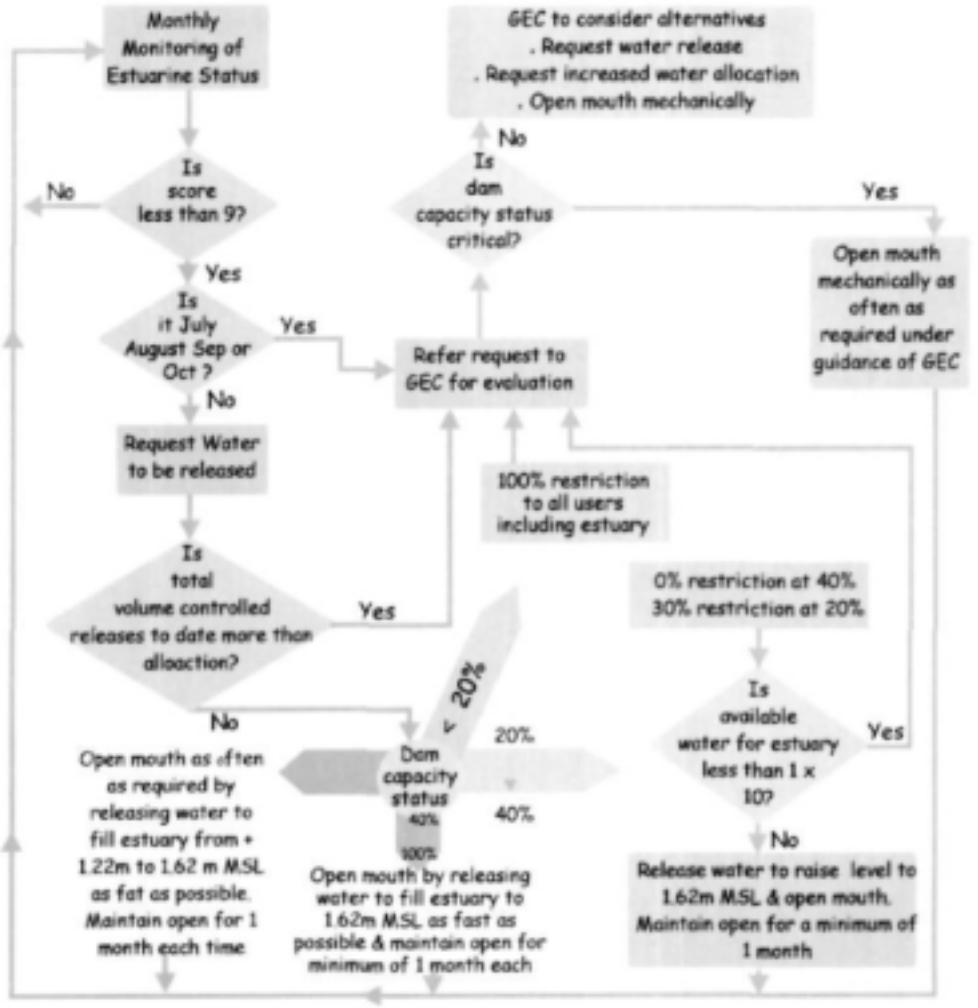
Linking monitoring and decision making: an example

The Wolwedans Dam was built upstream from the Great Brak Estuary, to supply fresh water to the Mossgas Refinery at Mossel Bay.

A monitoring and management programme was established to continually assess impacts on the estuary, and to assist in determining if the estuary mouth should be breached. The checklist and diagram were initally compiled for this programme to guide management actions. The programme has been strongly modified over the past ten years and a comprehensive review will be undertaken in the future.

The monitoring and management programme is widely regarded as a success. This can be attributed to the close link between monitoring and management action.

Criteria	Score	
	Yes	No
Is the mouth open?	2	0
Is the estuary water level less than + 1.22 MSL?	2	0
Is there a bad smell and/or excessive algal growth in the water?	0	1
Is the E coli level less than 1000?	2	0
Is the salinity more than 7 and less than 40?	2	0
Are the fish dying under stress eg. Gaping at the surface for air?	0	2
Is it February?	-1	0
Is it June?	-1	0
Is it November	-2	0



Some indices in current use

Indices provide a framework for gathering and presenting monitoring information so that it is easily comprehended and used for decision making. They simplify complex scientific information and provide insight into change so that remedial action can be designed and implemented.

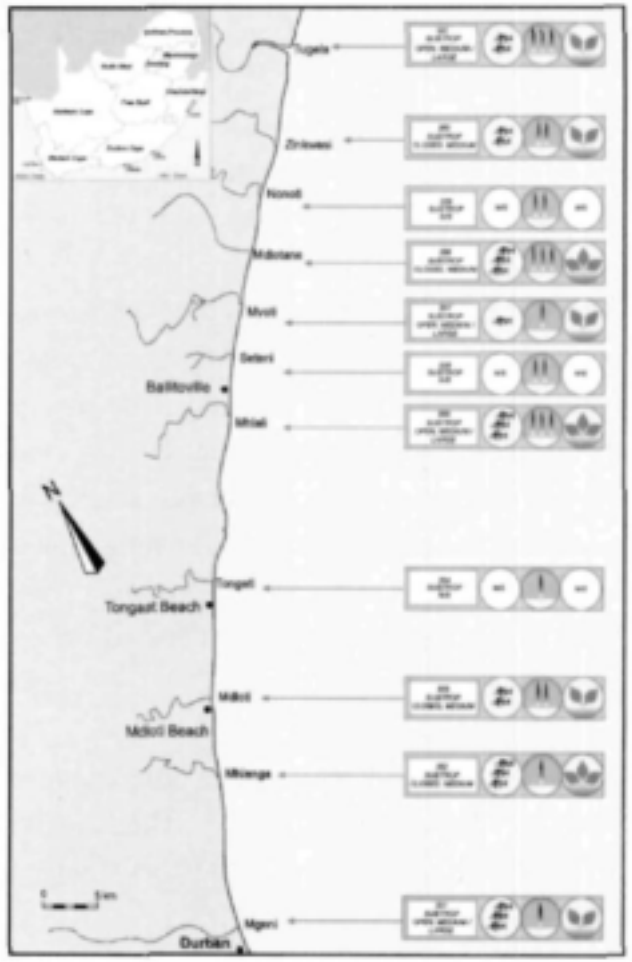
Estuarine Health Index

The Estuarine Health Index attempts to derive a picture of the health of an estuary according to four components, each based on a set of field derived data:

- size and mouth condition;
- water quality: evaluated according to three major components (suitability for aquatic life, suitability for human contact, trophic status);
- aesthetic state: degree of 'naturalness' of the system;
- biological health : occurrence of fish relative to a reference community (fish which would be found in the estuary under natural conditions).

The Estuarine Health Index simplifies the water quality aesthetic state and biological health data. Each component is scaled between 1 and 3 according to its relative status as either poor (1), average (2) or good (3). One method of representing the output is as a series of icons (see figure), which enables planners and managers to ascertain the state of estuaries along a section of coastline easily and effectively.

A difficulty in using indexes is that information continued in the underlying data, is often sacrificed for the perspective gained in simplifying and summarizing the data. A furthur factor to consider is that these scores are derived from 'snapshot' surveys, and may therefore not represent the long term condition of the estuary. They are, however, very helpful for establishing long term trends and can also serve as valuable baselines.



Botanical Importance Rating

Botanical Importance can be defined as the contribution of plants to the Conservation Importance of the estuary. Determination of the botanical importance rating is based on the size and number of different plant community types and their contribution in the form of energy to high trophic levels.

Calculation of the score for a particular estuary is based on summing a number of component scores (see figure). Thus the functional importance component is determined by multiplying the area (ha) of plants of a certain type by a productivity value for that type. Currently the following plant types are recognised:

- supratidal salt marsh;
- intertidal salt marsh;
- reeds and sedges;
- submerged macrophytes;
- mangroves;
- intertidal benthic microalgae;
- phytoplankton;
- macroalgae;
- swamp forest.

In addition to determining the area occupied by plants of a certain type, it is also necessary to conduct a survey of richness in the estuary. The total number of plant communities and species is used to determine the richness score (see table).

No of plant community types	Plant community richness score
1 to 3	20
4	40
5	60
6	80
7 to 9	100

The final component of the score is rarity. The occurrence of rare species or communities in an estuary will result in a higher score for this category.

The final score enables estuaries along the coastline to be compared with respect to their botanical importance and plant conservation significance. It is also possible to rate importance from scores based on earlier aerial photography and survey data. Thus the botanical importance of an estuary prior to development can be compared with the current state.

Botanical importance = sum of components listed below

Functional importance +Area of plant cover (ha) x Productivity

+

Species richness = No. of plant species

+

Plant community type richness = No. of plant community types

+

Plant community type rarity = Occurrence of community type in South

KEY ISSUES

- Policy and legislation requires that estuaries are managed for sustainable use
- Policy and legislation facilitates active participation of civil society in estuary management
- Use the provisions of legislation to protect and promote sustainable use of estuaries

ENVIRONMENTAL RIGHT

'Everyone has the right -

a) to an environment that is not harmful to their health or well-being; and
b) to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that -
   i) prevent pollution and ecological degradation
   ii) promote conservation
   iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development'

The Constitution

The South African Constitution provides the framework for governance and is the overarching law of the country. All government policies, laws and the actions must accord with the constitution.

In terms of the Constitution, South Africa has three spheres of government: national, provincial and local. These spheres are described by the Constitution as 'distinctive, interdependent and interrelated'.

The Constitution includes a Bill of Rights that applies to all laws and must be adhered to by government. The Bill of Rights also binds all people. The Constitution lays the basis for environmental law in South Africa through an environmental right (see box) which is included in the Bill of Rights.

National Government

The national sphere of government has a legislative component and an executive component. The legislature consists of Parliament and the National Council of Provinces. The legislature is responsible for creating national laws.

The executive component of national government consists of the President and the Cabinet. The Cabinet consists of Ministers and Deputy Ministers who are responsible for the various national government departments. The two national government departments that play large roles in estuary management are:

- the Department of Water Affairs and Forestry which is responsible for the management of South African water resources. The management of water is a national government competency; and
- the Department of Environmental Affairs and Tourism which is responsible for environmental matters. Environment is a shared competency with provincial government.

Provincial Government

The provincial sphere of government also has legislative and executive components. Provincial legislation is promulgated by the provincial parliament.

The executive component of provincial government consists of the provincial Premier

and the provincial Cabinet. The Cabinet consists of Ministers and Deputy Ministers who are responsible for the various provincial government departments. In a provincial government the department that plays the most important role in estuary management is the department that is responsible for environmental matters.

Local Government

Local government consists of municipalities that have been established for the whole of South Africa. The legislative and executive authority of a municipality rests with the municipal council. The municipal council has a support structure of municipal officials that implements the decisions of the council.

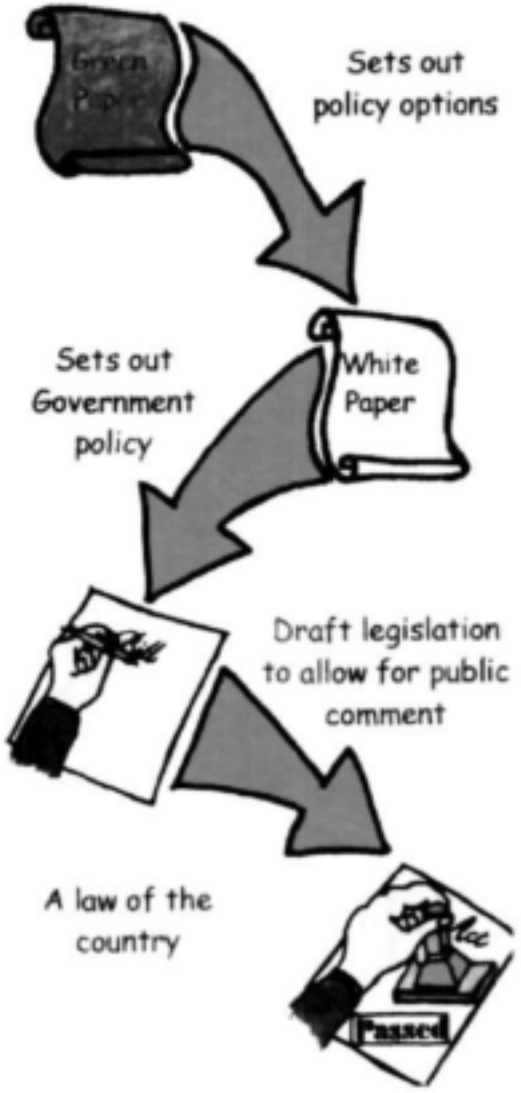
The law making process

The national law making process in South Africa normally follows the route below:

- government publishes a Green Paper that sets out policy options that the government is considering for a particular subject area. A Green Paper allows consideration of, and input into, policy options by interested parties; this is followed by the publication of a White Paper. A White Paper lays out government policy for a particular subject area. A White Paper can propose the promulgation of one of more laws to meet the objectives of the policy;
- to pass a law the government must first draft a Bill. A Bill is a draft Act. A Bill lays out the law that parliament intends to pass. It is written to allow for public and parliamentary consideration of the intended law;
- once a Bill is passed by parliament it becomes an Act. An Act is a law of the country;
- most Acts empower appropriate government ministers or heads of departments to pass regulations. An Act will provide a clear indication of what type of regulations can be promulgated. Regulations do not need the approval of parliament.

Provincial parliaments are empowered to pass laws that are applicable to their province and fall within the competency of provincial government. Provincial laws cannot conflict with national laws. The provincial legislative process is usually similar to the legislative process of national government.

Municipalities are able to pass by-laws for their area of jurisdiction that fall within the competency of local government. They cannot conflict with provincial and national laws.



The law making process in South Africa
(Illustration: Lauren Glennie)

There are many information sources on South African Environmental Law

Environmental Management

What is the environment?

There are many different definitions of the environment. In South Africa the environment has been defined as the biosphere in which people and other organisms live. It consists of renewable and non-renewable natural resources, natural ecosystems and habitats and ecosystems and habitats that have been constructed or modified by people.

The management of the environment consists of the management of a vast range of issues and includes the management of estuaries.

How is environmental management governed?

Environmental management is a joint responsibility of national and provincial government. The national government policy for the management of the environment is laid out in the *White Paper on Environmental Management Policy for South Africa* that was published in May 1998. The policy lays out the principles to be applied to environmental management and the goals and objectives of national environmental management. Some of the key principles are:

- renewable and non-renewable natural resources, cultural resources and land are all part of South Africa's environmental heritage. They are public assets belonging to the nation's people;
- the government acknowledges that it has a constitutional duty to protect the environment for the benefit of current and future generations.

The National Environmental Management Act (No 107 of 1998) gives effect to the white paper on environmental management policy for South Africa. The Act provides a framework for the integration of the environmental management activities of the various spheres of government.

The Act establishes a Committee for Environmental Coordination that comprises representatives of national government departments, relevant provincial departments and local government. The purpose of the Committee is to promote the integration and coordination of the environmental functions of the various organs of state. The Committee has a Coastal Management Subcommittee.

The Act also established a number of procedures to promote cooperative environmental governance. The Act requires that national government departments whose activities may affect the environment and all provinces prepare environmental implementation plans. Similarly, all national government departments that are involved in the management of the environment are required to prepare environmental management plans.

One of the key features of the Act is a provision that empowers members of the public to take legal action in the public interest or in the interest of protecting the environment. This legal action can be taken when a law concerned with the protection of the environment has been broken (or there is a threat that such a law may be broken). This is a very powerful provision that allows anyone to take legal action to ensure that the environmental laws of the country are upheld.

Integrated Environmental Management

The National Environmental Management Act includes a section that gives effect to the objectives of integrated environmental management. This section allows activities that may significantly impact on the environment (Chapter 5) to be identified by the Minister of Environmental Affairs as requiring authorisation prior to implementation. No regulations have yet been passed in terms of this section. However, Environmental Impact Assessment Regulations were promulgated on 5 September 1997 in terms of the Environment Conservation Act (No 73 of 1989). Eventually these regulations will be superseded by regulations under the National Environmental Management Act.

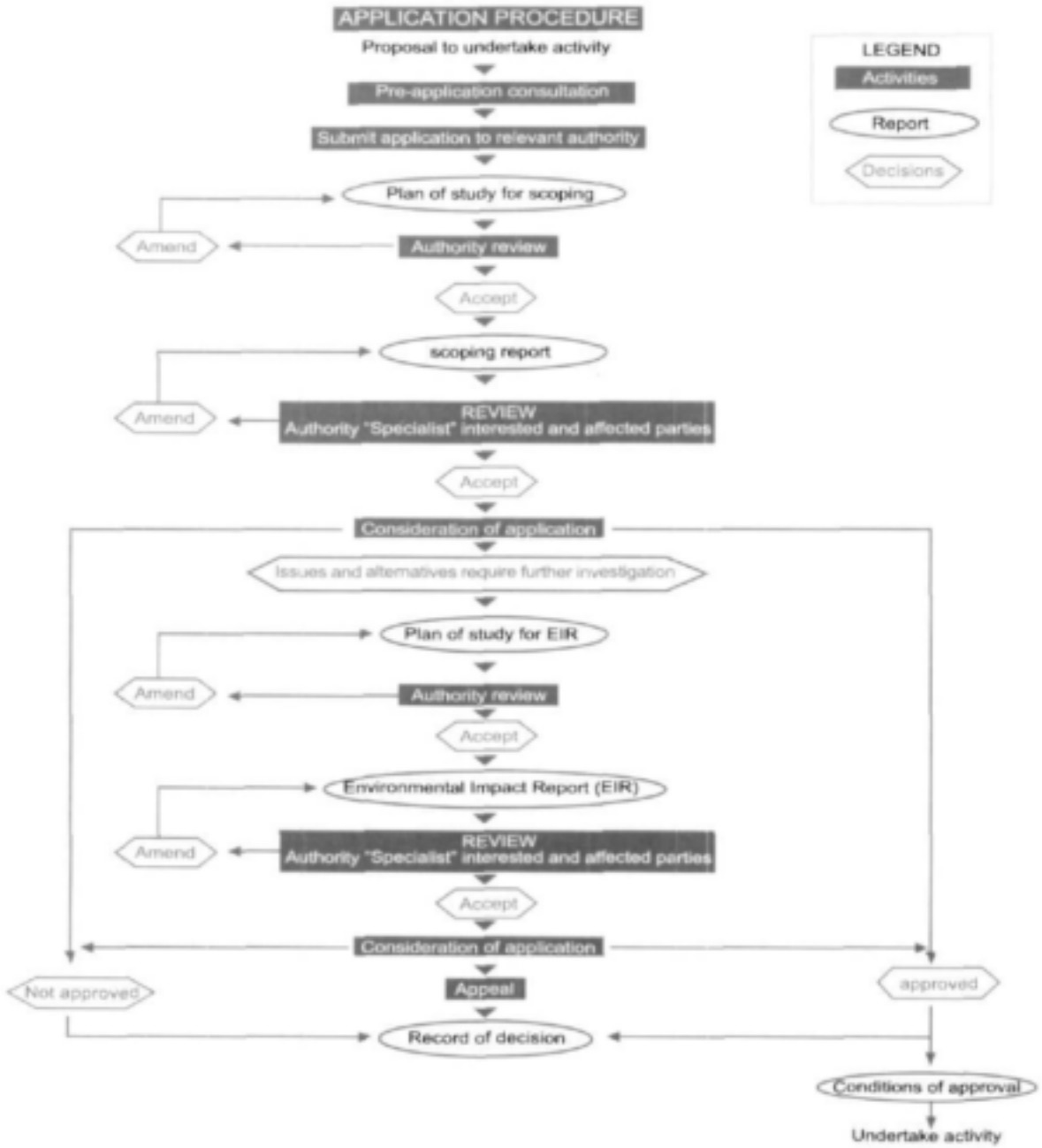
Environmental Impact Assessment regulations

The September 1997 regulations list activities that may be harmful to the environment. To implement any listed activity permission is required from the environmental department of the province in which the activity is planned to take place. To obtain permission an application must be made to the environmental department. The department could then require that the applicant complete one or more environmental reports. Many of the activities listed could impact estuaries (Chapter 5), for example:

- The construction or upgrading of marinas, harbours and all structures below the high-water mark of the sea;
- The construction or upgrading of public and private resorts and associated infrastructure; and
- The reclamation of land below the high-water mark of the sea and inland water including wetlands.

Civil society plays a very important role in environmental impact assessments because government looks to society for direction in decision making. Estuary Management Forums (Chapter 5) would be influential interested and affected parties.

Those who use and benefit from the goods and services of estuaries should play a role in estuary management (Picture: Margaret McKenzie)



Environmental Impact Assessment process

In order to obtain approval for an activity listed in the Environmental Impact Assessment regulations, an applicant must follow the procedures summarised in the diagram on the left. This procedure has three core phases that are outlined below.

Submission of the application

During this phase the applicant consults with the appropriate provincial environmental department regarding the proposed activity. During the consultation the applicant can determine if the regulations apply to the proposed activity, can obtain general guidance about the process and determine if the other authorities need to be involved in the decision making process. Once the applicant has confirmed that the regulations apply to the activity, an application for authorisation is lodged with the appropriate provincial environmental department.

Scoping Report

Once the application has been submitted, the applicant will have to complete a Scoping Report on the proposed activity. The Scoping Report must include:

- a description of the proposed activity;

a description of how the environment may be affected;
a description of environmental issues identified;
a description of alternatives identified;
a description of the public participation process.

A number of other components could be included depending on the nature of the proposed activity.

Once the Scoping Report has been submitted, the relevant authority will review the report and make one of the following decisions:

authorise the proposed activity (with or without conditions);
identify that certain issues need further investigation and ask the applicant to submit an environmental impact report;
reject the application.

Environmental Impact Report

If instructed by the relevant authority the applicant will be required to submit an Environmental Impact Report that must include:

a description of each alternative for the proposed activity that includes the extent and significance of environmental impacts and the possibility for mitigation;
a comparative assessment of these alternatives.

Other components could be included depending on the nature of the proposed activity.

Once the Environmental Impact Report has been submitted, the relevant authority reviews the report in order to determine if the activity should be authorised (with or without conditions) or not.

Sensitive Coastal Area Regulations

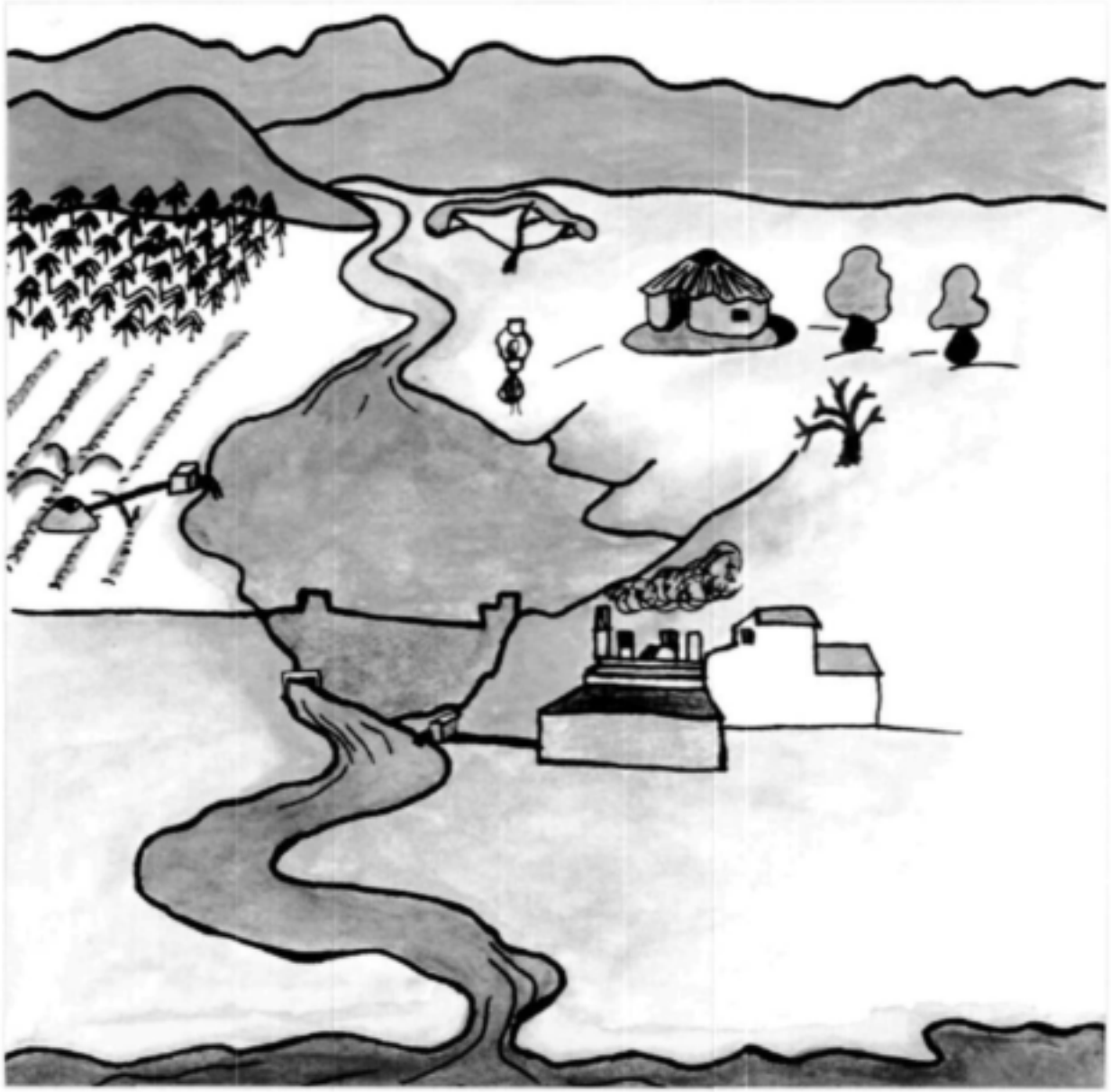
Sensitive Coastal Area regulations are a second set of regulations that implement portions of the integrated environmental management process. These are promulgated for specific areas such as Outeniqua, Pennington and Umtamvuna. These regulations list four activities that can only be undertaken in the specified area with a permit:

disturbance of vegetation;
earthworks;
dredging; and
dune stabilisation.

To obtain a permit for one of these activities an application must be made to the relevant municipality and be accompanied by an Environmental Impact Report. It is possible that large portions of the coast could eventually be declared sensitive coastal areas.

Example of the types of negative environmental impact the EIA regulations are designed to prevent (Picture: Stephen Cohen)

The San Lameer holiday development. Construction was set back from the estuary to protect it from negative impacts (Picture: Bruce Mann)



Examples of different types of water uses. The Reserve defined by the Water Act is the water required to maintain aquatic systems and meet basic human needs (Illustration: Lauren Glennie)

Fresh water and estuaries

Estuaries are dependent for normal functioning on an inflow of fresh water (Chapter 3). The management of fresh water resources can therefore play an important role in the management of an estuary.

How are water resources governed?

The management of South Africa's water resources is the responsibility of national government. National government policy for the management of water resources is laid out in the White Paper on Water Policy published in April 1997. The policy includes a number of water law principles. Two key principles are:

- all water, wherever it occurs in the water cycle, is a resource common to all, the use of which shall be subject to national control;
- the water required to meet basic human needs and the needs of the environment shall be identified as the Reserve and shall enjoy priority of use by right. The use of water that remains after the Reserve's need has been satisfied is subject to authorisation.

The first principle confirms that water is a national asset and that it is controlled by national

government. The second principle establishes the concept of a Reserve for basic human needs and the environment. The Reserve has a priority over all other water uses. All other water uses require authorisation.

The National Water Act (No 36 of 1998) gives effect to the white paper on water policy. The Act defines the reserve as the quantity and quality of water required to meet basic human needs and to protect aquatic resources. To give effect to the reserve the Act requires that a Reserve should be determined for all significant water resources.

The Act also sets out the framework for the management of water resources in South Africa. The framework provides for three levels of management: national, catchment and local (Chapter 5).

National water management

The Minister of Water Affairs and Forestry has overall responsibility for the management of water resources. The Act requires the development of a national water resource strategy. This strategy provides the framework for the protection, use, development, conservation, management and control of water resources for the country.

Catchment management

The Act provides for establishment of catchment management agencies for the water management areas that have been defined in terms of the Act. Each water management area covers several catchments. Catchment management agencies have several functions, including the development of catchment management strategies.

The catchment management strategies that are developed by the catchment management agencies must be compatible with the national water resource strategy. The Act requires that a catchment management strategy should set 'the strategies, objectives, plans, guidelines and procedures for the catchment management agency for the protection, use, development, conservation, management and control of water resources in its water management area.' A catchment management strategy should include the following components:

- social component;
- institutional component;
- biophysical management component;
- legislative/Policy component;
- water allocation plan;
- economic component.

Local

The Act provides for the establishment of water user associations. A water user association is essentially a co-operative association of water users that jointly manage water related activities. Water user associations provide catchment management agencies with a mechanism to devolve aspects of their catchment management strategies to a local level. Water user associations can take responsibility for the local level execution of aspects of the catchment management strategy.

Water user associations can be established for a wide range of purposes. For example:

- to prevent the wastage of water resources;
- to protect water resources;
- to supervise a water resource.

An estuary management forum could perform some of these functions on behalf of a catchment management agency.

COASTAL MANAGEMENT

How is coastal management governed?

National government policy for coastal management is laid out in the White Paper for Sustainable Coastal Development in South Africa. The white paper includes a vision, principles, goals and a plan of action for coastal management. The key messages highlighted by the white paper are:

- the value of the coast must be recognised;
- sustainable coastal management must be facilitated;
- coastal management must be coordinated and integrated;
- government must adopt a cooperative style of management.

The white paper lays out a framework for national, provincial and local coastal management.

National

The Department of Environmental Affairs and Tourism will be the coastal management lead agent and will be responsible for preparing State of the Coast reports and coordinating the implementation of the plan of action required in the white paper. A coastal management subcommittee of the Committee for Environmental Co-ordination (established in terms of the National Environmental Management Act) will be constituted.

Provincial

Each of the coastal provinces is required to identify a department that will be the coastal lead agent. This lead agent will be responsible for monitoring the state of the coast and reviewing provincial legislation. In each province a Coastal Working Group will be established.

Local

Municipalities will continue to be involved in many coastal management responsibilities. Where appropriate local coastal forums will be established, to promote dialogue and improve co-ordination between coastal roleplayers.

Coastal management legislation

The white paper is being implemented, but this has not yet led to new coastal legislation. The primary coastal law that currently exists is the Sea-Shore Act, which dates back to 1935 (Act 21 of 1935). The Act establishes the government as the owner of the sea (the territorial waters of South Africa) and the sea-shore (the area that lies between the high water mark and the low water mark of the sea), except where ownership was transferred to individuals prior to the promulgation of the Sea-Shore Act. The Act includes estuary water surfaces in its definition of the sea and estuary banks in its definition of the sea-shore. Only land uses specified by the Act or a resolution of parliament can take place on the sea-shore. Otherwise, the public has the right to use the sea-shore and the sea, provided this use does contradict other rights granted in terms of the Act.

Development on land within the 'visual basin' of an estuary that falls outside the defined sea-shore area is controlled by local authority plans, local by-laws, provincial planning legislation and national planning and environmental legislation.

ESTUARY RESOURCE USE

How are estuary resources governed?

The national government policy is laid out in the Marine Fisheries Policy for South Africa that was published in 1997. The foundation of the policy is a 'belief that all natural marine living resources of South Africa, as well as the environment in which they exist.... are a national asset and a heritage of all its people, and should be managed and developed for the benefit of present and future generations in the country as a whole.' The Marine

Fisheries Policy excludes estuary species; however, the policy laid the basis for the Marine Living Resources Act (No 18 of 1998).

The Marine Living Resources Act regulates marine living resource use within South African waters including estuarine areas. The main purpose of the Act is to 'provide for the conservation of the marine ecosystem, the long-term sustainable utilisation of marine living resources and the orderly access to exploitation, utilisation and protection of certain marine living resources'. The Act lays down a number of important objectives and principles including:

- the need to achieve optimum utilisation and ecologically sustainable development of marine living resources;
- the need to conserve marine living resources for both present and future generations;
- the need to utilise marine living resources to achieve economic growth, human resource development, capacity building within fisheries and mariculture branches, employment creation and a sound ecological balance consistent with the development objectives of the national government;
- the need to protect the ecosystem as a whole, including species which are not targeted for exploitation;
- the need to preserve marine biodiversity.

An important feature of the Act is that no fishing can be undertaken unless a right to fish (a license) has been granted by the Minister of Environmental Affairs and Tourism. The minister also determines the maximum quantity of fish (and other marine animals and plants) of individual species or groups of species that are available for harvesting annually. In addition, the Minister determines limitations regarding the number of vessels and methods of fishing for individual species or groups of species and what portion of the total harvest is allocated to which sectors.

The Act also provides the minister with a number of other mechanisms to regulate fishing such as the establishment of fisheries management areas, the declaration of priority fishing areas, the establishment of zones for subsistence fishers and the establishment of marine protected areas.

Should you require information or assistance consult the list of expertise provided at the end of the book.

Self regulation by estuary users is necessary to support the work of officials (Picture: Charles Breen)

PLANNING

What is planning?

A plan is a statement of intent at a particular time. Planning is a process whereby one continually envisions the future and prepares for it. So planning is an ongoing activity involving continual adjustment.

The future is uncertain. We should be cautious in what we plan to do so that future options are not foreclosed. The longer term our 'plan' the less flexible we are - and the more likely it is that we will entrench poor decisions. It is wise to have long term vision and medium and short term plans.

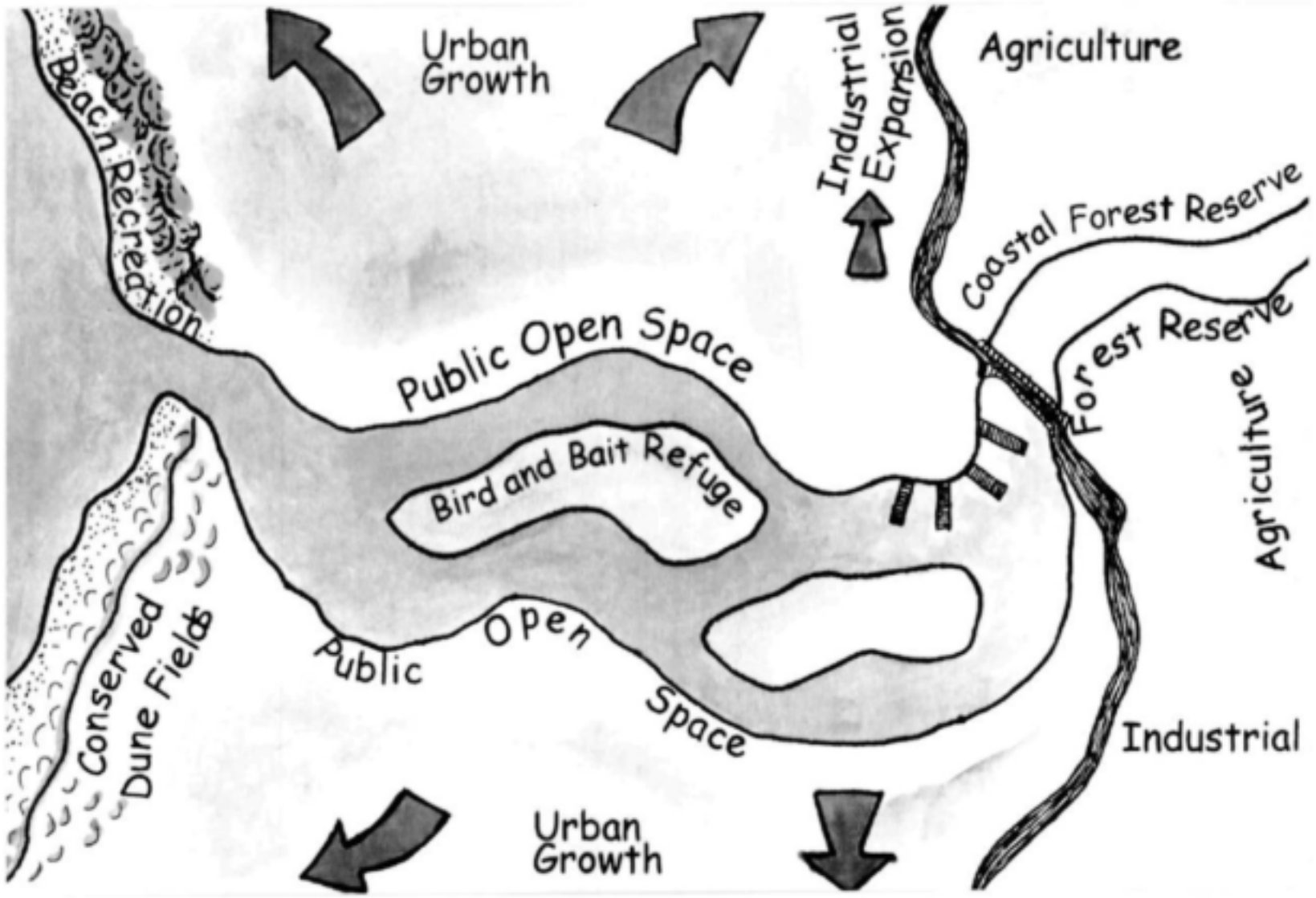
What governs planning?

Planning the development of an area is the responsibility of the municipality for that area. Various national and provincial laws lay the framework in which this municipal planning takes place. One of the key national laws is the Local Government Transition Act (209 of 1993) that requires all municipalities to draw up Integrated Development Plans for the development and management of their areas of jurisdiction. An Integrated Development Plan encompasses planning for the many areas that are dealt with by municipalities, such as water planning, transport planning, spatial planning and environmental planning. Some provinces also have planning laws.

The planning process

The planning process varies. However, the CSIR has suggested a generic planning process for an integrated development plan.

- the Workplan phase: this involves the preparation of workplan for the preparation of an integrated development plan;
- the Vision phase: this involves developing a vision for the area;
- the Development Framework phase: in this phase the key issues for the area are identified and goals of the integrated development plan are developed;
- the Development Strategies phase: during this phase strategies for attaining the integrated development plan goals are developed;
- the Operational Planning phase: the necessary finances and resources are allocated to ensure the implementation of the strategies during this phase;
- the Monitoring, Evaluation and Review phase: the integrated development plan is assessed and the outcomes of the assessment feed into the ongoing development of the integrated development plan.



An example of planning for the land use around an estuary
(Illustration: Lauren Glennie)

CONTEXTUAL DEFINITION OF TERMS

The definitions provided here are intended to assist readers interpret the text. They are not necessarily conventional or precise definitions.

Adsorb	To become attached onto sediment particles (in this case).
Aesthetics	Relating to, or possessing, a sense of beauty.
Anguillid	A family designation for certain species of eels.
Asset register	Official list of properties recording their value.
Attenuate	Reduced or weakened flow rates (in this case).
Bacteria	Microscopic organisms without well defined nuclei.
Base Flow	Flow in a river after run off from the surface surrounding land has ceased.
Benthos	Organisms, usually small, living on or in the surface layer of the sediment.
Biodiversity	Structural, functional and compositional diversity of organisms and their environments.
Biogeography	The spatial distribution of plants and animals.
Bivavles	An animal with a hinged double shell.
Body corporate	A body established by civil society.
Carnivorous	An organism that feeds on animals.
Catchment	The area from which the river is fed.
Conspicuous	Catching the eye / noticeable.
Consumers	Organisms that consume other organisms (in this case).
Colloid	Very small particles suspended in the water column.
Crustacea	Animals with jointed legs and external skeletons e.g. crabs and shrimps.
Culvert	A drain or pipe, usually quite large, over which a road or railway passes.
Delta	A flat area at the mouth of the river where the main stream splits into seaward branches.
Deplete	Reduce in numbers or quantity.
Detritus	Aggregation of fragments resulting from breakdown of organisms.
Decomposers	Organisms that breakdown dead organic matter.
Ebb-tide	Out-going tide.
Ecosystem	An interacting living system (physical, chemical and biological) e.g. estuary, pond, forest.
Episodic	Infrequent events e.g. floods.
Erode	To wear away e.g. river flow removing sediment.
Finance	Money affairs or revenue.
Flood-tide	Incoming tide.
Focal point	Point or region of great activity.
Gene	Unit of heredity.
Genetic resource	A store of material (genes) which determines form, structure and function of organisms.
Goods	Things which have value.
Habitat	The normal environment in which an organism lives.
Hazardous	Dangerous.
Hydraulic	Movement and force of water.
Hydrodynamics	Mechanical behaviour of water.
Icon	A picture depicting, for example, the health of an estuary.
Impoundment	Dam.

CONTEXTUAL DEFINITION OF TERMS *(continued)*

The definitions provided here are intended to assist readers interpret the text. They are not necessarily conventional or precise definitions.

Index	Composite numerical summary of environmental data that can be used to gain overall insight into the state of the environment.
Indicator	Physical, chemical, biological or socioeconomic measures of particular attributes used to indicate state or condition.
Inorganic	Compounds e.g. salt which do not contain carbon.
Intertidal	The area that is exposed as water recedes from high water to low water tide levels.
Intrinsic value	Inherent (belonging to) value, not market value.
Invertebrate	An animal that does no have a backbone.
Larval	Free living immature development stage of organisms such as fish and crabs.
Legitimacy	Justification by legal or accepted standards.
Macroalgae	Large plants not differentiated into stems, roots and leaves (i.e. thalloid). Mostly seaweeds.
Macrophyte	Large plants, usually aquatic, differentiated into stems, roots and leaves. Mostly flowering plants.
Mangrove	Trees growing in regularly flooded parts of estuaries and along tropical coasts in other parts of the world.
Mariculture	The cultivation of marine organisms such as oysters, mussels and fish.
Marina	Complex of canals and associate habitation created to provide a water-associated lifestyle. Can be inland or on the coast.
Microalgae	Small, usually microscopic, chlorophyll containing organisms. Commonly aquatic.
Microclimate	Climatic conditions pertaining to restricted or small spaces e.g. within the canopy of a tree.
Migrate	To move from one location to another.
Modelling	To construct and operate a physical or abstract representation of the estuary so that consequences of actions (impacts) can be determined and evaluated.
Monetary value	Having value expressed as money.
Nekton	Very small organism, e.g. bacteria. Smaller that phytoplankton and zooplankton.
Nitrogen fixation	Transformation of gaseous nitrogen (in the atmosphere) to organic nitrogen by microorganisms, commonly bacteria.
Non-monetary value	Value which is not expressed as money e.g. spiritual value.
Nursery Areas	Areas where juvenile animal mature
Nutrient	Natural substances (elements) necessary for nourishment of life.
Nutrient cycling	The natural process of incorporation of nutrients into living organisms and their release back into the environment during death and decay.
Obligate	Necessary, essential.
Option value	Value ascribed to choices that may be made in the future.
Organic	Substance comprised predominantly of carbon, hydrogen and oxygen e.g. starch, sugar and protein.
Perennial	Lasting through the year.
Photosynthesis	The process occurring whereby green plants use chlorophyll to capture the energy of sunlight and combine carbon dioxide and water to produce sugars and other organic materials.
Phytoplankton	Very small (microscopic) plants living in the water column.
Precipitate	Deposited in solid form from a solution.
Predator	An organism which preys upon another.

CONTEXTUAL DEFINITION OF TERMS (continued)

The definitions provided here are intended to assist readers interpret the text. They are not necessarily conventional or precise definitions.

Producers	Organisms, usually green plants, that produce organic materials.
Pylon	Solid structure for support e.g. for bridges.
Rate revenue	The money accruing to authorities (e.g. municipalities) from levies charged on properties and services.
Refuge	A place of shelter.
Refurbish	To repair and renovate.
Sandwinning	Mining of sand
Seaweeds	Large algae (Macroalgae) growing in the sea and estuaries.
Service	An ecosystem process (e.g. water purification) which is useful to society and which has value.
Stagnant	Stale from not moving e.g. stagnant water.
Standing stocks	Existing, usually living, store of plants and animals in an ecosystem.
Statutory	Established (enacted) by law.
Substratum	Solid surface e.g. soil, plant surface and constructed surfaces.
Succession	A process whereby species, or groups of organisms, are replaced by others as conditions change over time (usually) or space.
Supratidal	Above the level of the high tide.
Thalloid	Descriptive of a plant body not differentiated into stems, roots and leaves.
Threshold	A level at which something becomes of notable concern.
Tidal prism	The volume of water associated with tidal movement in an estuary.
Trophic status	The level of productivity of the system.
Turbidity	Lack of clarity, in this case, of water.
Zooplankton	Very small (microscopic) animal living in the water column.

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SOURCES OF ASSISTANCE

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Printed by Formeset Printers Cape

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