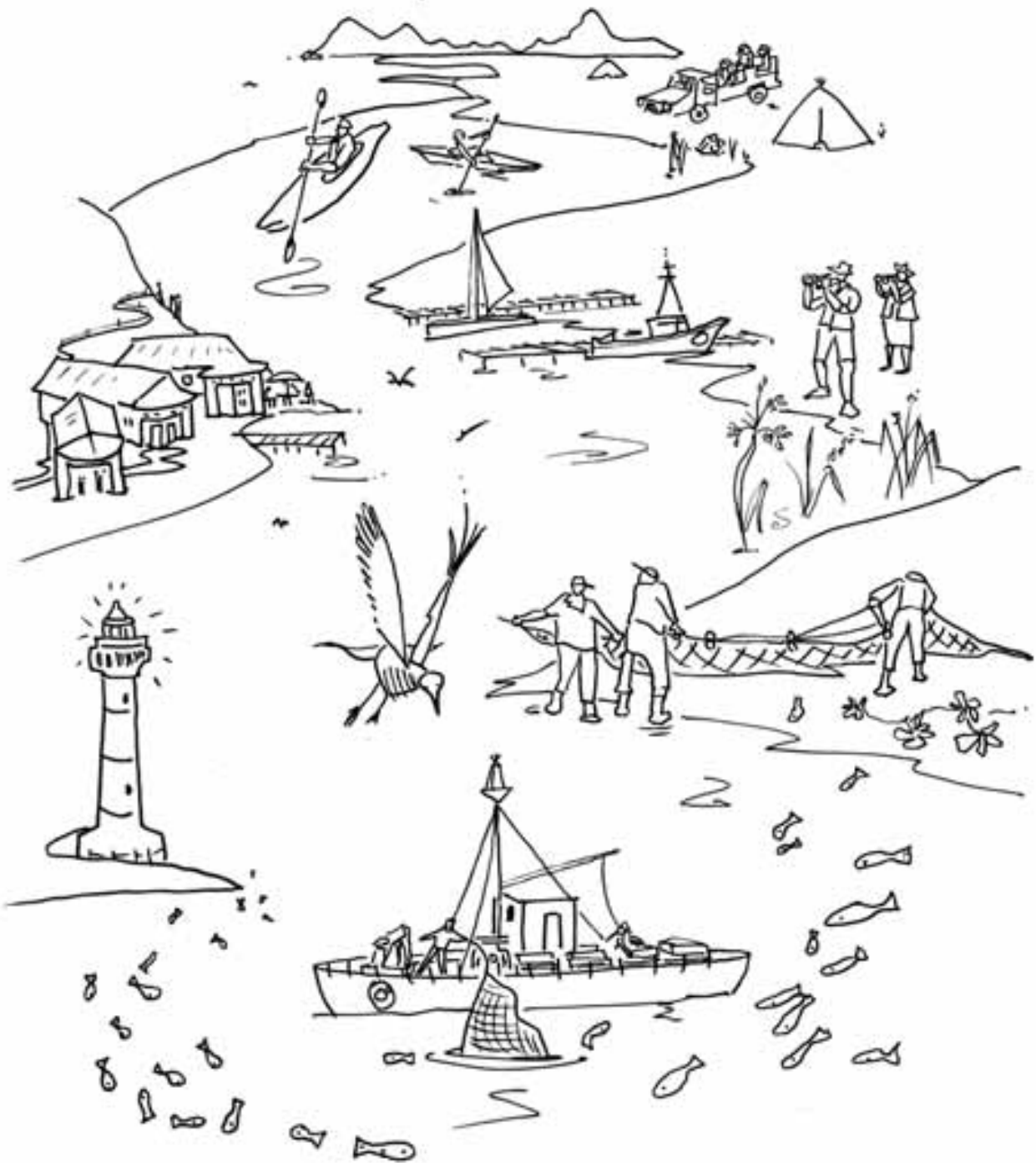
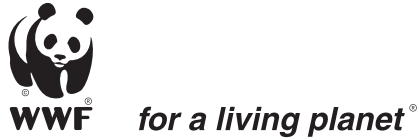


TAKING CARE OF

# Our Estuaries

WHY AND HOW





### **Preface and Acknowledgements**

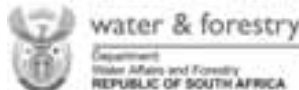
This booklet is part of a series to support a capacity-building initiative for Catchment Forums and Water Users Associations in the Olifants-Doring Water Management Area of the Western Cape. This initiative is a pilot, for possible implementation elsewhere in South Africa. The booklet is therefore designed to be used throughout the country. However, it serves a specific and limited purpose. It is a basic, practical introduction to estuaries, aimed at encouraging users to become involved in activities to better understand and manage a local estuary. As such the booklet is neither detailed nor comprehensive. It provides a bridge to more technical and regional materials available elsewhere.

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For more information on the materials and the capacity-building initiative, contact Rodney February, rfebruary@wwf.org.za.



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# What Are Estuaries?

## Definition of an Estuary

According to the National Water Act (36 of 1998) an estuary is defined as: *“a partially or fully enclosed water body that is open to the sea permanently or periodically, and within which the seawater can be diluted, to an extent that is measurable, with freshwater drained from land”.*

While there are other definitions, this is generally considered the most useful. It does emphasise the link to the marine environment perhaps more strongly than to the riverine (or catchment) component, but makes it clear that the dilution of the seawater by the freshwater is a very important feature of estuaries.

A more simple definition could be : *Where rivers meet the sea.*

## Geographical Boundaries of Estuaries

The methods for Resource Directed Measures for estuaries developed under the National Water Act provide the clearest and most useful administrative definition, but this is not legally binding in its present format. The definition states:

- Seaward boundary: **Estuary mouth** (however, there are systems where the ‘estuary’ often expands to the nearshore marine environment and where this boundary definition may need to be reconsidered in future).
- Upper boundary: **Extent of tidal influence**, i.e. the point up to which tidal variation in water levels can still be detected or the extent of saline intrusion, whichever is furthest upstream.
- Lateral boundaries along the banks: **The 5.0m above mean sea level (MSL) contour.**

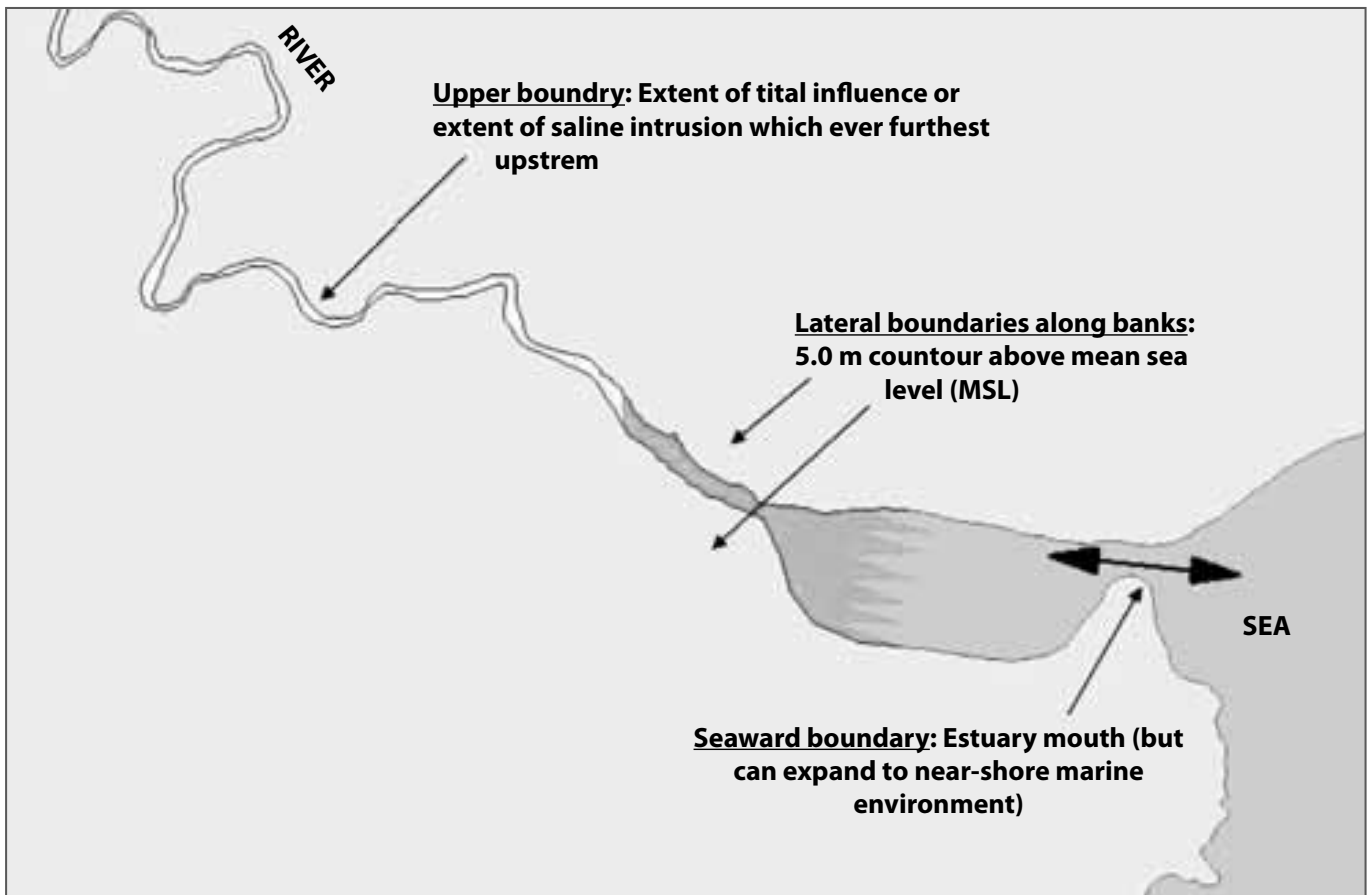
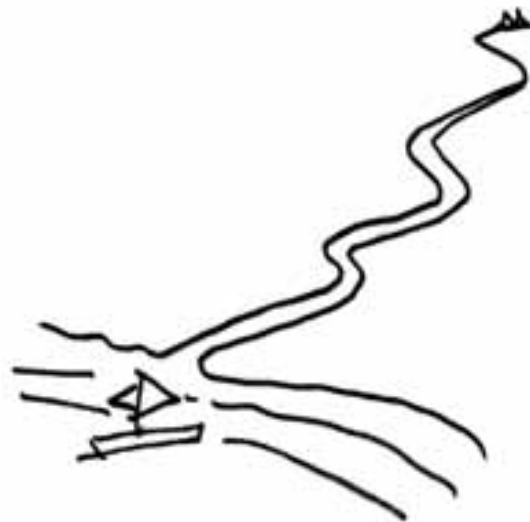


Figure 1: Geographical Boundaries of Estuaries

## Types of Estuaries

There are more than 250 estuaries in South Africa and these are generally considered to fall into five (5) types as identified by Whitfield (1992):

- **Permanently open estuaries:** Usually quite large systems with a perennial river and/or strong tidal exchange with the sea. For example, the Breede and Swartkops estuaries.



- **Temporarily closed/open estuaries:** These estuaries are often closed for many months of the year and sometimes for more than a year at a time. For example, the Van Stadens and Mhlanga estuaries.



- **Estuarine lakes:** These estuaries occur where a coastal lake is connected to the sea by a channel of varying length and width. For example, St Lucia and Kosi estuaries.



- **River mouths:** All rivers flowing into the sea have a river mouth. However, estuaries under this category are usually permanently open to the sea. For example, the Orange, Olifants and Thukela estuaries.



- **Estuarine bays:** These estuaries have wide mouths with strong tidal exchange resulting in a continuously open mouth, and the regular replacement of sea water in the lower and middle reaches. For example, Durban Bay and Knysna.



# Why Care?

## Importance of Estuaries

Estuaries are extremely important in a number of ways. **They can have commercial and industrial, subsistence, recreational and ecological importance.** In fact it is their importance in so many ways that can lead to conflicts about how they are used and managed.

Estuaries are focal points for **community and business activities** along the coast as they provide a range of opportunities and benefits. They are an important location for **cultural and recreational activities** for coastal residents and visiting tourists.

Many communities derive a high proportion of their **subsistence needs** from the resources provided by estuaries.

## Economic Values

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 (like certain types of crabs and prawns), for transport or for a place to provide facilities for tourists which, in turn, helps to support business and jobs in the coastal region (for example, Durban, Knysna and Kosi).

## Ecological Values

In terms of their ecological value, estuaries are often called the **nurseries of the sea.** More than 100 species of fishes, prawns and crabs in South African off-shore waters use estuaries as nurseries and/or feeding grounds. The lifecycle of most of these species involves egg production at sea, often close inshore and near an estuary mouth. Eggs and larvae develop at sea, but

the larvae and juveniles migrate to estuaries in great numbers. In fish, this migration takes place mainly during late winter, spring and early summer when millions of juveniles swim into estuaries. Many **bird species also depend on estuaries** at different stages in their lives and in their migration patterns.

Estuaries provide **rich food sources** for many species of fish, birds and mammals.

## Water Management Values

Estuaries also have the ability to **control or reduce flooding**, while improving the **quality of water**.

## Goods and Services

Another approach to valuing estuaries and recognizing their importance is based on the idea of the **'Goods and Services'** they provide. As estuaries are ecological systems these are often referred to as **'ecological goods and services'**.

Table 1 on page 11 provides a summary of estuarine goods and services, and the opportunities these provide.

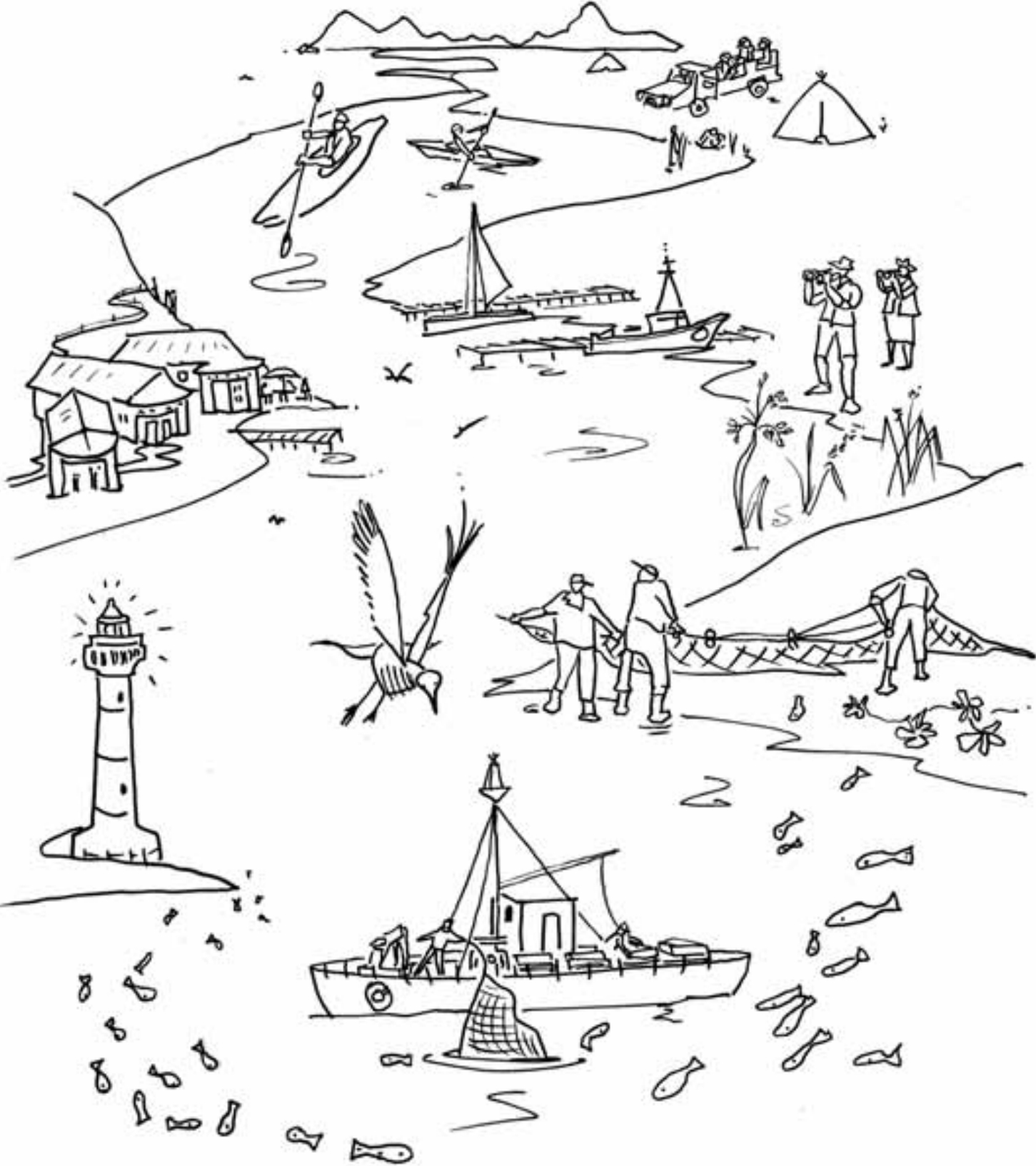


Figure 2: Estuaries – Places of Great Value

Category	Goods and Services	Examples of opportunities & activities
<b>Ecological</b>	Biological control Refugia/Migratory corridors Sediment supply Erosion control Soil formation Nutrient supply and cycling through food chains. Genetic resources Disturbance regulation	Maintaining the balance/diversity of plants/animals Fish and crustacean nurseries and roosts for migratory birds Creation and maintenance of beaches, sand bars and sandbanks Prevention of soil loss by estuary vegetation, and by capturing soil in reed-beds and mangroves Accumulation of sediment and organic material on flood plains and in mangroves Nutrient supply, nitrogen fixation and nutrient cycling Genes for mariculture, ornamental species and fibre Flood control, drought recovery and refuges from natural and human induced catastrophic events (e.g. oil spills)
<b>Subsistence</b>	Collection of living resources for food Raw material for subsistence use (e.g. building material)	Line fishing, inter-tidal collecting, beach and seine netting Harvesting of craftwork and house-building materials
<b>Recreational &amp; Tourism</b>	Nature appreciation Scenic views Culture Sports fishing Water sports	Providing access to estuaries and associated wildlife for viewing and walking Resort, residential houses, housing complexes and offices with scenic views, increasing turnover of properties with a sea-view Aesthetic, educational, research, spiritual, intrinsic and scientific values of estuary ecosystems Estuary flyfishing, estuary and inshore conventional fishing Water sports: swimming, sailing, canoeing, skiing and kayaking
<b>Commercial and Industrial</b>	Waste treatment Water supply and regulation Mariculture (e.g. oysters, bait, etc.) Commercial food production Raw material for commercial use Transport services	Breaking down of waste and detoxifying pollution Water supply to marine environment and water for mariculture Production (natural and cultivated) of fish, crustaceans and worms Fishing Diamond and titanium mining Ports, harbours, marinas and ski-boat launching sites

**Table 1: Estuarine Goods and Services (Adapted from Van Niekerk, *et al.*, 2006.)**

## Total Economic Value

One way to try and quantify the different values is through the idea of 'Total Economic Value'. This is seen as a way of measuring the total value of an ecosystem in financial terms. The idea is to demonstrate that even activities or values that appear to have little direct economic value, do in fact contribute to economic development.

The Total Economic Value of an ecosystem includes Direct Use, Indirect Use, and Non-Use (or 'Option') values.

- **Direct use** values may be generated through the consumptive or non-consumptive use of resources. In the case of South African estuaries most, if not all, of this use is subsistence or recreational, and includes both consumptive (fishing and bait collecting) and non-consumptive (e.g. boating, bird-watching) activities.
- **Indirect use values** are outputs generated by estuaries that contribute to other sectors of the economy, or to economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functioning such as water purification and nursery functions.
- **Non-use values** include the value of having the option to use the resources (e.g. genetic) of estuaries in the future, and the value of knowing that their biodiversity is protected. Although far less tangible than the above values, non-use values are reflected in society's willingness to pay to conserve these resources. This can be seen as an investment in the future, ensuring that the values of the estuaries are maintained.

# How Do Estuaries Work?

Estuaries are essentially very dynamic systems, and are subject to almost continual changes depending on a number of physical components, both natural and human induced. These changes have profound impacts on the ecological health of the estuaries. There is therefore a very strong link between the **physical (or 'driving') components** and the **biological (or 'response') components**.

Estuaries are also highly variable environments in terms of **hydrodynamics** (e.g. water level variations and water speeds), **water quality** (e.g. salinity, temperature, pH and oxygen) and **sediment dynamics**.

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It is important to realize that changes in the biological components of estuaries can have major impacts on the values of the goods and services they provide.

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## Main Physical Components

Physical components refer to **hydrodynamic** (water movement patterns), **sediment dynamic** and **water processes** in estuaries. These components are the important driving forces for the changes observed in biological components.

The driving components in estuaries are mainly influenced by two forces, i.e. **river inflow** and **the ocean**.

The river inflow is evaluated in terms of **floods (occasional influence)** and **seasonal base flows (more regular influence)**.

Key aspects driven by **floods** include:

- long-term sediment erosion/deposition cycles, and
- sand/mud distribution patterns along the length of an estuary.

Key aspects driven by **seasonal base flows** include:

- state of mouth in temporarily open/closed estuaries (duration and frequency), and
- the extent of the salinity penetration in permanently open estuaries.

The interaction between the **river inflow and the marine environment** can be explained as follows:

- During **high tides**, seawater pushes up into the estuary, introducing more saline water into the system and, at the same time, raising water levels in the estuary.
- During **low tides**, water drains from the estuary, usually resulting in the water becoming fresher, while the water level in the estuary drops.

During periods of **low flow** (e.g. estuary during dry seasons or drought), the **sea's influence becomes dominant**, resulting in the **estuary becoming increasingly saline**. Under extreme conditions, the salinity in an estuary can even become higher than that of seawater due to evaporation (referred to as hypersalinity). Prolonged periods of these low flows could also cause premature closing of certain estuary mouths and/or longer periods of mouth closure.

During **floods**, most of the saline water in an estuary is flushed out to sea and the **entire system usually becomes fresh**.

Floods also influence the **sediment dynamics** of an estuary, which in turn influence the following estuarine features:

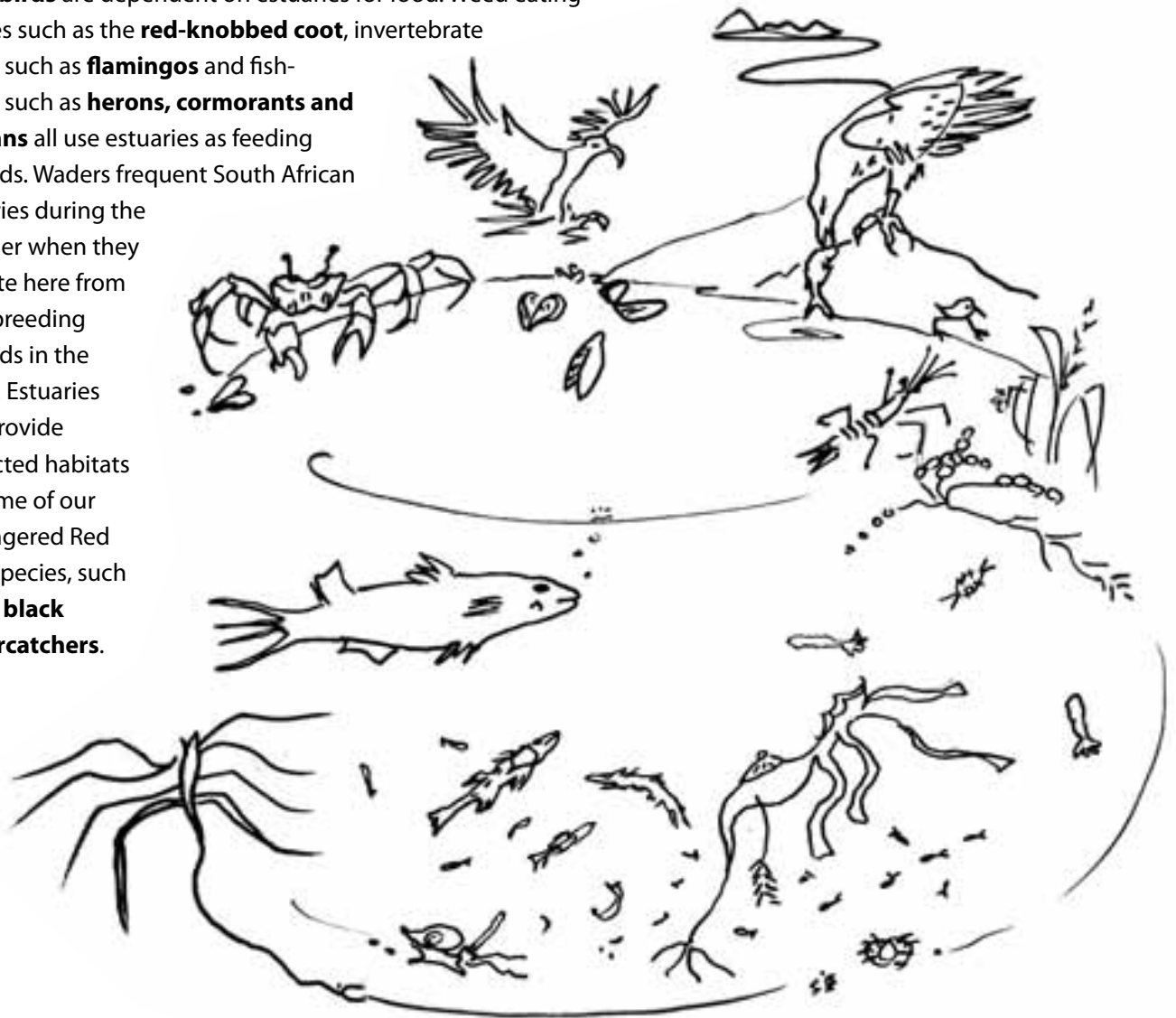
- **depth and shape** of an estuary (Bathymetry),
- **distribution of sediment types** (e.g. mud versus sand), and
- **state of the mouth** (in temporarily open/closed systems).

## Main Biological Components

Biological components refer to estuarine vegetation, benthic invertebrates, fish and birds. Estuarine life is usually capable of tolerating the highly variable environments of these systems if this variation is 'natural'. If the variation is affected by artificial means (such as manipulation of river flows) it may become too extreme for the estuarine plants and animals to cope with.

- **Micro-algae** form a crucial part of the food chain in estuaries and include phytoplankton (minute water-borne plants) and benthic micro-algae (found on the estuary bed).
- **Macrophytes (large plants)** include mangroves, salt marshes, submerged macrophytes, reeds and sedges. The vegetation both provides a safe habitat from predators and forms a crucial part of the food chain in estuaries.
- **Benthic invertebrates** refer to organisms such as **crabs, sand prawns, mud prawns, various mussel species and surface feeders**. Crabs, for example, forage during low tide on the material deposited during the preceding high tide. These organisms provide an important food source to other estuarine inhabitants such as fish and birds.

- As many as **100 species of fish** are wholly or partially dependent on South African estuaries, while up to 400 species frequent estuaries at some time of their lives. Common estuarine fish species include **kob, white steenbras and stumpnose** that grub in the sediment for mud prawns, sand prawns and molluscs. **Shad, leervis and sharks** are predators that hunt other fish. The most abundant fish in estuaries are often **mullet** which are detritus feeders. Most fish that occur in estuaries breed in the sea. Large numbers of their juveniles return to the shelter of estuaries where they mature until they themselves are able to breed. Estuaries are therefore important nursery grounds for many fish. Some fish, such as the **sand goby and the needle fish**, are dependent on estuaries for their entire life cycles.
- Many **birds** are dependent on estuaries for food. Weed eating species such as the **red-knobbed coot**, invertebrate eaters such as **flamingos** and fish-eaters such as **herons, cormorants and pelicans** all use estuaries as feeding grounds. Waders frequent South African estuaries during the summer when they migrate here from their breeding grounds in the Arctic. Estuaries also provide protected habitats for some of our endangered Red Data species, such as the **black oystercatchers**.



**Figure 3: Biological Richness of Estuaries**

## Estuarine Food Web

The food chain in estuaries relies heavily on the death and decay of various types of plants. The fragmented remains of plants, called **detritus**, together with organic matter that is introduced from the rivers and sea, form the **main source of food** for the prolific estuarine animals.

**Tidal action is important for estuaries.** The flood tide carries in the larvae of invertebrates and juvenile fish from the sea and the ebb tide flushes pollutants out to sea. A large tidal range increases the area of the intertidal flats that are exposed at low tide. **These flats are the most productive part of the estuary** and provide a home for invertebrates like the mud-prawn, an essential part of the estuarine food web.

**Adapted from: Van Niekerk, et al., (2006) and Coastcare Factsheet 1A, Estuaries and Lagoons.**

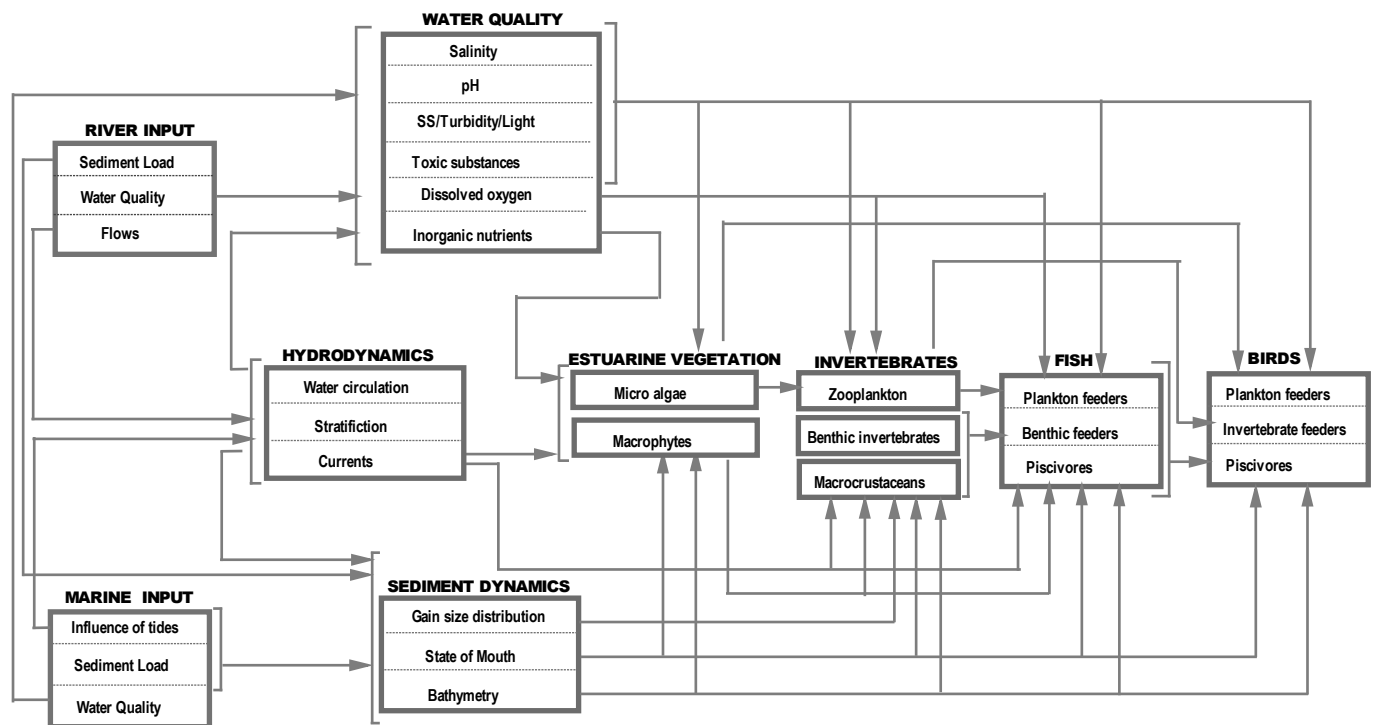


**Figure 4: An Estuarine Food Web**

## The Whole Picture

An estuary is a complex system involving both physical (abiotic) and biological (biotic) processes and interactions. Together these provide the context in which many animals and plants live out all or part of their lives. They also provide many of the goods and services needed by human communities. A breakdown in any of these processes and interactions can have disastrous effects on the overall functioning of the system and on the resources that are so important to us and the other inhabitants of the estuary.

The whole picture, in all its complexity, is captured in Figure 5, by Taljaard *et al.* (2003).



**Figure 5: Conceptual Framework of the Anticipated Abiotic and Biotic Processes and Interactions Relevant to Estuaries**

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Reducing the freshwater input can critically upset the balance needed to maintain the natural functioning, both physical and biological, of estuaries. This must be taken into consideration when setting the Reserve throughout the whole length of the river.

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## River Estuary Interface (REI)

The overlap between the freshwater provided by rivers and the seawater coming in through open estuary mouths is considered **one of the most critical areas for biological productivity**. The size of this area depends very much on the freshwater flow, and varies according to river conditions and tidal influence.

From this it is clear that both the **quantity and quality of freshwater available to the estuary is important in maintaining the biological diversity** of the system.

### The Importance of the REI

In the paper: *"The importance of the river-estuary interface (REI) zone in estuaries"* (GC Bate, AK Whitfield, JB Adams, P Huizinga and TH Wooldridge, 2002), the authors suggest that **"freshwater is important if estuaries are to maintain their natural function. The importance has been demonstrated for micro-algae, invertebrates and fish. Not only is the strength of the REI determined by freshwater inflow quality, but also the size of the REI is influenced by both rate of base flow and periodical flooding"**. They also state that: *"...the quality of freshwater that will in future be permitted to flow into estuaries will have an influence on the structure of fish communities. This type of influence must be taken into account when allocating water to estuaries..."*

# What Can Go Wrong?

There are a number of issues or threats affecting many of South Africa's estuaries. These are often linked with the types of activities that take place directly **in and around the estuaries**, or **higher up in the river catchments**, or **further out to sea** or **along the coast** from them.

## Major Human Impacts On Estuaries

South African estuaries are subject to a range of impacts:

- **Pollution** – from industry, agriculture and sewage causes deterioration in water quality resulting in the death of animals and plants and the development of sludge communities.
- **Siltation** – farming often leads to soil erosion, which increases siltation, suffocating benthic fauna and turbidity, reducing light penetration, decreasing the production of plants and excluding visual feeders. Siltation and turbidity can also be caused by building development and by activities such as mining, quarrying, 'sand winning' and dredging.
- **Reduction of freshwater flow** – the abstraction of water and the building of dams, weirs and roads and the invasion of catchments by 'water-greedy' alien plants restrict the flow of rivers with serious effects on the estuarine ecosystem. The reduction of freshwater flow leads to a shallow estuary that may remain closed to the sea for many years so that fish and invertebrate larvae can no longer migrate freely between the sea and estuary to complete their life cycles. Even where estuaries remain open, lack of fresh water can increase the salinity beyond what some organisms can tolerate. The result is a decrease in diversity and productivity at all levels.
- **Urban encroachment** – harbour development, artificial breaching, the disruption of wetlands, and demands to control natural process such as flooding can all affect the health of estuaries.

- **Over-exploitation of the resources** – in addition to the over-abstraction of the water itself for industrial, agricultural and domestic development purposes, many of the resources within estuaries are vulnerable to over-use. These include the fish species, particularly those species absolutely reliant on the estuaries for protection at critical stages in their lives, and bait organisms needed by so many fish and birds for their survival.
- **Colonisation/Invasion** – of the water body and the riparian areas by alien plants and animals. In addition to sometimes demanding more water than indigenous plants, alien invasive plants can change the entire biological character of estuaries by colonizing large areas and suppressing the growth of the natural vegetation. Alien fish species can literally wipe out populations of indigenous fish, some species of which are already endangered through changes in the water flows and salinity regimes, or through over-fishing.

Specific threats are related to particular activities, some of which are illustrated in Table 2.

### Land Use, Infrastructure and Development

Threat	Concern
<ul style="list-style-type: none"> <li>• Marina development</li> <li>• Bridges</li> <li>• Low-lying developments along banks</li> <li>• Bank stabilization &amp; destabilization</li> <li>• Mouth stabilization</li> <li>• Lack of maintenance of infrastructure (e.g. sewage plants)</li> <li>• Cumulative impacts of development</li> <li>• Dredging</li> <li>• Mining (e.g. sand winning)</li> <li>• Exceeding carrying capacity resulting from boating, bathers etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Destruction, fragmentation or modification of estuarine habitats and/or ecosystems</li> <li>• Reduction in estuarine productivity</li> <li>• Artificial Mouth Breaching               <ul style="list-style-type: none"> <li>– Artificial mouth breaching is a common practice in estuaries where coastal developments have occurred at too low levels next to temporarily open/closed estuaries. As a result, the mouth is breached artificially before natural breaching levels are reached to prevent flood damage to properties. Problems which are associated with artificial mouth breaching include breaching at the wrong time of year, breaching at too low water levels, breaching at the wrong position or digging a too shallow initial trench, resulting in increased sedimentation, no juvenile fish migration in spring or summer if closed, and saltmarsh vegetation die-off due to long inundation.</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Poor agricultural practices</li> </ul>	<ul style="list-style-type: none"> <li>• Destruction of riparian area</li> <li>• Soil erosion</li> <li>• Pollution caused by agricultural return flow (see water quantity and quality concerns)</li> </ul>

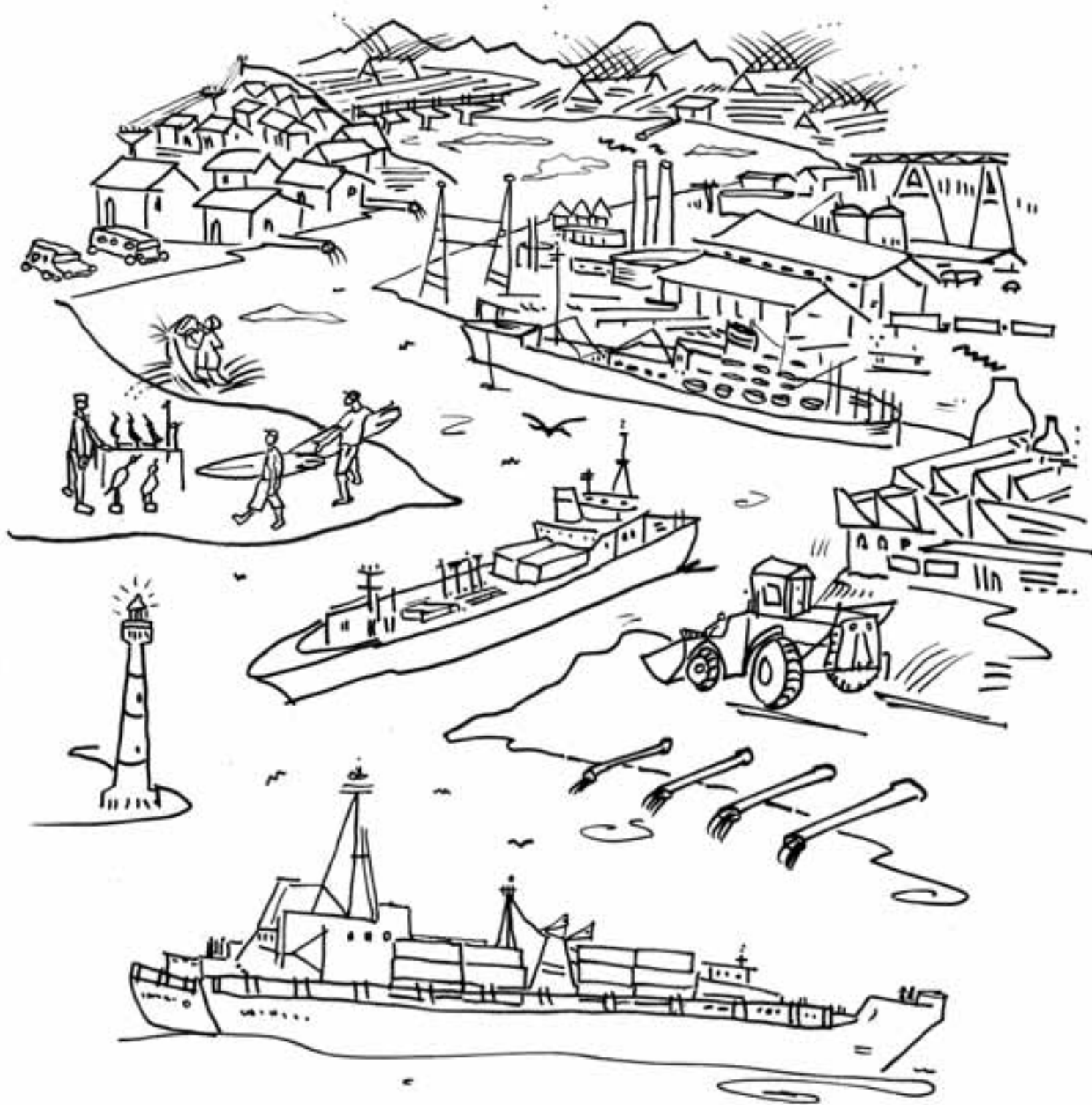


Figure 6: Estuaries Under Threat

## Water Quantity and Quality

Threat	Concern
<p><b>Water Quantity Issues</b></p> <ul style="list-style-type: none"> <li>• Reduced run-off to estuaries due to:               <ul style="list-style-type: none"> <li>– Construction of major dams</li> <li>– Direct abstraction by local farmers and industry</li> <li>– Cumulative impact of numerous small farm dams</li> <li>– Afforestation</li> <li>– Infestation by alien vegetation</li> <li>– Inter-basin transfers</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Altered turbidity and/or siltation</li> <li>• Interference with natural migration patterns</li> <li>• Early and extended mouth closure, due to loss of river inflow</li> <li>• Increase in sedimentation due to decrease in major floods (less scouring)</li> <li>• Decrease in sedimentation due to major dams sometimes acting as sediment traps</li> </ul>
<ul style="list-style-type: none"> <li>• Enhanced river flows</li> <li>• Inter-basin transfers</li> <li>• Waste water treatment works</li> <li>• Hardening of catchments</li> </ul>	<ul style="list-style-type: none"> <li>• Altered mouth closure regimes</li> </ul>
<p><b>Water Quality Issues</b></p> <p><i>Point source discharges</i></p> <ul style="list-style-type: none"> <li>• municipal waste (including sewage disposal)</li> <li>• industrial effluent( including cooling water) discharges</li> <li>• Litter</li> <li>• Mariculture waste products</li> <li>• Pollution related to shipping activities in harbours</li> </ul>	<ul style="list-style-type: none"> <li>• Human health issues</li> <li>• Ecosystem degradation</li> </ul>
<p><i>Diffuse discharges</i></p> <ul style="list-style-type: none"> <li>• Septic and conservancy tank seepage</li> <li>• Agricultural and pastoral run-off containing fertilisers, pesticides and herbicides</li> <li>• The inflow of contaminated storm-water or groundwater</li> </ul>	<ul style="list-style-type: none"> <li>• Non-natural salinity and temperature levels</li> <li>• Nutrient enrichment</li> <li>• Human health issues</li> <li>• Ecosystem degradation</li> </ul>

## Exploitation of living resources

Threat	Concern
<ul style="list-style-type: none"> <li>• Recreational fishing</li> <li>• Commercial fishing (e.g. net fishing)</li> <li>• Traditional fish traps</li> <li>• Poaching</li> <li>• Bait collection</li> <li>• Aquarium fish collecting</li> <li>• Inappropriate levels of recreational activities (e.g. fishing competitions)</li> <li>• Mariculture</li> <li>• Harvesting of mangroves</li> <li>• Translocated and alien fauna and flora</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of biodiversity (e.g. loss of fish and bait species)</li> <li>• Loss of ecosystem structure</li> <li>• Destruction of habitat</li> </ul>

## Legal and Institutional Structure

Threat	Concern
Lack of communication, coordination and cooperation between government departments	<ul style="list-style-type: none"> <li>• No communication between government departments</li> <li>• Lack of coordination (Government)</li> <li>• Lack of cooperation within national departments</li> <li>• Duplication of work, lack of responsibility</li> </ul>
Lack of clearly defined, legislated responsibilities	<ul style="list-style-type: none"> <li>• Legislative mandate not clear</li> <li>• Conflicting legislation</li> <li>• Jurisdiction / Responsibility: don't know who is responsible</li> <li>• Narrow jurisdiction e.g. control of bait collection only</li> <li>• Lack of funds</li> </ul>
Lack of effective planning, implementation and management	<ul style="list-style-type: none"> <li>• Corrective Action - procedures and follow up!</li> <li>• Need monitoring protocols</li> <li>• No holistic management plan for each estuary</li> <li>• Problems in implementing Integrated Catchment Management</li> <li>• Difficulties in implementing solutions to problems (e.g. removing sedimentation)</li> </ul>

Threat	Concern
Socio-economic problems	<ul style="list-style-type: none"> <li>• Migration to coastal areas due to rising unemployment</li> <li>• Poverty</li> <li>• Need for community beneficiation</li> </ul>
Lack of enforcement of legislation and the capacity to do so	<ul style="list-style-type: none"> <li>• Lack of capacity and commitment</li> <li>• Failure to implement environmental legislation and plans</li> <li>• Lack of resources (human and financial) for enforcement</li> </ul>
Lack of internalisation of costs by developers	<ul style="list-style-type: none"> <li>• Lack of internalisation of costs</li> <li>• Risk and responsibility should be carried by developers or municipality</li> </ul>
Stakeholders	<ul style="list-style-type: none"> <li>• Stakeholder fatigue</li> <li>• Range of different interest groups with different needs (difficult to manage)</li> </ul>
Lack of data and knowledge on estuaries and poor distribution of existing information	<ul style="list-style-type: none"> <li>• No database for general access</li> <li>• Lack of distribution of information - poor communication</li> <li>• Lack of indicators of estuarine health</li> <li>• Lack of environmental knowledge: engineers, town planners</li> <li>• Lack of knowledge on socio-economic uses</li> <li>• Lack of knowledge in communities living next to estuaries (i.e. understanding systems)</li> <li>• Inventory of resource base lacking</li> </ul>

**Table 2: Threats and Concerns (from Van Niekerk, *et al.*, 2006)**

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Estuarine management is necessary to reduce threats to levels which do not interfere with the natural functioning of the estuary. Estuarine management is necessary to reduce threats to levels which do not interfere with the natural functioning of the estuary.

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Estuaries are therefore faced with a considerable number of threats, many of them linked to the **levels** of activities such as **fishing, water abstraction, development and recreation**. Such activities may be **compatible with maintaining a healthy estuary** provided they are **not carried out in excess**.

Other threats, such as **pollution, introduction of alien species and poaching** must be **avoided altogether**.

# How Do We Take More Care?

Estuary management is mostly concerned with the **maintenance of the physical and biological processes** that make estuaries the rich and dynamic places they are. This is vital in order to **conserve the estuarine resources** for both the human and ecological needs.

Estuary management is faced with particular challenges, as **many of the threats originate outside the estuaries themselves**; higher up the rivers and catchments, out to sea, and along the coastline. So estuary management should be located in **wider management strategies, including whole catchment management and integrated coastal zone management (ICZM)**.

Estuary management is therefore an extremely complex process involving a large number of stakeholders over a wide area. It involves both **direct and indirect actions** which can be **proactive or reactive**, and applied **locally** (in the estuary itself), or **broadly** (in the wider context of the coastline or river catchment).

What this can mean is that the people most directly involved in and dependent on the use of the estuary's resources (those living around the estuary) may feel that there is little they themselves can do to conserve and manage these resources. However there are both direct and indirect actions that they can take.



**Figure 7: Working together to Protect the Estuary**

## Direct and Indirect Actions

The focus here will be on the **actions** that can be taken by individuals and groups directly involved in the use of the estuarine resources.

**Table 3: Direct and Indirect Actions**

Threat	Direct action	Indirect action
<b>Pollution:</b>		
<b>Industrial/ commercial, including petrol stations (chemicals/oils etc.) and mines</b>	<ul style="list-style-type: none"> <li>• Continuously monitor all industrial outfalls (including via streams and storm drains) into estuary</li> <li>• Report any incidents or concerns immediately to the appropriate authorities</li> <li>• Follow through to ensure appropriate action is taken</li> <li>• If owner or manager of industrial or commercial concern, ensure that all pollution control measures are in place and checked regularly</li> <li>• Comply fully with requirements of NEMA and other legislation</li> </ul>	<ul style="list-style-type: none"> <li>• Establish estuary forum, WUA (or similar)</li> <li>• Involve owners and managers of industrial and agricultural concerns in estuary forum or WUA</li> <li>• Involve municipality and community representatives in estuary forum or WUA</li> <li>• Work with municipality to ensure only appropriate industrial and commercial development in SDF and IDP</li> <li>• Work with municipality to ensure only appropriate housing and infrastructure development in SDF and IDP</li> <li>• Work with municipality to establish continuous monitoring of all outfalls from sanitation and other water services infrastructure</li> </ul>
<b>Agricultural (fertilizers/ pesticides/oils)</b>	<ul style="list-style-type: none"> <li>• Continuously monitor all sections of estuary adjoining agricultural land, and at highest point where freshwater enters estuary</li> <li>• Report any incidents or concerns immediately to the appropriate authorities</li> <li>• Follow through to ensure appropriate action is taken</li> <li>• If farmer, avoid any application of fertilizers and pesticides in riparian (bankside) zone</li> <li>• Do not exceed recommended application rates anywhere</li> <li>• Dispose of containers in appropriate registered sites</li> <li>• Comply fully with requirements of NEMA and other legislation</li> </ul>	<ul style="list-style-type: none"> <li>• Work with department of agriculture and department of water affairs and forestry to establish monitoring of farm run-offs and of estuary in general</li> <li>• Ensure that estuary forum and/or WUA contributes to Catchment Management Strategy developed by CMA</li> <li>• Ensure that estuary forum and/or WUA contributes to integrated coastal zone management planning</li> <li>• Ensure that estuary forum and/or WUA contributes to estuary management plan</li> <li>• Work with Department of Water Affairs and Forestry and water research institution to develop water monitoring programmes</li> </ul>
<b>Domestic (sewage etc.)</b>	<ul style="list-style-type: none"> <li>• Continuously monitor all outfalls from water treatment works and other sanitation infrastructure (including via streams and storm drains) into estuary</li> </ul>	<ul style="list-style-type: none"> <li>• Involve water users in monitoring programmes</li> <li>• Work with municipality and other stakeholders to develop disaster management plans</li> </ul>

Threat	Direct action	Indirect action
<b>Siltation</b>		
<b>Agriculture</b>	<ul style="list-style-type: none"> <li>• Continuously monitor all sections of estuary, especially those adjacent to farmland, build development sites and mining and sand winning activities. Also at highest point in estuary</li> <li>• Report any incidents or concerns immediately to the appropriate authorities</li> <li>• Follow through to ensure appropriate action is taken</li> <li>• <b>If farmer</b>, adopt practices to reduce exposure of bare soil to water and wind. Avoid cultivation of riparian areas, avoid overgrazing</li> </ul>	<ul style="list-style-type: none"> <li>• Establish estuary forum, WUA (or similar)</li> <li>• Involve farmers, developers and mining companies in forum/WUA</li> <li>• Work with municipality to ensure that build/ industrial development zones in SDF and IDP are at appropriate distance from the estuary</li> <li>• Work with department of agriculture, department of water affairs and forestry, and department of minerals and energy to establish monitoring of farming, building and mining activities</li> <li>• Ensure that estuary forum and/or WUA contributes to Catchment Management Strategy developed by CMA</li> </ul>
<b>Build Development (building sites etc.)</b>	<ul style="list-style-type: none"> <li>• <b>If builder/developer</b>, ensure that site is enclosed to prevent soil or building dust (cement etc.) being blown or washed into estuary</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure that estuary forum and/or WUA contributes to integrated coastal zone management planning</li> </ul>
<b>Mining, quarrying, sand winning, dredging etc.</b>	<p><b>If mine owner or manager, or owner/ manager of sand-winning concern</b>, ensure operations are conducted to keep siltation or disturbance of the river bed to a minimum (i.e. sand winning only above the water level at appropriate stages in the tidal cycle)</p> <p>Comply fully with licence conditions</p> <p>All comply fully to relevant legislation including NEMA and Mineral and Petroleum Resources Act</p>	<ul style="list-style-type: none"> <li>• Ensure that estuary forum and/or WUA contributes to estuary management plan</li> <li>• Work with department of water affairs and forestry and water research institution to develop water monitoring programmes</li> <li>• Involve water users in monitoring programmes</li> </ul>

Threat	Direct action	Indirect action
<b>Urban encroachment</b>		
<b>Harbour development</b>	<ul style="list-style-type: none"> <li>• All actions to counter the damaging effects of inappropriate development are likely to be indirect actions.</li> </ul>	<ul style="list-style-type: none"> <li>• Establish estuary forum, WUA (or similar)</li> <li>• Involve municipality in forum/WUA</li> <li>• Work with municipality to ensure only appropriate industrial and commercial development, including harbour development in the SDF and IDP</li> <li>• Work with municipality to ensure only appropriate housing and infrastructure development in the SDF and IDP. Such development should not take place within a flood plain, or within limits of '100 year' flood potential. (This is to avoid demands for artificial breaching and for 'hard' flood defences along estuary banks.)</li> <li>• Work with municipality to ensure that wetlands are NOT identified as development zones in the SDF and IDP</li> <li>• Work with the municipality to design a development strategy that works with the estuary's natural processes</li> <li>• Ensure that estuary forum and/or WUA contributes to estuary management plan</li> </ul>
<b>Artificial breaching (in temporary closed/open estuaries)</b>	<ul style="list-style-type: none"> <li>• Flood control</li> </ul>	<ul style="list-style-type: none"> <li>• Disruption of wetlands</li> </ul>

Threat	Direct action	Indirect action
<b>Over-exploitation of Resources</b>		
Water	<ul style="list-style-type: none"> <li>• Everyone except Schedule 1 water users must register their water use and seek licences.</li> <li>• Comply fully with the conditions of the licence</li> <li>• Continuous monitoring/policing of water use by registered (and other) users</li> </ul>	<ul style="list-style-type: none"> <li>• Establish estuary forum, WUA (or similar)</li> <li>• Involve water users, fishers, harvesters and mineral concerns in forum/WUA</li> <li>• Ensure that estuary forum and/or WUA contributes to Catchment Management Strategy developed by CMA</li> <li>• Ensure that estuary forum and/or WUA contributes to estuary management plan</li> </ul>
Fish, shellfish and bait animals	<ul style="list-style-type: none"> <li>• <b>All fishers and shellfish collectors</b> must apply for appropriate fishing permit (subsistence, recreational, commercial), also for bait collection. If commercial they must also apply for a quota.</li> <li>• Comply fully with the conditions of the permits and quotas, including the types of equipment that can be used.</li> <li>• Continuous monitoring/policing of catches and bait collections</li> <li>• Monitoring of fish populations</li> </ul>	<ul style="list-style-type: none"> <li>• Work with department of water affairs and forestry and fishery research institution to develop fish survey and monitoring programmes</li> </ul>
Plants (including seaweeds)	<ul style="list-style-type: none"> <li>• <b>All harvesters</b> must apply for permits to collect any plants (either from the provincial department of environmental affairs, or from the Marine and Coastal Management)</li> <li>• Comply fully with the permit conditions</li> <li>• Continuous monitoring of plant harvesting</li> </ul>	
Minerals (including sand)	<ul style="list-style-type: none"> <li>• All necessary permits and licences must be obtained</li> <li>• Comply fully with permit or licence conditions</li> <li>• Continuous monitoring of mineral extraction</li> </ul>	

Threat	Direct action	Indirect action
<b>Colonisation/Invasion by alien plant and animal (fish) species</b>		
Alien Plants	<ul style="list-style-type: none"> <li>• Avoid any introduction of any alien plants into any part of estuary system</li> <li>• Recording/mapping of current location and extent of colonisation</li> <li>• Establishing work teams (volunteer and/or paid) to remove invasive plants</li> <li>• Establishing work teams (volunteer and/or paid) for restoration of natural vegetation (in-stream or riparian)</li> <li>• Continuous monitoring of location, extent and spread of invasive plants</li> </ul>	<ul style="list-style-type: none"> <li>• Develop vegetation map of riparian and in-stream vegetation</li> <li>• Develop strategy, within catchment management strategy for control of aliens and restoration of natural vegetation</li> <li>• Work with municipality and others to develop biodiversity conservation plan within IDP</li> <li>• Work with department of agriculture and department of water affairs and forestry to initiate poverty relief programmes for removal of alien vegetation and restoration of natural vegetation</li> </ul>
Alien fish and other animals	<ul style="list-style-type: none"> <li>• Avoid introduction of any alien fish or other animal species into any part of estuary system</li> <li>• Conduct fish survey throughout estuary</li> <li>• Establish team of fishers to work to remove all alien fish from estuary</li> </ul>	<ul style="list-style-type: none"> <li>• Work with department of water affairs and forestry and fishery research institution to develop fish survey and monitoring programmes</li> <li>• Work to develop strategy to eliminate alien species</li> </ul>

## Proactive and Reactive Actions

The key actions identified here can be divided into proactive and reactive actions:

- **Proactive (or preventative)** – Actions that are taken to **prevent problems occurring**. These include:
  - Establishing estuary forums, or Water User Associations (WUAs) to bring the users of the estuary together to discuss and address issues
  - Developing estuary management plans and catchment management plans
  - Developing disaster management strategies to deal with potential problems
  - Developing monitoring programmes
  - Monitoring and policing resource use
  - Including environmentally sensitive development and biodiversity conservation plans in the local SDF and IDP

- Developing strong collaborations with government departments and research institutions
  - Conducting base-line surveys of vegetation and fish
  - Complying with all relevant legislation, including environmental legislation in all activities
  - Complying with permit and licence conditions.
- **Reactive** – Actions that are taken to **deal with problems that already exist**. These include:
    - Assessing the nature and scale of the problems (pollution, alien species, over-exploitation etc.)
    - Developing strategies to deal with the problems
    - Accessing funding to deal with the problems
    - Organising, equipping and training work teams (volunteer or paid) to deal with the problems
    - Conducting clean-ups, removals of aliens etc. (See the companion booklet *Taking Care of Wetlands*)
    - Conducting restoration of natural vegetation etc. (See the companion booklet *Taking Care of Wetlands*)
    - Taking legal action against those in breach of legislation, including environmental legislation (See the companion booklet: *Summary of Key Legislation*)
    - Taking legal action against those in breach of permit or license conditions.

## Monitoring

As can be seen from Table 3, one of the most important actions that should be taken is to continuously monitor different aspects of the health of the estuary.

There are many different aspects that can be monitored to provide indications of the health of the estuary, including:

- **The water quality** – this can involve the use of a number of monitoring tools such as **chemical testing** for: salinity; pH (acidity); turbidity/light penetration\*; toxic substances; dissolved oxygen, and inorganic nutrients.
- In addition water quality can be assessed by monitoring the **aquatic invertebrates** using the **South African Scoring System (SASS)\***.
- **The water quantity** – involving monitoring of base flow rates through the different seasons.
- **The river habitats** – through the use of the Index of Habitat Integrity (IHI)\* developed by the Institute for Water Quality Studies (now the DWAF sub-directorate Resource Quality Services).

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\*These indicators are all used by the River Health Programme in assessing the condition of rivers for the *State of Rivers Reports*. More information on these is available from the River Health Programme website: [www.csir.co.za/rhp](http://www.csir.co.za/rhp), or see the companion booklet *Taking Care of Rivers* in this series.

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- **The riparian (bankside) vegetation** – through use of the Riparian Vegetation Index (RVI)\* developed by the Institute for Water Research (IWR), or more simply to monitor for the presence and spread of alien invasive plants.
- **The fish** – through monitoring programmes such as the **line-fish monitoring programme** (run by the Oceanographic Research Institute, ORI), or the Fish Assemblage Integrity Index (FAII)\* developed by the Institute for Water Quality Studies (now the DWAF sub-directorate 'Resource Quality Services).
- **The birds** – through regular **counts of key species** such as pelican, flamingo, black oystercatcher and observations of top predators such as the fish eagle.
- **Harbour and other development in the area** – to assess the potential impacts of the development on the estuary. It is perhaps more important, and certainly more effective, to work with the local municipality to ensure that planning frameworks such as the IDP do not promote inappropriate developments likely to have negative impacts on the estuary.

The above can be quite complex and technically difficult approaches to monitoring, but we can all do something. The *EnviroFacts* publication sheet on Estuaries has useful advice for simple monitoring of the condition of estuaries:

### WHAT YOU CAN DO

- Get to know the estuaries in your area by walking along their shoreline or canoeing throughout their length. Report signs of damage to the local authority.
- List the plants and animals living in these estuaries. Photograph the upper, middle and lower reaches of the estuary from fixed vantage points and monitor change between seasons and from year to year.
- Find out what the estuary is used for, which local authority is responsible for its management and what strategies have been prepared to control development alongside it.
- Read *The Biology and Conservation of South Africa's Vanishing Waters* (Davies and Day, 1986) which has a very useful chapter entitled "What you can do."



**Figure 8: Keeping and Eye on the Situation**

## Agencies Involved in Estuary Protection and Management

Many of South Africa's estuaries are afforded some degree of protection, this either by being part of protected areas under management by national or provincial conservation agencies, or through international designation such as the Ramsar Convention which recognises wetlands, including estuaries, of international importance.

Table 4 summarises the protection afforded these estuaries:

Estuary	Protected area	Agency	Amount of estuary included	Category assigned
Orange*	(Planned)#	Provincial	Part	Low
Rietvlei/Diep	Rietvlei NR	Municipal	Part	Medium
Wildevöelvlei	Table Mountain NP	SANP	Entirely (new)	Medium
Krom	Table Mountain NP	SANP	Entirely	High
Sand	Sandvlei NR	Municipal	Top <10% of estuary	Low
Heuningnes*	De Mond NR	CNC	All	High
Wilderness*	Wilderness Lakes NP	SANP	Part	Medium
Swartvlei*	Wilderness Lakes NP	SANP	Part	Medium
Goukamma	Goukamma NR	CNC	Most	High
Knysna	-	SANP	Part	Medium
Keurbooms	Keurbooms River NR	CNC	Part (upper reaches)	Low
Sout (Oos)	Tsitsikamma NP	SANP	All	High
Groot (Wes)	Tsitsikamma NP	SANP	All	High
Bloukrans	Tsitsikamma NP	SANP	All	High
Lottering	Tsitsikamma NP	SANP	All	High
Elandsbos	Tsitsikamma NP	SANP	All	High
Storms	Tsitsikamma NP	SANP	All	High
Elands	Tsitsikamma NP	SANP	All	High

Estuary	Protected area	Agency	Amount of estuary included	Category assigned
Groot (Oos)	Tsitsikamma NP	SANP	All	High
Tsitsikamma	Huisklip NR	ECNC	Lower reaches	Medium
Seekoei	Seekoei River NR	ECNC	Part (upper)	Low
Gamtoos		ECNC	Part	Low
Van Stadens	Van Stadens NR	Municipal	All	Medium
Nahoon	Nahoon NR	Municipal	Very small part	Low
Nkodusweni	Pondoland MPA	DEAT	Tidal reaches	Low
Mntafufu	Pondoland MPA	DEAT	Tidal reaches	Low
Mzintlava	Pondoland MPA	DEAT	Tidal reaches	Low
Mbotyi	Pondoland MPA	DEAT	Tidal reaches	Low
Mkweni	Pondoland MPA	DEAT	Tidal reaches	Low
Msikaba	Pondoland MPA	DEAT	Tidal reaches	Low
Mtentu	Pondoland MPA	DEAT	Tidal reaches	Low
Sikombe	Pondoland MPA	DEAT	Tidal reaches	Low
Mnyameni	Pondoland MPA	DEAT	Tidal reaches	Low
Mpenjati	Mpenjati NR		All	High
Mgeni	Beachwood NR		Part	Medium
Mhlanga			All	High
Mlalazi		EKZNWS	All	High
Mhlathuze		EKZNWS	All	Medium
Mfolozi*	GSLWP	GSLWP Authority	All	High
St Lucia*	GSLWP	GSLWP Authority	All	High
Mgobezeleni*	GSLWP	GSLWP Authority	All	Low
Kosi*	GSLWP	GSLWP Authority	All	High

**Table 4 Estuaries with some level of protection status, and the degree of protection (Taken from Turpie, J.K. 2004.**

\*Ramsar sites or estuaries that fall within Greater St Lucia Wetland Park Ramsar site.

# There is already some protection of the Orange River as part of the estuary is considered 'no-mans land' (due to the diamond mining interests and the border with Namibia), and fishing and general access is restricted.

It should be noted, however, that due to the deterioration in the condition of this river and the estuary there is some risk of it losing its Ramsar site status.

### **The categories of protection in Table 4 are defined as follows:**

#### *High:*

- whole estuary within a protected area
- significant restrictions on consumptive and non-consumptive activities
- significant restrictions on surrounding development.

#### *Medium:*

- part of estuary within a protected area
- some restrictions on activities
- some restrictions on surrounding development.

#### *Low:*

- part of estuary within a protected area
- little restriction on activities
- little restriction on surrounding development.

### **The conservation agencies identified in the table are:**

- South African National Parks (SANParks)
- Cape Nature Conservation (CNC) – now known as Cape Nature (CN)
- Ezemvelo KZN Wildlife Service (EKZNWS) – now known as EKZNW
- Eastern Cape Nature Conservation (ECNC)
- Greater St Lucia Wetland Park Authority (GSLWP Authority).

A few estuaries are under the protection of local municipalities, such as Van Stadens, in the Eastern Cape, which comes under the Nelson Mandela Metropole (Port Elizabeth).

### **Other agencies involved in estuary protection and management include:**

- Working for Water programme (DWAF) – focusing mostly on removal of invasive alien vegetation
- CoastCare programme (DEA&T) – focusing mostly on maintenance of beaches and coastline, including removal of alien invasive vegetation

- LandCare programme (DoA) – focusing on control of soil erosion, removal of invasive plants (alien and indigenous), and improvement on agricultural productivity.

## National Government Departments

National government departments are responsible for the implementation of specific legislation related to their areas of responsibility. These responsibilities are identified in the companion booklet *Summary of Key Legislation concerning Water/Catchment Management and Protection*.

## Local and Provincial Government Responsibilities

All local and district municipalities have the responsibility for environmental protection under NEMA and other legislation. They are also obliged to develop environmental management strategies, and environmental protocols in association with their IDPs and SDFs.

Provincial governments have the task of developing province-wide biodiversity conservation strategies, and are also responsible for ensuring that Environmental Impact Assessments are conducted as stipulated in the legislation, and for issuing Records of Decision (RoD) in relation to these. The RoD will state whether any development should or should not go ahead, and/or whether any mitigating measures need to be put in place to protect the environment.

## Non-Governmental Organisations (NGOs)

A number of national (and international) NGOs are involved in estuary management and protection:

- **Wildlife and Environment Society of South Africa (WESSA)** – WESSA has many local branches working with local communities and schools. It manages the South African Eco-Schools programme, where schools are involved in environmental learning and in addressing environmental issues in their areas.
- **Mondi Wetland Programme (MWP)** – This is a programme sponsored by the Mondi paper company to train and encourage local communities to take care of and protect their local wetland resources.
- **World Wildlife Fund (WWF)** – The Aquatic Programme of WWF-SA is focused on the conservation of both freshwater and marine habitats and species. The freshwater component of the programme is funding the development of this course.

# For More On Estuaries

## Further Reading and References

\*TALJAARD, S, VAN NIEKERK, L, HUIZINGA, P and JOUBERT, W (2003)  
**Resource monitoring procedures for estuaries for application in the Ecological Reserve determination and implementation process.** Water Research Commission Report No. 1308/1/03. Pretoria

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**Introductory Course to Estuarine Management in South Africa.**  
Training Course Manual.

\***Nurseries of the Environment** – Enviro-Kidz feature in The Water Wheel, January/February 2006, DWAF

\***Estuaries and Lagoons** – CoastCare FactSheet 1A, Claire Attwood, 2000, DEA&T

\***Estuary Management** – CoastCare FactSheet 2D, Margo Branch, 2000, DEA&T

\***Estuaries** – Enviro Factsheet no 27, Sharenet

\*Turpie, J.K. 2004. **South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 3: Estuary Component.** South African National Biodiversity Institute, Pretoria.

(\* All of these above are included on the CD)

**South African Estuaries and Their Importance to Fishes.** Port Elizabeth Museum.

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**The Living Shores of Southern Africa.** Margo and George Branch. Struik, Cape Town, 1981.

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**Estuaries of the Cape (Parts 1&2).** CSIR.

**Estuaries of Natal (Parts 1&2).** Natal Town and Regional Planning Commission, Pietermaritzburg.

**Estuarine Ecology with Special Reference to Southern Africa.** J. Day, Balkema, 1981.

## **Handy Addresses**

**South African Institute for Aquatic Biodiversity (SAIAB).** Rhodes University, P.O. Box 94 Grahamstown 6140

**Oceanographic Research Institute.** P.O. Box 736 Durban 4000

**Universities:** Cape Town, Port Elizabeth, Rhodes, Kwazulu-Natal (Departments of Zoology)

