Coral reefs are spectacular natural wonders and are among the world’s most diverse and complex ecosystems. Coral reefs are also very valuable to man. For thousands of years coastal communities have relied for their livelihoods on the fish and invertebrates associated with coral reefs. The massive coral structures protect islands from erosion and storms by acting as natural breakwaters, while reef related eco-tourism continues to increase in importance.

Coral Reefs built over millions of years

Coral reefs are built over millions of years by tiny individual coral animals called polyps. Each polyp, which is related to and looks like a tiny sea anemone, secretes a cup-shaped limestone skeleton in which it sits. As they grow, divide and reproduce, so the coral reef grows, forming complex coral colonies made up of millions of polyps fused together by their skeletons. The polyps have tentacles armed with stinging cells that they use to paralyse the tiny animals (plankton) that they eat. The ability of these tiny coral animals to form such enormous masses of limestone is due largely to minute, single celled plants called zooxanthellae that live within the coral tissue. Like all plants, zooxanthellae use the sun’s energy to make food for themselves and for the coral polyps. By removing carbon dioxide during photosynthesis the zooxanthellae also assist the rate of deposition of the calcium carbonate coral skeletons. Because of this association, reef-building corals are only found in warmer seas. Coral reefs and communities are found in about 110 countries, the majority lying between the tropics of Cancer and Capricom, extending further north and south where warm currents provide a favourable habitat.

Diversity

Coral reefs are among the world’s most diverse marine ecosystems. Fish and other animals, including sponges, sea squirts, molluscs, crustaceans, echinoderms and, of course, corals are all found on the reefs. Numerous algae (sea weeds) also occur on coral reefs. Because of the abundance of food, reefs also attract larger animals such as turtles, sharks and marine mammals. The plants and animals all live together by sharing the reef, each specialising in a different lifestyle and occupying a different niche.

Corals in South Africa

The warm Agulhas Current that flows down the east coast of South Africa allows many tropical species, such as corals, to extend their distribution. In KwaZulu-Natal (KZN), coral reefs occur primarily in the Greater St Lucia Wetland Park at Kosi Bay, Sodwana Bay and Leadsman Shoal. Further south, summer flooding of large rivers results in turbid inshore waters which limits hard coral growth. At Aliwal Shoal, located 3km off Umkomaas on the KZN south coast, some hard corals do occur, but with lower diversity.

Unlike most coral reefs, the South African corals have grown on the remnants of ancient sand dunes formed during periods of lower sea levels. Geologically speaking, the reefs are relatively young, only about 4 000 years old. Another unique feature of the reefs is that they are dominated by soft corals.
and not the hard corals common on most true coral reefs. A reason for the soft corals’ success may be that they are less susceptible to damage by the powerful swells that move directly over the reefs during rough weather.

Sodwana Bay is in a subtropical transition zone between the tropics to the north and the warm temperate region to the south. This results in a vast diversity of fish and invertebrate species. Hundreds of species of hard and soft corals, and sponges have been identified to date. However, as the invertebrates have not yet been intensively studied, many new species probably await discovery. A large percentage of South Africa’s coastal fish species can be found in these waters; at least 25 shark and ray species and over 400 bony fish have been identified.

**Impact of human activity**

Worldwide, coral reefs are showing signs of serious damage, largely as a result of escalating human needs and pressures. Coral reefs are common in developing countries, where human needs often appear to be in conflict with nature. A better understanding of the value of coral reefs is required to ensure that the damage inflicted by humans is minimal. Many reef fisheries have already been overexploited. Yields are declining and it is taking fishers longer to catch their fish. Damaging fishing techniques such as dynamite fishing, dredging and the use of poisons all impact negatively on coral reefs. Molluscs, corals and other curios are also collected from coral reefs.

Coral reefs provide an excellent draw card for tourists and reef related tourism plays an important role in the economies of many countries. However, damage can be caused through rapid increases in eco-tourism. Tourism can affect coral reefs through increased sewage pollution and greater exploitation of resources to satisfy the demand for curios and food. Even human activities inland can have a negative effect on coral reefs. Bad farming practices and insensitive coastal developments have resulted in increased soil erosion. This increases silt loads in rivers and estuaries. A fraction of the silt is carried downstream into the sea. Silt lowers the light intensity and hinders the photosynthetic ability of the zooxanthellae. Land based sources of pollution, such as fertilizer run off, effluent disposal and other chemical pollutants in particular threaten coral reefs. Oil spills also have the potential to destroy reefs.

Not only are reefs under threat as a result of human intervention, but natural damage to reefs also occurs. Storms, changes in sea level and predator outbreaks such as the crown-of-thorns starfish kill coral reefs. Global warming appears to be affecting reefs, particularly in shallower areas. The increased water temperature is causing corals to expel their zooxanthellae and then die.

In South Africa, over 100 000 dives are logged in the Sodwana Bay region annually and hundreds of fishermen visit the area to try their luck with the large gamefish common in the area.

The KwaZulu-Natal Wildlife protects the coral reefs in the Greater St Lucia Wetland Park. Research undertaken by the Oceanographic Research Institute shows that the impact of tourism has been minimal. If human activities are properly managed, South Africa’s coral reefs should continue to provide a fascinating ecosystem and valuable national asset.

### What you can do to help

- Do not buy products that have obviously been removed, alive, from a coral reef.
- Do not anchor on a coral reef.
- When snorkelling or diving on a reef, be careful not to touch the corals.
- Adjust your buoyancy before you descend to the reef to make sure that you will not bump or break the coral.
- Resist the temptation to collect shells while diving. Every shell provides a home for another animal.

Author: Judy Mann-Lang September 2000

**FURTHER INFORMATION:**

- Oceanographic Research Institute, P.O. Box 10712, Marine Parade 4056. Tel: (031) 3773536, Fax: (031) 3772132
- KwaZulu-Natal Wildlife (formerly KwaZulu-Natal Nature Conservation Service) P.O. Box 13053, Cascades, Pietermaritzburg 3200. Tel: (033) 8451999

**RELATED FACTSHEETS:**

- Hard and Soft Corals
- Maputaland Coast
- Safety at Sea
An ecosystem is a system of organisms which interact with one another and their surrounding environment. The coastal and marine environment has a fascinating variety of eco-systems each functioning as a dynamic unit under the influence of a set of physical factors such as tides, sea temperature, wave action, currents, light levels, wind, type of substratum and climate. Plankton, seaweeds, animals and bacteria form an intricate food web. Humans also influence these eco-systems. Some ecosystems are in a fairly stable state while others may be recovering from a major event such as a storm, an El Niño warming event, a flood, an oil spill, a lethal red tide or over-exploitation. Some ecosystems are in a state of change due to imbalances caused by human activities such as development, pollution or even global warming that change the physical or biological components.

**EXAMPLES OF COASTAL AND MARINE ECOSYSTEMS**

Some of the main ecosystems found in the sea are briefly described below.

**Sandy beaches**

Sandy beaches are characterised by their instability. The sand is continually lifted and moved by the waves. No seaweeds are able to grow here as there is no firm attachment. The animals are either tiny, such as worms and crustaceans that live in the spaces between the grains of sand, or are large enough to burrow, such as plough snails and crabs that emerge from or dig into the sand following the rhythms of the rising and falling tide. The food web is dependent on plankton, seaweeds and edible food items being deposited on the beach by the waves. At high tide predators such as swimming crabs, cuttlefish, galjoen, sand sharks and rays cruise over the sand where they feed on plough shells, burrowing clams and prawns. At low tide birds probe the exposed beach for crustaceans, bivalve molluscs and stranded marine plant and animal matter.

**Estuaries**

Estuaries are dynamic systems where rivers enter the sea. Apart from other influences, plants and animals living here have to contend with changing salinity (salt concentrations). At high tide the sea pushes into the river mouth bringing salty water, while at low tide the river flows out carrying fresh water, humus and soil which create mud flats. Seasonally the river may flood or it may dry up, causing the temperature and salinity in the lagoon to rise to high levels. Estuaries can be extremely productive because they trap organic nutrients brought down by the

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**A COASTAL ECOSYSTEM**

- **LIVING COMMUNITY**
  - Primary producers – algae
  - Consumers – animal
  - Decomposers – bacteria
  - Compete for space, food and mates
  - Co-operate

- **ENVIRONMENT**
  - Climate
  - Pollution
  - Rivers
  - Salinity
  - Type of substratum
  - Rock, sand
  - Wind
  - Currents
  - Waves
  - Tides
  - Air temperature
  - Sea temperature
river and carried in by the sea. Salt marsh plants grow in these rich calm waters and mangroves occur in sub-tropical areas. Bacteria and microscopic diatoms thrive and small bivalves, sand prawns and burrowing worms feed on the detritus (decaying plant matter). Estuaries provide a calm nursery ground for many juvenile fishes, and support large numbers of wading birds. Tropical estuaries are lined with mangrove swamps.

**Rocky shores**

Rocky shores provide a firm substratum to which both plants and animals can cling. This is a stressful area in which physical conditions vary with the tides. As a result plants and animals have adapted to different zones. Plants and animals high on the shore are adapted to dry conditions while those low on the shore must contend with strong wave action and competition for space and food. There are many herbivores, like molluscs, feeding on seaweeds and filterfeeders such as barnacles and mussels that sieve small particles of food from the water. The predators include crabs, starfishes, fishes and birds.

**Kelp forests**

Extensive kelp forests are found subtidally on the west coast where the water is cold and rich in nutrients due to upwelling. The large kelp plants attach to the rocky sea bed and break the force of the waves, thus providing shelter and food for a wide range of animals, including urchins, abalone, fish and rock lobsters (crayfish). Kelp that is torn off by storms often washes up on beaches, where it is an important source of food.

**Coral reefs**

Coral reefs occur in the tropical regions of the world. They are found off the warm east coast of South Africa. Corals are colonial anemone-like animals that form extensive reefs by slowly depositing calcium carbonate skeletons. The living animals capture food with their tentacles and also house microscopic algae in their flesh which use the corals' waste-products to photosynthesise and, in the process, provide food and assist in the release of calcium carbonate for the coral skeletons. The coral reef is alive with a myriad of different brightly-coloured fishes, shells, crabs and other creatures. Many of them have developed symbiotic relationships to aid survival in this competitive and dangerous habitat where there is little plant life and many predators.

**Pelagic zone**

The upper layers of the open ocean are known as the pelagic zone. In this ecosystem life is adapted to floating, drifting or swimming in the water. Phytoplankton underpins the food web, providing nourishment for zooplankton and other animals. In areas where productivity is high this zone supports huge shoals of fishes, such as pilchards, snoek and yellow tail. Whales, seals and many of the fishing birds feed in this zone. Floating organisms like jellyfish and bluebottles float on the open ocean. Plankton blooms prolifically where there is upwelling of nutrients, and certain species form toxic red tides which can severely influence the balance within the inshore pelagic ecosystem. Many species of zooplankton migrate to the surface at night and sink during the day, followed by fish and squid. There is nowhere to hide in the open ocean so animals are silver, transparent or blue and many of them form large swarms or schools which affords them safety in numbers. Many pelagic fish grow and mature quickly and have a short life.

**Demersal ecosystems**

The deep seabed of the open ocean is the demersal ecosystem. Here the water is generally cold, calm and dark. Due to the low light levels there is no plant life and animals rely on detritus raining down from above, or they are sluggish predators waiting in the dark to ambush their prey. Some, like the monkfish, even use lighted lures to attract prey. This is the domain of hake, kingklip, sole and monkfish. Demersal animals are able to withstand pressure. Hake migrate into upper waters to feed at night and have well developed air bladders to control their buoyancy at different depths.

Author: Margo Branch September 2000

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**FURTHER INFORMATION:**

**RELATED FACTSHEETS:**
- Rocky Shores • Sandy Beaches • Coastal Vegetation • Mangrove Swamps • Kelp Forests • Estuaries and Lagoons • Rock Pools on the South and West Coast • Rock Pools on the East Coast • Coral Reefs • Pelagic Fishing

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Estuaries are formed at the interface between rivers and the sea. They are either permanently or periodically open to the sea and there is a variation of salinity within estuaries due to the mixing of sea water with fresh river water. Lagoons are formed when an estuary is cut off from the sea by a sand bank. Evaporation can cause lagoons to become very saline environments.

Estuaries are dynamic systems that are constantly altered by tides, wave action and rainfall. Every tide brings a change in salinity but there may also be more dramatic changes of salinity in times of drought or flooding. For instance, high rainfall can transform an estuary into a strong-flowing muddy river, while strong coastal currents and a slow flowing river might cause a sandbank to form at the river mouth, trapping the water and forming a lagoon.

Rapid daily fluctuations in temperature, salt content and oxygen concentrations in the estuarine environment make estuaries one of the harshest ecological systems on earth. The wide variety of plant and animal species that have adapted to estuarine life are able to tolerate these fluctuations and their tolerance to varying conditions determines their distribution within estuaries. For instance, eelgrass, Zostera, beds occur in the lower reaches of estuaries where salinities resemble those of seawater, whereas the aquatic grass, Potamogeton, can only tolerate low concentrations of salt in the water and is found in the upper reaches of estuaries.

Water-loving plants thrive in estuaries

- **Phytoplankton** are free-floating, microscopic single-celled plants. They are consumed in large quantities by estuarine fish such as mullet.
- **Seagrasses** are able to tolerate complete or intermittent submergence by water.
- **Saltmarshes** are made up of salt-tolerant plants and form around the edges of estuaries.
- **Mangroves** are the only trees adapted to growing in salty tidal waters. They grow special aerial roots that stick out of the mud and absorb oxygen.
- **Reeds** grow at the head of estuaries where salt content is low. They form dense banks that filter silt and nutrients from the river water. In this way reeds fulfill a vital function by keeping the estuary clean.

**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.

*A typical estuary along our eastern shores*
Fishes and estuaries

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. They, unlike many other species, are able to tolerate fluctuating oxygen levels that are caused by the presence of large quantities of decaying plants.

Birds and estuaries

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 and comorants 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. Langebaan Lagoon is particularly attractive to avian migrants, offering as it does vast mudflats that ooze with countless molluscs and crustaceans. The mud at Langebaan is said to contain some 60 million bacteria in every cubic centimetre and is recognised as one of the most biologically productive areas in the world. Langebaan Lagoon supports up to 55 000 waders in summer. It is common to see migratory waders such as Curlew Sandpipers, Turnstones, Whimbrels, Curlews, Godwits and Greenshanks there in the summer months.

A delicate balance

The plants and animals that survive in estuaries are able to tolerate fluctuations in the estuarine environment. But changes of long duration inhibit migrations of organisms between the estuarine and marine environments. As a result, siltation is probably one of the greatest threats to estuarine systems. Siltation rates are greatly increased by the following human activities:

- Damming rivers or removing water through irrigation. This results in a reduced input of freshwater and altered river flow patterns. Flood events become smaller and less frequent and sediment is not properly flushed from the estuary. Siltation increases, estuaries are starved of water and become shallower and more saline.
- Agricultural practices such as planting crops too near to river banks causes erosion and increases the amount of silt that is deposited in estuaries.
- Building causeways and bridges can interfere with tidal action and upset natural estuarine flow and circulation.
- Property development alongside estuaries often results in shallow estuarine waters being filled with rubble or soil or even converted into marinas. Estuary mouths then have to be breached artificially to prevent flooding of buildings.

Clearly, a major cause of estuarine degradation is the manipulation of riverine flow. Fish which have been dangerously depleted as a result of alterations to riverine flow include estuarine pipefish, freshwater mullet and eels. In addition, some important linefish species have declined as a partial result of the degradation of estuarine habitat, eg white steenbras. It is evident that proper management and rehabilitation of estuaries can only be achieved through the management of water resources in entire catchments.

Pollution is a further threat to estuaries. Pollutants take many forms and affect estuaries in several ways. For instance, industrial waste such as heavy metals accumulate in food chains and poison top predators. Effluent from sewage systems or food processing leads to increased concentrations of organic compounds in estuarine systems. This leads to excessive plant/algal growth which in turn may lead to anoxia and eutrophication.

Author: Claire Attwood September 2000

FURTHER INFORMATION:
- A brochure on estuaries and lagoons is available from CoastCARE.

RELATED FACTSHEETS:
- Salt Marshes • Estuary Management • Orange River Mouth • Langebaan Lagoon • Erosion and Siltation • Kosi Bay • Eels • Garden Route

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
In tropical climates mangrove swamps occur in the littoral zone where they are daily flooded and exposed during the rise and fall of the tide. They are usually found in marine bays and tidal estuaries. Warm temperatures and fresh water are needed for the development of a mangrove community. In South Africa most of the mangrove swamps occur along the KwaZulu-Natal coast but they do extend south to estuaries in the Eastern Cape.

**Physical environment**

Mangroves occur in tropical climates because they need consistently warm conditions for development and survival. Temperature is generally regarded as the most important factor governing the distribution of mangroves. However, it appears that water temperature, rather than air temperature is most important, as mangrove swamps have developed in temperate areas, but only where a warm ocean current is found. Other requirements for the establishment of mangroves are soft, muddy substrata, with low wave action, which restricts their distribution to sheltered shores close to fresh water sources, where the accretion of suitable mud can occur. In tropical areas, direct rainfall may provide sufficient fresh water. This mud is usually anaerobic with oxygen only present in a very thin upper layer.

**Mangrove trees**

Mangrove trees grow between high and low spring tide levels. This means that while part of the mangrove swamp will be under water twice daily, the upper areas will only be flooded every two weeks, at spring tide. The roots of the trees are, therefore, specially adapted to cope with episodic flooding and drying out. Mangrove trees are halophytes (salt loving) and possess special mechanisms for coping with conditions of high salinity. They are also adapted to cope with the low levels of oxygen available in waterlogged soil and have aerial roots (pneumatophores).

Three species of mangrove trees are commonly found in South Africa. The white mangrove, *Avicennia marina*, the black mangrove, *Bruguiera gymnorrhiza* and the red mangrove, *Rizophora mucronata*. In the northern areas another two species of mangroves are found, namely the Tagal mangrove, *Ceriops tagal*, and the Kosi mangrove, *Lumnitzera racemosa*. In 1999 a new species of mangrove tree, *Sylocarpus granatus*, was discovered in Kosi Bay. The different mangrove species have adapted in different ways although all have some form of aerial roots. The white mangrove has an extensive shallow system of horizontal cable roots that radiate out from the base of the trunk. Unbranched pencil roots grow up from the cable roots, providing the tree with pneumatophores by which the subterranean portion of the tree is able to breathe. In the black mangrove knee roots protrude from the mud for the aerial breathing. The red mangrove possesses prop roots that

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**Mangrove Swamps**

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emerge from the trunk at various levels and go underground at random, thereby forming a tangled root mass. The trees also have leaves adapted for the exclusion or extrusion of salt and seeds adapted for quick germination in the muddy, unstable soils. A few other tree species can survive on the edge of mangrove swamps.

**Animals**

The animals need special adaptations to live in mangrove swamps. Most of them are mud dwellers such as the mud-skippers and crabs.

The male fiddler crabs have an enlarged, brightly coloured claw that is used in defence and courtship. The females are smaller and dull in colour. These small crabs feed on exposed mud banks at low tide. They shovel mud into their mouths, remove the food material from the mud and deposit the waste mud in small round pellets.

The sesarmid crabs are slightly larger than the fiddler crabs and have a dull brown body with bright red nippers. They feed on fallen mangrove leaves, which they drag into their permanent burrows in the mud. Water for respiration is reused by circulating water from the gills over aeration plates on their bodies, enabling them to breathe out of water.

Mangrove snails live on the mud and climb up and down the tree trunks with the rise and fall of the tides.

Many species of fish are also found in mangrove swamps and the sheltered waters are important nursery areas for marine fish and invertebrates. Mudskippers, Periophthalmus spp., are small fish that inhabit the edges of mangrove swamps where they prey on small invertebrates and fish. They can remain out of water for short periods, as they are able to retain water in the gill chamber. The water is re-oxygenated by taking in gulps of air. Mudskippers can move on land by using their adapted pectoral fins as levers.

**Impact of human activity**

Mangrove swamps are threatened by humans in a number of different ways. In some areas, especially along the Eastern Cape coast, mangrove trees have been felled for their valuable hardwood for use as firewood or for the building of houses and fences. In other countries, mangrove forests have been cleared to build ponds for shrimp farming and the swamps have been irreparably damaged.

Mangrove swamps are often drained to provide land for developments. Durban Bay, once home to many hectares of mangroves, has been cleared for the harbour. In Richards Bay, a nature reserve has been established to conserve a representative portion of its mangrove swamps.

Any construction that alters water level and tidal flow will impact on mangrove swamps. Dams reduce the amount of fresh water flowing into the swamps, thereby raising their salinity. When bridges and embankments are built close to the mouth of an estuary they may restrict tidal flow, while at the same time impounding the river and flooding the mangroves. Mangrove swamps are useful silt traps and form a natural barrier to the penetration of salt water from the sea into the adjacent agricultural land. The impact on the natural functioning of a mangrove system must be taken into account when planning coastal developments.

**What you can do**

- If you have the opportunity, visit a mangrove swamp. They are fascinating in spite of the mud! Be careful where you walk as you may be destroying the homes of small animals. Look and listen quietly, many of the animals are shy and only emerge if you wait very patiently.
- Do not buy carvings, furniture or firewood made from mangrove wood.

Author: Judy Mann-Lang September 2000

**FURTHER INFORMATION:**

- KwaZulu-Natal Wildlife (formerly KZN Nature Conservation Service). P.O. Box 13053, Cascades, Pietermaritzburg 3200. Tel: (0331) 8451999
- Oceanographic Research Institute, Sea World, Sea World Education Centre P.O. Box 10712, Marine Parade 4056. Tel: (031) 3373536, Fax: (031) 3372132

**RELATED FACTSHEETS:**

- Maputaland Coast • Mudskippers / Mudhoppers • Crabs • Kosi Bay

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (021) 402-3208 Fax: +27 (021) 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Rocky Shores

Rocky shores range from headlands with vertical cliffs to wide, wave-cut platforms or jumbles of boulders polished by the motion of the ocean. A fascinating array of plants and animals live on rocky shores, where they can grip on the firm substratum and hide in nooks and crannies. Many animals live totally submerged in pools and gullies while those on open rocks are exposed by the fall of the tide twice a day and confronted with physical stresses such as heat and water loss that lead to the formation of distinctive zones on the shore.

Rocky shore zonation

The marine organisms on rocky shores are well adapted to a variety of environmental conditions. Twice a day, when the tide is high, they are submerged by seawater. Then, when the tide retreats, they are exposed to air and the drying effects of the sun. They are pounded by waves and attacked by predators that are similarly engaged in a dramatic fight for survival. Plants and animals that live on rocky shores have adapted their vital functions - respiration, excretion and reproduction - to two completely different environments: the marine environment when the tide is high, and the terrestrial environment when the tide is low.
A close look at rocky shores at low tide reveals that the position of plants and animals within the intertidal zone depends on the amount of exposure to air and wave action they are able to withstand. For instance, those that dominate the lower shore are only out of water at low tide and are able to tolerate short periods of exposure to the air but can tolerate strong waves. The organisms that live near the high tide mark are able to withstand much longer periods out of water. For example, hardy, small Littorina periwinkles that live high on the shore can breathe air, and use mucus to attach themselves to the rock and then withdraw their bodies into their shells. In this way they are able to reduce their contact with the sun-warmed rocks.

Biologists have described four distinct bands, or zones of colonisation, that typify South Africa’s rocky shores: the Littorina zone is at high tide level; the Upper Balanoid and Lower Balanoid zones are at mid-tide level and the infratidal zone occurs at low tide level. Each zone is characterised by a well-defined group of plants and animals. The species that occur in each zone vary according to their location around the coast. For instance, rocky shores on the east coast provide a home for warm-water species, while those on the west coast are colonised by species that thrive in cold water. The south coast is an intermediate, temperate zone which contains a high proportion of species that are unique to South Africa. The following are brief descriptions of the distinct zones that occur on rocky shores around South Africa (see diagram):

- **The littorina zone** is the highest and most barren zone on the shore. It is inhabited by small, air-breathing Littorinid snails, one species on the west and south coasts and three species on the east coast. Purple laver, Porphyra is a hardy seaweed able to withstand severe desiccation.

- **The upper balanoid zone** is dominated by barnacles. Winkles, limpets and a few seaweed are able to survive the semi-dry conditions that prevail in this zone.

- **The lower balanoid zone** on the west coast supports thick beds of fleshy seaweed. On the east coast you will find slippery, green zoanthids and brightly coloured sponges, brown mussels and coraline seaweeds.

- **The infratidal zone** is the lowest region on the shore and the richest in plant and animal life especially red bait (sea squirts), anemones, sea urchins and starfish. Colourful, branched seaweeds are found on the east coast, while large kelp flourish on the west coast.

Additional zones occur on particular coasts:

- **The oyster belt** on the east coast is dominated by oysters. Whelks also occur here.

- **The cochlear zone** on the south coast supports dense bands of pear limpets, Scutellastra cochlear, at the low-tide mark, between the infratidal and the lower balanoid zones.

- **The cochlear/argenvillei zone** is a feature of the west coast. The zone takes its name from the tall, Argenville's limpet, Scutellastra argenvillei, which occurs in a band, together with large numbers of Scutellastra cochlear limpets. Black mussels are also found in this zone.

**A valuable source of protein**

Many South Africans routinely harvest molluscs such as mussels, oysters and limpets from rocky shores. For some rural communities, inter-tidal organisms are an important food and a vital source of protein. However, coastal populations are growing and harvesting has led to overexploitation, especially along the east coast, where inter-tidal resources are less productive and harvesting pressure is more intense.

In an effort to control harvesting from rocky shores, permits have been introduced and there are restrictions on the numbers and sizes of species that may be collected as well as the use of certain implements that damage the ecosystem. Marine protected areas are maintained to protect habitat and spawning stocks and to seed adjacent areas. Along the Wild Coast and in northern KwaZulu-Natal, education programmes and co-management systems are helping to regulate the inter-tidal harvests of rural communities.

Author: Claire Attwood September 2000

**FURTHER INFORMATION:**

- Permits and collecting regulations are obtainable from Marine and Coastal Management or Post Offices.

**RELATED FACTSHEETS:**

- Bait Collecting • Fishing Regulations • Tides • Mussel Harvesting • Oyster Harvesting • Sustainable use of Coastal Resources • Gastropods • Algae

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: + 27 (0)21 418-2582 e-mail: cmz@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Kelps are the largest and fastest-growing marine algae, or seaweeds, and belong to the brown algae known as Phaeophyta. In the nutrient-rich upwelling areas of the west coast they grow in dense beds, forming under-water forests that support a rich community of organisms. Although four species of kelp occur in South Africa, the most familiar is the sea bamboo *Ecklonia maxima*, which is often found washed up in large quantities on the shore. It is attached to the rocky substratum by a holdfast, but this is often ripped loose in heavy storms.

The kelp plant has a hollow, gas-filled stipe up to 12 metres long, ending in a swollen bulb that keeps the fronds bouyed up near the surface. The fronds grow at a rate of 13 millimetres per day, and are constantly eroded away at the tip.

*Ecklonia maxima* is the dominant kelp on the south-western Cape coast, but gives way to the smaller split-fan kelp *Laminaria pallida*. Another west coast species, the bladder kelp *Macrocystis angustifolia*, is less common, being found only in sheltered waters.
The forest community

Kelp forests are a source of food and shelter for a variety of animals, the community exhibiting three distinct zones. Inshore, where light is abundant in the shallow waters, many other algal species live underneath the forest canopy formed by the Ecklonia kelps, but few animals can survive in this turbulent zone. In the intermediate zone, Laminaria grows beneath the Ecklonia canopy, and only immobile animals such as mussels and sponges are able to withstand the wave motion. However, animals dominate the quiet waters of the offshore zone. Here dense communities of mussels, sponges, sea urchins, rock lobster and abalone live in between patches of Laminaria, which replaces Ecklonia in deeper water.

Four types of herbivores are common in the kelp forest. The kelp limpet, Patella compressa, is specially adapted to live and graze on Ecklonia stipes, each defending its territory by pushing against intruders until they move off. The abalone or perlemoen, Haliotis midae, secures its food by trapping a drifting piece of kelp or the end of a kelp frond as it sweeps by, lifting up part of its shell and foot and then clamping down. The alikreukel or giant periwinkle, Turbo sarmaticus, sometimes trap-feeds on drifting kelp, but mostly grazes on other seaweeds in the kelp bed. The sea urchin, Parechinus angulosus, feeds on fragments of kelp, and also scrapes the surface of rocks for micro-algae and young plants, including kelp sporelings. Research has shown that removal of sea urchins results in increased kelp recruitment.

The most important group of animals in the kelp forest are the filter-feeders, such as mussels, sponges, red bait and sea cucumbers, which typically comprise 70-90% of the animal community. The mucus released from kelp fronds is rich in organic compounds that encourage the growth of bacteria, which are in turn a food source for protozoans such as flagellates and ciliates. Filter-feeders consume these micro-organisms, as well as phytoplankton (microscopic algae), kelp spores and tiny fragments eroded away from the tip of the growing kelp fronds.

The most important carnivore, at the top of the food chain, is the rock lobster, Jasus lalandii. It feeds on many species in the kelp forest, but prefers mussels, crushing the shells with its strong mandibles. Starfish, Marthasterias glacialis, and octopus Octopus vulgaris also eat mussels, although the latter are also able to prey on rock lobster. Other carnivores in the kelp forest include anemones, whelks, Hottentot fish, dogfish and seals.

Kelp plants washed up on the shore are a food source for amphipods and isopods, better known as sand hoppers and sea ices. These crustaceans are in turn preyed upon by birds such as sand plovers and sandgangers. In addition, the crustaceans help to break down the kelp into fragments small enough to be consumed by filter-feeders in the surf zone, such as white mussels. Where kelp plants occur they are thus an integral part of sandy beach ecosystems.

Importance to Man

Kelp forests are an important marine resource, with both direct and indirect value. Apart from supporting commercially valuable species such as rock lobster and abalone, kelp beds help to buffer the shore from strong wave action, thereby reducing erosion and the risk to coastal developments. Washed-up kelp is collected by licensed concessionaires from beaches and processed for alginate, used as a gelling agent in thousands of everyday products such as toothpaste, cosmetics, flavoured milks, salad dressings and pizza toppings. Limited harvesting of fresh kelp is permitted for production of an agricultural growth stimulant and as a food source for cultured abalone. This harvest is carefully managed to ensure that these extremely productive ecosystems are safeguarded.

Author: Sue Matthews September 2000

FURTHER INFORMATION:
• Seaweed Unit, Marine & Coastal Management, Private Bag X2, Roggebaai 8012.

RELATED FACTSHEETS:
• Seaweed and their Uses • Rock Lobster • Abalone • Brown Algae

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
PHYSICAL AND CHEMICAL CONDITIONS IN POOLS

Temperature
In South Africa sea temperatures are almost always lower than air temperatures, especially during the day, so that minimum temperatures in pools are recorded when they are flooded by the incoming tide. During low tide the maximum temperature attained by a pool is determined by the length of exposure and the rate of heat input. The higher a pool is on the shore the longer it will be exposed during the tidal cycle. The heat input is determined by air temperature, solar radiation and, to a lesser extent, humidity and wind speed. Pools exposed over the hottest part of the day continue to absorb heat from the rocks for some time after midday, and reach their maximum temperatures, as high as 32°C in summer, at about 15h00. In South Africa low neap tides occur at about 15h00 in the afternoon and 03h00 at night and so the highest water temperatures in pools are recorded during neap tides. Temperatures are highest in the high-shore pools that are not inundated at all during high neap tide. At night the peak temperatures are also recorded high on the shore but there is less heat input and the temperatures are lower than during the day.

The low spring tides in South Africa occur at about 09h00 and 18h00. During spring tides (when the tidal range is greatest) the temperature in pools does not rise so high because, during the mid-afternoon heat, the tide inundates even the highest pools. The extreme low tides occur in the cool of the morning and evening.

Salinity
When the temperature in a pool rises, the water evaporates and the salinity increases. In small high-shore pools the salinity can fluctuate between a saturated solution, when salt crystals encrust the rims of the pool, to almost fresh water after a shower of rain. Lower on the shore the sea flushes out the pools more often and the salinity does not fluctuate much.

Oxygen
The metabolic activities of plants and animals change the amounts of dissolved oxygen in rock pools. During the day plants photosynthesise (using the energy from sunlight to convert carbon dioxide and water into sugars and oxygen) and as a result oxygen levels increase. In pools with lots of seaweeds the oxygen level can rise as high as 200% saturation. During both day and night oxygen is used for respiration by both plants and animals. Low-shore pools support more life and so more oxygen is used than in high shore pools but low shore pools are isolated from the sea for a short period so the oxygen levels do not drop very low. Mid-tide pools have plenty of life and are isolated from the sea for longer and so experience maximum diurnal fluctuations in oxygen concentration (often...
less than 20% at night and over 200% during the day). High shore pools are harsher environments with great temperature and salinity fluctuations. Fewer plants and animals can survive there and consequently have little influence on the oxygen concentration. The exceptions are the green seaweeds, sea lettuce (Ulva spp.) and tubular Enteromorpha, which can tolerate wide temperature and salinity changes. During the day they are covered with bubbles of oxygen as a result of photosynthesis.

By Margo Branch December 2000

FURTHER INFORMATION:
• Huggett, J & Griffiths C. L. 1986. Some relationships between elevation, physicochemical variables and biota of intertidal rock pools. Marine Ecology Progress Series. Vol 29: 189-197

RELATED FACTSHEETS:
• Rock Pools on the East Coast • Tides • Rocky Shores • Sea Shells • Sea Urchins • Starfish • Octopus • Gastropods • Anemones • Crabs • Aquariums in South Africa • Marine Protected Areas • Coastal and Marine Education

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Reproduction in pools

Many of the seaweeds and animals in pools are broadcast spawners. This means that their eggs and sperm, or spores in the case of seaweeds, are shed in vast numbers into the water where fertilisation takes place externally. Many of them have a floating or swimming larval stage. Spawning is usually triggered when the cold sea water floods the pools on the rising tide so that the eggs and sperm can be dispersed while the tide is high, and enter the sea during the planktonic stage.

Sandy anemones have been observed spawning synchronously on the rising tide in summer. The female anemones shed thousands of pale brown eggs while the males produce milky white clouds of sperm. Creatures that are broadcast spawners include mussels, abalone, limpets, starfish, sea urchins and some fish. The green sea lettuce sheds such vast quantities of microscopic spores that they form a green scum in the pools.
Animals that are mobile can leave their pools during high tide. Creatures like crabs, octopuses and fishes can swim out in search of food or a mate. Many of them mate and fertilisation of their eggs is internal. This is a less wasteful means of reproduction than broadcast spawning and so fewer and larger eggs are produced. If the larvae are planktonic they can disperse to colonise new pools.

Larval dispersal is not always an advantage; a few of the molluscs, such as whelks, lay their eggs in capsules on or near their prey so that the young hatch near their food source and they do not have a planktonic phase.

There is also no gain for high-shore creatures to be widely dispersed in the sea as that would limit their chances of being able to return to high shore pools that are seldom flooded. The striped false limpets lay their eggs in gelatinous rings stuck to the floor of high-shore pools and dwarf cushion starfish lay their eggs under rocks where they hatch directly into tiny starfish, without a larval stage.

**Fish communities of tide pools**

The fishes living in rock pools are either residents or transients. The most common residents are the gobies (family Gobiidae), klipvis (family Clinidae) and rock suckers. The klipvis are well adapted to residency in tidal pools where they often defend territorial hideouts. The females do not lay eggs, but undergo internal fertilization and give birth to fully developed juveniles. The gobies and rock suckers attach their eggs under stones and have a reduced pelagic phase in the life cycle to ensure that they remain in pools.

Transient species, that commonly visit pools on the east and south coast and in subtropical regions to the north, include lots of colourful tropical fishes. Many transient fishes are spawners and their juveniles use pools as nursery grounds, where there is plenty of food, shelter and protection from large predators. Juveniles of the family Cheilodactylidae such as red fingers and two-tone fingerfin, and of the family Sparidae, such as zebras, black tails, Cape stumpnose and musselcrackers are seasonally common in pools on the east and south coast. The juveniles of mullet usually frequent estuaries but they do occur in tide pools when the larvae have failed to recruit to estuaries. Streepies, Sarpa salpa, migrate to KwaZulu-Natal to breed in winter. The larvae then drift southwards in the Agulhas current to coastal habitats in the Cape, where they use tidal pools, reefs and estuaries as nursery areas. The Cape silverside is one of the few transient species where the adults are abundant in pools.

More species of fish have been recorded in pools on the east coast (66) than on the south coast (44) and the west coast (40).

Author: Margo Branch September 2000
The coastal vegetation around South Africa reflects the vastly different climatic conditions experienced on the east and west coasts and the variety of habitats that occur in this dynamic coastal environment because of the interactions between topography, wind, sand, salt and tides.

Regional distribution - Major Floral Kingdoms

The regional distribution of the coastal vegetation is determined by the climate. On the one extreme, the arid coastal plains of the west coast experience low winter rainfall, less than 300 mm, and extreme temperatures, 4 - 40°C, so that the vegetation is a low-growing, succulent scrub moistened by fog – The Karoo-Namib Flora. The opposite extreme is the fringe of high coastal dunes on the east coast, where the high summer rainfall, reaching 1000 mm, and high temperatures, 18 - 40°C, nurture tall, dense dune forests – The Indian Ocean Coastal Flora. The Eastern Cape is a transitional zone where plants from both these floras can be found as well as those belonging to the Cape Flora, the Afromontane Flora (typified by Knysna forest), and the Tongoland-Pondoland Flora found on the rolling hills of Transkei.

The vegetation types (biomes)

As one moves inland the conditions change. Near the sea, only a few pioneer plants withstand the harsh salt spray, wind and unstable sand. Further inland where it is less harsh, more sheltered, shaded and fertile, there are many different species in climax communities. The microclimate, which is created by proximity to the sea, geomorphology, shading from other plants and the interaction with animals, influences the vegetation locally. The plant communities can be grouped according to their ability to grow in different conditions of moisture and salinity.

1. XEROPHYTES

Xerophytes are plants that grow in dry habitats with low moisture, and high evaporation, often with extreme temperature. They are common on the west and south coasts and on frontal dunes in the following communities.

Littoral strand vegetation (dune vegetation)

Several plants are important early colonisers that stabilise the shifting frontal dunes, allowing other plants to establish themselves. Seeplakkie Scaevola plumieri, and goat’s foot Ipomoea brasiliensis, with their extensive roots and waxy leaves, are important colonisers along the east coast. The succulent
hottentot’s fig, Carpobrotus sauerae, is a stabiliser on the west coast. Some daisies invade the dunes with their seeds. Once the dunes have been stabilised the soil is enriched by humus and, by slow succession, species-rich climax communities of coastal thicket or dune forest can develop.

Karoo. A semi-desert vegetation composed of succulents, some grasses and many small bushes occurs inland of the coastal dunes along the Namaqualand coast and drier patches on the south coast. Important families are the Aizoaceae (vygies) and the Asteraceae (daisies). Coastal fogs play an important part in providing moisture and moderating the high summer temperatures.

Cape fynbos is a complex of Cape species (characterised by the protea, erica and restio families) growing in nutrient-poor soil and usually in winter rainfall areas, although it is also found in the southern and eastern Cape areas. The low shrubs often have small leaves that are curled, hairy or waxy to survive the hot, drying windy summers. Fynbos can be further subdivided into dune, mountain and grassy fynbos.

2. MESOPHYTES

Mesophytes are plants that thrive in wet climates. They are common along the east and south coasts, and form the climax communities at the top of the shore. These include the following examples.

Afromontane forests occur in areas of year-round rainfall and contain large forest trees, such as the magnificent yellowwoods of Knysna, which have affinities with forests in central Africa.

Subtropical thickets thrive in areas of high rainfall and year-round high temperatures, in nutrient-rich soils along stabilised dunes and rivers. Thickets are dense, composed of woody shrubs and small trees with a closed canopy. Many of these trees have tough, waxy leaves and bear fleshy fruits. They may be laced together by creepers. Some important species belong to the milkwood and gardenia families (Asclepiadaceae and Rubiaceae). Thickets can be further subdivided into

dune thicket on the seaward slopes of dunes, coastal

forest on the landward aspect of the dunes (especially in KwaZulu-Natal), valley bushveld along river valleys and swamp forests in Maputaland.

Savanna occurs inland of dune thickets. Here small Acacia karoo trees invade grasslands, and are often indicative of land disturbed by agriculture and slash-and-burn practices.

Grasslands cover the rolling hills of the Transkei coast. Sour grassveld occurs at higher altitudes or along the coastal strip in areas of high rainfall. Sweet grassveld occurs inland in areas of summer or lower rainfall and is palatable for livestock.

3. HALOPHYTES

Halophytes are plants able to tolerate saline wet conditions. Plants able to live in salty water include seaweeds and flowering plants living in estuaries and salt marshes, or on salt-sprayed rocky cliffs.

Seaweeds are large algae that live in seawater - especially shallow well-lit zones with firm substrata. Many are adapted to handle desiccation during low tide but they cannot survive above the high-water mark. The west coast has vast underwater forests of kelp and a wide range of seaweeds. On the east coast the seaweeds are small and contain anti-herbivore chemicals such as lime or tannins.

Mangrove trees grow in saltwater on intertidal mudflats in estuaries or sheltered coasts. They are confined to the warm waters of the east coast from Transkei northwards. Mangrove roots trap fine mud which is rich in organic matter but low in oxygen. They have special above-ground roots called pneumatophores, that allow them to breathe in spite of flooding.

Estuarine and salt marsh vegetation include several flowering plants, adapted to living in saline water. These plants are low-growing and many are succulent or have reduced leaves to minimise water loss. These salt-adapted plants are abundant but usually grow in single-species stands and show distinct zonation as one moves from the intertidal onto higher ground. Higher up the river, where the salinity is lower, various pondweeds form submerged mats and reeds line the banks.

Author: Margo Branch September 2000

FURTHER INFORMATION:
• University of Cape Town, Botany Department, Private Bag, Rondebosch 7700 • Department of Plant Sciences, Rhodes University, Grahamstown, 6140

RELATED FACTSHEETS:
• Dune Vegetation • Mangroves • Coastal Forests • Estuaries and Lagoons • Wetlands • Kelp Forests • Saltmarshes • Dune Mining
Afromontane forests of the Southern Cape

Anyone who has travelled South Africa's famous ‘Garden Route’ will have noticed the remarkable change in vegetation from Mossel Bay towards Tsitsikamma, where the southern Cape is blessed with year-round rainfall and sea mists. The fynbos becomes more lush and exuberant as one travels east but nothing can prepare one for the full splendour of the southern Cape indigenous forest. Here massive trees, their limbs coated with lichen, present their fine leaves to the light.

This forest is, however, more fragile than this lush and verdant view implies, for it is rooted in poor shallow soils. The forest functions as a ‘closed nutrient cycle’ in which almost all the available nutrients are held in the plants themselves and little is allowed to remain on the forest floor before it is reabsorbed by the plants. The indigenous forest of the southern Cape covers some 60 000 hectares and has affinities to those of Central Africa, all forming part of the Afromontane Flora.

The ‘big trees’ in the forest are mighty Outeniqua yellowwoods, Podocarpus falcatus. The largest, over 30 m tall and spreading into a canopy 30 m across, can be viewed in the Tsitsikamma Forest National Park. This park was proclaimed in 1964 and protects over 122 woody trees and shrub species, such as the ironwood, stinkwood, candlewood, white pear, cape beach, upright yellowwood and the pink-flowered Cape chestnut. Beneath the canopy are tree ferns, creepers, several different orchids, lichens and mosses. A variety of indigenous fungi grow on old felled trees. If you look beneath rotting logs you may find a velvet worm, Peripatus, perhaps even feeding on an insect that it has trapped with slime. Velvet worms, unchangeable for 500 million years, are often called ‘missing links’ between worms and arthropods (centipedes and insects) and are of great interest to scientists. Fruit bats and birds, such as the green and red Knysna Loerie, feed on the fleshy fruits in the trees, while blue duikers, mice, bush pigs and baboons forage in the leafy litter on the floor. Grazers are, however, not abundant in the forest because much of the vegetation contains distasteful phenolic compounds.
Subtropical thickets and dune forests of the East Coast

Along the east coast where temperatures and rainfall are high and the soils rich in nutrients, thickets stabilise the dunes and spread up the rivers. The dense woody thickets are composed of shrubs and small trees with a closed canopy, rarely exceeding 3 m in height. Many of these trees have tough, waxy leaves a few centimetres long, and bear fleshy fruits. They may be laced together by creepers. Several important species belong to the milkwood and gardenia families (Asclepiadaceae and Rubiaceae).

Dune thickets, on the seaward slopes of dunes, contain salt-tolerant shrubs and small trees that are usually wind-pruned to a uniform height. The Natal strelitzia is an exception and waves its split, banana-like leaves above the canopy. The fern Phymatodes and the flame lily Gloriosa superba add to the beauty of the understorey on the seaward slopes. A hike over the tall fringing dunes in the Maputaland Forest Reserve leaves one breathless and dripping from the humidity. A wary eye should be kept open for snakes that enjoy the warmth. On the landward aspect of the dunes coastal forest forms a diverse climax vegetation; a sneeze wood community occupies the crest of the dunes, a red milkwood community lives on the slopes and the base of the dunes is buffalo thorn country. Issoglossa is the common understorey plant in the hot, sheltered forest.

It is fun to follow rivers inland by boat. Mangrove swamps inhabit the mudflats of estuaries and on the river banks the succulent thickets of valley bushveld are often impenetrable. Many exotic swallow-tail and metallic butterflies may be seen and the constant song of birds, such as the Narina trogon, Redbilled Woodhoopoe, sunbirds, robins, warblers and fish eagles, epitomises the call of Africa. Spectacular swamp forests occur in Maputaland where the dominant species are a wild fig, Ficus tripoda, the waterberry, Syzigium, raphia palms, Raphia australis and climbing ferns. The massive raphia palms have enormous leaves with large, spongy, stalks that the local folk twine together to make rafts. The Palm Nut Vulture may be seen feeding on the fruits of the palms, which are only produced once in a lifetime when the palm flowers at an age of about 30 years and then dies. In this hot moist climate there is a danger of contracting malaria – heralded by the evening whine of mosquitoes.

Exploitation

Since 1711 the southern cape forests have been exploited. The wood was used for houses, furniture, sailing ships and fuel; with the discovery of gold on the Witwatersrand in 1876, it was used as supports in mine shafts. The fine-grained, golden yellowwood and dark stinkwood are used in some of the finest examples of Cape furniture. The forest is also threatened by man’s expansion, because agricultural clearings and roads remove the canopy and expose the understorey, which dries out so that new trees cannot grow and replace the felled giants, some over 1000 years old. Introduced aliens such as black wattle and Hakea are quick to invade these clearings and further encroach on the forest.

The planting of quick-growing trees, including gums and pines, has provided for the timber and paper needs of the country and helped to save some of the slow growing indigenous trees.

J ust inland of the dune forests one often encounters small Acacia karoo trees. These invade grasslands along the coast and often indicate land disturbed by agriculture and slash-and-burn practices. A controversial issue is the mining of dunes for heavy metals, for the dune forests are destroyed and, even where care has been taken to rehabilitate the dunes, the new forest is often predominantly Acacia karoo and the climax communities may never return.

Author: Margo Branch September 2000

FURTHER INFORMATION:

RELATED FACTSHEETS:
- Mangroves • Coastal Vegetation
**Sands formed from rocks**

Although most of the rock-making minerals are present in sand, quartz is by far the most common; because it is abundant in rocks, it is comparatively hard and it has practically no cleavage planes so it is not readily worn down to a fine state. Moreover, it is nearly insoluble in water and does not decompose. Quartz consists of silicon dioxide or silica (SiO$_2$). Lime or calcium carbonate and feldspar are often common in sea sand. All sands contain small quantities of "heavy" rock-forming minerals such as garnets, tourmaline, zircon, tuffite, topaz, pyroxenes, amphiboles and iron ores. In desert areas such as Namibia the high iron content gives the dunes their characteristic orange glow. In certain areas these heavy metals become concentrated by the removal of the lighter particles by currents or wind. Economically valuable deposits of heavy metals are being mined in Namaqualand and around Richards Bay and further deposits have been identified in the Transkei. Dune mining is an ecologically sensitive operation as dune vegetation is often destroyed. Dune reclamation is a compulsory part of dune mining but unfortunately it is almost impossible to replace climax dune forests that have taken aeons to develop.

**Sands from sea shells**

The hard shells from marine organisms are so plentiful in some areas that they form a major part of the sand particles. On the west coast huge banks of shells are cast up on the shore after winter storms. These are gradually worn down by the elements to become sand grains. In coral seas and on the east coast of S. Africa, the hard skeletons of the coral comprise part of the sand. Sea urchins, with sturdy spines, break down to form coarse calcareous sands and are common in the Galapagos and Mozambique. Some sands when examined under the microscope are seen to contain millions of beautifully sculptured shells of tine marine organisms that occur in plankton, these are foraminifers, diatoms and radiolarians.

**Abrasive action of sand**

A walk along a windy beach with the sand blasting against one’s legs, makes one realise the abrasive force of sand. The movement of sand by the wind is an important geological process, especially in desert regions. It produces a highly distinctive landscape with wind sculptured balancing rocks, and wind swept valleys with polished rocks. The early diamond finds in the Spergebied of southern Namibia were largely due to the sifting and sorting of the sand by the winds. For hundreds of miles from the Karoo to the Kalahari there are rows of reddish dunes, urged north westwards by the prevailing south-easterly winds. The older dunes are covered by vegetation but the newer dunes march relentlessly forward. The Quiseb River forms a barrier and each rainy season the floods wash away the sand that has accumulated. At the river mouth however the dunes...
have won the battle and the river flows under the towering dune barrier only to emerge again at the coast at Sandwich Harbour.

**Don't build on dunes!**

There are also dramatic examples of sand movement where people have built houses in dune fields. A classic example is at Rooiels in the Cape where houses were built in the dunes so that their owners could enjoy prime views and access to the beach. Owners discovered that their homes formed a barrier to the wind blown sands, which soon reached window height and threatened to engulf them. As a solution vegetation was planted on the small dunes in front to trap the sands and protect the houses. But ten years down the line another problem emerged. The frontal dunes had reached such a height that the houses no longer had their stunning views. So the owners wanted to removed the vegetation and let the sand blow away - but where to! Dune fields are some of the most dynamic environments and should not be built on or interfered with.

**Waves and sand**

Waves also drive the sand grains creating a powerful abrasive force, grinding away cliffs, rocks and promontories. The sand is continually moved and sorted by the waves and then as the waves dissipate, the sand is dropped to contribute to sandy beaches. It is very important to use models of harbours and breakwater barriers to test the effects of waves and sand movement before building such structures.

**Uses of sand**

The abrasive properties of quartz sand have been put to many uses as sandpaper, grindstones and for sand blasting. Garnet sand is used in fine quality abrasive polishes for jewellery. In 1994 the Chinese ship the Apollo Sea sank off the Cape coast causing a devastating oil spill that coated the Cape Peninsular beaches. The sand beaches had to be laboriously sieved to remove the oil - which resurfaced again the following year when the winter storms turned over the sand. The oil that coated the high level boulders was removed by blasting sand in a high-pressure jet of water to loosen the oil. In these conditions, another option would be to use steam cleaning techniques.

Very pure quartz sand is used as a source of silica in pottery, porcelain, glass making and silicate (water glass) industries.

Quartz is a non-conductor of electricity and is not acted on by acids (except hydrofluoric acid used for etching). It will fuse in an oxyhydrogen flame to form a clear colourless glass. This is used to line the hearths of acid steel furnaces and for making moulds in which metals are cast.

Quartz comes in many beautiful colours and textures, creating popular gemstones such as agate, purple amethyst, aventurine, carnelian, rose quartz and garnets. Tiger’s eye is a silica replacement of asbestos, which maintains the fibrous texture of the asbestos.

**Sand in building**

Sand is an important component of cement and concrete, which is used to stick together bricks and to build structures. Cement used in building is made by grinding clay and limestone together. The mixture is then burnt in a large kiln at such high temperatures that it starts to melt. The small lumps, clinkers, formed on cooling are ground into a fine grey powder. When mixed with water, this powder sets as hard as stone within a few hours. The cement can be strengthened by the addition of gravel or stone or by reinforcing it with steel rods. This reinforced concrete is used to build skyscrapers. Sand used for building is usually obtained from rivers or older dunes from which the salt has been leached away. Builders must have a permit to collect sand. Sand mining can have a detrimental effect on the dune vegetation and must be carefully controlled. Children on the Cape Flats have been smothered and killed by collapsing sand banks while playing in mined areas that were not properly fenced off.

**Sandstone**

Sand stone is formed from sand and sediment that settles in layers over a long period. Under the weight and pressure of many layers, sometimes several kilometres thick, the sand becomes cemented into solid rock by silica or calcium carbonate. Sedimentary coastal rocks such as Table Mountain Sandstone and Malmesbury Shales are made up of layers of sand and mudstone and these often contain the remains of living organisms preserved as fossils.

Author: Margo Branch September 2000

FURTHER INFORMATION:

- Geology Department, University of Cape Town, P B Rondebosch, W Cape 7706.

RELATED FACTSHEETS:

- Erosion and Siltation
- Sandy Beaches
- Dune Vegetation
- Sensitive Coastal Areas
- Orange River Mouth
- Dune Mining
- Mining the Sea
- Marine Fossils

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
The coast is the dynamic interface where the land meets the sea and forms the edge of continents and islands. The coastline, or seashore, is the area between high and low water marks but the influence of the land extends into coastal waters, usually to the edge of the continental shelf, while the influence of the sea reaches inland to include dunes, cliffs, tidal estuaries and lagoons. Defining coastal boundaries is a challenge faced by all countries when applying coastal management. Generally a narrow coastal zone is used when applying permit procedures and a broader zone is encompassed for planning and development purposes. The State President “owns” the seashore between low and high water mark as well as the sea within territorial waters, 12 nautical miles from low water mark, on behalf of all South Africans.

Biophysical components of our coast

The coast of South Africa extends for 3 000 km and links the east and west coasts of Africa and connects our continent to the Indian, Atlantic and vast Southern Ocean. The character of our coast is shaped by its location at the southern tip of Africa where the patterns of weather and climate are controlled by large-scale atmospheric systems over Southern Africa, and by the adjacent oceans. South Africa has a linear coastline with few natural harbours and bays. About 1 700 km of the coast is made up of sandy shores with the rest being rocky or mixed sand and rock. Fifteen islands occur off the west coast between Saldanha and False Bay and there is a cluster of 6 islands near Port Elizabeth. Most of these islands are small.

How is the ocean influenced by the land?

Currents: The ocean is in continual motion due to winds and the rotation of the earth. Currents, both on a global and local scale, are deflected by the land masses in their paths. The east coast is warmed by the fast-flowing, nutrient-poor Agulhas current that flows south from the tropical latitudes of Mozambique and Madagascar. In contrast, the west coast is warmed by the fast-flowing, nutrient-poor Agulhas current that flows south from the tropical latitudes off Mozambique and Madagascar. In contrast, the west coast is...
bathed by the sluggish Benguela current that flows northwards. Cold nutrient-rich water upwells to the surface under the influence of the southeasterly winds that blow surface water away from the land.

**Waves:** Waves generated by winds move across the ocean as swell. They release their energy in the surf zone where they form breakers. These breakers erode rocky headlands and deposit sand in calm bays. Most of our coast has moderate to high energy waves of 1-3 m height, but waves of over 12 m have been recorded in storms.

**Tides:** The daily rise and fall of tides is most apparent at the interface between sea and land. South Africa experiences two almost equal tides daily with a tidal range between one and four metres during neap and spring tides respectively.

**Rivers:** The coast is strongly influenced by rivers that carry fresh water, sediments, nutrients and pollutants to the ocean. The vast majority of the 343 rivers occur on the east coast where they are fast flowing and deposit 400 tons of sediment per square kilometre per year. There are only 13 estuaries entering the sea on the arid west coast. The Orange River, the largest in South Africa, drains half the country including the Gauteng area and enters the sea on the border with Namibia.

**How is the land influenced by the oceans?**

**Shaping the land:** The land is being continually reshaped by the sea. Rocks are pounded and eroded, while the resultant sand is transported, sorted and deposited by currents and waves.

**Temperatures:** Along the coast temperatures are moderated by the influence of the ocean, which neither gains nor loses heat as quickly as the land does. As a result the temperatures at the shore do not rise as high or drop as low as they do inland.

**Rainfall:** Precipitation is also influenced by the sea and prevailing winds. Wind passing over warm water, such as the Indian Ocean along the east coast, gathers moisture. As the air rises and cools over the land the water vapour condenses and falls as rain. The east coast experiences good rainfall increasing from 800 mm, in the south to 1 300 mm at the border with Mozambique. The west coast is characterised by southerly winds in summer and north westerly winds in winter and low winter rainfall which decreases northward from 700 mm in Cape Town to 60 mm at Port Nolloth. When winds pass over a cold ocean the moisture in the air condenses into fog and provides scant moisture to the adjacent land.

**Salt:** The coastal environment is laden with salt from the sea water and spray.

**A variety of habitats unique to the coast**

The coast has a whole range of habitats which include the intertidal zones on rocky and sandy shore, kelp forests offshore on the west coast, coral reefs on the east coast, mangroves, lagoons, estuaries, salt marshes, cliffs, dunes and coastal forests. Each habitat supports its own community of plants and animals adapted to the special conditions experienced there. The vast majority of seaweeds are confined to the coastal fringe where the water is shallow enough for them to gain sufficient light and nutrient, as well as a firm surface on which to cling. Many of these habitats are vulnerable to changes - particularly those brought about by humans, such as building of roads and houses, the constriction of estuaries with bridges, mining of dunes, draining of salt marshes and mangroves, building of harbours and breakwaters and many forms of pollution.

**The human impact**

People are attracted to the coast for a number of reasons. These may be for aesthetic appreciation, recreation, harvesting of marine life, transport, a place to live, work or play, or for tourism. The human impact on the coast is enormous. Four coastal cities contain the major concentration of the coastal population (over 6 million in Cape Town, Port Elizabeth, East London and Durban and growing rapidly). These cities, as well as Richards Bay and Saldanha Bay, provide harbours to conduct trade with distant lands and to service the inland region.

The smaller coastal towns and resorts experience a seasonal influx of holiday makers. As a result the coast has become a centre for economic activity.

**Author:** Margo Branch

**September 2000**

**FURTHER INFORMATION:**
- University of Cape Town, Rondebosch, 7700 , Cape Town • Marine and Coastal Management

**RELATED FACTSHEETS:**
- Ecosystems in the Sea • Coastal Vegetation • Erosion and Siltation • Ocean Currents • Tides • Upwelling • Coastal Management

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
How do wetlands function?

The characteristically gentle slopes of wetlands, coupled with the resistance offered by the dense wetland vegetation, slows the water moving through the catchment. By slowing down the movement of water and detaining it for a while, wetlands act like sponges which reduce floods and also prolong streamflow during low flow periods. The water that is lost through evaporation is usually reduced in a wetland area because the cover provided by wetland vegetation reduces evaporation from saturated or flooded soil by sheltering it against the sun and wind. Wetlands are also natural filters, helping to purify water by trapping pollutants such as excess nutrients (nitrogen and phosphorus), pesticides and heavy metals as well as disease-causing bacteria and viruses.

Why do we need wetlands?

Without water there would be no life on earth. Plants, animals and people need water to survive and grow. South Africa does not have an abundance of water and the water in many streams is polluted. Both droughts and floods are common. Wetlands are able to reduce the severity of droughts and floods by regulating streamflow. Wetlands also purify water and provide habitat for many different plants and animals.

Besides these indirect benefits to society, wetlands provide many direct benefits in the form of resources such as fibre for making crafts. Until very recently the benefits of wetlands to society were often not recognised and many wetlands have been destroyed or poorly managed.

The Ramsar Convention

The Convention on Wetlands (also known as the Ramsar Convention) was signed in Ramsar, Iran in 1971. The convention aims to highlight the importance of wetlands and protect rare or unique wetlands around the world. Sixteen wetlands in South Africa have been declared ‘Wetlands of International Importance’ or Ramsar sites, either because they are rare or unique types of wetlands, or because they support vulnerable or endangered species or ecological communities. Ten of South Africa’s 16 Ramsar sites are located at or near to the coast. A description of each of these wetlands is given here:

The Kosi Bay system, in northern KwaZulu-Natal, is a complex of six large lakes, two lesser lakes and an estuary. The system is undoubtedly the best preserved large estuary along South Africa’s Indian Ocean coastline. It is little degraded and supports a great diversity of fish and other aquatic fauna. The swamp forests found in this area are the largest in the country. The giant palm Raphia australis, on which the Palmnut Vulture Gypohierax angolensis, is dependent, finds its natural southern limit here. This is the only area in South Africa where five species of mangrove are found.
Lake Sibaya, in northern KwaZulu-Natal, is the largest natural freshwater lake in the country, with an area of 60 to 70 m². Surface water on the surrounding coastal plain may disappear during dry years, making the lake the only source of permanent water for birds, mammals and people who live on the shores of the lake.

Another Ramsar site comprises two adjacent protected areas, the St Lucia Marine Reserve and the Maputaland Marine Reserve. This coastline is the only truly subtropical section of the South African coast; its coral reefs, inter-tidal zone and turtle breeding areas are still in a natural and undisturbed state, making the region particularly worthy of conservation.

The St Lucia Ramsar site forms a large part of the Greater St Lucia Wetland Park a world heritage site which consolidates a number of protected areas including the St Lucia Game Reserve, False Bay Nature Reserve, St Lucia Park, Sodwana Bay State Forest, Cape Vidal State Forest, Eastern Shores State Forest, part of the Dukuduku State Forest, Umlolozzi Swamps State Forest, Mkuzwe Swamp and Mhlutuze State Forest. Situated in northern KwaZulu-Natal, the St Lucia system is the largest estuarine system on the African continent and forms a critical habitat for a large number of species and several communities.

The Wilderness Lakes system represents one of only a few coastal lake systems in southern Africa. It comprises a lagoon and the floodplain of the Touws River, linked by a natural channel to the three lakes Eilandvlei, Langvlei and Rondevlei, which are fringed by coastal fynbos and evergreen forests. These lakes, situated between George and Knysna in the Western Cape are the only warm-temperate coastal lakes with a marine connection in South Africa.

De Hoop Vlei is situated within the De Hoop Nature Reserve, 65 km from Bredasdorp in the Western Cape Province. The wetland is partly located in a gorge with high limestone cliffs and consists of a coastal lake 16 km long, formed where the mouth of the Sout River is blocked by coastal dunes. The lack of a visible outlet to the sea and widely fluctuating salinities make this system unique within the south-western Cape.

Situated within the De Mond State Forest in the Western Cape, the estuary of the Heuningnes River extends approximately 12 km across the flat coastal plain of the Zoetendals Valley farm area before breaking out to sea through a double dune ridge. The wetland was designated a Ramsar site, primarily for its importance as one of the few confirmed South African breeding sites of the Damara tern Sterna balaenarum. This species is endemic to southern Africa and is possibly the rarest seabird in South Africa.

The Langebaan Ramsar site is situated approximately 100 km northwest of Cape Town and includes the islands Schaapen, Marcus, Malgas and J utten, the Langebaan Lagoon and a section of Atlantic coastline. The lagoon is entirely marine with a relatively stable salinity and supports dense populations of molluscs and crustaceans. The lagoon also serves as a nursery area for juvenile fishes.

Verlorenvlei is one of the most important estuarine systems in the Western Cape and one of the largest natural wetlands along the west coast of South Africa. It is also one of the few coastal fresh water lakes in the country. The system comprises a coastal lake and reedswamp connected to the sea by a small estuary. The lake is approximately 13 km long and occurs in the transition zone between the karroid and fynbos vegetation types.

Orange/Gariep River Mouth Wetland

The mouth of South Africa’s largest river is located on the Atlantic coast and forms the border with Namibia. The wetland can be described as a delta type river mouth with a braided channel system during low flow months. The Orange River usually flows directly into the Atlantic Ocean but at times its access to the sea is blocked by sand bars. It is therefore not a true estuary and is best termed a river mouth.

Further information:

- Department of Environmental Affairs and Tourism Private Bag X447, Pretoria 0001 Tel: (012) 310-3911 Fax: (012) 322-2476
- Department of Water Affairs and Forestry Private Bag X313, Pretoria 0001 Tel: (012) 336-7500 Fax: (012) 326-2715 http://www.dwaf.pwv.gov.za

Related Factsheets:

- Estuaries and Lagoons • Kosi Bay • Maputaland Coast • St Lucia • Langebaan Lagoon • West Coast • Orange River Mouth

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Physical processes
Sandy beach ecosystems can be divided into three zones:

- The surf zone, where waves break
- The beach, which includes the intertidal and backshore zones
- The dunes, made up of small, recently formed foredunes and large, established backdunes.

In the sea, waves and currents continually move sediment along the shore, as well as on- and offshore, in a process known as littoral transport. On land, wind blows sand from the beach into the dunes, called aeolian transport. When sand blown up the beach by onshore winds is trapped by plants growing near the driftline, it forms mounds called hummocks, which initiate the development of foredunes. Sandy beach systems therefore comprise a marine wave-driven ecosystem and a terrestrial wind-driven ecosystem that together make up the littoral active zone – the area in which sand exchange occurs.

While sand exchange is an ongoing process, some seasonal effects linked to weather conditions are noticeable. During stormy weather, rough seas erode sand away from the beach and foredunes and deposit it as a sandbar offshore. When calm conditions return, gentle waves carry the sand back to rebuild the beach. In this way, the beach undergoes seasonal cycles of erosion and accretion.

Flora and fauna
At first glance sandy beaches may seem devoid of life, but they support a diversity of animals and plants interacting in a complex food web. Many of these organisms are hidden below the sand.

Life between the sand grains In the moist sands of the surf and intertidal zones, as well as in the slacks between dunes where the water table is close to the surface, an entire community lives between the sand grains. Microscopic diatoms are the primary producers of this food web, and together with fungi and bacteria that obtain nutrients from organic matter, they provide food for protozoans such as flagellates and ciliates. Meiobacteria, which are no larger than 2 mm and include nematodes, copepods and ostracods, have a range of feeding forms. They consume bacteria, diatoms, protozoans, other meiofauna and detritus, and are found in particularly dense concentrations beneath decomposing seaweeds stranded on the shore. This so-called interstitial food web therefore plays an important role in sandy beach ecosystems by breaking down organic matter and recycling nutrients.

Life in the surf zone In the surf zone of high-energy and nutrient-rich beaches, dense blooms of phytoplankton (microscopic algae) provide a source of food for zooplankton, such as small shrimps and prawns. A variety of fish are also found in the surf zone of sandy beaches, including pompano, baardman, mullet, steenbras, galjoen, elf and sandsharks. While some are plankton-feeders, others eat mussels, crabs and worms from the sandy bottom, or prey on fish.

Life in the intertidal zone No rooted plants or attached seaweeds can survive the harsh environment of the intertidal zone (the area between the high and low water mark), but some animals are able to burrow into the sand to escape the pounding waves, and rely on food imported from the sea. For example, sand mussels and mole crabs filter phytoplankton from the water, as well as the detritus of seaweeds broken down into small particles by the pounding surf. The plough snail emerges from the sand to scavenge on stranded jellyfish and bluebottles, and is preyed upon by the three spot swimming crab. However, birds are the top predators of the sandy beach food web. Kelp gulls and oystercatchers are
able to crack open the shells of sand mussels to reach the succulent flesh inside, while plovers and Sanderlings pick shrimps and worms from the sand and may even nip off the protruding siphons of sand mussels and clams.

**Life in the backshore zone** In the backshore zone (that part of the beach above the high tide mark), stranded animals and seaweeds that accumulate along the driftline are food for ghost crabs, insects, amphipods and isopods. They in turn are consumed by predatory beetles and birds. In addition, African Black Oystercatchers, White-fronted Plovers and Damara Terns nest in this zone, while in Kwazulu-Natal leatherback and loggerhead turtles lay their eggs at this level.

**Tidal and lunar rhythms**

Many of the animals that live on the sandy shore have tidal or lunar rhythms to help them survive. The plough snail migrates up and down the beach with the tides to feed on stranded animals, while the mole crab and some types of sand mussel migrate with the tides to ensure that they remain in the surf zone – the best place for filter-feeding. Isopods and ghost crabs are most active at night, when the moon is not full, thereby reducing the risk of predation and desiccation, and only emerge at low tide to avoid being swept away by waves. Sandhoppers emerge from the sand at dusk and migrate down the beach to feed on debris such as decomposing kelp, and then return at dawn to bury themselves in the sand near the driftline. They use the light of the moon for orientation.

**Life in the dunes**

Behind the driftline, vegetation encourages the development of dunes by trapping mobile sand. Strong wind, high salt loads and rapid sand movement restrict the vegetation in this area to a few ‘pioneer’ species, mostly grasses and creeping plants such as sea pumpkin, dune gazania and pipe grass. These hardy plants are adapted to grow ahead of accumulating sand, stabilising it so that other plant types can follow as the dune matures, in a process known as succession. Pioneer species give way to a community of shrubs such as waxberry, taaibos, hottentot’s fig and blombos, which may be replaced on older and more stable dunes further inland by scrub-thicket comprising milkwoods, sea guami and bietou. On the oldest dunes, and where rainfall is sufficiently high, a climax community of dune forest may develop, as in Kwazulu-Natal.

The most abundant invertebrates in dunes are insects such as ants, bees, wasps, beetles, earwigs and flies, although spiders are also common. A total of 932 vertebrates (amphibians, reptiles, birds and mammals) have also been recorded from our dunes, the number increasing from the dry semi-desert west coast through to the high rainfall dune forest of the east coast. The west coast, however, supports higher numbers of the 31 species that are endemic to dunes. Of these, 13 are listed in the Red Data Book as in need of conservation.

**Threats to sandy beach ecosystems**

Sandy beaches and dunes are sensitive systems that can be damaged or disrupted in a number of ways.

- Development in the littoral active zone, including breakwaters, groynes or buildings, impedes the natural movement of sediment along the shore, as well as between the dune, beach and surf zone. This may result in erosion of beaches or sand inundation of buildings. Artificially stabilising dunes with vegetation (often through unchecked infestation by alien species), or removing the foredunes for development or mining, removes the reservoir that supplies sand to the beach.

- Off-road vehicles (ORVs), and trampling by people and livestock, may destroy dune vegetation. As a result, dunes may gradually move inland, devaluing and threatening adjacent property. ORVs may also crush animals buried in the sand, as well as the eggs and young of birds nesting above the driftline. Furthermore, their tracks can impede the movement of small animals, such as turtle hatchlings and ghost crabs.

- Pollution also impacts sandy beaches, especially oil spills, which can have devastating consequences. Oil is toxic to most animals, and can smother them or affect their swimming ability. Plastic and other forms of litter are not only unsightly, but can cause painful death for animals if they are mistaken for food.

Author: Sue Matthews September 2000

**FURTHER INFORMATION:**


**RELATED FACTSHEETS:**

- Off-road Vehicle Use • Dune Vegetation • Ecosystems in the Sea • Erosion and Siltation • Tides

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za  Website: http://sacoast.wcape.gov.za
Zonation

Four major zones of vegetation can be identified on coastal dunes.

In zone 1, just above the high water mark, only a few hardy ‘pioneer’ species - mostly grasses and creeping plants such as sea pumpkin, dune gazania and pipe grass - can tolerate the strong winds, high salt loads and rapid sand movement typical of this area. These plants trap windblown sand so that small mounds, called hummocks, form around them, initiating the development of foredunes. The pioneer plants are adapted to grow ahead of the accumulating sand, stabilising it so that other plant types can become established as the dune matures, in a process known as succession.

In zone 2, on the established foredunes a little further inland, the pioneer species give way to a community of shrubs and clumped bushes, such as waxberry, taibaos, hottentot’s fig, dune kokerboom and blombos. Beneath the canopy is an understory of herbs, creepers, climbers, annuals and succulents.

Zone 3, on the older and more stable dunes, is known as the scrub-thicket zone. It consists of a dense community of dwarf trees and shrubs with a compact canopy flattened by wind pruning. Instead of a dense understory there is a thick layer of plant litter covering the sandy floor. Plant species typical of this zone are milkwoods, sea guarri, coast olive and bietou.

Zone 4 is only evident in areas of high rainfall and wel-developed soils, where a thicket-forest community develops on the oldest dunes furthest from the sea. This is known as a climax community as it represents the final stage of succession. Beneath the canopy of tall milkwood, coast olive and kershout trees are creepers, vines and low herbaceous species.

Few dunefields exhibit all four zones, as in most areas the shoreline is eroding or rainfall is not sufficiently high to support a climax community. On the west coast dune daisies and succulents survive on the moisture that condenses from coastal fogs and in these low-rainfall areas, only the initial successional stages are present. Along the prograding (growing) shoreline in the Mtunzini area of KwaZulu-Natal, all four zones are evident, the climax community taking 120 years to develop.

Four zones of dune vegetation occur along the wet east coast, only the first two zones occur on the dry west coast.
Bushpockets

In the low rainfall areas of the Western and Eastern Cape, many of the dunefields are largely unvegetated. The most impressive example is the Alexandria dunefield, a 'sea of sand' extending for 50 km along the northern shore of Algoa Bay. Under the influence of the dominant south-westerly winds, the dunes migrate in a north-easterly direction at a rate of 2-5 m per year, depending on their position in the dunefield.

Few plants are adapted to withstand these conditions of low rainfall, strong winds and mobile sand, but deep within the dunefield, sheltered in protected hollows, are over 270 isolated pockets of vegetation. These small communities, known as bushpockets, migrate with the dunes through a process of succession.

Initially the waxberry, which is both the dominant species in the bushpockets and the major pioneer, colonises bare sand on the eastern flank of the pocket. New species can become established once the micro-environment has been sufficiently altered, primarily by slowing sand movement. Eventually a community of small bushes and shrubs, with a canopy of about a metre in height, establishes itself on the western edge of the pocket, but it is soon smothered by the advancing dunes. Thus the bushpockets constantly extend their eastern borders while sand inundates their western borders. In this way they migrate with the dunes at a rate of 2-3 m per year in an easterly direction; however, aerial photographs reveal that one advanced 150 m in 40 years, at a rate of 3.75 m per year!

The plant communities in the bushpockets are largely maintained by animal seed dispersal, called zoochory. A total of 44 bird species have been recorded in the bushpockets, although only four are resident and breed there. One study showed that birds defecate seeds of 19 plant species, and most of these are deposited in the bushpockets, where they are more likely to survive. Mammals such as bushpig, bushbuck, vervet monkey and black-backed jackal were found to disperse 29 plant species. Altogether, approximately 23 million seeds are deposited in the dunefield annually in 10 000 kg of faeces, which provide an immediate source of nutrients and moisture for the germinating seeds. Thereafter the plants must rely on rainfall and dew for their water requirements.

Plant species dispersed by both birds and mammals include the primary coloniser waxberry, as well as secondary species such as guarie, white milkwood, candlewood, kraal honey-thorn and wild olive. Unfortunately, seeds of invasive alien species are also spread in this way. The alien acacias rooikrans and Port Jackson have invaded many coastal areas, and have a major impact on sandy shores by stabilising mobile dunefields.

Dune slacks

In the Alexandria dunefield, between the unvegetated transverse dunes closest to the beach, are low-lying, damp areas known as dune slacks. Here the groundwater, which is rich in nutrients, lies close to the surface as it flows towards the sea. Since root systems can reach down to the water table, plants in the slack are not limited by nutrient or water availability, as they are in other parts of the dunefield. Rather they are limited by salt deposition and sand inundation. The pounding surf on this high-energy beach creates a haze of sea spray, which even fairly gentle winds can carry 200 m inland. Since the dominant wind direction is south-westerly, most spray is deposited on the eastern side of the dune slack. This, combined with sand inundation, results in successional changes across the slack.

The transverse dunes on each side of the slacks migrate in an easterly direction at a rate of 7 m per year. As the dune on the eastern side of the slack migrates, it exposes virgin sand that is colonised by salt-tolerant pioneer species, such as sea pumpkin and sand grass. These give rise to low herbaceous plants, such as dune gazania, and eventually sedges and rushes, which are slowly smothered by the advancing western dune.

Author: Sue Matthews January 2001

FURTHER INFORMATION:


RELATED FACTSHEETS:

• Coastal Vegetation • Sandy Beaches • Coastal Forests • Off-road Vehicle Use • Sensitive Coastal Areas

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za
Saltmarshes are found on the landward side of mud- and sandflats in the upper tidal zone of calm coastal waters, such as sheltered bays, river mouths and estuaries. They are extremely harsh environments, as they are flooded by tides twice daily, and experience salinities up to three times higher than seawater. Few plants can withstand these conditions, so saltmarshes generally have a low species diversity. The tolerance of different plant species to certain factors, such as soil salinity and depth and duration of tidal submergence, influences their vertical distribution on the shore, with the result that a marked zonation pattern is a characteristic feature of saltmarshes.

**Distribution of saltmarshes**

Saltmarshes occur mainly in the temperate areas of the world – in tropical and sub-tropical areas they tend to be replaced by mangrove swamps. Only in the Gulf of Mexico states of the USA and in south-east Australia do both vegetation types occur along the same stretch of coastline.

South Africa has a rough and rugged coastline, so saltmarshes are limited to estuaries along the Cape coast where suitable habitat occurs – along the sub-tropical KwaZulu-Natal coast they are replaced by mangroves. True saltmarshes are found in approximately 70 of the Cape’s 155 estuaries. Of these, the most extensive are in the Swartkops estuary (170 ha), Olifants River estuary (200 ha), Knysna lagoon (1 800 ha) and Langebaan Lagoon (5 700 ha), which together make up about three-quarters of the total saltmarsh area along the coast. Langebaan Lagoon is unique in that it is not an estuary as there is no river flowing into the system. This means that salinity and water-depth fluctuations are more constant, allowing extensive saltmarshes to develop in the southern reaches.

**Zonation of saltmarsh flora**

The zonation patterns of all saltmarshes are similar, but those in Langebaan Lagoon are used here as a case study.

On the fine substrata of the lowest levels, which are only exposed at spring low tides, extensive beds of eelgrass, Zostera capensis, develop. These plants have horizontal underground stems and long, narrow leaves with tiny notches. When exposed at low tide the plants lie flat on the ground, but stand upright and sway gently in the current when under water. The width of the Zostera bed is dependent on the slope, substratum, current velocity and water turbidity. The plants prefer relatively saline water, so the beds may experience massive diebacks after floods.

Further up the shore, Zostera is replaced by the cord grass Spartina maritima. This plant forms tufts of narrow, spiky and rough inrolled leaves. In the deeper areas lower down on the

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*Saltmarsh at Langebaan Lagoon tolerates tidal submergence in seawater*
shorn it is fairly sparse and grows to a height of 80 cm, while higher up it is denser but only 10-15 cm tall.

Above the Spartina zone is a mixed community of the glasswort Sarcocornia perennis and the bulbous marshweed Triglochin bulbosa. Sarcocornia is 5-10 cm tall and resembles a small succulent with jointed stems. Under stressful conditions, such as high salinity, chlorophyll pigments that give plants their green colour are broken down in Sarcocornia. Orange pigments known as carotenoids then predominate, with the result that the Sarcocornia beds change from green to red. Sarcocornia dies if submerged continuously for longer than two weeks.

Triglochin is also known as the arrow grass because the young flower buds are densely packed at the top of the long stalk and resemble an arrow head. The plant grows to 15 cm tall, forming a narrow spike of flowers en sheathed by thin upright leaves.

Since both Sarcocornia and Triglochin are soft, juicy plants that are palatable to grazing animals and grow on a firm substratum that allows access to livestock and humans, this zone is subject to disturbance. If damaged, the plants do not easily regrow, and bare patches in the saltmarsh may erode severely.

At the top of this zone, the purple-flowered sea lavender, Limonium depauperatum, is often found. Higher up, in the rarely-flooded area above the high water mark, are taller, shrubbier plants, collectively known as salt bushes. Species include the soutbossie Chenolea diffusa, the seablite Suaeda caespitosa, the sapphire Sarcocornia pillansiae and the pink lagoon mesem Disphyma crassitolium.

Saltmarshes facilitate sedimentation by reducing water velocity and retaining many of the particles deposited. The changing conditions may favour other species, resulting in a succession of species.

The value of saltmarshes

Saltmarshes provide much of the detritus (decaying plant matter) that forms the basis of the estuarine food web. For example, the tips of Zostera leaves continually break off and are colonised by bacteria and fungi, which not only decompose them to detritus but also impart greater nutritional value. In this form they are consumed by benthic invertebrates such as sand and mud prawns, bloodworms, crabs, snails and filter-feeding mussels and clams, as well as by swimming prawns and mullet fish.

Shrimps and snails graze on the unicellular and filamentous algae that grow epiphytically on living Zostera leaves, while some herbivorous fish eat the leaves themselves. In the case of the adult strelie Sarpa salpa, only the epiphytic algae are assimilated – the Zostera is not digested. Juvenile Cape stumpnose, Rhabdosargus holubu, also consume Zostera leaves, but much of the plant material is returned to the system as faeces, where it forms part of the detrital food web.

Because the Zostera beds are food-rich environments for many invertebrates and juvenile fish, they in turn provide food for large numbers of birds such as flamingos, terns and waders. As such they have great value as a conservation and ecotourism resource. Apart from being an important nursery area for fish, saltmarshes contribute to the food webs that sustain nearshore fisheries. Some also provide valuable grazing for sheep, cattle and horses, although this is not always an appropriate use!

Furthermore, saltmarshes are important in dissipating wave energy, so they help protect coastlines from erosion. They are also useful for assimilating sewage nutrients such as phosphorus.

Threats to saltmarshes

Since estuaries are prime areas for coastal development, many saltmarshes have been lost to marinas and harbours. They are also impacted by human and livestock trampling, as well as overgrazing. Abstraction or impoundment (damming) of water in the catchment area may alter the salinity regime of estuaries, while poor catchment management practices may result in increased siltation downstream, both with negative consequences for saltmarshes. Saltmarshes are also impacted by pollutants such as heavy metals, nutrient-rich sewage or organic effluent, and oil. Indeed, they are priority areas for protection following oil spills because they can trap large quantities of oil and are difficult to clean. While some saltmarshes take decades to recover, others do so within one or two years.

Author: Sue Matthews October 2000

FURTHER INFORMATION:

RELATED FACTSHEETS:
- Estuaries and Lagoons
- Langebaan Lagoon
- Wetlands

For more information, please contact: The Coastal Management Office, Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, Cape Town, South Africa. Tel: +27 (0)21 402-3208 Fax: +27 (0)21 418-2582 e-mail: czm@mcm.wcape.gov.za Website: http://sacoast.wcape.gov.za