Mangrove Ecosystem Study

In this study you will be looking at the mangroves as an ecosystem. Your study will deal with all the following:

• abiotic and biotic factors and the interactions between them.
• trophic relationships in that ecosystem.
• the changes between high and low tide.
• biodiversity within the ecosystem using information keys and food webs.
• positive and/or negative human impact/influence on the ecosystem.

Curriculum link

GRADE 10 STRAND 3: ENVIRONMENTAL STUDIES - Biosphere to Ecosystems

Aquatic biomes of Southern Africa:
How climate, soils and vegetation influence the organisms found in each biome.

Ecosystem structure and functioning and the abiotic and biotic factors and how they affect the community:

Abiotic factors:
• physiographic factors (aspect, slope, altitude)
• light (day length, seasonal changes)
• temperature (effect of day/night, seasons)
• water (water cycle, importance of wetlands)

Biotic factors: (Links to Grade 8)
• producers
• consumers
• decomposers

Energy flow through ecosystems and relationship to trophic structure (food pyramids):
Producers, consumers (herbivores, carnivores and omnivores, decomposers). Human activities in and interactions with the natural environment.
South African Mangrove Forests

Together with coral reefs and seagrass beds, mangroves rank as one of the most productive ecosystems in the world.

Physical Environment
Mangrove forests are found in the littoral zone, the band between the sea and the land that is flooded and exposed during the rise and fall of the tide. They occur in estuaries which are either predominantly or permanently open to the sea and tidal in nature. Mangroves are usually only found in tropical climates, as they need consistent 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 forests 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, where the accretion of suitable mud can occur. This mud is usually anaerobic, and oxygen is usually only present in a very thin upper layer. Although most of the mangrove forests in South Africa occur along the KwaZulu-Natal coast, they do extend south to estuaries in the Eastern Cape.

Plants
Very few species of trees are specially adapted to cope with the varying conditions of salinity, tidal inundation and anaerobic mud. Mangrove trees grow in the area between the high and low spring tide levels. This means that while part of the mangrove swamp will be under water twice daily, the inland 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 northern KwaZulu-Natal another two species of mangroves are found, namely the Tagal mangrove, (Ceriops tagal), and the Kosi mangrove, (Lumnitzera racemosa).

Structure of a Mangrove Forest and Adaptations
The different mangrove species have adapted in different ways to cope with the harsh conditions associated with life in a mangrove swamp. The trees have leaves adapted for the exclusion or extrusion of salt and seeds adapted for quick germination in the muddy, unstable soils. Their root systems all have some form of aerial roots.
The White Mangrove (*Avicennia marina*) with its pencil roots is found closest to the edge of the estuary shoreline. The white mangrove tree exudes excess salt through glands on the under-surface of the leaf. They have 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. Fruits are shed mainly during March and April resulting in seeds being dispersed at equinox high tide. Seedlings establish when the water recedes and the seed is deposited in the mud where it quickly takes root.

Black Mangrove (*Bruguiera gymnorrhiza*)
The black mangrove collects salt in the leaves which age rapidly, turn yellow and fall from the tree taking excess salt with them. This species has knee roots that protrude from the mud and are the aerial breathing roots. The seeds are cigar shaped. Some germination takes place while the seed is still on the tree. Seeds fall directly into the mud below the tree, and can develop roots within a few hours or be carried by the tide to other areas along the coast.

Red mangrove (*Rhizophora mucronata*)
can usually only establish in sediments which have already been stabilized by *Avicennia marina*. The red mangrove possesses prop roots that emerge from the trunk at various levels and go underground at random, thereby forming a tangled root mass seen above ground.

A few other tree species can survive on the landward side of mangrove forests.
1. Which four abiotic (non-living) factors are characteristic of a mangrove habitat?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

2. Which three varying conditions have mangrove trees adapted to cope with?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

3. What are halophytes? What special mechanisms may they have to enable them under those conditions?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

4. Label the following diagrams
   Name the mangrove tree?

Type of root system of the mangrove tree?

5. The first and the third species of tree in the diagram deal with excess salt differently. Describe these differences.

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

6. Why do these trees need to have such unique root systems?
Animal Residents of the South African Mangroves

There is a whole diversity of organisms which use mangrove areas.

- Invisible organisms – bacteria.
- Barely visible – the water contains many forms of larvae in the form of zooplankton.
- Many creatures live in the mud – at least twenty different species of invertebrates can be found in one teaspoon of mud.
- Commonly visible – climbing whelks, mudskippers, crabs, prawns, fish, etc.

Fish: Marine migrants use the estuary as a nursery e.g. spotted grunter and mullet, marine stragglers which normally occur at sea but may wander into the estuary and freshwater stragglers such as Mozambique tilapia.

Birds: A variety of water birds e.g. herons, egrets, cormorants, storks, seed eaters and some specials such as the mangrove kingfisher. Look out for fish eagles.

Reptiles e.g. snakes and lizards, including monitors.

Mammals: Water mongoose, monkeys.

Truncated Mangrove Snail
*Cerithidea decollata*
This snail lives high on the tree trunks of the mangroves out of the reach of aquatic predators. At low tide it descends onto the mud to feed on detritus.

Red Mangrove Crab
*Neosarmatium meinerti*

The red mangrove crab has a dull brown-black body with bright red chelipeds (leg with claw) and is much larger than the *Uca* species described below.

The red mangrove crab makes its burrow in the dryer, shaded spots of the landward side of the estuary shore. Young crabs are often seen scurrying across the mud and tree roots. During low tide the adult crabs are found in the mouths of their burrows, emerging only for essentials like food. At high tide they escape the water and its predators by withdrawing into their burrows and sealing the entrance with mud. The reason for the red mangrove crab not seen foraging as much as the fiddler crab, is because it is not a plankton eater and thus does not have to sift through the sand for food particles in the sediment. The crabs can detect leaves falling onto the ground, presumably by vibration. Once the leaf is seized, the crab will manoeuvre it with its chelipeds and mouth parts to cut into smaller pieces. The smaller pieces of leaves are taken into the burrow to be eaten. The crab does not consume the whole leaf and the other cut up pieces may sink to the bottom of the burrow where it sustains a food web of bacteria and organic matter for other mangrove creatures.

The successful existence of the red mangrove crabs out of water is largely due to the breathing specialisation of oxygenated water constantly passing through the gill cavity as it would in underwater conditions. A small sample of water from the gill cavity is continuously redirected over specialised aeration plates on the body surface while the crab is out of the water – these aeration grids are visible to the naked eye as a sparkling appearance along the ‘cheeks’ and sides of the crabs as the constant trickling of the water reflects in the light.
**Fiddler Crab**

*Five different Uca species.*

These crabs are easily identified by the male’s one pronounced and vividly coloured cheliped, used for mating rituals and territorial displays. Females’ chelipeds are both of the same size and are much smaller than the enlarged cheliped of the male. The chelipeds are used to push food into the mouth. The fiddler crabs feed on organic detritus and plankton deposited on the sand and mud surfaces. Adapted mouth parts sort the food particles from the sediment and the food is swallowed while the sediment is deposited as small round pellets. Males use only the smaller of the two chelipeds for feeding while females alternate.

Fiddler crabs are amphibious, equally at home on land and in water. They are rather passive in the water but very active on land and the sideways walk so typical of land crabs can quickly turn into a speedy run. These crabs are adapted to pick up vibrations on land through minute hairs on their legs and bolt off when they are approached. In the absence of a hiding place they run in a strongly zig-zag pattern of avoidance.

The fiddler crabs have gills for breathing, organised in the usual crustacean manner within a gill cavity below the carapace. These gills are modified for breathing on land. They are small and stiff so they do not stick together when surrounded by air, losing valuable surface area in the process. The walls of the gill cavity are richly endowed with blood vessels so that they provide supplementary absorptive surfaces. Furthermore, the gill cavity is reduced in size and fringed with hairs to limit evaporation from the gill cavity. These adaptations allow the crabs to be out of the water for hours.

Fiddler crabs are burrowers. The burrows are constructed by males and females and play a central role to the crab’s territory as they are in constant use. The burrows always have some water in them and the crab returns for replenishment of water to the gills as well as for refuge during the high tide or to avoid predators. The entrance will be plugged with mud to keep some air in the burrows during high tide and to protect them from predators. After impressive mating displays by the males, using their colourful chelipeds, breeding takes place and the females will carry the eggs on their bodies to protect them until free-swimming larvae hatch.

**Mudskipper**

*Periophthalmus kalolo*

The mudskipper is a peculiar fish that is just as likely to be found on a mangrove tree root as it is in the water. It is most common at the estuary shore edge and alongside waterways and puddles and, with its mottled grey-brown pigmentation, it blends into its surroundings perfectly. A few adaptations allow this little fish to exist for some time out of the water:

Firstly, the skeleton and muscles have adapted to carry the weight of the fish in air. The pectoral fins are very well developed with a fleshy base to the fin-rayed appearance and an elbow-like bend to support the body. These structures are used in locomotion referred to as crutching - a progression that can carry the fish up gradients out of the water. The pointed tail is employed during the skipping motion that gives the fish its name. Before each leap the tail is bent forwards and to one side, and is pushed into the mud. With an upward thrust from the pelvic fins and straightening of the entire body, the fish is projected in the air with the pectoral fins providing some stability. The mudskipper uses this motion to escape predators and also feed on dry land. It captures a range of invertebrates. When the mud-skipper is in the water it breathes like other fish by water running over the gills, but on land the fish has an ability to seal the gill passages after gulping air. The result is a sealed cavity with plenty of air and some residual water to assist in breathing during the dry period. The air and water have to be replaced periodically and thus the fish never strays too far from the water.
Leaf Litter – leaves fall from the tree and decompose forming part of the detritus. The leaves are also taken by the mangrove crabs.

Detritus – the organic matter that is broken down and utilized by other organisms

Plankton – microscopic plants (phytoplankton) and animals (zooplankton). The phytoplankton will photosynthesize and the zooplankton will feed on the phytoplankton.

Prawns – crustacea that burrow into the sediment and feed on detritus.

Worms – found in the sediment (soil). They feed on detritus.

Spotted Grunter – juveniles live in estuaries and grow in size until they are ready to return to the sea. They feed on prawns, worms and small crabs. Very small juveniles will also feed on plankton.

Egret - These carnivorous birds are incredibly opportunistic. They feed on a wide variety of small creatures, though most of their food is aquatic and includes worms, crabs, prawns and small fish.

Fiddler crab – small crabs, usually no bigger than 3cm that feed off the detritus found in the sandy sediments of the mangroves.

Mangrove crab – these crabs burrow into the sediment and drag leaf litter into their burrows where they feed on it.

Mangrove Whelk – found moving between the sediment and the trunks of the mangrove trees. They feed on detritus.

Mudskipper – a small fish that is able to hold pockets of oxygenated water in its gills so that it can sit out of the water on the sediment surface. They feed on worms and larger zooplankton.

1. On the picture, draw in the connections (line with arrow) to complete the mangrove food web. Remember to draw your arrows in the correct direction (the direction of the arrow shows the movement of energy)
2. Using the diagram and associated key, create a food pyramid. List the names of each of the trophic levels in the food pyramid.

3. Choose three animals from your food web and describe how they would be affected by tidal changes, and what they would need to do to cope with those changes:

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
Specialized functions of mangroves

Mangroves stabilize and protect estuarine shorelines with their intricate root systems and they filter and trap land-based sediments.

Mangroves are important nursery areas for many juvenile fish and invertebrate species which are an important food source for humans. They perform vital ecosystem services as global sinks, absorbing carbon and pollutants from the air, thus providing us with clean air to breathe – 11% of the total global carbon is absorbed by mangroves.

Water quality control - they also absorb pollutants and harmful heavy metals from water. They filter the wastewater and domestic sewage that washes the shores of estuaries.

They provide protection against storms, protecting shorelines from erosion, high seas due to cyclones and tsunamis etc. by creating a buffer between the land and the sea.

Mangroves and People:

Mangroves provide food, shelter and livelihoods. Mangroves are important for recreation and tourism which also have the potential to create jobs.

Impact of Human Activity

Mangroves are threatened by humans in a number of different ways. In some areas, especially along the Eastern Cape coast, large areas of mangrove trees are being cut down for their valuable hardwood. The wood is then used as firewood or for the building of houses and fences. In other areas of the world, mangrove forests have been cleared to provide space to build ponds for shrimp farming. This use damages the forests irreparably.

Many mangrove areas have also been drained to provide land for developments. The Durban Bay was once home to many hectares of mangroves, however, much of the original area has been cleared for the harbour. In Richards Bay, a nature reserve has been established to conserve a representative portion of the mangroves. Any construction that alters the water level and tidal flow will impact on mangrove forests. Dams have decreased the amount of fresh water flowing into these areas, thereby raising the salinities of the area. The amount of seawater flowing into the mangroves may also be restricted when bridges and embankments are built close to the mouth of an estuary, while at the same time impounding the river and flooding the mangroves. Mangroves are vulnerable to changes of water level, because they can drown if the pneumatophores are submerged for too long.

Conservation Guidelines

Mangrove swamps are silt traps and form a natural barrier to the penetration of salt water from the sea into the adjacent land. The impact on a mangrove area should be taken into account when decisions are made regarding the siting of bridges and causeways, as well as other coastal developments that may impact on the natural functioning of a mangrove system.

What You Can Do

If you have the opportunity, visit a mangrove forest. They are fascinating and are certainly not the smelly swamps many people think of. When visiting, be careful where you walk as you may be destroying the homes of small animals. Look and listen carefully; many of the animals are very shy and will only emerge if you wait very patiently. Do not buy carvings, furniture or firewood made from mangrove trees.
1. Why are the mangroves so important along coastlines?
_________________________________________________________________________________

2. What are some of the ways in which mangroves are impacted by human beings?
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

3. If you were in charge, what kind of laws do you think you could make to ensure the protection of our mangroves?
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
The mangrove ecosystem is part of an estuary in South Africa

Estuaries are transitional environments where land meets sea and fresh water meets salt water. As such, they are among the most biologically productive ecosystems on the planet, acting as nutrient traps, are rich in biodiversity and yield detritus to the sea. Unfortunately, activity within their catchment areas may eventually affect the estuary environment and can upset this natural function.

An estuary’s unique features are determined by rainfall, geology and the interaction between river water and sea water, and are the result of the physical and biological features, and consist of a number of different habitats:

- water column
- salt marshes, reeds and grasses
- mangroves - the only trees adapted to living in salty water
- intertidal banks and reed beds and submerged rocks
- sandy and muddy bottoms

Estuaries are dynamic - with each tidal change or after heavy rain and floods, changes occur within the system. However, the species that have adapted to living in this environment can tolerate these changes and thrive on the changing conditions.

Physical Conditions

Salinity

The changing salinity of the water is one of the most significant factors in determining the kind of organisms able to both survive and thrive in estuarine environments. Both tides and river flow alter the salinity, the mouth usually being the most saline area. As the tide rises, salt-water is pushed higher up the estuary, only to retreat on the ebb. Sea and river water does not mix uniformly; salt water, being denser, sinks and the fresh water rises. This layering protects those bottom living organisms that are fresh-water intolerant.

During droughts there may not be enough inflowing fresh water to counteract evaporation so then the salinity of the estuary becomes more concentrated and it may even become hyper-saline (excessively salty). Floods have the opposite effect, filling the estuary with fresh water and diluting the salinity. Both of these conditions affect the species rate of survival under those conditions.

Some fish and invertebrate species migrate to cope with changes in salinity; others regulate the concentration of salts in their tissues through a process called osmoregulation, the process of osmosis and diffusion.

Temperature

The ocean has a relatively constant temperature, but in estuaries temperatures change with the tides and weather, the head (top of the estuary) having a greater variation than the mouth. Temperature causes stress by impacting an organism’s metabolism. The distribution of some species can be determined by their adaptation to temperature variations e.g. of five species of fiddler crabs those with a higher tolerance of high temperature can feed for longer on exposed bare sands, while others are limited to areas with shade.
Tidal Flow
Currents in estuaries are the result of both tidal action and river-flow and directly affect the substrate and may also wash animals out to sea. Most species of estuarine zooplankton practice daily vertical migrations that may assist them in maintaining their position in estuaries. Most estuarine species are small, grow quickly and reproduce rapidly.

The sand prawns Callianassa kraussi have adapted by eliminating their planktonic stage, the eggs hatch into miniature adults and burrow to avoid the tidal flow, and the snail Nassarius kraussianus brood their eggs thereby reducing their larval stage (which is more susceptible to being carried by water flow).

Rainfall and Siltation
Deposition and removal of sediments are both very important processes. Floods scour the river beds and banks, changing the environment for benthic animals, and excessive siltation both smothers and fills in the estuary. Deposited sediments are stabilized by plant growth which helps to avoid erosion, and are also trapped by mangrove roots where they are present, creating a more stable environment for associated animals.

References:
Williams, T. Hands-on East Coast estuaries and mangroves, a field guide, ShareNet 1992
Berjak, B, Campbell, G.K., Huckett, B and Pammenter, N.W. In the Mangroves of South Africa, Wildlife & Environment Society of South Africa, 2011

https://saeis.saeon.ac.za/