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National Marine Ecosystem Diagnostic Analysis (MEDA)

Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project

ASCLME
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ANNEXES

Executive Summary

South Africa has an extensive coastline in the southern section of Agulhas and Somali Current Large Marine Ecosystem (ASCLME) region, with the coastal provinces of KwaZulu Natal (KZN), Eastern Cape and Western Cape forming the seaboard. The southeast coastline is remarkably linear, with a narrow continental shelf descending to an abyss (deeper than 4,500 m) in the southern Transkei Basin. The Agulhas Bank reaches a maximum width of 260 km offshore of the east-west trending south coast; half-heart bays occur in the lee of several capes formed by resistant rocks of the Cape Supergroup. South Africa has proclaimed an Exclusive Economic Zone (EEZ) of 200 nautical miles from the coast.

South Africa's population in 2009 was 49.32 million, with 79.3% being African, 9.1% White, 9% Coloured and 2.6% Indian/Asian. Some 52% of the population is female, with nearly one-third of the total population being younger than 15 years of age and 7.5% 60 years or older. While schooling is compulsory for all children aged between 7 and 15 years, there are still substantial educational disparities that can be traced to the apartheid past. Access to potable water is improving and about 60% of the households have access to improved sanitation.

In the ASCLME region, there are major commercial ports at Richards Bay, Durban, East London and Port Elizabeth, as well as a new deep water port at Coega in Algoa Bay. There are also a number of smaller fishing harbours. The socio-economic character of the coastal regions varies considerably, and the northern regions of KZN and the Wild Coast are characterised by a sparsely distributed, rural population with a low per capita income. There is also extensive subsistence and recreational harvesting of inshore marine resources. The commercial ports are supported by a modern and well-developed transport infrastructure, with Durban the largest city. The regions around the ports also support agriculture, light industry and tourism, while the coastal strips are characterized by the presence of highly developed prime real estate.

The South African Heritage Resources Agency is charged with the protection and management of South African heritage. Places of special national significance must be identified, while structures older than 60 years as well as archaeological, palaeontological and meteorite impact sites, and public monuments and memorials may not be destroyed, altered or disturbed without a permit. Over 2,700 vessels are known to have been lost along the South African coast since 1500, while there are a number of archaeological sites relating to early African agricultural groups settling in the subcontinent as well as colonial conflicts.

The Agulhas Current is the dominant oceanographic feature in the Southern Africa region, and is one of the three largest currents in the world's oceans. It brings with it warm surface waters from the tropics and subtropics which have a major influence on the weather and climate of the whole southeast coast, and extend the subtropical biogeographic region southwards. Coral reefs of Indo-Pacific origin occur as far south as Cape St Lucia, while some of the southernmost corals in the world are found on the Aliwal Shoal. Mangrove forests occur in estuaries as far south as East London.

Dynamics on the shelf regions inshore of the Agulhas Current are important for localised conditions. South of Cape St Lucia the gentle Natal Bight means that the shelf widens up to 45 km, formed mainly by the deposition of terrigeneous sediments from fast-flowing rivers, notably the Tugela river. These muddy banks support a crustacean trawl and trap industry. A coastal upwelling cell occurs in the lee of Cape St Lucia, and sporadic, short-lived upwelling brings nutrients to the surface waters, which can be transported southwards to a semi-permanent cyclonic eddy off Durban. Associated elevated levels of primary production and calanoid copepods have also been found in this area. Farther south, upwelling of cold water also occurs inshore of the Agulhas Current, increasing in prevalence south of the Mbashe area to Algoa Bay. Wind-driven upwelling occurs preferentially at the prominent capes leading to a chlorophyll-rich inshore zone, and is important for larval distribution processes: the area supports a local squid jig fishery.

The subtropical biogeographic region has summer rainfall, while the warm temperate region which starts at Mbashe has lower, year-round rainfall. The corresponding coastal vegetation comprises Grassland on the east coast, Albany Thickets on the south-east coast, and Fynbos on the south coast. Estuaries are at the receiving end of bad catchments practices, such as pollution, soil erosion, excessive water abstraction and impoundments, and only 25% remain permanently connected to the sea. The other 75% of the estuaries are closed at some

stages because of low river flow, high wave action and the availability of sediment. The sheltered nature of estuaries and aesthetic appeal has made them the focus of coastal development. Poorly regulated activities have destroyed many estuarine habitats. While many estuaries are still in a relatively good state, about 40% are in a fair to poor condition.

Tides around South Africa can be classified as semidiurnal and microtidal, with spring high and low tides generally varying by less than 2m. Offshore habitat types support unique assemblages of marine life and in many cases species of considerable commercial importance. The small pelagic fisheries dominate the sector with respect to volume, while large pelagic fisheries are relatively small but South Africa's EEZ is heavily fished by foreign tuna fleets. In the demersal trawl fishery, hake is the most valuable fishery, but crustacean and squid fisheries are also important. Linefish is one of the largest multi-faceted fishery sectors in terms of areas fished and numbers of fishers involved, including subsistence and recreational users. Deepwater trawls and high seas fishing are targeting the new deepwater species regime with a unique set of biodiversity impacts. In all these fisheries there are significant problems with bycatch.

South Africa is very rich in marine mammals, with 32 species of toothed whales, 13 species of baleen whales and 6 species of seals. All species of marine mammals are fully protected. However, the taxonomy and biology of the majority of marine mammals are poorly known. Turtles are best known in the reptiles, and the nesting beaches of both the loggerhead and leatherback are proclaimed RAMSAR sites and MPAs. Of concern is that climate change could affect the distribution and sex ratios of turtles, since these are determined by incubation temperatures and there is no clear expectation if the net effect will be positive or negative.

In total, 119 species of seabird have been recorded in South Africa waters, and the shoreline also supports 133 species of coastal birds from 27 families. Of the 15 species of seabirds that breed in South Africa, 10 are classified as threatened or near-threatened, including six of the endemic taxa. Offshore islands are particularly important breeding localities for seabirds, including some 40% of the world population of African penguin in Algoa Bay, and 70% of the global population Cape gannet. Fisheries impact on seabirds both through reduction of fish stock and by birds being part of the bycatch.

Areas under special management comprise MPAs, closed areas to protect certain commercially fished species, the *iSimangaliso* Wetland Park World Heritage Site at St Lucia, Ramsar sites (which mainly comprise estuaries) and Biosphere Reserves. The new Integrated Coastal Management (ICM) Act established the statutory requirements for integrated coastal and estuarine management in South Africa. It makes provision for the establishment of coastal set-back lines for controlling development along ecologically sensitive or vulnerable areas, or any area that poses a hazard or risk to coastal communities. Moreover, the Act requires that the potential effects of climate change are taken into account when determining the coastal set-back lines. Nonetheless, local communities are often at odds with the conservation and management processes, and education and poverty alleviation measures are required to obtain buy-in. Moreover, monitoring, control and surveillance must be improved.

Many of the problems in the marine ecosystems arise from an incomplete understanding of the systems, and there is a requirement to increase the research capacity. Moreover, a number of useful monitoring programmes have been terminated, in particular involving South Africa's water resources and sediment discharges. A promising meiofauna programme ground to a halt in the 1980s, and is now hampered by a shortage of taxonomists. Funding for marine pollution research has decreased considerably, and the almost complete lack of recent data on pollutant concentrations in water, sediment and biological tissue makes it impossible to determine whether these pose a risk. It is also urgent that the impacts of introduced marine species are assessed.

The climate change is manifesting itself in terms of temperature changes in the atmosphere and ocean, an increase in east coast rainfall (but a reduction in soil moisture), and increases in the magnitude of coastal winds and sea level. Coral bleaching is already occurring, although it is less extensive as compared to other areas in the Indian Ocean. The areas along the coast that are most vulnerable to flooding due to sea level rise need to be identified.

In South Africa, there is a net migration of people to coastal areas, and about 40% of South Africa's population

lives within 100 km of the coast. As a consequence, much of the terrestrial habitat along the coastline can be considered endangered or vulnerable. Moreover, unsustainable and intensive commercial land uses (e.g. forestry, sugarcane and livestock) associated with over-abstraction of water from rivers, as well as over-grazing and poor land use management practices has led to land degradation and soil erosion in inland areas. This has resulted in heavy sediment loads in many rivers, changing estuarine mouth dynamics with negative consequences for ecosystems such as mangroves and saltmarshes. In some areas, this has led to smothering of benthic algal communities and coral reefs. Sand-winning results in a loss of aesthetic value and ecosystem degradation, with 18 out of 64 estuarine systems in KZN supporting such operations.

Increasing coastal populations have also resulted in intense exploitation of inshore resources by recreational and subsistence sectors. Along the Wild Coast and parts of KZN rural communities rely heavily on intertidal marine resources to supplement their diet and for sale to tourists. In some places the rocky shore is regularly stripped of all sessile organisms, posing a severe threat to biodiversity and the sustainability of these resources. Abalone poaching for illegal export to lucrative Asian markets is a particularly iniquitous form of exploitation, with many well-equipped, armed and dangerous poachers. Unfortunately, the ratio of FCOs per km of coastline is 1:17 compared to the international norm of 1:5, making policing difficult.

Many coastal fish and invertebrate stocks are also overexploited, with significant impacts on both target and non-target species. This has translated into dramatic changes in the structure of exploited communities. Disturbance of coastal areas may also have adverse impacts for seabirds and shorebirds utilizing the coastal environment. Marine and estuarine areas under special management, in particular MPAs are attempts at finding a solution, though in places there is considerable resistance to the expansion of MPAs from disadvantaged communities and local commercial and recreational fishermen.

Offshore, the effects of overfishing and bycatch on stocks has been highlighted in §2.9.2 but the problems also relate to other species. Thus sea birds are caught on longlines and drowned, or killed through colliding with demersal trawl gear. Marine mammals such as killer whales and offshore dolphin species (common and bottlenose) are regularly killed while depredation by killer whales also occurs. Turtle mortalities are also common. Competition for resources with fisheries has impacted severely on some species, for instance seabirds feeding on anchovy and sardine have suffered large decreases in the past 50 years, and the African Penguin has become endangered. Marine mammals such as seals benefit from fishing in that they scavenge discards and remove fish from fishing lines and nets, but this has led to a strong reaction and retaliation from fishermen.

Infrastructure construction, including harbours, launch sites, cities, towns, housing, roads and tourism, dredging activities and the disposal of sediments, impact heavily on coastal areas. Sewage from bucket toilets, pit latrines and septic tanks enter the coastal zone via stormwater runoff or groundwater flow, while large volumes of poorly treated sewage effluent is discharged into rivers from wastewater treatment works. Stormwater discharges appear to be the most significant source of pollution, yet little to nothing is known about the types and loads contributed. On the other hand, the most frequently detected pollutants are pesticides and herbicides, but the importance of agriculture as a source of pollutants is unknown. From offshore there is also the continued threat of pollution associated with increasing volumes of international shipping. The position of the new Coega/ Ngqura port in Algoa Bay is a concern as it is located adjacent to the Addo Elephant National Park and its newly-acquired MPA, which includes the seal and penguin colonies on Bird and St Croix islands. Moreover, local diversity and accompanying changes in abundance and biomass of meiofauna are being affected by disturbances such as chemical pollution, dredging and landscape alterations. It is crucial that the ecological impacts of introduced marine species are assessed as a matter of urgency.

Many persistent organic pollutants have a high bioaccumulation and endocrine disruption potential, and accumulation of heavy metals and pesticides in marine mammals may impact negatively their survival and reproductive rates. However, in the early 1990s funding for marine pollution research decreased considerably. The almost complete lack of recent data on pollutant concentrations in water, sediment and biological tissue from the South African coastline makes it impossible to determine whether these pose a risk to ecological and human receptors. This lack of data also prohibits the identification of pollution hotspots and tracking of spatio-temporal trends.

A factor inhibiting conservation of marine resources and the management of their use is that responsibility is shared by a number of different authorities along the South African coastline. This also applies to policing. The ICM Act makes provision for a hierarchical structure, which is dependent on Municipalities to make the required progress towards developing and implementing Integrated Development Plans, Spatial Development Plans and Land Use Management Systems. Unfortunately, the conservation of natural resources and ecosystems has historically not been prioritised by Local Municipalities and has often been in conflict with development. In some cases, disputes over land and natural resources have resulted in conflict between local communities and conservation authorities.

More positive attitudes towards and support for the management of resource use and conservation can only be achieved through a combination of programmes that alleviate poverty and dependence on natural resources with conservation programmes that increase environmental awareness. Environmental education projects initiated in the absence of poverty alleviation measures that give poor people realistic alternatives to using natural resources will have little or no effect. Projects which can provide access to cash incomes through jobs or business opportunities are the key priority, while these can also be used to improve water use and sanitation.

Other concerns involve a lack of finances for equipment and resources, as well as a lack of capacity to research and analyse the problems and provide solutions, e.g. the study of meiofauna in South Africa is hampered by the shortage of trained taxonomists. Moreover, useful monitoring programs have been stopped, e.g. the last inventory on the reduction in fresh water flow to the coast was done in 1986, and inflows are gauged in less than 10 % of the rivers flowing into estuaries. In the 1970's information on the sediment load entering estuaries was regularly collected, but this monitoring programme has been suspended. A programme for the collection of bathymetric data at selected estuaries to monitor the rate of *in situ* sediment accretion/erosion was terminated in 1999.

Various gaps have also been identified involving better understanding of marine ecosystems. These include lack of current data and information on the sizes, distributions, populations and migrations and movements of various birds, fish, mammals and reptiles. These data need to be collected using modern technology. Also, there is a need for the existing information to be collated and threats to breeding/spawning, roosting/nesting and feeding sites identified. A crucial and relatively inexpensive form of monitoring changes in coastlines, vegetation cover, human settlements and estuaries should be promoted, for instance through the use of aerial photographic surveys and remote-sensing. In the marine areas, the spatial distribution and intensity of bottom trawling as well as the distribution and profile of reefs need also to be mapped.

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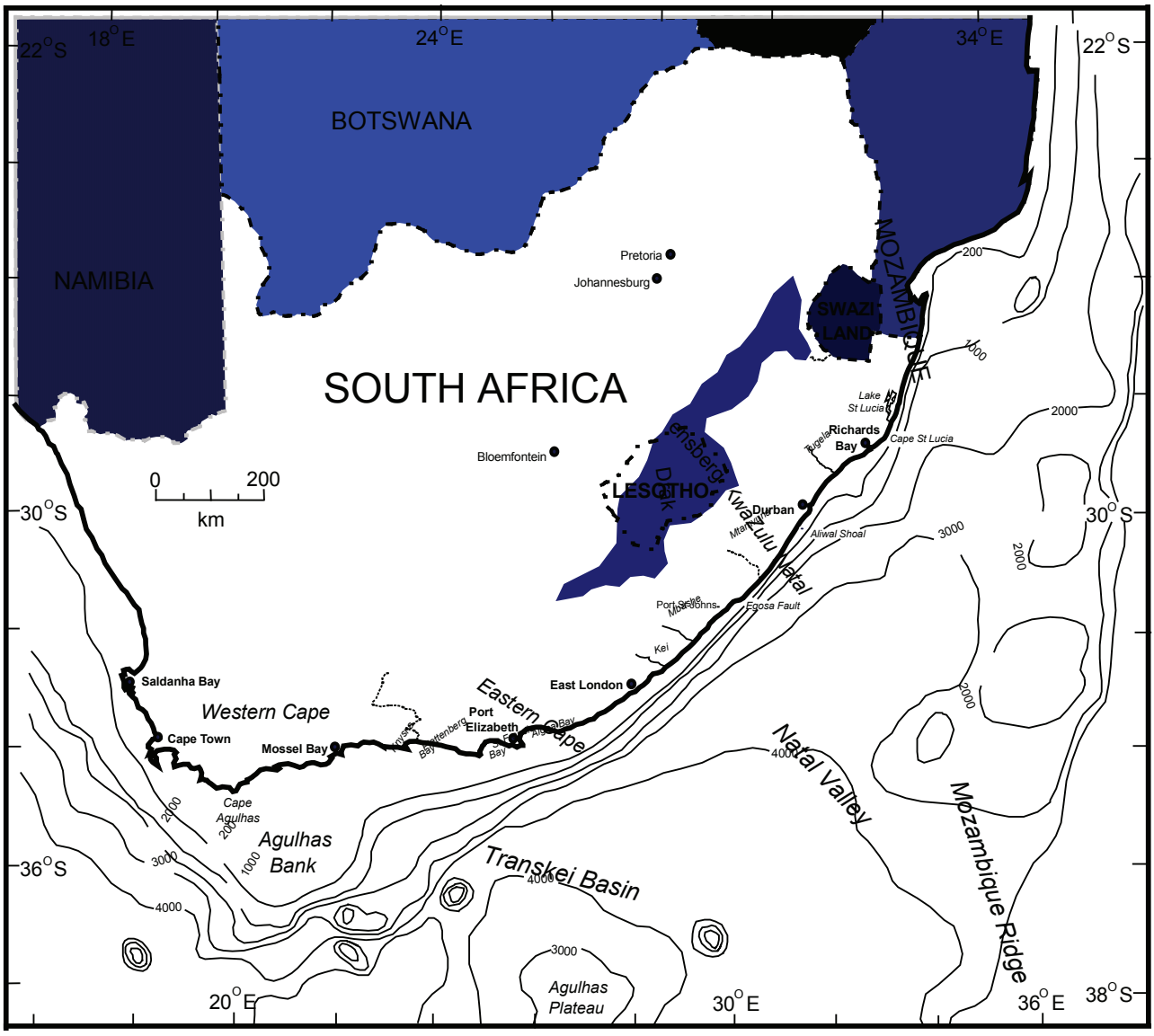

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Acronyms

ASCLME:	Agulhas and Somali Current Large Marine Ecosystems
CCSBT:	Commission for the Conservation of Southern Bluefin Tuna
CMP:	National Coastal Management Programme
CSIR:	Council for Scientific and Industrial Research
DAFF:	Department of Agriculture, Forestry and Fisheries
DEA:	Department of Environmental Affairs
DWAF:	Department of Water Affairs
EASSy:	Eastern Africa Submarine Cable System
EEZ:	Exclusive Economic Zone
EKZNW:	Ezemvelo KZN Wildlife (previously Natal Parks Board)
ENSO:	El Nino Southern Oscillation phenomenon
GCM:	Global Circulation Model
GDP:	Gross Domestic Product
GPS:	Global Positioning System
ICM:	Integrated Coastal Management
IDZ:	Industrial Development Zone
IPCC:	Inter-Governmental Panel on Climate Change
IOTC:	Indian Ocean Tuna Commission
IUCN:	International Conservation Union
KZN:	Kwa Zulu Natal
LME:	Large Marine Ecosystem
MLRA:	Marine Living Resources Act
MCN:	Marine and Coastal Management
MEDA:	Marine Environment Diagnostic Analysis
MPA:	Marine Protected Area
NDMC:	National Disaster Management Centre
NEPAD:	New Partnership for Africa's Development
NHRA:	National Heritage Resources Act
NMMU:	Nelson Mandela Metropolitan University
NSBA:	South Africa's National Spatial Biodiversity Assessment
PAA:	Protected Areas Act
PRASA:	Passenger Rail Agency of South Africa
RSA:	Republic of South Africa
SADC:	Southern Africa Development Community
SAEON:	The South African Environmental Observation Network
SAHRA:	South African Heritage Resources Agency
SAMSA:	South African Maritime Safety Authority
SANBI:	South African National Biodiversity Institute
SANPARKs:	South Africa National Parks
SANRAL:	South African National Roads Agency
SAWS:	South African Weather Service
SST:	Sea Surface Temperature
SWIO:	South West Indian Ocean
SWOT:	Strength, Weakness, Opportunities and Threats
VMS:	Vessel Monitoring System
WACS:	West African Cable System
WIO:	Western Indian Ocean
UNDP:	United Nations Development Programme

COUNTRY OVERVIEW

The Republic of South Africa is situated at the southern tip of the continent of Africa. The republic covers an area of about 1.22 million km^2, and has a coastline of about 3,600 km. It is bordered by Namibia, Botswana, Zimbabwe, Mozambique and Swaziland, while Lesotho is entirely contained within the country's borders (Figure 1). South Africa is surrounded by the Atlantic Ocean to the west and the Indian Ocean to the east, with Africa's southernmost point, Cape Agulhas, serving as the boundary between the two.

The South African ASCLME coastline extends from the border with Mozambique at about 26° 51' S and 32° 53' E in the north to Cape Agulhas at 34° 50' S and 20° 00' E in the south. Of the nine provinces in the country, only KwaZulu Natal (KZN), the Eastern Cape and the Western Cape have coastlines on the east and south coast falling into the ASCLME region. South Africa has proclaimed an Exclusive Economic Zone (EEZ) of 200 nautical miles from its coast, as well as around its two sub-Antarctic islands - the Prince Edward Islands - in the Southern Ocean.

Figure 1. South Africa, with the ASCLME region extending from the Mozambique border in the north to Cape Agulhas in the south.

The apartheid policies of the previous National Party government resulted in political, cultural and economic isolation until the end of the 1980s. Following a period of negotiations between the National Party (NP) and the African National Congress (ANC), an interim Constitution was agreed upon in 1993, and the country's first democratic general elections took place in April 1994. Mr. Nelson Mandela was inaugurated as the first democratically elected President on 10 May 1994. Over the next decade access to new markets and liberalisation of exchange controls encouraged diversification in exports. While mining for gold, platinum products, coal and diamonds still dominates export and revenue earnings, the manufacturing and agricultural sectors have also become important contributors to the economy.

South Africa has a population of 49 million people, of which 79.3% are African, 9.1% White, 9% Coloured and 2.6% Indian/Asian. The country has 11 official languages which include English, Afrikaans, Xhosa and Zulu. Large socio-economic inequalities are prevalent in South Africa and unemployment rate is high, being 25.5% in the third quarter of 2009.

A National Marine Fisheries Policy forms the basis of the Marine Living Resources Act (18) of 1998. The Act provides for "the conservation of the marine ecosystem, long-term sustainable utilisation of marine living resources and orderly access to exploitation, utilisation and protection of certain marine living resources". Transformation is a cornerstone of the Act, and steps have been taken over the last decade to transfer fishing rights to people who were previously disadvantaged, bringing much-needed stability to the industry.

A number of other South African laws have a bearing on the marine and coastal environment, including the Biodiversity Act, the Protected Areas Act, the Environmental Impact Assessment Regulations, the Seals and Seabirds Act, and the Integrated Coastal Management (ICM) Act. In addition, South Africa is a signatory to a variety of international treaties and conventions concerning fisheries management, conservation and environmental protection. It therefore has an obligation to protect its marine and coastal resources from threats such as overexploitation, habitat destruction (e.g. through coastal development, mining and fishing-gear damage), pollution, invasive alien species and climate change.

BIOPHYSICAL ENVIRONMENT

Description of the Coast

South Africa's stretch of coast that falls within the ASCLME region extends from the country's border with Mozambique to Cape Agulhas, the southernmost tip of the African continent. In the north, Maputaland lies at the southern limit of the Mozambique coastal plain. The intermingling of tropical and temperate flora results in highly diverse vegetation, dominated by grasslands, open woodlands and woody species tolerant of water logging. The shoreline primarily comprises coarse-grained sandy beaches, interspersed with rocky platforms or outcrops. A ridge of dunes 100-200 m high above sea level acts as a coastal barrier that confines the region's coastal lakes and estuaries. These include the four lakes of the Kosi Bay system, Lake Sibaya- the country's largest natural freshwater lake, and Lake St Lucia- Africa's largest estuarine system. The artificial stabilisation of the inlet of the St Lucia Lagoon has had a profound negative effect on the character of this system (Avis *et al.,* 1998; Davey-Moran *et al.*,1998).

The port of Richards Bay was constructed in the 1970s on half of an existing bay of the Mhlatuze river, and is home to the world's largest coal export facility as well as two aluminium smelters. The remaining southern section of the bay, identified as a sanctuary area, has experienced heavy siltation because of canalisation of the river. Just to the north of the port dredge mining of titanium dioxide takes place in a 2 Km wide, 17 Km long strip of mineral-rich sand dunes.

The *Zululand* region extends southward to the Tugela River, followed by the *Dolphin Coast* to some 70 km north of the city of Durban. This coastal zone is characterised by short stretches of coarse sandy beaches, interspersed with rocky headlands and numerous estuaries. Durban harbour- Africa's busiest port lies in the lee of the Bluff- a prominent landscape feature consisting of two parallel 100 m high sand dunes (Avis *et al.,* 1998; Davey-Moran *et al.,* 1998).

South of Durban, the 130 km stretch of coast to the Mtamvuna River and boundary with the Eastern Cape is known as the South Coast or *Hibiscus Coast*. Numerous towns form a coastal ribbon development of holiday homes and resorts interspersed by estuaries, some on substantial but seasonal rivers. Offshore reef complexes such as Aliwal Shoal and Protea Banks provide important natural habitat, and are popular dive sites.

The *Wild Coast* extends some 270 km from the Mtamvuna River to the Kei River in the south. It is a rural region, isolated by the poor road network and rugged nature of the terrain, particularly in the Egosa fault region where steep cliffs line the coast. The southern portion of the region is characterised by low rolling hills with wave-cut rocky platforms interspersed with sandy beaches. The coastal vegetation is dominated by indigenous forest and grasslands, while mangroves occur in many of the estuaries (Avis *et al.,* 1998; Davey-Moran *et al.,* 1998).

South of the Kei River, the coastline continues in a south-westerly direction for some 450 km to Algoa Bay. It is dominated by fine-grained sandy beaches with sections of wave-cut rocky platforms and a few dolerite and aeolianite (dune rock) headlands, as well as numerous estuaries. There are also found well-established harbours at East London and Port Elizabeth. The newly-constructed port of Ngqura at Coega is located some 20km north-east of Port Elizabeth. The flora reflect a transition between the subtropical and warm temperate biogeographical provinces, with elements typical of both. In the north the coastline is backed by a high, narrow cordon of forested dunes, while in the south the dunes are vegetated with scrub thicket. The northern shore of Algoa Bay contains a 50 km long and 2-3 km wide largely unvegetated sea of sand known as the Alexandria Coastal Dune field. It is the largest dune field in South Africa. This area, with the St Croix and Bird Island groups, have been incorporated into the Addo Elephant National Park (Avis *et al.,* 1998; Davey-Moran *et al.,* 1998).

From Port Elizabeth, the coast changes to an east-west orientation. The *Garden Route* region, named for its indigenous Afromontane forests and verdant growth, extends to Mossel Bay and encompasses a number of large estuaries and coastal lakes. Here the Tsitsikamma coastal plateau - 10 km wide and deeply incised by narrow gorges - borders the sea in spectacular cliffs that rise up to 170 m above sea level. Mossel Bay is primarily

a fishing port, but it also provides infrastructure for the gas field located some 85 km offshore. Further west the coastline is initially dominated by wavecut rocky platforms, and then by long stretches of fine-grain sandy beaches. Rocky headlands separate the sequence of bays through to Cape Agulhas, which demarcates the southern boundary of the ASCLME region (Avis *et al.,* 1998; Davey-Moran *et al.,* 1998).

The Climate

The dominant feature of the atmospheric circulation over southern Africa is the high pressure system encircling the southern hemisphere, with the South Atlantic anticyclone in the west, and the Indian Ocean anticyclone (IOA) in the east. The positions of these cells are critical for advection of moisture inland, as they ridge either behind a progressing cold front or migrate in a north-south orientation, respectively. Both cells show a latitudinal seasonal movement of about 5 to 6°, while the IOA is about 24° farther east in summer. Generally in summer, fronts ridge eastward south of the continent, while in winter a high pressure region is established over the subcontinent and the fronts pass over the land. This also results in the south-western Cape winter rainfall area. Small-scale coastal lows have been shown to be associated with these fronts. These systems intensify off the KZN coast, resulting in strong south-westerly 'busters'. These associated winds tend to blow parallel to the coast, with a greater degree of variability than on the west coast.

Regional anomalies in sea surface temperature can be a predictive measure of rainfall over the south-eastern sub-continent, as higher and longer persistence of warm water may extend the intensity and duration of rainfall (Walker 1990; Fauchereau *et al.,* 2003). Hunter (1988) found that the Agulhas current assumes a major role in the local atmospheric forcing. Being a warm-cored water mass, it drives evaporation into the atmosphere though heat exchange, and cloud lines are a frequent feature of the path of the current (Lutjeharms *et al.*, 1996).

South Africa ranges in climate from semi-arid to hyper-arid, with the 400 mm isohyet running approximately north-south through the centre of the subcontinent (Davies and Day, 1998). Most of the rain falls eastwards of the Drakensberg, while similarly on the south coast the mountains cut off a wet coastal belt from a dry interior. The southern coastal regions and adjacent interior receive rainfall throughout the year, while farther north more than 80% of the annual rainfall occurs between October and March (Tyson and Preston-Whyte 2000). Most of the summer rainfall is of convective origin. The four common composite circulation types that produce widespread rainfall are cut-off lows and ridging highs, westerly and easterly waves, easterly lows and cut-off lows, and easterly waves and lows together with ridging high pressure systems (Tyson and Preston-Whyte, 2000). Cut-off lows account for many flood-producing rains over southern Africa (Taljaard 1985; Engelbrecht *et al.,* 2009), with their frequency peaking during the transition seasons in March to May and September to November, and with the lowest number of occurrences between December and February (Taljaard 1982).

Portions of all African countries south of about 15° S are influenced by the El Niño Southern Oscillation – the so-called ENSO events (e.g. Ropelewski and Halpert 1987, 1989; Mason and Jury 1997). Both the drier (El Niño) and wetter (La Niña) conditions are frequently associated with warm or cold events during the rainfall season from November to May. The influence of ENSO is strongest during December to March when the upper westerlies have retreated poleward. However, during warm events a northward shift of the westerlies occurs and the rain producing tropical systems are located further north. Extremely dry conditions over the region usually occur when a La Niña event occurs during a near-decadal epoch of below-normal rainfall (Kruger 1999; Reason and Rouault 2002). Fortunately ENSO events have the potential to be predictable on a seasonal time scale and with several months lead-time (Zebiak and Cane 1987; Stockdale *et al.* 1998; Landman and Mason 2001).

Sea surface temperature (SST) anomalies in the oceans adjacent to southern Africa are related to southern African rainfall variability (e.g. Mason 1995). Anomalous SSTs in the areas surrounding southern Africa may therefore help to improve predictions of rainfall variability over the region (Landman and Mason 1999). Thus SSTs are anomalously warm (cold) in the equatorial Indian Ocean, and cool (warm) to the south-east of Africa during dry (wet) conditions over south-east Africa (Jury 1992; Reason 1998; Washington and Preston 2006). The warming of the Indian Ocean is possibly an important transmitter of the ENSO signal to southern Africa, but Indian Ocean warm events have on occasion occurred independently of ENSO events (Cadet 1985). SST variability in the Agulhas system can also account for some of the variability of the summer rainfall

over southern Africa (Reason 1998). Notwithstanding the promise of improved forecast skill levels from fully coupled modeling systems, there are still difficulties in predicting SST anomalies over key areas of the global ocean believed to be important in the prediction of rainfall variability over land (Landman *et al.*, 2009).

I) Issues

Forecast skills in South Africa are still limited, in particular predicting SST anomalies over large areas of the global ocean which are believed to be important in the prediction of rainfall over the land, eg low skill associated with ocean area south of Madagascar (Landman *et al.*, 2009)

Increased understanding that other areas other than the South Indian Ocean (e.g. Southern Ocean and South Atlantic) influence the weather and climate over South Africa (Mason, 1995; Reason *et al.,* 2006)

II) Gaps

Better predictions of ENSO events in Southern Africa.

Utilisation of nearshore SST anomalies data to improve predictions of rainfall variability.

Use of coupled ocean-atmosphere models for extra-tropical areas.

Downscaling of global models and research.

Marine and Coastal Geology

The southeast coastline of South Africa is remarkably linear with few major features (Figure 1). This is a consequence of the movement of the Falkland Plateau past the continental margin during the breakup of Gondwanaland about 150 to 100 Myr ago (Martin and Flemming, 1988). The resultant forces caused the extrusion of magma through fissures and cracks in the Earth's surface, capping existing sedimentary rock formations and forming the Drakensberg Mountains. These latter mountains reach a maximum height of 3482 m above sea level and form the western boundary of KZN, running parallel to the coast into the Eastern Cape.

The Natal Valley separates the continent from the shallow Mozambique Ridge, and plate tectonic reconstructions indicate that south of Durban is floored by oceanic crust. Farther south, the Transkei Basin reaches depths in excess of 4500 m. However, the extensive Agulhas Plateau is shallower than 2500 m in places. From the northern boundary of South Africa to north of Richards Bay, the continental shelf is very narrow, averaging 5 km to the shelf break at about 100 m or shallower, and with a steep shelf slope. The shelf in this section of the coast is also incised with a number of canyons, which in 2000 were discovered to be home to coelacanth. Farther south a gentle bight occurs in the coastline, while offshore the Tugela cone forms a triangular-shaped marginal plateau extending 220 km southeast of the Tugela River. This major feature was formed by the deposition of terrigeneous sediments by numerous fast-flowing rivers, notably the Tugela. The sediment thickness is approximately 4900 m in the northern Natal Valley (Dingle *et al.*, 1978). The continental shelf width reaches a maximum of about 45 km in this zone.

At Durban, the shelf break lies some 10 to 12 km offshore, although the slope is gentle and the 500 m isobath is found at about 60 km. Thereafter the depth increases rapidly along the southern east-west trending border of the Tugela cone. South of about 30° 20' S the continental shelf is again very narrow, with a steep slope. The inner continental shelf is smooth because of its cover of Holocene sediments, whereas the mid and outer shelf is punctuated by a series of rugged linear shoals (Martin and Flemming, 1988). Large sand dunes observed on the shelf were formed by the vigorous flow of the Agulhas Current.

Just north of Port St Johns the continental margin is displaced westwards by the Egosa fault, forming an offset to the coastline with precipitous cliffs and a waterfall plunging 60 m into the ocean. Farther south the shelf continues to be narrow and shallow, with a well-defined shelf break at about 100 m, and a steep, locally rugged continental slope (Dingle, *et al.*, 1978). Southwest of East London, the shelf widens rapidly to form the Agulhas Bank, with an abrupt shelf break between 120 m and 180 m. West of Port Elizabeth the break swings west and then south, forming a concave salient towards the coast. West of Mossel Bay, the Agulhas Bank reaches a maximum width of about 260 km. In the central Bank area southeast of Cape Agulhas the Alphard Banks reach within 20 m of the surface.

The south coast is characterised by a number of half-heart or log spiral bays on the eastern side of capes formed by erosion resistant rocks such as the quartzites of the Cape Supergroup. Algoa Bay, the easternmost of these bays has two small island groups – Bird and St Croix – consisting of Table Mountain Sandstones protruding through more recent sedimentary structures.

Sediment transport both by wave-induced longshore drift and by wind on land is in an eastward direction, and spectacular by-pass dune fields have developed at the capes at Algoa Bay and St Francis Bay (Illenberger and Burkinshaw, 1996). On the other hand, at Plettenberg Bay an extensive submerged spit bar consisting of Holocene sediments is found east of the cape (Martin and Flemming, 1988). Settlements over the last century have stabilised sections of these dune fields, and have affected the sand budgets of local beaches.

I) Issues

Much of the information regarding marine and coastal geology and the bathymetry has been gained through oil and gas exploration and is thus focused on certain areas. Marine and coastal geological data is also not freely available.

II) Gaps

- High resolution bathymetric coverage is very sparse for the South Africa, or if they exist they are confidential. Side-scan sonar is also limited to a few areas of commercial and scientific interest.
- Offshore stratigraphy is developed almost entirely from the oil and gas exploration and large areas remain unexplored.
- Sediment distribution maps (Birch *et al.*, 1986) are regional in nature and detailed studies are only limited to areas covered by high resolution bathymetric, side scan sonar and sea floor sampling.
- Seismic studies are either low resolution single channel reflection studies (Dingle *et al.,* 1978, Martin *et al.,* 1982, Goodlad 1986) or high resolution low penetration single channel seismic studies concerned with shelf sediments (Martin and Flemming 1988; Sydow 1988; Ramsay 1994; Shaw 1998).
- Sea floor sediments maps are very regional in nature and only a few higher resolution areas are covered, such as the Thukela banks (Bosman 2000) and the Durban bight (Richardson 2005). The taxa and distribution of nannofossils in the area is poorly known and is now being addressed within the ACEPII sampling initiative in the Natal Bight.

Estuaries, Freshwater Resources and Drainage

The total estuarine area in South Africa is about 75 000 ha of which about 60 000 ha, or more than 80%, occurs in the ASCLME region. These estuaries fall within two biogeographical regions: the subtropical region on the east coast and the warm temperate region which extends approximately from the Mbashe River to west of Cape Agulhas (Whitfield 1992). River inflow to estuaries is determined by climatic conditions as well as the size and shape of the catchment (Reddering and Rust 1990). This river inflow to the coast as well as tidal flows are the major forces that maintain open mouth conditions in estuaries, while the major closing forces are wave energy and sediment availability from both marine and fluvial sources. In particular, presence of shallow sills at the mouths of some estuaries has resulted in an asymmetric tidal signal with shorter and stronger flood tides promoting a net influx of sediment into the estuaries.

Only about 25% of South Africa's estuaries are permanently connected to the sea (Whitfield 1992), and they normally have large catchments and relatively high runoff throughout the year. The estuarine area is normally also large enough for tidal flow to play a significant role in maintaining open mouth conditions, or otherwise the mouths are protected from high wave conditions or little sediment is available for mouth closure. The other 75% of the estuaries are not permanently open to the sea because of low river flow, high wave action and availability of sediment in the vicinity of the mouth. A sand berm then forms across the mouth during periods of low river inflow or when river inflow has stopped altogether. Such estuaries remain closed until their basins fill up and the berm is breached, either as a result of high water level in the estuary or following increased river flow. Mouth breaching may result in the removal of significant amounts of sediment, though infilling from marine and fluvial sediment can be rapid as soon as flow decreases.

In the northern summer rainfall area, the presence of the Drakensberg Mountains means that drainage areas are relatively short. Only Tugela River has the largest catchment (Davies and Day 1998). Begg (1978) carried

out an extensive review of pertinent information available on 73 of KZN's estuaries, noting that the first ecological surveys only date back to 1947. Estuaries along the Wild Coast continue these characteristics, while in the warm-temperate region with its largely bi-modal rainfall there is no substantial seasonal variation in inflow. Apart from occasional floods, the river inflows tend to be low throughout the year.

Warm temperate estuaries are characterised by high salinities and low turbidity due to low rainfall and runoff, significant seawater input and evaporative loss. On the other hand, the subtropical estuaries have lower salinities and higher turbidity due to relatively high runoff (Harrison 2004). Research studies in Eastern Cape estuaries have shown that intense haloclines can occur at neap tides when the tidal flow is not energetic enough to cause mixing through the water column. At spring tides, greater mixing causes more homogenous conditions. Estuarine temperatures follow trends that are similar to those of marine coastal waters, being generally warmer in the subtropical estuaries. There are also seasonal variations with inflowing summer river waters being warmed in the catchment areas. In upwelling regions temperatures can vary markedly as the cold upwelled water enters an estuary. For instance, in the Knysna Estuary a temperature drop of over 13˚C was registered in a period of 2 hours.

South Africa has been exploiting its water resources at a very high rate due to rapid industrialisation and a burgeoning population that has caused an increased demand for fresh water. This has altered the flow regime of many of South Africa's rivers. Estuaries are also at the receiving end of bad catchments practices, such as pollution, soil erosion, excessive water abstraction and impoundments. This is particularly evident during low flow periods (dry seasons) when the river flow entering the estuaries contain high concentrations of nutrients due to irrigation return flows as well as the water having longer residence times within the estuaries (Turpie 2004). In wet seasons increased sedimentation in South Africa's estuaries is a major concern as it compromises both the recreation potential and ecological functioning of these systems (Schumann, 2003). At present there is no information on the sediment load entering estuaries. It is however estimated that current sediment discharges into the estuaries exceed long-term averages by a factor of 12 to 30.

The sheltered nature of South African estuaries has led to them becoming the focus of coastal development (Morant and Quinn, 1999). Poorly regulated activities have destroyed many estuarine habitats by infra-structural development such as mouth stabilisation, low lying developments, canalisation, land reclamation, harbour development, pollution and dredging. Begg (1978) expressed concern that South African estuaries were being degraded by bridges and settlements in mouth areas, and increases in silt, trees and debris brought down by floods.

The most recent assessment of the health status of South African estuaries was done as part of the National Spatial Biodiversity Assessment (Turpie 2004). In terms of assessing the health of South Africa's estuaries, a comparison between the health status of 27 estuaries assessed in the 1990s (Whitfield 1995 & 2000) and more recently (Turpie 2004) showed a decline in the health of six of the 27 estuaries evaluated. Turpie (2004) did however, conclude that many of South Africa's estuaries are still in a relatively good state. Those in excellent condition comprise 28%, good condition 31%, fair condition 25% and poor condition 15%.
Tables 1 and 2 describe the types of estuaries in South Africa and their distribution.

Table 1: Different estuarine types along South Africa's coast (Whitfield 1992)

TYPE	GENERAL DESCRIPTION	TIDAL PRISM	CATCHMENT
Temporarily open/ closed (75%)	Systems range in size, but smaller than estuarine lakes; periodically closed off from the sea by a sand bar formed across the mouth. Closure is determined by river flow, high wave action and availability of sediment in the vicinity of the mouth.	Small ($<10^6$ m^3) (absent under closed conditions)	Usually small (<50 km^2)
Permanently open (18%)	Medium to large (50 - 3 600 ha), permanently open systems where tidal exchange is sufficient to keep the restricted mouth open even during periods of low river inflow. Upstream intrusion of saline water is largely controlled by river inflow, with extensive intrusion occurring during extended low flow periods.	Medium (10^6-10^7 m^3)	Medium to large (>500 km^2, but often $>10\,000$ km^2)
River mouths (4%)	Usually small to medium (e.g. 10 – 200 ha) systems that are open to the sea, although mouth closure occurs during extended periods of low river inflow. River inflow is characterised by heavy silt loads, consequently the systems are shallow (<2 m water depth). Saline intrusion seldom occurs any significant distances upstream.	Small ($<10^6$ m^3)	Large ($>10\,000$ km^2)
Estuarine bays (2%)	Large (>1 200 ha), permanently open systems with deep mouths (>3 m). This results in marked tidal variation in the middle to lower reaches, and marine dominance.	Large ($>10^7$ m^3)	Relatively small compared to their size
Estuarine lakes (3%)	Large systems (>1 200 ha) but with a restricted connection to the sea (e.g. sand bar). When cut off from the sea, the systems function as coastal lakes.	Small to negligible	Small to medium

Table 2: Distribution of estuary types in the warm temperate and subtropical biogeographical regions of South Africa (Whitfield 1992)

ESTUARINE TYPE	BIOGEOGRAPHICAL REGION	
	WARM TEMPERATE	SUBTROPICAL
Estuarine bay	1	3
Permanently open estuary	29	16
Estuarine lake	4	4
Temporarily open/closed estuary	86	94
Modified or canalised estuary	2	0
River mouth	6	4

I) Issues

Rapid industrialisation and a burgeoning population have caused a high demand for fresh water. This has altered the flow regime of many of South Africa's rivers. Estuaries are now at the receiving end of poor catchments practises, such as pollution, soil erosion, excessive water abstraction and impoundments. Poorly regulated activities have destroyed many estuarine habitats by infrastructural development such as mouth stabilisation, low lying developments, canalisation, land reclamation, harbour development, pollution and dredging (RSA DEAT 2008).

There is a decline in the health of some of the major estuaries in South Africa. However, Turpie (2004)

concluded that many of South Africa's estuaries are still in a relatively good state.

The distribution of South Africa's estuaries in terms of their health status is illustrated in Figure 2.

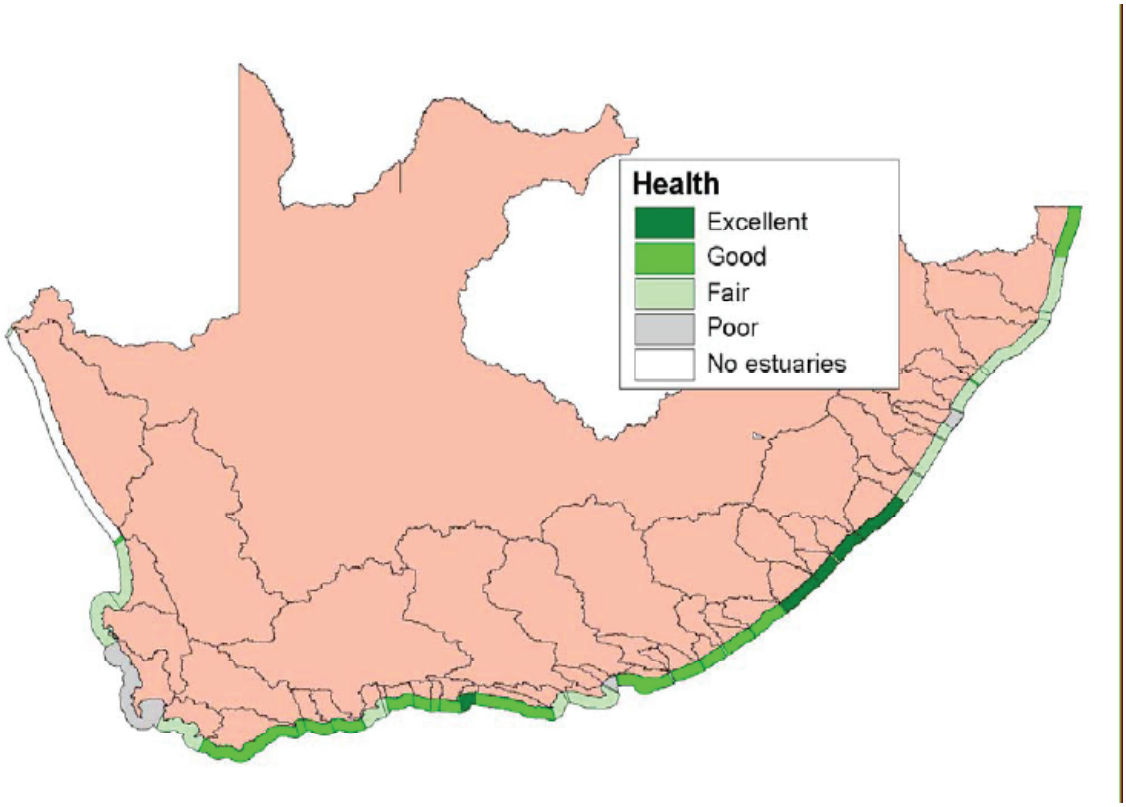


Figure 2: The health status of South African estuaries (Turpie 2004)

The deterioration in the health of estuaries located adjacent South Africa's urban areas is mostly related to overexploitation of living resources, pollution and habitat destruction. On the other hand, the deterioration in health of the more rural estuaries is mainly the result of reduction in freshwater inflow, although pollution from agricultural activities cannot be excluded. In future, impacts on estuaries are likely to be particularly severe in the south and Western Cape, where demands on freshwater supplies are immense. Similarly along the KZN coast the impacts of development and the demand for water are going to place the estuaries under great pressure (Turpie 2004).

The degradation of intertidal estuarine habitats that are particularly important for over-wintering Palaearctic migrant bird species is a matter of concern. Should these habitats be severely degraded or destroyed, a drastic reduction in the numbers and even extinction of these bird species could occur. In the longer term, sea level rise as a consequence of global warming could result in the loss of many intertidal and estuarine habitats which are important bird habitats (Clark *et al.*, 2002).

The South Africa Outlook 2006 (DEAT 2006) reported that there is little information on the status of estuarine species. This is considered to be a serious gap in the overall conservation database. Because of habitat degradation and increasing human pressures, four fish species occurring in South African estuaries are listed on the IUCN Red Data List as critically endangered. These include Knysna seahorse (*Hippocampus capensis*), St Lucia mullet (*Liza luciae*), and estuarine pipefish (*Syngnathus watermeyeri*).

Sand-mining in estuaries is causing direct impacts resulting in loss of aesthetic value and ecosystem degradation. It also causes secondary threats to the long-term sustainability of the coastal sand resource and stability, especially in view of large scale coastal erosion that is occurring along the Kwazulu Natal (KZN) coast. A recent inventory of the sand-mining operations in KZN estuaries from the Thukela to the Mtamvuna estuaries showed that 18 out of 64 systems along this coastline supported sand-winning operations (WESSA-KZN 2007). These activities modify flows, produce high suspended solids loading and destroy riparian and instream habitat.

The fragmentation of estuarine management among the different national, provincial and local-government agencies has complicated efforts geared towards conservation and protection of estuaries as critical habitats in South Africa.

Many Universities, Science Councils and environmental consultants have physical, chemical and biological data on South Africa's estuaries. These data have been collected as part of research projects or commercial contracts. Some institutions have also established their own databases, while in some cases, individual researchers keep their data. There is a need for establishment of a comprehensive estuarine database system in South Africa. Initial attempts in this regard, are being made by SAEON.

II) Gaps

South Africa has been exploiting its water resources at a very rapid scale. Many catchments are classified as water stressed in the sense that entire river flow volume has been allocated to various uses. At present there are no recent data on the reduction in fresh water flow to the coast. The last inventory was done in 1986. Freshwater flows are gauged in less that 10 % of the rivers flowing into estuaries. About 120 Wild Coast river systems are especially poorly monitored. It is critical that a network of river gauging stations be established. It is also recommended that the network of water quality monitoring stations be extended to include more sites in the lower reaches of rivers bordering the estuaries.

Increased sedimentation in South Africa's estuaries is a major concern as it is compromising the recreation potential and ecological functioning of these systems. At present there is no data and information on the sediment load in most of the estuaries. In the 1970s such data was regularly collected by the Department of Water Affairs (DWA). However, DWA have since suspended this monitoring programme. Land-use change in the river basins has significantly increased and as a result it is thought that sediment load to estuaries and the coast has also increased markedly in the recent past. This, however, needs to be verified by empirical research. It is also recommended that the Department of Environmental Affairs (DEA) re-institutes the collection of bathymetry data in selected estuaries around the country to monitor the *in situ* accretion/erosion rates. This monitoring programme ran for 13 years (1986 to 1999) on 43 systems but was terminated in 1999.

A crucial and relatively inexpensive method of monitoring changes in estuaries is the use of aerial photography and remote-sensing. Aerial photographs and remote-sensing images have proven to be invaluable in establishing trends and processes in estuaries. It is therefore strongly recommended that an aerial photography and remote-sensing monitoring programme be established on a national scale. Estuarine surveys should be carried out at an interval of five years.

Significant volumes of wastewater including sewage and industrial effluents (e.g. fish processing plants) are being discharged into South Africa's estuaries. In 2004, DWA adopted the *Operational Policy for Disposal of Land-Derived Water Containing Waste to the Marine Environment of South Africa* in July 2004 (DWAF 2004). Although not legally enforceable at this stage, this policy articulates the Department's *modus operandi* for wastewater discharges to the marine environment. The policy recognises estuaries as sensitive ecosystems where wastewater discharges will not be considered except in exceptional circumstances (e.g. where inflows are required to improve or maintain the resource quality objectives or where the ecological functioning has been irreversibly modified). Effective implementation of this policy however, is still lacking. Also, there has been no large-scale assessment of the impact of existing wastewater discharges on estuarine ecosystem.

In terms of estuarine biota, there has been no systematic data collection programme since the 1980s (birds) and 1990s (fish). It is recommended that a national monitoring programme be re-instituted so as to allow for systematic collection of data on estuarine vegetation, invertebrates, fish and birds. There is currently no systematic monitoring programme of the living resource exploitation in South African estuaries. It is therefore of the utmost importance that funds be made available so that the National Line Fish Survey (last done in 1996) is restarted and expanded to estuaries.

Further, there is very limited understanding of the impact of climate change on the estuaries of South Africa. There is an urgent need for a dedicated programme focussing on both (physical and biological parameters) to quantify the risk and vulnerabilities that estuaries face and to provide insights into possible mitigation

strategies.

Physical Oceanography

Currents

The Agulhas Current system forms the western section of the South Indian Ocean gyre, transporting warm tropical and sub-tropical water southwards along the southern section of the Eastern African coast. As such, the confluence of waters originating in the Mozambique Channel and from east of Madagascar is generally well established by the time it reaches the northern border of South Africa (Lutjeharms, 2006a,b). As one of the largest western boundary currents, the Agulhas takes the form of a well-defined jet. This jet is about 100 km wide and more than 1000 m deep. Maximum speeds of more than 2.5 m/s occur in the southern section of the current and the volume transport is estimated to be 70 x 10^6 m^3/s. The narrow shelf north of Richards Bay means that the Agulhas Current also flows close to the coast. However, in the Natal Bight the Current lies farther offshore. Lutjeharms *et al.*, (1988a,b) and Lutjeharms *et al.*, (2000a) have described an upwelling cell in the lee of Cape St Lucia, supported by earlier evidence from Carter and Schleyer (1988).

The gentle shelf slope on the southern boundary of the Tugela cone off Durban results in a predominantly northwards current flow off Durban. Further south at the KZN border, the Agulhas Current again flows close inshore at the shelf break, resulting in an onshore flow farther north as part of the recirculation cell off Durban. Farther south the coastal offset caused by the Egosa Fault is also responsible for a small lee eddy.

The continental shelf widens southwest of East London to form the Agulhas Bank, and cold upwelled water is often visible on the inshore shelf, probably forced by the same mechanisms as the Natal Bight upwelling. Lutjeharms *et al.*, (2000b) have suggested the existence of an 'upwelling cell' at Port Alfred south of East London, but it is likely that this just forms part of processes whose effects increase farther south to Algoa Bay. The upwelling is often observed north of Mbashe, and Beckley and van Ballegooyen *et al.*, (1994) show sections of such upwelling at both East London and Port Alfred. The Agulhas Current demonstrates great lateral stability in this section to Algoa Bay, though small-scale meanders are a regular feature of the inshore boundary. Lutjeharms *et al.*, (1989b) and Goschen and Schumann (1990) used SST satellite imagery to establish that at East London and upstream of Port Elizabeth, the Current's inshore boundary does not vary by more than 15 to 20 km offshore for 90% of observations.

On the other hand, Lutjeharms (1981) described large meanders which moved the core of the Current more than 150 km offshore. These large meanders occurred two or three times per year, and are dubbed *Natal Pulses* because of their apparent origin off the province of Natal, now KwaZulu Natal. These Natal Pulses propagate downstream with a phase speed of around 20 km/day. Lutjeharms *et al.*, (2000) have shown that the water within the cyclonic eddy is transported with the Pulse. The Natal Pulses may be triggered by mid-ocean eddies in the southwest Indian Ocean impinging on the northern Agulhas Current, abetted by the morphology of the Natal Bight. Off Algoa Bay the shelf edge is more than 50 km offshore and correspondingly the Agulhas Current is also forced farther offshore. The variability and size of the meanders, with attached plumes increase considerably.

Further west, the main flow of the Agulhas Current turns southward in the concave salient, and models indicate that the main shear edge eddy remains trapped (Lutjeharms *et al.*, 2003), but leakages may trigger detachment of a cyclonic lee eddy at the tip of the Agulhas Bank. Boyd *et al.*, (1985, 1994) have measured northeastward current speeds between 30 and 60 cm/s in the plume, while in the main Current south to southwestward flows of up to 2.5 m/s were found.

Schumann and Beekman (1984) have shown that intense thermoclines develop over the Agulhas Bank in summer, while more isothermal conditions exist in winter with strong westerly winds and seasonal radiation losses. Swart and Largier (1987) postulated the existence of a cool ridge of upwelled water extending over the midshelf regions in a northeast-southwest line inshore of the Agulhas Current, possibly associated with a cyclonic eddy. This feature was also observed by Boyd and Shillington (1994). Walker (1990) described a

situation where the Agulhas Current played a dominant role in the surface warming of southeast Atlantic waters while large scale upwelling occurred on the Bank.

Along the south coast preferential upwelling occurs regularly at the prominent capes with easterly winds. At Cape Recife (Algoa Bay) Goschen and Schumann (1998) found that such cold upwelled water is taken into the Bay by a subsequent westerly wind. Such coastal upwelling and its associated currents is important for larval dispersal processes. In winter the coastal currents oscillate with the varying winds while in summer the upwelling events can transport larvae westwards and offshore, being returned to the coast with subsequent downwelling conditions. Roberts and van den Berg (2005) found that on the Tsitsikamma coast east of Plettenberg Bay the coastal currents were predominantly eastwards, with baroclinic conditions in summer. Schumann (1999) found that wind variability occurred on time scales from 2 to 6 days, and that upwelling events responded rapidly but were consequently of short duration. When the main flow of the Agulhas Current has passed the Agulhas Bank it undergoes a dramatic change in direction, the *Retroflection* (Lutjeharms and van Ballegooyen, 1988). In this process it turns back on itself into the South Indian Ocean as the Agulhas Return Current. This causes a major and important transfer of water from the Indian to the Atlantic Oceans, both through plumes of surface water drifting into the cold Benguela system (Lutjeharms and Cooper, 1996), and through a process of ring shedding at the retroflection.

The retroflection area has some of the most energetic meso-scale eddy kinetic energy in the ocean with the most consistent easterly position at about 20°E; the westernmost position is probably around 10 to 15°E, but is difficult to identify because surface cooling destroys the surface temperature expression. It has been estimated that an Agulhas Current ring is shed into the south-eastern Atlantic Ocean about once every two months (Lutjeharms, 1996).

The eastward flow of Agulhas water is usually called the Agulhas Return Current (Lutjeharms, 2006) up to more or less the Kerguelen Plateau, at 70°E; beyond this point it is known as the South Indian Ocean Current. The Agulhas Return Current lies at about 40°S and mostly directly adjacent to the Subtropical Convergence, though at times it lies slightly to the north, forming a secondary front, the Agulhas Front. It meanders strongly in specific places where it crosses prominent bottom features such as the Agulhas Plateau, indicating that the current extends to depths exceeding 4000 m; this meandering was demonstrated graphically by a satellite-tracked buoy.

Vertical hydrographic sections through the Agulhas Return Current water near the retroflection show little difference to those of the Agulhas Current, but as it progresses eastward its surface waters lose heat to the extent that it is difficult to detect with satellite thermal images; it also mixes with ambient waters and therefore exhibits a downstream change in its general temperature-salinity characteristics. Surface current speeds decrease to well below 1 m/s.

I) Issues

Current measurements within the Agulhas current are extremely hard to take, given the strength of the current. Ships time is expensive to perform routine monitoring and fixed buoys have a tendency to break away from their moorings. Currently Dr Mike Roberts of Oceans and Coasts DEA is developing a bouy which is able to withstand the extreme currents. Assoc. Prof Lisa Beale of the University of Miami, also has bouys in place in the Agulhas Current to measure the volume transport. These are very new projects and much more work needs to be done.

Numerical modeling of the Agulhas Current remains very difficult given the dynamics involved. Again work is being done in South Africa and internationally to improve this.

Satellite imagery above the Current is often limited due to the cloud formation and close to the coast, the information is not reliable.

It is difficult to use drifters, such as Argo floats, or gliders, given the strength of the Current.

II) Gaps

As highlighted above, there are limited data collected within the Agulhas Current system. These need to be addressed by use of new oceanographic and remote-sensing technologies. There is an increased interest regionally and internationally in this area.

Key gaps existing in the understanding of the source regions of the Agulhas Current, seasonal through to interannual variability, number, duration and impact of perturbations within the Current (such as Natal pulses), how to define and measure the leakage into the South Atlantic, etc. Since the formation of the SCOR working group 136 on the Climatic Importance on the Greater Agulhas Current, as well as numerous papers in Nature, there has been an increased thrust towards better understanding of the role of the Agulhas in both regional systems as well as its global impact.

Tides and Extreme Water Levels

Tides around South Africa are dominated by the semi-diurnal tide with a period of 12.42 hours. However, the diurnal tide (23.93 hours) is also significant. Tidal ranges in spring tide are 1.8 m, which categorizes these tides as micro-tidal. However, tidal ranges at times can be over 2 m, which would classify them as meso-tidal (Searson and Brundrit, 1995). The neap tide range varies between about 0.4 m and 0.5 m. The timing of the tide around the coast is almost coincident, with spring high tide occurring at all west coast stations within eight minutes and all the south and east coast stations occurring some thirty minutes later. This means that tidal currents move essentially on and off shore and, except for narrow coastal inlets, are small.

The South African Navy Hydrographic Office maintains a tide gauge network consisting of ten stations (Port Nolloth, Saldanha, Granger Bay/Cape Town, Simon's Bay, Mossel Bay, Knysna, Port Elizabeth, East London, Durban and Richard's Bay) around the coast of South Africa, and two stations (Walvis Bay and Lüderitz) in Namibia. The CSIR maintains a network of wave recorders on behalf of Transnet (http://wavenet.csir.co.za) at seven offshore locations (Saldanha Bay, Cape Point, Mossel Bay, the MossGas Platform, East London, Durban and Richard's Bay) around the coast of South Africa. These observations are used to provide virtual buoys at Table Bay and Port Elizabeth. Sea level observations are archived at ten minute intervals and used for the construction of tide tables at these stations (South African Annual Tide Tables).

Wind-driven storm surges are associated with passing weather systems and the actual sea level experienced can differ from the predicted tide by up to almost a metre, especially on the south coast (Searson and Brundrit 1995). The offshore significant wave heights are also higher off the south coast, exceeding 8m on an annual basis (Rossouw 1989).

Cuevas *et al*., (1986) described long period changes in sea level – of the order of days –propagating in an anti-clockwise manner around the South African coast. These events are coastal trapped waves with large-amplitudes (> 50 cm) due to a situation of near resonance with atmospheric coastal lows (Gill, 1977). Current reversals can be attributed to the passage of such waves, as well as occurrences of extreme sea levels (Searson and Brundrit 1995), and sea level rise around the coast of South Africa (Brundrit 1995; Mather *et al.,* 2009). The coastal trapped waves do not appear to progress to Durban, possibly because the atmospheric system outran the oceanic response (Jury *et al*., 1990), or because of damping in the Agulhas Current (Brink, 1990). At short periods – between 12 minutes and 1 hour – Shillington (1984) described coastally-trapped edge waves generated by atmospheric pulsing. These waves also propagated around the coast with amplitudes up to 60 cm.

The South African coastline is generally subject to moderate (1-2 m) to strong (2-3 m) wave action, with peak roughness diminishing northwards and eastwards (DEAT 2007/8). Local winds with a short fetch generates waves with typical periods of around 8 seconds, while waves originating in the Southern Ocean can have periods as long as 22 seconds. These waves are modified by bottom bathymetry as they approach the coastline, and in shallower water are also responsible for moving between one and two million tonnes of sediment annually in an overall northwards drift along the coast (Lombard *et al*., 2004). Coastal developments such as harbours have impeded this sediment movement, forming new beaches upstream and causing erosion downstream, which then require expensive corrective measures.

Surface gravity waves are also modified by ocean currents, and the Agulhas Current has become notorious for the occurrence of giant waves which causes extensive damage to shipping on the South African east coast. Waves from the southwest are focused into the Current, resulting in increases in wave height, a decrease in wavelength and a consequent sharp increase in wave steepness.

The observations from Walvis Bay, Simon's Bay, Port Elizabeth and Durban are supported by the sea level recorder maintained by the National Research Foundation at Marion Island in the South Indian Ocean. These contribute to the Tsunami Sea Level Station Monitoring Facility (www.sealevelstation.net).

I) Issues

Climate change is accelerating the present modest rates of sea level rise in South Africa. It is also leading to the intensification of storms approaching the coasts. These two effects of climate change will combine in the future leading to more frequent and intense extreme sea level events along the coast, with increased possibility of coastal erosion and flooding (Theron 2007). Natural coastal systems will be under threat. Sand dune systems will be eroded and wetlands will be overwhelmed. Recent storms that resulted in the loss of coastal property and protective dunes along the south and east coast have highlighted the risks associated with climate change.

As more and more people migrate into urban centres along the coast, there is increasing pressure for the housing, infrastructure and services. Where these are located in what will become high risk areas, there will be increased economic vulnerability for the community. Proper recognition of these concerns needs to be taken into consideration in coastal zone planning.

II) Gaps

A detailed coastal vulnerability atlas for South Africa is urgently required, so that proper risk assessments can be instituted in specific localities along the coast. This atlas should provide information relevant to climate change. It should also adopt the format of the African Marine Atlas (www.africanmarineatlas.net) and the recently produced Risk and Vulnerability Atlas (www.rava.qsens.net)

Surface waves are routinely observed on wave recording buoys located in offshore stations. These provides valuable wave data and allows for wave predictions in deep waters. As such waves travel towards the coast, their characteristics evolve in both height and directions. Such information is required for establishing surf zone characteristics and inshore coastal processes. Operational wave modelling can simulate such virtual buoys. However, this is only possible in harbours in Cape Town and Port Elizabeth.

Tsunamis crossing the Indian Ocean from the tectonically active plate boundaries along the Indonesian island of Sumatra have demonstrated their destructive power in the last decade (Merrifield *et al.*, 2005). Measurements in two recent tsunami events demonstrated that the tsunami reached its maximum amplitude in the entire Western Indian Ocean at Port Elizabeth. An assessment of the vulnerability of the south and east coasts of South Africa to attack by tsunamis is urgently needed.

Sea level change

A recent assessment of sea level rise for South Africa is contained in Goschen *et al.*, (2009). Limited historical sea level rise research has been conducted in South Africa, using the records from the tide gauge network maintained by the South African Navy Hydrographic Office. This network consists of ten stations and the records are of variable quality. A study on monthly variability in mean sea level by Brundrit (1995) revealed the long-term interannual structure for the west coast of southern Africa. A later comprehensive analysis of the Southern African sea level record was undertaken by Mather *et al.,* (2009). The results show that in general, sea level is rising around the South African coast in agreement with current global trends. However, there are significant regional differences in the rate of sea level rise. The west coast of South Africa is rising by +1.87 $mm.yr^{-1}$, the south coast by +1.47 $mm.yr^{-1}$ and the east coast by +2.74 $mm.yr^{-1}$. These differences are attributed to the differences in vertical crust movements between the east and west coasts of South Africa, and the different oceanographic processes around the coasts.

I) Issues

Climate change is expected to lead to acceleration in the present modest rates of sea level rise in South Africa. In fact, it has been found that sea level has been rising at different rates in the last 20,000 years. However, anthropogenic influences since the end of the 18th century are causing accelerated sea level rise. The rate of global sea level rise has doubled in the past fifteen years, though it remains modest. There is general agreement that the primary role played by the melting glaciers and ice sheets (47%) as opposed to thermal expansion due to increasing heat content (25%), will be enhanced in the future. Of concern is that polar ice sheets contain large amounts of water which if released will contribute substantially to global sea level (7m from the Greenland ice sheet and 5m from the West Antarctic ice sheet). How these changes are going to impact the South African coast are unknown as the rate of sea level rise varies from place to place and there is a lack of serious analysis of existing sea level data. As highlighted below, there are large gaps in data and the data which is present contain a good deal of noise. Currently in South Africa, there is limited capacity on sea level data analysis.

Coastal environments and habitats are vulnerable to sea level rise. Efforts are needed to identify the most vulnerable localities and to forecast the effect of sea level rise. Low lying coastal areas are particularly vulnerable. Soft coasts will be eroded and wetlands flooded, while urban infrastructure and services will be at risk. Coastal defences will need to be strengthened and planning measures put in place in order to discourage migration and investment in high risk areas. In South Africa, the cost of adapting to sea level rise may exert more pressures on economic growth.

II) Gaps

There are no accepted reliable forecasts of future rates of sea level rise in South Africa, although currently various proposals are attempting to address this gap. An index was derived by Hughes and Brundrit (1992) to assess South Africa's vulnerability to sea level rise using variables that identified risk in the relief, rock types, landform, vertical movement of land, shoreline displacement, tidal range and wave height to identify high- and low-risk locations. They identified the Garden Route and low lying areas in the coastal cities as being particularly at risk, and concluded that the greatest hazards in the immediate future were from extreme storm and flood events. They also noted that the most vulnerable coastal infrastructure was that of private housing, which suggests that damage costs would be borne by individuals and not by the nation as a whole. A re-assessment of coastal vulnerability is urgently needed so that proper risk assessments can be instituted in specific localities along the coast where extensive development has taken place despite intensification of storm damage.

Temperature and Salinity Patterns

Characteristics of South Africa's ASCLME region

The hydrographic characteristics of the ASCLME component located off the South African east and south coasts are dominated by the Agulhas Current system and the conditions on the adjacent southern African continental shelf (Figure 3).

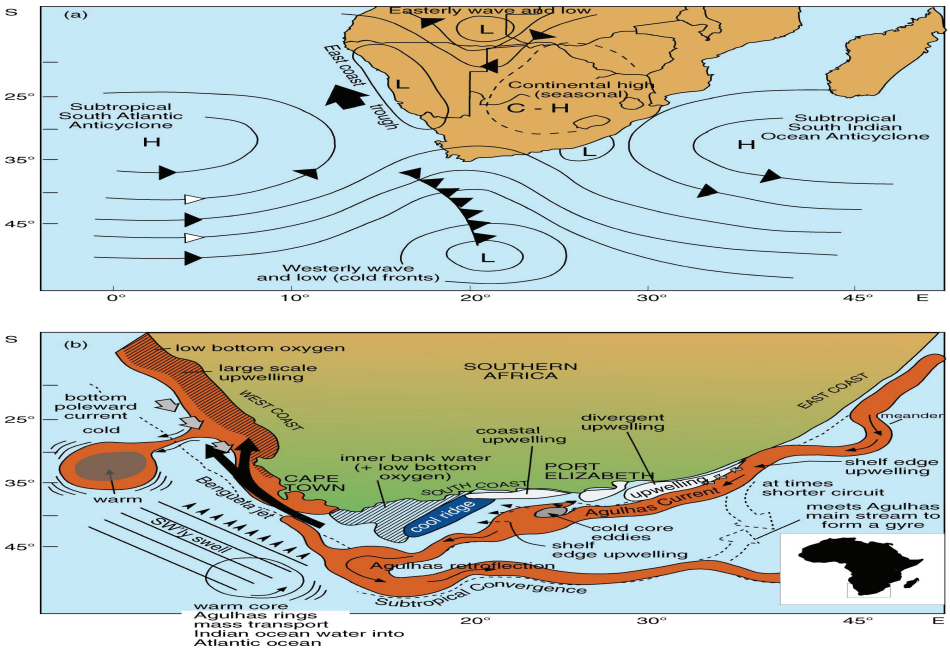


Figure 3: Physical processes on the Agulhas Bank (from Mike Roberts.ppt., BCLME Southern Boundary Workshop Report, May 2006)

The temperature and salinity properties of the Agulhas Current system are similar to a large degree to those of the 14 different water types found in the wider South Indian Ocean, of which the following are the most important:

Surface and central water	Tropical Indian Surface water South Indian Subtropical Surface Water Tropical Thermocline Water South Indian Central Water Subantarctic Mode Water
Intermediate water	Red Sea Water Antarctic Intermediate Water
Deep water	North Atlantic Deep Water Indian Deep Water
Bottom water	Antarctic Bottom Water

Northern Agulhas Current Regime

This part of the Agulhas Current system stretches from approximately the southern mouth of the Mozambique Channel (~ 28°S) to the eastern edge of the Agulhas Bank at Port Alfred. Ocean surface temperatures at the northern end range between 28°C in February and 23°C in July. At the southern end, they range between 25°C in January and 21°C in August (Christensen 1980; Lutjeharms 2006a). Salinities at the surface are on average 35.3 PSU along and over the shelf and up to 35.5 PSU in the northern part of the current itself. Surface waters of the northern Agulhas Current consist of a mixture of Tropical and Subtropical surface waters (salinities < 35.0 and > 35.5 PSU). The purer Subtropical Surface Water is responsible for a salinity maximum at 150-200 m depth (Lutjeharms 2006b). Subsurface water masses consists of South Indian Intermediate Water (4-6°C, salinity < 35.6 PSU), Red Sea Water (salinity > 34.7 PSU and very low dissolved oxygen values), North Atlantic

Deep Water and Antarctic bottom Water. In general temperature-salinity of subsurface waters in the northern Agulhas Current changes little from north to south.

Southern Agulhas Current Regime

Surface temperatures on the western Agulhas Bank range between 15.9°C in August and 21.2°C in February; on the eastern bank the range is 17.0-21.6°C with a slight tendency to increase eastwards. Bottom temperatures on the inner western bank range between 9-16°C and on the outer bank 7-10°C (Roberts 2005). On the eastern bank, bottom temperatures range from > 16°C inshore to 9-10°C on the outer bank. Perhaps the most prominent and important surface features on the Agulhas Bank is the Port Alfred upwelling cell on the far eastern side, and the cold ridge over the central part of the Bank. The upwelled water is South Indian Central water from depths greater than 400 m (Goschen and Schumann 1988). Cold water on the surface is on average about 30 km wide and may stretch 180 km along the edge of the current while water colder than 10°C spreads westward over the bottom of the Agulhas Bank, contributing to the intense stratification observed in the interior of the bank during the summer (Lutjeharms 2006b). Coastal upwelling is also common during the summer at the major headlands, Cape Recife, Cape St Francis, Plettenberg Bay, Cape Agulhas and Cape Point. The upwelling is particularly extensive and intensive between Tsitsikamma and Knysna, resulting in plumes of cold water (11-15°C) that extend 10-40 km offshore (Figure 4). Associated with upwelling in this location is an oceanographic feature known as the cool water ridge that was first described by Swart and Largier in 1987. Various possible mechanisms for the forcing of the feature have been given, but its formation is now believed to be controlled by a combination of easterly winds, which cause upwelling, and westward flow, which extends the plume or filament of cool upwelled water.

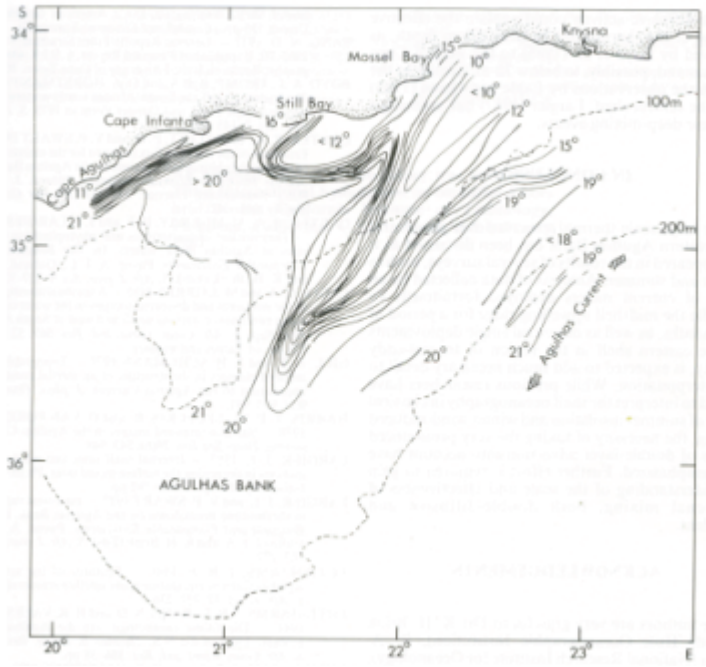


Figure 4: Thermal structure on the Agulhas Bank showing the cold ridge feature (after Swart and Largier 1987)

The Agulhas Current Retroflection

The point where the Agulhas Current bends back on itself to flow eastward along the Subtropical Convergence as the Agulhas Return Current is known as the 'retroflection'. The retroflection is located directly north of the Subtropical Convergence (~ 40°S) between 9° 40' E and 20° 30' E (Lutjeharms and van Ballegooyen 1988). The thermal and salinity characteristics of the most important water masses found in the Agulhas retroflection and immediate vicinity can be summarised as follows (Valentine *et al.*, 1993).

Water type	Temperature	Salinity
Surface water	16.0-26.0°C	> 35.5 PSU
Central Water South East Atlantic Ocean South West Indian Ocean	 6.0-16.0°C 8.0-15.0 °C	 34.5-35.5 PSU 34.6-35.5 PSU
Antarctic Intermediate Water South East Atlantic	2.2°C 2.0-6.0 °C	33.87 PSU 33.8-34.8 PSU
Deep Water North Atlantic Deep Water (South-east Atlantic) Circumpolar Deep Water (South-west Indian)	 1.5-4.0°C 0.1-2.0°C	 34.8-35.0 PSU 34.63-34.73 PSU
Antarctic Bottom Water	-0.9-1.7°C	34.64-34.72 PSU

The Agulhas Return Current

Vertical hydrographic sections through the Agulhas Return Current water near the retroflection show little difference to those of the Agulhas Current, but as it progresses eastward its surface waters lose heat to the extent that it is difficult to detect with satellite thermal images. It also mixes with ambient waters and therefore exhibits a downstream change in its general temperature-salinity characteristics. The characteristic oxygen minimum of the Agulhas Current proper is still seen in the Agulhas Return Current near the retroflection, but is usually not distinguishable far down its trajectory

ISSUES

The oceanographic studies focussed on the measurements of temperature and salinity are sparse, difficult to obtain and expensive. Although this can, in part be done through remote sensing, this only provides details of the surface waters and is often obscured by clouds.

GAPS

There is a lack of regular monitoring of temperature and salinity. Most information is from occasional offshore oceanographic or fisheries research related cruises.

Ocean-Atmosphere Interactions

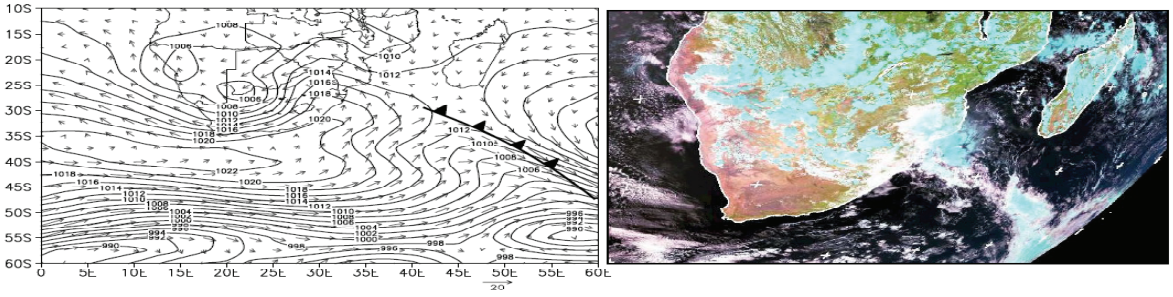
South Africa lies within the subtropical zone, which is dominated by higher pressures in the lower atmosphere, with subsiding air resulting in stable conditions. The climate is mostly arid, but rainfall can occur regionally and seasonally when conditions are favourable. Atmospheric circulation patterns causing rainfall over South Africa are anomalies from the dry subtropical circulation, and are predominantly driven by interaction between the synoptic circulation and surface topographic and thermal forcing (Hewitson *et al.*, 2008).

There is a significant contrast between the cold waters of the Benguela Upwelling System on the west coast, (Hutchings *et al.*, 2009), and the warm waters of the Agulhas Current on the south-east coast (Lutjeharms. 2006). Interactions between the mid-latitude synoptic circulation (cold fronts) over the ocean and warm atmospheric conditions over the eastern parts of the continent are linked in tropical-temperate troughs, which are an important cause of summer rainfall.

Hunter (1988) indicated that the Agulhas current assumes a major role in the local atmospheric forcing. Being

a warm-cored water mass, it drives evaporation into the atmosphere though heat exchange. Warm sea-surface temperatures over the Agulhas increase the likelihood of rainfall over the southern parts of Africa, more especially the eastern most parts. Both the position of the Atlantic and Indian Ocean high pressure cells are critical for advection of moisture inland, as they ridge either behind the progressing cold front or migrating in a north-south orientation, respectively. Regional anomalies in sea surface temperature can be a predictive measure of rainfall over the south-eastern sub continent, as higher and longer persistence of warm water may extend the intensity and duration of rainfall, (Walker 1990; Fauchereau *et al.,* 2003).

Figure 5 shows summer rainfall over South Africa is often caused by continental atmospheric pressure disturbances in the normally dry subtropics. Higher continental radiation allows for the formation of low pressure regions (cyclones), which draw moist air from the northern tropics (as shown by wind vectors, left and clouds, right). Cold fronts, followed by anticyclones (high pressure) allow for onshore air flows and rainfall over the southern and eastern coastline and interior.



During summer months higher continental radiation allows for the formation of low pressure regions (cyclones or troughs) which draw moist air from the northern tropics (see lower pressures over the west of the continent with wind vectors (left) and clouds on the satellite image (right)). Cold fronts followed by higher surface pressures (anticyclones or ridges) allow for onshore flow of air, with rainfall over the southern and eastern coastline and adjacent interior (see higher pressure to the south of the continent). Synoptic map (left) of Sea Level Pressure (SLP) in hPa (contours) and wind vectors on the 850 hPa pressure level for 17 January 2008, 12:00 UTC, as obtained from NCEP/NCAR reanalysis data (http://www.cdc.noaa.gov/cdc/reanalysis/reanalysis.shtml) (left), and a visible Meteosat SEVIRI image (University of Dundee: www.sat.dundee.ac.uk) of the same date and time (right).

Figure 5: Synoptic map (left) of Sea Level Pressure in hPa (contours) and wind vectors on the 850 hPa pressure level; visible Meteosat SEVIRI image (right), both images for 17 January 2008 (taken from Hewitson and Rautenbach 2008)

I) Issues

Climate change is expected to lead to a shift in the timing and intensity of synoptic weather systems. This may have a profound effect on the regional winds and the distribution of rainfall over the continent. This has considerable impact on rain-fed agriculture.

Wind strength and persistence are fundamental drivers of the dynamics of both the Benguela Upwelling System and the Agulhas Current and their biogeochemistry. Over the recent past, stronger upwelling favourable winds have led to enhanced productivity in the Benguela Current Ecosystem, with greater nutrient enrichment, but this in turn has led to a greater volume of low oxygen subsurface water.

There has also been a warming of the Agulhas Retroflection area to the south of South Africa, possibly due to a poleward migration of the oceanic westerly winds with an increase of the leakage of Indian Ocean waters into the South Atlantic and beyond (Biastoch *et al.,* 2009). This will have potential consequences on the global thermohaline overturning circulation.

II) Gaps

Observations of ocean-atmosphere interactions have been made as part of short term projects, with few measurements being made on a routine basis. The advent of operational oceanography will allow for the collection of an integrated set of observations on a routine basis, with the measurements being disseminated to the marine community through regular state of the marine environment reports.

Only now are the processes of ocean atmosphere interaction being investigated in ocean models, with the detail of regional variability incorporated. A concerted effort is needed to move towards downscaling from global to regional to local models, with the eventual objective of developing operational real-time predictive models,

utilising observations from operational oceanography.

The above will enable studies of local features along both the west and south-east coasts of South Africa. An example would be an investigation of locally driven upwelling cells along the south and east coasts of South Africa where the dynamic forcing behind their formation is still not clearly studied, although Roberts (2005) believes they are a function of local winds.

Chemical and Biological Oceanography

Nutrients

Nutrients were measured on a routine basis by the CSIR on cruises of the RV *Meiring Naudé* off KZN from 1970 until the ship was sold in 1989. These results were synthesized by Carter and d'Aubrey (1988). In the offshore area to 200 m depth, off Richards Bay they found sporadic, short-lived upwelling with a positive nutrient gradient with depth. Off Durban, upwelling was also evident in the semi-permanent cyclonic eddy while off Port Edward higher nutrient values were found in the bottom Ekman layer. More recently, Meyer *et al.,* (2002) found that the main source of nutrients on the Natal Bight is the St. Lucia upwelling cell. They further surmised that nutrient-rich water is transported southwards and the eddy off Durban weakly upwells nutrients in its core. Primary productivity is sustained along the shelf edge by this upwelling of nutrient whereas the southward flow of nutrients is affected by considerable mixing.Off Algoa Bay, the current-induced upwelling bring nutrient-rich waters to the shelf basal layers.

With regard to the south coast of South Africa, historic nutrient data for the period 1925-1985 were retrieved from the South African Data Center for Oceanography and reported by Lutjeharms *et al.,* (1996). The distribution of nutrients shows strong regional and seasonal differences over the Agulhas Bank, which is orientated approximately south of South Africa. The Agulhas Bank covers an extensive continental shelf area extending from Cape Point (18°E) to East London (28°E). The Bank may be divided into western, central and eastern sectors, each characterized by different hydrological conditions (Probyn *et al.*, 1994). The phosphate and silicate concentrations as described by Lutjeharms *et al.,* (1996) were found to be higher in the western Bank than in the eastern Bank. These differences in the distribution of nutrients between the western and eastern Bank can be partially associated with different processes and bottom topography between the two regions. The western Bank is characterized by a persistent coastal upwelling of cold bottom water which elevates the levels of nutrients in the water column and at the surface (Boyd *et al.,* 1985). The distribution of nitrate, silicate and phosphate in the eastern Bank varies at depth 50, 75 and 100m between 1 and 20µmol.l^{-1}, 0.4 and 2µmol.l^{-1} and 1 and 20µmol.l^{-1} respectively, whereas the western Bank revealed high nutrient concentration.

Seasonal variation over the Agulhas Bank occurs with nutrient concentrations in the surface layers during summer ranging between 0.1 and 1.3µmol.l^{-1} for nitrate, 0.18 and 0.46µmol.l^{-1} for phosphate and between 0.8 and 1.9 for silicate. During winter, nutrient concentration ranged between 2.4 and 6.5µmol.l^{-1} for nitrate, between 0.5 and 1.18µmol.l^{-1} for phosphate, and between 2.2 and 8.8µmol.l^{-1} for silicate.

I) Issues

Nutrient samples are collected at each standard depth during the Pelagic pre-recruitment survey in March, April-May South Coast Hake Biomass, May-June Pelagic recruitment and October-November Pelagic Spawner Biomass. The data covers the area between Hondeklip Bay and Port St. Johns. However, nutrient concentrations measured in the water column are of limited use, as they only reflect levels at the time of sampling. The dynamics of nutrient uptake or release are infrequently studied, yet much nitrate is taken up in the thermocline region of the Agulhas Bank, at rates commensurate with the diffusion of nutrients across the thermal gradient. This supports sustained phytoplankton productivity over summer with no measurable change in nutrients above and below the thermocline. Changes in nutrient concentrations in source waters for upwelling may be occurring but few measurements are available in ocean areas away from the coast.

II) Gaps

No nutrient data are available between 1999 to mid 2001. Nutrient samples collected during this period were found to be attacked by bacteria because they were stored for too long before they were analyzed.

Persistent organic pollutants

During the 1970s and 1980s, there was a strong research focus on persistent organic and inorganic pollutants in South African coastal waters (O'Donoghue and Marshall 2003). This research was performed within a well-funded and coordinated national marine pollution research programme managed by the CSIR. The predominant focus of the chemistry component of the programme was on contaminant accumulation in sediment and biological tissue, with the initial focus mainly on metals and subsequently also on chlorinated hydrocarbons (e.g. DDT, PCBs). These studies provided evidence that metal contamination of sediment was most pronounced in the vicinities of coastal cities, and the remainder of the coastline was unpolluted (e.g. Hennig 1985). A similar trend was evident for metal accumulation in biological tissue. There was little evidence that chlorinated hydrocarbons have accumulated in sediment to a significant degree, although relatively high concentrations were measured in the tissue of dolphins from the east coast (e.g. Cockcroft *et al.,* 1988).

Persistent organic and inorganic pollution of offshore South African coastal waters is not significant, at least by international standards (e.g. Griffiths *et al.,* 2004). Thus data from deepwater marine effluent and dredged spoil disposal ground monitoring programmes off the east coast (e.g. CSIR 2008a, b, 2009a), have demonstrated that the magnitude and spatial extent of the contamination of water, sediment and/or biological tissue is low and is temporally variable. A possible reason for this is the high-energy nature of the South African coastline, since strong ocean currents aid in the dilution and dispersion of discharged wastewater, while fine-grained sediment and organic matter with which most persistent organic and inorganic pollutants preferentially associate, does not settle from the water column. Moreover, nearshore areas tend to be dominated by sand which sequesters low contaminant concentrations, and significant bedload sediment transport probably also results in natural remediation. However, since most pollution monitoring is restricted to about 3 to 4 km offshore and is performed over small areas near point sources, there is a poor understanding of whether contaminants may be accumulating in coastal waters where the accumulation of fine-grained material is significant (e.g. the Tugela Bank).

The situation for estuaries and ports is different since weak currents and the so-called salting out effect facilitate the accumulation of fine-grained material and the scavenging of contaminants from the water column to the bottom sediment through flocculation and adsorption. Most South African ports show evidence for the contamination of sediment by a suite of metals (e.g. CSIR 2008c, 2009b,c). In some cases the level is high, although it is typically restricted to relatively small areas and to the surface sediment due to frequent maintenance dredging. Persistent organic pollutant concentrations (predominantly polycyclic aromatic hydrocarbons) are monitored in a few ports, and there is also evidence for contamination of sediment but this is typically at a relatively low level (e.g. CSIR 2008c, 2009b). Sediment in estuaries within coastal cities is almost certainly also contaminated by persistent organic and inorganic pollutants, but so few studies have been performed over the past 10 years that it is impossible to reach any conclusions on the spatial extent, magnitude and temporal trends of contamination.

Persistent organic and inorganic pollutants have been measured in fish (e.g. Grobler *et al.,* 1996), sharks (e.g. Watling *et al.,* 1981), seals (e.g. Stewardson *et al.*, 1999), dolphins (e.g. de Kock *et al.,* 1994) and birds (e.g. Evans and Bouwman 2000) from South African coastal waters, but the major focus on contaminant accumulation by fauna has been on invertebrates (e.g. Hennig 1985). Mussel Watch programmes are in place at a few stations and concentrations of some persistent organic pollutants in the tissue of mussels collected near stormwater discharges are elevated and pose a potential human health risk (e.g. CSIR 2008a).

I) Issues

Many persistent organic pollutants have a high bioaccumulation and endocrine disruption potential. The almost complete lack of data on persistent organic pollutant concentrations in water, sediment and biological tissue from the South African coastline makes it impossible to determine whether these pose a risk to ecological and human receptors. This lack of data also prohibits the identification of pollution hotspots and the tracking of temporal trends.

The most significant source of persistent organic and inorganic pollutants to South African coastal waters is land-based activities, of which effluent and stormwater discharge appear to be the most significant, yet little to nothing is known about the types and loads contributed by these sources. The significance of stormwater

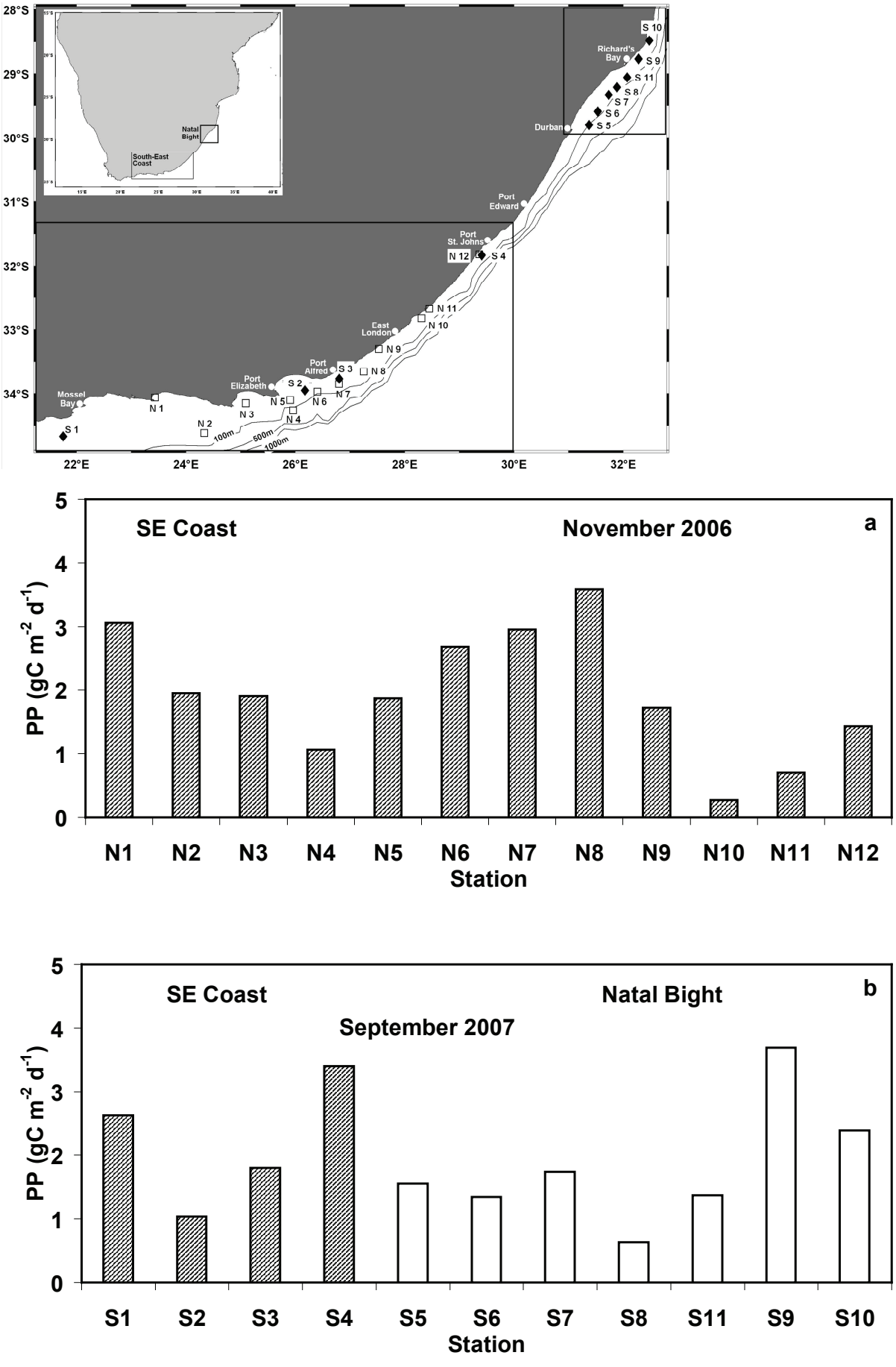


Figure 7: Integrated primary production (PP) at various stations for (a) November 2006 (N1-N12) and (b) September 2007 (S1-S11) (Barlow *et al.*, 2009)

discharges is that these discharge into the surf zone. Shoreline discharges are often trapped within the surf zone and dilution is less pronounced compared to offshore discharges. This leads to the exposure of shoreline fauna to contaminants for prolonged periods, increasing the potential for uptake and accumulation.

II) Gaps

In the early 1990s, funding for marine pollution research decreased considerably and the CSIR changed from a research to a commercially oriented organisation. Since then there has been a steady decrease in the volume of research performed on persistent organic and inorganic pollutants. At present, there is limited active research on inorganic and especially organic pollutants in South African coastal waters. Most of the data that has been generated over the past 10-15 years comes from environmental quality monitoring programmes (e.g. deepwater marine effluent discharge monitoring programmes) or from specialist studies for Environmental Impact Assessments. These data are focused in or near large coastal cities and few data are available for less developed regions of the coastline.

The spatial extent, magnitude and significance of different sources of persistent organic pollution of water, sediment and biological tissue from most areas of the South African coastline is extremely poorly understood. A national survey for a suite of persistent organic pollutants in sediment and commonly consumed fish and shellfish and in various potential sources (most importantly effluent and stormwater discharges) in and near large coastal cities should be performed as a matter of urgency. Persistent organic pollutant monitoring is however, expensive and the focus should therefore be on a suite of persistent organic pollutants that are know to be problematic in terms of the risks they pose to ecological and human receptors (e.g. those defined by the Stockholm Convention).

The data from such a survey will provide an understanding of whether persistent organic pollutants pose ecological and human health risks in the monitored areas, identify important sources and hotspots, and provide a 'baseline' against which to track temporal changes.

The importance of agriculture as a source of persistent organic pollutants to coastal waters in South Africa is unknown. Some of the most frequently detected persistent organic pollutants in coastal waters in many regions of the world are pesticides and herbicides. Importantly, nine of the 12 persistent organic pollutants identified in the Stockholm Convention are pesticides. Surveys of the persistent organic pollutants in estuaries will provide valuable information in the importance of pesticides applied to agricultural lands in the hinterland as contaminants of coastal waters.

Primary production

Primary production involves photosynthesis, and for this chlorophyll *a* is necessary. Satellite sensors to detect chlorophyll *a* were first flown on the *Nimbus-7* spacecraft in 1978, and South Africa's proposal for participation was one of only two non-USA proposal accepted (Shannon, 1986). Such imagery is now available on a daily basis, and is used extensively by the fishing industry to locate fish stocks. Initial studies of primary production in the wider Indian Ocean were conducted in the 1960s, where Ryther *et al.,* (1966) reported zones of elevated productivity (>1.0 gC m^{-2} d^{-1}) along the east African coast and a range of 0.1-3.1 gC m^{-2} d^{-1} on the Natal shelf. Burchall (1968a,b) reported levels of 0.2-2.2 gC m^{-2} d^{-1} on the Natal Bight. A review of data up to 1988 for the Natal Bight indicated that the range in chlorophyll *a* concentration is 0.03-3.9 mg m^{-3} (Carter and Schleyer, 1988). Measurements in 1989 over the whole Bight revealed elevated chlorophyll *a* concentrations in the northern section as a consequence of upwelling (Lutjeharms *et al.,* 2000a)(Figure 6).

A recent study revealed that integrated chlorophyll *a* levels in the euphotic zone were 20-70 mg m^{-2} on the Natal Bight during spring (Barlow *et al.,* 2008). Pigment indices showed that small flagellates generally dominated the communities on both bights, but diatoms were more prominent in two small sectors in the northeast and southwest. Further unpublished data from recent research cruises on the southeast coast suggested no significant differences in productivity between spring and summer. However, pigment indices indicated that there were seasonal differences in community composition, where diatoms dominated in summer and mixed diatom-small flagellate populations prevailed in spring. Physiological studies indicated that communities adapted to environmental variability by varying the proportion of chlorophyll *a* and photosynthetic carotenoids for the absorption of light, increasing their maximum quantum yield of photochemistry, increasing maximum

photosynthetic rates and increasing their light-limited photosynthetic efficiency under low light conditions and at elevated temperatures.

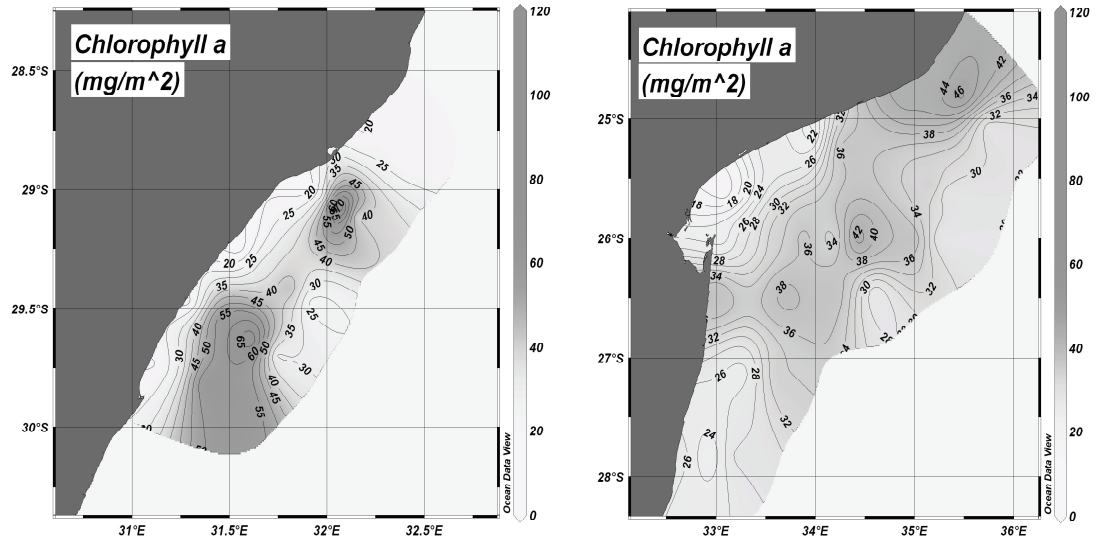


Figure 6: Spatial distribution of integrated chlorophyll a (mg m^{-2}) in the Delagoa Bight (left) and on the Natal Bight (right) (Barlow *et al.,* 2008)

On the Agulhas Bank, a chlorophyll-rich zone is usually present in the inshore zone of the eastern Agulhas Bank, with concentrations of 2-5 mg m^{-3} in the maximum layer, but levels of >1 mg m^{-3} can extend across the entire shelf with a high degree of spatial heterogeneity (Probyn *et al.,* 1994). Chlorophyll profiles indicate that the maximum is usually located subsurface from 10-30 m. The eastern Bank appears to be characterized by higher levels of primary production and rates of 1.2-2.8 gC m^{-2} d^{-1} have been observed in the vicinity of the shelf break, while higher levels (5.3 gC m^{-2} d^{-1}) were estimated for the coastal and mid-shelf areas in summer (Figure 7).

Unpublished data from recent research cruises on the SE coast and Natal Bight showed that primary production varied from 0.27-3.58 gC m^{-2} d^{-1} in November 2006 and 0.63-3.69 gC m^{-2} d^{-1} during September 2007 (Figure 10) (Barlow *et al.,* 2009), suggesting no significant differences in productivity between spring and summer. Pigment indices indicated that there were seasonal differences in community composition where diatoms dominated in summer and mixed diatom-small flagellate populations prevailed in the spring. Physiological observations indicated that communities adapted to environmental variability by: (1) varying the proportion of chlorophyll *a* and photosynthetic carotenoids for the absorption of light; (2) increasing their maximum quantum yield of photochemistry; (3) increasing maximum photosynthetic rates; (4) increasing their light-limited photosynthetic efficiency under low light conditions and at elevated temperatures.

Secondary production

The most comprehensive study of zooplankton in the Indian Ocean unfolded during the pioneering International Indian Ocean Expedition (IIOE) of 1959 to 1965, that also included sections onto the Agulhas Bank (Figures 8 and 9). Subsequently, most offshore zooplankton research off South Africa has been concentrated on the West and South Coasts (see the review by Verheye *et al*., 1992), due to the importance of the fisheries in the Benguela upwelling ecosystem. Extensive zooplankton sampling has been undertaken since 1988 on the Agulhas Bank, where large populations of the copepod *Calanus agulhensis* provide an important food source for spawning anchovy (Huggett and Richardson, 2000). As the zooplankton samples were collected during the

acoustic surveys of pelagic fish, which terminated at or before Port Elizabeth, sampling for zooplankton east of this region over the past two decades has been rare to non-existent.
Much of what is known of East Coast zooplankton communities stems from surveys conducted in the 1960s (De Decker, 1964; De Decker and Mombeck, 1964). In a review of near-surface copepod distributions in the south-western Indian Ocean (SWIO) and south-eastern Atlantic Oceans, De Decker (1984) showed greatest copepod diversity to be associated with the Agulhas Current. During a cruise in the SWIO in 1961, De Decker and Mombeck (1964) identified various species that were associated with "Mozambique and Agulhas Current" water from 0-500 m; *Centropages furcatus* was also identified as an Indo-Pacific indicator species for the Agulhas Current.

Carter (1977) and Carter and Schleyer (1988) investigated the seasonal abundance and distribution of calanoid copepods between the KZN border and St Lucia, and identified neritic, oceanic and mixed copepod communities. They also noted the development of large populations of *Calanoides carinatus*, an upwelling species, in association with eddy centre upwelling off Durban. Schleyer (1977) researched the chaetognath community within the same region. The hydromedusae and siphonophore assemblages have been documented more recently (Buecher *et al*., 2005, Thibault-Botha *et al*., 2004, Thibault-Botha and Gibbons 2005).

Clupeiform-directed ichthyoplankton surveys were conducted along the East Coast between 1951 and 1973, and again in 1990/1991 (Beckley and Hewitson 1994; van der Lingen and Huggett 2003). The presence of anchovy and sardine eggs and larvae suggests that this region forms an extension of the spawning environment of South African temperate clupeoids. Beckley (1998) documented the presence and cross-shelf abundance of other species of fish larvae. Diversity was extremely high, with over 130 families recorded, including myctophids, scombrids, species associated with coral reefs, and perciform families.

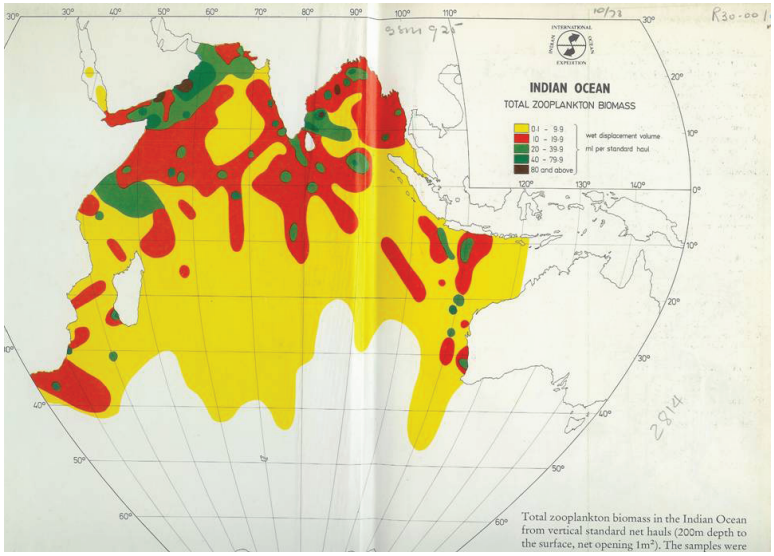


Figure 8: Total zooplankton biomass (wet displacement volume) from vertical standard net hauls (200 m to surface) during the International Indian Ocean Expedition (Zeitschel 1973)

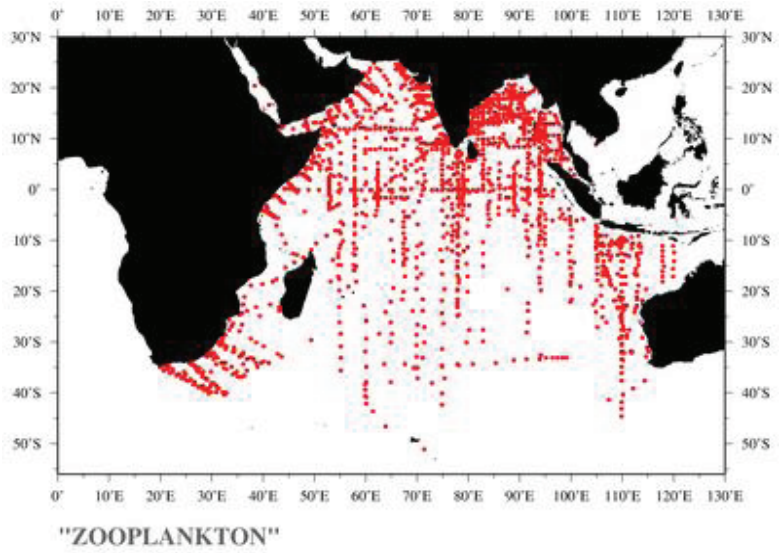


Figure 9: Location of zooplankton sampling positions during the International Indian Ocean Expedition of 1959-1965 (O'Brien 2005)

Issues

In contrast to the South East Atlantic off the west coast of southern Africa, comparatively little is known about the pelagic ecosystem of the South West Indian Ocean (SWIO). To date, most research in the SWIO by South African scientists has been conducted in the region influenced by the southern Agulhas Current, downstream from Port Elizabeth, mainly due to the long-term focus on the Benguela Current Upwelling Ecosystem and the commercially important pelagic fish that feed largely on zooplankton (see Gibbons *et al.*, 1992; Verheye *et al.*, 1992). Extensive zooplankton sampling has been undertaken since 1988 on the Agulhas Bank, where large populations of the copepod *Calanus agulhensis* provide an important food source for spawning anchovy (Huggett and Richardson 2000). As the zooplankton samples were collected during the acoustic surveys of pelagic fish, which terminate at or before Port Elizabeth, sampling for zooplankton east of this region over the past two decades has been rare to non-existent. South Africa's involvement in programs such as the Continuous Plankton Recorder will help to address these issues.

II) Gaps

- Lack of a substantial wasp-waist component in the coastal ASCLME region suggests quite different trophic functioning from most other LMEs around the world. There is thus a need to investigate the abundance, biomass and production of both the coastal zooplankton ecosystem and the oceanic community, and to see how these relate to both the physical and biotic environment.
- Smaller species and early developmental stages are important, understudied components of planktonic communities (Hopcroft *et al.*, 1998, Hopcroft *et al.*, 2001). This can be addressed by using smaller mesh nets in combination with traditional larger meshed samplers.
- Although copepod biomass in tropical systems has historically been believed to be lower than in temperate systems (Raymont 1983), this is at least partly a result of inadequately sampled small stages/species (Hopcroft *et al.*, 1998) and differences may still be offset by higher growth rates (e.g. Clarke and Roff 1990, Hopcroft and Roff 1995). It has been suggested that, far from being areas of low productivity, tropical environments may have productivities comparable to, or in excess of, temperate ecosystems (Hopcroft *et al.*, 1998). This hypothesis needs to be tested in the Indian Ocean.
- From a biological perspective, eddies are of interest as mechanisms of potential enrichment, concentration and retention of biological productivity, in line with Bakun's triad of processes that yield favourable reproductive habitats for pelagic fish (Bakun 1996). Eddies that form in the Mozambique Channel and near Madagascar are a topical focus of study (e.g. Lutjeharms and Jorge da Silva 1988, De Ruijter *et al.*, 2003, Quartly and Srokosz 2004) and hydrographic studies donducted in the Maputaland-Delagoa Bight suggest it to be an important semi-enclosed system characterized by recurrent cyclonic lee eddies, and a potential nursery ground for many fish species. However, there was no eddy present during any of these cruises.

- Further work on eddies therefore needs to be carried out, in particular on Mozambique Channel eddies' ability to carry plankton into the Agulhas Current System and the presence of similar patterns of variability in the Bight in the presence of an eddy.

Coastal Zone and Continental Shelf

Extent of coastal and marine habitats

South Africa's 2004 National Spatial Biodiversity Assessment (NSBA) was the first comprehensive assessment of biodiversity throughout the country. According to Sink and Attwood (2008), offshore habitats in the South African EEZ include shelf habitats such as deep reefs, banks that support deepwater coral and sponge communities, and unconsolidated sediments of sand, gravel, mud and various intermediate and mixed sediments. The shelf break represents a distinct habitat and in areas the shelf is incised by submarine canyons. There are also several seamounts in the south. Different offshore habitat types support unique assemblages of marine life and in many cases species of considerable commercial importance. Muddy areas of the shelf support sole fisheries and the shelf break on the southern Cape coast supports trawl and demersal longline fisheries. The deep reefs are the habitat of many commercial linefish species including several endemic and threatened species. Rocky areas of the upper slope support rock lobster trap fisheries and muddy offshore banks on the east coast support a crustacean trawl fishery. Seamounts are productive habitats that support diverse fish communities. The pelagic environment supports fisheries for sardine, anchovy, horse mackerel and tuna (Sink and Attwood 2008).

In mapping the subtidal abiotic environments, five sources of spatial data were used, namely the deep-sea sedimentary environment, the texture of surficial sediments of the continental margin, submarine canyons, untrawlable grounds because of hard outcrops on the Agulhas Bank, and seamounts (see Lombard *et al.*, (2004) for detailed maps. Also see figures 10 and 11 below.

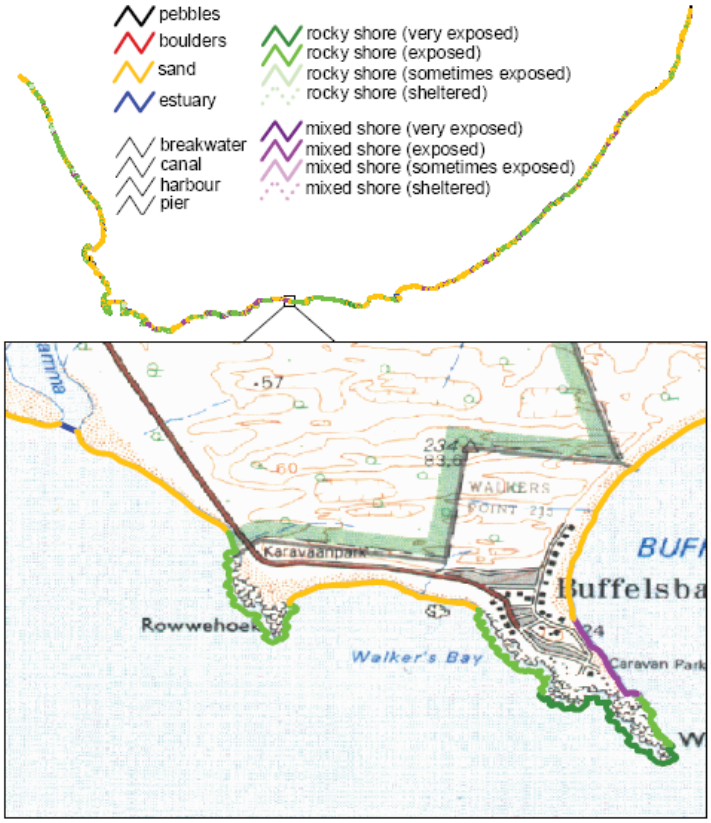


Figure 10: Intertidal habitats on the South African coastline. The inset shows a scanned 1:50 000 topocadastral map in the background (Lombard *et al.,* 2004)

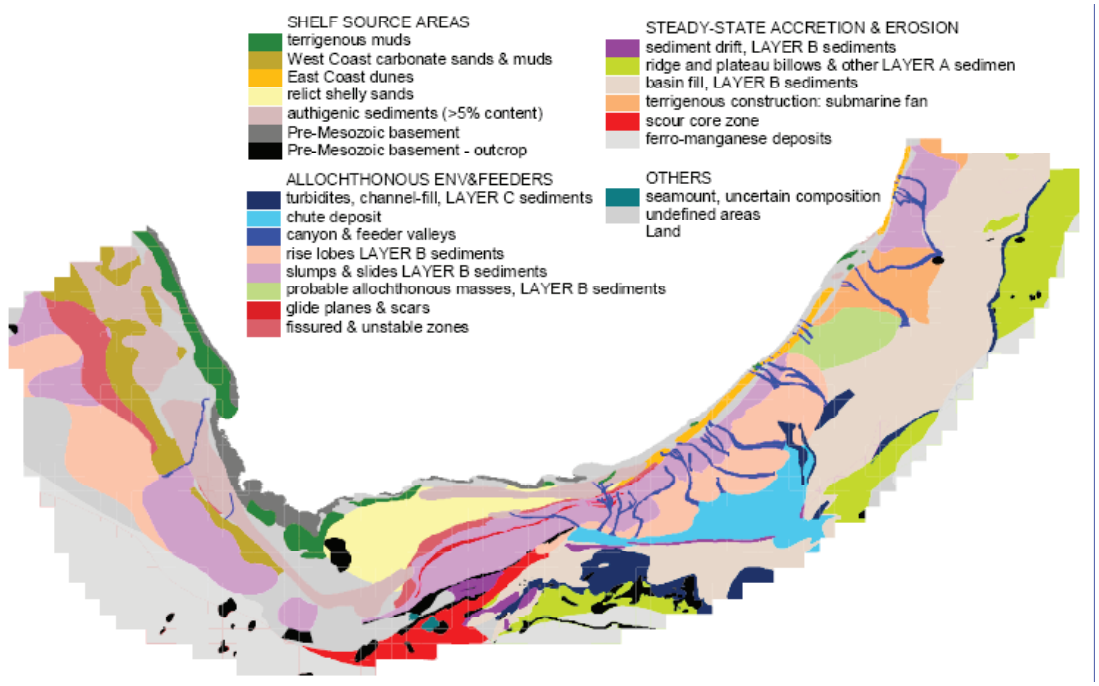


Figure 11: Deep-sea sedimentary environments in the South African EEZ, after Dingle *et al.* (1987). Canyons have been augmented with data from P. Ramsay (Lombard *et al.,* 2004)

The Terrestrial Component of the NSBA 2004 (Rouget *et al.,* 2004) used the South African National Biodiversity Institute (SANBI) vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006) as the main habitat layer. This provides a comprehensive description of more than 440 vegetation types, including some in estuaries and on the seashore, such as salt marshes and kelp beds.
Vegetation types have been classified into nine biomes or major habitats, and the coastal vegetation of South Africa's ASCLME region comprises Grassland on the east coast, Albany Thicket on the south-east coast, and Fynbos on the south coast. The areas where natural habitat has been lost were also mapped, and this shows that the coastal strip has been severely transformed (Rouget *et al.,* 2004). Moreover, threatened vegetation types were classified, and it is clear that much of the terrestrial habitat along the ASCLME coastline can be considered endangered or vulnerable.

I) Issues

Lombard *et al.,* (2004) noted that their data and analyses should be considered preliminary and concluded that no offshore habitats reach the internationally recommended target of protecting ≥ 20% of the extent of habitats, given that South Africa has no offshore MPAs. During the writing of this MEDA, plans were underway to implement some test areas for offshore MPAs in conjunction with the Marine Stewardship Council by SANBI) and SAEON.

One of the key problems in assessing trawl impacts is the lack of adequate control areas – for example, pristine soft-bottom habitat in which to measure the normal abundance of biogenic habitat in soft sediments. Trawling on the shelf slope is a concern as it could result in landslides or slope collapse, which could have a significant impact on the diversity of this poorly known habitat. In South Africa, there is concern that all trawlable grounds on the west and south coast have already been damaged. On the east coast, there are only three main areas that provide significant habitat for prawns in South Africa: the Tugela Bank, and specific areas off Richards Bay and St Lucia. All of these have been trawled (Sink *et al.,* 2004).

Five types of mining are currently considered to threaten marine biodiversity in South Africa: sand-winning; mining for titanium, diamonds, fossil fuels and phosphate. Sand-winning particularly in estuarine habitats, can have a large knock-on effect disrupting downstream or nearshore sediment processes. Strip-mining for titanium or other heavy minerals transforms dune communities in KwaZulu-Natal, but this impact is offset to

some extent by rehabilitation programs (Sink *et al.,* 2004). More recently, mining rights have been granted to Transworld Energy Minerals to strip-mine titanium and other heavy minerals from a 22 km coastal strip at Xolobeni on the Wild Coast (Legal Resources Centre).

Coastal development includes development activities such as infrastructure, as well as dredging activities and the disposal of sediments and need to be very strictly controlled. These developments pose a major threat to many components of the marine environment, owing to their cumulative effects, such as organic pollution of runoff and sewerage, transformation of the supratidal environment, alteration of dune movement, increased access to the coast and sea, and the negative impacts on estuaries. These are often not taken into account by impact assessments (Sink *et al.,* 2004).

A gap analysis conducted as part of the NSBA 2004 Terrestrial Component revealed that most South African ecosystems are not adequately conserved within the 6% of land that is protected. Protection status was defined as the percentage of the biodiversity target met in Type 1 protected areas, which includes National Parks, Provincial Nature Reserves, Local Authority Nature Reserves and DWAF Forest Nature Reserves (Rouget *et al.,* 2004).

It is evident that much of South Africa's ASCLME region is poorly protected, although a new national park is planned on the Wild Coast to protect the Pondoland Centre of biological diversity and endemism. Coastal habitats are vulnerable to the increasing pressure of increased population density and the associated development, mining, agriculture and afforestation, habitat fragmentation and alien plant invasion.

II) Gaps

Sink *et al*., (2004) identified the following priority areas for future research:

- The spatial distribution and intensity of bottom trawling requires mapping at the finest scale possible.
- The distribution and profile of reefs requires mapping. The Reef Atlas Project currently in progress aims to achieve this for incorporation into the NSBA 2010.
- Sandy beaches need to be classified into habitat categories (e.g. reflective versus dissipative beaches).
- The supratidal zone (those components that influence or are influenced by, the marine environment), needs to be analysed together with estuaries and intertidal habitats, as well as all appropriate species data, in an integrated coastal conservation assessment.
- Finer scale regional conservation assessments are required all along the South African coastline for incorporation into regional and local land-use planning initiatives.
- Habitat degradation as a result of, for example, grazing, harvesting of natural resources, and alien invasive plants, was not adequately mapped in the NSBA 2004. South Africa lacks information on the spatial pattern of land degradation at a scale that can be used for conservation planning. This is a major limitation as land degradation is the only substantial form of habitat transformation in some ecosystems. Mapping of land degradation (broken down into several degrees or types of degradation) at a scale suitable for conservation planning will be crucial for future conservation works (Rouget *et al.,* 2004).

Productivity of the Coastal Zone

The productivity of South Africa's coastal zone increases from the country's border with Mozambique towards the west, coinciding with cooler temperate waters and the upwelling of cold, nutrient-rich bottom waters to the surface. However, riverine input of nutrients, which peaks in mid- to late summer after the rainfall is maximal in the north-east and diminishes westward. Various ecosystems contribute to the productivity of the coastal zone, not only by supporting complex food webs, but also by providing habitat and nursery areas for a variety of animals, including commercially important fish and invertebrates.

Corals occur primarily in northern KZN, and north of the St Lucia estuary there are three major reef areas. The corals do not form their own reefs, but are Indo-Pacific species that have colonised submerged outcrops from the late Pleistocene (Ramsay & Mason 1990). The reefs are dominated by filter-feeding invertebrates such as hard and soft corals, sponges and ascidians (Riegl, 1993). Further south, the most prominent reef systems are the Aliwal Shoal/Landers complex just south of Durban, and the Protea Banks north of the KZN border. The

reefs are dominated by filter-feeding invertebrates, and are not true coral reefs. Nevertheless, they comprise some of the southernmost corals in the world and host several unique communities, with an unusually high abundance of soft corals and gorgonians, with black and whip corals being particularly conspicuous (Schleyer, 1995). The reefs are thus valuable from a biodiversity perspective. Aliwal Shoal is subject to periodic turbidity due to riverine input and discoloured plumes of water discharged from the SAPPI-SAICCOR pipeline.

Kelps are the largest and fastest-growing algae that support a rich community of organisms. Four species occur in South Africa, but only the spined kelp *Ecklonia radiata* is common in the ASCLME region. Others occur west of Cape Agulhas. Kelps are found in deep rock pools and gullies, and seldom forms solid stands. Although herbivores such as limpets, abalone and sea urchins are able to graze on kelp, most of the animals in kelp forests are filter-feeders such as mussels, which are in turn eaten by commercially valuable rock lobster.

Mangroves occur in estuaries along the east coast of South Africa as far south as the Nahoon River at East London. Two species, the Tagal mangrove *Ceriops tagal* and Kosi mangrove *Lumnitzera racemosa*, extend no further south than the Kosi system, while the red mangrove *Rhizophora mucronata* and black mangrove *Bruguiera gymnorrhiza* reach their limits on the Wild Coast, together with the mangrove associate *Acrostichum aureum*, a halophytic fern. The white mangrove *Avicennia marina* extends to East London (Steinke 1995).

South Africa has a high-energy exposed coastline, so seagrass beds are limited to the sheltered waters of estuaries. The eelgrass *Zostera capensis* colonises muddy bottoms forming a distinct zone at the lowest regions of the intertidal zone, where it is only exposed at spring low tides. The plants prefer relatively saline water, so the beds may experience diebacks after floods.

Saltmarshes occur mainly in temperate areas, so in South Africa they are found in suitable estuarine habitat along the south and south-east coasts. Further north in the sub-tropical parts they are replaced by mangroves. The most extensive true saltmarsh in the ASCLME region is the 1,800 ha in the Knysna Lagoon on the south coast. Common species include the cordgrass *Spartina maritima*, the glasswort *Sarcocornia perennis* and the marsh samphire *Salicornia meyeriana*.

Issues

Climate change is expected to have a negative impact on salt marshes and mangroves as a result of sea level rise, since these communities depend on a tidal cycle of inundation and exposure, and may not be able to retreat upshore. Warmer air and water temperatures may also impact their distribution and productivity. Offshore, coral reefs could be affected by both ocean acidification and coral bleaching (the loss of symbiotic zooxanthellae from the tissue of host corals). In 2000 and 2001, monitoring studies at Sodwana Bay showed that bleaching had increased from <1% in 1998 to 5-10% in 2002, although it was less than that experienced by reefs elsewhere in the Indian Ocean (Sink *et al*., 2004).

White, red and black mangrove trees are harvested for their wood, which is very durable. At Kosi Bay mangroves are harvested for building materials and for construction of fish traps, and there is some harvesting in Richards Bay. Extensive mangrove cutting is considered a problem in many of the Wild Coast estuaries, particularly the Mngazana, Mtata, Xora and Mntafufu (Sink *et al.,* 2004).

Over-abstraction of water from rivers, impoundments, and afforestation and alien plant invasion in the catchment all result in modified river flows, and hence changes in estuarine mouth dynamics, with negative consequences for mangroves and saltmarshes. Poor catchment management may also increase siltation, causing smothering of benthic algal communities and coral reefs (Sink *et al.* 2004).

Marine and Estuarine Meiofauna

In South Africa, nematodes are the most abundant meiofaunal component, typically comprising more than 50% of total meiofauna. Furstenberg and Dye (1982) reported that nematodes accounted for 20% of meiofauna assemblages on the northern KNZ coast and approximately 60% in the Port Elizabeth area, indicating an abundance increase from east to west. Harpacticoid copepods are usually second in abundance, but may dominate in some coarse grained sediments (Higgins and Thiel, 1988). No comprehensive assessments of the meiofaunal communities of offshore and deep sea environments along the east coast of South Africa have been

conducted in the last two decades.

South African research on meiofauna, and nematodes in particular, went through a very promising developmental period in and around Algoa Bay during the late 1970's and early 1980s. These studies investigated ecological aspects of meiofauna in sandy beaches (McLachlan 1977a, b; McLachlan *et al.,* 1977a, b; McLachlan and Furstenburg, 1977), while Dye (1979, 1978a, b, 1983a, b, c), Dye *et al.,* (1978) and Dye and Furstenburg (1978) investigated the composition, distribution and seasonal fluctuations of meiofauna in various estuaries along the east coast (reviewed by Furstenberg and Dye, 1982). More recently, Nozias *et al.,* (2005) reported that meiofauna consumption rates reached as high as 54% of the microphytobenthic standing stock in some areas of the Mdloti Estuary in KZN. Pioneering work on the meiofauna of rocky shores has been conducted by Gibbons (1988a, b, c, 1991) and Gibbons and Griffiths (1986, 1988). However, there appears to be only one study with the main focus on the nematode communities of rocky shores (Garner, 1995).

I) Issues

Gage (1996) postulated that meiofaunal communities attain the greatest biomass and/or abundance in shallow water environments. Local diversity is continuously affected by disturbances such as chemical pollution, dredging and landscape alterations resulting in changes in diversity patterns often accompanied by changes in abundance and biomass. This problem is compounded by lack of information on the meiofauna of the shallow water and offshore environments. This concern has become increasingly relevant in light of the proposed sand dune mining along the east coast of South Africa.

The study of meiofauna in South Africa has been hampered by the lack of meiofauna experts in South Africa. The very few researchers studying meiofauna are mainly generalists who do not investigate meiofaunal communities beyond the major faunal groups comprising the meiofauna. Nematology expertise, for example, is seriously lacking since the retirement of all active nematologists in the last decade. Further capacity building in the field of meiobenthology and funding for research projects is urgently required. Realising the lack of expertise in South Africa, Gibbons *et al.,* (1999) has in particular lamented the lack of trained taxonomists, especially those that work with meiofauna. This compromises South Africa's ability to move the field of meiobenthology forward.

The study of meiofauna is further hindered by a lack of readily available identification literature. The likelihood of discovering new species of meiofauna, especially new nematode species, along the poorly surveyed east coast of South Africa is very high. Often identification literature can only be found internationally in hard copies which are difficult to obtain. The only comprehensive identification literature for nematodes, for example, is the illustrated identification guide, *Free-living marine nematodes*. It has subsequently been found that meiobenthologists from the southern hemisphere have erroneously identified typical British nematode species due to the lack of expertise, experience and identification literature.

II) Gaps

Pioneering work on the meiofauna of rocky shores has been conducted (Gibbons 1988a, b, c, 1991; Gibbons and Griffiths 1986, 1988). However, much work is still to be done. Studies with the main focus on the nematode communities of rocky shores have unfortunately been few and far between, and to the best of our knowledge, the only work is that of Garner (1995). She investigated the nematodes on subtidal macroalgae at a sheltered, moderately exposed and fully exposed rocky shore.

Dye (1983a, b, c) investigated the composition, distribution and seasonal fluctuations of meiofauna in the permanently open Mngazana River estuary situated along the east coast of South Africa. Since this early pioneering work few studies on the meiofauna and nematodes of permanently open estuaries, temporary open closed estuaries and beaches has been conducted. Despite the studies on the meiofauna in coastal systems, nematodes have received almost no independent attention in the last two decades along the east coast of South Africa.

Meiofauna is present in great numbers in every aquatic environment known to man, making this group of organisms ideal candidates for pollution monitoring. Despite this potential of meiofauna and nematode communities as monitors of ecosystem health and pollution (Bongers 1990, Roberts 1996, Gyedu-Ababio *et*

al., 1999, Gyedu-Ababio and Baird 2006), very little work has been conducted in South Africa in this respect. The study and monitoring of organic and metal pollution through the assessment of meiofaunal communities must receive greater support from academic and governmental institutions. Development and capacity building in the field of meiofauna as pollution indicators is needed to manage existing and future pollution events.

Currently, limited work on the use of meiofauna and nematode communities as indicators of ecosystem health is being conducted – or at least published. Meiofauna are being used by the CSIR in one of their research programmes to assess the health of isolated beaches and offshore marine sediments along the east coast of South Africa, but the results of their efforts are not as yet public knowledge. As far as is known, no comprehensive assessments of the meiofaunal communities of offshore and deep sea environments along the east coast of South Africa have been conducted in the last two decades. Research in conjunction with international experts in the field of meiobenthology is drastically needed to explore our meiobenthic diversity and to build capacity to continue research in this field into the future.

Unfortunately, we must still consider South African marine nematology to be in its infancy. Although sample analysis and species identification is a time consuming process and upcoming meiobenthologists generally lack the expertise to identify most species, alternative approaches to traditional taxonomy exist elsewhere in the world that could be usefully employed locally. Ambitious molecular bar-coding projects have been initiated (Bhadury *et al.,* 2006, 2008) in leading meiofaunal laboratories, making the process of identification much easier. The crux, however, remains that nematodes and other meiofaunal groups are excellent indicators of ecosystem health and pollution. They play key roles in biogeochemical processes and recycling, and are simple, fascinating models for phylogenetic studies that can be used to test a plethora of fundamental ecological questions. It is time that South African nematology and meiobenthology joined the twenty-first century!

Macrofauna

Invertebrates

While records of marine invertebrate species are not as complete as for vertebrate taxa, 9 368 species are known from the South African coast (Griffiths *et al.,* in press). Intertidal and near-shore habitats are the most extensively surveyed for invertebrates with a number of studies recording species distributions around the coast (Stephenson 1939, 1944, 1948; Day 1967a,b; Stephenson and Stephenson 1972; Brown and Jarman 1978; Emanuel *et al.,* 1992; Bustamante and Branch 1996; Sink 2001; Monniot *et al.,* 2001). Based on data from these sources Awad *et al.,* (2002) analysed patterns of species richness and endemicity around the South African coastline.

Two general patterns have emerged from this survey. Firstly, invertebrate species richness is lower on the west coast than on the south and east coasts (Figure 12). Although the pattern varies slightly among taxa, species richness tends to peak at False Bay and then remains consistently high as far as Durban, with peaks at Port Elizabeth and Durban. From Durban northwards to Mozambique species diversity declines notably, but this is likely due to lower sampling intensity in this area. Secondly, endemicity peaks along the south coast. This is, however, likely an artifact of this being the region furthest from South Africa's political borders.

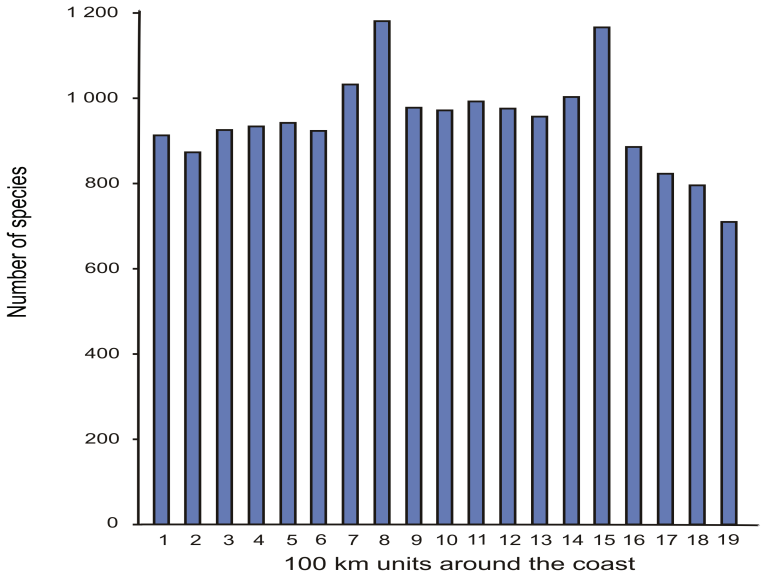


Figure 12: The number of marine invertebrate species per 100km units from Cape Agulhas to the Mozambique border (modified from Awad *et al.,* 2002)

Most recently harvesting of intertidal resources in this region has been focused in the Eastern Cape (the former Transkei) and northern KwaZulu-Natal (Hockey *et al.,* 1988; Lasiak 1992; Kyle *et al.,* 1997; Harris *et al.,* 2003). Harvesting is undertaken by both the recreational and subsistence sectors. The brown mussel *Perna perna* forms the major portion of these catches, but whelks (*Thais* species), limpets (*Cymbula* and *Scutellastra* species), abalone (*Haliotis* species), oysters (*Saccostrea cucullata*), red-bait (*Pyura stolonifera*) and octopus (*Octopus granulatus*) are also collected (Siegfried *et al.,* 1985; Kyle *et al.,* 1997; Tomalin and Kyle 1998). Subtidally the east coast rock lobster (*Panulirus homarus*) is harvested in shallow areas.

I) Issues

The east and south coasts of South Africa have high coastal population density relative to the west coast, resulting in intense exploitation of inshore resources by recreational and subsistence sectors. As a result many coastal fish and invertebrate stocks are overexploited, with significant impacts on both target and non-target species having been recorded (Siegfried *et al.,* 1985; Hockey and Bosman 1986; Lasiak and Dye 1989; Lasiak 1991). This has translated into dramatic changes in the structure of exploited communities (Hockey and Bosman 1986; Lasiak and Dye 1989).

Alien species pose a major threat to biodiversity on a global scale. The most recent assessment of this problem along the South African coast has lead to the identification of more than 85 alien species (Mead *et al.,* in prep). Besides the Mediterranean mussel *Mytilus galloprovincialis,* which occurs on the open coastline of the south coast as far east as East London (Robinson *et al.,* 2005), all alien species on the south and east coasts are restricted to the sheltered sites of Knysna Lagoon, Port Elizabeth, East London, Durban and Richards Bay harbours (Mead *et al.,* in prep).

Near and offshore pipelines are used to discharge large volumes of sewage, fish waste and industrial effluent into the marine environment. The majority of near-shore pipelines are concentrated around a few major harbours and estuaries, thus leaving most of the coast unaffected (Griffiths *et al.,* in press). It is important to note, however, that no formal assessment of the impact of these releases has been made.

Climate change is likely to affect the coastal zone through rising sea level and changes in circulatory and sea surface temperature patterns. Increasing sea level is not anticipated to be of great consequence to many coastal species, as they will simply move higher up on the shore. An exception might occur on the South African east coast, where many shores consist of rock platforms in the lower shore bounded by sandy habitats above. Here rising sea levels may result in the loss of some upper intertidal species (Griffith *et al.,* in press). Temperature rise is likely to result in the southward expansion of the distributional ranges of coastal species, although enhanced upwelling and cooling at the coast can also result.

Physical disturbance is not considered a major threat to invertebrates along the South African coast. The main sources of disturbance are human trampling and diving activities. Both of these are thought to be limited both spatially and temporally, being very focused around recreational areas during holiday periods.

II) Gaps

To date no broad scale assessment has been made of the volume of discharges released via pipelines into the sea along the South African coast. Should this be done, surveys of invertebrate communities in the vicinity of these outfalls could be carried out, and historical data from these sites extracted, offering a unique opportunity to consider long-term changes in relation to coastal pollution.

Since 1994 and the change in political environment in South Africa, the subsistence use of intertidal resources may well have changed in rural coastal areas. This may have released some invertebrate species from harvesting pressure, which in turn may translate into changes in biological community changes. These potential changes should be investigated, so as to provide support to conservation and management efforts.

Fish and Fisheries Resources

Overall fishery sector

South Africa has a coastline that spans two ecosystems over a distance of 3,623 km, extending from the Orange River in the west on the border with Namibia, to Ponta do Ouro in the east on the Mozambique border. The western coastal shelf (BCLME) has highly productive commercial fisheries similar to other upwelling ecosystems around the world, while the east coast (ASCLME) is considerably less productive but has high species diversity, including both endemic and Indo-Pacific species.

From a National Marine Resource Ecosystem perspective, the South African fisheries sectors extend out to the Exclusive Economic Zone. Exploitation however, from South African nationals in some instances, extends beyond this boundary into the high seas. In this regard South African flag state vessels may influence areas beyond national jurisdiction and need to be licensed with "high sea" permits.

In a regional context, South Africa shares high seas resources with international fleets exploiting mostly tunas and large pelagic species most of which migrate freely between the Indian, Atlantic and Southern Oceans. South African commercial operators have also exploited deep-water bottom-dwelling species on the Southwest Indian Ocean Ridge. From a transboundary diagnostic point of view, the management of these highly migratory and demersal resources in the ASCLME is obviously a critical concern.

The third critical consideration in the transboundary analysis is the extent to which fishery issues in South African waters are influenced by the activities of neighbours, or the activities of international fleets of other distant water fishing nations. On the South African eastern maritime border with Mozambique there are shared stocks as well as migratory resources found in the southern Indian Ocean and in particular, associated with the dynamics of the Mozambique /Agulhas currents. These are areas that fall both outside and within national fishing zones (EEZs) and the exploitation of resources in these areas has obvious implications relating to the transboundary management of stocks in the ASCLME area.

The South African fishing industry is regulated by the Department of Environmental Affairs and Tourism (Marine and Coastal Management Branch). The commercial and recreational fishing industry (including primary and secondary industries) is valued at approximately R4-5 billion annually (< 1 million USD) and provides employment for an estimated 36 500 individuals, both land-based and sea-going.

Fish resources are however broader than just the commercial fisheries, and in this context South Africa has a unique complexity of species that include tropical, temperate and cold water species – with a high proportion of endemic species. With respect to transboundary characteristics, the mixing of waters off the Agulhas Bank with the cooler Benguela Current raises many management and stock-related issues that may impact species diversity. In this regard the management of commercial fisheries in the region, with all the related issues such as by-catch, discarding, substrate effects, Unreported, Unregulated and Illegal (IUU) fishing etc is obviously an

important consideration for transboundary diagnostics in the ASCLME region.

Biodiversity and genetics

Marine fisheries in South Africa are diverse, and because of the different ecosystems and irregular coastline, are diversified, both with respect to species caught and fishing gear deployed (Lombard *et al.,* 2004). In taxonomic terms, nearly all-global groups of species are found in South African waters (Table 4), with the most diverse groupings found in the ASCLME region i.e. east of 20°E (or east of Cape Agulhas). Broadly, species exploited can be divided into the following based on bathymetry:

- Estuarine and intertidal fish species;
- Near-shore species exploited by linefishers and generally limited to < 3 nm offshore;
- Shelf species exploited by industrial fisheries to ~ 800 m
- Deepsea species exploited off the shelf (generally greater than 800 m water depth).

The above grouping can be further sub-divided into species groups, such as crustacea, cephalopods, elamobranchs, demersal (bottom living), meso-pelagic (midwater), small pelagic (near-surface) and large pelagic (highly migratory tunas, billfishes and sharks) and "linefish" (includes many endemic species).

From a biodiversity perspective the taxonomy and species groupings are also broadly separated between the superclass *Pisces* split into the bony fishes (Osteichthyes) and cartilaginous fishes (Chondricthyes). Smith's Sea Fishes (Smith and Heemstra 2003) describe many hundreds of species. However, with regard to the potential impact on the biodiversity of fish species, the number of species affected by commercial exploitation is reduced to about 250 species. Some fisheries impact only on the target species with minimal impact on bycatch, such as the nearshore and offshore crustcean trap fisheries (Groeneveld 2002). The small trawl shrimp fishery on the Kwazulu Natal coast is typical of shrimp trawl fisheries globally with a small target component but a very high fish bycatch as well as incidental catches of turtles (Fennesey and Isaksen 2007). Others fisheries, such as the midwater trawl, targets horse mackerel (*Trachurus capensis)* with emphasis on catch volume (up to 100 tonnes per trawl) but also impacts (as bycatch) on hakes, large pelagic sharks and occasional marine mammals (dolphins and cape fur seals) – Tables 3 and 4.

The most valuable fishery, directed at hake, has different sectors using different gear types that include bottom trawl, bottom-set longline and handline. Observer sampling data demonstrates the selective nature of different gear types. In the longline fishery some 60 species have been recorded, with 80% of the catch (by number) accounted for by four species (Cape hakes, kingklip and jacopever). Deep sea hake trawl on the other hand has recorded at least 220 different species with the most common 16 species dominating (75% by number recorded). In the large pelagic longline sector, 75% of the catch is made up of five species (yellowfin tuna, bigeye tuna, blue shark, longfin tuna and mako shark) with up to 61 species recorded as "retained". Some of the "retained" species have also been reported as discarded on some vessels – in all the Observer programme reports some 64 species were discarded (Offshore Resources Observer Programme- Marine and Coastal Management).

Because of the extent of the ACLME area, exacerbated by the mixing with the Benguela Current System in the south, the delineation of numerous commercial fish resources is problematic. For example the genetic studies conducted on Cape Hakes to separate the stocks of the two species between the Agulhas Bank, West Coast and Namibia stocks remains inconclusive (Grant *et al.,* 1987). In the Western Cape area, the infrequent high availability of yellowfin tuna in that area is believed to be due to the influx/migration of Indian Ocean stocks when favorable environmental conditions prevail. Similarly, the occurrence of deep water lobster off the Natal coast has been associated with migrations in the Mozambique/South Africa transboundary area (Groeneveld *et al,.* 1995). Further, the status of shrimp stocks caught both in the shallow and deep waters on the northern Kwazulu Natal waters is uncertain – the same species are found and exploited along the entire East African coast to Kenya and also off the Indian Ocean islands, especially Madagascar. The status of the stocks of these shrimp species are being investigated using genetic analysis in the South West Indian Ocean Fishery Project (SWIOFP - Groeneveld, pers comm).

Key species groups exploited

The main commercial fisheries sectors are shown in Table 3 and the primary species in each sector listed in Table 4. Figure 13 shows the distribution of main commercial fisheries in South African waters showing main fishing ports.

Small Pelagic Fisheries

Small pelagic fisheries dominate the commercial fishing sector with respect to volume, fishing with purse seine gear (from surface to about 60 m depth) and focus on a few species. Catches in this sector are highly variable from year to year – a factor related to their short-lived life history and year-to-year environmental variability. The fishery is however relatively "clean" and bycatch is low (van der Lingen *et al.,* 2006).

I) Issues

Ecosystem impacts – the target species are a primary food chain fish species and their exploitation has trophic impacts on many other predatory fish species, marine birds and mammals – these impacts have been modelled although there remain uncertainty regarding trophic effects (Shannon *et al.,* 2004);

Cape fur seals are often trapped and drown in nets;

Species mixing between juvenile anchovy (*Engraulis encrasicolus)* and juvenile sardine (*Sardinops sagax*) is an "early season" fishery problem (before fish separates into discrete shoals) presenting fishery management issues such as discarding and dumping;

Shifts in stock biomass of sardine from the west to the east coast has been evident in recent years, possibly linked to climate change;

There is a seasonal bycatch problem with juvenile horse mackerel – this issue however is mostly restricted to the west coast. On the east coast (ASCLME area), high bycatches of horse mackerel is problematic at times;

Monitoring, control and surveillance of bycatch and dumping is a concern;

There are no transboundary issues on the east coast with the main small pelagic stocks contained within the Benguela and Agulhas systems but not extending beyond RSA borders.

Large Pelagic Fisheries

This is a relatively small fishing sector in South Africa. However, the South African EEZ and surrounding waters are heavily fished by foreign tuna fleets that access South African ports for servicing and fish transhipments. Because of the highly migratory nature of the species exploited, transboundary concerns are a priority management issue. South Africa is however bound by regional agreements and collaborates closely with Regional Fisheries Management Organisations such as the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). Large pelagic fisheries target four or five species but impact many other species (non-directed bycatch), including sharks, killer whales (depredation) and marine birds (Grantham *et al.,* 2008).

I) Issues

- Stock status: yellowfin tuna is depleted according to IOTC assessments; bigeye tuna is considered stable but at risk; status of swordfish is uncertain; declining levels of shark in particular blue and mako sharks;
- Monitoring, control and surveillance issues: monitoring of high seas fleets, misreporting of landings, illegal transhipping and other IUU activities all pose a threat to resource sustainability in the region;
- Shark bycatch and targeting: fining is a global concern prevalent in South African and adjacent waters in the ASCLME;
- Bird bycatches: incidence of bird mortality on tuna-directed longlines is high (seasonally) on the Agulhas Bank;
- Depredation by killer whales is an increasing problem;
- Discarding and targeting on non-tuna species such as the oilfish *Rivettus pritiosus* is a growing problem in the tuna longline sector. This is also linked to declining availability of target tuna species.

Demersal Trawl Fisheries

In the hake sector, the demersal longline component is relatively selective compared to the bottom trawl. Longlines selectively target large hake, trawls catch the full spectrum of size classes of hake (except for the smallest fish generally below 15cm in length). Longline hake bycatch is restricted to species such as kingklip (*Genypterus capensis)*, jacopever (*Helicolenus dactylopterus)* and dogshark such as *Squalus megalops* (Japp 1997). In the offshore trawl sector, targeting the Cape hakes, *M. paradoxus* (deepwater hake) and *M. capensis* dominates

the commercial sector in terms of value. As with most trawl fisheries the gear is relatively unselective and there is both a large "retained" and "discarded bycatch (Leslie 2008). The state of the target species is well known and to a lesser extent the main bycatch species such as kingklip, monk, sole and panga. However, annual biomass surveys since the mid 1980s has facilitated rough assessments of many of the commonly caught bycatch and discard species (Leslie 2008). The results are largely inconclusive, however in many species there is a general trend towards declining availability.

I) Issues

- Stock status of Cape Hakes: Shallow-water hake catch rate has declined in recent years, although there are no major concerns at this point relating to spawner biomass levels. Deep-water hake stock levels are estimated to be < 30% of B_{msy};
- Some bycatch species are targeted necessitating precautionary catch limits for kingklip and monk. Kingklip stock status is uncertain with closed areas and seasons on the eastern Agulhas Bank;
- Trawl substrate impacts are a global issue and is a concern in South African waters – Agulhas Bank is most vulnerable due to higher benthic species diversity and sensitive deep-water corals;
- Bycatch of chondrichthyans and linefish, particularly in the inshore trawl fishery (under 110 m isobath) is problematic. Issue is under review and is a condition under Marine Stewardship Certification of the hake trawl fishery;
- Monitoring, Control and Surveillance issues are mostly well controlled although discarding and misreporting of landings does occur.

Squid Jig Fishery

South Africa's squid-jigging fishery targets chokka squid (*Loligo vulgaris reynaudi*) and is primarily situated on the Eastern Agulhas Bank. There are no major stock issues although annual catches are somewhat variable and dependent on environmental/oceanographic conditions. There are also no bycatch issues.

I) Issues

Significance of squid in ecosystem/trophic structure and impact of exploitation is poorly understood. There is a need for research in this area.

Crustacean Trawl and Trap Fisheries

The crustacean trawl fishery targets pink prawn (*Haliporoides triarthus*), langoustine (*Metanephrops andamanicu*) and *Nephropsis stewarti*, red crab (*Chaceon macphersoni*), Natal deepwater rock lobster (*Palinurus delagoae*) and an assortment of other crustacean and fish species. Areas of operation are confined to the province of Kwazulu-Natal. The inshore shrimp fishery operates on muddy grounds at depths of 20 m to 45 m primarily on the Tugela Bank. The offshore fishery operates at depths of 100 to 600 m from Port Edward to Cape Vidal. There is a small fleet of trap boats targeting deepwater rock lobster on the Agulhas Bank.

I) Issues

- Trap fisheries are selective with no major bycatch concerns;
- Prawn trawl fishery (deep and shallow) has a major bycatch concern. Issues are similar to other shrimp fisheries on the East African coast (Mozambique, Tanzania, Kenya and Madagascar included);
- Incidental mortality of turtles is problematic – vessels deploy Turtle Excluder devices (TEDs). There have been experiments with bycatch reduction devices (BRDs) to reduce fish bycatch.
- Similar substrate impacts to demersal trawl for hake although target areas are mud banks with lesser substrate impacts.

Midwater Trawl

Exploitation targeting horse mackerel is limited to one large vessel at present with *ad hoc* targeting by other demersal hake-directed vessels. Exploitation concentrates on the eastern Agulhas Bank.

I) Issues

- Hake, mackerel (*Scomber japonicus*) and ribbonfish (*Lepidopus caudatus*) bycatch.
- Discarding of juvenile horse mackerel.
- Incidental mortality of large pelagic species including dolphins (common and bottlenose), large pelagic sharks, sunfish species.

- Horse mackerel stock status uncertain – Precautionary catch limits are set.

Linefish

"Linefish" is one of the biggest fishery sectors in South Africa in terms of areas fished and numbers of fishers involved. This multi-faceted sector is complex with many fishers, subsistence folk and recreational users. There is a dedicated commercial linefish sector (350 boats) distributed around the whole coast targeting primarily snoek and cob as well as numerous other line-caught species. However, the effective declaration of a crisis in this sector in 1999 and the introduction of a Linefish Management Protocol (LMP) in 1999 (Griffiths *et al.,* 1999) introduced effort management based on geographical zones. In addition to the commercial linefish sector, there is a substantial recreational linefish sector as well that operates around the entire coast – catches are restricted by permit type and bag limits. Also falling within the small-scale and subsistence sectors is a small beach seine fishery distributed around the coast, small-scale gill net fishers on the west coast, wild oyster pickers and intertidal harvesting by subsistence fishers for mussels and other species, particularly in the Pondoland and Kwazulu-Natal coastal regions (Refer to Tables 3 and 4).

I) Issues

- High proportion of endemicity – stock status of most linefish species is uncertain or highly depleted (Mann 2000);
- High level of misreporting and unknown mortality – monitoring of commercial and recreational catches is under capacity and generally inadequate;
- Bycatches of linefish in other sectors present major problems for stock management – main species of concern are snoek, cob species and numerous other common linefish and shark.

Deepwater Trawl and High Seas

In the 1990s, there was a shift in trawl effort towards deeper water and industrial deep-sea operations targeting deepwater species such as orange roughy (*Hoplostethus atlanticus),* Cardinal (*Epigonus telescopus*), Alfonsino *(Beryx splendens) and* deep water dory (*Allocyttus verrucosus*) and others (FAO 2007, 2009). Efforts in or adjacent to the South African EEZ were largely short-lived with few economically commercial stocks identified (Japp and James 2005). Nevertheless, most deep-water species have life history strategies that are generally vulnerable to exploitation (slow-growing, aggregating behavior, etc). These fisheries are also associated with hard grounds and sensitive deep-water corals and other benthic flora and fauna. The trend in the hake-directed offshore trawl, particularly on the South and East coasts, towards deeper fishing (> 600 m) has resulted in exploitation of a new "deepwater" species regime with a unique set of biodiversity impacts linked to the continental shelf break (500 – 2000 m water depth).

In the context of the ACLME region, perhaps the most significant development in the 1990s was the discovery of rich deepwater resources (mostly demersal species) on the South West Indian Ocean Ridge including trawling on deep-sea seamounts. The exploitation of this area has been documented in FAO technical reports and by Japp (2006). This has led to initiatives by the fishing industry to limit the impact of trawling by voluntarily halting trawling in eleven deep-sea areas of the southern Indian Ocean. This will protect and conserve the bottom of the sea floor, or bentho, associated fish fauna and related biodiversity in what is effectively a marine protected area.

I) Issues

- Over-harvesting of deepwater stocks.
- Lack of capacity to manage fisheries of this nature.
- Lack of regional MCS capacity to monitor high seas demersal fisheries.
- Impact of heavy deepwater gear on deep water substrate with potential impacts on unknown deepsea biodiversity.

Catch locations of non-commercial threatened species

The main non-commercial species impacted in South African fisheries include:

Coelacanths – located on the northern Kwazulu Natal coast in areas close to the coast in depths from 50 m. There is no direct supporting evidence of fisheries impacts;

Sea birds – albatrosses and petrels primarily – well documented impacts of pelagic longlines and trawls. Main impact areas are the Agulhas Bank with seasonal high effects particularly in winter;

Marine mammals – primarily killer whales (orca) and offshore dolphin species (common and bottlenose). Main impact area is southern Agulhas Bank on shelf edge. Depredation by killer whales results in unquantified mortalities. Killer whale problem extends around the whole coast into Mozambique channel.
Turtle species – minor problems reported in KZN prawn trawl. Turtles are also extensively caught on pelagic longlines – there are rough estimates for the Agulhas Bank extending into Mozambique Channel for tuna and swordfish-directed longlines.

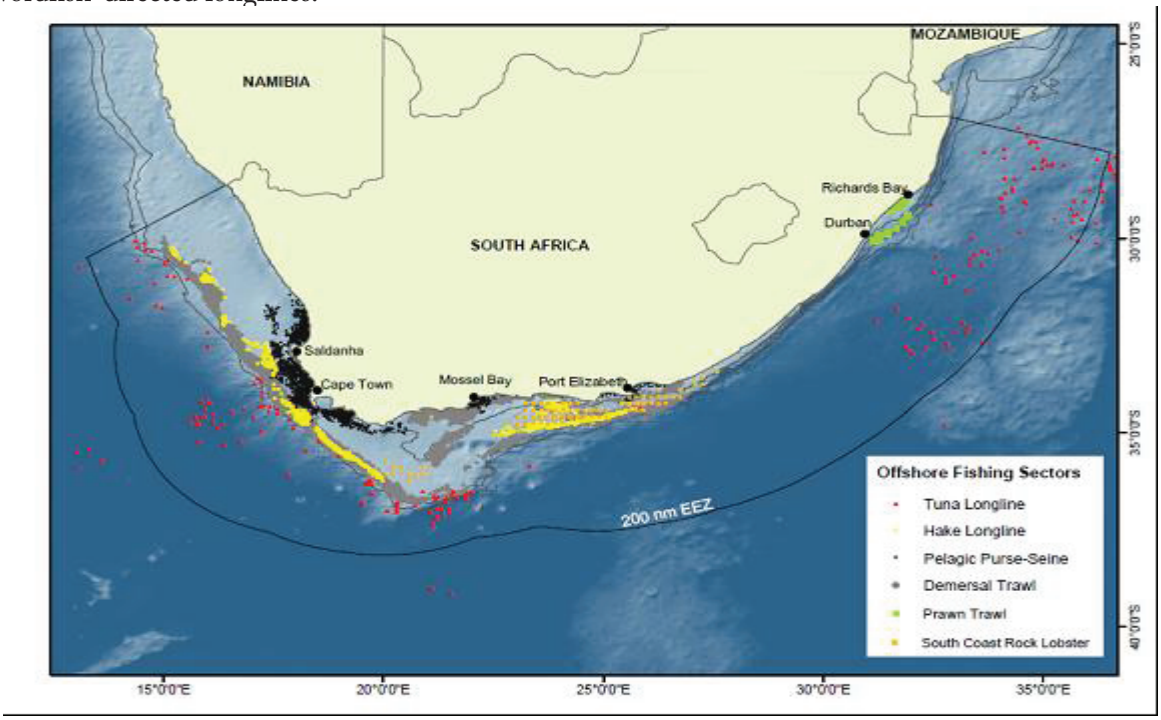


Figure 13: Distribution of main commercial fisheries in South African waters showing main fishing ports

Table 3. Inventory of main South African fisheries relevant to the ACLME region

Fishery	Area	Depth zone	Vertical distribution	Bottom type	Main target species	*Associated species*	Incidental Catches	Gear type	Approx catch
Small pelagic fishery	West and South Coasts	Shelf - Upper shelf (up to 100m)	Pelagic	soft bottom, gravel-sandy	*Sardinops sagax, Engraulis encrasicolus*	*Trachurus capensis, Etremeus whitheadi*	Cape Fur seal	single boat purse seines	500000
Demersal fisheries	West and South Coasts	Slope - Upper slope (200 m - 500 m)	Demersal	soft bottom, gravel-sandy	*Merluccius capensis, M. paradoxus*	*See Table 4*	Cape Fur seal	Otter trawls	200000
Midwater trawl fishery	South Coast	Slope - Upper slope (200 m - 500 m)	Pelagic	soft bottom, gravel-sandy	*Trachurus trachurus capensis*	*Lepidopus caudatus, Scomber japonicus*	Cape Fur seal,common dolphin,bottlenose dolphin	midwater otter boards	48000
large pelagic fishery	South African Coast	Unspecified	Pelagic	Unspecified	*Xiphias gladius, Thunnus albacares, Thunnus obesus, Thunnus alulunga, Thunnus maccoyii*	*See Table 4*	White-chinned petrel, albatross sp.	Pelagic longlines up to 3000 hooks	3000
Crustacean fisheries	South African Coast	Shelf - Upper shelf (up to 100 m)	Demersal	hard, rocky bottom	*Jasus lalandi*		Octopus	Traps and pots on lines and single	2800
Abalone fishery	West and East Coasts	Coastal - Shallow waters, inshore waters (0 m - 50 m)	Benthic	hard, rocky bottom	*Haliotus midae*		Nil	divers only	250
Shark fisheries	South African Coast	Unspecified	Demersal, Pelagic	soft bottom, gravel-sandy	*Galeorhinus galeus, Mustelus palumbes, Mustelus mustelus, Isurus Oxyrhincus,Prionace glauca*	*See Table 4*	White-chinned petrel, albatross sp.	single and longlines	2500
squid fishery	South African Coast	Slope - Upper slope (200 m - 500 m)	Demersal, Pelagic	soft bottom, gravel-sandy	*Loligo vuklgaris reynaudii*		Nil	jigs and traps	4000-10000
linefish fishery	South African Coast	Slope - Upper slope (200 m - 500 m)	Demersal, Pelagic	hard, rocky bottom	*Thyrsites atun, Seriola lalandi, Argyrosomus sp., Atractoscion aequidens*	*See Table 4*	Cape Fur seal	hook and line	3000
seaweed fishery	South African Coast	Coastal - Shallow waters, inshore waters (0 m - 50 m)	Benthic	hard, rocky bottom			Nil	had harvesting and beach collection	1000
Pilchard - purse seine	West and South Coasts	Shelf - Upper shelf (up to 100 m)	Pelagic	soft bottom, gravel-sandy	*Sardinops sagax*	*Trachurus trachurus capensis, Etremeus whitheadi, Engraulis encrasicolus*	Cape Fur seal	single boat purse seines	150,000
Offshore Trawl	West and South Coasts	Slope - Upper slope (200 m - 500 m)	Demersal	soft bottom, gravel-sandy	*Merluccius paradoxus*	*See Table 4*	Cape Fur seal	Otter trawls	150,000
Inshore Trawl	West and South Coasts	Shelf - Upper shelf (up to 100 m)	Demersal	soft bottom, gravel-sandy	*Merluccius capensis*	*See Table 4*	Cape Fur seal	Otter trawls	15,000
Hake Longline	West and South Coasts	Slope - Upper slope (200 m - 500 m)	Demersal	soft bottom, gravel-sandy	*Merluccius capensis, M. paradoxus*	*Genypterus capensis, Helicolenus dactylopterus*	Cape Fur seal	bottom set longlines up to 20000 hooks	10,000

Fishery	Area	Depth zone	Vertical distribution	Bottom type	Main target species	*Associated species*	Incidental Catches	Gear type	Approx catch
Hake handline	South Coast	Shelf - Upper shelf (up to 100 m)	Demersal	soft bottom, gravel-sandy	*Merluccius capensis*	*Genypterus capensis*	Cape Fur seal	hook and line up o 10 hooks per line	3,000
Sole trawl	South and East Coast	Shelf - Upper shelf (up to 100 m)	Demersal	soft bottom, muddy or muddy-sand	*Austroglossus pectoralis*	*Merluccius capensis*	Cape Fur seal	Otter trawls	900
Maasbanker	South and East Coast	Slope - Upper slope (200 m - 500 m)	Pelagic	soft bottom, gravel-sandy	*Trachurus trachurus capensis*	*Lepidopus caudatus, Scomber japonicus*	Cape Fur seal,common dolphin,bottlenose dolphin	midwater otter boards	45,000
Tuna directed longline	South Africa offshore	Unspecified	Pelagic	Unspecified	*Thunnus albacares, T. obesus, T. alalunga*	*See Table 4*	White-chinned petrel, albatross sp.	Pelagic longlines up to 3000 hooks	2,500
Swordfish-directed longline	South Africa offshore	Unspecified	Pelagic	Unspecified	*Xiphias gladius*	*See Table 4*	White-chinned petrel, albatross sp.	Pelagic longlines up to 3000 hooks	1,000
Shark pelagic-directed	South Africa offshore	Unspecified	Pelagic	Unspecified	*Isurus oxyrinchus*	*See Table 4*	White-chinned petrel, albatross sp.	Pelagic longlines up to 3000 hooks	1,500
Offshore rock lobster	South Coast	Shelf - Deep shelf (100 m - 200 m)	Demersal, Benthic	hard, rocky bottom	*Palinurus gilchristi*	*Scyllarides elisabethae*	Nil	Plastic traps on longline in short sets	377
Deepwater east coast lobster	South and East Coast	Slope - Upper slope (200 m - 500 m)	Demersal, Benthic	hard, rocky bottom	*Palinurus delagoae*	*Palinurus gilchristi, Scyllarides elisabethae*	Nil	Plastic traps on longline in short sets	not det
Abalone fishery	Eastern Cape	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	hard, rocky bottom	*Haliotus midae*		Nil	divers only	50
Vaalhaai and Hound sharks	West and South Coasts	Shelf - Upper shelf (up to 100 m)	Demersal	hard, rocky bottom	*Galeorhinus galeus, Mustelus mustelus, M. palumbes*	*See Table 4*	Cape Fur seal	Bottom set longlines up to 3000 hooks	1,000
St Joseph, Hound and vaalhaai, mullet	West and South Coasts	Coastal - Shallow waters, inshore waters (0 m - 50 m)	Demersal, Pelagic	soft bottom, gravel-sandy	*Callorhincus capensis, Liza richardsonii*	*Galeorhinus galeus, Mustelus mustelus, M. palumbes*	Cape Fur seal	shallow inshore gill net sets	300
Octopus pot	West and South Coasts	Coastal - Shallow waters, inshore waters (0 m - 50 m)	Demersal, Benthic	soft bottom, gravel-sandy	*Octopus vulgaris*		Nil	pots (var)	50
Linefish commercial	RSA Coast inshore	Shelf - Upper shelf (up to 100 m)	Demersal, Pelagic	hard, rocky bottom	*Thyrsites atun, Seriola lalandi, Argyrosomus sp., Atractoscion aequidens*	*See Table 4*	Cape Fur seal	hook and line by hand only	2,500
Linefish recreational	RSA Coast inshore	Shelf - Upper shelf (up to 100 m)	Demersal, Pelagic	hard, rocky bottom	*Thyrsites atun, Seriola lalandi, Argyrosomus sp., Atractoscion aequidens*	*See Table 4*	Cape Fur seal	hook and line by hand only	1,000
Seaweed	West and South Coasts	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	hard, rocky bottom	*Ecklonia maxima*		Nil	by hand beach and intertidal collection	1,000
Trek Net	RSA Coast inshore	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	soft bottom, gravel-sandy	*Liza richardsonii, Seriola lalandi*	*Callorhincus capensis*	Cape Fur seal	Hand pulled beach seine	500
Oysters	South and East Coast	Coastal - Intertidal	Benthic	hard, rocky bottom	*Pinctada capensis*		Nil	hand picking	100

Table 4. Inventory of Primary species in South African fisheries relevant to the ASCLME region

Resource and area	Family	Genus and species	Depth zone	Vertical distribution	Bottom type
Sardine - West, South and East Coast of South Africa	Clupeidae	*Sardinops sagax*	Upper shelf	Pelagic	Soft bottom, gravel-sandy
Anchovy - West and South Coast of South Africa	Clupeidae	*Engraulis encrasicolus*	Upper shelf	Pelagic	Soft bottom, gravel-sandy
Redeye pilchard - West, South and East Coast of South Africa	Clupeidae	*Etrumeus whitheadi*	Slope - Upper slope (200 m - 500 m)	Pelagic	Soft bottom, gravel-sandy
Horse mackerel (juveniles) - West and South Coast of South Africa	Carangidae	*Trachurus capensis*	Upper shelf	Pelagic	Soft bottom, gravel-sandy
Other small pelagic resources - South Africa	Myctophidae, Sternoptychidae	*Lampanyctodes hectoris, Maurolicus muelleri*	Slope - Upper slope (200 m - 500 m)	Pelagic	Unspecified
White hake - West, South and East Coast of South Africa	Merlucciidae	*Merluccius capensis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Black hake - West, South and East Coast of South Africa	Merlucciidae	*Merluccius paradoxus*	Slope - Upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Monk - West and South Coast of South Africa	Lophiidae	*Lophius upsicephalis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Redspot tonguefish - South and East Coast of South Africa	Cynoglossidae	*Cynoglossus zanzibarensis*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
East Coast sole - South Coast and East Coast of South Africa	Soleidae	*Austroglossus pectoralis*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, muddy or muddy-sand
Panga - South and East Coast of South Africa	Sparidae	*Pterogymnus laniaris*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Kingklip - West, South and East Coast of South Africa	Ophidiidae	*Genypterus capensis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Cape gurnard - West, South and East Coast of South Africa	Triglidae	*Chelidonichthys capensis*	Slope - Upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Lesser gurnard - West, South and East Coast of South Africa	Triglidae	*Chelidonichthys queketti*	Slope - Upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Other shelf and upper slope demersal resources - South Africa	Scorpaenidae, Bramidae, Squalidae, Callorhinchidae, Rhinobatidae, Rajidae	*Helicolenus dactyopterus, Brama brama, Squalus megalops, Squalus mitsukurii, Callorhincus capensis, Rhinobatos annulatus, Raja springeri, Cruriraja parcomaculata, Raja pulopunctata, Raja wallacei, Raja clavata, Raja alba, Raja straeleni*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Other slope demersal resources deep water- South Africa	Macrouridae, Trichiuridae, Zeidae, Moridae, Centrolophidae, Polyprionidae, Congridae, Trachichthydae, Epigonidae, Berycidae, Oreostomatidae, Moridae, Pentacerotidae	*Caelorinchus fasciatus, Lepidopus caudatus, Malacocephalus laevis, Zeus capensis, Zeus faber, Coelorinchus braueri, Antimora rostrata, Hyperoglyphe antarctica, Polyprion americanus, Conger wilsoni, Hoplostethus atlanticus, Epigonus telescopus, Beryx splendens, Allocyttus verrucosus, Centrolophus niger, Lepidion capensis, Neocyttus rhomboidalis, Mora moro, Penatceros capensis, Selachophidium guentheri*	Slope - Upper slope (200 m - 500 m), Slope - Deep slope (500 m -1000 m)	Demersal, Pelagic (bluefish)	Soft bottom, gravel-sandy, Hard rocky bottom (Wreckfish, Orange roughy)
Horse mackerel - West, South and East Coast of South Africa	Carangidae	*Trachurus capensis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Other midwater resources - South Africa	Trichiuridae, Molidae, Scombridae	*Lepidopus caudatus, Mola mola, Scomber japonicus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal,Pelagic	Soft bottom, gravel-sandy, Unspecified
Broadbill swordfish - West, South and East Coast of South Africa	Xiphiidae	*Xiphias gladius*	Slope - Deep slope (500 m -1000 m)	Pelagic	unspecified

Resource and area	Family	Genus and species	Depth zone	Vertical distribution	Bottom type
Yellowfin tuna - West, South and East Coast of South Africa	Scombridae	*Thunnus albacares*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Bigeye tuna - West, South and East Coast of South Africa	Scombridae	*Thunnus obesus*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Longfin tuna - West Coast of South Africa	Scombridae	*Thunnus alalunga*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Southern bluefin tuna - Offshore South Africa	Scombridae	*Thunnus maccoyii*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Skipjack tuna - West, South and East Coast of South Africa	Scombridae	*Katsuwonus pelamis*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Atlantic Bonito - West, South and East Coast of South Africa	Scombridae	*Sarda sarda*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Other large pelagic resources - South Africa	Scombridae, Gempylidae	*Katsuwonus pelamis, Sarda sarda, Ruvettus pretiosus, Lepidocybium flavobrunneum*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m), Shelf - Upper shelf (up to 100 m)	Pelagic	unspecified
South coast lobster - South and East Coast of South Africa	Palinuridae	*Palinurus gilchristi*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Hard rocky bottom
Natal spiny lobster - South and East Coast of South Africa	Palinuridae	*Palinurus delagoae*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Hard rocky bottom
Shoveller lobster - South and East Coast of South Africa	Scyllaridae	*Scyllarides elisabethae*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Deep sea crustaceans - West, South and East Coast of South Africa	Geryonidae, Lithodidae	*Chaceon maritae, Chaecon macphersoni, Lithodes ferox*	Slope - Deep slope (500 m -1000 m)	Demersal	Hard rocky bottom
Soupfin shark - West, South and East Coast of South Africa	Triakidae	*Galeorhinus galeus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Smooth houndshark - West, South and East Coast of South Africa	Triakidae	*Mustelus mustelus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
White spotted houndshark - West, South and East Coast of South Africa	Triakidae	*Mustelus palumbes*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Soft bottom, gravel-sandy
Shortfin mako - West, South and East Coast of South Africa	Lamnidae	*Isurus oxyrinchus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
Blue shark - West, South and East Coast of South Africa	Carcharhinidae	*Prionace glauca*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Other sharks - West, South and East Coast of South Africa	Alopiidae, Sphyrnidae	*Alopias vulpinus, Sphyrna zygaena*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
Other sharks - West and South Coast of South Africa	Lamnidae, Carcharhinidae	*Lamna nasus, Carcharhinus brachyurus*	Shelf - Upper shelf (up to 100 m),Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Other sharks - South and East Coast of South Africa	Carcharhinidae	*Carcharhinus obscurus, Caracharhinus leucas, Carcharhinus longimanus, Galeocerdo cuvieri*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
Loligo squid - South and East Coast of South Africa	Loliginidae	*Loligo vulgaris reynaudii*	Upper shelf	Demersal,Pelagic	Soft bottom, gravel-sandy
Octopus (shallow waters) - West, South and East Coast of South Africa	Octopodidae	*Octopus vulgaris*	Upper shelf	Demersal,Benthic	Hard rocky bottom
Other cephalopods - West, South and East Coast of South Africa	Ommastrephidae, Histioteuthidae, Octopodidae, Sepiidae	*Toderopsis eblanae, Histioteuthis elongata, Octopus dolfleni, Toderopsis sagittatus, Sepia australis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m), Upper shelf (Sepia australis)	Demersal,Benthic, Pelagic	unspecified, Hard rocky bottom
Other cephalopods - West and South Coast of South Africa	Ommastrephidae	*Todarodes angolensis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal,Pelagic	unspecified
Snoek - West and South Coast of South Africa	Gempylidae	*Thyrsites atun*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal,Pelagic	unspecified
Cape Stumpnose - West and South Coast of South Africa	Sparidae	*Rhabdosargus holubi*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
Galjoen - West and South Coast of South Africa	Coracinidae	*Coracinus capensis*	Coastal - Close to the shore, littoral (0 m - 20 m)	Demersal,Pelagic	Hard rocky bottom

Resource and area	Family	Genus and species	Depth zone	Vertical distribution	Bottom type
Bellman - South and East Coast of South Africa	Sciaenidae	*Umbrina canariensis*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
Blue Hottentot - South and East Coast of South Africa	Sparidae	*Pachymetopon aeneum*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
Red Steenbras - South and East Coast of South Africa	Sparidae	*Petrus rupestrus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Demersal	Hard rocky bottom
White sea catfish - South and East Coast of South Africa	Ariidae	*Galeichthys feliceps*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, muddy or muddy-sand
Soldier - South and East Coast of South Africa	Sparidae	*Cheimerius nufar*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
Geelbek - South and East Coast of South Africa	Sciaenidae	*Atractoscion aequidens*	Upper shelf	Demersal,Pelagic	unspecified
Carpenter - South and East Coast of South Africa	Sparidae	*Argyrozona argyrozona*	Upper shelf	Demersal	Soft bottom, gravel-sandy
Yellowtail - South and East Coast of South Africa	Carangidae	*Seriola lalandi*	Upper shelf	Demersal,Pelagic	unspecified
Bank steenbras - South and East Coast of South Africa	Cheilodactylidae	*Chirodactylus grandis*	Upper shelf	Demersal	unspecified
Red stumpnose - South and East Coast of South Africa	Sparidae	*Chrysoblephus gibbiceps*	Upper shelf	Demersal	Soft bottom, gravel-sandy
Red Roman - South and East Coast of South Africa	Sparidae	*Chrysoblephus laticeps*	Upper shelf	Demersal	Hard rocky bottom
Spotted grunter - South and East Coast of South Africa	Haemulidae	*Pomadasys commersonni*	Shelf - Upper shelf (up to 100 m)	Demersal	Soft bottom, gravel-sandy
Cob - West, South and East Coast of South Africa	Sciaenidae	*Argyrosomus holoepidotus*	Upper shelf	Demersal,Pelagic	unspecified
Shad - West, South and East Coast of South Africa	Pomatomidae	*Pomatomus saltatator*	Shelf - Upper shelf (up to 100 m)	Demersal,Pelagic	unspecified
White stumpnose - West, South and East Coast of South Africa	Sparidae	*Rhabdosargus globiceps*	Shelf - Upper shelf (up to 100 m)	Demersal	unspecified
Other shelf linefish - South and East Coast of South Africa	Carangidae, Sphyraenidae, Serranidae, Sparidae, Parascorpididae, Cheilodactylidae	*Elagatis bipinnulata, Sphyraena barracuda, Epinephelus gauza, Boopsoidea inomata, Parascorpis typus, Chirodactylus brachydactylus*	Shelf - Upper shelf (up to 100 m)	Pelagic, Demersal	unspecified, Hard rocky bottom, Soft bottom, gravel-sandy
Other coastal linefish - West, South and East Coast of South Africa	Mugilidae	*Liza richardsonii*	Coastal - Close to the shore, littoral (0 m - 20 m)	Pelagic	unspecified
Gastropods - South Africa	Haliotidae	*Haliotus midae*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Abalone - West, South and East Coast of South Africa	Haliotidae	*Haliotus midae*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Kelp - South Africa	Laminariaceae	*Ecklonia maxima, Laminaria pallida*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Sea Bamboo - West and South Coast of South Africa	Laminariaceae	*Ecklonia maxima*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Kelp - West and South Coast of South Africa	Laminariaceae	*Laminaria pallida*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Gracilaria - West, South and East Coast of South Africa	Gracilariaceae	*Graclaria gracilis*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Gelidium - West, South and East Coast of South Africa	Gelidiaceae	*Gelidium spp*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Cape Pearl Oyster - South and East Coast of South Africa	Pteriidae	*Pinctada capensis*	Coastal - Close to the shore, littoral (0 m - 20 m)	Benthic	Hard rocky bottom
Cape Fur Seal - West and South Coast of South Africa	Otariidae	*Arctocephalus pusillus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
Common dolphin - West, South and East Coast of South Africa	Delphinidae	*Delphinus delphis*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
Bottlenose dolphin - West, South and East Coast of South Africa	Delphinidae	*Tursiops truncatus*	Shelf - Upper shelf (up to 100 m),upper slope (200 m - 500 m)	Pelagic	unspecified
White chin petrel - West, South and East Coast of South Africa	Procellariidae	*Procellaria aequinoctialis*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified
Albatrosses - West, South and East Coast of South Africa	Diomedeidae	*Diomedea sp*	Upper slope (200 m - 500 m),Deep slope (500 m - 1000 m)	Pelagic	unspecified

Mammals

South Africa is very rich in marine mammals, with 32 species of toothed whales, 13 species of baleen whales and 6 species of seals. There are however no marine mammal species that are endemic to southern Africa. The taxonomy and biology of the majority of these cetaceans are poorly known, and for certain offshore species the only scientific information available is from occasional stranded animals. All marine mammals are fully protected in South Africa.

Unsustainable whaling practices in the past led to a severe decline in population of large whales, but most are in a recovery phase following the introduction of international protection measures. South Africa closed its last whaling stations in 1975. The two most common large whales observed in the ASCLME area are the southern right whale *Balaena glacialis* and the humpback whale M*egaptera novaeanglia.* Southern right whales calve and mate in South African waters, mainly off the southern Cape between May and December. The nursery ground of the humpback whale is mainly off Mozambique and to reach it from their feeding grounds in the Southern Ocean, the whales migrate northwards through South African waters during May to August, returning in October to December. The dolphins most frequently sighted on the east coast and south coast are the Indian Ocean bottlenose *Tursiops aduncus*, Indopacific humpback *Sousa chinensis* and common *Delphinus spp.* dolphins.

There is a lucrative and well-regulated whale and dolphin watching industry in South Africa with about 16 whale watching areas evenly distributed along the coast from northern KZN to west of Cape Agulhas to reduce negative impacts. Permits are required approach whales and dolphins, with one to two potential permits per area.

Seals are much better studied than cetaceans and their biology, distribution and genetics are well understood and there is general consensus regarding their taxonomic classification. There is only one species of seal breeding on the mainland of South Africa, the Cape fur seal *Arctocephalus pusillus pusillus*. The other five species are rare vagrants. The southern elephant seal and subantarctic fur seal are the most common with two to four sightings per year. The other three species - the Antarctic fur seal, leopard seal and crabeater seal - rarely visit South Africa.

Historically, seals have been killed for food by the KhoiSan. Commercial harvesting for their pelts led to a severe decline in seal numbers, but legislation passed in 1893 regulated harvesting and the seal population made a spectacular recovery. Today, there are almost 2 million seals breeding on 40 colonies, mainly on the west coast. There are two small breeding colonies east of Cape Agulhas, one near Mossel Bay (4000 seals) and one in Algoa Bay near Bird Island (2500 seals), while they are found as far east as East London. Seals also follow the annual sardine run into KwaZulu-Natal during the winter months with many other predators such as fish, sharks, seabirds and dolphins.

I) Issues

- Seals are opportunistic carnivores that feed on a wide variety of prey. They have learned to scavenge from fishing activities, in particular targeting demersal, small pelagic and handline fishing boats. This has led to a strong negative reaction from fishermen who view seals as a pest that competes with them for fish and in the process destroys their fishing gear. Some fishermen retaliate by killing seals at sea by shooting or clubbing them.
- Another cause for concern is the fact that marine mammals accumulate heavy metals and pesticides that may negatively impact their survival and reproductive rates. Transfer of the mother's accumulated load to her first calf may endanger its life.
- Marine mammals and in particular seals benefit directly from fishing in that they scavenge discards and remove fish from fishing lines and nets. However, as fishing activities by humans have reduced fish stocks on which some marine mammal species depend, the reduction in prey resources would have a negative impact on their populations.
- Dolphins, whales and seals are caught and killed in fishing nets and rock lobster traps and for certain species of dolphins this may have negative impacts on their populations. It is therefore necessary to provide means of preventing entanglements.

- Habitat and/or prey of marine mammal populations may be affected by medium to long term ecosystem shifts caused by climate or human activities.
- A survey of existing literature relating to the region's mammals needs to be undertaken.

II) Gaps
- A genetic study and collection of rare stranded animals should be undertaken to better understand the taxonomy and stock structure of cetaceans.
- Further information on the sizes and distributions of populations of cetaceans is required. This would require ship- and land-based surveys and the use of satellite transmitters.
- Studies to investigate the impact of ecotourism activities both on a local and global scale need to be undertaken. Socio-economic studies would greatly enhance knowledge of positive impact of marine mammal tourism on local coastal communities.
- Diet and stable isotope studies are necessary to investigate the prey of marine mammals, their position in the foodweb and to better understand their vulnerability to ecosystem changes.

Reptiles

There are only two groups of true marine reptiles, these being sea snakes and sea turtles. Sea turtles have great value to the people of the region with significant interactions between them for centuries (Plug 2004; Frazier 2005). On the other hand, sea snakes are rarely encountered and very little is known about species frequenting South African waters, such as the yellow-bellied sea snake (*Pelamis platurus*). For this reason, this assessment is focused on sea turtles.

There are seven species of sea turtles in the world, and five of these frequent the Western Indian Ocean. These are leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and olive ridley turtles (*Lepidochelys olivacea*) (Hughes 1974). All sea turtle species are conservation dependent and the two species in greatest need are hawksbill and leatherbacks, both being critically endangered.

The life histories of turtles are largely the same, with mature females coming ashore to nest, laying large numbers of eggs per nest (~50 to 100 depending on the species). The hatchlings return to the ocean where they spend the first half of their life as oceanic, pelagic drifters and then change to a neritic lifestyle (Mortimer *et al.,* 2000). Leatherbacks, however, keep their pelagic lifestyle, feeding permanently on jellyfish (Musick and Limpus 1996; Bjorndal 1996), whereas the other species change their diet from being "jelly-vorous" to carnivorous and in the case of green turtles to largely herbivorous. Sea turtles therefore utilize a broad range of habitats throughout their lives, and all of these habitats must be intact for decades for them to complete their lifecycles. It should therefore raise concern that the turtle populations of the world, this region included, are generally displaying declines.

Monitoring Programmes

A few long-term turtle monitoring programmes have been established in South Africa. These are:
- The long-term nest monitoring programme hosted and funded by Ezemvelo KZN Wildlife (and partners), which started in 1963 and has taken place every season since.
- Bather protection net catches and bycatch monitoring hosted and funded by the Natal Sharks Board, which has been operating in a standardized and consistent means since 1981.
- Longline observer programme managed by CAPFISH and funded by MCM (since 1998) reporting species of turtle caught, date and location. No detailed information such as size and condition is available.
- Strandings and rehabilitation reports by each of the major aquaria in South Africa (uShaka Marine World, Bayworld and Two Oceans) – although patchy.
- Illegal imports/exports through all the monitored ports should be monitored by customs officials.
- A six month bibliographic survey on all published and unpublished literature regarding sea turtles and their habitats for the Southwestern Indian Ocean has been completed. A total of about 400 references were assembled on nesting numbers and distribution of turtles, research and monitoring programmes, as well as impacts on turtles. This was managed as a contract by NMMU and funded by CMS/IOSEA. This bibliography will soon appear as an online database (also on www.IOSEATURTLES.org).

Spatial Information

Spatial information is available on nesting distribution from EKZNW. Satellite tagging information of loggerhead and leatherbacks has been published in Luschi (2003). The data for the last three years (~ 9 leatherbacks) tagged by MCM is not published as the programme is still ongoing.

I) Issues

Impacts on turtles can be summarized into three categories, namely targeted harvesting, incidental mortality and habitat-related: these are discussed below.

Direct Harvesting: Turtle nesting is spread across multiple countries, and the bulk for the southwestern Indian Ocean loggerhead and leatherback turtles takes place in South Africa, with about 15% shared with Mozambique and Madagascar. Nest protection started in the early 1960s as a consequence of large numbers of turtles being slaughtered along the beaches of Maputaland for meat and eggs (McAllister *et al.,* 1965). The nesting beaches of KZN have now been proclaimed RAMSAR sites and MPAs, and have world heritage status, making it illegal to harvest sea turtles, or even disturb a turtle or be in possession of turtle products without a permit (Hughes, 2009). Since this *in situ* protection started, nest raids have become incidental and slaughtering of turtles is rare. The effect has been an increase in the population of both loggerhead and leatherback turtles (Nel 2008).

Habitat Destruction: South Africa also houses noticeable numbers of non-nesting green and hawksbill turtles from rookeries in the Mozambique Channel (Hughes 1974). Exemplary protection is afforded to most of the critical developmental, feeding and nesting turtle habitat through a network of MPAs (Hughes 1974). To a large extent this also eliminates pollution, with a relatively good inshore water quality, especially in the north of the country, and no turtle tumors (fibropapillomas) have been reported yet. Potentially destructive activities such as coastal development also do not take place without proper environmental impact assessments, and tourism activities and turtle viewing, beach driving and research are heavily regulated and require a permit (Hughes 2009). However, there is pressure on the conservation areas adjacent to nesting beaches to be lucrative tourism areas, resulting in aspects such as installing lights in remote areas where dark beaches are required for turtle nesting and hatching (Jacobson and Lopez 1994; Witherington and Martin 1996; Wilson and Tisdell 2001). Other destructive practices such as cyanide and dynamite fishing are rare or absent.

Incidental Mortality The non-natural sources of mortality in South Africa that pose the greatest threat to sea turtles are long lining, with 100 – 600 estimated mortalities per annum (Petersen *et al.,* 2009), followed by gill-netting in bather protections nets with about 50 turtles caught per annum of which about half are released alive (Young 2001; Nel 2008). Shrimp trawling is minimal in South Africa with a very low estimated mortality (<5 per year (Fennesy and Isaksen 2007; Bourjea *et al.,* 2008)). There are no estimates on the number of sea turtles that die through ghost netting, boat strikes or ingestion of plastic. Destructive fishing practices such as coastal gill nets, purse seiners (with FADs) and drift nets are banned in South Africa.

Leatherback turtles nesting in South Africa receive the same legislative and conservation protection as loggerhead turtles, but have failed to show the same recovery (Nel 2008). One potential reason for this is the wandering lifestyle of leatherbacks, while an alternative explanation is in the male-female population structures in Mozambique and South Africa. Either way, leatherback numbers in the South Western Indian ocean are very small, with an estimation of less than 100 females nesting per annum (Lombard 2006; Nel 2008). Any death of a leatherback should be seen as a setback for the local population.

II) Gaps

There are a number of gaps regarding turtles that are currently preventing a detailed population modellimg despite the good data being collected in some of the above mentioned programmes.

Nesting success, emergence success, sex ratios, predation etc. are outstanding components to model natality on the nesting beaches, including the effect of sea level rise and climate change.

Natural and non-natural causes of mortality are not well documented (especially quantitatively). Specific observer information to be obtained should include more detailed information of mortality in all commercial fisheries including longlining. Data that need to be collected include *inter alia* genetic samples, size information, status when released, tagging of released turtles to assess survival, etc.

Experimentation with bycatch reduction methods such as circle hooks, or reduced soak times in longline fishing.

Satellite telemetry information documenting the distribution of loggerheads, hawksbills and green turtles

frequenting South African waters.

Knowledge Gaps & Recommendations
To construct a population model for any given sea turtle population seems simple especially since emigration/immigration factors can be excluded due to nest fidelity. However, the late maturing, complex life history and migratory behaviour make it very difficult to construct a reliable population model for sea turtles.

Population dynamics – natality
The current strength of turtle conservation in South Africa is the well-documented nesting trends of adult females nesting along the coast of KZN. However, nesting success, emergence success, sex ratios, etc. are not well documented – especially with recent environmental changes and tourist use. However, University of Stellenbosch and Nelson Mandela Metropolitan University (NMMU) have carried out research evaluating some of these aspects.

GAP: A complete evaluation of nest success, hatching success, emergence success, sex ratio of both loggerhead and leatherback turtles are required over multiple seasons for the entire rookery, but preferably the entire sub-population, to assess if there is sufficient production of hatchlings to maintain these populations over time.

Population dynamics – mortality
Ezemvelo KZN Wildlife (previously Natal Parks Board) has been monitoring nesting females for over 4 decades. This programme also had a specific experiment where loggerhead hatchlings were notched, with a year-specific code. Now 20 – 30 years later these females are returning providing an estimate of age at maturity and an estimate of survival rate (i.e. natural and non-natural mortality combined). Three sets of data can be used to assess some aspects of mortality. These are;

- The age/size at maturity of loggerhead turtles evaluated by Tucek and Nel.
- The monitoring in conjunction with MCM/CAPFISH and NSB provide an estimate of annual mortality (in South African waters).
- An Honours project (by Wayne Brazier at NMMU) is evaluating the impacts of the shark nets on loggerhead and leatherback populations. This is a similar, but more up-to-date evaluation than Young (2001).

GAP: In order to assess the mortality/survival rates of incidentally captured (and released) turtles, it is recommended that turtles caught in any of the fisheries be documented properly recording size, sex, location (GPS coordinate) and species information (as is currently the case for NSB). Further, each of the animals released need to be tagged by NSB/onboard observers when being released to assess survival rates of release.

Genetic identity
The genetic identity of nesting loggerhead and leatherbacks have been evaluated in terms of the place in the global populations (see Bowen *et al.*, 1994; Dutton *et al.*, 1999).

The genetic structure of the marine turtles of the iSimangaliso Wetland Park wase determined between 2009 and 2012, by a postgraduate student of the Nelson Mandela Metropolitan University.

South Africa has contributed genetic samples to a collaborative project evaluating genetic structures of green turtles in the Western Indian Ocean managed from Reunion Island (Taquet *et al.*, unpublished data).

Migration routes
Females of both sea turtle species are tagged each summer using titanium flipper tags. Each of these contains a return address with a reward notification. Approximately 5 flipper tag returns are received per annum, mostly from loggerhead turtles. These tag returns provide an idea of the foraging areas that turtles frequent in the remigration periods.

Approximately 100,000 loggerhead hatchlings have been notched per annum for approximately 20 years. This provided some indication of the direction and the rate of dispersal of hatchlings along the coast for each of those seasons. Notched loggerhead hatchlings have been reported stranded all along the coast to Cape Town.

Satellite telemetry studies have been conducted for leatherback females and these are ongoing. However, each of the last three seasons indicated a range expansion for leatherback turtles. This indicated that there is still much to learn. Published information on the distribution of nesting females include (Papi *et al.,* 1997; Hughes *et al.* 1998; Luschi *et al.,* 2003; Luschi *et al.,* 2003a; Luschi *et al.,* 2003b; Sale *et al.,* 2006; Luschi *et al.,* 2006 and Lambardi *et al.,* 2008).

GAP: The distribution of all life history stages of turtles in the WIO, including for South African leatherback and loggerhead turtles, are relatively poorly documented. The "lost years" - the post-hatching to sexually mature phase has not been studied at all, with scattered reports of locations but not any idea of the parent population.

GAP: No information is available on the abundance or distribution of the male turtles of any of the turtle species in the WIO, including loggerheads and leatherbacks from South Africa.

Diseases & Pollution
At this stage, the threats and impacts of pollution and diseases on turtles are very poorly documented for the region. There are no reports of fibropapillomas, which may be attributed to good water quality or lack of information.

General

GAP: fisheries impacts outside of the South African EEZ are very poorly covered, with virtually no quantitative bycatch information available in any of the fisheries, or for any of the countries. Bycatch needs to be quantified for all fisheries, how these activities overlap with the distribution of turtle species.

GAP: the effects of climate change will be dramatic to the distribution and sex ratios of turtles, since sex ratios are determined by incubation temperature, and any factor that will affect this, such as ambient temperature, rainfall, erosion and over-wash, will affect the success of the species. There is no clear expectation if the net effect will be positive or negative.

Birds

Seabirds and coastal birds

There are 15 species of seabirds that breed in South Africa, of which 7 are endemic to southern Africa. Additionally, 2 subspecies are endemic to the region (Kemper *et al.,* 2007). Of the 15 species, 10 are classified as Threatened or Near-Threatened in terms of criteria of the IUCN, including six of the endemic taxa (Kemper *et al.,* 2007). Thirteen of the 15 have been recorded breeding east of Cape Agulhas in South Africa's Indian Ocean sector and Leach's storm petrel has been recorded at St Croix Island. Only the bank cormorant is restricted to the southern African west coast (Hockey *et al.,* 2005). More than 70 other seabirds have been recorded in South Africa's Indian Ocean sector, ranging from vagrants to common visitors (Ryan and Rose 1989). In total, 119 species of seabird have been recorded in South Africa waters, including at the Prince Edward islands (Department of Environmental Affairs and Tourism 2007). In addition to the seabirds, the South African shoreline supports 133 species of coastal bird from 27 families (Department of Environmental Affairs and Tourism 2007).

Offshore islands are particularly important breeding localities for seabirds, there being six that are utilized by seabirds in Algoa Bay. These provide the easternmost limits to the breeding range of several southern African endemics, including African penguin *Spheniscus demersus*, Cape gannet *Morus capensis* and Cape cormorant *Phalacrocorax capensis*, species that feed primarily on anchovy *Engraulis encrasicolus* and sardine *Sardinops sagax*. Sardine annually migrate in a north-easterly direction along the coast of KwaZulu-Natal in winter, pursued by flocks of seabirds as well as fish and mammalian predators (Armstrong and Thomas 1989). The islands in Algoa Bay also provide the Indian Ocean's westernmost breeding localities for roseate tern *Sterna dougallii* (Tree 2005).

Seabirds additionally breed on coastal stacks, islets, cliffs, beaches and dunes, as well as in estuaries and lagoons, often utilizing artificial water bodies such as are provided by saltworks (e.g. Martin and Randall 1987). The

dunefields east of Port Elizabeth are the most eastern breeding locality for the endemic Damara tern *S. balaenarum* (Randall and McLachlan 1982). Lake St Lucia is an important breeding locality for great white pelican *Pelecanus onocrotalus*, grey-headed gull *Larus cirrocephalus* and Caspian tern *Sterna caspia* (Hockey *et al.* 2005). Shorebirds make extensive use of the coastline, including sandy and rocky shores, mangroves, mudflats, estuaries and lagoons (Hockey *et al.,* 2005).

I) Issues

Possible impact of environmental change
There has been an anticlockwise shift around the southern African coast in the distribution of several seabirds, which has matched an altered distribution of anchovy and sardine (Crawford *et al.,* 2008b). The anticlockwise shift in the distribution of anchovy and sardine may be related to climate change. This has led to a mismatch in the distributions of breeding localities and prey for several seabirds in southern Africa (Crawford *et al.,* 2008a).

Localised concentrations of large proportions of some global populations
About 70% of the global population of Cape gannets is presently located at Bird Island, Algoa Bay (Crawford *et al.,* 2007) and Algoa Bay supports some 40% of the world population of African penguins (Kemper *et al.,* 2007, Crawford *et al.,* 2009). This renders large proportions of the overall populations of these species susceptible to local events, e.g. disease at one island or an oil spill near Port Elizabeth. The latter is a particular concern given the close proximity of the recently constructed Coega harbour to St Croix Island, which in 2009 held the world's largest colony of African penguins.

Competition with fisheries for food
Seabirds feeding on anchovy and sardine compete with purse-seine fisheries for food and some have suffered large decreases in the past 50 years (Crawford 2007).

By-catch of seabirds
Seabirds are caught and drowned on long-lines or killed through colliding with demersal trawl gear, with substantial impacts on some populations including albatrosses and petrels that breed at the Prince Edward Islands and range north to South Africa's territorial waters (Environment and Tourism 2008).

Disturbance
Disturbance of coastal areas may have adverse impacts for seabirds and shorebirds utilizing the coastal environment (e.g. Randall *et al.,* 2002, Williams *et al.,* 2004).

II) Gaps

Population sizes and distributions
Further information on the sizes and distributions of populations of scarce or vulnerable coastal birds and seabirds is required. Existing information needs to be collated. Threats at breeding, roosting and feeding sites need to be identified.

At-sea distributions
The at-sea distributions of some seabirds are poorly understood. Further tracking of individuals of some species using remote technology is required more fully to investigate their overlaps with fisheries and their susceptibility to other threats. Further studies need to be conducted on the efficacy of closed areas as a means to mitigating competition between seabirds and fisheries for food. Further information is required on the impact of by-catch in fisheries on some seabird populations, and the best means to mitigate it.

Adaptations to environmental change
Means of adapting to influences of climate change, e.g. a mismatch in the distributions of breeding localities and prey of seabirds, need to be addressed, for example to establish colonies closer to food resources.

Disasters

Contingency measures need to be put into place to handle disasters, e.g. outbreaks of disease and oil spills.

Monitoring
The use of seabirds and coastal birds as monitors of climate change in the south-west Indian Ocean needs to be investigated.

Literature survey
There is currently no survey of existing literature relating to the region's birds (seabirds and coastal birds).

Exotics and Invasive Species

Marine introductions are strongly connected to shipping and have occurred mainly via ballast and hull fouling. Both the nature and intensity of these introductions have changed through time (Griffiths *et al.,* 2009b), and today species introduced via ship fouling tend to be dominated by sessile organisms such as ascidians, sponges and mussels, although small mobile crustaceans and other associated infauna may also occur. In contrast, species introduced by ballast water tend to be planktonic (e.g. dinoflagellates or copepods) or have planktonic life stages (e.g. bivalves and hydroids). In addition, large volumes of sediment can be loaded along with ballast water, containing significant numbers of infaunal species that would not be translocated via external fouling (Hewitt *et al.,* 2009). Although no introductions have been linked to aquaculture, the threat from this industry remains significant. Additionally, parasites, diseases and epifaunal species associated with target species may accidentally be introduced (Minchin *et al.,* 2009).

The most recent published account of marine introductions along the South African coast lists only 22 confirmed alien species and 18 cryptogenic species (Griffiths *et al.,* 2009a). However, current work has raised this number to 86 introduced species and a further 40 cryptogenic species (Mead *et al.,* University of Cape Town, unpublished data). Most of these species are confined to the sheltered environments offered by harbours, lagoons and estuaries and only two – the Mediterranean mussel *Mytilus galloprovincialis* and the Pacific barnacle *Balanus glandula* - have become widespread on the open coast. However, only the mussel is found along the south coast (as far east as East London (Robinson *et al.,* 2005)) with no known introductions along the exposed shores of the east coast. In total a further 47 introduced species are recorded from the region. These are known from Knysna Lagoon (23 species), Port Elizabeth (24 species), East London (12 species), Durban (26 species) and Richards Bay (14 species) (Mead *et al.,* University of Cape Town, unpublished data).

I) Issues
Due to the strong link between shipping and marine introductions, the threat from new alien species in the region remains high due to the high volume of shipping processed at Richards Bay and Durban harbours.

Although no introductions along the south and east coasts have been linked to aquaculture, the threat from this industry remains significant. Elsewhere in the world major ecological impacts have been recorded due to naturalization of the cultured species (Minchin 2007). Additionally, parasites, diseases and epifaunal species associated with target species may accidentally be introduced (Minchin *et al.,* 2009).

II) Gaps
At present the ecological impacts of introduced marine species in this region have not been assessed. This should urgently be addressed.

Long-Term Predicted Atmospheric Changes

While there have been advances in exploring the regional expression of global change over southern Africa, the IPCC (2007) assessment report remains the primary resource for large scale projections. Based on the above principles, the IPCC report and regional ongoing work, the current overall understanding of the projections for the Southern Africa sub-continent and associated eastern regions are:

- An increase in temperatures, more so in the interior (2-5°C by the second half of the 21st century) than on coastlines or over the oceans (1-3°C).
- East coast wetting, including an increase in the intensity of rainfall and associated risk of extreme events, flooding, and high volume runoff, most especially where there is strong topographical forcing.

- An increase in long shore wind strengths (primarily during the summer) along the southern and south-east coastlines.

These conclusions are based on recognizing the Southern Africa region is one of high variability on seasonal to inter-annual scales, regionally dominated by the oceanic high pressure systems and the mid-latitude westerlies to the south, and modulated by hemispheric and global scale modes of variability.

The GCM projections for the 21st century indicate a strengthening of the sub-tropical oceanic high pressure systems, a poleward retreat of the mid-latitude westerlies, but with uncertain changes in the tele-connection relationship to El Nino. An associated increase in atmospheric humidity is related to intensified rainfall when rain does occur over South Africa. The increase in temperature, however, is a significant factor leading to likely reduction in overall mean soil moister for the extra-tropical regions. Downscaled projections performed in South Africa, based on the GCM large scale changes, do allow for additional detail at local spatial scales. This also reveals local scale changes consistent with the general patterns of change, yet with significant local scale complexity especially in relation to coastal regions and regions of complex topography.
Figure 14 shows the median rainfall seasonal anomaly (mm) downscaled from 9 GCMs of the CMIP-3 archive, showing the regional response by mid-21st century under a moderate to high growth greenhouse gas emissions scenario (based on the downscaling method of Hewitson and Crane 2006).

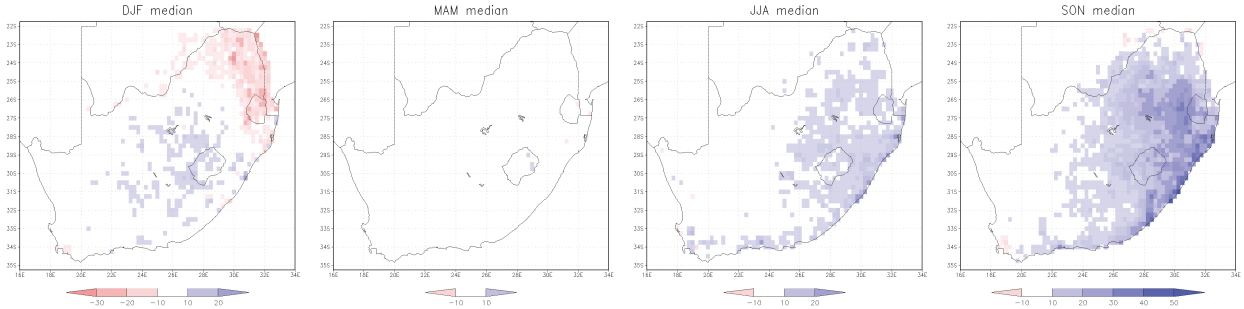


Figure 14: Median rainfall seasonal anomaly (mm) downscaled from 9 GCMs of the CMIP-3 archive, showing the regional response by mid-21st century under a moderate to high growth greenhouse gas emissions scenario (based on the downscaling method of Hewitson and Crane 2006)

I) Issues

- At the local and regional scale, the envelope encompassing the range of possible change remains large. Difficulties largely relate to the magnitude of change rather than the direction of change. The weak areas in understanding projected change are due to the resolution issues of what the models are able to capture, and the quality of the downscaling used to regionalize the GCM information. The largest concern in this regard is the temptation to select one model, or one data product, and over-interpret this possibly leading to inappropriate response actions.
- Addressing concerns related to the limitations on the science of projecting climate change requires concerted efforts on a number of fronts, and is complicated by the limited infrastructural and human capacity in the Southern Africa region.
- Further compounding these issues is the question of data availability. Across the South African region there are notable gaps in the observational system, while there is a need for data rescue of old archives. Access is limited through regulations or infrastructural constraints. The marine sector is notably constrained in this regard.
- While the above are areas of concern in relation to the core knowledge base, there is equally a limitation in relation to the translation, tailoring and communication of climate projections, especially in regard to users understanding the limitations and assumptions of different data products. Little attention is currently given to this issue, with the consequence that data products are readily treated as more authoritative then their underlying robustness would allow for. In general, the awareness of the nuanced nature of regional climate change in relation to the robustness of global scale warming is not well understood.

II) Gaps

- There are a broad range of gaps in the complexity of projecting regional climate change. However, in considering the weakest links, the main gaps would include the following:

- A lack of a consistent analysis of uncertainty in relation to regional scale projections.
- Weak analysis of historical change compounded by a highly variably regional climate and a poor signal to noise ratio.
- Gaps in understanding the dynamics of the coupling and feedbacks of the climate system and how this may modulate the regional response to global change.
- Frameworks to communicate and disseminate climate information to users remain limited, especially in regard to effective communication of the information content of data products.

HUMAN ENVIRONMENT

Coastal Populations

According to the Mid-year Population Estimates released by Stats SA in July 2009, the population of South Africa is estimated to be 49.32 million. Out of this total population, 21.2% is concentrated in KZN, 13.5% in the Eastern Cape and 10.9% in the Western Cape (Figure 15). According to the State of Environment Report, 40% of South Africa's population lives within 100 km of the coast. In the ASCLME region the coastal population is concentrated in the cities of Durban, East London and Port Elizabeth. There is also a large rural population along the Wild Coast.

Of the total population, 79.3% is black African, 9.1% White, 9% Coloured and 2.6% Indian/Asian. Some 52% of the population is female and nearly one-third of the total population is younger than 15 years of age. Also, approximately 7.5% of the population is 60 years or older. The country has 11 official languages. In the coastal provinces of the ASCLME region, Zulu is the dominant home language in KZN, Xhosa in the eastern parts of the Eastern Cape, and Afrikaans along the southern parts of the Eastern and Western Cape. English is commonly spoken in urban centres and is the *lingua franca* of the country based on the mid year Population Estimates released by Stats SA in July 2009 (http://www.statssa.gov.za).

Migration is an important demographic process in shaping the age structure and distribution of the provincial population. For the period 2006–2011, it was estimated that approximately 390,000 people migrated from the Eastern Cape, primarily to the central provinces of Gauteng and the Western Cape. South Africa is also heavily impacted by international migration. Since 1996, there was an inflow of one million Africans and an outmigration of 500,000 of mainly Whites.

The socio-economic character of the coastal regions varies considerably (Avis *et al.,* 1998; Davey-Moran *et al.,* 1998), and in the north the Maputaland region is characterised by a sparsely distributed, rural population with a low per capita income. The inhabitants belong to the Shangaan-Tsonga group, and most practise subsistence agriculture. Farther south, the Zululand region is predominantly rural, but there has been a marked increase in the urban population over the last three decades due to the development of the industrial areas of Richards Bay, and Isithebe-Mandeni. Sugar-farming and timber-growing plays a vital role in the region's economy.

Durban is the largest city within South Africa's ASCLME region, with a thriving commercial and industrial sector that has resulted in an influx of people in search of jobs and a better quality of life. The Dolphin and Hibiscus coastal regions to the north and south contain a number of small residential nodes, with the economy dominated by agriculture, light industry and tourism. There is extensive recreational harvesting of inshore marine resources, and some subsistence use, while the coastal strip is considered prime real estate and is highly developed.

The Wild Coast is one of the most under-developed areas of South Africa. The population is primarily engaged in rural subsistence activities, with those living at the coast supplementing their diet with intertidal resources. There are only a few coastal settlements and small holiday resorts. The Border/Kei region surrounds East London, which has a port serving the city's industries, dominated by the motor, textile and pharmaceutical trades.

Port Elizabeth is the fifth largest city in South Africa and the largest in the Eastern Cape. Its port supports the manufacturing and service industries, as well as a fishing fleet. Fishing boats in the linefishery and squid-fishery also operate from small-boat harbours at Port Alfred and Cape St Francis, with the coastal strip being popular for holiday and retirement homes.

The Garden Route is a premier tourism and retirement destination, while forestry remains a significant land use. There is a substantial fishing harbour at Mossel Bay, and the area also experienced sudden growth in the 1980s with the development of the Mossgas Project. Farther west to Cape Agulhas is a sparsely populated agricultural area, with small development nodes of holiday and retirement homes, mainly at estuary mouths.

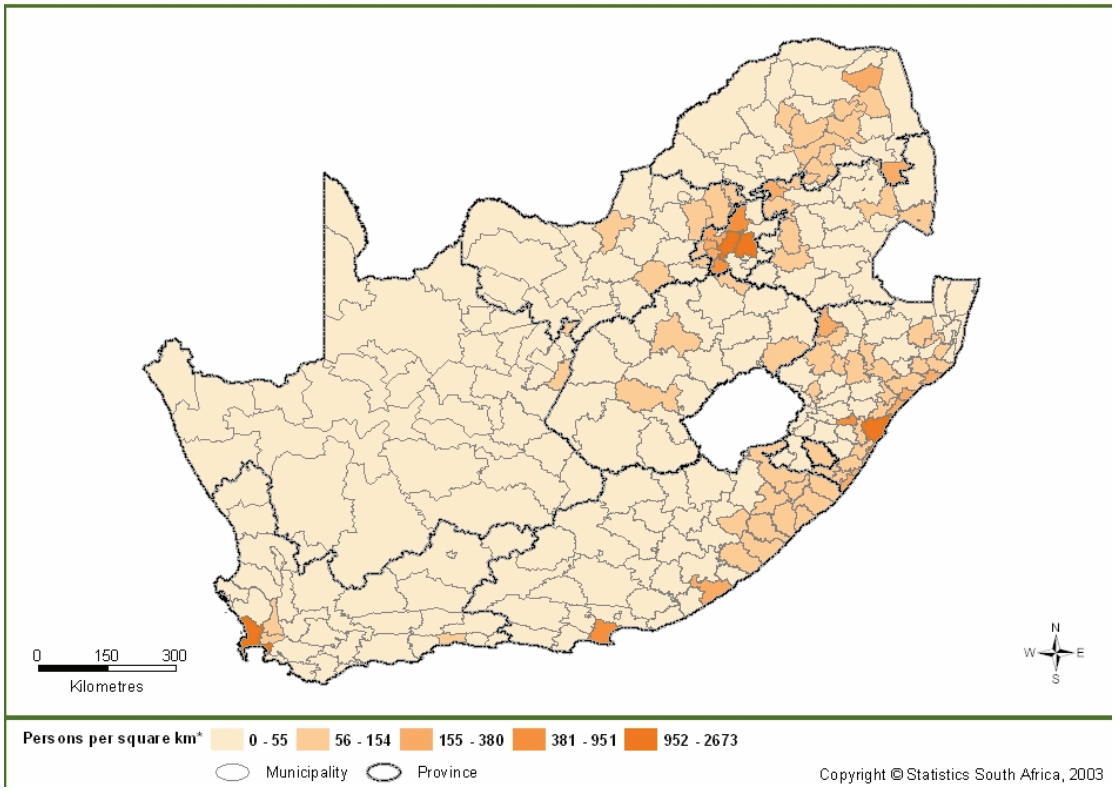


Figure 15: National population density in 2001, according to Census 2001 data.

I) Issues

Water supply and contamination issues

The influx of people to coastal towns (KwaZulu-Natal, the Port Alfred and Cape St Francis and Port Elizabeth, and the Garden Route) has placed tremendous pressure on water supply infrastructure and services. Most of the coastal settlements have inadequate water supplies, and those that source water from boreholes close to the sea or from desalination plants, must contend with brackish water. Expansion and development of new coastal settlements and resorts is constrained by such water supply problems. Most of the homes along the coast make use of septic tanks for sewage disposal. However, overflows and leaks cause groundwater contamination as well as nutrient enrichment of estuarine and inshore environments.

Development pressure along the coastline

The intense development pressure on the coastline threatens natural biodiversity and its ability to provide ecosystem services such as protection from storm damage. Many linefish species targeted by increasing numbers of recreational fishers are considered severely overexploited, while development is in danger of ruining the aesthetic appeal of scenic areas. The lack of effective land use management and spatial development planning by local Municipalities, particularly in the underdeveloped former homeland areas such as Kwa-Zulu, Transkei and Ciskei, has also facilitated strip development along many parts of these undeveloped coastal areas.

Poverty and pressure on natural resources

Along the coastal sections of the under-developed former homeland areas such as Kwa-Zulu, Transkei and Ciskei, high rural population densities, pervasive poverty, lack of development and very limited control over natural resource use have resulted in unregulated and illegal stripping of coastal shellfish and other natural resources for subsistence consumption. In some cases, disputes over land and natural resources have also resulted in considerable conflict between local communities and the conservation authorities.

Abalone poaching

Abalone poaching for illegal export to lucrative Asian markets has been a major activity along the South African coastline over the last decade or more. While there has been some success in curbing poaching activities along

some parts of the coastline, attempts by conservation authorities to enforce compliance with regulations in many areas have been undermined by capacity constraints and threatening and violent tactics used by poachers. Some efforts are also now being made to facilitate the commercial production/farming of abalone for the export market.

Land degradation and erosion

Unsustainable, intensive commercial land uses (i.e. forestry, sugarcane and livestock) and, in the poverty-stricken communal areas, heavy livestock grazing pressures and poor land use management practices, results in high levels of land degradation and soil erosion. This has resulted in heavy sediment loads in many rivers and their associated estuaries and coastlines.

Management of marine resources and coastal development

Conservation of marine resources and the management of their use is a responsibility that is shared by a number of different authorities along the South African coastline. The Marine Protected Areas (MPAs) along the coast are managed by a variety of provincial and national government institutions such as South Africa National Parks and the various provincial departments of Environmental Affairs. The monitoring and management of the use of marine resources outside of these MPAs is the responsibility of Marine and Coastal Management (MCM). The ability of these authorities to ensure compliance and conservation is constrained by capacity constraints.

The local municipalities along the coastline are responsible for land use development and planning in the non-reserve areas as well as the management of municipal waste and public facilities. In general, most of the local municipalities are under staffed and have problems securing and keeping suitably qualified staff. This is particularly problematic for more rural municipalities. .

Climate change

Property owners and local municipalities along South Africa's coastline have recently faced a variety of problems relating to storm damage. Climate change is expected to increase the frequency and intensity of storm events and associated coastal flooding. In some areas it will likely also result in more frequent droughts. Increasing water scarcity will increase pressure for dam/water storage projects and water extraction from rivers and groundwater aquifers, which will probably have negative effects on rivers and estuaries. In the long term, climate change may also have negative impacts on some productive economic activities, and could result in population movements.

II) Gaps

Given the above mentioned issues of concern, the following interventions are recommended as a means of promoting sustainable use and conservation of marine and coastal resources:

Capacity building to facilitate regulation of coastal development

Local Municipalities need assistance with planning and regulating development along the coastline and formulation of effective disaster management plans. This assistance should include building their financial, physical, organisational and human resources capacity which is necessary for planning, regulating and ensuring compliance.

Enhancing compliance with coastal and marine regulations

MCM, SANPARKs and other provincial and municipal authorities need assistance to develop appropriate regulations and build their capacity to ensure compliance. This assistance could and should include building their financial, physical, organisational and human resources to ensure compliance. These bodies also need to facilitate the participation of non-government stakeholders in the management of coastal resources and their use and look for ways to extend conservation and management efforts beyond the boundaries of formally protected MPAs.

Poverty alleviation and promotion of food security

In the disadvantaged rural areas, and amongst the urban poor, there is a need to alleviate poverty and promote

food security in order to reduce pressure on coastal and marine natural resources. Ultimately, poverty alleviation requires facilitating effective and productive participation in the national and international economy. Key priorities include projects which can provide access to cash incomes through jobs or business opportunities; assist people to access the resources they need to make productive use of the land and other human resources they have; provide alternative sources of food to natural coastal and marine resources, or provide effectively regulated sustainable commercial use of such resources.

Improving water use and sanitation

Projects that make residents, holiday makers and tourists more aware of the need for water conservation and appropriate management of wastewater and other kinds of sanitation related problems, should be supported. Projects that facilitate more efficient use of water and harvesting of rainwater would also help to alleviate the pressure on coastal freshwater resources and their associated coastal and marine environments. The development of appropriate policies on desalinisation water projects and measures needed to ensure the protection of the marine and coastal environments associated with such projects should also be invested in.

Climate change

There will be a continuing need to monitor climate change and its impacts, particularly in the marine and coastal environments. It will also be necessary to invest resources in developing effective adaptive strategies.

Sites of Historical, Religious or Cultural Significance

The South African Heritage Resources Agency (SAHRA) is the Government agency charged under the National Heritage Resources Act (NHRA) of 1999 with the protection and management of South African heritage. According to the Act, SAHRA must identify those places with qualities so exceptional that they are of special national significance, while provincial heritage resources authorities must identify those places which have special qualities making them significant in the context of the province or a region. The Act affords protection to structures older than 60 years as well graves and traditional burial places, archaeological, palaeontological and meteorite impact sites, and public monuments and memorials. None of these may be destroyed, altered or disturbed without a permit issued by the relevant provincial authority.

Maritime archaeology: The NHRA also provides strong legal protection for underwater heritage and historical wrecks in South African waters. Archival research has already identified more than 2700 vessels known to have been lost along the South African coast since 1500, including wrecks from 37 different nations. The Act provides blanket protection for any wreck or wreck material over 60 years of age and no person may, without a permit, "destroy, damage, excavate, alter, deface, or otherwise disturb" any wreck or wreck site. It is also an offence to own, collect, trade or sell any wreck material. Nonetheless, many of the accessible wrecks have been damaged by the divers who visit them, and the SAHRA has produced a "Notice to Divers" sign and poster, which outlines the legal position of wrecks.

Regional highlights: A brief description of some cultural highlights of the coastal regions, from north to south is given below (Avis *et al.,* 1998, Davey-Moran *et al.,* 1998).

Archaeological sites along the KZN coast date predominantly from the Early (250-1000 AD) and Late Iron Age (1000-1840AD), the period when black agricultural groups moved into and settled in the subcontinent. Sites generally take the form of shell middens and attest to an extremely long history of harvesting along the eastern seaboard. The *iSimangaliso Wetland Park* includes the Tembe-Tsonga artisanal fishtrap system in the Kosi lakes, probably the most significant cultural feature on the Maputaland coast as they represent the last occurrence of a traditional fishing technique dating back 700 years. The Catalina flying-boat harbour and RAF station on the eastern shores of Lake St Lucia played a significant role in coastal defence during WWII while the St Lucia Lighthouse and the meteor crater site at Kosi Bay are also important heritage sites.

In the Mbonambi area three sites within the dune cordon have been identified as culturally significant by the Mbuyazi Traditional Authority. Ntongande, named after a founding *iNkosi* of the lineage, was historically a refuge during times of civil unrest, while the adjacent Mananga dune is the burial site of 14 subsequent Mbuyazi *amaKhosi*, and *KwaMabodla* is the site of the homestead of a celebrated Mbuyazi *sangoma* of the 18th

Century. In the Sokhulu area the burial sites of five Mthiyane *amaKhosi* are conserved by the local community through ritual restriction and avoidance taboo. As a result, five discrete patches of climax dune forest (about 10 ha each) have remained preserved within an area dominated by commercial plantations.

The region has a number of sites associated with internecine Zulu and colonial conflicts. Port Durnford was an embarking and landing site for maritime cargo in the last century, and is the place where the captive Zulu King, Cetshwayo, was taken into exile in 1879. The battles of Ndondakasuka were the scenes of heavy fighting during the Anglo-Zulu War of 1879, while Fort Pearson and Fort Tenedos on the banks of the Tugela River, mark a wagon-route fording point and also the limit to which shallow-draft seagoing vessels could sail. The groves of Raffia palms at Mtunzini are a Provincial Heritage Site.

Durban has a large number of heritage sites in the form of historically important buildings, but it is the Beachwood Mangroves at the mouth of the Umgeni River that are of most relevance to the coastal environment: the reserve is now a provincial heritage site. Further south along the Hibiscus Coast, shell middens representing both Late Stone Age and Iron Age occupations, are the dominant archaeological feature, while San rock art is also present. There are early harbour and port facilities, pioneer agricultural settlements, the remains of the Alfred County Narrow Gauge line, and colonial-period seaside retreats.

There are several lighthouses of historical and cultural importance along the coast: Port Shepstone near the KZN border, Hood Point on East London's West Bank, Great Fish Point, Cape Recife at Port Elizabeth and Cape St Francis. The Diaz cross, just east of Algoa Bay, marks one of the landing sites of Bartholomew Dias. On the Wild Coast, there are two famous shipwrecks at Mkambati - the Sao Bento (1554), and the Grosvenor (1782).

Middens also occur along the entire Eastern Cape coastline, mainly in the dunes. These represent sites of 'Strandloper' dwellings, and Klasies Cave, near Plettenberg Bay, is regarded as an archaeological site of international importance. It was occupied by Middle Stone Age people between 125,000 and 70,000 years ago, and later re-occupied by Late Stone Age people.

Further along the Garden Route, Mossel Bay has a number of important heritage sites such as the Bartolomeu Dias Museum Complex, Post Office Tree and St Blaise Lighthouse. In the Agulhas Region there are historical fishing cottages, and of particular importance are the traditional stone fishtraps, known as viswyvers. The Cape Agulhas lighthouse – the 3rd to be commissioned in South Africa in 1849 – marks the western boundary of the ASCLME region.

I) Issues

Many of the accessible wrecks around South African coast have been damaged by the divers who visit them. While some of this damage is the result of anchoring on the site, the vast majority is from divers looting sites for souvenirs. Both are indicative of a lack of understanding of the importance, fragility and non-renewable nature of underwater cultural heritage.

Despite the fact that historical wrecks have enjoyed legal protection as archaeological sites in South Africa since 1986, there remains a belief amongst some divers that wrecks are an underwater 'scratch patch' where anything found is free for the taking.

II) Gaps

Generally, most of the heritage resources along the South Africa coastline are legally protected and many of them are well known and are conserved. The growth of tourism in South Africa has resulted in more attention being given to the protection of heritage resources and attractions. Consequently, no serious gaps have been identified.

Human Health

Access to potable water: A safe supply of drinking water and hygienic sanitation practices are vital for protecting human health. In February, 2001, the South African government made a policy decision to provide 6000 litres of free water to households per month. As of October 2009, 86% of the poor population of 23 million (earning

less than R800/month) now enjoys access to free water (Figure 16). The water is not necessarily delivered as piped water, but may be supplied either by trucks or is supplied from communal taps and tanks (StatsSA 2003). A small number of diarrhoea outbreaks raised concerns about the quality of drinking water supplied by some municipalities, especially in rural areas. Urgent attention to improving monitoring and disinfection of rural water supplies is required in order to minimise the risk of bacteriological failure (DWAF 2009).

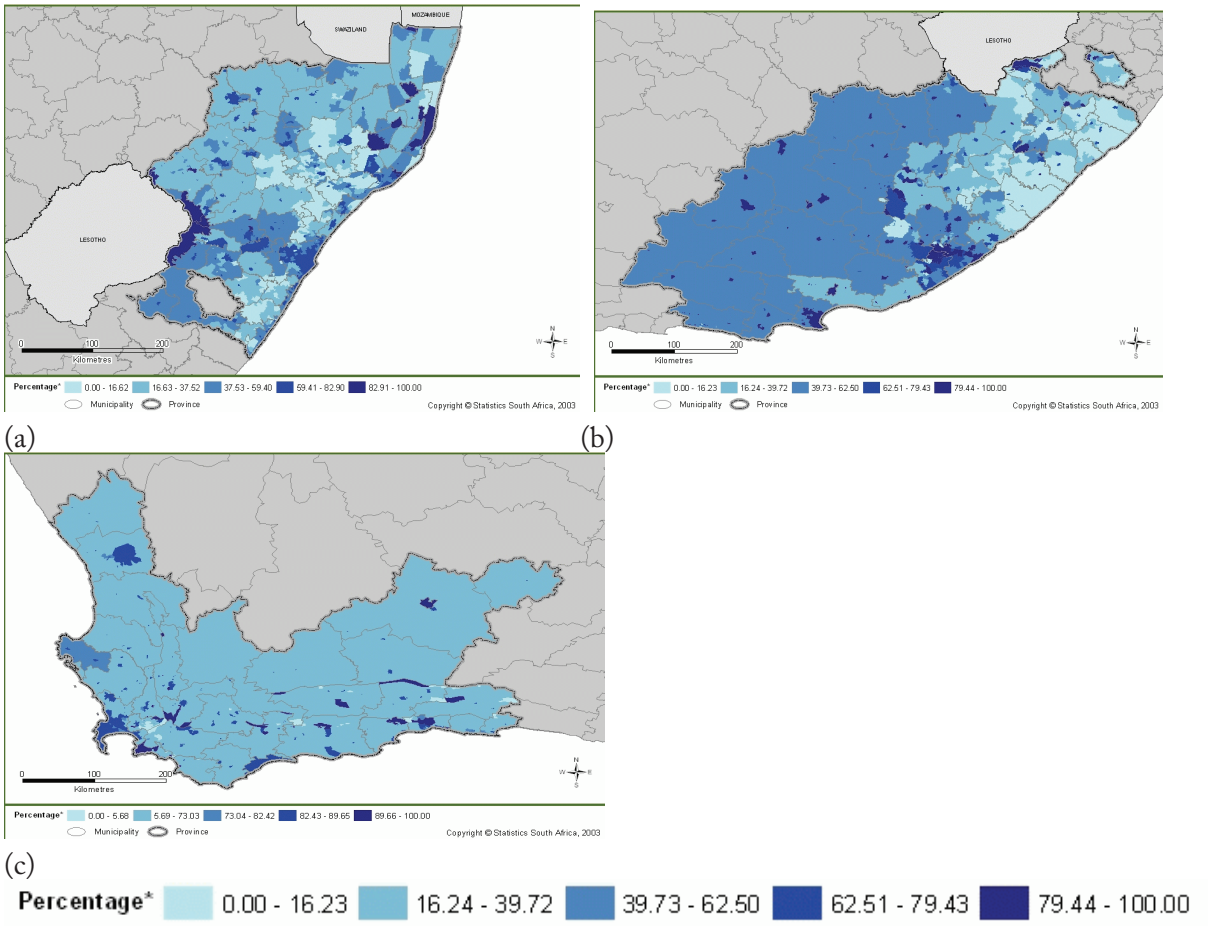


Figure 16: Percentage of households with access to piped water in 2001, according to Census 2001 data, in (a) KwaZulu-Natal, (b) Eastern Cape, (c) Western Cape

Sanitation: Community Survey 2007 (Stats SA 2007) revealed that a little more than 60% of households countrywide had access to a flush toilet. However, in the Eastern Cape 25.2% of households have no toilet facilities at all. Less than 1% of households had chemical toilets, while 13.2% and 8.2% had pit latrines with ventilation in KZN and Eastern Cape, respectively. The Wild Coast and some inland areas of KZN areas are particularly under-resourced in this regard, despite the fact that the coastal strip in KZN is dominated by well-serviced holiday towns (Figure 17).

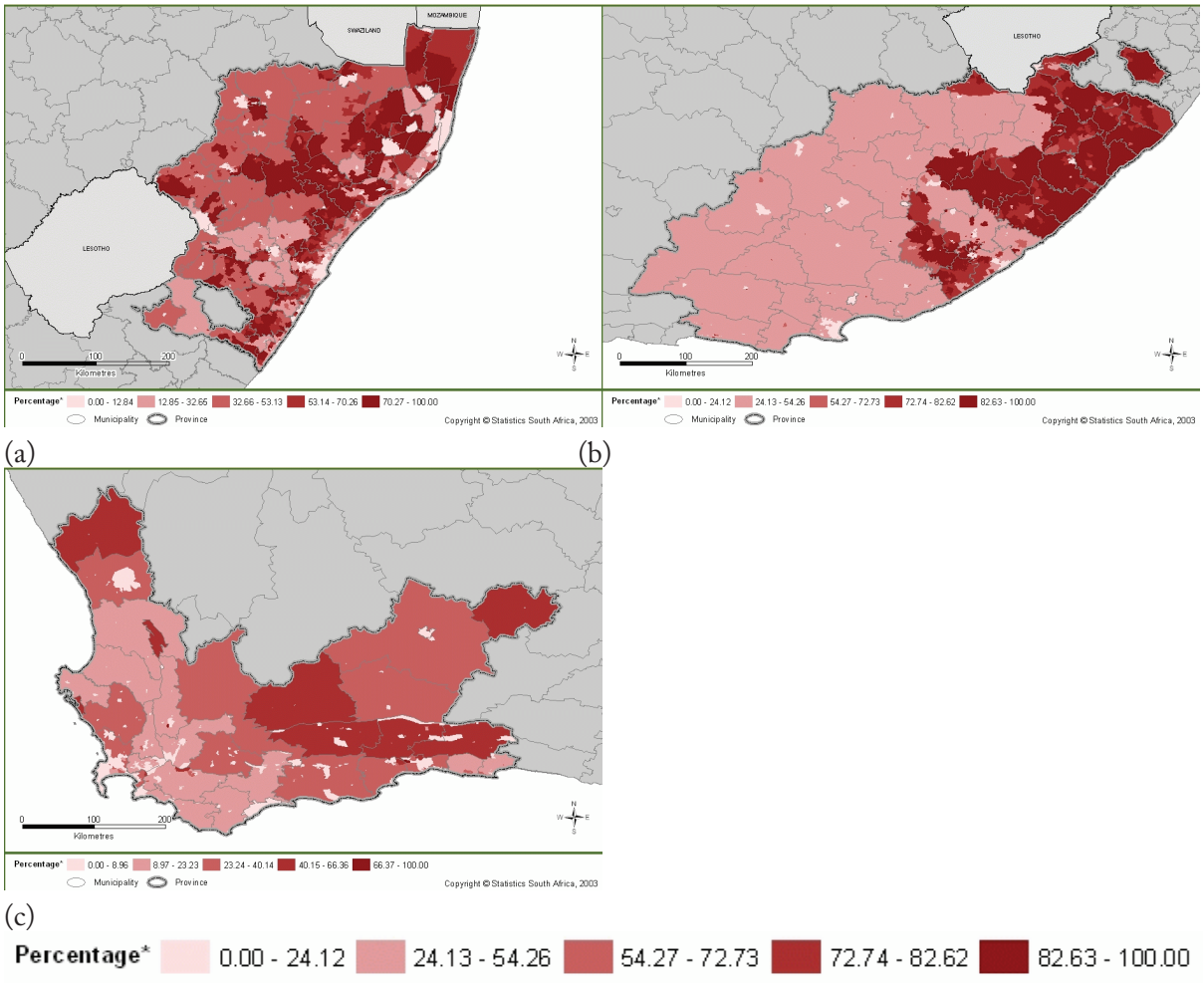


Figure 17: Percentage of households without 'improved' toilet facilities in 2001, according to Census 2001 data, in (a) KwaZulu-Natal, (b) Eastern Cape, (c) Western Cape

Life expectancy and the impact of HIV: In South Africa, life expectancy at birth is currently estimated at 53.5 years for males and 57.2 years for females. The infant mortality has decreased from 63 per 1,000 live births in 2001 to an estimated 45.7 in 2009. The fertility has declined from an average of 2.87 children per woman in 2001 to 2.38 children in 2009 (Stats SA 2009). In 2009, the number of births is estimated at 1,044,900 and the number of deaths at 613,900, 43% of which are attributable to AIDS. The number of AIDS orphans is estimated at 1.91 million. The overall HIV prevalence rate is approximately 10.6% with an estimated 5.21 million people infected, which includes17% of the population aged 15–49 years. The total number of new HIV infections for 2009 is estimated at 413,000, including 59,000 children. Approximately one-fifth of South African women in their reproductive ages are HIV positive. In 2009 it was estimated that 800,000 adults over the age of 15 years and 70,000 children were receiving antiretroviral drugs. Also, 1,524,000 adults and 106,000 children are in need of antiretroviral treatment.

Education: In South Africa, schooling is compulsory for all children aged between 7 and 15 years, and the overwhelming majority were attending school in 2001. However, there are still disparities in education caused by the apartheid past. In 1996, only 3.0% of black Africans aged 20 years and above had attained a post-school education. This number increased to 5.2% by 2001, while among whites it increased from 24.1% to 29.8% (Figures 18 and 19 show schooling statistics per province). Countrywide, in 2001 there were approximately 4.6 million people aged 20 years or more with no schooling, and 94.0% of these were black Africans (Stats SA, 2003). Stats SA (2005) concludes that there has been an improvement in access to education over the time period between the two censuses. Among people aged 20 years or more, there is clear evidence of an increase in the proportion of people with higher educational levels, and larger numbers are obtaining at least some secondary education or completing their secondary education and attaining tertiary qualifications. There was also a tendency for people to enter educational institutions at an earlier age and in 1996 the largest number of attendees at an educational institution was at the age of 12 years. This had decreased to 10 years in 2001. The

quality of teaching in schools in different areas of the country varies, but the fact that some black African and coloured children are moving through the system rather slowly implies that improvements are necessary.

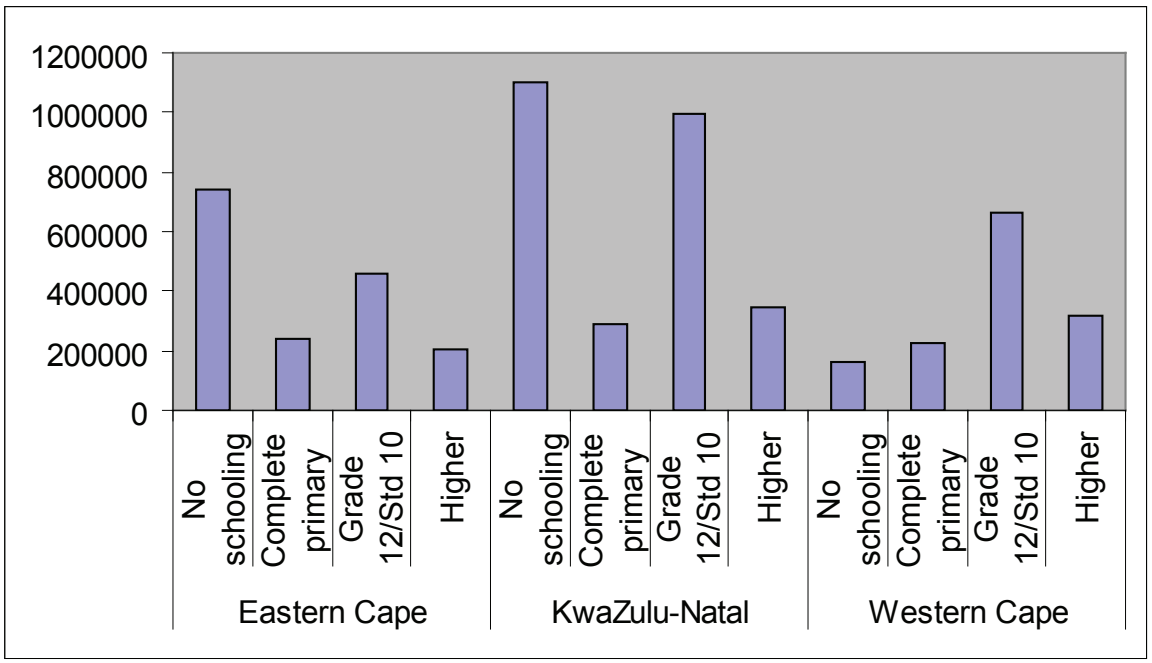


Figure 18: Numbers of persons over the age of 20 years with no schooling, primary education, secondary education, and tertiary education in the three coastal provinces of South Africa's ASCLME regions in 2001

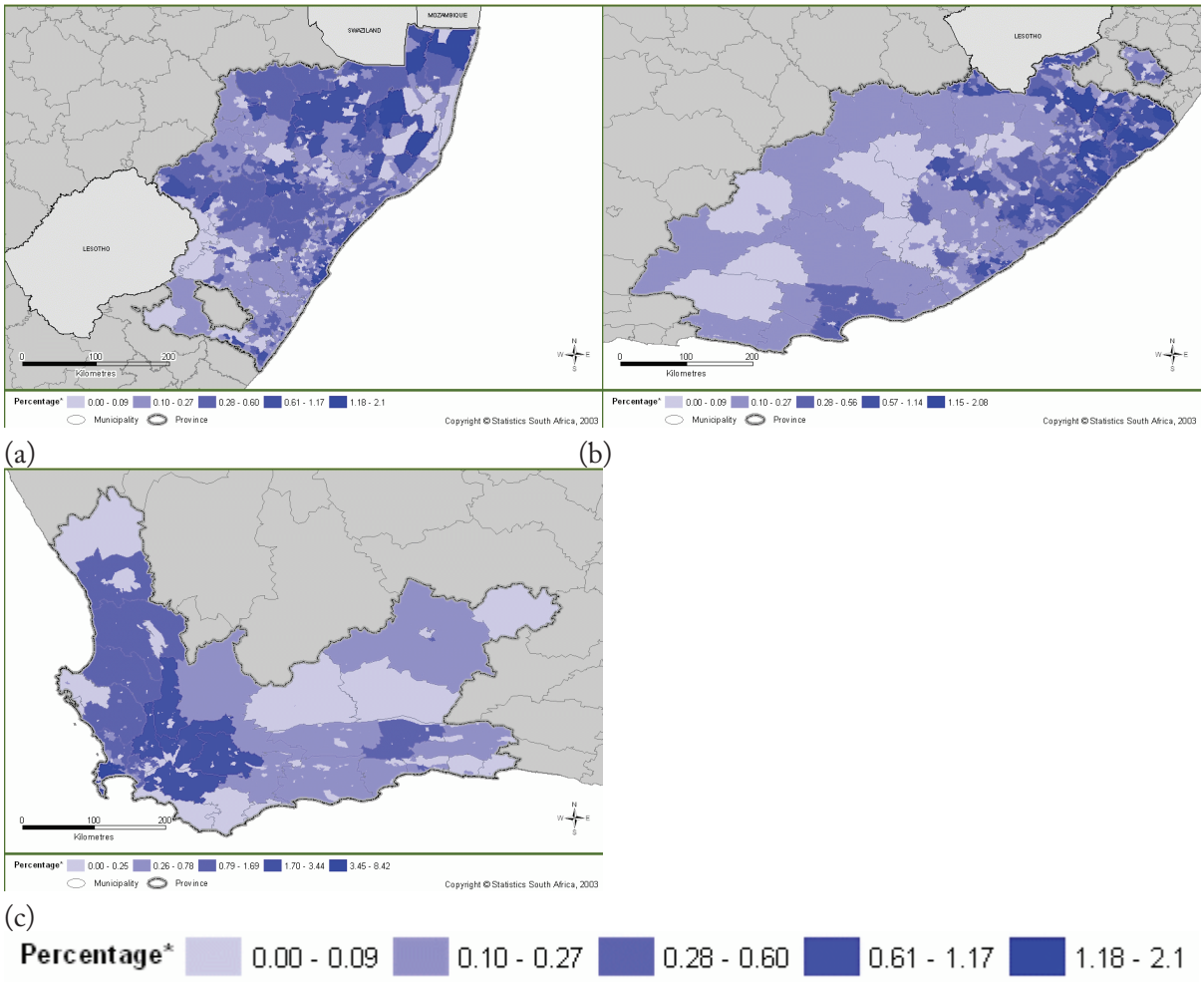


Figure 19: Percentage of Persons over the age of 20 years with no schooling in 2001 in (a) KwaZulu-Natal, (b) Eastern Cape, (c) Western Cape

I) Issues

Apart from obvious concerns about the health and welfare of all South Africans, a number of the aspects discussed above have implications for the country's marine and coastal environment. For example, untreated sewage from bucket toilets, pit latrines and septic tanks may enter the coastal zone via stormwater runoff or groundwater flow. Large volume of poorly treated sewage effluent is discharged into rivers from wastewater treatment works. This may result in the degradation of coastal water quality and diseases.

The poor education levels in some parts of the country limit the ability of the already disadvantaged people to secure employment opportunities and thus limit their alternatives to a subsistence lifestyle. Along the Wild Coast (former Transkei homeland) of the Eastern Cape, as well as parts of the KwaZulu-Natal coast, rural communities rely heavily on intertidal marine resources to supplement their diet. In some places along these coastlines, the rocky shores are regularly stripped of all sessile organisms posing a severe threat to biodiversity and the sustainability of these resources.

Given the large disparities in income and education amongst different population groups in South Africa, there are considerable differences in attitudes towards conservation and to Marine Protected Areas. While there is resentment among the poor, on the one hand there is considerable support for conservation efforts by many wealthy local residents and holiday homeowners, as well as from nature-based tourism developers/operators, and the local conservation organizations and environmental activists.

However, there are also many wealthier visitors and residents of the area who are not environmentally aware and do not actively support conservation efforts. Many of these people are attracted to the area because of the fishing or other recreational activities available and are opposed to conservation efforts that are perceived to restrict their recreational activities and lifestyles.

In addition, there is the 70% of the population (mostly black Africans or colored people) who live in poverty. These depend on natural resources for their water, sanitation, fuel wood, building materials and food and medicinal supplies. The collapse of the local fishing and timber industry and the creation of protected areas are viewed as the cause for considerable unemployment and economic hardship and decline in many of these coastal communities. It is not surprising therefore that such communities have developed negative attitudes towards the conservation of marine and forest resources.

Recent fisheries licensing processes aimed at restricting fishing effort are also perceived to have benefited the commercial sector more than the small-scale coastal fishing sector. The recent attempts to develop a Bay Management Proposal for the Plettenberg Bay area has shown that there is considerable resistance to the expansion of MPAs from such disadvantaged communities and from local commercial and recreational fishermen. As a consequence of this, more emphasis is being placed on management and control areas – rather than exclusion zones.

Much of the growth of tourism along the Garden Route, Eastern Cape and Kwa-Zulu Natal coastlines have been associated with the construction of holiday homes and has not generally alternative livelihoods for most of the disadvantaged. The influx of visitors during the summer and other holiday periods is not sufficient to sustain the development of a viable (non-seasonal) retail and service sector. In addition, many of the disadvantaged residents in these areas cannot access jobs in the tourism sector due to their spatial dislocation from tourism sites/centres and their lack of suitable language, managerial and practical skills for the sector. This difficulty in securing access to the economic benefits of tourism represents an additional obstacle to the transformation of local attitudes towards coastal/marine conservation and MPAs.

So while there is considerable support for conservation effort, there is also considerable apathy and opposition. The development of coastal- and nature-based tourism has encouraged the growth of environmentalism, but the skewed distribution of access to and economic benefits from these developments effectively limits the extent to which it can be used to expand support for conservation measures. The key to achieving sustainable economic growth based on coastal- and nature-based tourism will lie in shifting it from a seasonal to a sustained economic activity that provides economic opportunities for all sectors of society, but particularly for the poor.

II) Gaps

Sanitation

In order to address the problems of sewerage polluting rivers, estuaries and coastlines, there is a need to support projects aimed at introducing, upgrading and managing sanitation systems and sewerage treatment facilities. The capacity of the Local Municipalities to monitor water quality and manage these systems needs to be developed. Effective monitoring will facilitate the identification and management of potential problems.

Education and attitudes towards natural marine and coastal resources

More positive attitudes towards and support for the management of resource use and conservation in the coastal and marine areas, for the large poor majority of the population can only be achieved through a combination of programmes that alleviate poverty and dependence on natural resources with conservation programmes that increase environmental awareness. However, environmental education projects initiated in the absence of poverty alleviation measures that give poor people realistic alternatives to using natural resources will have little or no effect.

Infrastructure

South Africa has a modern and well-developed transport infrastructure servicing its cities and ports, but parts of the country are relatively poorly serviced.

Ports

The South African coastline has historically been an important international trade route and remains so today. South Africa has six major commercial ports along its coastline that facilitate international trade and shipment of goods, namely Richards Bay, Durban, East London, Port Elizabeth, Cape Town and Saldanha Bay. A new deep water port, Ngqura, is also under construction at Coega, close to Port Elizabeth. All of these ports are managed by Portnet and major advances in efficiency and standards have been made over the last decade. Besides the construction of the new harbour at Ngqura/Coega, there are also major port expansions underway in Durban.

Most of these ports have specialised facilities for exporting local goods. For example, Durban handles general cargo, especially cereals, Cape Town specialises in fruit, wine and vegetables, Saldhanha was built to export mineral ores from the northern Cape, while Richards Bay was built in the mid 1970s to export coal. However, most have been expanded and upgraded to cater for importation as well. There are also considerable ship-repair facilities and a major waterfront tourism development in Cape Town's harbour. In addition, the growth of tourism in South Africa over the last decade and the country's long beautiful coastline make the ports attractive stop-overs for large passenger liners.

The new deepwater port of Coega/Ngqura is part of a newly developed 12 000 ha Industrial Development Zone (IDZ), which will serve as a primary location for new industrial development for export-driven industries. Various smelters and other industries wishing to export minerals and other products are considering investing in the IDZ. The potential for developing South Africa's first oil refinery in this IDZ is also currently under investigation.

Roads

The South African road network comprises some 532 000 km of proclaimed national, provincial and municipal roads, and about 220 000 km of unclassified roads, most of which provide rural access (Figure 20).

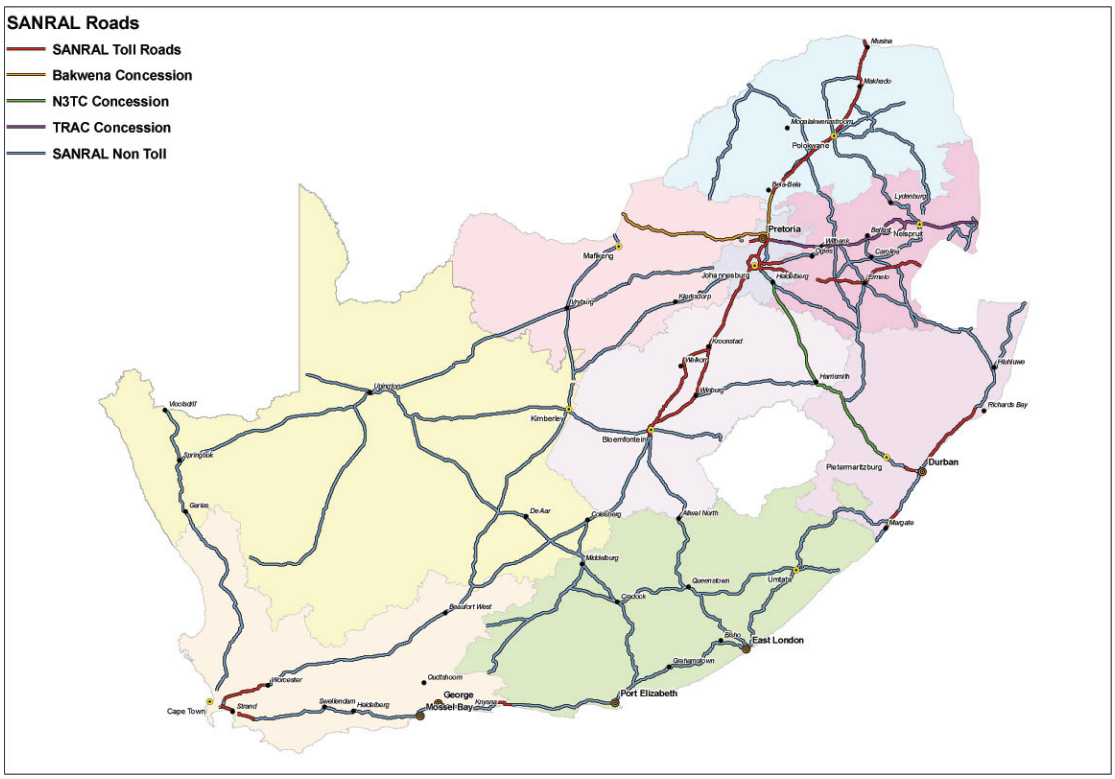


Figure 20: Roads administered by the South African National Roads Agency (SANRAL), including the N2 national route, which broadly traces the coastline

Two areas of the coast within South Africa's ACLME region have historically had rather poor levels of transport infrastructure. In the far north of KwaZulu-Natal, the only tarred road apart from the N2 ran parallel to the Swaziland and Mozambique border, and was often in poor condition on the seaward side of Jozini. However, as part of the Lubombo Spatial Development Initiative implemented towards the end of the 1990s, the R22 road along the coast from Hluhluwe to Ponto do Oura in Mozambique was upgraded, with new sections constructed. This has greatly improved transport in the region.

Similarly, in the north-eastern most regions of the Eastern Cape, access to the Wild Coast – the former Transkei homelands – is hampered by the state of the roads and the rugged terrain. The N2 highway runs parallel to the coastline but well inland of the coast. While there are a number of untarred roads that provide access to particular places along the Wild Coast, there is no road-link and movement of tourists or goods along the coastline. The existing untarred roads are often in poor condition due to heavy seasonal rainfall and poor maintenance. The only tarred roads to the coast from the N2 are those to Port St Johns and Coffee Bay, the latter notorious for its potholes, wandering animals and heavy pedestrian traffic.

However, the provincial Government has recently embarked on a comprehensive road improvement programme through its Ten Years Provincial Road Infrastructure Turn Around Plan. In addition, the Hospital Roads programme, which focuses on improving the quality of roads leading to hospitals in the former Transkei, is underway. This and other road maintenance projects are being implemented under the Expanded Public Works Programme, in which poor people from local communities are given training and employment. Furthermore, a six-year project to construct a road known as The Wild Coast Meander commenced in October 2009. This road runs parallel to the N2 and meanders between the sea and other small inland towns from Kei Mouth near East London to Port St Johns.

Rail

Rail transport has diminished in importance with the development of South Africa's road system. Nationally, only half of the nation's 20 000 km of track is being fully utilized, and some 35% carries no or very low activity. Accordingly, Transnet is moving towards an emphasis on freight, rather than passengers in order to keep the rail system profitable. Transnet Freight Rail is the largest division of Transnet Limited, a public company with the South African government as its sole shareholder.

The Passenger Rail Agency of South Africa (PRASA) merges the operations, personnel and assets of the South African Rail Commuter Corporation, Metrorail, Intersite Property Management Services, Shosholoza Meyl and the long distance bus company, Autopax (Translux and City-to-City). The most important reason for consolidating passenger rail entities was the need to address the under-performance of rail passenger services and the historical under-investment in this sector. At present, the PRASA Group constitutes around 70% of the resources coming from Government as subsidies, while the balance comes from internally generated cash-flow. PRASA's main-line division, Shosholoza Meyl, provides long-distance (inter-city) passenger rail-services. Servicing 19 scheduled routes, it carries over 3.2 million passengers per year, many of whom are migrant workers travelling between the rural areas and the metropolitan centres of South Africa, as well as migrant workers from neighbouring countries. Shosholoza stops at 95 stations and owns 1223 rail coaches, of which some 1086 are used for passenger transport (Figure 21).

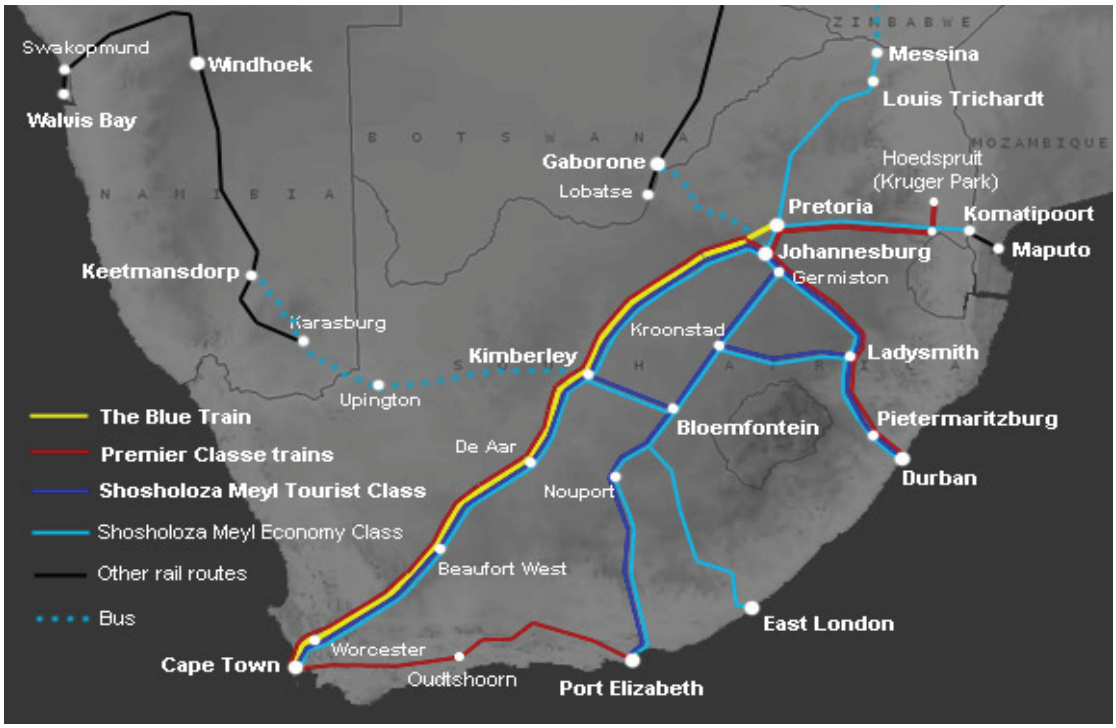


Figure 21: Long-distance passenger train services previously operated by Transnet

The Metrorail commuter services operated by PRASA in Cape Town, the Eastern Cape Province, Durban, and greater Johannesburg and Pretoria are responsible for transporting up to 2 million passengers daily. PRASA owns 317 stations of the 468 stations Metrorail operates, with the remainder belonging to Transnet Freight Rail, and provides commuter rail services on 3180 kilometres of track of which it owns 2228 kilometres and Transnet Freight Rail the rest.

The Eastern Cape Department of Transport runs the Kei Rail daily train service between East London and Mthatha in the former Transkei. Passengers are conveyed from East London station to Amabele (76 km north of East London) by bus, and the trip takes about 12 hours.

Airline

South Africa has 21 air traffic control centres supporting operations that cover some 125 licensed airports as well as 54 approved heli-stops. There are three international airports, the largest being Oliver Tambo International Airport at Johannesburg, followed by Cape Town International Airport and Durban International Airport. Due to the latter's constraints, a new international airport was developed at La Mercy to the north of Durban.

Four of ACSA's 10 airports serve the coastal areas of South Africa's ASCLME region – Cape Town and Durban International airports, as well as the domestic airports of East London, Port Elizabeth and George. There is also the Richards Bay Airport, owned by the local municipality, which serves northern KwaZulu-

Natal. Table 5 lists passenger and aircraft numbers for four coastal airports.

Table 5: Statistics for ACSA's four airports serving South Africa's ACLME areas from north to south, as of May 2008

Airport	Passenger numbers	Aircraft movements
Durban International	750 871 (5461 international)	8 604
East London	119 382	5 691
Port Elizabeth	245 552	11 126
George	105 943	7 745

Electricity

South Africa has an extensive power generation and distribution networks. State energy company Eskom is one of the world's 10 biggest electricity generators providing 95% of the electricity used in South Africa and also exporting power to other African countries. Electricity is generated mostly from 17 coal powered stations close to the Highveld mines in the interior, but there is also a nuclear power station near Cape Town, one gas turbine power station near East London, two major hydro-electric power stations in the interior, and four smaller ones on the Wild Coast - the former Transkei homelands in the Eastern Cape.

The biggest immediate threat to South Africa's continued economic growth is an electricity capacity constraint that has arisen largely because of the country's strong economic performance over the last decade. The response plan includes spending about R343-billion over five years to fund a new generation of power stations, as well as a raft of measures to reduce residential and industrial demand. Eskom has started work on two new coal-fired power stations and plans to reopen three power stations that were mothballed in the 1990s. It is considering bids to build a new nuclear power station, and plans to build two open-cycle gas turbines and complete a hydro scheme in the Drakensberg. The expansion programme has resulted in significant increases in the cost of electricity for users, with knock-on effects on economic growth and inflation. Countrywide, some 80% of South Africans use electricity for lighting, but may still use alternative sources of energy – such as gas or burning wood - for cooking and warmth. Table 6 shows the percentage of households that use electricity for lighting.

Table 6: Percentage of households using electricity for lighting

Province	Census 2001	Community Survey 2007
KwaZulu-Natal	60,9	71,5
Eastern Cape	50	65,5
Western Cape	88	94

Telephone

South Africa has the best developed and most modern communication system in Africa. State-controlled Telkom is responsible for the installation and maintenance of exchange lines, of which there were 4,425 million in use in 2008. In the same year there were some 45 million mobile cellular phones in use. There are four GSM cellular network operators in the country, namely Vodacom, MTN, Cell-C and Virgin Mobile, which uses the Cell-C network for coverage.

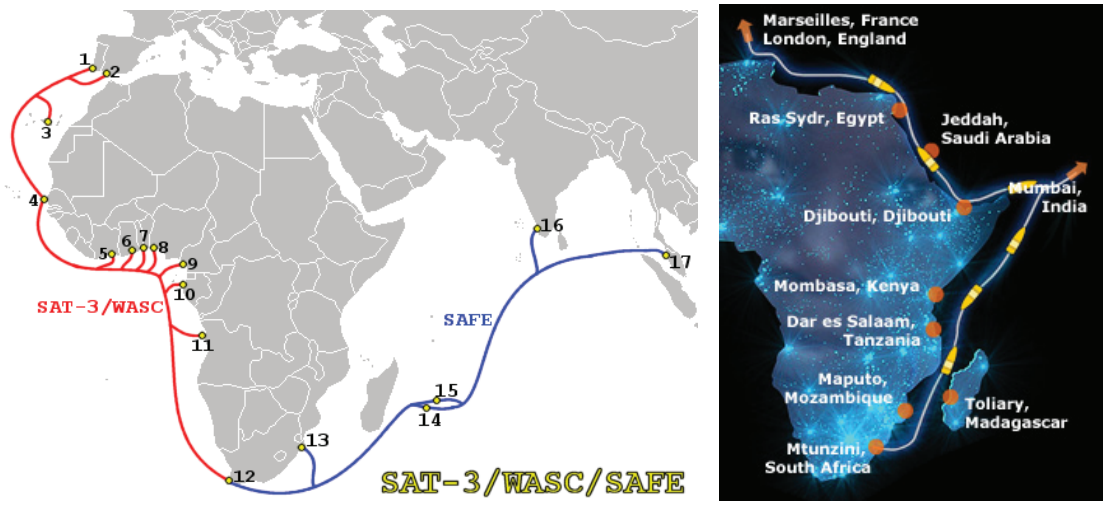
Internet

According to a new World Bank report, *Information and Communications for Development 2009: Extending Reach and Increasing Impact*, access to ICT services is vital for economic and social development of sub-Saharan Africa. It maintains that every 10% increase in high-speed internet connections in developing countries leads to a 1.3% increase in economic growth. In 2009, South Africa made up only 9% of Africa's total internet subscriber base, with 5.1-million users. In 2000, the country had 2.4-million subscribers, but this represented 53% of internet users across the continent.

It is expected that prices for international connectivity will drop, and the number of subscribers increase rapidly, as new fibre-optic cable systems are implemented. Until recently South Africa's Internet services have been dependent on the SAT3/WASC/SAFE undersea cable system, but a second cable - Seacom - came onstream in July 2009.

SAT3/WASC (Southern Africa - Western Africa Submarine cable) is a 15,000 km high-performance fibre

optic cable linking South Africa to Europe and a number of countries on the West African coastline. SAFE (South Africa - Far East) continues the connection another 13 800 km as far as Malaysia via Reunion and Mauritius, with a landing that brings India into the system. The two South African landing points are at Melkbosstrand on the West Coast and Mtunzini on the KwaZulu-Natal coast. The 15,000km Seacom cable connects Africa to Europe, the Middle East and Asia (Figure 22).



(a) (b)

Figure 22: Existing undersea fibre-optic cable providing broadband connectivity: (a) SAT-3/WASC/SAFE (b) Seacom

Other cable systems in the planning stages include EASSy - the Eastern Africa Submarine Cable System and WACS - the West African Cable System. EASSy is an important component of the NEPAD ICT Broadband Network known as Umojanet, which aims to free the continent from its dependence on expensive satellite systems to carry voice and data traffic. NEPAD (the New Partnership for Africa's Development) is the African Union's blueprint for socio-economic development on the continent.

I) Issues

Ports: The process of expanding and deepening port facilities in South Africa is a cause for concern in terms of its impact on the coastline and marine environment, as well as the threat of pollution associated with increasing volumes of international shipping traffic. The new Coega/Ngqurha port in the Eastern Cape is located adjacent to the Addo Elephant National Park and its newly acquired Marine Protected Area (MPA), which includes the seal and penguin colonies on Bird island. The risk of oil spills from the proposed oil refinery and tanker docking facility could pose a serious risk to the marine life and ecosystems of this MPA and the adjacent coastline.

Roads: The infrastructure in most small coastal towns is inadequate to cope with the influx of holidaymakers during the summer season, leading to severe traffic congestion. In many areas, bridges and causeways for coastal roads and railway lines have disrupted estuarine floodplains, aggravating floods, increasing sedimentation and limiting seawater exchange, which has a range of ecological impacts.

A decision is imminent regarding environmental authorisation for the N2 Wild Coast Toll Road Project tendered by SANRAL. The road is intended to improve the existing road link between East London and Durban – a distance of approximately 631 km (Figure 23). Approximately 80% of the total route utilises existing road alignments of the N2 and R61 routes. The remaining 20% consists of a new section between Port St. Johns and Port Edward, referred to as the "Greenfields Corridor", which will shorten the journey between Durban and East London by an estimated 81 km. However, environmentalists have objected to the project on the grounds that the Greenfields section passes through the Pondoland Centre of Plant Endemism, and that a tolled road will not address the socio-economic needs of the local communities.

Electricity: The electricity capacity constraints and power cuts over the last two years in South Africa have had significant negative economic impacts. While the current economic recession has reduced the demand

for electricity and alleviated the electricity problems, these problems are likely to resurface as economic growth recovers. This will remain the case until significant new power generation capacity is developed. One concern associated with investment in electricity power stations is the plan to develop a number of new nuclear power stations along the coastline. This is advocated as a means of reducing South Africa's dependence on coal power stations, which are major air polluters that make South Africa the 14th highest emitter of greenhouse gases in the world.

II) Gaps

- There is limited information or exploration regarding viable low carbon emission power alternatives to nuclear power.
- Limited capacity of environmental and disaster management linked to oil refinery at Coega/Ngqura Port and IDZ.
- Lack of monitoring of port expansions and deepening, as well as a lack of effective management of environmental impacts.
- Need for further information to understand the impact of the development of road and rail infrastructure on the coastal and estuarine environments.

Figure 23: The route of the proposed N2 Wild Coast Toll Road

COASTAL LIVELIHOODS

A comprehensive coastal livelihoods assessment has been carried out. Chapter summaries are presented below, and the full Coastal Livelihoods Assessment may be found in Annex VIII for further information.

Small-Scale Fisheries

At a policy and regulatory level, small-scale fisheries in South Africa have traditionally been included with the commercial, recreational and subsistence fisheries under the Marine Living Resources Act. This Act largely defined the small-scale fishery as an activity based around fulfilling the basic food security needs. It has been estimated that nearly 100,000 people are directly involved in the sector, while more than 28,000 households are dependent on subsistence fisheries. The commercial fishery, which also include some aspects of the small-scale sector contribute 0.5% to GDP and brings in R80 billion annually. As a whole, small-scale fishing along the east coast has traditionally focused on shore-based activity as a means of livelihood, while small-scale fishers along the west coast have normally been drawn into the commercial fishery.

The failure to govern the small-scale fishery as a distinct sub-sector, along with a number of other factors, has produced several constraints around management of the sector. For example, lack of capacity building programmes and local management plans recognizing the uniqueness of the small-scale sector, as well ineffective top-down management and failure to protect the sector from the industrial sector, all highlight the challenges around policy and management in small-scale fisheries. Low levels of compliance, poor information dissemination to the local level, as well as lack of trust among coastal communities of the fisheries authorities in general, also indicate a failure to effectively manage this sector in the past. Issues around capacity have also been raised, particularly evident in the lack of enforcement, insufficient surveillance techniques, poor post-harvest support and structures and the failure of past co-management schemes. There are however, strengths that can be taken advantage of in order to mitigate some of these issues. For example, good local knowledge of fishing grounds, the country's strong marine science research capacity, as well as links within the sector to international NGOs, etc are attributes that could be employed to improve management in the sector. Likewise, high productivity and biodiversity, along with the country's long coastline and relatively well understood marine ecosystems, are clearly great strengths that could be built upon. Of particular note is the example of effective co-management systems that have been set up and maintained over at least a decade in the Province of KwaZulu Natal. These examples of best practice could be replicated in other parts of South Africa.

As of 2010, a draft fisheries policy has been designed solely for inshore small-scale fisheries with the aim of addressing pre-harvest, harvest and post harvest activities, which have the potential of advancing co-management structures and placing greater emphasis on the role of the post-harvest sector in local development. There are also other economic opportunities evident in the potential to diversify market share through value-addition, the potential to begin marketing traditional products in the tourism sector, as well as the opportunity to tap into surging domestic and international demand for fishery products. Nevertheless, conflicts among resource users, political interference and lack of strong direction in policy and planning, does pose a threat to the implementation of the new policy.

Tourism

Tourism is the third largest contributor to GDP, the fourth largest source of foreign exchange and accounts for 7.4% of all jobs in South Africa, making it a vital sector in the country's economy. Tourism is also one of South Africa's fastest growing sectors. The sector grew from .6% in 1993 to 8.3% in 2007, while foreign arrivals and revenue from foreign tourism increased by 7.8% and 23.4% respectively between 2007 and 2008. Domestic tourism is also vibrant, generating R16 billion annually, making up 67% of all activity in the sector. Provincially, Gauteng and Western Cape are the most frequented destinations for foreign travellers, while KwaZulu Natal is the largest beneficiary in the domestic market.

While growth in tourist activity has been rapid, numerous challenges are still prevalent in the sector. For example, the seasonal-based fluctuations in activity, along with the over-dependence on tourism as a means of promoting economic development, particularly in coastal communities, has clearly become problematic. Similarly, weak capacity at the provincial and municipal level has made local governments ineffective in promoting further development, while community tourism still remains a supply-driven industry with lack of

value chain distributions within community structures. Crime and the perceptions that accompany it have not been conducive to growth in the sector, as has the failure to enhance linkages between business and both the formal and informal aspects of the sector. These constrictions should not, however, overshadow the positives inherent in the sector, particularly the ability of tourism to economically empower historically-disadvantaged populations. The country's extensive biodiversity, long scenic coastline and favorable climate should also facilitate the perpetuation of growth patterns into the future, irrespective of the aforementioned challenges.

As a whole, it is clear that the abundance of opportunities in tourism magnifies the untapped potential prevalent in the sector. For example, there are clear opportunities to extend the season of enterprises, which would also bring more stability to associated labor markets. Likewise, the potential for commercial enterprises to tap into the market around historically disadvantaged populations, as well the opportunity to develop joint-ventures with communities in a participatory manner, highlights the extent to which the potential of the tourism sector has been partly unrealized. Given the present growth rates in the sector, there is also a significant opportunity to engage foreign entrepreneurs, as well as opportunities for the government to take great steps in redressing socio-economic imbalances along the coast. In all cases, it is thus clear that tourism has the potential to not only provide meaningful employment, but also has the potential to socially and economically empower historically disadvantaged communities in the coastal zone.

Mariculture

Medium and large-scale mariculture activity is well established in South Africa, with commercial farming prevalent in abalone, seaweed, mussels and oysters and pilot commercial projects underway in dusky kob, silver kob and yellowtail finfish. Research is also ongoing for the production of clownfish, white margined sole, west and east coast rock lobster, scallop and blood worm. Small-scale production is however, scarce in the country as most projects are being developed by the private-sector with an emphasis on pump ashore systems. This lack of small-scale production has been attributed to several factors including poor environmental conditions, inadequate participatory approaches, poor fish growth, very low returns, lack of interest and neglect. Medium and large-scale farms are, nevertheless, providing employment outside urban areas, particularly in the Eastern and Western Cape.

There are constraints documented in the sector, many of which are constricting the development of small-scale operations. For example, the high energy nature of the country's coastline makes sea-based culture systems capital intensive and technically difficult to develop, which make small-scale development costly and unfeasible. Likewise, because of these factors, the potential for small-scale development in rural communities remains very weak, which is even more problematic considering the high barriers to entry and the excessive competition between resource users in the sector. Legislation, permitting and the approval process is also very confusing in the sector. This acts as a barrier to small-scale investors. Compliance with environmental legislation has also become burdensome for the medium and large-scale producers active in the sector. Improved coordination from government is thus, essential in order for the sector to move forward.

Despite these constraints, there are many strengths and opportunities in mariculture that can be capitalized on in the future. For example, good infrastructure, technical expertise in the country's universities, training in aquaculture at the tertiary level and suitable climate on the coast all highlight the positives that could be utilized to develop the sector. Likewise, opportunities for community-based and land-based finfish production, as well as further opportunities for commercial farms in rural areas, highlight the great potential that is inherent in the sector, particularly in providing employment to rural communities. Mariculture development nodes are also being developed, which in conjunction with the credible policies being constructed by the government, should facilitate further private-sector interest in the sector. Culture-technologies are also being developed around new species which, along with the potential for expansion in the abalone sub-sector, highlights the opportunities for further development. Hence, with proper financial support measures and a national development strategy, mariculture can certainly meet its productive potential in the coming years.

Agriculture and Forestry

Agriculture and forestry in the coastal zone is utilized for both subsistence and commercial purposes, with the value of benefits from its goods and services on a national level estimated to be equal to 35% of GDP. The forestry sector alone accounts for 4.1% of total export earnings, while deciduous fruit exports account for 15%

of total agricultural export earnings. Livestock production and dairy industry are also significant sub-sectors, with 4,300 milk producers employing an estimated 60,000 workers and indirectly providing employment for an additional 40,000 people. The broilers and other fowls also generated an income of nearly $1.24 million USD in 2001, making it the most important contributor to the value of agricultural production in South Africa.

25% of South Africa's population lives within 60km of the coastline and 70% of this population is considered poor. Thus, great pressure is inevitably being placed on coastal resources, which is leading to degradation and depletion. Commercial forestry also has the potential to have a severe impact on biodiversity and disrupt sensitive habitats in the coastal zone, which would also have a significant impact on alternative income generating activities by coastal rural communities. Attempts to mitigate the over-exploitation of coastal resources have also been constrained by weak infrastructure and weak capacity in rural communities, which has made national policy relatively ineffective. The effects of land reform, particularly on ownership, also remains unclear, while it has also been suggested that the established private-sector actors on the coast may not respond well to current policies favoring participatory resource management.

Despite these obstacles, several positives can be seen in the sector. For example, strong exports as well as a vibrant economy based around urban centers in the coastal zone should ensure issues pertaining to coastal development will be focused on at high policy levels. Likewise, the potential to expand tourist activity and develop non-traditional high value crops highlights the opportunity for growth in substitute sectors in the coastal region. Similarly, participatory forest management, particularly the new concept of forestry outgrowers, not only highlights the ability of local communities to work in conjunction with commercial forestry operators, but also highlights the commitments being made to empower local communities to manage the resources they depend on. Thus, while poverty and an over-dependence on coastal resources remains problematic, there are strengths and opportunities in the agriculture and forestry sector that can be utilized to promote sustainable socio-economic development in the coastal zone.

Energy

The petroleum industry contributes 2% to GDP, providing direct and indirect employment for over 100,000 people and over R34 billion in tax revenue to the government. The country produces 35,000 barrels per day of crude oil, with proven reserves estimated to be 15 million barrels. The country also produced 115 billion cubic feet of gas in 2008, with reserves estimated to be 320 billion cubic feet. South Africa also has Africa's second largest oil refinery system, comprised of four refineries and two synfuel plants producing 692,000 barrels per day in 2008. Coal is however, the most dominant source of energy providing for 75% of primary consumption. Activities in biofuels are marginal, as the country is not yet involved in large-scale biofuels production.

Numerous strengths and opportunities have been identified in the energy sector, despite the low level of activity in some sub-sectors. For example, not only are four biofuels projects currently being planned with the support of a Biofuels Industrial Strategy, but a new crude refinery near Port Elizabeth, Africa's largest, is to be completed by 2015, which is expected to provide nearly 18,500 permanent jobs and 27,500 jobs during construction. The country also has the technical and financial capacity to support agribusiness for biofuels, which could assist in meeting projected energy demand, while the country's strong economy, skilled workforce and sound environmental legislation provides a solid base for developing the energy sector. Companies in the sector are also contributing to development at the community level. For example, Petro SA, Chevron, Sasol and Engen all support various programs around schools and education, while BP is supporting community-based job creation enterprises such as the Scarborough Fishersmen's Company in Ocean view. Chevron, BP and Total have also been supporters of various HIV projects, as well as multiple environmental awareness campaigns.

A number of constraints have, however, been highlighted in the sector. For example, poor rural infrastructure and a lack of capacity at the local level continues to constrict the sustainable development process, while limited land availability has been identified as a clear constraint for the development of biofuels. Biofuels development could also negatively affect food security, while an abundance of maritime activity in oil and gas leaves the country's coast vulnerable to spills. Poverty and intense disparities in wealth have also been highlighted as constraints, as not only does the latter make national policies difficult to implement, but the former reduces livelihood opportunities for coastal communities, which facilitates the overutilization of natural resources. Despite these obstacles, growing energy demand is expected to incentivize development in oil, gas

and biofuels respectively, which has the potential to not only provide extensive employment opportunities for formerly disadvantaged coastal communities, but also shift labour away from the more deleterious, resource-intense income generating activities.

Ports and Coastal Transport

South Africa has six major commercial ports, all of which are connected to inland areas through road and rail. Durban is the largest point for imports and exports to and from inland South Africa, while the port at Richards Bay is the country's largest bulk port. Port Elizabeth is the Eastern Cape's busiest port, handling iron ore transports from the Northern Cape and providing container services for the city's vibrant automobile industry, while the port at Mossel Bay is almost solely dedicated to the handling of petroleum products. The port in East London mainly serves the Border and Transkei areas, while the port in Ngqura has largely been developed as a catalyst for industrial development. Ports, terminals, as well as the country's rail services, are all state-owned and operated by Transnet National Ports Authority, while road transport is provided and maintained by the private sector.

Many of the challenges and constraints identified in the sector are, for the most part, facilitated by the monopoly maintained by Transnet in the sector. For example, inefficiencies are clearly abundant in ports and rail services and over-regulation of the sector continues to deter private-sector investment, both of which have led to loss of competition in relation to the less restrictive transport sectors in Namibia and Mozambique. Transport policy has also heavily favored road haulage, which has facilitated the decline of rail services, most evident in the inability of the rail services to meet increased demand during the recent pre-recession global economic boom. Government policy towards black economic empowerment, while clearly designed with good intentions, has also led to a loss of skills in the sector, which further perpetuates the inefficiencies noted above. Government control of the sector has also led to heavy unionisation in the sector, which could hamper development in the future. Political patronage, corruption and fiscal constraints have all also been highlighted as major threats and weaknesses prevalent in the sector.

Many opportunities are however, apparent in the sector, despite the challenges aforementioned. The potential for industrial development around the Ngqura port as well as an expanding container trade in Durban and Cape Town have been identified as opportunities. Likewise, the country's well developed cargo clearing and handling services will continue to support imports and exports, while the long term shift of manufacturing activity to the coast should facilitate more efficiency in coastal transport services. Similarly, current capital constraints in the government and Transnet have the potential to induce some concessions and privatization, which would be fruitful in terms of competition and efficiency. The country also still maintains the largest general cargo port in the Southern Hemisphere in Durban, as well as a highly efficient road transport, both of which are strengths to build upon. Thus, despite the constraints posed by the Transnet monopoly, the ability of the sector to accentuate economic activity, particularly in the larger urban centers on the coast, should allow the sector to realize its full potential in the future.

Coastal Mining

South Africa has the world's largest reserves of chrome, gold, vanadium, manganese and platinum group metals, making mining the most dominant sector in the country's economy. In 2008, mining accounted for 9.5% of GDP, 41% of total exports and employed over half a million people. However, on the east coast, mining activity is less prevalent in the coastal zone, focused around heavy mineral sand mining near Richards Bay and elsewhere in KwaZulu Natal, and limestone for cement.

Much of the mining activity on the east coast is also being utilized as a means to develop adjacent communities. For example, Richards Bay Minerals has implemented a Black Economic Enterprises program, which has helped historically-disadvantaged populations develop small-businesses and supply goods and services, now worth $61 million USD, to Richards Bay Minerals. Similarly, Pretoria Portland Cement has also developed employment and skills in the New Brighton Township with the Latita soap making project, while Exxaro, Lafarge and Natal Portland Cement have all done work focusing on education in disadvantaged communities. All mining activity along the coast also provides the government with taxes and royalties, which could be utilized to support social services in adjacent communities.

Coastal mining does, however, face numerous challenges, despite the socioeconomic benefits aforementioned. For example, water pollution and waste has become problematic around all mines and electricity shortages particularly in 2008, have caused massive losses in production. Likewise, as mines get older, costs go up and yields inevitably shrink, which will also facilitate decreases in production. Federalism as well as the prospects for nationalization in the sector have also been highlighted as threats in coastal mining. However, these challenges should not overshadow the prevalent opportunities and the overall socioeconomic value of the sector. For example, the potential for heavy sand mining in the Transkei, the country's strong coastal zone development policy and the presence of investment agencies in the provinces magnifies the strengths and opportunities apparent. Likewise, the strong tradition of mining, the abundance of mineral resources and the government's commitment to the sector all highlight the support existent in the sector. Thus, while decreases in production and environmental challenges remain problematic, the ability of the sector to reinforce the country socially and economically is clearly well pronounced in the report.

Conclusion

As a whole, a number of strengths and opportunities across several sectors that could be supportive to sustainable socio-economic development in the coastal zone can be identified. South Africa is the largest economy in Africa and has the potential of both further developing its own economy and that of the Southern Africa region. Coastal management efforts in South Africa have undergone a dramatic transformation in recent decades: from a bureaucratic and biophysical focus towards an approach rooted in participation, empowerment and promotion of sustainable coastal livelihoods. Confronting poverty is arguably the most important and challenging issue for the South African Government. The goods and services derived from South Africa's coast have an important contribution to make in meeting basic needs and improving the well-being of coastal communities. South Africa is attempting to utilise the sustainable livelihoods approach to foster more people-centered, pro-poor, Integrated Coastal Management (ICM). The sustainable livelihoods approach complements and enriches ICM and could help to bridge the gap between sustainability rhetoric and the reality facing poor coastal communities.

One clear strength prevalent across sectors is the natural diversity and robustness of the country, both in terms of natural heritage and population. For example, the country's extensive bio-diversity, long coastline, favorable climate and cultural diversity are great strengths in the tourism sector. Similarly, environmental conditions are highly conducive for mariculture development, while both the natural and commercial coastal forestry sectors are strong export earners and employers. The abundance of mineral resources has also been documented, as well as the opportunities for large scale industrial development supported by an excellent transport network and infrastructure. The development of new and innovative policies in the small-scale fisheries sector for example has the potential to allow better access to resources for small-scale fishers and also improved management of these resources.

Nevertheless, the natural strengths of the country are being threatened by several factors. One constraint highlighted in some sectors is the obstacle posed by excessive regulation. For example, the lack of small-scale investors in mariculture has been partly attributed to the constraints and confusions surrounding legislation, permitting and the approvals process, while compliance with environmental legislation has been identified as highly burdensome for medium and large-scale companies in mariculture as well. In ports and coastal transport, the monopoly held by Transnet has not only reduced efficiency and overall competitiveness, but it has allowed patronage to filter into the sector. Corruption and poor policy are main challenges in the sector, while the potential nationalization of some of the country's mines is a threat in the coastal mining sector. Yet, despite these cases of poor governance, the government has also been the source of numerous positives in the coastal zone. For example, the institutionalization of participatory forest management is vital in empowering local communities to manage their own natural resources, while solid infrastructure and government support are strengths in mariculture. Likewise, in the coastal mining sector, government support, provincial investment initiatives and a credible coastal zone development policy have all been highlighted as great benefits moving forward.

There is the potential for further socio-economic development and employment in coastal communities. In tourism alone, the potential to extend the season of enterprises, form joint-ventures with communities and tap into the market around historically disadvantaged populations is very promising in terms of potential to generate

employment. In mariculture, the potential to generate investment and employment in rural communities is seen as an opportunity for coastal populations. Likewise, expanding container operations in Durban and Cape Town ports, as well as the development of the port in Ngqura, could both be highly beneficial to adjacent local residents, while the potential for heavy sand mining in the Transkei is certainly encouraging for the region. Similarly, extensive employment opportunities have been highlighted throughout the energy sector, particularly prevalent in the development of biofuels, as well as in the construction of a new refinery near Port Elizabeth. These opportunities will however need to be developed in a sensitive and responsible manner to ensure their success into the future.

Ultimately, it is clear that in order to realize these opportunities and capitalize on the country's strengths, commitment from government, civil society and the private sector are all required, as none of these is capable of facilitating sustainable socioeconomic development in the coastal zone alone. Sustainable Coastal Livelihoods initiatives need to be promoted with the goal of identifying non-consumptive or alternative methods of utilizing coastal resources. By combining the resources and knowledge of the government, private sector and civil society, coastal communities can be empowered to co-manage their own resources and develop alternative streams of income, which can potentially not only reduce the pressures being placed on coastal resources, but could ultimately be instrumental in reducing poverty in the coastal zone.

PLANNING AND MANAGEMENT

National Disaster Management Plans

South Africa's Disaster Management Act 2002 recognises the need to avoid and reduce disaster losses in South Africa through the concerted efforts of all spheres of government, civil society and the private sector. The national disaster management framework is the legal instrument specified by the Act that provides a coherent, transparent and inclusive policy on disaster management. The Act requires the establishment of a National Disaster Management Centre (NDMC) which is responsible for promoting management policy. There are also disaster management advisory forums at provincial and municipal levels. Aspects covered include the following;

Tsunamis. The Council for Geoscience has completed the first phase of upgrading five stations of the South African National Seismograph Network. This station sends real-time data to the International Data Centre as part of South Africa's contribution towards the Indian Ocean Tsunami Warning System (Department of Minerals and Energy Annual Report 2007/2009). In the event of seismic activity, relevant authorities are immediately alerted.

Extreme weather events and storm surges. These are closely monitored by the South African Weather Service (SAWS) through the use of radar, forecasting workstations, lightning detection, NWP and observations. In the event of an extreme weather event and/or storm surge, the SAWS notifies the Disaster Management where information is consolidated and distributed to the relevant authorities and the media. A Joint Response Committee (JRC) comprising of the relevant authorities applicable to the disaster is then assembled to deal with the incidents as they occur.

Oil Spills. South Africa has a large number of ships passing through its waters that presents a risk of marine pollution due to possible tanker collisions, groundings, oil cargo and bunker transfers, structural failure or any other maritime emergencies or accidents. In particular, around 19 million tonnes of crude oil is imported into South Africa annually, while approximately 120 million tonnes pass its coasts bound for world markets. Hence, there is a significant risk of an oil spill incident. Offshore installations pose an additional risk. However, no major spills have occurred in South Africa.

The Department of Environmental Affairs (DEA) is assigned the responsibility of combating oil and other hazardous spills in the marine environment. The South African Maritime Safety Authority (SAMSA) is assigned the responsibility of preventing pollution from ships through control and prosecutions. South Africa has a National Contingency Plan drafted in 1986, and maintains 18 Regional/ Local Contingency Plans in the ASCLME region which address responsibilities within municipalities, clean-up methods and combating techniques for different areas along the coast. These allow equipment and manpower to be mobilised at short notice to protect beaches, estuaries, bird colonies and other sensitive areas.

I) Issues

- Since there are a variety of potential disaster events, contingency plans have to be adapted accordingly and in some instances these plans may not exist.
- Early Warning Systems for storm surges, tsunamis, and extreme weather conditions may only be activated a matter of hours before they occur, leaving very little time for relevant authorities to be notified and to react.
- Communication and coordination between the relevant authorities may not always be well-established.
- Communication to rural communities in the event of an upcoming disaster is difficult.
- The lack of training opportunities, the response time to get equipment on site from the Oil Spill store in Cape Town and regular updating of contingency plans are concerns. Moreover, Southern Africa's capability of addressing a tier 3 spill necessitating international assistance is unclear. Countries in the region need to become signatories to all appropriate international conventions. Regular updating of all contingency plans is crucial to take into account changes in coastal sensitivity and high turnover of key staff in relevant government institutions.

II) Gaps

- There are limited regular desktop and deployment of oil spill response equipment exercises between stakeholders responsible for prevention and combating of oil spills.
- Countries in the WIO region need to become signatories to all relevant international conventions in order to have assurance that funds will be made available to address oil spills from tankers and bulk carriers.
- More attention should also be given to spills of hazardous noxious substance into the marine environment.
- There is also a need for an objective risk assessment for the region in order to determine what the impacts of an oil or chemical spill would be for the region.

Environmental Sensitivity Mapping

Coastal sensitivity mapping involves assembling information and resources and deciding on priorities through consultation with relevant organisation and has been widely utilised to determine the priorities and vulnerability to oil spills. In order to make priority decisions, the maps should include shoreline type, sub tidal habitats, wildlife and protected areas, fish, fishing activities, shellfish, and aquaculture, socioeconomic features and oil spill response features. The Coastal Sensitivity Atlas of Southern Africa was developed for the Department of Transport. The purpose of the atlas is to direct responses during incidences such as an oil spill, to areas most in need of protection. Such priority areas are identified on the basis of their environmental sensitivity as well as their biological and socio-economic importance. The Coastal Sensitivity Atlas of Southern Africa map recognises the following:

Estuaries which are the most sensitive environmental type in terms of heir physical response to pollution such as oil spills. However, they play an important function as nursery grounds for many marine species of fish and prawns, essential habitat for birds and they act as nutrient traps.
Marine reserves and sanctuaries that maintain undisturbed breeding populations of heavily exploited or otherwise threatened species; to protect representative examples of various ecosystems; to provide point of reference against which to measure change, and to provide research, educational and recreational facilities.
Biological resources such as fish, marine mammal, and bird migration path and breeding areas.
Recreational facilities.

LAND-BASED ACTIVITIES	RESPONSIBLE DEPARTMENT (SECTOR)	PROBLEM											
		Sitation	Modification of streambeds	Coastal erosion	Destruction of dunes & sandy shores	Destruction of coastal habitat	Microbial contamination	Eutrophication	High Suspended solids	Marine litter	Thermal pollution	Toxic chemical pollution	Alteration of salinity distribution and nutrient supply
Climate change	Environment Affairs	●		●	●	●			●				●
Coastal infrastructure development (Includes transport and recreational activities)	Environment Affairs Housing Municipalities Department of Local and Provincial Government	●	●	●	●	●	●		●				●
Mining	Minerals and Energy Environmental Affairs	●	●	●	●	●			●			●	●
Freshwater abstraction and flow modification	Water Affairs	●	●	●	●	●			●				●
Municipal wastewater (Sewage and septic tank seepage)	Water Affairs Environmental Affairs Municipalities		●				●	●	●	●		●	●
Industrial wastewater*	Industries						●	●	●		●	●	●
Urban storm water (Includes runoff from informal settlements)	Water Affairs Environmental Affairs Municipalities Housing						●	●	●	●		●	
Agricultural practices	Agriculture	●					●	●	●			●	●
Port and harbour operations	Transnet: NPA	●	●	●	●	●	●	●	●	●		●	●
Off-road Vehicles	Environmental Affairs			●	●	●							
Solid waste disposal (and littering)	Environmental Affairs Municipalities									●		●	
Atmospheric deposition	Environmental Affairs Municipalities							●				●	
Introduction of alien vegetation	Environment Affairs Conservation Boards					●							
Harvesting of living resources**	Environmental Affairs					●							
Aquaculture**	Environmental Affairs Water Affairs Department of Aquaculture				●	●	●	●	●			●	

Economic Resources which include areas around South Africa that that are highly productive and support a number of commercial fisheries.
Marine Intakes and Discharges areas around the coastline.

I) Issues

Currently South Africa's Coastal Sensitivity Atlas is outdated and needs to be reviewed.

II) Gaps

Data may not be easily available or accessible to update the atlas. Data regarding additional survey work for coastal regions and economic coastal developments is needed.

Coastal Management and Development Planning

Past coastal management efforts were characterised by the fact that the value of the coastal ecosystem was not sufficiently acknowledged as a cornerstone for development. Consequently the new Integrated Coastal Management Act (No. 24 of 2008) (ICM Act) has been promulgated to establish the statutory requirements for integrated coastal and estuarine management in South Africa. This also includes norms, standards and policies. One of the many reasons for the adoption of this form of management is to promote the conservation of the coastal environment, and to maintain the natural character of coastal landscapes and seascapes. Implicit in the above purposes is the need to ensure that the development and use of natural resources in the coastal zone is socially and economically justifiable, as well as being ecologically sustainable. The ICM Act is an expression of a shared responsibility to wisely manage the coastal area with its unique natural resources and complex relationship with humans. The Act is meant to guide behaviour and actions to ensure that its benefits can be sustainably and equitably distributed. It is also intended to raise public awareness of the complexities of the coastal area, thereby promoting active participation and shared management.

The ICM Act still requires other more practical "tools" to achieve integrated coastal management in provinces and municipalities. Thus it allows for a hierarchical relationship for the development of a strategic and overarching national coastal management programme (CMP) followed by consistent provincial CMPs and municipal CMPs that must be consistent with both the provincial and National CMPs. This arrangement includes increasing levels of local management detail and also accommodates management responses that are sensitive to natural, social and economic differences along coastline. Other management tools such as integrated development plans and environmental management plans/programmes must be aligned and give effect to both the National CMP and provincial CMPs. Table 7 shows major land-based activities and potential linkages to typical problems experienced if managed inappropriately.

Currently South Africa does not have specific legislation dealing with climate change. DEA is the lead agency for directing and formulating the national climate change response programme. DEA also has the responsibility of ensuring that South Africa meets its obligations to combat climate change in terms of the United Nations Framework Convention on Climate Change (1992). However, these obligations are largely related to combating climate change rather than dealing with the effects of climate change on the country's resources. Various national and provincial studies into vulnerability to climate change have indicated the critical importance of including climate change scenarios into regulations and guidelines for relevant land-based activities, e.g. coastal infrastructure development, port and harbour operations, increased sea storminess, and altered precipitation regimes, amongst others.

The ICM Act makes provision for the establishment of coastal set-back lines. These may be drawn for various reasons and there may be more than one set-back line in any given area. Coastal set-back lines assist in controlling development in ecologically sensitive or vulnerable areas, or in areas that pose a hazard or risk to humans. The lines may even be situated wholly or partially outside the coastal zone. In effect, coastal set-back lines prohibit or restrict the construction, extension or repair of structures that are either wholly or partly seaward of the line. The intention of the coastal set-back line is to protect or preserve coastal public and private property and the aesthetics or "sense-of-place" of the coastal zone, as well as for public safety in the face of extreme climate and other natural events. Furthermore, the ICM Act recognises that the number and severity of natural disasters may increase due to the effects of global climate change, and that these threats need to be taken into account when determining the coastal set-back lines.

Table 7: Major land-based activities and potential linkages to typical problems experienced if managed inappropriately.

Areas Under Special Management

Marine and estuarine areas under special management in South Africa comprise:
Marine Protected Areas (MPAs) declared under the Marine Living Resources Act (MLRA), with some also "co-declared" under the Protected Areas Act (PAA).
Closed Areas in terms of the MLRA to protect certain commercially fished species.
The iSimangaliso Wetland Park World Heritage Site.
Ramsar sites which mainly comprise estuaries.
Biosphere Reserves.

Most protection is provided through MPAs, with 20 currently declared, 3 others having been formally proposed, and more in detailed stages of preparation. Of these, the following fall within the ASCLME region: Stilbaai (west of Mossel Bay), Goukamma (Knysna), Robberg (Plettenberg Bay), Tsitsikamma National Park (Garden Route), Sardinia Bay (Port Elizabeth), Bird Island (Algoa Bay), Dwesa-Cwebe (Wild Coast), Hluleka (Port St Johns), Pondoland (between Port St Johns and the KZN border), Trafalgar (Hibiscus Coast), Aliwal Shoal and iSimangaliso Wetland Park (St. Lucia). Key inputs on biodiversity protection status and planning are received from the South African National Biodiversity Institute who together with DEA, are developing approaches and guidelines for Offshore Marine Protected Areas. Expansion of protected areas is being guided by a "bio-regional approach" to ensure all habitat and species benefit.

Despite the number of MPAs, the status of certain coastal marine stocks in particular line fish is very poor, with a number of stocks reduced to below 10% of their pristine levels which has resulted in them being regarded as "endangered". Often MPAs are the only areas in which viable numbers of reproductive fish are found and so their continuation is a necessity in order to maintain many of these commercially important fisheries. However, MPAs do not only require areas of complete protection, and appropriate zonation is viewed as the primary way forward, although no-take areas will need to be maintained and increased at appropriate sites. Often this result in greater resistance by communities and stakeholders, and thus integrated consultative management and co-operative governance must be improved to promote eco-tourism and yield benefits to local communities, whilst still prioritizing the conservation of biodiversity.

MPAs are the responsibility of the Oceans and Coastal Management Branch within the DEA, but all are managed primarily by national and provincial authorities through different "memoranda of agreement". This is largely possible because most MPA's are adjacent (or partially adjacent) to formally protected coastal areas. Many of these areas have been subject to successful "land-claims" and since there are community owned, they are subject to co-management and benefit sharing in different forms.

Table 8 shows a list of South Africa's Marine Protected Areas and responsible institutions.

I) Issues

Poaching – An increasing problem in protected areas as stocks in certain open areas are becoming increasingly depleted and criminal elements have increased. Poaching for own consumption is viewed as a lesser threat, but still needs to be addressed. Law enforcement capacity is inadequate and community support for conservation measures is needed.

Coastal development – Inappropriate coastal development is a problem mainly outside protected areas, in particular along the margins of estuaries and within their historical flood plains. The new ICM Act introduced a "Coastal Protection Zone", where special authorization will be required for development. Pollution is mainly a problem in urban coastal waters and estuaries, and is related to both development and inadequate or neglected infrastructure like sewerage treatment works

Conflict between users and lack of participation in planning process – This can take the form of conflict between legal users (eg. fishers and scuba-divers) or conflict involving illegal activities. Here, the actors do not view themselves as the main problem (or even illegal), but they regard each others activities as causing the conflict. Clearly joint approaches, such as being done in the development of estuarine management plans are an important part of the solution.

Lack of education and awareness of the value of managed areas – This is a key area to which all levels of government, NGOs and civil society can contribute. It may require that parallel approaches to address regulations or other measures which are regarded as unfair are addressed as well. Some of the benefits also need to accrue locally, and to those in most need of them.

Conflict over increasing area under protection – This can be addressed by a consultative approach and through guidance by acceptable policy and strategy documents (e.g. on MPAs, on Subsistence Fishing) to ensure that the "costs of conservation" are borne equitably. Zonation of Protected areas is a very powerful tool in ensuring that communities and stakeholders are not "shut out" of areas altogether, although they may need to do things differently.

Table 8: List of South Africa's Marine Protected Areas and responsible institutions

MPA NAME	MANAGEMENT ARRANGEMENTS	LOCAL MANAGEMENT AGENCY
Langebaan Lagoon	Gazette only, Park Plan dealing with MPAs in advanced phase of preparation	SANParks
Sixteen Mile Beach	Gazette only, Park Plan dealing with MPAs in advanced phase of preparation	SANParks
Malgas, Jutten Island and Marcus Island	Gazette only, Park Plan dealing with MPAs in advanced phase of preparation	SANParks
Table Mountain National Park	Strategic plan, plus Park plan	MCM & SANParks
Helderberg	Gazette only.	CT Metro
Betty's Bay	Management plan	CapeNature
De Hoop	Management plan	CapeNature
Stilbaai	Management plan	CapeNature
Goukamma	Management plan	CapeNature
Robberg	Management plan	CapeNature
Tsitsikamma National Park	Park Plan	SANParks
Sardinia Bay	Gazette only	Nelson Mandela Metropolitan Municipality
Bird Island	Strategic plan; Expansion plan being developed	SANParks
Dwesa-Cwebe	Gazette, Draft MPA adaptive management recommendations	ECPB
Hluleka	Gazette only	ECPB
Pondoland	Management plan is being redrafted	MCM & ECPB (need arrangements for area outside ECPB contract)
Trafalgar	Not specifically for MPA	EKZNW
Aliwal Shoal	Management plan. Needs review.	EKZNW
St. Lucia (iSimangaliso Wetland Park)	Integrated Management Plan	iSimangaliso Wetland Park Authority & EKZNW (compliance contracted)
Maputaland(iSimangaliso Wetland Park)	Integrated Management Plan	iSimangaliso Wetland Park Authority & EKZNW (compliance contracted)

Monitoring, Control and Surveillance

The mandate of Marine and Coastal Management's Chief Directorate: Monitoring, Control and Surveillance (MCS) is to monitor and enforce compliance with the Marine Living Resources Act, Regulations and fishing permit conditions through land and sea based inspections and patrols along South Africa's entire coastline. The resources available to fulfil this mandate include Fishery Control Officers (FCOs), Compliance Stations, Environmental Protection Vessels (EPVs), Vessel Monitoring System (VMS) and a*d hoc* hiring of aircraft. For the ASCLME area service providers have been appointed to provide monitors and rangers as well as to ensure that 100% of the landings for all Total Allowable Catch (TAC) controlled fisheries are monitored.

The fisheries sectors that are monitored are the following:

- 22 Consumptive Commercial Fishing sectors (± 3 000 Right-holders), 2 non-consumptive sectors, Fish

Processing Establishments (FPEs), Fish Landings and Restaurants
- ± 250 000 Recreational Fishers, ± 800 Subsistence Fishers and ± 1000 Interim relief fishers
- 800 – 1000 port visits per annum by Foreign Flagged Vessels
- 53 aquaculture farms
- Exports and imports of fish at points of entry and exit
- Compliance in MPAs and Closed Areas
- Off Road Vehicle regulation (driving in the coastal zone).
- South Africa is signatory to the SADC Protocol on Fisheries. In 2008 a Statement of Commitment was also signed by South Africa, which has in the past assisted coastal SADC countries by making EPVs available for sea patrols. South Africa enforces strict port state control and monitors compliance with RFMO regulations by means of administrative screening and *ad hoc* inspection of landings.

I) Issues
- Financial constraints.
- Human capacity: the current ratio of FCOs per kilometre of coastline is 1:17 compared to the international norm of 1:5, making shift work and 24 hour coverage impossible.
- Lack of night- and thermal-imaging capabilities.
- Outdated equipment and aging small craft fleet.
- Full-time aerial platform with offshore and night vision capabilities are required.
- Split mandate: South African Police Services (SAPS), South African National Defense Force (SANDF), South African Revenue Services (SARS) and local authorities (municipalities)
- Development of compliance monitoring and transgression databases.

II) Gaps
- Level of compliance in the different fisheries sectors is unknown.
- Crime syndicates operating in fisheries such as abalone poaching.
- Under resourced.

COST-BENEFIT ANALYSIS

The contribution of the coast to the economy

The South African GDP in 2009 was US$319 billion or R2.4 trillion (Stats SA 2010a). The largest contributing sectors were manufacturing, mining and quarrying, and finance and business services which are centred in the Gauteng Province. Agriculture, forestry and fisheries contributed 2.9% of the GDP, with fisheries accounting for approximately 0.5% of this (Stats SA 2010a). The coastal provinces are however the second highest contributors to the GDP after Gauteng. In 2009 the coastal provinces on the east coast (Western Cape, Eastern Cape and Kwa-Zulu Natal) of South Africa contributed approximately 38% to the annual GDP (Stats SA 2010a, Figure 24), highlighting the importance of the coast to the South African economy.

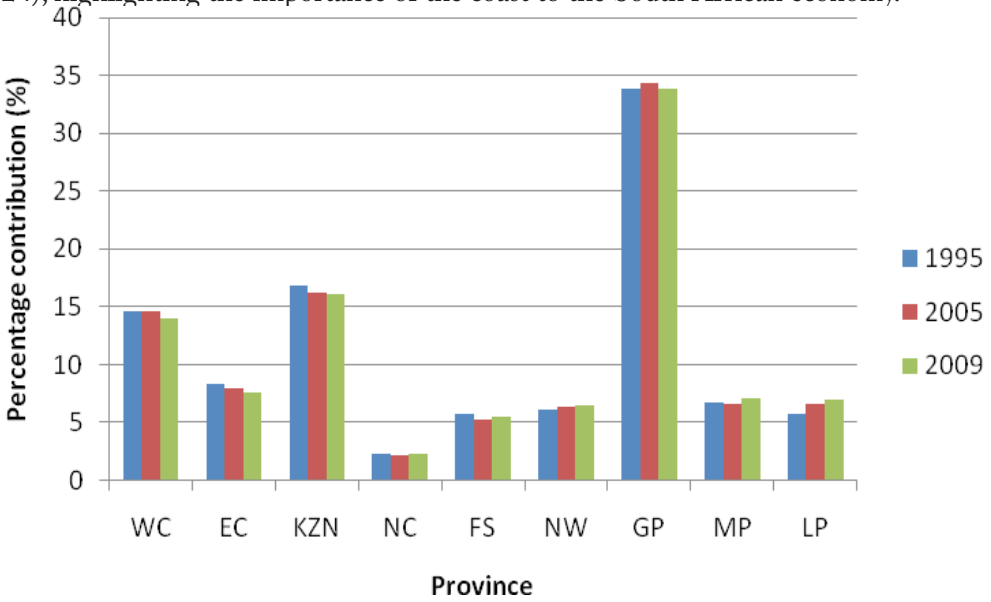


Figure 24: Provincial contribution to the South African economy 1995, 2005, 2009 (Stats SA 2010a).
(WC: Western Cape, EC: Eastern Cape, KZN: KwaZulu-Natal, NC: Northern Cape, FS: Freestate, NW: North West, GP: Gauteng Province, MP: Mpumalanga, LP: Limpopo Province)

THE VALUE OF THE COAST

Fisheries

The cold waters of the Atlantic Ocean on the west coast of South Africa support large numbers of commercially-important fish species, such as pilchard and anchovy, hake, sole, kingklip and rock lobster (CLA Report 2011). Most commercial fishing activities are found along the more temperate western and southern coastal regions of the country. The warm waters of east coast however support fewer large-scale commercial species, but do have a higher number of species (CLA Report 2011). Small-scale fishing communities can be found along the entire South African coastline, using a variety of different fishing methods and catching a variety of different species. Recreational fishing is very important along the coastline and is undertaken in the inshore waters as well as in many of the estuaries along the coast (CLA Report 2011).

The users of marine resources are divided into three major groups, recreational, subsistence and commercial. The recreational users collect or catch fish and other marine species as part of leisure activities. These include shore anglers, spear fishers, shellfish and bait collectors and recreational boat anglers (Stats SA 2010b). Subsistence fishers are largely individuals that collect fish for their own consumption. The commercial fisheries make up the formal fishing industry and range from relatively small-scale and labour intensive inshore fisheries to the highly industrialised deep-water trawls (Stats SA 2010b).

Commercial Fisheries

There are 18 recognised commercial fisheries, which are divided into four clusters (Table 9). In 2010, it was estimated that the commercial fishing industry made an annual turnover of approximately US$12 billion or R80 billion and contributed 0.5% to the South African GDP (CLA Report 2011). Catch in the commercial

sector was estimated at R5-6 billion per annum and it is estimated that this sector provides direct employment to some 27,000 people and indirectly to a further 81,000 people (CLA Report 2011). These numbers and values are dominated by a few large fisheries, but also include some small-scale fisheries such as the west coast rock lobster, oysters, traditional line fish, net fisheries and white mussels.

Table 9: South Africa commercial fishing industry clusters (StatsSA 2010b)

	Species	Type of fishing
Cluster A	Hake (*M. paradoxus; M. capensis*)	Deep water bottom trawl
	Hake (*M. paradoxus; M. capensis*)	Inshore bottom trawl
	Sole (*Austroglossus pectoralis*)	Inshore bottom trawl
	Horse mackerel (*Trachurus spp.*)	Mid-water trawl
	Patagonian toothfish (*Dissostichus eleginoides*)	Long-line
	South coast rock lobster (*Palinurus gilchristi*)	Trap long-line
	KZN prawn (*Metapenaeus monoceros*)	Bottom trawl
Cluster B	Hake (*M. paradoxus; M. capensis*)	Long-line
	West coast rock lobster (*J. lalandii*)	Off-shore traps
	Squid (*Loligovulgaris reynaudii*)	Jigging
	Seaweed	Harvesting
	Tuna Albacore (*Thunnus alalunga*)	Pole
	Demersal shark	Long-line
Cluster C	Hake (*M. paradoxus; M. capensis*)	Handline
	West coast rock lobster (*J. lalandii*)	Near-shore hoop-nets
Cluster D	Net fish	Gillnets, beach seine & KZN beach seine
	Oysters	
	White mussels	

The bulk of the commercial fishing value in South Africa is derived from off the West and South-western coasts, but these fisheries do extend around Cape Agulhas into the ASCLME to some extent. Over the past few decades the distribution of these fisheries have changed significantly and it is expected that in the future climate change will impact on the distribution and range of some of these fisheries around the west and south coasts of South Africa. This requires further investigation and understanding.

The demersal (deep water) sector is the most valuable commercial fishery in South Africa and is worth over US$187 million (R1.4 billion) annually (Kashorte 2003). The two hake species (*M. paradoxus; M. capensis*) are the most important of the fishery. However as with most trawl fisheries there are a number of other commercially important and valued species that are caught as by catch, these include, kingklip, monkfish and sole (Kashorte 2003). There are approximately 61 vessels and 7767 employees in the deep-sea trawl industry, with a market value of around US$146 million (R1.1 billion, 2009 Rands) (Sauer *et al.*, 2003) and a payroll of US$69 million (R518 million, 2009 Rands) (Sauer *et al.*, 2003). This fishery is, however, concentrated in the Western Cape and reliant on the productive cold waters of the west and south coasts, and for the most part does not fall within the ASCLME area. Using distribution information for the demersal fishery, it can be estimated that approximately 40% of the commercial catch falls east of Cape Agulhas. Therefore the fishery has a market value of some US$58 million (R435 million).

The hake inshore fishery has a total of 29 vessels and employs 1171 people (Sauer *et al.,* 2003). The fishery targets shallow water hake and Agulhas sole from Mossel Bay eastwards to Port Elizabeth. The fishery has a market value of US$77 million (R576 million, 2009 Rands) and a payroll of US$9 million (R66.5 million, 2009 Rands) (Sauer *et al.,* 2003).

The pelagic fishery is the second most valuable fishery in the country. Pelagic fish have a lower unit price than the demersal fish and are used mainly for canning, fish meal and oil (Kashorte 2003). Pelagic catches fluctuate every year mainly as a result of environmental conditions. There are approximately 7800 employees and 65 purse-seine vessels involved, with a total value of approximately US$92 million per annum (R691 million, 2009

Rands) (Sauer *et al.* 2003). Roughly 50% of the pelagic catch falls east of Cape Agulhas with a total value of $46 million (R345 million).

The rock lobster fishery is based on two species, one on the west coast and one on the south coast. The west coast rock lobster is caught using traps and hoopnets that are deployed from small vessels, whereas the south coast species is a deep water species and caught using long lines of traps set by larger vessels (Kashore 2003). Only the south coast rock lobster fishery will be considered for this study of the Western Indian Ocean Region. There are approximately 13 vessels engaged in the south coast rock lobster fishery which extends from East London to Cape Agulhas (Sauer *et al.,* 2003). It supports 400 employees and has a total landed value of US$12.4 million per annum (R93 million, 2009 Rands), with a wholesale value of US$21 million (R156 million, 2009 Rands) (Kashore 2003).

The squid fishery is based in the Eastern Cape Province and supports around 2500 employees on 120 vessels and is worth approximately US$45 million per annum (R338 million, 2009 Rands) (Kashore 2003). Between 2000 and 10 000 metric tons of squid are harvested annually.

The commercial line fishery harvests approximately 13 000 tons of line fish species, such as yellowtail, snoek, kob and reef fish every year with a value of about US$133 million (R1 billion, 2009 Rands) (Kashore 2003). The majority of this value is however attributable to the west coast of South Africa and it is estimated that 60% of the line fishery value comes from the west and south-western Cape. Forty percent or US$53 million (R400 million, 2009 Rands) is attributable to the ASCLME area. The commercial line fishery can be broken up into traditional line fishery, the hake handline fishery and the tuna handline/pole fishery.

The KZN prawn fishery harvests approximately 400 tons of crustaceans annually (Sauer *et al*., 2003). There are 5 inshore and 3 offshore permits for the fishery with an annual catch value of approximately US$2 million (R15.5 million, 2009 Rands) with a retail value of US$4 million (R29.6 million, 2009 Rands) (Sauer *et al.,* 2003).

The beach-seine and gill-net fisheries are South Africa's oldest commercial fisheries (Lamberth *et al.,* 1997). Lamberth *et al.,* (1997) recorded a total of 316 gill nets and 121 beach seine nets on the southern Cape coast, Eastern Cape coast and KwaZulu-Natal coast. Of these 52% were in the southern Cape coast, 4% in the Eastern Cape and 45% in KwaZulu-Natal (Lamberth *et al.* 1997). Lamberth *et al.,* (1997) worked on a net-to-crew ratio of three and 10 persons for gills nets and beach seine nets respectively, equating to 2158 fishers involved in the two fisheries on the east coast. The seine and gill net fisheries on the East coast have a total value of US$2.3 million (R16.7 million, 2009 Rands) (Lamberth & Turpie 2003).

Subsistence Fishery

There are approximately 147 fishing communities along the South African coastline with an estimated 28,388 fishing households and 29,233 people who are considered to be subsistence fishers (Clark *et al*. 2002). Most of these subsistence fishers were found on the east coast in KwaZulu-Natal and the former Transkei (Clark *et al*., 2002). They live in both rural and urban settings and harvest a variety of different species from the intertidal, shallow subtidal and near shore environments (Clark *et al*. 2002). The majority of households reported that fish was the most commonly caught/harvested resource with mussels, octopus, rock lobster, sand and mud prawns, limpets and redbait also being important marine resources harvested by subsistence households (Branch *et al*., 2002). Fish, rocky intertidal invertebrates and sandy beach invertebrates are harvested by subsistence fishers around the entire coast but estuarine invertebrates feature more prominently on the southern and northern regions of the East coast (Clark *et al*., 2002). On the east coast of South Africa from Cape Agulhas to the Mozambican border there are an estimated total of 163 422 people that are dependent on subsistence fishing for their livelihoods (Clark *et al*., 2002).

The White Paper for Sustainable Coastal Development (DEAT 2000) valued subsistence fishing along the coast at US$3.6 million per annum (R27.5 million, 2009 Rands). This value includes some line fishing, intertidal collecting and beach netting.

Recreational Fishery

It is estimated that there are some 750 000 recreational anglers in South Africa (McGrath *et al.,* 1997). There are three groups of recreational anglers; shore anglers that fish directly from the shore, off beaches and in estuaries, boat-based recreational fishing which takes place off from small boats in estuaries or from larger boats that target reef fish or game fish offshore, and underwater spearfishing which is practised along the entire coastline (CLA Report 2011).

Recreational shore angling is very intense; especially along the southern Cape coast the length of the Agulhas Plain, with 2.29 anglers km^{-1} on average, compared with 0.36 km^{-1} further east (Turpie *et al.*, 2003). Recreational shore angling is important to the economy and supports other industries such as bait and tackle outlets, which result in further employment (Turpie *et al.*, 2003). Shore angling contributes the most in generating income and employment (McGrath *et al.*, 1997). The recreational shore and ski-boat anglers in the southern Cape, Eastern Cape and KwaZulu-Natal are estimated to contribute US$453 million (R3.4 billion, 2009 Rands) and US$4.3 million (R32.5 million, 2009 Rands), respectively, to the economy (McGrath *et al.*, 1997). Underwater spearfishing is entirely recreational and has an estimated 7000 participants in South Africa (Turpie *et al.*, 2003). The landed catch value for the fishery as a whole is approximately US$200 000 (R1.5 million, 2009 Rands), and the total value of the fishery is estimated to be in the order of US$12.8 million (R96 million, 2009 Rands) (Turpie *et al.*, 2003). The total gross output for the recreational fishery section is estimated at US$470 million (R3.5 billion, 2009 Rands).

Table 10 is a summary of the different economic value measures that were calculated during this study for the commercial, subsistence and recreational fisheries in South Africa.

Table 10: Summary of the economic values for the fisheries sector in South Africa

Type of fishery	Gross economic output	Number of jobs
Hake Offshore	58	7 767
Hake Inshore	77	1 171
Pelagic	46	7 800
South Coast Rock Lobster	12.4	400
Squid Fishery	45	2 500
Commercial Line fishery	53	
KZN Prawn Fishery	2	
Net fishery	2.3	2 158
Recreational Fishery	470	-
Subsistence Fishery	3.6	29 233
Total	769.3	> 51 029

Coastal agriculture and forestry

The South African coastline provides significant opportunities for agriculture, especially on the east coast where soils are rich and productive (CLA Report 2011). There are over 3 million people (users and dependents) that rely on subsistence agriculture at the coast and important commercial agricultural products on the coast include sugar-cane and bananas. However subsistence and commercial agriculture and plantation forestry along the coast are not attributable to the coast per se (i.e. they are not dependent on the coast). Nevertheless some of these activities, such as plantation forestry, do impact on the coastal zone and catchment areas.

It is understood that a large number of the coastal population are involved in agriculture – but the value that is ascribed to this cannot be linked to the coast unless the product being farmed is only able to be farmed at the coast. The White Paper for Sustainable Coastal Development in South Africa (DEAT 2000) found that over 3 million people living along the coast depended on coastal agriculture and the estimated value of this was US$264 million or R1.9 billion (2009 Rands). This calculation is however based on generic global values and should be considered as a rough estimate.

Mariculture

Aquaculture development in South Africa has focused on medium to large scale commercial on shore systems that are designed primarily for abalone but also include recent developments into finfish production (CLA Report 2011). These commercial aquaculture farms provide employment opportunities in rural communities – although many of these farms are located in urban areas, there are some that are found in the more rural areas of the Eastern Cape Province. The high wave energy on the South African coastline can be very problematic for the establishment of small scale or subsistence aquaculture production systems (CLA Report 2011). Most of the mariculture is conducted in the Western and Eastern Cape with some finfish production occurring along the KwaZulu-Natal coast (Britz *et al.,* 2009). The South African Government is currently taking steps to expand offshore finfish aquaculture production.

A total of 2 441 tons of seafood was produced in South Africa in 2008 (Table 11), with abalone contributing 934 tons of this and employing a total of 1 040 people on 18 different farms (CLA Report 2011). The total gross output (at farm gate) for mariculture in South Africa in 2009 was US$37.9 million (R284 million, 2009 Rands) (Britz *et al.,* 2009). Abalone production is far more valuable than any of the other aquaculture products, and most of the farms are located to the west of the ASCLME area. It has been estimated using the numbers of farms on the east coast of South Africa, that the mariculture value associated with the ASCLME coast is US$10 million (R75 million, 2009 Rands).

Table 11: Mariculture production and value in South Africa (US$ 2009) (Britz *et al.,* 2009)

Farming activity	Annual Production in 2008 (tons)	Value (Million US$)	Employment	Number of Farms
Abalone	934	35.9	1040	18
Seaweed	608	0.09	-	
Mussels	600	0.8	26	1
Oysters	289	1.13	100	9
Finfish	10	0.06	68	7
TOTAL	**2441**	**37.98**	**1234**	**35**

Energy

South Africa's oil and gas deposits are relatively small but its refining and downstream oil sector is developing fast (SA Government 2011). Exploitation of the natural gas fields off the South African south coast at Mossel Bay led to the development of PetroSA's gas-to-liquids (GTL) refinery, one of the largest GTL refineries in the world (SA Government 2011). The refinery produces 36 000 barrels per day – a crude oil equivalent of 45 000 barrels per day. The Mossel Bay GTL plant serves up to 15% of South Africa's transport fuel requirements by producing unleaded gasoline, low sulphur diesel, kerosene, drilling fluids, liquid petroleum gas, fuel oil, liquid oxygen, liquid nitrogen and waxes (PetroSA 2010). PetroSA is currently developing Project Jabulani off Sandbaai on the south coast for further GTL production. Gas production will start in mid 2012 (PetroSA 2010). A total of 45 000 barrels of crude oil a day equates to 16 425 000 barrels per annum. In 2009 the average price for global oil per barrel was US$76, resulting in a total gross output of US$ 1.25 billion (R9.4 billion, 2009 Rands).

Ports and Coastal Transport

With 95 percent of South Africa's trade volume being seaborne (or approximately 80 percent in value terms) the country is dependent upon the effectiveness and efficiency of the commercial ports found along its coastline (Chasomeris 2005). South Africa's commercial ports are important not only for trade but also for economic growth and development of the entire southern African region (Chasomeris 2005). In 2002 total port cargo handled was roughly 190 million tons, representing 3.5 percent of the world sea trade volumes (Chasomeris 2005). South Africa is placed within the top 12 international maritime trading nations.

The South African Indian Ocean coastline is 1620 kilometres long stretching from Cape Agulhas to the Mozambican border at Manguze (CLA Report 2011). Along this coast there are six major commercial ports; Mossel Bay, Port Elizabeth, Ngquru (Coega), East London, Durban and Richards Bay (CLA Report 2011).

These ports are all linked to the interior of the country via road and rail. In 2009, these ports handled a total of 224 million tons of deepsea import-export cargo and 3 million tons of petroleum products via coastwise shipping (CLA Report 2011). The South African maritime division has had an average year on year revenue growth of 9.5% between 1996 and 2006 (Trade and Industry Chamber 2007). The revenue generated from the maritime division was estimated to be US$1.5 billion per annum (R11.2 billion, 2009 Rands, Trade and Industry Chamber 2007).

Coastal mining

The coastline of South Africa is mined for heavy metals (titanium and zirconium), mineral sands, and cement and aggregates (RBM 2011). South Africa is Africa's main producer of titanium and zirconium, and supplies 30% of world production (RBM 2011). Ilmenite, rutile and leucoxene are the primary ore minerals of titanium and usually found in localised beach deposits, known as Heavy Mineral Sands. Richards Bay Minerals (RBM) on the north east coast of KZN are the main producers in South Africa of titanium minerals, high purity pig iron, rutile and zircon, as well as space-age metals. Sand is mined extensively along the coastline, especially in the former Transkei. Most of the sand mining is illegal and large, with a very small proportion actually having legal licenses. Production is unknown, and as result the value of sand mining cannot be estimated.

Mining and quarrying in South Africa contributed US$26.4 million or R198 million (9.1%) to GDP in 2009 (StatsSA 2010a). 'Other Metal Ores' represented 2.2% of this or US$6.3 million (R47 million, 2009 Rands). Heavy mineral sand mining along the coastline would fall within this category. KZN contributed US$900 000 (R6.8 million), the Western Cape US$100 000 (R755 000) and the Eastern Cape US$91 000 (R683 000) (StatsSA 2010a). However, it is not known how much of this can be attributable to the coast. Using mineral production values and the standard prices for Ilmenite in 2009, it was estimated that the KZN mineral mines have a gross value of US$200 million (R1.5 billion).

Coastal tourism

Tourism contribution to the South African economy has grown significantly over the past 15 years (Pan African Research & Investment Services 2010). South Africa's cultural diversity, biodiversity, natural beauty and unique location on the African continent all contribute to its attractiveness as a leading tourist destination. The South African coastline represents an important attraction and contributes significantly to the overall tourism value. Leisure accounted for the major reason for travel in the country, representing 57% of total arrivals (Pan African Research & Investment Services 2010). The coast of South Africa east of Cape Agulhas is characterised by beautiful beaches with warm water and a number of different eco-tourism activities, such as scuba diving, shark diving, turtle watching, whale watching and a number of coastal hiking adventures, such as the Whale Route and the Otter Trail. Recreational activities like game fishing, spear fishing and surfing also attract a large number of tourists and holiday makers to the east coast of South Africa.

Tourism contributed 9.3% to the GDP in 2008 (Pan African Research & Investment Services 2010) and the World Travel and Tourism Council (WTTC) has predicted that tourism will contribute approximately R328.2 billion or 11.4% to GDP in 2011 (WTTC 2011). Tourism is the third largest contributor to the economy after manufacturing and mining and quarrying (CLA Report 2011). Tourism in South Africa is expected to support directly 594,000 jobs (4.5% of total employment). This includes employment by hotels, travel agents, airlines and other passenger transportation services (WTTC 2011). The total contribution of travel to employment in South Africa is expected to be 1,334,000 jobs (10.1% of total employment) in 2011 (WTTC 2011). This includes the wider effects from investment and the supply chain (WTTC 2011). It is expected that South Africa will attract 11,877,000 international tourist arrivals in 2011, generating approximately R82.8 billion in visitor exports (foreign visitor spending, including spending on transportation) (WTTC 2011). This is a 23% increase from the 9,600,000 international tourist arrivals in 2009 (Pan African Research & Investment Services 2010).

Nature based tourism can be divided into passive or active forms, the latter being further divided into ecotourism and adventure tourism (Figure 25, Turpie *et al.,* 2003).

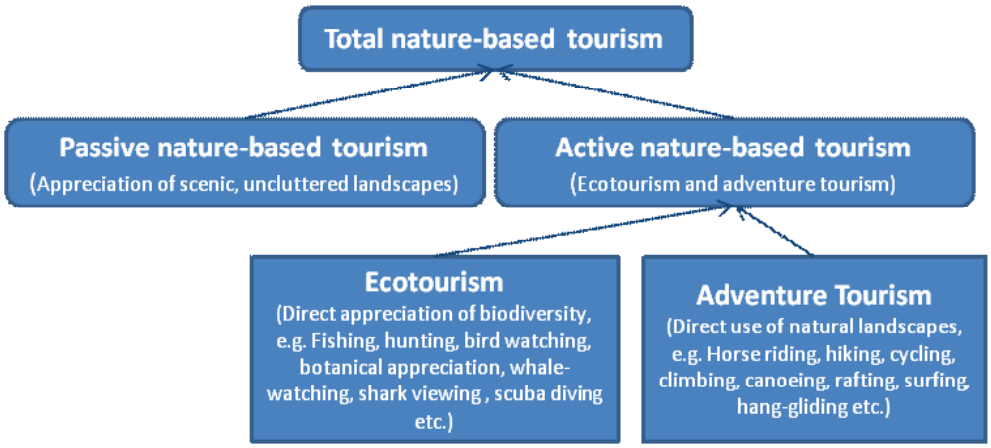


Figure 25: The different nature based activities that contribute to total nature-based tourism (Source: Turpie *et al.*, 2003).

Nature-based tourism activities contribute significantly to the attractiveness of the coastline as a tourist destination. An economic assessment of the boat-based whale watching industry in South Africa (Turpie *et al.*, 2005) established that this industry generates US$8.3 million (R62 million, 2009 Rands) in tourist expenditure and contributes approximately US$6.8 million (R51 million, 2009 Rands) to South Africa's GDP each year. A study by Findlay (1997) found that the shore-based whale watching industry had an estimated tourist expenditure of US$1.5 million (R11 million) per year. Diving with sharks is another ecotourism activity that contributes largely to the value of the coast. Diving with Tiger sharks on the east coast at Aliwal Shoal was found to have a direct value of US$1.65 million (R12.4 million) (Dicken & Hosking 2009) and great white shark diving in the Gansbaai area was found to generate US$5.6 million each year (R42 million, 2009 Rands) (Hara *et al.*, 2003). The Sardine Run on the east coast of the country is directly influenced by the Agulhas Current and contributes to tourism as well as local livelihoods. A study in the Pondoland MPA which runs boat based diving and photographic packages during the sardine run was estimated to have a direct value of US$720 000 (R5.4 million). It is estimated that the total gross value for guided ecotourism activities (such as whale watching, shark diving, scuba diving, eco-trails etc.) is approximately US$16 million (R120 million, 2009 Rands), with around 80% of this or US$ 13.3 million (R100 million) being attributable to the ASCLME coast. The gross value of other nature based tourism (which includes adventure tourism, and passive nature based tourism) is in the region of US$186 million (R1.4 billion, 2009 Rands).

Gauteng was the most visited province with a 46% share of the total arrivals whereas the Western Cape, Eastern Cape and KwaZulu-Natal had a share of 31.2% of total arrivals in 2009 (Tourism SA 2010). These three coastal provinces captured 40% of the bed nights in 2009, a total of 28 472 000 bed nights spent in these provinces (Tourism SA 2010). Gauteng and the Western Cape captured most of the tourism revenue in South Africa followed by KwaZulu-Natal. The Western Cape, Eastern Cape and KwaZulu-Natal had a total foreign direct spend of US$4.2 billion (R31.7 billion, 2009 Rands) (Tourism SA 2010). Not all of this can be attributable to the coast, and Cape Town in the Western Cape does not fall within the ASCLME. Therefore, it has been estimated (using information on bed nights in each region) that the total foreign direct spend attributable to the ASCLME coast is US$1.8 billion (R13.1 billion, 2009 Rands).

Other ecosystem services

Coastal ecosystems (coral reefs, mangroves, seagrass beds and coastal forests) cover almost 20 000km^2 in South Africa. These habitats provide regulatory services, food and raw materials, as well as recreational and cultural services. The WIO-LaB Report (2008) presented the value of ecosystem goods and services attributable to these habitats, however, the calculations were based on generic global values as found in Costanza *et al.* (1997). Empirical evidence is needed to make a more confident and accurate estimate of the economic value of these coastal ecosystems and therefore the values presented here are considered to be a rough approximation that warrants further investigation. Regulatory services provided by coastal habitats were found to have a value of some US$2 945 million. Coral reefs cover a relatively small area of 50km^2 off the north coast of KwaZulu-Natal, and the regulatory services value provided by the reefs has not yet been estimated. Coastal forests contribute

98.7% of the regulatory services value in South Africa, with mangroves and seagrass beds contributing 0.9% and 0.4% respectively (Table 12).

Table 12: Valuation (million US$) of regulatory services provided by mangroves, coastal forests and segrass beds (UNEP-WIO-LaB 2008 based on Costanza *et al.*, 1997).

	Seagrass	Coastal Forest	Mangroves
Climate regulation	-	434.9	-
Disturbance regulation	-	9.8	5.6
Water supply	-	15.6	-
Erosion control	-	477.8	-
Nutrient cycling	13.0	1 798.1	-
Waste treatment	-	169.7	20.1
Biological control	-	-	-
Habitat refuge	-	-	0.5
TOTAL	**13.0**	**2 905.8**	**26.2**

Role of coastal resources in poverty alleviation

Fisheries

Fishing communities occur along the entire South African coastline with an estimated 29 000 subsistence fisher households (Clark *et al.*, 2002). Poverty levels amongst the subsistence fishing communities were found to be high; shown by low household income, low levels of employment and high rates of food insecurity (Branch *et al.*, 2002). Branch *et al.,* (2002) also found that it was low levels of education and high unemployment rates that were central to this. Subsistence harvesting made a significant contribution to the basic needs of food security in these communities, either by consumption of their catch or by sale to generate money to buy their own food (Branch *et al.*, 2002). South Africa has a high coastal population density with some 80 people per one km^2, and there is considerable dependence on coastal and marine resources for both income and food (Brown *et al.,* 2008).

Branch *et al.,* (2002) found that poverty was differentially distributed along the South African coastline, with the poor and ultra-poor being over represented along the former Transkei and KZN coasts, where education levels were lower than elsewhere and unemployment reached 50% or more. Relative poverty levels were highest on the former Transkei Coast (57% poor) and in KZN (49% poor) and are much lower than on the South and West coasts of South Africa (Branch *et al.* 2002). This may be a result of the biogeographic distribution of marine and coastal resources because the western and southern coasts experience higher productivity and support the majority of the commercial fishery stocks (Branch *et al.*, 2002). Poverty is generally higher in rural areas as there is less opportunity for employment, isolation from markets, low levels of education and poor service delivery – Branch *et al.*, (2002) found that rural fishers were twice as likely to be poor than fishers found in other areas. The marine and coastal resources that are harvested by coastal communities are either sold, eaten or used for bait with almost all of the fish and rock lobster being sold and rocky intertidal organisms being eaten, such as mussels and limpets. Branch *et al.*, (2002) also found that the use of subsistence resources was the most intense along the KZN coast, where biomass of marine and coastal resources is lowest.

Tourism

Tourism in South Africa is one of the largest contributors to the economy and coastal tourism contributes significantly to this. The coastline of South Africa is a major attraction for a significant proportion of international tourists as well as domestic tourists. The promotion of tourism has been identified as a key strategy that can lead to economic upliftment, community development and poverty relief in the developing world (Binns & Nel 2002, Myeza *et al.*, 2010). Ecotourism is one of the fastest expanding tourism markets and presents an excellent opportunity for local economic development (Myeza *et al.* 2010). Coastal ecotourism is considered to be particularly effective in providing economic upliftment and social benefits to poor communities (Myeza *et al.*, 2010). Ecotourism activities such as whale watching, shark cage diving and coastal hikes offer some

employment opportunities and reliable income for communities living on the coast, but most of this seems to go to the wealthy investors with very little making its way down to the local level or poorer population.

In the Eastern Cape and KZN where poverty and unemployment levels are some of the highest in South Africa, there are opportunities for increased tourism and community outreach and involvement. An example of this is in KZN along the Hibiscus Coast where the annual sardine run presents an ecotourism opportunity that could benefit the local communities in the Ugu District (Myeza *et al*., 2010). The sardine run, which is an annual phenomenon, has become a major tourist event over the past few years attracting crowds of international and local tourists. Myeza *et al*., (2010) found that the participation in the sardine run by the poorer residents was very low when compared to the wealthier residents along the coast, with most of the tourism value going into hotels, bed and breakfasts and restaurants along the south coast. The study also found that 17.6% of the community gained financially from the event and that over 70% showed a willingness to receive training about the event in order to benefit more from it. Myeza *et al*., (2010) also calculated that total earnings by the poor sector of the community (110 000) amounted to an average of R160 per person for the season. The total population could therefore earn around R18 million per year from the sardine run (Myeza *et al*., 2010). With a multiplier effect of 2 to 3, then the financial benefit to the local community could be as much as R36 - R54 million (Myeza *et al*., 2010). Management strategies and development plans are needed to assist these communities in training exercises that would enable them to benefit from this ecotourism activity.

Mariculture

The AISA aquaculture benchmarking survey states that the odds are stacked heavily against the entry of small businesses into aquaculture, which is a serious concern for policy makers who favour small business development as a way to create jobs in developing countries (Britz *et al.,* 2009). The aquaculture sector is still young and developing but it was found that 51% of the aquaculture businesses were operating at below 50% capacity and that the marine aquaculture sector was very capital intensive, favouring medium sized enterprises. Most of the aquaculture enterprises in South Africa were financed by private investments and loans, with only a small percentage having government participation of any kind (Britz *et al.,* 2009). Although the sector is young and developing, employment grew by 80% between 2005 and 2008, with permanent employment growing substantially. The sector has potential for creating jobs and for creating alternative livelihoods for those living along the coast. However a number of interventions are needed in order to achieve this (Britz *et al.,* 2009):

- Research, technology development and transfer.
- Capacity to monitor and guarantee the safety of the aquaculture producers
- Facilitate access to finance
- Monitoring of water quality for export purposes
- Promotion of aquaculture education, training and skills development

Energy, Coastal Mining and Ports

The energy, coastal mining and coastal transport sectors play an important role in employment and the national economy. These sectors employ a significant number of skilled and unskilled labourers living along the coast. There are six large ports along the east coast of South Africa and these are important in terms of economic growth and development in southern Africa. The mining and energy sectors are however often linked with conflict and negative impacts. Mining is often associated with exploiting the poor, not recognising labour rights, not following regulations and being unsustainable (Bourassa 2009). Mining often benefits only the local elites and not the indigenous communities or labourers. A number of these negative associations have been attributed to poor governance, poor strategies and policies, and an ineffective balance of power in society (Bourassa 2009). The mining sector requires transformation towards sustainability, capacity for good governance and an enabling environment in order for more equal benefit distribution and development to be felt (Bourassa 2009). The following table is a summary of the contribution of coastal resources to national income and poverty alleviation in South Africa. The estimated total contribution (without regulatory services) to the South African economy is in the order of some US$5.7 billion (Table 13).

Table 13: Summary of the contribution to national income (million US$) of the different activities and their contribution to poverty alleviation in South Africa.

Activity		Contribution to Gross Economic Ouput (Million US$)	Jobs	Contribution to poverty alleviation
Renewable resource extraction	Commercial	242.8	30 000	Important in west and south west
	Subsistence	3.6	29 500	Very important
	Recreational	470	(750 000)	Negligible
Non-renewable resource extraction		1 450	±10 000	Important – jobs and national income
Coastal Tourism		1 734	594 000	Very important – national income, jobs and opportunities for small entrepreneurs
Coastal agriculture & forestry (not necessarily attributable to the coast)		264	?	Small-scale/subsistence agriculture very important. Commercial agriculture – declining employment.
Mariculture		9.6	±1500	Important in some areas – jobs and alternative livelihoods
Ports/harbours		1 500	?	Important – jobs and national income
Regulatory Services		2 945	-	

Policy and Governance

A comprehensive report was prepared on Policy and Governance, which is Annex V to this MEDA. A summary is presented below.

South Africa has yet to agree on the EEZ boundaries with Mozambique. Some gaps and recommendations identified for the effective implementation of an ecosystem based approach to managing marine and coastal resources are:

South Africa has not adopted several of the conventions related to marine and freshwater resources and marine pollution related conventions such as the Convention on the Conservation and Management of Fishery Resources in the South East Atlantic, 2001 (signed in 2001, not ratified), Convention on the Protection of the Underwater Cultural Heritage, 2001 (neither signed nor ratified), Revised Protocol on Shared Watercourses in the Southern African Development Community Region, 2003, Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 (neither signed not ratified) and International Convention on the Control of Harmful Anti-Fouling Systems, 2001 (neither signed not ratified)

The South African Marine Living Resources Act 18 of 1998 includes a set of principles whose underlying tenet is sustainable utilization and/or ecosystem based management. The Marine Living Resources Act provides for a fisheries management mechanism, empowering the Minister to declare fisheries management areas, for the management of identified species (sect 43). The Minister may in addition approve a plan for the conservation, management and development of the fisheries in question. The Department of Fisheries should be encouraged to include an Ecosystem Based Approach in these fisheries management area plans. The application for the allocation of fisheries quotas could be made the subject of an environmental assessment and this could include the requirement that the effect on the ecosystem in question be taken into account prior the allocation of the quota.

South Africa has enacted a progressive National Environmental Management Act: Integrated Coastal Zone Act (24 of 2008) which rests on the foundation that the coastal ecosystem is a dynamic area and management decisions should be undertaken on a holistic basis. It provides a model for other legislation and it is recommended that an ecosystem approach be adopted in other legislation, for example planning laws.

South Africa is party to a number of Regional Fisheries Management Organizations (RFMOs). Of particular relevance are: the Western Indian Ocean Tuna Organization (WIOTO), and the South West Indian Ocean Fisheries Commission (SWIOFC). It is recommended that South Africa promote an Ecosystem Based Approach ('EAB') in these regional fora.

It is recommended that an Ecosystem Based Approach be put on the respective inter-governmental committees known as MINTECs (Ministerial Technical Committees) and MINMECs (Provincial Ministerial Advisory Committees). There is also much room to strengthen both institutional and law enforcement capacity in South African government agencies.

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