STATE OF THE OCEANS AND COASTS AROUND SOUTH AFRICA 2016 REPORT CARD

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STATE OF THE OCEANS AND COASTS AROUND SOUTH AFRICA

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Cover design:

Artistic depiction of the global ocean observing system and the ocean that it serves to monitor - Glynn Gorick (commissioned by GOOS office).

INTRODUCTION

South Africa is a maritime nation, whose coastline stretches approximately 3,000 km around the southern portion of Africa, from the Orange River mouth on the Namibian border to Ponta do Ouro on the Mozambique border. Additionally, the Prince Edward Islands are South African territory in the southwest Indian Ocean. The marine exclusive economic zone over which South Africa exercises jurisdiction (*ca* 1,553,000 km²) is one of the largest in the world and the country has lodged applications to extend its continental shelf claim of the sea bottom by a further 1,245,000 km².

South Africa's marine and coastal ecosystems provide a multitude of services for its inhabitants, including: supporting services, such as nutrient recycling, primary production, sediment deposition and transport, which are necessary for the production of other ecosystem services; provisioning services, for example, minerals from mining and food from fishing; regulating services, such as waste decomposition, sequestration of carbon, production of oxygen, purification of water and mitigation of storm damage; and cultural services, e.g. nature recreation, water sports, science and education. Historically, pursuits such as fishing, mining and transport played a major role in the utilisation of South Africa's oceans and coasts. These activities continue to be emphasised, but other usages are currently expanding. For example, in 2015 the African Penguin colony at Boulders became the most-visited penguin colony in the world and the possibility that the ocean will provide alternative forms of energy is being investigated. It is hoped that in the future South Africa's oceans and coasts will provide increased employment and benefits for South Africans of both present and future generations.

The various activities listed above have aggregated impacts on the environment. Furthermore, a changing climate is having a noticeable impact on South Africa's marine ecosystems, as is evident for example in the ongoing redistribution of several species. In order to ensure the healthy and sustainable functioning of South Africa's ocean and coastal ecosystems, which is a major objective of the Department of Environmental Affairs (DEA), the various stressors need to be managed in a holistic manner. This requires extensive cooperation with various stakeholders, including national and provincial government departments, businesses, universities and non-governmental organisations. This collaboration is required both nationally but also regionally and internationally, as the oceans and coasts adjacent to South Africa are influenced by happenings elsewhere in the world. Therefore, it is expedient for South Africa to participate in relevant international agreements and investigations.

This report is compiled primarily by staff within the Chief Directorate: Oceans and Coasts Research that resides within the Branch: Oceans and Coasts. Contributors from outside the Department are acknowledged. The Branch maintains and seeks to grow human capacity and infrastructure in all aspects of marine sciences towards improving understanding and management of marine ecosystems.

In this report, DEA provides updated information on the status of some parameters for South Africa's oceans and coasts, ranging from chemical and physical properties to biological assessments. These have been selected as potentially-useful indicators of the change, health and management of South Africa's marine ecosystems.

The format of this report card is aimed at providing a brief overview of the research and monitoring undertaken within the Department, with articles generally not exceeding a page. This format does not allow for an in-depth description or discussion. Readers are welcome to contact contributing authors within the Chief Directorate for more information on the various research aspects covered. The Department wishes to express its appreciation to the many collaborating agencies that have contributed to the work presented in this compilation.

Climate change is starting to have noticeable effects on South Africa's marine ecosystems. Its impact on the faunas of high-latitude ecosystems, such as Antarctica where this Emperor Penguin chick is approaching the stage at which it will first venture to sea, have been apparent for some time.

Dr Monde Mayekiso,
Deputy Director-General, Branch: Oceans and Coasts
Photograph: RJM Crawford

1. SEA SURFACE TEMPERATURE AROUND SOUTH AFRICA

Ocean temperature is a critical environmental variable for marine organisms. Long-term environmental records allow for the separation of short-term signals and long-term (interannual to decadal) climate variability and trends. The latest version of the Pathfinder Sea Surface Temperature Climate Data Record, produced by the United States National Oceanic and Atmospheric Administration (US NOAA), provides a global 33-year time-series of sea surface temperatures (SSTs) at 4-km horizontal and 12-hour temporal resolution. These data are derived from NOAA's Advanced Very High-Resolution Radiometer (AVHRR) satellites. While the Pathfinder algorithm has some known shortcomings off the west coast of South Africa, this SST time-series is undeniably the longest and most consistent ocean environmental record available for the entire South African EEZ.

The long-term average SST around South Africa (Figure 1) is determined primarily by latitude and secondarily by major ocean circulation features such as the Agulhas Current, one of the strongest ocean currents in the world.

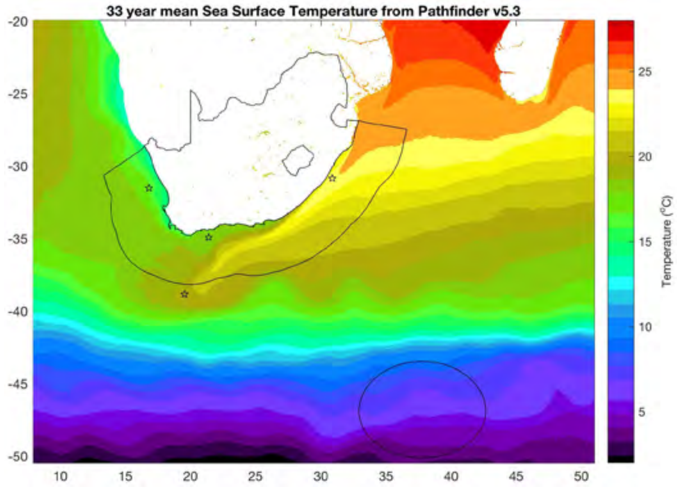


Figure 1: Long-term mean SST. South Africa's borders and Exclusive Economic Zone are outlined in black. Black stars indicate representative analysis locations.

The long-term record of SST at the location on the West Coast in the Benguela upwelling system is shown in Figure 2.

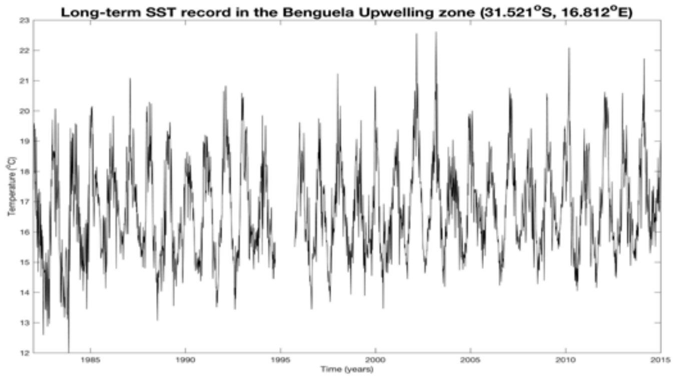


Figure 2: Long-term record of SST at a representative site on the West Coast in the Benguela upwelling system

Computation of a harmonic (sine-wave) climatology from individual SST measurements at a site presents the average conditions at that site for any given day of the year computed over a number of years, in this case 33 years. The annual cycle for different marine zones can thus be determined with a high degree of confidence from this dataset, owing to its long duration. South Africa has a number of ocean climate zones with distinct characteristics, some examples of which are shown in Figure 3.

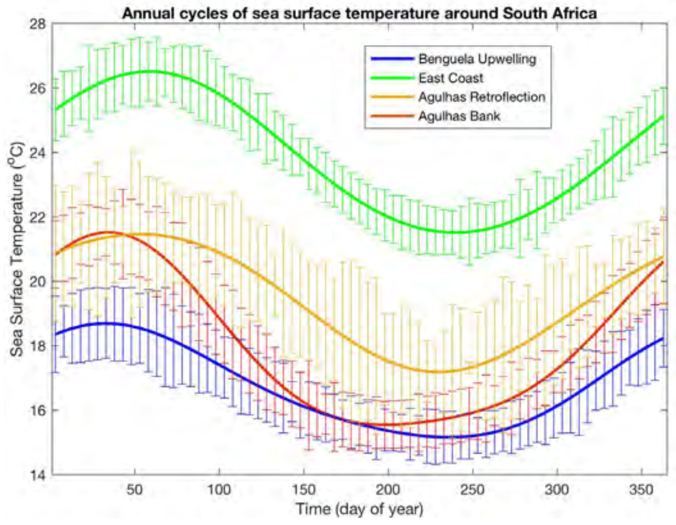


Figure 3: Annual cycles of SST around South Africa. Vertical bars show the variability in SST over 33 years on the given day of the year. The four locations plotted are shown in Figure 1.

Based on knowledge of the long-term ocean climate, environmental anomalies and trends can be calculated, as shown in Figure 4 for the west coast of South Africa. Over time, the signal of global warming can be seen as anomalies become more frequently positive (> 0).

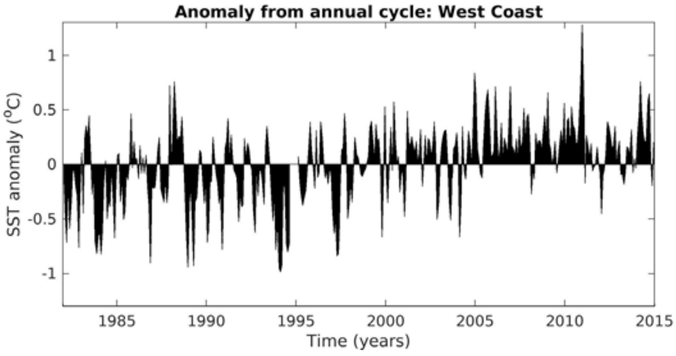


Figure 4: SST anomalies on the west coast of South Africa over time. The average annual cycle has been removed. Note the increase in the number of warm anomalies from 1999 onward, compared with the prevalence of cool anomalies prior to 1999.

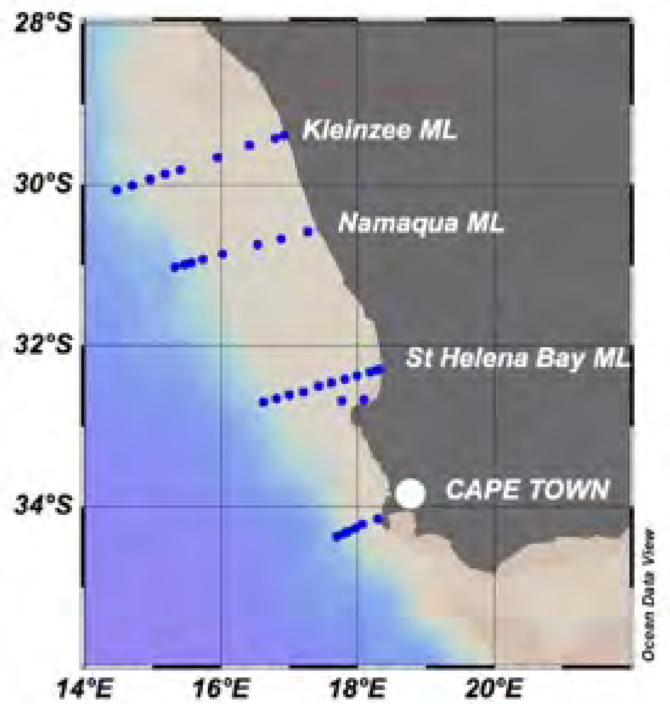
Author: DA Byrne

Data: S Baker-Yeboah, K Saha, D Zhang, KS Casey, KA Kilpatrick, RH Evans and T Ryan (2016). AVHRR Pathfinder version 5.3 level 3 collated (L3C) global 4km sea surface temperature. NOAA National Centers for Environmental Information. doi:10.7289/V52J68XX [2016–10–12]

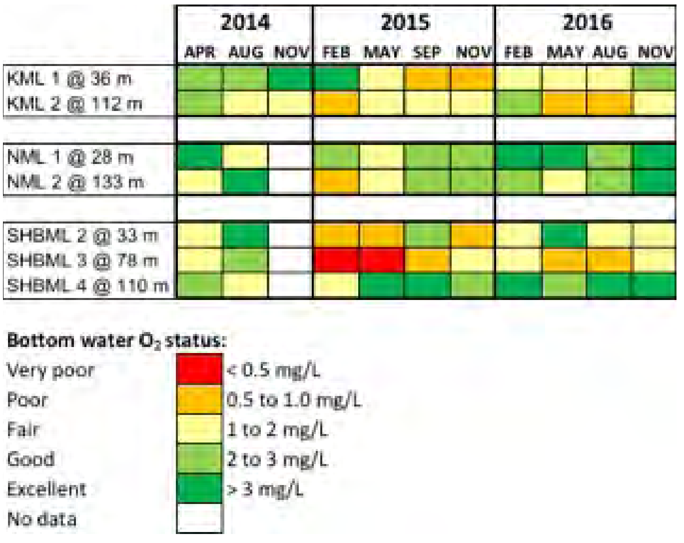
2. MONITORING OF BOTTOM WATER OXYGEN LEVELS ALONG THE WEST COAST IN THE SOUTHERN BENGUELA UPWELLING SYSTEM

Concentrations of dissolved oxygen (O_2) in seawater are determined by a combination of factors, including exchange with the atmosphere and temperature-dependent solubility factors, biological production and respiration, and mixing processes. There is increasing evidence for a trend of global change towards lower levels of seawater dissolved oxygen, which poses a threat to marine ecosystem health.

In the southern Benguela upwelling system, the lowest seawater O_2 levels are typically found in inshore bottom waters, and low levels are more pronounced during the summer and autumn months, in response to the respiration of phytoplankton biomass produced during spring and autumn upwelling events.



Map showing the monitoring lines of the Integrated Ecosystem Programme off the West Coast, sampled quarterly in 2016



Very Poor, or anoxic (O_2 < 0.5 mg/L), conditions can result in mass mortality of marine species and the formation of 'dead zones'.

Fair and ***Poor***, or hypoxic (O_2 < 2 mg/L), conditions can result in benthic fauna starting to show aberrant behaviour.

Status of Bottom Water O_2 in 2016:

St Helena Bay Monitoring Line (SHBML)

► ***Poor*** at 78 m depth (Station 3) in May and August, recovering to ***Fair*** by November.

Namaqua Monitoring Line (NML)

► ***Fair*** at 133 m (Station 2) in May, recovering to ***Excellent*** by November.

Kleinzee Monitoring Line (KML)

► ***Poor*** at 112 m (Station 2) in May and August, recovering to ***Fair*** by November.

Summary:

Along all three West Coast monitoring lines, O_2 levels were generally higher in 2016 than in 2015.

Authors: S de Villiers and M Tsanwani
Contributors: K Vena, G Kiviets, H Ismail, K Siswana, B Mdokwana and G Tutt

3. DISTRIBUTION OF SURFACE SEAWATER pH OFF THE WEST COAST OF SOUTH AFRICA IN LATE SUMMER

The upper waters of Eastern Boundary Upwelling Systems naturally have a comparatively low pH due to seasonal upwelling, making these regions vulnerable to ocean acidification. The uptake of anthropogenic CO_2 by the oceans has already reduced the global ocean pH by approximately 0.1 units indicating the need for monitoring long-term changes.

Data on the distribution of pH on the west coast of South Africa were collected aboard the RV *Algoa* during the February 2017 cruise of the Integrated Ecosystem Programme: West Coast (IEP: WC; Figure 1). Surface pH was measured underway using a pH sensor incorporated into an Idronaut OCEAN SEVEN On-Line module.

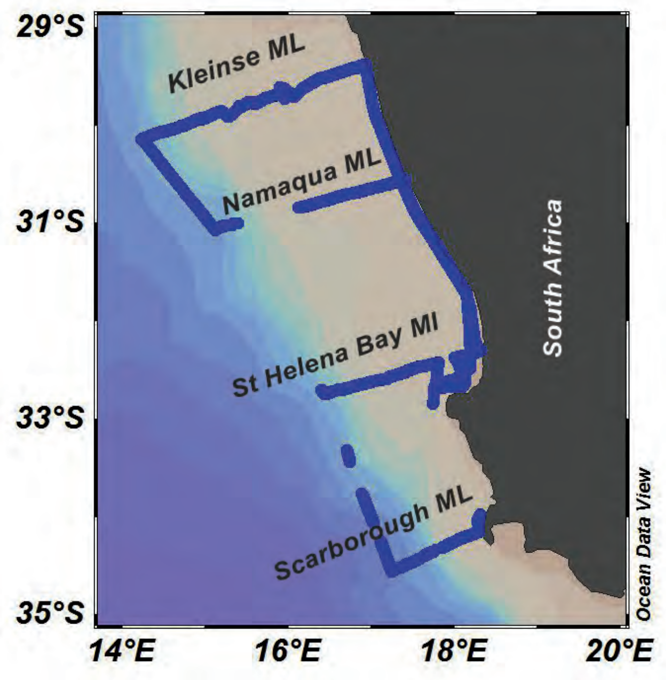


Figure 1: Map showing the cruise track of the IEP: WC cruise off the west coast of South Africa in February 2017

Figure 2 illustrates that surface waters of low pH in the inshore zone are characterized by low dissolved oxygen (DO), low temperature and low salinity.

- The surface pH in the inshore zone ranged from 7.23 to 8.56.
- The lowest DO value of 1.18 ml/L was found at the inshore station of the St Helena Bay Monitoring Line, and was associated with a pH of 7.51 and a temperature of 10.57 °C.
- High surface pH values with a maximum value of 8.56 and DO values reaching a maximum of 12.69 ml/L were measured across patches of a red tide bloom encountered in St Helena Bay during the cruise.
- pH values in offshore areas were on average 8.12.
- Low-pH waters with low DO and low temperatures observed in the inshore zone suggest that these conditions were caused by both physical (upwelling) and biological (local degradation of organic matter) processes.
- Salinity in the inshore zone was low with values of 34.57–34.81 PSU compared to higher values of up to 35.42 PSU observed offshore.

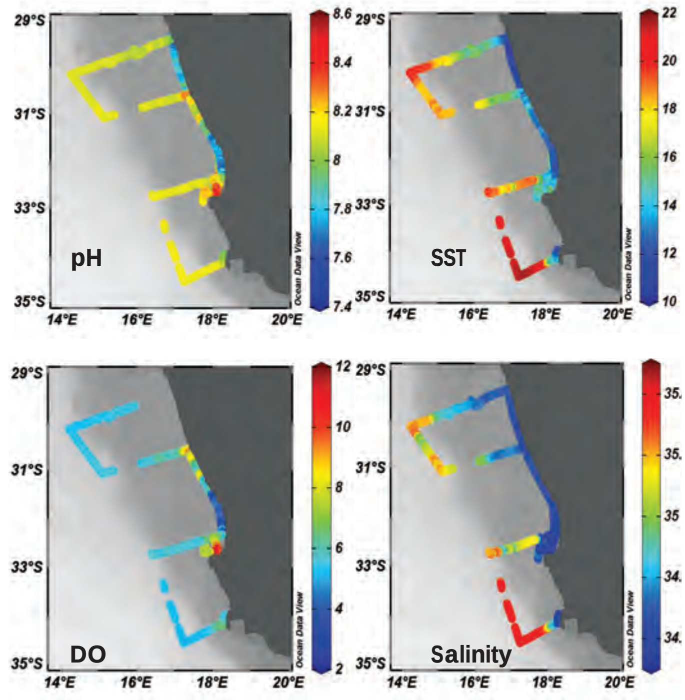


Figure 2: Distribution of surface pH, dissolved oxygen (DO), temperature (SST) and salinity in February 2017

Summary

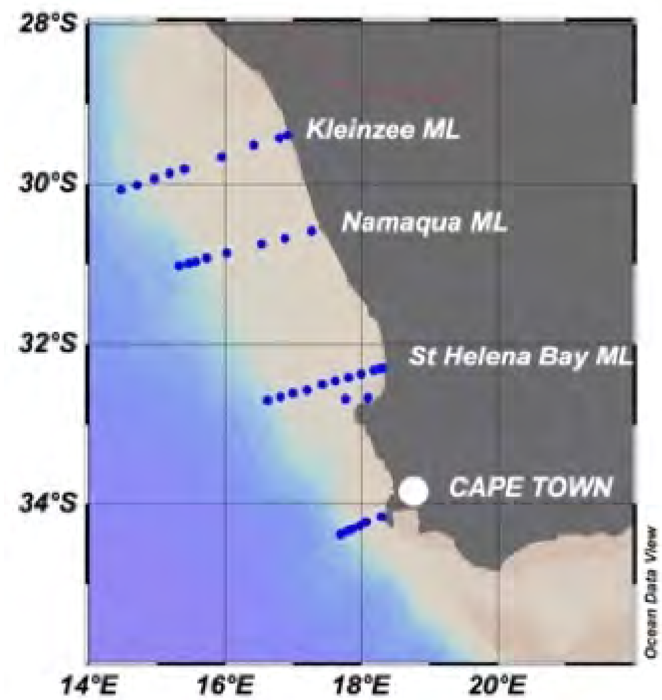
The extremely low pH values observed inshore off the West Coast during late summer make this region predisposed to the effects of ocean acidification. It is evident that organisms living near the shore are periodically exposed to low pH conditions and may have to adapt to a chemically changing environment due to the absorption of atmospheric CO_2 by the ocean.

Author: M. Tsanwani
Contributors: D Jozana, BW Mdokwana, M Lombi and V Mlandeli

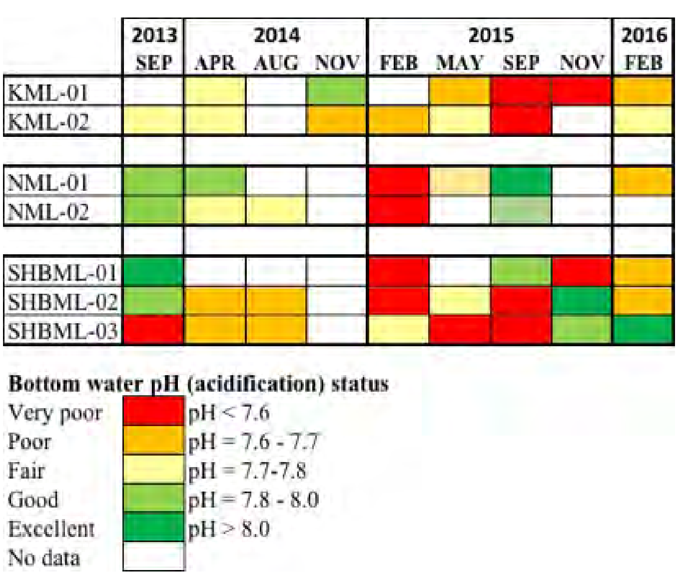
4. OCEAN ACIDIFICATION IN THE BENGUELA UPWELLING SYSTEM, ALONG SOUTH AFRICA'S WEST COAST

Oceanic uptake of anthropogenic CO_2 is changing the ocean's chemistry, leading to more acidic conditions (lower pH) and lower chemical saturation states (Ω) for the calcium carbonate ($CaCO_3$) minerals formed by many marine species. If seawater becomes under-saturated with respect to $CaCO_3$ ($\Omega < 1$), the shells and skeletons of organisms such as corals, pteropods, molluscs and foraminiferans can begin to dissolve. Increased ocean acidification can have enormous implications for marine ecosystem health and functioning as a result.

Seawater in highly productive upwelling areas, such as the Benguela upwelling system, has naturally low pH values. This is a consequence of the temperature-dependent solubility of CO_2 and processes such as the respiration of organic matter that produces high CO_2 and low pH conditions.



Map showing the monitoring lines of the Integrated Ecosystem Programme off the West Coast.



Water samples collected from September 2013 to February 2016 were analysed for their total dissolved inorganic carbon and alkalinity content, to establish accurate pH values. Analysis of subsequent samples is currently underway.

A pH of 7.7 is equivalent to an aragonite saturation state of *ca* 1 and indicates the onset of stress for calcifying organisms.

Status of bottom water pH in 2013, 2014, 2015 and February 2016:

In the southern Benguela upwelling system, the lowest pH values are observed in the bottom waters of inshore stations, corresponding with areas where phytoplankton productivity in the overlaying water is highest.

St Helena Bay Monitoring Line (SHBML)

► ***Very Poor*** conditions were observed in bottom waters at Stations 1 and 2 in February, at Station 3 in May, at Stations 2 and 3 in September, and at Station 1 in November, in 2015.

► ***Poor*** conditions were observed in bottom water at Stations 1 and 2 in February 2016.

Namaqua Monitoring Line (NML)

► ***Very Poor*** at 28 m depth (Station 1) and 133 m depth (Station 2) in February 2015, however, conditions improved to Poor in February 2016.

Kleinzee Monitoring Line (KML)

► ***Very Poor*** in bottom waters at Stations 1 and 2 in September 2015 and at Station 1 in November 2015.

► ***Poor*** to Fair conditions were observed at Stations 1 and 2 in February 2016.

Summary:

Low pH and aragonite saturation state conditions are confined to the nearshore environment along the three monitoring lines (KML, NML and SHBML).The occurrence of low pH and low aragonite saturation state conditions pose a huge threat to shells and skeletons of marine organisms. The continued uptake by the ocean of anthropogenic atmospheric CO_2 will lead to more acidic conditions, threatening marine species such as abalone, prawns, mussels and oysters, which are important for the aquaculture industry.

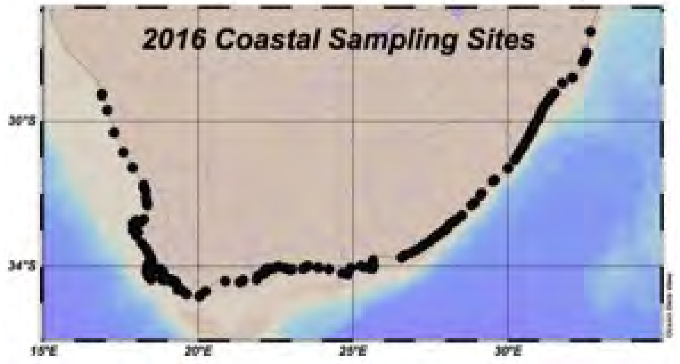
Authors: M Tsanwani and S de Villiers
Contributors: BW Mdokwana, K Siswana, V Mlandeli, K Vena, H Ismail and G Kiviets

5. STATUS OF OCEAN ACIDIFICATION IN SOUTH AFRICA'S COASTAL WATERS

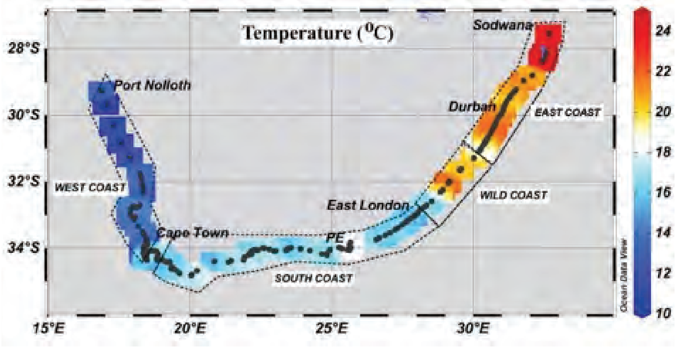
Ocean acidification manifests as lower seawater pH values, and is caused primarily by the absorption of anthropogenic atmospheric CO_2 by the ocean. This can harm marine creatures that form calcium carbonate ($CaCO_3$) shells or skeletons, such as corals, oysters and mussels, and the larval stages of these and most fish species.

At present, the average pH of global open ocean surface water is about 8.1, i.e. seawater is slightly alkaline. This is about 0.1 pH units lower than 200 years ago, and represents a 25% increase in H^+ activity, or acidity. At pH values below 7.7, seawater becomes under-saturated with respect to the $CaCO_3$ mineral aragonite and marine organisms that form shells or skeletons containing aragonite, e.g. corals, mussels and oysters, become susceptible to dissolution. At a pH value of 7.4, seawater is 200% more acidic than at 8.1, and the consequences for marine organisms that depend on biogenic $CaCO_3$ formation will be catastrophic.

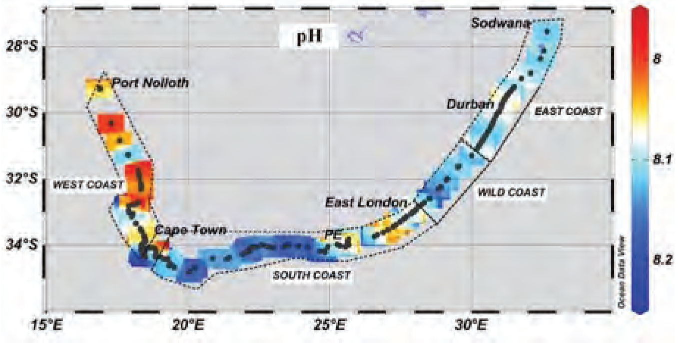
In order to monitor ocean acidification trends and to assess which areas and organisms are potentially most susceptible to acidification, a database representative of spatial and temporal variability has to be established first. In 2016, the coastal baseline survey, which was started in 2015, was expanded from 42 to 180 sampling sites, and seasonal sampling was initiated along the West Coast (Cape Town to Port Nolloth). The sampling locations are shown in the map below.



Since temperature (°C) has an important control on the CO_2 content of seawater, and therefore its pH, it is a key parameter for interpreting pH variability. During the 2016 sampling surveys coastal water temperature varied from 10.4° to 14.8° along the West Coast in August and from 11.2° to 21.7° in November. In May–June, temperature varied from 14.4° to 18.9° along the South Coast, from 16.2° to 22.2° along the Wild Coast, and from 18.5° to 24.6° along the East Coast. These different regions represent three different biogeographic regions: the cool temperate West Coast, the warm temperate South Coast and the subtropical East Coast. Marine species representative of each of these biogeographic regions can be expected to have both different temperature and pH tolerance levels.



CO_2 is more soluble in cold seawater, and the lower pH values observed along the West Coast compared to the warmer East Coast water (illustrated below), are consistent with expectations. Along the West Coast, pH varied from 7.6 to 8.2 in August and from 7.8 to 8.5 in November. In May–June, it varied from 7.8 to 8.3 along the South Coast, from 8.1 to 8.2 along the Wild Coast, and from 8.0 to 8.2 along the East Coast.



The pH data illustrated above contain data obtained during different times of the day, and represent different types of coastal habitats, e.g. rocky shores and sandy beaches. The data obtained in 2016 suggest significant diurnal changes in coastal water pH, driven by coastal primary producers rather than intrusions of offshore water masses. Understanding these control mechanisms is key to predicting the susceptibility of coastal ecosystems to ocean acidification.

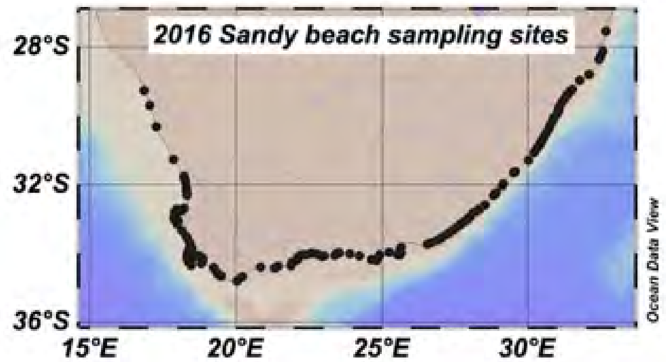
In 2017, sampling efforts will be refined and geared towards understanding the processes influencing coastal water pH variability in more detail.

Author: S de Villiers
Contributors: K Vena and K Siswana

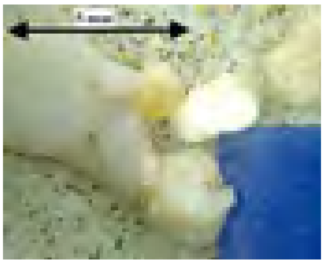
6. MICRO-PLASTIC POLLUTION: QUANTIFYING THE MICRO-FIBRE CONTENT OF SOUTH AFRICA'S SANDY BEACH SEDIMENTS

The accumulation of plastic waste in the marine environment has become a growing global concern over the past decade. Plastic polymers do not degrade easily and will remain in the environment for hundreds to thousands of years, where they break down into smaller pieces as a result of UV radiation, oxidation and hydrolysis. Micro-plastics are fragments smaller than 5 mm in size.

Over 660 marine species worldwide are known to be affected by plastic waste. Micro-plastic particles smaller than 1 mm can potentially be ingested by invertebrates such as mussels, barnacles, polychaete worms and sea cucumbers. The ecological significance of micro-plastic ingestion is still poorly understood.



In 2016, DEA conducted sampling at 153 sandy beach sites along the coastline, from Port Nolloth to Sodwana, to assess and quantify the extent of micro-plastic pollution along most of the coastline.



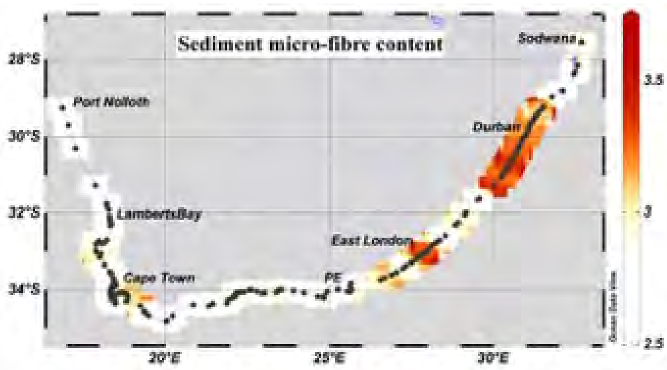
Above: *micro-plastic fragments from Mnandi Beach, False Bay*

Left: *macro-plastic pollution at Merebank, south of Durban*

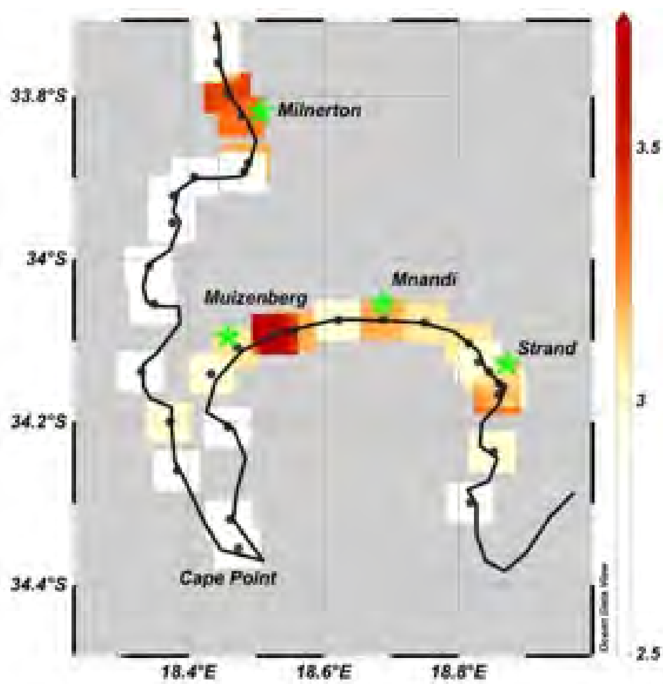
Industrial pellets were found in only one sample, and a minority of samples contained fragments and foamed pieces (shown above). The micro-plastic composition of all samples consisted primarily of fibres, occasionally as a clump but usually as individual fibres that can be counted and classified into different colour categories.

Clump of fibres from Wesbank, south of East London

2016 Micro-fibre pollution hotspots



- ►KZN south coast
- ►East London
- ►Cape Peninsula (see expanded map below)



In 2017, continued monitoring efforts will attempt to establish the dominant sources of micro-plastic pollution along the South African coastline, in particular the respective roles of rivers, urban runoff through storm water pipes, and offshore discharge pipes. Efforts are also under way to establish potential seasonal variability in micro-plastic abundance, and the extent to which sandy beach micro-fibre content serves as an indicator of the presence of other land-based pollutants.

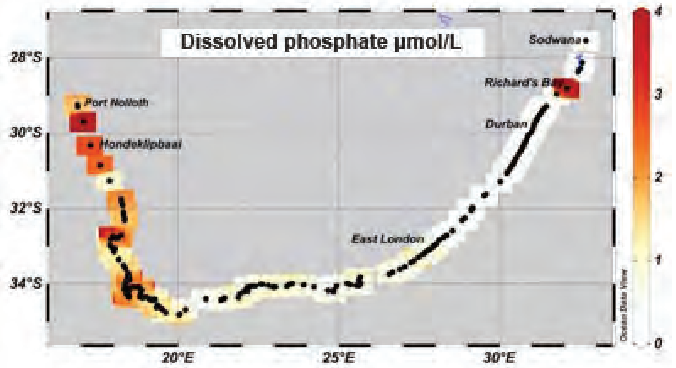
Author: S de Villiers
Contributor: K Vena

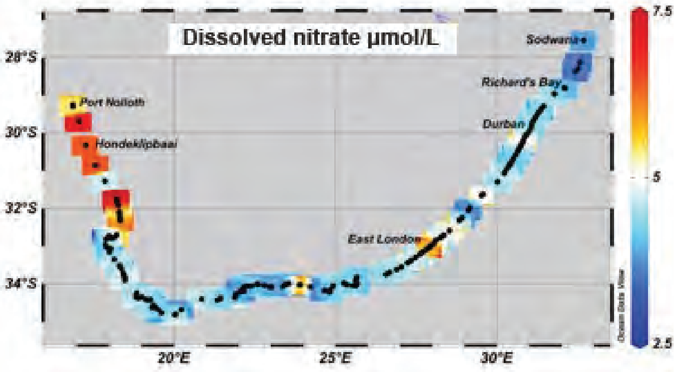
7. EUTROPHICATION STATUS OF SOUTH AFRICA'S COASTAL WATERS

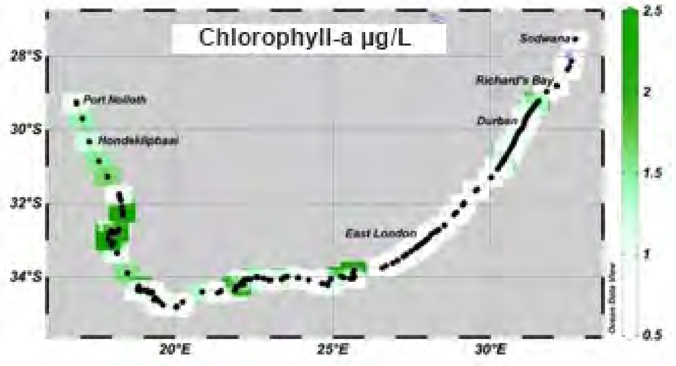
Eutrophication is one of the biggest global threats to coastal water quality. The primary cause is increased nutrient input (e.g. dissolved phosphorus and nitrogen) from either natural (e.g. upwelling) or anthropogenic land-based sources (e.g. polluted rivers, offshore effluent discharges in pipelines).

Water quality parameters typically used as indicators of eutrophication – and measured as part of DEA's monitoring efforts – are concentrations of dissolved inorganic phosphate and nitrate, and chlorophyll *a*, an indicator of enhanced phytoplankton abundance that may result from eutrophication.

Coastal seawater samples were collected at 180 sites in 2016, compared to 41 sites in 2015. Results for dissolved phosphate, nitrate and chlorophyll *a* shown below, represent sampling in May–June along the South and East coasts, and August along the West Coast. Black dots indicate sampling locations.







Recommended Water Quality Guidelines for Coastal Ecosystem Function

WQ PARAMETER	P[a]	N[a]	Chla[a]
International[b]:			
Good	**< 1.6**	**< 35**	**< 15**
Fair	**1.6–3 .2**	**35–70**	**15–30**
Poor	**> 3.2**	**> 70**	**> 30**
Western Indian Ocean[c]:			
Seagrasses	**< 1.6**	**< 35**	**-**
Mangroves	**< 3.2**	**< 70**	**-**
Coral reefs	**< 0.16**	**< 1**	**-**

[a] P = Dissolved P in µmol/L, N = Dissolved N in µmol/L, Chla = chlorophyll a in µg/L; [b] Literature compilation; [c] EQTs (environmental quality targets) from CSIR Report CSIR/NRE/CO/ER/2009/0115/A (2009).

Dissolved inorganic phosphate:

► ***Poor*** status in the Richards Bay area, as was observed in 2015. The most likely source is the offshore effluent discharge pipe. This is a concern for all of the subtropical marine ecosystem types in this region, including mangroves.

► ***Poor*** status in False Bay, as was observed during monthly sampling in 2015, most significantly at Seekoeivlei, adjacent to the Cape Flats WWTW.

► ***Fair*** status in Algoa Bay, in the vicinity of the Fish Water Flats WWTW.

► High levels along the West Coast (> 3.2 µmol/L) are most likely from natural sources (upwelling).

Dissolved inorganic nitrate:

► ***Good*** status at all of the sampling sites, against the < 35 µmol/L guideline value, including at coastal upwelling sites; however, values are elevated relative to background values in the vicinity of the Nahoon WWTW in East London.

Chlorophyll *a*:

► ***Poor*** (> 30 µg/L) status in False Bay, in the Muizenberg to Strandfontein area, adjacent to the Cape Flats WWTW.

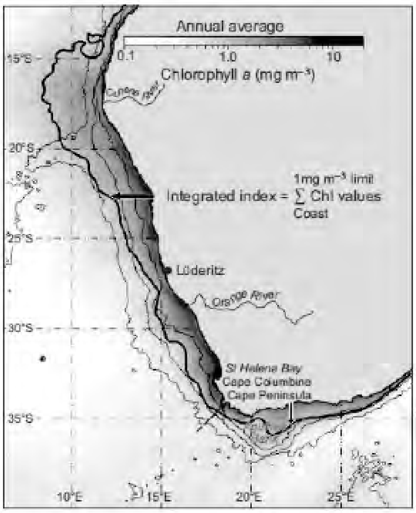
► ***Good*** (< 15 µg/L) status at all other sampling sites (values > 15 µg/L along the West Coast are the result of natural upwelling processes).

In 2017, seasonal sampling along the West Coast will continue, and the South and East coasts will be sampled twice, to develop a dataset representative of seasonal variability in these water quality parameters.

Author: S de Villiers
Contributor: K Vena

8. CHLOROPHYLL VARIABILITY ON THE WEST AND SOUTH COASTS

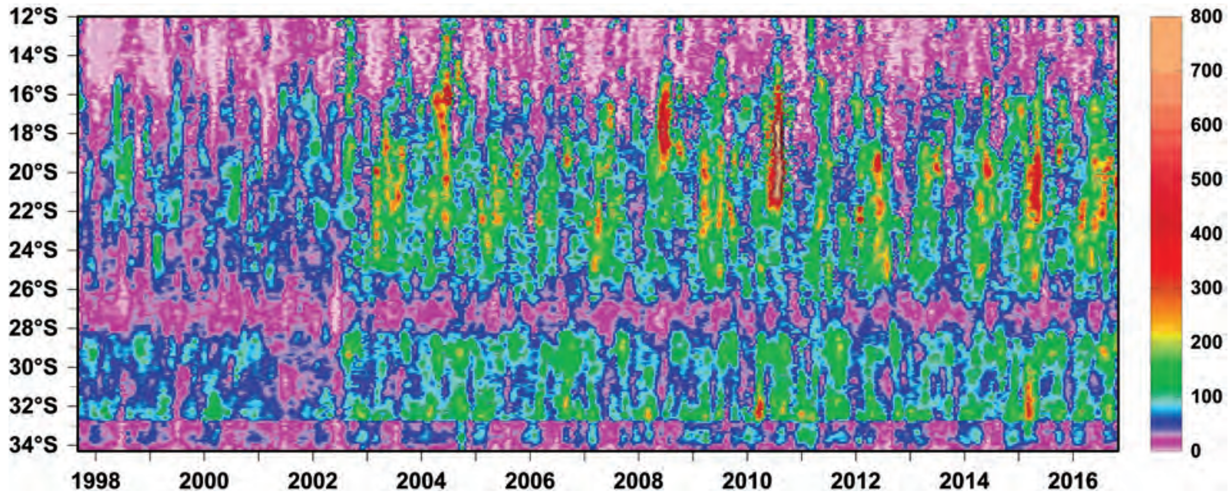
An index of chlorophyll *a* concentration along the southern African coast is computed routinely by integrating satellite-derived surface chlorophyll *a* from the coast to the 1mg m^{-3} level.



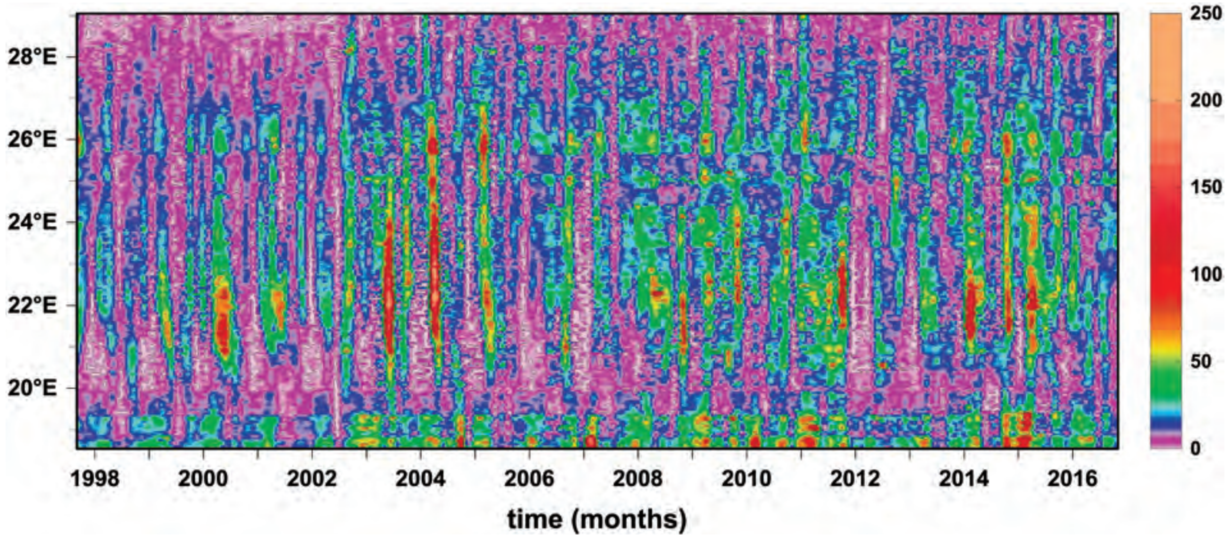
On the West Coast, the highest chlorophyll index values are found off Namibia (16–26°S). During the first half of 2015, the index shows higher values than in 2013 and 2014. During 2016, high values were maintained throughout the year, with peaks in April and August.

Off South Africa (28–34°S), elevated chlorophyll index values occur in the region affected by the Namaqualand, Cape Columbine, and Cape Peninsula upwelling cells. During the first half of 2015, the index shows higher values than in 2013 and 2014. During 2016, values were lower overall than those observed in 2015, with a peak in August at 29°S.

Along the South Coast (18.5–29°E), chlorophyll index values are generally lower than on the West Coast. During 2015, the index was high throughout the year, with maximum values found in the western part in February and March 2015, and in the central part in March and April 2015. During 2016, chlorophyll index values along the South Coast were lower overall than those in 2015.



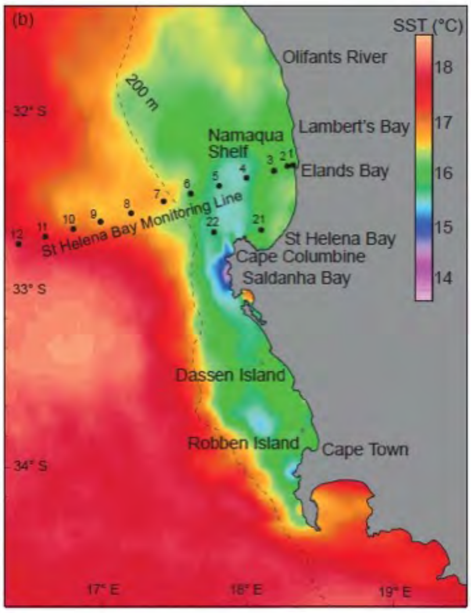
West Coast Chlorophyll index

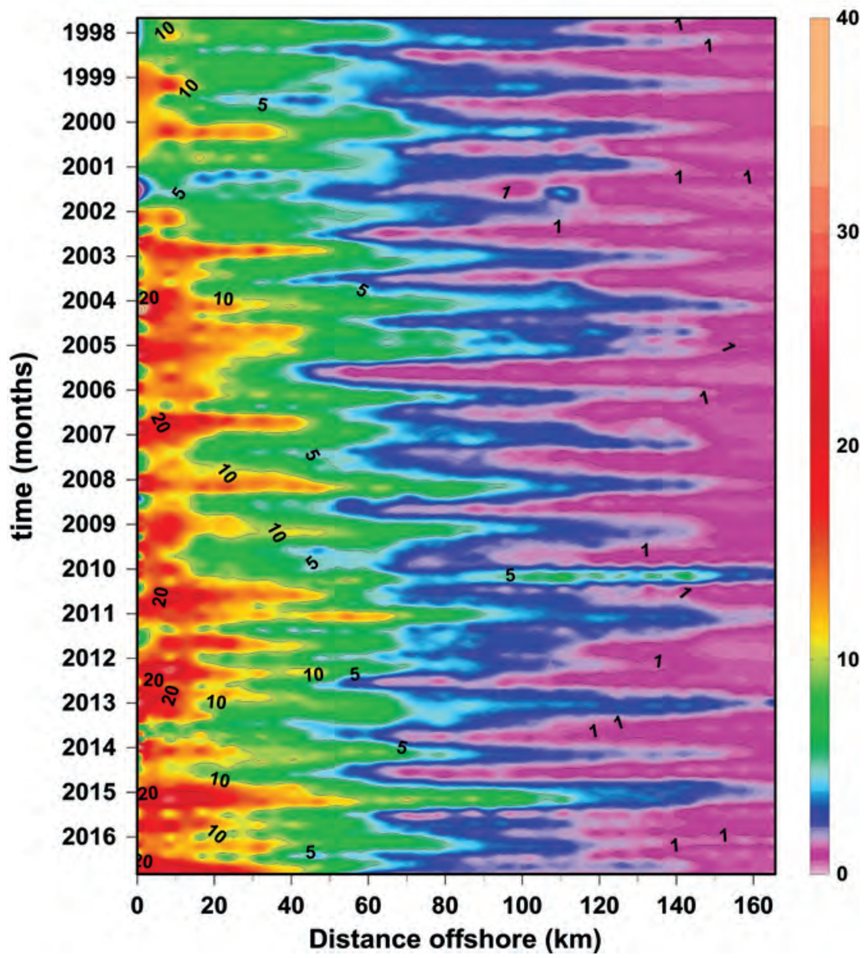


South Coast Chlorophyll index

Author: T Lamont
Contributor: K Britz

9. SURFACE CHLOROPHYLL *a* CONCENTRATIONS ALONG THE ST HELENA BAY MONITORING LINE (SHBML)





On the west coast of South Africa, St Helena Bay is one of the most productive regions of the Benguela Current Large Marine Ecosystem (BCLME), and has been the focus of environmental research and monitoring for many decades.

Satellite-derived surface chlorophyll a concentrations show a clear seasonal signal, with maxima in spring/early summer and late summer/autumn. Generally, higher concentrations always occur close to the coast and decrease with distance offshore. During 2015, concentrations above 20 mg m^{-3} occurred close to the coast in autumn (March, April, May) and spring/early summer (October, November, December).

In March 2015, elevated chlorophyll (> 10 mg m^{-3}) extended *ca* 125 km offshore, the furthest offshore extension since March 2010. In contrast, values > 20 mg m^{-3} were observed close to the coast during the latter half of 2016, and the furthest offshore extent of values > 10 mg m^{-3} was observed in January 2016.

Author: T Lamont
Contributor: K Britz

10. LONG-TERM VARIATIONS IN THE AUTUMN COPEPOD COMMUNITY ON THE WEST COAST, 1951–2016

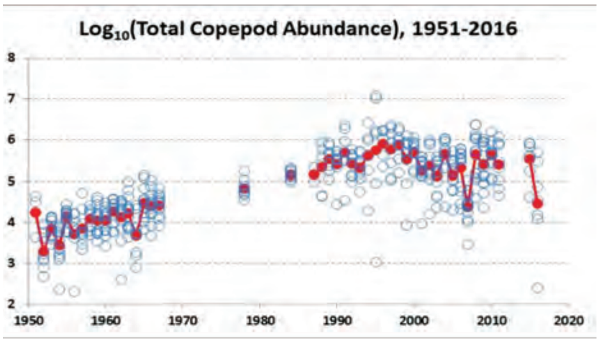
Marine plankton comprise phytoplankton and zooplankton, free-floating plants and animals, that provide food and energy for other marine life. Without plankton, there would be no marine ecosystem services (totalling US$21 trillion per year) on Earth, including fish production, nutrient cycling, gas production and climate regulation.

Because they are abundant, short lived, not harvested, and highly sensitive to changes in temperature, nutrients and acidity, plankton provide ideal indicators of environmental change. Plankton indicators such as basic bulk status variables (e.g. total abundance, mean size) are internationally known as ‘Essential Ocean Variables’ (EOVs) and are particularly useful for the assessment of marine biodiversity and ecosystem health. They have a high impact in responding to scientific and societal needs and importantly have a high feasibility of sustained observation.

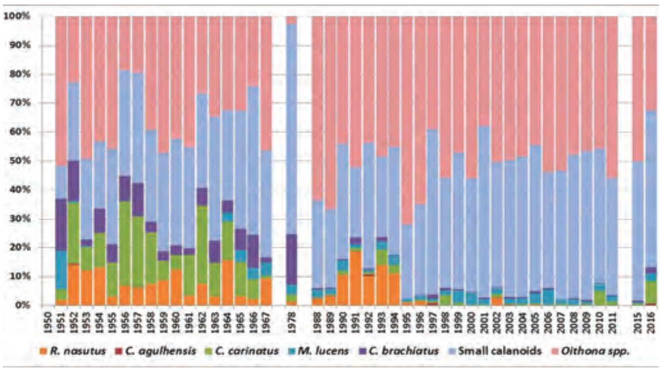
Copepods, the commonest zooplankters, are the most abundant multi-cellular animals on Earth, outnumbering even insects (hand-drawn by Wilhelm Giesbrecht (1892) Plate 2 – from BioDivLibrary)

To summarize long-term trends and decade-scale variations in West Coast zooplankton since 1951, total copepod abundance (i.e. the sum of abundances of all copepod species) and the average copepod community size (ACCS) index (a zooplankton size index based on total body length of adult female copepods) in St Helena Bay are used as zooplankton indices. Data were obtained from eight historical and ongoing plankton sampling programmes in the St Helena Bay region, including the current Integrated Ecosystem Programme: West Coast (IEP: WC).

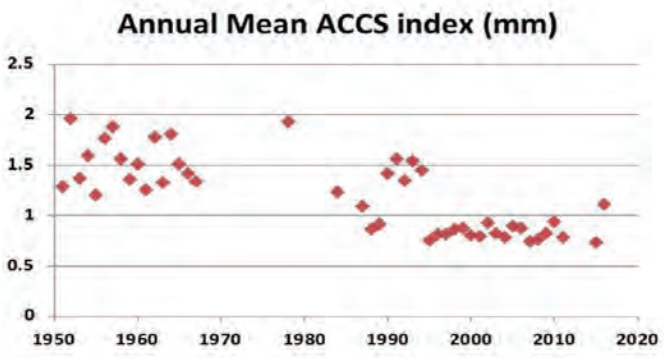
Whereas bulk indices are less sensitive to environmental change and may mask the subtleties provided by individual species, they represent the general functional response of plankton to a changing marine environment over multiple decades.



Long-term change in total copepod abundance along a transect in St Helena Bay, 1951-2016. Abundances are expressed in Log10[No.m^{-2}]+1; blue circles represent autumn sample values; red dots are their annual means.



Long-term changes in autumn copepod community structure (species composition) in St Helena Bay, 1951–2016



Long-term changes in autumn copepod community size structure in St Helena Bay, from large-species (>1 mm; 1950s–1960s) to small-species (<1 mm; mid-1990s–2000s) dominance

The long-term increase and subsequent decline in copepod abundance and shifts in copepod community species and size composition may be linked to an ecological regime shift during the mid-1990s to early-2000s, which was likely induced by environmental changes (e.g. ocean warming) but exacerbated by a shift in prey size-based predation pressure by pelagic fish stocks on the West Coast.

Further information:

Verheye H, Lamont T, Huggett JA, Kreiner A and I Hampton. 2016. Plankton productivity of the Benguela Current Large Marine Ecosystem (BCLME). *Environmental Development,* 17: 75-92.

Author: HM Verheye
Contributors: J van der Poel, E Wright, M Worship

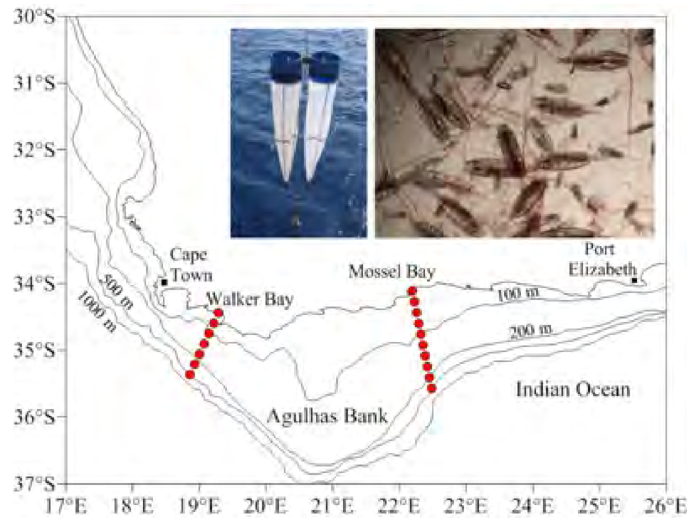
11. LONG-TERM VARIABILITY IN COPEPODS OFF THE SOUTH COAST DURING SPRING & EARLY SUMMER, 1988-2016

Copepods dominate the zooplankton community and are an important food source for organisms such as fish and squid. With their short life-spans, they respond quickly to their environment and make excellent indicators of changing conditions in marine ecosystems.

Annual sampling of copepods off the south coast of South Africa during spring and early summer (October – December) was initiated in 1988. There was a four-year hiatus in sampling due to the unavailability of the FRS *Africana* from 2012 to 2015, but sampling resumed in 2016. The map indicates the location of sampling stations over the continental shelf off Walker Bay (western Agulhas Bank, WAB) and Mossel Bay (central Agulhas Bank, CAB) between 1988 and 2016.

Copepod biomass on the WAB has been variable over the time-series, but shows a gradual decline since a peak in 1996. There was also a long-term decline in the biomass of *Calanus agulhensis*, the dominant large copepod on the Agulhas Bank. This is reflected in the graph illustrating copepod species composition (in terms of biomass), with a decline in the proportion of *Calanus* since 1988.

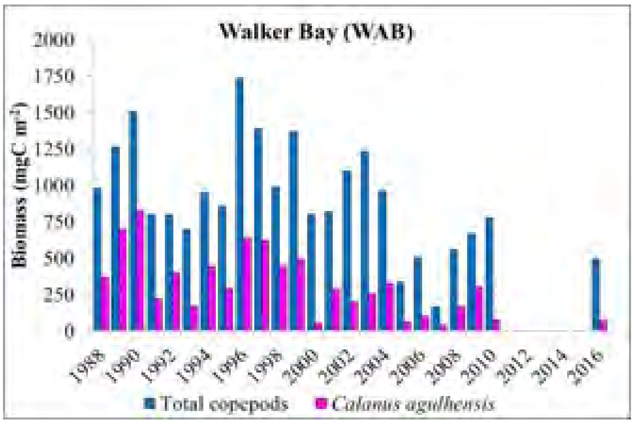
There was a significant long-term decline in both total copepod biomass and biomass of *C. agulhensis* on the CAB between 1988 and 2011. Copepod species composition for the CAB shows the decline in *C. agulhensis* between 1988 and 2011, and a corresponding increase in small calanoid copepods. The greater biomass and proportion of *C. agulhensis* in 2016 compared to 2011 suggests a reversal of these trends, but it is unknown whether this was gradual or sudden.

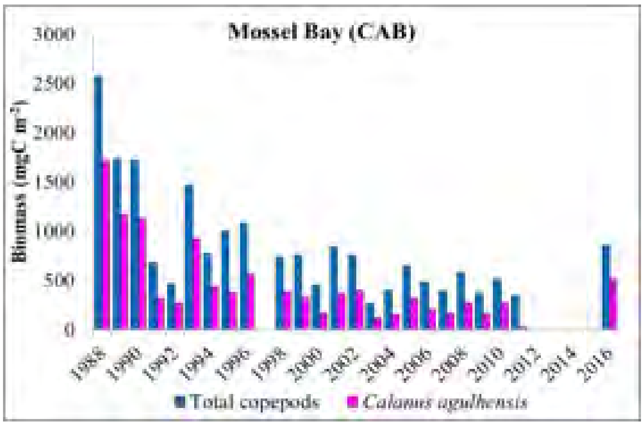


Map showing annual sampling locations (1988-2016)

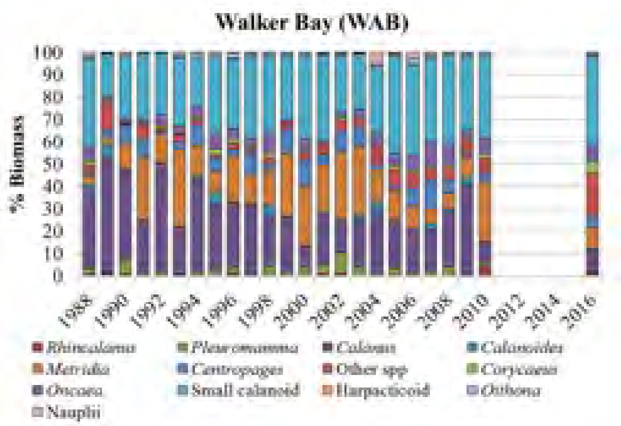
Changes in copepod biomass and composition on the Agulhas Bank are thought to be largely driven by predation by pelagic fish, but are also influenced by environmental variability.

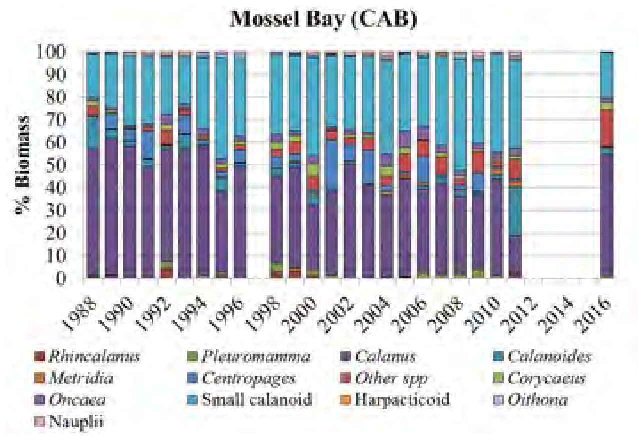
Author: JA Huggett
Contributors: E Wright and S Setati





Biomass of total copepods and C. agulhensis, 1988–2016





Species composition by size: large (bottom) to small (top).

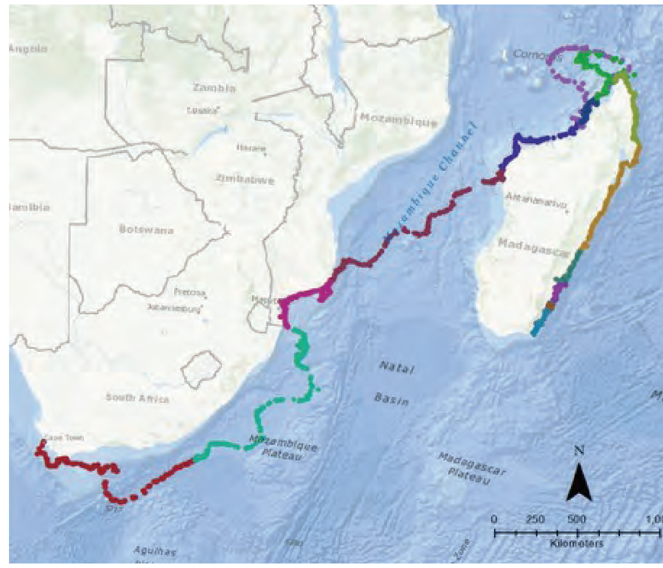
12. LIFE AFTER REHAB: A TURTLE STORY

Turtle strandings are not uncommon along South Africa's coastline. Individuals tend to wash ashore if they have veered off course due to strong currents or winds, or due to injury or illness. The Two Oceans Aquarium (TOA) in Cape Town has initiated and successfully developed a turtle rehabilitation programme, whereby stranded turtles undergo rigorous rehabilitation treatment before they are released back into their natural environment. Treatment programmes vary between a few months and several years, depending on turtle condition.

In June 2014, two Hawksbill Turtles (*Eretmochelys imbricata*) were found stranded in Yzerfontein and Gansbaai and were admitted into the TOA rehabilitation programme. For Otto, an adult female, and Winston, a young male, the rehabilitation process included extensive veterinary care consisting of augmented feeding, parasite removal and treatment of cold shock as well as correcting impaired buoyancy. By December 2015 their condition and weight had improved sufficiently to return them to the wild. Both turtles were fitted with satellite transmitters and released offshore from Cape Point.

There were concerns that the animals might not adapt quickly enough during the first few weeks and could re-strand if exposed to colder waters for extended periods. However, after two months of tracking, Otto arrived at the inshore waters off Maputaland. After a short stay, she crossed the Mozambique Channel to the Madagascan coast, where she has remained since. The second turtle, Winston, had a more protracted stay in Cape Town's waters before heading offshore and northwards into the Benguela Current system. Currently he is resident in coastal waters off Ghana.

Both individuals demonstrated well-defined migration tracks typical of the species, and the destinations were within the known range for the species. If their destinations reflect their respective sources, then South Africa apparently plays host to Hawksbill Turtles from both the East Atlantic and Western Indian Ocean stocks. Furthermore, this tracking study provides evidence that turtles of this species held in captivity (for almost two years in this case) can survive re-introduction to the wild. Considering this, rehabilitation efforts could have long-term benefits for bolstering wild populations of this species, which is listed in the IUCN Critically Endangered red list category.



The travel path taken by Otto between Cape Town and her most recent location west of Madagascar. Each coloured part of the track represents a new month.

The travel path taken by Winston in the East Atlantic Ocean. Each coloured path of the track represents a new month.

Authors: D Anders, S Singh, M Musson (TOA),
T Beukes (TOA), G Cole (TOA), K Spiby (TOA),
L Williams and M Farquah (TOA).

13. KELP GULL *LARUS DOMINICANUS*

2015 National Red List status: Least concern
2016 Global Red List status: Least concern

Kelp Gulls have a wide distribution in the southern hemisphere. The race *L. d. vetula* is endemic to southern Africa.

Protected by:

Sea Birds and Seals Protection Act No. 46 of 1973.

Conservation measures:

Applied:

Several South African colonies are in national parks or nature reserves.

Management:

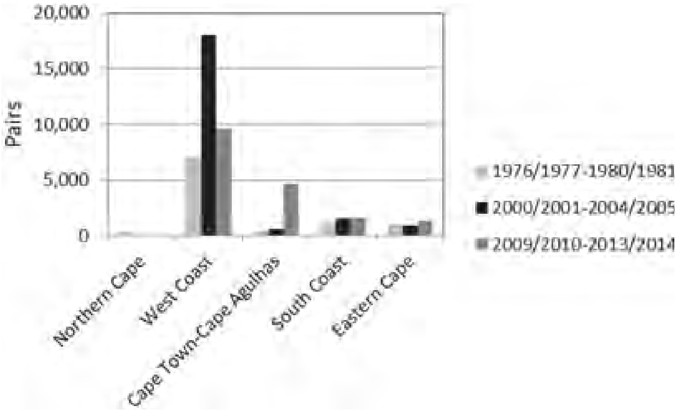
At some localities management measures are applied to reduce adverse interactions with threatened seabirds.

Population trend:

South Africa's population of Kelp Gulls numbered about 10,000 pairs during the period 1976/1977–1980/1981, increased to 21,000 pairs from 2000/2001 to 2004/2005 and then decreased to 17,500 pairs from 2009/2010 to 2013/2014. The increase in the late 20th century and the decrease in the early 21st century were mainly attributable to respectively large increases and decreases in numbers breeding at islands off the west coast of South Africa.

The increases followed cessation of controls on Kelp Gulls at the islands in the 1970s and were associated with supplementary food provided by fisheries and landfill sites, whereas the decreases were influenced by substantial predation of chicks by Great White Pelicans *Pelecanus onocrotalus*.

The decreases of Kelp Gulls at islands off the west coast of South Africa in the early 21st century were offset to some extent by an increase in numbers breeding on mainland sites, especially around greater Cape Town and along the south coast of South Africa. The proportion of Kelp Gulls breeding on the South Coast increased from 15% in 2000/2001–2004/2005 to 44% in 2009/2010–2013/2014.



Trends in numbers of Kelp Gulls breeding in different regions in South Africa, 1984–2015 (from Whittington et al. *2016)*

Further information:

Whittington PA, Crawford RJM, Martin AP, Randall RM, Brown M, Makhado AB, Dyer BM, Upfold L, Harrison KHB, Huisamen J, Waller L, Witteveen M. 2016. Recent trends of the Kelp Gull *Larus dominicanus* in South Africa. *Waterbirds* 39 (Special Publication 1): 99–113.

Authors: AB Makhado, BM Dyer, L Upfold and RJM Crawford
Photograph: RJM Crawford

14. SWIFT (GREATER CRESTED) TERN *STERNA BERGII*

Global Red List status: Least concern
National Red List status: Least concern

The Swift Tern occurs around coastlines of the southeast Atlantic, Indian and western Pacific oceans. The nominate race *S. b. bergii* is endemic to the Benguela upwelling ecosystem off southwestern Africa, where it breeds at 22 localities in Namibia and South Africa. About 80% of the South African population breeds in the Western Cape in late summer and autumn, the remainder in Algoa Bay in the Eastern Cape.

Conservation measures:

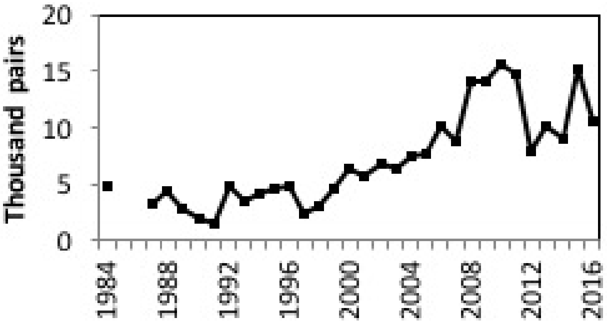
Applied:

Colonies at major islands are protected by CapeNature and SANParks.

Population trend:

Numbers of Swift Terns breeding in South Africa increased rapidly after the recent turn of the century. Less than 5,000 pairs bred annually during the period 1984–1999, whereas > 10,000 pairs bred in most years during 2006–2016. After 2005, numbers in the north Western Cape decreased markedly and most birds now breed in the southwest sector of this province.

The increase in numbers breeding commenced at about the same time as a large increase in the combined biomass of sardine and anchovy. Several factors may have contributed to the increase, including good recruitment to the mature population and an increase in the proportion of mature birds breeding. In southern Africa, swift terns show low fidelity to breeding localities, which enables a rapid adjustment of the location of breeding to an altered availability of their prey.



Trends in numbers of Swift Terns breeding in South Africa, 1984–2016

Further information:

Crawford RJM. 2009. A recent increase of swift terns *Thalasseus bergii* off South Africa – the possible influence of an altered abundance and distribution of prey. *Progress in Oceanography* 83: 398–403.

Authors: AB Makhado, BM Dyer,
L Upfold and RJM Crawford
Photograph: RJM Crawford

15. CORMORANTS (PHALACROCORACIDAE)

Five species of cormorant breed in South Africa. Three are marine and endemic to the greater Benguela ecosystem of southern Africa: Cape *Phalacrocorax capensis*, Bank *P. neglectus* and Crowned *Microcarbo coronatus* Cormorants. The White-breasted Cormorant *P. lucidus* utilizes marine and freshwater environments in southern Africa and farther north in Africa. The Long-tailed (Reed) Cormorant *M. africanus* is a freshwater species and also occurs farther north in Africa. Summary information for the four species that use the marine environment is provided below. It is noteworthy that populations of the two cormorants that compete with fisheries for prey (Cape and Bank) have decreased substantially, whereas those of the two species that do not do so (Crowned and White-breasted) have remained stable in the long term.

Cape Cormorant *Phalacrocorax capensis*

Global Red List status: Endangered
National Red List status: Endangered

In South Africa, Cape Cormorants have bred at 53 localities between the Orange River and the east Eastern Cape.

Protected by:
Sea Birds and Seals Protection Act No. 46 of 1973.

Conservation measures:

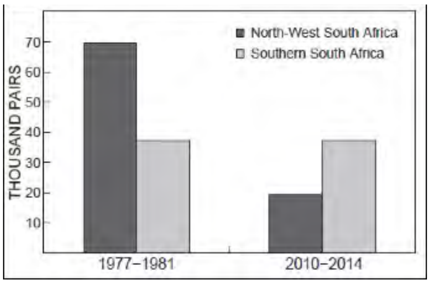
Applied:

- Colonies at major islands are protected by CapeNature and SANParks;
- Disease is controlled by burning carcases of dead birds.

Possible:

- Close purse-seine fishing around Dyer Island (South Africa's main colony);
- Establish a new colony on the South Coast closer to the present distribution of food;
- Limit mortality inflicted by seals near colonies, especially at Dyer Island.

Population trend:
Numbers breeding in South Africa decreased by nearly 50% from about 107,000 pairs in 1977–1981 to 57,000 pairs in 2010–2014. Almost all the decrease occurred after the early 1990s off northwest South Africa, between the Orange River estuary and Dassen Island. This is thought to have resulted from displacement of the main prey of Cape Cormorants (anchovy and sardine) to the southeast. Cape Cormorants are breeding in increasing numbers at mainland localities in the south, e.g. at Stony Point, Knysna Heads, Robberg and Tsitsikamma National Park.



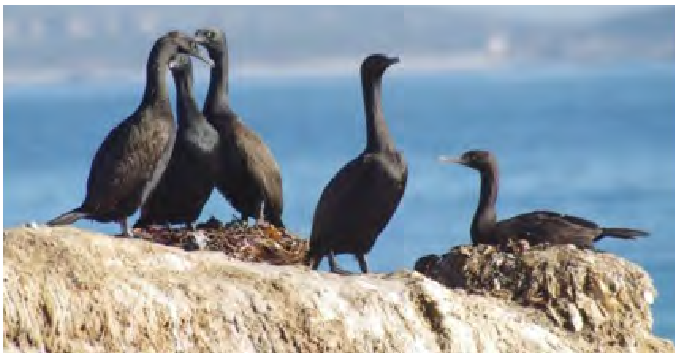
Numbers of Cape Cormorants breeding off north-west (Orange River to Dassen Island) and southern (Koeberg Nuclear Power Station to Eastern Cape) South Africa during 1977–1981 and 2010–2014 (from Crawford et al. 2016)

Further information:

Crawford RJM, Randall RM, Cook TR, Ryan PG, Dyer BM, Fox R, Geldenhuys D, Huisamen J, McGeorge C, Upfold L, Visagie J, Waller LJ, Whittington PA, Wilke CG, Makhado AB. 2016. Cape cormorants decrease, move east and adapt foraging strategies following eastward displacement of their main prey. *African Journal of Marine Science* 38: 373–383.

Bank Cormorant *Phalacrocorax neglectus*

Global Red List status: Endangered
National Red List status: Endangered



In South Africa, Bank Cormorants have bred at 37 localities in the Northern and Western Cape provinces west of Cape Agulhas

Protected by:
Sea Birds and Seals Protection Act No. 46 of 1973.

Conservation measures:

Applied:
Colonies at major islands and Stony Point are protected by CapeNature and SANParks.

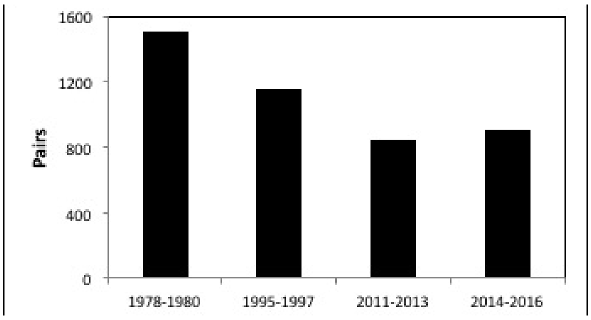
Possible:

- Close fishing of rock lobsters around the main South African breeding colonies;

- Limit disturbance at breeding colonies;
- Erect wooden platforms at key sites to increase breeding habitat;
- Develop an ex situ breeding programme.

Population trend:

Numbers breeding in South Africa decreased by 40% from about 1,500 pairs in 1978–1980 to 900 pairs in 2014–2016. Extinction of the colony at Lambert's Bay and large decreases between Saldanha Bay and Dassen Island coincided with a shift to the south-east of rock lobster, an important prey item of the species in South Africa. Numbers at the southern colony of Stony Point have increased.



Numbers of Bank Cormorants breeding in South Africa during four periods between the late 1970s and the mid-2000s (updated from Crawford et al. 2015)

Further information:

Crawford RJM, Makhado AB, Whittington PA, Randall RM, Oosthuizen WH, Waller LJ. 2015. A changing distribution of seabirds in South Africa – the possible impact of climate and its consequences. *Frontiers in Ecology and Evolution* 3: 10, 1–10. doi: 10.3389/fevo.2015.000010.

Crowned Cormorant *Microcarbo coronatus*

Global Red List status: Near threatened
National Red List status: Near threatened

In South Africa, Crowned Cormorants have bred at 37 localities between the Northern Cape and Tsitsikamma National Park. Up until 1982, Crowned Cormorants were only recorded breeding to the west of Cape Agulhas, but in 2003 four pairs bred in the Tsitsikamma Coastal National Park and since 2005 breeding has also occurred at Waenhuiskrans.

Protected by:

Sea Birds and Seals Protection Act No. 46 of 1973.

Conservation measures:

Applied:

Colonies at major islands and Stony Point are protected by CapeNature and SANParks.

Possible:

Limit disturbance at breeding colonies.

Population trend: Numbers breeding in South Africa have been stable since the late 1970s at 1,700 to 1,900 pairs.

Further information:

Crawford RJM, Dyer BM, Geldenhuys D, Makhado AB, Randall RM, Upfold L, Visagie J, Waller L. 2012. Trends in numbers of crowned cormorants in South Africa, with information on diet. *African Journal of Marine Science* 34: 411–424.

White-breasted Cormorant *Phalacrocorax lucidus*

Global Red List status: Least concern
National Red List status: Least concern

White-breasted Cormorants have bred at 108 localities around the South African coastline.

Conservation measures:

Applied:

Colonies at major islands and Stony Point are protected by CapeNature and SANParks.

Possible:

Limit disturbance at breeding colonies.

Population trend:

Numbers breeding in South Africa have been stable since the late 1970s at about 1,500 pairs.

Further information:

Crawford RJM, Randall RM, Whittington PA, Waller LJ, Dyer BM, Allan DG, Fox C, Martin AP, Upfold L, Visagie J, Bachoo S, Bowker M, Downs CT, Fox R, Huisamen J, Makhado AB, Oosthuizen WH, Ryan PG, Taylor RH, Turpie JK. 2013. South Africa's coastal-breeding white-breasted cormorants: population trends, breeding season and movements, and diet. *African Journal of Marine Science* 35: 473–490.

Authors: RJM Crawford, BM Dyer, L UPfold and AB Makhado
Photographs: RJM Crawford

16. GANNETS AND BOOBIES (SULIDAE)

Africa's only gannet, the Cape Gannet, is endemic to the Benguela upwelling ecosystem off south-western Africa. Various boobies *Sula* spp. breed farther north in Africa and at associated island archipelagos.

Cape Gannet Morus capensis

2015 National Red List status: Vulnerable
2016 Global Red List status: Vulnerable

In South Africa the Cape Gannet breeds at three localities: Bird Island (Lambert's Bay) and Malgas Island on the West Coast and Bird Island in Algoa Bay on the South Coast.

Protected by:

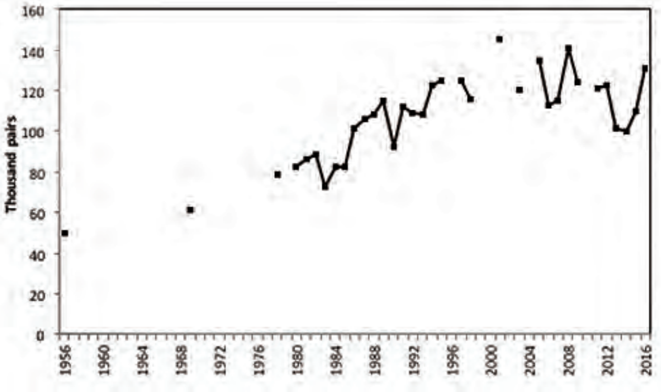
Sea Birds and Seals Protection Act No. 46 of 1973.

Conservation measures:

- All colonies are protected by CapeNature and SANParks;
- Long-line fishing permits have conditions with regard to operation in order to limit the by-catch of birds;
- Mortality inflicted by seals near colonies is controlled through removal of damage-causing animals.

Population trend:

The overall population decreased from about 250,000 pairs in the 1950s and 1960s to 144,000 pairs in 2016. This was primarily a result of a decrease of > 90% of Namibia's population following the collapse of Namibia's sardine resource in the 1970s. The species' preferred prey is lipid-rich sardine and anchovy. Namibia held > 80% of the global population in 1956; 60 years later, in 2016, South Africa had 90% of the population. Numbers in South Africa increased between 1956 and the recent turn of the century and have since fluctuated around a level of 120,000 pairs. Recently, numbers have decreased in the Western Cape but increased in Algoa Bay in accord with a shift to the south and east of mature sardine and anchovy off South Africa. In 2016, the colony in Algoa Bay held 62% of the overall population.



Numbers of Cape Gannets breeding in South Africa, 1956–2016

Further information:

Crawford RJM, Makhado AB, Whittington PA, Randall RM, Oosthuizen WH, Waller LJ. 2015. A changing distribution of seabirds in South Africa – the possible impact of climate and its consequences. *Frontiers in Ecology and Evolution* 3: 10, 1–10. doi: 10.3389/fevo.2015.000010.

Authors: RJM Crawford, BM Dyer, L Upfold and AB Makhado
Photograph: RJM Crawford

17. PHOEBETRIA ALBATROSSES

Sooty Albatross *P. fusca*

Global Red List status: Endangered
National Red List status: Endangered

Light-mantled Albatross *P. palpebrata*

Global Red List status: Near threatened
National Red List status: Vulnerable

Sooty Albatross breeds at sub-Antarctic islands in the South Atlantic and Indian oceans; Light-mantled Albatross at sub-Antarctic islands in the South Atlantic, Indian and Pacific oceans. Sooty Albatross has a more northern distribution than Light-mantled Albatross. South Africa's Prince Edward Islands (PEIs; Marion and Prince Edward) hold 18% and 3% of the global populations of Sooty Albatross and Light-mantled Albatross, respectively.

Protected by:

- Sea Birds and Seals Protection Act No. 46 of 1973;
- PEIs Marine Protected Area (proclaimed 2013);
- Agreement on the Conservation of Albatrosses and Petrels (Appendix 1).

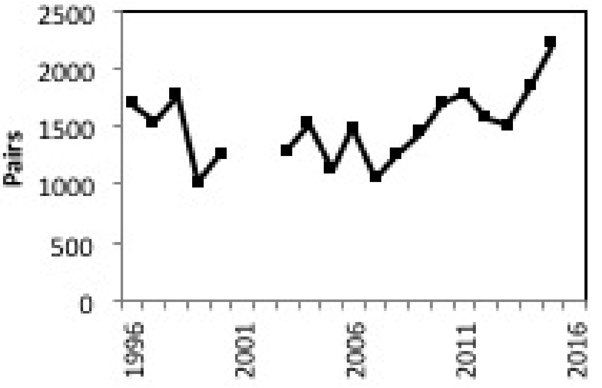
Conservation actions:

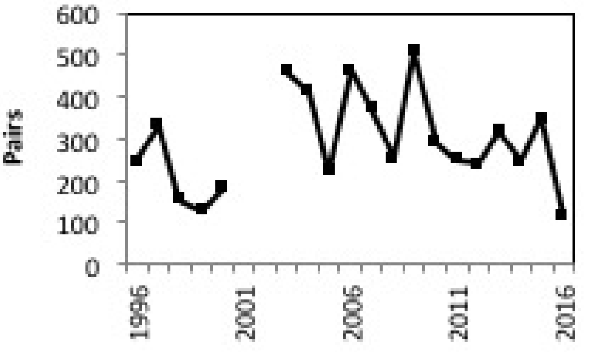
PEIs are a Special Nature Reserve under National Environmental Management: Protected Areas Act (2004);

National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (2008).

Population trends:

Numbers of Sooty and Light-mantled albatrosses breeding at Marion Island have been monitored since 1996. Sooty Albatross decreased there in the 1990s, perhaps as a result of by-catch mortality in international longline fisheries. It increased after the mid-2000s, possibly as a consequence of uptake of measures to mitigate by-catch. By contrast, estimates for Light-mantled Albatross increased after the 1990s, likely as a result of better coverage of the island, but decreased after 2006, perchance as a result of warming at the island.





Numbers of Sooty Albatrosses (top) and Light-mantled Albatrosses (bottom) breeding at Marion Island between 1996 and 2016 (updated from Schoombie et al. 2016)

Further information:

Schoombie S, Crawford RJM, Makhado AB, Dyer BM, Ryan PG. 2016. Recent population trends of sooty and light-mantled albatrosses breeding on Marion Island. *African Journal of Marine Science* 38: 119–127.

Authors: AB Makhado, BM Dyer, L Upfold and RJM Crawford
Photographs: RJM Crawford

18. PENGUINS SPHENISCIDAE

African Penguin *Spheniscus demersus*

2015 National Red List status: Endangered
2016 Global Red List status: Endangered

The African Penguin is endemic to the Benguela upwelling ecosystem, where it breeds at 28 localities in Namibia and South Africa.

Protected by: Sea Birds and Seals Protection Act No. 46 of 1973.

Management plan: African Penguin Biodiversity Management Plan 2013.

Some conservation measures:

Applied:

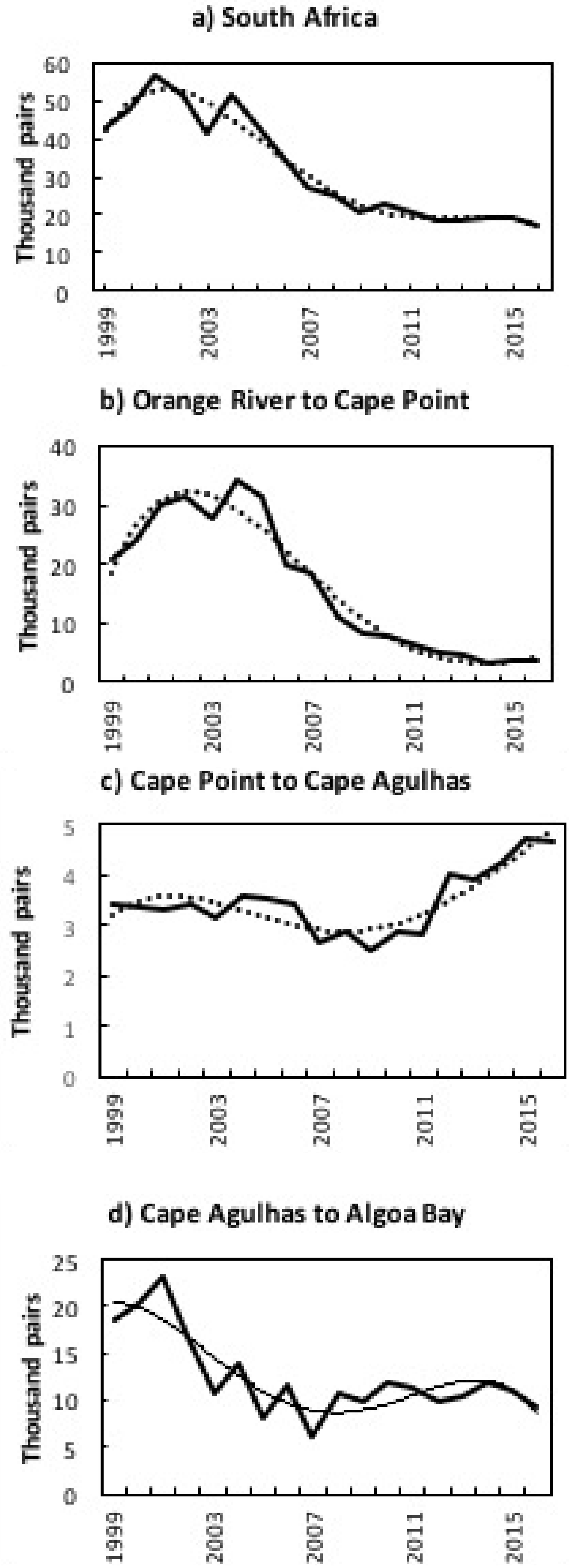
- Most breeding localities are within national parks or nature reserves;
- Oiled and injured birds are rescued and rehabilitated;
- Orphaned chicks are reared and returned to wild;
- Disease is controlled.

Proposed:

- Closing purse-seine fishing around major colonies;
- Establishing a new colony on the south coast closer to the present distribution of food;
- Improving breeding habitat through provision of nest boxes;
- Limiting mortality inflicted by seals near colonies.

Population trend:

African Penguins decreased in South Africa from > 50,000 pairs in 2002 to *ca* 17,000 pairs in 2016. A large decrease in the Eastern Cape in the early 2000s was followed by a collapse north of Cape Town in mid-2000s when adult survival fell. This was thought attributable to food scarcity as prey (sardine and anchovy) shifted south and east.



Numbers of African Penguins breeding in (a) South Africa and (b–d) along three sections of the South African coast, 1999–2016. Polynomial regressions (dots) are shown along with observed data (solid lines).

Gentoo Penguin *Pygoscelis papua*

2013 Regional Red List status: Endangered
2013 Global Red List status: Least concern

Gentoo Penguins have a circumpolar breeding distribution that ranges in latitude from > 65ºS on the Antarctic Peninsula to 46°S at the Crozet Islands. The population at South Africa's Prince Edward Islands is near the northern extremity of the species' range.

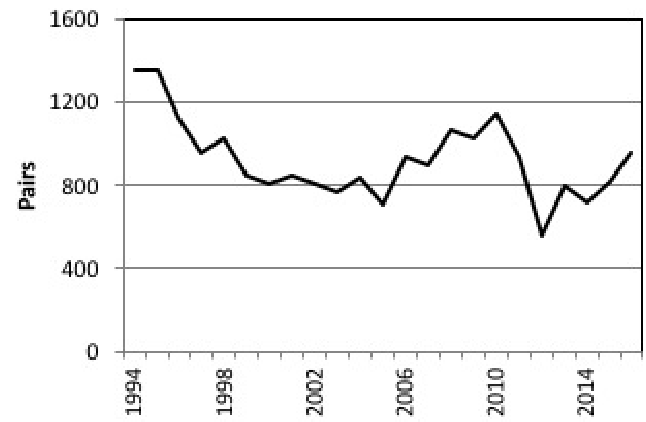
Protected by:

- Sea Birds and Seals Protection Act No. 46 of 1973;
- Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Population trend:

In 2016, 954 pairs of Gentoo Penguin bred at Marion Island. An estimated 475 pairs bred at Prince Edward Island in 2003. Therefore, the overall population at the Prince Edward Islands is *ca* 1,400 pairs.

At Marion Island, > 1,300 pairs of Gentoo Penguin bred during 1974–1977 and in 1994 and 1995. This decreased in a fluctuating manner to ca *550* pairs in 2012, the lowest value yet recorded at the island, but numbers have since partially recovered to about 950 pairs.



Numbers of Gentoo Penguins breeding at Marion Island, 1994–2016

Further information:

Crawford RJM, Dyer BM, Upfold L, Makhado AB. 2014. Congruent, decreasing trends of Gentoo Penguins and Crozet Shags at sub-Antarctic Marion Island suggest food limitation through common environmental forcing. *African Journal of Marine Science* 36: 225–231.

Crested penguins

Two species of crested (*Eudyptes*) penguins breed at South Africa's Prince Edward Islands.

Southern Rockhopper Penguin *E. chrysocome*

2015 Regional Red List status: Endangered
2016 Global Red List status: Vulnerable

There are two subspecies of Southern Rockhopper Penguin. *E. c. chrysocome* is found in southern Chile and Argentina and at the Falkland Islands and South Georgia in the southwest Atlantic Ocean. *E. c. filholi* occurs at islands in the south Indian Ocean and the southwest Pacific Ocean. Its latitudinal range for breeding varies from 46ºS at the Crozet Islands to 54ºS at Macquarie Island.

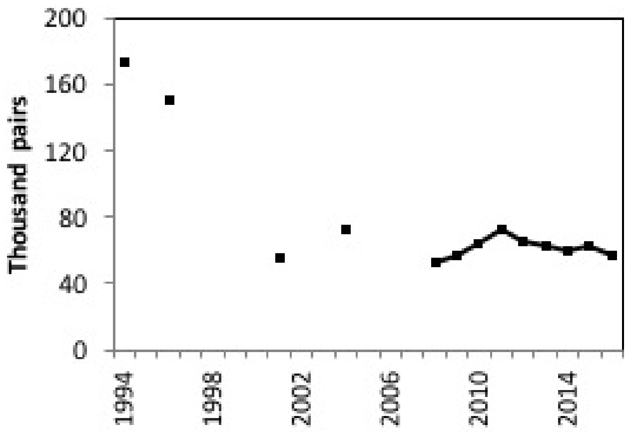
Protected by:

- Sea Birds and Seals Protection Act No. 46 of 1973;
- Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Population trend:

In 2016, 57,000 pairs of Southern Rockhopper Penguins bred at Marion Island. An estimated 38,000 pairs bred at Prince Edward Island in 2008. Therefore, the overall population at the Prince Edward Islands is *ca* 95,000 pairs.

At Marion Island, the population decreased from >170,000 pairs in 1994 to about 60,000 pairs at the turn of the recent century and has since remained stable with fluctuations. The decrease was associated with a reduced mass of adults returning to the island from winter feeding grounds and a diminished breeding success.



Numbers of Southern Rockhopper Penguins breeding at Marion Island, 1994–2016

Further information:

Dyer BM, Crawford RJM. 2015. Southern Rockhopper Penguin *Eudyptes chrysocome*. In: Taylor MR, Wanless RM and Peacock F. (eds) *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg, 152–154.

Macaroni Penguin Eudyptes chrysolophus

2015 Regional Red List status: Vulnerable
2016 Global Red List status: Vulnerable

The Macaroni Penguin has a more southerly distribution than most other crested penguins, breeding between latitudes 46° and 65°S in the western Indian and South Atlantic oceans. It also extends into the south-east Pacific Ocean along the coastline of southern Chile. The largest colonies are north of about 55°S.

Protected by:

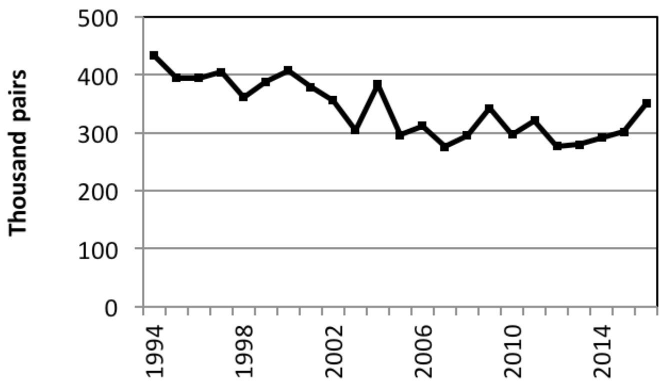
Sea Birds and Seals Protection Act No. 46 of 1973;

Convention for the Conservation of Antarctic Marine Living Resources.

Population trend:

In 2016, *ca* 350,000 pairs of macaroni penguins bred at Marion Island. An estimated 12,000 pairs bred at Prince Edward Island in 2008. Therefore, the overall population at the Prince Edward Islands is *ca* 360,000 pairs.

At Marion Island, the population decreased from >430,000 pairs in 1994 to about 300,000 pairs soon after the turn of the recent century and it has since fluctuated around that level. Outbreaks of disease caused severe decreases at the two largest colonies.



Numbers of Macaroni Penguins breeding at Marion Island, 1994–2016

Further information:

Dyer BM, Crawford RJM. 2015. Macaroni Penguin *Eudyptes chrysolophus*. In: Taylor MR, Wanless RM and Peacock, F. (eds) *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg, 248–250.

Authors: RJM Crawford, BM Dyer, L Upfold and AB Makhado
Photographs: RJM Crawford

19. MANAGEMENT INTERVENTION: LOSS OF BREEDING SPACE FOR AFRICAN PENGUINS AT VONDELING ISLAND, SOUTH AFRICA

Changes in the marine environment off the west coast of South Africa led to an eastward shift in the distribution of prey species (sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus*) targeted by top predators such as African Penguins *Spheniscus demersus* and Cape Fur Seals *Arctocephalus pusillus pusillus*. Whereas the Cape Fur Seal is a generalist feeder that can successfully target alternative prey resources, the African penguin has a specialised diet, therefore reduced availability of their preferred prey has led to low reproductive success and high mortality of penguins on the West Coast. The situation is potentially exacerbated by the recolonization by Cape Fur Seals of an important seabird breeding island on the West Coast, namely Vondeling Island (Figure 1). The Cape Fur Seal is both a predator of, and a competitor with, the African Penguin (and other seabird species).

Figure 1: Map showing the location of Vondeling Island

The population of penguins at Vondeling Island has decreased since the recent turn of the century (Figure 2). This is thought to be attributable mainly to food shortages, although loss of breeding space due to the expansion of seals on the island may also have played a role.

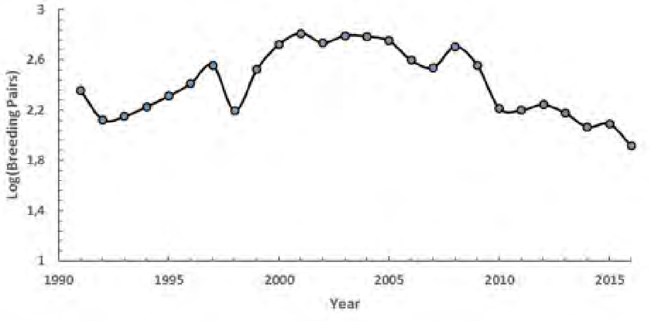


Figure 2: Population trend of the African Penguin at Vondeling Island

DEA and stakeholders implemented management interventions in 2016, following comprehensive research initiated in 2013. Fifty artificial breeding nests made of environmentally friendly fibre cement pipes were installed at the island. The pipes were longitudinally halved and each half was situated to provide shelter from weather and protection from seals (Figure 3). Rocks were placed against the nests for extra stability. Camera traps were installed to monitor progress of the interventions.

Figure 3: A completed fibre cement artificial nest (left) and an example of an active artificial nest (right)

Three monitoring visits were conducted in May, August and September of 2016. Results to date indicate that utilization of nests has increased since their installation (Table 1).

Table 1: The use of artificial nests by penguins in 2016

Date checked	Active	Inactive	Not found
May	15	27	8
August	20	21	9
September	23	26	1

An 'active nest' should have evidence of occupation, e.g. presence of eggs, chicks, an adult or feathers (Figure 3). Of the 23 active nests monitored in September 2016, 13 were occupied by chicks. Parents are likely to have relocated to the artificial nests from less favourable sites elsewhere at the colony.

The increasing number of active nests (Table 1) is encouraging for a colony in decline. Monitoring will continue for the foreseeable future in order to establish the efficacy of such management interventions where seals and penguins compete for available space.

Authors: SM Seakamela, MA Meÿer, PHG Kotze, S McCue, AB Makhado, BM Dyer, M Mamabolo, T Cebekhulu and T Coetzee
Partner Institutions: Cape Nature and SANParks

20. ABUNDANCE AND HABITAT PREFERENCES OF INDIAN OCEAN HUMPBACK DOLPHINS (*SOUSA PLUMBEA*) ALONG THE SOUTH COAST

Globally there is considerable concern over the vulnerability of small Humpback Dolphin populations to extinction. In South Africa, the Indian Ocean Humpack Dolphin *Sousa plumbea* (Figure 1) has recently been uplisted to 'Endangered'. For adequate conservation management, there is an urgent need for a greater understanding of the abundance and habitat preferences of the population.

Figure 1. Humpback Dolphins Sousa plumbea

The current dearth of information is being partly addressed through a joint DEA-NMMU study that has used small boats as survey platforms along a 150-km stretch of coastline on the South Coast (the Garden Route; Figure 2).

The distribution of Humpback Dolphins along the coast was unequal, with a clear preference for sandy coastal habitat. Encounters were rare in two of the three MPAs in the study area, namely Tsitsikamma and Robberg (Figure 3), probably because of the lack of sandy habitat in these MPAs. On the other hand, the Goukamma MPA, nearby Buffels Bay and parts of the coastline of Plettenberg Bay (outside of MPAs), where there is an abundance of sandy habitat, had the highest densities of Humpback Dolphins.

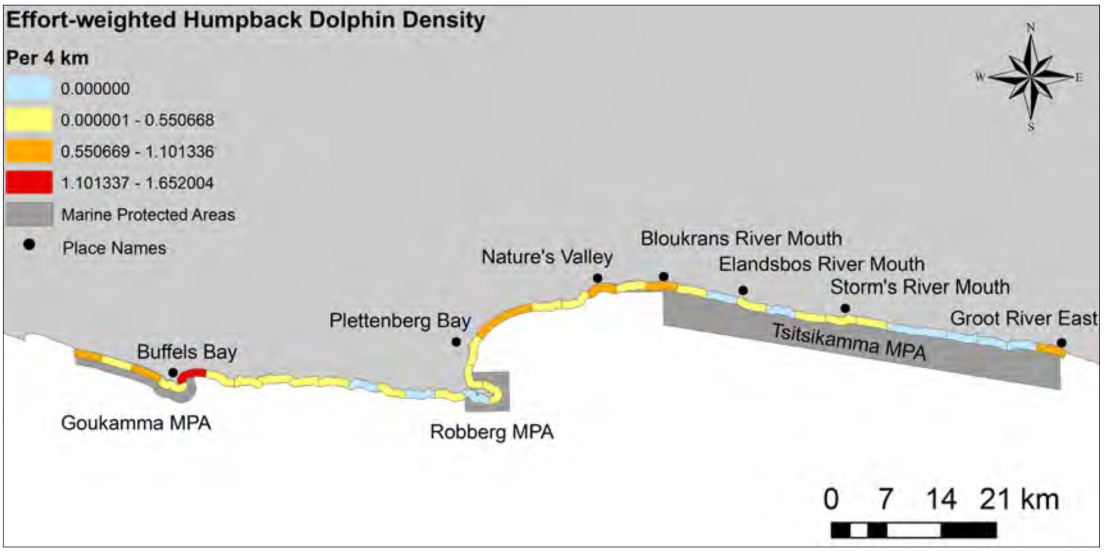


Figure 2: The extent of the study area, showing the boundaries of MPAs overlaid by effort-weighted density of Humpback Dolphin sightings within 4-km sections of the study area

Mark-recapture methods applied to photo-identification data produced abundance estimates of approximately 84 individuals (95% CI: 72-115) within the study area in 2014/15. A mean group size of 3.94 individuals (range 1-12; SE = ± 0.28) was observed during the study, indicating a decline in mean group size of approximately 45% relative to a previous study in 2002/03. This may be an indication of a change in social structure in response to alterations in prey availability; reduction in group size was also observed for the sympatric Indo-Pacific Bottlenose Dolphin (T. aduncus).

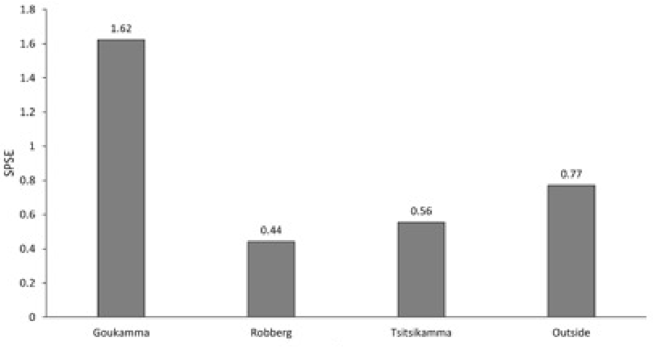


Figure 3: Effort-weighted Humpback Dolphin densities (SPSE: sightings per survey effort) within three MPAs and outside of MPAs

Authors: DS Conry (NMMU), SP Kirkman and PA Pistorius (NMMU)

21. INDICES OF DISTRIBUTION AND ABUNDANCE OF INDO-PACIFIC BOTTLENOSE DOLPHINS

Indo-Pacific Bottlenose Dolphin *Tursiops aduncus* (Figure 1) occur in a narrow range of coastal water and as such are susceptible to numerous anthropogenic threats. Their low growth potential (long-lived, slow maturing) also means that they have limited ability to recover from impacts.

Figure 1. Indo-Pacific Bottlenose Dolphin

A joint DEA-NMMU study has been undertaken in the Garden Route area (Figure 2) to address the current lack of information on this species ('Data Deficient', IUCN) including abundance, trends, distribution and habitat utilization.

The study has included both boat-based and aerial surveys. In-depth analyses are in progress but a summary of effort and preliminary estimates are provided in Table 1. Low re-sighting rates of known individuals (fin recognition) seem to confirm that *T. aduncus* in the study area are migratory and possibly visit the area seasonally, but further validation is required.

Table 1: Summary of survey effort and preliminary estimates.

	Boat	**Plane**
Abundance estimate method	Mark-recapture	Distance sampling
Start date	16/7/2013	27/4/2015
End date	26/6/2016	21/4/2016
Total hours surveyed	1036	52
Total km surveyed	11275	4263
Total encounters	202	52
Encounter rate per 100 km	1.8	1.2
Pod size mean	43 ± 55.3 SD	47 ± 46.2 SD
Pod size range	1-350	1-200
Mean depth and SST at encounters	12 m ± 7.9 SD 17.4°C ± 2.1 SD	N/A

Encounters were greatest during autumn (March–May; Figure 3). Compared with a previous boat-based study of *T. aduncus* in Plettenberg Bay in 2002-03, encounter rates are similar, but the mean group size has decreased by as much as 80% between the two study periods (Table 1). Declines in group size of Indian Ocean Humpback Dolphins *Sousa plumbea* have also been observed for the area. The decreased group sizes may indicate changes in social structure in response to altered prey availability. However, mark-recapture analyses based on fin recognition need to be completed before it can be ascertained whether there has also been a decline in abundance.

Table 2: Comparison with a past study at Plettenberg Bay

	Boat	**Plane**
Total trips	91	71
Sighting rate*	55%	53%
No. of encounters/day		
- Mean	0.8	1.4 ± 1.4 SD
- Range	1-5	0-6
Pod size		
- Mean	120	23 ± 23.5 SD
- Range	2-500	1-100

** % of surveys with encounters*

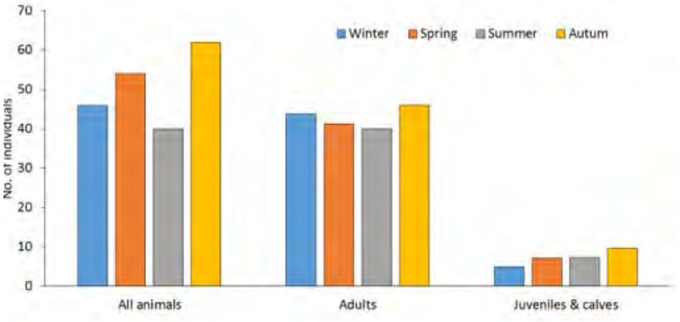


Figure 3. Encounters per season during boat-based surveys

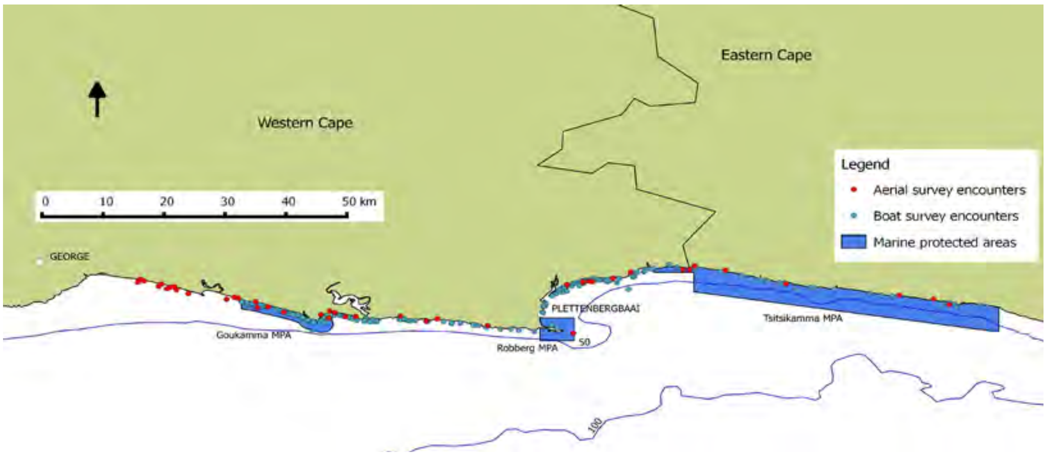


Figure 2. The study area showing the distributions of encounters and the boundaries of current MPAs

Authors: OA Vargas-Fonseca (NMMU); SP Kirkman (DEA) and PA Pistorius (NMMU)

22. HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*): THE DISCOVERY OF LARGE FEEDING AGGREGATIONS (SUPER-GROUPS) ON THE WEST COAST AND THEIR TOURISM POTENTIAL

Humpback Whales migrate between productive high-latitude feeding grounds in summer and low- latitude breeding grounds in winter. DEA conducted four Humpback Whale cruises off the west coast of South Africa during 2011, 2014, 2015 and 2016. One of the objectives was to establish the local distribution and long-range movements of Humpback Whales relative to biotic and abiotic parameters. The cruises covered the area between Dassen Island and Groenriviermond.

Figure 1: Feeding super-groups (black dots) observed during DEA cruises on the West Coast during 2014–2016

The cruises were timed to precede and coincide with the southward migration of Humpback Whales to their high-latitude feeding grounds (October–November).

The first observations of large foraging groups of Humpback Whales were made from the RV *Algoa* in 2011. It was realised that these 'super-groups' represented feeding behaviour that was previously unknown off South Africa's coast. In 2014, a second research vessel, the FRS *Ellen Khuzwayo*, was introduced to the study. While RV *Algoa* conducted environmental sampling and whale abundance and distribution surveys, the FRS *Ellen Khuzwayo* was able to focus on sampling of whale groups (e.g. DNA, photo ID, tagging).

During sampling operations several feeding aggregations were encountered (Figure 1). A total of 44 feeding super-groups were observed during the four cruises. Of these, 31 groups were observed from the FRS *Ellen Khuzwayo* during dedicated whale searches.

Table 1: Summary of Humpback Whale feeding super-groups

Year	Vessel	Median Group Size	Largest Group Size
2011	RV *Algoa*	20	30
2014	FRS *Ellen Khuzwayo*	47,5	175
2015	RV *Algoa*	30	30
2015	FRS *Ellen Khuzwayo*	50	120
2016	RV *Algoa*	32,5	60
2016	FRS *Ellen Khuzwayo*	40	60

Large aggregations of Humpback Whales feeding north of their Southern Ocean summer feeding grounds have not been documented before in the Southern Hemisphere. This 'new' behaviour is potentially due to alterations in prey availability leading to a switch in feeding strategies, an increase in the probability of detection as the population recovers and numbers increase off the west coast of South Africa, or the return of a feeding strategy that was latent during and after the period of large-scale commercial hunting.

To avoid conflict between user groups (e.g. shipping, fishing and mining industries) impacting on the whale feeding behaviour, the extent of the area where large feeding aggregations occur should be seen as an important focus area for marine spatial planning (MSP).

Further information:

Findlay KP, Seakamela SM, Meÿer MA, Kirkman SP, Barendse J, Cade DE, Hurwitz D, Kennedy A, Kotze PGH, McCue SA, Thornton M, Vargas Fonseca OA, Wilke CG. 2017. Humpback whale "super-groups" - A novel low-latitude feeding behaviour of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) in the Benguela Upwelling System. PLoS ONE 12 (3): e0172002. doi: 10.1371/journal.pone.0172002

Authors: SM Seakamela, K Findlay (CPUT), MA Meÿer, PHG Kotze and S McCue
Contributors: SP Kirkman, J Purdon (UP), K Venter (UP), L Swart, S Yapi, A Sobekwa, T Thwala, M Makhale, L Skolo, Z Nkumanda, M Mamabolo, T Cebekhulu, T Coetzee, S Sivewright, N Fata and P Mpange
Partner Institutions: University of Pretoria, BirdLifeSA, NOAA, Oregon State University and DAFF

23. CAUTION ON THE DECLINE IN POPULATION TRENDS OF SOUTHERN RIGHT WHALES (*EUBALAENA AUSTRALIS*) IN SOUTH AFRICA

Southern Right Whales (SRW) *Eubalaena australis* annually visit South African waters to mate and calve. This species displays a high degree of natal philopatry, returning to the coast of birth, and fidelity to a particular nursery. This highly predictable behaviour was used by whalers and later by scientists when conducting population censuses.

Figure 1: Area of the aerial photographic survey off the southern Cape

South Africa's SRW population has been censused since the 1970s, providing the longest continuous monitoring effort of a large whale species worldwide. The surveys are conducted between Nature's Valley and Muizenberg in October each year (Figure 1). The surveys target nursing females or cow-calf (CC) pairs (Figure 2) and unaccompanied adults.

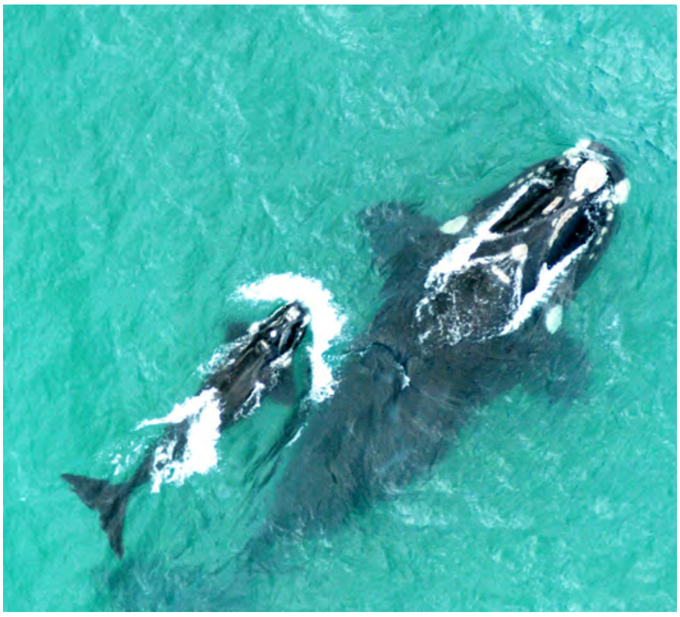


Figure 2: Southern Right Whale cow-calf pair

The SRW population increased at 7% per year from 1979 to 2011. Between 231 and 275 CC pairs were counted between 2002 and 2007, increasing to 268–461 CC pairs during the period 2008–2014 (Figure 3). In 2015, numbers decreased considerably to < 250 CC pairs and plummeted further to only 55 CC pairs in 2016.

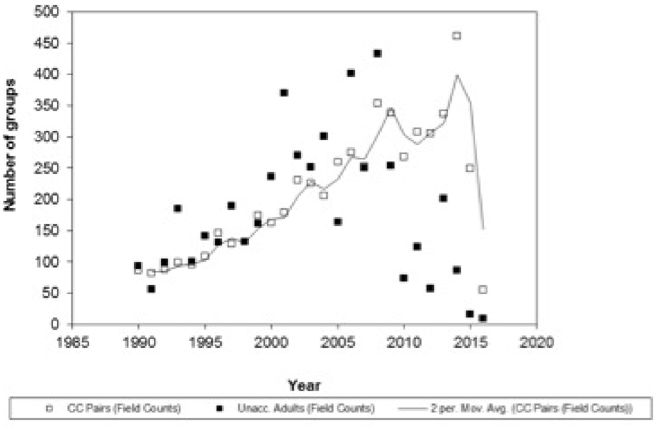


Figure 3: Numbers of Southern Right Whale cow-calf pairs and unaccompanied adults counted in the survey area off South Africa's south coast (data provided by the Mammal Research Institute of the University of Pretoria)

These results have been supported by reports from the Boat Based Whale Watching (BBWW) industry and the scientific community working off the South Coast. The remaining whales off the South Coast are subject to intensified disturbance from the BBWW industry. This is because, at such low whale numbers, operators would need to revisit individual CC pairs multiple times to satisfy customer's expectations.

This situation calls for a review of permit conditions and how they can be better enforced, as well as potential mitigation measures for the South Coast. This could entail a specialist advisory panel constituting DEA officials and stakeholders. In line with the DEA mandate, it is also recommended that DEA scientists lead an investigation into the possible causes of the decline in South Africa's Southern Right Whale population. This could include satellite tagging during their northward migration to investigate possible changes in nursery areas.

Authors: SM Seakamela and C Wilkinson (UP)
Contributors: P Best †, M Thornton (UP), K Findlay(CPUT) and M Meÿer
Partner Institution: University of Pretoria (UP)

Acknowledgements: data used in this report were supplied by and used with permission of the Whale Unit of the Mammal Research Institute at UP

24. 2016: RECORD NUMBER OF LARGE WHALE ENTANGLEMENTS IN SOUTH AFRICA AND IMPLICATIONS FOR CONSERVATION

Large migratory whales such as Humpback Whales (HBW) *Megaptera novaeangliae* and Southern Right Whales (SRW) *Eubalaena australis* are impacted by human activities globally. In South Africa, the most notable impact is whale-fisheries interactions, with large whales occasionally becoming entangled in static fisheries gear. Since 2006, DEA and other stakeholders have responded to reports of whale entanglements and have attempted to release afflicted animals. The South African Whale Disentanglement Network (SAWDN) has 19 national centres with fully trained staff and/or volunteers in whale disentanglement. Here we report on whale entanglement for the twelve months up to September 2016.

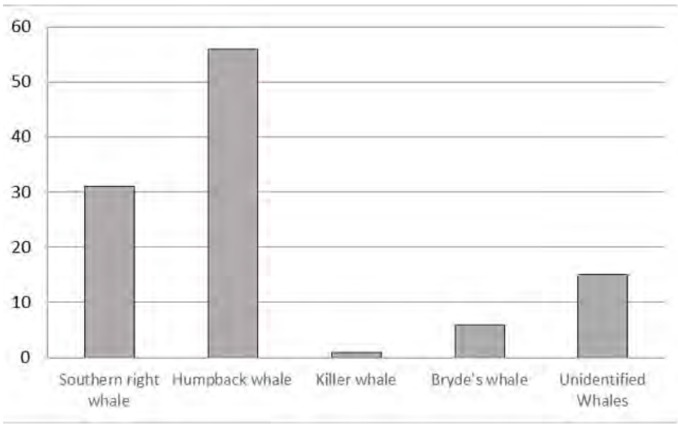


Figure 1: Numbers of reported entanglement incidents per species for the period 2006–2016

Between 2006 and 2016, 109 entanglements were reported, of which 80% involved large migratory whales including 31 SRW and 56 HBW (Figure 1). However, whereas the average for 2006–2015 was 10 incidents per year, the number of entanglements in 2016 soared to 24 (Figure 2). Most entanglements in 2016 were reported for the West Coast (Figure 3).

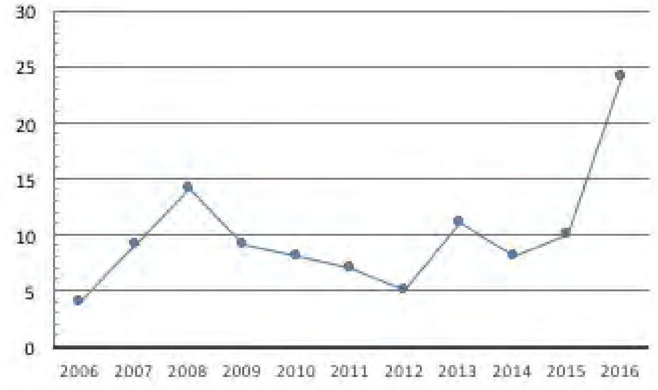


Figure 2: Annual trend in large-whale entanglements for South Africa, 2006–2016

It is uncertain why there has been such a remarkable increase in whale entanglements in such a short period of time. The HBW population has been recovering at > 10% per annum following years of overexploitation and the local population off the West Coast has increased as is evident from the recent discovery of feeding 'super-groups' with numbers exceeding 200 animals per group. The recovery of whale populations is likely to increase encounter rates between whales and human activities.

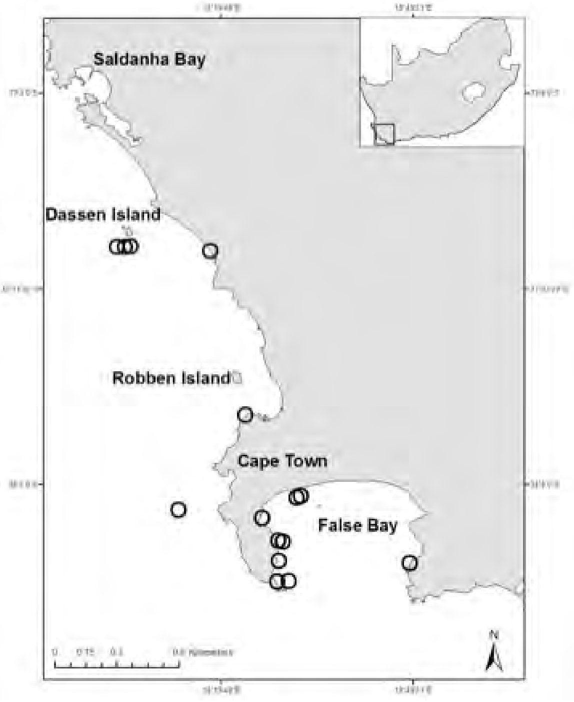


Figure 3: Locations of reported entanglements in 2016

The majority of entanglements removed from whales were associated with fishing gear (Figure 4). Growth of fisheries that use entangling materials such as ropes or longlines will most likely result in continued increases in entanglement events and a heightened need for adequate mitigation measures. The issue warrants consideration in the context of Marine Spatial Planning for management of such activities that impact on whales (also including shipping).

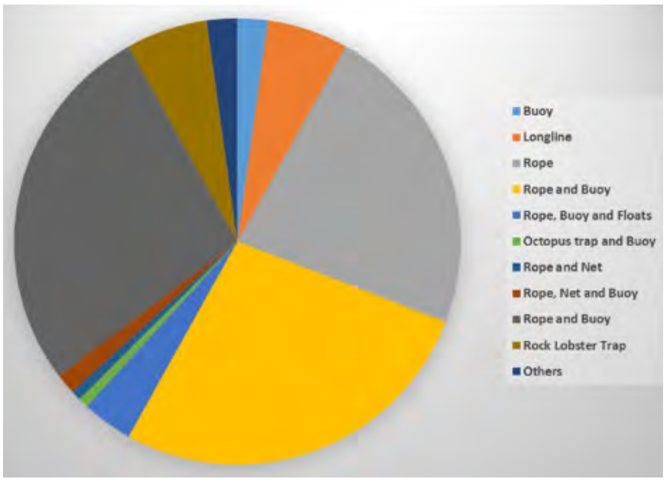


Figure 4: Relative contributions of different types of entanglement found on whales in South Africa, 2006-2016.

Authors: S McCue, M Meÿer, D Kotze, L Swart and M Seakamela

25. REEFS OVER TIME: LONG-TERM MONITORING WITHIN MPAS

Many of the existing Marine Protected Areas (MPAs) in South Africa were established with fisheries management or species conservation as their primary goal. As such, non-commercial or non-focal species have been disregarded and a sound scientific basis of ecosystems is lacking. This calls for an improvement in the science base for MPAs.

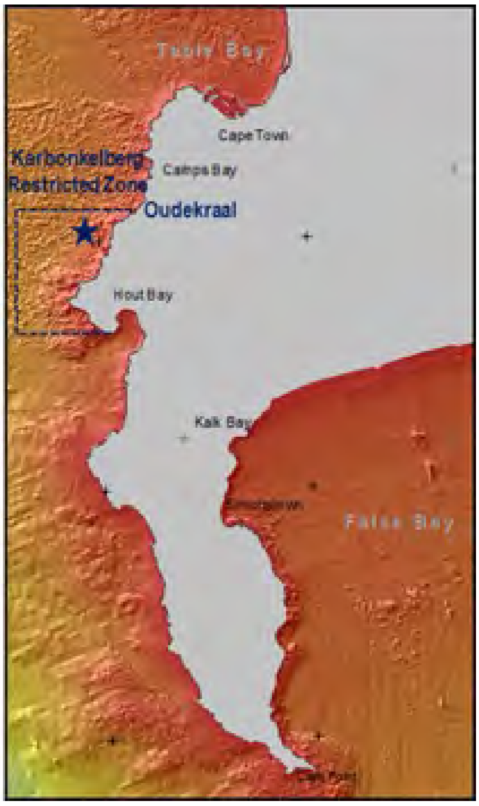


Figure 1: Current study site (star) in TMNP MPA

For example, non-commercial sessile and semi-motile reef invertebrates, despite being key ecological species, have been largely unexplored. Moreover, no standardized long-term monitoring exists for such communities and establishing this within MPAs will allow us to better understand the role of natural processes in changing community assemblages. A better description of these communities and an improved understanding of how they change over time may strengthen conservation decisions.

Figure 2: Setting up permanent monitoring lines

In 2016, such a long-term monitoring programme was initiated in the Table Mountain National Park (TMNP) MPA (Figure 1). One site within the Karbonkelberg restricted zone has been set up and surveyed (Figure 2). Permanent monitoring lines consist of two secured pins *ca* 5–10 m apart. Surveys are conducted by connecting a swim line between pins and photographing the same points during consecutive surveys.

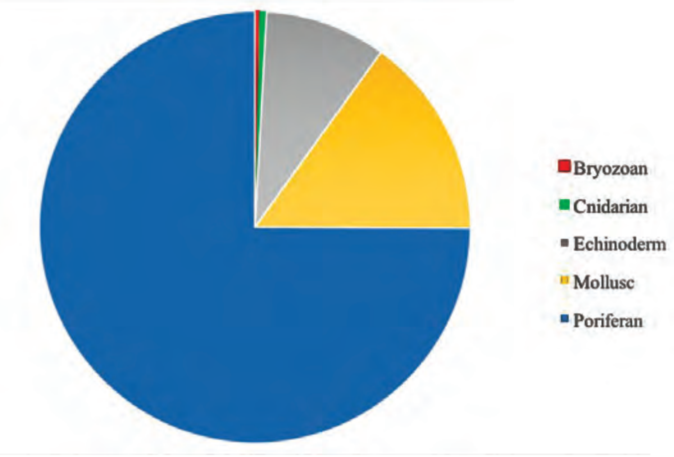
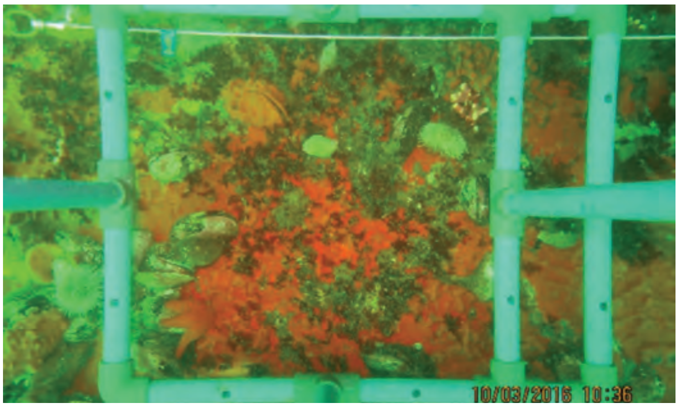


Figure 3: Percentage cover of different phyla

Preliminary analysis of baseline data (Figure 3) indicates that the poriferan (sponge) *Crambe actuata* (49.78%), mollusc *Aulacomya ater* (9.97%) and echinoderm *Parechinus angulosus* (4.6%) together make up the highest percentage cover. Given the ecological role and fragility of sponges, their dominance in the community may be an indicator of good ecosystem health, possibly attesting to protection provided by the restricted zone.



Future work will include setting up monitoring lines at additional sites inside and outside the restricted zone. Sites will be surveyed biannually and monitoring will be complemented with jump camera surveys of major reef areas to better describe fauna at greater depths. The aim is to standardize this programme across MPAs where such monitoring surveys are required.

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Contributors: S Kirkman, T Samaai, D Anders, L Snyders, I Malick, A Bernard (SAIAB) and A Götz (SAEON

26. DEEP-SEA RESEARCH COMES TO LIFE: CAPE CANYON EXPLORATION RESEARCH IN SOUTH AFRICA

Submarine canyons, such as the Cape Canyon (situated just 2 km off the west coast of South Africa), are internationally recognized as important biodiversity hotspots. The low productivity and the rarity of natural disasters in the deep-sea, together with the slow growth rates and longevity of species adapted to such environments, results in canyon ecosystems being sensitive to disturbances. However, significant variations between different canyon ecosystems occur, including with regard to the composition of biological communities and their sensitivity to change. Consequently, a regional approach to the study of canyon ecosystems has been encouraged in the international deep-sea research community.

Canyon research is still an emergent field in South Africa, and the true potential of canyons as biodiversity hotspots has seldom been studied in an integrated context. To address the gap, the DEA: Oceans and Coasts research group initiated a multi-disciplinary expedition on board the RV *Algoa* (7–18 March 2016). During this expedition a high-resolution bathymetric map of the Cape Canyon head was obtained (Figure 1).

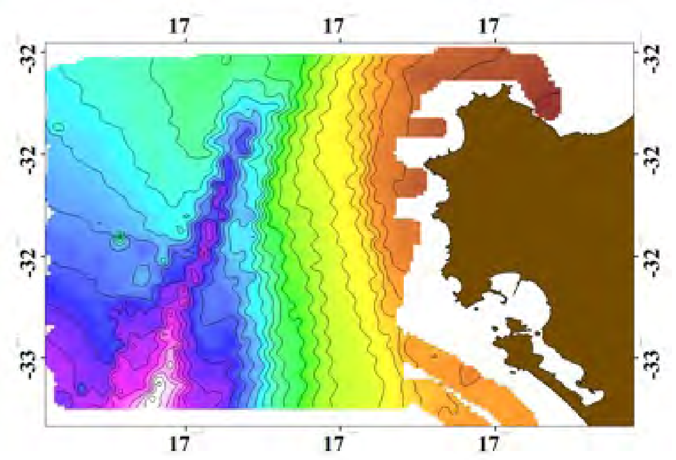


Figure 1: Map showing the bathymetry of the Cape Canyon head

Biodiversity information was collected with an underwater camera, of which footage showed unconsolidated benthic communities dominated by echinoderms, molluscs and crustaceans, and a few rocky outcrops were also recorded (Figure 2).

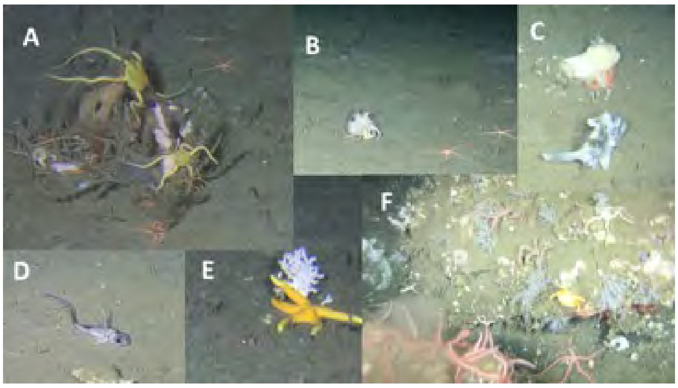


Figure 2: Benthic fauna of the canyon head: A) brittle stars attached to a rocky outcrop encrusted by sponge; B) a hermit crab, and brittle stars in a consolidated habitat; C) a jacopever sheltering under a sponge, and a dory in a consolidated habitat; D) a rat-tail species in a consolidated habitat; E) a sea star next to a hydrocoral in a consolidated habitat; F) a rock habitat dominated by hydroids, brittle stars and sponges.

Hydrographic data were collected with a CTD-O (an instrument used to measure salinity, temperature and oxygen at depth). Profiles of dissolved oxygen through the water column showed anoxic conditions in the bottom layers of the nearshore region. Within the canyon below 300 m depth, the oceanographic data indicated water that was cooler, less saline, and more oxygenated than that in the bottom layers further offshore, suggesting that upwelling was occurring in the canyon.

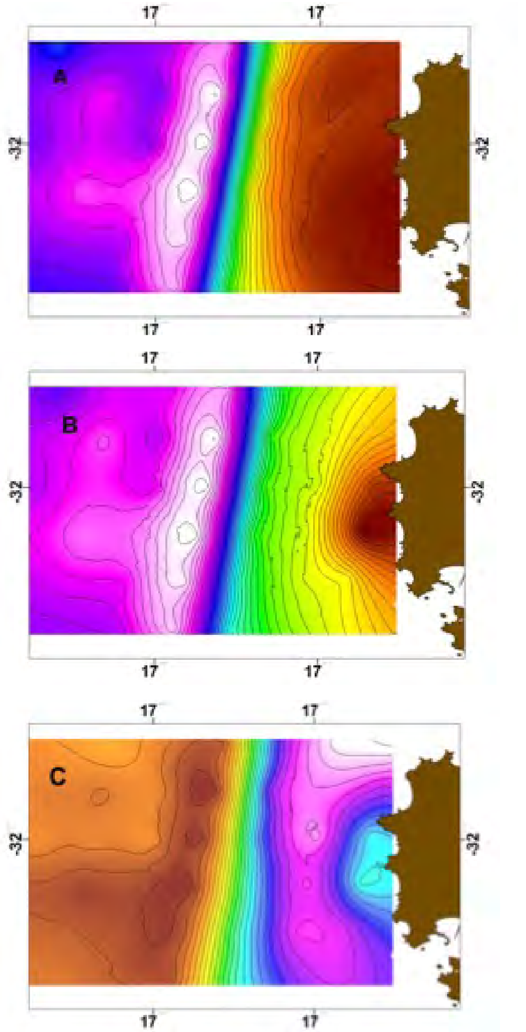


Figure 3: Maps showing (A) bottom salinity (PSU), (B) bottom temperature (°C) and (C) bottom dissolved oxygen (ml/L)

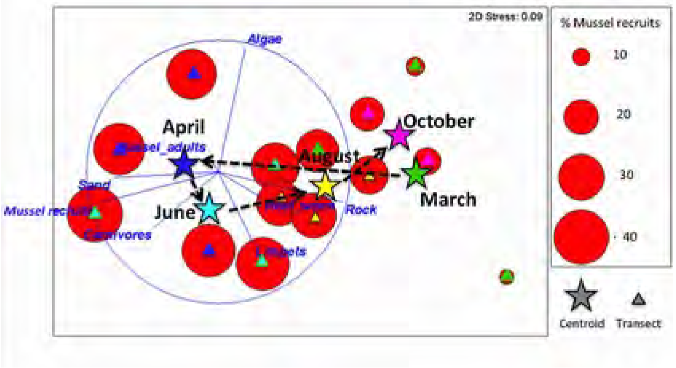
An expedition to the Cape Canyon in 2017 will build on these findings. Information from the study will be useful for informing place-based management in the area, for example by adding to Vulnerable Marine Ecosystem (VME) or Ecologically or Biologically Significant Area (EBSA) descriptions of the feature.

Authors: Z Filander, T Lamont, M van den Berg, L Snyders, M Lombi, L Jacobs and T Samaai

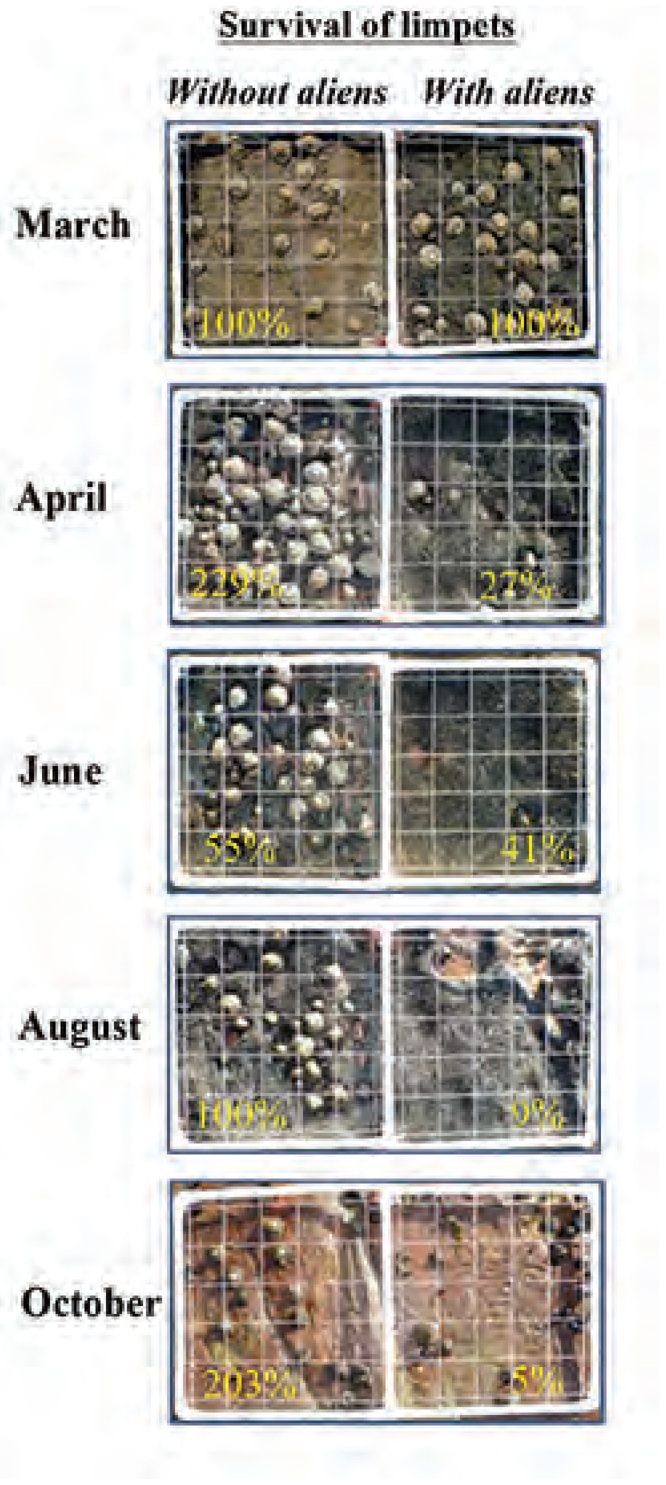
27. SHIFTS IN ROCKY SHORE COMMUNITY STRUCTURE FOLLOWING A MASS RECRUITMENT EVENT OF ALIEN MUSSELS

Along the South African west coast, two alien mussels (*Mytilus galloprovincialis* and *Semimytilus algosus*) thrive on wave-exposed rocky shores. In recent years *S. algosus* has started invading wave-sheltered habitats, which would typically feature dense aggregations of the indigenous limpet *Cymbula granatina*, among other grazers. In February 2016 an unusual mass recruitment event of *S. algosus* occurred at Elands Bay at a wave-sheltered rock ledge. A carpet of tiny mussel recruits formed over the entire lower shore causing all benthic life to be smothered beneath a layer of sand that was bound by the mussels' byssus threads.

In March 2016, five 50 x 50 cm² plots were cleared of alien mussels, leaving all limpets intact. At monthly intervals the numbers of surviving limpets were recorded in the clearings and uncleared control plots. Results from this and observations of community structure along permanently installed transects spanning the entire ledge have shown that survival of limpets was severely impacted by the invasion. Communities were functionally transformed from grazing-dominated to filter-feeding assemblages. While not previously reported for South African shores, such sweepstake recruitment events can have profound long-term effects on coastal communities.



Multi-dimensional scaling of community structure showing shifts in functional communities from a grazer-dominated to an alien mussel- and predator-dominated system following the invasion of alien mussels



Key findings and recommendations:

- Alien mussel cover increased rapidly following mass recruitment, but declined with the onset of winter storms and rain.
- Limpet numbers declined drastically, but showed signs of recovery with the decline of alien mussels.
- Monitoring of this nature should continue to further un

Authors: M Pfaff, R Dalwai, I Malick, I Weideman and T Samaai

28. INFORMATION MANAGEMENT

In 2014 the White Paper on National Environmental Management of the Ocean (NEMO) outlined the importance for the Government to collect, analyse, preserve, and disseminate data and information about the oceans and coasts in order to protect and conserve the marine environment for the sustainable use and benefit of the Nation. At the same time, Operation Phakisa was put in motion to advance the Oceans Economy: exploitation of ocean-based resource utilization and development of marine industry and endeavours.

The National Oceans and Coasts Information Management System (OCIMS) is one of the functional aims of Operation Phakisa, and its development is being undertaken by Meraka Institute of CSIR. An ISO-14721 data management system, the Marine Information Management System (MIMS), an underlying module of OCIMS, will provide a repository for marine and coastal data satisfying the mandates of the NEMO White Paper and the National Environmental Management Act (NEMA) – to allow the Government to preserve and provide marine environmental information for the benefit of the Nation.

The MIMS is being implemented within DEA and is connected on the 1 Gbps SANReN network provided by TENET. To meet the core data management functions, Archive Management System (AMS) software obtained through an agreement with NOAA/NCEI will be installed, and RESTful oceanographic data services such as LAS, THREDDS, ERDDAP and a geoportal will be provided once the system is fully operational. The ability to host and process marine remote sensing data is an important ancillary capability to support DEA's research and OCIMS operations.

While still in the test phase, MIMS has to date accumulated 450 GB of marine data generated by the Oceans and Coasts Research group, including aerial survey images, whale identification photographs, intertidal survey photographs, cruise data, and weather station data for testing purposes.

Summary of the process for MIMS installation and expansion. Target dates are approximate. The status of MIMS is currently (Feb 2017) between Test Phase 2 and the Interim Server. Procurement of the 24 TB of back-up storage for the Temporary Server is on track. Hardware for the Interim Server has been procured but the server software is not yet fully installed and configured.

Phase	Initialisation	Temporary Server	Interin Server	Operational Server Phase I	Operational Server Phase II
Functionality	Test Phase 1 (database)	Test Phase 2 accepting data through AMS	Functional Repository (Operational AMS)	Repository + RESTful services + Marine Remote Sensing Support (MIMS)	MIMS + OCIMS and SAEON Co-hosted at DEA data centre.
Processing capability	Workstation 16 cores 32 GB RAM	Workstation 16 cores 32 GB RAM	Blade Server 3 blades Each blade has 20 cores 256 GB RAM	Blade Server 16 blades Each blade has 20 cores 256 GB RAM	Blade Server 16 blades Each blade has 40 cores 512 GB RAM
Storage capacity	2 TB storage	24 TB HDD	220 TB HDD	500 TB HDD	2000–3000 TB
Target date	2016	2016–2017	2017–2018	2018–2019	2020

Authors: C Duncombe Rae and D Byrne

29. OUTREACH EFFORTS

The outreach campaign of the Chief Directorate: Oceans and Coastal Research (OCR) within DEA aims to raise awareness of our work and to improve conservation of ocean and coastal ecosystems. The awareness campaign is aimed at educating the general public with an emphasis on the youth and introducing them to marine-related professions. It endeavours to bring the science 'alive' to allow politicians, the general public and particularly the young to understand the role of the oceans and their value to South Africa. Millions of South Africans depend on the oceans for critical ecosystem services such as wastewater disposal, rainfall and ecotourism.

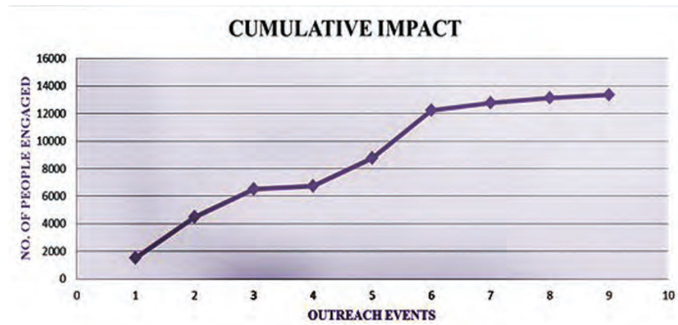
Location of outreach events in South Africa during 2016.

Our outreach efforts during 2016 spanned from pure scientific events such as the Benguela Symposium 2016 (November 2016), where fundamental and applied research results were disseminated to the larger scientific community, to presentations at schools. Each year DEA's Branch: Oceans and Coasts celebrates National Marine Week (NMW) during the second week of October in order to highlight the importance of the oceans. This is the largest outreach effort for the Branch. This year, DEA also hosted the CITES COP 17 conference, where more than 180 countries agreed on better protection of our fauna and flora.

DEA Staff at the NMW 2016 exhibition, Kimberley.

In addition, DEA supports other Departmental outreach events, such as World Oceans Day and International Coastal Clean-up. We also exhibited at the Eastern Cape Maritime Summit, DAFF's World Fisheries Celebration, and various career exhibitions.

Overall, in 2016, dozens of DEA marine scientists spent close to 5,000 hours sharing information with *ca* 14,000 members of the public in five provinces. This tally excludes participation in expert scientific conferences. Through print and online media, OCR's outreach efforts also extended to an international audience. Topics included marine pollution, the ocean economy and South Africa's globally significant conservation efforts.



Cumulative number of people engaged with during consecutive outreach events staged by DEA.

Outreach event schedule for 2016.

EVENT	DATE	PLACE	AUDIENCE	NUMBER ATTENDING
SA Agulhas II Open Day	13 May	Port Elizabeth	Public, Portfolio Committee	1500
World Oceans Day & International Coastal Clean-up	17 June	Durban	Public	3000
DEA Environmental Career Expo	19–20 July	Gugulethu (CPT)	School learners	2000
Penguin Conference	4–9 Sept	Cape Town	Delegates (Scientists, students)	250
CITES COP 17	23 Sept– 5 Oct	Johannesburg	Delegates, Scientists, Managers, Government officials, school learners, public	2000
National Marine Week - School Eng agement	17–21 Oct	Northern Cape	School learners	3500
National Marine Week - Exhibition	19 Oct	Kimberley	School learners	500
EC Maritime Summit	27–28 Oct	East London	Delegates, School learners	400
World Fisheries Day	21 Nov	Mossel Bay	Fishermen, school learners, local businessmen, local government officials	200

Authors: N Hargey and DA Byrne