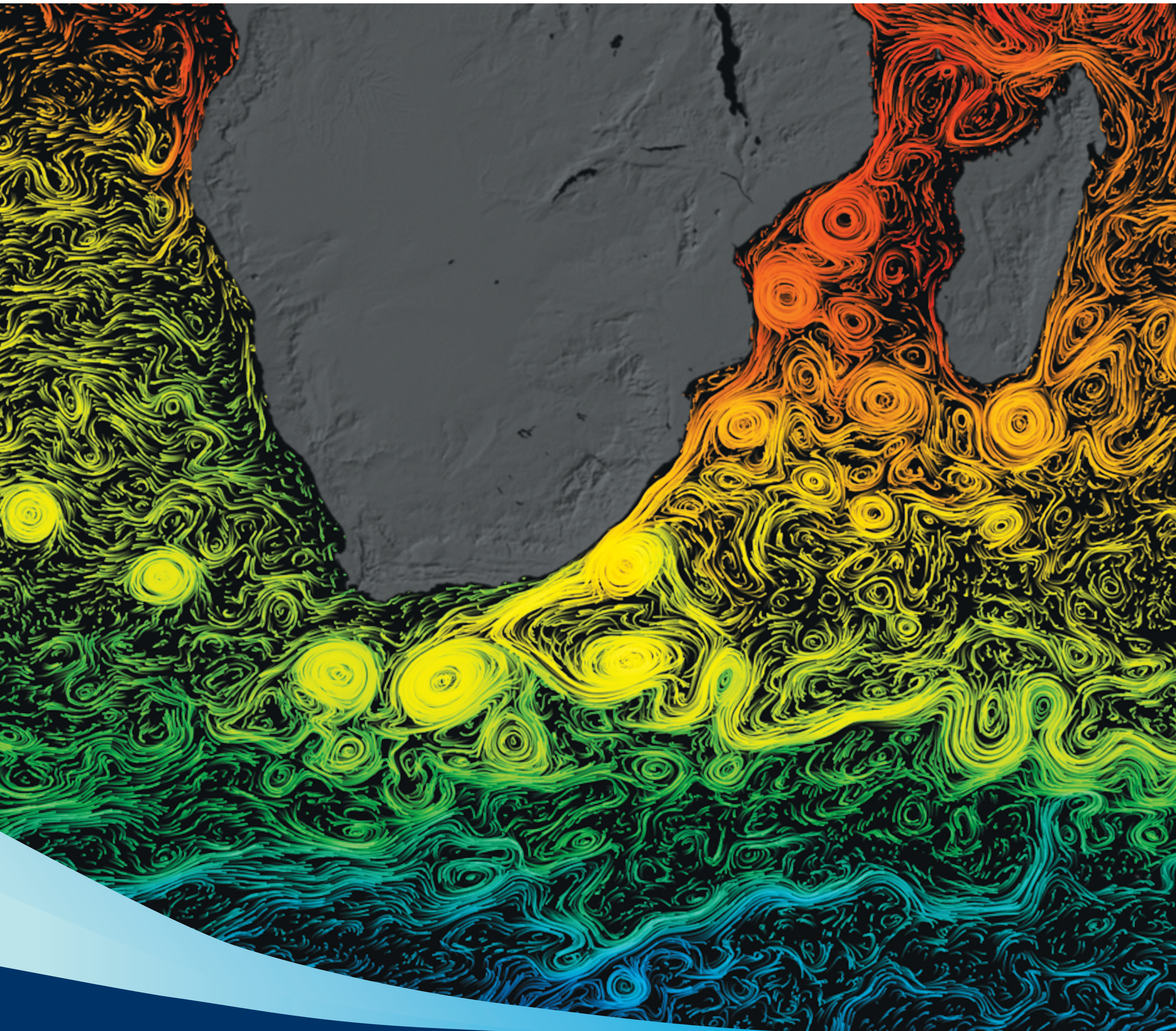
Oceans and Coasts

Annual Science Report

2020



Report No. 20

forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

Oceans and Coasts

Annual Science Report

2020

Department of Forestry, Fisheries and the Environment

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ACKNOWLEDGEMENTS

Most staff members of the Chief Directorate: Oceans & Coastal Research contributed in one way or another to the contents and production of the Oceans and Coasts Annual Science Report, 2020 (previously known as the State of the Oceans and Coasts around South Africa Report Card). The Department also wishes to express its appreciation to the many other agencies that have contributed to the work presented in this report. The at-sea, ship-based work and many coastal field trips for data collection and community engagements undertaken by the Branch: Oceans and Coasts are facilitated by the Chief Directorate's science managers and made possible by the various units within the Branch's Corporate Management Services and Financial Management Services. Rushdi Ariefdien, Rodashia Basson, Jaimie Ceasar and Ndanduleni Malwela are thanked for assisting with the Glossary for the report. Catherine Boucher is gratefully acknowledged for assisting with the design and layout.

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COVER IMAGE

A visualization of sea surface current flows in the oceans around Southern Africa, with circular features indicating mesoscale eddies. The flows are coloured by corresponding sea surface temperature data, with higher temperatures in the north in shades of red, and lower temperatures in the south in shades of blue. Courtesy of NASA/Goddard Space Flight Center Scientific Visualization Studio.

RP123/2021
ISBN: 978-0-621-49396-2

SUMMARY AND PERSPECTIVES FOR DECISION AND POLICY MAKERS

Introduction

The science activities of the Department's Chief Directorate: Oceans and Coastal Research (O&C Research) support the purpose of the Branch Oceans and Coasts in the 'promotion, management and strategic leadership of oceans and coastal conservation and sustainable use in South Africa'. The Oceans and Coasts Annual Science Report, 2020, presents results of these activities around South Africa, in the Southern Ocean, or in other parts of the African ocean regions.

The various science programmes of O&C Research focus on a number of physical, chemical and biological aspects of oceans and coasts (including estuaries). These programmes are guided by a medium- to long-term ecological research and monitoring plan that was developed for the period 2016–2030. Underlying the plan is the understanding that the most valuable scientific data collections or observations are those taken within a long-term context. However, within the framework of long-term programmatic work aimed at providing continuous or sustained observations (monitoring) and descriptions of key aspects of the marine environment, some shorter-term research elements are conducted as projects. Such projects allow for deeper understanding of specific areas or ecosystem processes.

The science activities are undertaken by internal staff but the Chief Directorate also seeks to partner and support the various national and international marine research nodes in other departments and universities. Integral to the plan is the development of human capacity. Wherever applicable, capacity development of staff, interns, students and outside researchers is therefore emphasised in the report. Also essential to the plan is technological innovation in the marine sciences. Thus, in addition to monitoring and research, descriptions of technological developments to support O&C Research's various programmes, or the dissemination of data and information generated in the programmes, are showcased in this report.

Data, information and knowledge products generated from the science activities must be useful for informing managers and policy makers, as well as the broader scientific community and the public. In addition to the national needs and priorities, the plan takes into account the strategic goals, requirements or guidance of regional and international organisations and agreements. These include goals and targets of the global United Nations forums such as the Convention on Biological Diversity (CBD), Sustainable Development Goals (SDGs), and the Framework Convention on Climate Change (UN-FCC), as well as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Strategic Action Programme of the Benguela Current Convention (BCC), and numerous others.

Globally, these organisations play important roles in that they provide platforms for discussions on policy direction regarding the sustainable use and conservation status of natural resources. Increasingly, they require basic information on natural systems, so that management directions can be guided and to be able to measure successes and failings of already implemented interventions. For example, the CBD Secretariat's Global Biodiversity Outlook 5 report showed that none of the targets for the Strategic Plan for Biodiversity 2011–2020 would be fully met, threatening the achievement of SDG goals and undermining global efforts to address climate change.

As the Parties to the CBD deliberate on a Post 2020 Global Biodiversity Framework for bringing about a transformation in society's relationship with biodiversity, other science interventions of relevance to the ocean have already been established for this decade. Notable among these is the United Nations Decade of Ocean Science, supporting efforts to reverse the cycle of decline in ocean health. In terms of this, all countries are being urged to maintain and increase science investments in describing and understanding the ocean and the role it plays in the planet system. The contributions in this report provide evidence of South Africa's ongoing investment in this regard. The body of the report is made up of 28 contributions, termed report cards. Seven of the report cards are listed under the heading 'Monitoring Programmes', a further fourteen of them summarise 'Research Highlights', while seven showcase various 'Tools and Technologies' that have been developed or utilised in support of the various science programmes. This is followed by a list of scientific outputs for 2020, including peer-reviewed publications and other products that speak to both the volume and quality of work accomplished by O&C Research. A glossary of terms, acronyms and abbreviations is included at the end of the report, for readers to refer to if needed.

Monitoring Programmes

One of the main functions of O&C Research is to develop and maintain long-term measurements of Essential Ocean Variables (EOVs) across South Africa's immediate ocean space as well as in the deeper ocean surrounding it. The EOVs, which have been identified as a summary set of observations that balance information or knowledge requirements and cost-effectiveness for ocean science in a global context, include physical, biogeochemical, biological, as well as ecosystem variables. These are supported by a number of other related measurements required to better understand the observed changes and variations. Collectively, these variables provide an indication of how healthy and productive the oceans around South Africa are, and how they are changing in the short-, medium- and longer-term, thus contributing to the knowledge base on which to build policy and management actions.

The Chief Directorate, in partnership with other local, regional, and international government science agencies, works to increase observations of EOVs in the coastal and offshore areas adjacent to South Africa. Time series of EOVs and related variables for South African waters and the Southern Ocean that have been updated or initiated in 2020 and are summarised in this report, include: sea temperatures, currents, coastal upwelling, chemical and biological properties of the ocean including pH, carbonate chemistry and dissolved oxygen levels, chlorophyll *a* concentration, and zooplankton biomass and diversity.

Two oceanographic moorings that have been deployed and maintained between the Prince Edward Islands (PEIs) since 2014 have been providing continuous measurements of bottom water temperatures (Report Card 1) and water column current speed and direction (Report Card 2). During 2019–2020, above-average bottom temperatures and an unusual, sustained period of strong northeasterly flow were recorded. These phenomena were related to the proximity and orientation of fronts and mesoscale eddies around the PEIs at the time. Both water temperatures and currents can influence the geographical distributions of prey in the water column for the vast colonies of top predators (seabirds and marine mammals) that breed at the islands, with consequences for their reproductive success and healthy population numbers.

An updated upwelling index for the West Coast upwelling cells, namely Namaqualand, Cape Columbine and Cape Point, indicate a continuation of a long-term increase in the intensity of upwelling in this region (Report Card 3). This is attributed to the long-term, poleward (southward) migration of the South Atlantic High Pressure Cell, due to global warming. Less well understood at the moment, however, are the effects of climate changes on ocean chemistry in the region. Monitoring of dissolved oxygen levels in St Helena Bay on the West Coast for a ten-month period up to January 2020, showed similarity with the known seasonal cycle, including protracted periods of hypoxia (low oxygen) in the bottom waters and conditions approaching anoxia (even lower oxygen values) during autumn 2019 (Report Card 4). Dissolved oxygen in seawater is essential for survival of most marine organisms, but its concentrations have been decreasing globally over the last few decades. With ocean warming and other changes, it has been predicted that marine organisms will face progressively lower dissolved oxygen levels in the coming years.

Hypoxic or anoxic conditions in St Helena Bay were associated with low pH and associated calcium carbonate ($CaCO_3$) under-saturation of bottom water (Report Card 4). This is unsurprising because dissolved oxygen levels and acidity are related, both being influenced by the process of respiration which uses oxygen and produces carbon dioxide (CO_2) as a by-product. Respiration in turn can be expected to increase with increased upwelling. This is because, during upwelling-favourable periods, the higher availability of nutrients in the upper layers leads to greater biomass of phytoplankton (the basis of marine food webs), and hence a more productive ecosystem with increased levels of respiration. The uptake of anthropogenic CO_2 emissions, however, further increases the acidity and $CaCO_3$ under-saturation of upwelled waters. The resulting corrosive conditions will make it more difficult for calcifying marine organisms (such as mussels and oysters) to maintain their shells or exoskeletons, or to develop new ones. Long-term monitoring is imperative to assess how local trends will correspond to predictions by global biogeochemical climate models and data analyses, namely that this region will experience corrosive and irreversible consequences of ocean acidification within the 21st century.

Based on satellite-derived surface values, chlorophyll *a* concentration on the West Coast were, as expected highest near the most prominent upwelling cells, namely Namaqualand, Cape Columbine and Cape Point (Report Card 5). Higher chlorophyll *a* values are usually associated with greater phytoplankton biomass and a more productive ecosystem, which largely results from the higher availability of nutrients in the upper layers during peak upwelling periods. Surprisingly, considering the long-term increase in upwelling at these locations (Report Card 1), there appears to have been a slight downward trend in chlorophyll *a* concentration on the West Coast since the 1990s, although the concentrations in 2020 were elevated compared with 2019. High chlorophyll *a* concentrations recorded along the St Helena Bay Monitoring Line in 2019 and 2020 also indicated elevated productivity over the past couple of years (Report Card 6).

Corresponding with a long-term decrease in productivity off the South Coast (based on satellite-derived chlorophyll *a* concentration; Report Card 5), zooplankton biovolume and the biomass of copepods (usually the dominant component of zooplankton communities) have declined in this region since the 1980s. While long-term trends are likely to be environmentally driven ('bottom-up control'), it is thought that shorter-term, interannual variability in zooplankton abundance and diversity on the South Coast is mainly driven by 'top-down control', namely predation by pelagic fish. Sustained zooplankton monitoring is thus essential to understand changes in food availability for numerous fish, mammals and seabirds.

Research Highlights

The simultaneous impacts of warming, low oxygen conditions, acidification and other drivers can lead to interactive, complex, and amplified impacts for marine species and ecosystems. However, while continued monitoring of these EOVs is essential to determine long-term trends, shorter-term focused research can allow for better understanding of the ecosystem processes that link organisms and their environment. In this regard, the PEIs and surrounds in the Southern Ocean provide the setting for four of the Research Highlights presented here.

Investigation of satellite products showed considerable interannual and decadal-scale variations in Sea Surface Temperature (SST) and currents around the PEIs (Report Card 8). These may be driven by major climate modes such as the El Niño-Southern Oscillation (ENSO) and the Southern Annular Mode (SAM). However, the interactions of mesoscale eddies with the PEI shelf environment can also be an important determinant of variability in water temperatures and flow characteristics in the region. Tracking of mesoscale eddies, once again using satellite products, showed that the majority of these eddies that interact with the PEI shelf originate within about 150 km of the area (Report Card 9). This is contrary to the commonly-held theory that the most of these mesoscale eddies originate much further to the southwest, at the Southwest Indian Ridge, which is known as an 'eddy generation hotspot'. The considerable length of time over which the eddies interact with the PEI shelf, suggests that their influence on oceanographic conditions and biological communities should not be under-estimated (Report Card 10). In another result that seems counter-intuitive, satellite-tracked sub-Antarctic fur seals *Arctocephalus tropicalis* appeared to avoid mesoscale eddies when foraging (Report Card 11). As these eddies are typically associated with elevated productivity, the result is unexpected and the relationship between the eddies and other resident top predator species should be investigated further.

Moving northwards, satellite-derived SST data were used to investigate changes in conditions on South Africa's east coast, where the powerful, southwestward flowing Agulhas Current has been warming since 2002 (Report Card 12). In contrast, the coastal and shelf regions adjacent to the Agulhas Current showed cooling since 2002. This may be caused by the current adopting an increasingly meandering pathway, possibly due to larger basin- or global-scale climate changes. Impacts of this increased meandering on other ecosystem processes and marine organisms requires further research. Variability of the Agulhas Current and the Agulhas Retroflection (the region where the current is redirected back into the Indian Ocean to become the Agulhas Return Current) can affect the exchange of heat, salt, energy and biota between the Southwest Indian and South Atlantic Ocean basins. A new locally-developed monitoring tool applied to satellite-derived altimetry data for the region since 1993, was able to identify years when 'early retroflections' took place (Report Card 13). 'Early retroflections' are extreme eastward retreats of the Agulhas Retroflection, which have a significant impact on inter-ocean exchange and can potentially affect the dynamics of the highly productive Agulhas Bank ecosystem.

Staying with the Agulhas Current, the influence of its variability on zooplankton communities was assessed during ship-based surveys (Report Card 14). Zooplankton abundance was greater inshore of the current and at the current edges, but lower within the current itself. However, there was considerable variability between surveys, especially for the stations inshore of the fast-flowing current, where strong depth and environmental gradients across the narrow continental shelf create a dynamic and productive transition zone. Further afield in the Southwest Indian Ocean, the zooplankton communities associated with three shallow seamounts were assessed (Report Card 15). Seamounts are recognised as hotspots of biodiversity, attracting large numbers of top predators, although zooplankton biomass is sometimes found to be lower above the summit compared to the surrounding waters. However, this study found no evidence that the seamounts affected the abundance and size distribution of zooplankton, compared with surrounding waters.

Seamounts, canyons and other oceanographic features were included in the expansion of South Africa's Marine Protected Area (MPA) network in 2019. However, with increasing demands on ocean space from a growing human population (especially in coastal areas), there is an urgent need to show whether existing MPAs are actually effective in meeting their objectives. In the Table Mountain National Park MPA, comparison of size and density of a commonly harvested limpet between harvested sites and no-take areas, showed that no-take areas are effective in protecting rocky shore biodiversity from the impacts of harvesting (Report Card 16). High densities and sizes of limpets were maintained in the no-take areas, whereas in harvested areas, removal of limpets led to rocky shore communities becoming algal-dominated.

The efficacy of spatial protection for more mobile organisms is often less clear. For example, the value of closing areas around Endangered African penguin *Spheniscus demersus* breeding colonies to small pelagic fishing, in order to benefit foraging penguins, is a subject of ongoing scientific debate. However, other Endangered local seabirds, such as the Cape cormorant *Phalacrocorax capensis*, also appear to be disadvantaged by small pelagic fishing (Report Card 17). The diet of this species, which is in continuing decline, shows a high degree of overlap with the fishery in terms of species and size composition.

Survival, abundance, diet and behaviour of top predator species such as seabirds can tell us a lot about the state of the ocean, but as yet no one can be quite sure what the stranding of typically open-ocean cetaceans tells us about the ocean's condition. While there are many theories for why these animals strand, examination of carcasses generally provides little by way of evidence for the cause of stranding. This has been the case for pygmy *Kogia breviceps* and dwarf sperm whales *K. sima* which strand occasionally on Western Cape beaches (Report Card 18). A concerning spike in strandings of the latter species occurred in 2020, with 11 recorded strandings, compared with an average of less than one per year in the previous ten years. The South African National Strandings Network, co-ordinated in part by O&C Research, will continue to monitor the situation and respond to such stranding events, which provide useful samples and data on otherwise little known cetaceans such as these rarely-seen kogiids.

Monitoring and research is often essential to guiding management decisions and interventions. In many cases, it has also allowed us to develop the means to predict scenarios that can inform management options. In the coastal zone, inundation (flooding) is regarded as one of the most dangerous and destructive coastal hazards. Consequently, predictions of sea-level rise associated with climate change need to be urgently considered. Report Card 19 demonstrates the testing of an accessible and technologically simple GIS technique (using a part of the city of Cape Town as a pilot site), that can inform coastal zone planners and management about possible future inundation scenarios. The application of this technique will potentially be highly useful for decisions and interventions on matters of disaster management and climate change adaptation at a relevant spatial scale.

Moving to the national scale, Marine Spatial Planning (MSP) has been enacted in South Africa, and is in the process of being initialised. Marine Spatial Planning seeks to better manage ocean spaces by balancing ecological, social and economic objectives, using public and participatory processes. Areas recognised as Ecologically or Biologically Significant Marine Areas (EBSAs) were identified as a useful tool to guide MSP ecological objectives for South Africa. This required revision of South Africa's EBSAs to enhance their use as a scientific and technical tool for spatial management (Report Card 20). The revision process, now complete, included identification of new EBSAs and re-defining the boundaries of many existing EBSAs. Along with other marine spatial biodiversity priorities, EBSAs have been incorporated within South Africa's first Critical Biodiversity Area (CBA) Map for the coastal and marine environments (Report Card 21). A CBA Map is essentially a spatial plan for the natural environment, to aid planning and decision-making in support of sustainable use and development. The coastal and marine CBA Map, along with sea-use guidelines that have been developed for the different map categories, is the basis for the initial Environment Sector Plan, which is currently being developed to inform South Africa's first MSP. It will also help to identify suitable areas for future MPA expansion.

Tools and Technologies

The first three report cards on Tools and Technologies that support O&C Research's monitoring and research programmes, describe instruments that are used for recording oceanographic or atmospheric observations. Report Card 22 introduces Pressure-equipped Inverted Echo Sounders (PIES), which O&C Research has deployed in the South Atlantic in collaboration with several national and international institutions. Measurements of the travel-time of acoustic signals from the bottom-moored PIES to the sea surface and back, can be translated to water column estimates of temperature, density and salinity. Moving from the deep ocean to the coastline, Automatic Weather Stations that have been deployed and maintained by O&C Research at three locations on the West Coast, are collecting important wind speed and direction data (Report Card 23). Further off the West Coast, ship-mounted Acoustic Doppler Current Profilers are being used to monitor ocean circulation. This forms part of the Chief Directorate's Southern Benguela Integrated Ecosystem Programme, with an example shown for the St Helena Bay Monitoring Line (Report Card 24).

The Annual Science Report number 19 (2019) provided an introduction to the Department's data and information management systems, and related data and computing knowledge products that are either already available or under development. Three such products are described here, the first of which allows for real-time identification and tracking of ocean currents (in particular mesoscale eddies), thereby increasing the monitoring capabilities of ocean observing systems (Report Card 25). An operational ocean forecasting model, described in Report Card 26, was piloted in Algoa Bay, and is aimed at providing routine forecasts of nearshore oceanographic conditions and potential movements of surface oil spills. This system can support the management of bunkering operations (vessel refuelling) and aid mitigation efforts in response to spill events. Report Card 27 describes a stage in the development of a high-resolution shelf-scale model optimised for South Africa's Exclusive Economic Zone. This model will allow for the analysis of long-term changes in South Africa's ocean environment.

Perhaps fittingly, the final report card (Report Card 28) in this section is about communicating science to the public. A web-based application that was designed for the De Hoop MPA fish monitoring program, provides a user-friendly platform for communicating results from a long-term time series (since the 1980s) to all stakeholders. The app is educational and will disseminate information on the ecological benefits of the MPA to the public in an easy to understand format, thereby promoting awareness and conservation.

Concluding remarks

Whereas nearly half of the contributions to the Annual Science Report for 2019 were reporting on Monitoring Programmes, only a quarter of the contributions in this report are under the same heading. Research Highlights, on the other hand, occupy half of the contributions for 2020 compared to a third in 2019. These disparities were certainly influenced by the COVID-19 pandemic in 2020, with field excursions either cancelled or severely limited for much of the year. Thus, updated time series on EOVs for estuaries and rocky shores, and Essential Biological Variables (EBVs) such as seabird abundance or seal diet, are lacking in this issue. On the other hand, monitoring or research using satellite-derived products were not affected by the adjusted working conditions.

Researchers tended to focus on data management, analyses, write-ups and preparations for publication under the adjusted working conditions of 2020. Evidence for this is in the vast number of datasets that were published in the Department's Marine Information Management System (MIMS) in 2020 (see Outputs for 2020). These datasets, created by O&C Research through research cruises, fieldwork, or the deployment of data generating instruments, are now safeguarded in the MIMS long-term archival data repository, which conforms to international ISO standards pertaining to data management and hardware. This ensures that the stored data are protected against loss or unauthorised alteration, and are discoverable and citable by the broader community. The available MIMS datasets can be accessed via the internet (www.ocean.gov.za).

While contributions to conferences or symposia in 2020 were understandably reduced compared with previous years, the 30 peer-reviewed scientific papers published by the members of the Chief Directorate in 2020 well exceeds the Branch target of 20 per year. Many more papers that were advanced during 2020 are likely to be published in 2021. Additional products for disseminating data and information and capacitating stakeholders are described under Tools and Technologies or listed in the Outputs for 2020. Producing high quality products, publishing findings in peer-reviewed literature and aiming for open dissemination of the data and data products that are generated, are all key to ensuring that the research and monitoring undertaken by O&C Research remains relevant, applied, appreciated and usable. It is apparent from the outputs that researchers have taken advantage of the adjusted working conditions of 2020, to meet these goals.

In terms of location, the six report cards dedicated to the Prince Edward Islands and surrounds in the Southern Ocean, reflect the Chief Directorate's continuing interest in this region. This is related to the fundamental role of the Southern Ocean in influencing our regional and global climate. The Southern Ocean is also an ideal location to investigate climate variability and ecosytem processes, because it experiences low levels of anthropogenic influence. Monitoring Programmes off mainland South Africa are still focused on the West and South Coasts and lacking off the East Coast, as highlighted in previous reports. However, three studies focused on the Agulhas Current, as reported on under Research Highlights, could set the scene for permanent monitoring of EOVs on the East Coast.

As for the 2019 Annual Science Report, a significant number of the contributions for 2020 are concerned with, or of relevance to, understanding or detecting climate-related changes or climate change effects in the marine environment. Many of the report cards conclude with recommendations for continued monitoring for longer time series, or else highlight where further investigations into potential drivers, stressors, or related questions, can be undertaken. Continuation of the EOV time series is essential to be able to distinguish longer-term trends from the shorter-scale fluctuations that characterise South Africa's highly dynamic and variable marine environment. Ecosystem functioning and processes result in the tangible ecosystem services that we benefit from. These range from fish availability to safe shipping and rainfall and oxygen production. National competencies in understanding local marine ecosystems secures the return on the considerable human and science infrastructure investments that have been made in developing these time series. Interrogating these observations and developing fundamental research questions and more focused investigations, where applicable, are essential for building scientists' and policy makers' understanding of the marine environment. This will contribute to developing appropriate advice and recommendations for the sustainable use and conservation of marine resources, for well-informed management decisions and interventions.

Another theme that is conspicuous in this report is spatial management, including the prioritisation of areas of biodiversity importance to inform spatial management processes, such as MSP or further MPA expansion. In this regard, the information packages that describe EBSAs, and made possible the development of the CBA Map and associated sea-use guidelines, are themselves largely products of data and knowledge emanating from research and monitoring by the Department and other organisations. The MSP process is intended to be an iterative and flexible one that can take into account changing needs and interests of the multiple sectors involved. With the planned development of South Africa's ocean economy, including growth of emerging sectors such as petroleum and mariculture, the needs and interests of resource utilisation sectors are set to intensify, not diminish. It will be essential that the Environment Sector's priorities are continually updated based on best available scientific evidence, to be able to continue to provide robust and scientifically defendable proposals to spatial managers. This requires that the many identified data and knowledge gaps for marine biodiversity and ecosystem functioning, continue to be addressed through focused research and ongoing monitoring.

1. LONG-TERM VARIABILITY IN BOTTOM TEMPERATURE ON THE PRINCE EDWARD ISLANDS SHELF

Despite their small size, the Prince Edward Islands (PEIs) provide crucial breeding habitat for vast populations of marine mammals and birds. Many of these animals depend strongly on the ambient oceanographic conditions at and around the islands. Historically, hydrographic observations in the region have largely been limited to April/May each year, during annual relief voyages to re-supply the research base. Since April 2014, two moorings on the inter-island shelf (Fig. 1) have been providing continuous measurements of bottom temperature in the region.

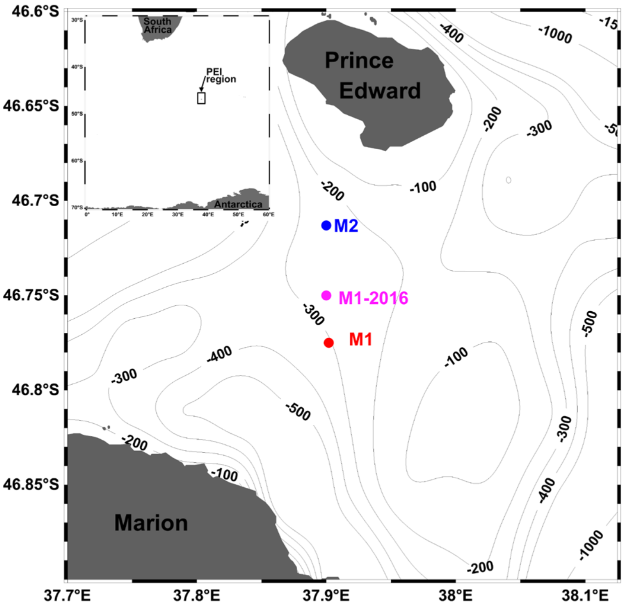

Figure 1. *Bathymetry on the PEI shelf. Mooring positions M1 and M2 are shown in red and blue, respectively. The pink dot shows the location of M1 between April 2016 and April 2017.*

Mooring M2 (260 m deep) showed lower temperatures than M1 (174 m deep). Both moorings showed similar daily changes, as well as substantial short-term, seasonal, and interannual variability in bottom temperature. The mean seasonal cycle indicated highest temperatures in autumn (March–May) and lowest values in spring (September–November). Extensive periods where temperatures were either consistently lower or higher than the long-term mean (Fig. 2), corresponded to meridional meanders of the southern branch of the sub-Antarctic Front (S-SAF). When the S-SAF was to the north of the islands, bottom temperatures were lower due to the stronger influx of cooler Antarctic waters. In contrast, when the S-SAF was south of the islands, bottom temperatures were higher due to the larger proportions of warmer sub-Antarctic and even subtropical waters.

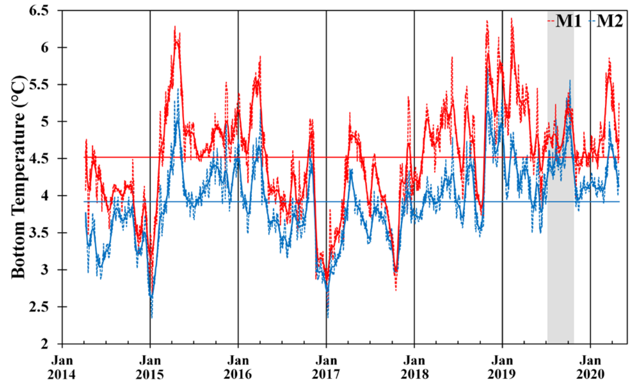

Figure 2. *Daily mean bottom temperature (°C) at moorings M1 (red) and M2 (blue). Dashed lines indicate measurements while solid lines show low-pass filtered values. Horizontal lines show mean temperature for each time series. Grey shading shows the period of strongest northward flow at M2.*

For most of 2019–2020, temperatures exceeded the 6-year mean, reflecting a more southerly location of the S-SAF. Between May and October 2019 (Fig. 2), persistent strong northward flow occurred at M2 (see Fig. 2, Report 2), due to the proximity and orientation of fronts and mesoscale eddies around the PEIs (Fig. 3). During this period, temperatures were 0.5–1.5°C above the means for each time series (Fig. 2).

Water temperatures influence geographical distributions of the prey species on which the vast numbers of seabirds and marine mammals breeding at the PEIs depend. Thus, temperature variations are likely to affect the distances that these animals have to travel from the islands to find food. This has consequences for time and energy spent foraging, the survival of young that are dependent on the foraging efficiency of adults, and ultimately for the reproductive success and numerical trends of these populations.

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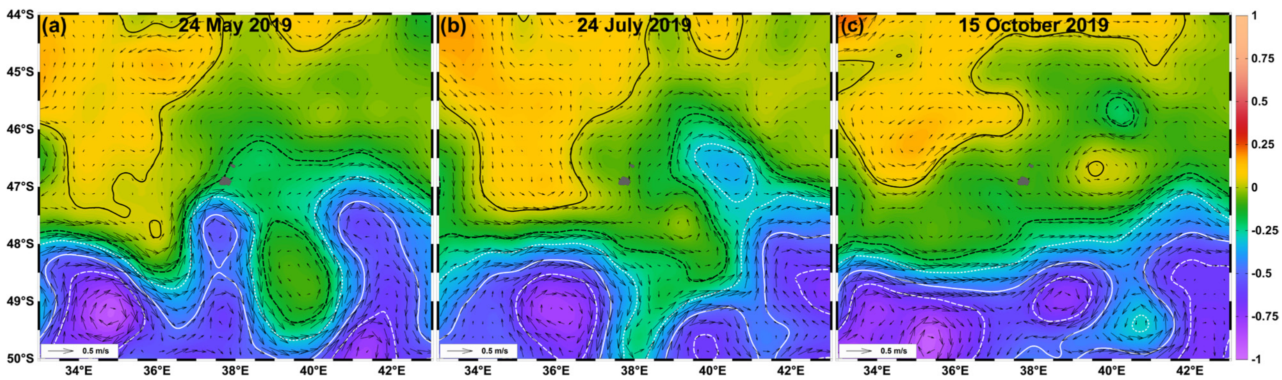

Figure 3. *Selected satellite sea surface height (m) maps with geostrophic current vectors. The middle (M-SAF) and southern (S-SAF) branches of the sub-Antarctic Front are indicated by black solid/dashed contours, and the northern (N-APF), middle (M-APF), and southern (S-APF) branches of the Antarctic Polar Front are indicated by white dotted/solid/dashed contours.*

2. LONG-TERM OBSERVATIONS OF CURRENTS ON THE PRINCE EDWARD ISLANDS SHELF

The Prince Edward Islands (PEIs) are a remote island archipelago in the sub-Antarctic zone of the Southern Ocean. The islands provide crucial breeding habitat for vast populations of seabirds and marine mammals. It is well-known that there are strong links between the oceanography and biological communities, but observations have been largely limited to periods coinciding with annual relief voyages to re-supply the research base. Since April 2014, two moorings on the inter-island shelf (Fig. 1) have been providing continuous measurements of water column current speed and direction in the region.

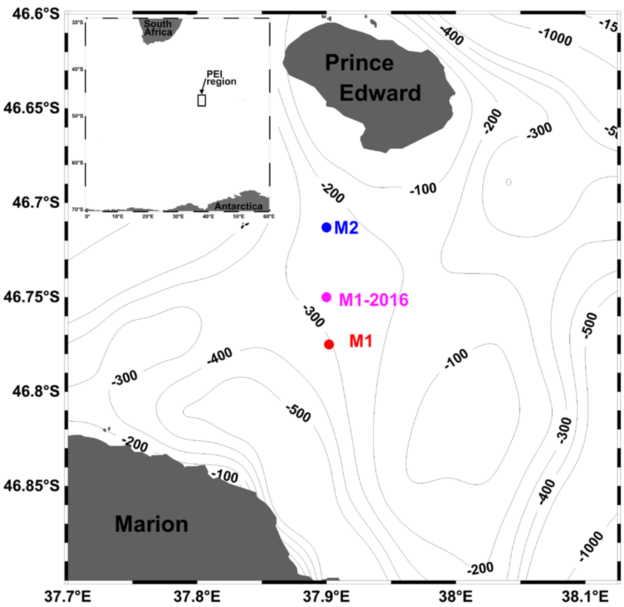

Figure 1. *Bathymetry on the PEI shelf. Mooring positions M1 and M2 are shown in red and blue, respectively. The pink dot shows the location of M1 between April 2016 and April 2017.*

During 2014–2020, daily mean current speeds at mooring M1 ranged between 0.01 and 50.90 cm s^{-1}, while those at M2 varied from 0.03 to 67.32 cm s^{-1} (Fig. 2). Zonal (east/west) flow was typically much greater than meridional (north/south) flow, due to the strongly zonal nature of the Antarctic Circumpolar Current. Persistence of westerly flow in the bottom waters at M2, and throughout the water column at M1, suggests the continuous presence of a Taylor column (a stationary anticyclonic circulation over the shelf). Taylor columns likely play a critical role in the retention of nutrients and biota, thus maintaining enhanced productivity on the shelf. Therefore, the presence of one at the PEIs would account for the persistence of an ecosystem that is able to sustain high concentrations of marine biota. Due to its coarse spatial resolution, satellite altimetry is not useful for determining flow in the inter-island region, thus more extensive *in situ* measurements are required to fully resolve the spatial structures of currents and their variability.

The strongest flow (> 50 cm s^{-1}) at M2 was observed between May and July 2019 (Fig. 2), due to the close proximity of the southern branch of the sub-Antarctic Front (S-SAF) to the islands (see Fig. 3, Report 1). The subsequent configuration of fronts and mesoscale eddies around the PEIs resulted in unusually strong northward flow at M2 (red dashed lines, Fig. 2), which persisted for several months (July to October). This caused stronger northward to northeastward advection of shelf waters, in contrast to the more regular eastward advection observed at the islands.

This was the first observation of such extensive periods of northeasterly flow at M2 (Fig. 2). Such flow changes could potentially influence the distribution of preferred prey, and hence the feeding patterns of seabirds and marine mammals breeding at the PEIs. Comparisons between currents and feeding behaviour, diet, and reproductive performance of selected predators is recommended to determine whether predators provide signals of unusual flow dynamics.

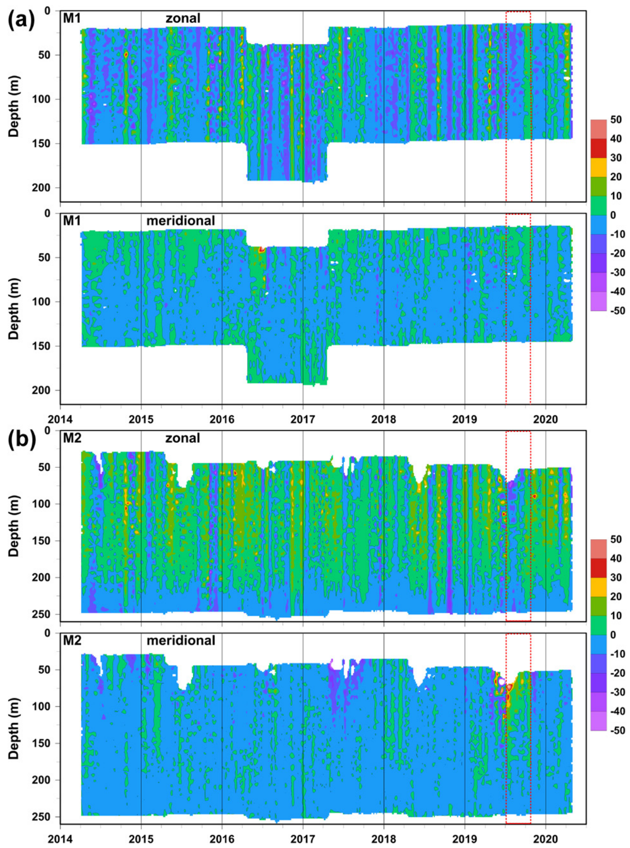

Figure 2. *Daily mean zonal and meridional current components (cm s^{-1}) at (a) M1, and (b) M2. Positive values denote eastward (zonal) and northward (meridional) flow; negative values denote westward (zonal) and southward (meridional) flow. Dashed red lines show the period of strongest northward flow at M2.*

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3. LONG-TERM TRENDS IN UPWELLING INDICES FOR THE WEST AND SOUTH COASTS

Wind-driven coastal upwelling is caused by wind generated surface Ekman drift that is directed offshore. Upwelling causes high levels of productivity that characterises all Eastern Boundary Upwelling Systems around the world, including the Benguela Upwelling System (BUS) in southern Africa.

In the BUS northwards of Hondeklip Bay in the Northern Cape (Fig. 1), upwelling magnitude is generally strong and relatively consistent. Southwards of Hondeklip Bay, it is weaker and more variable. However, it is predicted that coastal upwelling in the southern part of the system will intensify because of the long-term poleward migration of the South Atlantic High Pressure Cell (SAHP), due to global warming. This prediction is being evaluated by monitoring long term trends in an upwelling index for the three major upwelling cells on the West Coast, and one upwelling cell on the South Coast (Fig. 1).

The upwelling index was derived from the United States Navy Fleet Numerical Meteorology and Oceanography Centre model output on offshore Ekman transport, at 1-degree spatial resolution (https://coastwatch.pfeg.noaa.gov/erddap/griddap). A 41-year long time series of data (1981–2021) was used to visualise linear trends (Fig. 2). Maximum upwelling occurs during the summer months of December, January and February (DJF) in this region, therefore we used the annual average for DJF as our upwelling index.

All four selected sites exhibit strong interannual and decadal variability in upwelling. Between sites, the pattern is as expected with upwelling intensity declining southwards from Hondeklip Bay, and the weakest upwelling on the South Coast (Fig. 1). Whereas in 2019, upwelling values at all the West Coast sites were below the 5-year mean (2015–2020), in 2020 the upwelling values for Cape Point and Cape Columbine exceeded the 5-five year mean, with Hondeklip Bay below the mean. Long-term linear trends in the time series show an overall increase in the upwelling index for the West Coast upwelling cells (Fig. 2), consistent with the prediction that upwelling should intensify in this region with southward migration of the SAHP.

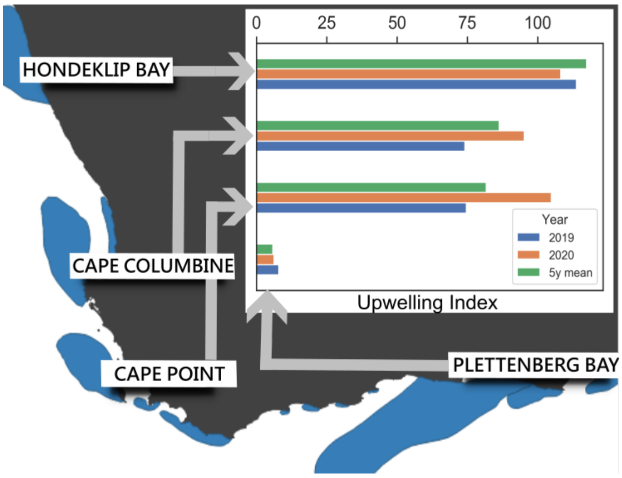

Figure 1. *The location of upwelling cells off Hondeklip Bay, Cape Columbine, Cape Point and Plettenberg Bay. The inset bar plot shows the upwelling index for two years (2019 and 2020) and the five year mean for each location.*

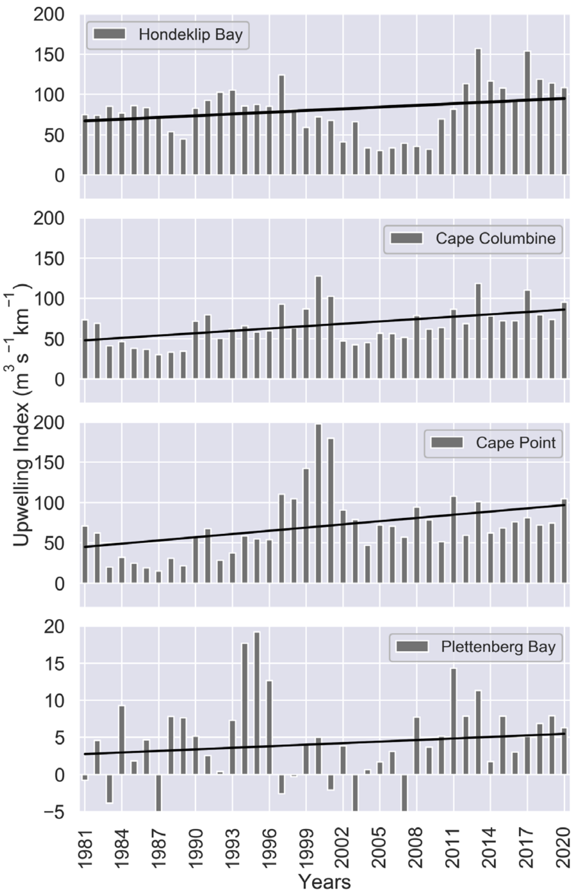

Figure 2. *Time series of DJF upwelling index values at four upwelling locations during 1981–2020, with linear trendlines.*

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4. ST HELENA BAY – AN OBSERVATORY FOR OCEAN ACIDIFICATION AND DEOXYGENATION

Coastal upwelling regimes inshore of Eastern Boundary Currents are the most biologically productive ecosystems in the global ocean, but changes resulting from human activities are beginning to emerge in these regions. For example, carbon dioxide derived from fossil fuel combustion is resulting in increased acidity (i.e. Ocean Acidification – OA) of upwelled waters. OA is associated with the reduction in the availability of calcium carbonate ($CaCO_3$), which is needed by calcifying marine organisms such as corals, pteropods, molluscs and foraminifera to build their shells or skeletons. These organisms are unable to develop these structures when seawater is under-saturated with respect to $CaCO_3$. In some areas, increases in upper ocean temperatures and productivity have also increased the extent and intensity of low oxygen waters (i.e. deoxygenation).

St Helena Bay is the most productive region of the southern Benguela and is an important nursery area for fish. It is also an area that is subject to hypoxia and anoxia, and occasionally, marine resources are severely impacted. *In situ* measurements of dissolved oxygen have been made sporadically in St Helena Bay since the 1950s, but assessment of long-term change is severely compromised by comparison of data sets with temporal and/or spatial biases. In 2015, O&C Research established a coastal observatory in St Helena Bay to provide consistent high-resolution measurements of oxygen and pH by means of bottom-moored instrumentation (Fig. 1). Here we present surface and bottom oxygen, pH (measure of acidity) and Ωaragonite (measure of carbonate ion concentration that is used to track OA). The pH and Ωaragonite were calculated from *in situ* samples of dissolved inorganic carbon and total alkalinity collected at 0, 3, 8, 14, and 50 m depths from April 2019 to January 2020 (Fig. 2). These observations will serve to calibrate moored pH sensors.

Low oxygen (< 1.4 ml l^{-1}), low pH (< 7.6) and low Ωaragonite (< 1) were observed in the bottom waters during autumn (April and May), spring (September to November), and summer (December and January) (Figs. 2 and 3). During autumn, conditions approached anoxia (0.07–0.10 ml l^{-1}) prior to winter (June to August) mixing. The corrosive conditions from concurrently low pH and Ωaragonite in bottom waters, particularly during autumn, are an additional stressor for calcifying marine organisms in this area.

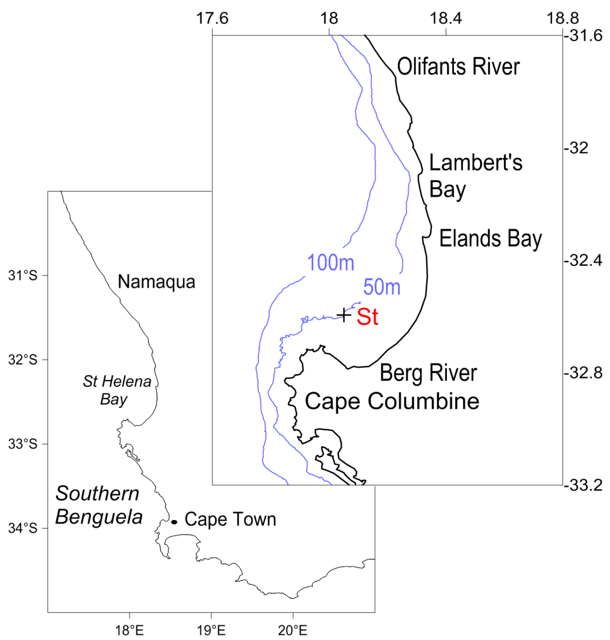


Figure 1. *Map of St Helena Bay showing the location of a coastal observatory (St) at the 50 m depth contour.*

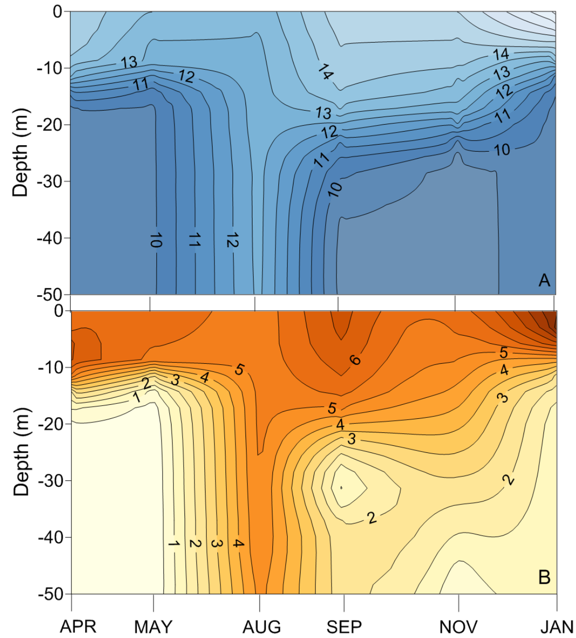


Figure 2. *Time series of (A) temperature and (B) dissolved oxygen for the water column in St Helena Bay from April 2019 to January 2020.*

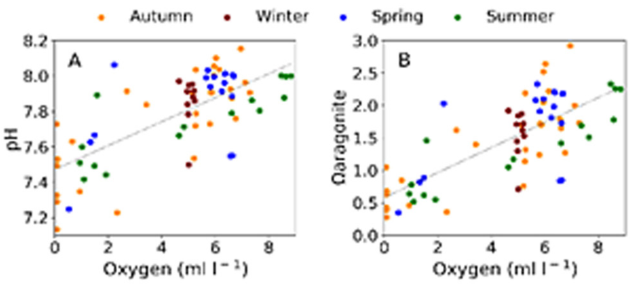


Figure 3. *The correlations between (A) pH and dissolved oxygen (pH = 7.47 + 0.07*Oxygen), and (B) aragonite saturation state (Ωaragonite) and dissolved oxygen (Ωaragonite = 0.57 + 0.19*Oxygen).*

Ocean acidification and oxygen content are clearly related, since both are influenced by the process of respiration. Lower pH is associated with lower oxygen, and vice versa. Thus, climate change is expected to result in concurrent acidification and deoxygenation. At present, the response of the southern Benguela to climate change is not well understood. Therefore, monitoring efforts should be maintained and strengthened, in order to improve our understanding of OA and deoxygenation, and the consequent ecological effects on marine organisms.

Authors: Tsanwani M (O&C Research), Pitcher GC, Du Randt A, Seanego K (Aquaculture Research), Mdokwana BW (O&C Research)

5. CHLOROPHYLL VARIABILITY ON THE WEST AND SOUTH COASTS

Phytoplankton play a crucial role in a number of key marine processes, such as the modulation of food webs, CO_2 exchanges, and the cycling of carbon and other nutrients. On the west and south coasts of southern Africa, the Benguela upwelling system and the Agulhas Bank are economically and ecologically significant as they host productive ecosystems with complex trophic structures that support numerous commercially harvested resources. To monitor environmental conditions, an index of chlorophyll *a* concentration is computed by integrating satellite-derived surface values from the coast to the 1 mg m^{-3} level further offshore (Fig. 1). Higher values are usually associated with greater phytoplankton biomass and a more productive ecosystem, while lower values indicate lower biomass and a less productive ecosystem.

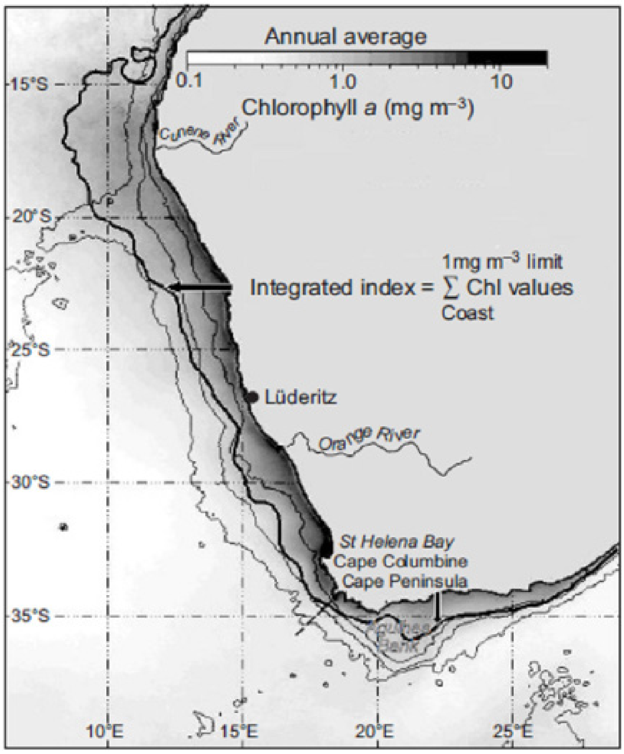


Figure 1. *Annual average chlorophyll a concentration and location of the 1 mg m^{-3} contour (thick line).*

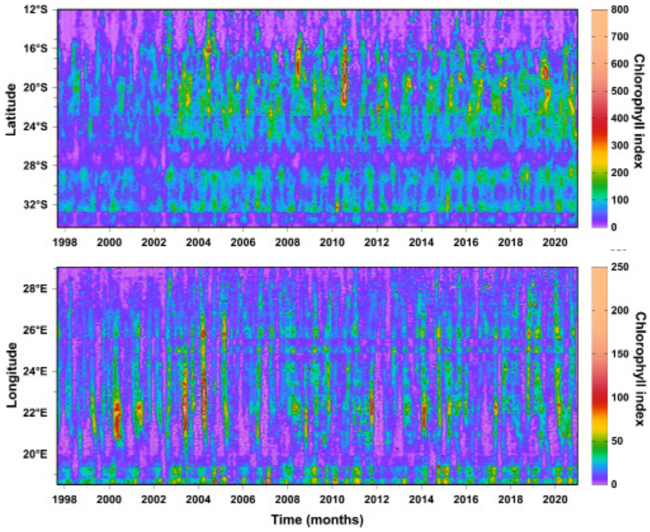


Figure 2. *Monthly chlorophyll indices (1997–2020) for the west coasts of Namibia and South Africa (top panel) and for South Africa's south coast (bottom panel).*

Along the west coast of southern Africa, the highest index values are found off Namibia (16–26°S; Fig. 2). Low values in 2018 suggested that this was the least productive year, with the lowest phytoplankton biomass since 2013. The Lüderitz cell (*ca.* 27°S) is typically associated with very low index values due to persistent upwelling and offshore transport, but elevated values during October–December 2020 suggested less upwelling than usual.

Along South Africa's west coast (28–34°S), elevated index values occur in areas influenced by the Namaqualand, Cape Columbine and Cape Peninsula upwelling cells. Off Namaqualand (28.5–30°S), the second half of 2018 showed the highest index values since 2013. The 2019 values were only slightly lower than those in 2018 but remained elevated throughout the year. Higher values in 2020 suggested an increase in productivity.

Along South Africa's south coast (18.5–29°E), index values are generally lower than on the West Coast. During the period 2013–2020, the highest values occurred at 22°E in January–February 2014. The lowest values were observed in 2016, suggesting that this was the least productive year with the lowest phytoplankton biomass on the South Coast during 2013–2020. In 2019, high values extended across the central and eastern part of the region during the first half of the year, with much lower values during the second half of the year. During 2020, high values were observed east of 22°E during the first and last quarters of the year, but high values between 20 and 22°E suggested increased productivity during most of year.

The apparent large increase on the West Coast since mid-2002 is due to a platform change from the SeaWiFS to the MODIS Aqua sensor. When accounting for this change, there is a small but significant long-term increase in chlorophyll *a* off Namibia, with a decrease off the west coast of South Africa and on the Agulhas Bank. These trends are much smaller than the seasonal and interannual variations that occur in these regions, and substantially more years of data are required to properly distinguish long-term trends from seasonal and interannual variations.

Author: Lamont T (O&C Research)

6. SURFACE CHLOROPHYLL *A* CONCENTRATIONS ALONG THE ST HELENA BAY MONITORING LINE

St Helena Bay on the west coast of South Africa is one of the most productive areas of the Benguela ecosystem and has been the focus of environmental research and monitoring for several decades (Fig. 1). It is a well-known retention area, with significantly elevated plankton biomass compared to the rest of the upwelling system off South Africa, and is an important region for pelagic fish, hake, and rock lobster.

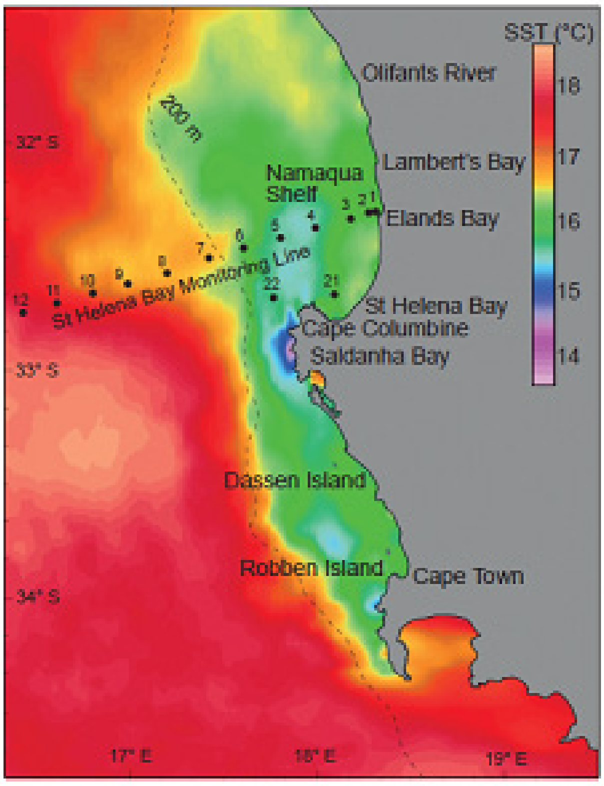


Figure 1. *Map of sea surface temperature, illustrating cooler waters typically found inshore and warmer waters offshore, as well as the location of the St Helena Bay Monitoring Line.*

Upwelling of water along the west coast of South Africa is driven by southeasterly winds which transfer surface waters offshore, resulting in cool, nutrient-rich waters being uplifted to the surface from deeper depths. On a seasonal scale, higher chlorophyll *a* concentrations coincide with larger amounts of upwelling, which occur throughout the upwelling season (October–March) each year. Satellite-derived surface chlorophyll *a* concentrations clearly illustrate this seasonal signal, with maxima in spring/early summer and late summer/autumn (Fig. 2).

Higher chlorophyll *a* values are usually associated with greater phytoplankton biomass and a more productive ecosystem, which largely results from the higher availability of nutrients in the upper layers during the peak upwelling periods. In contrast, lower chlorophyll *a* concentrations indicate lower phytoplankton biomass and a less productive ecosystem, usually associated with lower amounts of upwelling and less nutrient availability in the surface layers during late autumn to early spring (April–September) each year (Fig. 2).

Generally, higher values of chlorophyll *a* occur close to the coast and decrease with distance offshore (Fig. 2). During 2015, high concentrations (> 20 mg m^{-3}) occurred close to the coast in autumn (March) and late spring/early summer (September to November). Elevated chlorophyll (> 5 mg m^{-3}) extended approximately 110 km offshore in March – the farthest offshore extent for such high concentrations since March 2010. In contrast, concentrations > 20 mg m^{-3} were observed closer to the coast between August and October 2016, during June, August and December 2017, in March and August 2018, and during April, June, and September 2019. During 2020, such high values were observed only in February–March.

In 2016, the farthest offshore extent (*ca.* 80 km) of values above 5 mg m^{-3} was observed in February and March, while in January 2017, January/February 2018, February/March 2019, and January–March 2020, such values extended only *ca.* 70 km offshore. Chlorophyll *a* values near the coast in 2017 were lower than peak values in 2016, but remained elevated throughout the year. Values were even lower during 2018, suggesting that the ecosystem was less productive. High values (> 10 mg m^{-3}) throughout most of 2019 and 2020 suggest increased productivity over the past two years. While peak values in 2019 occurred during April–August, suggesting a more productive autumn/winter than usual, 2020 peak values were observed in March and October, in agreement with the usual seasonal maxima.

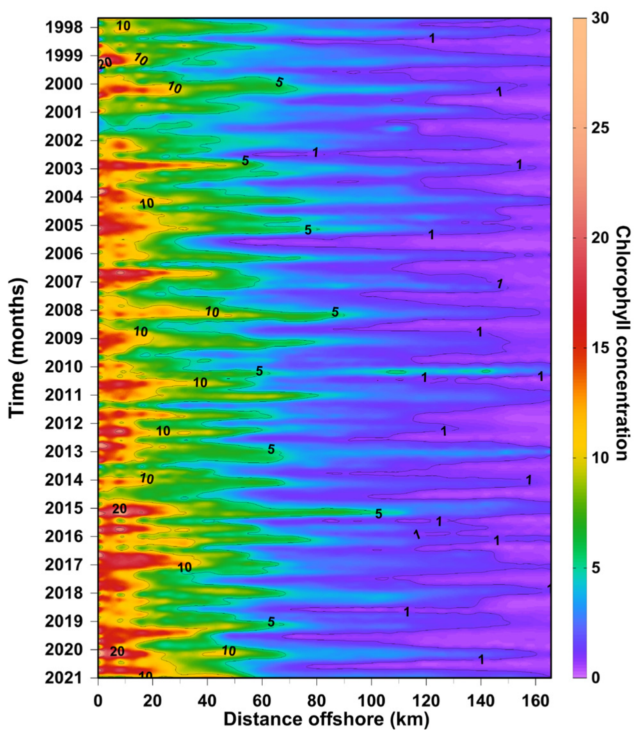


Figure 2. *Time series of monthly chlorophyll* a *(mg m^{-3}) along the St Helena Bay Monitoring Line between 1997 and 2020.*

Author: Lamont T (O&C Research)

7. ZOOPLANKTON BIOMASS AND DIVERSITY ON THE SOUTH COAST (1988–2019)

Plankton form the foundation of most marine food webs, and zooplankton provide a crucial source of food for higher trophic levels, including commercially important fish, marine mammals and seabirds. With relatively short lifespans, plankton respond quickly to changing environmental conditions and are ideal sentinel organisms of climate-related change in marine ecosystems. Due to these, as well as other important functions, the Global Ocean Observing System (GOOS) identified 'Zooplankton biomass and diversity' as an Essential Ocean Variable (EOV) for monitoring.

Annual zooplankton sampling off the south coast of South Africa during spring to early summer (October–December) was initiated in 1988, as part of routine acoustic surveys of pelagic fish biomass. Monitoring lines off Walker Bay (western Agulhas Bank) and Mossel Bay (central/eastern Agulhas Bank; Fig. 1) were selected to explore long-term changes in zooplankton biomass and diversity.

Despite considerable interannual variability, both zooplankton biovolume and total copepod biomass have declined over the time series, significantly so for copepod biomass in both areas, and for zooplankton biovolume off Mossel Bay (Fig. 2).

Biomass of *Calanus agulhensis*, the dominant large calanoid copepod on the Agulhas Bank, also declined significantly in both areas, and small calanoid copepods declined significantly along the Mossel Bay line (Fig. 2). While zooplankton variability may reflect environmental fluctuations, referred to as bottom-up control, changes in copepod biomass and composition on the Agulhas Bank are thought to be largely driven by predation from pelagic fish, i.e. top-down control. The recent increase in copepod biomass in 2018 and 2019, particularly of the large species preferred by planktivorous fish, suggests reduced predation by small pelagic fish, likely due to a decrease in pelagic fish biomass. Sustained zooplankton monitoring is thus essential to understand changes in food availability for numerous fish, mammals and seabirds.

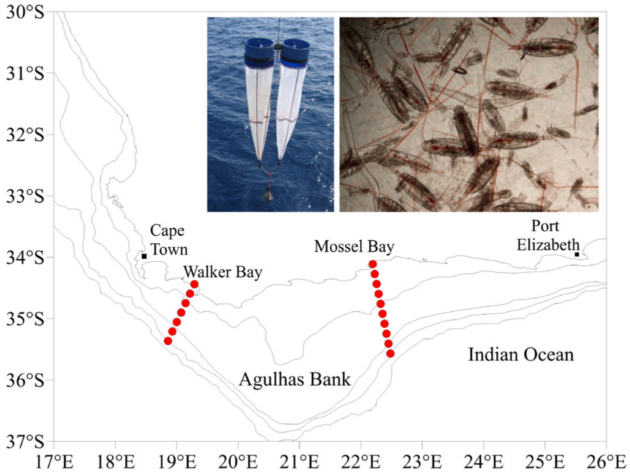


Figure 1. *Location of sampling stations off Walker Bay and Mossel Bay on the Agulhas Bank. Inserts show a Bongo net used for sampling, and copepods, which dominate zooplankton communities.*

Author: Huggett JA (O&C Research)
Contributor: Wright E (O&C Research)

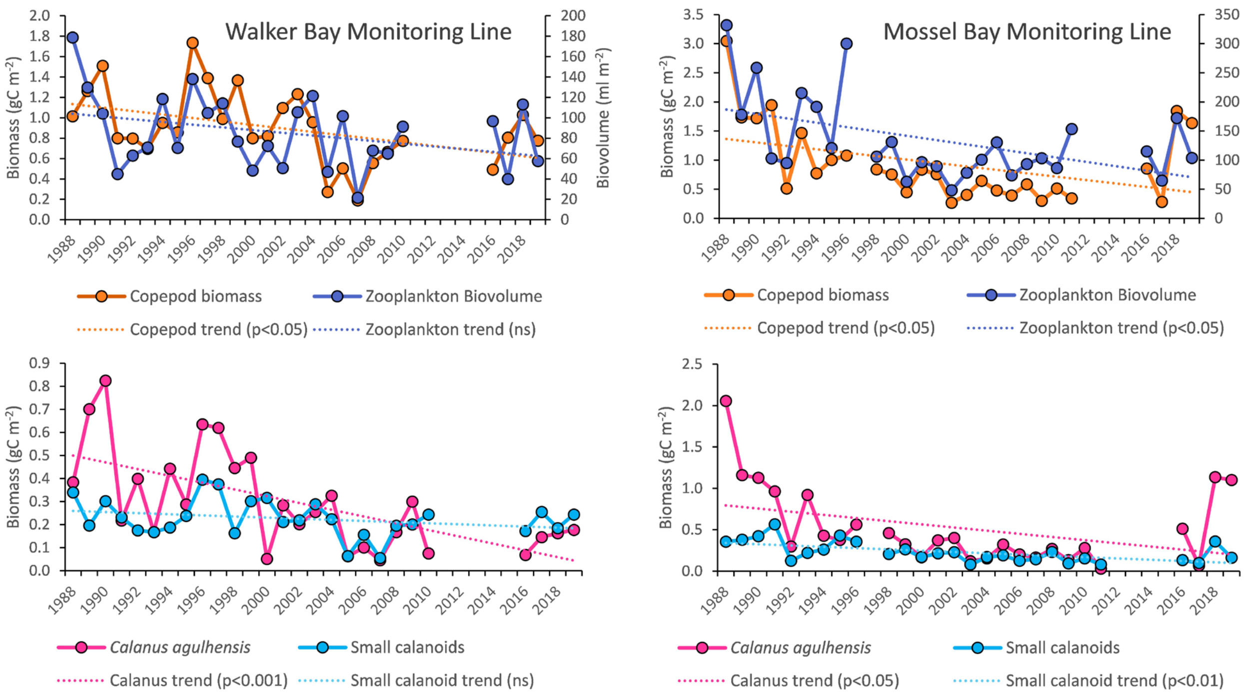


Figure 2. *Mean zooplankton biovolume and total copepod biomass (top panels), and mean biomass of* Calanus agulhensis *and small calanoid copepods (lower panels), along the Walker Bay (left) and Mossel Bay (right) monitoring lines during late spring/early summer from 1988 to 2019. Dotted lines represent linear trends where the significance (p value) is indicated in brackets and (ns) means not significant.*

8. INTERANNUAL VARIABILITY AND LONG-TERM TRENDS OF SURFACE TEMPERATURE AND CURRENTS AROUND THE PRINCE EDWARD ISLANDS

Located in the Southern Ocean between the sub-Antarctic Front and the Antarctic Polar Front, in the path of the Antarctic Circumpolar Current, the Prince Edward Islands (PEIs) experience low anthropogenic influence and are an ideal location to investigate climate variability. *In situ* observations at and around the PEIs have been limited to single snapshots of conditions during annual relief voyages to re-supply the research base, or to time series at single locations on the inner shelf. Satellite and reanalysis datasets, however, enable the investigation of surface hydrographic variability over much larger areas and longer periods. In this study, we used daily gridded satellite products (0.25° spatial resolution) to investigate interannual variability and long-term trends in Sea Surface Temperature (SST) and surface currents around the PEIs (Fig. 1).

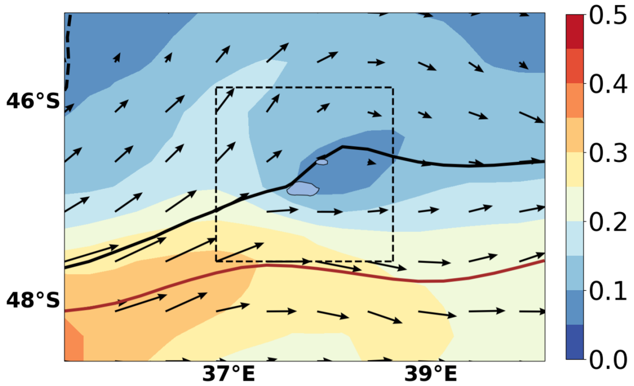


Figure 1. *Long-term (1993–2016) mean geostrophic current speed (m s^{-1}) around the PEIs. The dotted black box indicates the 2° x 2° area (45.875–47.625°S; 36.875–38.625°E) around the islands within which satellite data were averaged. The solid black contour indicates the southern branch of the sub-Antarctic Front (S-SAF) and the solid brown contour indicates the northern branch of the Antarctic Polar Front (N-APF).*

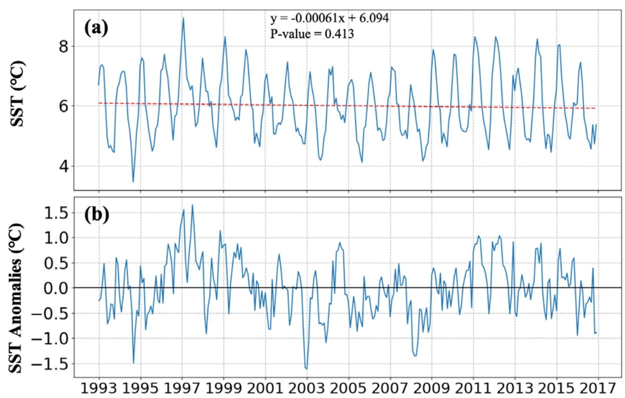


Figure 2. *Monthly (a) mean, and (b) anomalies of, SST (°C) around the PEIs. No significant linear trend was evident (red dotted line; P > 0.05).*

Between 1993 and 2016, SST showed a clear seasonal cycle, with maxima typically in February and minima in September. The long-term linear decrease in SST was very small and statistically insignificant (Fig. 2a), but substantial interannual and decadal-scale variations were evident. The warmest summer (8.8°C) was observed in 1997, while the coolest winter (4.5°C) occurred in 1994. At the decadal scale, positive SST anomalies reflected warmer-than-average conditions from 1996–2001 and 2009–2015 (Fig. 2b), while cooler-than-average conditions (negative anomalies) occurred from 2001–2009 (Fig. 2b).

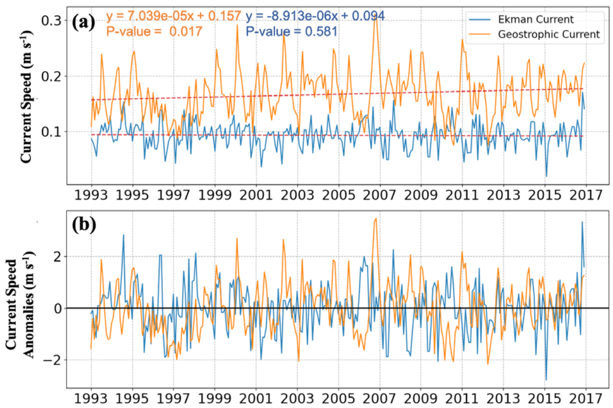


Figure 3. *Monthly (a) mean, and (b) anomalies of, geostrophic and Ekman current speeds (m s^{-1}) around the PEIs. Dotted lines show a small positive linear trend (P < 0.05) for geostrophic but not Ekman currents (P > 0.05).*

Wind-driven (Ekman) currents were typically much weaker than geostrophic (circulation-driven) currents, reflecting their minimal contribution to the total current variability at the PEIs (Fig. 3a). However, at times Ekman currents were comparable to or even larger than geostrophic currents, reflecting occasionally stronger wind forcing and/or periods of comparatively weaker oceanic circulation. While there was no clear long-term linear trend for Ekman currents, there was a significant but small increase in geostrophic current speeds between 1993 and 2016.

Interannual differences in wind forcing and oceanic circulation were large, but no obvious decadal-scale changes were evident (Fig. 3b). Interannual and decadal-scale variations in SST and currents may be associated with the influence of major climate modes such as the El Niño-Southern Oscillation (ENSO) and the Southern Annular Mode (SAM), but further research is required to confirm this.

The PEIs are home to large populations of breeding marine mammals and seabirds, and the oceanic environment provides vital foraging grounds for them. As marine ecosystems respond to global climate variations, the consequent changes in temperature and currents are likely to affect the distribution of preferred prey species, and the foraging patterns of top predators around the islands.

Authors: Toolsee T (UCT), Lamont T (O&C Research)

9. ORIGIN AND PROPAGATION PATHWAYS OF MESOSCALE EDDIES AROUND THE PRINCE EDWARD ISLANDS

Mesoscale eddies in the Southern Ocean play a crucial role in meridional exchanges of heat and salt across frontal zones. They can also substantially influence primary production through uplift and advection of water masses. The Andrew Bain Fracture Zone, a gap within the Southwest Indian Ridge (SWIR) centred at *ca.* 50°S; 30°E, is a well-known eddy generation hotspot. Eddies generated in this region have been reported to drift northeastward, following the eastern side of the SWIR toward the Prince Edward Islands (PEIs).

Previous studies have shown that eddies approaching the islands from a southerly direction introduce cooler, less saline waters, with biota of sub-Antarctic or Antarctic origin, to the PEI shelf environment (i.e. waters shallower than ± 1 000 m). In contrast, mesoscale eddies originating further north can be expected to carry warmer, more saline waters to the PEIs, and introduce more subtropical biota to the island ecosystem. Thus, knowledge on the origins and propagation pathways of mesoscale eddies is necessary in order to evaluate their potential impacts on the PEI ecosystem.

We applied automated eddy tracking to 26 years (1993 to 2018) of daily gridded satellite altimetry maps, to identify and track mesoscale eddies in the PEI region (Fig. 1). Eddies were separated into four categories according to where they were 'born' and where they 'died', in relation to the PEI region. Hence, those with a generation and demise date within the region were categorised as 'born inside, died inside'. Similarly, the other categories were 'born inside, died outside', 'born outside, died inside', and eddies that were 'born outside, died outside', having propagated through the region at some stage of their life.

A total of 395 cyclonic and 377 anticyclonic eddies were detected and tracked in the PEI region over the 26-year period, amounting to roughly 16 cyclonic and 15 anticyclonic eddies per year. For both eddy types, more than half the total number of detected eddies were 'born inside, died inside', with substantially smaller proportions (≤ 25%) in the other categories. The majority of eddies propagated less than 150 km from their origin and had relatively short (< 60 days) lifespans. This was surprising since we expected that eddies found in the PEI region would have originated from the SWIR eddy hotspot, as previously described.

By comparison, 724 cyclonic and 515 anticyclonic eddies were tracked in the SWIR region over the 26-year period. Of these, only 14 cyclonic and 1 anticyclonic eddy propagated into the PEI region. Thus, the study demonstrated that the SWIR eddy hotspot region has a much smaller direct influence on the PEI region than previously thought, with an average of less than one eddy per year from the SWIR entering the ocean region around the PEIs.

The eddy distribution patterns showed preferential formation and propagation pathways which seemed to be associated with the underlying bathymetry, the background flow, as well as meandering of the various branches of the SAF and APF, but more comprehensive investigations are required to examine these relationships, as well as their relative importance, in greater detail. Although eddies can interact strongly with the PEI shelf, such direct interactions seem to be limited to an average of around 30 eddies per year.

Authors: Lamont T, van den Berg MA (O&C Research)

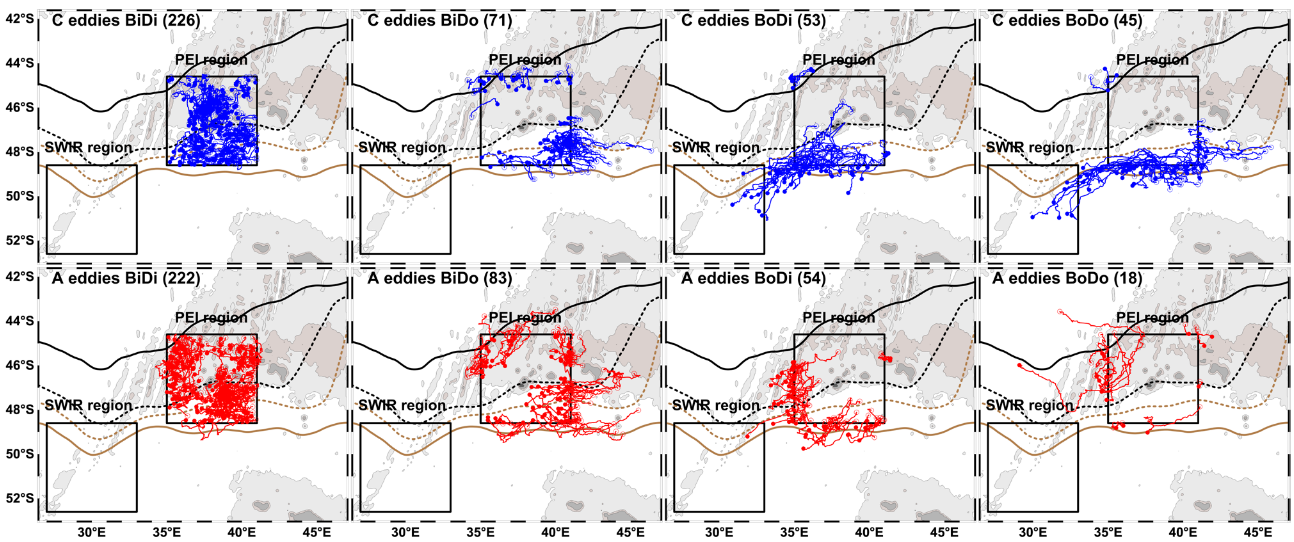


Figure 1. *Formation locations (filled circles), propagation pathways (lines), and death locations (open circles) for cyclonic (C) eddies (blue) and anticyclonic (A) eddies (red) that were 'born inside, died inside' (BiDi); 'born inside, died outside' (BiDo); 'born outside, died inside' (BoDi); and 'born outside, died outside' (BoDo) the PEI region. Quadrangles indicate the PEI and SWIR regions as defined in this study (each 295 704* km^2*). Long-term (1993–2018) mean positions of the middle (solid black contour) and southern (dashed black contour) branches of the sub-Antarctic Front, as well as the northern (dashed brown contour) and middle (solid brown contour) branches of the Antarctic Polar Front are shown.*

10. FREQUENCY OF MESOSCALE EDDIES INFLUENCING THE PRINCE EDWARD ISLANDS

The Prince Edward Islands (PEIs) form a biological hotspot comprised of assorted benthic and fish communities, as well as numerous top predators that breed at the islands. Previous studies have shown that these biological communities depend strongly on the surrounding oceanographic environment. Mesoscale eddies can result in substantial warming or cooling of waters on the PEI shelf, and are known to transport biological organisms onto the PEI shelf from further afield. Similar to Report 9, we applied automated eddy tracking to 26 years (1993 to 2018) of daily gridded satellite altimetry maps to identify and track mesoscale eddies. We then quantified the number of eddies interacting with the PEI shelf, and the length of time over which they affected the islands.

Eddies in the region can influence their surroundings over an area of up to twice the eddy radius. Thus, we defined the eddy impact area as a circle of two times the eddy radius. An eddy was considered to be interacting with the PEI shelf when the eddy impact area intersected the 1 000 m isobath (Fig. 1). There are relatively few cyclonic and anticyclonic eddies (< 10 per year) that get close enough to the PEIs such that their impact areas intersect with the 1 000 m isobath, and even fewer eddies that interact directly with the shelf (Figs. 2a and 3a). Despite this low number, these eddies can influence the shelf for a substantial portion of the year (Figs. 2b and 3b).

Often, there are multiple eddies interacting with the shelf at the same time, making it difficult to discriminate between the impacts of individual eddies. There appeared to be more cyclonic than anticyclonic eddies influencing the shelf in recent years, and a general decline in the number of impact days per year was evident (Fig. 3). However, these trends were not statistically significant, and no clear seasonality was observed. Nevertheless, the considerable length of time over which eddies interact with the PEI shelf suggests that their influence may be just as important as changes in the geographical position of the Antarctic Circumpolar Current fronts relative to the islands, if not more so.

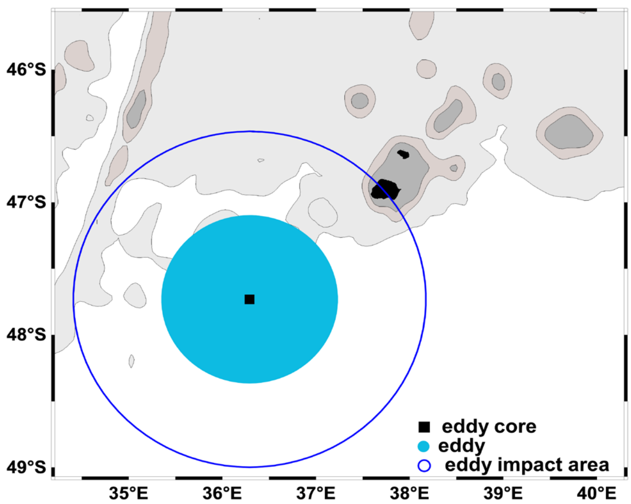


Figure 1. *Schematic of an eddy interacting with the PEI shelf. Regions > 3 500 m are shaded in white. Light grey shading shows depths of 2 000–3 500 m, light brown shading shows 1 000–2 000 m, and darker grey shading denotes areas < 1 000 m deep.*

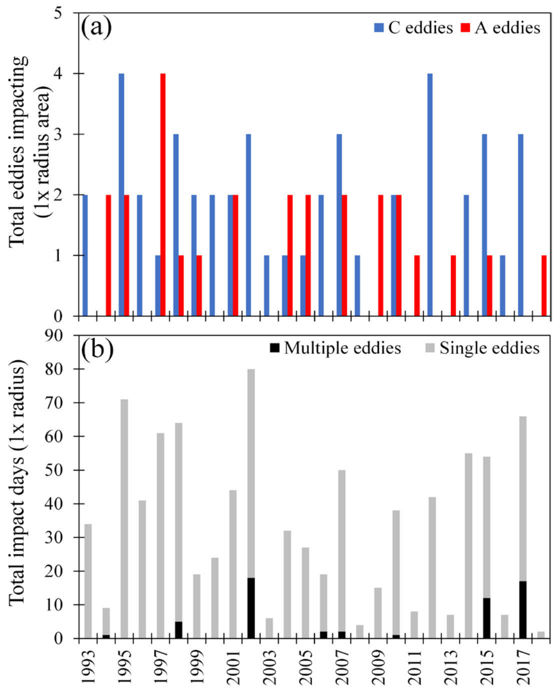


Figure 2. *Total number of (a) cyclonic (C) and anticyclonic (A) eddies, and (b) days per year, when the eddies intersected the 1 000 m isobath of the PEI shelf.*

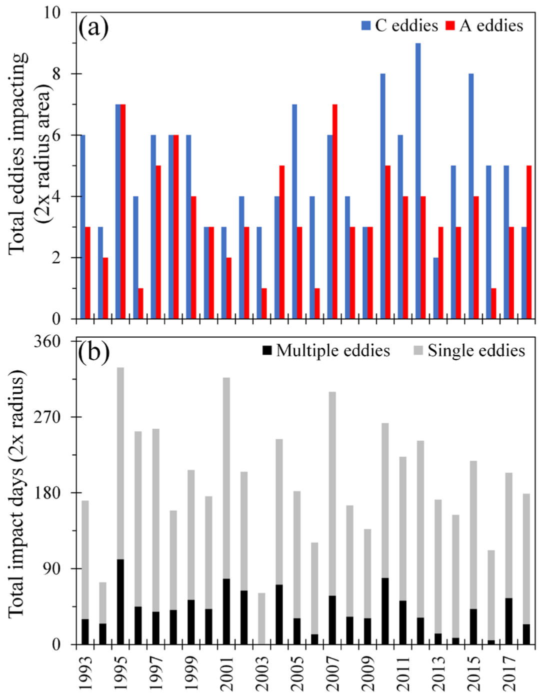


Figure 3. *Total number of (a) cyclonic (C) and anticyclonic (A) eddies, and (b) days per year, when their impact area (2 x radius) intersected the 1 000 m isobath of the PEI shelf.*

Authors: Lamont T, van den Berg MA (O&C Research)

11. AVOIDANCE OF MESOSCALE EDDIES BY SUB-ANTARCTIC FUR SEALS?

The Prince Edward Islands (PEIs) in the Southern Ocean provide crucial breeding habitat for large populations of top predators such as seals and penguins, and the PEI Marine Protected Area was proclaimed partly to secure the foraging requirements of these populations. Although marine top predators generally feed on prey resources that are patchily distributed over a wide range of spatial scales, numerous studies have documented clear relationships between foraging areas and specific oceanographic features and processes that influence the distribution of preferred prey. In particular, mesoscale features, such as eddies, which are ubiquitous across the Southern Ocean, have been shown to be important centres of biological production.

Cyclonic eddies are typically associated with elevated plankton biomass levels, due to upwelling of nutrient-rich waters in their interiors, and consequently a more productive food chain. In contrast, anticyclonic eddies are generally characterised by lower plankton biomass levels due to downwelling of nutrient-poor surface waters in their interiors, although they may also accumulate potential prey organisms due to the convergence of waters in their surface layers. In this study, we examined the relationship between the movements of sub-Antarctic fur seals (SAFs; Fig. 1) and mesoscale eddies around the PEIs.

Figure 1. *A sub-Antarctic fur seal mother-pup pair.*

We used the at-sea locations of 12 lactating SAFs from Prince Edward Island, which were tracked using satellite platform terminal transmitters during 2011–2012. The locations of each animal were incorporated in 'state space' models, which allowed 'foraging' locations to be distinguished from 'travelling' locations, based mainly on speed and angles of movements between consecutive positions. Similar to Report 9, mesoscale eddies were detected and tracked by applying an objective eddy detection method to satellite altimetry data. The impact area of each eddy was defined as a circle of twice the eddy radius. Regions of overlap between the impact areas of the eddies were treated as a separate class.

Each geographic coordinate along the seals' modelled tracks was co-located with eddy tracking results, to determine if the seals were travelling or foraging inside or outside of eddies, or within the eddy impact areas. This ability to objectively associate seal activity patterns with individual mesoscale eddies improves substantially on previous investigations, where such relationships were determined by visual assessment or by comparisons with parameters which do not represent individual mesoscale eddies as accurately.

Figure 2 shows the co-located tracks for one of the tagged seals. Contrary to expectation, this particular seal did not travel into (0%) or forage within (0 %) the interior of cyclonic eddies. Similarly, very little time (2.78 %) was spent foraging in anticyclonic eddies. In fact, most of the seal's travelling (7.09%) and foraging time (58.99 %) was spent outside of eddies or eddy impact areas. A similar pattern was observed for the 11 remaining seals, with the overwhelming majority of observations associated with areas outside of those influenced by mesoscale eddies. When locations were associated with eddies, it was more likely to be anticyclonic eddies. The latter finding is inconsistent with the general expectation that cyclonic eddies tend to be more productive than anticyclonic eddies.

It thus appears that mesoscale eddies are less important for SAF foraging than expected. However, other top predator species may have different relationships with mesoscale eddies, perhaps showing greater dependency. This highlights the necessity for further research that quantitatively investigates the relationships between foraging activities of top predators and oceanographic processes and features.

Authors: Lamont T, Kirkman SP (O&C Research)

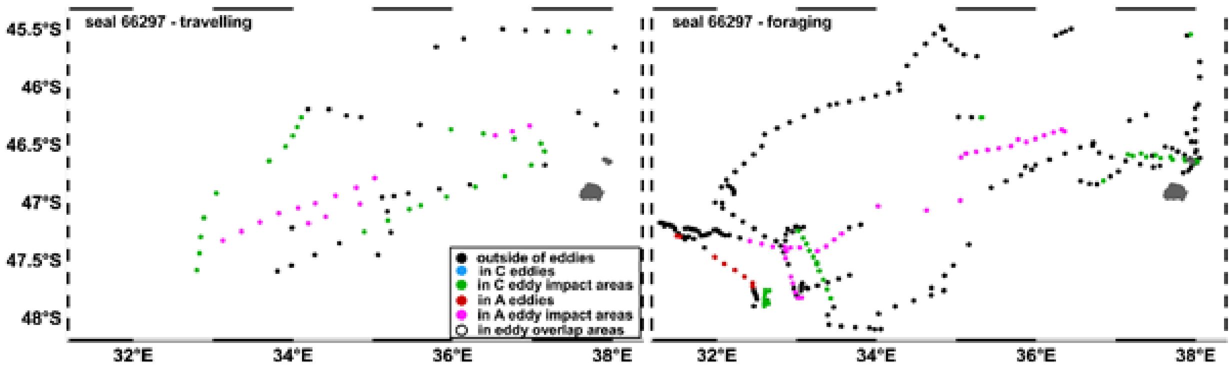


Figure 2. *Geographic coordinates of a sub-Antarctic fur seal (tag # 66297) track in relation to cyclonic (C) and anticyclonic (A) eddies and their impact areas around the PEIs, during periods of travelling and foraging.*

12. DRIVERS OF SEA SURFACE TEMPERATURE TRENDS ALONG SOUTH AFRICA'S EAST COAST

The Indian Ocean is the fastest warming ocean basin and most of that warming is accumulated at its western boundary and transported southward by the Agulhas Current (AC). The AC, which flows along the eastern shores of South Africa, is the strongest Western Boundary Current of the southern hemisphere. Changes in the AC heat content may have profound regional effects with changes felt both in the atmosphere and in the coastal and shelf regions neighbouring the current. Potential impacts include changes in rainfall patterns, storm intensification, sea level rise, ocean acidification, coral bleaching, and changes to migration pathways of various biota.

A satellite-derived Sea Surface Temperature (SST) product was used to study changes in SST along South Africa's east coast between 2002 and 2019. This product blends observations from both Infrared and Microwave sensors using optimal interpolation, and provides users with daily and gap-free global SST maps at a spatial resolution of 9 km. The linear decadal SST trend between 2002 and 2019 shows warming over the current, which reaches maximum values of about 0.3°C per decade (Fig. 1).

The local maximum SST trends over the AC are either aligned with the location of the highest SST averages, or found at the inshore edge of the AC. While the current seems to be warming since 2002, many of the shelf regions inshore of the 200 m isobath appear to be cooling. The shelf regions off Port Elizabeth (*ca.* 26°E) show the strongest cooling trend, typically cooling by 0.6°C per decade with a maximum cooling rate of close to 1°C per decade at 34.9°S; 26.2°E. Over the shelf regions off Durban (*ca.* 30°S), the SST trend is close to zero despite a clear warming over the AC further offshore.

The path followed by the AC is subject to natural variability, with bends in the flow at times causing the current to move 100 to 200 km offshore. An algorithm which tracks the position of the AC was used to better understand the impact of large AC offshore excursions, or meanders, on the coastal environment. The algorithm exploits the clear signature of the AC in satellite-derived maps of Sea Surface Height and outputs daily AC positions.

Comparisons between the SST extracted directly over the moving AC and the SST for shelf regions (< 1 000 m) showed periods of differences off East London. Occasionally, coastal and shelf waters were significantly cooler than those observed over the AC (Fig. 2). Near East London, where the AC is generally close to the shore, the largest negative SST anomalies (cool events at the coast) always occur at times of large AC offshore excursions.

The AC is changing in response to climate change. While the current is warming, many of the coastal and shelf regions are cooling. Preliminary analyses suggest that the opposing temperature trends between the AC and neighbouring coastal regions may be associated with an increasing variability in the AC path.

Further research should be done to confirm the role of the AC as the main driver of cold SST anomalies near the coast and to establish what impact an increasingly meandering AC would have on migration pathways of biological species, cross-shelf exchanges, and the bio-chemistry of the coastal and shelf waters.

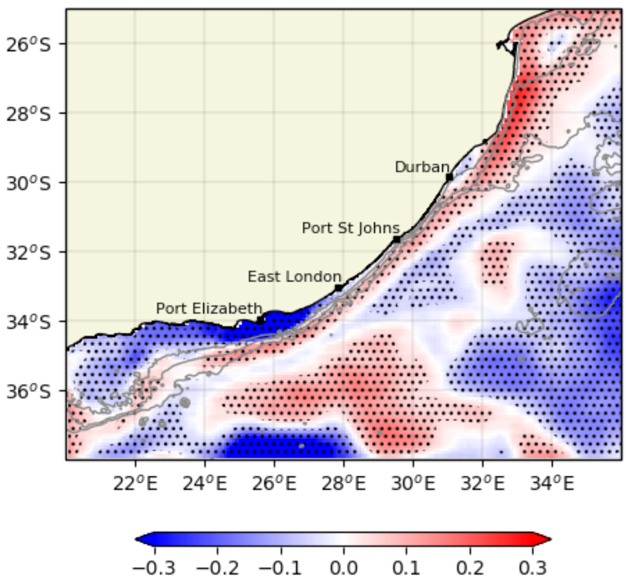


Figure 1. *SST decadal trend (°C) between June 2002 and September 2019. The black dots show regions where the trend is significant at the 95% confidence level. The grey contour lines on the maps show the location of the 200 m, 1 000 m and 2 000 m isobaths.*

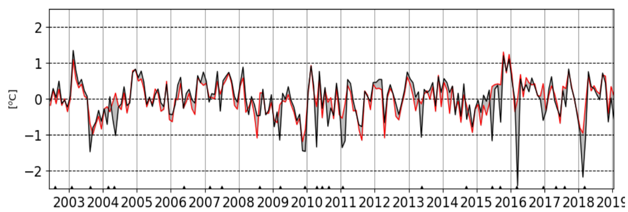


Figure 2. *Time series of the monthly SST detrended anomaly extracted near East London (33.3°S). The red line shows SST extracted directly over the AC while the black line shows the spatially averaged SST between 1 000 m and the coast. Black markers on the x-axis indicate occurrences of large AC meanders.*

Author: Krug M (O&C Research)
Contributor: Braby L (SAEON)

13. EARLY RETROFLECTIONS OF THE AGULHAS CURRENT BETWEEN 1993 AND 2019

The Agulhas Current is a unique Western Boundary Current in that it undergoes a directional change at its westernmost extremity. In this region known as the Agulhas Retroflection (AR), the southwestward-flowing current is redirected back into the Indian Ocean forming the Agulhas Return Current (Fig. 1). The variability of the AR has considerable global and local importance since it is a region of substantial exchange of heat, salt, energy and biota between the Southwest Indian and South Atlantic Ocean basins. Extreme eastward retreats of the AR are classified as early retroflections, which have a significant influence on inter-ocean exchange and potentially affect the dynamics of the highly productive Agulhas Bank ecosystem. We applied the LACCE (Location of the Agulhas Current's Core and Edges) monitoring tool to 26 years (1993–2019) of daily satellite altimetry data to extract the position of the AR, and identify early retroflection events.

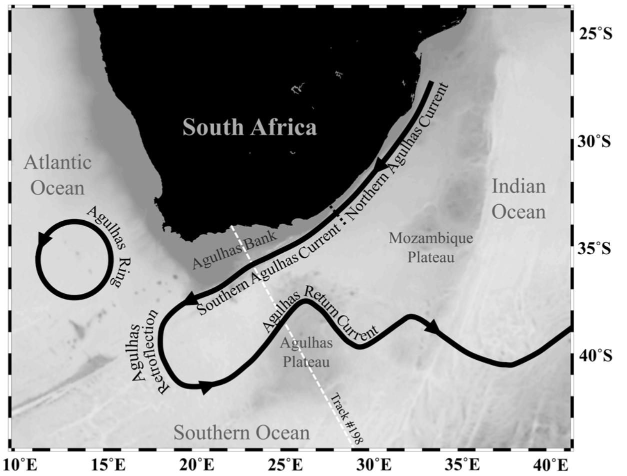


Figure 1. *Schematic depiction of the greater Agulhas Current system (solid black line). The grey shading illustrates the bathymetry, with darker grey indicating shallower regions. The dashed white line indicates the location of the* in situ *CrossRoads transect (Track #198) used to validate the output of LACCE.*

On average, the AR was located between 15.01–20.03°E and 38.44–40.47°S (Fig. 2). While it appeared to be located further west in summer and further east in winter, this seasonal variation was not statistically significant. Similarly, there was no clear long-term shift in the AR position, likely due to its substantial short-term variability. Between 1993 and 2019, seven extreme eastward retreats of the AR were identified (Fig. 2). They were confirmed by satellite Sea Surface Temperature distributions illustrating the eastward retreat of warmer Agulhas Current waters.

While the events in 1999, 2000–2001 and 2008 have been previously identified and studied, those in 2013, 2014, 2018, and 2019 have not. Using a cut-off longitude of 22.54°E (i.e. two standard deviations east of the long-term mean longitude of the AR), only five (1999, 2000–2001, 2008, 2013 and 2019) of the seven events were classified as 'true' early retroflections. In contrast, the other two less extreme events (2014 and 2018) were associated with the shedding of Agulhas Rings. Most early retroflection events took place during spring and summer.

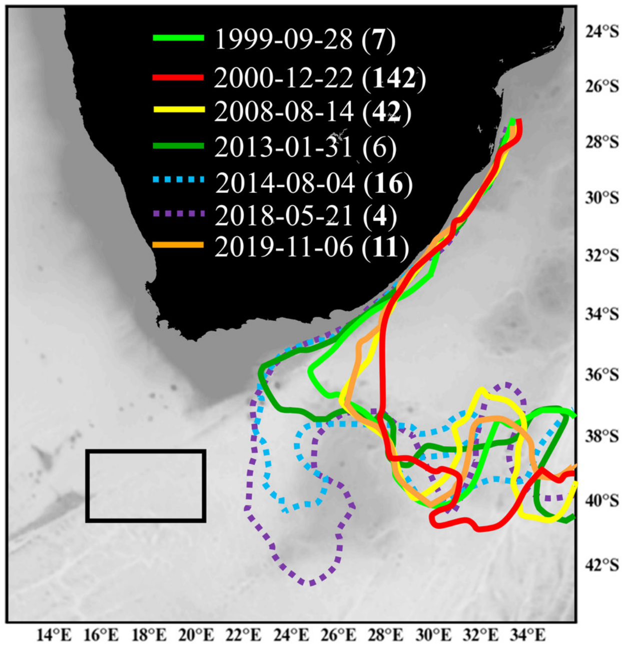


Figure 2. *Composite illustration of all early retroflection events. Solid lines indicate early retroflections (east of 22.54˚E) while the dashed lines indicate events associated with Agulhas Ring shedding. The bold number in parentheses indicates the total length in days of each event. The black box shows the long-term average location of the Agulhas Retroflection.*

The ability of LACCE to simultaneously monitor both the Agulhas Current and Agulhas Return Current confirmed previous hypotheses of the mechanism triggering early retroflections. Off the Agulhas Bank, large Natal Pulses (cyclonic eddies inshore of the Agulhas Current) resulted in southward deflections of the Agulhas Current, while simultaneous northward extensions of the Agulhas Return Current caused the Agulhas Current's flow to short-circuit east of 22.54°E. Further research is needed to better quantify the impact of these events on inter-ocean exchange and ecosystem dynamics.

Authors: Russo CS (SAEON), Lamont T, Krug M (O&C Research)

14. ZOOPLANKTON VARIABILITY ACROSS THE AGULHAS CURRENT

The Agulhas Current is the strongest Western Boundary Current in the southern hemisphere. It plays a key role in global ocean circulation and climate variability, transporting heat and salt from the tropical Indian Ocean to the Atlantic Ocean. It also influences local rainfall and drives shelf-edge upwelling and productivity on South Africa's south and east coasts. To explore variability in current dynamics and its influence on biota, zooplankton samples were collected at 20 stations along a transect crossing the Agulhas Current off the southeast coast of the country (Fig. 1), during five surveys in April 2015, July 2016, January 2018, July 2018 and July 2019.

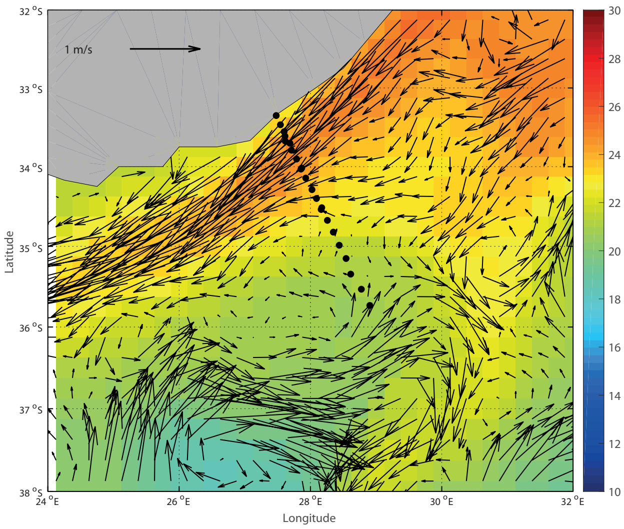


Figure 1. *Location of sampling stations along a transect crossing the Agulhas Current, superimposed on a satellite image of Sea Surface Temperature (SST; °C), with current velocity (m s⁻¹) vectors overlaid.*

The Agulhas Current typically extended between stations 3–8, indicated by warmer water (> 22°C) and faster current speeds (1–2 m s^{-1}; Fig. 2). Mean current speed was fastest (> 2 m s^{-1}) at Station 3, declining offshore. Mean surface chlorophyll *a* concentration (Chl *a*), an index of phytoplankton biomass, was elevated (> 2 mg m^{-3}) at the inshore edge of the current but was otherwise quite consistent (mean 1.40 mg m^{-3}). Chl *a* variability was high at the offshore stations, possibly a consequence of strong mesoscale activity related to the passage of eddies.

Mean zooplankton biovolume at Station 2 (0.9 ml m^{-3}) was more than twice the mean biovolume (0.4 ml m^{-3}) across the transect (Fig. 2). The zooplankton community was dominated by copepods (75%), followed by larvaceans (7.6%), chaetognaths (3.4%) and ostracods (2.7%). Copepod abundance was greatest inshore (> 1 000 m^{-3}), elevated (690 m^{-3}) at the current edge, and low within the current (*ca.* 200 m^{-3}) and beyond.

There was considerable variability in temperature, Chl *a* and zooplankton between surveys, but seasonal patterns could not be evaluated due to insufficient data during summer. Although zooplankton indices were greatest for the first three stations, they also displayed the highest variability. This was likely a consequence of the strong depth and environmental gradients across the narrow continental shelf, creating a dynamic and productive transition zone inshore of the fast-flowing Agulhas Current. Zooplankton data for the outer transect stations were limited, as adverse sea conditions sometimes curtailed net sampling, most notably in January 2018 when, due to gale force winds, only seven stations could be sampled safely.

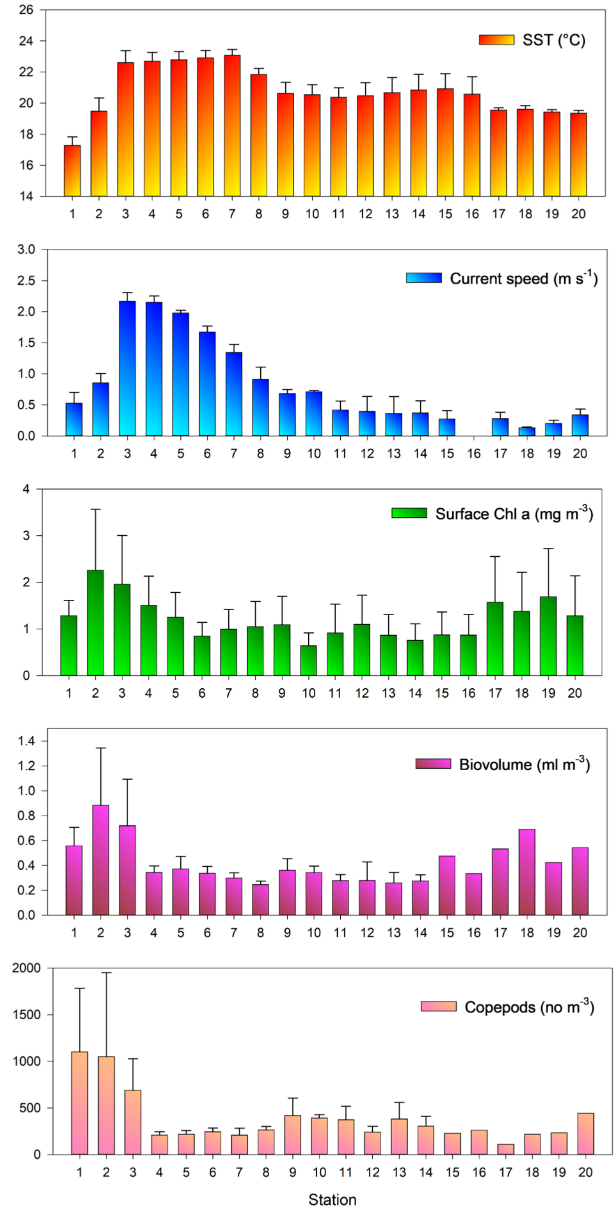


Figure 2. *Mean (± standard error) of SST, near-station current speed, surface Chl* a, *zooplankton biovolume and copepod abundance at each station along the transect.*

Continued sampling, better seasonal coverage, and more detailed analyses are required to assess longer-term variability in plankton biomass and diversity in relation to Agulhas Current dynamics, and to determine potential impacts downstream on the Agulhas Bank ecosystem.

Authors: Huggett JA (O&C Research), Morris T (SAWS), Msweli N, Walker D (CPUT), Bergman S (O&C Research)
Contributors: Batyi-Nkwenkwe K, Kakora H, Mdazuka Y, Setati S, Worship M, Wright E (O&C Research), Ansorge I, Fawcett S (UCT), Bornman T, Braby L, Hermes J (SAEON)

15. DO SEAMOUNTS INFLUENCE ZOOPLANKTON COMMUNITIES? A COMPARISON OF THREE SITES IN THE SOUTHWEST INDIAN OCEAN

Seamounts are recognised as hotspots of biodiversity, attracting large numbers of top predators, although the underlying mechanisms are still unclear. Hypotheses include nutrient enrichment from localised upwelling, as well as retentive features (so-called 'Taylor columns') that can trap advected material over the seamount (Fig. 1). Zooplankton biomass is often not affected, but sometimes found to be lower above the summit compared to the surrounding waters, especially over shallow seamounts that penetrate the sunlit zone. This may be caused by increased predation pressure from pelagic predators associated with seamounts, or vertically migrating zooplankton becoming trapped on the summit during their daily descent, leading to increased encounter rates with predators.

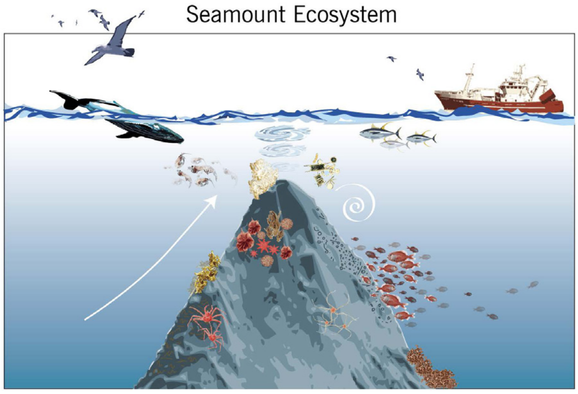


Figure 1. *Schematic of a seamount ecosystem (Image courtesy of Erika Mackay, National Insitute of Water and Atmospheric Research Ltd).*

We studied zooplankton abundance and size distribution at three seamounts with summits at shallow water column depths in the Southwest Indian Ocean: La Pérouse (LP, 60 m), MAD-Ridge (MR, 240 m) and Walters Shoal (WS, 18 m; Fig. 2). Samples were analysed using a ZooSCAN, an instrument designed for automated counting, sizing and identification of zooplankton.

Differences were observed among the three seamount areas, with significantly higher zooplankton biovolume at LP and MR compared to WS, as reflected by a greater intercept along the vertical axis in their Normalised Biovolume Size Spectrum (NBSS; Fig. 3). The NBSS slopes, which reflect the zooplankton size distribution, were similar at LP and MR, whereas WS had a flatter slope, indicating more large organisms. Zooplankton abundance overall was dominated by copepods (70%), with copepods and chaetognaths (larger carnivorous zooplankton) comprising the bulk of the biovolume (60%). Biovolume at WS comprised smaller copepods and more chaetognaths and euphausiids (krill).

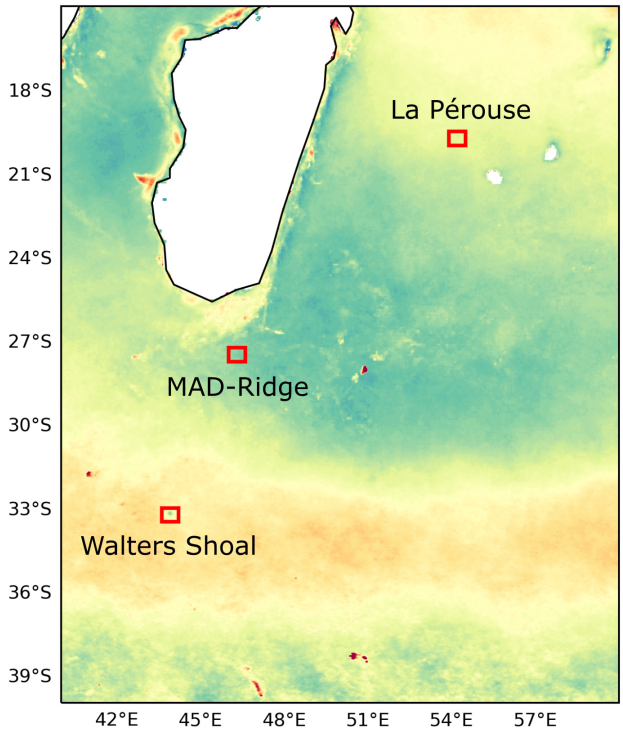


Figure 2. *Location of the study sites on a map of seasonal variability in surface Chlorophyll* a *concentration. Low variability is shown in green and high variability in red colours.*

Zooplankton abundance, biovolume, size spectrum and size diversity were not significantly influenced by the LP or MR seamounts. At the time of sampling, MR was influenced by a large circulation feature, a cyclonic/anticyclonic eddy pair, that impacted the local zooplankton distribution, potentially masking any seamount effect. The shallowest seamount, WS, had low zooplankton abundance with a size spectrum that differed greatly from the two other seamounts, which was attributed to seasonality and zooplankton population dynamics. The other two seamounts exhibited a more 'typical' oligotrophic pelagic ecosystem, at equilibrium and dominated by small organisms. The Normalised Biomass Size Spectrum approach contributed to a better understanding of regional ecosystem dynamics, revealing little variability in zooplankton communities within a stable oligotrophic environment, as observed at LP and MR.

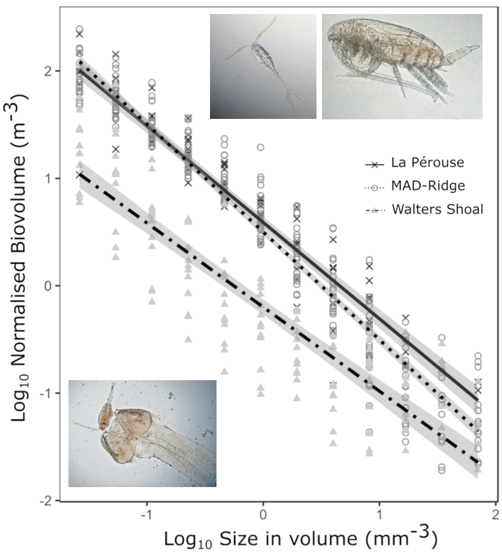


Figure 3. *Normalised Biovolume Size Spectra of zooplankton communities at the three seamounts. Insets show small (≤ 1 mm) copepods (top) and a chaetognath preying on a small copepod (bottom). Photo credits: Shigeru Gougi, Stéphane Gasparini, Robert Perry.*

Authors: Noyon M, Rasoloarijao Z (NMU), Huggett JA (O&C Research), Ternon J-F (IRD), Roberts M (NMU)

16. DO NO-TAKE AREAS IN TABLE MOUNTAIN NATIONAL PARK PROTECT INTERTIDAL ROCKY SHORE COMMUNITIES?

Subsistence harvesting of rocky shore organisms has intensified in South Africa in recent decades due to increased human population densities in coastal areas. Harvesting has led to severe reductions of many species around the world, and the knock-on effects of over-harvesting have transformed entire biotic communities. To reduce harvesting pressure and allow for the recovery of overexploited species, Marine Protected Areas (MPAs) have been established.

This study evaluated the effectiveness of the Table Mountain National Park MPA for protection of the commonly harvested limpet *Cymbula granatina*, and the rocky shore communities that they live in. This was achieved by comparing sizes and densities of limpets between harvested sites (Wireless Island and Wireless Point, near Kommetjie) and sites in nearby no-take areas of the MPA where harvesting is restricted. For the harvested sites we also compared limpet size and density, as well as community composition, with historical data for these sites (1970) from before the formation of a low-income settlement nearby.

We found higher densities of *C. granatina* and larger-sized individuals inside the MPA no-take area, compared with the harvested sites (Fig. 1). We also found that the average sizes and densities of *C. granatina* at the two harvested sites have declined considerably since 1970 (Fig. 2). With increased harvesting pressure, rocky shore community composition at the heavily harvested Wireless Point has changed, from being dominated by limpets to domination by algae. The moderately harvested Wireless Island has additionally been invaded by the Mediterranean mussel *Mytilus galloprovincialis* (Fig. 3).

This study demonstrates that the Table Mountain National Park MPA is effective in protecting rocky shore biodiversity from the impacts of harvesting within no-take areas by maintaining high densities and sizes of the limpet *C. granatina*. On the other hand, nearby populations outside of no-take areas have declined radically. By reducing the grazing pressure exerted by limpets, intensive harvesting has transformed rocky shore communities outside to being algal-dominated. Other South African MPAs are facing similar pressures and similar assessments are needed to inform appropriate management actions.

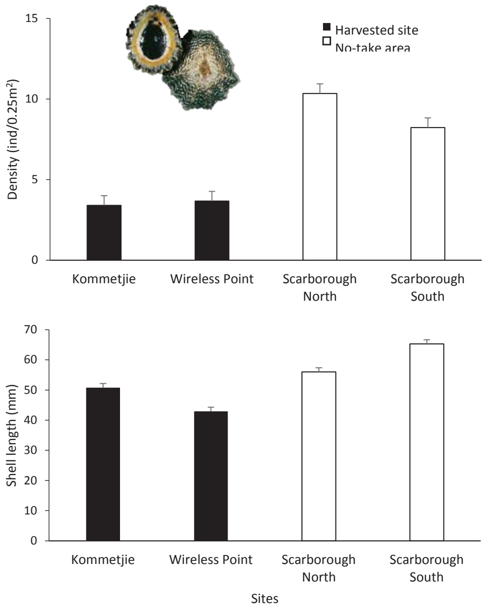


Figure 1. *Differences in mean densities and sizes (+ standard error) of* C. granatina *(see insert of shell from below and above) between harvested sites (left) and those in an MPA no-take area (right).*

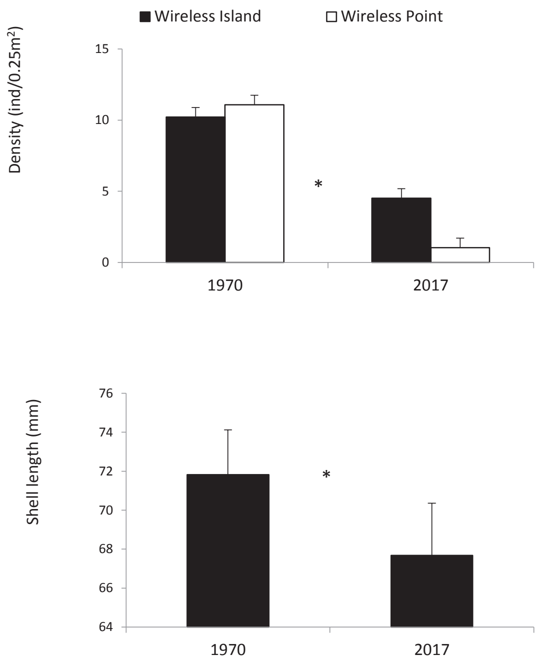


Figure 2. *Reductions in mean (+ standard error) densities (top panel) and sizes of the* C. granatina *between 1970 and 2017 at two sites near Kommetjie where harvesting has increased due to growing coastal developments. Stars indicate statistically significant differences.*

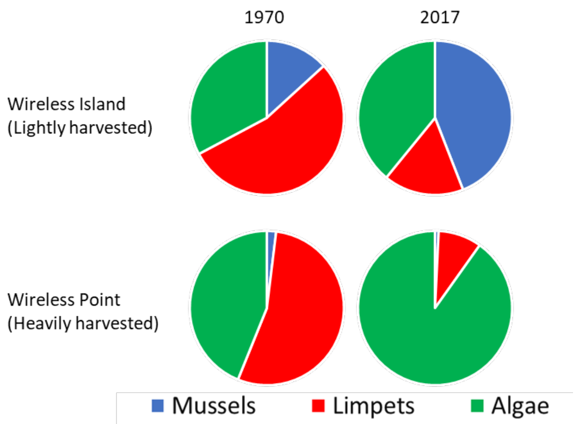


Figure 3. *Pie charts showing a reduction of limpets and an increase of algae and mussels between 1970 and 2017 at Wireless Island (moderately harvested) and Wireless Point (heavily harvested), outside of MPA no-take areas.*

Authors: Baliwe N, Pfaff MC (O&C Research), Branch G (UCT)

17. ARE CAPE CORMORANTS LOSING THE COMPETITION? DIETARY OVERLAP WITH COMMERCIAL FISHERIES

The Cape cormorant *Phalacrocorax capensis* is one of seven seabird species endemic to the Benguela upwelling region. Its breeding distribution stretches from southern Angola to South Africa's Eastern Cape Province.

Historically, the Cape cormorant was the most abundant breeding seabird in the region, but the population declined from an estimated 277 000 pairs in the late 1970s / early 1980s, to an estimated 130 000 pairs in the past decade. In 2016, the decrease over the three most recent generations was assessed to be > 50%, and the species was listed as globally Endangered in terms of the IUCN Red List criteria. This decrease has been associated with reduced prey availability, particularly of anchovy *Engraulis encrasicolus* and sardine *Sardinops sagax*. These changes are likely due to environmental shifts, exacerbated by effects of fishing. To investigate effects of these changes on the diet of Cape cormorants, 1 903 regurgitates collected at 11 localities in the Western Cape (WC) from 1988–2007 (Fig. 1), were analysed.

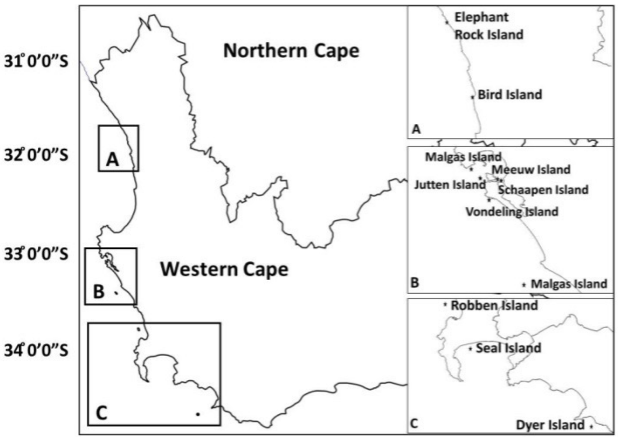


Figure 1. *Map showing 11 locations where Cape cormorant regurgitates were collected from 1988–2007, in (A) the northwest Western Cape (WC), (B) the Saldanha Bay vicinity, and (C) the southwest WC.*

From 1988–2007, 71% of the total number of prey items eaten were anchovy and 11% were sardine. Anchovy was the most important prey item in all years, except for 1992–1993 and 2007 when sardine and 'other' fish dominated the diet. The proportional contributions of anchovy to the diet increased between the first ten years of study (1988–1997) and the next decade (1998–2007) in the northwest and southwest of the WC, whereas it decreased in the Saldanha Bay vicinity (Fig. 2). The proportional contributions of sardine, however, decreased from the first decade to the second across all locations (Fig. 2). For anchovy and sardine, the proportions eaten in different periods varied in accordance with known changes in their abundance and distribution, as determined from scientific surveys conducted from a government research vessel. Cape cormorants have a narrow prey base, with only a few species contributing to the bulk of their diet, however, they have demonstrated flexibility when preferred prey species are unavailable.

Anchovies in the diet were similar-sized throughout the study area. However, sardines eaten in the Saldanha Bay vicinity (their nursery area) were immature, while mostly mature sardines were eaten in the southwest of the WC (their spawning area). Most anchovy and sardine eaten by Cape cormorants had caudal (body) lengths of 5–9 cm and 15–21 cm, respectively, and showed considerable overlap with sizes in fishery catches (Fig. 3).

The high degree of this dietary overlap indicates competition with the small pelagic fishery, a competition that is being lost by the cormorants, in view of their continuing decline.

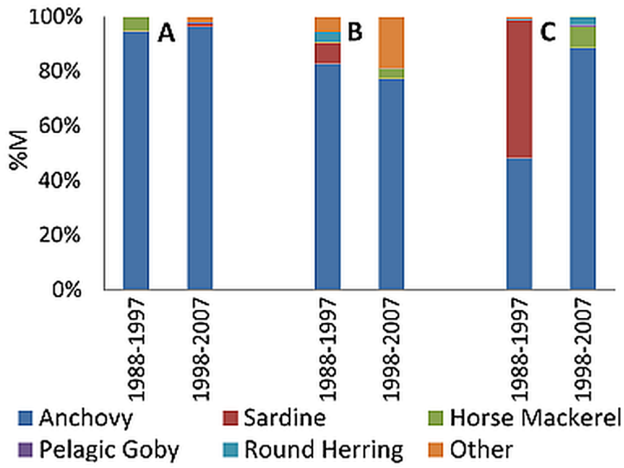


Figure 2. *Proportional contributions by mass (%M) of five fish species and other prey to Cape cormorant diet during 1988–1997 and 1998–2007, in (A) northwest WC, (B) the Saldanha Bay vicinity, and (C) southwest WC.*

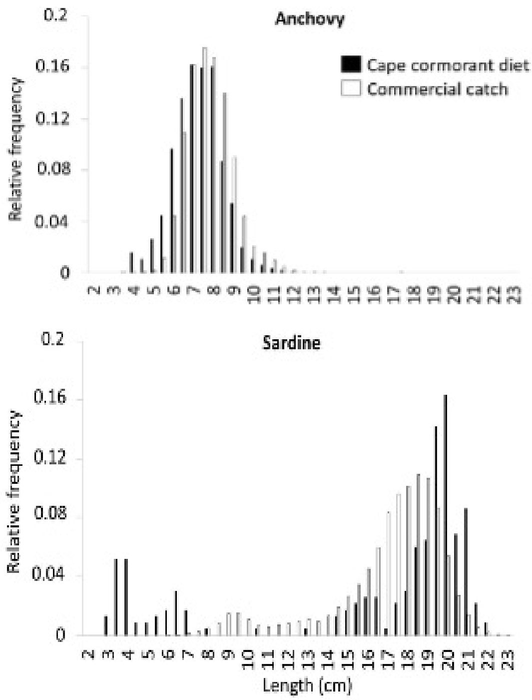


Figure 3. *Size distributions of anchovy and sardine in the diet of Cape cormorants (black bars) and in commercial purse-seine catches (white bars), throughout the study period and region.*

Authors: Masiko OB, Makhado AB (O&C Research)

18. UNUSUAL MORTALITY LEVEL OF KOGIID WHALES IN 2020

Pygmy *Kogia breviceps* and dwarf sperm whales *K. sima* are the only two members of the family Kogiidae. They are open-ocean species that are distributed in temperate and tropical waters. Their abundance and population trends in South African waters are unknown, and the little that is known about their distribution and general ecology has been derived mainly from stranding records (Fig. 1).

Figure 1. *A stranded* K. sima *calf*

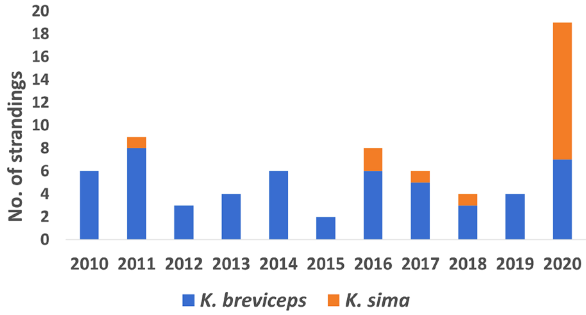


Figure 2. *Numbers of stranding records of kogiid whales between Strandfontein and the Groot Brak River, per year for the period 2010–2020. The overall number of strandings was 72, of which 70 were identified to species level.*

The South African National Strandings Network, co-ordinated in part by O&C Research, responds to cetacean stranding events in South Africa and collects scientific data and samples. Strandings provide a window for cetacean scientists to better understand rare open-ocean species such as kogiid whales, which have been assessed as 'Data Deficient' in South Africa, in terms of the IUCN Red List criteria. Stranding necropsies also allow interactions between response teams and the public, and offer educational opportunities for young scientists, O&C Research interns and learners in nearby communities, inspiring increased public interest in whales and dolphins.

Incidences of kogiid whale strandings (Fig. 1) in South Africa were conspicuous during 2020. Comparison of 2020 with stranding records for the previous ten years, concentrating on the coastline between Strandfontein (31°45'16.88"S; 18°13'28.22"E) on the West Coast and the Groot Brak River (34°3'39.2"S; 22°14'24.3"E) on the South Coast, highlights the unusual spike in mortality in 2020 (Fig. 2). The number of kogiid strandings in 2020 (n = 19) was considerably higher than the annual average during the previous ten years (n = 7), and more than double the highest number recorded in 2011 (n = 9). A remarkable increase in the number of *K. sima* strandings was mostly responsible for the spike in 2020. From 2010–2019, this species accounted for only 9% of annual kogiid strandings, on average, whereas in 2020 alone it accounted for 60%.

In terms of seasonality, 40% of the total strandings were recorded during winter, with only 15% in summer (Fig. 3). Strandings of *K. breviceps* peaked during winter, while the most *K. sima* stranded during autumn and winter (Fig. 3). These seasonal stranding patterns are consistent with previously published accounts for the South African coast. The occurrence of strandings throughout all seasons may indicate the presence of a resident population.

Causes of strandings continue to baffle cetacean scientists worldwide. Possible causes include diseases, parasites, pollutants (noise and chemical), naval exercises involving sonar, and coastal topography. These may contribute to strandings independently or interactively. Open-ocean whales, such as kogiid whales, make use of geomagnetic cues for navigation, and a handful of studies have linked their strandings with geomagnetic anomalies. That is, strandings may be linked to misguided orientation caused by these anomalies, potentially compounded by coming into contact with topographically complex coastal environments with which the whales are unfamiliar. However, there is insufficient evidence at this stage to support this theory conclusively.

The examination of carcasses has generally provided little evidence for the causes of stranding. For example, with the exception of a single entanglement-related mortality, most of the kogiid carcasses retrieved during 2020 were in good condition, with no obvious causes of death. This suggests that disease, parasites, or pollutants are unlikely to be the predominant causes of these events. However, more in-depth laboratory analyses are required for a better understanding of the health of the stranded animals. Monitoring and continued responses to cetacean strandings are essential to clarify whether the high mortality level of 2020 was indeed an anomaly, or the start of an alarming upswing in kogiid strandings, in particular for *K. sima*.

We thank organisations participating at Cape Agulhas, Cederberg, City of Cape Town, Hessequa, Mossel Bay, Overstrand, Saldanha Bay, and Swartland Municipalities for their contribution to generating these data through continuous reporting of strandings to O&C Research.

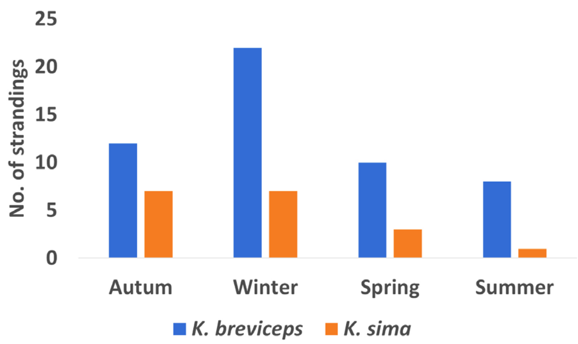


Figure 3. *Numbers of stranding records of kogiid whales between Strandfonten and the Groot Brak River during 2010–2020, grouped according to season.*

Authors: Seakamela SM, Kotze PHG, McCue SA (O&C Research)
Contributors: South African National Strandings Network

19. DEVELOPMENT OF A GIS-BASED COASTAL INUNDATION MODEL AS AN IMPROVEMENT TO EXISTING BATHTUB MODELS

Coastal zones are dynamic spaces where human activities and infrastructure are exposed to natural forces, climate change and extreme weather events. Coastal inundation is regarded as one of the most dangerous and destructive natural hazards, but currently-used predictive technologies such as numeric and hydrodynamic models are data hungry, computationally expensive, and limited for use by specialists. Coastal decision makers can easily access GIS techniques to determine scenarios based on sea level, but these methods have their own limitations.

Conventional GIS-based 'bathtub' models have been used to determine sea-level rise impacts based on the land's topography. This technique has, however, been incorrectly used to determine coastal inundation for episodic events such as storm surges, which - unlike sea level rise - is driven by forcing events, such as wind. Therefore, this study aimed at developing a GIS-based enhanced Bathtub Model (eBTM) that improves on the widely used simple Bathtub Model (sBTM) to make it more appropriate to coastal inundation modelling, particularly of storm surges.

The eBTM incorporates coastal topography, beach slope and surface roughness, and instils hydrological connectivity relevant for event-scale coastal inundation, unlike the sBTM, which only uses topographic elevation above sea level as input.

For a test site in Cape Town, South Africa, inundation levels for three independent scenarios were modelled using the average spring high tide level and extreme sea level for a 1-in-100-year storm: the first was based on the present mean sea level, and the others assumed two sea level rise scenarios. Each scenario was run on both the sBTM, and the eBTM. The resulting inundation limits and water depths, relative to ground level and considering buildings and other surface objects (i.e. the input digital surface model for the most extreme sea level rise scenario with water levels of 2.61 m above the present mean sea level, are provided in Figure 1.

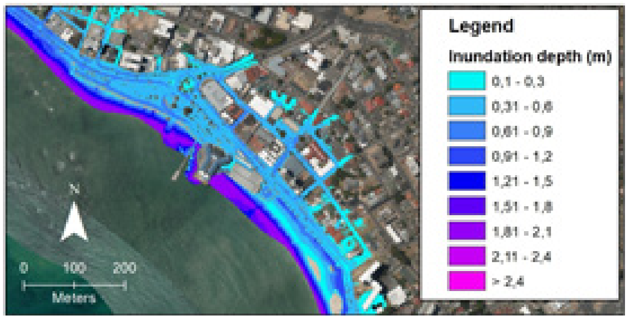


Figure 1. *Inundation depth (m) of a Cape Town coastal development derived from the enhanced Bathtub Model (eBTM) for a scenario of 2.61 m above present mean sea level.*

The resulting eBTM outputs were compared to sBTM results, both using digital terrain models (DTMs, derived from 1-m resolution LiDAR) and digital surface models (DSMs) as input. Model results were validated using historic inundation extent data (Fig. 2).

The use of the eBTM and a DSM showed more realistic trajectories (compared to the DTM) of the inundation (i.e. flood) water moving through the model area, including more conservative inundation results and no disconnected areas of (unrealistic) inundation. The eBTM also produces inundation water levels relative to structures and thus allows for quantifying the coastal inundation risk to infrastructure, which is of relevance in the disaster response context.

While the GIS-based approach chosen in this study might still not produce inundation outputs as accurate as those from highly complex hydrodynamic modelling, the outputs from the technologically simpler eBTM are nevertheless an improved and more accessible means for informing authorities in matters of disaster management and climate change adaptation at a relevant spatial scale.

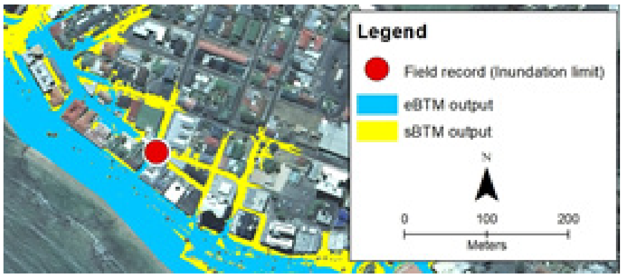


Figure 2. *Locations of field recording (red point) and results from the simple Bathtub Model (sBTM, yellow) overlaid with the enhanced Bathtub Model (eBTM, blue), using digital surface models (DSMs).*

Authors: Williams L (O&C Research), Lück-Vogel M (CSIR)

20. SOUTH AFRICA'S REVISED ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREA NETWORK

Ecologically or Biologically Significant Marine Areas (EBSAs) describe delineated features or areas of oceans or coasts that are of high value for biodiversity and ecosystem services. The Convention on Biological Diversity (CBD), to which South Africa is a Party, encourages countries to consider enhanced conservation or management measures for EBSAs, through formal protection or other means, with the aim of counteracting the rapid loss of biodiversity and associated ecosystem services. For South Africa, areas meeting the EBSA criteria have been identified and described through CBD processes, and were adopted at the 12th CBD Conference of the parties in 2014.

Under the Marine Spatial Management and Governance (MARISMA) project, South Africa conducted revisions to its EBSA network. The aim was to enhance EBSAs as a technical and scientific tool to inform spatial management, such as Marine Spatial Planning (MSP), which is being initialised in the country, and Marine Protected Area (MPA) expansion.

Original EBSA delineations were largely based on expert opinion and were considered to be too coarse to be useful for integration into spatial management plans that also need to include other sectors or stakeholders. In the revision, we used the most up to date available spatial data, national workshops with experts and stakeholders, and sophisticated analytical methods. Participation of experts and stakeholders was also facilitated by an interactive EBSA website (https://cmr.mandela.ac.za/EBSA-Portal), hosted by the Institute for Coastal and Marine Research of the Mandela University.

Twelve EBSAs within South Africa's mainland Exclusive Economic Zone and two transboundary EBSAs with Namibia were revised. Revisions to the descriptions included changes in boundary delineations (Fig. 1), name changes (to be more descriptive), amendments in criteria scoring and updated content. Two of the original EBSAs (Offshore of Port Elizabeth, and Agulhas Slope and Seamounts) were each split into two EBSAs (Fig. 1). Three new EBSAs were proposed, namely Seas of Good Hope, Protea Seamount Cluster, and Tsitsikamma-Robberg.

The revisions addressed the need for a more systematic approach to EBSA assessments (as opposed to being wholly expert-based), as encouraged by the CBD. The project report underwent international review (along with EBSA revisions of other Benguela Current states, Namibia and Angola), and following Ministerial approval, the final report was submitted to the CBD's Secretariat.

The revised EBSA delineations provide better alignment of their boundaries with the ecological and biological features that they capture, resulting in more defined and spatially explicit EBSAs as input layers for spatial management processes. These are being integrated with other marine spatial biodiversity priorities to establish the initial Environmental Sector Plan, which will inform the development of the country's first marine area plans from an environmental perspective (see Report Card #21).

Authors: Kirkman SP (O&C Research), Holness SD, Harris LR (NMU), Sink KJ (SANBI)

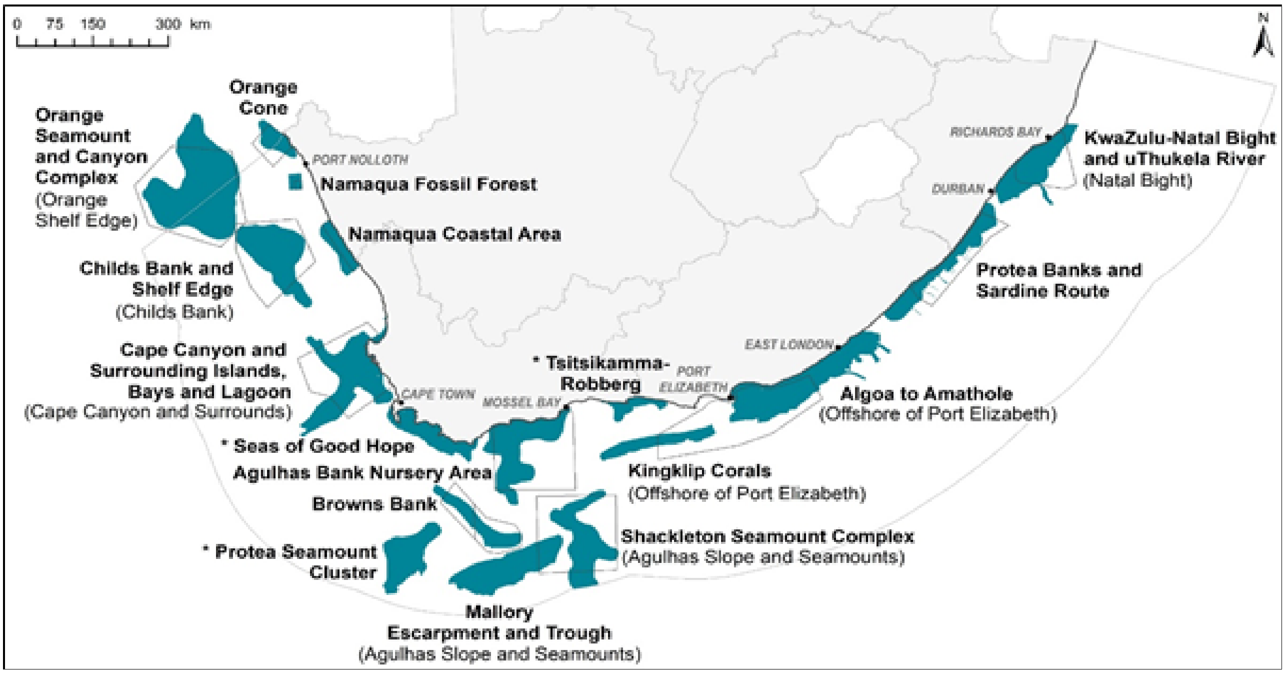


Figure 1. *Map showing new and revised EBSA boundaries (blue polygons) and original EBSA boundaries (lines). New EBSAs are indicated with an *, and original names are given in parentheses.*

21. SOUTH AFRICA'S FIRST NATIONAL COASTAL AND MARINE SPATIAL BIODIVERSITY PLAN

A Critical Biodiversity Area (CBA) Map presents a spatial plan for the natural environment, designed to inform planning and decision-making in support of sustainable development. CBA Maps comprise three categories of priority areas: protected areas, CBAs, and Ecological Support Areas (ESAs). These are important for meeting national protection targets and to ensure the persistence of viable representative ecosystem types, species and long-term ecological functioning of the land- and sea-scape. CBA Maps have been used for a long time to inform land-use planning and protected area expansion in South Africa.

In 2020, South Africa's first National Coastal and Marine Spatial Biodiversity Plan (the Plan), comprising a coastal and marine CBA Map and accompanying sea-use guidelines, was developed. The project was supported by a Pew Fellowship (KJ Sink) and the Marine Spatial Management and Governance (MARISMA) project, in collaboration with DFFE. The intent of the Plan is to consolidate the Environment Sector's spatial prioritisation of the coast and oceans, for application in national Marine Spatial Planning (MSP) and related processes.

To this end, all available marine spatial biodiversity data were incorporated, including data on species, ecosystems and ecological processes. A range of biodiversity data layers from the marine science community, including those generated for defining Ecologically or Biologically Significant Marine Areas (EBSAs; see Report #20) and numerous products from the National Biodiversity Assessment, such as ecosystem classifications and condition maps, provided the main input layers for the Plan. The decision-support software Marxan, reinforced by initial stakeholder engagements, was used to integrate the data layers and delineate the different CBA Map spatial biodiversity priorities (Fig. 1). To achieve a spatially efficient configuration of priority areas that meet the national biodiversity targets, the process followed systematic biodiversity planning principles. These include, amongst others, that there must be adequate representation of ecosystem types in CBAs, and that costs to other sectors (e.g. fisheries, petroleum, mining) must be minimised by avoiding their spatial areas of activity or interest as much as possible.

Sea-use guidelines were compiled to give recommendations for management, taking into account the compatibility of different activities with the objectives of various priority areas. Broadly, the objective for CBAs is to keep them in a natural or near-natural state because they are irreplaceable or near-irreplaceable (CBA1 in Fig. 1), or otherwise the best available option for representing features (CBA2). The objective for ESAs is to keep them at least ecologically functional, even if they are already in a modified state.

South Africa's first National Coastal and Marine Spatial Biodiversity Plan will be iteratively updated over time to accommodate new and improved data. The Plan provides the basis for the Environment Sector Plan, which is currently being developed to inform South Africa's first MSP marine area plans. It also contributes towards identifying focus areas for MPA expansion, building on work that supported the declaration of 20 new MPAs in 2019. Ultimately the purpose of the Plan is to help ensure that marine biodiversity assets and ecological infrastructure are secured, and that development of the ocean economy is sustainable.

Authors: Harris LR, Holness SD (NMU), Sink KJ, Majiedt P, Driver A (SANBI), Kirkman SP (O&C Research)

Figure 1. *Schematic diagram indicating the technical process of compiling a CBA Map: (A) Integration of biodiversity data layers in Marxan, and (B) application of biodiversity planning principles to achieve (C) a spatially efficient configuration of priority areas.*

22. PRESSURE-EQUIPPED INVERTED ECHO SOUNDER (PIES) TECHNOLOGY ENHANCES DEEP-WATER OBSERVATIONS OFF SOUTH AFRICA

Worldwide recognition of the critical importance of the role of the South Atlantic Ocean in the global thermohaline circulation has led to the creation of an international community initiative to investigate the South Atlantic Meridional Overturning Circulation (SAMOC).

International collaboration between O&C Research, the University of Cape Town (UCT), the National Oceanic and Atmospheric Administration (NOAA) in the United States, the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) and Laboratoire de Météorologie Dynamique (LMD) in France, has resulted in the deployment and maintenance of the eastern part of the South Atlantic MOC Basin-wide Array (SAMBA) along 34.5°S in the Cape Basin.

The aim of the array is to ensure sustained long-term measurements to characterise the time-mean and time-varying components of the SAMOC, as well as heat and salt fluxes across 34.5°S. Enhanced collaboration between O&C Research and NOAA has recently secured 11 additional Pressure-equipped Inverted Echo Sounders (PIES) to augment observations (Fig. 1a). The PIES are equipped with complex circuitry housed in a 17-inch glass sphere (Fig. 1b). This is to measure the round-trip travel time (Tau) of an acoustic signal (12 kHz frequency) sent from the bottom-moored instrument to the sea surface and back (Fig. 1c). The units have highly stable and accurate instruments to provide bottom pressure measurements (Paroscientific Digiquartz sensors) and temperature readings (internal Sensirion Model SHT75 sensors). Tau measurements (Fig. 2) can be combined with hydrography-derived look-up tables to obtain full water column estimates of temperature, salinity, and density.

A recent series of international workshops and at-sea training sessions have capacitated O&C Research staff to manage the setup, servicing, deployment and retrieval of these instruments. Further training sessions that are planned will improve in-house data processing capabilities. These recently acquired instruments and skill sets present a first for South Africa, and are essential to ensure the longevity of the observations along 34.5°S. We anticipate that this knowledge will be used to further capacitate young South African tertiary students, interns, scientists and technicians, by broadening their exposure to available technologies.

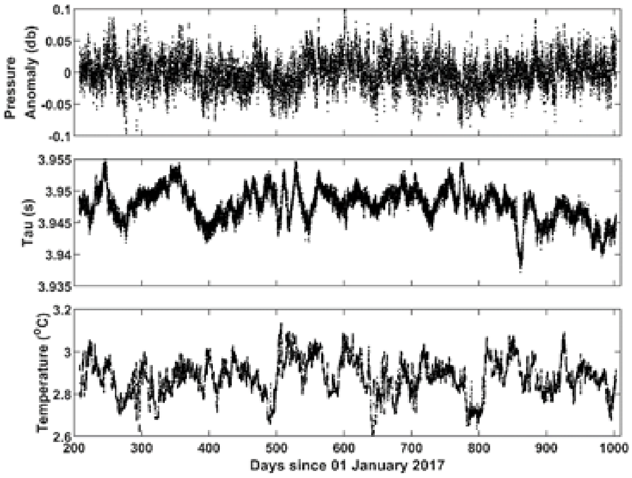


Figure 2. *Pressure anomaly (db), Tau (seconds), and temperature (°C) measurements from a PIES deployed at a depth of 2 100 m (34.5°S; 17.2°E).*

Authors: Louw GS, Lamont T (O&C Research)
Contributors: van den Berg MA, Tutt GCO (O&C Research)

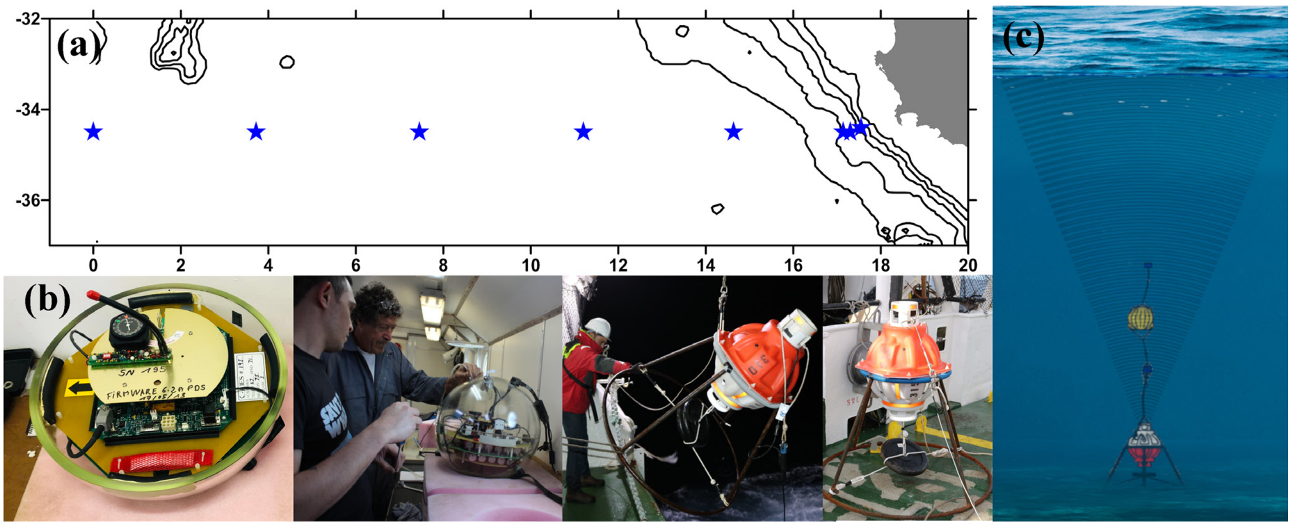


Figure 1. *(a) Map illustrating positions of 8 PIES (blue stars) currently deployed as part of the SAMBA array (1 000, 2 000, 3 000 and 4 000 m bathymetry contours indicated in black); (b) selected images illustrating the PIES internal circuitry, the instrument ready for deployment, and being deployed; and (c) schematic illustration of the acoustic signal from a bottom-moored PIES to the ocean surface.*

23. AUTOMATIC WEATHER STATIONS ON THE WEST COAST

Since April 2015, O&C Research has been managing a network of three Automatic Weather Stations (AWS) installed at Port Nolloth, Elands Bay and Cape Columbine, along the west coast of South Africa (Fig. 1). These instruments provide measurements of wind speed and direction, air temperature, humidity and rainfall at hourly and daily rates.

We compared frequency distributions of AWS wind magnitude and direction with similar global reanalysis (ERA5) datasets over a period of five years. ERA5 data is obtained by combining satellite and *in situ* observations with modelled data in order to compare past and present climate conditions. For the west coast of South Africa, the ERA5 dataset does not include *in situ* measurements from these three AWS at this stage. For comparison with AWS, the ERA5 datasets were extracted from selected offshore locations corresponding to the AWS positions (Fig. 1).

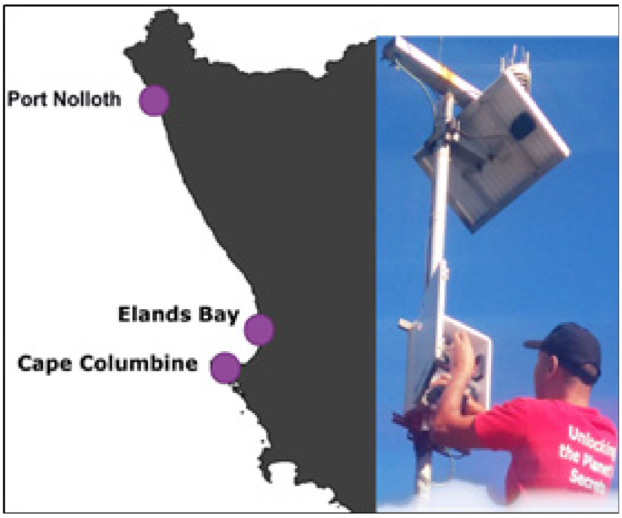


Figure 1. *Map of the AWS positions and a picture of a technician performing routine maintenance on the Port Nolloth weather station. Photo taken by M Tyesi.*

ERA5 winds blow from the south or southeasterly direction, most of the time. The magnitude of wind in the ERA5 dataset is at least 20% higher than the AWS-recorded winds, which predominantly blow from the southwesterly direction, a 30° offset relative to ERA5 wind direction (Fig. 2).

The significantly weaker wind magnitude and the offset in direction in the *in situ* datasets, may be due to the coastal wind speed drop-off not being adequately captured in the global ERA5 reanalysis. Satellite-derived data are often inaccurate near the coast because of 'land contamination' that compromises satellite observations of the ocean.

The inability of reanalysis data to adequately capture climate parameters such as wind or sea temperature closer to the coast impacts our ability to model and predict the coastal ocean environment. *In situ* observations from the AWS allowed us to assess the limitations of the ERA5 data. Incorporation of the data from these three AWS can strengthen the ERA5 dataset for the West Coast.

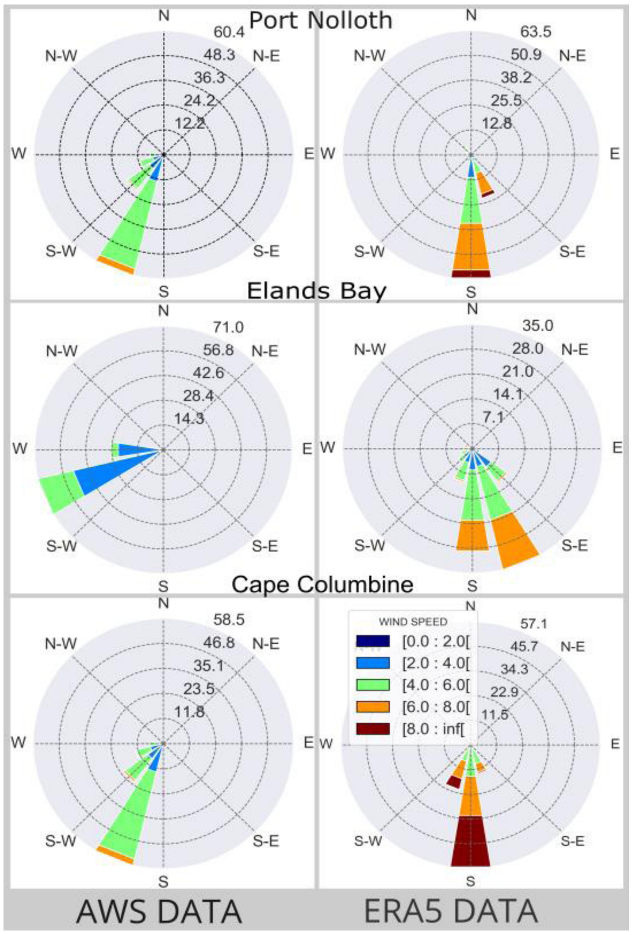


Figure 2. *Frequency distributions of wind magnitude and direction over a period of five years (2015–2020), for the AWS and ERA5 datasets. The legend shows colour-coded scales of wind magnitude in meters per seconds.*

Authors: Tyesi M, Krug M, Anders D, Frantz F (O&C Research)

24. MONITORING OCEAN FLOW AROUND SOUTH AFRICA USING ACOUSTIC DOPPLER CURRENT PROFILERS (ADCPs)

Oceans and Coasts Research routinely monitors the oceans around South Africa to enhance our understanding of ocean processes, ecosystem functioning and the impacts of climate variability. The Southern Benguela Integrated Ecosystem Programme (IEP) is a multidisciplinary monitoring programme focussed on the west coast of South Africa, in the Benguela Upwelling System. The region is well known for the prevalence of wind-induced upwelling, which promotes uplift of nutrient-rich waters, leading to productive fisheries.

Acoustic Doppler Current Profilers (ADCPs) are instruments that can be moored in the ocean or mounted on the hull of research vessels to monitor ocean circulation. They emit sound waves which interact with the particles present in seawater. Analyses of the Doppler shift (the change in wave frequency moving away from the source) from these acoustic signals are used to determine the ocean flow (both speed and direction) at different depths. Figure 1 shows surface currents measured by a Ship-mounted ADCP (S-ADCP) along the IEP monitoring lines during November 2019.

By integrating flow data over time, one can gain an estimate of the volume of water transported by ocean currents around our coastline. The IEP St Helena Bay Monitoring Line (Fig. 2a) is used as an example to show how observations from S-ADCPs are used to estimate volume transport. Positive values in Fig. 2b (red hues) indicate a northward water movement, while negative values (blue hues) show a southward flow. This example indicates northward flow in the upper 200 m of the water column, between stations 8 and 13, commonly referred to as the Benguela Jet current. The Benguela Jet is located between the 200 and 500 m isobaths and is constrained to the upper 200 m of the ocean. Below the Benguela Jet lies a weaker poleward undercurrent.

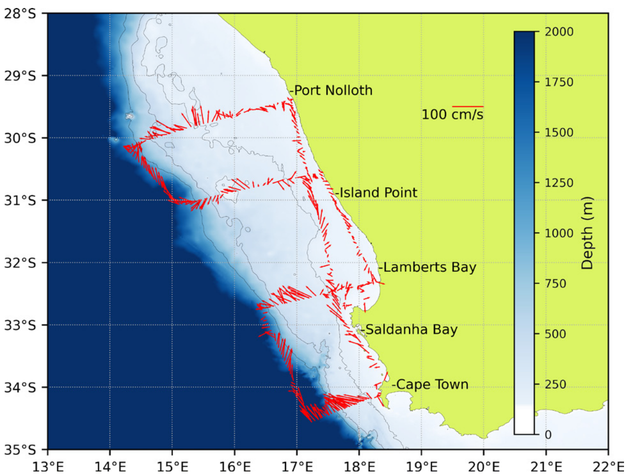


Figure 1. *Current vectors along the IEP monitoring transects off the west coast of South Africa during November 2019. Red arrows indicate the speed and direction of the ocean currents at the surface measured by S-ADCP as the vessel travels through the region.*

The northward volume transport across the St Helena Bay Monitoring Line during the survey shows that approximately 500 000 cubic metres of water is transported northward in the Benguela Jet every second (Fig. 2b). For comparison, the volume of water transported northwards by the Benguela Jet would fill the Theewaterskloof Dam, the largest dam in the Western Cape water supply system, approximately ninety times every day.

Repeated surveys along monitoring lines can provide insights into the mean circulation and its variability in the region. Such knowledge is important to understand how heat is transported in the ocean and how ocean currents may impact the marine ecosystem.

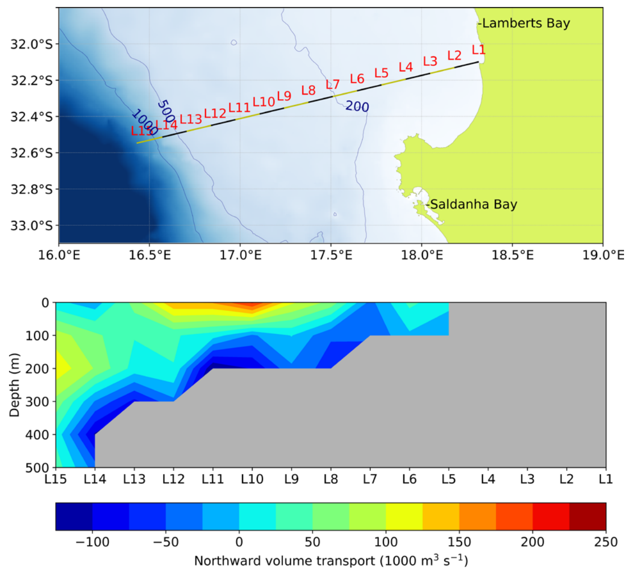


Figure 2. *(a) Location of the St Helena Bay Monitoring Line (yellow and black line) as well as the segments, labelled in red, off the west coast of South Africa; (b) northward volume transport for the upper ocean layer along the St Helena Bay Monitoring Line during November 2019.*

Authors: Bergman S, Ismail H, Ceasar J, Krug M (O&C Research)

25. EDDY IDENTIFICATION AND TRACKING IN THE OCEAN AND COASTAL INFORMATION MANAGEMENT SYSTEM (OCIMS)

The constant motion of the global ocean results in the formation of various current structures of different spatial and temporal scales. Among these, mesoscale eddies have typical spatial scales of 50–100 km and timescales of the order of one month, and account for more than half of the variability in the global oceans. These eddies have been shown to entrain and transfer water masses and biological material, and thus play an important role in the physical and biological variability of marine ecosystems. It is therefore vital that oceanographic monitoring systems are able to identify and track mesoscale eddies.

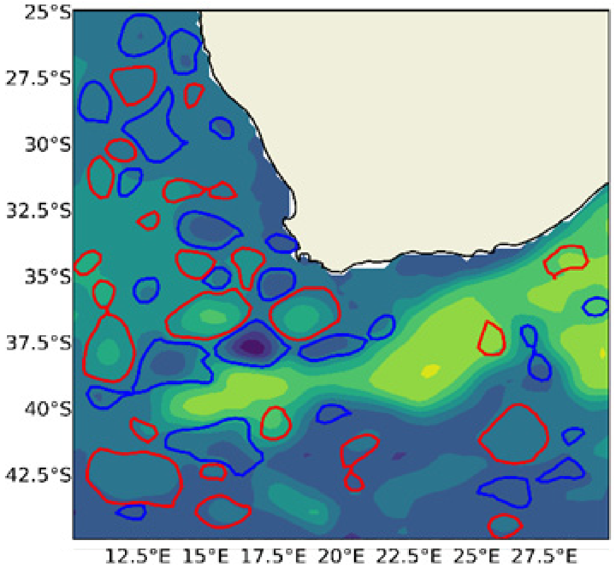
As part of the Oceans and Coasts Information Management System (OCIMS), an open source and peer-reviewed eddy detection scheme, named 'py-eddy-tracker', is currently being applied to Sea Level Anomaly (SLA) maps derived from satellite altimeters. The eddy detection scheme tracks and identifies eddies within the southern African marine region in real time. It is envisaged that the real time tracking and identification will be disseminated via the OCIMS website in the near future.

The detection scheme uses closed contours of filtered SLA to detect mesoscale eddies. Before the closed contours are declared as eddies, they are subjected to additional tests to analyse the shape error, the number of SLA pixels within the contours, and the amplitude (height of the sea surface). The scheme provides numerous diagnostics, including the location of the eddies, their sizes, and the speed at which they spin and move across geographical regions. The scheme has also been successfully applied to numerical ocean model outputs, which allows for the forecasting of mesoscale eddies within the region.

Here we illustrate examples of the outputs from the eddy tracking scheme for the west and south coasts of South Africa (Fig. 1). The top panel shows the location and the type of eddy (cyclonic or anticyclonic) while the bottom panel shows where selected cyclonic eddies came from. These outputs would allow stakeholders to anticipate environmental changes driven by the presence of the eddies and the associated impacts. For example, suspended particles such as red tides or oil spills can be transferred inshore or offshore depending on the location and spin of nearby eddies. Thus, identifying nearby eddies under these scenarios would inform stakeholders if action is required.

The real-time identification of mesoscale eddies provides an additional tool to increase the monitoring capabilities of ocean observing systems. The dissemination of ocean eddy pathways and properties through OCIMS might also be of value to various stakeholders interested in monitoring large anomalies in ocean circulation.

Author: Carr M (SAEON)
Contributors: Krug M (O&C Research), Veitch J (SAEON)



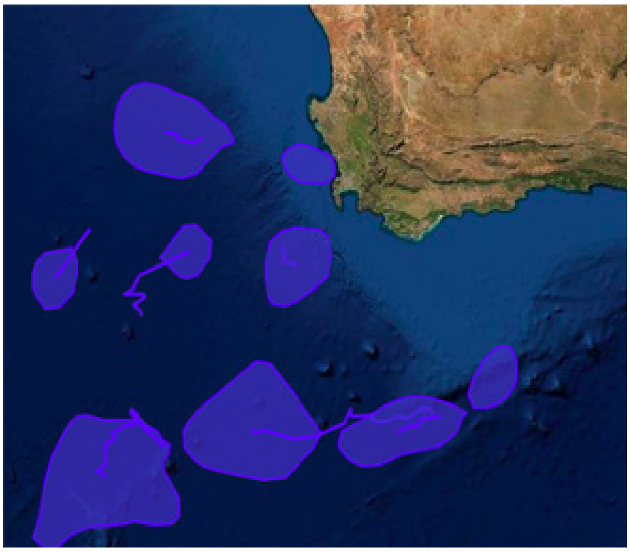


Figure 1. *Top: The cyclonic (blue contours) and anticyclonic (red contours) mesoscale eddies detected by the 'py-eddy-tracker' on 26 January 2021. Eddy contours are overlaid onto the Absolute Dynamic Topography of the region. Bottom: Selected cyclonic eddies (blue polygons) on 26 January 2021 and their associated historical tracks (blue lines).*

26. OPERATIONAL OCEAN FORECASTING: ALGOA BAY PILOT STUDY

As a tool to provide information and decision support for effective management of South Africa's oceans and coasts, operational ocean forecasting was highlighted as a top priority for the national Oceans and Coastal Information Management System (OCIMS). To this end, there is ongoing development of an operational ocean forecast system for the Algoa Bay region, located on the southeast coast of South Africa (Fig. 1).

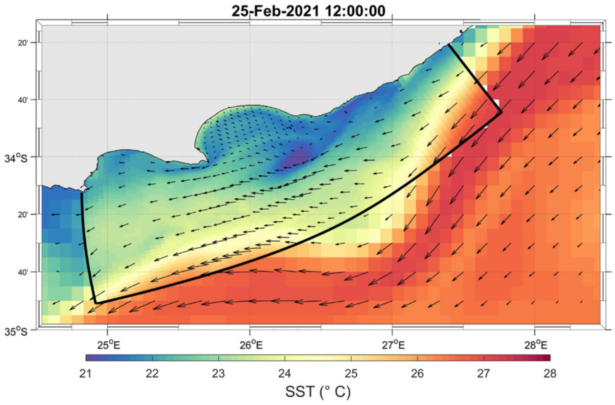


Figure 1. *Sea surface temperature and surface current velocity vectors for 25 February 2021, forecasted from a model run on 22 February 2021. The black box denotes the extent of the Algoa Bay high resolution (500 m) model, while data outside this box is from the coarser resolution (9 km) global forecast product.*

Algoa Bay was selected as a pilot site for the forecast system, primarily due to pressing environmental risks associated with ongoing bunkering operations (vessel refuelling). These activities have already resulted in two small oil spill events (14 August 2016 and 6 July 2019) which necessitated significant clean-up operations. The aim of the system is to provide routine forecasts of nearshore oceanographic conditions and potential movement of surface oil spills, thereby supporting the management of bunkering operations and aiding mitigation efforts in response to spill events.

The forecast system computes the past, present and future ocean state using a Coastal and Regional Ocean COmmunity (CROCO) numerical model configuration, the extent of which is shown by the black box in Figure 1. A limited domain model such as this requires oceanic data (temperature, salinity, water levels and currents) to be applied at its offshore boundaries. We obtain these boundary conditions from a *ca.* 9 km resolution global ocean forecast product from Mercator Ocean. The model surface requires atmospheric forcing in the form of surface winds, heat fluxes, and freshwater fluxes, which we obtain from the Global Forecast System. The Mercator forecast product applied at our model boundaries ensures that large-scale oceanographic variability is included in our model, while our high model resolution (*ca.* 500 m over Algoa Bay) allows for the simulation of local bay-scale phenomena. The forecast system is currently running operationally (one initialisation per day), producing hourly output for a period covering 5 days into the past to 5 days into the future.

In this report, we illustrate the forecasted sea surface temperature (SST) and surface currents for 25 February 2021 (Fig. 1), obtained from the model run on 22 February 2021. Interestingly, Figure 1 depicts the passage of a Natal Pulse (a large offshore deviation of the Agulhas Current) off Algoa Bay. These features are known to induce the uplift of cooler water from depth onto the shelf. The forecast model is able to capture this response (Fig. 1), further demonstrating that ocean dynamics in Algoa Bay are complex and greatly influenced by the variability in the Agulhas Current.

Forecasting the movement of oil spills at the surface is an important application of the operational system. Taking into account the combined influence of surface currents and wind drift, Lagrangian particle tracking is presently being used to simulate surface oil movements. The predicted location of a hypothetical oil spill on 22 February 2021 is shown in Figure 2, with the surface current and wind drift vector fields indicating landward advection of the spill. Such predictions are being generated routinely and are intended to provide valuable input toward mitigation efforts in the event of future spill events. It is envisaged that both the high-resolution model output and oil spill trajectory forecasting will be disseminated routinely on the OCIMS website in the near future.

The 'downscaling' strategy adopted for this pilot site can easily be applied to other regions around the South African coastline, and it can also be adapted for other applications (e.g. marine search and rescue, water quality forecasting, fisheries and aquaculture management). The CROCO model also represents a useful tool for undertaking scientific research and is currently being used to improve our understanding of the drivers of bay-scale variability for Algoa Bay.

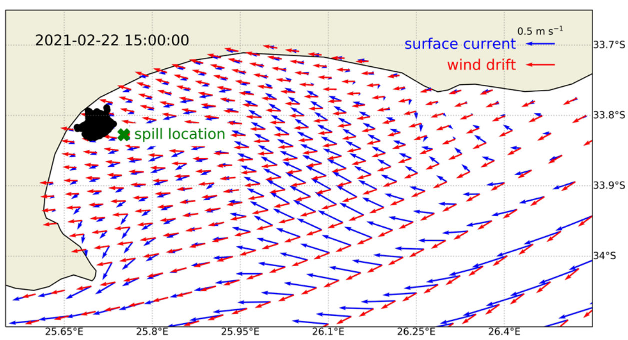


Figure 2. *Forecasted location of a hypothetical surface oil spill (shown in black) at 15h00 on 22 February 2021, from a model initiated at 00h00 on the same day.*

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27. EVALUATING GLORYS OCEAN MODEL FOR SOUTH AFRICA

GLORYS (Global Ocean Reanalysis and Simulation) is a global ocean reanalysis model produced by Mercator Ocean as part of the Copernicus Marine Environment Monitoring Service (CMEMS) framework. Reanalysis is a scientific method for developing a comprehensive record of how climate is changing over time. GLORYS provides a comprehensive dataset of physical ocean variables spanning 1993 to present, allowing for the investigation of various scales of change, from sub-seasonal to long-term trends. In order to produce the most accurate four-dimensional representation of the oceans recent past, all appropriate and accessible observational data are incorporated into a numerical model via a state of the art data assimilation scheme.

A key objective of the 'Sustainable Ocean Modelling Initiative: a South African Approach' (SOMISANA) is to develop a high resolution shelf-scale model optimised for South Africa's Exclusive Economic Zone (EEZ) that will allow for the analysis of long-term changes in the ocean environment. In order to do this, a global model (such as the GLORYS ocean reanalysis model) feeds information into the high resolution model at the lateral boundaries. Based on a thorough evaluation of three freely accessible global ocean reanalysis products, GLORYS was found to be the most proficient at capturing key features of South Africa's ocean dynamics. In this report we present a few highlights of the GLORYS evaluation.

The evaluation protocol included both *in situ* and satellite datasets; the former to interrogate shelf-scale processes throughout the water column, and the latter to assess large-scale surface characteristics. The *in situ* datasets are from mooring arrays that have been continuously monitored for at least two or three seasonal cycles, namely the ACT/ASCA array that crosses the Agulhas Current and the SAMBA array that crosses the Benguela Jet and extends into the turbulent Cape Basin. Despite being notoriously difficult to model, comparisons with the *in situ* datasets reveal that the magnitude and variability of the volume transport of the Agulhas Current is successfully captured by GLORYS. For example, the comparison with the ASCA dataset for volume transport (Fig. 1) reveals a significant correlation.

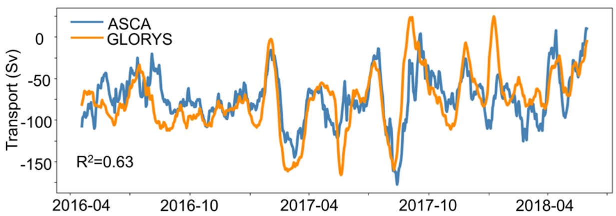

Figure 1. *Volume transport time series, spanning April 2016–June 2018, based on the current observations made by the ASCA mooring array (blue), and derived from the GLORYS model (orange). The x-axis labels are year-month.*

Various statistical metrics are used to compare satellite datasets with modelled surface properties. Here we show the summer (December to February) and winter (June to August) Sea Surface Temperature (SST) trends (Fig. 2), based on the GLORYS model and one satellite product, for their common period (2003–2018). During summer, we note a persistent dipole structure of cooling toward the north and warming toward the south in the southwest Indian Ocean, a persistent warming throughout the southeast Atlantic and coastal cooling along the west and south coasts of South Africa. Except for a clear warming of the Agulhas Current, the winter trend is dominated by cooling.

The model plainly captures the fairly different summer and winter trends. These findings indicate that the GLORYS model is well suited to provide lateral boundary information for an optimised, high resolution model of South Africa's EEZ that is a top priority of the SOMISANA initiative.

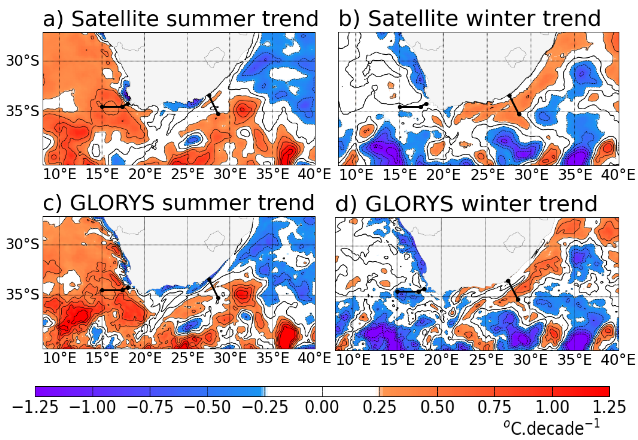

Figure 2. *Seasonal linear trend of SST during summer (December–February) and winter (June–August), based on GLORYS model and satellite data. Black lines indicate the ACT/ASCA and SAMBA arrays off the east and west coasts of South Africa, respectively.*

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28. COMMUNICATING SCIENCE TO THE PUBLIC – AN APP FOR THE DE HOOP MPA FISH MONITORING PROJECT

Unlike commercial fishing data, recreational fishing data are not easily collected or incorporated into measures of fish abundance. The De Hoop Marine Protected Area (MPA) is a no-take area where an ongoing scientific monitoring project provides a reliable, long-term (since 1984) dataset on surf-zone fishes. These data have provided valuable insights on the biology of recreationally targeted fish species (e.g. home ranges, dispersal), their relative status (abundance and trends), and the effectiveness of the MPA with respect to protection and recovery of exploited species. The project is run by DFFE in collaboration with the University of Cape Town (UCT) and CapeNature, and involves teams of volunteer anglers. The anglers catch, tag and record vital information (species, size, location of capture, sex, etc.) for each captured fish before safely releasing them back to the ocean.

Results from the monitoring project have been published in several scientific peer-reviewed articles that have in turn been cited worldwide in papers on MPAs, fish movement and conservation. However, the communication of these scientific results to all stakeholders (the public, MPA managers, fisheries managers, recreational anglers, etc.) remains a challenge.

To address this, an R Shiny application (app) called 'De Hoop MPA Monitoring Programme' was developed to provide a user-friendly platform for communicating the De Hoop fish monitoring results to all stakeholders. R Shiny is a statistical freeware package that allows one to query datasets via a user-friendly web interface and create graphical and/or tabular query outputs instantly. This makes it an ideal tool to explore data without requiring expertise from the user.

In the app, a fish species of interest can be selected in a drop-down menu, and data can be disaggregated according to sampling area (Koppie Alleen or Lekkerwater) and year (1984–2018) using interactive toggle switches and slide bars that are intuitive to use (Fig. 1). This provides a customised experience to users for viewing species and data of interest to them, as per the example shown for galjoen *Dichistius capensis* (Figs. 2 and 3).

With over 400 thousand recreational anglers and 3 000 km of coastline, managing our marine resources is challenging, and education about MPAs is imperative. The De Hoop MPA Monitoring Programme app aims to disseminate information on the ecological benefits of MPAs to the public in an easy to understand format, thereby promoting awareness and conservation.

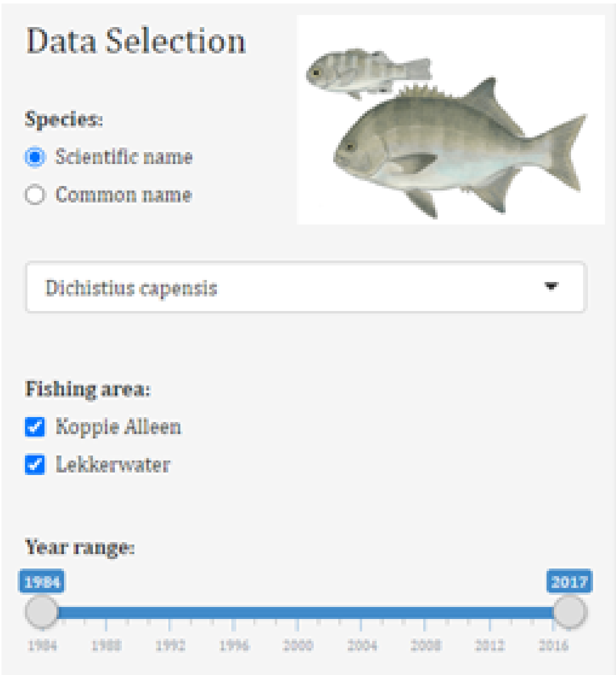

Figure 1. *The app interface, with galjoen selected as an example to display the catch per unit effort from 1984 to 2017 at both study sites.*

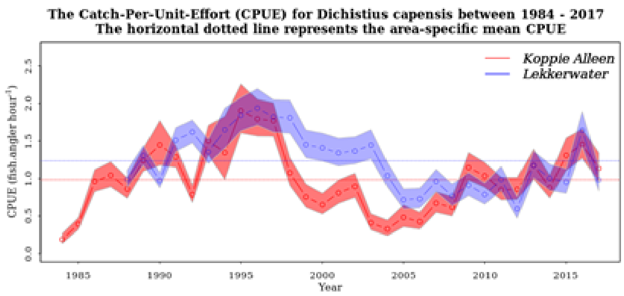

Figure 2. *The graphic output for data selection as specified in Figure 1.*

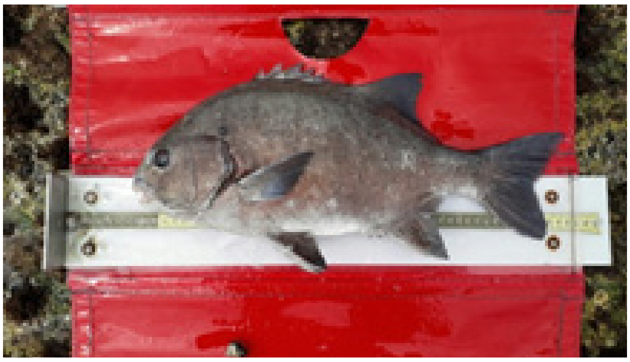

Figure 3. *A galjoen being measured prior to tagging.*

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Contributors: Horton M, Attwood C (UCT)

Peer-reviewed publications

Adams LA, Maneveldt GW, Green A, Karenyi N, Parker D, Samaai T, Kerwath S. 2020. Rhodolith bed discovered off the South African coast. *Diversity* 12: 125.

Bakir A, van der Lingen CD, Prestyn-Whyte F, Bali A, Geja Y, Barry J, Mdazuka Y, Mooi G, Doran D, Tooley F, Harmer R, Maes T. 2020. Microplastics in commercially important small pelagic fish species from South Africa. *Frontiers in Marine Science* 7: 574663.

Barlow R, Lamont T, Gibberd M-J, Russo C, Airs R, Tutt G, Britz K, van den Berg M. 2020. Phytoplankton adaptation and absorption properties in an Agulhas Current ecosystem. *Deep-Sea Research I* 157: 103209.

Botha JA, Kirkman SP, Arnould JPY, Lombard AT, Hofmeyr GJG, Meÿer MA, Kotze PGH, Pistorius PA. 2020. Geographic variation in at-sea movements, habitat use and diving behaviour of female Cape fur seals. *Marine Ecology Progress Series* 649: 201–218.

Carneiro APB, Pearmain EJ, Oppel S, Clay TA, Phillips RA, Bonnet-Lebrun A-S, Wanless RM, Abraham E, Richard Y, Rice J, Handley J, Davies TE, Dilley BJ, Ryan PG, Small C, Arata J, Arnould JPY, Bell E, Bugoni L, Campioni L, Catry P, Cleeland J, Deppe L, Elliot G, Freeman A, González-Solís J, Grandeiro JP, Grémillet D, Landers TJ, Makhado A, Nel D, Nicholls DG, Rexer-Huber K, Robertson CJR, Sagar PM, Scofield P, Stahl J-C, Stanworth A, Stevens KL, Trathan PN, Thompson DR, Torres L, Walker K, Waugh SM, Weimerskirch H, Dias MP. 2020. A framework for mapping the distribution of seabirds by integrating tracking, demography and phenology. *Journal of Applied Ecology* 57: 514–525.

Carpenter-Kling T, Reisinger RR, Orgeret F, Connan M, Stevens KL, Ryan PG, Makhado A, Pistorius PA. 2020. Foraging in a dynamic environment: Response of four sympatric sub-Antarctic albatross species to interannual environmental variability. *Ecology and Evolution* 10: 11277–11295.

Flynn RF, Granger J, Veitch JA, Siedlecki S, Burger J, Pillay K, Fawcett SE. 2020. On-shelf nutrient trapping enhances the fertility of the southern Benguela Upwelling System. *Journal of Geophysical Research Oceans* 125: e2019JC015948.

Hindell MA, Reisinger RR, Robert-Coudert Y, Hückstädt LA, Trathan PN, Bornemann H, Charrassin J-B, Chown SL, Costa DP, Danis B, Lea M-A, Thompson D, Torres LG, Van de Putte AP, Alderman, R, Andrews-Goff V, Arthur B, Ballard G, Bengtson J, Bester MN, Blix AS, Boehme L, Bost C-A, Boveng P, Cleeland J, Constantine R, Corney S, Crawford RJM, Dalla Rosa L, de Bruyn PJN, Delord K, Descamps S, Double M, Emmerson L, Fedak M, Friedlaender A, Gales N, Goebel ME, Goetz KT, Guinet C, Goldsworthy SD, Harcourt R, Hinke JT, Jerosch K, Kato A, Kerry KR, Kirkwood R, Kooyman GL, Kovacs KM, Lawton K, Lowther AD, Lydersen C, Lyver PO'B, Makhado AB, Márquez MEI, McDonald BI, McMahon CR, Muelbert M, Nachtsheim D, Nicholls KW, Nordøy ES, Olmastroni S, Phillips RA, Pistorius P, Plötz J, Pütz K, Ratcliffe N, Ryan PG, Santos M, Southwell C, Staniland I, Takahashi A, Tarroux A, Trivelpiece W, Wakefield E, Weimerskirch H, Wienecke B, Xavier JC, Wotherspoon S, Jonsen ID, Raymond B. 2020. Tracking of marine predators to protect Southern Ocean ecosystems. *Nature* 580: 87–92.

Kainge P, Kirkman SP, Estevão V, van der Lingen CD, Uanivi U, Kathena JN, van der Plas A, Githaiga-Mwicigi J, Makhado A, Nghimwatya L, Endjambi T, Paulus S, Kalola M, Antonio M, Tjizoo B, Shikongo T, Nsiangango S, Uahengo T, Bartholomae C, Mqoqi M, Hamukuaya H. 2020. Fisheries yields, climate change, and ecosystem-based management of the Benguela Current Large Marine Ecosystem. *Environmental Development* 36: 100567.

Kersalé M, Meinen CS, Perez RC, Le Hénaff M, Valla D, Lamont T, Sato OT, Dong S, Terre T, van Caspel M, Chidichimo MP, van den Berg M, Speich S, Piola AR, Campos EJD, Ansorge I, Volkov DL, Lumpkin R, Garzoli S. 2020. Highly variable upper and abyssal overturning cells in the South Atlantic. *Science Advances* 6: eaba7573.

Kirkman SP, Baliwe NG, Nhleko J, Pfaff MC. 2020. Ecosystem health and human wealth – A comparison of sub-Saharan African Large Marine Ecosystems. *Environmental Development* 36: 100551.

Lamont T, van den Berg MA. 2020. Mesoscale eddies influencing the sub-Antarctic Prince Edward Islands Archipelago: Origin, pathways, and characteristics. *Continental Shelf Research* 210: 104257.

Lerata MS, D'Souza S, Sibuyi NRS, Dube A, Meyer M, Samaai T, Antunes EM, Beukes DR. 2020. Encapsulation of Variabilin in Stearic Acid solid lipid nanoparticles enhances its anticancer activity in vitro. *Molecules* 25: 830.

Lopes F, Oliveira LR, Kessler A, Beux Y, Crespo E, Cárdenas-Alayza S, Majluf P, Sepúlveda M, Brownell RL Jr., Franco-Trecu V, Páez-Rosas D, Chaves J, Loch C, Robertson BC, Acevedo-Whitehouse K, Elorriaga-Verplancken FR, Kirkman SP, Peart CR, Wolf JBW, Bonatto SL. 2020. Phylogenomic discordance in the Eared Seals is best explained by incomplete lineage sorting following explosive radiation in the southern hemisphere. *Systematic Biology* doi: 10.1093/sysbio/syaa099.

Nolte CR, Nel R, Pfaff MC. 2020. Determining body condition of nesting loggerhead sea turtles (*Caretta caretta*) in the Southwest Indian Ocean. *Journal of the Marine Biological Association of the United Kingdom* 100: 291–299.

Nolte CR, Pfaff MC, de Lecea AM, de Gouvello D, Nel R. 2020. Stable isotopes and epibiont communities reveal foraging habitats of nesting loggerhead turtles in the South West Indian Ocean. *Marine Biology* 167: 162.

Noyon M, Rasoloarijao Z, Huggett J, Roberts M, Ternon J-F. 2020. Comparison of mesozooplankton communities at three shallow seamounts in the South West Indian Ocean. *Deep Sea Research Part II* 176: 104759.

Pinheiro U, Calheira L, Martins C, Janson L, Taylor R, Samaai T. 2020. Two new species of freshwater sponges from Neotropical and Afrotropical Regions. *Zootaxa* 4728: 363–371.

Ropert-Coudert Y, Van de Putte AP, Reisinger RR, Bornemann H, Charrassin J-B, Costa DP, Danis B, Hückstädt LA, Jonsen ID, Lea M-A, Thompson D, Torres LG, Trathan PN, Wotherspoon S, Ainley DG, Alderman R, Andrews-Goff V, Arthur B, Ballard G, Bengtson J, Bester MN, Blix AS, Boehme L, Bost C-A, Boveng P, Cleeland J, Constantine R, Crawford RJM, Dalla Rosa L, de Bruyn PJN, Delord K, Descamps S, Double M, Emmerson L, Fedak M, Friedlaender A, Gales N, Goebel M, Goetz KT, Guinet C, Goldsworthy SD, Harcourt R, Hinke JT, Jerosch K, Kato A, Kerry KR, Kirkwood R, Kooyman GL, Kovacs KM, Lawton K, Lowther AD, Lydersen C, Lyver PO'B, Makhado AB, Márquez MEI, McDonald BI, McMahon CR, Muelbert M, Nachtsheim D, Nicholls KW, Nordøy ES, Olmastroni S, Phillips RA, Pistorius P, Plötz J, Pütz K, Ratcliffe N, Ryan PG, Santos M, Southwell C, Staniland I, Takahashi A, Tarroux A, Trivelpiece W, Wakefield E, Weimerskirch H, Wienecke B, Xavier JC, Raymond B, Hindell MA. The retrospective analysis of Antarctic tracking data project. *Scientific Data* 7: 94.

Samaai T, Kelly M, Ngwakum B, Payne R, Teske PR, Janson L, Kerwath S, Parker D, Gibbons MJ. 2020. New Latrunculiidae

(Demospongiae, Poecilosclerida) from the Agulhas ecoregion of temperate southern Africa. *Zootaxa* 4896: 409–442.

Samaai T, Pillay R, Janson L. 2020. Suggestion of Spongia (*Heterofibria*) *peddemorsi* as replacement name for *Spongia* (*Heterofibria*) *cooki* Samaai, Pillay & Janson, 2019. *Zootaxa* 4728: 149–149.

Shannon LJ, Ortega-Cisneros K, Lamont T, Winker H, Crawford R, Jarre A, Coll M. 2020. Exploring temporal variability in the Southern Benguela ecosystem over the past four decades using a time-dynamic ecosystem model. *Frontiers in Marine Science* 7: 540.

Sherley RB, Crawford RJM, de Blocq AD, Dyer BM, Geldenhuys D, Hagen C, Kemper J, Makhado AB, Pichegru L, Tom D, Upfold L, Visagie J, Waller LJ, Winker H. 2020. The conservation status and population decline of the African penguin deconstructed in space and time. *Ecology and Evolution* 10: 8506–8516.

Steinfurth A, Oppel S, Dias MP, Starnes T, Pearmain EJ, Dilley BJ, Davies D, Nydegger M, Bell C, Le Bouard F, Bond AL, Cuthbert RJ, Glass T, Makhado AB, Crawford RJM, Ryan PG, Wanless RM, Ratcliffe N. 2020. Important marine areas for the conservation of northern rockhopper penguins within the Tristan da Cunha Exclusive Economic Zone. *Endangered Species Research* 43: 409–420.

Tavares CD, Moura JF, Acevedo-Trejos E, Crawford RJM, Makhado A, Lavers JL, Witteveen M, Ryan PG, Merico A. 2020. Confidence intervals and sample sizes for estimating prevalence of plastic debris in seabird nests. *Environmental Pollution* 263: 114394.

Vargas-Fonseca OA, Kirkman SP, Oosthuizen WC, Bouveroux T, Cockcroft V, Conry DS, Pistorius PA. 2020. Abundance of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) along the south coast of South Africa. *PLoS ONE* 15: e0227085.

Vanstreels RET, Pichegru L, Pfaff MC, Snyman A, Dyer BM, Parsons NJ, Roberts DG, Ludynia K, Makhado A, Pistorius PA. 2020. Seashell and debris ingestion by African penguins. *Emu Austral Ornithology* 120: 90–96.

Williams LL, Lück-Vogel M. 2020. Comparative assessment of the GIS based bathtub model and an enhanced bathtub model for coastal inundation. *Journal of Coastal Conservation* 24: 23.

Wilhelm MR, Black BA, Lamont T, Paulus SC, Bartholomae C, Louw DC. 2020. Northern Benguela *Merluccius paradoxus* annual growth from otolith chronologies used for age verification and as indicators of fisheries-induced and environmental changes. *Frontiers in Marine Science* 7: 315.

Yemane D, Kirkman SP, Samaai T. 2020. Use of openly available occurrence data to generate biodiversity maps within the South African EEZ. *African Journal of Marine Science* 42: 109–121.

Popular articles

Nel R, Harris LR, Sink KJ, Bachoo S, Anders D, Singh S, Snyders L. 2020. Tamsyn the leatherback turtle validates locations of new MPAs in South Africa. *Indian Ocean Turtle Newsletter* 32: 10–16.

Presentations at symposia, conferences and workshops

Carr MD, Lamont T. 2020. Identifying suitable satellite Sea Surface Temperature products for monitoring the Southern African marine region. *Nansen-Tutu 10th Anniversary Symposium: Ocean, weather and climate, science to the service of society, Cape Town, South Africa, 10–12 March 2020.*

Gula J, Tedesco P, Menesguen C, Penven P, Krug M. 2020. The impact of meso and submesoscale frontal eddies on cross-shelf transport in the Gulf Stream and Agulhas Current. *Invited Presentation, Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Gulekana M. 2020. Experience with shipboard capacity building and technology transfer. What are the related opportunities and challenges. Regional workshop – *Pan African and Surrounding Island States – UN Decade of Ocean Science for Sustainable Development (2021–2030), Nairobi, Kenya, 27–29 January 2020.*

Gulekana M. 2020. Innovation for a sustainable ocean. *DFFE National Marine Week Webinar, 13 October 2020.*

Haupt T, Payne R, Nadjim A, Muhando C, Kithakeni T, Samaai T. 2020. Exploring benthic communities of the Western Indian Ocean. *The 5th World Conference on Marine Biodiversity, University of Auckland, Online, 13–16 December 2020.*

Huggett JA. 2020. Report on South African SIBER/IIOE-2 related cruises and outputs. *Sustained Indian Ocean Biogeochemistry and Research (SIBER) 10th Scientific Steering Committee Meeting, Online, 24 March 2020.*

Huggett JA. 2020. Networks, collaboration, capacity building and monitoring programmes in the South-West Indian Ocean. *16th Annual Meeting of Indian Ocean Global Ocean Observing System (IOGOOS), Online, 16 July 2020.*

Kersalé M, Meinen C, Perez R, Le Hénaff M, Valla D, Lamont T, Sato O, Dong S, Terre T, van Caspel M, Chidichimo MP, van den Berg M, Speich S, Piola A, Campos E, Ansorge I, Volkov D, Lumpkin R, Garzoli S. 2020. Temporal variability of the Meridional Overturning Cells in the South Atlantic. *EGU General Assembly 2020, Online, 4–8 May 2020.*

Kersalé M, Perez RC, Meinen CS, Le Hénaff M, Valla D, Lamont T, Sato OT, Speich S, Piola AR, Ansorge IJ, Chidichimo MP, Campos EJ. 2020. Volume Transport Variability of the Atlantic Meridional Overturning Cells at 34.5 °S. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Ketelhake S, Lamont T, van der Lingen C, Payne M, Schmidt J. 2020. Supporting Ecosystems Based Management for Fisheries in Atlantic Upwelling Regions (AtlantOS use case). *6th International Marine Conservation Congress, Online, 17–28 August 2020.*

Kirkman SP. 2020. Ecosystem restoration in the marine and coastal context: practicalities, lessons learned and opportunities. *Biodiversity Research and Evidence Indaba, DFFE, Online, 8–9 September 2020.*

Kirkman SP. 2020. Oceans and coasts research scientific capacity. Status quo: needs, opportunities and plans. *Biodiversity Research and Evidence Indaba, DFFE, Online, 8–9 September 2020.*

Kirkman SP. 2020. MPA project update. *MPA Forum Webinar, Online, 8–9 December 2020.*

Koppelmann R, Martin B, Lamont T, Louw D, Moloto T, Heinatz K, Thomalla S. 2020. Combining in situ and satellite derived proxies of temperature and chlorophyll with microplankton analyses to determine differences at the base of the food web in the northern and southern Benguela Upwelling Systems. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Krug M, Braby L. 2020. Impact of regional and temporal changes in the Agulhas Current's course on coastal and shelf regions. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Krug M, Lamont T. 2020. Variability of the northern Agulhas Current and impact on the coast and shelf. *Western Boundary Current-Subtropical Continental Shelf Interactions Workshop, Virtual Pre-Workshop, 10th and 17th November 2020.*

Lamont T. 2020. Supporting Ecosystem Based Management for Fisheries in Atlantic Upwelling Regions. *All-Atlantic Ocean Observing System (AtlantOS program) Town Hall. Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Lamont T, Barlow RG, Verheye H. 2020. Plankton variability around southern Africa. *Invited Keynote. Nansen-Tutu 10th Anniversary Symposium: Ocean, weather and climate, science to the service of society, Cape Town, South Africa, 10–12 March 2020.*

Lamont T, van den Berg M. 2020. Origin, pathways, and characteristics of deep-ocean mesoscale eddies influencing the shelf seas of a sub-Antarctic Archipelago in the Southern Ocean: The Prince Edward Islands. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Mdluli N, Carrasco N, Harris S, Huggett J, Lombard AT. 2020. Do submarine canyons influence zooplankton communities? A case study from the east coast of South Africa. *The Conservation Symposium, Online, 4–9 November 2020.*

Meinen CS, Kersalé M, Valla D, Lamont T, Sato OT, Perez RC, Le Hénaff M, Dong S, Terre T, Chidichimo MP, van den Berg M, Speich S, Piola AR, Campos EJ, Ansorge IJ. 2020. Variability of the Deep Western and Eastern Boundary Currents and their relationship to the Meridional Overturning Circulation at 34.5°S. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Santamaria-Aguilar S, Lück-Vogel M, Williams LL, Kelln J, Soltau F, Vafeidis AT. 2020. A regional scale assessment of coastal flooding in South Africa. *Coastal Hazards in Africa, Online, 28–29 October 2020.*

Silima R, Veitch, J, Hermes J, Lamont T. 2020 Inter-annual variability of the Southern Benguela Upwelling System. *Nansen-Tutu 10th Anniversary Symposium: Ocean, weather and climate, science to the service of society, Cape Town, South Africa, 10–12 March 2020.*

Sun J, Krug M, Swart S. 2020. Evaluation of Satellite-Derived Sea Surface Temperature (SST) Using Ocean Glider Data in the Agulhas Current System. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Taukoor S, Penven P, Ansorge I, Mashifane T, Lamont T. 2020. How can models contribute to our knowledge on coastal upwelling? *Nansen-Tutu 10th Anniversary Symposium: Ocean, weather and climate, science to the service of society, Cape Town, South Africa, 10–12 March 2020.*

Toolsee T, Lamont T. 2020. Seasonal variation in surface hydrographic conditions around the Prince Edward Islands. *Nansen-Tutu 10th Anniversary Symposium: Ocean, weather and climate, science to the service of society, Cape Town, South Africa, 10–12 March 2020.*

van den Berg M, Lamont T, Ansorge IJ. 2020. Characterising the influence of deep-ocean eddies and fronts on the shelf seas of a sub-Antarctic Archipelago in the Southern Ocean: The Prince Edward Islands. *Ocean Sciences, San Diego California, USA, 16–21 February 2020.*

Published datasets

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (February 1991–July 1991). DFFE. doi: 10.15493/DEA.MIMS.26052270.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (July 1991–November 1991). DFFE. doi: 10.15493/DEA.MIMS.26052271.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (November 1991–March 1992). DFFE. doi: 10.15493/DEA.MIMS.26052272.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (March 1992–July 1992). DFFE. doi: 10.15493/DEA.MIMS.26052273.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (July 1992–November 1992). DFFE. doi: 10.15493/DEA.MIMS.26052274.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (November 1992–May 1993). DFFE. doi: 10.15493/DEA.MIMS.26052275.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (May 1993–November 1993). DFFE. doi: 10.15493/DEA.MIMS.26052276.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (March 1994 - July 1994). DFFE. doi: 10.15493/DEA.MIMS.26052277.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (July 1994–February 1995). DFFE. doi: 10.15493/DEA.MIMS.26052278.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (February 1995–August 1995). DFFE. doi: 10.15493/DEA.MIMS.26052279.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (August 1995–February 1996). DFFE. doi: 10.15493/DEA.MIMS.26052280.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (February 1996–September 1996). DFFE. doi: 10.15493/DEA.MIMS.26052281.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (September 1996–April 1997). DFFE. doi: 10.15493/DEA.MIMS.26052282.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (April 1997–October 1997). DFFE. doi: 10.15493/DEA.MIMS.26052283.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (October 1997–March 1998). DFFE. doi: 10.15493/DEA.MIMS.26052284.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (March 1998–September 1998). DFFE. doi: 10.15493/DEA.MIMS.26052285.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of daily bottom temperatures at Port Nolloth (September 1999–February 2000). DFFE. doi: 10.15493/DEA.MIMS.26052286.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (February 1991–July 1991). DFFE. doi: 10.15493/DEA.MIMS.26052287.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (July 1991–November 1991). DFFE. doi: 10.15493/DEA.MIMS.26052288.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (November 1991–March 1992). DFFE. doi: 10.15493/DEA.MIMS.26052289.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (March 1992–July 1992). DFFE. doi: 10.15493/DEA.MIMS.26052290.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (July 1992–November 1992). DFFE. doi: 10.15493/DEA.MIMS.26052291.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (November 1992–May 1993). DFFE. doi: 10.15493/DEA.MIMS.26052292.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (May 1993–November 1993). DFFE. doi: 10.15493/DEA.MIMS.26052293.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (March 1994–July 1994). DFFE. doi: 10.15493/DEA.MIMS.26052294.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (July 1994–February 1995). DFFE. doi: 10.15493/DEA.MIMS.26052295.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (February 1995–August 1995). DFFE. doi: 10.15493/DEA.MIMS.26052296.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (August 1995–February 1996). DFFE. doi: 10.15493/DEA.MIMS.26052297.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (February 1996–September 1996). DFFE. doi: 10.15493/DEA.MIMS.26052298.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (September 1996–April 1997). DFFE. doi: 10.15493/DEA.MIMS.26052299.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (April 1997–October 1997). DFFE. doi: 10.15493/DEA.MIMS.26052300.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (October 1997–March 1998). DFFE. doi: 10.15493/DEA.MIMS.26052301.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (March 1998–September 1998). DFFE. doi: 10.15493/DEA.MIMS.26052302.

Anders D, van den Berg MA, Lamont T. 2020. Long-term observations of hourly bottom temperatures at Port Nolloth (September 1999–February 2000). DFFE. doi: 10.15493/DEA.MIMS.26052303.

Haupt T, Snyders L, Auerswald L. 2020. Long term monitoring of seawater temperature in the microhabitats of intertidal marine invertebrates in Sea Point. DFFE. doi: 10.15493/DEA.MIMS.26052350.

Krug M. 2020. GINA Seaglider project 2017 (SG547). DFFE. doi: 10.15493/dea.mims.26052144.

Krug M. 2020. Raw Seaglider data collected during GINA 2017 by Seaglider SG547. DFFE. doi: 10.15493/dea.mims.26052145.

Krug M. 2020. Processed Seaglider data collected during GINA 2017 by Seaglider SG547. doi: 10.15493/dea.mims.26052146.

Krug M. 2020. CTD and bottle test data during GINA 2017 for Seaglider SG547 collected in Cape Town harbour. doi: 10.15493/dea.mims.26052147.

Krug M. 2020. Seaglider test data collected during GINA 2017 by Seaglider SG547 in Cape Town harbour. doi: 10.15493/dea.mims.26052148.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052020.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052023.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (April 2016 - April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052026.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052029.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052032.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052035.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052038.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (April 2016–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052041.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052044.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052047.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 1 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052320.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (April 2014–April 2015). DFFE. doi: 10.15493/dea.mims.26052321.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (April 2015–April 2016). DFFE. doi: 10.15493/dea.mims.26052322.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (April 2016–April 2017). DFFE. doi: 10.15493/dea.mims.26052323.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (April 2017–April 2018). DFFE. doi: 10.15493/dea.mims.26052324.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (April 2018–May 2019). DFFE. doi: 10.15493/dea.mims.26052325.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 1 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052326.
Lamont T, van den Berg MA. 2020. Long-term observations of daily currents on the Prince Edward Island shelf at Mooring 2 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052327.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (April 2014–April 2015). DFFE. doi: 10.15493/dea.mims.26052328.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (April 2015–April 2016). DFFE. doi: 10.15493/dea.mims.26052329.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (April 2016–April 2017). DFFE. doi: 10.15493/dea.mims.26052330.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (April 2017–April 2018). DFFE. doi: 10.15493/dea.mims.26052331.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (April 2018–May 2019). DFFE. doi: 10.15493/dea.mims.26052332.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly currents on the Prince Edward Island shelf at Mooring 2 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052333.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052021.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052024.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2016–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052027.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052030.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052033.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052036.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052039.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2016–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052042.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052045.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052048.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052022.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052025.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2016–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052028.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052031.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052034.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2014–April 2015). DFFE. doi: 10.15493/DEA.MIMS.26052037.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2015–April 2016). DFFE. doi: 10.15493/DEA.MIMS.26052040.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2016–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052043.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2017–April 2018). DFFE. doi: 10.15493/DEA.MIMS.26052046.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (April 2018–May 2019). DFFE. doi: 10.15493/DEA.MIMS.26052049.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 1 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052346.
Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 1 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052347.
Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures on the Prince Edward Island shelf at Mooring 2 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052348.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures on the Prince Edward Island shelf at Mooring 2 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052349.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (April 2014–April 2015). DFFE. doi: 10.15493/dea.mims.26052334.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (April 2014–April 2015). DFFE. doi: 10.15493/dea.mims.26052335.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (April 2015–April 2016). DFFE. doi: 10.15493/dea.mims.26052336.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (April 2015 - April 2016). DFFE. doi: 10.15493/dea.mims.26052337.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (April 2016–April 2017). DFFE. doi: 10.15493/dea.mims.26052338.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (April 2016–April 2017). DFFE. doi: 10.15493/dea.mims.26052339.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (April 2017–April 2018). DFFE. doi: 10.15493/dea.mims.26052340.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (April 2017–April 2018). DFFE. doi: 10.15493/dea.mims.26052341.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (April 2018–May 2019). DFFE. doi: 10.15493/dea.mims.26052342.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (April 2018–May 2019). DFFE. doi: 10.15493/dea.mims.26052343.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 1 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052344.

Lamont T, van den Berg MA. 2020. Raw ADCP data for long-term observations of currents on the Prince Edward Island shelf at Mooring 2 (May 2019–April 2020). DFFE. doi: 10.15493/dea.mims.26052345.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 3 (July 2014–December 2014). DFFE. doi: 10.15493/DEA.MIMS.26052051.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 4 (July 2014–December 2014). DFFE. doi: 10.15493/DEA.MIMS.26052054.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 4 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052057.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 4 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052060.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 7 (September 2014–November 2015). DFFE. doi: 10.15493/DEA.MIMS.26052063.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 7 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052066.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 7 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052069.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 8 (September 2014 - November 2015). DFFE. doi: 10.15493/DEA.MIMS.26052072.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 8 (December 2015 - April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052075.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 8 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052079.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents measured by DVS at SAMBA Mooring 8 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052076.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents measured by DVS at SAMBA Mooring 8 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052080.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 9 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052083.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 9 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052086.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 9 (April 2017–May 2018). DFFE. doi: 10.15493/DEA.MIMS.26052090.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents measured by DVS at SAMBA Mooring 9 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052087.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents measured by DVS at SAMBA Mooring 9 (April 2017–May 2018). DFFE. doi: 10.15493/DEA.MIMS.26052091.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 10 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052094.

Lamont T, van den Berg MA. 2020. Long-term observations of daily currents along the SAMBA transect at SAMBA Mooring 10 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052097.

Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures along the SAMBA transect at SAMBA Mooring 3 (July 2014–December 2014). DFFE. doi: 10.15493/DEA.MIMS.26052052.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures along the SAMBA transect at SAMBA Mooring 3 (July 2014–December 2014). DFFE. doi: 10.15493/DEA.MIMS.26052053.

Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (July 2014–December 2014). DFFE. doi: 10.15493/DEA.MIMS.26052055.

Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052058.

Lamont T, van den Berg MA. 2020. Long-term observations of daily bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052061.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (July 2014 - December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052056.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (November 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052059.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly bottom temperatures along the SAMBA transect at SAMBA Mooring 4 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052062.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (September 2014–November 2015). DFFE. doi: 10.15493/DEA.MIMS.26052064.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052065.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052067.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052068.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052070.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 7 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052071.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (September 2014–November 2015). DFFE. doi: 10.15493/DEA.MIMS.26052073.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052074.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052077.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052078.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052081.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 8 (April 2017–October 2018). DFFE. doi: 10.15493/DEA.MIMS.26052082.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052084.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052085.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052088.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052089.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (April 2017–May 2018). DFFE. doi: 10.15493/DEA.MIMS.26052092.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 9 (April 2017–May 2018). DFFE. doi: 10.15493/DEA.MIMS.26052093.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 10 (September 2014–November 2015). DFFE. doi: 10.15493/DEA.MIMS.26052095.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 10 (September 2014–December 2015). DFFE. doi: 10.15493/DEA.MIMS.26052096.

Lamont T, van den Berg MA. 2020. Long-term observations of daily subsurface temperatures along the SAMBA transect at SAMBA Mooring 10 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052098.

Lamont T, van den Berg MA. 2020. Long-term observations of hourly subsurface temperatures along the SAMBA transect at SAMBA Mooring 10 (December 2015–April 2017). DFFE. doi: 10.15493/DEA.MIMS.26052099.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052104.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052105.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052106.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052107.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052108.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052109.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052110.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052111.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P4 (July 2011–October 2011). DFFE. doi: 10.15493/dea.mims.26052112.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (September 2010–January 2011). DFFE. doi: 10.15493/dea.mims.26052113.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (May 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052114.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (July 2014–June 2015). DFFE. doi: 10.15493/dea.mims.26052115.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily currents on the continental shelf and slope off Port Edward along the east coast of South Africa at location P6 (July 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052116.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of currents measured by DVS on the continental shelf and slope off Port Edward along the east coast of South Africa at location P6 (July 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052117.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052118.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052119.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052120.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052121.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052122.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P1 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052123.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052124.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052125.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052126.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052127.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052128.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P2 (April 2006–September 2006). DFFE. doi: 10.15493/dea.mims.26052129.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052130.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052131.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (September 2005–December 2005). DFFE. doi: 10.15493/dea.mims.26052132.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly bottom temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P3 (December 2005–April 2006). DFFE. doi: 10.15493/dea.mims.26052133.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P4 (July 2011–October 2011). DFFE. doi: 10.15493/dea.mims.26052134.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P4 (July 2011–October 2011). DFFE. doi: 10.15493/dea.mims.26052135.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (September 2010–January 2011). DFFE. doi: 10.15493/dea.mims.26052136.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (May 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052137.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (July 2014–June 2015). DFFE. doi: 10.15493/dea.mims.26052138.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (September 2010–January 2011). DFFE. doi: 10.15493/dea.mims.26052139.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (May 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052140.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P5 (July 2014–June 2015). DFFE. doi: 10.15493/dea.mims.26052141.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of daily sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P6 (July 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052142.

Louw GS, van den Berg MA, Lamont T. 2020. Short-term observations of hourly sub-surface temperatures on the continental shelf and slope off Port Edward, along the east coast of South Africa at location P6 (July 2011–December 2011). DFFE. doi: 10.15493/dea.mims.26052143.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 088, December 2000. DFFE. doi: 10.15493/dea.mims.26000006.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 089, January 2001. DFFE. doi: 10.15493/dea.mims.26000004.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 091, February 2001. DFFE. doi: 10.15493/dea.mims.26000007.

Pillay K, Worship MM. 2020. Raw Bongo (U4) dip data from the St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 091, February 2001. DFFE. doi: 10.15493/dea.mims.26500013.

Pillay K, Worship MM. 2020. Validated Bongo (U4) dip data from the St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 091, February 2001. DFFE. doi: 10.15493/dea.mims.26500014.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 181, August 2003. DFFE. doi: 10.15493/dea.mims.26000001.

Pillay K, Worship MM. 2020. Raw Bongo (U4) dip data from the St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 181, August 2003. DFFE. doi: 10.15493/dea.mims.26500010.

Pillay K, Worship MM. 2020. Validated Bongo (U4) dip data from the St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 181, August 2003. DFFE. doi: 10.15493/dea.mims.26500011.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 189, February 2004. DFFE. doi: 10.15493/dea.mims.26000015.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 216, March 2006. DFFE. doi: 10.15493/dea.mims.26000008.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 222, August 2006. DFFE. doi: 10.15493/dea.mims.26000005.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 230, February 2007. DFFE. doi: 10.15493/dea.mims.26000000.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 234, July 2007. DFFE. doi: 10.15493/dea.mims.26000003.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RS *Ellen Kuzwayo* Voyage 005, January 2008. DFFE. doi: 10.15493/dea.mims.26000002.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 249, January 2009. DFFE. doi: 10.15493/dea.mims.26000009.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RS *Ellen Kuzwayo* Voyage 037, April 2009. DFFE. doi: 10.15493/dea.mims.26000014.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RS *Ellen Kuzwayo* Voyage 057, March 2010. DFFE. doi: 10.15493/dea.mims.26000013.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 269, January 2011. DFFE. doi: 10.15493/dea.mims.26500000.

Pillay K, Worship MM. 2020. Raw Bongo (U4) dip data from St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 269, January 2011. DFFE. doi: 10.15493/dea.mims.26500001.

Pillay K, Worship MM. 2020. Validated Bongo (U4) dip data from St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 269, January 2011. DFFE. doi: 10.15493/dea.mims.26500002.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the FRS *Africana* Voyage 271, February 2011. DFFE. doi: 10.15493/dea.mims.26000012.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RS *Ellen Kuzwayo* Voyage 085, March 2011. DFFE. doi: 10.15493/dea.mims.26000011.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line (SHBML) on the RV *Algoa* Voyage 183, April 2011. DFFE. doi: 10.15493/dea.mims.26052314.

Pillay K, Worship MM. 2020. St Helena Bay Monitoring Line

(SHBML) on the RS *Ellen Kuzwayo* Voyage 105, January 2012. DFFE. doi: 10.15493/dea.mims.26000010.

Pillay K, Worship MM. 2020. Integrated Ecosystem Programme: Southern Benguela (IEP:SB) on the RV *Algoa* Voyage 259, May 2019. DFFE. doi: 10.15493/dea.mims.26500006.

Pillay K, Worship MM. 2020. Integrated Ecosystem Programme: Southern Benguela (IEP:SB) on the RV *Algoa* Voyage 267, November 2019. DFFE. doi: 10.15493/dea.mims.26500008.

Tutt G, Lamont T. 2020. Processed CTD continuous observations from the FRS *Africana* Voyage 006, February 1983. DFFE. doi: 10.15493/dea.mims.26052362.

Tutt G, Lamont T. 2020. Processed CTD discrete observations from the FRS *Africana* Voyage 006, February 1983. DFFE. doi: 10.15493/dea.mims.26052363.

Tutt G, Lamont T. 2020. Raw CTD continuous observations from the FRS *Africana* Voyage 006, February 1983. DFFE. doi: 10.15493/dea.mims.26052364.

Tutt G, Lamont T. 2020. Raw CTD discrete observations from the FRS *Africana* Voyage 006, February 1983. DFFE. doi: 10.15493/dea.mims.26052365.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2013 Marion Relief Voyage on SA *Agulhas* Voyage 007. DFFE. doi: 10.15493/dea.mims.26052149.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2014 Marion Relief Voyage on SA *Agulhas* Voyage 011. DFFE. doi: 10.15493/dea.mims.26052150.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2014 Marion Relief Voyage on SA *Agulhas* Voyage 011. DFFE. doi: 10.15493/dea.mims.26052151.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2015 Marion Relief Voyage on SA *Agulhas* Voyage 015. DFFE. doi: 10.15493/dea.mims.26052152.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2015 Marion Relief Voyage on SA *Agulhas* Voyage 015. DFFE. doi: 10.15493/dea.mims.26052153.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2016 Marion Relief Voyage on SA *Agulhas* Voyage 019. DFFE. doi: 10.15493/dea.mims.26052154.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2016 Marion Relief Voyage on SA *Agulhas* Voyage 019. DFFE. doi: 10.15493/dea.mims.26052155.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2017 Marion Relief Voyage on SA *Agulhas* Voyage 024. DFFE. doi: 10.15493/dea.mims.26052156.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2017 Marion Relief Voyage on SA *Agulhas* Voyage 024. DFFE. doi: 10.15493/dea.mims.26052157.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2019 Marion Relief Voyage on SA *Agulhas* Voyage 036. DFFE. doi: 10.15493/dea.mims.26052158.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2019 Marion Relief Voyage on SA *Agulhas* Voyage 036. DFFE. doi: 10.15493/dea.mims.26052159.

van den Berg MA. 2020. Raw Expendable Bathythermograph (XBT) casts collected during the 2020 Marion Relief Voyage on SA *Agulhas II* Voyage 042. DFFE. doi: 10.15493/dea.mims.26052161.

van den Berg MA. 2020. Processed Expendable Bathythermograph (XBT) casts collected during the 2020 Marion Relief Voyage on SA *Agulhas II* Voyage 042. DFFE. doi: 10.15493/dea.mims.26052162.

van den Berg MA. 2020. Marion Island Relief Voyage on the SA *Agulhas II* Voyage 042, April 2020. DFFE. doi: 10.15493/dea.mims.26052160.

Published models

Williams LL. 2020. Coastal Inundation (eBTM with variable surface roughness input). DFFE. doi: 10.15493/DFFE.10000005.

Technical reports

Harris LR, Sink KJ, Holness SD, Kirkman SP, Driver A. 2020. *National Coastal and Marine Spatial Biodiversity Plan, Version 1.0 (Beta 2)*: Technical Report. South African National Biodiversity Institute, South Africa, 105 pp.

Kirkman SP, Huggett JA. 2020. *South Africa's Oceans and Coasts Annual Science Report, 2019*. Oceans and Coasts, DFFE, Report 19, March 2020. ISBN: 978-0-621-48531-8, 48 pp.

Theses

Heye S. 2020. Impact of Agulhas Current Mesoscale Variability on surface dispersion in the KwaZulu-Natal Bight. BSc Honours Thesis (Oceanography), University of Cape Town, Cape Town, 32 pp.

Morris T. 2020. Downstream evolution of ocean properties and associated fluxes in the greater Agulhas Current system: Ad hoc Argo experiments and modeling. PhD Thesis (Oceanography), University of Cape Town, Cape Town, South Africa, 113 pp.

Naidoo AD. 2020. Ocean Governance in South Africa: Policy and Implementation. PhD Thesis (Economic and Management Sciences), University of the Western Cape, Cape Town, 335 pp.

Rambaran R. 2020. Defining the potential ecological roles of three sea turtle species (*Caretta caretta*, *Chelonia mydas* and *Eretmochelys imbricata*) along the eastern seaboard of South Africa. MSc Thesis (Zoology), Nelson Mandela University, Port Elizabeth, 91 pp.

Toolsee T. 2020. Seasonal variability of surface hydrographic conditions around the Prince Edward Islands. BSc Honours Thesis (Oceanography), University of Cape Town, Cape Town, 76 pp.

Williams LL. 2020. Developing a spatial risk profile: Assessing building vulnerability to extreme coastal inundation hazard. PhD Thesis (Geography and Environmental Studies), Stellenbosch University, Stellenbosch, Cape Town, 170 pp.

GLOSSARY OF TERMS, ABBREVIATIONS AND ACRONYMS

Term	Explanation	Report no.
Antarctic Circumpolar Current	The world's largest system of ocean currents that flow from west to east along a roughly 25 000 km path around Antarctica.	2, 8, 10
Acoustic	Refers to the use of underwater sound to study the sea (e.g. currents, water masses), its boundaries (e.g. bathymetry), and its contents (e.g. pelagic fish biomass).	7, 22, 24
ACT/ASCA	Agulhas Current Time-series (ACT) / Agulhas System Climate Array (ASCA). An array of moored instruments designed to measure current velocity, temperature, and salinity throughout the water column on the east coast of South Africa. ASCA is a continuation and expansion of ACT, which measured the velocity of the Agulhas Current over a three-year period, between 2010 and 2013.	27
Adaptation	A change in structure, function, or behaviour, whereby a species or individual improves its chance of survival in a specific environment.	19
ADCP	Acoustic Doppler Current Profiler. A hydroacoustic instrument that uses a principle of sound waves (called the Doppler effect) to measure water current velocities over a depth range.	24
Agulhas Bank	A wide, shallow part of the southern African continental shelf extending up to 250 km south of Cape Agulhas before falling steeply to the abyssal plain.	5, 7, 13, 14
Agulhas Current	The Western Boundary Current of the Southwest Indian Ocean, which flows poleward along the South African east coast and then turns back on itself (i.e. retroflects) to flow eastward.	12, 13, 14, 26, 27
Agulhas Retroflection	The area at the southwestern extreme of the Agulhas Current, where the current turns back on itself and continues flowing eastward.	13
Anoxia	Severe depletion of oxygen within the water column.	4
APF	Antarctic Polar Front. One of the three major Southern Ocean fronts, located in the central part of the Antarctic Circumpolar Current, and separating cooler Antarctic waters from the relatively warmer sub-Antarctic waters.	1, 8, 9
Anticyclonic eddies	Coherent vortices characterised by counter-clockwise circulation around a centre in the southern hemisphere, and clockwise circulation in the northern hemisphere.	9, 10, 11, 15, 25
Aquaculture Research	Aquaculture Research, Department of Forestry, Fisheries and the Environment	4
Aragonite	A common, naturally occurring crystal form of calcium carbonate, $CaCO_3$. The measure of its concentration is seawater (Ωaragonite is used to track ocean acidification).	4
AWS	Automatic Weather Station. An instrument that automatically records and transmits meteorological observations, including wind speed and direction, air temperature, humidity, air pressure, and rainfall.	23
Bathtub model	A GIS-based model that estimates the area of coastal inundation for storm surges.	19

Term	Explanation	Report no.
Bathymetry	Underwater depths of ocean-, lake- or sea floors; equivalent to underwater topography.	9
Benguela Current	The Eastern Boundary Current of the South Atlantic Ocean, which flows equatorward along the South African west coast.	20
Benguela Jet	Often also referred to as the Good Hope Jet. It is an intensified northward-flowing current at the continental shelf edge, usually between the 200 and 500 m isobaths.	24, 27
Benguela Upwelling System(BUS)	Wind-driven coastal upwelling system along the west coasts of South Africa, Nambia, and Angola.	3, 5, 24
Benthic	Anything associated with or occurring on the bottom of a body of water.	10
Biodiversity	The variety of living organisms on earth, or more specifically within regions or ecosystems.	15, 16, 20, 21
Biomass	The total mass of living organisms in a given area.	5, 6, 7, 11, 14, 15
Biota	All living organisms, e.g. of a region or a period.	2, 9, 12, 13, 14
Biotic	Relating to living organisms (biota).	16
Biovolume	The volume of living organisms in a unit amount, e.g. of seawater.	7, 14, 15
Bottom-up control	Control of ecosystem structure and functioning by nutrient supply and primary production (e.g. by physical oceanography and phytoplankton).	7
Calcifying	Hardening of body tissue due to deposition of calcium carbonate.	4
Cape Basin	An oceanic basin in the Southeast Atlantic Ocean, to the southwest of the South African Western Cape Region.	22, 27
CapeNature	A public conservation agency with the statutory responsibility for biodiversity conservation in the Western Cape Province of South Africa.	28
CBA	Critical Biodiversity Area. Area required to meet biodiversity targets for ecosystems, species and ecological processes, as identified in a systematic biodiversity plan.	21
CBD	Convention on Biological Diversity. A multilateral treaty with three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from genetic resources.	20
Cetacean	A member of a group of aquatic mammals that includes whales and dolphins.	18
Chaetognaths	Small, transparent marine worms commonly known as arrow worms. These worms are planktonic predators that feed on other planktonic organisms.	14, 15
Chlorophyll *a*	A specific form of chlorophyll, which is any of the several green pigments that enable the absorption of energy from light by photosynthesizing plants or algae. Chlorophyll *a* is used as an indicator of phytoplankton biomass and abundance. It can be measured or estimated using a variety of methods ranging from direct extraction in a laboratory, or by indirectly using *in situ*	5, 6, 14, 15

Term	Explanation	Report no.
	instruments or satellite sensors which rely on the principles of absorption, scattering, and fluorescence.	
Climate change	A long-term change in global or regional climate patterns. Changes since the early 20th century are mainly driven by human activities, particularly fossil fuel burning, and are commonly referred to as global warming. Natural processes, including internal variability (cyclic patterns such as El Niño, La Niña, Southern Annular Mode, etc.) and external forcing (such as volcanic activity, changes in the Earth's orbit, variations in the Sun's energy output), can also contribute to climate change.	4, 12, 19
CMEMS	Copernicus Marine Environment Monitoring Service. Implemented and operated by Mercator Ocean International, CMEMS provides oceanographic products and services for maritime safety, coastal and marine environment, climate and weather forecasting and marine resources users.	27
Copepods	Small crustaceans that are food to many organisms. Many are planktonic and are usually the dominant component of zooplankton communities.	7, 14, 15
CPUT	Cape Peninsula University of Technology.	14
CROCO	Coastal and Regional Ocean COmmunity model. A modelling platform for the regional and coastal ocean using realistic or idealised multiscale approaches.	26
CSIR	Council for Scientific and Industrial Research.	19
Cyclonic eddies	Coherent vortices characterised by clockwise circulation around a centre in the southern hemisphere, and counter clockwise circulation in the northern hemisphere.	9, 10, 11, 13, 15, 25
Data assimilation	A process in which available information from a variety of sources is used to estimate as accurately as possible the state of a system. In oceanography, this includes both direct observational data and output from numerical models.	27
DFFE	The Department of Forestry, Fisheries and the Environment	4, 18, 21, 22, 24, 28
Deoxygenation	The reduction of the oxygen content of the oceans, primarily as a consequence of human activities.	4
Digital surface model	A model representing the earth's surface and all objects on it.	19
Digital terrain model	A 3D computer graphics representation of elevation data to represent terrain.	19
Doppler shift	The change in frequency of any kind of light or sound wave produced by a moving source in relation to an observer.	24
Downwelling	The accumulation and sinking of higher density surface waters beneath lower density subsurface waters.	11
Eastern Boundary Currents	Equatorward-flowing ocean currents on the eastern side of all major ocean basins (adjacent to the west coasts of major continents), which transport cold water from higher latitudes to lower latitudes. Examples include the Benguela Current off Southern Africa, the California Current off North America, the Canary Current off northern Africa, and the Humboldt Current off South America.	4

Term	Explanation	Report no.
Eastern Boundary Upwelling Ecosystems (EBUEs)	Wind-driven upwelling systems at the eastern margins of all major oceans, which bring nutrient-rich water to the coasts, rendering these regions the ocean's most productive ecosystems that support *ca*. 20% of the world's fish landings.	3
EBSA	Ecologically or Biologically Significant Marine Area. An area of the ocean that has special importance in terms of its ecological and biological characteristics: for example, by providing essential habitats, food sources or breeding grounds for particular species.	20, 21
Ecosystem	A community of living organisms and non-living components functioning as a system.	2, 4, 5, 6, 9, 13, 14, 15, 20, 21, 24
Ecosystem Services	Services, products or processes provided by the natural environment that directly or indirectly benefit humans.	20
EEZ	Exclusive Economic Zone. The area of sea extending 200 nautical miles to seaward from the coast, in which a sovereign state has special rights regarding the exploration and use of marine resources.	20, 27
Ekman currents/ drift/transport	Surface currents/flows that develop in response to steady wind forcing. In the southern hemisphere, the Coriolis effect deflects the wind-generated surface current to the left of the direction of the wind.	3, 8
ENSO	El Niño-Southern Oscillation. A recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean, which directly affects the atmospheric circulation and rainfall in the tropics, and can have a strong influence on air and sea temperatures and rainfall worldwide.	8
EOV	Essential Ocean Variable. Variables that have been defined as essential for ocean observation in a global context. They include ocean physics, biogeochemistry, ocean biology and ecosystem variables.	7
ERA5	A global reanalysis dataset that provides hourly estimates of a large number of atmospheric, land and oceanic climate variables.	23
ESA	Ecological Support Area. A CBA map category which plays an important role in supporting the ecological functioning of CBAs and/or in delivering ecosystem services.	21
Euphausiids	Small shrimp-like crustaceans; krill.	15
Fisheries Management Research	Fisheries Management Research, Department of Forestry, Fisheries and the Environment	28
Geomagnetic	Of, or relating to, the magnetic field of the earth.	18
Geostrophic Currents	Oceanic currents that follow surfaces with a constant pressure.	1, 8
GIS	Geographic Information System. A framework for capturing and analysing spatial and geographic data, by organising layers of information into visualisations using maps and 3D scenes.	19
Global thermohaline circulation	A global system of currents that spans all ocean basins and is driven by differences in water density, which is controlled by fluctuations in temperature (thermo) and salinity (haline).	22

Term	Explanation	Report no.
GLORYS	Global Ocean Reanalysis and Simulation. A global ocean reanalysis product that objectively combines the outputs of a numerical ocean general circulation model, which simulates the evolution of ocean physical properties with observations to generate a synthesised estimate of the state of the ocean. It is produced by Mercator Ocean as part of the Copernicus Marine Environment Monitoring Service (CMEMS) framework.	27
GOOS	Global Ocean Observing System. A sustained, collaborative system of ocean observations, encompassing *in situ* networks, satellite systems, governments, United Nations agencies and individual scientists.	7
Hydrodynamic models	Efficient, comprehensive numerical computational systems that are able to simulate water dynamics in coastal and open ocean environments.	19
Hydrographic	Of, or relating to, the hydrography of the ocean over time.	1, 8
Hydrography	The science that measures and describes the physical features of water bodies and their adjacent land areas.	22
Hypoxia	State of low or depleted oxygen in a water body.	4
IEP	Integrated Ecosystem Programme. Scientific monitoring programme for the Southern Benguela region coordinated by DFFE: O&C Research. The programme includes quarterly research cruises.	24
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer (French Research Institute for Exploitation of the Sea). An oceanographic institution in France.	22
In situ	In its original place. In marine science, this term is mostly used for measurements taken directly in the sea, as opposed to those from remote sensing.	2, 4, 8, 13, 23, 27
Intertidal	Referring to the area at the rim of oceans that is above water level at low tide and under water at high tide.	16
IRD	Institut de Recherche pour le Développement (Institute of Research and Development). A French public research institution with representatives in many developing countries.	15
Isobath	An imaginary line on a map or chart that connects all points with the same depth below a water surface.	10, 12, 24
IUCN	International Union for the Conservation of Nature. An international organisation working in the field of nature conservation and sustainable use of natural resources.	17, 18
IUCN Red List	A comprehensive record of the global conservation status of biological species and subspecies, published by the IUCN.	17, 18
LACCE	Location of the Agulhas Current's Core and Edges. A tool for the daily monitoring of the Agulhas Current's core and edges.	13
Lagrangian	A way of looking at fluid motion where the observer follows individual fluid parcels as they move through space and time.	26
Larvaceans	Free swimming tunicates that are filter feeders and exist throughout the world's oceans within the pelagic zone.	14

Term	Explanation	Report no.
LiDAR	Light Detection and Ranging. A remote sensing method that measures distances by using light in the form of a pulsed laser.	19
Limpets	A group of aquatic snails that exhibit a conical shell shape and a strong muscular foot.	16
LMD	Laboratoire de Météorologie Dynamique (Dynamic Meteorology Laboratory). A French public research laboratory dedicated to the study of climate, pollution and planetary atmospheres.	22
Lüderitz cell	The largest upwelling cell within the Benguela Upwelling System, hydrographically separating the northern part (off Namibia and Angola) from the southern part (off South Africa).	5
MARISMA	Marine Spatial Management and Governance Programme. MARISMA promotes sustainable ocean use in the Benguela Current region by focusing on the implementation of Marine Spatial Planning practices. The programme is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, the Benguela Current Convention (BCC) and its member states Namibia, Angola and South Africa. It is implemented by the German Development cooperation in partnership with the BCC.	20, 21
Marxan	Decision-support software designed to help systematic reserve design based on conservation planning.	21
Mercator Ocean	A French centre for forecasting and analysis of the global ocean.	26, 27
Meridional	Of, or relating to, meridians, which are the imaginary lines that connect the north and south poles and indicate changes in longitude.	1, 2, 9, 22
Mesoscale eddies	Hydrodynamic instabilities in the ocean that form circular current features (eddies) with diameters of 10s–100s km that persist from days to months. Mesoscale eddies are ubiquitous in the ocean, they penetrate deep in the water column and can be cyclonic or anticyclonic depending on the direction of the current.	1, 2, 9, 10, 11, 14, 25, 27
MIMS	Marine Information Management System.	
MODIS	Moderate Resolution Imaging Spectroradiometer. An instrument aboard the Terra and Aqua satellites that views the entire Earth's surface every one to two days, measuring multiple parameters to improve our understanding of dynamics and processes occurring on land, in the oceans, and in the lower atmosphere.	5
MPA	Marine Protected Area. A geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives.	11, 16, 20, 21 28
MSP	Marine Spatial Planning. A governance process of collaboratively assessing and managing the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives.	20, 21
N-APF	Northern branch of the Antarctic Polar Front.	1, 8
Normalised Biovolume Size Spectrum	A size-based approach for assessing and comparing plankton communities, providing information on trophic state, productivity, and total biovolume (biomass).	15
Necropsy	An autopsy to understand the cause of death.	18

Term	Explanation	Report no.
NMU	Nelson Mandela University.	15, 20, 21
No-take area	An area where no extractive activity (e.g. fishing) is allowed.	16
NOAA	National Oceanic and Atmospheric Administration. An American scientific agency within the United States Department of Commerce that focuses on the conditions of the oceans, major waterways, and the atmosphere.	22
Numerical model	A mathematical model that is designed to simulate and reproduce the physical (or other) behaviour of a particular system, such as the ocean system, based on relevant hypotheses and simplifying assumptions.	26, 27
O&C Research	Department of Forestry, Fisheries and the Environment, Branch: Oceans & Coasts, Chief Directorate: Oceans & Coasts Research.	18, 23
Ocean Acidification	The ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide from the atmosphere.	4, 12
OCIMS	Oceans and Coastal Information Management System. A national decision support system for the effective governance of South Africa's Oceans and Coasts.	25, 26
Ostracods	A class of small crustaceans, also known as seed shrimps, which may be found in planktonic or benthic communities, and are common in the fossil record.	14
PEIs	Prince Edward Islands. Collective name for two South African sub-Antarctic islands, Marion Island and Prince Edward Island.	1, 2, 8, 9, 10, 11
Pelagic	Relating to or living in the water column of the open ocean.	6, 7, 15, 17
pH	A measure of how acidic or alkaline liquid solutions are. The range is from 0 (extremely acidic) to 14 (extremely alkaline). Solutions with a pH of 7 are neutral (e.g. pure water). The pH of seawater is typically limited to a range between 7.5 and 8.4.	4
Phytoplankton	Microscopic algae that comprise the photosynthesising component of the plankton community and form the base of several marine and freshwater ecosystems.	5, 6, 14
PIES	Pressure-equipped Inverted Echo Sounders. Oceanographic instruments that measure the average speed of sound in the water column.	22
Planktivorous	Feeding on plankton.	7
Plankton	A diverse group of unicellular and multi-cellular organisms that are unable to propel themselves against currents and therefore drift with them. More than 90% of the biomass in the oceans is planktonic.	6, 7, 11, 14
Primary production	The formation of chemical energy in organic compounds by living organisms from atmospheric or aqueous carbon dioxide. Most primary production in the ocean is derived from photosynthesis by algae (mostly phytoplankton), which require nutrients and light for growth. All life on earth relies on primary production, either directly or indirectly.	9
Productivity	The rate of production of new biomass by an individual, population, or community, such as primary production by phytoplankton and secondary production by zooplankton.	2, 3, 4, 5, 6, 14

Term	Explanation	Report no.
Real-time	An event or function that is detected or processed instantaneously.	25
Reanalysis	A systematic approach to produce data sets for climate monitoring and research. These data sets are created by assimilating climate observations using the same climate model throughout the reanalysis period in order to reduce the effects of modelling changes on climate statistics.	8, 23, 27
Rocky shore	An intertidal ecosystem found along the coastline where solid rock prevails.	16
S-ADCP	Ship-mounted Acoustic Doppler Current Profiler.	24
SAEON	South African Environmental Observation Network.	12, 13 14, 25, 26, 27
SAMBA	SAMOC Basin-wide Array. A SAMOC observation system at 34.5°S that consists of a variety of deployed instruments and cruises that span the South Atlantic basin, between South Africa and Brazil.	22, 27
SAMOC	South Atlantic Meridional Overturning Circulation, i.e. the portion of the Meridional Overturning Circulation (MOC) in the South Atlantic Ocean. The MOC is a three-dimensional circulation system that encompasses all ocean basins, but is centred in the Atlantic Ocean. It carries the majority of the oceanic components of the global transport of mass, heat, and salt, and thus has profound impacts on global and regional climate.	22
SANBI	South African National Biodiversity Institute.	20, 21
Satellite altimetry	A method of satellite remote sensing which measures the time taken for a radar pulse to travel from the satellite to the Earth's surface and back again, and is used to map the topography of the surface.	2, 9, 10, 11, 13
SAWS	South African Weather Service.	14
Sea Level Anomaly	The difference between the total sea level and the average sea level for any particular given time.	25
Sea level rise	An increase in the world's sea level due to the effects of global warming.	12
Seamount	A large geological landform that rises from the ocean floor but does not break the ocean's surface.	15, 20
SeaWiFS	Sea-viewing Wide Field-of-view Sensor. A satellite-borne sensor designed to collect ocean biological data. It was active from September 1997 to December 2010, with the primary mission of measuring chlorophyll *a* produced by marine phytoplankton from space.	5
Shelf	Relatively shallow oceanic region surrounding continents and islands. Shelf regions have different oceanographic and ecological processes to the open ocean.	1, 2, 8, 9, 10, 12, 14, 26, 27
SOMISANA	Sustainable Ocean Modelling Initiative: a South African Approach. An operational ocean modelling initiative with a vision to facilitate the local development and sustainability of an operational ocean current forecast system for the South African EEZ, and to do so in a transformative fashion.	27

Term	Explanation	Report no.
South Atlantic High Pressure Cell	A semi-permanent atmospheric pressure high system centred at about 25°S; 15°W in the Atlantic Ocean.	3
Southern Annular Mode	A low-frequency mode of atmospheric variability of the southern hemisphere that captures north-south variations in the belt of strong westerly winds or low pressure surrounding Antarctica.	8
Southwest Indian Ridge	A mid-ocean ridge located along the floors of the Southwest Indian Ocean and Southeast Atlantic Ocean.	9
S-SAF	Southern branch of the sub-Antarctic Front.	1, 2, 8, 9
SST	Sea Surface Temperature.	6, 8, 12, 13, 14, 26, 27
Statistically insignificant	Results of statistical analyses that are more likely to have occurred due to chance. A p-value of > 0.05 is usually taken to indicate that a test result is statistically insignificant.	8
Statistically significant	Results from statistical analyses that cannot be explained by chance alone. A p-value of < 0.05 is usually taken to indicate that a test result is statistically significant.	10, 13, 16
Stranding	When one or more cetaceans are found on a beach, either in a live or dead state.	18
sub-Antarctic	Relating to the region (46–60°S) immediately north of the Antarctic region.	1, 2, 8, 9, 11
sub-Antarctic Front	The northern boundary of the Antarctic Circumpolar Current in the Southern Ocean.	1, 2, 8, 9
Taylor column	A fluid dynamics phenomenon that occurs as a result of the Coriolis effect.	2
Time series	A sequence of data points arranged along a chronological axis. In environmental sciences, time series are used to monitor changes in the environment, and to understand processes and cause-effect relationships.	1, 3, 4, 6, 7, 8, 12, 27
Top-down control	Control of the community and structure and dynamics of ecosystems by top predators.	7
Trophic level	The position an organism occupies within a food web. A food chain is a succession of organisms that eat other organisms and may, in turn, be eaten themselves.	7
UCT	University of Cape Town.	8, 22, 28
Upwelling	An oceanographic phenomenon involving the movement of dense, cooler, nutrient-rich waters from depth toward the ocean surface, replacing the warmer, usually nutrient-depleted waters at the surface.	3, 4, 5, 6, 11, 14, 15, 17, 24
Upwelling cell	A localised area of intense upwelling of subsurface water.	3, 5
Western Boundary Current	Narrow, deep-reaching and fast-flowing poleward currents at the western boundaries of ocean basins. They transport warm waters from the tropics towards the poles and can be found adjacent to the eastern coastline of all continents.	12, 13, 14
Zooplankton	Heterotrophic plankton that consist of microscopic organisms and the immature stages of larger animals, such as fish and rocky shore invertebrates.	7, 14, 15