State OF THE Bay 2017

Saldanha Bay and Langebaan Lagoon

ANCHOR environmental

Saldanha Bay Water Quality Trust

Foreword

The residents living in and around Saldanha Bay and Langebaan Lagoon are truly blessed to have such a unique ecological wonder on their doorstep. Visitors to our region continually confirm this view. It has taken millennia of natural processes to provide this phenomenon. The advent of man and his need to develop, almost at all costs, has the potential to destroy this gift within a short time. The question is – *how do we balance the need to conserve our natural heritage with the requirement to develop and prosper economically*?

There is no simple answer to this very basic question. The conservationists have shouted their 'green' messages from the tree tops whilst the industrialists have simply argued the need to 'provide jobs and grow'. "Never the twain shall meet". We will all have to change our attitudes and work together to find the balance. This is a team effort. The government has taken the first steps in providing legal guidance with the proclamation of the National Environmental Management Act and the Integrated Coastal Management Act. These Acts still have a way to go before they have the required impact to provide the answer to our question.

Saldanha Bay has been identified as an economic development node by national government and the establishment of an Industrial Development Zone is well under way. The Bay hosts a major natural harbour and is actively exporting iron ore, lead, copper and manganese. To date, most environmental impact studies have been localized and the entire Saldanha Bay and Langebaan Lagoon ecological system has not been considered. The Saldanha Bay Water Quality Trust has been instrumental in the establishment of the Integrated Governmental Task Team (IGTT) that has been given the mandate to address this problem and provide environmental guidance for all future development in and around our region and Saldanha Bay. The above-mentioned legislation plus the IGTT Environmental Guidelines will form the cornerstone to a balanced approach in terms of environmental sustainability, social wellbeing and economic growth in the future.

None of the above can take place without scientifically based information on the 'State of the Bay'. The Saldanha Bay Water Quality Trust has been the pioneer in this regard and has conducted a series of all-encompassing scientific tests with minimal resources over the last 18 years. The report is once again a perfect example of the wonderful work that they perform. The report further comes at a critical time in answering our question of balancing conservation and development.

Let us all, National, Provincial and Local Government with the Private Sector and Non-Governmental Organizations, as partners, take hands and make a difference in conserving our Saldanha Bay and Langebaan Lagoon for future generations whilst ensuring responsible development.

Councillor André Kruger
Portfolio Chairperson: Infrastructure and Planning Services
Saldanha Bay Municipality
Chairperson: Saldanha Bay Water Quality Trust

Cover image: The mouth of Langebaan Lagoon into Saldanha Bay. Photo: J. Trefson

Contents

The residents living in and around Saldanha Bay and the Langebaan Lagoon are *truly blessed* to have such an unique ecological *wonder* on their doorstep.

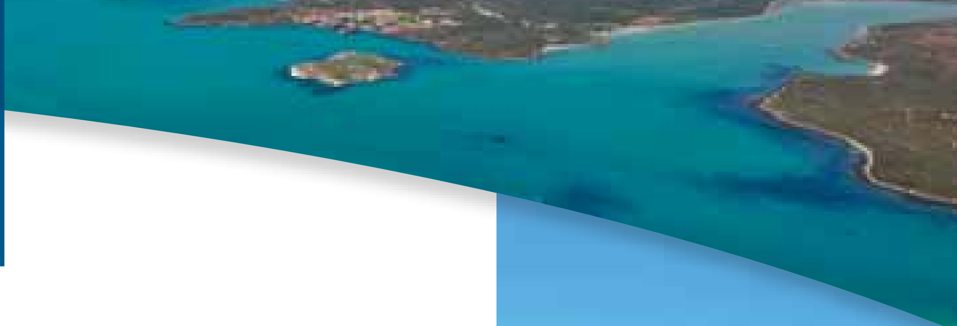
Langebaan Lagoon at sunset

Summary

Developments in Saldanha Bay and Langebaan Lagoon during the past thirty years have inevitably impacted on the environment. Most parameters investigated in this study suggest that a considerable degree of negative impact has occurred over the last few decades. Long-term decreases in populations of fish (e.g. white stumpnose) and many bird species in Saldanha Bay and Langebaan Lagoon are of particular concern. These decreases have been caused by a range of forces that include overfishing, reductions in habitat quality (sediment and water quality), human disturbance (both in Saldanha-Langebaan and on feeding and breeding grounds elsewhere) and reductions in the abundance of important forage species (e.g. benthic macrofauna that feed fish and birds). Recent improvements in some of these indicators (e.g. sediment quality and macrofauna abundance and composition) are encouraging, though, and will hopefully translate into improvements in the higher order taxa as well. Recent efforts by management authorities at local, provincial and national levels to improve levels of protection afforded to Saldanha Bay are welcomed and it is hoped that these will translate into action on the ground as well in the near future. At the same time, pressure on Saldanha Bay continues unabated, with development continuing to encroach onto, and along the shoreline, and in Saldanha Bay itself, and volumes of wastewater discharged to the Bay rise inexorably every year.

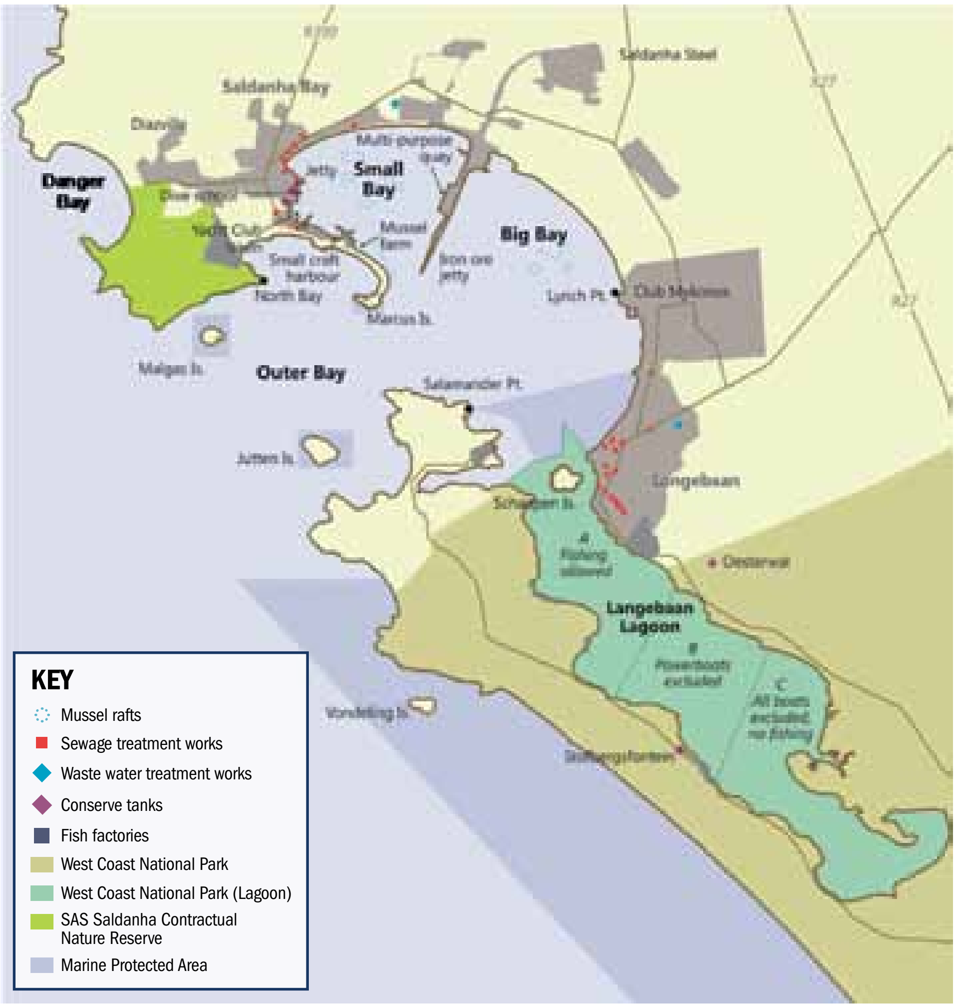
Developments in Saldanha Bay and Langebaan Lagoon during the past thirty years have *inevitably impacted* on the environment.

A view of Small Bay



Introduction

Saldanha Bay is situated on the west coast of South Africa, approximately 100 km north of Cape Town, and is directly linked to the shallow, tidal Langebaan Lagoon. Saldanha Bay and Langebaan Lagoon are areas of exceptional beauty, and are considered South African biodiversity "hot spots". A number of marine protected areas have been proclaimed in and around the Bay, while Langebaan Lagoon and much of the surrounding land falls within the West Coast National Park. Langebaan Lagoon was also declared a Ramsar Site in 1988, along all the islands within Saldanha Bay (Schaapen, Marcus, Malgas, Jutten and Vondelig). As such, Saldanha Bay and Langebaan Lagoon have long been the focus of scientific interest.



« Regional map of Saldanha Bay and Langebaan Lagoon with conservation areas shaded dark green and dark blue

In spite of its conservation status, there have been substantial human impacts on the area. Saldanha Bay and Langebaan Lagoon serve as both a major industrial node and port, and an area important to tourism and fishing activities. The development of the Port of Saldanha has significantly altered the physical structure and hydrodynamics of the Bay, whilst all developments within the area (industrial, residential, tourism etc.) have the potential to negatively impact on ecosystem health. As such, regular, long-term environmental monitoring is essential to identify negative human impacts on the environment as they occur (e.g. pollution), and enable proactive mitigation of such impacts.

A view into Big Bay

The State of the Bay (SoB) report was first commissioned by the Saldanha Bay Water Quality Forum Trust (SBWQFT) in 2006 and has been produced annually since 2008. The report presents information on a wide range of indicators that provide insight into the health of the Saldanha Bay-Langebaan Lagoon ecosystem. SBWQFT is a voluntary organisation representing various organs of State, local industry and other relevant stakeholders and interest groups in the Saldanha Bay- Langebaan Lagoon area. The 2017 State of the Bay technical report is the 11th in the State of the Bay series and provides an update on the state of the Bay of all monitored parameters in Saldanha Bay and Langebaan Lagoon.

This document is the accessible summary version of the State of the Bay reports and serves to communicate key findings from the technical report in a format accessible to a wide audience. It draws together all available information on water quality and aquatic ecosystem health, and on activities and discharges affecting the health of Saldanha Bay and Langebaan Lagoon. This edition serves to highlight changes in the system over the last 50 years, with a specific focus on key changes that have occurred since the last summary report of 2011.

The SoB reporting system incorporates a ranking system that covers a range of different measures of ecosystem health to provide a comprehensive picture of the State of the Bay.

RANKING	ECOLOGICAL PERSPECTIVE	MANAGEMENT PERSPECTIVE
	No or negligible modification from the natural state	Relatively little human impact.
	Some alteration to the physical environment. Small to moderate loss of biodiversity and ecosystem integrity.	Some human-related disturbance, but ecosystems essentially in a good state, however, continued regular monitoring is strongly suggested.
	Significant change evident in the physical environment and associated biological communities.	Moderate human-related disturbance with good ability to recover. Regular ecosystem monitoring to be initiated to ensure no further deterioration takes place.
	Extensive changes evident in the physical environment and associated biological communities.	High levels of human related disturbance. Urgent management intervention is required to avoid permanent damage to the environment or human health.

Activities and Discharges Affecting the Bay

Urban and Industrial Development

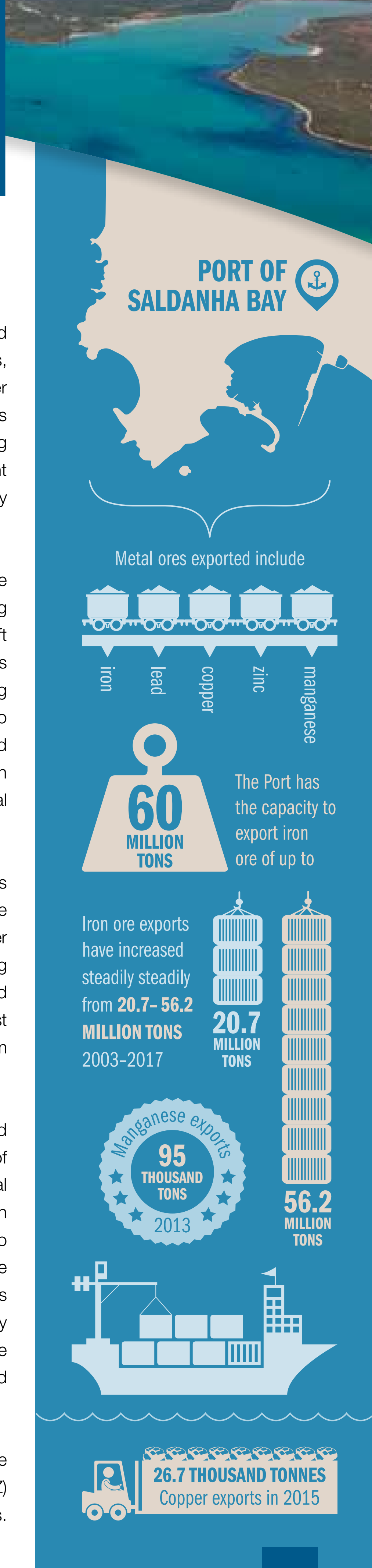
Shelter from wave action, abundant fish resources and the sheer beauty of Saldanha Bay and Langebaan Lagoon have made it an attractive place for the development of human settlements, a fishing industry and an industrial port. European settlers first colonised the area shortly after the establishment of a permanent settlement at the Cape in 1652. A fish trading post was established at Oostewal, Langebaan Lagoon, in the early 1700s. The first fish processing factory was established in 1903, and a whaling station at Donkergat in 1909. Port development began in earnest in the 1970s, with the construction of the iron ore terminal and a causeway linking Marcus Island to the mainland in 1973.

Port facilities in Saldanha Bay now include the iron ore terminal with berths for three ore carriers, an oil jetty, a multi-purpose terminal, and a general maintenance quay, a fishing harbour which is administered by the Department of Environmental Affairs, a Small Craft Harbour which is used by fishing vessels and tugs, three yacht marinas (Saldanha, Mykonos and Yachtport SA), a Naval boat yard at Salamander Bay and numerous slipways for launching and retrieval of smaller craft. Development of the port and fishing industry have served to attract other industry to the area, including oil and gas, ship repair and steel industries, and also resulted in a rapid expansion in urban development in Saldanha and Langebaan. Urban and industrial developments encroaching into coastal areas have caused the loss of coastal habitats and affect natural coastal processes, such as sand movement.

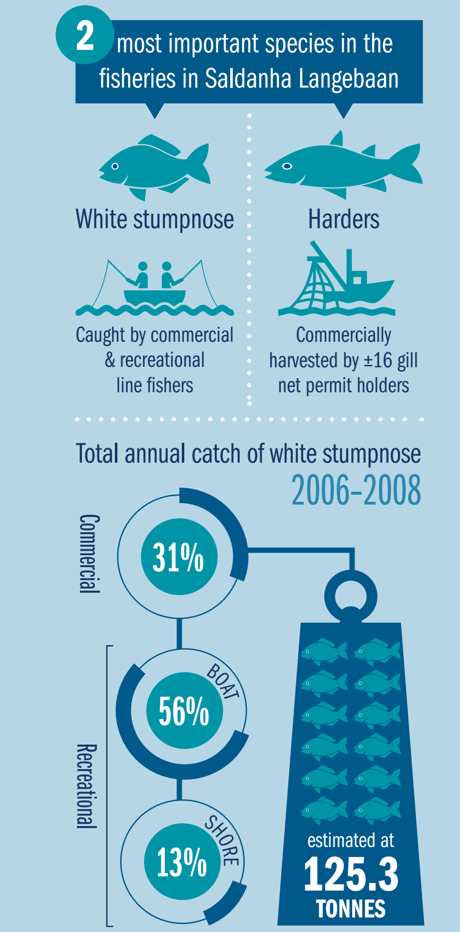
Dredging, required for the establishment and maintenance of port facilities in Saldanha Bay, has had a devastating impact on the ecology of the Bay. The largest dredging event undertaken in the Bay took place during the commissioning of the iron ore terminal, when somewhere in the order of 25 million tonnes of rock and sediment were dredged from the Bay. Several smaller dredging events have been implemented since this time, some to expand the capacity of the port and others simply to remove sediment that had accumulated in existing dredged areas. The most recent dredging was conducted for the extension of the general maintenance quay project from July 2015 until October 2016 where a total of 25 000 cubic metres of sediment was removed.

Metal ores exported from the Port of Saldanha Bay include iron, lead, copper, zinc, and manganese. The Port of Saldanha currently has the capacity to export up to 60 million tons of iron ore per year but is in the process of upgrading the infrastructure to support an annual export of 80 million tons. Iron ore exports have increased steadily from 20.7 to 56.2 million tons between 2003 and 2017. Metal exports from the multi-purpose terminal (MPT) have also increased exponentially since 2007. Initially only lead, copper and zinc were exported from the MPT with lead comprising the largest proportion of the exported material in 2011. Copper is exported in small quantities compared to all other metal ores although exports have steadily increased since 2011, peaking at 26.7 thousand tonnes in 2015. Manganese exports from the MPT in Saldanha Bay only commenced in 2013 (95 thousand tonnes) but have gained significant momentum in the last three years.

Transnet are proposing to expand their port facilities in Saldanha considerably in the future (see graphic top of page 6) to accommodate the new Industrial Development Zone (IDZ) which includes facilities for the oil and gas industry, cargo handling and ship repair operations.



Current port layout (left). Proposed future layout (right, 2050).

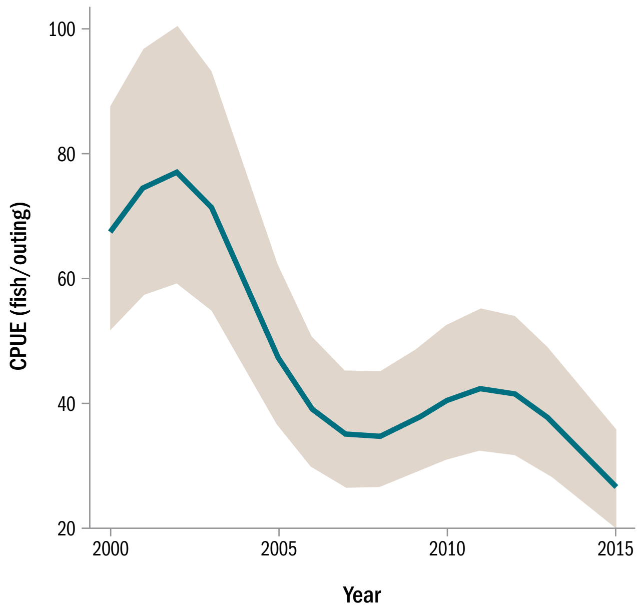


Fisheries

There is a long history of fishing within the Bay and Lagoon, with commercial exploitation beginning in the 1600s. At the present, there is a traditional netfishery that targets mullet (or harders), while white stumpnose, white steenbras, silver kob, elf, steentjie, yellowtail and smooth hound shark support large shore angling, as well as recreational and commercial boat line-fisheries. These fisheries contribute significantly to the tourism appeal and regional economy of Saldanha Bay and Langebaan.

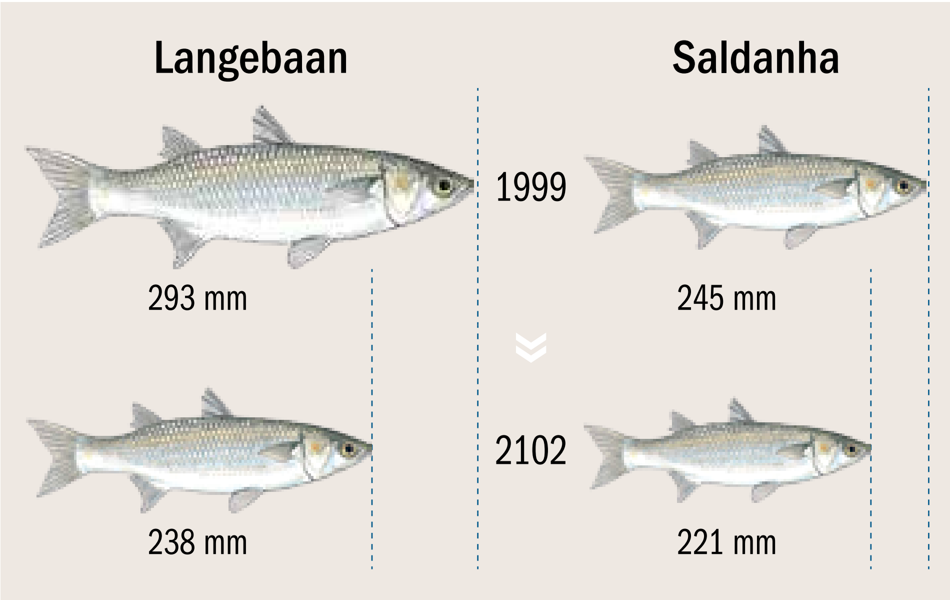
The two most important species in the fisheries in Saldanha Langebaan are white stumpnose that are caught by commercial and recreational line fishers, and harders that are commercially harvested by approximately 16 gill net permit holders. The total annual catch of white stumpnose by commercial (31% of total) and recreational line fishers (boat: 56% and shore 13%) was estimated at 125.3 tonnes for the 2006–2008 period. Assuming a selling price of R40/kg, the landed catch value of the commercial sector's catch of 39 tonnes is approximately R 1.6 million; the value of the recreational fisheries in the region has not yet been quantified, but undoubtedly exceeds the landed catch value of the commercial fisheries. Commercial white stumpnose catch-per-unit-effort has declined considerably in the last 15 years, whilst recruitment has also crashed (see fish section). This Saldanha – Langebaan white stumpnose stock is clearly under threat and more stringent catch control measures are required.

Saldanha Fishing Gear

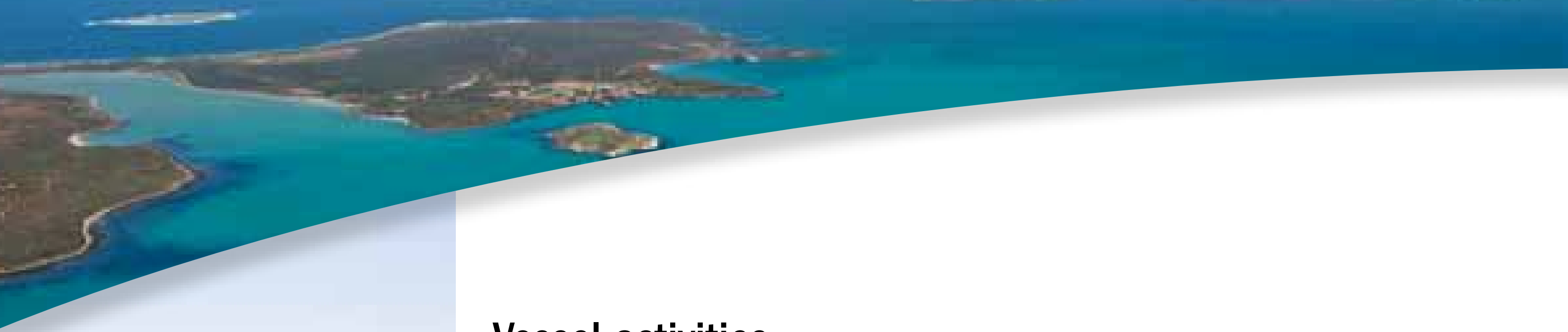


Annual CPUE estimates (± 95% CI) of white stumpnose derived from commercial boat catches logged in the NMLS database (Parker et al 2017).

The commercial gill net fishery in Saldanha Langebaan reports an average of approximately 20 tonnes per year with a landed catch value of around R200 000. This stock also appears to be under pressure with a notable decline in the average size of harders landed in both Saldanha and Langebaan between 1999 and 2012. The observed shift towards a smaller size class of harders in catches does suggest that growth overfishing is occurring and further increases in fishing pressure will probably lead to declines in overall yield (catch in terms of mass) from the fishery. There has been considerable pressure to open the restricted Zone B within the Langebaan MPA to all commercial gill net fishers resident in Saldanha and Langebaan. Permitting increased fishing effort within Zone B would drive further declines in average harder size which has a disproportionate negative impact on the reproductive output of the stock, as large female fish spawn exponentially more eggs as the grow. This would negatively impact the productivity of the harder stock in the Saldanha-Langebaan system and may lead to further long-term declines in the overall fishery catch.



Langebaan Lagoon and Saldanha Bay support large shore angling, recreational and commercial boat line-fisheries which contribute significantly to the tourism appeal and regional economy.



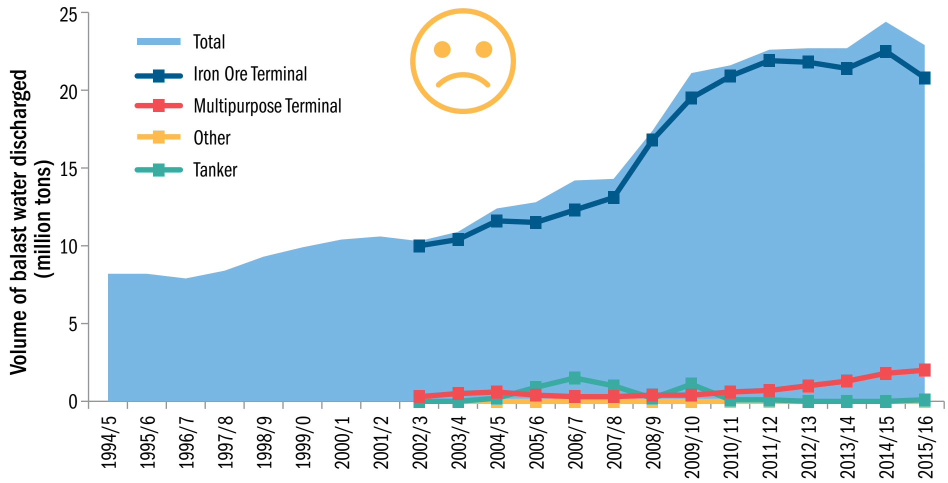
Large industrial ships in Saldanha Bay alongside mariculture

Vessel activities

The vessel traffic of Saldanha Bay poses a hazard for marine life due to disturbance from the vessels themselves, and accidental and deliberate discharges of ballast water from these vessels. Ballast is essential for the efficient handling and stability of ships, and accounts for most of the effluent discharged from vessels into the Bay, with a doubling of the volume discharged since 2004. Water is pumped into ballast tanks when cargo is offloaded and is discharged when cargo is loaded, along with the eggs, larvae and adults of marine species picked up in the ports or seas from which it was drawn. Despite international protocols encouraging practices such as open-ocean ballast water exchange, it is estimated that at least 85 alien marine species have been introduced to South Africa, 62 of which are thought to occur in Saldanha Bay and Langebaan Lagoon. In addition, since ballast water is generally taken up in ports, discharges into the bay can contain high concentrations of contaminants such as trace metals and hydrocarbons.

Oil spills are an ever present threat associated with shipping traffic but fortunately few such events have been recorded in Saldanha Bay to date. Discharges of sewage and bilge water from vessels, ranging from small yachts and power boats to large ships, also contribute to pollution in the bay.

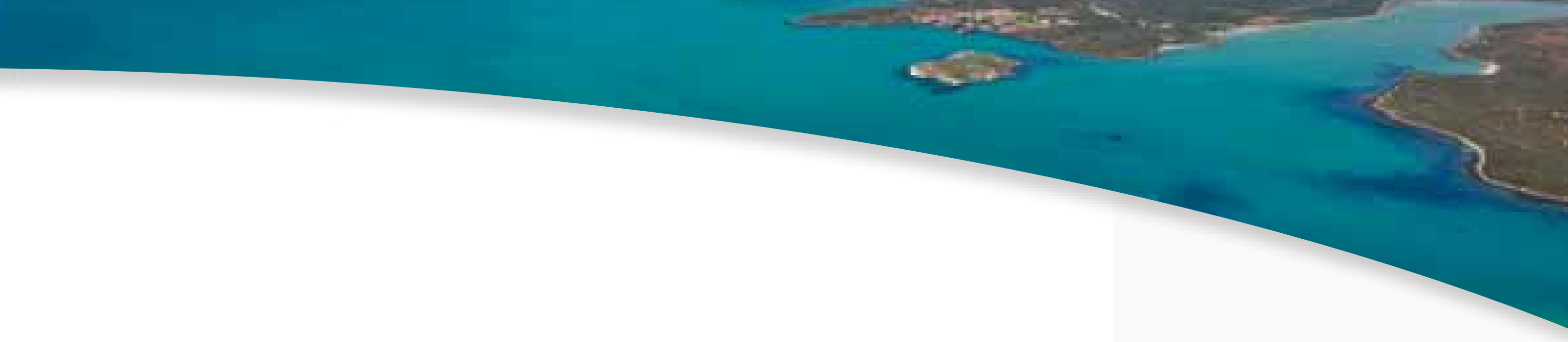
Volumes of ballast water discharged tons in Saldanha Port. The total amount of ballast water discharged in Saldanha Port between the years 1994 and June 2017 is shown as the blue area. Ballast water discharged by vessels docking at the iron ore terminal, the multipurpose terminal, tankers and other vessels are shown in blue, red, green and purple respectively. Data for the different types of vessels is only available from 2003 onward (Marangoni 1998, Awad et al. 2003, Transnet-NPA unpublished data 2003-2017).

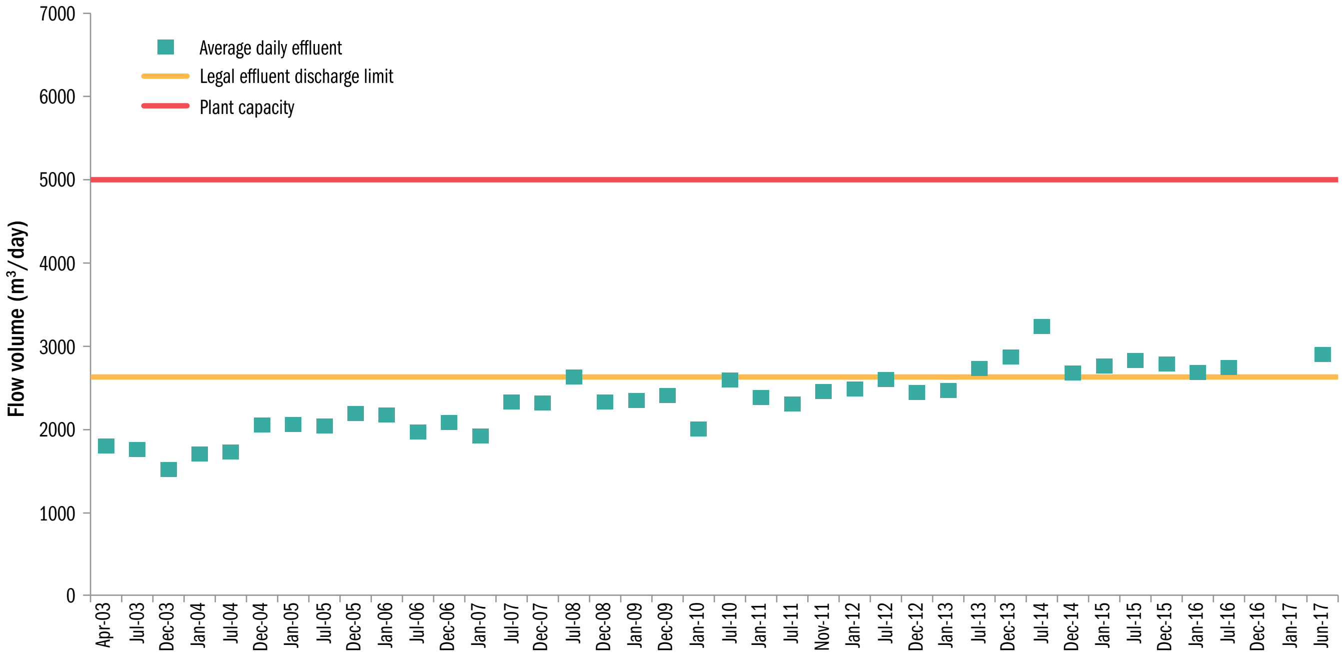


Effluent discharges into the Bay

The expanding population of the area surrounding the Saldanha Bay – Langebaan Lagoon generates ever increasing volumes of sewage, which finds its way into the Bay, either in partially treated form from the wastewater treatment works in Saldanha and Langebaan or, in some instances, as untreated sewage when treatment infrastructure malfunctions. In addition to *E. coli* and faecal coliform levels (indicators for pathogens or disease-causing organisms that pose a risk to human health), sewage contains high concentrations of nutrients such as nitrates and phosphates (ingredients in fertilizers). These nutrients stimulate the growth of phytoplankton and algae, which together with the decomposition of the organic material in the wastewater can deplete oxygen in the Bay, threatening other marine species. While there are guidelines in place that specify maximum concentrations of contaminants in wastewater discharges, these guideline levels are often exceeded due to a inadequate capacity to treat such large volumes of effluent and equipment failure.

Transnet intends to upgrade the existing stormwater infrastructure in the Port to ensure that runoff can be contained to prevent excessive pollution of the marine environment





Trend in average daily effluent (m^3/month) released from the Saldanha Wastewater Treatment Works, April 2003–June 2017. Allowable discharge limits in terms of the exemption issued by DWS under the National Water Act (No. 36 of 1998) are represented by the dashed orange line and the design capacity of the plant by the red line (Source: Saldanha Bay Municipality).

Storm water runoff is also a major threat to the health of the Bay. When rain falls on, and washes over hardened surfaces in urban and industrial areas where it is prevented from soaking into the ground, it accumulates debris, bacteria and chemical contaminants (i.e. trace metals, hydrocarbons and toxic substances such as insecticides, pesticides and solvents). These are then washed down into the Bay where they accumulate in sediments and in the tissues of aquatic organisms. Regulating this type of discharge has been proven difficult. Management at source by means of project-specific and strategic management plans are considered the only effective tool. For example, a Stormwater Management Master Plan has been drafted for Saldanha and acts as a precursor to an action plan to improve stormwater management in the area. In fulfilment of this plan, Transnet intends to upgrade the existing stormwater infrastructure in the Port of Saldanha to ensure that runoff resulting from anything up to a 1:50 year flood event can be contained to prevent excessive pollution of the marine environment.

The fish processing plant Sea Harvest has been discharging effluent into Small Bay for more than a decade. Although there has been considerable effort to decrease effluent volumes and improve effluent water quality, the assimilative capacity of Small Bay is already severely compromised due to cumulative impacts on water quality. Sea Harvest was issued with a Coastal Waters Discharge Permit (CWDP) on 25 June 2017. Chemical oxygen demand, total suspended solids, as well as soap, oil and grease must be reduced dramatically for Sea Harvest to ensure compliance with this permit. Premier Fishing historically used to operate a large fish processing plant in Saldanha, has been closed for many years but now in the process of re-commissioning and upgrading this plant.

Transnet NPA built a desalination plant in Saldanha Bay in 2012 to produce freshwater for dust mitigation during the loading and offloading of iron ore. Desalination plants can have severe impacts on the receiving marine environment due to the highly saline and negatively buoyant brine water that is discharged by these plants, which often contains biocides that serve to limit

Sampling the artificial rocky shore of the iron ore terminal

marine growth in their intake pipe work. Brine effluent containing biocides cause benthic macrofauna mortality around the outfall point and the impact zone size depends on the amount of effluent discharged. Additional desalination plants are also been considered as one of the options for meeting the increasing water demand by the industry and the domestic sector in the Western Cape. At a time of drought in the Western Cape, the recycling of wastewater has also become a consideration in supplementing water production. Industry in Saldanha Bay is proposing to invest in wastewater reclamation infrastructure if the SBM is willing to make treated effluent from the wastewater treatment plant available at no cost for the next twenty years. It is projected that this would reduce municipal water demand by 23%. Such an agreement between the municipality and industry would constitute an important step towards improving water quality in Saldanha Bay.

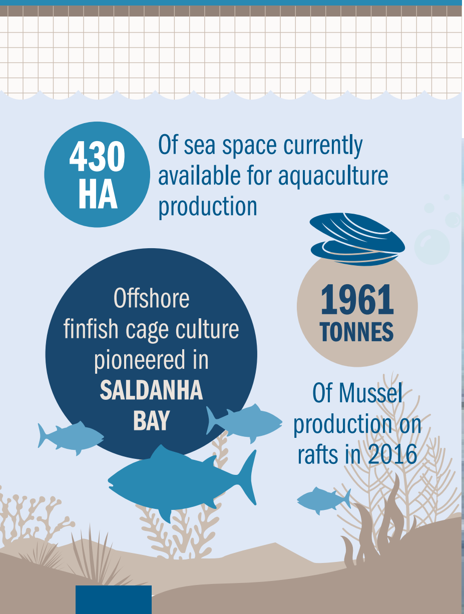
Transnet are proposing to expand their port facilities in Saldanha considerably in the future to accommodate the new Industrial Development Zone (IDZ) which includes facilities for the oil and gas industry, cargo handling and ship repair operations

The Department of Environmental Affairs is currently in the process of issuing licences to the various operators that discharge wastewater into Saldanha Bay. Implementation of effluent and environmental monitoring programmes combined with meaningful effluent quality limits are another way to encourage industry to discharge better quality effluent.

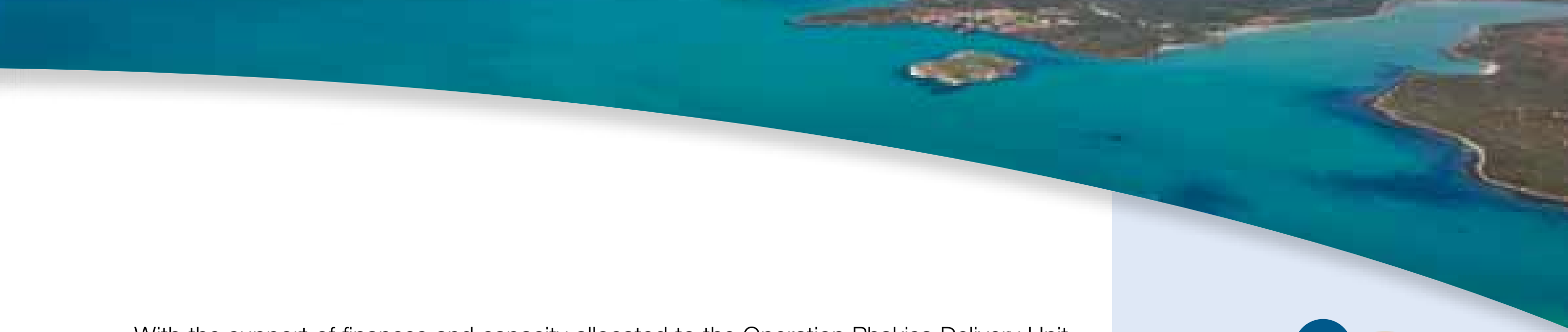
Saldanha Bay mariculture

Mariculture and Aquaculture Development Zone

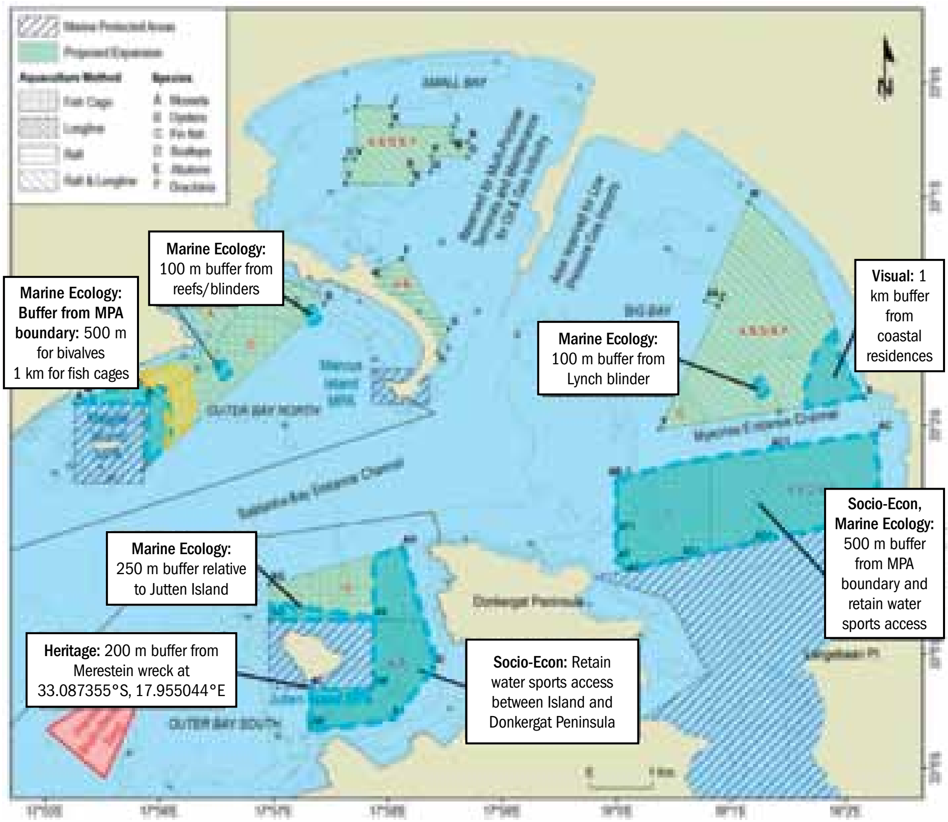
The Department of Agriculture, Forestry and Fisheries (DAFF) is currently driving accelerated development of the aquaculture sector in South Africa with the aim to create jobs for marginalised coastal communities, and to contribute to food security and national income. Being one of few natural sheltered embayments in South Africa, Saldanha Bay is a major area for mariculture. A combined 430 ha of sea space is currently available for aquaculture production in Outer Bay, Big Bay and Small Bay. Mussel production on rafts in Saldanha Bay has quadrupled since 2000, reaching 1 961 tonnes in 2016. Offshore finfish cage culture is currently being pioneered in Saldanha Bay and is largely focused on the farming of salmonid species, including Atlantic salmon (*Salmo salar*) and rainbow trout (*Onchorhynchus mykiss*). Molapong Aquaculture (Pty) Ltd has experimenting with small quantities of finfish (<50 tonnes) in the last year, and has applied for environmental authorisation which will allow them to increase this to as much as 2 000 tonnes production capacity per annum.



Offshore finfish cage culture is currently being pioneered in Saldanha Bay and is largely focused on the farming of Atlantic salmon and rainbow trout

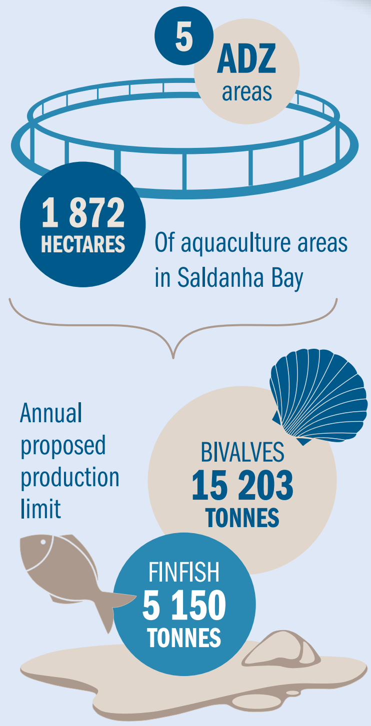


With the support of finances and capacity allocated to the Operation Phakisa Delivery Unit, DAFF proposes to establish a sea-based Aquaculture Development Zone (ADZ) in Saldanha Bay. The potential ADZ areas comprise five precincts totalling 1 404 ha of new aquaculture areas in Saldanha Bay for a total ADZ comprising 1 872 ha (currently farmed areas will be incorporated into the ADZ). The proposed production limit within the ADZ for bivalves and finfish is 15 203 tonnes and 5 150 tonnes per annum, respectively. The proposed ADZ project triggers activities listed in terms of Listing Notice 1 of the EIA Regulations, 2014, requiring Environmental Authorisation.



Aquaculture Development Zone in Saldanha Bay as proposed by the Department of Agriculture Forestry & Fisheries (DAFF). Also indicated are areas of the pre-mitigation scenario to avoid in mitigation of impacts

There is much concern regarding this proposed ADZ from local residents and visitors given that Saldanha Bay is an area with diverse users including recreational water sports enthusiasts, recreational and commercial fishing, and the fact that it also adjoins unique and internationally important Lagoon and Island habitats some of which have been designed as Marine Protected Areas (MPAs). Three of the proposed ADZ areas abut directly onto MPAs that serve to protected vulnerable species and habitats. Mariculture, particularly, finfish farming, has had severe environmental impacts globally and development at this scale could have devastating impacts on an already stressed ecosystem. The public and conservation organisations alike have expressed concern regarding the potential impacts of the proposed development, submitting 60 submissions and 1 600 petitions in response to the Basic Assessment Report (BAR). A decision by the Department of Environmental Affairs is to be expected towards the end of this year.



The mussel beds on the iron ore terminal rocky shore

Water Quality

Preparing to sample fish from the shore

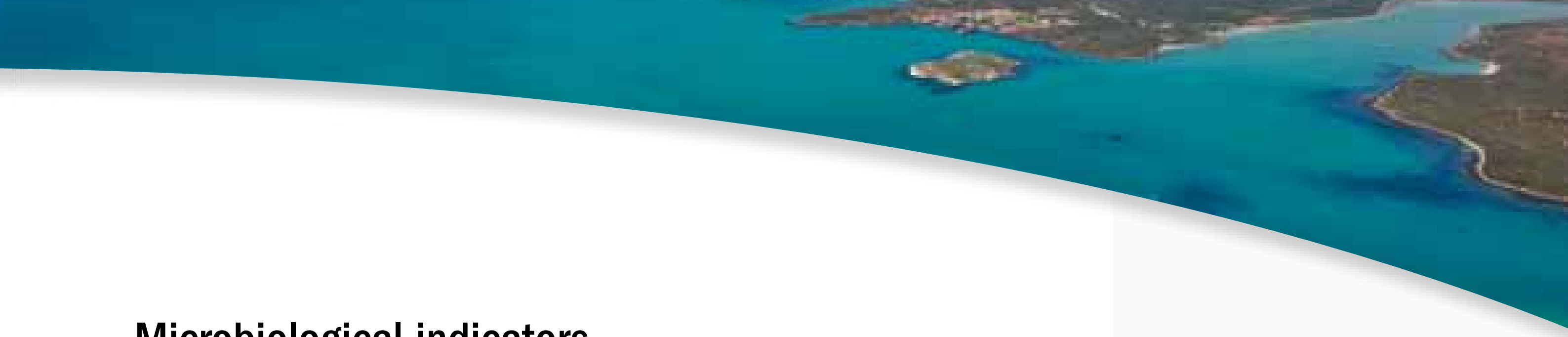
The measurement of temperature, salinity, dissolved oxygen, nutrients and chlorophyll a (an indicator of phytoplankton abundance) provides scientists with a snapshot of marine water quality at a specific point in time. Water quality is also influenced by wave action, current strength and circulation patterns, all of which can be affected by environmental utilisation and coastal development.

Oceanographic indicators

Large-scale harbour development in the early 1970s had notable impacts on water movement patterns and wave action in Saldanha Bay. When the Bay was split into two sections by the Iron ore Terminal, the Marcus Island causeway created a barrier for incoming swells, decreasing wave exposure and increasing the extent of sheltered and semi-sheltered areas, particularly within Small Bay. In the past, current strength and circulation in Saldanha Bay was determined by a combination of tidal movements and wind. Deeper currents followed more predictable patterns based on tide sand wind-induced processes. Both subtidal and surface currents have been modified as a consequence of port development.

Residence time of water in Small Bay has increased, which means that there is reduced potential for dilution and flushing of effluent and associated contaminants discharged into this part of the Bay. Contaminants now persist in the water column for longer periods, using up available oxygen, while others settle out in the sediments or are taken up by living organisms in the Bay. The most obvious impacts of effluent discharges can be seen in the effects on available oxygen in the water column in Small Bay, in trace metals that accumulate in filter-feeding organisms, and in nearshore bacterial concentrations.

Schematic representation of the surface currents and circulation of Saldanha Bay prior to the harbour development (pre-1973) and after construction of the causeway and iron ore terminal (present) (adapted from Shannon and Stander 1977 and Weeks et al. 1991a).



Microbiological indicators

Faecal pollution contained in, for example, untreated sewage, storm water and vessel runoff, can introduce disease-causing micro-organisms into coastal waters. These pathogenic micro-organisms constitute a threat to recreational water users and consumers of seafood. Bacterial indicators are used to detect the presence of faecal pollution. The South African Water Quality Guidelines for Coastal Marine Waters is used to assess compliance in respect of human health criteria (DEA 2012) and for mariculture use (DWAF 1995).

Regular monitoring of microbiological indicators at 10 water quality stations in Small Bay, five in Big Bay and five in Langebaan Lagoon indicate that the chronic problems with faecal coliform pollution that were experienced in the past (pre-2005) have improved considerably since this time. Currently, 16 of the 20 monitoring stations in the Bay are rated as having ‘Excellent’ water quality in terms of recreational use, one site is rated as ‘Good’ and two sites are rated as ‘Fair’. Only the beach at the Bok River Mouth was rated as ‘Poor’ in the last four years.

Guideline limits for mariculture are much stricter than the recreational guideline limits, and nine out of the 10 sites in Small Bay were rated as not compliant with mariculture guideline limits for faecal coliforms in recent years. Given the current importance and likely future growth of both the mariculture and tourism industries in Saldanha Bay and Langebaan Lagoon, it is imperative that efforts undertaken in recent years to combat pollution by faecal coliforms (e.g. upgrading of sewage and storm water facilities to keep up with demand) should be increased and applied more widely. Efforts to maintain the good water quality at the popular swimming and water sport sites must be continued, as must the continued monitoring of bacterial indicators (intestinal Enterococci in particular) to assess the effectiveness of adopted measures. These efforts should be undertaken at all sites on a bimonthly basis.

Currently, 16 of the 20 monitoring stations in the Bay are rated as having *‘Excellent’* water quality, one site is rated as *‘Good’* and two sites are rated as *‘Fair’*.

Saldanha Bay and Langebaan Lagoon serve as both a major industrial node and port, and an area important to tourism and fishing activities

SITE	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1. Beach at Mussel Rafts	Fair	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
2. Small Craft Harbour	Excellent	Fair	Good	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent
3. Sea Harvest – Small Quay	Fair	Fair	Excellent	Excellent	Fair	Excellent	Fair	Excellent	Excellent	Excellent	Good	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent
4. Saldanha Yacht Club	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
5. Pepper Bay – Big Quay	Poor	Fair	Poor	Fair	Fair	Fair	Fair	Poor	Excellent	Excellent	Fair	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent
6. Pepper Bay – Small Quay	Poor	Fair	Fair	Good	Excellent	Good	Excellent	Excellent	Good	Excellent	Good	Good	Excellent	Good	Fair	Fair	Excellent	Excellent
7. Hoedjies Bay Hotel – Beach	Fair	Fair	Poor	Fair	Good	Poor	Poor	Good	Fair	Excellent	Fair	Fair	Poor	Poor	Fair	Good	Fair	Good
8. Beach at Caravan Park	Fair	Fair	Fair	Poor	Excellent	Fair	Poor	Excellent	Good	Poor	Fair	Fair	Fair	Poor	Good	Fair	Excellent	Fair
9. Bok River Mouth – Beach	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Excellent	Fair	Poor	Poor	Good	Excellent	Poor	Fair	Good	Excellent	Poor
10. General Cargo Quay – TNPA	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
11. Seafarm – TNPA	Excellent	Fair	Excellent	Excellent	No data	No data	Excellent	Excellent	Excellent	No data	Excellent	No data	No data	Excellent	Excellent	Excellent	Excellent	Excellent
12. Mykonos – Paradise Beach	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
13. Mykonos – Harbour	Fair	Fair	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	Good	Fair	Excellent
14. Leentjiesklip	No data	No data	Good	Fair	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Good	Excellent	Excellent
15. Langebaan North	Excellent	Fair	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Good	Excellent	Good	Excellent
16. Langebaan – Main Beach	No data	No data	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent
17. Langebaan Yacht Club	No data	No data	No data	No data	No data	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Fair
18. Tooth Rock	No data	No data	No data	No data	No data	Fair	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
19. Kraalbaai North	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	Excellent	Excellent	Excellent	Excellent	Excellent
20. Kraalbaai South	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	Excellent	Excellent	Excellent	Excellent	Excellent

Excellent
Good
Fair
Poor
No data

Sampling site compliance for recreational use based on *E. coli* counts for sites in Small Bay (sites 1–10), Big Bay (sites 6–14) and Langebaan Lagoon (sites 15–20).

Trace metal indicators

Concentrations of trace metals in marine organisms (mostly mussels) in Saldanha Bay have been monitored intermittently since 1997. Data suggest that concentrations of trace metals are high along the shore (particularly for lead near the Multipurpose Quay) and are consistently above published regulatory limits for foodstuffs at many sites. Concentrations of trace metals in the cultured mussels on offshore mussel rafts are much lower; although concentrations of lead and cadmium occasionally rise above the limit for foodstuffs, which is concerning.

The reasons for the lower concentrations of trace metals in farmed mussels compared with those on the shore may be linked with higher growth rates for the farmed mussels, and the fact that the cultured mussels are feeding on phytoplankton blooms in freshly upwelled water that has recently entered the Bay from outside and is thus relatively uncontaminated. The high concentrations of trace metals along the shore points to the need for management interventions to address this issue, as metal contamination poses a serious risk to the health of people harvesting mussels from the shore.

Sediment Quality

The health of sediments in Saldanha Bay has been monitored through sediment particle size composition, concentrations of organic matter (particulate organic carbon and nitrogen) and trace metals.

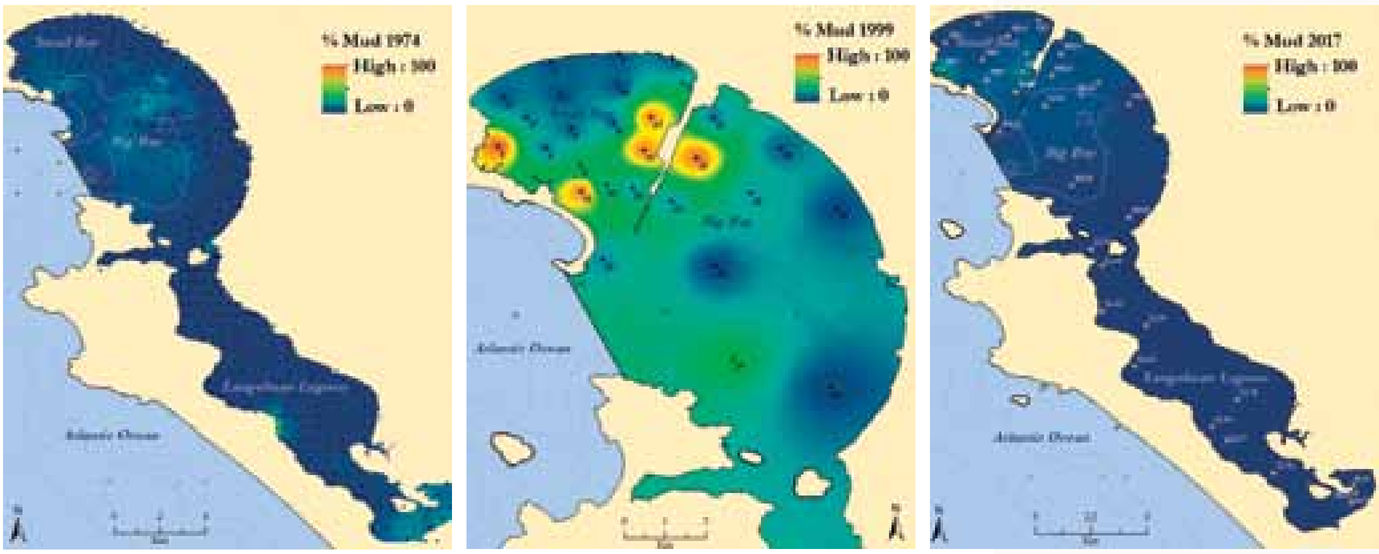
The earliest records from Saldanha Bay (1974) indicate that sediments in Saldanha Bay were predominantly sandy (i.e. fairly coarse), with a low concentration of organic matter and trace metals. Following construction of the Marcus Island causeway and iron ore terminal in the 1970s, fine sediment (mud) started to build up in the more sheltered parts of Small Bay (particularly around the Yacht Club Basin and Small Craft Harbour). There was also fine sediment build up in the dredged shipping channels around the iron ore terminal. Elevated inputs of organic material from the wastewater treatment works, fish factories and mussel farms have further contributed to this problem. Trace metals, which typically associate with finer sediments and organic material, also started building up at this time as a result of discharges of effluents into the Bay and port operations (ore loading and vessel maintenance). The accumulation of fine sediment, trace metals and organic material has led to a depletion of oxygen in the sediments in Saldanha Bay and to these sediments becoming toxic for marine organisms in some areas.

Areas of greatest concern are located either in close proximity to the source of contamination (e.g. adjacent to the multi-purpose and iron ore terminals), or in the calmer areas of the bay where fine sediments accumulate (e.g. in the Yacht Club Basin and Small Craft Harbour in Small Bay). Normally these oxygen-poor and toxin-rich sediments would become buried over time, and hence isolated from the water above. However, periodic dredging in Saldanha Bay has stirred up much of this material as well as other fine material long buried beneath Saldanha Bay. Once stirred up, this fine material is suspended in the water with its associated contaminants, before eventually settling in the calmer and deeper parts of the Bay, further impacting on water and sediment quality in those areas. The most recent dredging in the system (2015–2016) caused a slight change in sediment composition in close proximity to the impact site, but did not have any noticeable impacts further afield.

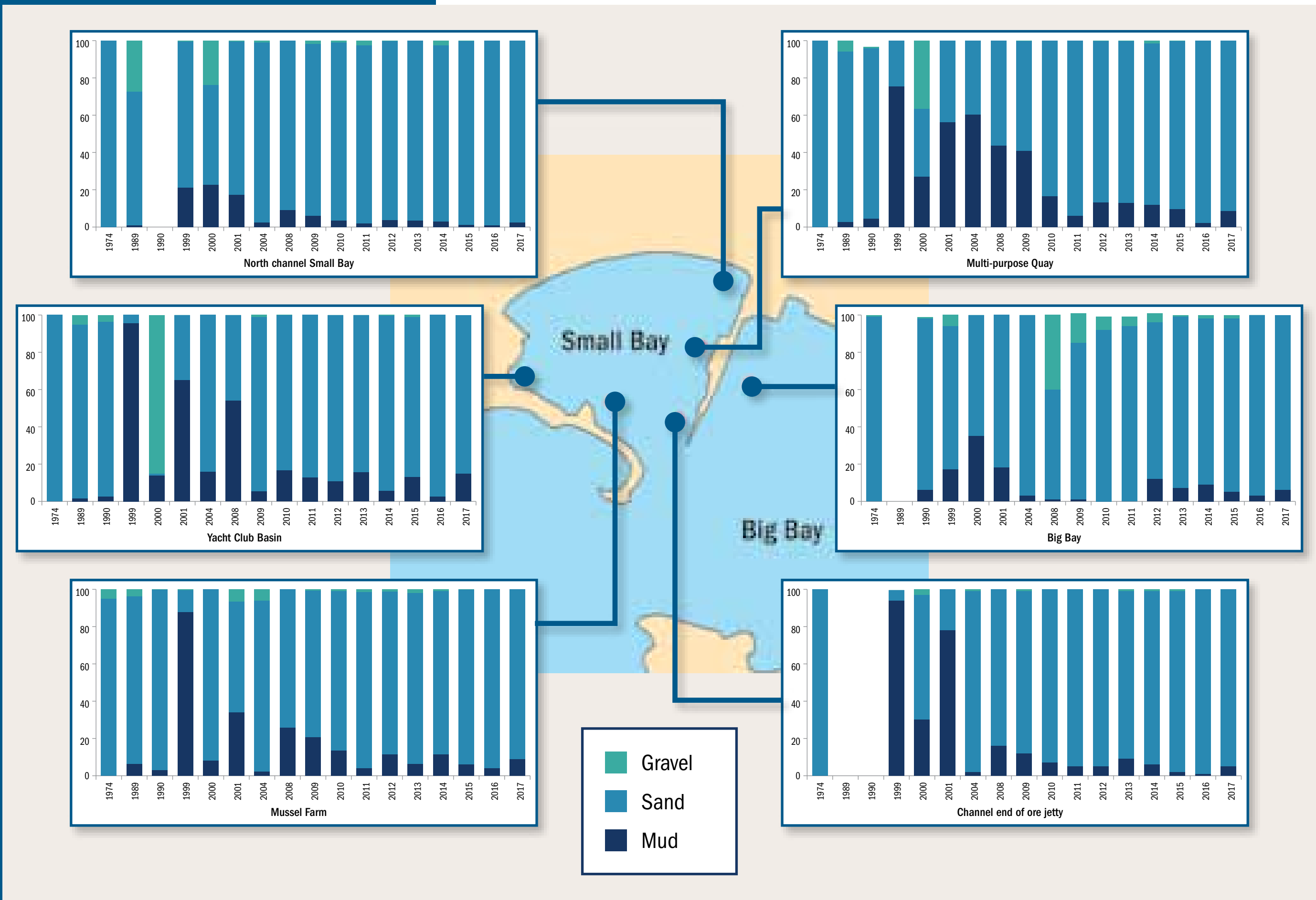
Sediment particle size

Fine sediment has accumulated in the more quiescent parts of the Bay, particularly Small Bay (in and around the Yacht Club Basin and Small Craft Harbour) and in the dredged shipping channels adjacent to the iron ore terminal.

The amount of fine sediment for which historical data exists (1974–2017) in Saldanha Bay shows a drastic change in the sediment characteristics in the Bay. In 1974, sediments in the Bay were comprised mostly of sand with a very small mud fraction, with Big Bay having higher mud content than Small Bay. After construction of the causeway and iron ore terminal, fine sediments started to build up in the more sheltered parts of Small Bay (especially around the Yacht Club Basin and Small Craft Harbour) and in the dredged shipping channels adjacent to the iron ore terminal. By 1999, the mud content in the sediments in these areas had reached very high levels (96% around the Yacht Club Basin) but has declined again since this time to levels that are only marginally higher than that recorded in 1974.



Variations in mud percentage in Saldanha Bay in 1974 (Flemming 1974), 1999 (CSIR 1999a) and 2017.

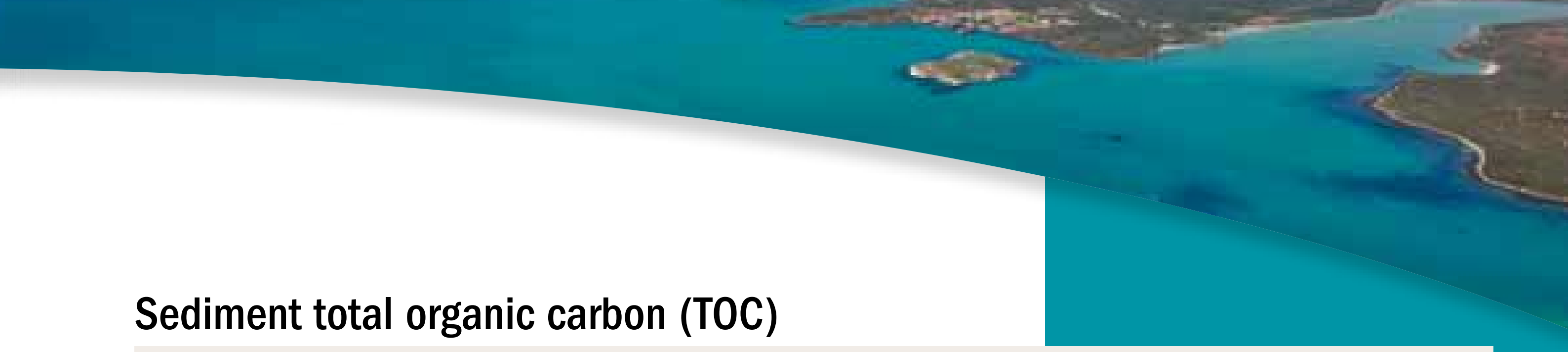


Left: A view from Small Bay towards the iron ore terminal

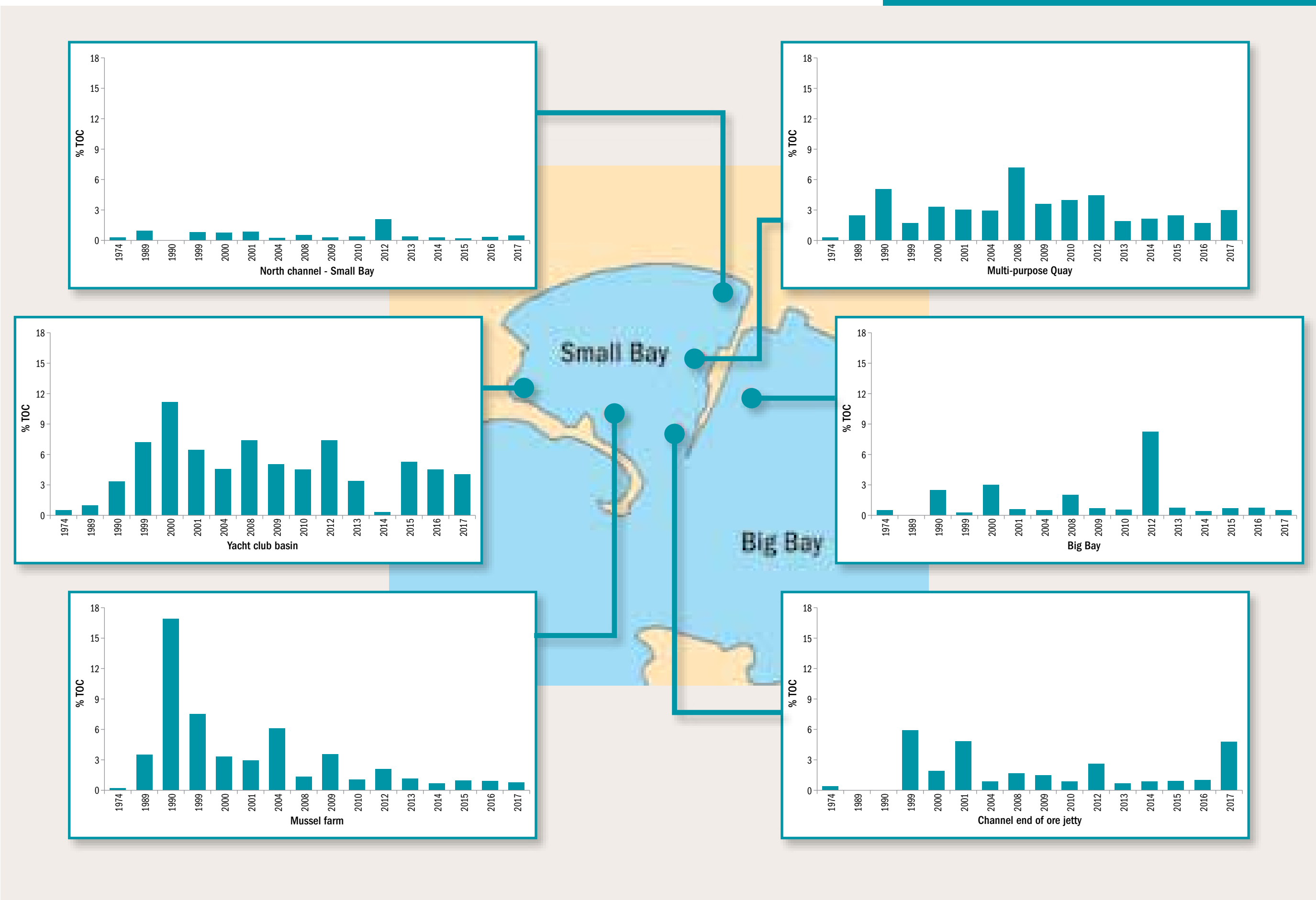
Middle: Marcus Island causeway

Right: The artificial intertidal habitat of the iron ore jetty. Note the red colouration from the iron ore dust

Particle size composition (percentage gravel, sand and mud) of sediments at six localities in the small bay area of Saldanha Bay between 1974 and 2017.



Sediment total organic carbon (TOC)

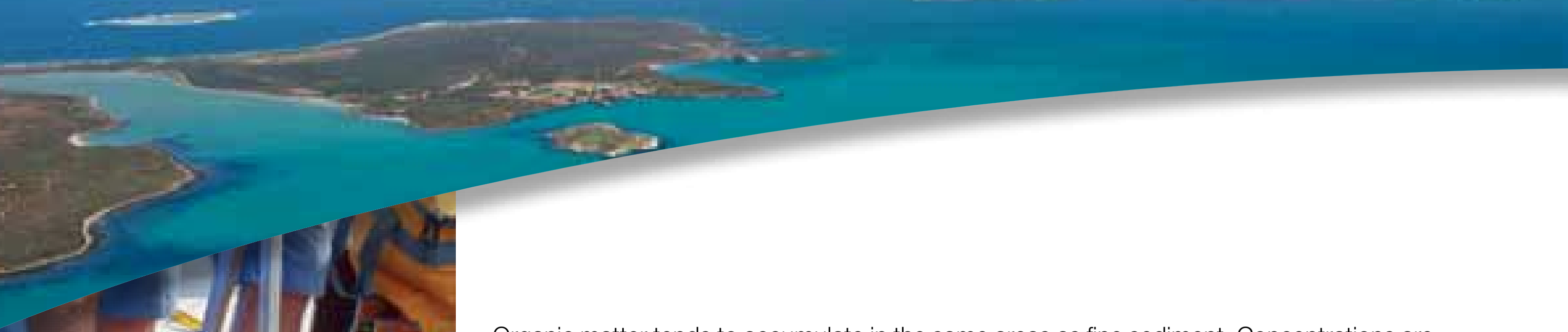


Total organic carbon percentage (TOC%) occurring in sediments of Saldanha Bay at six locations between 1974 and 2017.

Left: A Big Bay beach

Middle: Langebaan Lagoon yacht club

Right: A bed of mussels



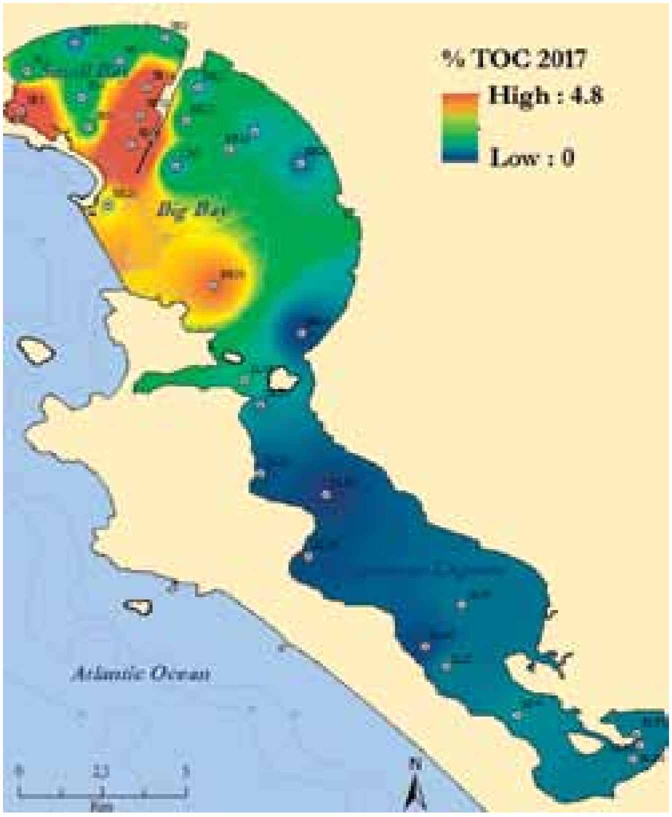
Top: Sampling of sediments for analysis using a metal grab

Middle: Sampling the mud flats using a 'prawn-pump

Bottom: Sorting of benthic macrofauna samples

Organic matter tends to accumulate in the same areas as fine sediment. Concentrations are particularly high in Small Bay where most of the sources of organic matter are located (wastewater discharges, mussels farms) and where water movement has been most severely reduced.

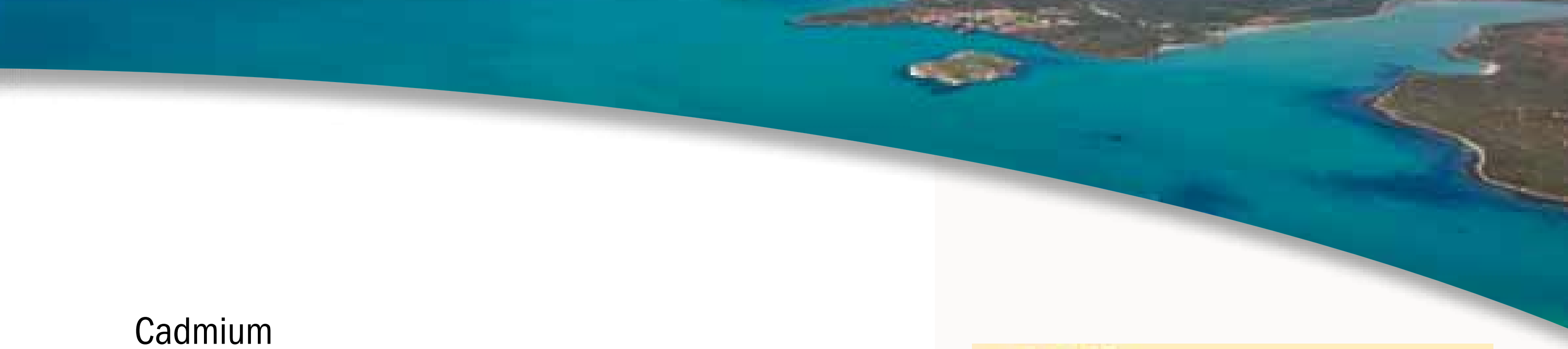
TOC levels in Saldanha Bay were mostly low (between 0.2 and 0.5%) throughout the Bay prior to any major development (pre-1974). Since then, however, TOC levels have been considerably elevated throughout the Bay.



Total organic carbon in Saldanha Bay as indicated by the 2017 survey results.

Trace metal concentrations

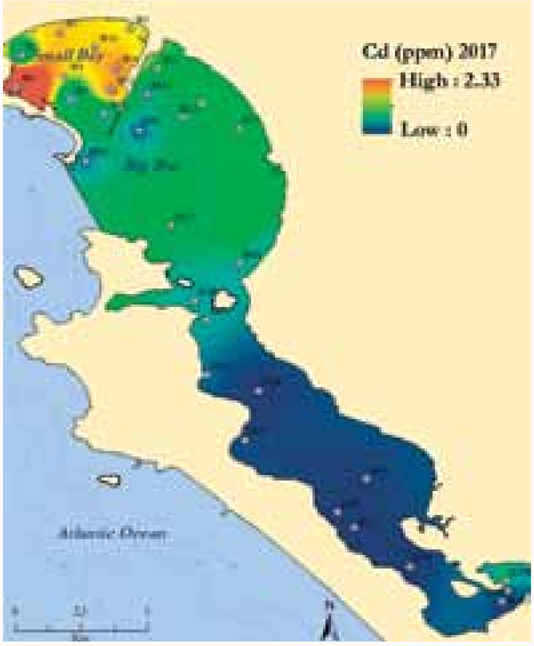
In areas of the Bay where muddy sediments tend to accumulate, trace metals and other contaminants often exceed internationally-accepted thresholds above which toxic effects can be expected. This may be due to naturally-occurring high levels of the contaminants in the environment (e.g. in the case of cadmium), or due to impacts of ore exports (e.g. iron, lead, copper, manganese and nickel), industrial waste and stormwater runoff. While trace metals are generally biologically inactive when buried in the sediment, they can become toxic to the environment when re-suspended as a result of mechanical disturbance. Concentrations of ten trace metals in sediments are monitored in Saldanha Bay and Langebaan Lagoon on a routine basis by the SBWQFT. Trends in the three trace metals of greatest concern (cadmium, lead and copper) are presented here.



Cadmium

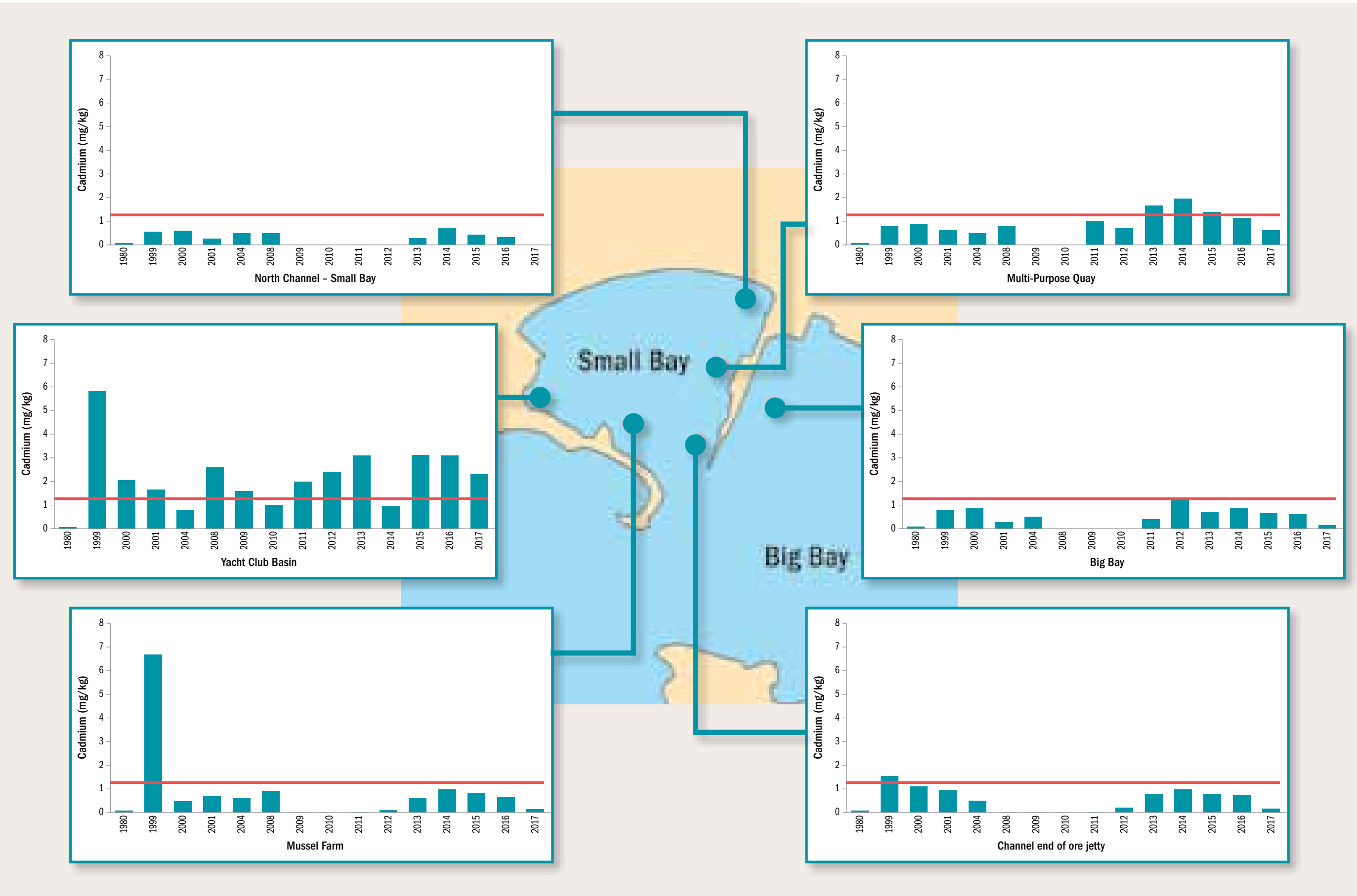
Cadmium (Cd) is widely distributed in the earth's crust at an average concentration of about 0.1 ppm, but natural background levels can be as high as 15 ppm. Anthropogenic sources of cadmium include emissions from industrial combustion process, metallurgical industries, road transport and waste streams. Cadmium is considered toxic to marine organisms at levels above 1.2 ppm and shows a strong tendency to accumulate in living organisms, and is thus a concern for both the marine environment and human consumption of seafood.

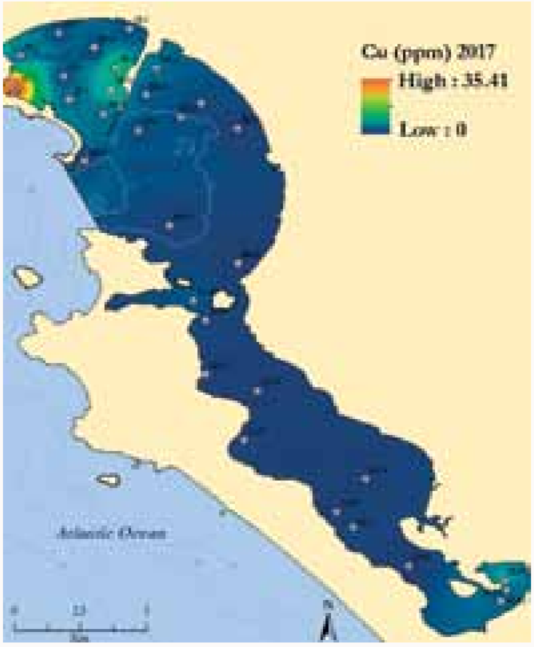
Cadmium levels in sediments in Saldanha Bay over the last seven years have been highest in Small Bay (near the Small Craft Harbour and), frequently exceeding the threshold of 1.2 ppm where toxic effects can be expected. Historically, high cadmium concentrations in the Bay have been associated with fine sediment. However, there has been a decline in the proportion of fine sediment over the last seven years, whilst cadmium concentrations have increased. This indicates that this accumulation must have an anthropogenic source.



Spatial interpolation of cadmium levels based measurements taken in 2017.

Concentrations of Cadmium (Cd) in ppm recorded at six sites in Saldanha Bay between 1980 and 2017. Solid red lines indicate Effects Range Low values for sediments above which toxic effects can be expected.



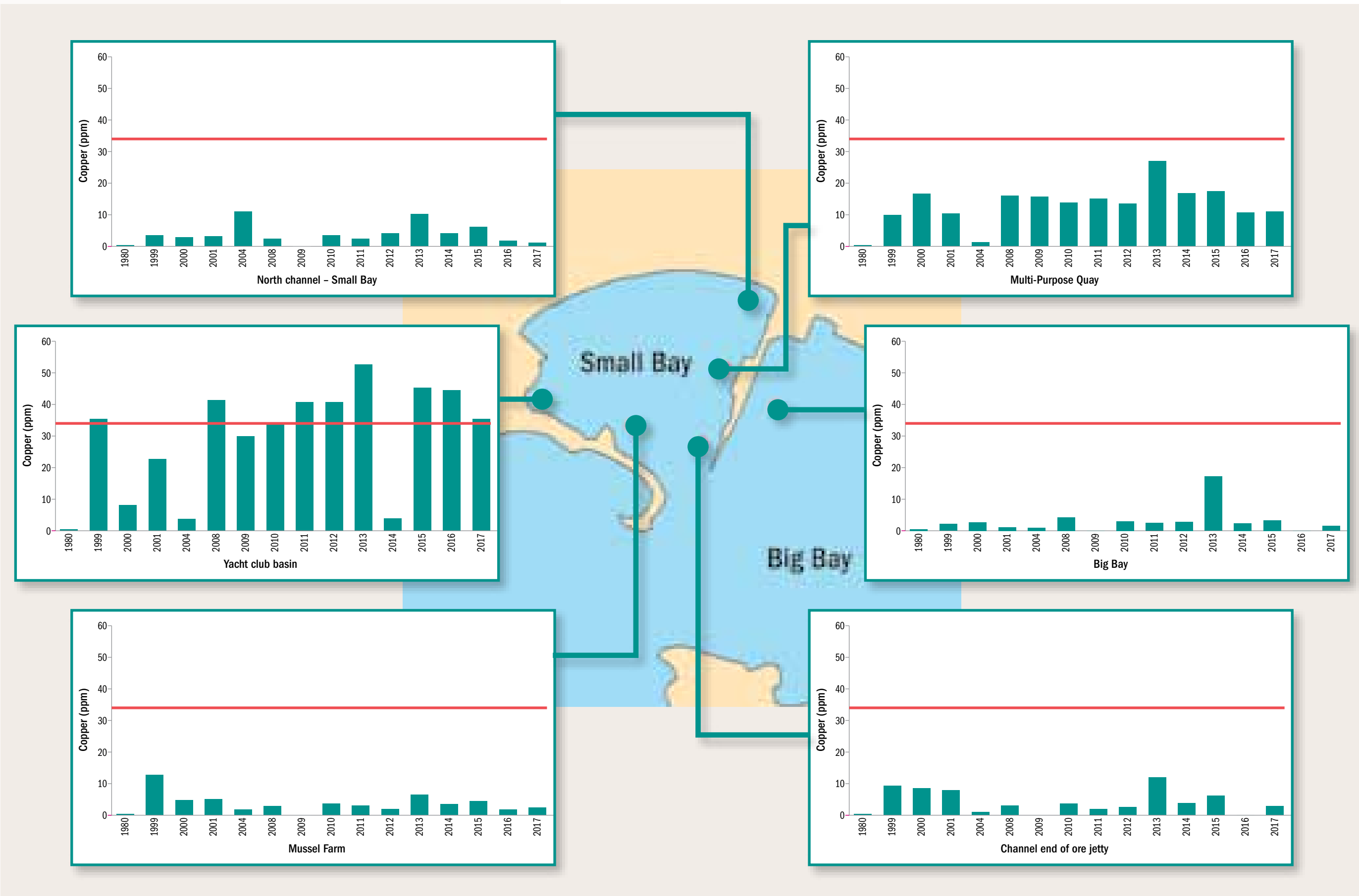


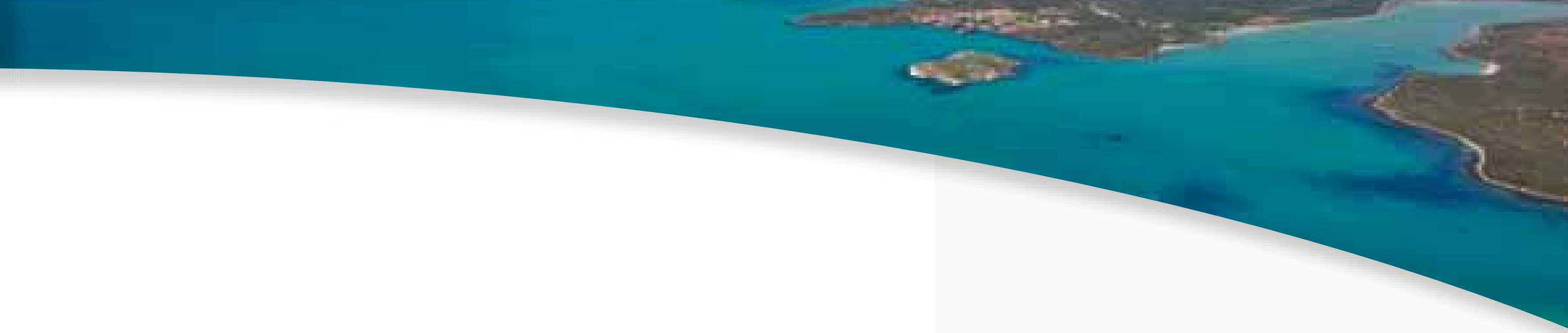
Spatial interpolation of copper levels based measurements taken in 2017.

Copper

As with many other trace metals, copper (Cu) is an essential micronutrient used by marine organisms for normal physiological process. However, when elevated above normal background concentrations (anywhere above 34 ppm) it becomes toxic to marine organisms. Major industrial sources of copper in Saldanha Bay are likely to include copper ore exports, anti-fouling paint and industrial waste. Copper also makes its way into the sea via the wastewater treatment works and atmospheric deposition. The total concentration of copper in the sediments has remained well below accepted threshold levels (34 ppm) since 1980, with the exception of the Small Craft Harbour which has exceeded acceptable levels in recent years.

Concentrations of Copper (Cu) in parts per million (ppm) recorded at six sites in Saldanha Bay between 1980 and 2017. Solid red lines indicate Effects Range Low values for sediments above which toxic effects can be expected.

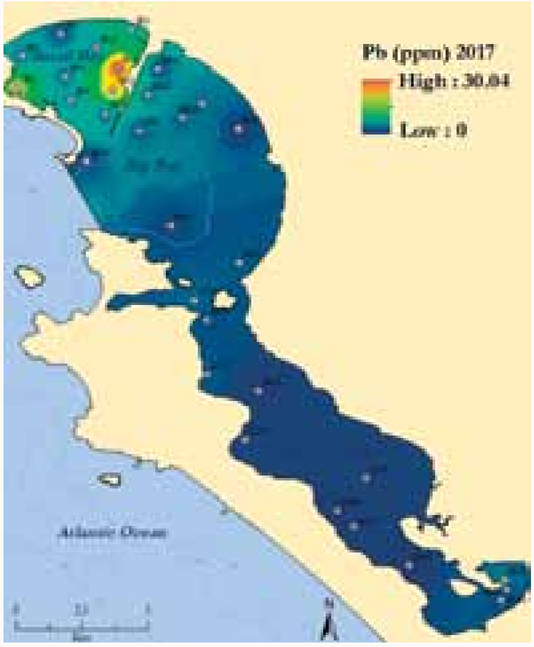




Lead

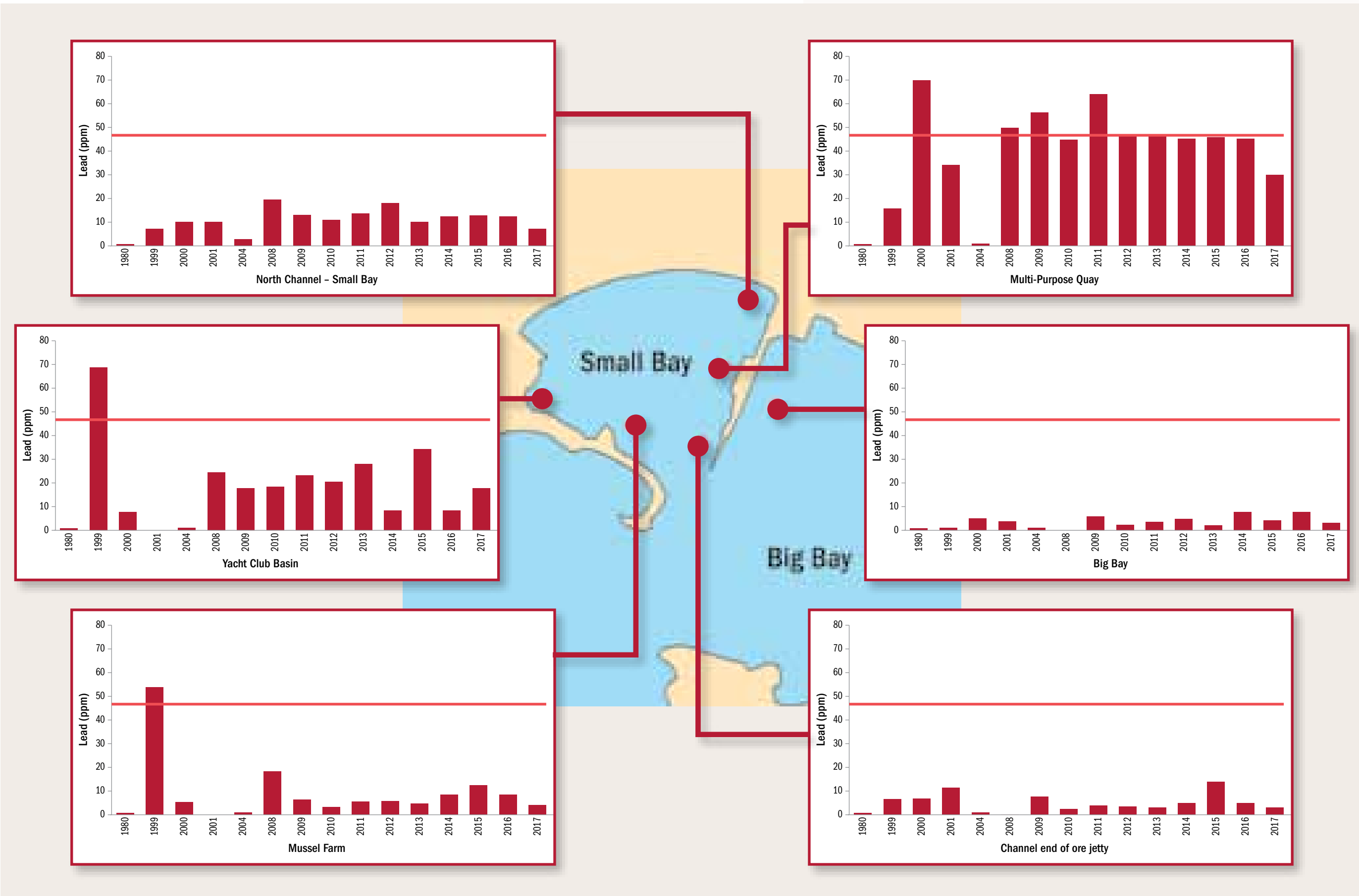
There has been a widespread elevation of lead (Pb) in the environment due to mining, smelting and the industrial use of this material. Lead is toxic to aquatic organisms, and thus contamination is of concern for the marine environment and human health, through consumption of contaminated seafood. Concentrations above 47 ppm in sediment are considered to be of concern.

Lead ore is exported via the multi-purpose terminal and concentrations in the Bay are most elevated in this region and have frequently exceeded acceptable levels over the last 15 years. As for other trace metals, lead concentrations are also elevated in the Small Craft Harbour.



Spatial interpolation of lead levels based measurements taken in 2017.

Concentrations of Lead (Pb) in parts per million (ppm) recorded at six sites in Saldanha Bay between 1980 and 2017. Solid red lines indicate Effects Range Low values for sediments above which toxic effects can be expected.



Groundwater

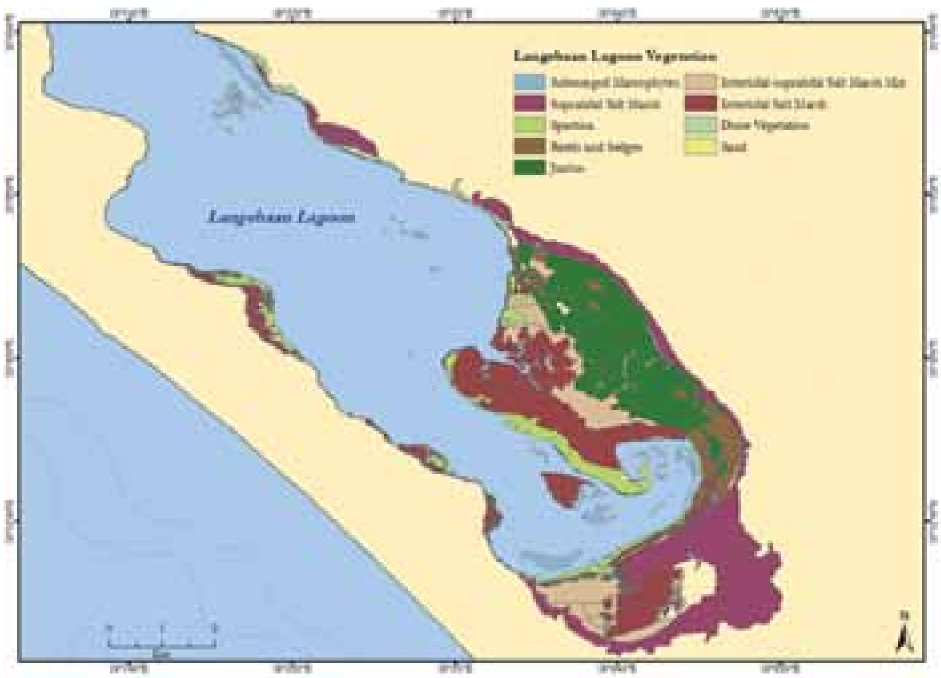
Top: The view from Churchhaven, in Langebaan Lagoon

Middle: Boat based sampling

Bottom: An aerial view of Langebaan Lagoon

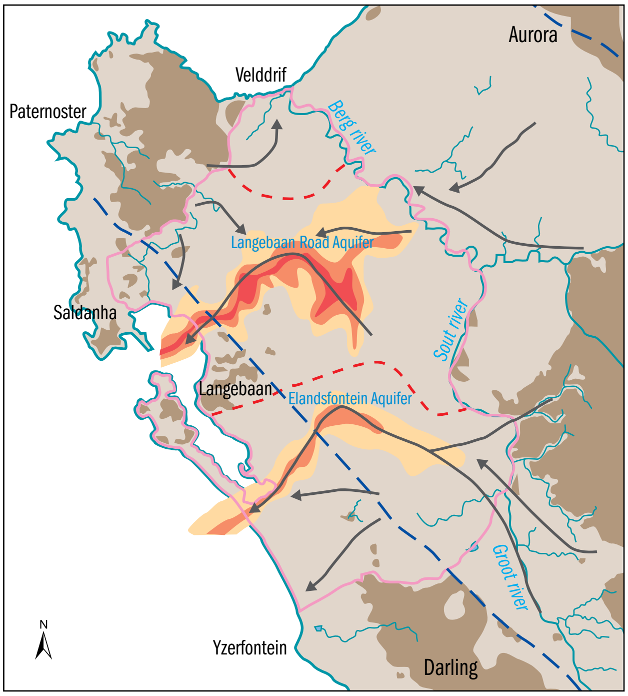
While Saldanha Bay and Langebaan Lagoon receives little freshwater input via rivers or streams (surface water), groundwater input is significant and plays an important role in sustaining marsh ecosystems around the periphery of the Bay, and especially the Lagoon. There are two main aquifer systems from which groundwater discharges into the Bay – the Langebaan Road Aquifer System and the Elandsfontyn Aquifer System. There is little exchange of water between these two aquifer units, each one discharging to the sea through its own paleo-channel. The Langebaan Road Aquifer System discharges into Saldanha Bay (Big Bay) through a northern paleo-channel while the Elandsfontyn Aquifer System discharges into Langebaan Lagoon through a southern paleo-channel. Growth of the reeds *Phragmites australis* and *Typha capensis* on the shoreline surrounding Langebaan Lagoon provide clear evidence of the significant influx of groundwater to the Lagoon, because these plants can only survive in water or damp soil, and are only able to tolerate salinity levels up to a maximum of 20–25 ppt (the salinity of the water in the lagoon is generally the same. or occasionally higher, than the 35 ppt of seawater).

Increasing pressure on available freshwater water resources in the Saldanha Bay area in recent years has resulted in attention being turned to exploitation of these groundwater resources. The West Coast District Municipality (WCDM) operates a wellfield on the Langebaan Road Aquifer that is licenced to abstract up to 1.46 million m^3 of groundwater per annum. Abstraction of groundwater from this aquifer resulted in a localised depression of water levels in the deeper portion of this aquifer by as much as 10 m in the first few years of operation between 2005 and 2009, and concern has been expressed over how this might be affecting groundwater discharge to Saldanha Bay now, and in the future. A modest (10%) reduction in abstraction rates was effected to address this but it is not clear how effective this has been.

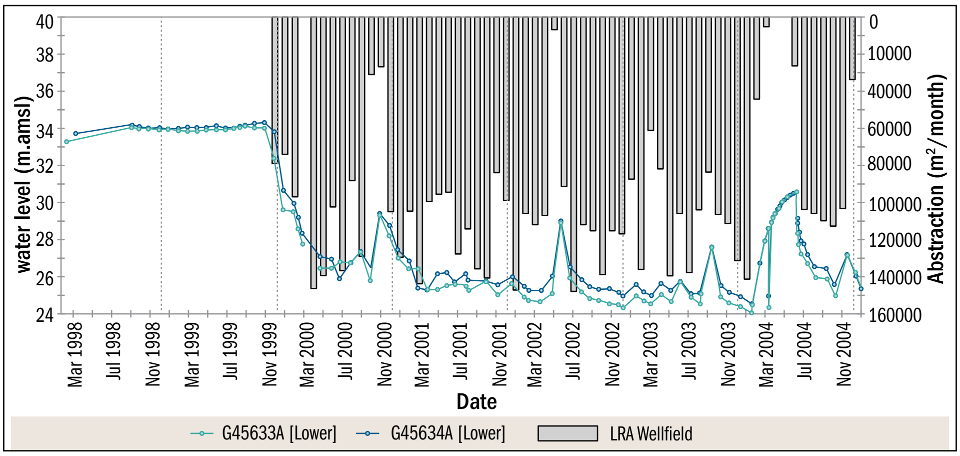


Vegetation and habitat structure at Langebaan Lagoon (source: Shapefiles provided by van der Linden 2013).

More recently, Elandsfontein Exploration and Mining (Pty) Ltd has started mining phosphate deposits in the area of the Elandsfontein Aquifer System on the eastern side of the R27. Mining is being conducted using an open-pit strip mining method which requires that groundwater levels around the mining pit be lowered to prevent the mine pit from being flooded. Groundwater is being abstracted from a series of boreholes surrounding the mine pit but is reinjected further away, in an effort to ensure that surrounding ecosystems (including the Lagoon) are not affected. Naturally, there is concern that these mitigation measures will not effectively mitigate impacts on the lagoon, so a comprehensive monitoring programme has been initiated to confirm that this is not the case. This includes monitoring of water levels and water quality in a series of boreholes between the mine site and the lagoon edge, and monitoring of salinity levels and macrofauna assemblages in the lagoon itself. Only time will tell if these mitigation measures have been effective or not.



Paleo-channels through which the Langebaan Road and Elandsfontyn Aquifers discharge (Redrawn from DWAF 2008).



Monthly abstraction and water level in the Upper and Lower Aquifers in the vicinity of the Langebaan Road Wellfield (up to Jan 2005) (Redrawn from SRK 2005).

Top: Langebaan Lagoon yacht club
Middle: Langebaan lagoon beach
Bottom: Shore based sampling

Benthic Macrofauna

Soft-bottom benthic macrofauna are *frequently* used as a measure to detect changes in the health of the marine environment as a result of anthropogenic impacts. This is because these species are short lived with rapid life cycles and their community composition responds *quickly* to environmental changes.

Soft-bottom benthic macrofauna (animals living in the sediment that are larger than 1 mm) are frequently used as a measure to detect changes in the health of the marine environment as a result of anthropogenic impacts. This is because these species are short-lived with rapid life cycles, and, as a consequence, their community composition responds quickly to environmental changes. Data are available on benthic macrofaunal communities in Saldanha Bay for 1999–2017 and for 1975–2017 for Langebaan Lagoon. While there are some earlier data available Saldanha Bay, these are not comparable to the more recent data due to differences in the manner in which the samples were collected. Benthic communities in Saldanha Bay have remained relatively constant from 1999 to 2017 as has been the case in Langebaan Lagoon. However, the longer time-series data from Langebaan Lagoon show that there were dramatic changes before this following the development of the Port.

Changes were also detected in macrofauna assemblages in Saldanha Bay and Langebaan Lagoon in 2008 and 2012. These changes in community composition, abundance and biomass involved a decrease in the abundance and biomass of filter feeders and an increase in shorter-lived opportunistic detritivores. The change that occurred in 2008 may be linked to extensive dredging that took place during 2007–2008, but it is not clear what caused the perturbation in 2012. Notwithstanding these, and some other less marked perturbations, overall abundance (and biomass) of benthic macrofauna in Saldanha Bay and Langebaan Lagoon seems to have increased over time since records began. This may be related to increasing nutrient and organic inputs to the Bay (from wastewater) and increased retention time (which allows primary producers more time to take advantage of the available nutrients) and is thus not necessarily a good sign.

Benthic macrofauna species frequently found to occur in Saldanha Bay and Langebaan Lagoon. »

A – *Upogebia capensis*

B – *Idunella lindae*

C – *Hippomedon normalis*

D – *Diopatra monroi*

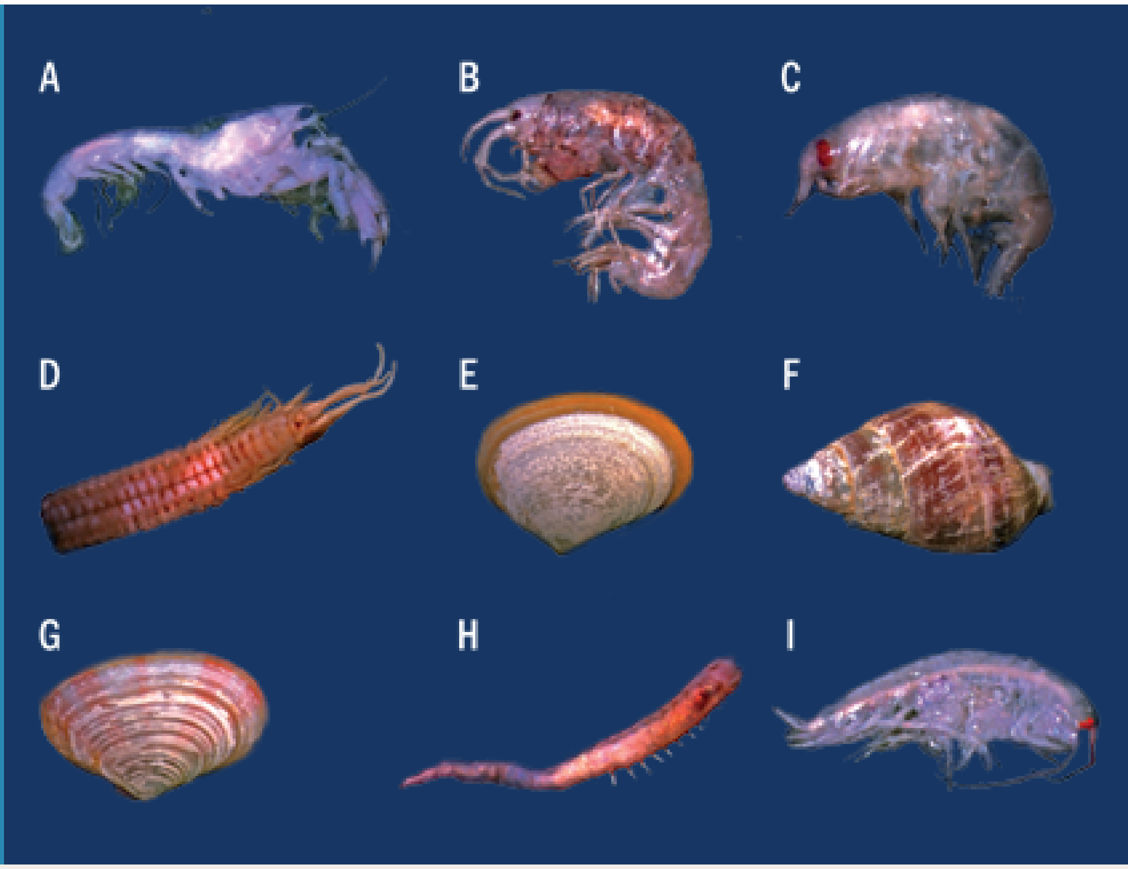
E – *Macoma c. ordinaria*

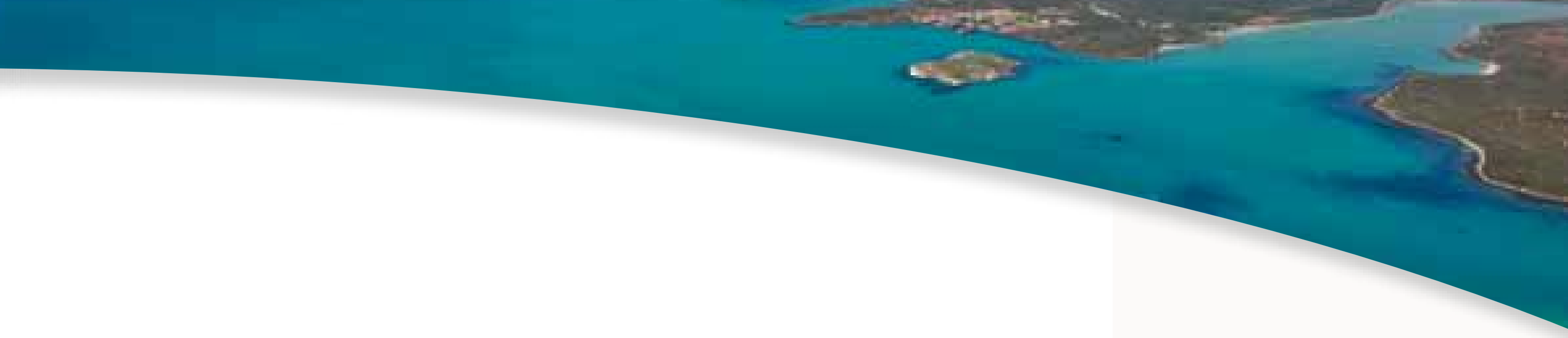
F – *Nassarius vinctus*

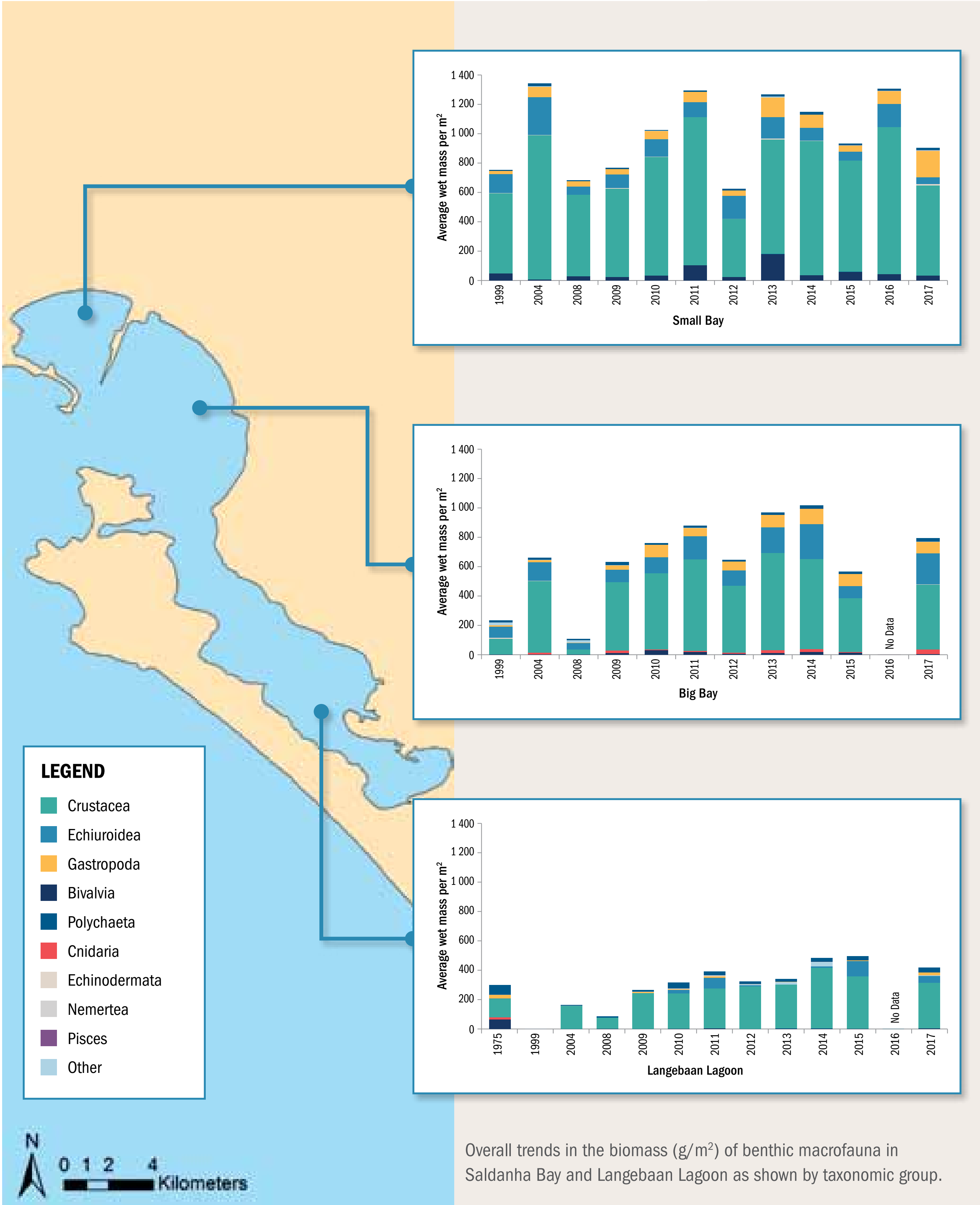
G – *Tellina gilchristi*

H – *Sabellides luderitzi*

I – *Ampelisca anomola*







Overall trends in the biomass (g/m^2) of benthic macrofauna in Saldanha Bay and Langebaan Lagoon as shown by taxonomic group.

Rocky Shore

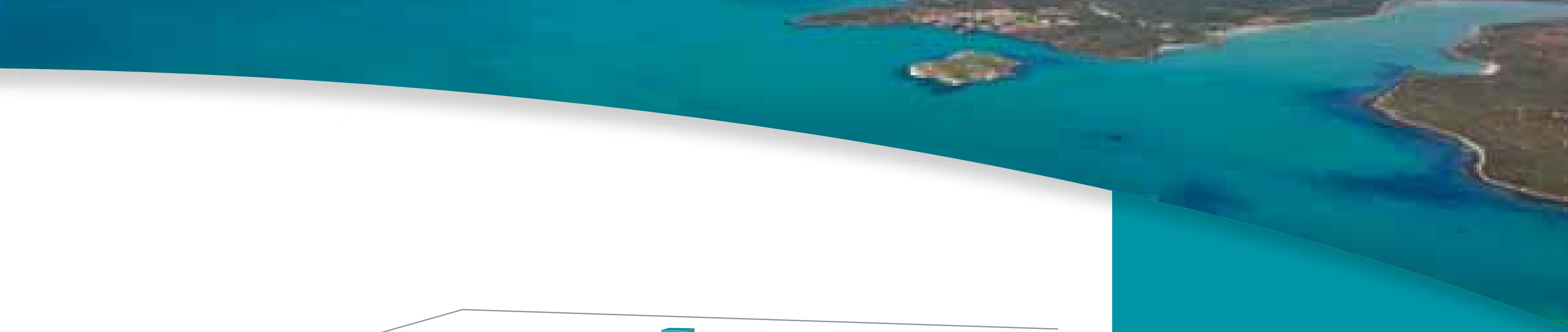
Rocky shore habitats are found on the islands, on rocky headlands in Saldanha Bay, and on artificial rocky shores e.g. the causeway and the iron ore terminal. Their invertebrate and algal communities are monitored at eight sites encompassing all these locations. These communities vary considerably between sites due to differences in of wave energy and shoreline topography.

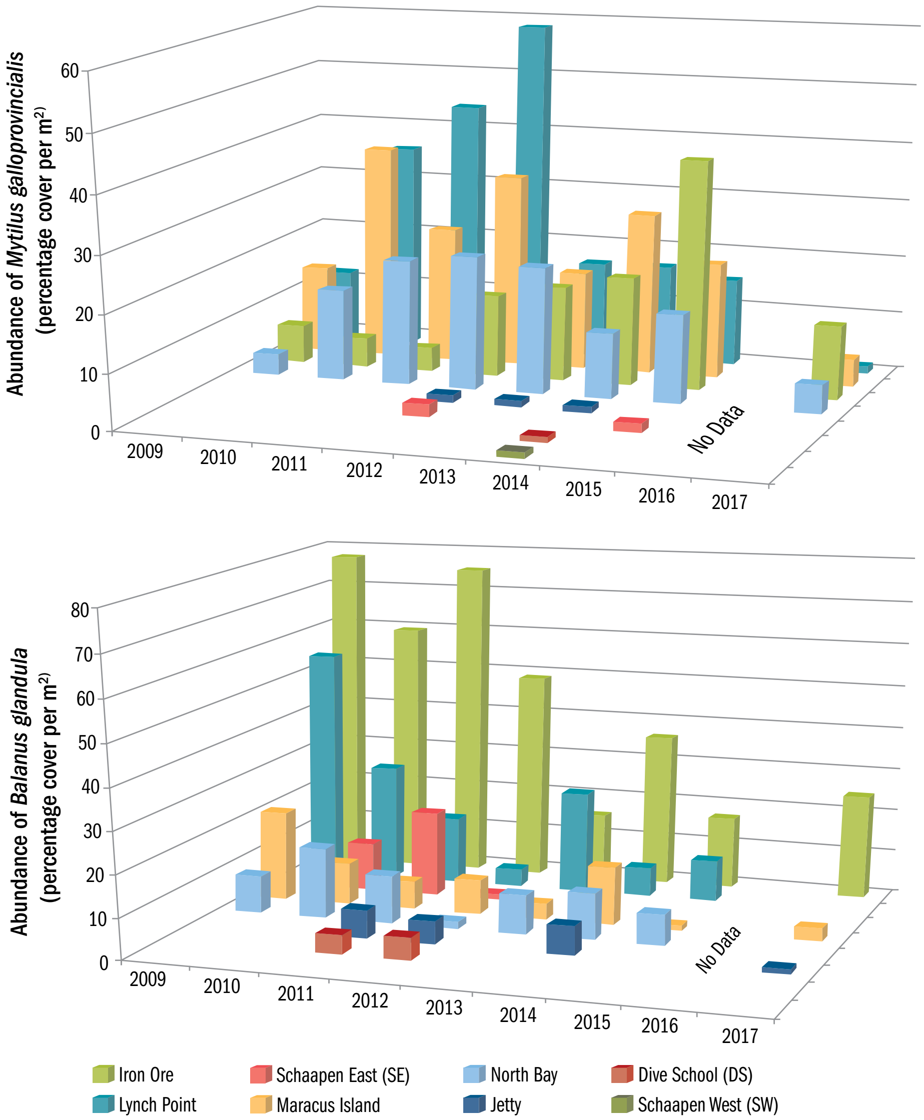
Rocky intertidal biota have been monitored annually in Saldanha Bay since 2008. A total of 116 taxa (species) have been recorded across the eight study sites, all of which are common along much of the South African West Coast. While the abundance and diversity of indigenous species would have changed due to the invasion of alien mussels, the species composition and abundance of rocky intertidal species have remained relatively constant since monitoring began in 2008.

The four main alien invasive species (the Mediterranean mussel *Mytilus galloprovincialis* and three alien barnacle species; *Balanus glandula*, *Amphibalanus amphitrite amphitrite* and *Perforatus perforates*) are believed to have been introduced by hull fouling, ballast water or mariculture at various points in the past. Two of these species, the Mediterranean mussel and the barnacle *Balanus glandula*, dominate intertidal communities on the midshore (occupying up to 30% or more of the space on the shore), especially at wave exposed sites. Results from the State of the Bay monitoring surveys indicate that populations of these two species expanded at most sites between 2005 and 2012 but have since begun contracting again.

Typical inhabitants of the West Coast rocky shore
Top: anemone
Middle: limpets

Below: Rocky shore sampling





Extent (as a percentage cover) of two invasive species on the Saldanha Bay rocky shores, the Mediterranean mussel *Mytilus galloprovincialis* and the barnacle *Balanus glandula*.

As expected, total biotic cover increases from high to low shore and differences in community structure are most pronounced at the low shore where the wave energy is greatest.Very few species occur on the high shore and considerable amounts of sand and gravel are present at very sheltered shores (i.e. Dive School and iron ore jetty). Barren rock dominates the high shores, while algal cover is extremely sparse. The mid shore at sheltered sites is also relatively barren, while exposed sites have higher biotic cover. Algal presence is generally low. With increasing wave force across sites, the mid shores are dominated by filter feeders, particularly two alien invasive species; the Mediterranean mussel *M. galloprovincialis* and the barnacle *Balanus glandula*. The tiny periwinkle *A. knysnaensis* is found nestling in amongst the barnacles, which provide shelter from wave action. Low shore communities are more visible at very sheltered sites (i.e. Dive School), and average faunal and algal cover is low in comparison with exposed low shore sites (i.e. North Bay and Marcus Island). The pear-shaped limpet *Scutellastra cochlear* (always surrounded by narrow gardens of fast-growing, fine red algae) is found exclusively in the low shore zone.

High shore:

Very few species occur on the high shore and considerable amounts of sand and gravel are present at very sheltered shores (i.e. Dive School and Jetty). Barren rock dominates the high shores, while algal cover is extremely sparse.

Mid shore:

The mid shore at sheltered sites is also relatively barren, while exposed sites have higher biotic cover. Algal presence is generally low. With increasing wave force across sites, the mid shores are dominated by filter feeders, particularly two alien invasive species; the mussel *M. galloprovincialis* and the barnacle *Balanus glandula*. The tiny periwinkle *A. knysnaensis* is found nestling in amongst the barnacles, which provide shelter from wave action.

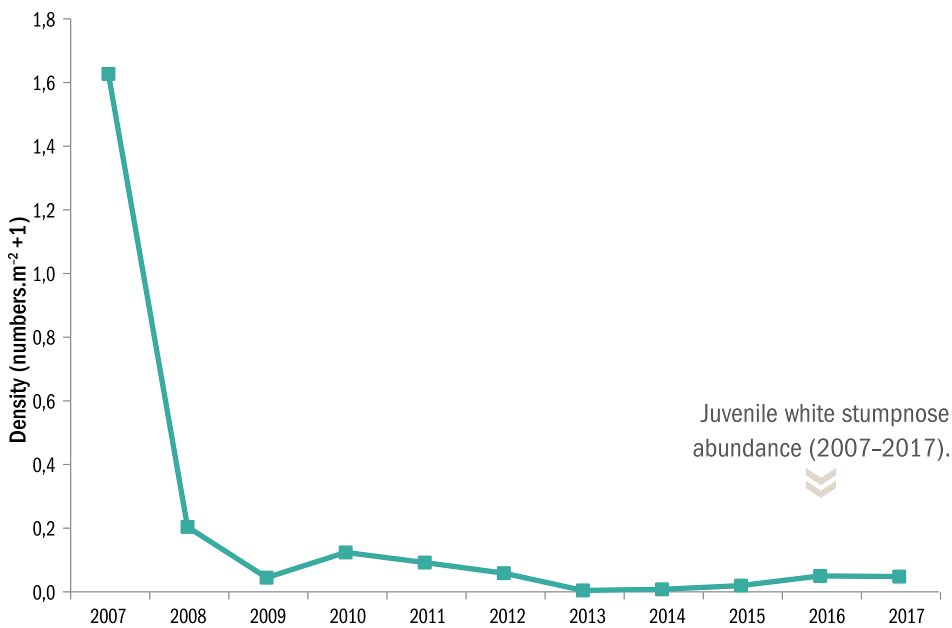
Low shore:

At the very sheltered sites (i.e. Dive School and Jetty), average faunal and algal cover is low in comparison with exposed low shore sites (i.e. North Bay and Marcus Island). The pear-shaped limpet *Scutellastra cochlear* (always surrounded by narrow gardens of fast-growing, fine red algae) is found exclusively in the low shore zone. As expected, total biotic cover increases from high to low shore and differences in community structure are most pronounced at the low shore where the wave energy is greatest.

Fish

The warm, sheltered sunlit nutrient rich waters of Saldanha Bay and Langebaan Lagoon provide a refuge from the cold, rough seas of the adjacent West Coast, and support a high abundance and diversity of fish species. The system also plays a particularly important role as a nursery area for the juveniles of many fish species that are essential to the healthy functioning of the ecosystem. A greater diversity of species has been captured in Big Bay (37) and in Small Bay (36), than the Lagoon (26), but a higher abundance is present in the Lagoon. Overall, there is no clear trend in species richness over time with the same ubiquitous species present in nearly all surveys. There is a concerning decrease in abundance most of the dominant species in Small Bay in surveys over the period 2008–2015 and a notable decrease in white stumpnose abundance throughout the system over this same period. The 2016 survey revealed some encouraging signs of increased white stumpnose recruitment in Small Bay, but 2017 catches were again lower than average. There is no decline in fish diversity or overall abundance in Small Bay, which suggests that the habitat quality remains good as a juvenile fish nursery. The strong elf recruitment in Big Bay evident in the 2016 and 2017 sampling bodes well for the recreational fishery for this species in coming years, and other species common in Big Bay catches were present in comparable numbers to earlier surveys.

The current status of juvenile fish communities overall in Saldanha Bay and Langebaan Lagoon appears satisfactory, with relatively stable fish diversity and overall abundance. This suggests that the habitat quality within the Saldanha Bay – Langebaan Lagoon system remains good as a juvenile fish nursery and that the marine protected area (MPA) is supporting adult spawning stock. The significant declines in juvenile white stumpnose abundance at all sites throughout the system and in linefish catches in recent years, however, suggest that the protection afforded by the Langebaan MPA may not be enough to sustain the fishery at the current high effort levels. A reduction of the daily bag limit and an increase in the minimum size limit for white stumpnose caught in the Saldanha Bay – Langebaan system is therefore recommended. These harvest control measures have an excellent chance of improving the stock status, catch rates and the size of white stumpnose in the future fishery.

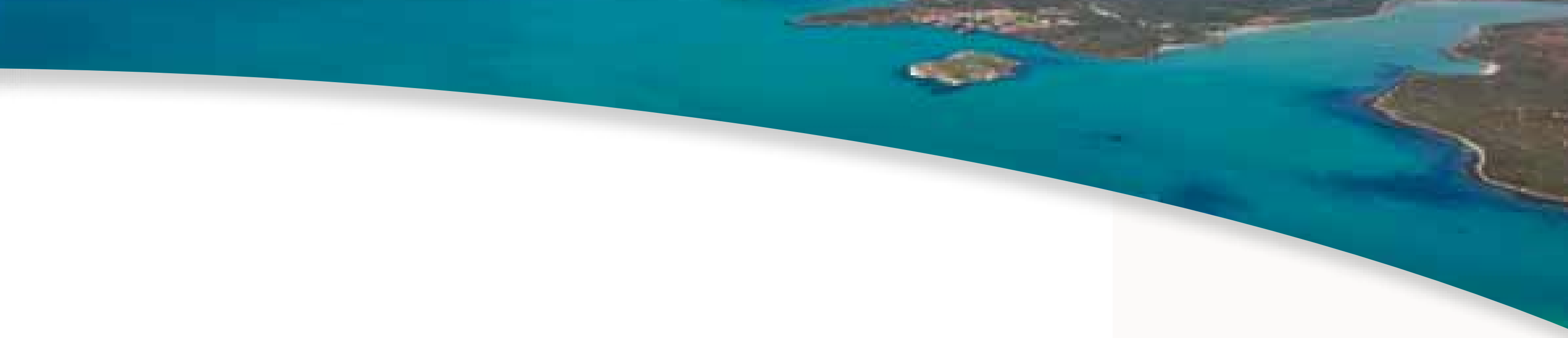


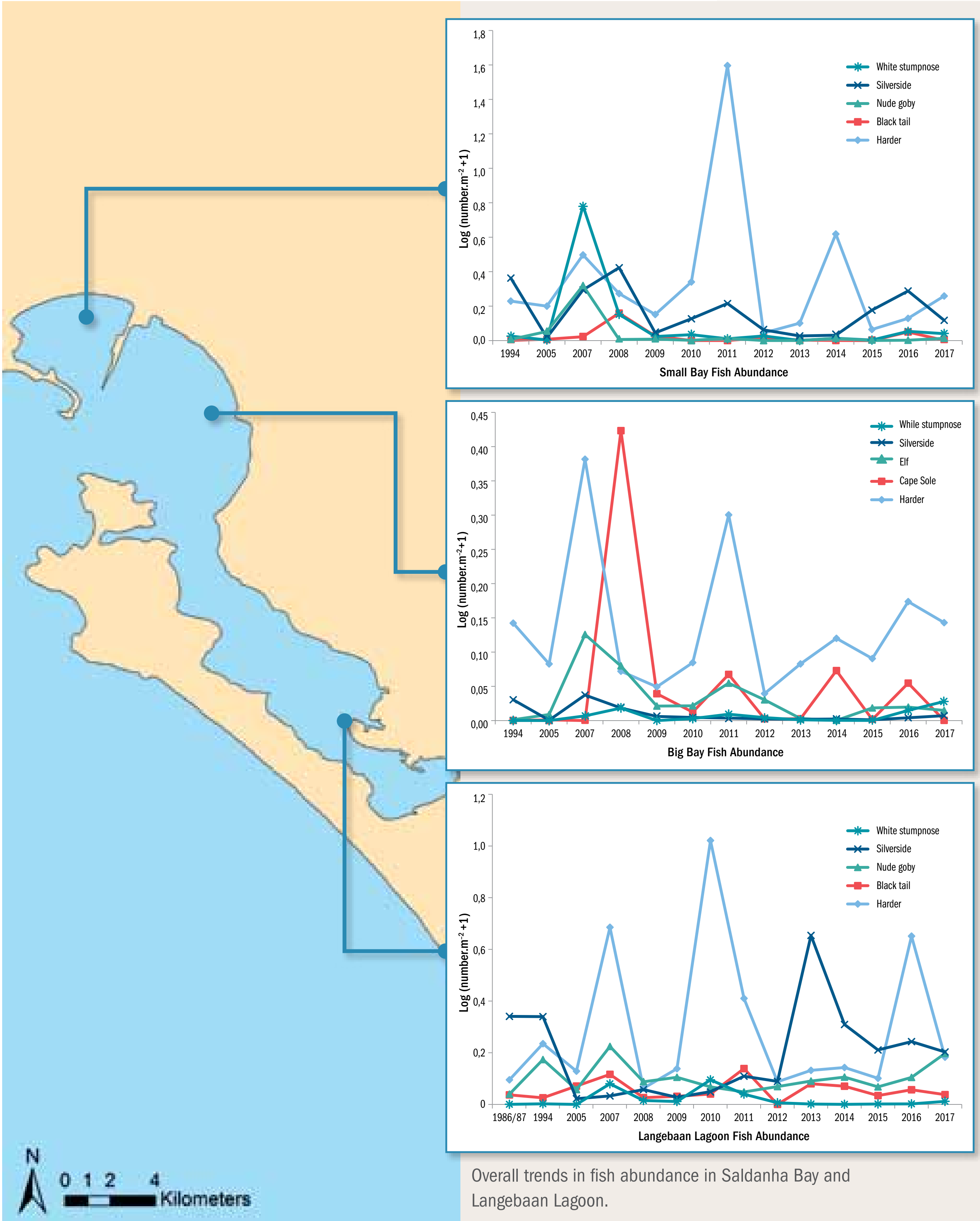
Juvenile white stumpnose abundance (2007–2017).

Top: A catch of white stumpnose

Middle: White steenbras

Bottom: Fisheries contribute significantly to the tourism appeal and regional economy of Saldanha Bay and Langebaan





Overall trends in fish abundance in Saldanha Bay and Langebaan Lagoon.

Birds

Top: African penguin
Middle: African penguins
Bottom: Kelp gull

Saldanha Bay and Langebaan Lagoon provide extensive and varied habitat for a large number of marine and coastal bird species. Key habitats in the area include exposed rocky shores and islands, tidal saltmarshes, sandflats and mudflats, reedbeds and sandy beaches. At least 56 non-passerine waterbird species use the area for feeding or breeding; 11 breed on the islands of Malgas, Marcus, Jutten, Schaapen and Vondeling alone. These islands support nationally-important populations of African Penguin, Cape Gannet, Swift Tern, Kelp and Hartlaub's Gull, and four species of marine cormorant, as well as important populations of the endemic African Black Oystercatcher. The lagoon is an important area for migratory waders and terns, as well as for numerous resident waterbird species. Waterbirds are counted annually on all the islands, and bi-annually in Langebaan Lagoon.

Birds of the Saldanha Bay Islands

The Saldanha Bay islands support important populations of five regional endemic birds. The African Penguin *Spheniscus demersus* (Endangered) breeds at 24 islands and one mainland colony from Namibia to Algoa Bay. The Cape Gannet *Morus capensis* breeds on three islands off Namibia and three islands off South Africa. Historically about half of South Africa's Gannets bred in the Western Cape, but this declined to 30% over the period 2003–2013 and now the largest colony is found on Bird Island in Algoa Bay where 78% of South Africa's gannets bred in 2013. Bank Cormorant *Phalacrocorax neglectus* (Endangered) breeds along the west coast of Namibia and South Africa. The Crowned Cormorant *Phalacrocorax coronatus* (Near Threatened) is endemic to Namibia and South Africa and is listed as Near Threatened due to its small and range restricted population. The African Black Oystercatcher *Haematopus moquini* (Near Threatened) is endemic to southern Africa.

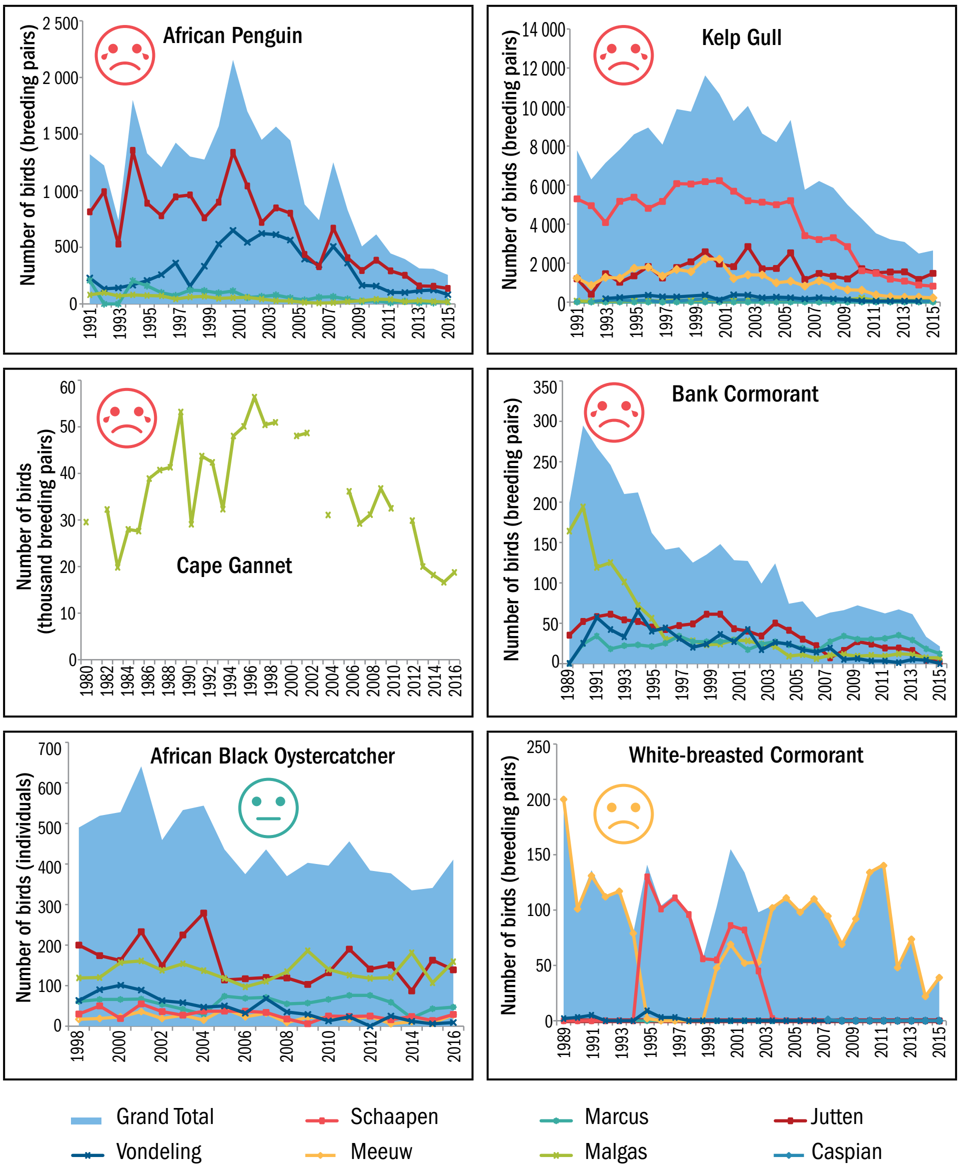
The islands also support important breeding populations of the more widespread Cape Cormorant *Phalacrocorax capensis,* White-breasted Cormorant *Phalacrocorax carbo lucidus,* Kelp Gull *Larus dominicanus*, as well as the Caspian Tern *Hydroprogne caspia.*

With the exception of the cormorants, the populations of the other seabirds that breed on the islands of Saldanha Bay were on an increasing trajectory from the start of monitoring in the 1980s and 90s until around 2000. Factors that probably contributed to this include the banning of egg collecting, the reduction and eventual cessation of guano collecting in 1991, increases in the biomass of small pelagic fish particularly sardines over this period, and in the case of the African Black Oystercatcher, the increase in mussel biomass as a result of the arrival and spread of the Mediterranean mussel.

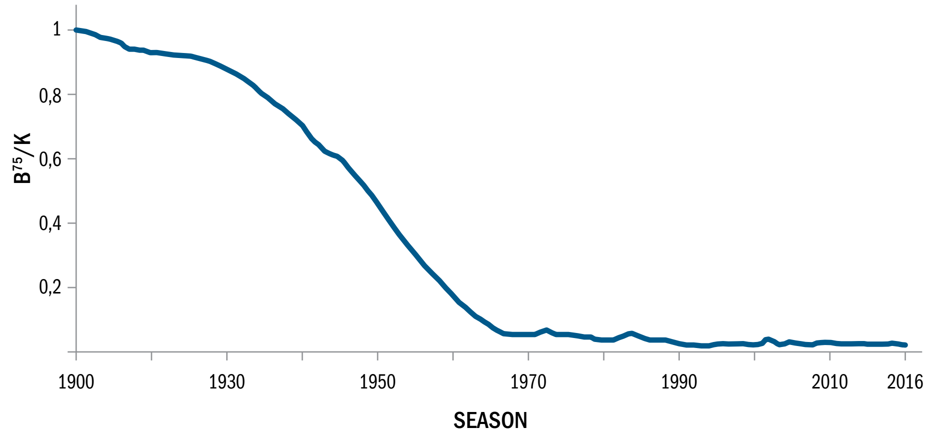
On the islands of Saldanha Bay, populations of all of these species then started to decline, particularly the penguins, gannets and gulls, which have declined to 12%, 39% and 22%, respectively of their populations at the turn of the century. Declines in the numbers of seabirds breeding on the Saldanha Bay Islands can be attributed to a number of causes. These include (1) emigration of birds to colonies further south and east along the South African coast in response to changes in the distribution and biomass of small pelagic fish stocks, (2) starvation as a result of a decline in the biomass of sardines nationally, and particularly along

the west coast over the last decade (see figure on sardine biomass below), (3) competition for food with the small pelagic fisheries within the foraging range of affected bird species, (4) predation of eggs, young and fledglings by Great White Pelicans, Kelp Gulls and Cape Fur Seals, and (5) collapse of the West Coast Rock Lobster stock upon which Crowned Cormorants feed.

Great White Pelicans breed on Dassen and Vondeling Islands and have learned to feed on chicks and eggs of sea birds in the island breeding colonies. This was first observed in the mid-1990s, and became severe enough to cause total breeding failure of Kelp Gulls at Jutten, Schaapen and Meeuw Islands in 2005 and 2006. This pressure has declined since then due to actively chasing pelicans away from nest sites as well as a decrease in their regional population.



Top: Crowned Cormorant
Middle: Cape Cormorant
Bottom: African Black Oystercatcher



Current cape rock lobster (*Jasus lalandii*) biomass in relation to pristine values for the resource as a whole. This graph shows the collapse of the West Coast Rock Lobster stock, upon which Crowned Cormorants feed.

The decline in Bank Cormorants started soon after monitoring began and numbers have decreased by 93% from the peak of 295 breeding pairs in 1992 to 21 in 2016. The major decline in stocks of the West Coast Rock Lobster, their main prey at the Saldanha Bay Islands, over preceding decades is probably largely to blame, but increased egg and chick predation may also have played a role in their continuing decline.
Oystercatcher numbers declined during the initial monitoring period, but have remained nearly stable since 2006. This possibly reflects stabilization in the alien Mediterranean mussel biomass as the island rocky shore ecosystems settle into their new equilibrium.

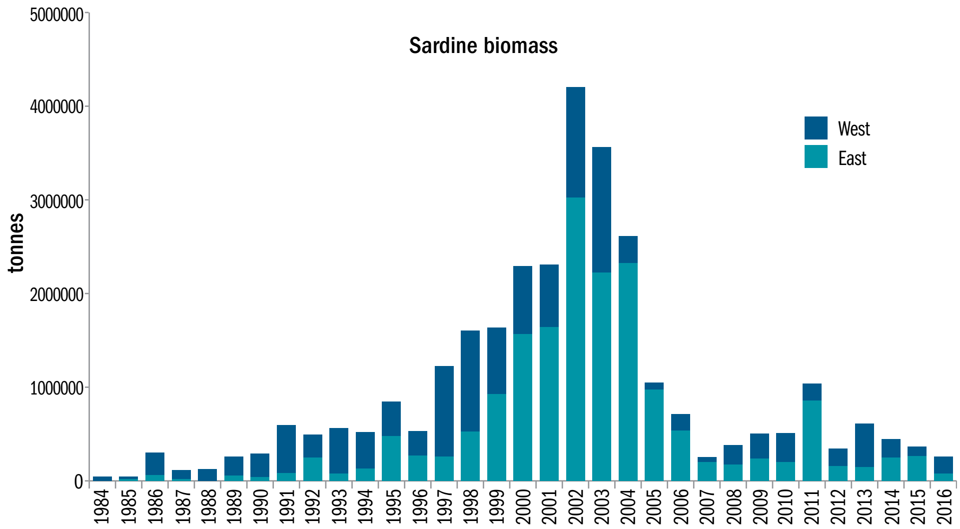
Numbers of White-breasted Cormorants have remained comparatively stable throughout the monitoring period, though they shifted *en masse* from Meeuw to Shaapen Island for a number of years before returning again. However, their numbers have dropped off dramatically within the last five years. This could represent another shift in breeding location to somewhere beyond the Bay, or something more serious happening within their breeding or feeding areas within the Bay. Monitoring data also suggest that Crowned Cormorant may also have started to decline in recent years. Numbers of Hartlaub's and Swift Terns are highly variable and do not show any discernible trend.

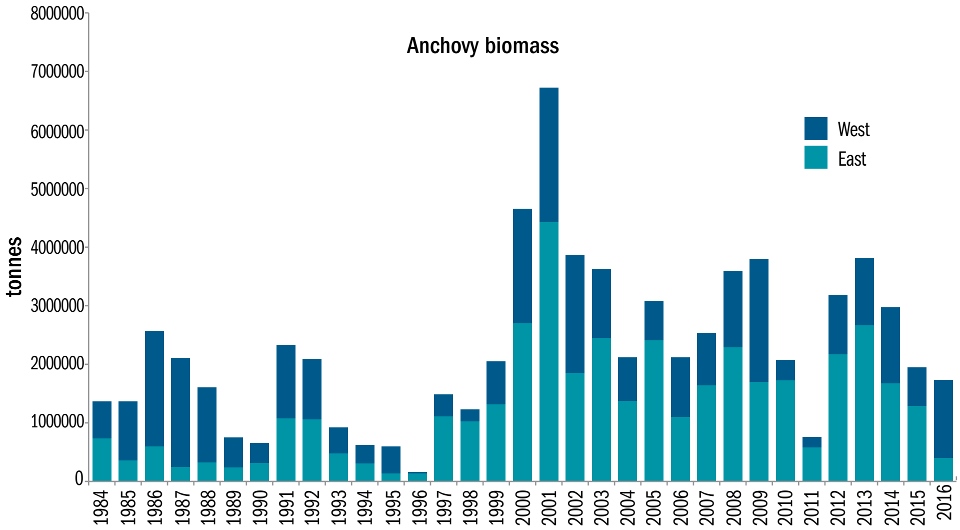
Langebaan Lagoon, with its warm, sheltered waters and abundance of prey, supports a high diversity and abundance of waterbirds, especially in summer when it is visited by thousands of migratory waders from the northern hemisphere. A number of commonly-found migratory waders are globally recognised as Near Threatened and include the Bar-tailed Godwit *Calidris ferruginea*, Black-tailed Godwit *Charadrius pallidus*, Chestnut-banded Plover *Haematopus moquini*, Curlew Sandpiper *Limosa lapponica*, Red Knot *Phoeniconaias minor*.

Waterbird numbers on Langebaan Lagoon have declined dramatically since monitoring began in the 1970s. This is largely due to changes in the numbers of waders, which used to account for more than 90% of bird numbers. In the 1970s and 1980s, migratory waders commonly numbered over 35 000 during summer, and over 10 000 in winter. Summer numbers have since decreased to fewer than 4 000 in 2017. Resident wader population numbers have roughly halved over the same period. Today, waders make up only 30–50% of summer bird numbers.

Top: White-breasted cormorant
Middle: White-breasted cormorant
Bottom: Bank Cormorant

Decreases in both migratory and resident wader numbers are a common trend around the South African coast. Decreases in numbers of migrants can be attributed to loss of breeding habitat and hunting along their migration routes as well as human disturbance and habitat loss on their wintering grounds. The fact that numbers of resident waders have also declined suggests that local human disturbance is also to blame at Langebaan Lagoon, and corresponds to the dramatic increases in visitor numbers to the area over the last two decades, and the more recent increases in sporting activities on the lagoon.





Variations in biomass of sardine and anchovy off the West and South coasts of South Africa

Birds of Langebaan Lagoon

Langebaan Lagoon, with its warm, sheltered waters and abundance of prey, supports a high diversity and abundance of waterbirds, especially in summer when it is visited by thousands of migratory waders from the northern hemisphere. A number of commonly found migratory waders are globally recognised as Near Threatened and include the Red Knot *Calidris canutus*, Curlew Sandpiper *Calidris ferruginea*, Bar-tailed Godwit *Limosa lapponica* and Eurasian Curlew *Numenius arquata*.

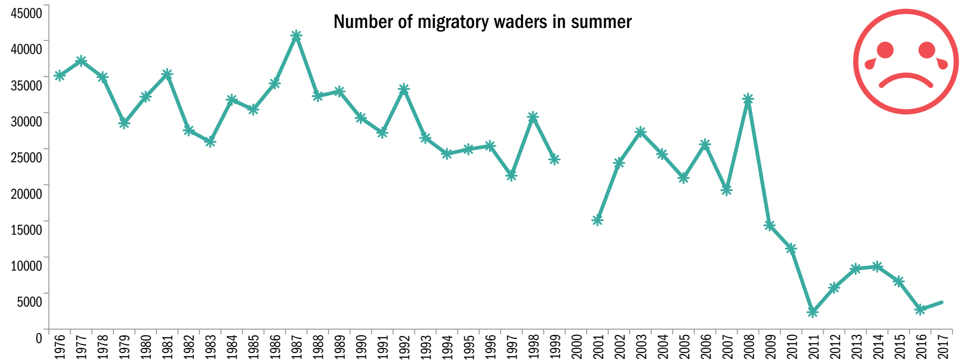
Top: Cape Gannet

Middle: Black-winged Stilt, a resident wader

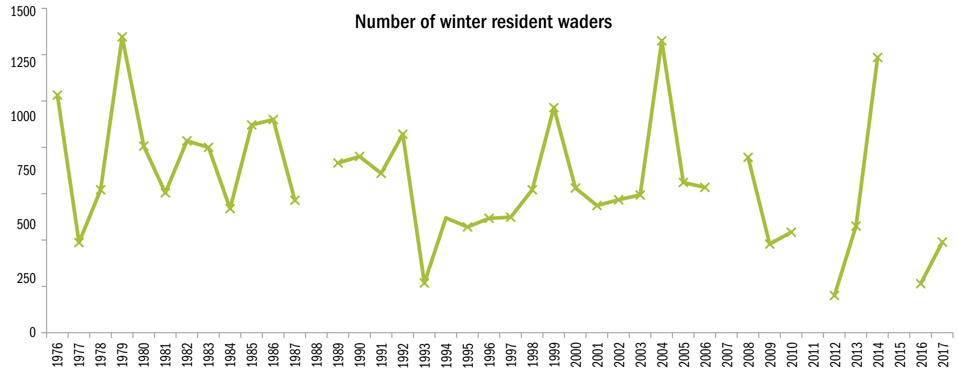
Bottom: Migratory terns, Langebaan Lagoon

Waterbird numbers on Langebaan Lagoon have declined dramatically since monitoring began in the 1970s. This is largely due to changes in the numbers of waders, which used to account for more than 90% of bird numbers. In the 1970s and 1980s, migratory waders commonly numbered over 35 000 during summer, and over 10 000 in winter. Summer numbers have since decreased significantly to fewer than 4 000 in 2017. Resident wader population numbers have roughly halved over the same period. Today, waders make up only 30–50% of summer bird numbers.

Decreases in both migratory and resident wader numbers are a common trend around the South African coast. Decreases in numbers of migrants can be attributed to loss of breeding habitat and hunting along their migration routes as well as human disturbance and habitat loss on their wintering grounds. The fact that numbers of resident waders have also declined suggests that local human disturbance is also to blame at Langebaan Lagoon, and corresponds to the dramatic increases in visitor numbers to the area over the last two decade, and the more recent increases in sporting activities on the lagoon.



Long term trends in the numbers of migratory waders counted in Summer in Langebaan Lagoon for the years 1976–2017 (Data source: Animal Demography Unit at the University of Cape Town).

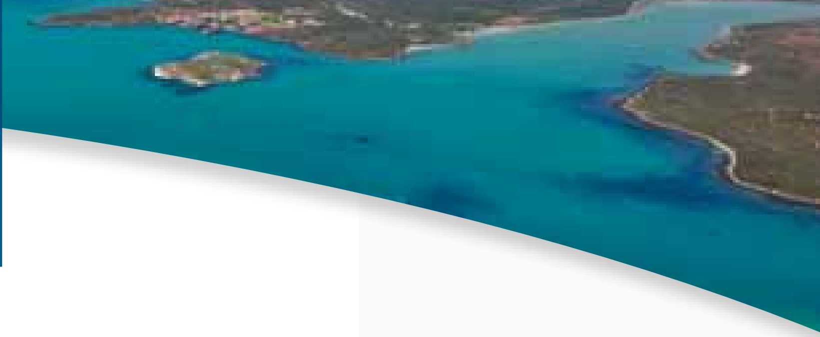


Long term trends in the numbers of resident waders counted in Winter in Langebaan Lagoon for the years 1976–2017 (Data source: Animal Demography Unit at the University of Cape Town)

Top: Greater flamingo

Middle: Common terns and curlew sandpipers

Bottom: Kittlitz's plover



Alien Species

Human-induced biological invasions have become a major cause for concern worldwide. The life history characteristics of alien species the ecological resilience of the affected area, the presence of suitable predators and many other factors, determine whether an alien species becomes a successful invader. Biological invasions can negatively impact biodiversity and can result in local or even global extinctions of indigenous species. Furthermore, alien species invasions can have tangible and quantifiable socio-economic impacts. Marine alien and invasive species have been introduced to South African waters mostly though shipping activities and mariculture.

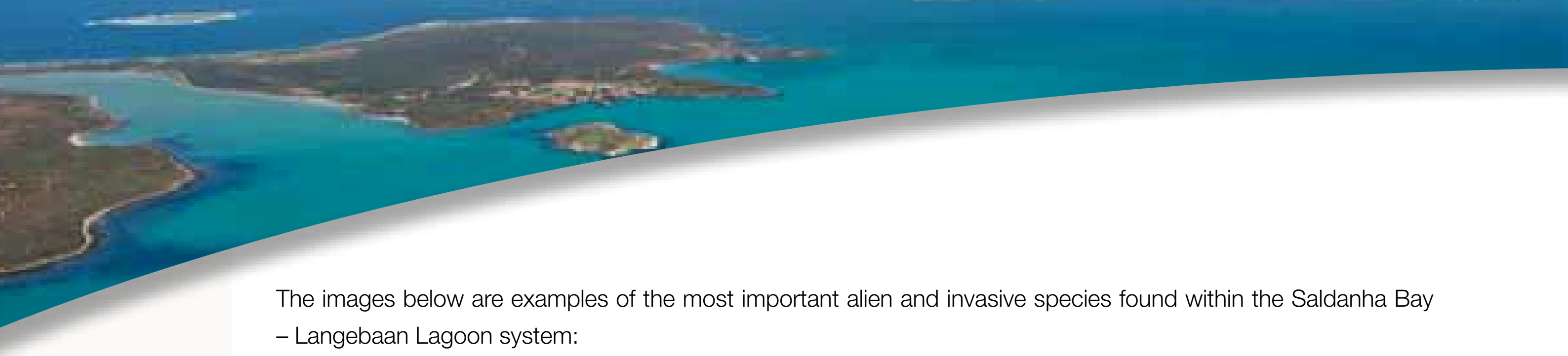
A recent update on the number of alien marine species present in South Africa lists 89 alien species as being present in this country, of which 53 are considered invasive i.e. population are expanding and are consequently displacing indigenous species. Approximately 70 of these alien species are present on the South Africa West Coast, and at least 30 are known to occur in Saldanha Bay and/or Langebaan Lagoon. The presence of at least three new alien species, the barnacle *Perforatus perforatus,* the Japanese skeleton shrimp *Caprella mutica,* and the European porcelain crab *Porcellana platycheles*, were confirmed in Saldanha Bay and Langebaan Lagoon in the last five years.

In addition to the 89 known alien species that have been introduced to South Africa, a further 40 species are regarded as cryptogenic (of unknown origin) but very likely introduced. The reasons for the confusion is mostly related to the fact that they were introduced before any detailed surveys were undertaken and hence cannot be confirmed as being alien. Of these 40 cryptogenic species, 21 have been recorded from Saldanha Bay.

Most of the introduced species in this country have been found in sheltered areas such as harbours, and are believed to have been introduced through shipping activities, mostly ballast water. Because ballast water tends to be loaded in sheltered harbours the species that are transported originate from these habitats and have a difficult time adapting to South Africa's exposed coast but thrive in the sheltered waters inside Saldanha Bay.

Human induced biological invasions have become a *major* cause for *concern* worldwide and in South Africa.

Left: *Mytilis galloprovincialis*
Right: Invasive barnacles



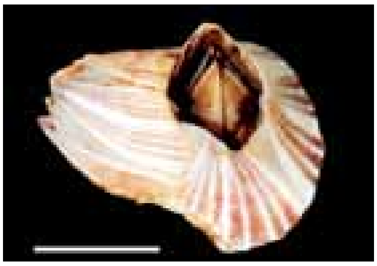
The images below are examples of the most important alien and invasive species found within the Saldanha Bay – Langebaan Lagoon system:

European mussel *Mytilus galloprovincialis – Origin: Mediterranean*

Pacific South American mussel *Semimytilus algosus* – Origin: Namibia

Acorn barnacle *Balanus glandula* – Origin: Pacific coast of North America

The volcano barnacle *Perforatus perforatus* – Origin: Pacific coast of North America

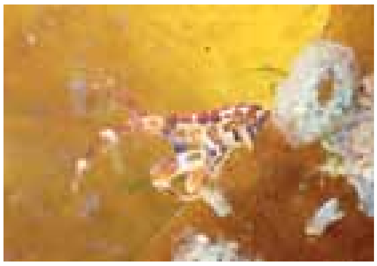


Amphibalanus amphitrite amphitrite – Origin unknown, worldwide distribution

Disc lamp shell *Discinisca tenuis* – Origin: Namibia

Dentate moss animal *Bugula dentate* – Origin: Indo-Pacific Region

Lagoon snail *Littorina saxatilis* – Origin: North Atlantic



Hitchhiker amphipod *Jassa slatteri* – Origin: Pacific North America

Brooding anemone *Sagartia ornata* – Origin: Western Europe, Great Britain and the Mediterranean

A typical aggregation of *Ciona robusta* – Origin: Mediterranean Sea and the English Channel

European porcelain crab *Porcellana platycheles – Origin: Mediterranean Sea and east Atlantic*

Ascidiella aspersa is often found covered in epibionts – Origin: Europe

Western pea-crab *Pinnixa occidentalis* – Origin: west coast of North America

Recommendations

- Ensure that all wastewater discharges to the Bay are properly licensed and adequately monitored (both volume and water quality);
- Prioritise the reclamation of wastewater to reduce effluent inputs into the Bay as well as to meet increasing water demands;
- Implement of the coastal management (development setback) lines around the perimeter of the Bay and Lagoon to provide adequate protection of both the environment and infrastructure;
- Sensitive habitats and fauna and flora in the Bay must be assigned levels of protection that ensure minimal disturbance to these areas/populations;
- Ecological impacts arising from any future proposed dredging programmes need to be carefully considered and these need to be weighed up against social and economic benefits that may be derived from such programmes or projects. Where such impacts are unavoidable, mitigation measures applied must follow international best practice;
- Future impact assessments must take cumulative impacts associated with the plethora of small and medium sized developments on the health of the Bay into account, rather than being viewed in isolation;
- Pressure must be put on the South African Maritime Safety Authority (SAMSA) to finalise and implement the Draft Ballast Water Management Bill initially published in April 2013, and re-released for comment in 2017, which aims to implement the International Convention for the Control and Management of Ship's Ballast Water and Sediments of 2004 (BWM Convention);
- The bag limit of white stumpnose should be reduced from 10 to 5 fish per person per day and the size limit should be increased from 25 cm TL to 30 cm TL. This should be implemented without delay;
- Pressure to allocate additional gill net licences in Saldanha Bay and Langebaan Lagoon, and to reduce protection provided by the Langebaan Lagoon MPA by allowing commercial gill net permit holders access to Zone B should be vehemently resisted, as such concessions will almost certainly lead to the collapse of stocks of other fish stocks such as harders, elf, white steenbras and sharks, in both Saldanha Bay and Langebaan Lagoon; and
- Continue to monitor and assess the overall health of the system.

Photography credits: Anchor Environmental Consultants, Biccard A, Griffiths CL, Trefson J, Turpie J, Clark B, Liebau V, Gittenberger A, Steffani N, National Museums Northern Ireland.

Citation: Clark BM, Hutchings K, Laird M, Biccard A, Massie V, Brown E, Harmer R, Wright AG & Turpie J.2017.The State of the Bay: Saldanha Bay and Langebaan Lagoon 2017. Report no. AEC1741/2 prepared by Anchor Environmental Consultants (Pty) Ltd.for the Saldanha Bay Water Quality Forum Trust.

© Saldanha Bay Water Quality Forum Trust 2017
Use of material contained in this document by prior written permission of the Saldanha Bay Water Quality Trust only

Top: Saldanha Bay and Langebaan Lagoon provide extensive, varied habitat for a large number of marine and coastal bird species

Middle: Langebaan Lagoon

Bottom: Shelter from wave action, abundant fish resources and the sheer beauty of Saldanha Bay and Langebaan Lagoon have made it an attractive place for the development of human settlements, a fishing industry and an industrial port

ANCHOR environmental

Saldanha Bay Water Quality Trust