State OF THE Bay 2022

Saldanha Bay and Langebaan Lagoon

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SBWQFT
Saldanha Bay Water Quality Forum Trust

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Cover: Sunset over Schaapen Island.

Bottom: Striped anemones among black mussels.

Summary

This glossy presents a number of environmental factors that have been used to monitor historic trends and the current state of ecosystem health in Saldanha Bay and Langebaan Lagoon. Regular, long-term monitoring is essential to identify negative environmental human impacts and to find ways in which to minimize these impacts. This is particularly critical in the Saldanha Bay and Langebaan Lagoon system, a uniquely important biodiversity area that is also host to a major industrial node, while supporting important tourism, recreation and fishing industries, all of which may negatively impact ecosystem health.

Activities and discharges

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. Port development in the 1970s attracted industry and resulted in a rapid expansion in urban development in Saldanha and Langebaan. Along with these developments, tourism has increased, with the numbers of visitors to the West Coast National Park now averaging around 205 000 guests a year. Coastal erosion of the beaches in Big Bay and at the entrance to Langebaan Lagoon has been an ongoing problem since the 1906s. While interventions like rock revetments, groynes and gabion walls have mostly been successful in halting the erosion, their impacts on safe beach access should be addressed. Some 531 vessels entered the Port of Saldanha in 2021/22, a decline from the peak of 600 vessels in 2017/18, possibly because of the global Covid-19 pandemic. The volume of ballast water discharged into the bay annually follows a similar pattern, with nearly 26 million m^3 discharged in 2022. Oil spills are an ever-present threat associated with shipping traffic and although few such events have been recorded to date, an oil leak occurred at the Strategic Fuel Fund Oil Terminal on 1 February 2022. Most of the oil was recovered, and the clean-up operation was concluded on 2 February 2022.

While fishing within Saldanha Bay and the Lagoon contributes significantly to the tourism appeal and regional economy long-term monitoring of targeted juvenile surf zone fish species has revealed some concerning trends. A significant decline in white stumpnose throughout the system from 2008–2022 suggests that the protection afforded by the Langebaan Marine Protected Areas may not be enough to sustain the fishery at the current high effort levels in the area, and recommendations have been made for the implementation of controls — a limit of five fish per person per day and an increase in the minimum size (30 cm total length). Similarly, the results of commercial harder catch analyses support recommendations for a reduction in fishing effort.

As of July 2022, 30 entities have been granted marine aquaculture rights in the sea-based Aquaculture Development Zone (ADZ) in terms of section 18 of the Marine Living Resources Act of 1998, mostly for mussels (*Mytilus galloprovincialis* and *Choromytilus meridionalis*) and the pacific oyster *Crassostrea gigas*. Rights to farm finfish (salmon *Salmo salar* and rainbow trout *Oncorhynchus mykiss*) have been issued to two farms, but neither is currently active in the bay.

Groundwater

The inflow of groundwater to the Saldanha Bay and Langebaan Lagoon system is highly important, because little other freshwater enters the system via rivers or streams. This groundwater supports the marsh ecosystems around the periphery of the Bay, and especially the Lagoon. Attention has turned to the use of this groundwater, due to the increasing demand for freshwater in the area. There is concern that use of this groundwater may reduce its flow into the Bay and Lagoon, with negative consequences to how the ecosystem functions. While monitoring has shown that this groundwater use is currently sustainable and is not reducing the freshwater flow to the Lagoon, any additional allocation of groundwater in the region needs to be carefully considered and controlled.

Marine water quality

While monitoring data shows no unequivocal evidence of significant changes in water quality in Saldanha Bay, there is clear evidence that the construction of the Saldanha Bay ore jetty and causeway has significantly altered the structure, wave energy and current patterns of the bay. Indeed, the wave energy is lower as a result, and the water remains in the system for longer, especially in Small Bay. This has contributed to the observed low levels of dissolved oxygen in the bottom waters in the Bay, and the high frequency of hypoxic (low oxygen) and anoxic (zero oxygen) conditions. Monitoring suggests that the mariculture may also be partially responsible for the low levels of dissolved oxygen seen in Small Bay. There has been a dramatic improvement in the levels of faecal coliforms in the Bay in recent years (an indication of how safe the water is for bathing and water sports), due to improvements in sewage treatment and reticulation infrastructure effected by the Saldanha Bay Municipality.

Sediments

Reduced current speed and wave strength after the Port development in the 1970s caused a build-up of fine sediment in the Bay. With no major dredging to disturb it, this fine sediment has gradually been flushed out of the Bay over the last 10 years, to the extent that most areas of the Bay are now very similar to how they were prior to any major development. Measures of organic enrichment, while high in some areas of the bay (near the yacht club basin and the ore terminal), have also declined in recent years, most likely due to a reduction in the amount of organic matter (waste) discharged into the Bay. Trace metals and toxic pollutants are associated with finer sediment types, and often reach unacceptably high levels in areas where these fine sediments accumulate. These metals are mostly harmless whilst buried on the seafloor, but disturbances like the 1999 dredging event cause them to become resuspended in the water, and this makes this toxic again. Although most have since returned to natural or close to natural levels due to flushing of the bay or reburial in sediments since 1999, they are very likely to become a serious risk again following any future dredging events.

Benthic macrofauna

The composition and abundance of the small animals that live within the sediment (benthic macrofauna) has changed substantially in Saldanha Bay and Langebaan Lagoon since monitoring first commenced in 1999, seemingly in response to the positive changes in sediment health. The overall numbers of macrofauna in Small Bay, Big Bay and Langebaan Lagoon have increased dramatically over 1999–2015, as levels of fine material in the sediment declined, but have since stabilised. Certain species known to be particularly sensitive to disturbance, such as the sea pen *(Virgularia schultzei)*, were absent in the early period, but have since returned to the Bay. This is one of the most encouraging trends in the Bay that that been revealed by the State of the Bay monitoring programme.

Rocky intertidal

The animals and plants that live and grow on the intertidal rocky shores of the Bay have been poorly surveyed in Saldanha Bay in the past and little can be deduced from changes in these communities. At the time when the monitoring of rocky intertidal communities began as part of the State of the Bay monitoring programme, two invasive alien species, the Mediterranean mussel *(M. galloprovincialis)* and the acorn barnacle *(Balanus glandula),* were already present. These two species are now the dominant occupiers of space on the rocky shores in the Bay and have displaced many of the indigenous species from this habitat.

Fish

The warm, sheltered and nutrient rich waters of Saldanha Bay and Langebaan Lagoon makes the system particularly important as a nursery area for the juveniles of many fish species targeted by commercial and recreational fisheries in the region. Sampling of surf-zone nursery areas since 2005 has shown that while more species (diversity) are present in Big Bay and Small Bay than in Langebaan Lagoon, there are generally a higher number of juvenile fish present (abundance) in the Lagoon. While the same ubiquitous species have been present in nearly all surveys, catches in 4 of the last 5 years have had lower than average diversity in Small Bay, Big Bay, and Langebaan Lagoon, suggesting that development and fishing pressure are taking a toll. There is also a concerning decrease in the abundance of some of the dominant species in the Bay over the last decade, particularly those that are targeted by commercial and recreational fisheries. Available data suggests that populations of white stumpnose, elf and harders are all overexploited and that reduction in fishing effort is necessary to ensure long term sustainability of catches of these species.

Birds

Saldanha Bay, Langebaan Lagoon and the associated islands provide important shelter, feeding and breeding habitat for some 53 seabird species. The islands of Malgas, Marcus, Jutten, Schaapen and Vondeling support breeding populations of African Penguin, Cape Gannet, four species of marine cormorants, Kelp and Hartlaub's Gulls, Swift Terns and African Black Oystercatcher. Numbers of these seabirds in Saldanha Bay have dropped dramatically since around 2004. Langebaan Lagoon has been identified as the most important wetland for waders on the west coast of southern Africa, with 67 species of waterbirds regularly recorded, peaking at some 27 000 individuals during summer. Most of these birds are migratory (visit the lagoon in summer only) but many are also resident throughout the year. Since 1980, the numbers of Lagoon waders (both migratory and resident) have decreased dramatically, which has been attributed to loss of breeding habitat and hunting along their migration routes, as well as human disturbance and habitat loss on their wintering grounds. A brief recovery in populations of some of these species was evident in 2021, likely an effect of the global Covid-19 pandemic, but this has unfortunately not been sustained.

Seals

Historically, seals have always frequented the seabird islands around Saldanha Bay. It is only since the turn of the century that a breeding colony has been established on Vondeling Island, currently at around 20 000 pups per annum. Seals have been observed killing Cape gannet fledglings at Malgas Island and considerable effort has been invested in recent years in keeping the seals away from the sea bird colonies.

Top: Rocky shore sampling site near Hoedtjiesbaai.

Middle: Diver inspecting biofouling growth underneath a mussel raft in Small Bay.

Bottom: Cape Sea Urchin – *Parechinus angulosus* forming part of the epifaunal community on mussel ropes in Small Bay.

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.

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 Forum Trust (SBWQFT) 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. Developing National Environmental Legislation and 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. The advent of "Climate Change" brings forth sea level rise and storm events. Thus, beach erosion and sediment movement are going to pose major challenges in the years ahead.

None of the above can take place without scientifically based information on the 'State of the Bay'. The SBWQFT has been the pioneer in this regard and has conducted a series of all-encompassing scientific monitoring activities with minimal resources over the last 23 years. This 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. To this end the following Strategic approach has been adopted and is being enthusiastically implemented:

Vision

The Saldanha Bay Catchment Area is a sustainable ecological system where the SBWQFT, industry, Government and the Community work together as a "Team".

Mission

To promote water quality and ecological system health through:
- Scientific monitoring, planning, evaluating and reporting
- Equitable sharing of cost
- Informing and the provision of related advice to influence decision making
- Communication with interested and affected parties
- Sound administrative and financial management

All this in order to meet legal, environmental and social responsibilities.

Values

- Accountability
- Openness and Transparency
- Integrity, Honesty, Fairness and Trust
- Cooperation, Synergy and Inclusivity

Principles

- Scientific Approach – monitor, evaluate and report
- User Pays (sharing monitoring cost)
- Stakeholder Representation (relevant entities/bodies/organisations)
- Public Participation
- Legal Compliance
- Financial Viability

In conclusion 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 Saldanha Bay and Langebaan Lagoon for future generations whilst ensuring responsible development.

Alderman André Kruger
Chairperson SBWQFT

ANCHOR environmental

Percy FitzPatrick Institute

South African National Parks

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South African Weather Service

environment, forestry & fisheries
Department: Environment, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Striped anemone – *Anthothoe stimpsonii.*

Introduction

Saldanha Bay is situated on the west coast of South Africa, some 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, with Langebaan Lagoon and much of the surrounding land also falling within the West Coast National Park. In 1988, Langebaan Lagoon was also declared a Ramsar Site, along with all the Saldanha Bay islands (Schaapen, Marcus, Malgas, Jutten and Vondelig).

Despite its conservation status, there have been substantial human impacts on the area. Saldanha Bay and Langebaan Lagoon represent a large proportion of the limited sheltered waters available on the South African West Coast, and so are also host to a major industrial node and port while supporting important tourism, recreation and fishing industries. All the past and current uses and developments within the area (industrial, residential and tourism) have the potential to negatively impact ecosystem health.

The Saldanha Bay Water Quality Forum Trust (SBWQFT) was established in 1996 as a voluntary organization representing various organs of State, local industry and other relevant stakeholders and interest groups with a common goal of protecting and conserving the bay for future generations. The SBWQFT initiated a programme to monitor important ecosystem indicators in the bay in 1999 and commissioned the first “State of the Bay” (SOB) report in 2006. The SOB reports are issued annually (the 2022 version being the 15th report in the series), while accessible summary versions of this report are produced approximately every five years. This is the fourth such report produced. The accessible summary reports are designed to complement the more detailed technical State of the Bay reports and serve to communicate key findings from the technical report in a format that is accessible to as wide an audience as possible.

The report draws together and provides a summary of information on activities and discharges affecting the health of Saldanha Bay and Langebaan Lagoon, and of changes in water quality and aquatic ecosystem health, focusing on the last five years. It incorporates a ranking system that covers a range of different measures of ecosystem health to provide a comprehensive and easy to understand picture of the current State of the Bay.

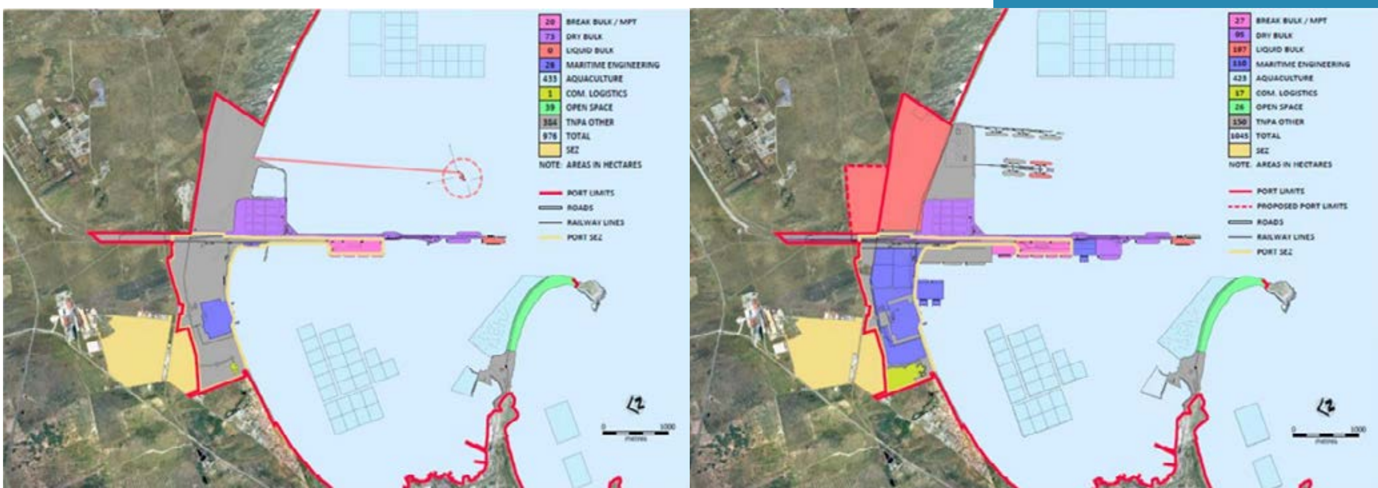
HEALTH CATEGORY	ECOLOGICAL PERSPECTIVE	MANAGEMENT PERSPECTIVE
Natural	**No or negligible modification** from the natural state.	Relatively **little human impact.**
Good	**Some alteration** to the physical environment. Small to moderate loss of biodiversity and ecosystem integrity.	**Some human-related disturbance**, but ecosystems essentially in a good state, continued regular monitoring is strongly recommended.
Fair	**Significant change** to the physical environment and associated biological communities; sensitive species may be lost, tolerant or opportunistic species beginning to dominate.	**Moderate human-related disturbance** with good ability to recover. **Management intervention required** to ensure no further deterioration takes place.
Poor	Extensive change to the physical environment and biological communities, majority of sensitive species lost, tolerant or opportunistic species dominate.	**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

Sheltered waters, 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. Port development began in the 1970s, with the construction of the iron ore terminal and a causeway linking Marcus Island to the mainland. Port facilities in Saldanha Bay currently include the iron ore terminal, an oil jetty, a multi-purpose terminal, and a general maintenance quay, a fishing harbour, a Small Craft Harbour (used by fishing vessels and tugs), three yacht marinas (Saldanha, Mykonos and Yachtport SA), a Naval boat yard at Salamander Bay and numerous slipways. Development of the port and fishing industry have attracted other industry to the area, including oil and gas, ship repair and steel export industries, and has resulted in a rapid expansion in urban development in Saldanha and Langebaan. Transnet are proposing to expand 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.

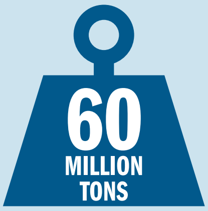
Transnet are proposing to *expand* port facilities in Saldanha considerably in the future to *accommodate* the new Industrial Development Zone (IDZ).

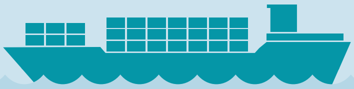


(Right) Current and (left) long-term layout (2044) of Transnet Saldanha Bay Port (Source: Transnet National Port Authority 2019, National Port Plans 2019 update).

Dredging, required for the establishment and maintenance of port facilities in Saldanha Bay, has had major impacts on the ecology of the Bay. The largest historical dredging event took place during the commissioning of the iron ore terminal, with some 25 million tonnes of rock and sediment removed. Several smaller dredging events for maintenance and expansion have been undertaken since, with the most recent dredging event occurring in September 2022 (18 398 m^3 sediment dredged).

The Port has the capacity to export iron ore of up to





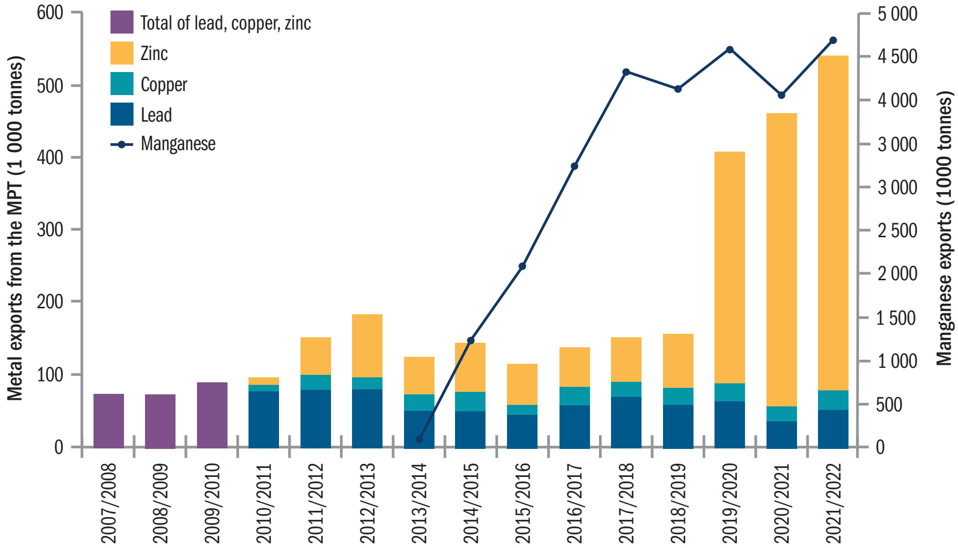
Total exports are expected to rise to roughly

1 MILLION TONNES

of Pb, Cu, and Zn per annum in the near future

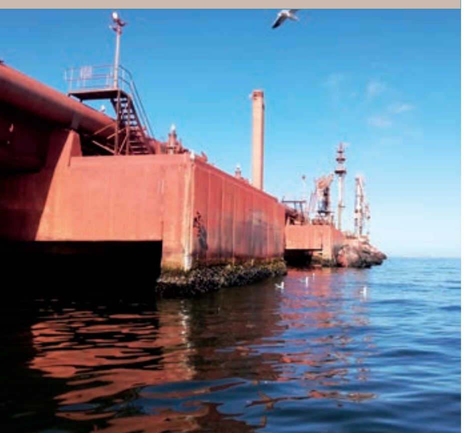
40M of shoreline lost in places in just the last 5 years

Metal ores exported from the Port of Saldanha Bay include iron, lead, copper, zinc, and manganese. The Port currently has the capacity to export up to 60 million tonnes of iron ore per year, and Transnet Port Terminals are in the process of upgrading infrastructure to support an export of 80 million tonnes per year. Total exports of lead, copper and zinc from the multi-purpose terminal increased in 2021/2022 to 462 000 tonnes per year, with total exports expected to rise to about 1 million tonnes per year in the near future. Manganese exports from Saldanha Bay commenced in 2013, increased rapidly, and is now stable at nearly 5 million tonnes per annum.



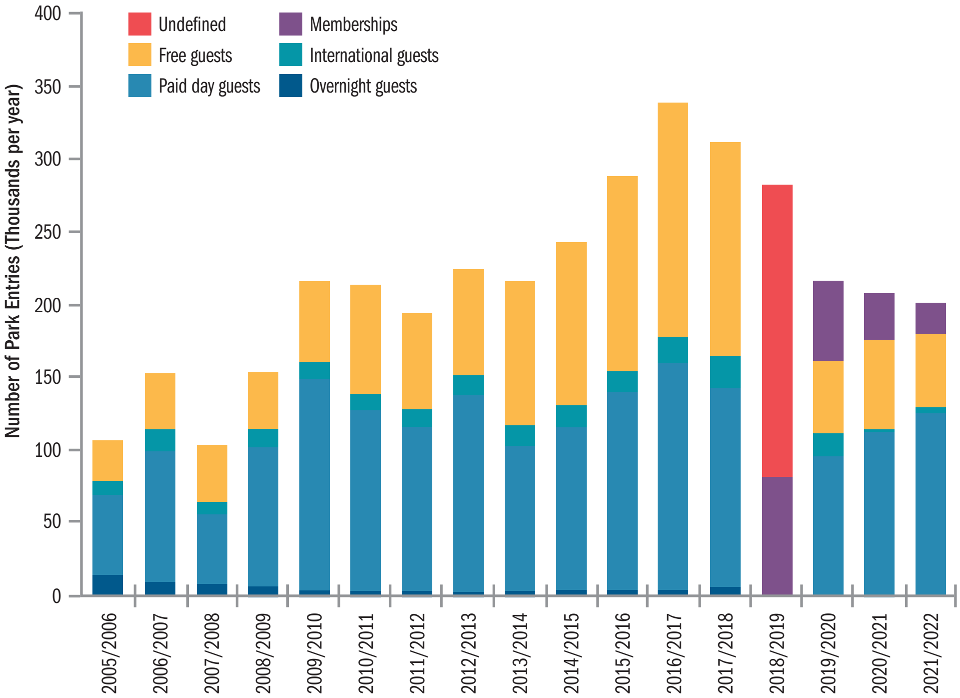
Annual exports of lead, copper, zinc and Manganese from the Multi-Purpose Terminal at the Port of Saldanha Bay: 2007–2022.

Along with the industrial and urban development, tourism development in the Saldanha Bay has increased, linked in part to the declaration of the various National Parks, Marine Protected Areas and Ramsar sites, along with the and establishment of holiday resorts. Tourist numbers peak annually in August and September (for the flower season), and again over the Christmas holidays. The number of visitors to West Coast National Park peaked in 2016/2017 (338 720 visitors), dropped off very sharply due to the Covid-19 Pandemic, and now averages around 205 000 guests a year, which is similar to the numbers seen in 2009–2014.



Top: Iron Ore Terminal.

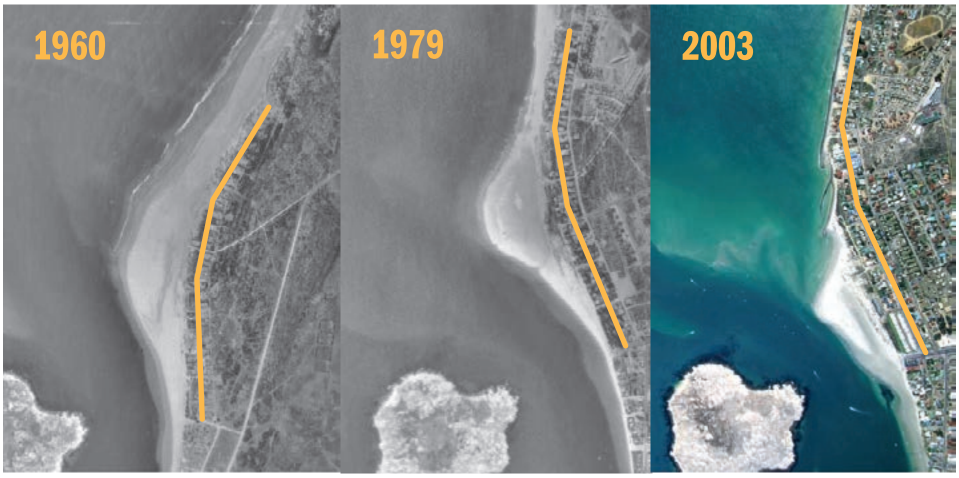
Bottom: Trawler vessels alongside in Small Bay.



Variation in the numbers of visitors to the West Coast National Park from 2005–2022.

Coastal erosion

Coastal erosion is a major problem in Saldanha Bay, affecting beaches mostly in Big Bay and at the entrance to Langebaan Lagoon. Erosion of the beaches at the entrance to the Lagoon has reportedly been going on since the 1960s, with the loss of over 100 m of beach in some areas and up to 40 m of shoreline lost in places in just the last 5 years.

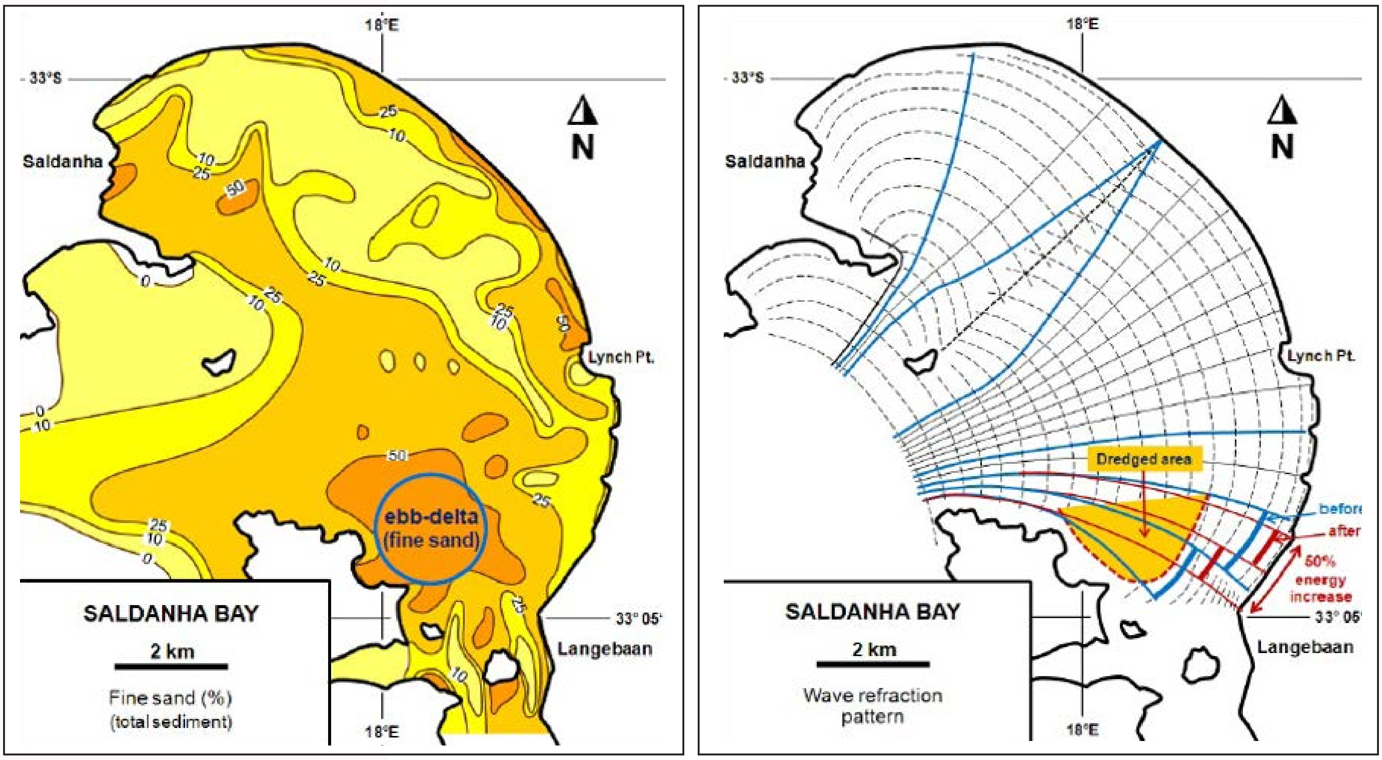


Top: Flower season in the West Coast National Park.

Bottom: View of Langebaan Lagoon from above Uitkyk in the West Coast National Park.

Erosion of the beaches at the entrance to Langebaan Lagoon in the period 1960–2003.

The causes of this erosion are not clear. Most experts feel that it is likely due in part to natural causes that have been exacerbated by the port development and associated dredging operations during the 1970s. At the time, a large amount of sediment was removed from the mouth of Langebaan Lagoon, an area where sediment had been deposited over many thousands of years (an 'ebb tide delta'), to construct the Marcus Island causeway. This removal of sediment reportedly changed the pathway and strength of the incoming waves, increasing the wave energy along this shoreline and contributing to erosion.

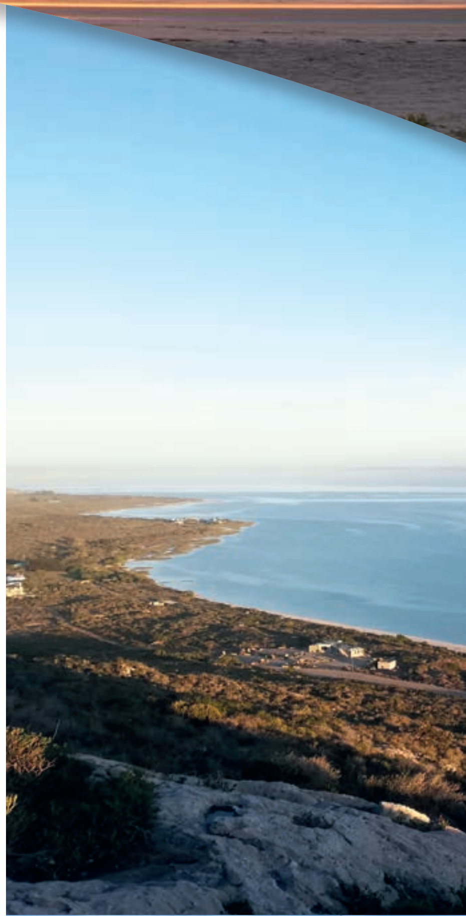


Ebb tide delta at the entrance to Langebaan Lagoon (left) where sediment was dredged for construction of the causeway between Marcus Island and the mainland in the late 1970s (left), and the impact that this sediment removal has had on wave refraction (right). Source: Flemming (2016).

Several largely successful interventions have been introduced to control erosion and to limit loss of sediment from beaches in Saldanha Bay, including the construction of rock revetments (1997–2002), the construction of groynes extending perpendicularly from the shore at Langebaan Beach (2004–2008), and construction of gabion walls on Paradise Beach near Club Mykonos. Additional interventions to enable reestablishment of beach habitat along the shoreline to the north of the existing groynes at Langebaan are warranted, as the shoreline here is currently made up of a rock revetment which makes access to the sea for people living in this area very difficult and dangerous. Historical monitoring of changes in the shoreline at Langebaan Beach, which provided valuable information on shoreline changes in this area, have recently been discontinued.

Langebaan Beach with groynes extending out perpendicularly from the shore on the lower (southern) end of the image and rock revetment extending all along the shore from the uppermost groyne towards the upper end of the image.

Looking south from one of the groynes in Langebaan Lagoon.



Top: Looking south towards Oesterwal.

Bottom: Preparing to sample fish from the shore.

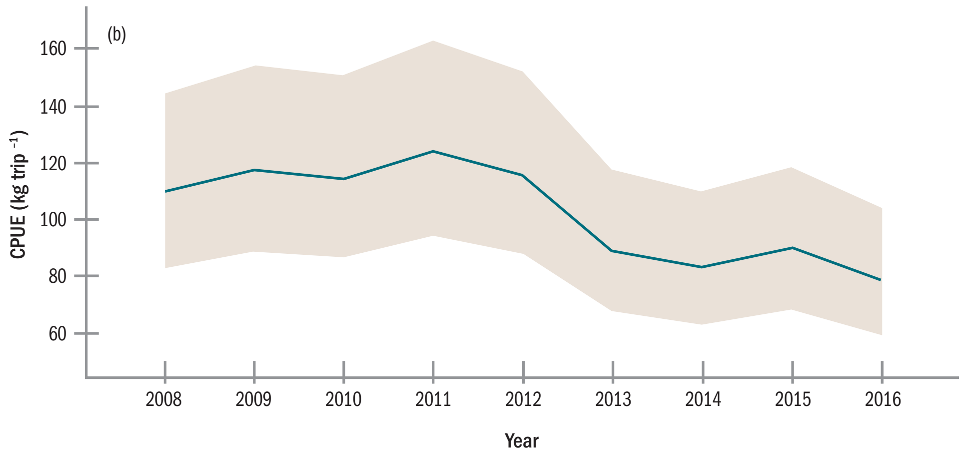
Top: Fish trekking from the shore.
Bottom: Measuring a catch of silverside.

Fisheries

There is a long history of fishing within Saldanha Bay and the Lagoon. Currently, there is a traditional gill net fishery that targets mullet (or harders), while white stumpnose, white steenbras, silver kob, elf, steentjie, yellowtail and smooth hound shark support shore angling, as well as recreational and commercial boat-based line-fisheries. These fisheries contribute significantly to the tourism appeal and regional economy of Saldanha Bay and Langebaan.

The white stumpnose stock in the Bay has declined severely over the last two decades due to too many fish being caught before they have a chance to spawn. This significant decline throughout the system suggests that the protection afforded by the Langebaan Marine Protected Areas may not be enough to sustain the white stumpnose fishery at the current high effort levels in the area. The reduction in fishing effort during the Covid-19 pandemic seems to have allowed some fish to spawn successfully, evidenced by an increase in the numbers of new recruits in the Bay in 2021 and to a lesser extent in 2022. This recovery is likely to be short-lived unless levels of fishing mortality are drastically reduced through the implementation of more conservative catch limits for white stumpnose. Indeed, a recent analysis by a team of fisheries scientists strongly recommends the implementation of controls — a limit of five fish per person per day and an increase in the minimum size (to 30 cm total length).

The reported annual catch of harders declined from around 130 tonnes per year in 2008–2012 to about 90 tonnes per year over the period 2013–2016, whilst effort remained fairly constant. Data on fishing effort in the last five years is, unfortunately, lacking, but an analysis of commercial harder catch data also indicated that the stock was overexploited and recommended a reduction in fishing effort. For this it is recommended to increase the minimum stretched mesh size of gill nets.

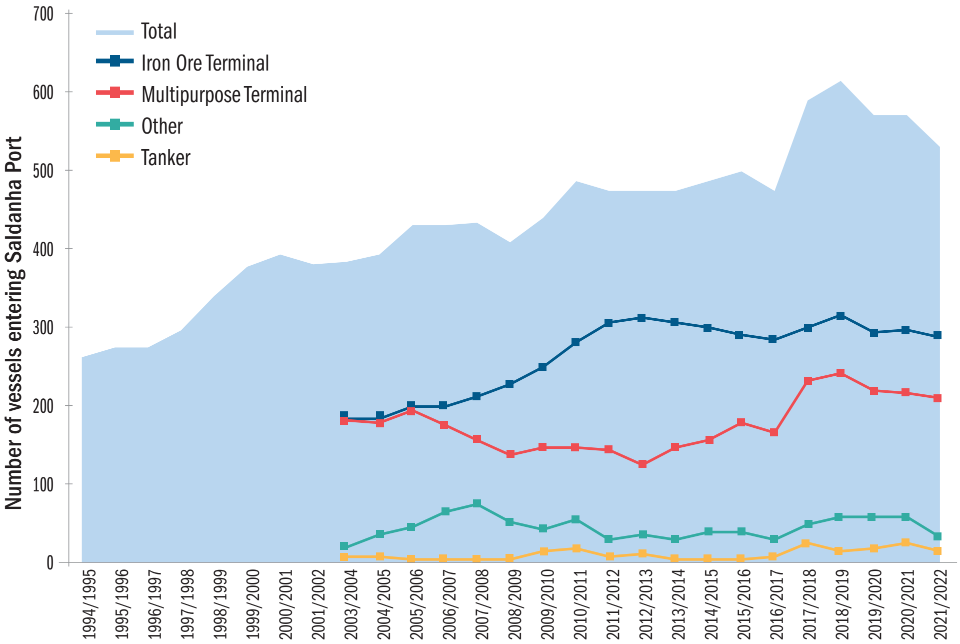


The standardised catch-per-unit-effort (CPUE) estimates for harders (with 95% confidence intervals, grey area) derived from mandatory catch records kept between 2008 and 2016. Source: Horton *et al*. (2019).

It has also been recommended that monitoring of fish stocks, catch and effort in the Bay be expanded to include regular catch and effort monitoring of the Bay's fisheries to provide complementary data to the current juvenile survey estimates.

Vessel activities

Vessel traffic in Saldanha Bay is a hazard for marine life due to disturbance from the vessels themselves, and accidental and deliberate discharges of ballast water. Ballast water is taken on board when the vessel is empty to maintain stability, but includes the eggs, larvae and adults of marine species present in the port of origin. Therefore, when it is discharged at the destination port (when cargo is taken onboard), it may potentially introduce alien and invasive species. Since ballast water is generally taken up in ports, discharges into the bay can also contain high concentrations of contaminants such as trace metals and hydrocarbons. The total number of ships entering the Port of Saldanha increased to nearly 600 vessels per annum in 2017/18, declining to 531 in 2021/22, possibly as a result of the global Covid-19 pandemic. The volume of ballast water discharged into the bay annually follows a similar pattern, increasing to nearly 26 million m^3 per annum in 2022.



Variation in the numbers and types of vessels entering Saldanha Port per year from 1994–2022.

Oil spills are an ever-present threat associated with shipping traffic and although few such events have been recorded in Saldanha Bay to date, an oil leak was reported to have occurred at the Strategic Fuel Fund (SFF) Oil Terminal on 1 February 2022. Most of the oil was recovered, and the clean-up operation was concluded on 2 February 2022. 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.

The West Coast has the most marine invasive species in South Africa, with

67 recorded alien species.

Of these **29** are present in Saldanha Bay and/or Langebaan Lagoon

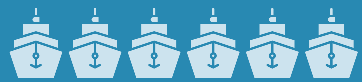
Vessel numbers entering the Port have been stable since the historical peak of nearly

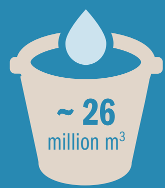
600 IN 2017/2018,

but declined to

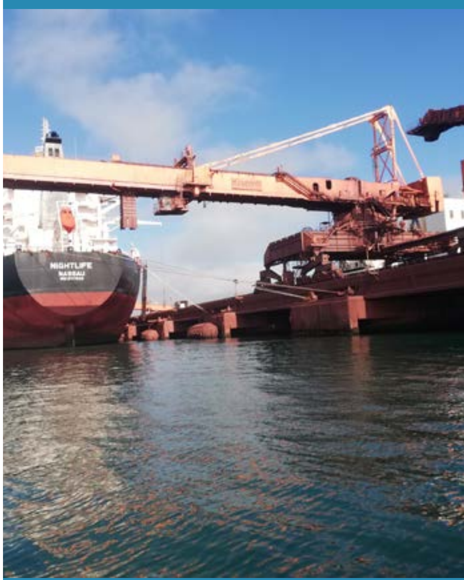
531 IN 2021/2022,

likely due to the impacts of the Covid-19 pandemic





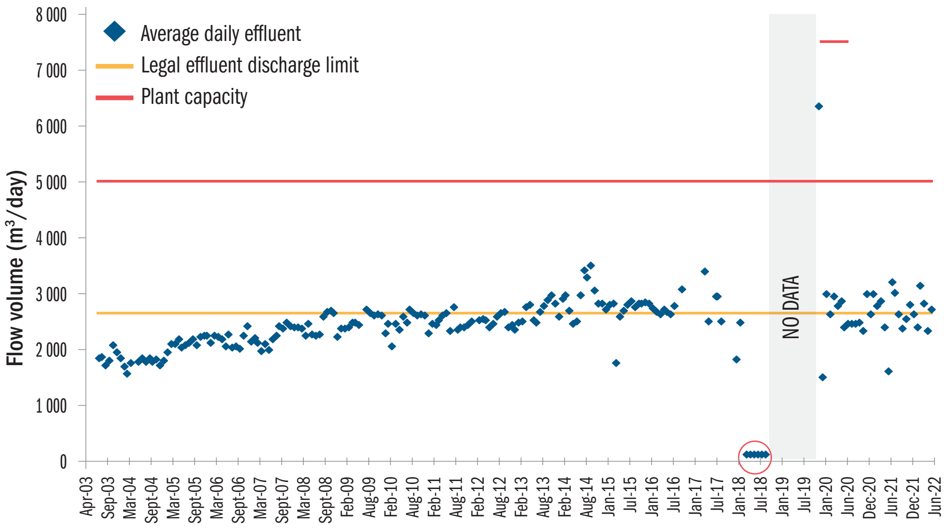
Ballast water discharge is ~ 26 million m^3 per annum



Iron Ore Terminal.

Effluent discharges into the Bay

The expanding human population in the area surrounding Saldanha Bay and Langebaan Lagoon generates an increasing volume of sewage, which finds its way into the Bay, either in partially treated form from the Saldanha and Langebaan wastewater treatment works or occasionally as untreated sewage when treatment infrastructure malfunctions. In addition to *E. coli* and faecal coliform levels (indicators for human health risk), sewage contains high concentrations of nutrients that stimulate the growth of phytoplankton and algae, which can lead to reductions in oxygen levels. While there are guidelines in place that specify maximum concentrations of contaminants in wastewater discharges, these guideline levels are often exceeded due to an inadequate capacity to treat such large volumes of effluent, and periodic equipment failure.



Trend in the volume of effluent (m^3/month) released from the Saldanha Wastewater Treatment Works, 2003–2022. The data points circled in red represent the estimated effluent discharged into the Bok River (60 m^3 per day, when discharge water was being diverted to alternate uses, primarily Arcelor Mittal).

Storm water runoff is another major threat to the health of the Bay. Runoff over hardened surfaces in urban and industrial areas picks up debris, bacteria and contaminants like trace metals, hydrocarbons and toxic substances (insecticides, pesticides and solvents). These are then washed into the sea where they accumulate in both the sediments and tissues of aquatic plants and animals. 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. A collaboration between Sea Harvest and Saldanha Bay Municipality saw the installation of a pilot stormwater litter trap in Saldanha Bay, which served to trap much of the litter and debris in the stormwater discharged from the Pepper Bay outlet, thereby preventing it from entering and polluting the Bay. Unfortunately, due to Covid-19 the project has not yet been expanded, but it is hoped that the initiative will resume in the future.

Diver sampling biofouling on the mussel ropes.

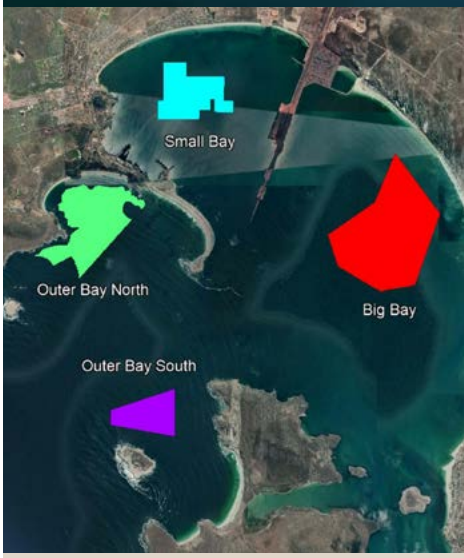
Mariculture and Aquaculture Development Zone

The Department of Forestry, Fisheries and the Environment (DFFE) secured Environmental Authorisation (EA) to establish a sea-based Aquaculture Development Zone (ADZ) in Saldanha Bay in January 2018. An ADZ is an area selected for its suitability for specific aquaculture sectors, which provides 'investment ready' platforms by providing strategic environmental approvals and management policies already in place, that allow commercial aquaculture operations to be set up without the need for lengthy, complex and expensive approval processes. The Saldanha ADZ covers an area of 884 ha, and is separated into four precincts, Small Bay, Big Bay, Outer Bay North and Outer Bay South.

As of July 2022, 30 entities have been granted marine aquaculture rights in the ADZ. Twenty-five of these right holders are currently operational, with two of these entities having more than one right allocated to them. Most established operators hold rights to farm mussels (*Mytilus galloprovincialis* and *Choromytilus meridionalis*) and the Pacific oyster *Crassostrea gigas*.

Mussel culture accounts for the greatest portion of the mariculture production in the Bay, at just under 3 500 tonnes in 2021. Oyster production has fluctuated between 150–350 tonnes over the two decades but looks like it is starting to take off now. Rights to farm finfish (salmon *Salmo salar* and rainbow trout *Oncorhynchus mykiss*) have only been issued to two farms in the ADZ, and although a pilot finfish study was conducted in the Bay, neither of the rights holders is currently active in the bay.

To ensure appropriate management of the ADZ, DFFE appointed an independent specialist to compile a Sampling Plan for the ADZ which was reviewed by local and international stakeholders and experts. A substantial body of work has been undertaken over the last few years to meet this, and other requirements of the EA, including water quality monitoring (temperature, dissolved oxygen and dissolved inorganic nitrogen), dispersion modelling studies, macrofauna and physicochemical surveys (2020, 2021, 2022), a hard substrate (reef) monitoring survey (2022), and a qualitative biofouling survey (2022). DFFE also undertakes regular, rapid synoptic surveys that involve high resolution mapping of chlorophyll and other water quality parameters such as salinity, temperature and dissolved oxygen in the bay. Reports have also been issued on the scientific recommendations for the management and expansion of the ADZ along with updates to the Sampling Plan, based on the results of monitoring work completed to date.



Top: Mussel raft from below.

Middle: Mussel raft from above.

Bottom: The four precincts that make up the entire ADZ area (884 ha).

Groundwater

2 Main aquifer systems from which groundwater dischargers in the Bay

- The Langebaan Road Aquifer System
- Elandsfontyn Aquifer System

3 039 Mm³ The Langebaan Road and Elandsfontyn Aquifers contain a very large volume of water

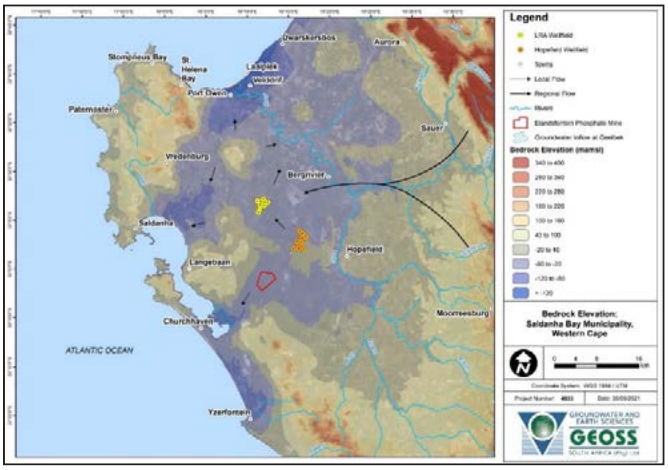
Existing licenced users have the capacity to abstract about **12–13M** Litres of water per day

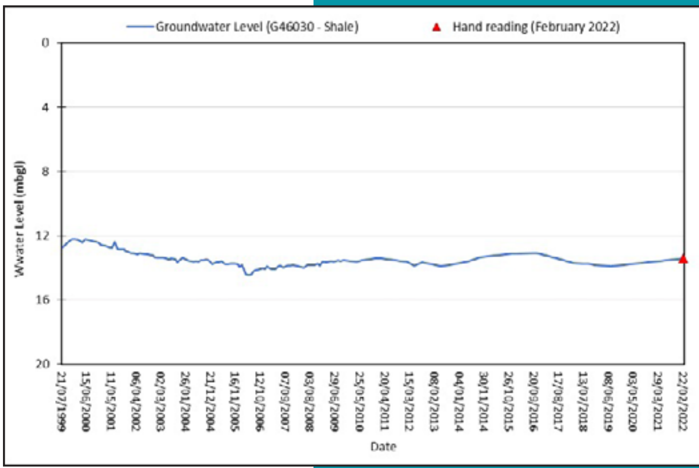
A view across the lagoon.

Saldanha Bay and Langebaan Lagoon receive little freshwater input via rivers or streams, and groundwater input 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 (located between the lower Berg River and Saldanha Bay) and the Elandsfontyn Aquifer System (which lies adjacent to Langebaan Lagoon and extends down to Darling in the south, and the Brak and Groen Rivers to the south-east and east). There is little exchange of water between these two aquifers, each one discharging into the sea through its own underground 'paleo-channel'. The Langebaan Road Aquifer System discharges into Saldanha Bay (Big Bay) through a northern channel while the Elandsfontyn Aquifer System discharges into Langebaan Lagoon through a southern channel. The inflow of groundwater into the Lagoon in particular, plays a very important role in balancing loss of freshwater from the system as a result of evaporation, and hence prevents the lagoon from becoming too salty. It also allows reeds *Phragmites australis* and *Typha capensis,* whose roots need to stand in freshwater, to thrive along the margins. These reed beds are critically important as roosting and feedings areas for many of the bird species that are associated with the lagoon.

These two aquifers contain a very large volume of water (some 3 039 million m^3) and increasing pressure on available freshwater resources in Saldanha Bay in recent years has resulted in attention being turned to exploitation of this resource. This is of concern as the unsustainable use of this water could ultimately lead to a reduction in groundwater flow into the Bay and Lagoon, which could disrupt the ecology and functioning of these systems. Existing licenced users of water from these aquifer systems include the Langebaan Road Aquifer (potential emergency supply in 1998 by the Department of Water & Sanitation, and a long-term water supply to Saldanha Bay Municipality), the Hopefield wellfield (emergency groundwater supply for the Saldanha Bay Municipality), and the agricultural sector (farmers) Collectively these groups have the capacity to abstract about 12–13 million litres of water per day from these two aquifer systems. The Elandsfontein Phosphate Mine sends the abstracted water back to the aquifer system immediately downstream of the mine. Monitoring of groundwater levels in the region suggest that the current levels of use are sustainable and are not impacting on the freshwater flow into the lagoon; however, any additional allocation of groundwater in the region needs to be carefully controlled or else this may change. Conditions at the Geelbek area of Langebaan Lagoon are being closely monitored by the SBWQFT using funds provided by the Elandsfontein Phosphate Mine to confirm that this is indeed the case. Unfortunately, only time will tell if this is true or not.

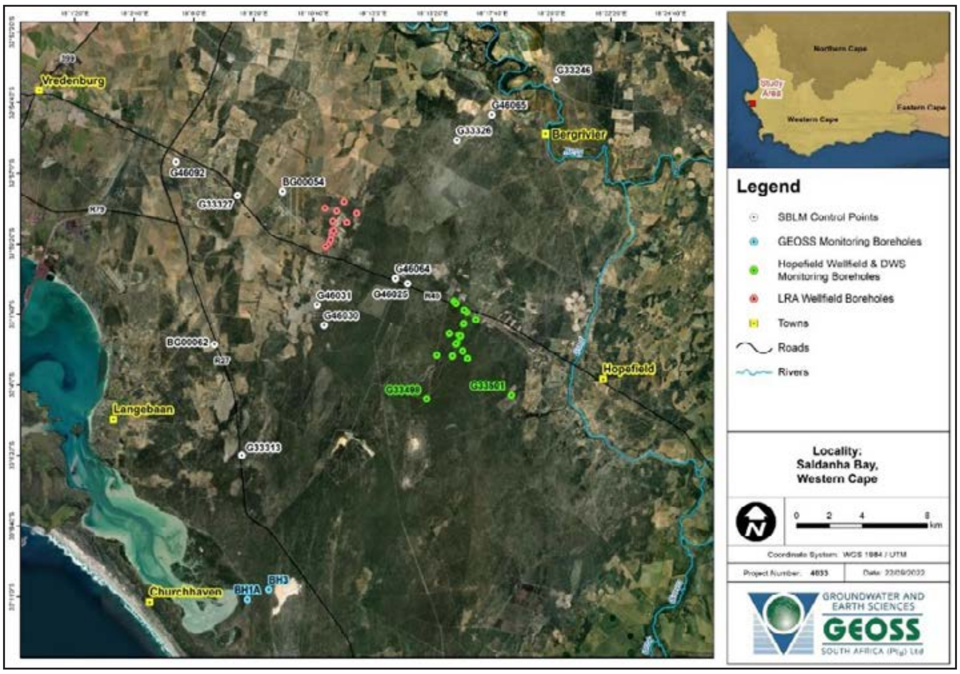
Over the past year, the Saldanha Bay Local Municipality, in collaboration with the private sector, has established a groundwater monitoring network of 12 boreholes. Currently, all monitored groundwater in the area (water levels, abstraction volumes and groundwater quality) remain stable, and no significant change in water level quality is occurring. This monitoring data, along with other hydrogeological data for the area, has been used to develop a geological and hydrologic model that can provide insight into the aquifer extent and layers, as well as groundwater flow. Using the model, different scenarios can be modelled, allowing for better planning and management of groundwater resources in the area.





Langebaan Road and Elandsfontyn Aquifers showing major flow paths for groundwater and the major areas for abstraction of groundwater from these aquifers.

Long-term changes in water level at one of the monitoring boreholes (G46030) in the Langebaan Road Aquifer.



Network of boreholes used for monitoring groundwater level in the Saldanha Bay area.

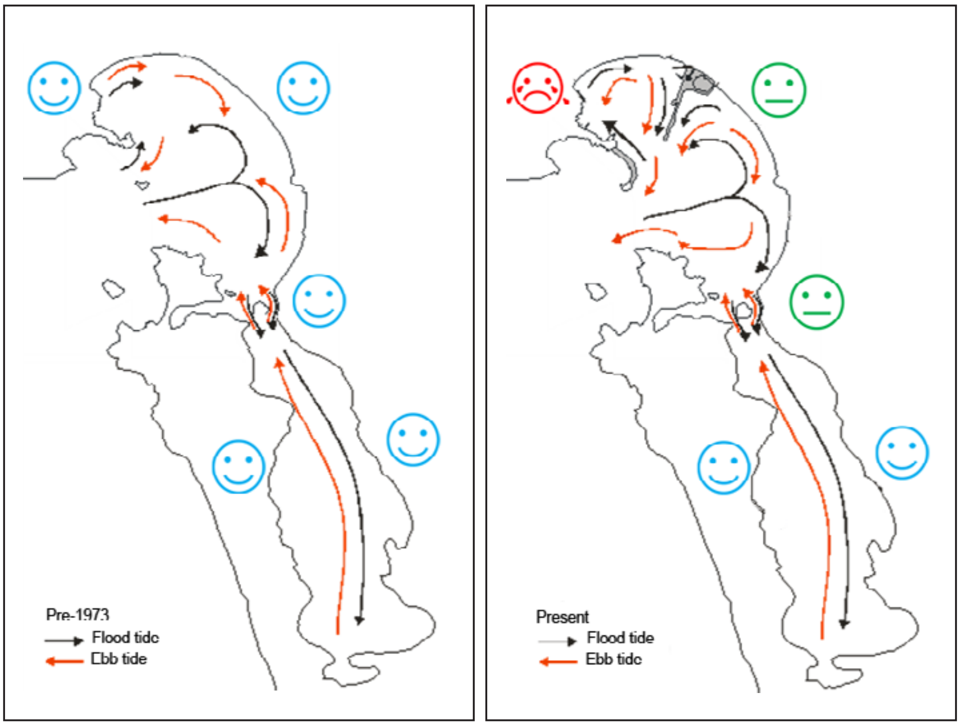
A monitoring borehole.

Water Quality

Oceanographic indicators

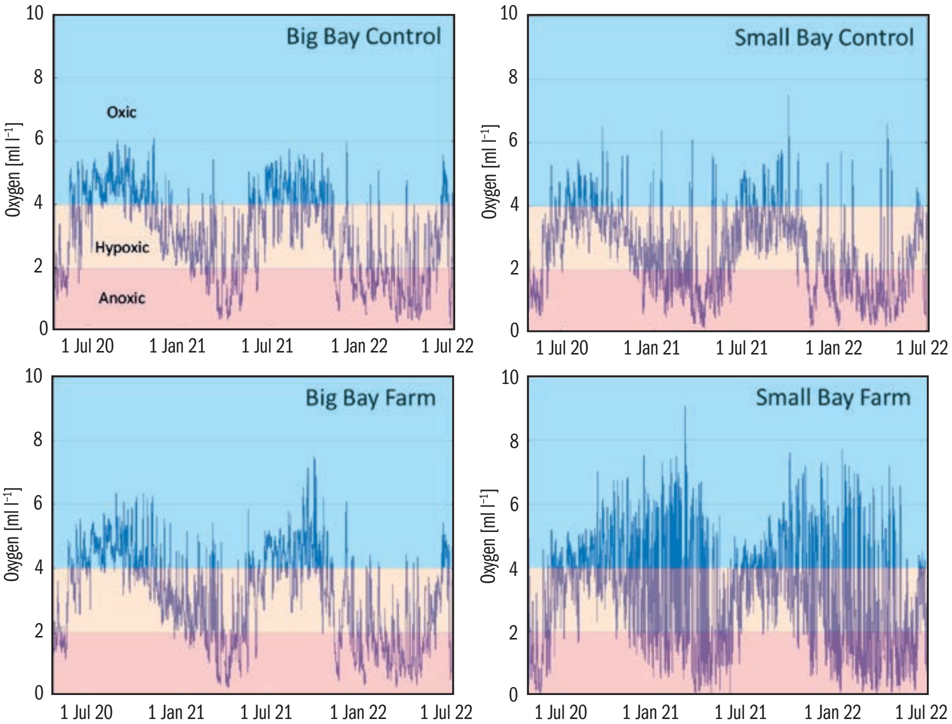
Contaminants now remain in the water for longer, enabling microbial growth which uses up available *oxygen* or settle out in the sediments.

The large-scale port development in the early 1970s had notable impacts on water and wave movement, patterns and strength in Saldanha Bay. In the past, current strength and circulation in the Bay was determined by a combination of tidal movements and wind. When the Bay was split into two sections by the iron ore terminal, the Marcus Island causeway created a barrier for incoming swell, which made the system more sheltered, particularly in Small Bay, and changed both surface and deeper water current flow in and out of the Bay.



Schematic representation of the surface currents and circulation of Saldanha Bay prior to harbour development (pre-1973) and after construction of the causeway and iron ore terminal (present).

These changes increased the length of time water remains in Small Bay before being flushed to the wider ocean, meaning that the system has a lower capacity to dilute and flush out effluent and associated contaminants in this part of the Bay. As a result, contaminants now remain in the water for longer, using up available oxygen, while others settle out in the sediments or are taken up by living plants and animals. The most obvious impacts of this can be seen in the effects on available dissolved oxygen in the water column in Small Bay, in trace metals that accumulate in filter-feeding organisms (like mussels and oysters), and in nearshore bacterial concentrations. Data collected by DFFE as part of the ADZ monitoring programme show that, in winter, bottom waters tend to be well oxygenated because of mixing caused by waves, while in summer, water are often hypoxic or even anoxic due to lower levels of mixing which prevents the water at the bottom from meeting the atmosphere and becoming reoxygenated. There is also evidence that mussel and oyster farms in the Bay are responsible for further depleting levels of dissolved oxygen in the water column, with levels of oxygen being noticeably lower in the vicinity of the aquaculture farms in both Small Bay and Big Bay than they are at sites further away.



« Variation in levels of dissolved oxygen at control (top row) and mariculture farm sites (bottom row) in Big Bay (left) and Small Bay (right).

Microbiological indicators

Faecal pollution contained in 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 and are detected using bacterial indicators. The South African Water Quality Guidelines for Coastal Marine Waters is used to assess compliance in respect to 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 pre-2005 have improved considerably. 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 beaches at the Bok River Mouth and at Hoedjiesbaai were 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, and the continued monitoring of bacterial indicators should be undertaken to assess the effectiveness of adopted measures at all sites on a bimonthly basis.

16 of the 20 monitoring stations in the Bay are rated as having 'Excellent' water quality in terms of recreational use,

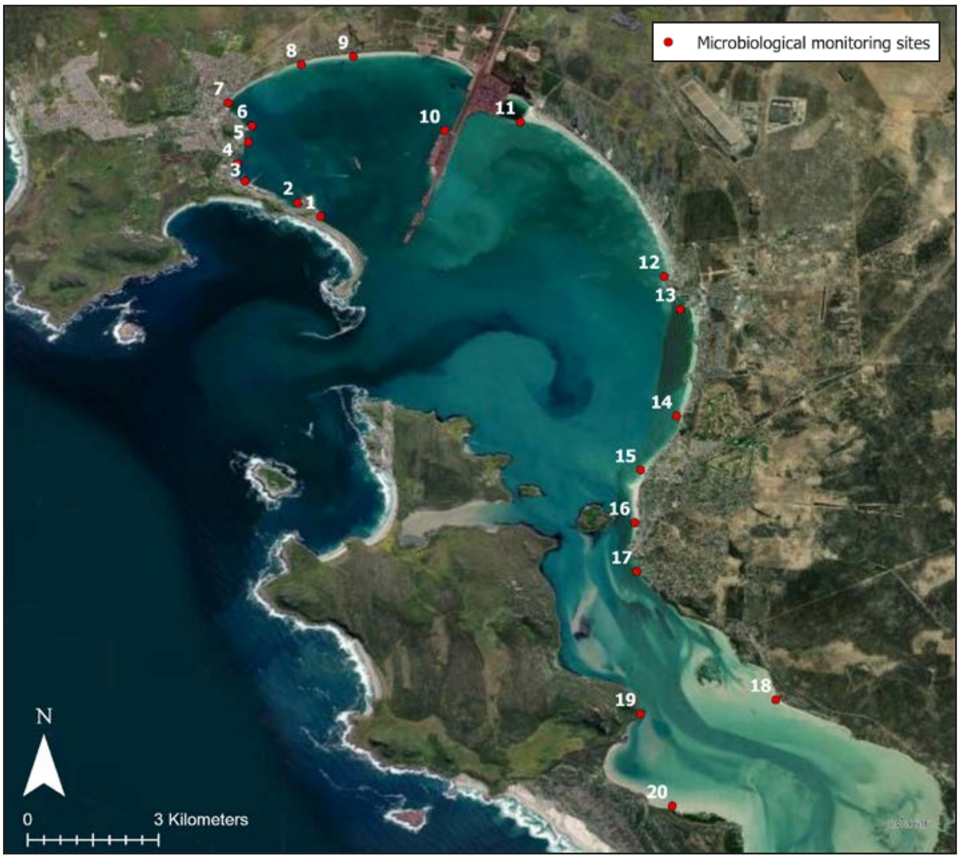
1 site is rated as 'Good' and

2 sites are rated as 'Fair'.

	SITE	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Small Bay	1. Beach at Mussel Rafts	Fair	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	No data	Excellent
Small Bay	2. Small Craft Harbour	Excellent	Fair	Good	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent
Small Bay	3. Sea Harvest – Small Quay	Fair	Fair	Excellent	Excellent	Fair	Excellent	Fair	Excellent	Excellent	Excellent	Good	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent
Small Bay	4. Saldanha Yacht Club	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent
Small Bay	5. Pepper Bay – Big Quay	Poor	Fair	Poor	Fair	Fair	Fair	Fair	Poor	Excellent	Excellent	Fair	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Good	Excellent
Small Bay	6. Pepper Bay – Small Quay	Poor	Fair	Fair	Good	Excellent	Good	Excellent	Excellent	Good	Excellent	Good	Good	Excellent	Good	Fair	Fair	Excellent	Excellent	Excellent	Excellent	No data	Excellent	Excellent	Excellent
Small Bay	7. Hoedjies Bay Hotel – Beach	Fair	Fair	Poor	Fair	Good	Poor	Poor	Good	Fair	Excellent	Fair	Fair	Poor	Poor	Fair	Good	Fair	Good	Fair	Poor	Poor	Poor	Poor	Poor
Small Bay	8. Beach at Caravan Park	Fair	Fair	Fair	Poor	Excellent	Fair	Poor	Excellent	Good	Poor	Fair	Fair	Fair	Poor	Good	Fair	Excellent	Fair	Fair	Fair	Fair	Fair	Excellent	Good
Small Bay	9. Bok River Mouth – Beach	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Excellent	Fair	Poor	Poor	Good	Excellent	Poor	Fair	Good	Excellent	Poor	Poor	Fair	Fair	Good	Poor	Poor
Small Bay	10. General Cargo Quay – TNPA	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Big Bay	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	Excellent	Excellent	Excellent	Excellent	Excellent	Good
Big Bay	12. Mykonos – Paradise Beach	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent
Big Bay	13. Mykonos – Harbour	Fair	Fair	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	Good	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Big Bay	14. Leentjiesklip	No data	No data	Good	Fair	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Good	Excellent	Excellent	Excellent	No data	Excellent	Excellent	Excellent	Excellent
Big Bay	15. Langebaan North	Excellent	Fair	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Good	Excellent	Good	Excellent	Good	Excellent	Excellent	Fair	Excellent	Excellent
Langebaan Lagoon	16. Langebaan – Main Beach	No data	No data	Fair	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	No data	Excellent	Good	Excellent	Excellent
Langebaan Lagoon	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	Good	No data	Excellent	Excellent	Excellent	Excellent
Langebaan Lagoon	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	Excellent	No data	Excellent	Excellent	Excellent	Excellent
Langebaan Lagoon	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	Excellent	No data	Fair	Excellent	Excellent	Excellent
Langebaan Lagoon	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	No data	Excellent	Fair	Excellent	Excellent

Excellent
Good
Fair
Poor
No data

Classification of bacteriological monitoring sites in Small Bay, Big Bay and Langebaan Lagoon in terms of their suitability for contact recreation based on guidelines published by the Department of Forestry, Fisheries and the Environment.



Microbiological monitoring sites.

Trace metal indicators

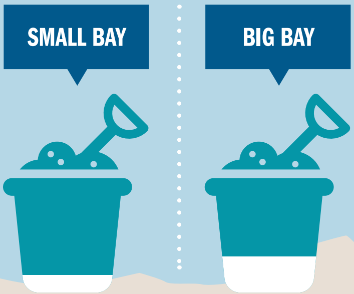
Concentrations of trace metals in marine organisms (mostly mussels) in Saldanha Bay have been monitored intermittently since 1997. Concentrations of trace metals within mussels tend to be high along the shore (particularly for lead near the multi-purpose quay) and are consistently above published regulatory 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 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.

Concentration of lead in mussels collected from the shoreline along the perimeter of Small Bay.

Sediment Quality

The amount of fine sediment mud in

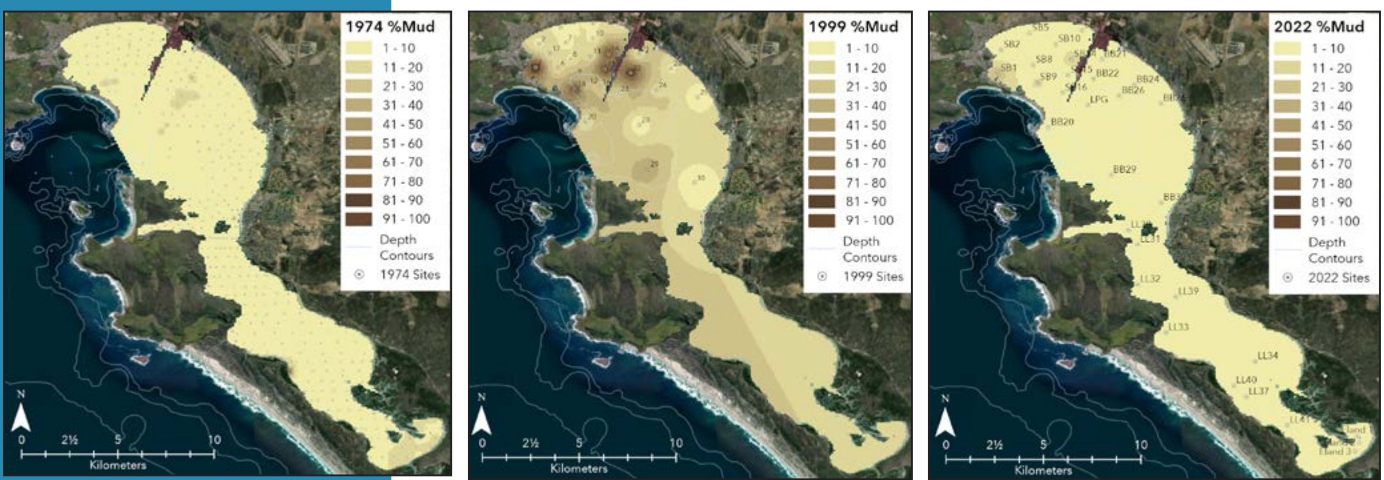


has continued to decline from the peak levels measured in 1999, and as of 2022, resembles the levels in 1974, before the major construction work commenced in the Bay

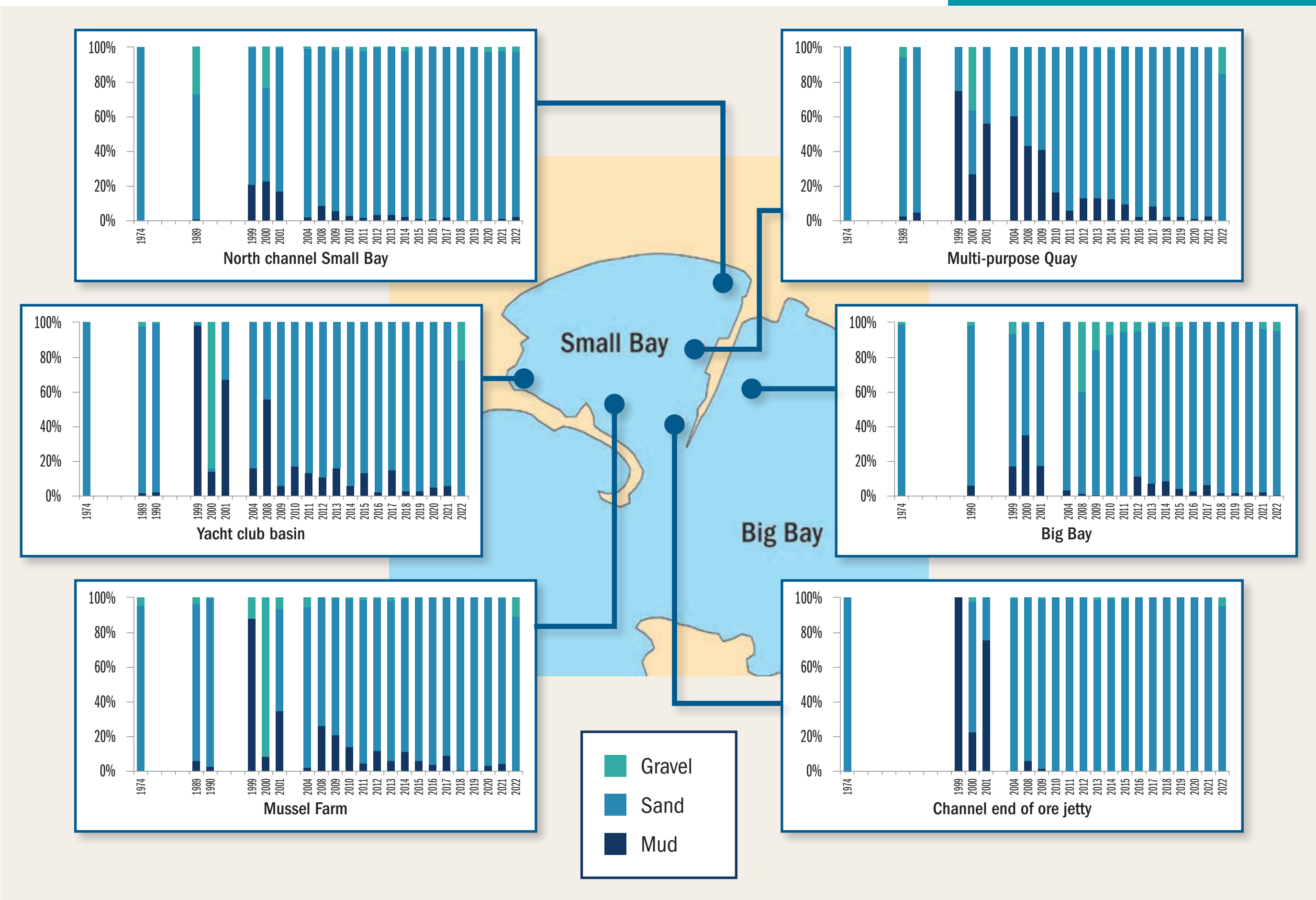
Marine sediments reflect changes to the environment across both space and time. The different properties of sediments (particle size, concentrations of organic matter and trace metals) are interconnected, and both influence and are influenced by physical, chemical and ecological processes. Lower wave energy and current speeds deposit finer sediment (mud), while strong currents flush this fine sediment away. Fine sediments have a greater surface area to which contaminants, like trace metals and toxic pollutants, can bind and hence lead to a build-up. The resuspension of these sediments though disturbances like dredging introduces these contaminants back into the water column where they can have negative impacts on the environment. Over the last five years, there has been a noticeable improvement in sediment quality within the general Saldanha Bay area.

Sediment particle size

The makeup of the sediments in Langebaan Lagoon are quite different to those in Saldanha Bay (generally much coarser), and have changed little since 1974. Sediments in Saldanha Bay were comprised mostly of sand with a very small mud fraction in 2022, with Big Bay having higher mud content than Small Bay, and closely resembling levels first recorded in 1974, before any major construction works commenced in the bay. While fine sediments are still accumulating in calmer areas of Small Bay, like in the Yacht Club Basin and Small Craft Harbour, there has been a noticeable decline in finer sediments in Saldanha Bay over time. This is a positive development and suggests that sediments in the Bay may be reverting to a more natural condition where sediments were comprised mostly of sand with a very small mud fraction.



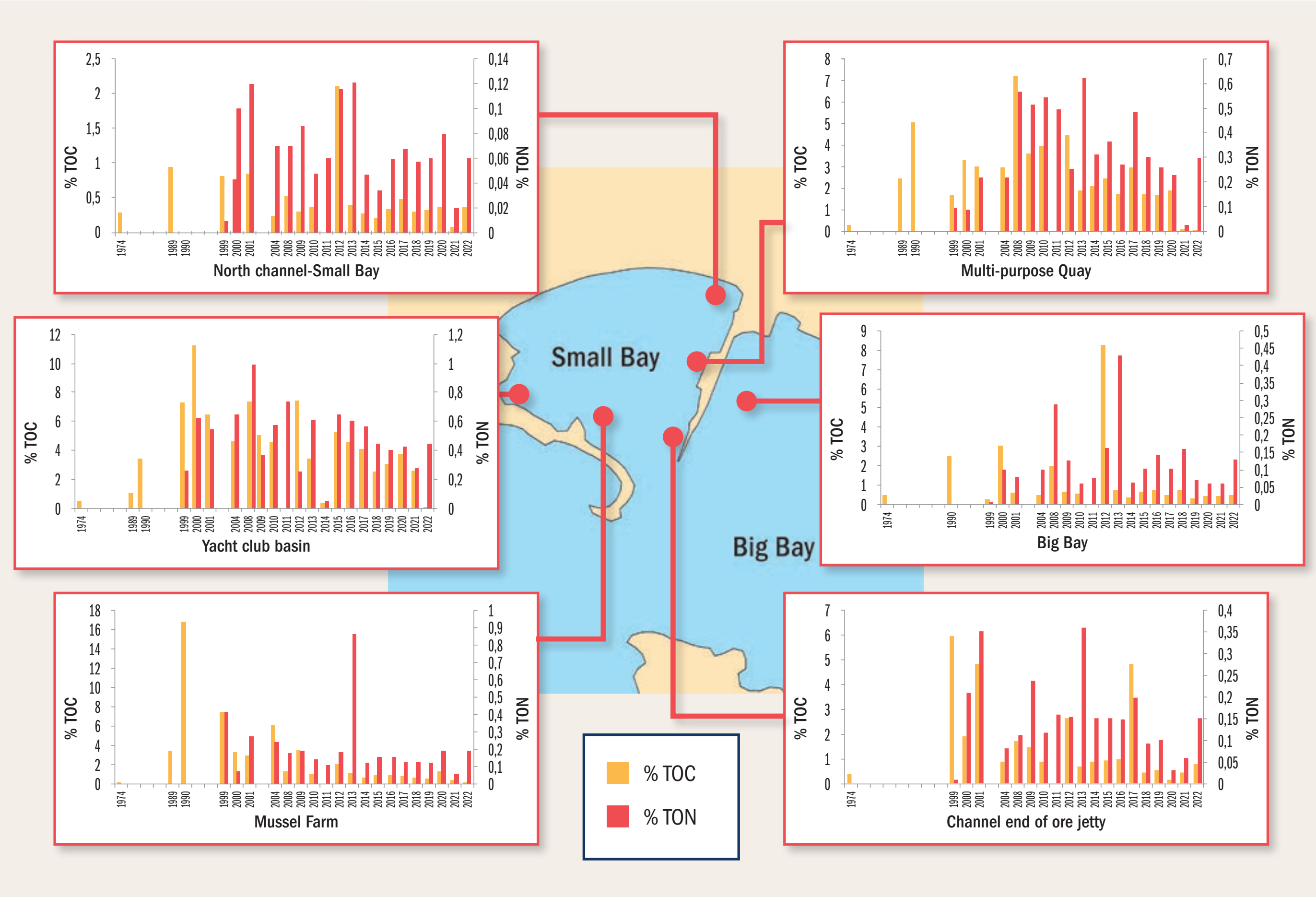
Change in the percentage mud in sediments in Saldanha Bay and Langebaan Lagoon between 1974 (left), 1999 (middle), and 2022 (right).



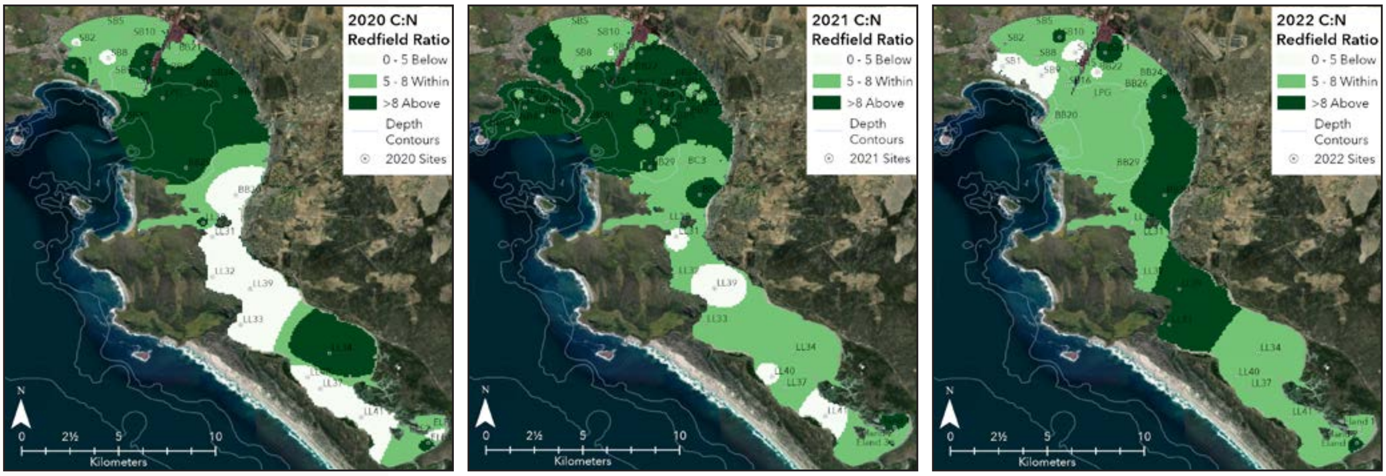
Particle size composition (percentage gravel, sand and mud) of sediments at six localities in the Small and Big Bay area of Saldanha Bay between 1974 and 2022.

Sediment total organic carbon (TOC)

Organic matter is also associated with finer sediments. While it is a source of food for the animals that live in or near the sediment, excessive organic matter accumulation can lead to oxygen depletion in the sediments and surrounding water column as it decomposes. As organic matter tends to accumulate in the same areas as fine sediment, there has been a concomitant decline in the amount of organic carbon (TOC) and Total Organic Nitrogen (TON) at most sites in the Bay. Concentrations of organic material are generally higher in Small Bay than Big Bay (due to the difference in the levels of wave energy and water movement), but the last five years has seen a considerable decline in TOC levels, particularly in Small Bay. Indeed, 2022 levels are more or less equal to those first recorded in 1974 at the majority of sites around the Bay, which is encouraging. The ratio of C:N (which indicates the source of the organics) showed a decrease from 2020 and 2021 across most sites to levels at or below those expected for natural marine sources (like phytoplankton). However, elevated organic inputs near the shore on the Langebaan side of Big Bay in 2022 do remain a concern.



Total organic carbon and nitrogen in sediments of Saldanha Bay at six locations between 1974 and 2022.



C:N ratios at different sites surveyed in 2020, 2021 and 2022 (dark green = exceeds the range expected for marine production; mild green = within the range expected for marine production and white = below range expected for marine production).

Trace metal concentrations

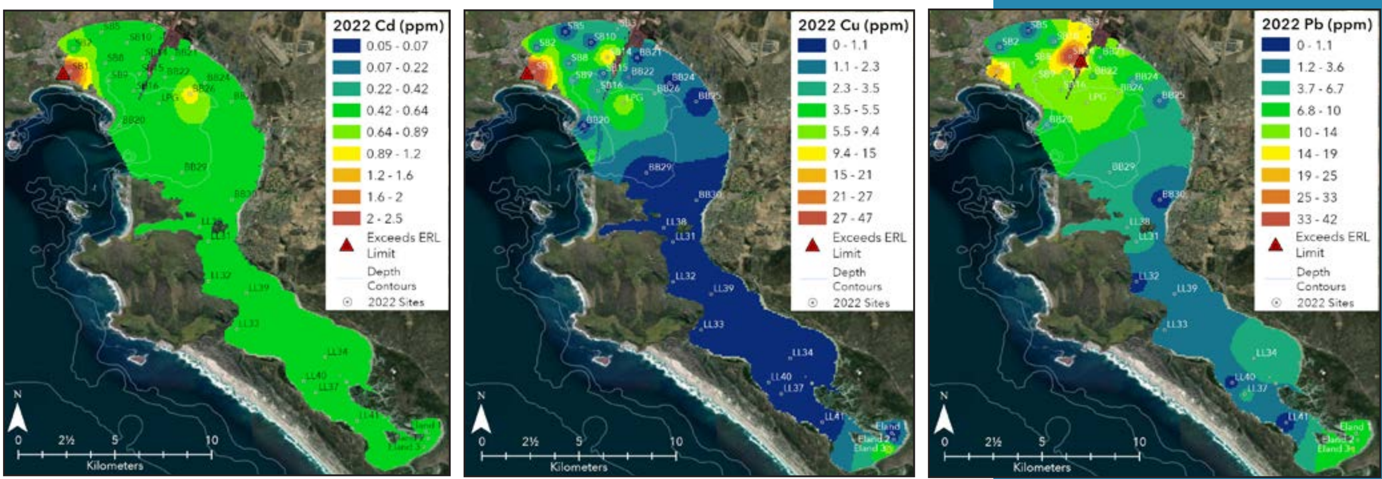
Trace/heavy metals are often regarded as pollutants of aquatic ecosystems and also tend to accumulate in areas of fine sediment. Levels in the environment may be elevated due to naturally occurring high levels of the contaminant in question (like cadmium, which is naturally elevated on the South African west coast), or due to anthropogenic activities like ore export (e.g. iron, lead, copper, manganese and nickel), effluent discharges and stormwater runoff. It is when these trace metal exceed internationally accepted thresholds (above which toxic effects can be expected) that concerns are raised, especially when resuspension by disturbance, such as dredging, occurs.

Each year since 2017, cadmium and copper concentrations have exceeded threshold guidelines at the Yacht Club Basin site in Small Bay. The concentrations of both metals decreased dramatically in 2020 at most sites (potentially as a result of the economic slowdown associated with the Covid-19 pandemic) and increased again in 2021/2022. It is of interest that there was very little fine sediment (mud) present at the Yacht Club Basin site in 2022, which indicates that there is an anthropogenic source of these metals here. Lead ore is exported via the multi-purpose terminal and concentrations in the Bay are most elevated in this region, and often exceed accepted threshold limits.

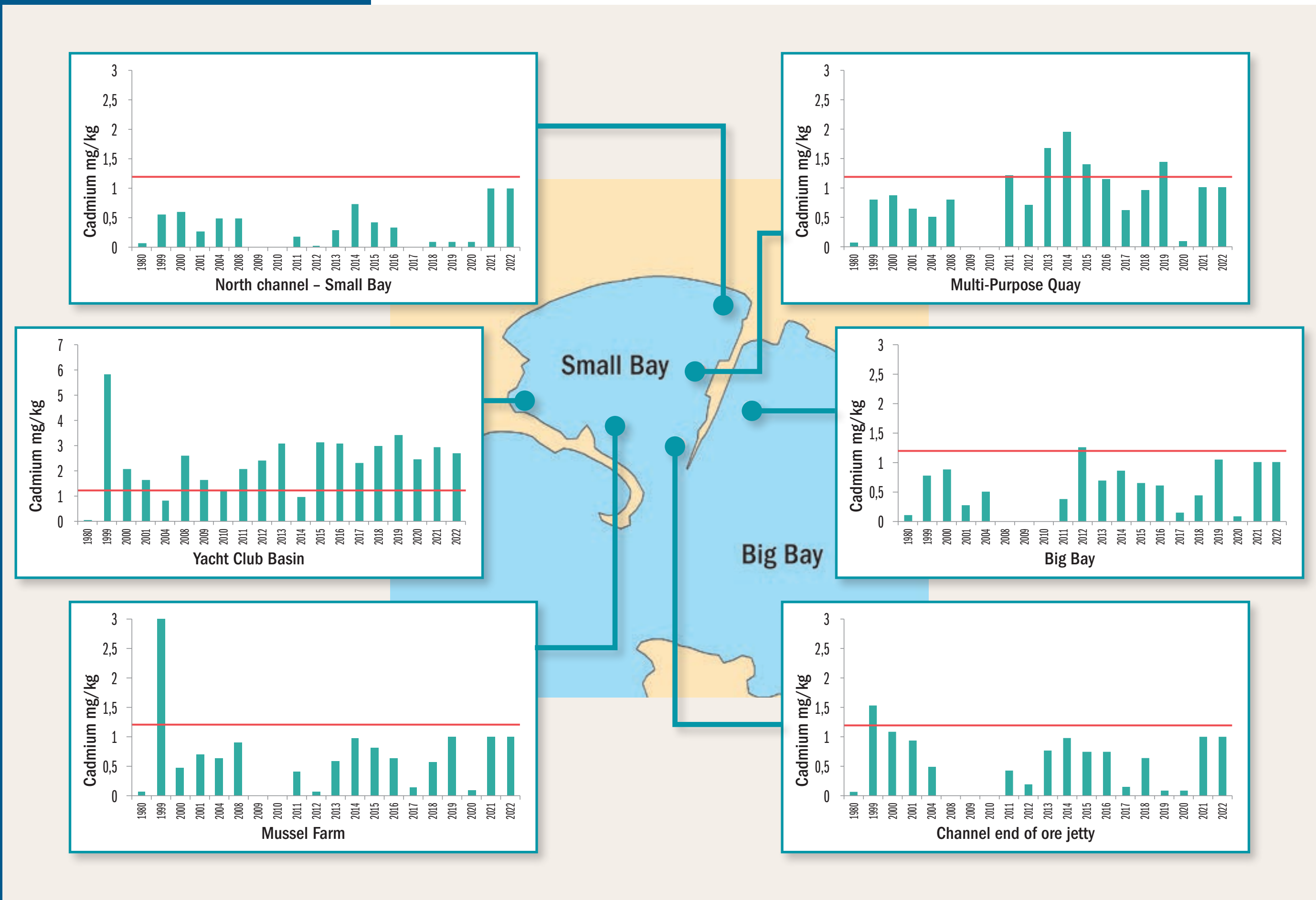
LEVELS IN THE ENVIRONMENT MAY BE ELEVATED DUE TO

Natural high levels of contaminant (e.g cadmium)

or due to anthropogenic activities like ore export (e.g iron, lead, copper, manganese and nickel)



Spatial interpolation of cadmium (Cd), copper (Cu) and lead (Pb) values measured in sediments in Saldanha Bay in 2022.

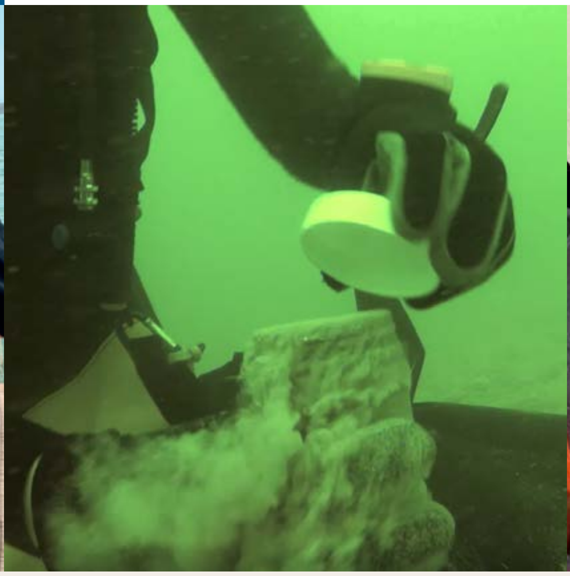


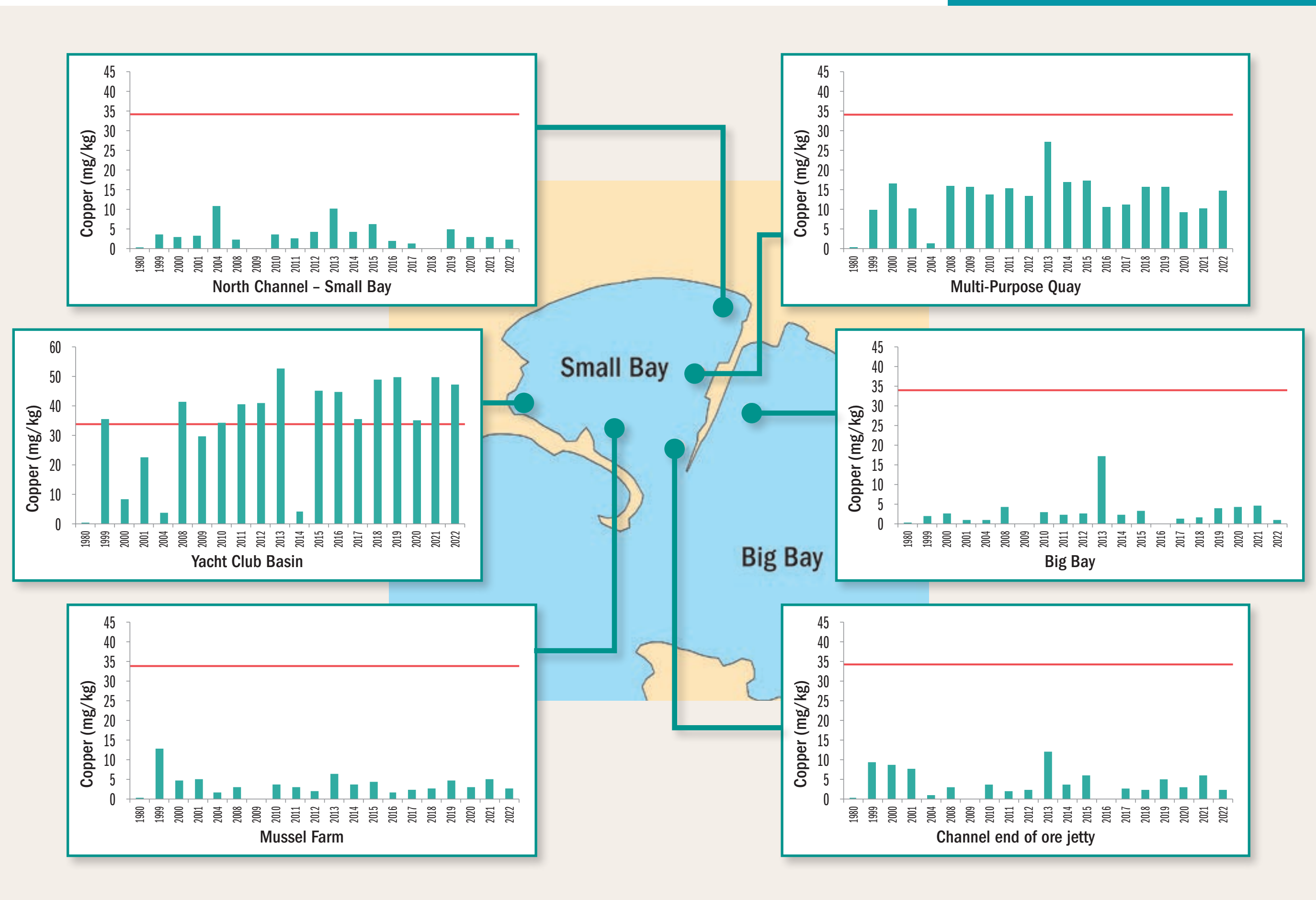
Concentrations of Cadmium (Cd) in mg/kg recorded at six sites in Saldanha Bay between 1980 and 2022. Red lines indicate the sediment quality threshold.

Left: Preparing to grab sample sediment.

Middle: Diver collecting sediment for trace metal analysis.

Right: Measuring chemical properties of sediment in the field.



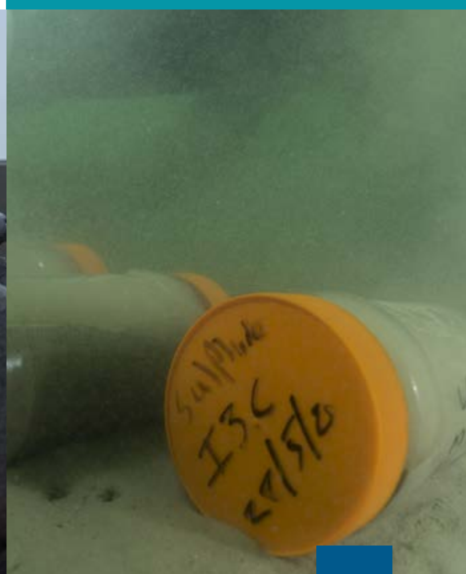


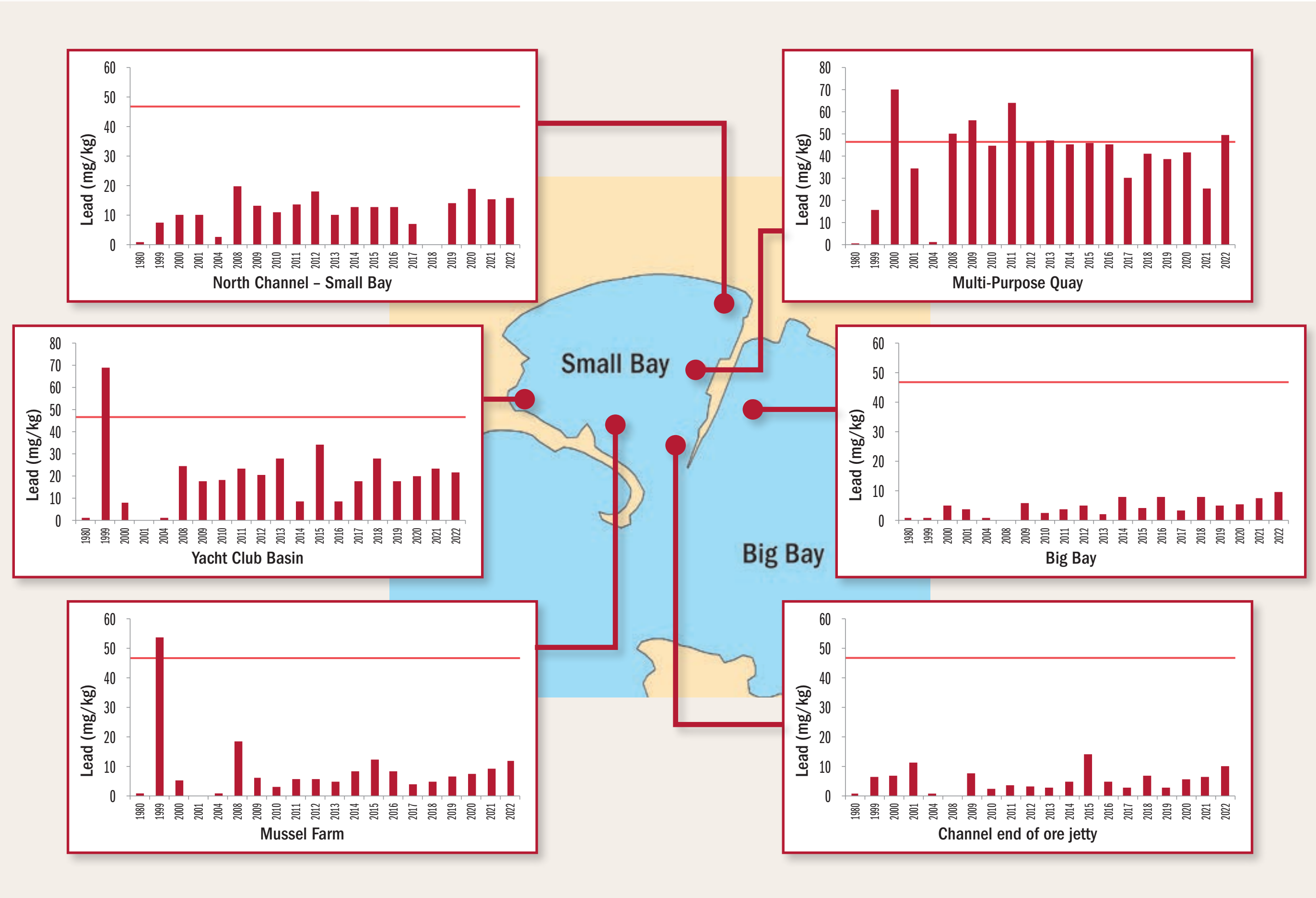
Concentrations of Copper (Cu) in mg/kg recorded at six sites in Saldanha Bay between 1980 and 2022. Red lines indicate the sediment quality threshold.

Left: Sieving sediment at sea.

Middle: Measuring chemical properties of sediment in the field.

Right: Some sediment samples are collected and sealed underwater by hand.





Concentrations of Lead (Pb) in mg/kg recorded at six sites in Saldanha Bay between 1980 and 2022. Red lines indicate the sediment quality threshold.

Scientific divers preparing to collect sediment samples.

Macrophyte (Vegetation) Communities

Generally, vegetated coastal areas support more types (species richness), a larger number (abundance) and a higher biomass of invertebrate and vertebrate animal species compared to unvegetated areas. In Langebaan Lagoon, there are three types of aquatic and intertidal macrophyte (vegetation) of particular interest: seagrass, salt marsh, and reeds and sedges. Seagrass includes the beds of eelgrass *Zostera capensis*, while salt marsh is dominated by cordgrass *Spartina maritime* and *Sarcocornia perennis* and the dune slack rush *Juncus kraussi.* Reed beds occur where groundwater flows and are characterised by the common reed *Phragmites australis* and the bullrush *Typha capensis*. These macrophyte habitats play an important role in the ecosystem, providing food, shelter and stability when compared to the unvegetated areas, thereby providing nursery areas for many species of fish and invertebrates.

A process of mapping and assessing changes in invertebrates macrophyte habitats (reeds and sedges, seagrass and salt marsh) in Langebaan Lagoon was initiated as part of the State of the Bay monitoring programme in 2020. Using the satellite imagery and Google Earth Engine (GEE) algorithms, the extent of each of these vegetation types in the Lagoon was mapped from 2016–2021.

Results suggest that the area occupied by common reeds increased slightly over the period 2016 to 2019 but has decreased quite markedly since (2019–2021). The reed beds in the Geelbek area (the head of the Lagoon) have been shrinking from both the landward and seaward edges and some of the smaller patches of reeds have disappeared entirely in the last few years. Note that on the map on the right, dark green pixels indicate long standing (and currently present) growth, whereas light green pixels indicate new or recently established patches of reeds. Areas with red pixels indicate where reeds were not present in the most recent images (2021) but were present for any number of years prior to 2021. Light red pixels indicate reeds were present for only one year between 2016–2020, while dark red pixels indicate where reeds were present in most years between 2016 and 2020.

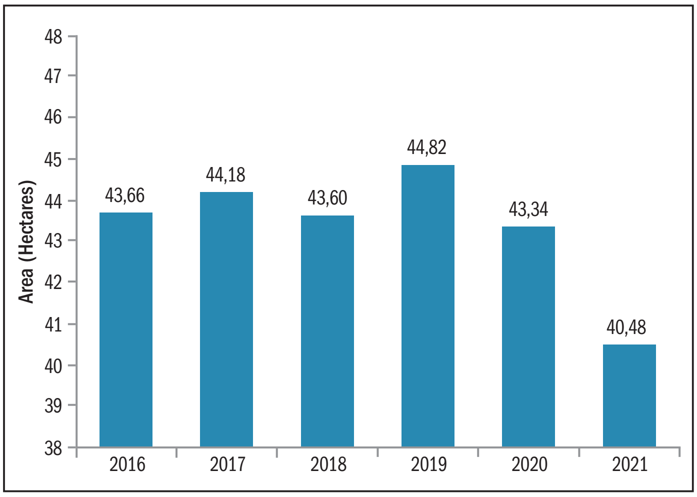
3 AQUATIC AND INTERTIDAL MACROPHYTE CLASSES are of particular interest within Langebaan Lagoon:

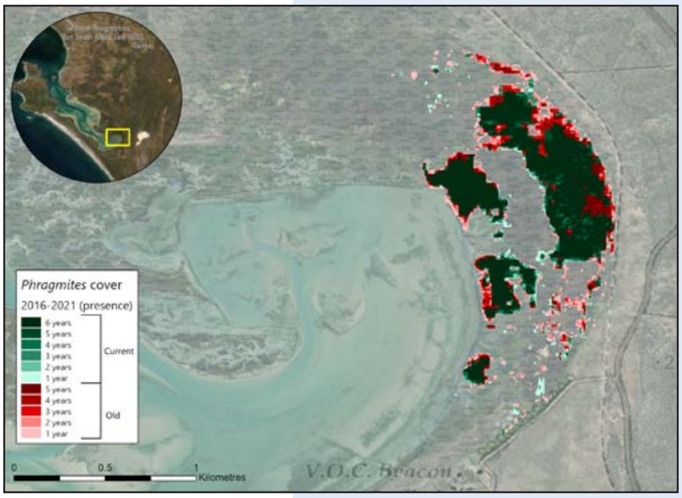
SEAGRASS BEDS

SALT MARSH

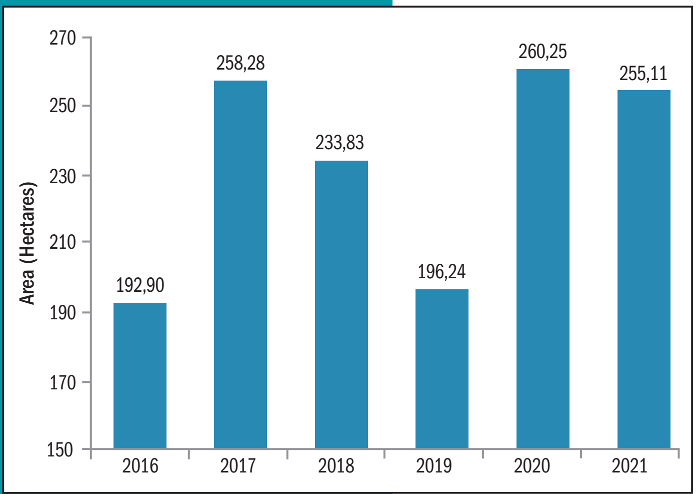
REED BEDS

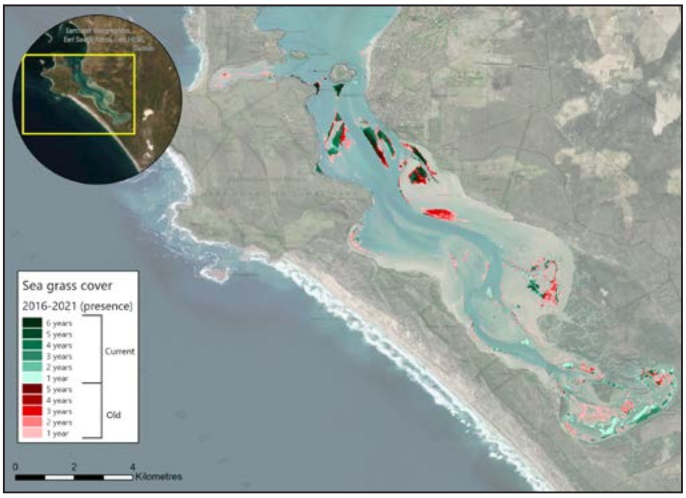
Variation in the area covered by the common reed *Phragmites australis* in Langebaan Lagoon, 2016–2021.





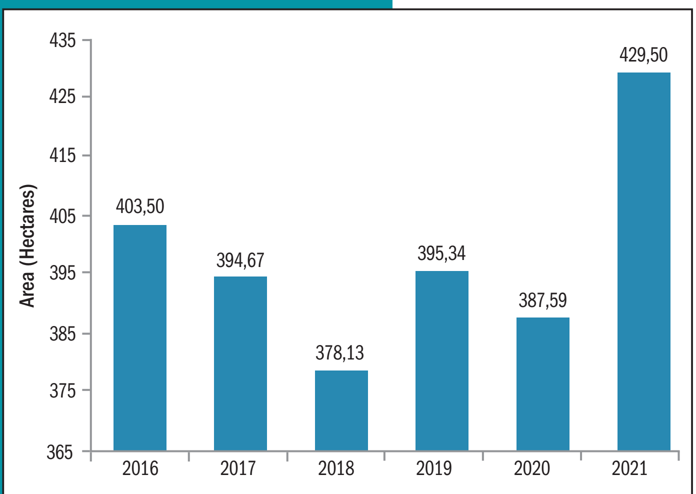
Spatial coverage of seagrass beds in Langebaan Lagoon has changed considerably over the last six years, increasing and decreasing by as much as 35% from one year to another, but with no overall change since 2016. Seagrass beds seem to have expanded at the entrance and head of the lagoon but have shrunk or even disappeared at many sites in the central parts of the lagoon. Colour coding on the map below is the same as that for the reeds.

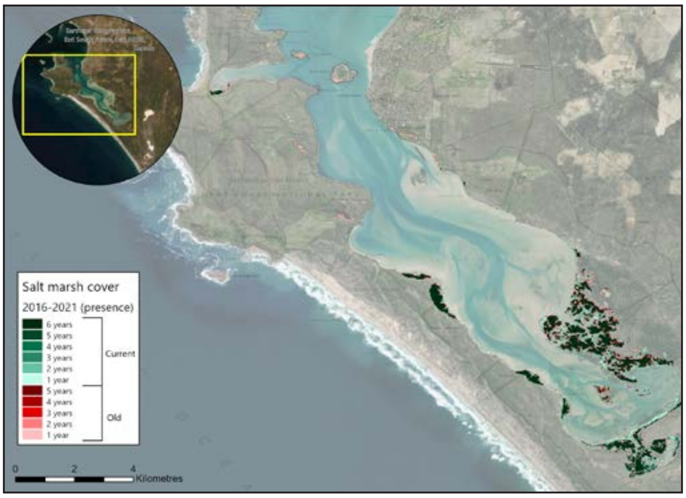




Variation in the area covered by the seagrass *Zostera capensis* in Langebaan Lagoon, 2016–2021.

The spatial extent of salt marsh habitats in Langebaan Lagoon showed little variability in the period 2016–2020 but expanded quite markedly (by 10%) between 2020 and 2021. Most of this new growth has been on the seaward edge of the existing salt marshes at the head of the lagoon.



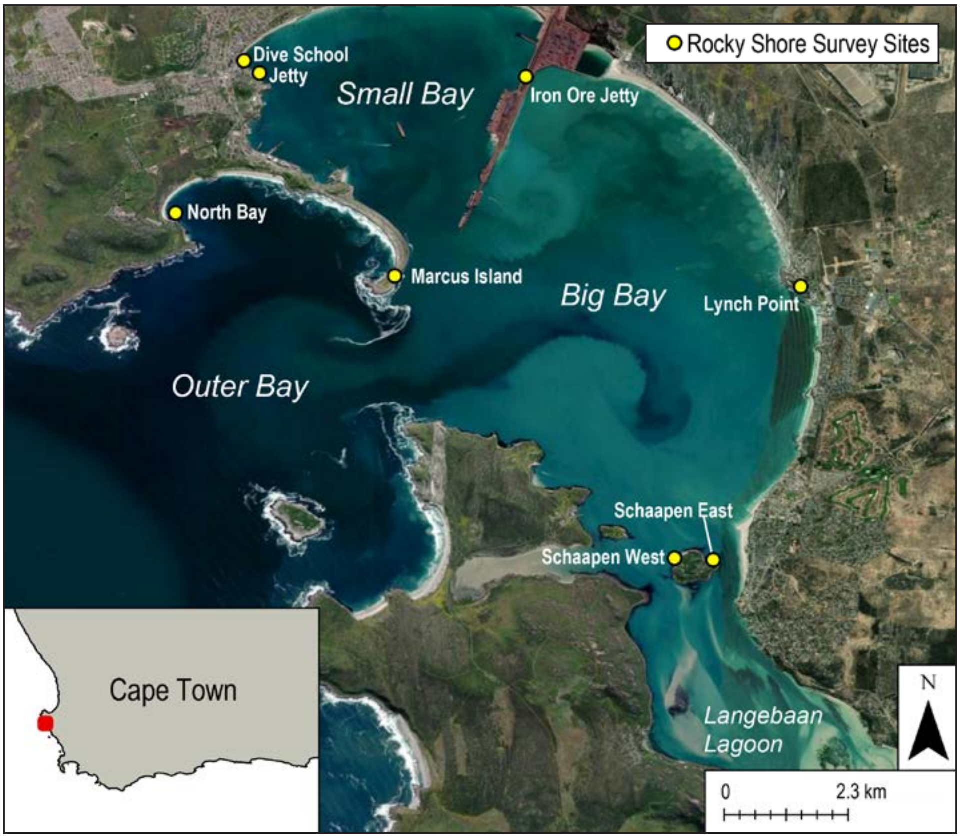


Variation in the area covered by the salt marsh plants (*Spartina maritime* and *Sarcocornia perennis*) in Langebaan Lagoon, 2016–2021.

Reasons for the observed changes in the spatial extent of these macrophyte communities is not clear at this stage but may be linked to yearly or longer-term changes in rainfall, groundwater discharge rates, water temperature, water quality or sea level. It is hoped that this will become clearer over time.

Rocky Intertidal Habitats

Intertidal rocky shore habitats are found on the islands, on rocky headlands in Saldanha Bay, and on areas that have been artificially hardened such as the breakwaters of the port, along the causeway linking Marcus Island with the mainland, and along the iron ore terminal. Invertebrate and algal communities inhabiting these areas are surveyed at eight sites around the bay every year. These communities vary considerably from one site to another due to differences in wave energy and shoreline topography.



The location of the eight rocky shore study sites in Saldanha Bay.

A total of 116 species have been recorded across the eight study sites since 2018, most of which are common along much of the South African West Coast. Most of the dominant species in these rocky intertidal habitats are in fact alien species, which have displaced many of the indigenous species that once used to live here. The four main alien invasive species are the Mediterranean mussel *M. galloprovincialis* and three alien barnacle species *Balanus glandula*, *Amphibalanus amphitrite amphitrite* and *Perforatus perforatus.* These invasive species are all believed to have been introduced by hull fouling, ballast water or mariculture at various points in the past. Most arrived long before monitoring started in Saldanha Bay, and so the species composition and abundance of rocky intertidal fauna and flora have changed little over this time. Two of these species, the Mediterranean mussel and the barnacle *B. glandula*, dominate intertidal communities on the midshore (occupying up to 30% or more of the space on the shore), especially at wave exposed sites. Populations of these two species expanded at most sites between 2005 and 2012 but have since begun declining again.

Top: Typical alga encrusted with bryozoans.

Middle: Rocky shore sampling.

Bottom: Crab camouflaged among the rocks.

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.

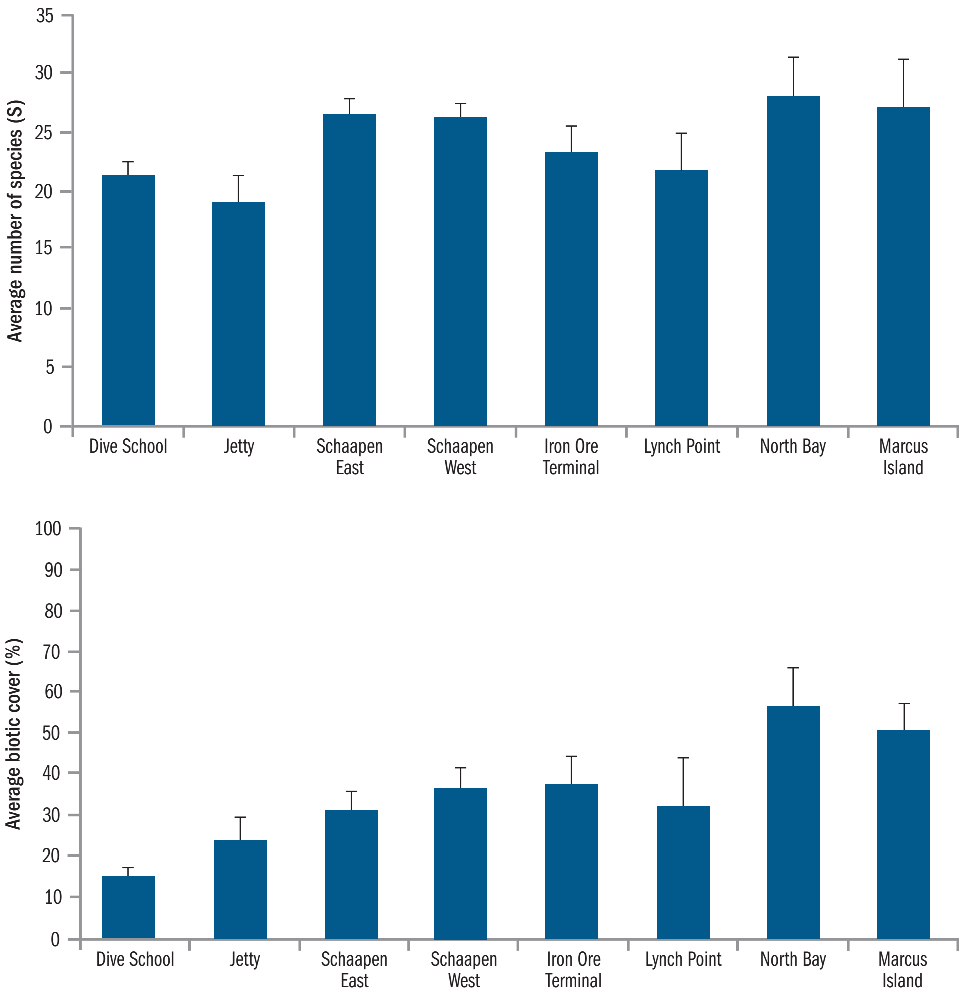
Mid shore

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

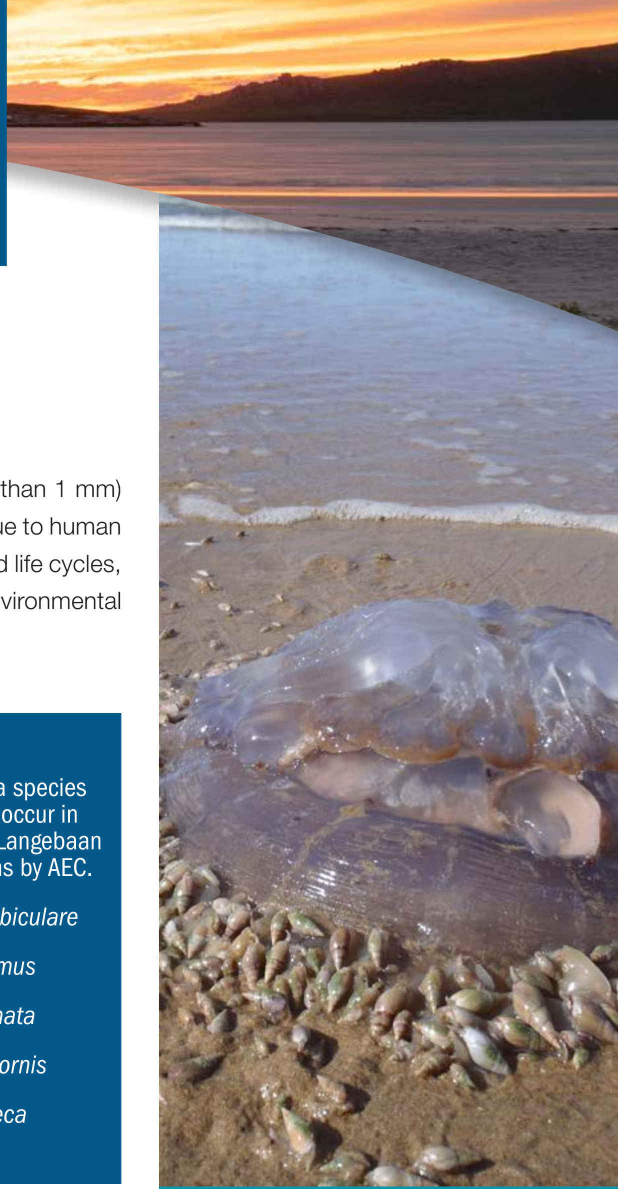
At the very sheltered sites (i.e. Dive School and Jetty), average faunal and algal cover is low in comparison with exposed low shore sites (i.e. North Bay and Marcus Island). The pear-shaped limpet *Scutellastra cochlear* (always surrounded by narrow gardens of fast-growing, fine red algae) is found 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.

Generally, the amount of space occupied by living organisms on the rocky shore increases from the high to the low shore, because very few species can survive on the high shore where it is much hotter and drier. Waves also bring in more food, and so rocky shores that are more exposed also tend to have a higher abundance of species. In particular, animals that feed by filtering particulate matter from the water column (like the invasive Mediterranean mussel *M. galloprovincialis* and the barnacle *B. glandula*) increase in numbers as one moves from sheltered to more exposed sites. Other organisms, such as the tiny periwinkle *A. knysnaensis* that nestles in amongst the barnacles to shelter from wave action, as well as predatory whelks, also become more common. Low shore communities are more visible at very sheltered sites (like Dive School), but overall plant (algae) and animal cover is still low at these sites in comparison with exposed low shore sites (like North Bay and Marcus Island). The pear-shaped limpet *Scutellastra cochlear*, which is always surrounded by narrow gardens of fast-growing, fine red algae, is found exclusively in the low shore zone at the more exposed sites.



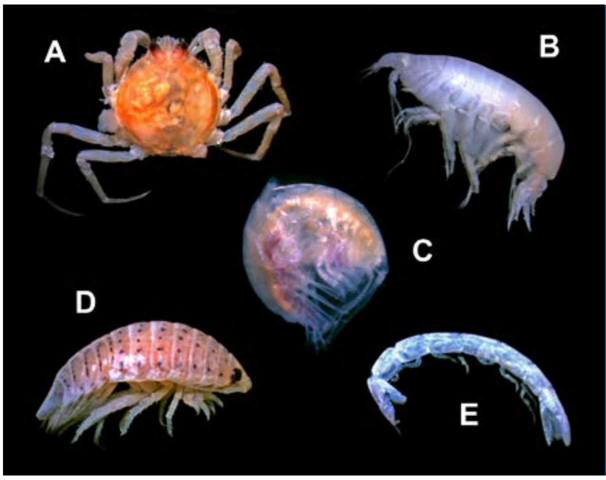
Variation in the number of species and biotic cover across the eight sites (STDEV error bars).

Subtidal Sandy and Rocky Habitats



Subtidal sandy habitats

Soft-bottom benthic macrofauna (animals living in the sediment that are larger than 1 mm) are frequently used to detect changes in the health of the marine environment due to human (anthropogenic) impacts. This is because these species are short-lived with rapid life cycles, and, consequently, the composition of their community responds quickly to environmental changes.



Benthic macrofauna species frequently found to occur in Saldanha Bay and Langebaan Lagoon, photographs by AEC.

A – *Hymenosoma obiculare*

B – *Socarnes septimus*

C – *Ampelisca palmata*

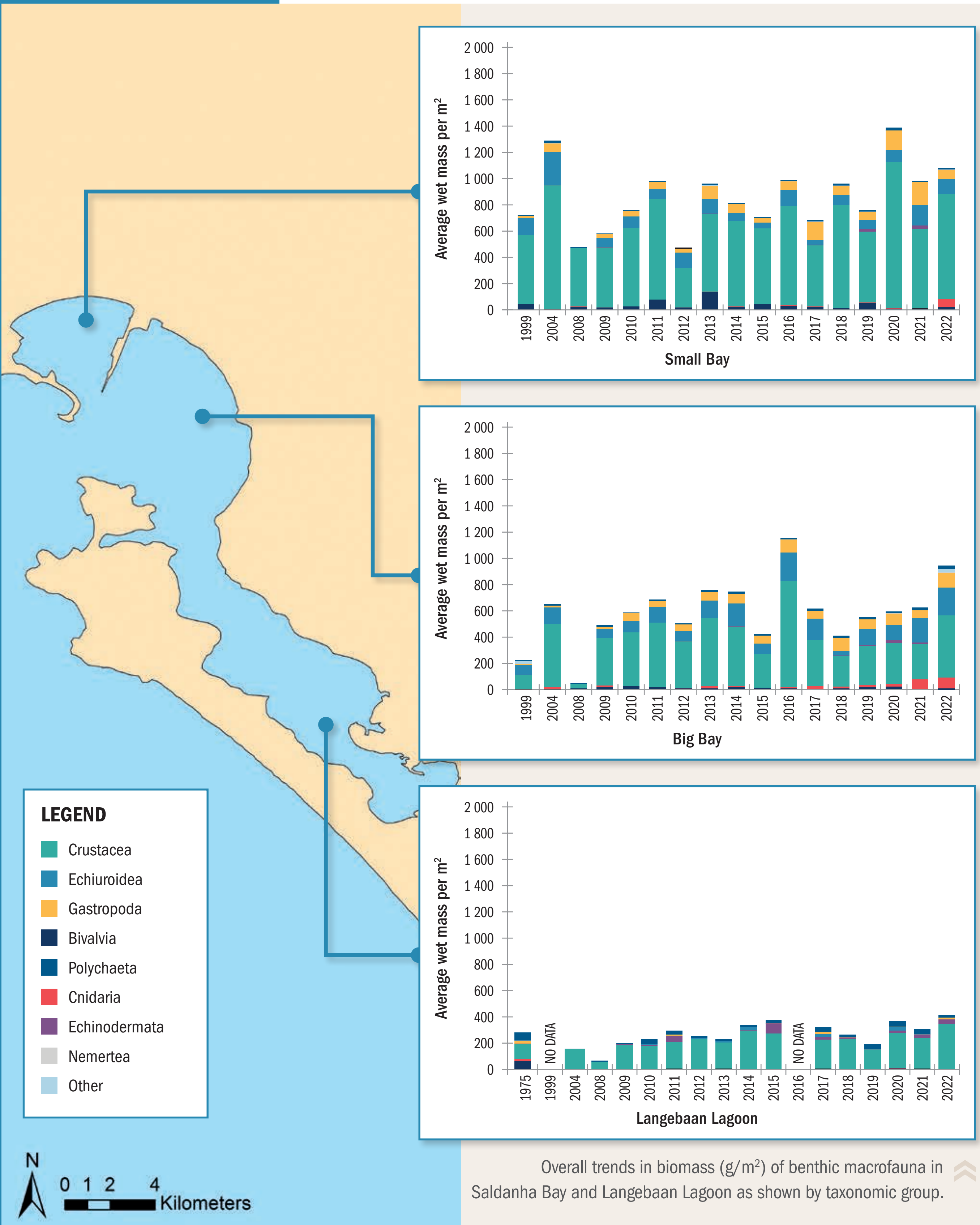
D – *Eurydice longicornis*

E – *Centrathura caeca*

The plough shell, *Bullia digitalis*, feeding on a stranded jellyfish.

Variations in the biomass (overall mass of living organisms per square meter) have been relatively stable in both Big Bay and Langebaan from 1999–2022. Biomass increased year-on-year in both areas from 1999 to 2014/2015, declined a little before stabilising after that. Changes in this trend were evident in 2008 and 2021, when biomass dropped quite dramatically in both areas. There was more variation in the biomass in Small Bay over the same time period, but the same basic underlying trends were evident, including a general increase in biomass evident over the period 1999–2014, dropping slightly and stabilising after this. The same clear perturbations were evident in 2008 and 2012. While it is not 100% clear what is driving these trends in biomass, we know that they are large scale (affecting all three areas) and are probably related to changes in the benthic environment (sediment characteristics) and/or the water (phytoplankton production and or water quality). The marked reduction in the amount of fine sediment (mud) and organic matter (particulate organic carbon and nitrogen) across the whole Saldanha Bay and Lagoon over the corresponding period where macrofauna biomass has been increasing (1999–2014) has almost certainly played an important role. Some more localised changes (improvements) are also evident in this data particularly in areas of Small Bay (e.g. Pepper Bay, Small Craft Harbour) where large amounts of fine sediment that was mobilised by dredging operations and organic matter from domestic wastewater and fish processing plant discharges had settled, and have since been removed through currents and waves. Improvements in wastewater treatment and reductions in the overall volumes of wastewater discharged to the Bay, have also almost certainly contributed to these improvements.

The *biomass* of benthic macrofauna has been relatively *stable* in both Big Bay and Langebaan from 1999–2022.



Overall trends in biomass (g/m²) of benthic macrofauna in Saldanha Bay and Langebaan Lagoon as shown by taxonomic group.

Subtidal reef habitats

The presence of extensive areas of low-profile reef was noted during the baseline surveys and deployment of monitoring instruments in Saldanha Bay for the sea-based ADZ. Based on available bathymetry data, there appears to be approximately 500 ha of reef habitat in Big Bay, with around 30% of this falling within the boundaries of the ADZ precinct. The potential effects of aquaculture on this habitat type and its associated communities has not previously been assessed in the Big Bay and has emerged as an issue of concern.

Most of this reef habitat in Big Bay can be described as a low-profile calcrete abrasion platform, however, substantial outcrops >1 m in height are present in places and form habitat for a well-established community of plants and animals living on its surface (epifauna). Monitoring surveys completed in 2021 and 2022 included the collection of underwater photographs and video footage of the fauna and flora associated with the reefs. A total of 51 species were recorded, with common species including: the West Coast rock lobster *Jasus lalandii*, red *Patiria granifera* and reticulated starfish *Henricia ornata*, nine different species of sponge, Cape urchins *Parechinus angulosus*, and beds of the common feather star *Comanthus wahlbergii.*

The extent of the reef in Big Bay is yet to be accurately determined and a detailed bathymetry survey of the entire area still needs to be undertaken. The full biodiversity importance and sensitivity of this habitat also needs to be established.

There appears to be approximately 500 ha of reef habitat in Big Bay, with around 30% of this falling within the *boundaries* of the ADZ precinct.

Examples of the reef habitat and associated epifauna found within the Big Bay ADZ precinct and elsewhere in Big Bay.

Fish

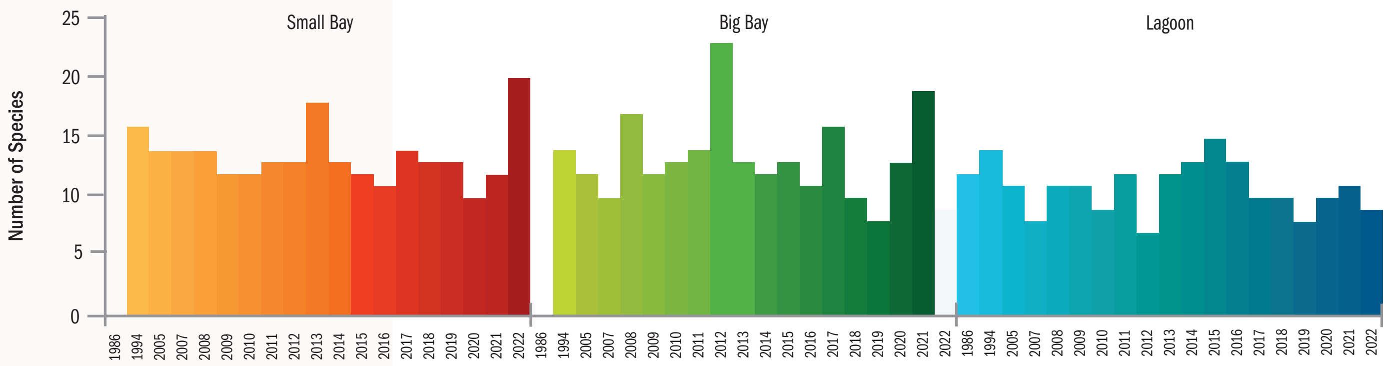
Top: Southern mullet.
Bottom: Guitarfish.

The warm, sheltered and 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 is particularly important as a nursery area for the juveniles of many species that are essential to the healthy functioning of the ecosystem. Sampling of surf-zone nursery areas since 2005 has found a greater diversity of species in Big Bay (41) and in Small Bay (37), than the Lagoon (26), but on average a higher abundance of juvenile fish is present in the Lagoon. Until recently, there was no clear trend in species richness over time with the same ubiquitous species present in nearly all surveys. The diversity of catches in the last five years has, however, been below average for four of those years in Small Bay, Big Bay, and Langebaan Lagoon.

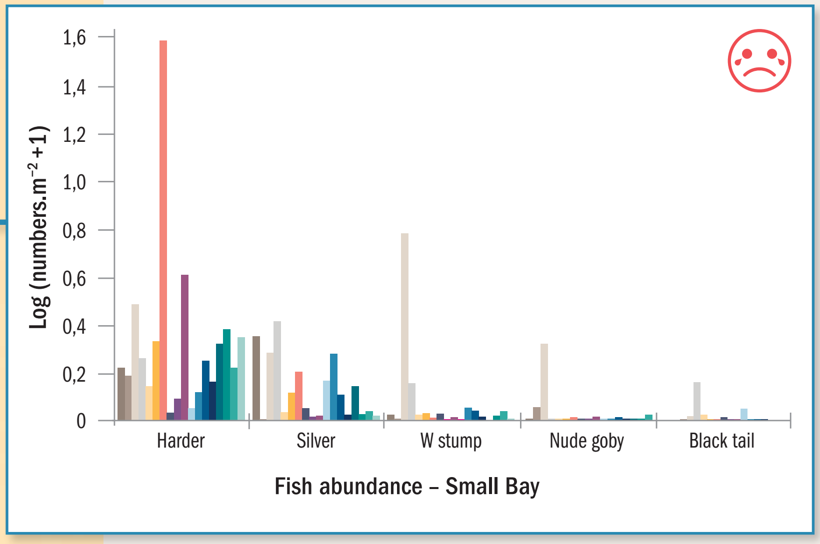
There is also a concerning decrease in the abundance of the five dominant species in Small Bay over the last five years (harder, silverside, white stumpnose, nude goby and blacktail). Within Big Bay, abundance of most of the common species has been satisfactory for the last three years with the exception of elf where recruitment to surf zone nursery habitats appears to have failed and only a single individual was caught in the last five years. The abundance of the dominant species like harders, white stumpnose, silversides and gobies in Langebaan Lagoon has also been lower than average in four out of the last five years.

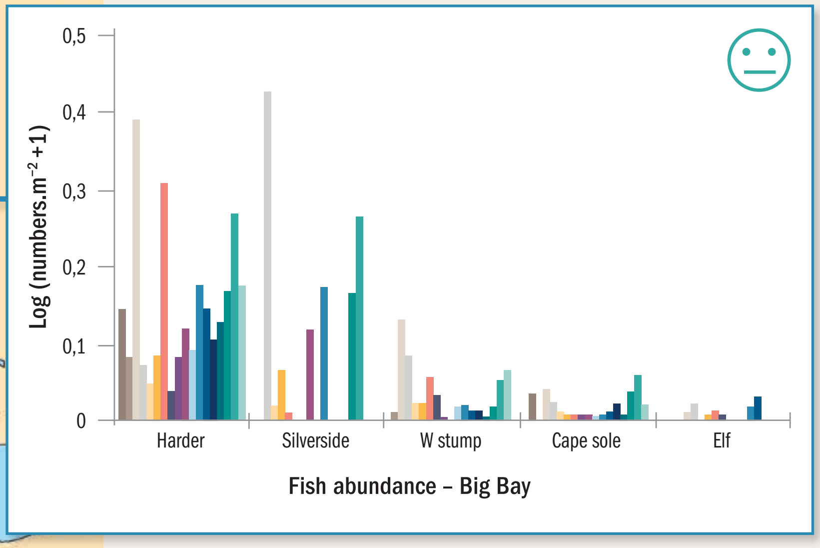
The current status of juvenile fish communities overall in Saldanha Bay and Langebaan Lagoon is slightly concerning, with generally lower than average fish diversity and fluctuating overall abundance. This suggests that either the habitat quality within the Saldanha Bay – Langebaan Lagoon system has deteriorated, and/or that fishing pressure on the adult spawning stocks has increased over the last five years. The relatively low abundance of juvenile white stumpnose has been a cause for concern for over a decade. The 2021 survey revealed some encouraging signs of increased white stumpnose recruitment across the whole system (mostly in Big Bay and the Langebaan Lagoon), but the 2022 catches were once again lower than average. The significant declines in juvenile white stumpnose abundance at all sites throughout the system and anecdotal accounts of reduced catch rates of adults in the line fishery, 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.

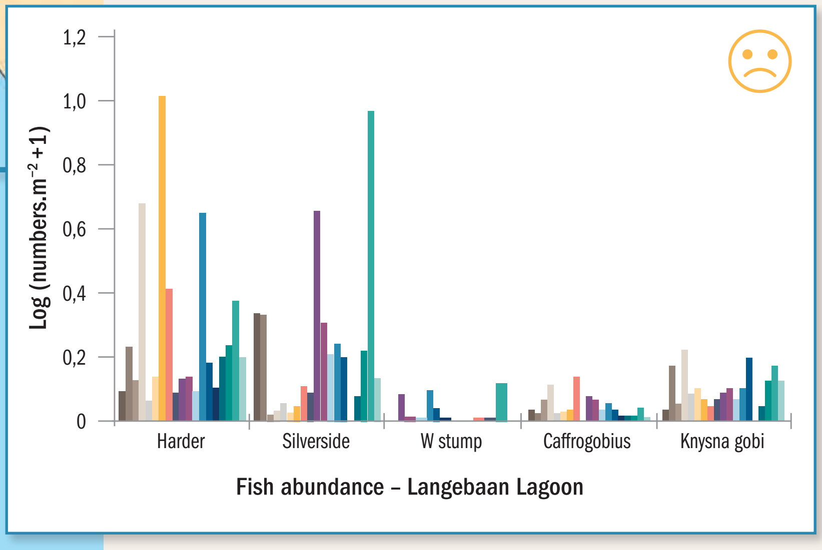
Number of fish species caught during 18 seine-net surveys in Saldanha Bay and Langebaan lagoon conducted over the period 1986–2022.

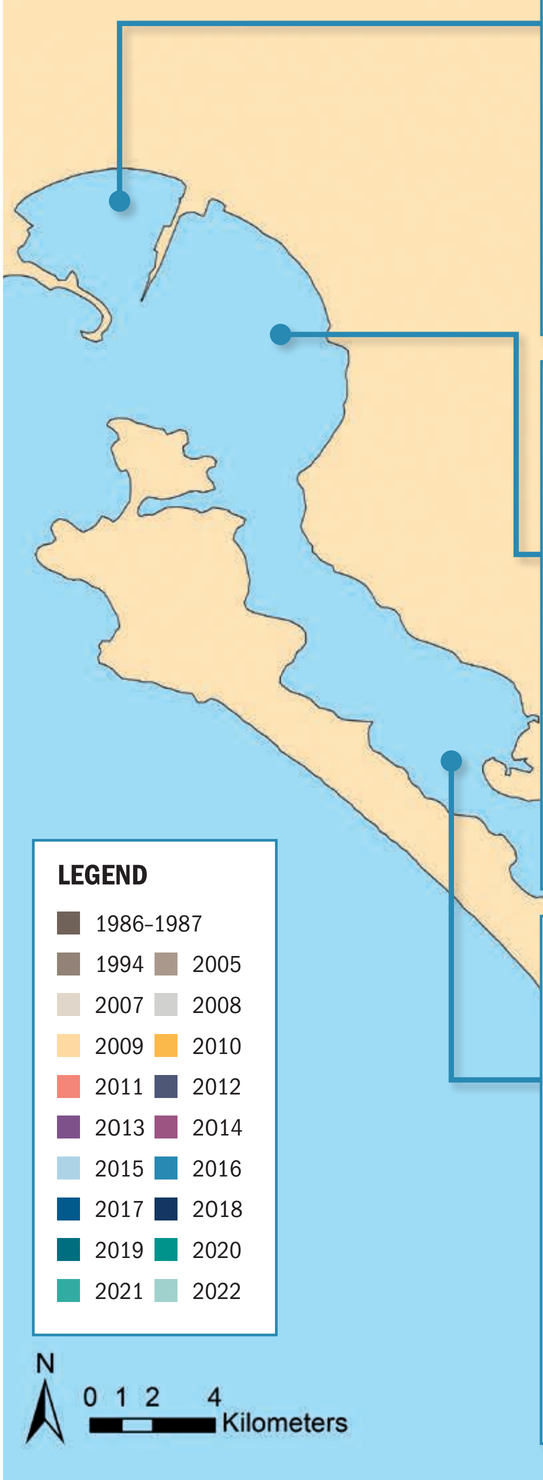


Abundance of the most common fish species recorded in annual seine-net surveys within Saldanha Bay and Langebaan Lagoon (1986/87, 1994, 2005 & 2007–2022).









Birds

DECLINE OF PENGUIN POPULATIONS CONTRIBUTING FACTORS INCLUDE

1. Emigration of birds to colonies further south and east along the South African coast
2. Starvation as a result of a decline in the biomass of sardines nationally
3. Competition for food with other predators
4. Predation of eggs, young and fledglings
5. Collapse of the West Coast Rock Lobster stock

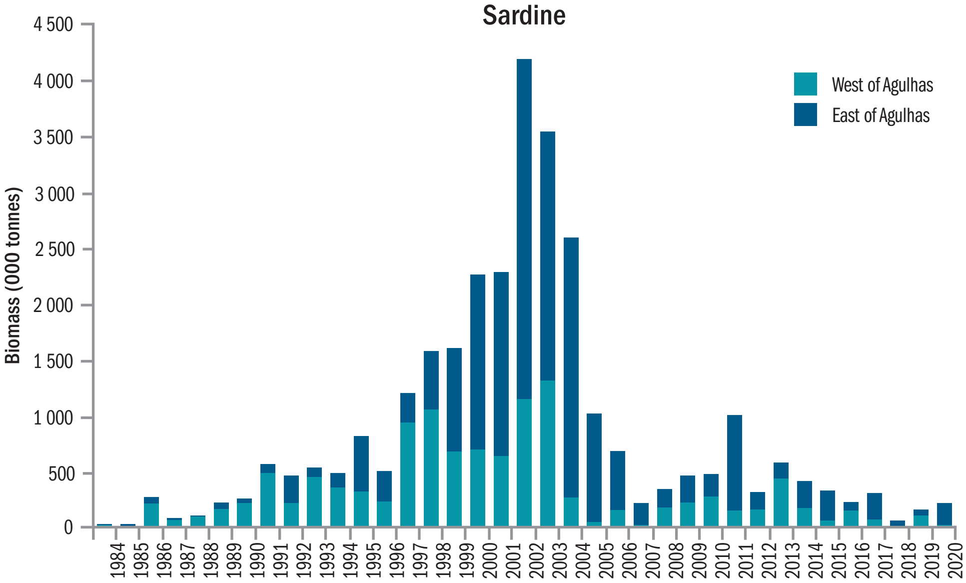
Waterbirds are excellent indicators of the health of marine and estuarine habitats. They are found high up on the food chain (meaning they tend to reflect any changes in the lower levels), they respond rapidly to changes in habitat quality, food or disturbance, and they are popular animals to observe and count (making them easy to monitor). A total of 283 bird species have been recorded within the boundaries of the West Coast National Park and at least 56 waterbird species use the area for feeding or breeding. Eleven seabird species are known to breed on the Saldanha islands. Langebaan Lagoon is a Ramsar site, a nationally significant area for migratory waders and terns, and for numerous resident waterbird species.

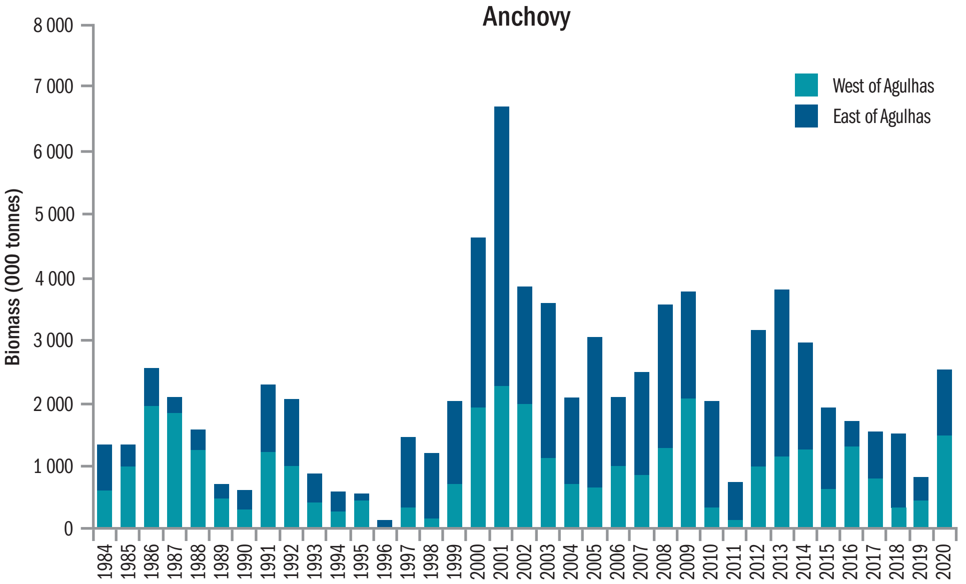
Birds of the Saldanha Islands

The islands of Malgas, Marcus, Jutten, Schaapen and Vondeling form part of the West Coast National Park Marine Protected Area, and 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.

In tandem with increases in sardine and anchovy biomass, the banning of egg collecting and the reduction and eventual cessation of guano collecting in 1991, the populations of many of the seabirds that breed on these islands increased until around 2004. Sardine biomass crashed thereafter, with the biomass along the west coast decreasing dramatically and remaining very low over the period 2015–2022. Populations of penguins, gannets and gulls breeding on the Saldanha islands followed suite and their populations are now at a fraction of what they once were. Other contributing factors to this decline include the emigration of birds to colonies further south and east in response to changes in the distribution of small pelagic fish, competition for food with other predators (including the small pelagic fisheries), predation of eggs, young and fledglings by Great White Pelicans, Kelp Gulls and Cape Fur Seals, and the collapse of the West Coast Rock Lobster stock upon which Bank Cormorants feed. As such, both the Cape Gannet *Morus capensis* and Cape Cormorant *Phalacrocorax capensis* have been upgraded to Endangered on the IUCN red list in the last five years, to join the African Penguin *Spheniscus demersus* and the Bank Cormorant *Phalacrocorax neglectus.*

Swift terns feeding. »





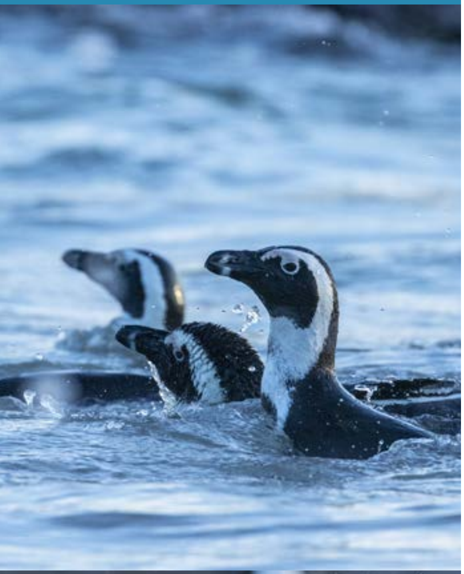
White-fronted Plover.

Long term trends in the biomass of small pelagic fish (sardine and anchovy) to the west and east of Cape Agulhas. Data source: Department of Forestry, Fisheries and Environment (2022).

Kittlitz's Plover on the grass beds.

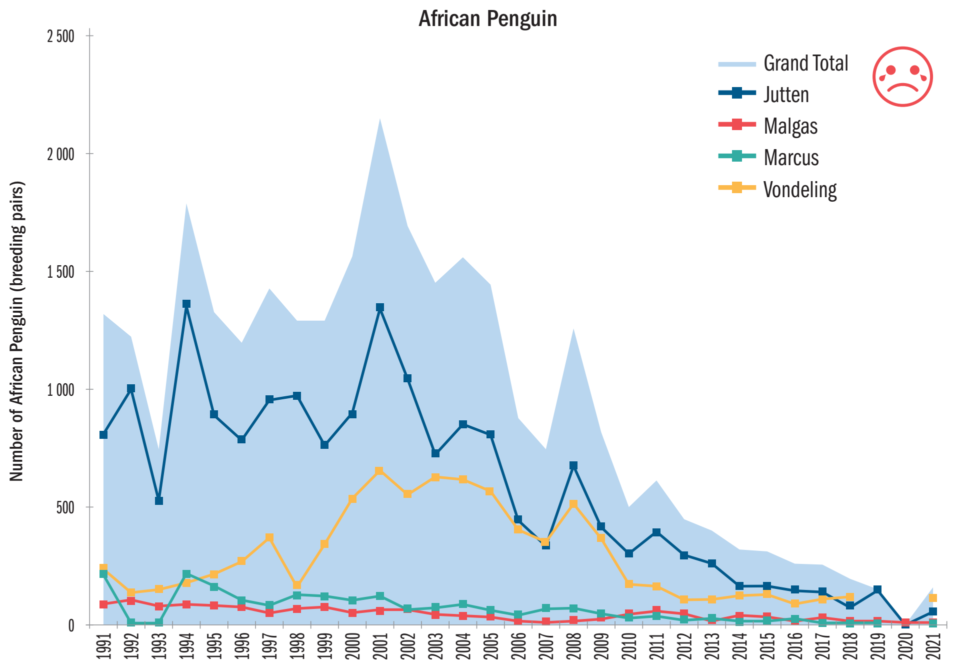
The majority (71%) of the global African Penguin population breeds within South African waters

Historically about half of South Africa's Gannets bred in the Western Cape, but this declined to less than 30% over 2003–2013



Top and Bottom: African Penguins.

The majority (71%) of the global African Penguin population breeds within South African waters. The Biodiversity Management Plan for the African Penguins has identified numerous interventions to try and arrest the population decline of this iconic sea bird, but food availability is still considered a major driver. In September 2022, the DFFE announced closures for small pelagic fishing around the major penguin breeding colonies. It was hoped that closures around Dassen and Robben Island would benefit penguin colonies on the west coast as a whole, and that the Dassen Island closure may benefit penguins nesting on the Saldanha islands as it is within the foraging range of the species.



Trends in African Penguin populations at Jutten, Malgas, Marcus and Vondeling islands in Saldanha Bay from 1991–2021 measured in number of breeding pairs. Data source: Department of Forestry, Fisheries and the Environment (2022).

The Cape Gannet *Morus capensis* breeds on six offshore islands, including two off the South African west coast (Malgas Island in Saldanha Bay), and one in Algoa Bay. Historically about half of South Africa's Gannets bred in the Western Cape, but this declined to less than 30% over 2003–2013, and now the largest colony is found on Bird Island in Algoa Bay.

Cape Cormorants breed throughout the Benguela Upwelling system (Angola, Namibia and South Africa) but the species also faces most of the threats listed above and there has been a continuing decline in mature individuals throughout its range.

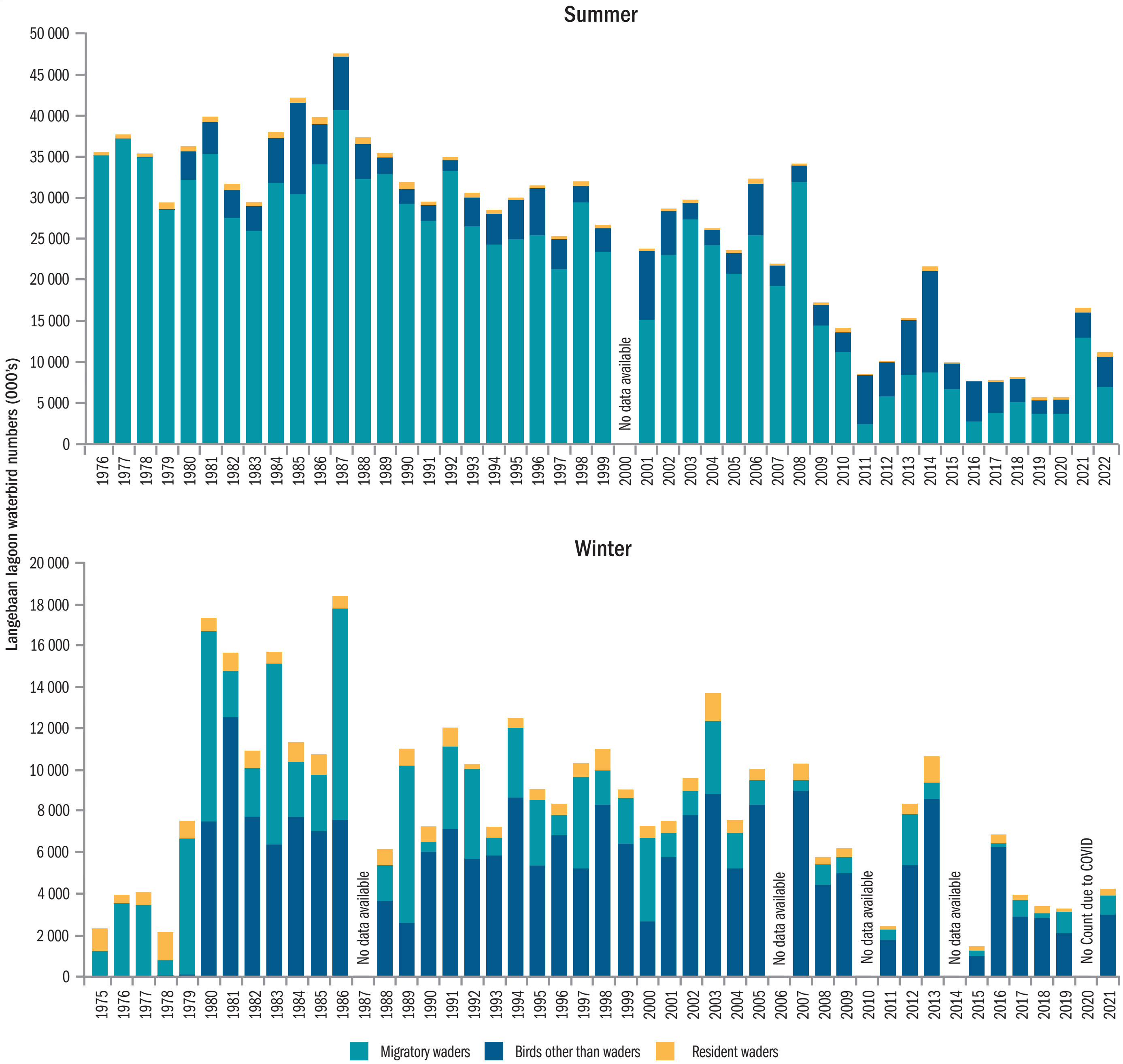
The Crowned Cormorant *Phalacrocorax coronatus* and the African Black Oystercatcher *Haematopus moquini* are both endemic to Southern Africa and their IUCN listings were downgraded to Least Concern in 2018. The population trend of the Crowned Cormorant is stable, and the Oystercatcher is increasing, which is thought to be a result of the increase in mussel biomass associated with the arrival and spread of the invasive Mediterranean mussel. The islands also support breeding populations of White-breasted Cormorant *Phalacrocorax lucidus*, Kelp Gull *Larus dominicanus*, and the Caspian Tern *Hydroprogne caspia,* all of which have increasing global populations and are ranked as Least Concern.

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 migratory waders that utilise Langebaan Lagoon 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* and Red Knot *Phoeniconaias minor*.

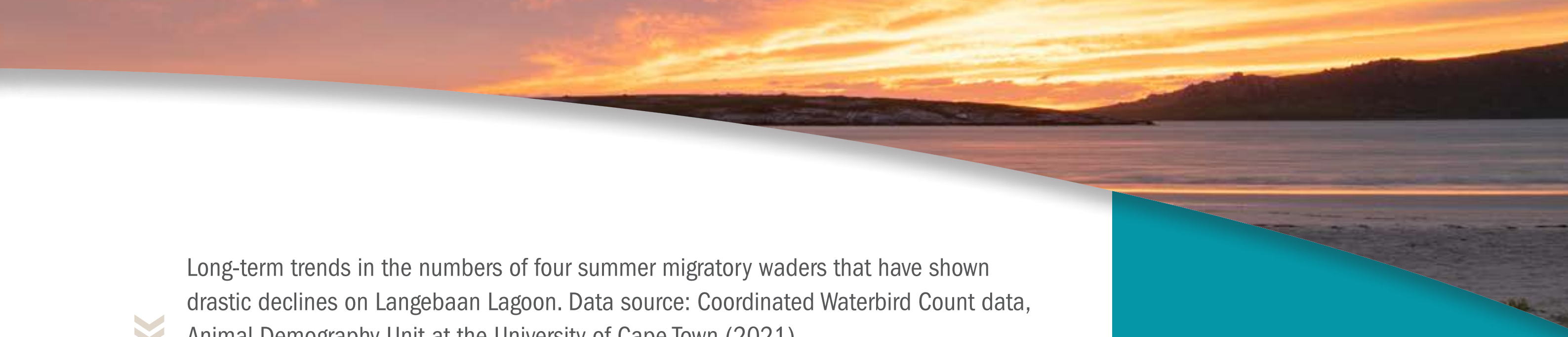
Waterbird numbers in Langebaan Lagoon have declined dramatically since monitoring began in the 1970s. This is largely due to changes in the numbers of waders, which used to account for more than 90% of bird numbers. Migratory waders commonly numbered over 35 000 during summer in the 1970s and 80s, and over 10 000 in winter. Migratory wader counts in summer appeared to stabilise at around 3 000–5 000 birds over 2015–2020 and recovered significantly to about 13 000 birds in 2021. The 2022 summer count of migratory waders was unfortunately much lower and revealed that the observed recovery was short lived and likely associated with the extraordinary global Covid-19 pandemic. Resident wader numbers in the winter of 2019 dropped to the lowest level in the 40-year count record, and the 2021 post-Covid count showed little recovery, a continuation of a declining trend over the last decade. Drastic population declines in four species, the Ruddy Turnstone, Red Knot, Grey Plover, and Curlew Sandpiper, exemplify this downward trend in summer migratory bird numbers. Other migratory wader species that have not fared as badly include Common Greenshank, Common Ringed Plover, Common Whimbrel and Little Stint.

Top: Curlew Sandpiper.
Middle: White-breasted Cormorant.
Bottom: Common terns leaving their roost on the banks of Langebaan Lagoon.

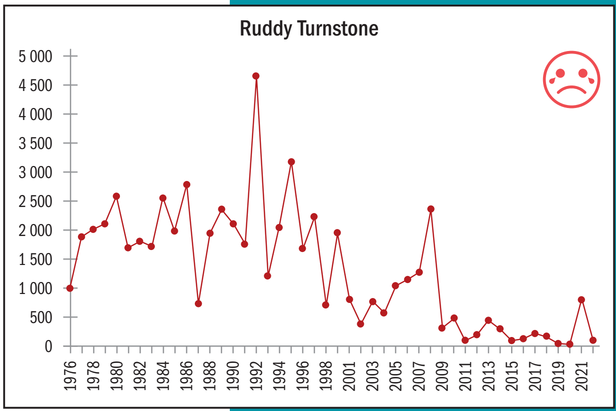


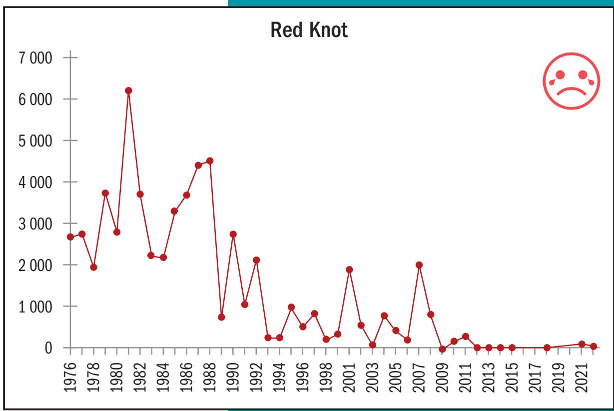
Long-term trend in the numerical composition of waterbirds in the Langebaan Lagoon. Data source: Coordinated Waterbird Count data, Animal Demography Unit at the University of Cape Town (2022).

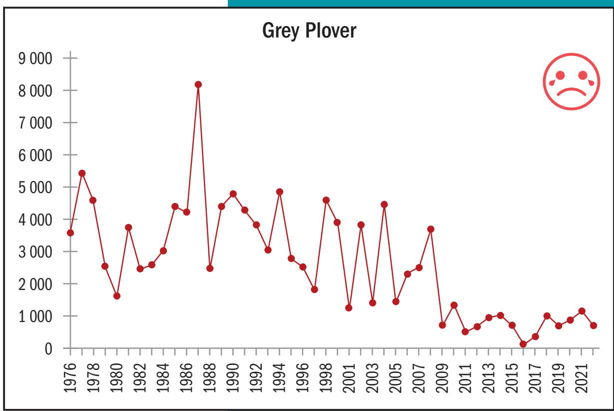
Decreases in both migratory and resident wader numbers are a common trend around the South African coast, which has been attributed to loss of breeding habitat and hunting along their migration routes as well as human disturbance and habitat loss on their wintering grounds. The fact that numbers of resident 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.

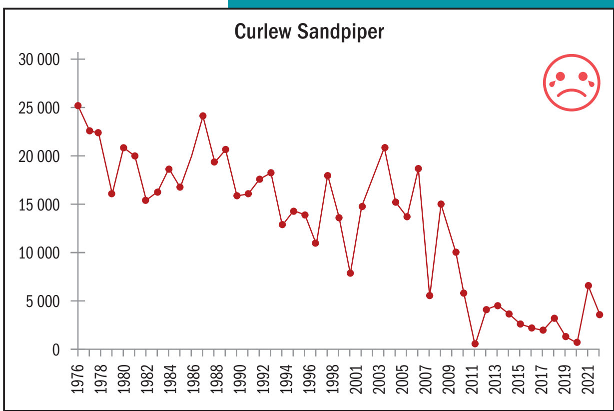


Long-term trends in the numbers of four summer migratory waders that have shown drastic declines on Langebaan Lagoon. Data source: Coordinated Waterbird Count data, Animal Demography Unit at the University of Cape Town (2021).

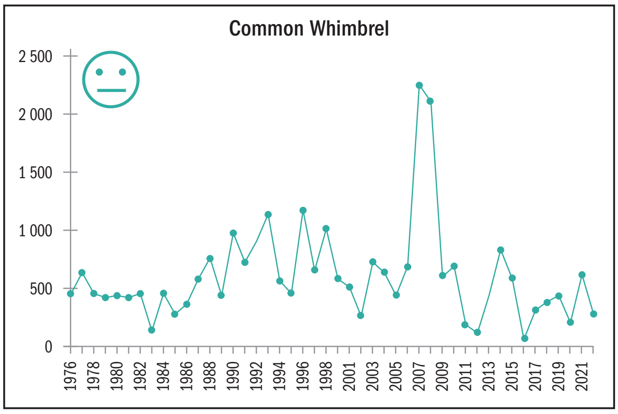


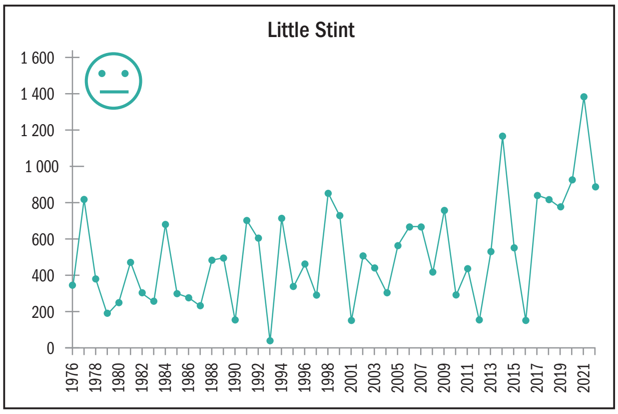


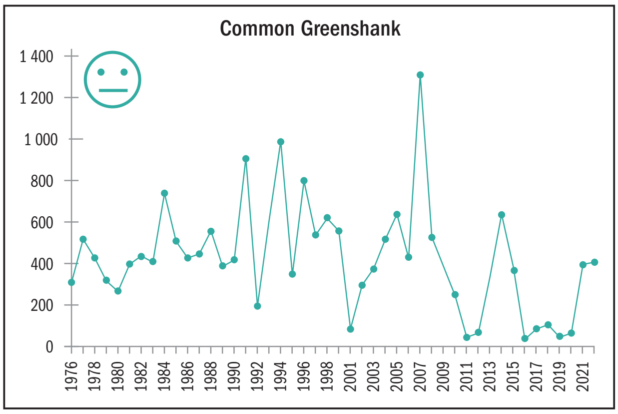


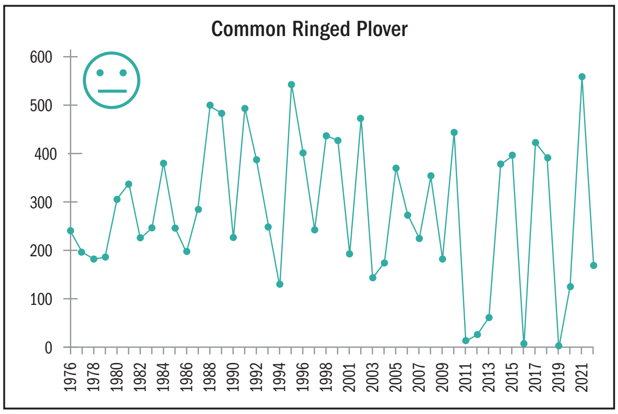


Long-term trends in the numbers of four summer migratory waders that have not shown drastic declines on Langebaan Lagoon. Data source: Coordinated Waterbird Count data, Animal Demography Unit at the University of Cape Town (2022)





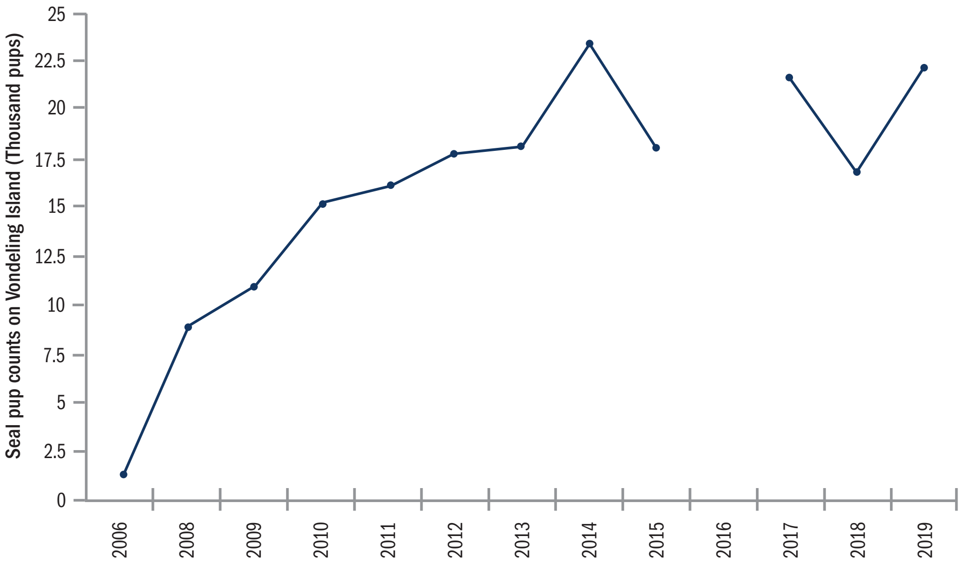




Seals

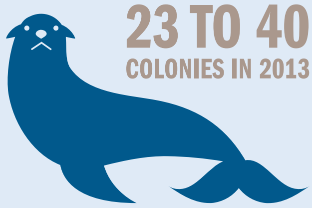
The Cape fur seal *Arctocephalus pusillus pusillus* is the only seal species that breeds in Southern Africa. It occupies a high position on the food chain in the Benguela ecosystem, competing with and predating upon seabirds. With the ban on seal hunting, the Cape Fur seal population grew by almost 20-fold in the 20th century before stabilising at about two million animals. In addition, the number of breeding colonies have increased from 23 in 1970 to 40 in 2013.

The distribution of these seals has been shown to vary in relation to prey distribution and abundance.There has been a general shift in seal numbers southwards of St Helena Bay with new breeding colonies being established on Vondeling Island, at Cape Point and potentially on the south coast near Betty's Bay. It is possible that this southward shift coincides with the south and eastwards shift of small pelagic fish species which are a key food source for these seals. Although seals historically would frequent the Saldanha islands (Jutten, Malgas and Vondeling), coming on land to rest or sun themselves, it is only since the turn of the century that a breeding colony has been established on Vondeling Island. The number of pups on this island increased dramatically up until 2010, thereafter (2010–2013), the rate of increase slowed and pup numbers on the island have varied significantly in recent years, peaking at 23 400 pups in 2014 and dropping to 16 700 in 2018. This variation suggests that the island may have reached carrying capacity (it can no longer support anymore seals). Some culling has been undertaken of seals off the west coast in recent years in an attempt to limit the mortality of seabirds that are of conservation importance. The culling of 'problem' seals seen killing Cape gannet fledglings at Malgas Island, located northwest of the Vondeling breeding colony, resulted in a reduced mortality of gannet fledglings; however, seals learnt to avoid the boat used for culling, and the predation of seabirds around the island is ongoing



Trends in seal pup counts collected during aerial surveys conducted at Vondeling Island, Saldanha Bay from 2006–2019. (Source: DFFE).

breeding colonies have increased since 1970 from



23 TO 40
COLONIES IN 2013

The rate of increase slowed with 23 400 pups in 2014 and dropping to

16 700
IN 2018

A Cape Fur Seal haul-out.

Alien Species

Human-induced biological invasions are a major cause for concern worldwide. 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 social and economic impacts. Most of the introduced species in South Africa are found only in sheltered areas such as harbours and are believed to have been introduced through shipping activities, mostly ballast water and hull fouling, and mariculture.

At least 67 alien species are known to occur along the west coast, 29 of which are confirmed to be present in Saldanha Bay and/or Langebaan Lagoon. The recent addition of five new alien species brings the total number of marine alien species present in South Africa to 95 species, 56 of which are considered invasive, i.e., population are expanding and consequently displacing indigenous species. These new species are the barnacle *Perforatus perforatus*, the Japanese skeleton shrimp *Caprella mutica*, the Northwest African porcelain crab *Porcellana africana*, the Chilean stone crab *Homalaspis plana* and the South American sunstar *Heliaster helianthus*.

The discovery of five new alien species in Saldanha Bay over the past 6 years raises significant concern and highlights the need for implementing more efficient management actions. These should focus on trying to eliminate the most problematic invasive species already present in the area, and on preventing further invasions. Watchlists have been identified as a useful preventative measure and are created based on selecting species with an invasion history, that occur in similar climatic regions, or those with biological traits that could predispose them to become successful invaders. This should be used in combination with protocols to monitor vessels entering South African harbours, the removal of hull fouling before entering, strict regulation of aquaculture imports and the regular monitoring of harbours for alien species.

Top: Pacific mussel.
Bottom: European mussel.

European Porcelain crab.

Acorn barnacle *Balanus glandula*

One of the more abundant species on rocky shores, although populations have been decreasing. Competes for space but does not significantly impact communities.

– Origin: Pacific coast of North America

European mussel *Mytilus galloprovincialis*

Densities have recently decreased at several sites. Potential to spread to subtidal habitats.

– Origin: Mediterranean

Pacific South American mussel *Semimytilus algosus*

Often mistaken for *Mytilus*. The establishment in subtidal zones of large individuals is concerning.

– Origin: Chile

Green fleece *Codium fragile ssp. tomentosoides*

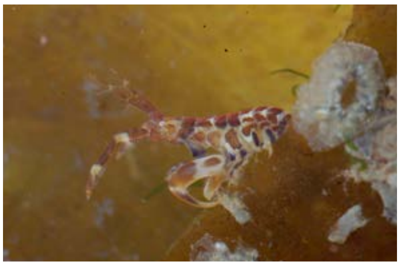
Globally the most invasive seaweed and tolerant to environmental fluctuations. Interspersed and often confused with the native *Codium*. Genetic clarification therefore required.

– Origin: Pacific Ocean near Japan

Western pea crab *Rathbunixa occidentalis*

No trend in their spread or site preference, although they flourish in deeper water in the Bay, are well established and have spread to the Lagoon. Impacts are undetermined.

– Origin: west coast of North America



Hitchhiker amphipod *Jassa slatteryi*

Occurs in high densities throughout the Bay. Potential food source for fish and other predators.

– Origin: Pacific North America

North West African porcelain crab ***Porcellana africana***

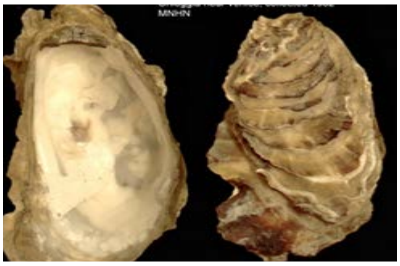
Has spread since the 2021 survey. Well established and abundant in Saldanha, including Schaapen Island West. No impacts anticipated.

– Origin: North West Africa

Vase tunicate ***Ciona robusta***

Economically important fouling species. Known to smother and kill farmed mussels.

– Origin: Mediterranean Sea and the English Channel



Pacific oyster ***Crassostrea gigas***

Established inside aquaculture dams, although no self-sustaining populations have been recorded in the Bay.

– Origin: Pacific Ocean

Alien barnacle *Perforatus perforatus*

Frequently recorded on rocky shores during annual surveys.

– Origin: Pacific coast of North America

Acorn barnacle *Amphibalanus amphitrite amphitrite*

A fouling organism and frequently recorded on rocky shores during annual surveys.

– Origin: unknown, worldwide distribution

Wood-boring amphipod *Chelura terebrans*

Considered a pest with negative economic implications due to its damage to wooden structures (only in presence of *Limnoria* isopods).

– Origin: Europe

Shell-boring spionid *Polydora hoplura*

Has negative economic implications due to infesting commercially cultured oysters and abalone in Saldanha.

– Origin: Europe, from the Mediterranean to England

Brooding anemone *Sagartia ornata*

Abundant in sandy areas around the Lagoon, although it has potential to spread to the Bay. Creates additional habitat which supports increased number of species and individuals.

– Origin: Western Europe, Great Britain and the Mediterranean

Lagoon snail *Littorina saxatilis*

Not a major threat to the Bay/ Lagoon ecosystems.

– Origin: North Atlantic

Red-rust bryozoan *Watersipora subtorquata*

A fouling animal forming calcareous crusts on hard surfaces and creating secondary habitat for invertebrates. Taxonomy showed changes in distribution and classification and genetic analysis is required.

– Origin: Unknown

Chilean stone crab *Homalaspis plana*

Discovered under a pier in Small Bay in 2017, although no other individuals have been recorded since. Could be reintroduced, spread and impact biodiversity.

– Origin: Chile

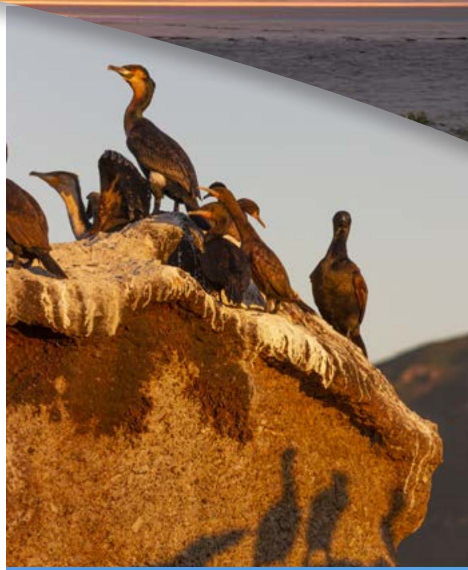
South American sunstar *Heliaster helianthus*

Discovered under a pier in Small Bay in 2015, although no other individuals have been recorded since. Could be reintroduced, spread and impact biodiversity.

– Origin: Southern Peru and northern and central Chile

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.
- Strictly enforce 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 adopted 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.
- The Draft Ballast Water Management Bill, initially published in April 2013 and re-released for comment in 2017, which aims to give effect to the International Convention for the Control and Management of Ship's Ballast Water and Sediments of 2004, must be enacted.
- Regular surveys must be undertaken in the Bay and Lagoon to enable the early detection of new alien species as they arrive, and steps taken to eliminate them before they become firmly established.
- The bag limit of white stumpnose should be reduced from 10 to five 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 such as harders, elf, white steenbras and sharks, in both Saldanha Bay and Langebaan Lagoon.
- Monitoring and assessment of the overall health of the Bay and the Lagoon must continue.



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Design and layout: Ink Design Publishing Solutions, Cape Town, www.inkdesign.co.za

Citation: Anchor Environmental Consultants (AEC) 2022. *The State of Saldanha Bay and Langebaan Lagoon.* Technical Report. Prepared for Saldanha Bay Water Quality Forum Trust, October 2022.

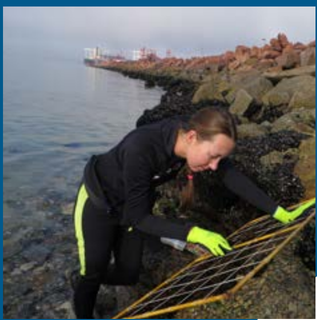
Top: White-breasted, bank and Cape Cormorants.

Middle: A view across the bay.

Bottom: Starwberry anemones – *Corynactis annulata*.









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