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Abbreviations

ADD	Average daily dose	ICMA	Integrated Coastal Management Act
Al	Aluminium	KCl	Potassium chloride
AMZ	Allowable Mixing Zone	LEC	Low-end consumer
ANOVA	Analysis of Variance	MPA	Marine Protected Area
As	Arsenic	Ni	Nickel
BCLME	Benguela Current Large Marine Ecosystem Programme	nMDS	Non-metric multidimensional scaling
CCT	City of Cape Town	NOAA	US National Oceanic and Atmospheric Administration
Cd	Cadmium	NOEC	No-Observable-Effects-Concentration
CEC	Contaminants of emerging concern	PO₄³⁻	Orthophosphate
CFU	Colony forming units	PAH	Polycyclic aromatic hydrocarbons
Cr	Chromium	Pb	Lead
CSF	Cancer Slope Factor	PNEC	Predicted no effect concentration
CSIR	Council for Scientific and Industrial Research	POP	Persistent organic pollutants
Cu	Copper	PPCPs	Pharmaceuticals and personal care products
CWDP	Coastal Waters Discharge Permit	RfD	Oral reference dose for non-carcinogenic health impacts
DFFE	Department of Forestry, Fisheries and the Environment	SCUBA	Self Contained Underwater Breathing Apparatus
DO	Dissolved oxygen	TMNP	Table Mountain National Park
ECR	Excess cancer risk	TOC	Total organic carbon
ERL	Effects Range Low guideline value	TPHs	Total petroleum hydrocarbons
ERM	Effects Range Medium guideline value	TSS	Total suspended solids
FIB	Faecal Indicator Bacteria	USEPA	United States Environmental Protection Agency
GEF	Global Environmental Facility	UVC	Underwater Visual Census
HAB	Harmful algal bloom	VOC	Volatile organic carbons
Hg	Mercury	WWTW	Wastewater treatment works

Abbreviations

HEC	High-end consumer	ZID	Zone of initial dilution
HQ	Hazard Quotient	Zn	Zinc

Definitions

Assimilative capacity	The ability of an ecosystem to absorb substances such as human waste and other pollutants without long-term ecological impacts.
Allowable Mixing Zone	The 'sacrificial' zone surrounding an outfall within which environmental parameters are not required to meet guideline values and permit conditions, and along the boundary of which routine monitoring is conducted for compliance and impact assessment purposes.
Amphipod/a	Crustaceans with no carapace and a laterally compressed body.
Anoxic	Oxygen depleted or deficient.
Anthropogenic	Relating to or resulting from the influence of human beings on a natural system.
Benthic	The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are collectively referred to as the "benthos", e.g. the benthic invertebrate community, including crustaceans and polychaetes.
Biodiversity	The variety of plant and animal life in a particular habitat.
Biogeography	The patterns and processes that have influenced the distribution of species and ecosystems over space and time.
Biomass	The mass of living biological organisms in a given area or ecosystem.
Carcinogenic	Synthetic chemicals, naturally occurring substances, physical and biologic agents that promotes the development of cancer by damaging DNA and causing cellular mutations.
Catchment	In relation to a watercourse of watercourses or part of a watercourse, this term refers to the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point of common points.
Community	A naturally occurring group of native animals/plants that interact in a unique habitat.
Coastal discharge	Discharging effluent to the coastal environment either to an estuary or the surf zone or through a coastal outfall (i.e. to the offshore coastal environment).
Crustacea/n	Generally, differ from other arthropods in having two pairs of appendages (antennules and antennae) in front of the mouth and paired appendages near the mouth that function as jaws.
Coastal Waters Discharge Permit	A permit to discharge effluent that originates from a source on land into coastal waters under section 69 (1) of the ICMA.
Dilution	The reduction in concentration of a substance due to mixing with water.
Diversity	The number of different species that are represented in a given community.
Domestic effluent	Wastewater/effluent arising from domestic and commercial activities and premises, which may contain sewage (as per General Authorisations - GG 20526 GN 1191 of 8 October 1999).
Ecoregion/ecozone	The 2011 National Biodiversity Assessment used the terms 'ecoregions' and 'ecozones' to replace the similar, but revised 'bioregions' and 'biozones' used previously and to avoid confusion between the different map layers from previous assessments.
Endemic/endemism	A species unique to a defined geographic location. Organisms that are indigenous to an area are not endemic if they are found elsewhere.
Environment	The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Epifauna	Benthic fauna living on the substrate (such as a hard sea floor) or on other organisms.

Definitions

Farfield	Within the context of ocean outfalls, the spatial/volumetric extent of the receiving water body in which the waste field is transported and dispersed after the initial dilution process.
Ichthyofauna	The fish species of a particular region or habitat.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Industrial effluent	Wastewater/effluent arising from industrial activities and premises. Contaminated stormwater drainage from industrial premises is included in this definition.
Initial dilution	The dilution of an effluent plume generated by jet momentum and the buoyancy effects that occur between the outlet ports of a marine outfall's diffuser and the sea surface.
Initial mixing zone	During the initial dilution process, ambient water is entrained by jet and buoyancy-induced turbulence and shear, causing dilution of the rising effluent plume. When the density of the discharge plume approaches the density of the seawater, the initial dilution process will cease and, depending on stratification in the water column, this process may stop below the surface. The spatial/volumetric extent of the initial dilution process is referred to as the initial mixing zone. This process can be manipulated by the hydraulic design of the outfall system (discharge rate and diffuser configuration). Ambient processes will control the further mixing of the effluent plume. However, these cannot be manipulated and the degree of mixing, when compared with the achievable initial dilutions, is almost insignificant. Only the physical location of the discharge structure can be optimised for achieving required dilutions at distant locations.
Invertebrate	An animal without a backbone (e.g. a starfish, crab, or worm).
Macrofauna	Also termed macrobenthos, are invertebrates that live on or in sediment, or attached to hard substrata – particularly those which are retained on a 0.5 mm sieve.
Marine outfall	A submarine pipeline originating on shore, which conveys wastewater from a head works to a submerged discharge location on or near the seabed beyond the surf zone.
Marine Protected Area	An area of sea and coastline that is dedicated to the protection of biodiversity and natural and cultural resources and is managed in a structured and legal manner. Different levels of MPAs exist, ranging from complete no-take zones (where nothing may be disturbed, caught or removed) to partial-take MPAs which have a suite of regulations that determine what activities may take place in which zone.
Mollusc/a	Invertebrate with a soft unsegmented body and often a shell, secreted by the mantle.
Municipal wastewater	Domestic wastewater or the mixture of domestic wastewater with industrial effluent and/or urban stormwater run-off.
Mutagenic	Describes both physical or chemical agents that can cause a genetic mutation i.e. a permanent change in DNA, which may increase the frequency of mutations above what is considered a natural rate.
Nearfield	Within the context of ocean outfalls, this refers to the spatial/volumetric extent of the receiving water body in which the initial dilution process takes place.
Offshore	Within the context of ocean outfalls, this is the area of the sea in which wave action has an insignificant effect on water circulation and shoreline processes (erosion and accretion). Also means beyond the surf zone.
Pollution	Any change in the environment caused by (i) Substances; (ii) Radioactive or other waves; or (iii) Noise, odours, dust, or heat emanating from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or well-being or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future (NEMA, 1998 and ICMA, 2008).

Definitions

Polychaete/a	Segmented worms with many bristles (i.e. bristle worms).
Preliminary treatment	Involves the removal from effluent of 'litter' and solids by coarse and/or fine screens as well as the removal of 'grit' (particles sizes > 0.2 mm and with a specific gravity > 2.6) by settling or separation. The effect on the suspended solid concentrations and BOD in the sewage is insignificant.
Pretreatment	Processes used in reducing or eliminating the contaminants in non-domestic effluent or in altering its nature, before discharging it into a wastewater treatment system.
Primary treatment	Involves the removal from effluent of settleable organic and inorganic solids by sedimentation tanks. The solids, which settle as sludge, have to be disposed of or treated. Fats (oil and grease) are also skimmed from the top of the settling tank. During primary treatment > 40% of total suspended solids and 20% of Biological Oxygen Demand (BOD) are removed.
Secondary dilution or dispersion	The further dilution that occurs after initial dilution when an effluent plume is advected away from the discharge area.
Secondary treatment	The separation of liquid and solids contained in primary treated effluent by a stabilising process, utilising micro-organisms and oxygen (aerobic biological treatment by biofilters and/or aeration tanks). The liquid and solids are separated through settling and the sludge is disposed of or treated. Normally secondary treatment removes > 70% of total suspended solids and BOD.
Shannon Diversity	An index used to characterize species diversity within a community, which accounts for both abundance and evenness of the species present.
Species	A category of biological classification ranking immediately below the genus, grouping related organisms. A species is identified by a two-part name; the name of the genus followed by a Latin or Latinised un-capitalised noun.
Synergist effect	When the effect of two chemicals acting together has a greater negative impact on an ecosystem than the impact of each chemical individually, or the sum of the individual impacts.
Taxon (plural = taxa)	Refers to any unit used in the science of biological classification, or taxonomy.
Tertiary treatment	Involves the further treatment of secondary treated effluent to remove nitrogen, phosphorus, ammonia, remaining total suspended solids, organic compounds, heavy metals and dissolved solids by special treatment processes.
Urban stormwater runoff	Stormwater run-off from paved areas, including parking lots, streets, residential subdivisions, of buildings, roofs, highways, etc.

1 INTRODUCTION

1.1 Background

Cape Town disposes of approximately five percent of its wastewater through three marine outfalls located along the western seaboard of the city (Figure 1-1). An outfall located at Green Point discharges sewage from the central business district and coastal areas between Woodstock and Green Point. A second one in Camps Bay discharges sewage from areas between Bantry Bay and Bakoven, and a third outfall discharges all sewage from Hout Bay. In each case, the wastewater receives preliminary treatment comprising the screening of solids and removal of sediment. The balance (i.e. about 95%) of sewage produced in the city is discharged after treatment at various wastewater treatment works either to inland waterways or to the coastline.

The marine outfalls have been a cause of public concern and have received frequent media attention over the past decade, due in part to the intermittent presence of visible effluent plumes on the ocean surface, and in part to a greater public awareness of the impacts of wastewater on the natural environment.

The outfalls are regulated by the Department of Forestry, Fisheries and the Environment (DFFE) in terms of the National Environmental Management: Integrated Coastal Management Act (ICMA, Act 36 of 2014). The DFFE issued Coastal Waters Discharge Permits (CWDPs) for each outfall, conditional upon certain limitations, monitoring, and reporting requirements.

In response to permit requirements and in order to better understand the effects of this method of wastewater disposal, the City of Cape Town (the metropolitan municipality responsible for wastewater management, 'the City', or 'CCT') is implementing a Receiving Environment Monitoring Programme aimed at monitoring environmental impacts resulting from the discharge of wastewater through the marine outfalls into the coastal environment; and assessing compliance with the CWDPs issued to the City by the DFFE.

The present Receiving Environment Monitoring Programme (Clark et al., 2024) follows several decades of periodic and increasingly comprehensive monitoring efforts. It provides for the assessment of the effects of the outfalls on the receiving environment through monitoring of pollutant concentrations and distribution in water, sediment, and the tissue of marine organisms; in addition, monitoring includes comparisons of ecological parameters between sites near the outfalls with distant reference sites, and the periodic assessment of concentrations of emerging contaminants such as microplastics, pharmaceutical compounds, and persistent organic pollutants.

This report was compiled following the first year of sampling, and presents data and assessments for the period July 2024 to June 2025.

Key questions to be addressed in the monitoring and assessment are –

- Whether there is a measurable change in the physical environment attributable to one or more of the marine outfalls;
- Whether this change is relevant to ecological health and results in ecological responses beyond the allowable mixing zone of each outfall; and
- Whether there are any measurable risks to human health arising from recreational or extractive uses of the coastal and marine environment in the vicinity of the outfalls.



Figure 1-1. Locations of the three offshore wastewater outfalls (Green Point, Camps Bay and Hout Bay) and the City's other WWTWs with their ultimate discharge locations indicated.

1.2 Outfall design and purpose

Coastal cities often utilise outfalls to dispose of municipal wastewater to the marine environment, after varying levels of treatment (Akdemir & Dalgic, 2021; Roberts et al., 2010). Marine outfalls rely on the effective mixing of wastewater with the surrounding seawater to achieve dilution and dispersion of pollutants to permitted levels. Mixing is achieved by the turbulent flow generated by the diffuser structure, the movement and large volumes of receiving seawater, and the buoyancy of generally warmer, fresher wastewater in relation to seawater (Akdemir & Dalgic, 2021; CSIR, 2017a).

The composition of municipal wastewater varies depending on the type and number of households, industries, and businesses in the catchment. It is typically mostly freshwater, with varying quantities of human waste, cosmetics and pharmaceuticals, cleaning agents, food fragments, grease and/or oil. It also often contains other contaminants such as heavy metals and certain hydrocarbons, depending on the source of the wastewater (albeit generally at very low concentrations). The preliminary treatment of wastewater prior to discharge removes most sediment and solids larger than the size of the screens through which it is passed.

The significance of the impacts of the discharge of wastewater depends on the coastal environment's assimilative capacity: that is, its capacity to receive pollutants without significant deleterious effects to aquatic life and human health beyond the limits of a defined "Allowable Mixing Zone" (AMZ). The assimilative capacity of a marine outfall will be dependent on the type of wastewater and the dispersion, dilution, and degradation of contaminants by the receiving environment. The western seaboard of Cape Town has a much higher assimilative capacity than sheltered waterbodies such as estuaries, due to its larger volume and high-energy environment.

A well-designed marine outfall aims to achieve adequate initial dilution and dispersion of wastewater to minimise impacts on sensitive environments, including recreational areas and ecologically important habitats (Roberts et al., 2010). This requires a diffuser configuration that promotes effective mixing under a range of oceanographic conditions. Dilution and dispersion can reduce concentrations of nutrients, organic matter, other contaminants, and pathogenic organisms to levels that may be considered acceptable in terms of the risk they pose to marine organisms and ecosystems. The impacts of certain pollutants such as organic toxicants, pharmaceuticals, and heavy metals may not be effectively regulated on a concentration basis alone, if they biomagnify or persist in the environment for long periods. For these substances, prevention and control at source are the only means of effectively reducing potential impacts.

The "Receiving Water Quality Objectives Approach" for management of discharge of waste into coastal waters is adopted by government authorities in South Africa. The primary focus of this approach is on meeting or maintaining receiving water quality objectives such that an affected waterbody largely remains or becomes largely fit for all "designated uses", while at the same time taking account of the assimilative capacity of that environment. Inherent in this approach is the recognition that water quality may not always be suitable for all designated uses within the area immediately surrounding an outfall, but that it should be fit for all such uses further away. Designated uses of the marine environment, in this context, include activities such as recreational use, harvesting of marine living resources, industrial use, and aquaculture as well as the protection of biodiversity and ecosystem functioning. This objectives-based management approach arose from the recognition that enforcing end-of-pipe wastewater limits in the absence of an established context, i.e. not recognising the assimilative capacity and/or requirements of receiving environments, would result in a point being reached where waterbodies would only be marginally fit for their designated uses and/or where it would not be possible to take advantage of the societal benefits that can be accrued from the assimilative capacity of the marine environment.

Wastewater discharged through marine outfalls enters the ocean under pressure through openings ('ports') in the diffuser structure. The buoyant nature of domestic wastewater initially drives further vertical movement (in addition to the effect of port exit velocity), and thus further dilution, of wastewater until neutral buoyancy is achieved. The immediate dilution achieved resulting from both port-induced turbulence and natural buoyancy of wastewater is referred to as "initial dilution". Initial dilution is completed when the effluent plume has lost its initial momentum and either reaches neutral buoyancy or reaches the sea surface. Generally, neutral buoyancy is achieved below the sea surface. In some cases, wastewater may not mix sufficiently to reach neutral buoyancy, reaching the sea surface instead. This may occur due to a multitude of ocean conditions, often driven by seasonality. The spatial and volumetric extent of the initial dilution process is called the initial mixing zone (RSA DWAF, 2004), and is also known as the zone of initial dilution (ZID). This extent is in constant flux and varies markedly in three dimensions over short timescales due to the highly variable nature of the marine environment and of the volume and pumping rate of wastewater. It is highly dynamic and elusive, rather than a consistent and easily-defined physical area surrounding an outfall.

For this reason, the 2024 Receiving Environment Monitoring Programme (Clark et al., 2024) continues the approach adopted previously for the CCT marine outfalls (Lwandle, 2020; CLS, 2022a, 2021; PRDW, 2020a, 2020b, 2021), in defining an 'allowable' mixing zone (AMZ). This is based on recommendations included in the "Assessment Framework For The Management of Effluent from Land Based Sources Discharged to the Marine Environment in South Africa" (Anchor Environmental, 2015), and with recommendations included in the "Operational Policy for the Disposal Of Land-Derived Water Containing Waste to the Marine Environment of South Africa", published by the Department of Water Affairs and Forestry (2004; Taljaard et al., 2007).

In terms of this framework, the magnitude of the AMZ for an offshore discharge (i.e. one discharging in water depth in excess of 10 m) is defined as the area of a circle 300 m in radius. In the case of an outfall that is fitted with a diffuser section at the end (which is the case for the three Cape Town outfalls), the AMZ is elongated to be equidistant from the diffuser section, forming a cigar-like shape the total area of which is equivalent to a circle with a radius of 300 m. At the Green Point outfall, which has 16 ports on the diffuser section spaced approximately 10 m apart, the distance from each of the ports to the boundary of the AMZ is 256 m. For the Camps Bay outfall (which has 8 ports spaced 12.2 m apart) this distance is 274 m, and for the Hout Bay outfall (which has 10 functional ports spaced 10 m apart) this distance is 272 m as indicated on Figure 1-2, Figure 1-3 and Figure 1-4 below. In each case the area of the AMZ is ~0.28 km² or 28 ha.

This approach to monitoring was accepted by the DFFE as set out in the 2024 Receiving Environment Monitoring Programme (Clark et al., 2024) for the three outfalls, and has the further advantages that it is possible to define the exact extent of the mixing zone for all outfalls in a consistent manner in space and time, and that they are comparable and equivalent for the three outfalls. Empirical data collected through this monitoring programme can be compared directly with the dispersion modelling data presented by PRDW (2020b, 2020a, 2021), and recent monitoring data (CLS, 2021, 2022a; Lwandle, 2020).

1.3 Cape Town's outfalls and their receiving environments

1.3.1 Green Point marine outfall

The Green Point outfall is situated in Table Bay west of the Port of Cape Town and extends 1 700 m offshore of Mouille Point in a north-westerly direction (**Figure 1-2**). It is designed to discharge up to 40 ML per day of wastewater, with a catchment area extending from Woodstock to Bantry Bay and including the City Bowl. Wastewater consists primarily of domestic sewage, but the area also includes industrial and extensive commercial land uses. Raw wastewater destined for the outfall undergoes preliminary treatment comprising screening (12 mm and 3 mm mesh sizes) to remove inorganic and non-degradable constituents. The outfall has an outer diameter of 800 mm and an inner diameter of 700 mm, and discharges at a depth of 28 m below sea level. It has 16 ports, arranged in four sections of four ports each with a 10 m spacing.

The oceanography of Table Bay is relatively well understood and documented (Quick & Roberts, 1993). Table Bay is in the Southern Benguela upwelling system and water properties and circulation in the bay are characteristic of the region. Water movement in the bay is primarily influenced by wind, with minor effects from shelf currents offshore (van Ieperen, 1971 in Quick & Roberts, 1993). Currents tend to flow northwards when wind blows from a south-easterly direction, resulting in an anticlockwise current within the bay. Currents flow south when winds blow from a north or north-westerly direction, which causes the water to move marginally clockwise in the bay (*ibid.*). The nearshore environment of Table Bay is also greatly influenced by waves and swell (*ibid.*).

Sensitive receptors in the area surrounding the Green Point outfall include surfers and beachgoers on the small beaches of Sea Point, Three Anchor Bay, and Green Point. Kayaking and other boat-based recreation occurs over a much wider area, including the area surrounding the outfall (Figure 1-2). Recreational fishing occurs both offshore and along the seawall. The area is also popular as a tourist destination, both land- and sea-based. Table Bay is a significant fishing ground, supporting a harbour and a protected area for the West Coast Rock Lobster (Quick & Roberts, 1993).

The latest version of the South African National Biodiversity Assessment (NBA) (Sink et al., 2019) identifies 150 different marine ecosystem types in the marine environment of South Africa. Shore zone ecosystem types that are present around the Green Point outfall include Cape Exposed Rocky Shore, Cape Kelp Forest and Cape Mixed Shore, while shelf ecosystem types include Cape Bay on the east side of the outfall and Cape Rocky Inner Shelf to the west of the outfall (Sink et al., 2019). All of the ecosystem types in the vicinity of the Green Point outfall are considered to be moderately well protected (i.e. >10% but <20% of that ecosystem type is included in the existing Protected Area Network) but were all rated as "Vulnerable" aside from the "Cape Bay" ecosystem type which was rated as "Endangered" (Sink et al., 2019). The Robben Island Marine Protected Area (MPA) extends west and south from Robben Island and includes the Green Point outfall. The MPA was proclaimed in 2019, and the outfall therefore pre-dates the establishment of the MPA by several decades.



Figure 1-2. Allowable mixing zone and nearby receptors potentially at risk around Green Point marine outfall.

1.3.2 Camps Bay marine outfall

The Camps Bay outfall extends 1 497 m offshore from Camps Bay Beach in a north-westerly direction (Figure 1-3). It is designed to discharge 5.0 ML per day of wastewater, with a catchment area that includes Clifton, Camps Bay and Bakoven. The outfall was commissioned in 1977 to replace an earlier, shallower outfall constructed in 1927 (Eagle et al., 1977).

Wastewater discharged from this outfall consists primarily of domestic sewage as there are only limited commercial activities in the catchment. Wastewater is subjected to preliminary treatment in the form of screening using 12 mm and 3 mm mesh screens to remove inorganic and non-biodegradable solids. The outfall discharges at a depth of 23 m below sea level. It has eight ports,

spaced 12.2 m apart; the end of the outfall is capped. Wastewater is discharged horizontally through elbow bend ports, with alternating discharge directions. The Camps Bay outfall has a permitted discharge capacity of 11.3 ML per day, more than twice its design capacity. Its actual metered discharge varies between 1.96 ML per day on average in the winter/spring and 1.68 ML per day in the summer/autumn.

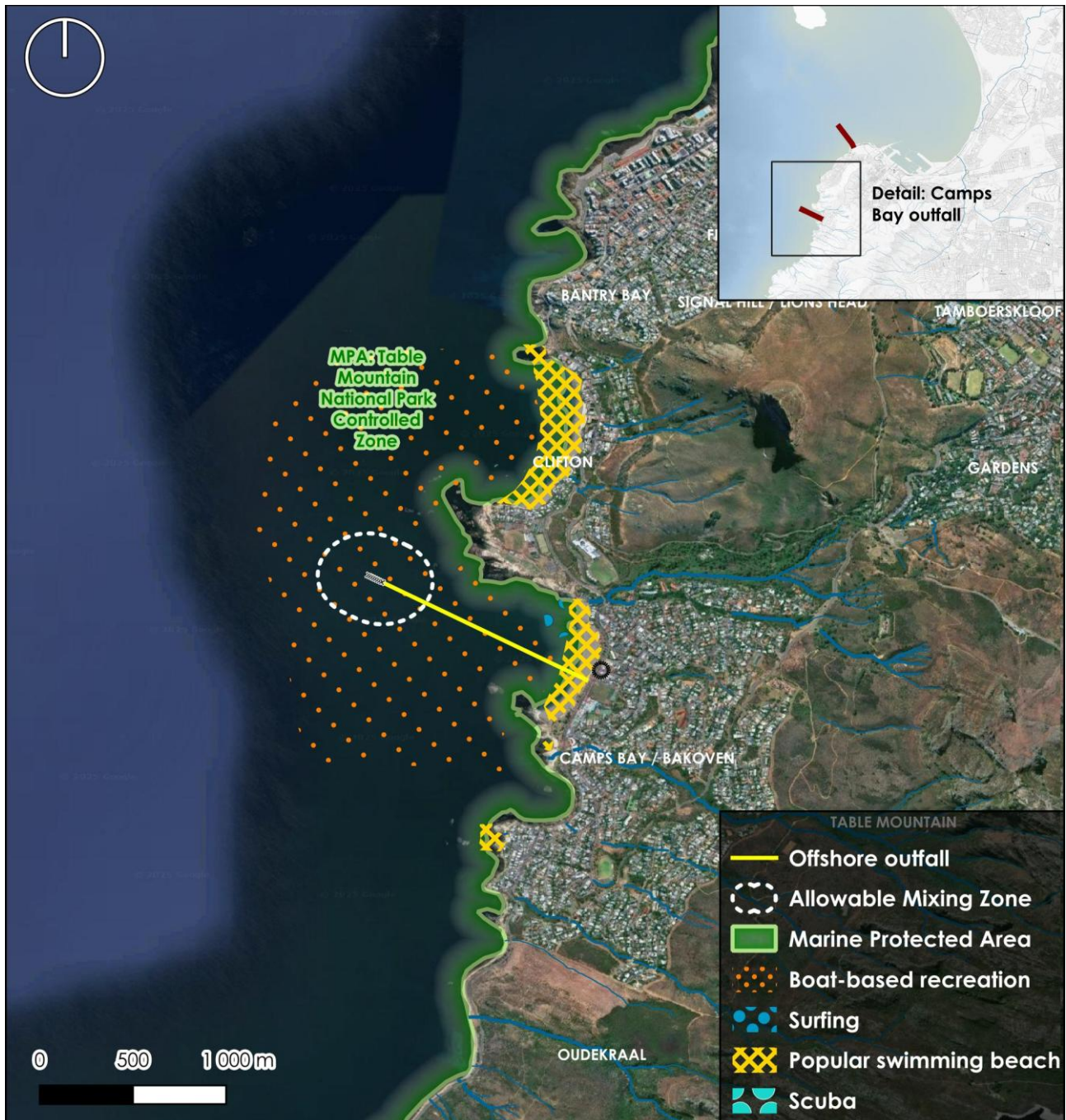


Figure 1-3. Allowable mixing zone and nearby receptors potentially at risk around Camps Bay marine outfall.

At around 850 m wide, Camps Bay is relatively small and enclosed by the rocky headlands of Camps Bay Drive and Maidens Cove (CSIR, 2017a). The seabed in Camps Bay is comprised of a mix of sand and exposed bed rock, where the area inshore of the diffuser section is mainly sand and the area to the north and south of the diffuser section is bed rock with interspersed pockets of sand (CSIR, 2017a; Eagle et al., 1977). The oceanography of Camps Bay has not been thoroughly investigated, although

previous research by Harris (1978) suggested that local winds do not significantly influence the circulation.

Shore zone ecosystem types that are present around the Camps Bay outfall include Cape Exposed Rocky Shore, Cape Kelp Forest, Cape Mixed Shore, and Southern Benguela Dissipative Intermediate Sandy Shore, while shelf ecosystem types are restricted to Cape Rocky Inner Shelf (Sink et al., 2019). These ecosystem types are all considered to be moderately well protected (i.e. >10% but <20% of that ecosystem type is included in the existing Protected Area Network) and are rated as "Vulnerable" except for "Southern Benguela Dissipative Intermediate Sandy Shore" which is considered to be well protected ($\geq 20\%$ of that ecosystem type in good condition in the existing Protected Area Network) and as such has been rated as "Least Concern" (Sink et al., 2019).

The Table Mountain National Park (TMNP) MPA encompasses around 1000 km² over 127 km from Mouille Point to Muizenberg and includes the Camps Bay area along the Atlantic seaboard. The MPA was originally proclaimed in 1997 and has undergone revisions in 1997 and 2004. The Camps Bay outfall discharges into the TMNP MPA Controlled Zone, but pre-dates the establishment of the MPA by two decades.

There are many sensitive receptors in the area surrounding Camps Bay outfall, with Camps Bay, Glen and Clifton Beaches being exceptionally popular with beachgoers and swimmers as well as for snorkelling in the summer. The Atlantic seaboard is also used by kayakers, cruises, and for other boat-based recreation. Commercial and recreational fishing occurs offshore, and shellfish harvesting and recreational fishing take place along the beaches and rocky shores.

1.3.3 Hout Bay marine outfall

The Hout Bay outfall has a total length of 2 162 m, extending out into the bay from the shoreline south of the Hout Bay harbour and bending east then southwest to run parallel with the coastline (Figure 1-3). It is buried along much of its length, with only the last 650 m to its terminus exposed above the seabed. The discharge point is approximately 750 m from the nearest shoreline – the Sentinel at the northwestern head of the bay. The catchment is the urban area of Hout Bay, and the design capacity of the outfall is 9.8 ML per day. Constructed in 1993, it replaced an earlier surfzone discharge point south of the harbour. The Hout Bay outfall discharges wastewater from mainly domestic sources as there are very limited commercial and industrial activities in the catchment.

Prior to discharge, preliminary treatment of wastewater takes place at the Hout Bay wastewater treatment works. The wastewater passes through two coarse screens (12 mm mesh size) to remove inorganic and nondegradable constituents, followed by a degritter to remove sand and stones and then two finer screens (3 mm mesh size) to remove smaller inorganic and non-biodegradable constituents. The Hout Bay wastewater treatment works also macerates the wastewater to reduce the size of solid waste to minimise the chance of blockages (PRDW, 2020b, 2020b). The outfall discharges at a depth of 37 m below sea level. It has 15 ports, of which five are flanged closed to ensure the present volume of wastewater is discharged at the correct pressure; the end of the pipe is also sealed. They are arranged with a 10 m spacing. The Hout Bay outfall was designed for 9.8 ML of wastewater per day, but the CWDP specifies a capacity of 5 ML per day. Its actual metered discharge varied between 5.32 ML per day on average in the winter/spring and 5.05 ML per day in the summer/autumn in previous studies (PRDW, 2020b).

Sensitive receptors in the area surrounding the Hout Bay outfall include beachgoers and swimmers at the popular Hout Bay beach. The world-famous surfing break known as Dungeons is located west of the outfall. The bay is also used by kayakers and contains a number of shipwrecks popular with

scuba divers and snorkellers. Subsistence and recreational fishers make use of the rocky shores on either side of the bay, and West Coast Rock Lobster and shellfish are harvested in the nearshore. The western shore of Karbonkelberg is a no-take zone for West Coast Rock Lobster but is still subjected to intense fishing pressure. Duiker Island is a protected island in terms of the Sea Birds and Seals Protection Act, No 46 of 1973.



Figure 1-4. Allowable mixing zone and nearby sensitive receptors potentially at risk around Hout Bay marine outfall.

1.4 Previous monitoring

1.4.1 Marine outfalls monitoring

The CSIR (1990) analysed faecal coliforms in seawater samples from Green Point outfall. Sediment collected from 97 sites in Table Bay, Camps Bay and Hout Bay was analysed for metals, particulate organic carbon, nitrogen and stable isotopes of both carbon and nitrogen. The CSIR also analysed sediment quality at 67 sites around the outfalls in 2003 (CSIR, 2003) and a reduced suite of three sites in Table Bay and Hout Bay in 2005-2006 and in 2011 (CSIR, 2006a, 2011b). Other studies from the 1970's on, by the CSIR and others, have also assessed impacts of the CCT marine outfalls but are not readily available or directly relevant to the present monitoring effort.

An extensive monitoring programme for Green Point, Camps Bay and Hout Bay outfalls was implemented in 2015/2016 (CSIR, 2017a) to determine impacts on the integrity of the marine environment due to the discharge of wastewater entering the receiving environment. This assessment included a characterisation of wastewater discharged at the outfalls, in which wastewater was sampled daily for seven months in 2015 to determine conductivity, pH, chemical oxygen demand and the concentrations of total suspended solids (TSS), ammonia, total kjeldahl nitrogen, orthophosphate, anions, cations, and trace metals. Wastewater was also sampled every two months over an 18-month period and analysed for pharmaceutical and organic chemicals.

Sediment quality measurements, including sediment grain size, total organic content, metal content and organic chemical concentration were planned to be taken at 67 sites around the outfalls similar to previous monitoring conducted in 2003, but only 40 sites were successfully sampled (including both dive and grab samples). The report recommended that sediment quality analyses should continue but with a modified (and downscaled) monitoring programme.

Human health risks posed by chemicals in wastewater from the three marine outfalls and the concentrations of chemicals in wastewater were determined in the tissue of black mussels and West Coast Rock Lobsters, based on assessments of the concentrations of organic chemicals and metals in the tissue of these organisms followed by a risk assessment to determine the possible risks to human health by exposure through consuming shellfish.

As part of the same CSIR monitoring programme, whole-effluent toxicity was tested in diluted wastewater samples from each outfall collected every two months over an 8-month period in 2016 from each outfall pumpstation. Tests were conducted on gametes extracted from adult sea urchins (*Echinometra mathaei* and *Tripneustes gratilla*).

The next marine impact assessment was conducted by Lwandle Marine Environmental Services and its successor CLS over the course of three years from late 2019 to late 2022 (CLS, 2022b; Lwandle, 2020, 2021). The impact assessment included a seawater quality monitoring programme, mussel bag bioaccumulation investigation, and hydrodynamic data collection. Toxicity testing was conducted biannually for three years, using seawater samples taken from near the three outfalls (within the AMZ), to assess toxicity effects of the wastewater once diluted in the marine environment.

Water quality monitoring in the 2019-2022 project consisted of seawater samples being collected from the shoreline, nearshore, and offshore, and the determination of faecal indicator bacteria (FIB), physico-chemical parameters, orthophosphate, and ammonia for six weeks in winter and four weeks in summer. The concentration of trace metals in mussel tissue and the impact on mussel growth of exposure to diluted wastewater were investigated over a six-week period in summer and winter. CLS conducted a once off biodiversity survey at the Camps Bay marine outfall in 2022 (CLS, 2022c), involving rock lobster counts, quadrant observations of sessile and macroalgal species, baited remote underwater video (BRUV) deployments, and benthic infauna monitoring.

1.4.2 Coastal microbiological monitoring

The CCT also undertakes regular (weekly or fortnightly) monitoring of FIB at 107 sites located along its coastline. Located mostly at recreational beaches, these sites are sampled by CCT staff and analysed by accredited laboratories for intestinal enterococci as the primary indicator of faecal pollution. The "Know Your Coast" report is produced annually, reporting on these data.

1.5 Current monitoring programme

The effects of pollutants on the environment can be detected in a variety of ways as can the concentrations of the pollutants themselves in the environment. The principal methods for assessing the concentration of pollutants in aquatic ecosystems and their likely effects on living organisms and people include:

- Analysis of pollutant concentrations in the water itself (Agunbiade & Moodley, 2014; D'Agostino et al., 2020; Ohoro, Adeniji, Okoh, et al., 2021; Ohoro, Adeniji, Semerjian, et al., 2021; Sigonya et al., 2022);
- Analysis of pollutant concentrations in sediments (Ohoro, Adeniji, Okoh, et al., 2021; Ohoro, Adeniji, Semerjian, et al., 2021; Suami et al., 2020);
- Analysis of pollutant concentrations in biological tissue (Gerofke et al., 2005; Pojana et al., 2007);
- Toxicity testing on commonly used indicator species (Kim et al., 2007; Shi et al., 2022; Teixeira & Granek, 2017; Yang et al., 2021; Zheng et al., 2023); and
- Comparison of community structure (species composition and abundance) surrounding the outfalls to appropriate reference sites (Vila-Costa et al., 2023; Yi et al., 2021).

A Receiving Environment Monitoring Programme for the three marine outfalls was prepared by Infinity Environmental and Anchor Environmental in 2024, and was approved by the DFFE in July 2024. The 2024 Receiving Environment Monitoring Programme (Clark et al., 2024), was formulated taking into account CWDP requirements, past monitoring efforts and findings, areas of public concern, and local and global scientific literature.

The intended outcome was a holistic monitoring programme relying on a range of indicators to detect and quantify potentially deleterious effects on the receiving environment and risks to users in Cape Town associated with the discharge of wastewater through the three marine outfalls. To achieve this, six main focus areas have been incorporated into this programme. Each of these six areas is structured as a monitoring plan, which when combined make up the monitoring programme and will be assessed in a single, three-yearly Marine Impact Assessment. The six plans are as follows.

1.5.1 Water Quality monitoring

Water quality monitoring is conducted at all sites on a monthly or quarterly basis. Physico-chemical parameters, and enterococci are monitored monthly and metals and nutrients are analysed quarterly. All sites are sampled at the sea surface, mid-depth, and bottom depth.

This report includes data and analysis for the twelve monthly sampling events between July 2024 and June 2025.

1.5.2 Ecotoxicity monitoring

Risks from synergistic, additive, and antagonistic toxic effects of the wastewater discharged from the outfalls are being assessed using sea urchin fertilisation toxicity tests performed on a monthly basis in accordance with standard protocols. The first year of the three-year monitoring programme included monthly ecotoxicity monitoring. Four sample sites have been established around the perimeter of each outfall's AMZ. Each outfall has one or more corresponding reference sites. Water samples were

collected from three depths at each AMZ and reference site (surface, mid-water and bottom) and tested for toxicity.

This report includes data and analysis for the twelve monthly sampling events between July 2024 and June 2025.

1.5.3 Sediment monitoring

Sediment is collected on an annual basis from sites around each outfall to quantify contaminants that may accumulate in sediment as a result of the wastewater discharge. Samples are analysed for grain size, metals, and organic pollutants.

This report includes data and analysis for the annual sampling event in February 2025.

1.5.4 Bioaccumulation monitoring

This segment of the monitoring programme comprises two separate components – yearly bioaccumulation analysis in wild-caught organisms, and three-yearly bioaccumulation analysis in caged organisms exposed to the environment near the outfalls for a period of time.

The annual environmental bioaccumulation monitoring consists of collecting resident fish (bream), rock lobsters, and black mussels from a variety of sites in the vicinity of each outfall and analysis for their tissue for evidence of bioaccumulation (i.e. elevated concentrations of metals relative to samples collected from comparable reference sites), and determination of the associated risks to the health of human consumers of these species.

This report includes data and analysis for the annual environmental bioaccumulation sampling conducted in February 2025.

The three-yearly bioaccumulation assessment consists of deploying bags of black mussels near each outfall for an eight-week period, to quantify potential differential accumulation of metals in these organisms relative to those at reference sites distant from the outfalls.

The first caged bioaccumulation study took place between August and September 2025 and will be reported on in the 2025/2026 annual report.

1.5.5 Contaminants of Emerging Concern monitoring

The CEC monitoring plan has two components: contaminants of emerging concern (predominantly pharmaceuticals and personal care products [PPCPs]) and microplastics. PPCPs will be investigated over the course of one summer and one winter every third year, looking at PPCP content in water and bioaccumulation in the tissue of black mussels, fish, and rock lobsters. A suite of PPCPs that are commonly used in Cape Town and found in the wastewater and waterbodies of Cape Town have been included.

The first PPCP study will take place in 2026 and will be reported on in the 2026/2027 annual report.

Microplastics are monitored at a higher frequency than PPCPs as they have not been included in previous monitoring programmes, and the surveys are intended to provide an initial determination of the scale of the potential concern. As with PPCPs, this is an evolving field of science, and environmental quality guidelines for these substances are not yet determined. This part of the monitoring programme serves as a starting point for assessing the contribution the marine outfalls may be making to microplastic pollution in the marine environment surrounding Cape Town.

This report includes data and analysis for quarterly microplastics monitoring between July 2024 and June 2025.

1.5.6 Ecological Effects monitoring

Conducted every third year, rotating with PPCP monitoring and mussel bag bioaccumulation studies, this monitoring assesses the impact of wastewater discharge on marine ecosystems proximate to each of the outfalls. Surveys of soft-bottom benthic infauna and reef epifaunal communities were conducted for each outfall in 2025. These surveys are similar in design to historic surveys conducted and are tailored to suit the nature of the environment adjacent to each outfall (i.e. sediment or rocky reef). This report includes data and analysis for the ecological effects monitoring conducted in February 2025.

1.6 Purpose of this report

Reporting on the findings and outcomes of the 2024 Receiving Environment Monitoring Programme is required on an annual basis, in terms of the Coastal Waters Discharge Permits issued by the DFFE for the three offshore outfalls. The objectives of the monitoring include assessing the impact of the discharges on the ecology of the receiving marine environment, and determining any significant risks to people.

This Marine Outfalls Receiving Environment Monitoring Report reports on data, analyses, and assessment of the status and trends in the receiving environment during the year under review (July 2024 to June 2025). Data collected during the annual monitoring cycle are presented, along with an analysis of compliance, risks, changes and trends relevant to the health of ecosystems and people.

1.7 Structure of this report

This report is structured as follows:

Chapter 1 provides background and introduces the study and monitoring undertaken;

Chapter 2 presents data and analyses from water quality monitoring, including ecotoxicity monitoring;

Chapter 3 presents microplastics monitoring data and analysis;

Chapter 4 analyses sediment quality data;

Chapter 5 presents the results and analysis of ecological effects monitoring;

Chapter 6 presents bioaccumulation data from the first year of monitoring; and

Chapter 7 is a summary and conclusion on the status and trends apparent in the first year of monitoring data.

A **bibliography** of cited literature is provided, followed by appendices presenting supplementary information, explanatory notes, and raw data tables. Appendices include:

- **Appendix I:** Methodology and Metadata
- **Appendix II:** Water Quality Guidelines, Data Tables and Supplementary Figures
- **Appendix III:** Microplastics Data Tables and Supplementary Figures
- **Appendix IV:** Sediment Data Tables
- **Appendix V:** Bioaccumulation Data Tables

1.8 Acknowledgements

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2 WATER QUALITY

2.1 Background

The analysis of pollutant concentrations in water itself is the backbone of most marine outfall monitoring programmes (Karydis & Kitsiou, 2013). It is used for assessing risk to public health and marine ecosystems and monitoring the regulatory compliance of each outfall. The rationale behind the design of the CCT marine outfalls water quality monitoring plan is set out in the 2024 Receiving Environment Monitoring Programme (Clark et al., 2024). As wastewater is discharged into the water column, it begins to dilute and disperse in the environment. During this initial phase of dilution, changes in pollutant concentrations in the water column are almost immediate. The volume and composition of wastewater discharged from Cape Town's marine outfalls are more or less continuous and are sustained over long periods of time but their effects are expected to vary on a seasonal basis with changes in weather and ocean currents. Sampling of water quality parameters is therefore undertaken at a relatively high frequency (monthly) to capture this variability.

Monthly water sampling was undertaken at each outfall to provide data responding to three key questions:

- Is the outfall compliant with permit conditions for receiving environment water quality?
- Does the outfall pose a detectable risk to sensitive receptors, including both human and ecological receptors?
- Where is the wastewater dispersion plume, and how far can it be traced from each outfall? This affects both of the above and is useful in assessing the accuracy of the modelled plume behaviour.

A combination of physical, chemical, and microbiological parameters was sampled at three depths at defined sampling sites between July 2024 and June 2025. In addition to determining concentrations of individual contaminants, the potential synergistic, additive, and antagonistic toxic effects of wastewater discharged from the outfalls was assessed using sea urchin fertilisation toxicity tests. The CCT's coastal microbiological data, collected weekly from over 100 coastal sites, has also been used to evaluate potential risks to recreational users of the coastal environment.

2.1.1 Chapter structure

With such a large spatiotemporal dataset gathered over the course of a full year, reporting will by necessity involve summaries and simplifications to derive useful conclusions and actionable insights. This chapter is structured to systematically address the three key questions raised in the introduction.

- **Methods** relating to this water quality monitoring effort are described in §2.2;
- **Results and Discussion** are presented separately for each of the three marine outfalls, Camps Bay (§2.3), Green Point (§2.4), and Hout Bay (§2.5), as follows:
 - an analysis of broad physico-chemical temporal trends is presented (§2.3.1, 2.4.1, and 2.5.1) to describe the seasonal variation in ocean conditions across the Atlantic seaboard;
 - a summary of key spatial trends observed in each monthly sampling event is provided (§2.3.2, 2.4.2, and 2.5.2);
 - the inferred position and movement of the effluent plume based on these data interpreted in light of the detailed dispersion modelling conducted in 2020/2021 are described (§2.3.3, 2.4.3, and 2.5.3); and
 - the compliance of each outfall with specific permit conditions and guidelines is described (§2.3.4, 2.4.4, and 2.5.4).

- **Results and Discussion - Recreational water quality:** All available microbiological data for the Atlantic seaboard are drawn on to assess potential outfall associated impacts on recreational water quality. Both the outfall monitoring programme and other weekly/bi-weekly recreational beach water quality monitoring data collected by the CCT are used for this section;
- **Conclusions** (§2.7) are drawn from these results, along with historical data from 2015 to 2022, to respond to the three guiding questions for this assessment in relation to permit compliance; risks to sensitive receptors, including both human and ecological receptors; and behaviour of the effluent plume.

2.2 Methods

Water quality sampling was conducted in line with the approved 2024 Receiving Environment Monitoring Programme, comprising boat-based in-field measurements of physical and chemical parameters and the collection of water samples for analysis by accredited analytical laboratories. Methods of implementation are described in more detail in the 2024 Receiving Environment Monitoring Programme.

2.2.1 Sample sites

Sample sites were selected to allow for monitoring of compliance with permit conditions and water and sediment quality guidelines – they therefore include sites on the boundary of the AMZ,* as well as sites near all beneficial use areas, such as surfing and swimming areas, and reference (control) sites.

Water quality monitoring sites were established in the following areas for each marine outfall (refer to **Figure 2-8** (Camps Bay), **Figure 2-23** (Green Point) and **Figure 2-39** (Hout Bay) showing the sites surrounding each outfall, with the three-letter codes indicating the relevant site types):

- **Allowable Mixing Zone:** AMZ sites were located on the boundary of the AMZ for each outfall. These serve to monitor compliance with the CWDP and are also used to identify the presence of pollutants that may be impacting the receiving environment beyond the immediate area of the outfall(s). Each outfall has six AMZ sites located around the mixing zone.
- **Nearshore Screen:** NSS sample sites were established in the nearshore between the outfall and identified sensitive receptors, typically swimming beaches or other recreational areas.
- **Mid-Shore Screen:** MSS sample sites were located between the outfall and the NSS sites, allowing screening for the dispersion of contaminants from the outfall toward sensitive receptors.
- **Outer-Bay Screen:** OBS sample sites were specific to the Hout Bay outfall, where there were three layers of screening sites between the diffuser section of the outfall and the Hout Bay beach. OBS sites are the outer most layer of screen sites.
- **Other Point Sources:** OPS sample sites were located near known or suspected point sources or inflows of pollutants other than the marine outfalls to assist in distinguishing the specific influence of the outfall relative to other specific pollution sources.
- **Reference sites:** REF sites were used for the comparison of monitoring results against the background state, to allow for a determination as to whether the outfalls are causing a significant deleterious effect on the receiving environment, and for comparison purposes where water quality guidelines are determined relative to ambient or background values. Reference sites were placed where the likelihood of a direct impact from the outfalls or other anthropogenic pollution sources is low and where other physical characteristics are similar to the sites monitored.
- **Shoreline:** Shoreline sites are separately monitored by the CCT for FIB; data from these sites are reported on in relation to the risk to recreational users.

* Refer to section 1.2

The location and number of sites required were outlined in the 2024 Receiving Environment Monitoring Programme (Clark et al., 2024) based on dispersion modelling results (PRDW, 2020a, 2020b, 2021), the locations of sensitive receptors, and other local factors specific to each area. Where possible, sites from previous monitoring efforts (CLS, 2022a; CSIR, 2017a; Lwandle, 2021) were retained.

Figure 2-1 displays total sample numbers for water quality analysis collected at each of the three marine outfalls over the period July 2024 to June 2025.

	Allowable mixing zone	Mid-shore screen	Near-shore screen	Offshore screen	Other point source	Outer-bay screen	Reference
Hout Bay -	216	108	72		72	108	72
Green Point -	216	174	180	72	72		34
Camps Bay -	216	33	324	36			39

Figure 2-1. Number of water samples collected per outfall and site type from July 2024 to June 2025 at the Camps Bay, Green Point and Hout Bay marine outfalls.

During the first sampling efforts in July 2024, minor amendments were made to the sample site locations to fit them to conditions encountered in-field. Finalised sampling stations are mapped and their coordinates are included in **Appendix I**.

Samples were collected from the surface, mid-water and bottom at each site, to account for the three-dimensional nature of the effluent plume. Bottom and mid-depth water samples primarily allow for plume tracking, compliance monitoring and ecological effect monitoring, while surface water is most relevant for monitoring potential health hazards for recreational users. **Figure 2-2** (Camps Bay), **Figure 2-3** (Green Point), and **Figure 2-4** (Hout Bay) show the range of depths at which samples were collected for each outfall. Depths varied because of tidal range and weather / sea conditions, as well as because of local topographic differences – in the complex reefs around Camps Bay in particular, depths can vary by tens of metres within a small area.

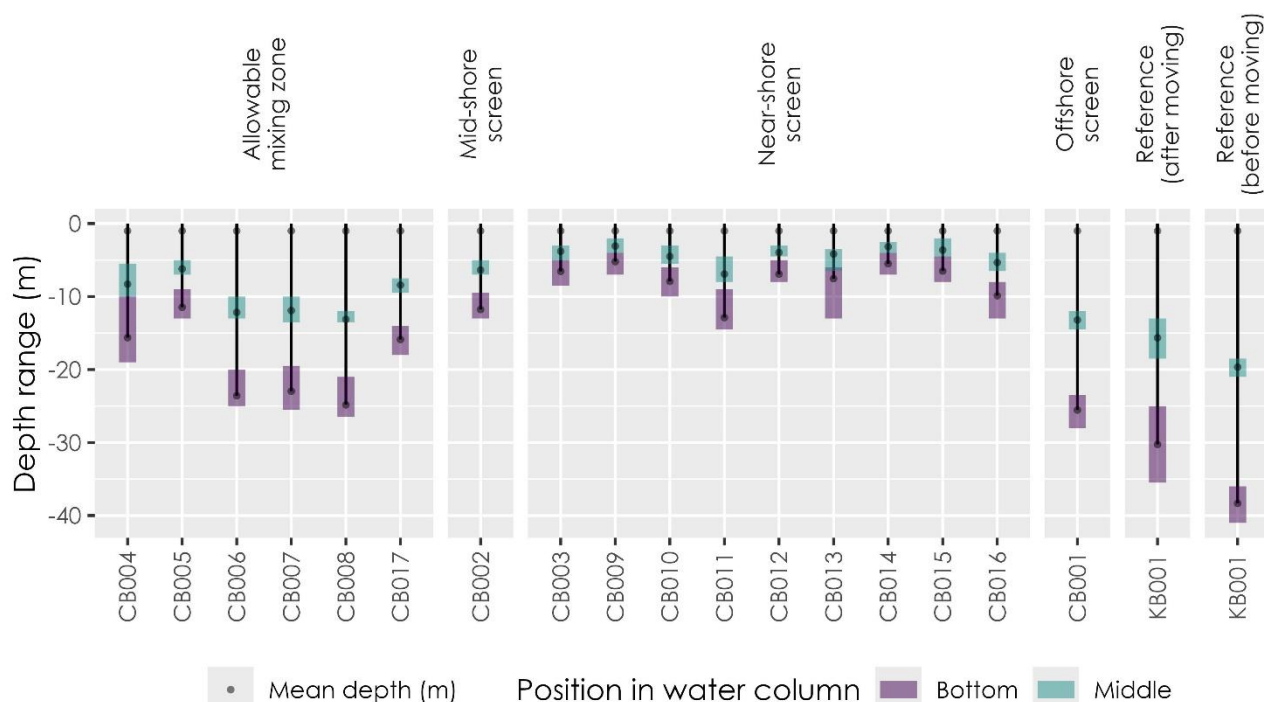


Figure 2-2. Range of depths for each site around the Camps Bay marine outfall and the Karbonkelberg reference site. Filled bars show the range of values for each depth category, and points show the mean depth. The Karbonkelberg reference site was moved in September 2024 to be more comparable with the mixing zone sites, but depths at this site vary significantly over a small area. Surface samples were all collected at 1 m, so there is no variability in depth.

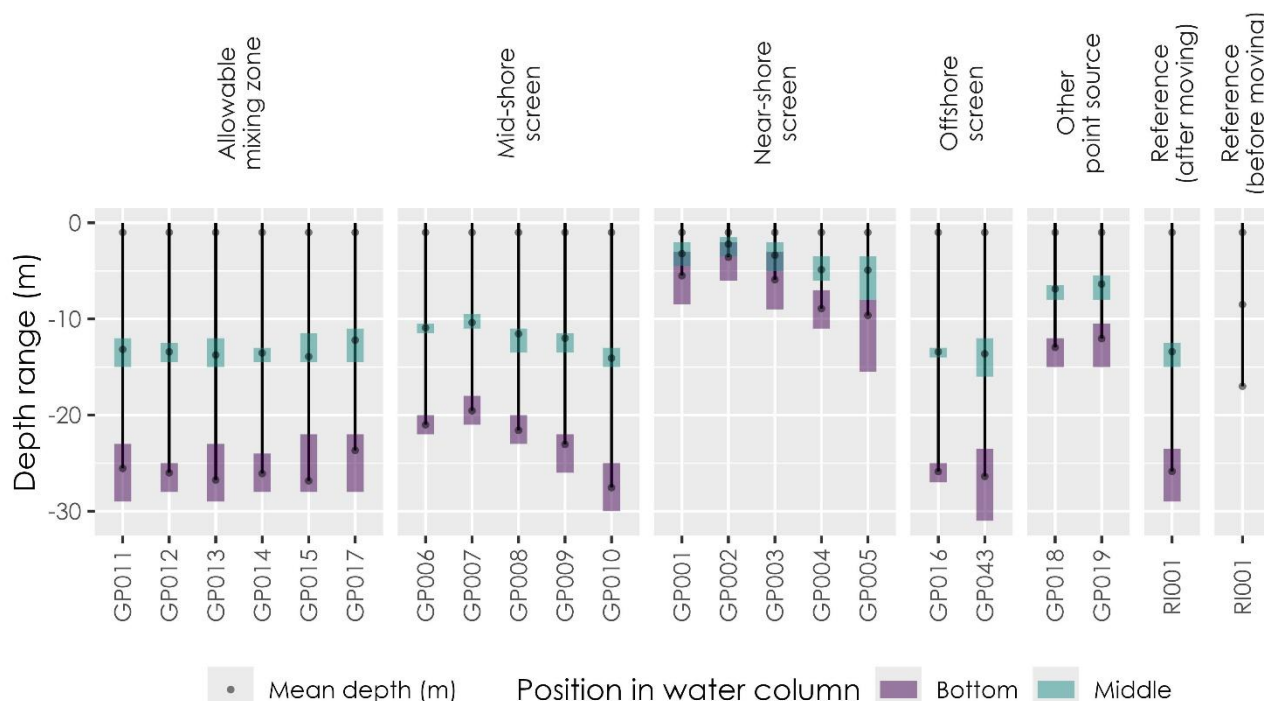


Figure 2-3. Range of depths for each site around the Green Point marine outfall and the Robben Island reference site. Filled bars show the range of values for each depth category, and points show the mean depth. The Robben Island reference site was moved in September 2024 to be comparable with the depth of the mixing zone sites. Surface samples were all collected at 1 m, so there is no variability in depth.

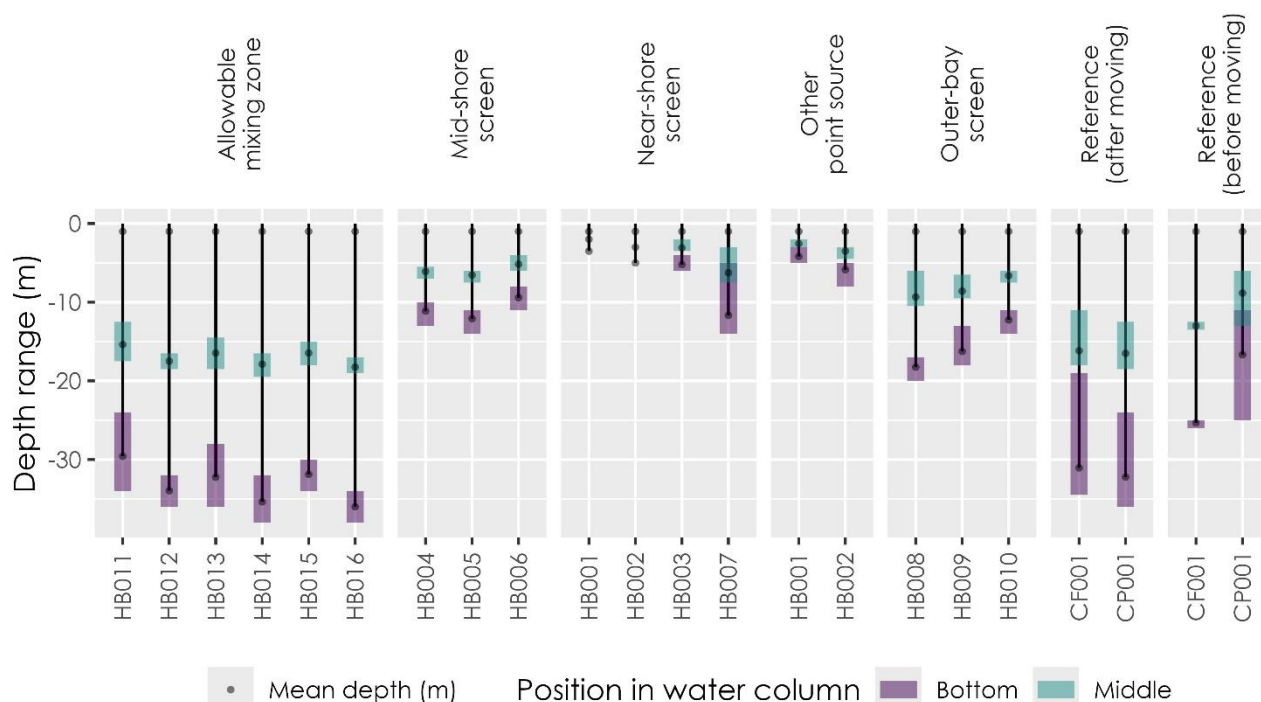


Figure 2-4. Range of depths for each site around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Filled bars show the range of values for each depth category, and points show the mean depth. The reference sites were moved in October 2024 to be comparable with the depth of the mixing zone sites. Surface samples were all collected at 1 m, so there is no variability in depth.

2.2.2 Sampling methods

Sampling was conducted from a small (6 or 8 metre) rigid inflatable craft. Operational safety limits established for sampling were that forecasted swell should not exceed 4 metres and winds should not be in excess of 25 knots on the day of sampling.

These operational limits still often encompassed rainy conditions, rough seas and strong winds, in an effort to ensure that the data reflect a range of sea conditions.

Vessels were equipped with basic geographic positioning systems (GPS) and sampling station accuracy was therefore affected both by the absolute accuracy of these systems (~3m) and more significantly, by the effects of wind and currents during the time elapsed between deploying and retrieving instruments and sampling vessels at depths of up to 40 metres. An accuracy threshold of 30 metres was established for determining whether to re-sample a site in the event of substantial drift. Actual GPS coordinates for each sample were collected on every occasion. On a small number of occasions, it was not possible to collect a sample at the actual GPS location due to unsafe conditions (breaking waves). In these cases, the sample was collected at the nearest safe location.

Water samples were collected using a 2.5 L free-flow polyvinyl chloride Niskin sampler, and decanted into clean bottles stored on ice. Samples were collected at three depths: 'bottom' samples at one metre above the sea floor; 'mid-depth' samples at half of the measured depth, and 'surface' samples at one metre below the surface (**Figure 2-5**).

A calibrated In-Situ Aqua TROLL® 400 Multiparameter Probe was used for the collection of in situ data including dissolved oxygen, pH, salinity, and temperature. Turbidity of samples was measured in the laboratory using a calibrated Apera TN400 device.



Figure 2-5. Sampling using a Niskin sampler at Green Point (left) and Hout Bay (centre), with probes (right) lowered to the appropriate depths for in situ measurements

2.2.3 Laboratory analyses and associated limitations

Laboratory analyses for enterococci, nutrients, total suspended solids, and metals were conducted at analytical laboratories accredited by the South African National Accreditation System (SANAS) for the specific parameters and medium (i.e. seawater) assessed. Metals analyses for the fourth quarter under review were undertaken by a UKAS[†]-accredited UK-based laboratory. All samples were collected in appropriate containers pre-labelled with unique identifiers for traceability. Unless otherwise specified, samples were stored on ice or refrigerated at 6°C between sampling and analysis.

2.2.3.1 Microbiology

Microbiological samples were kept on ice from the time of sampling, in coolers with integrated temperature loggers to ensure they remained between 2°C and 8°C until submission to the laboratory. Samples were transported to the laboratory immediately after sampling, and analysis was started on the day of sampling. The membrane filtration method was utilised for analysis.

2.2.3.2 Ecotoxicity

Seawater samples for ecotoxicity testing were collected on a monthly basis at each outfall, including samples from three depths at four sites located on the boundary of the AMZ, and from three depths at each reference site. Samples were kept on ice before being delivered to the laboratory and refrigerated until analysed. In addition, a control water sample was collected from Kommetjie and filtered through a 0.8 µm Cellulose Acetate Filter to act as a laboratory control and ensure that no external pollutant sources are introduced in the laboratory setting.

The main objective of the ecotoxicity testing assessment was to determine potential acute impacts of the diluted wastewater from the marine outfall on biota in the surrounding environment. Although the concentrations of known individual contaminants/pollutants within the sewage can be used to estimate toxicity to the receiving environment, these analyses alone are mostly inadequate for assessing the risk once these constituents are all mixed/combined. This information on toxicity is not available for all chemicals, and many chemicals with known toxicity have unknown additive, antagonistic or synergistic toxic effects when present in complex mixtures. For example, wastewaters that are thoroughly characterised chemically, and considered safe on this basis, can still be toxic due to unknown additive, antagonistic or synergistic effects.

It is in this context that toxicity testing (sometimes called direct toxicity testing) assumes an important role. Environmental regulatory authorities in many regions of the world require toxicity testing of

[†] United Kingdom Accreditation Service. This is the sole national accreditation body recognised by the British government to assess the competence of organisations that provide certification, testing, inspection and calibration services.

complex effluents/pollutants. Environmental toxicity or ecotoxicity testing describes the aggregate toxic effect of an aqueous sample (e.g. seawater containing diluted wastewater) as measured by an organism's response upon exposure to the sample (e.g. lethality, impaired growth, or impaired reproduction – in this case, the latter). Toxicity tests recommended by the United States Environmental Protection Agency (USEPA) replicate the total effect of environmental exposure of aquatic life to toxic pollutants in wastewater without requiring the identification of the specific pollutants (USEPA, 2000c).

Toxicity testing measures the toxicity of an effluent regardless of its physical and chemical properties and accounts for antagonistic, additive, and synergistic effects of the potentially thousands of constituents in an effluent/pollution source. Toxicity testing also puts chemical analytical data into perspective, as it directly assesses biological availability of all chemical substances in the effluent/pollution source. This is important since the mere presence of a chemical in water or sediment does not imply it is in a bioavailable form (i.e. a form that can cross biological membranes). Only if it is in a bioavailable form can a chemical exert an effect (adverse or beneficial). Metals bound in the crystal lattice of sediment grains, for example, are in a non-bioavailable form, while metals dissolved in the water column are generally in a bioavailable form. To further complicate matters, because a chemical is in a bioavailable form does not mean it will exert an effect. This can only occur if there is exposure, that is, an organism actually comes into contact with the chemical. Toxicity testing takes these complexities into account. Toxicity tests using sea urchin fertilisation assays can determine whether contaminants are present in a mixture and concentration that directly inhibit fertilisation. It should be noted that while this assay is a standard, sensitive and widely recognised method for assessing sublethal toxicity in marine environments, it cannot exclude the presence of other toxicants acting through different mechanisms.

Water sample toxicity testing was undertaken using the Cape sea urchin *Parechinus angulosus* collected from the intertidal zone at Kommetjie, on the Cape Peninsula (Figure 2-6). This species has been successfully used by the authors for the last six years during effluent ecotoxicity testing, and standard protocols were followed, as laid out in the American Public Health Association (APHA, 2012).

Spawning was induced by injecting each urchin with two 0.5 ml doses of 1 mol potassium chloride (KCl). Female urchins were left to spawn, allowing eggs to fall to the bottom of the conical flask (Figure 2-6). Males were removed and placed upright on petri dishes to avoid premature activation of the sperm (Figure 2-6).

The lowest sperm to egg ratio that produces more than 70% fertilisation in filtered seawater has been determined to be 100:1 for *P. angulosus* (APHA, 2012). The Standard Methods prescribe that 1 000 eggs should be added to each test tube, which means that this requires 100 000 sperm to achieve the 100:1 sperm to egg ratio. Stock solutions were prepared such that approximately 0.5 mL of egg stock solution contained ~1 000 eggs, while 0.1 mL sperm stock solution contained ~100 000 sperm. Eggs from each female were tested for viability by removing a small sample of eggs and observing them under a compound microscope.

Fertilisation was determined by the presence of a clear fertilisation membrane surrounding the egg (Figure 2-7). Acceptable control fertilisation is considered to be $\geq 70\%$ (APHA, 2012). International best practise requires that a toxicity experiment should be conducted using at least one control with a minimum of three replicates. The sea urchin egg fertilisation success rate was determined based on a minimum of 100 eggs from four replicates for each seawater sample (filtered seawater control, reference samples and AMZ samples). All seawater samples were inverted multiple times in their respective bottles prior to decanting to ensure a representative (homogenised) sample was tested.



Figure 2-6. The spawning phase of seawater toxicity testing at the laboratory using the Cape Sea Urchin *Parechinus angulosus*.

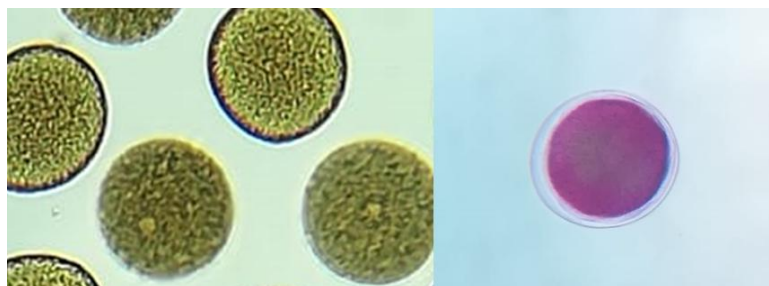


Figure 2-7. *P. angulosus* eggs; unfertilised (left), fertilised and stained with Rose Bengal (right).

2.2.3.3 Total suspended solids

Total suspended solids (TSS) analyses were conducted by an analytical laboratory utilising a SANAS-accredited method based on the Standard Methods for the Examination of Water and Wastewater (APHA, 2025), which has certain limitations when used with a high-salinity matrix like seawater. When samples are filtered, the dissolved salts can become trapped in the filter. The standard method involves washing of the filter and collected solids with three successive 10 mL aliquots of distilled water, before drying. If salinity is high, this limited washing may be insufficient to remove all dissolved solids from the filter and can result in falsely high TSS readings. Absolute concentrations of TSS presented in this report may therefore be higher compared than would be determined were additional rinsing included in the methodology (in contrast to Standard Methods). 100 mL of seawater was filtered for each sample.

2.2.3.4 Turbidity

In the 1995 SA Water Quality Guidelines (DWAF, 1995), turbidity guidelines are specified according to the impact that turbidity has on the depth of the euphotic zone (a human-eye perception of water

transparency, based on Secchi disc depth). The Draft 2022 guidelines specify that the upper limit of acceptable turbidity should be set by the 80th percentile of a suitable reference data set, as well as requiring that the natural depth of the euphotic zone not be changed by more than 10% relative to a reference site. The data that were collected are point turbidity data collected at multiple depths, and measured in nephelometric turbidity units (NTU) which are useful for tracking suspended particles associated with pollution in a repeatable and observer-independent manner. There is no direct relationship between euphotic zone depth and NTU, so compliance assessments in this report are based on the 2022 guidelines (DFFE, 2022) which allow for a direct comparison of point data from various depths, rather than on Secchi depth.

2.2.3.5 Metals

A subset of water quality sites around each outfall, and all reference sites, were analysed for metal concentrations on a quarterly basis. Analyses were performed by a laboratory accredited by SANAS for a seawater medium. The first three datasets exhibited much higher-than-expected interseasonal variation. July 2024 data had excessively high results for certain metals (As, Hg, Pb) across all sites, including all four reference sites based on available literature quantifying metals in seawater across the Cape Town area (CSIR, 2016, 2017a, 2017b). October 2024 concentrations determined by the laboratory were much lower, and with the range of previous studies, but January 2025 data were once again excessively high and with no apparent difference between reference and impact sites. Concentrations of arsenic, mercury and lead reported by the laboratory were between two and three orders of magnitude at all sites, including reference sites, than had previously been found to occur in the Cape Town Harbour – an area known to be heavily polluted (Okoro et al., 2013). In response to this high level of variability, subsamples were submitted for analysis by three separate laboratories in January 2025: the original, SANAS-accredited laboratory, a second South African non-accredited laboratory, and a UK-based UKAS-accredited laboratory. A very high inter-laboratory variation was found in these data, with the original SA-based lab determining concentrations orders of magnitude above those reported by the other two laboratories. The fourth quarterly samples in April 2025 were submitted only to the UK laboratory.

All three laboratories made use of Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) to detect trace metals in water. The direct analysis of seawater by ICP is notoriously difficult, mainly because of low levels of trace metals in natural seawater and matrix interferences from the high dissolved salt content. When aspirating samples with high levels of dissolved solids, salt may deposit on the interface (cones) during the analytical run, degrading signal stability. Additionally, high levels of dissolved salts can cause spectral (polyatomic) interferences. Because these interferences originate from the seawater matrix itself, standard ICP-OES for seawater analysis can often lead to false positive results that are much higher than the actual concentrations in the solution. While matrix effects have not been conclusively determined as the source of errors, it is clear from the interlaboratory variation that accurate quantification of metals has not been consistently possible during the first year of sampling. Metals data are presented in **Appendix II** for the sake of completeness, but are not assessed in this report. Investigations and verification to assure accuracy of metal analyses are underway and will allow for data presentation in the second annual report.

2.2.3.6 Nutrients

Nutrient concentration analyses were also conducted by a laboratory accredited for the method, but results were similarly inconsistent and differed by orders of magnitude from data reported for the region and the southern Benguela upwelling system more generally (P. Chapman & Bailey, 1991; P. Chapman & Shannon, 1985; Dangl et al., 2023; Flynn et al., 2020). These anomalies may be due either to methodological inconsistencies or instrument calibration issues, but it is clear from the data that accurate quantification of nutrients has not been consistently possible during the first year of sampling. Nutrients data are presented in **Appendix II** for the sake of completeness, but are not

assessed in this report. Investigations and verification to assure accuracy of nutrient analyses are underway and will allow for data presentation in the second annual report.

2.2.4 Data presentation and data sources

The water quality data collected for this monitoring programme provide a time series of 'snapshot' data points, each reflective of a unique set of hydrodynamic, weather, and wastewater discharge conditions. Data are therefore presented in terms of events and ranges to better describe the variability of the data, with summary statistics (either mean or median, or both) used only in the assessment of compliance with permit conditions.

Apart from the data collected directly by Infinity and Anchor staff as part of this monitoring programme, data for analysis and comparison purposes were obtained from the following sources:

- Historical data from previous outfall monitoring programmes were provided by the CSIR and CLS;
- Coastal microbiological data from routine monitoring were supplied by the City of Cape Town
- Wastewater quality data were supplied by the City of Cape Town; and
- Weather data for the Constantiaberg weather station were obtained from the South African Environmental Observation Network (SAEON) Open Data Platform (odp.saeon.ac.za).

All data are presented in Appendix II.

2.2.5 Approach to compliance assessment

The three marine outfalls on the Atlantic coast of Cape Town are subject to permit conditions as set out in the relevant Coastal Waters Discharge Permits issued for each outfall. These permits were issued in 2019 (Hout Bay) and 2023 (Camps Bay and Green Point). Discharges from the Hout Bay marine outfall are required under the permit conditions to meet specific target values, ranges or descriptions for various common water quality parameters. The Camps Bay and Green Point marine outfalls do not have similar criteria in the permit conditions, but it is specified in all permits that water quality at the boundary of the AMZ should comply with the South African Water Quality Guidelines for Coastal Marine Waters (Volume 1): Natural Environment as published by the Department of Environmental Affairs (1995). These guidelines provide specific target values and ranges for water quality parameters in the marine environment in South Africa, and are referred to in this chapter as '**the 1995 Guidelines**'. The **2022 draft Guidelines** (DFFE, 2022)[‡] are used to supplement the interpretation of the 1995 guidelines in this report. They specify that water quality be measured against a reference data set that is appropriate for the discharge location. In the case of the present outfall monitoring programme, comparing the current data to absolute target values and ranges may be misleading in some cases where seasonal and event-driven variability cause natural fluctuations outside of target values, as is commonly the case in Cape Town.

Due to the dynamic nature of Cape Town's Atlantic coastline, the water quality in the receiving environment is naturally variable across- and within seasons. Annual averages of water quality data are used for sites at the boundary of the AMZ, where compliance is measured, as well as at reference sites. Reference sites were selected in such a way that the water quality characteristics resemble that of the AMZ but are far enough away that there is no likely impact from the outfall discharge or any other anthropogenic source. Reference site selection is challenging in Cape Town, as sites that are far enough away from the impact area may also be subject to very different physical and environmental conditions. Samples were collected on the same days from both reference sites and AMZ sites, in an effort to make comparison as accurate as possible. Data are considered from three points (top, middle and bottom) in the water column.

[‡] Refer to **Appendix II** for a summary of the relevant parameters in both sets of water quality guidelines

2.3 Camps Bay Outfall: Results and Discussion

Water quality sampling sites for the Camps Bay outfall are shown in Figure 2-8.



Figure 2-8. Sample sites for water quality around the Camps Bay outfall and its corresponding reference site at Karbonkelberg.

All water quality data for the first year of Camps Bay outfall sampling are tabulated in **Appendix II**.

2.3.1 Seasonal patterns and variation in water quality

2.3.1.1 Temperature

Sea temperature exhibited high seasonal variation (an average difference of 1.8°C between seasonal median temperatures) across the Camps Bay sites, as expected for the Atlantic seaboard (Figure 2-9). Summer water temperatures were cooler at all sites, with cooler temperatures at depth. Winter temperatures were warmer and exhibited little to no vertical stratification. As would be expected, shallower, more sheltered sites (such as those in the Clifton Bay) exhibited less seasonal variability in temperature. These seasonal patterns reflect the differences in water movement (upwelling) associated with seasonal changes in the prevailing wind direction. During winter months, the prevailing north-westerly wind brings with it intense winter storms and heavy wave action, resulting in a well-mixed and homogenous water column, whilst the prevailing south-easterly winds in summer transport surface water offshore, driving a strong summer upwelling, bringing with it cold and nutrient rich waters. Sea temperature ranged between 9.4°C and 15.4°C across the monitoring cycle, with both the warmest and coolest temperatures measured during summer months (CB004M and CB002S respectively).

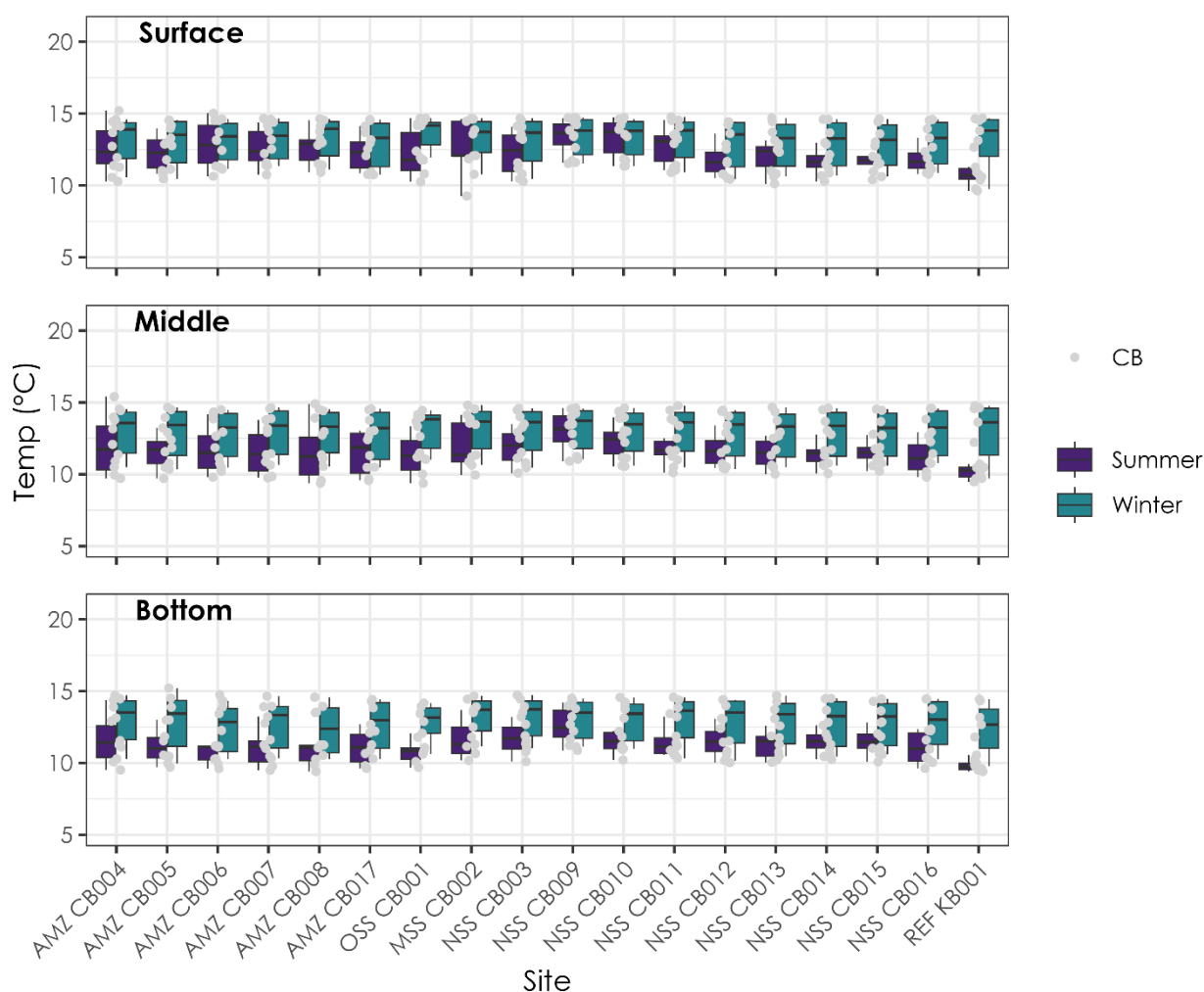


Figure 2-9. Boxplots indicating the seasonal variability of temperature for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.3.1.2 Salinity

Salinity (Figure 2-10) was generally higher in winter in sub-surface samples and more variable at the surface. A few instances of low salinity were measured at bottom and middle depths at AMZ sites, potentially corresponding to effluent plume dispersion, but also at all depths at nearshore sites in the sheltered Clifton Bay, and at the Karbonkelberg reference site. Salinity in the summer season was typically highest at the surface and decreased with depth. Salinity levels in the middle of the water column displayed less seasonal variability than both surface and bottom waters. The lowest recorded salinity was 32.88 PSU at CB008B and the highest was 37.51 PSU at CB003B.

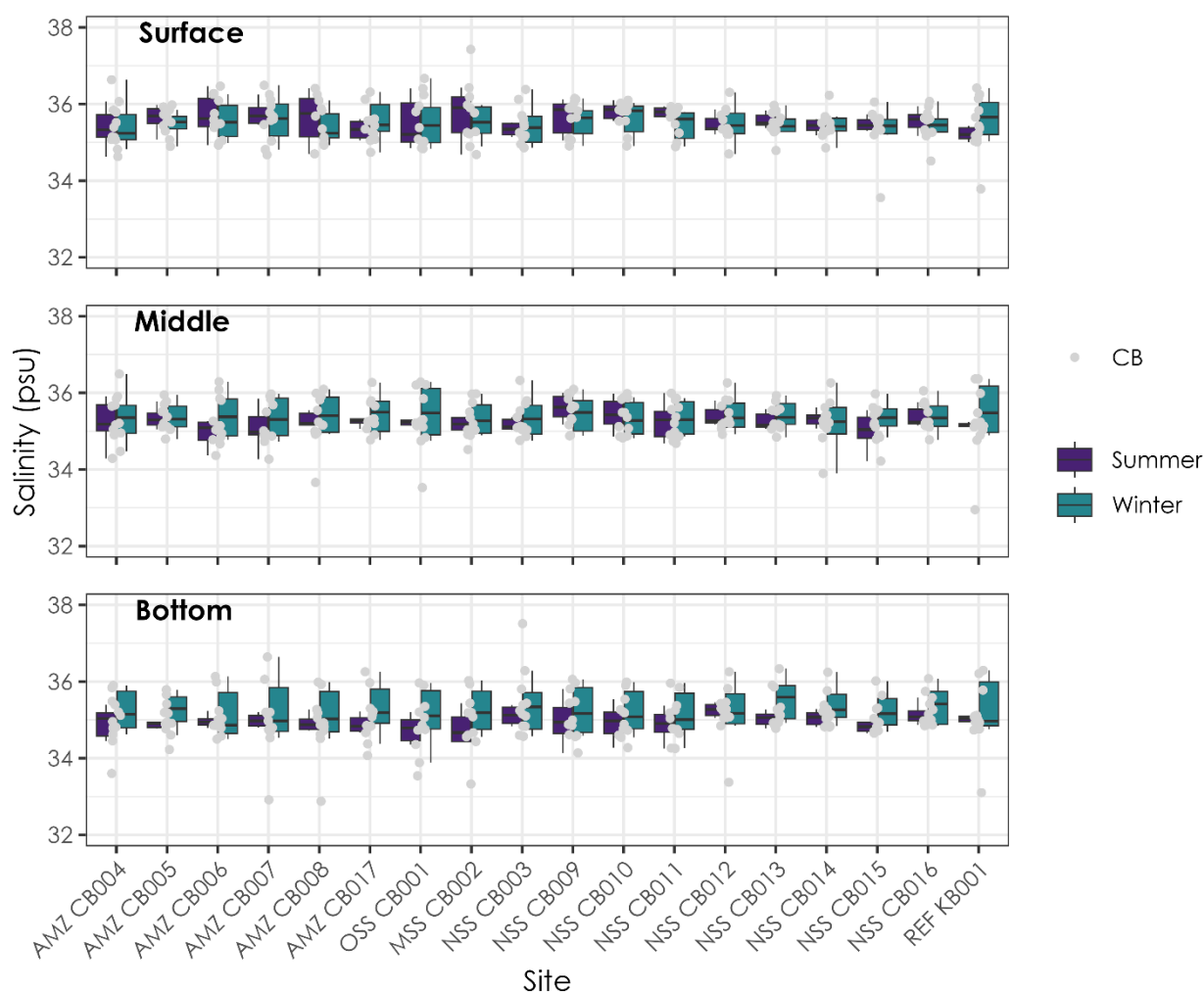


Figure 2-10. Boxplots indicating the seasonal variability in salinity for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.3.1.3 pH

pH exhibited similar seasonal trends to temperature – lower in summer and higher in winter (Figure 2-11). With the cold water brought in during summer upwelling, the solubility of CO₂ in seawater increases, making for slightly more acidic conditions (lower pH). Conversely, the well mixed and slightly warmer conditions in winter means CO₂ is less soluble in seawater, subsequently lowering the concentration of carbonic acid and increasing pH. These trends were most pronounced in bottom waters, with seasonal variation decreasing with proximity to the surface. These trends were driven by primary production and sea-air exchange near the surface that buffer changes in CO₂ concentration and the resulting shifts in pH.

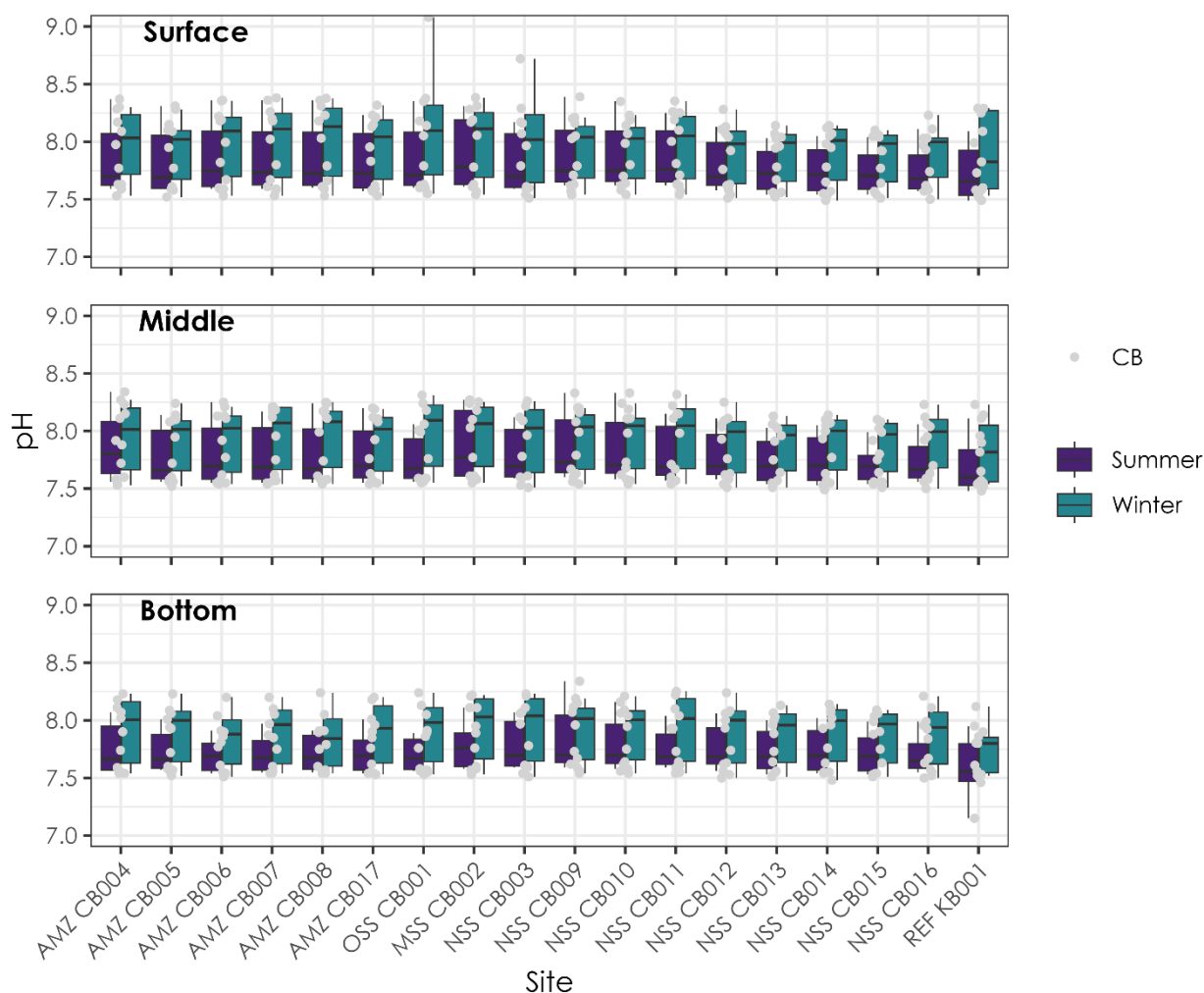


Figure 2-11. Boxplots indicating the seasonal variability of pH for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.3.1.4 Dissolved oxygen

In line with other physico-chemical parameters, oxygen saturation displayed strong seasonal trends around Camps Bay (Figure 2-12). Regardless of season, oxygen was highest at the surface and decreased with depth. Seawater generally had lower oxygen saturation levels during summer months, with more pronounced seasonal differences in middle and bottom waters. Lower oxygen

saturation levels during summer months were likely driven by the combination of upwelling (and associated oxygen depletion at depth), and thermal stratification of the water column preventing vertical mixing and subsequent transport of oxygen down through the water column.

In Camps Bay, surface waters were mostly very well oxygenated and often supersaturated (peaking at 144.73%). Oxygen saturation levels decreased with depth on all sample dates. This pattern was also observed in dissolved oxygen concentrations, with a maximum and minimum concentration of 11.83 mg/L (CB009) and 5.63 mg/L (KB001) respectively at the surface. This decreased to a maximum and minimum concentration of 10.62 mg/L (CB016) and 3.59 mg/L (CB001) at bottom depth. Minimum oxygen saturation was 39.2%. Winter oxygen saturation displayed less variability, reflecting strong mixing and little to no stratification.

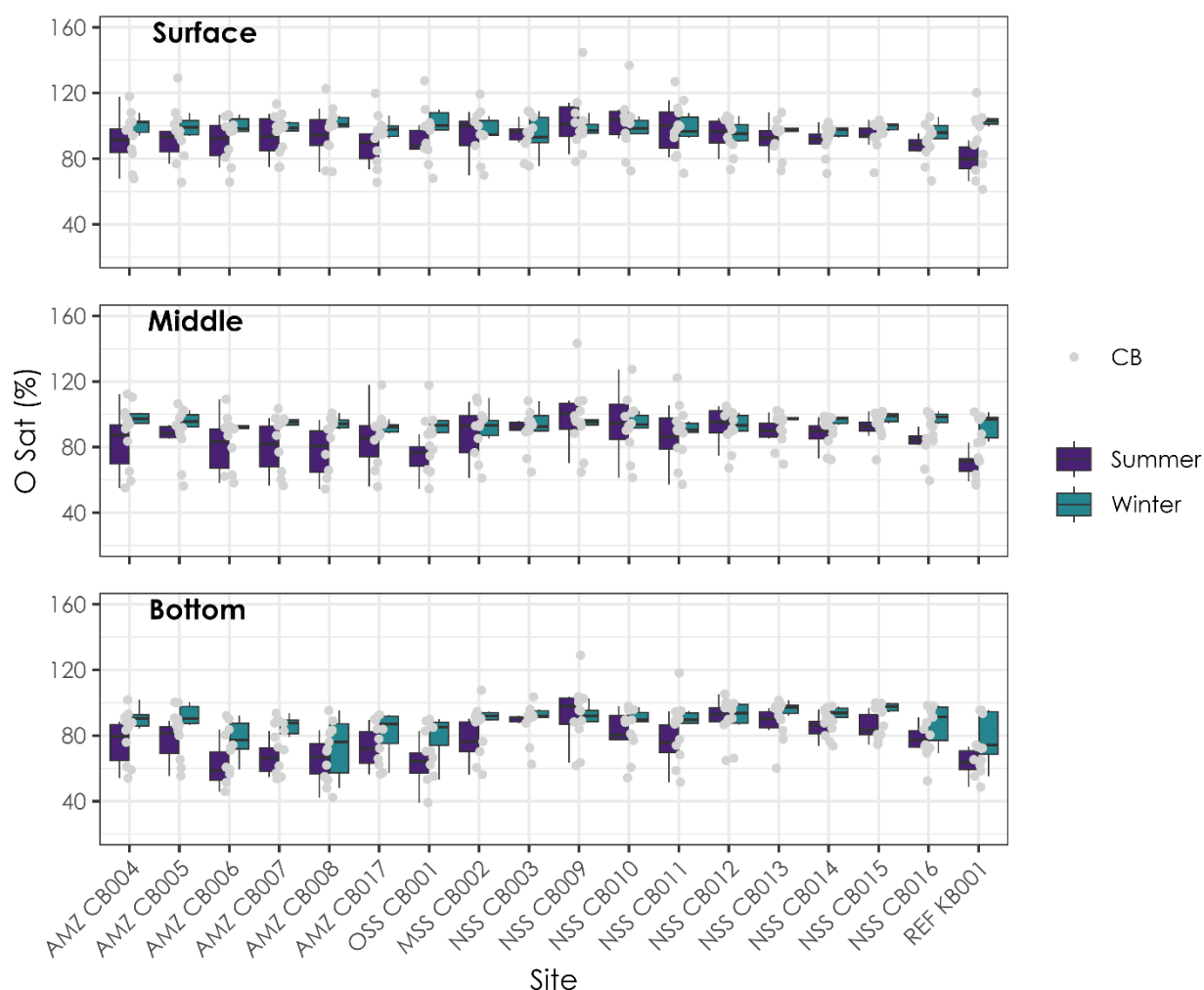


Figure 2-12. Boxplots indicating the seasonal variability of oxygen saturation for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.3.1.5 Total suspended solids

TSS data did not display a clear seasonal signal, with most observations during summer and winter falling within a similar range (Figure 2-13). A more detailed description of monthly variations in TSS data at Camps Bay is provided in §2.3.2. As TSS was primarily used as an indicator of the effluent

plume, mean and median values are less informative than the raw data. The elevated interquartile ranges (IQRs) observed at the AMZ sites CB005M, CB008M, CB004B and CB001B are of interest as they suggest an increased proportion of elevated TSS readings, potentially reflecting the effect of the effluent plume, or of wave action stirring up bottom sediments. Slight increases in IQRs at several nearshore sites during winter are likely attributable to enhanced wave action resuspending sediment into the water column at this time of year.

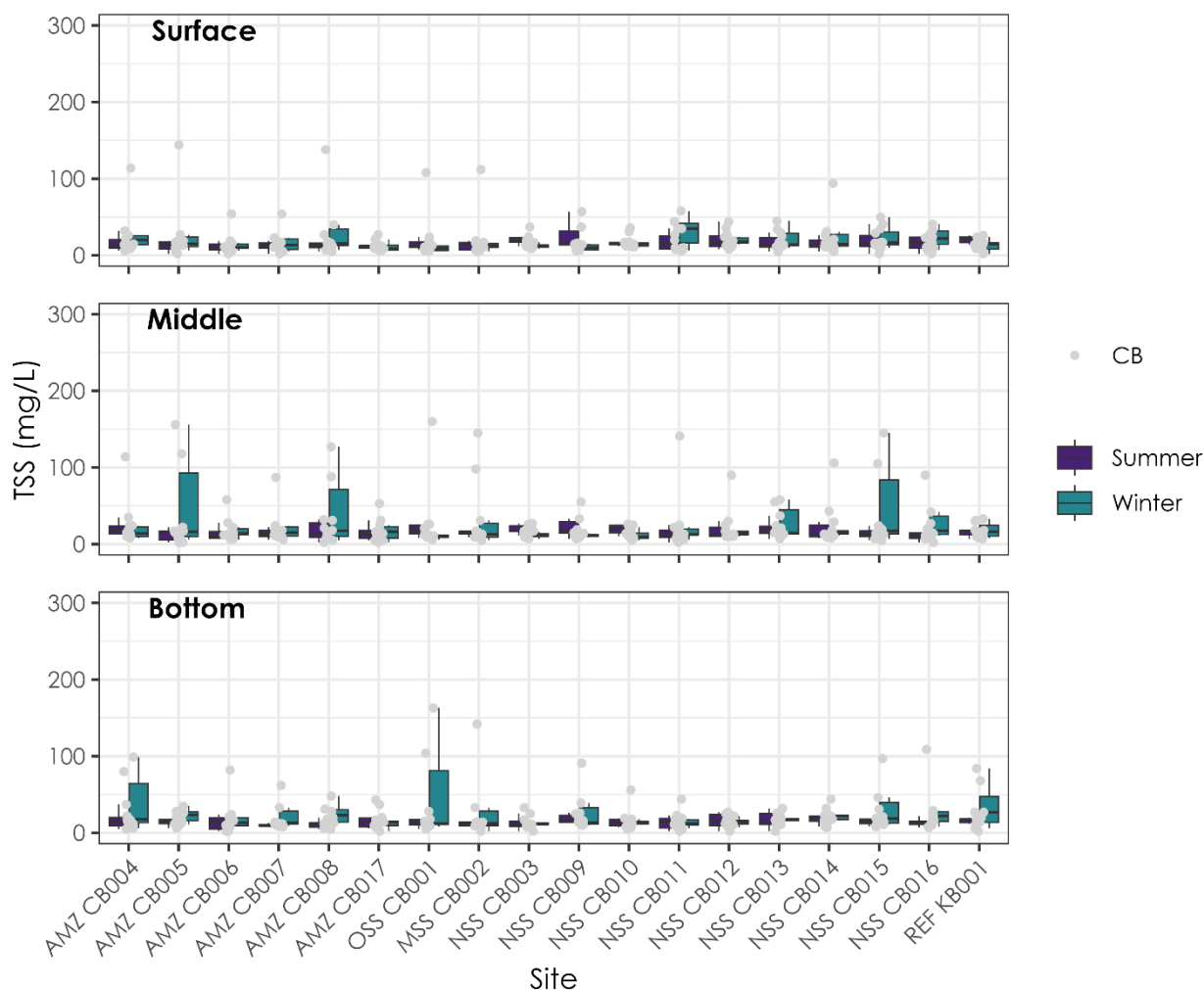


Figure 2-13. Boxplots indicating the seasonal variability of total suspended solids (TSS) for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024–June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.3.1.6 Enterococci

In Camps Bay, FIB were periodically detected in seawater samples near the outfall, but only exceeded risk-based guideline values of 185 colony-forming units (cfu)/100ml on two occasions: at the surface at sites CB002 and CB008, and only one of these samples exceeded the single-sample operational guideline of 240 CFU/100mL. This equates to 0.3% of all samples over the 12 month sampling period (n=609). The highest counts of FIB (enterococci) were typically found in surface waters at the boundary of the AMZ, while nearshore sites typically had very low bacterial counts. Bacterial were also frequently detectable below risk thresholds in mid-depth waters around the AMZ.

Figure 2-14 illustrates the higher enterococci counts throughout the water column at AMZ sites, most likely as a result of the effluent plume. CB014, CB015 and CB016, three nearshore screens south of the outfall, had slightly higher counts of enterococci in comparison to other screening sites, but still well below risk-based guideline thresholds and in the 'Excellent' water quality risk category applied by the CCT – refer to §2.6.1. This finding is in line with modelled plume behaviour, and discussed further in §2.3.2.

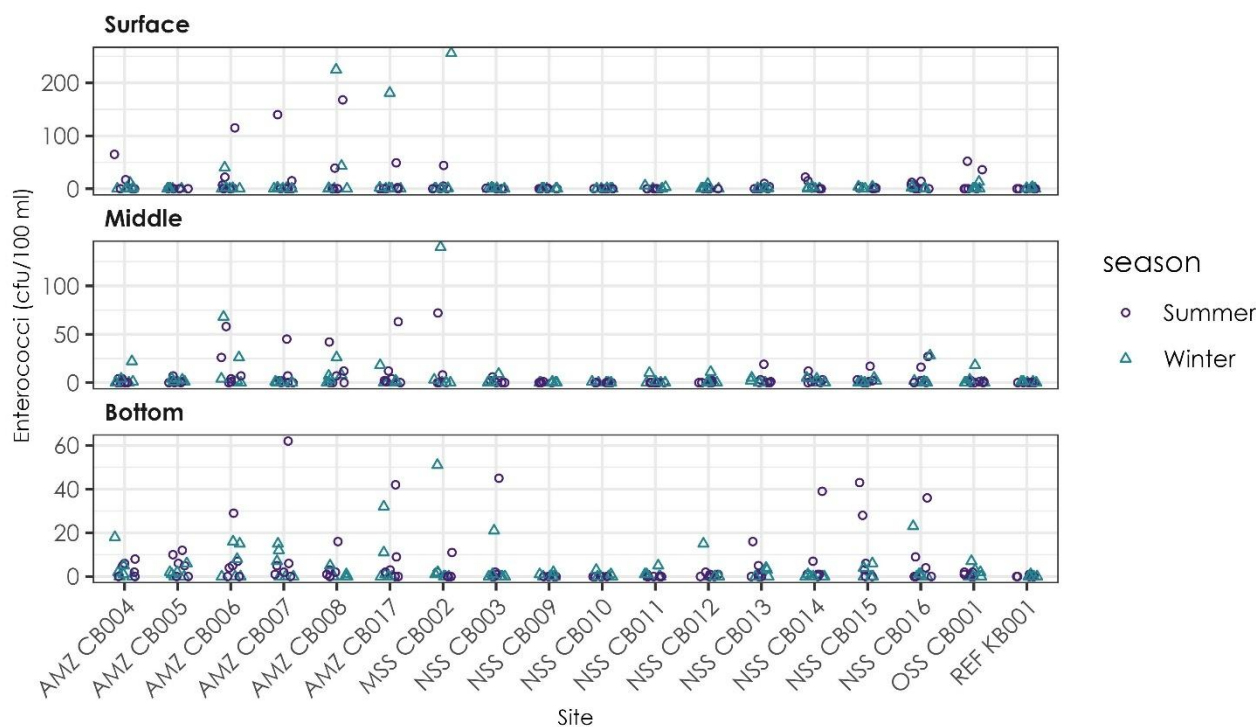


Figure 2-14. Distribution of enterococci counts in CFU/100 ml for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

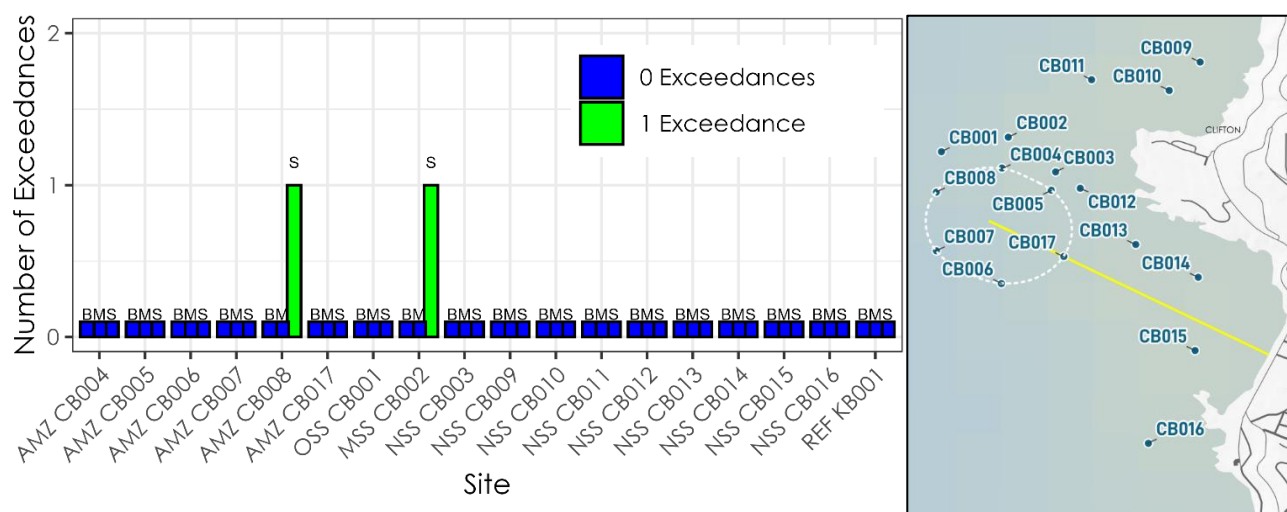


Figure 2-15. Bar plots indicating the number of times that the count of enterococci in CFU/100mL exceeded the guideline threshold of 185 CFU/100mL for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025.

2.3.1.7 Environmental toxicity testing

In sea urchin fertilisation experiments, control fertilisation success can vary significantly, and acceptable control fertilisation success is considered in standard methods to be $\geq 70\%$ (APHA, 2012). In the absence of a locally determined control fertilisation success rate 70% fertilisation is used here as a general threshold for toxicity. Both surface and mid-water AMZ sites (Figure 2-16) were consistently found not to have a toxic effect with high average fertilisation success, regardless of the season ($>93.9\%$ in summer and $>95.4\%$ in winter). In winter and summer, average fertilisation success for three of the four bottom water AMZ samples was high ($>94.8\%$ in summer and $>96.8\%$ in winter). Bottom water samples from site CB007 had a toxic effect on sea urchin reproduction on two occasions (February and March 2025). A single toxicity event also occurred in bottom water at CB007 in April 2025 increasing the winter variance at this site. Variation in the Karbonkelberg reference site percentage fertilisation success was also high at all three depths in summer, and at the surface and mid-water in winter. This is due to toxic effects recorded at the surface and bottom in February and at mid-depth in April 2025. The surface and mid-water samples at KB001 in March and surface sample in April all had relatively low average fertilisation rates ($<75\%$) which also increased variability.

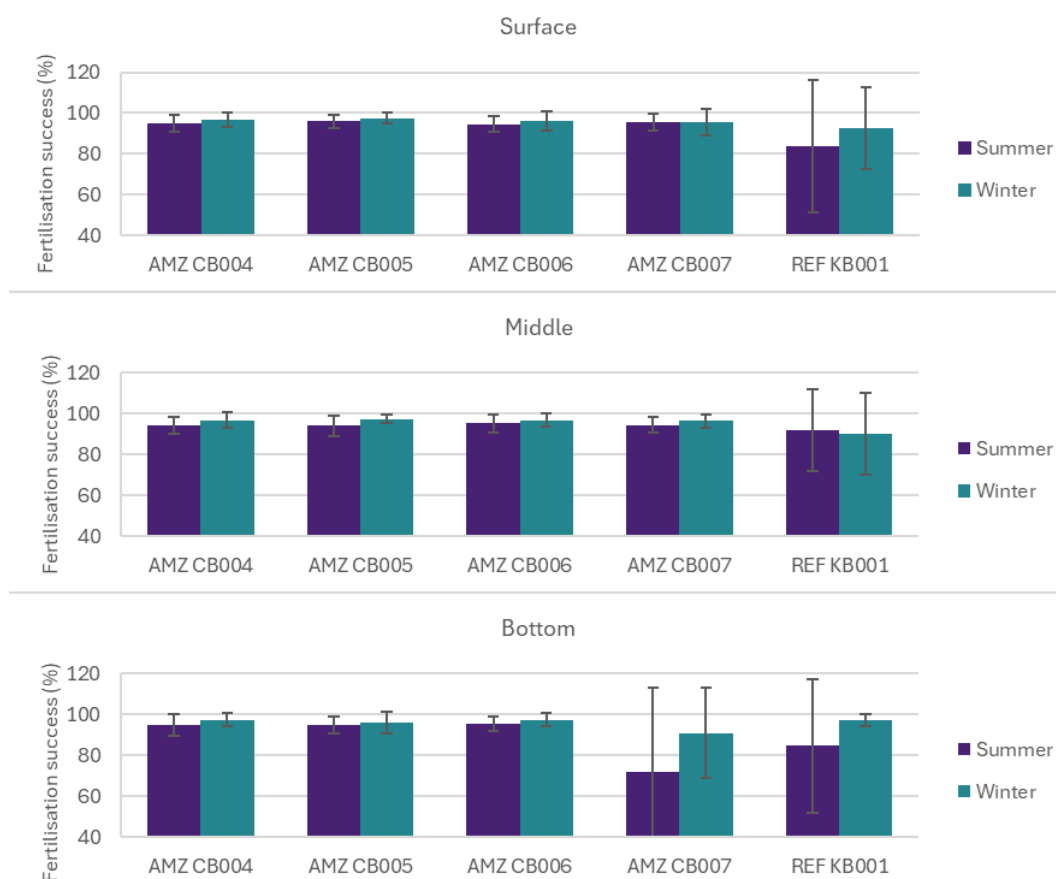


Figure 2-16. Boxplots indicating the seasonal variability of urchin toxicity (average percentage fertilisation success) for each of the Camps Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark purple, was defined as months from October to March. Winter, displayed in teal, was defined as months from April to September. Site IDs prefixed by AMZ and REF indicate allowable mixing zone and Karbonkelberg (KB) reference sites, respectively.

2.3.2 Monthly data summaries

Key observations from samples collected around the **Camps Bay** outfall on **22 July 2024** in cold temperatures with heavy rain (>40 mm) in the preceding three days, and north-westerly winds, include:

- FIB were not found at any sites, at any depths on this date, suggesting that the effluent plume was not detected at any of the survey positions on the boundary of the AMZ;
- TSS were present in elevated concentrations at AMZ sites in mid-depth and surface samples, relative to other sites in Camps Bay; in the absence of corresponding bacterial counts, it is not clear whether this indicates wastewater-derived solids or relates to salt being insufficiently eluted during analyses;
- Turbidity, in contrast, was low (<10 NTU) at all sites, but lowest at the AMZ and highest at sites along the shoreline, likely due to wave action and suspension of sediments;
- Coastal waters were well-mixed, with little variation in salinity across the depth profile, at all sites except a nearshore site off Glen Beach, where the surface sample had a much lower salinity than any other site on this date;
- Sea urchin toxicity tests from around the AMZ had high average fertilisation success (>97%) at all depths, indicating no evidence of toxicity; and
- Oxygen saturation at all three depths averaged over 90%, and at the surface slight supersaturation was apparent (between 100% and 110% saturation) at sites further offshore; dissolved oxygen concentrations were above 7 mg/L at all sites and all depths.

Sampling in **Camps Bay** during **August 2024** was affected by severe weather conditions (strong north-westerly winds and high seas, with 11 mm of rainfall and cool temperatures) and had to be split over two days (**20 and 23 August 2024**) due to unsafe conditions during the first day of sampling. A further 20 mm of rain fell in the two days preceding sampling on 23 August; on the day of sampling, winds were shifting between westerly and northerly, at speeds up to 8 m/s. Eight sites were sampled on 20 August (CB004, CB005, CB007, CB008, CB013, CB015, KB001), and 11 sites were sampled on the 23 August, including another reference sample (CB001, CB002, CB003, CB006, CB009, CB010, CB011, CB012, CB014, CB017, KB001). Key observations include:

- FIB were detectable at low counts at mid-depth (26 CFU) and at the surface (11-43 CFU/100mL) at the offshore boundary of the AMZ, but at no other sites during this survey – these counts are indicative of a very diluted effluent plume, with no other likely sources;
- TSS were slightly higher at the offshore boundary of the AMZ (40 mg/L, with all other AMZ sites in the range 9-27 mg/L); TSS at mid-depth and at the bottom at nearshore sites was also elevated, potentially due to the suspension of sediments due to stormy conditions;
- Turbidity data suggests slight elevations of turbidity at mid-depth at the boundary of the AMZ and near the shoreline, with the highest recorded value being 16 NTU on the northeastern boundary of the AMZ;
- Sea urchin toxicity tests from around the AMZ had on average high fertilisation success (>96.5%) at all depths, indicating no evidence of toxicity; and
- The stormy conditions are evident in the salinity, temperature and oxygen concentration data, which were similar at all three depths and across all sampling sites, indicative of very well mixed conditions.

Key observations from **Camps Bay** sampling on **23 September 2024** which was undertaken under moderate south-easterly winds, moderate temperatures, and with no recent rainfall, include:

- North-westerly dispersion of the effluent plume, detectable in low counts of FIB at mid-depth (8–18 CFU/100mL) and higher FIB counts at the surface (225 CFU/100mL) on the offshore boundary of the AMZ (**Figure 2-17**);
- No FIB contamination was detected at nearshore sites – counts were between 0 and 3 CFU/100mL at all sites other than those indicated above;
- Turbidity was measured as 0 NTU § in nearly all samples, indicating very clear conditions with no visibly detectable effluent plume, even where enterococci counts were elevated;
- Slightly reduced salinities and higher temperatures at the same sites where bacteria were detected, possibly also indicative of the fresher, warmer effluent plume reaching the AMZ boundary;
- Sea urchin toxicity tests from around the AMZ had on average good fertilisation success (>93%) at all depths, indicating no evidence of toxicity; and
- A slight depth gradient was apparent in dissolved oxygen concentrations, ranging from saturations between 80 and 92% in bottom waters, to between 95 and 102% at the surface.

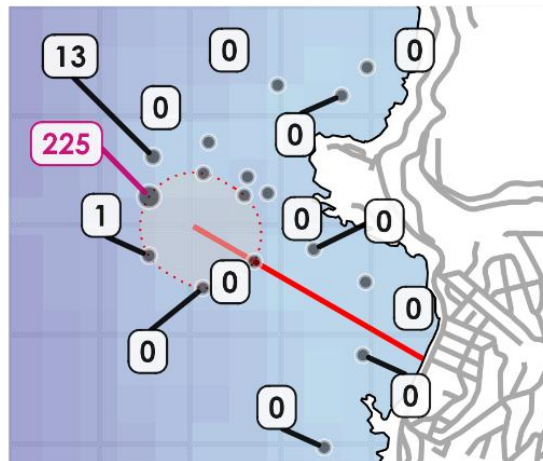


Figure 2-17. Camps Bay enterococci counts in cfu/100ml at the surface in September 2024.

Key observations from **Camps Bay** sampling on **16 October 2024** with strong south-easterly winds, moderate temperatures, and no recent rain, include:

- Southward dispersion of the effluent plume, apparent in elevated FIB counts at the surface (115 to 140 CFU/100mL) at sites on the southern boundary of the AMZ (**Figure 2-18**);
- A weak inverse halocline and a strong thermocline, with warmer, higher-salinity surface waters and cooler, less saline bottom waters at all sites;
- No apparent turbidity elevations at sites where FIB were elevated, and generally low turbidity and TSS concentrations at all sites sampled;
- Low oxygen saturations at all sites monitored: ranging from 70% to 90% in bottom waters, 74% to 96% at mid depths, and 84 to 92% at the surface – low oxygen saturations were also measured at all depths at the Karbonkelberg reference site on this date; and
- Sea urchin toxicity tests from around the AMZ had on average good fertilisation success (>92.5%) at all depths, indicating no evidence of toxicity despite the measurable presence of effluent at the southernmost sites.

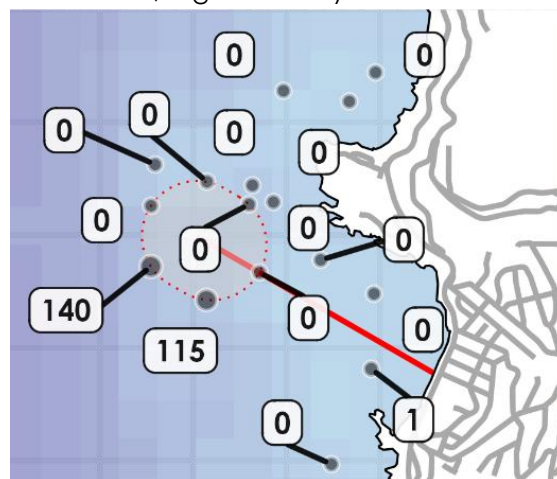


Figure 2-18. Camps Bay enterococci counts in cfu/100ml at the surface in October 2024.

Key observations from **Camps Bay** sampling on **11 November 2024** in strong south-easterly winds with cool temperatures and no recent rainfall include:

- FIB counts at all sites and depths on this date were low (≤ 2 CFU/100mL) or zero, suggesting that the effluent plume was adequately diluted before reaching the boundaries of the AMZ;

§ Instrument reported value = 0 NTU at a manufacturer-reported 0.01 NTU resolution, but in reality zero turbidity is highly unlikely and a turbidity of 0 NTU should be understood to represent a very low (but unmeasurable) turbidity.

- High average fertilisation success in sea urchin toxicity tests from around the AMZ (>95%) at all depths, indicating no evidence of toxicity;
- Very low turbidity at all sites monitored (0 NTU)s;
- A consistent inverse halocline and strong thermocline was present, with warmer, higher-salinity surface waters and cooler, less saline bottom waters evident at all sites; and
- A clear depth gradient in oxygen saturations at all sites monitored: ranging from 70% to 90% in bottom waters, 74% to 96% at mid depths, and 84 to 92% at the surface, with all sites having dissolved oxygen concentrations greater than 7 mg/L.

Key observations from **Camps Bay** sampling on **19 December 2024** in westerly and southerly winds, moderate temperatures, and with no recent rainfall include:

- Low (3-22 CFU/100ml) FIB counts at two surface AMZ sites on the southern boundary of the AMZ, with no (≤ 2 CFU/100ml) enterococci detected at nearshore sites and the remainder of the AMZ, indicating dilution of the plume to within recreational guideline limits at the boundary of the AMZ;
- Reduced TSS concentrations relative to winter values, with most samples between 5 mg/L and 30 mg/L and no clear spatial trends in these data;
- Low turbidity at all sites, with very slightly elevated values at nearshore sites than at offshore sites;
- High average fertilisation success in sea urchin toxicity tests from around the AMZ (>95%) at all depths, indicating no evidence of toxicity;
- A slight halocline and thermocline, with warmer, higher-salinity surface waters and cooler, less saline bottom waters at all sites;
- A clear depth gradient in oxygen saturations at all monitoring sites with relatively lower saturations on this date, between 60% to 86% in nearshore and AMZ sites at the bottom, and between 82% and 87% at the surface – the shallowest sites closest to the shoreline and reefs being generally better mixed and better-oxygenated at all depths.

Key observations from **Camps Bay** sampling on **14 January 2025** with strong southerly and westerly winds, warm temperatures, and no rainfall, include:

- Elevated (65-168 CFU/100mL) FIB counts at the surface at two AMZ sites on the western (offshore) boundary of the AMZ, with lower (44-52 CFU/100mL) counts at the surface at offshore sites beyond the AMZ. These data were among the highest recorded at the surface in Camps Bay during the year of monitoring (though still well below risk-based guideline thresholds), and suggest a northward movement of the effluent plume, but diluted to within recreational water guidelines by the time it reached the boundary of the AMZ, and not impacting on the nearshore screen of sites between the outfall and recreational beaches, at which bacterial counts were ≤ 15 CFU/100mL (**Figure 2-19**);
- Very low turbidity at all sites and depths sampled;
- High average fertilisation success in sea urchin toxicity tests from around the AMZ (>94%) at all depths, indicating no evidence of acute toxicity;
- A well-mixed water column at all sites, with limited variation in temperature and salinity across the depth profile; and
- Generally low oxygen saturations at all sites, ranging from 70 to 89% saturation at the surface

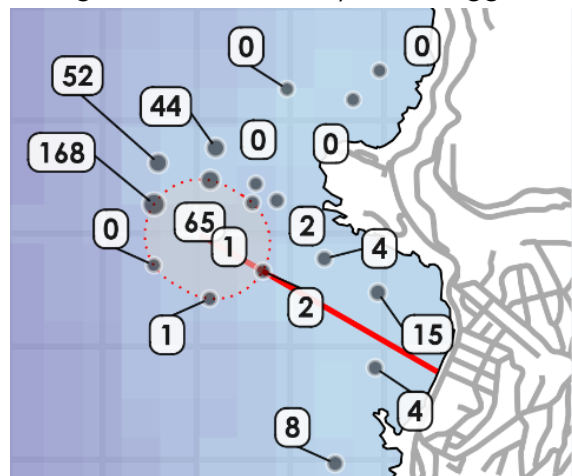


Figure 2-19. Camps Bay enterococci counts in cfu/100ml at the surface in January 2025.

and from 50-70% saturation at depth, corresponding to between 6 and 7 mg/L at the surface and between 5 and 6 mg/L at depth.

Key observations from **Camps Bay** sampling on **12 February 2025**, with strong south-easterly winds, warm temperatures, and no recent rainfall, include:

- Low (7-49 CFU/100mL) FIB counts at the surface, at five of six sites around the boundary of the AMZ and one additional site offshore of the AMZ, and similar counts (42-63 CFU/100mL) at mid-depth on the AMZ boundary, suggesting that diluted wastewater reached the boundary of the AMZ, but remained well within recreational water guideline limits;
- Detectable, but low, FIB counts at nearshore sites near Camps Bay Beach and Bakoven (27-36 CFU/100mL) south of the AMZ, and potentially reflecting onshore plume dispersion under upwelling conditions;
- A failure (15.8% average) of fertilisation in the sea urchin gamete toxicity test, at one AMZ site on the western (offshore) boundary in bottom waters; this site had FIB counts of <10 CFU/100mL and was not obviously impacted by an undiluted effluent plume on this date, since TSS were not elevated and salinities and temperatures are similar to other sites. A similar failure of the ecotoxicity testing occurred at the Karbonkelberg reference site on the same day, in both surface waters (41.8% average fertilisation success) and at depth (23.5% average fertilisation success). Although the cause of these acute toxicity events is unknown, the fact that the reference site was similarly affected suggests causes other than wastewater from the outfall;
- Low (<2 NTU) turbidity at all sites, including at sites with elevated FIB counts;
- A halocline and a thermocline at all offshore sites, with lower salinities and temperatures at depth where surf action did not result in good vertical mixing; and
- High dissolved oxygen concentrations at sheltered, inshore sites near Clifton (110-145 % saturation at the surface, and up to 129 % saturation at depth, but low oxygen saturations (51%) on the southern boundary of the AMZ at depth, corresponding to levels of dissolved oxygen of 11 mg/L at the surface and between 5 and 6 mg/L at depth.

Key observations from **Camps Bay** sampling on **20 March 2025** in hot weather (33°C), with no recent rainfall and in light north-easterly winds, include:

- Low enterococci counts (12 to 26 CFU/100mL) at mid-depth on the boundary of the AMZ and at nearshore sites south of the outfall, and similar detections of these bacteria (9 to 62 CFU/100mL) in bottom waters at the same sites. At the surface, no bacteria were detected on the boundary of the AMZ, and counts were very low, between 1 and 22 CFU/100mL, in the nearshore; these were well below recreational water quality guidelines but may indicate a southward dispersion of the diluted effluent plume;
- A second failure (29.3% average fertilisation success) in the sea urchin gamete toxicity test, at the same AMZ site on the western (offshore) boundary in bottom waters; a similar event again occurred at the Karbonkelberg reference site on the same day, at mid-depth with a fertilisation success of only 70.8% on average; as in February, the simultaneous low fertilisation success in water from the reference site makes it difficult to attribute toxicity to any particular cause;
- A reverse halocline and a thermocline at all offshore sites, with lower salinities and temperatures at depth where surf action did not result in mixing; and
- Very low (<1 NTU) turbidity at all sites and all depths;
- Generally low oxygen saturations (39-46% / 3.7-4.1 mg/L) and cooler temperatures (10.7-11.1°C) at depth at two of the deepest offshore sites, with otherwise typical stratification in oxygen concentrations, from around 80% at depth to around 100% at the surface.

Key observations from **Camps Bay** sampling on **23 April 2025**, in cool weather with 2.5 mm of recent rainfall and strong south-easterly winds, include:

- FIB detected only at mid-depth on the boundary of the AMZ, where one site had a count of 68 CFU/100ml, and at one nearshore site off Bakoven (23-28 CFU/100mL at bottom and mid-depths). All surface samples across Camps Bay had counts below 5 CFU/100ml, well below risk thresholds for recreational use;
- Very high (>98%) average fertilisation success at mid-depth and surface sites, but a third consecutive monthly failure (this time with a 60% average fertilisation success) at the same offshore site on the offshore boundary of the AMZ as in February and March 2025, in bottom waters; this sample had enterococci counts of 7 CFU/100ml, low TSS concentrations, and a salinity and temperature consistent with other nearby sites; for the third consecutive month the Karbonkelberg reference site also had reduced urchin fertilisation success, with 61.8% average fertilisation in the mid-depth sample on this date and 74.8% average fertilisation in surface water – as in February and March, the simultaneous acute toxicity at the distant reference site makes it difficult to attribute the toxicity event to any particular cause;
- Very low turbidity at all sites and depths sampled;
- Generally well-mixed conditions at all sites, with limited depth gradients in salinity, temperature, and dissolved oxygen, but a generally depressed oxygen saturation of less than 80% (5-6 mg/L) at all sites.

Key observations from **Camps Bay** sampling on **15 May 2025** in north-easterly winds with no recent rainfall and warm temperatures, include:

- Very low counts of FIB in bottom and mid-depth waters at sites surrounding the AMZ and other nearby sampling sites, with enterococci counts between 1 and 32 CFU/100ml in bottom waters and between 1 and 26 CFU/100ml in mid-depth samples (**Figure 2-20**);
- An elevated, but below guideline thresholds, enterococci count (181 CFU/100 ml) at the surface at a single AMZ site shoreward of the outfall, suggesting that the effluent plume may have reached the surface at this point, but with no detected bacterial contamination (<5 CFU/100mL) at sites nearer the shoreline;
- A return to high fertilisation rates in sea urchin toxicity tests from all AMZ sites, with none under 95% average fertilisation success;
- Low TSS concentrations across all sites, but with elevated turbidity (up to 17 NTU) at mid-depth and in surface waters roughly congruent with FIB distribution and consistent with a dispersed effluent plume;
- Well-mixed conditions with limited stratification in salinity or temperature; and
- A marked reduction in dissolved oxygen concentrations with depth: surface samples were super-saturated across most of the survey area, while sites from bottom waters at greater depths were below 50% saturation.

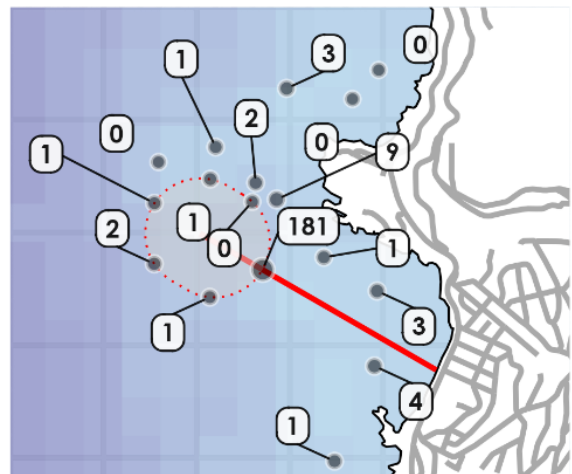


Figure 2-20. Camps Bay enterococci counts in cfu/100ml at the surface in May 2025.

Key observations from **Camps Bay** sampling on **10 June 2025** in cool conditions (9°C, with significant rainfall in the past three days (>70 mm) and southerly winds, include:

- Elevated enterococci counts at a site north of the AMZ (CB002), where the surface sample had a count of 256 CFU/100 ml (**Figure 2-21**); and the mid-depth sample a count of 140 CFU/100 ml, suggesting a slight risk to any recreational users at this offshore site on this date; FIB were detected in low numbers on the boundary of the AMZ at bottom and mid-depths;
- A slightly elevated turbidity reading at the same site described above (2.7 NTU), with zero readings at all other sites, supporting an interpretation of this as constituting a sample of the diluted effluent plume;
- Very low (<5 CFU/100ml) enterococci counts at all nearshore screen sites, suggesting that the effluent plume is unlikely to have reached the shoreline without significant dilution and that recreational water quality would not have been negatively impacted at the nearby beaches;
- No evidence for acute toxicity in the sea urchin fertilisation toxicity tests carried out on water samples from the AMZ, with all samples achieving fertilisation rates higher than 86%;
- No obvious stratification in salinity or temperature, and oxygen saturations reflective of well-mixed conditions at all sites.

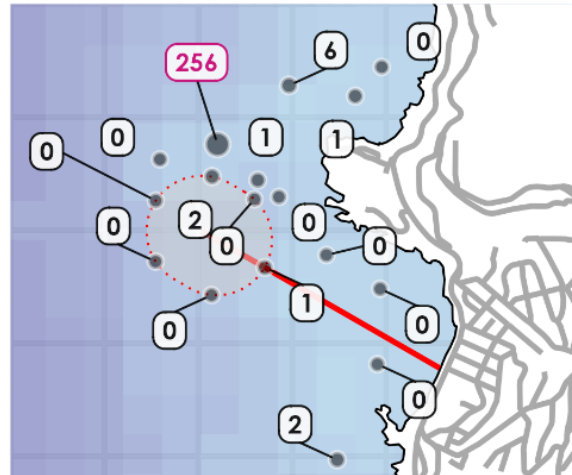


Figure 2-21. Camps Bay enterococci counts in cfu/100ml at the surface in June 2025.

2.3.3 Effluent plume and dispersion model comparisons

The CCT undertook detailed, three-dimensional dispersion modelling for the effluent plume at each of the three outfalls, to inform an understanding of the movement of contaminants from the outfall in space and time. The model outputs are reported on in PRDW (2021).^{**}

The modelled effluent plume movement is extremely dynamic, but key patterns and trends include:

- Due to low discharge rates at the Camps Bay outfall, the positively buoyant effluent plume usually becomes passive within a short distance from the seabed, resulting in a more concentrated plume near the seabed.
- **Surfacing** of the plume occurs only occasionally, during periods of high wastewater flows or stagnant hydrodynamic conditions.
- Under typical conditions, the effluent plume is advected in a predominantly **northward, longshore** direction by the prevailing longshore currents.
- Strong south-easterly winds may spread the surface plume **offshore** on occasion, and are more frequent in summer months.
- **Onshore** movement occurs when the plume becomes entrained in horizontal currents or eddies arising from a combination of wind and breaking waves.
- Occasional upwelling events can also contribute to **onshore** transport, particularly of the more concentrated seabed plume. This is more likely to occur during summer and is associated with

^{**} Available for download at the time of writing at:

https://resource.capetown.gov.za/cityassets/Media%20Centre%20Assets/B_Numerical_Dispersion_Modelling_Reports_Marine_Outfalls.zip

south-easterly winds. During these events, recreational beaches are expected to be exposed to bacteria concentrations above the guideline limits for short periods of time.

- Upwelling events can also push the wastewater to the surface at the shoreline, but the plume is characteristically more diluted in such events.
- In contrast, downwelling events associated with north-westerly winds force the less concentrated surface plume onshore and the seabed plume offshore.
- The minimum number of dilutions achieved at the boundary of the 274 m AMZ was 3480 under modelled conditions, while key constituents of the wastewater (ammonia, TSS, and oxygen demand) are expected to be diluted to acceptable levels within 25 m, 115 m, and 25 m, respectively, well within the bounds of the AMZ. According to the model, recreational guideline values should be met at the boundary of the AMZ for enterococci a minimum of 90% of the time. It is important to note that the dispersion modelling did not include other sources of faecal contamination such as stormwater and river runoff.

FIB counts from the 2024-2025 surveys suggest that the Camps Bay effluent plume was detected (usually after sufficient dilutions to pose no significant risk to recreational users) at the boundary of the AMZ on several occasions during the year of monitoring:

- In winter, at mid-depth and at the surface on the offshore western or northern side of the AMZ: (in August 2024 in north-westerly winds and in September 2024 in strong south-easterly winds, and in June 2025 in southerly winds);
- In spring and summer, at the surface to the south of the outfall (in October and December 2024, and February 2025, all in south-easterly winds);
- In summer in bottom waters, to the south of the outfall (in March 2025, in low winds);
- In summer, to the north of the outfall at the surface (January, southerly winds); and
- In autumn, at mid-depth and bottom sites to the south of the outfall (in April 2025 in strong south-easterly winds).

These findings align well with modelled conditions reported by PRDW (2021).

Due to the comparatively low volumes of wastewater discharged from the Camps Bay outfall, the plume had almost always diluted to acceptable levels by the time it reached sampling sites on the boundary of the AMZ. On one occasion FIB were present in excess of single sample recreational water quality guidelines (in June 2025 north of the AMZ at one site, at the surface). On a separate occasion (September 2024) an elevated count below the single-sample threshold was detected at the offshore boundary of the AMZ at the surface.

2.3.4 Compliance with Permit Conditions

2.3.4.1 Temperature

The 1995 Guidelines specify that the temperature in the receiving environment should not exceed 1°C above or below the ambient temperature. The 2022 draft Guidelines also set the temperature range relative to the ambient temperature of the environment but specify that the temperature should not fall outside the 20th and 80th percentiles of a suitable reference data set.

As described in §2.3.1.1, sea temperature is highly variable seasonally across all depths. Compliance assessments therefore utilised mean temperature values as a better comparator for these highly variable data.

At the Camps Bay marine outfall, the mean surface temperatures tended to be slightly higher than the mean temperatures from the reference site at Karbonkelberg, about 12 km to the south. The Karbonkelberg site is more exposed, better-mixed and deeper, and summer temperatures at all depths were much lower and less variable than at any sites in Camps Bay (refer to Figure 2-9).

Three sites from the offshore boundary of the AMZ (CB006, CB007 and CB008) had mean surface temperatures that were more than 1°C warmer than the reference site (12.96, 12.89 and 12.97°C compared to 11.86°C). Sites on the onshore boundary of the AMZ had slightly lower mean temperatures at 12.58, 12.62, and 12.87 respectively – as these sites are shallower, the difference may reflect differences in stratification, with deeper sites tending to be less well-mixed than shallow sites. All other temperature values for Camps Bay were within 1°C of the mean temperatures at the reference site (Figure 2-22). Neither the mean nor the median temperature values from any of the AMZ sites fell outside the 20th or 80th percentiles of the water temperatures measured at the reference site, and this was true throughout the water column.

Compliance statement: Surface temperatures at three of the six Camps Bay AMZ sites were far more variable than at the Karbonkelberg reference site, and their mean values were more than 1°C higher than those at the reference site. This is technically non-compliant with the 1995 Guidelines but is in this case a function of the reference site location, rather than a reflection of a negative impact. Seawater temperatures at all mid-depth and bottom AMZ sites were compliant with the 1995 Guidelines, and all AMZ sites' temperatures were compliant with the 2022 draft Guidelines.

2.3.4.2 Salinity

In the 1995 guidelines, salinity is measured against a target range of values, relevant to the coastal zone of South Africa. The 2022 guidelines for salinity indicate that values should be measured against a range defined by the 20th and 80th percentiles of a suitable reference data set.

All annual mean values for salinity at the Camps Bay outfall fell within the range specified by the 1995 guidelines (34.9 PSU to 35.64 PSU), and both the mean and median values fell within the 20th and 80th percentile range of the Karbonkelberg reference site (KB001).

Compliance statement: All salinity measurements at the Camps Bay AMZ sites at all depths were compliant with both the 1995 Guidelines and the 2022 draft Guidelines.

2.3.4.3 Dissolved oxygen

Target values and ranges for dissolved oxygen are generally specified according to lower limits. The 1995 Guidelines have specific target lower limits for the south and east coasts, but for the west coast the 1995 Guidelines specify that dissolved oxygen should not fall below 10% of established natural variation. According to the 2022 draft Guidelines, the values should not fall below the 20th percentile

of an appropriate reference data set. Oxygen concentration was highly variable both on a seasonal basis and among sites, thus both mean and median values were used for comparison.

For the Camps Bay marine outfall, dissolved oxygen concentrations were generally higher at the AMZ sites compared to the reference site, except for two sites at the bottom of the water column, both of which were lower than the reference site on average but not by more than 10% (Figure 2-22). Across the year, none of the median or mean dissolved oxygen values fell below the 20th percentile of the reference data set.

Compliance statement: All Camps Bay AMZ sites at all depths were compliant with both the 1995 Guidelines and the 2022 draft Guidelines for dissolved oxygen.

2.3.4.4 Turbidity

Turbidity data were measured as absolute values in nephelometric turbidity units (NTU), which can only be assessed in terms of the 2022 draft Guidelines and compared to the 80th percentile of the reference data. Because turbidity values at sites in Camps Bay, and at the reference site, included a large number of reported zero values (noting that instrument-reported zeros should be interpreted simply as very low values), median values at most sites are zero, and mean data are instead used for comparison purposes.

The Camps Bay reference site (KB001) had very low mean annual turbidity values (Surface: 0.66 NTU, Mid-depth: 0.31 NTU, Bottom: 0.22 NTU). Mean values exceeded the 80th percentile of the reference site data across all AMZ sites.

Two sites had notably higher mean turbidity (between 1.04 and 3.04 NTU) throughout the water column relative to other sites, CB004 and CB005 on the northern boundary of the AMZ (Figure 2-22). All sites in Camps Bay had high turbidity in August 2024 relative to other months, with sampling having taken place during and after a heavy rainfall event. In May 2025, elevated turbidity at these AMZ sites was tentatively attributed to the presence of the effluent plume.

Mean turbidity values at most Camps Bay sites exceeded the 80th percentile of the reference site data. With rare exceptions, the absolute values of turbidity were still very low.

Compliance statement: Mean turbidity at Camps Bay AMZ sites exceeded reference site values by more than 10%. Absolute values were low and most often zero, and averages were skewed by elevated turbidity at shallow AMZ sites during two winter sampling events. Non-compliance with guideline values is most likely linked to increased levels of sediment entrainment from wave action at the Camps Bay sites which are mostly shallower than the reference sites, rather than being linked to wastewater discharge.

2.3.4.5 Total suspended solids

The recommended concentration of TSS in the receiving environment is specified as an upper limit against a background concentration. The 1995 Guidelines state that the concentration of TSS should not be increased by more than 10% of the ambient concentration. The 2022 draft Guidelines recommend that the TSS be measured against the 80th percentile of a suitable reference data set.

Median values across the sites and throughout the water column did not exceed the 80th percentile of the data from the Karbonkelberg reference site.

However, several AMZ sites had mean TSS levels more than 10% above mean levels at the reference sites. For site CB004, TSS concentrations throughout the water column exceeded guideline limits derived from the reference site data. For sites CB005 and CB008, the concentrations exceeded the upper guideline limits at the surface and in the middle of the water column (Figure 2-22). High values

across sites and throughout the water column in July 2024 tended to skew the data and increase the mean. High rainfall and river and stormwater runoff on some of the sample dates likely contributed to increased sediment loading on the Atlantic coastline. This pattern of high TSS can also be seen at sites not adjacent to the AMZ.

Compliance statement: Mean TSS concentrations at Camps Bay AMZ sites exceeded reference site mean values by more than 10%. Sediment entrainment from wave action is likely a contributing factor. Median values across the sites and throughout the water column did not exceed the 80th percentile of the data from the Karbonkelberg reference site. Median data are a good indicator of the general trend, while mean data will highlight any particularly high outliers. The difference when comparing means and medians suggests that the data at AMZ sites are generally within similar ranges to reference sites, but a small number of higher values resulted in higher means.

2.3.4.6 pH

The 1995 water quality guidelines specify a range of pH values, from 7.3-8.2. The 2022 guidelines specify that a range needs to be calculated from the 20th and 80th percentiles of a reference data set suitable to the discharge location. Additionally, the guidelines specify that any deviations of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated.

For the Camps Bay marine outfall, all median values fell within the specified range according to the 1995 guidelines, and all values fell within the 20th and 80th percentiles of the reference site data from Karbonkelberg. All values fell within the seasonal range of the reference site throughout the water column.

Compliance statement: Median pH values across the sites and throughout the water column did not fall outside the guideline range of the data from the Karbonkelberg reference site.

2.3.4.7 Concluding statement on permit compliance: Camps Bay

Water quality measured as salinity, dissolved oxygen, and pH at the Camps Bay marine outfall was compliant at the boundary of its AMZ with permit conditions. Temperature was not compliant with permit limits based on comparisons with the Karbonkelberg reference site, but this is attributed to environmental differences between the more exposed, rocky reference site and the generally more stratified AMZ sites around the outfall rather than to pollution impacts. Turbidity and TSS were also not compliant with permit limits based on reference site comparisons, due to increases during winter sampling events that are attributed to environmental, rather than anthropogenic, causes as the Karbonkelberg site is rocky, while sites nearer the outfall have a sandy bottom. Enterococci counts suggested that recreational activity at or near the boundary of the AMZ (were this to take place, although the AMZ is not recommended for full-contact recreation) would have posed a risk to human health on two occasions, and Hazen-based categories calculated for the AMZ sites were 'Poor' at one (offshore) site, 'Excellent' at two, and 'Good' at three of the six sites monitored – these categorisations are however strongly influenced by the low sample count (n=12), and are less valuable as measures of risk than the recreational water quality sampling carried out at a higher frequency by the CCT and reported in §2.6, which indicates that most sites along the Camps Bay shoreline are not exposed to faecal contamination at levels that would pose a risk to recreational users.

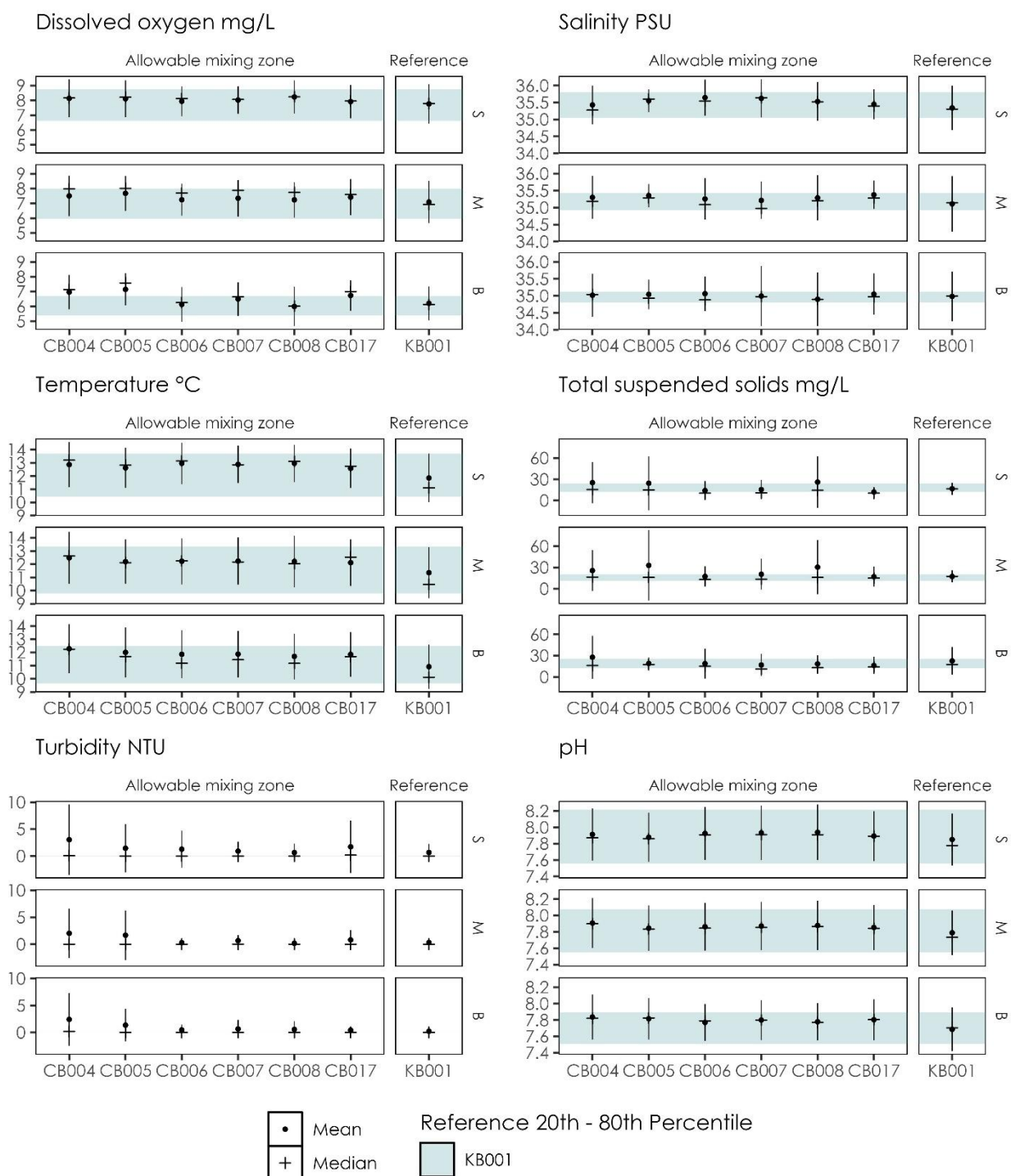


Figure 2-22. Annual median values for six of the parameters required to be monitored by the Camps Bay Coastal Waters Discharge Permit, relative to the reference site for the period July 2024-June 2025. Annual mean $\pm$ SD (points + error bars) is also shown for sites on the boundary of the allowable mixing zone for the Camps Bay marine outfall, shown against the 20th and 80th percentiles of the values from the Karbonkelberg reference site. For pH, the error bars show interquartile ranges (IQRs), not standard deviation. Note that IQR describes the middle 50% of values when ordered from lowest to highest.

2.4 Green Point Outfall: Results and Discussion

Sample sites for the Green Point outfall are shown in **Figure 2-23**.



Figure 2-23. Sampling sites for water quality around the Green Point outfall and its corresponding reference site at Robben Island.

All water quality data for the first year of Green Point outfall sampling are tabulated in **Appendix II**.

2.4.1 Seasonal patterns and variation in water quality

2.4.1.1 Temperature

Sea temperatures varied seasonally across all Green Point outfall sites and depths (Figure 2-24). Temperatures were almost always lower in the summer compared to the winter, with the exception of the surface at the Robben Island reference site which had a slightly higher median value in summer than in winter. Summer temperatures were typically more variable than in winter. The highest recorded temperature was 16.4 °C at a nearshore site, and the lowest was 9.1°C at the bottom at an AMZ site, both in summer. Winter temperatures did not differ significantly with depth.

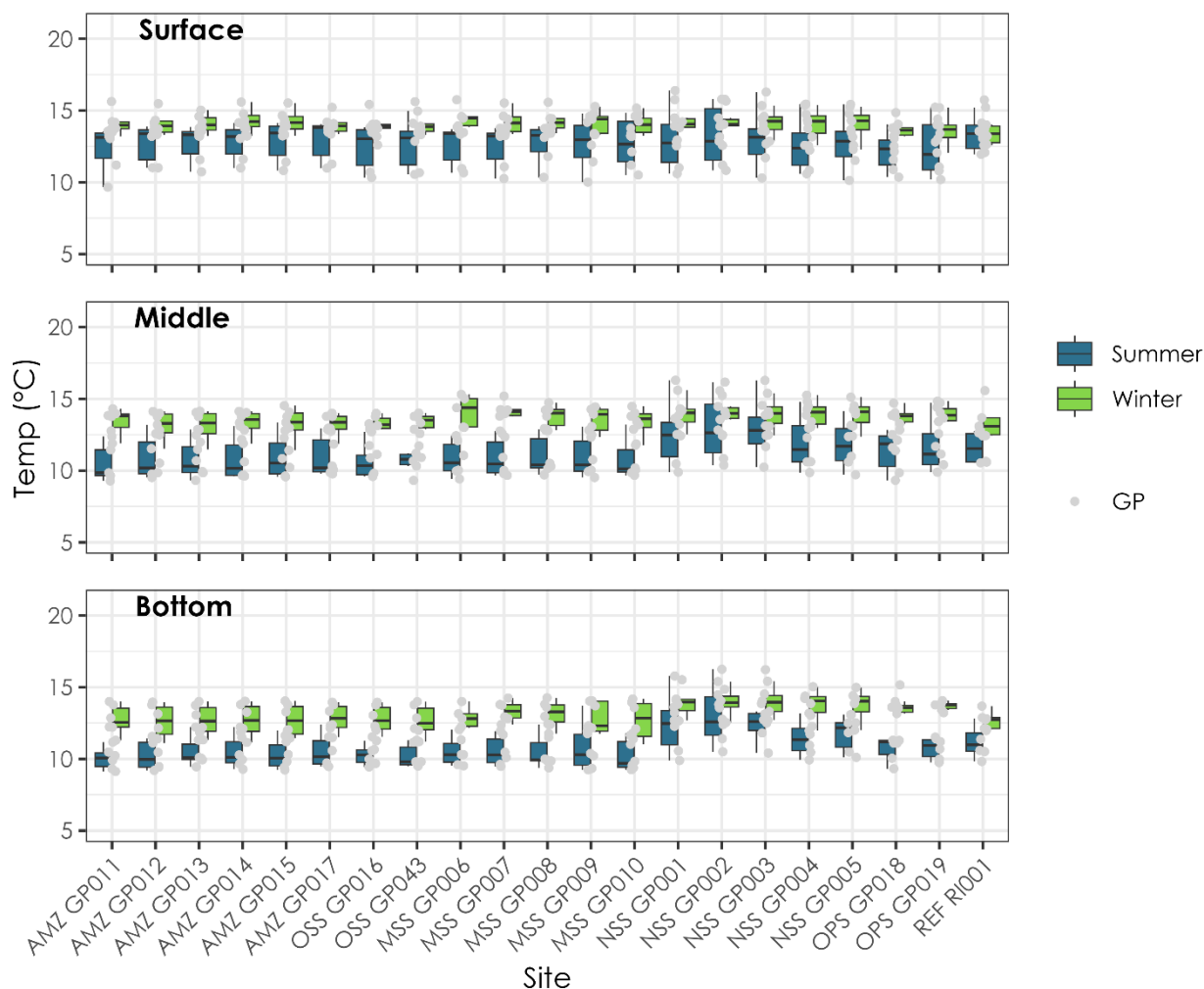


Figure 2-24. Boxplots indicating seasonal variations in temperature for each of the Green Point outfalls sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS, OPS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen, other point source and reference sites, respectively.

2.4.1.2 Salinity

Salinity was higher at the bottom and in mid-depths in winter (Figure 2-25), when surface waters were often fresher due to river and stormwater runoff. The lowest salinity recorded occurred at the surface at two sites in Table Bay (24.71 & 24.14 PSU respectively; not indicated in Figure 2-25 for easier visualisation). Salinity in the summer was higher at the surface (most median values approximate to 36 PSU) and decreased with depth across most sites. The highest salinity recorded was 37.23 PSU at the mid-shore site GP008 at the surface.

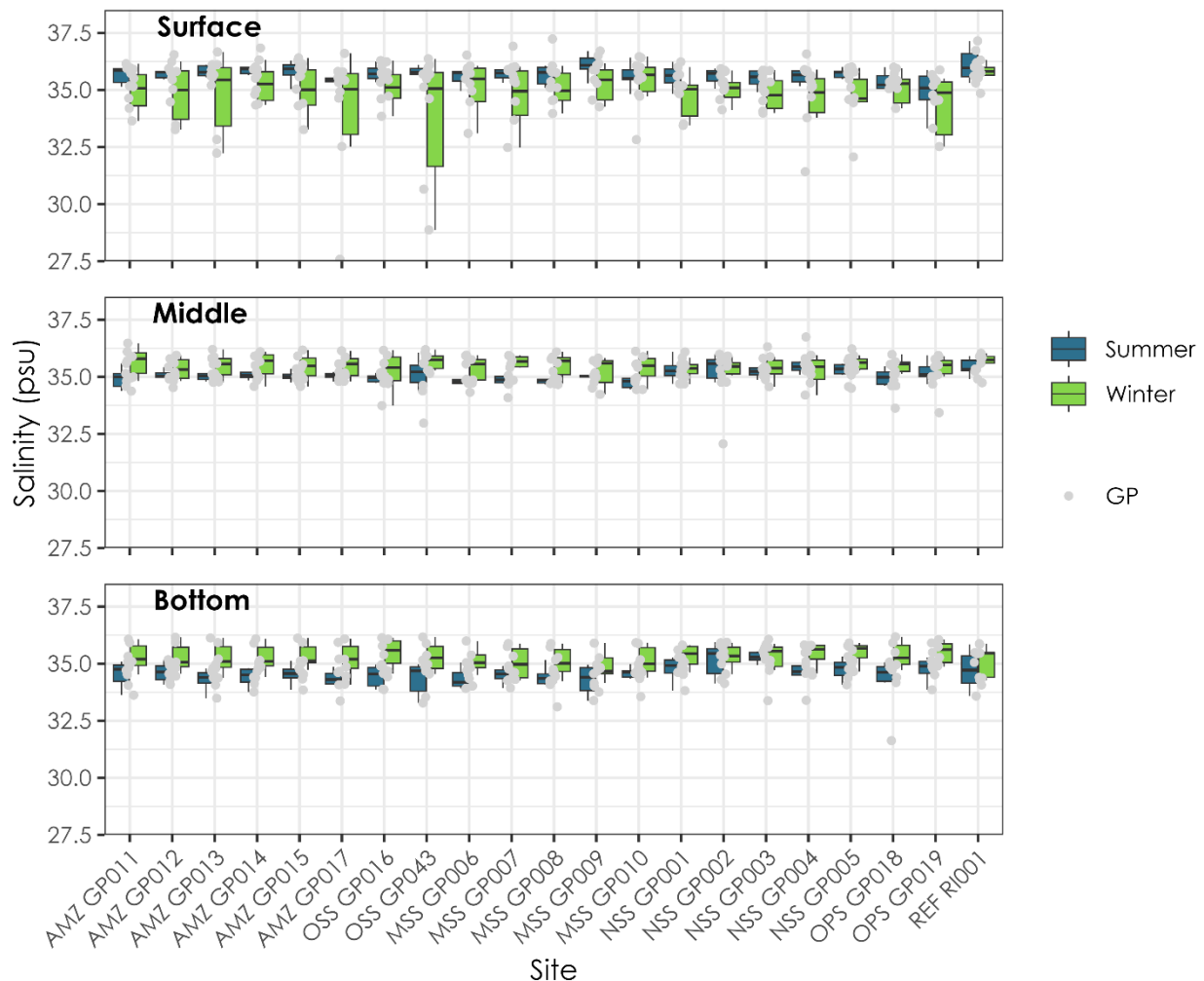


Figure 2-25. Boxplots indicating seasonal variations in salinity at each of the Green Point outfalls sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS, OPS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen, other point source and reference sites respectively. Note that the outliers at GP018S of 24 PSU and GP019S of 24.7 PSU are not shown on the plot for easier visualisation of the boxplots but was not excluded from the dataset.

2.4.1.3 pH

pH varied seasonally at Green Point and Table Bay sites, (Figure 2-26), tending to be lower in summer than in winter across all sites and depths. The maximum pH occurred in winter in surface waters (8.3-8.4). There was a clear decrease in pH with depth in both summer and winter, especially at offshore sites – the summer median values for these sites varied from approximately 7.8-7.6 from surface to bottom. Winter median values for these sites varied from approximately 8.3-7.8 with depth. Nearshore, shallow sites were better mixed and did not show this variation. Overall, pH was more variable in the winter and reached its lowest recorded value of 7.3 at a nearshore screen site.

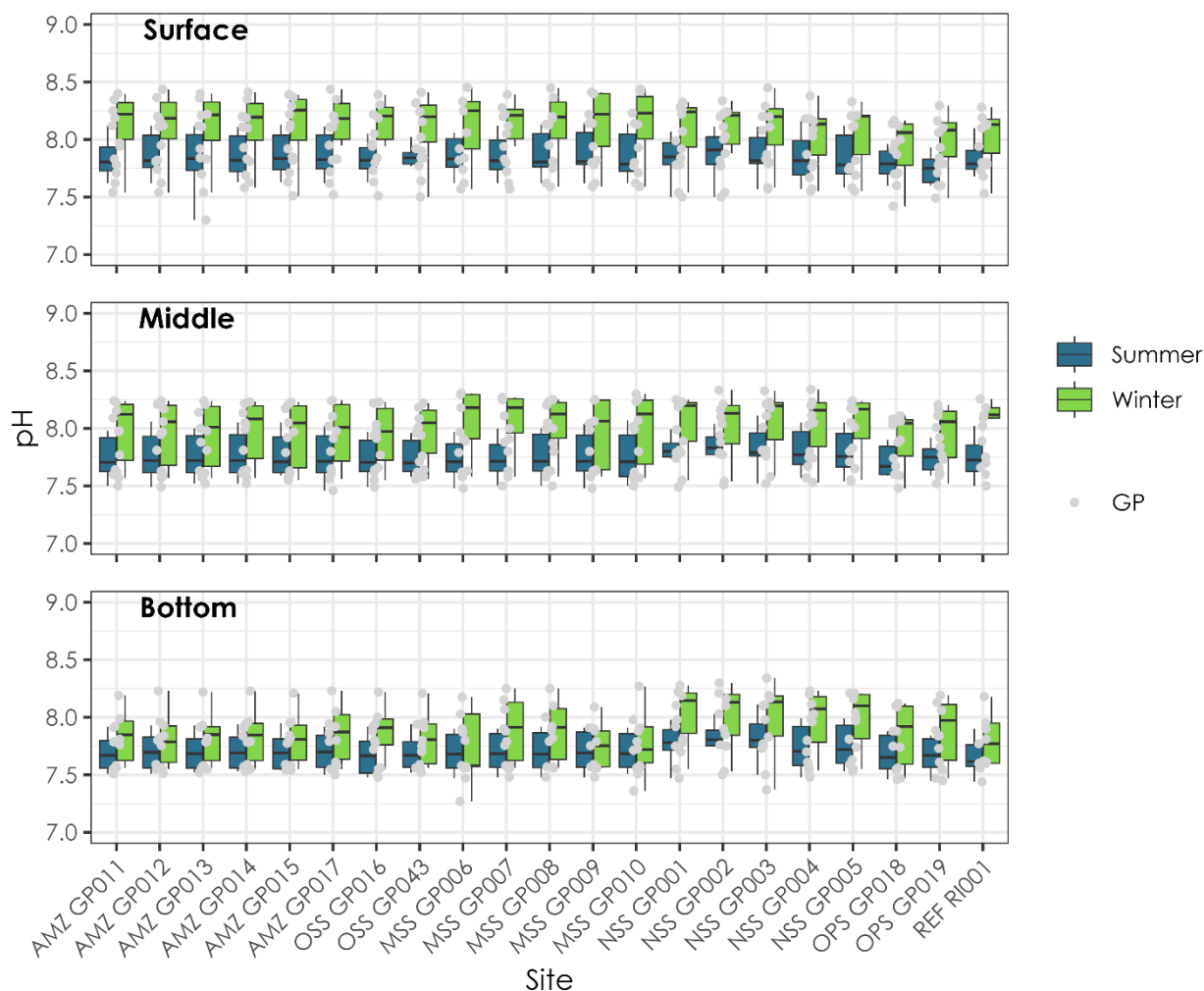


Figure 2-26. Boxplots indicating seasonal variability in pH for each of the Green Point outfalls sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.4.1.4 Dissolved oxygen

Dissolved oxygen saturation indicated seasonality with lower values in summer and higher values in winter (Figure 2-27). Surface waters were better oxygenated than at depth as seen in the oxygen saturation as well as the dissolved oxygen concentration. Summer median values varied from 85-90% at the surface to 60-70% at the bottom. Winter median values varied from 100-115% at the surface to 85-100% at the bottom. Oxygen saturations were more variable and spanned larger ranges at the surface (all seasons), at the middle depth in summer, and at the bottom in winter. The lowest value recorded was 27.0% at site GP043, at the bottom. A maximum and minimum dissolved oxygen concentration of 16 mg/L (GP008) and 5.57 mg/L (GP016) was observed at the surface respectively. The maximum and minimum dissolved oxygen concentration of 12.09 mg/L (GP001) and 2.49 mg/L (GP016) was observed at the bottom depth respectively.

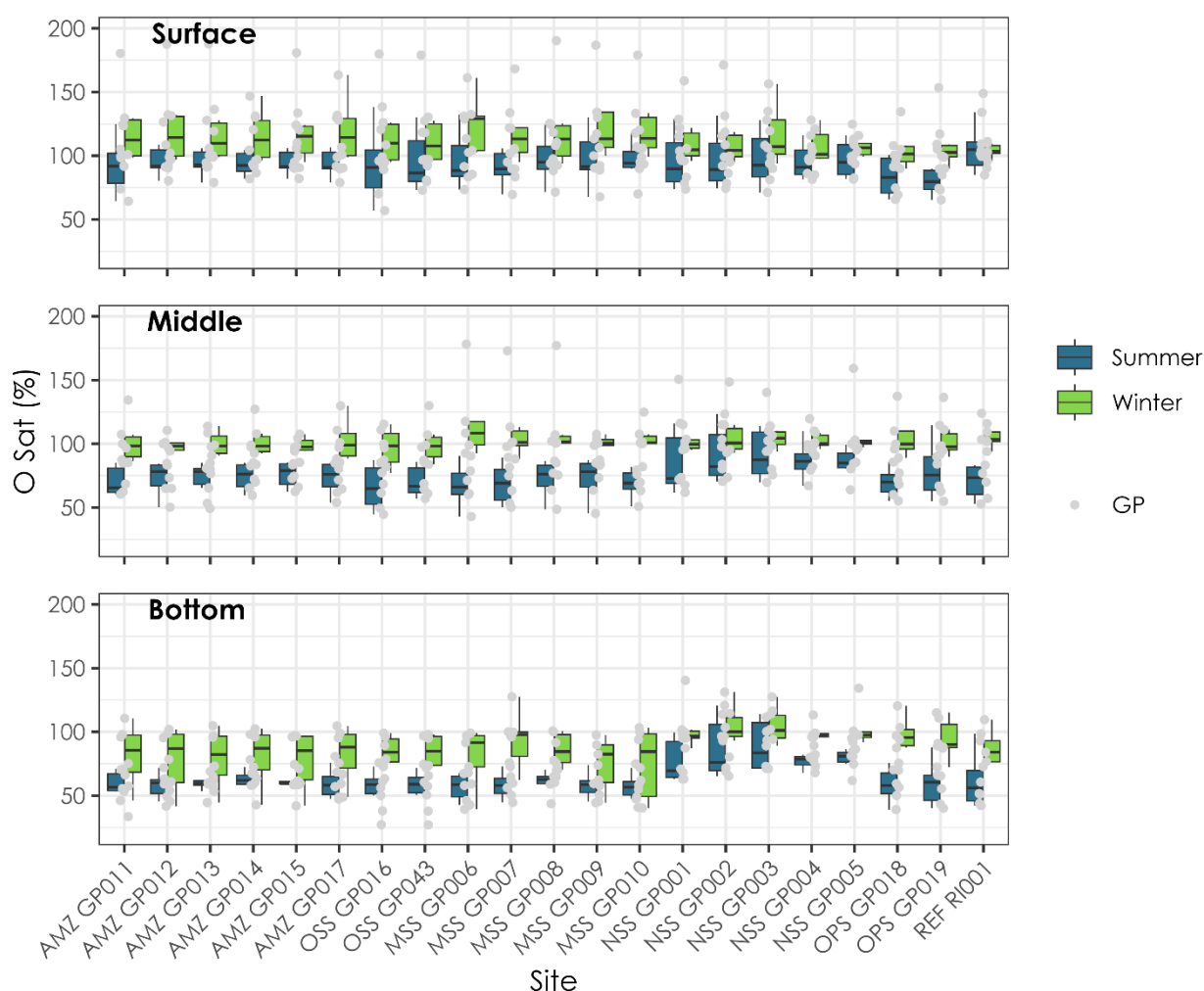


Figure 2-27. Boxplots indicating seasonal variations in oxygen saturation at each of the Green Point outfalls sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS, OPS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen, other point source and reference sites, respectively.

2.4.1.5 Total suspended solids

TSS did not show strong seasonal variation. Most observations in summer and winter were within similar median ranges (Figure 2-28). Medians ranged between 12 and 23.5 mg/L. Most TSS observations remained below 40 mg/L, although several outliers occurred among all site types. All outliers occurred in winter. These maximums ranged between 90 and 297 mg/L, of which the highest

occurred at an AMZ site. Nearshore sites and one mid-shore site had a higher spread (larger interquartile ranges) of TSS values across all depths in winter compared to other sites.

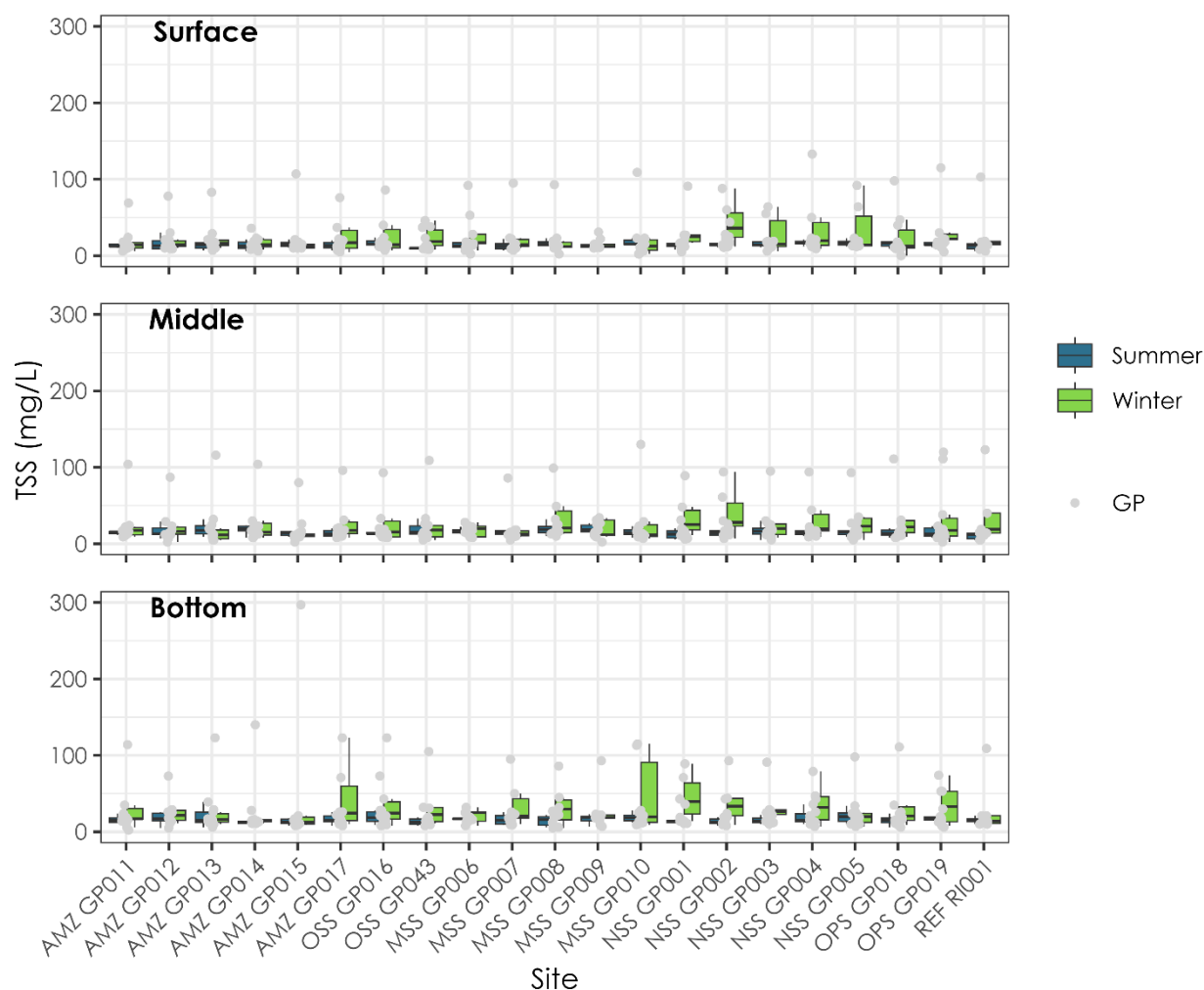


Figure 2-28. Boxplots indicating seasonal variation in TSS for each of the Green Point outfalls sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS, OPS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen, other point source and reference sites, respectively.

2.4.1.6 Enterococci

Nearly all sites sampled around the Green Point outfall and in Table Bay frequently had detectable numbers of enterococci, most notably in surface waters in winter 2024, when all sites exceeded what was for that sampling event the maximum limit of quantification ($n > 150$ CFU/100mL, Figure 2-29). The highest counts were in mid-depth waters, particularly at site GP013 on the northeastern boundary of the AMZ, which accords with results from the dispersion modelling study undertaken by PRDW(2020a). Occasional elevated counts at GP043 also reflect the expected movement of the diluted plume in a north-easterly direction. Lower, but still significant counts were often detected in mid-depth samples from all sites on the offshore boundary of the AMZ. Apart from during flood events, nearshore sites seldom had elevated counts at any depth. Sites distant from the outfall in Table Bay frequently had elevated counts in surface waters, which were attributed primarily to river flows conveying sewage contamination into the bay.

Figure 2-30 shows the total number of recreational water quality guideline exceedances in the twelve-month period; the highest number of guideline exceedances (five) occurred at GP013 at mid-depth, located on the AMZ boundary northeast of the outfall diffuser. Four exceedances occurred at GP018 near the Port of Cape Town. Several AMZ sites had two guideline exceedances at surface or middle depths. At all sites but one there was at least one occasion when it would have been considered unsafe to swim – most during the July 2024 sampling event, discussed in the next section.

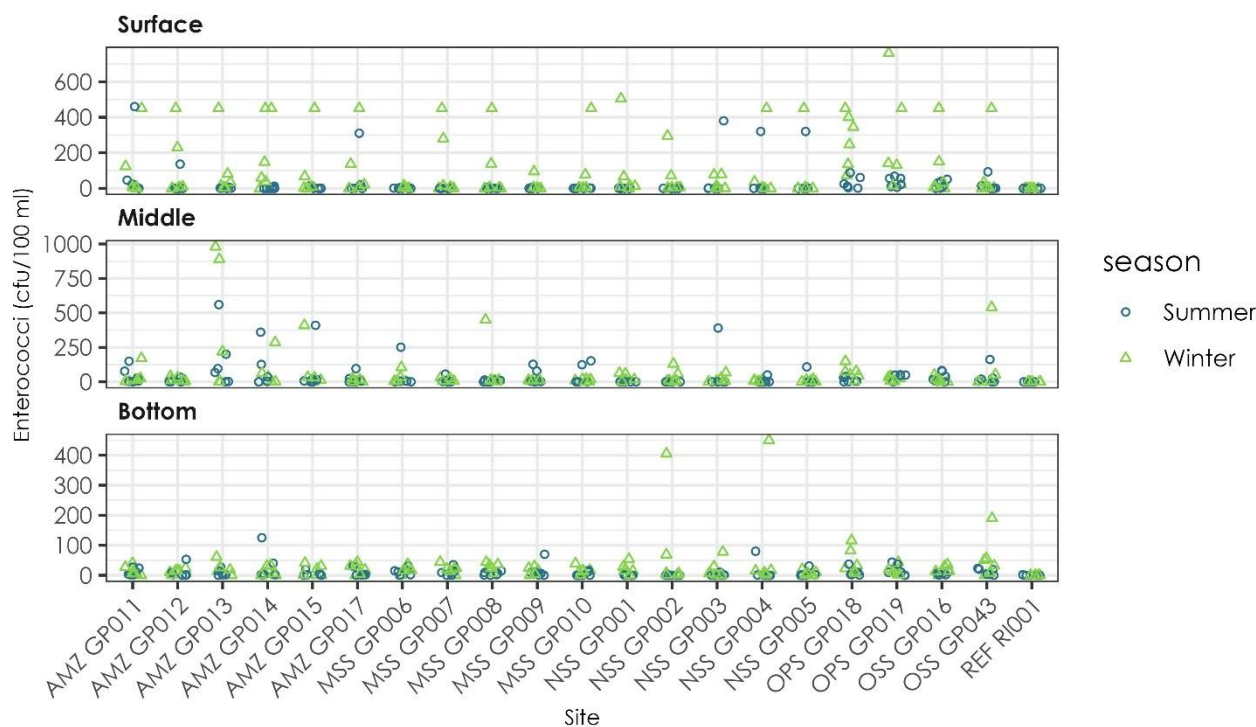


Figure 2-29. Distribution of enterococci counts in CFU/100mL for each of the Green Point outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months April to September. Site IDs prefixed by AMZ, OSS, MSS, NSS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen and reference sites respectively. Note vertical scales differ.

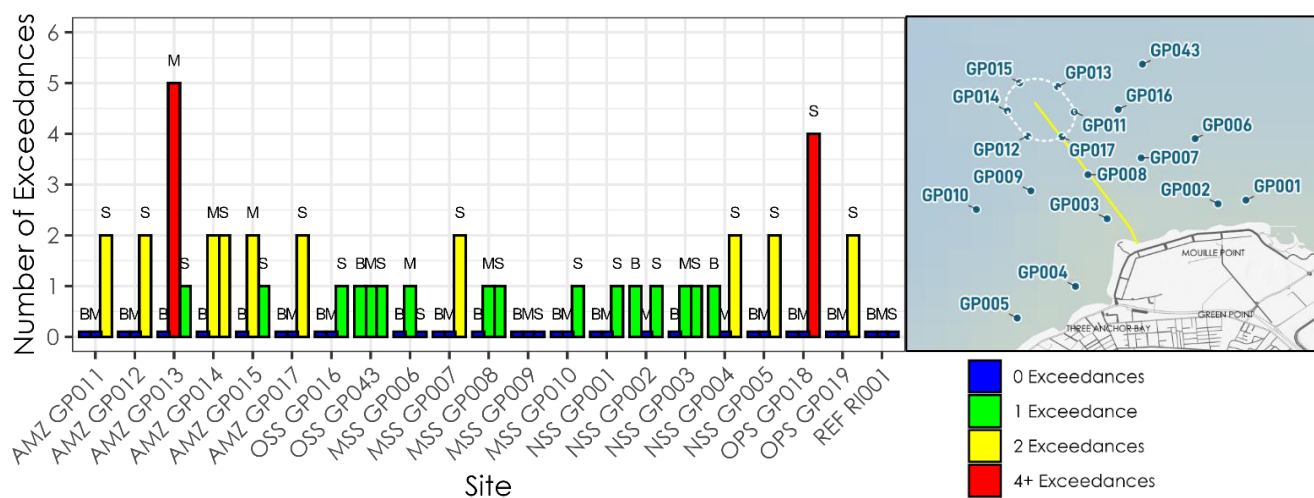


Figure 2-30. Bar plots indicating the number of times that the count of enterococci in CFU/100mL exceeded the guideline threshold of 185 CFU/100mL enterococci for each of the Green Point sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Site IDs prefixed by AMZ, OSS, MSS, NSS, OPS and REF indicate allowable mixing zone, offshore screen, mid-shore screen, nearshore screen, other point source and reference sites respectively.

2.4.1.7 Environmental toxicity testing

The average percentage fertilisation success across all sites and all three depths in Green Point was above 70% and was generally slightly higher in summer than in the winter months (Figure 2-31) (the opposite trend to what was observed at Camps Bay). All AMZ sites had no toxicity events, with a high average fertilisation success rate (>95.2%). Similarly, average percentage fertilisation success across all three depths at the Robben Island reference site was high (>95.9%) in summer. In winter, a single toxicity event in mid-water at the Robben Island reference site lowered the average seasonal fertilisation success to 75.7% (Figure 2-31).

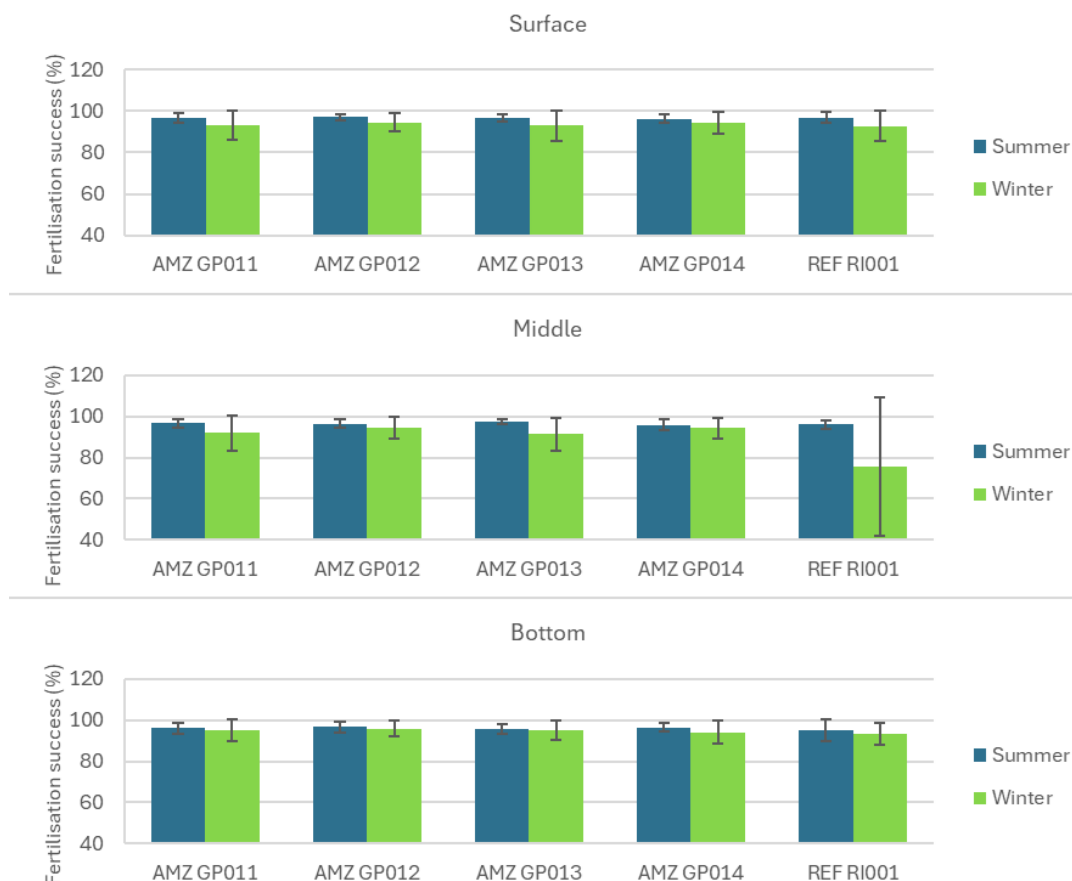


Figure 2-31. Boxplots indicating the seasonal variability of sea urchin toxicity (percentage fertilisation success) for each of the Green Point outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ and REF indicate allowable mixing zone and Robben Island (RI) reference sites, respectively.

2.4.2 Monthly data summaries

The interpretation of monthly water quality data from the area surrounding the Green Point outfall is particularly challenging due to an array of potential sources of pollution, including, but not limited to:

- The Green Point marine outfall itself;
- the large volumes of generally highly-polluted water from the Salt and Diep rivers discharged into Table Bay;
- shipping and harbour activities associated with the Port of Cape Town;
- sewage spills directly into the coastal environment from pump stations; and
- contaminated stormwater inputs, often including wastewater.

In interpreting FIB data for study areas surrounding the Camps Bay and Hout Bay outfalls, a diffuse and well diluted plume can often be traced from the presence of low (~20 CFU/100 mL) enterococci counts. In the Green Point study area, there are numerous contributors to low numbers of enterococci detections at mid-shore and nearshore screening sites, and these detections are more difficult to assign to any particular source.

Key observations from samples collected around the **Green Point** outfall on **15 July 2024** during strong north-westerly winds, large swell, and following 77 mm of rainfall include:

- Very low salinity surface waters at most sites, with particularly low salinity in Table Bay, at nearshore sites around Three Anchor Bay and Sea Point, and the southernmost AMZ site; these reflect a major rainfall event on 13-14 July 2024, which resulted in a fresh lens of river and stormwater on the sea surface (Figure 2-32);
- Corresponding high enterococci counts were detected at nearly all surface sites sampled on this date, including all sites surrounding the marine outfall as well as those in Table Bay and along the Sea Point coastline; the only exceptions being three nearshore sites along the coastline between Mouille Point and Granger Bay where salinity was also generally higher, indicating lower freshwater influence and better mixing;
- Relatively low rates of fertilisation in sea urchin gamete ecotoxicity tests in surface samples, ranging from 83 to 91%, potentially linked to the presence of fresher and potentially polluted flood-derived waters at the surface; acceptable, but low (80 to 85%) fertilisation rates were observed in middle waters on the eastern AMZ boundary too – these were not associated with elevated enterococci counts or low salinity, suggesting this was not linked to wastewater discharges;
- High turbidity readings in surface waters (15-42 NTU) at offshore and Table Bay sites, and lower turbidity in mid-depth and bottom waters, consistent with a turbid, fresh surface layer of floodwaters (see photo in Figure 2-32);
- Relatively low oxygen saturations at the surface, between 90 and 100%, with very little stratification, indicative of good mixing; and
- Mid-water FIB data from the AMZ were low (8-35 CFU/100mL), indicating the effluent plume was not reaching sampling sites on the boundaries of the AMZ in significant concentrations, but an elevated (>150 CFU/100 mL) count was found at a site landward of the AMZ and counts at sites along the nearshore boundary where stormwater influence would be most significant were generally elevated, particularly in bottom waters at Three Anchor Bay, where the CSIR has previously (CSIR, 1990, 2017a) concluded that bacterial contamination was introduced by stormwater rather than from the outfall.

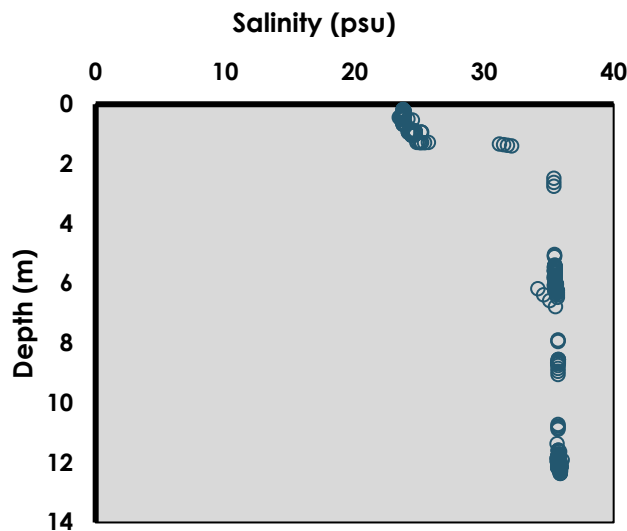


Figure 2-32. Salinity profile at GP018 in Table Bay with depth (left) and discoloured surface water across Table Bay on 15 July 2025.

Key observations from samples collected around the **Green Point** outfall on **13 August 2024** in cold conditions with north-westerly winds and 77 mm of rainfall in the preceding three days include:

- Detectable (>35 CFU/100mL) surface counts for FIB at most sites, including exceedances of recreational water quality guidelines at four sites between Mouille Point and the Port of Cape Town (280 to 345 CFU/100mL), and at sites on the AMZ, where one site on the western boundary had elevated counts (230 CFU/100mL) and others had counts detectable but below guideline thresholds (**Figure 2-33**);
- The survey took place following a significant rainfall event of more than 70 mm of rain, which may account for elevated enterococci counts in bottom waters at the nearshore site off Green Point, where counts were 505 CFU/100ml; slightly elevated counts at surrounding sites did not appear linked to the AMZ, since bacteria were not detected on the AMZ in bottom or middle waters on this date;
- Surface waters in Table Bay near the mouth of the Black River, and at certain sites directly surrounding the marine outfall, had lower salinities consistent with flood conditions; these were generally linked to elevated enterococci counts; the fresher values on the surface at the southern tip of the AMZ may have been contributed to by increased wet-weather storm flows being discharged through the marine outfall, but FIB did not exceed guideline values at these sites;
- Temperature and dissolved oxygen were not stratified with depth, with relatively warm temperatures >14°C at most sites and depths, and oxygen saturations of between 95% and 105% at most sites and depths;
- Higher TSS concentrations in sites nearer the shoreline than at the boundary of AMZ and offshore sites, potentially attributable to additions of sediment in flood flows or to suspension of sediments linked to strong wave action;
- Elevated turbidity in bottom waters at nearshore and offshore screen sites, with the highest levels corresponding to the site with the highest TSS value, southwest of the outfall; and

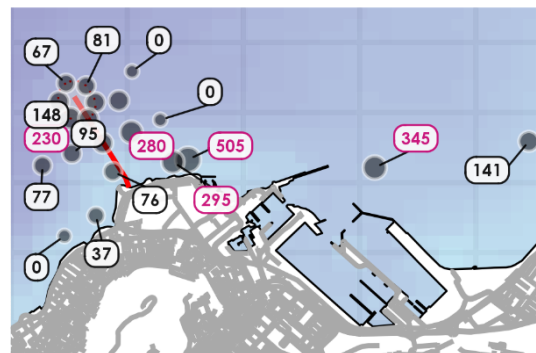


Figure 2-33. Green Point enterococci counts in cfu/100ml at the surface in August 2024.

- High average fertilisation success in urchin toxicity tests from the boundary of the AMZ (>95%) at all depths, indicating no acute toxicity in this area.

Key observations from samples collected around the **Green Point** outfall on **16 September 2024** following 4 mm of rain in the three preceding days and in cool conditions with a variable southerly, south-easterly and south-westerly winds, include:

- The effluent plume evidently reached and passed the bounds of the AMZ at mid-depth on this date, with enterococci counts of 170 and 890 CFU/100mL at sites on the northeastern boundary, and a count of 540 CFU/100mL at an offshore site east of the AMZ (**Figure 2-34**);
- Surface data for FIB indicated that the plume was either adequately diluted in terms of microbiological parameters or did not reach the surface at sampling sites, with counts of between 0 and 15 CFU/100ml in surface waters at the same sites;
- FIB data from nearshore sites between the outfall and the shore indicated that the effluent plume had not encroached towards toward the shore in any detectable concentrations, with enterococci counts of ≤ 20 CFU/100mL at these sites at all depths;
- No other sources of FIB contamination were detected over 10 CFU/100mL at near-shore and Table Bay sites – likely a result of low rainfall in the days leading up to sampling;
- No obvious relationship between TSS concentrations and effluent plume distribution as determined from FIB data, with generally higher TSS (and turbidity) nearer the shoreline than offshore, at all depths;
- A slight thermocline was evident at all sites, with warmer surface and cooler bottom water;
- Supersaturated oxygen conditions at all surface sites, with highly elevated saturations of over 180% (15 mg/L concentration) at all offshore sites and saturations in excess of 120% (11 mg/L concentration) at nearshore and Table Bay sites; these very high values can only be attributed to a possible phytoplankton bloom in the bay; and
- High but somewhat variable fertilisation success in urchin toxicity tests from around the AMZ (between 91% and 98% on average) at all depths, indicating that conditions were not acutely toxic to this organism, even at sites where bacteriological data indicated relatively low dilutions; there was no clear relationship between increased FIB counts and decreased fertilisation;
- The reference site in mid-depth waters at Robben Island failed the ecotoxicity testing with only 12.5% average fertilisation. This site was also supersaturated with oxygen (124% saturation at mid-depth, 148% at the surface and 109% at the bottom), suggestive of possible algal bloom conditions that may also have impacted on average fertilisation success.

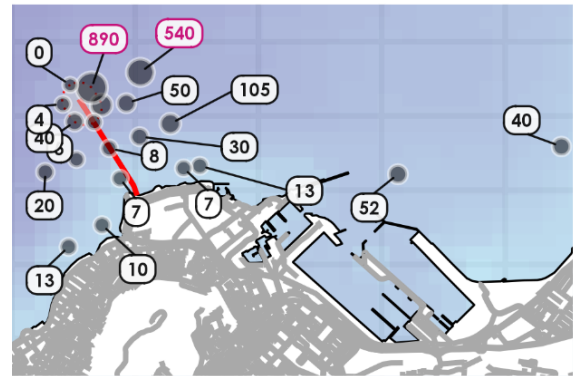


Figure 2-34. Green Point enterococci counts in cfu/100ml at mid-depth in September 2024.

Key observations from samples collected around the **Green Point** outfall on **17 October 2024** during strong south-easterly winds and with approximately 1.5 mm of rainfall in the preceding three days include:

- High enterococci counts in surface-water at sites on the southeastern boundary of the AMZ (310 and 460 CFU/100 ml), and elevated counts in mid-water at sites north-east and south-west of the marine outfall (78 to 200 CFU/100 ml);
- High enterococci counts in surface water at sites along the nearshore west of Mouille Point (320 to 380 CFU/100ml);

- FIB data suggest the plume was wide spread and not well diluted at the boundary of the AMZ, with at least part of the plume in bottom and middle waters likely moving towards the southwestern near-shore sites; anomalously high enterococci readings close to the green point pump station at surface and mid depths (with low readings at mid-shore screens) may be indicative of a shore-based spill event, although this could not be confirmed from available records;
- No obvious spatial trends in TSS data were apparent from this survey, and very low turbidity was recorded at all sites and all depths;
- A slight inverse salinity gradient at all sites, with surface waters being generally more saline than those at depth, and a thermocline with surface sites displaying warmer (12-14°C) temperatures than bottom waters (11-12°C);
- Clear stratification in dissolved oxygen levels, with oxygen saturations at depth ranging from 65% to 80%, and at the surface from 70 to 95%; no obvious differences between AMZ sites and other sampling sites were observed; and
- Sea urchin gamete fertilisation toxicity testing had success rates greater than 96% at all AMZ sites and all depths, indicative of conditions not acutely toxic to this organism's fertilisation.

Key observations from samples collected around the **Green Point** outfall on **19 November 2024**, a day with a moderate southerly and south-westerly wind, cool temperatures, and no rainfall in the three days leading up to sampling, include:

- No FIB counts exceeded guideline values, and none were detected above 2 CFU/100mL in surface waters, indicating that the effluent plume was sufficiently diluted and dispersed before reaching the boundary of the AMZ, or did not reach the surface at all;
- Enterococci counts were elevated in the mid-water samples at one site on the eastern AMZ boundary (96 CFU/100mL), and two sites east of the AMZ (17-162 CFU/100mL), likely indicating the diluted plume;
- Fresher water and detectable counts of FIB (10-50 CFU/100mL) were present at both Table Bay sites at all depths, suggestive of the significant contribution of the Diep and Salt rivers to pollutant loading in Table Bay, even during periods of low-to-no rainfall (**Figure 2-35**);
- Super-saturated oxygen conditions in surface waters at all sites, likely as a result of an algal bloom (>100% saturation, with many sites over 130% saturation);
- A strong thermocline, with surface temperatures between 12 and 14°C compared with mid and bottom-depth temperatures below 11°C;
- No clear trends in TSS concentrations, but generally higher values at sites around the outfall at mid-depth than at shoreline sites, not reproduced in turbidity data which had zero NTU turbidity at all sites; and
- Sea urchin gamete fertilisation toxicity testing had success rates greater than 93% at all AMZ sites and all depths, indicative of conditions not acutely toxic to this organism.

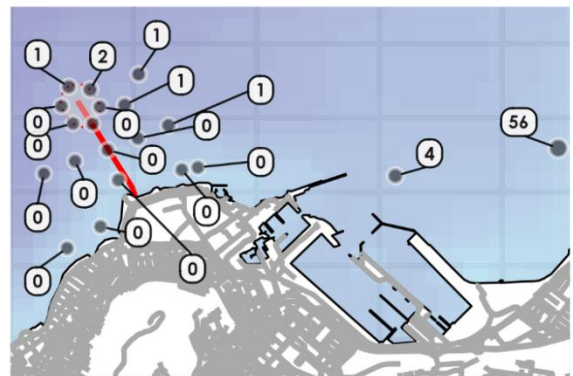


Figure 2-35. Green Point enterococci counts in cfu/100ml at the surface in November 2024.

Key observations from samples collected around the **Green Point** outfall on **15 December 2024** during strong westerly and north-westerly winds, with no rainfall in the preceding three days, include:

- No significant numbers of FIB at the sea surface at any sites, with the highest counts being 12 and 13 CFU/100mL on the northwestern boundary of the AMZ;
- FIB in excess of guideline values at the two north-western AMZ sites at mid depth, and the easternmost mid-shore screen site; FIB were elevated at most AMZ and mid-shore screen sites in the mid-water samples, although these did not reach the near shore screen sites at any detectable level (all nearshore counts <3 CFU/100mL);
- FIB counts were low in bottom waters, with the highest value being 35 CFU/100mL recorded at the mid-shore screening sites;
- Low turbidity readings at most sites, with the highest readings in bottom waters in the offshore screen sites southwest of the outfall;
- The above data suggest that although the part of effluent plume had been advected toward the coastline below the surface, it did not reach the shoreline or result in risks to recreational water users anywhere at the surface;
- Generally low oxygen saturations were measured below the surface at all sites other than the well-mixed nearshore sites, with saturations as low as 43% at depth and in the range 45-75% in mid-water, despite super-saturated conditions at the surface at these sites;
- Good (>94%) average fertilisation success rates in ecotoxicity tests for water collected at various depths on the boundary of the AMZ, suggesting that although the effluent plume was detected on the boundary in mid-water, it had diluted to the point that it was not acutely toxic to these organisms.

Key observations from samples collected around the **Green Point** outfall on **17 January 2025** during strong southerly winds with 15 mm of rain in the preceding three days and moderate temperatures, include:

- Detectable numbers of enterococci on the southern boundary of the AMZ (up to 96 CFU/100mL at mid-depth and up to 136 CFU/100mL at the surface), suggestive of southward transport of the effluent plume but with effective dispersion / dilution occurring within the AMZ;
- Elevated FIB counts at sites in Table Bay, distant from the outfall and separated from the effluent plume by sites without high bacterial counts – potentially indicative of the contribution of contamination from the Salt and Diep rivers following rainfall;
- No significant enterococci counts at AMZ boundary sites to the north of the outfall and all nearshore coastal sites at all depths (<2 CFU/100ml);
- High average fertilisation success (>95%) at all AMZ boundary sites, with no indication of acute toxicity at the boundary of the AMZ;
- Low turbidity at all sites and all depths;
- Cool temperatures, and fairly low oxygen saturations (ranging from 70-85% at the surface to 55-65% at depth, with concentrations of between 5 and 6 mg/L; and
- Low TSS concentrations at AMZ sites relative to the nearshore screen and Table Bay sites, which had substantially higher solids concentrations, potentially associated with recent rainfall or the suspension of sediments by wave action.

Key observations from samples collected around the **Green Point** outfall on **19 February 2025** during strong southerly winds with no significant rainfall in the preceding three days and moderate temperatures, include:

- Enterococci were detected along the northeastern boundary of the AMZ at mid-depth, with two readings >140 CFU/100mL, indicative of the effluent plume moving northward from the outfall;

the plume was adequately diluted before reaching the surface, however, where FIB counts of 46 to 93 CFU/100mL were recorded;

- No FIB were detected at any of the nearshore or mid-shore screening sites;
- FIB were present at detectable levels in Table Bay (44 CFU/100mL at depth to 56 CFU/100mL at the surface);
- High average fertilisation success (>94%) at all AMZ boundary sites tested for sea urchin gamete toxicity, with no indication of acute toxicity to this organism on the boundary of the AMZ;
- Similar TSS concentrations at all sites monitored, but with a slight elevation at the sites where the highest bacterial counts were recorded on the northeastern AMZ boundary, likely as a result of the plume;
- In general, conditions were stratified, with cooler, lower salinity water at depth, and warmer slightly saltier water at the surface; relatively low oxygen saturations were measured at all sites, ranging from 50-60% at depth (5-6 mg/L) to 80-90% at the surface (>8 mg/L) at all offshore sites.

Key observations from samples collected around the **Green Point** outfall on **19 March 2025** during strong southerly winds and hot temperatures, with 3mm of rainfall in the preceding three days, include:

- Detectable levels of FIB in mid- and bottom waters at the northwestern boundary of the AMZ, with mid-depth counts of up to 126 CFU/100mL and low bottom counts of between 15 and 40 CFU/100mL;
- Surface samples indicative of sufficient dilution of a plume potentially reaching the surface northeast of the outfall, with sites east of the AMZ showing low enterococci counts of between 15 and 39 CFU/100mL;
- Low FIB counts at mid-shore sites (<13 CFU/100mL) and no FIB detections at nearshore sites;
- Elevated FIB counts in Table Bay, likely indicative of sewage pollution from the Diep and Salt rivers discharging into the bay;
- High average fertilisation success (>94%) in sea urchin gamete toxicity tests for all samples collected from the AMZ;
- No clear pattern in the TSS concentrations, with similar values at all sites and depths;
- Very low turbidity (<1 NTU) at all sites and all depths monitored;
- Decreasing salinity and temperature with depth at all offshore sites;
- Decreasing oxygen saturation with depth, and similar values at all sites except those northeast of the outfall where anomalously low oxygen saturation coincided with the sites at which slightly elevated FIB counts were present to the northeast of the outfall; lower oxygen saturations persisted at all depths at this location, dropping to only 27% in bottom waters, corresponding to dissolved oxygen concentrations of between 2.49 and 2.6 mg/L.

Key observations from samples collected around the **Green Point** outfall on **14 April 2025** during south-westerly winds and moderate temperatures, with 23 mm of rainfall in the preceding three days, include:

- FIB exceeded guideline values for recreation at mid depth at the two north/north-east sites on the AMZ boundary (410 and 980 CFU/100mL respectively), indicative of a less diluted plume reaching the boundary at mid depth, mid-water column salinity values from these sites were also notably fresher than all other sites (**Figure 2-36**);

- Surface enterococci counts were low along the northern section of the AMZ (34-37 CFU/100mL), well within guideline values, suggesting the plume diluted sufficiently prior to reaching the sea surface;
- All mid-shore and nearshore sites had low (<25 CFU/100mL) enterococci counts, with all surface sites < 5 CFU/100mL;
- Both sites in Table Bay displayed high enterococci counts at the surface (135 and 760 CFU/100mL); surface samples from these sites were also less saline than at depth, indicative of polluted river inputs to Table Bay, as noted in previous monthly summaries;
- High average fertilisation success (>97%) at all AMZ boundary sites, with no indication of acute toxicity at the boundary of the AMZ, in spite of high enterococci counts at certain sites;
- Slightly elevated turbidity (3.4 NTU) in mid-depth samples where enterococci counts were highest, attributable to the plume; and
- Warm surface temperatures, decreasing with depth, and supersaturated oxygen (>10 mg/L) at the surface at all sites, decreasing rapidly with depth to as low as 37% saturation (3.3 mg/L concentration), northeast of the AMZ; a link between the effluent plume and the localised low oxygen levels cannot be ruled out.

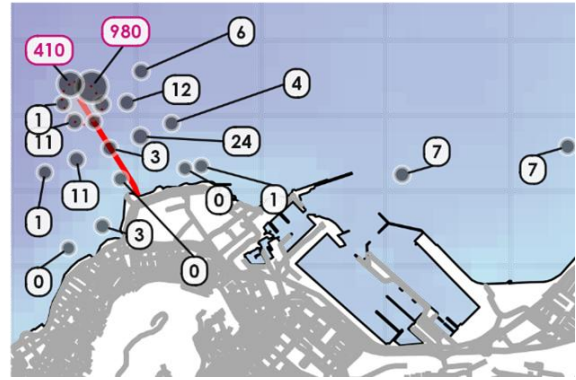


Figure 2-36. Green Point enterococci counts in cfu/100ml at mid-depth in April 2025.

Key observations from samples collected around the **Green Point** outfall on **12 May 2025** during north-westerly winds and cool temperatures, with 31 mm of rainfall in the preceding three days, include:

- Just one instance of enterococci above 65 CFU/100mL was recorded around the Green Point outfall at all depths, with an exceedance of recreational guidelines at the north-western AMZ boundary of 450 CFU/100mL at the surface (**Figure 2-37**);
- FIB were detected at most sites and depths, at low counts; this may be a result of the well mixed, turbulent sea having effectively diluted the plume; nearshore sites were also likely impacted by land-based inputs due to the 30 mm of rainfall prior to sampling;
- Elevated counts were found in Table Bay, likely as a result of separate, land-based sources (a conclusion based on the low FIB values between the outfall and these sites);
- Acceptable average fertilisation success (>88%) at all AMZ boundary sites, with no indication of acute toxicity to urchin gametes on the boundary of the AMZ;
- Supersaturated oxygen concentrations were recorded at the surface at nearly all sites (>120% and >10 mg/L at the surface; >100% and 9 mg/L at mid-depth), dropping to between 60 and 70% at the bottom at offshore sites;
- Turbidity was high at most sites, as high as 22 NTU at mid-depth east of the AMZ and consistent with the presence of floodwaters in the bay; and
- Fairly well-mixed conditions resulting in limited changes in temperature and salinity with depth.

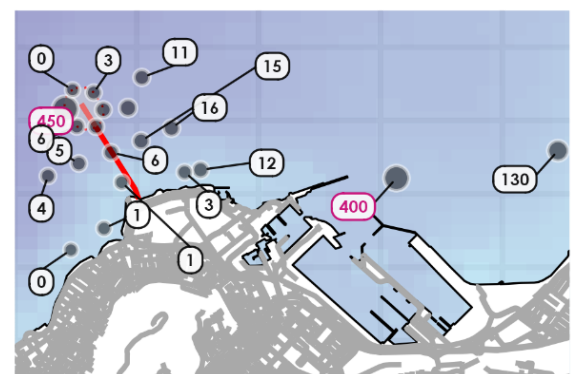


Figure 2-37. Green Point enterococci counts in cfu/100ml at the surface in May 2025.

Key observations from samples collected around the **Green Point** outfall on **12 June 2025** during very calm conditions with moderate temperatures, and 2.8 mm of rainfall in the preceding three days, include:

- Elevated (219 and 286 CFU/100mL) enterococci counts were found on the northern boundary of the AMZ at mid depth; lower enterococci counts were found at most other AMZ, offshore, and mid shore screen sites in mid- and bottom waters – likely a result of a generally well dispersed sub-surface effluent plume;
- Surface FIB counts across Green Point were generally low, with only two detections at 20-60 CFU/100mL on the boundary of the AMZ;
- The Table Bay site outside the Port of Cape Town exceeded recreational water quality guidelines at the surface, with a count of 247 CFU/100mL; once again, based on spatial distributions, likely reflective of a source of pollution in this area not related to the outfall;
- Lower than usual, but acceptable average fertilisation success (>85%) at all AMZ boundary sites;
- Low TSS concentrations at all sites, with no clear spatial pattern evident;
- Low turbidity across most sites, with isolated elevations of up to 15 NTU; and
- Reduced salinities at all depths, and no major change in salinity or temperature with depth, indicating well-mixed conditions.

2.4.3 Effluent plume and dispersion model comparisons

The City of Cape Town undertook detailed, three-dimensional dispersion modelling for the effluent plume at each of the three outfalls, to inform an understanding of the movement of contaminants from the outfall in space and time. The model outputs are reported on (PRDW, 2020a).^{††}

The modelled effluent plume movement is extremely dynamic, but key patterns and trends include:

- The spreading of the AMZ is dominated by longshore currents.
- South-west of the diffuser the currents are characterised by a narrower stream following the coastline. North-east of the diffuser the currents exhibit more two-dimensional features (i.e. variability in flow directions and horizontal eddies as the plume is advected towards Table Bay) which increases the mixing and spreading of the plume.
- South-easterly winds, which are frequent in the summer, advect the bacteria plumes eastwards into Table Bay.
- Onshore movement can occur during certain north-westerly wind conditions (e.g. current direction reversal causing the plume to approach the coastline in the process) or during local upwelling events associated with south-westerly winds.
- The effluent plume rises due to its buoyancy and usually becomes passive at mid-depth due to mixing with the ambient currents or trapping by stratification.
- Periodic surfacing of the plume happens during periods of high wastewater flows or stagnant hydrodynamic conditions.
- The minimum number of dilutions achieved at the boundary of the 256 m radius AMZ is 528 in winter/spring and 687 in summer/autumn (5th percentile dilution).
- The required dilution of 1 753 for TSS is met at distance of 1 400 m from the diffuser in winter/spring and 940 m in summer/autumn (5th percentile dilution).

^{††} Available for download at the time of writing at:

https://resource.capetown.gov.za/cityassets/Media%20Centre%20Assets/B_Numerical_Dispersion_Modelling_Reports_Marine_Outfalls.zip

The effluent plume with its elevated TSS is periodically visible as a lighter colour at the water's surface at the Green Point outfall. Over the first 12 months of monitoring, a visually identifiable effluent plume was present on more than one occasion during sampling.

FIB, specifically intestinal enterococci, are a useful indicator for tracing the dispersion and dilution of domestic wastewater in a marine receiving environment, since these bacteria are found only in faeces and are usually not present in unpolluted waters. The presence of high counts of enterococci in seawater collected near the outfalls should thus reflect the presence of wastewater (CSIR, 2017a). FIB counts suggest that the Green Point plume was detected at the boundary of the AMZ on several occasions during the year of monitoring:

- In winter, at mid-depth north of the outfall (June 2025 in variable winds);
- In spring, summer, and autumn, at mid-depth northeast of the outfall (September 2024, November 2024 and February 2025, in southerly winds and in April 2025 in south-westerly winds);
- In spring, at the surface and in mid-water south and east of the outfall (October 2024 in south-easterly winds);
- In summer, at mid-depth northwest, west and south of the outfall (December 2024 in north-westerly winds);
- In summer, at mid-depth northwest of the outfall and at the surface northeast of the outfall (March 2025 in southerly winds);
- In summer at mid-depth south of the outfall (January 2025 in southerly winds); and
- In autumn, at the surface west of the outfall (May 2025, in north-westerly winds).

Enterococci were also detected at levels that exceeded recreational water quality guidelines in surface waters in Table Bay and at nearshore sites on three occasions: in July 2025, August 2025, October 2024 and July. These were typically associated with rainfall events that resulted in widespread contributions of faecal pollution from both the outfall, stormwater, and other land-based sources of surface runoff. The exceedances in October 2024 could not be clearly or directly attributed to a specific source. These findings align well with modelled conditions reported by PRDW (2020a).

2.4.4 Compliance with Permit Conditions

2.4.4.1 Temperature

The 1995 SAWQ Guidelines specify that the temperature in the receiving environment should not exceed 1°C above or below the ambient temperature. The 2022 draft Guidelines also set the temperature range relative to the ambient temperature of the environment but specify that the temperature should not fall outside the 20th and 80th percentiles of a suitable reference data set.

As described in §2.4.1.1, sea temperature was highly variable seasonally across all depths. Compliance assessments therefore utilised mean temperature values as a better comparator for highly variable data.

The annual mean temperatures at the boundary of the AMZ of the Green Point outfall fell within 1°C of the values at the Robben Island reference site, throughout the water column (**Figure 2-38**). The median values of the annual temperatures at the boundary of the AMZ fell between the 20th and 80th percentiles of the temperature values at the reference site.

Compliance statement: All temperature measurements at the Green Point AMZ were compliant with the 1995 Guidelines and the 2022 draft Guidelines.

2.4.4.2 Salinity

In the 1995 guidelines, salinity is measured against a target range of values, relevant to the coastal zone of South Africa. The 2022 guidelines for salinity indicate that values should be measured against a range defined by the 20th and 80th percentiles of a suitable reference data set.

The annual mean salinity at the AMZ of the Green Point outfall fell within the target range for all sites throughout the water column, according to the 1995 guidelines. Only one value was close to the upper limit of the range - the surface value at the Robben Island reference site, with an annual mean of 35.9 PSU (**Figure 2-38**).

The target range defined by the 20th and 80th percentiles of reference site data was higher than the target range in the 1995 guidelines (35.6 to 36.3 PSU at the surface at the reference site).

The mean and median for bottom waters on the boundary of the AMZ fell within the guideline range based on the Robben Island 20th and 80th percentiles.

However, the mean and median for the values from the middle of the water column tended to fall just below the 20th percentile. The mean and median were close together, indicating that the tendency throughout the year was for slightly fresher water in the middle of the water column relative to the range defined by the 20th and 80th percentile. This may be indicative of the effluent plume reaching the AMZ in mid-depth waters and contributing to reduced salinity at this depth.

The median values for surface AMZ samples fell within or just below the 20th to 80th percentile range, while the means generally fell below the medians, indicating a few low outliers. It is worth noting that the surface waters at GP017, which is located directly over the pipeline on the shoreward boundary of the AMZ, had the lowest mean salinity over the year. This mean value included two very low salinity values in July and August 2024 (July: 27.6 PSU, August: 32.5 PSU), where the surface salinity was low across Table Bay due to high rainfall. The mean salinity for the other 10 months of the year was 35.5 PSU at this site.

Compliance statement: All sampled salinity values at the Green Point AMZ at all depths were compliant with the 1995 Guidelines for salinity. The mid-depth salinity (both mean and median) for all AMZ sites was lower than the target range determined in terms of the 2022 draft Guidelines based on the Robben Island reference site. The mid-depth difference is attributed to the likely effects of the freshwater effluent plume reaching the boundary of the AMZ; the surface difference from reference site conditions may be at least partially due to effects of the effluent plume, but was also strongly influenced by low salinities during winter rainfall flooding events – events which did not have an effect on salinity values as far offshore as Robben Island. Bottom water samples from all AMZ sites were within target ranges.

2.4.4.3 Dissolved oxygen

Target values and ranges for dissolved oxygen are generally specified according to lower limits. The 1995 Guidelines have specific target lower limits for the south and east coasts, but for the west coast the 1995 Guidelines specify that dissolved oxygen should not fall below 10% of established natural variation. According to the 2022 draft Guidelines, the values should not fall below the 20th percentile of an appropriate reference data set. Oxygen concentration was highly variable both on a seasonal basis and among sites, and both mean and median values were used for comparison.

The annual mean dissolved oxygen concentrations at the boundary of the AMZ of the Green Point outfall did not vary greatly from those at the reference site. Generally, dissolved oxygen was highest at the surface and lowest at the bottom of the water column. No site differed from the reference site by more than 10% (**Figure 2-38**). Neither the median nor the mean of the dissolved oxygen measured

at sites on the boundary of the AMZ fell below the 20th percentile of the reference data set (Figure 2-38).

Compliance statement: All Green Point AMZ oxygen concentrations at all depths were compliant with both the 1995 Guidelines and the 2022 draft Guidelines for dissolved oxygen.

2.4.4.4 Turbidity

Turbidity data were measured as absolute values in nephelometric turbidity units, which can only be assessed in terms of the 2022 draft Guidelines and compared to the 80th percentile of the reference data. Mean data are used for comparison purposes because turbidity values at sites in Green Point and at the reference site included a number of zero readings (refer to footnote on page 40) that resulted in median values of zero at both the reference site and at most sample sites. Median values were at or below the 80th percentile of the reference data set (exceptions GP012M median = 0.01 NTU and GP014M median = 0.01 NTU).

The mean turbidity values at the Robben Island reference site were low (maximum 0.54 NTU at the surface).

All AMZ turbidity values were higher than the reference site, with the highest mean turbidity being 4.6 NTU at GP011. The middle and bottom depths had lower turbidity than the surface, but still higher than the reference sites. One site (GP012) had relatively high turbidity throughout the water column, and two sites (GP011 and GP017) had elevated turbidity at the bottom of the water column relative to other sites. Every AMZ site's mean turbidity exceeded the 80th percentile of the reference site data at the relevant depth.

Data were skewed by a few outliers across the sites as July and especially August 2024 showed high TSS readings as a result of high rainfall, and resultant river and stormwater runoff into Table Bay and Green Point. Although the mean values exceeded the 80th percentile of the reference data, the turbidity values were generally low.

Compliance statement: Mean turbidity at all Green Point AMZ sites exceeded reference site values by more than 10%. Absolute values were low and most often zero, and mean values were skewed by elevated turbidity during two winter sampling events.

2.4.4.5 Total suspended solids

The recommended concentration of TSS in the receiving environment is specified as an upper limit against a background concentration. The 1995 Guidelines state that the concentration of TSS should not be increased by more than 10% of the ambient concentration. The 2022 draft Guidelines recommend that the TSS be measured against the 80th percentile of a suitable reference data set.

The median concentrations fell below the 80th percentile of the reference value for all sites, throughout the water column.

The mean concentration of TSS at the boundary of the AMZ of the Green Point outfall generally fell within 10% of the mean concentration at the reference sites, with a few exceptions. Three sites had mean concentrations at the bottom of the water column more than 10% higher than the reference site RI001 (23.5 mg/L), namely GP013 (26.6 mg/L), GP015 (36.8 mg/L) and GP017 (30.3 mg/L).

TSS data are skewed by a few outliers. Most of the AMZ sites experienced high TSS throughout the water column in July 2024, with the highest values seen at the bottom of the water column.

Compliance statement: Mean TSS concentrations at three Green Point AMZ sites exceeded reference site mean values by more than 10%, but only in bottom waters. Median values across the sites and throughout the water column did not exceed the 80th percentile of the data from the Robben Island reference site. The difference when comparing means and medians suggests that the data at AMZ sites are generally within similar ranges to reference sites, but a small number of higher values in bottom waters resulted in means higher than reference sites.

2.4.4.6 pH

The 1995 water quality guidelines specify a range of pH values, as 7.3 to 8.2. The 2022 guidelines specify that a range needs to be calculated from the 20th and 80th percentiles of a reference data set suitable to the discharge location. Additionally, the guidelines specify that any deviations of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated.

For the Green Point marine outfall, pH median values for all sites fell within the range specified by the 1995 guidelines, and within the range defined by the 20th and 80th percentiles of the Robben Island reference site. None of the sites had pH values that fell outside the seasonal range (summer = October to March, winter = April to September).

Compliance statement: Median pH values throughout the water column across all sites fell within the guideline range based on data from the Robben Island reference site.

2.4.4.7 Concluding statement on compliance

Temperature, salinity, dissolved oxygen and pH at the Green Point marine outfall were compliant with permit conditions at the boundary of its AMZ during the study period. Turbidity and TSS were not compliant with permit limits based on reference site comparisons, due to increases during winter sampling events that are attributed to environmental, rather than anthropogenic, causes. FIB counts suggested that recreational activity on the boundary of the AMZ (were this to take place, although the AMZ is not recommended for full-contact recreation) would have posed a risk to human health on at least three occasions, and Hazen-based categories calculated for the AMZ sites were 'Poor' at five, and 'Sufficient' at one of the six sites monitored – these categorisations are however strongly influenced by the low sample count (n=12), and are less valuable as measures of risk than the recreational water quality sampling carried out at a higher frequency by the CCT and reported in §2.6, which indicates that most sites along the Green Point shoreline were not exposed to regular incidences of faecal contamination at levels that would pose a risk to recreational users. The exceedances at Green Point occurred during winter flood events and are not believed to relate to the marine outfall specifically.

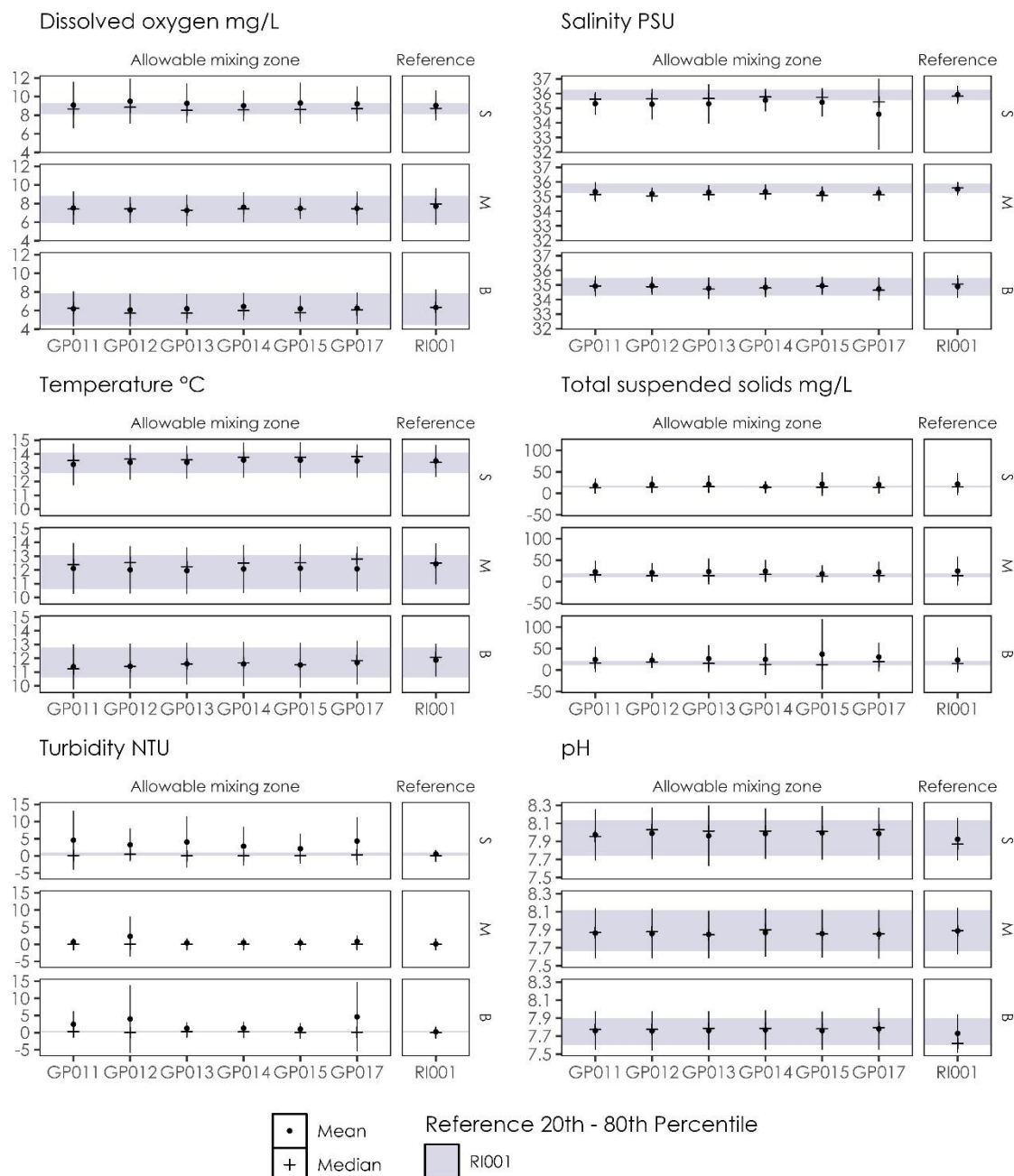


Figure 2-38. Annual median values for six of the parameters required to be monitored by the Coastal Waters Discharge Permits, relative to the reference site. Annual mean $\pm$ SD (points + error bars) is also shown for sites on the boundary of the allowable mixing zone for the Green Point marine outfall, shown against the 20th and 80th percentiles of the values from the Robben Island reference site. For pH, the error bars show IQR, not standard deviation.

2.5 Hout Bay Outfall: Results and Discussion

Sample sites for the Hout Bay outfall are shown in **Figure 2-39**.



Figure 2-39. Sample sites for water quality around the Hout Bay outfall and its corresponding reference sites at Chapman's Peak (CP001) and Crayfish Factory (CF001, near Kommetjie).

All water quality data for the first year of Hout Bay outfall sampling are tabulated in **Appendix II**.

2.5.1 Seasonal patterns and variation in water quality

2.5.1.1 Temperature

Sea temperatures varied seasonally at most sites (Figure 2-40), with lower temperatures in summer; the only exceptions to this pattern were the shallow nearshore sites which had more similar median temperatures throughout the year. Deeper offshore sites had lower temperatures at depth in summer. Summer temperatures were typically more variable than winter temperature in surface waters and at mid-depth, while in winter the bottom waters at deeper sites had the greatest temperature range. The highest recorded temperature was 19.3°C at the surface near the Hout Bay Harbour, and the lowest was 9.1°C in mid-water at the AMZ.

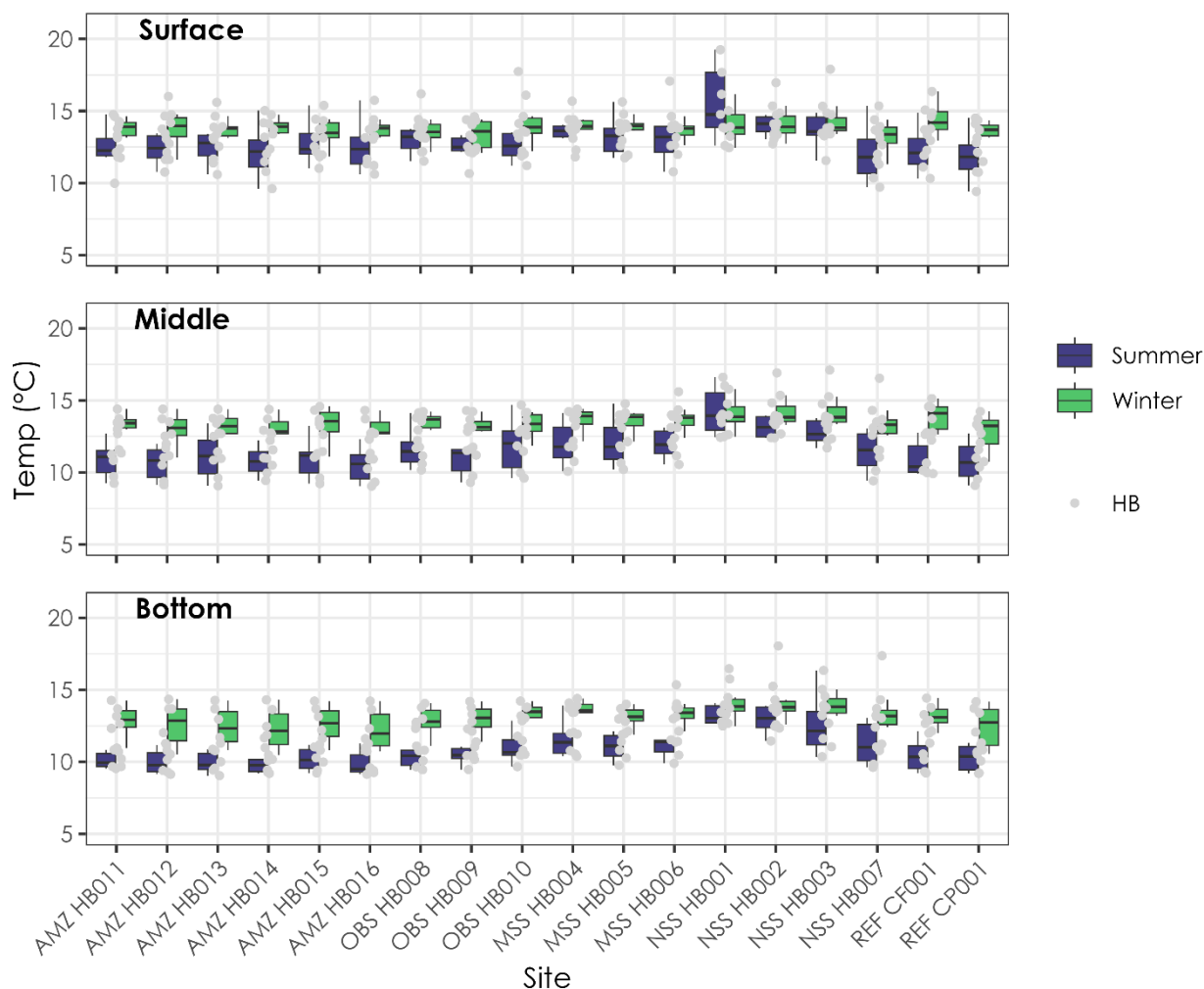


Figure 2-40. Boxplots indicating the seasonal variability of temperature for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B). Summer, displayed in purple, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.5.1.2 Salinity

Salinity (Figure 2-41) was highest in winter in bottom waters for all sites, and also tended to be higher in mid-depth samples at the deepest AMZ sites and at the offshore reference site south of Kommetjie. At the surface, salinity was higher in summer than in winter at all sites. There was substantial variability in all summer surface sites and a few winter sites, in AMZ and outer-bay sites at depth in winter and in particular in bottom waters at sites closest to the Hout Bay River outflow and other sources of land-

based runoff. Both the highest (37.5 PSU) and the lowest (32.4 PSU) salinity were recorded in summer at site HB002 directly offshore of the river mouth.

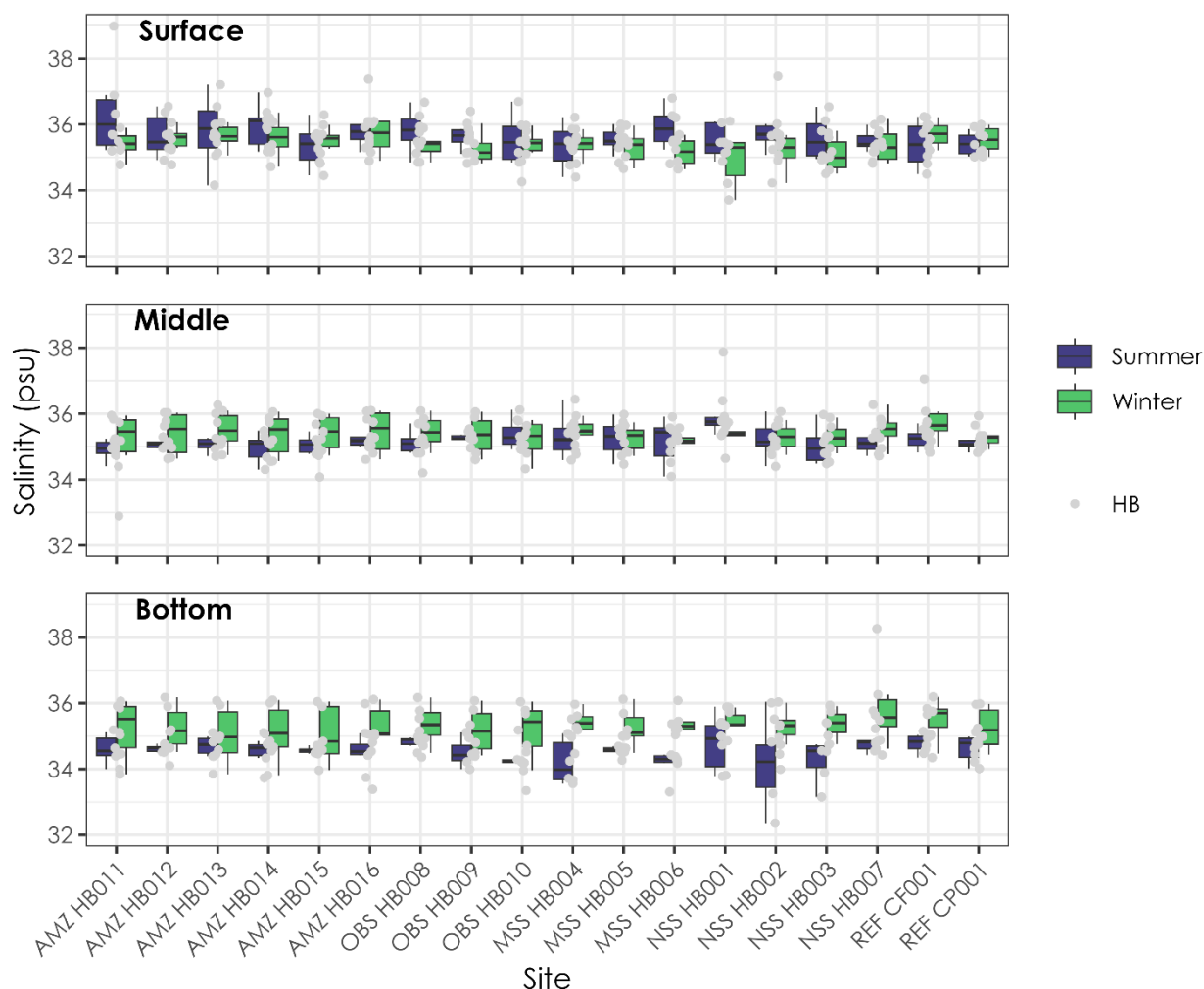


Figure 2-41. Boxplots indicating the seasonal variability of salinity for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B). Summer, displayed in purple, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites respectively.

2.5.1.3 pH

A clearly defined seasonal cycle was observed for pH (Figure 2-42). pH was lower in summer compared to winter across all sites and depths and there were relatively large differences between their medians. pH did appear to decrease slightly with depth as summer minimums reach closer to the 7.5 mark and winter medians decreased below 8.0 particularly within the AMZ, outer-bay and reference sites where water depths were greatest. Winter pH was more variable than summer, with the highest record being 8.7 at HB010S in the outer bay and the lowest being 7.3 at HB014B on the AMZ in winter. The lowest pH was 7.2 in summer, also on the AMZ boundary at the surface.

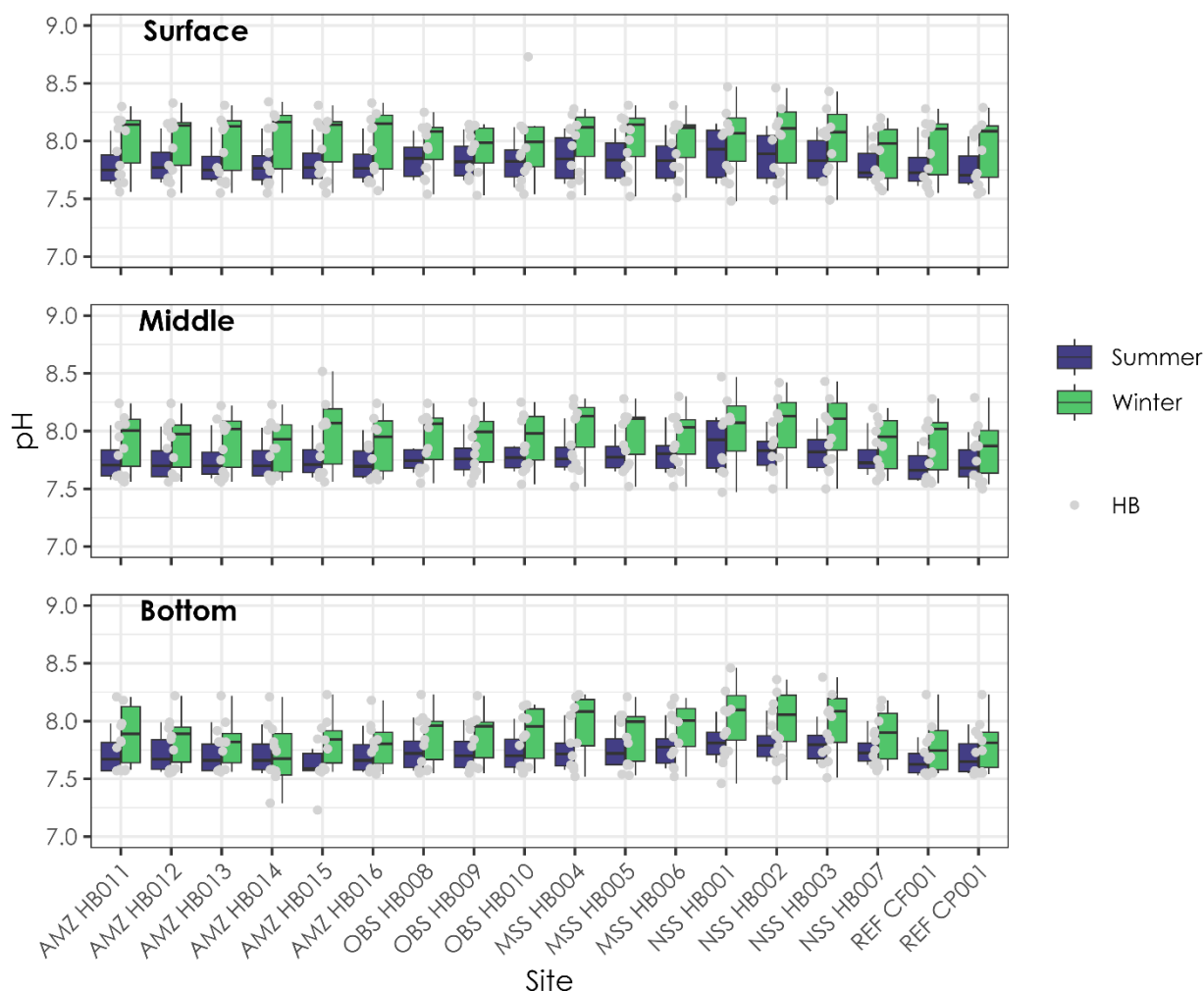


Figure 2-42. Boxplots indicating the seasonal variability of pH for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B). Summer, displayed in purple, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.5.1.4 Dissolved oxygen

Dissolved oxygen saturation varied seasonally with lower values in summer and higher values in winter across all depths (apart from site HB001 adjacent to the harbour at all depths, and site HB007 near Duiker Island, where the inverse was true; Figure 2-43). Generally, surface waters were the most oxygenated and often super-saturated (130%) at most sites except the AMZ and reference sites. Saturation progressively decreased with depth in all seasons, but this stratification was less defined at the shallower, nearshore sites. A similar pattern was observed for dissolved oxygen concentration. At the surface, all median oxygen saturation values were above 80%, decreasing to below 80% at deeper sites at middle depth in the summer. The maximum and minimum dissolved oxygen concentration was 11.75 mg/L (HB005) and 5.21 mg/L (HB010) at the surface respectively. In bottom waters, some winter medians also fell below the 80% saturation mark. Oxygen saturation was more variable at depth and at a few surface sites. The lowest value recorded was 44.3% in bottom waters at the Kommetjie reference site. The maximum and minimum dissolved oxygen concentration was 11.31 mg/L (HB002) and 4.03 mg/L (CF001) at bottom depth respectively.

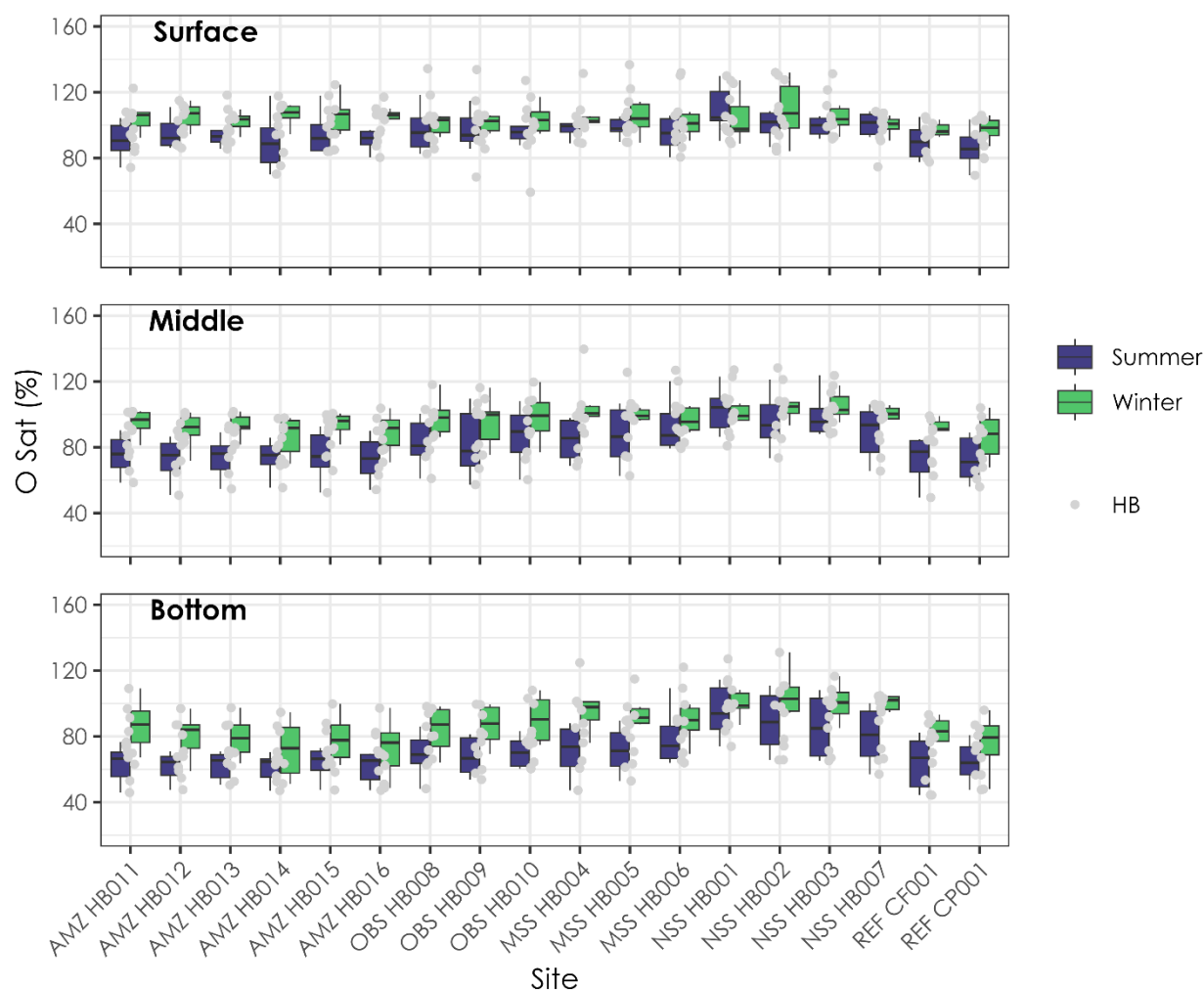


Figure 2-43. Boxplots indicating the seasonal variability of oxygen saturation for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B). Summer, displayed in purple, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.5.1.5 Total suspended solids

TSS did not display a prominent seasonal cycle as most observations remained within similar ranges between summer and winter (Figure 2-44). Medians ranged between 11.5-23.5 mg/L. Most TSS values remained below 40 mg/L, although several outliers were present among all site types. Almost all outliers occurred in winter across all depths, typically ranging between 95 and 150 mg/L. The only elevated value that occurred in summer was 223 mg/L at the site adjacent to the Hout Bay Harbour at bottom depth, which was also the highest recorded for Hout Bay.

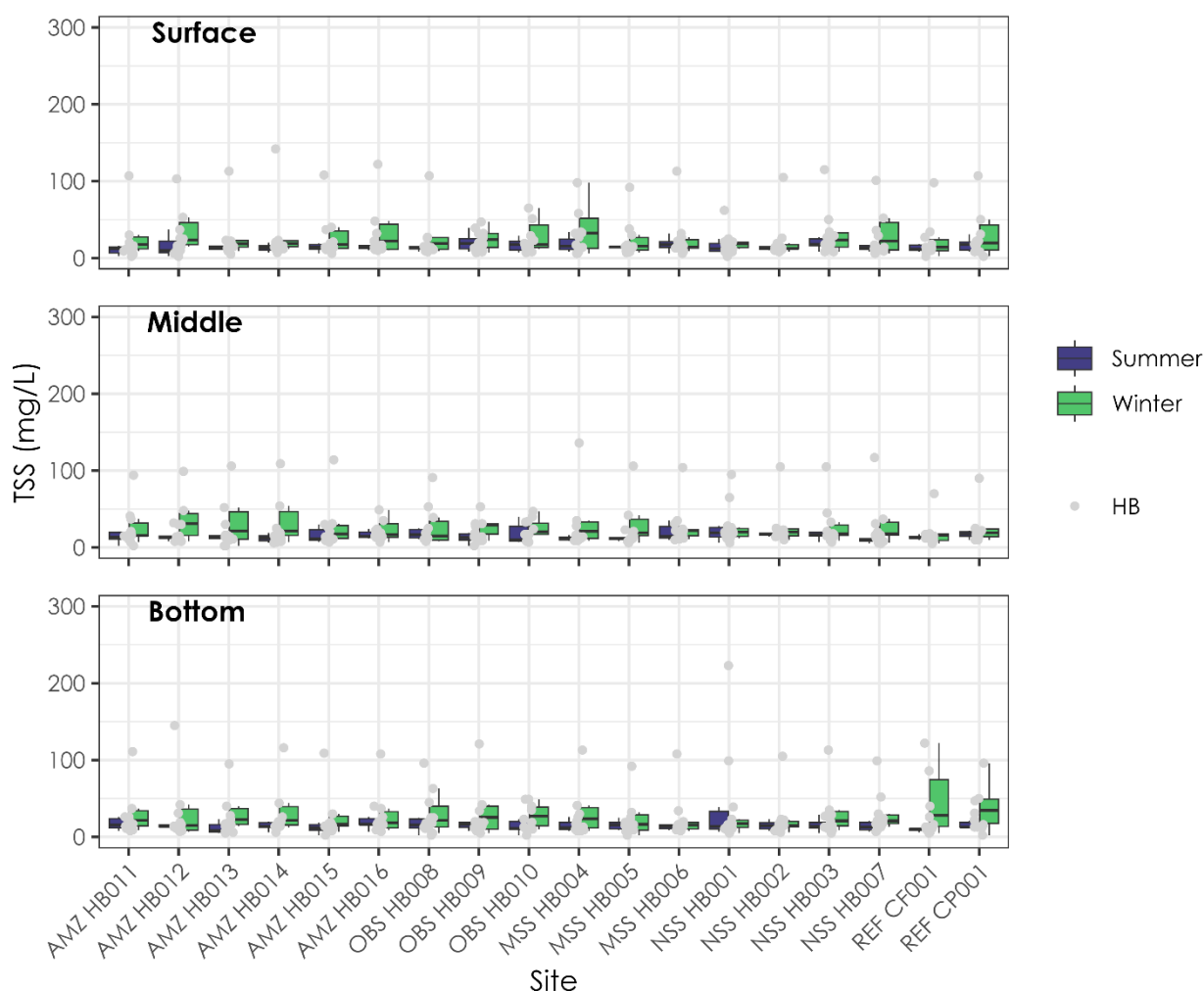


Figure 2-44. Boxplots indicating the seasonal variability of total suspended solids (TSS) for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B). Summer, displayed in purple, was defined as months from October to March. Winter, displayed in green, was defined as months from April to September. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.5.1.6 Enterococci

Enterococci were frequently detected in samples collected from Hout Bay, particularly at mid-water depths at sites on the boundary of the AMZ, and to lesser extents in surface waters in the middle of the bay and near the beach (Figure 2-45). Of the AMZ sites, the northern boundary (HB011) at mid-depth was where enterococci were most frequently detected. Periodic detections of bacteria in bottom waters at site HB005, located distant from the outfall and other known point sources of sewage pollution in the middle of the bay, are also noteworthy and not explained by available data.

In Hout Bay, while bacteria were frequently detectable in seawater samples, they exceeded risk-based guideline values in only six samples on the AMZ boundary (five at mid-depth and one at the bottom), and four times in mid-bay (three times at site HB005, of which two were at the bottom and one in mid-depth). Site HB001 near the harbour had two exceedances, once in mid-water and once at the surface.

The following section provides a month-by-month summary of key water quality data, interpreted with regard to the spatial distribution of the monitoring stations relative to the outfall.

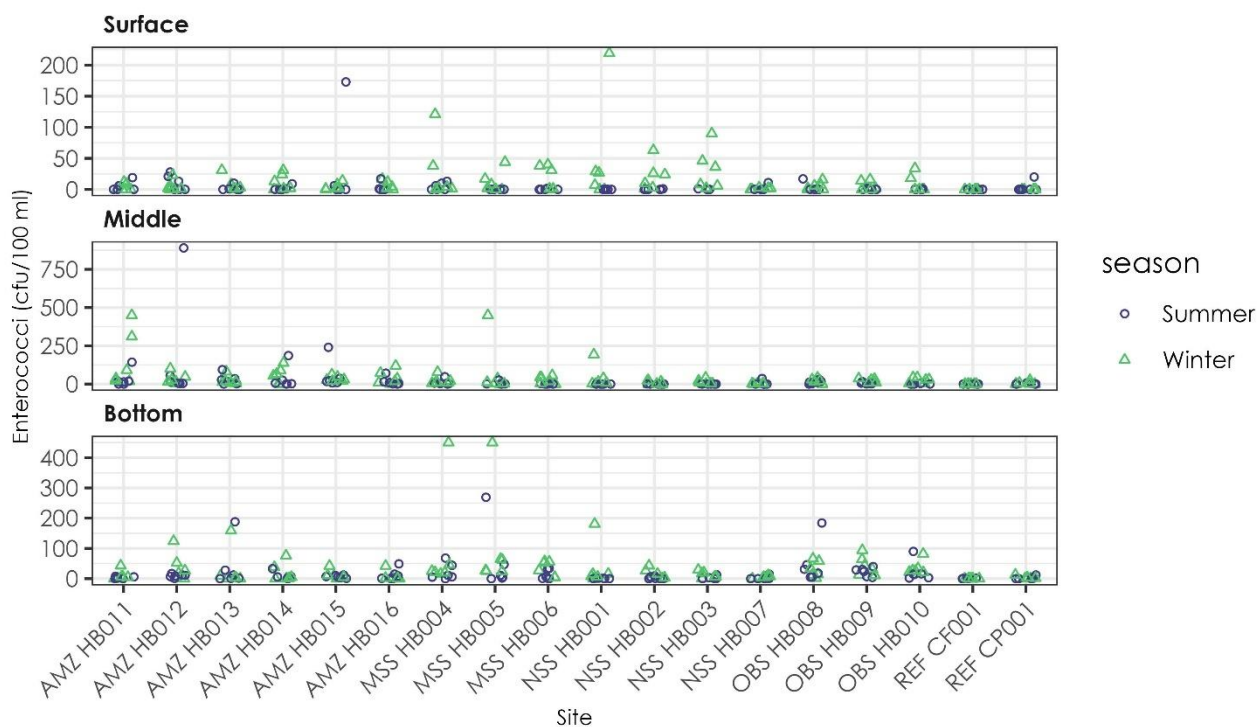


Figure 2-45. Distribution of enterococci counts in CFU/100mL for each of the Hout Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Site IDs prefixed by AMZ, MSS, NSS, OBS and REF indicate allowable mixing zone, mid-shore screen, nearshore screen, outer-bay screen and reference sites, respectively. Note vertical scales differ.

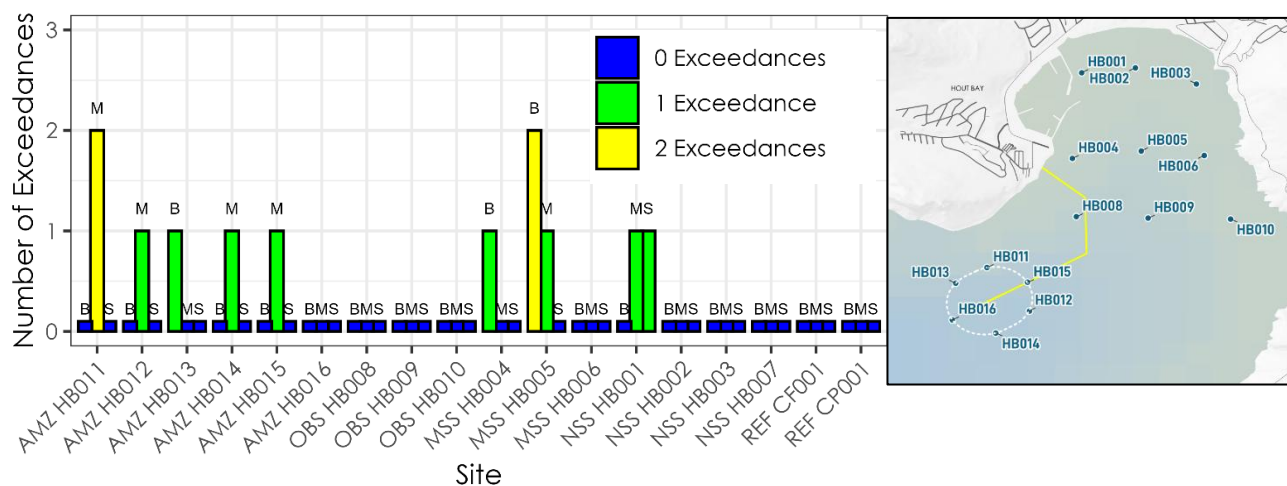


Figure 2-46. Bar plots indicating the number of times that the count of enterococci in CFU/100mL exceeded the guideline threshold of 185 CFU/100mL enterococci for each of the Hout Bay sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Green bars indicate zero exceedances, and yellow bars indicate 1 exceedance. Site IDs prefixed by AMZ, OBS, MSS, NSS and REF indicate allowable mixing zone, outer-bay screen, mid-shore screen, nearshore screen and reference sites, respectively.

2.5.1.7 Environmental toxicity testing

In Hout Bay the average fertilisation success rate was generally slightly higher in the winter months than in the summer months, with the exception of bottom water at the AMZ site HB013 (Figure 2-47). All average values were non-toxic and variation was low in all but five sites across all depths. Toxic samples were recorded at the Chapman's Peak mid-water Reference site and Crayfish Factory reference site bottom water in February, and low average fertilisation success (<73%) at the HB013 Bottom and HB016 Surface water site in March, explaining the higher variance and lower average fertilisation success seen at these sites in summer. In winter, only a single toxic sample occurred at the HB013 Bottom water site in April 2025.

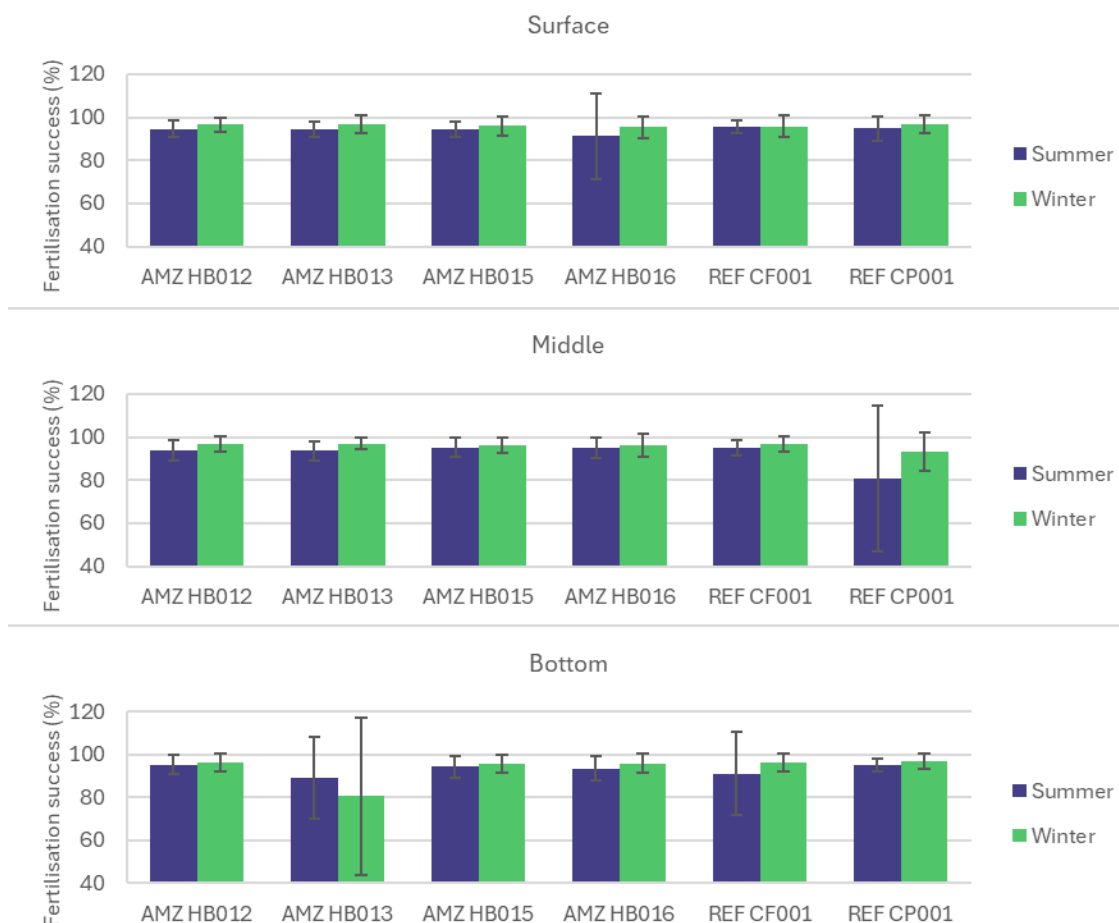


Figure 2-47. Boxplots indicating the seasonal variability of sea urchin toxicity (percentage fertilisation success) for each of the Hout Bay outfall sites for the three depth categories – surface (S), middle (M), and bottom (B) for the period July 2024-June 2025. Summer, displayed in dark blue, was defined as months from October to March. Winter, displayed in green, was defined as months April to September. Site IDs prefixed by AMZ and REF indicate allowable mixing zone and Crayfish Factory (CF) and Chapmans Peak (CP) reference sites, respectively.

2.5.2 Monthly data summaries

Key observations from samples collected around the **Hout Bay** outfall on **17 July 2024** in north-westerly winds, with 73 mm of rain in the preceding three days and cold temperatures, include:

- FIB were not detected in surface or bottom water samples on the boundary of the AMZ, but were present in moderate numbers at all sites around the AMZ in mid-water (between 35 and 81 CFU/100mL, and in excess of the upper limit of quantification at the northern inshore AMZ site (>150 CFU/100mL);
- This suggests that the effluent plume reached the boundary of the AMZ at mid-depth (approx. 15 m below the surface), and that if it reached the sea surface at all it had diluted to the point that faecal bacteria were not present in detectable quantities;
- Sites in the bay had generally elevated FIB counts at all depths on this date:
 - Counts ranged from 0 to 90 CFU/100mL in the screen of sites nearest the beach;
 - Counts were higher in the mid-bay screen, with >150 CFU/100mL at bottom and mid-depths;
 - No FIB were detected at the surface in the screen of sites in the outer bay closest to the outfall, although low counts (15-43 CFU/100mL) were present in mid- and bottom waters at these sites;
 - No FIBs were detected at the reference sites at Chapman's Peak and Crayfish Factory, nor at the Dungeons surf break site;
- Relatively lower salinities were measured at all depths in the inner part of the bay closest to the Hout Bay River estuary, suggesting that flood waters from the rainfall event preceding sampling (73 mm of rain) in July 2024 were a contributing factor to elevated bacterial counts in the inner bay;
- The sites on the AMZ, which are the deepest sites monitored in this programme at depths of between 33 and 40 m, displayed a clear salinity gradient with less saline waters at the surface and higher salinities at depth;
- Oxygen saturations were high at all sites, including at depth (>80% saturation at all sites), and did not display any apparent reduction in response to the effluent plume on the boundaries of the AMZ; supersaturated conditions were present at most mid-bay and AMZ sites (>100%);
- TSS concentrations were high throughout the bay, including at the Dungeons site, indicative of post-rainfall elevation seen elsewhere during the July 2024 survey;
- Turbidity was elevated above zero at most sites, with the highest values recorded in bottom waters (likely due to turbulent conditions stirring up sediment), and no evident spatial pattern; and
- High average fertilisation success in sea urchin toxicity tests from around the AMZ (>96%) at all depths, suggested no evidence of toxicity despite the presence of the diluted effluent plume on the AMZ boundary.

Key observations from samples collected around the **Hout Bay** outfall on **15 August 2024** in strong north-westerly winds, with 46 mm of rain in the past three days and cold temperatures, include:

- Low enterococci counts at sites on the AMZ boundary at all depths, ranging from 0 to 7 CFU/100mL at the bottom, through 0-27 CFU/100 ml in mid-water, and 0-24 CFU/100mL at the surface; these may indicate a very dilute plume reaching the boundary of the AMZ, but are not readily distinguishable from the potential contribution of the Hout Bay River – all sites within the bay also had slightly elevated enterococci counts at all depths, ranging from 18 to 63 CFU/100mL with the highest counts in surface waters near the mouth of the river;
- Surface waters in the inner part of the bay were fresher, indicative of the presence of floodwaters from the river and lending support to the conclusion that land based sources may have contributed to the widespread, albeit at low levels, detection of enterococci across the bay;

deeper sites, including those on the outer bay and AMZ, had higher salinities and depth profiles typical of well-mixed conditions;

- The river outflow was similarly apparent in water temperature data, which were cooler in surface waters close to the beach than at all other sites and depths;
- Oxygen saturations were high at all sites and depths; and
- Very high average fertilisation success was attained in urchin toxicity tests from around the AMZ (>98%) at all depths.

Key observations from samples collected around the **Hout Bay** outfall on **17 September 2024** in shifting north-westerly and south-westerly winds, cold temperatures, and 4 mm of rain in the preceding three days, include:

- Evidence of the effluent plume reaching the northern boundary of the AMZ at mid-depth, in the form of elevated (310 CFU/100mL) enterococci counts at this location (**Figure 2-48**); Low enterococci counts (0-38 CFU/100mL) were recorded at all other AMZ sites, suggesting effective dilution and dispersion before the plume reached the surface;
- FIB were detected in all bottom water samples, albeit at low levels, with the highest value of 61 CFU/100mL at HB005 (mid bay);
- Nearshore screen sites had negligible FIB counts (<5 CFU/100mL), with the exception of HB003, on the north-eastern shore of Hout Bay (46 CFU/100mL), which also displayed lower salinity than other sites; based on mid-shore FIB and salinity values, it is likely these slightly elevated bacterial counts were driven by land-based sources of faecal contamination;
- Generally lower TSS concentrations at all sites than during the preceding two months' sampling, with no clear spatial pattern;
- Turbidity was generally below 10 NTU at all sites and depths, with the highest turbidity (>8 NTU) at sites closest to the beach and the Hout Bay River – likely due to a combination of the polluted river inflows, and wave action causing sediment entrainment;
- Seawater temperature data showed partial thermal stratification at deeper sites, with cooler temperatures at depth and warmer temperatures at the surface;
- Oxygen saturation was high at all sites and all depths, and supersaturated at the surface; and
- High average fertilisation success was attained in sea urchin toxicity tests from around the AMZ (>95%) at all depths.

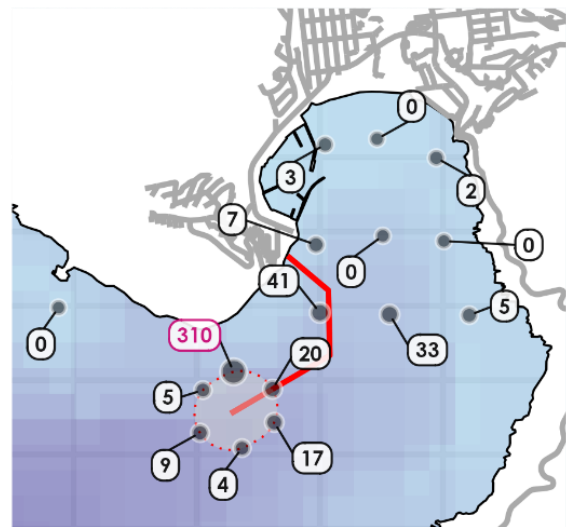


Figure 2-48. Hout Bay enterococci counts in cfu/100ml at mid-depth in September 2024.

Key observations from samples collected around the **Hout Bay** outfall on **18 October 2024** in southerly and south-westerly winds, with no significant rainfall and moderate temperatures, include:

- FIB were not detected in the nearshore screen sites at any depth (8 of 9 samples did not detect enterococci, and the ninth had 1 CFU/100mL) during this sampling event; this survey corresponded with the beginning of the summer dry season during which river flows are generally reduced and sewage-contaminated runoff would be reduced;
- The north-east sample on the AMZ boundary at mid-depth had elevated enterococci at 240 CFU/100mL, while all other AMZ counts were <15 CFU/100mL;

- Sites in the mid-bay and outer bay screens had non-zero FIB counts of up to 90 CFU/100mL, which, coupled with the low counts in the nearshore sites, suggests that the diluted wastewater may have been advected north-east into the bay (below the surface), but in concentrations well below guideline values for recreational use;
- Salinity was generally high at the surface, and lower at depth at the mid-bay and AMZ sites; this inverse halocline was associated with a relatively pronounced thermocline, with temperatures at depth of 10-11°C compared with surface temperatures of 13-14°C;
- Oxygen saturation decreased with depth at deeper sites in the mid- and outer bay (a function primarily of lower temperatures and increased pressure, as dissolved oxygen concentrations were consistently above 8 mg/L at all depths);
- No clear spatial trend in TSS concentrations was distinguishable in the data; turbidity was also very low at most AMZ and mid-bay sites at all depths;
- High average fertilisation success was attained in urchin toxicity tests from around the AMZ (>95%) at all depths, despite the presence of the effluent plume.

Key observations from samples collected around the **Hout Bay** outfall on **12 November 2024**, with no recent rainfall and strong, variable winds from westerly and south-easterly directions in the preceding three days and moderate temperatures, include:

- FIB were either not detected or were present at very low counts in the nearshore and mid-bay screen sites during this survey;
- High bacterial counts were present at mid-depth on the AMZ boundary (890 CFU/100mL) but had diluted to low levels (28 CFU/100mL) by the time the plume reached the surface. The plume appeared to have been advected northwards towards the outer bay screen site, with elevated FIB detected in bottom water samples (184 CFU/100mL) (Figure 2-49);
- Slightly lower average fertilisation success in sea urchin toxicity tests was attained at the mid-depth AMZ site which had very high FIB counts: 92.3%, or about 5% lower than the average on this date at all other AMZ sites, likely reflecting diluted wastewater exposure, but well above the acute toxicity threshold of 70% defined for the tests;
- No distinguishable spatial trend in the TSS data was observed, and turbidity was below 2 NTU at all sites and depths;
- Temperature data displayed a clear thermocline; a slight halocline was also evident, with lower salinities at depth; and
- Oxygen saturation was consistently near 100% (8-9 mg/L) across the depth profile in shallower nearshore sites, and decreased in bottom waters at deeper sites to between 60 and 70%, translating to between 6 and 7 mg/L.

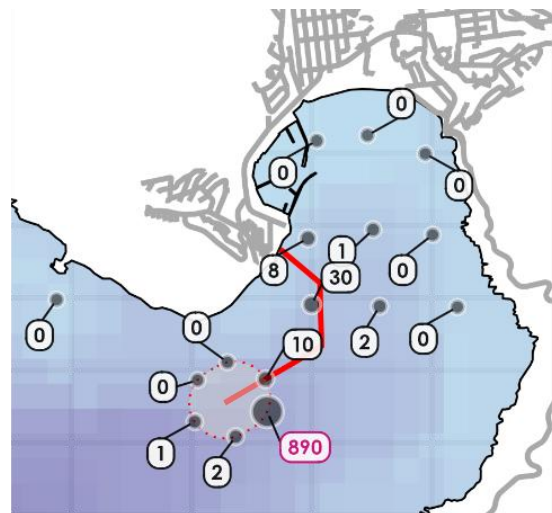


Figure 2-49. Hout Bay enterococci counts in cfu/100ml at mid-depth in November 2024.

Key observations from samples collected around the **Hout Bay** outfall on **10 December 2024** during light westerly and south-westerly winds and warm temperatures with no rainfall include:

- Virtually no FIB were detected in surface waters during this sampling event (all sites were non-detects, with the exception of two sites – 10 and 1 CFU/100mL each);
- FIB counts suggested the effluent plume had been advected south from the outfall in mid-waters, with enterococci counts of 186 CFU/100mL on the southern AMZ boundary at this depth;

- A high enterococci count was recorded in bottom waters from the middle of the bay (269 CFU/100mL) at site HB005; a source could not be traced, as there was no apparent elevation of enterococci in mid-depth or at surrounding sites and the site did not correspond to any changes in salinity, temperature, or TSS;
- A strong thermocline was observed, with warm sea surface temperatures and cool bottom waters at all deep-water sites;
- Generally very low (<5 NTU) turbidity was found at all sites and depths;
- Supersaturated oxygen levels (in excess of 10 mg/L) were recorded at the sea surface at all sites, decreasing with depth to between 60 and 70% in bottom waters at deepwater sites (~6 mg/L); and
- All toxicity tests revealed high fertilisation rates, indicating no acute toxicity of seawater on the boundary of the AMZ.

Key observations from samples collected around the **Hout Bay** outfall on **22 January 2025** during strong southerly and south-easterly winds and warm temperatures with minimal rainfall include:

- Low FIB counts at all sites and depths, indicating the plume did not reach, or had sufficiently diluted within, the bounds of the AMZ; all sites had fewer than 18 CFU/100mL in surface and bottom water samples;
- Low enterococci counts were observed throughout the water column at Dungeons (HB007: 11 to 36 CFU/100mL), possibly illustrative of the advection of the effluent plume in a north-westward direction under the prevailing south-easterly winds; however, there is a large seal colony close to the sample point which may have also contributed to this slight elevation;
- Salinity and temperature were slightly lower at depth;
- Low turbidity at all sites, with no readings above 1 NTU;
- Generally low (<90% saturation, between 5.0 and 6.0 mg/L concentrations) oxygen at the surface at offshore sites, potentially indicative of lower-oxygen water brought to the surface in a south-easterly wind driven upwelling event, and reflected at the two reference sites where surface oxygen saturation was also below 80%; and
- Lower fertilisation rates in sea urchin toxicity tests, typically less than 90% fertilisation but not below the threshold for acute toxicity.

Key observations from samples collected around the **Hout Bay** outfall on **7 February 2025**, during strong south-easterly winds and warm temperatures with 5.6 mm of rainfall in the past three days, include:

- Evidence of a diluted effluent plume reaching the northern and western boundary of the AMZ at all depths, with enterococci counts up to 188 CFU/100mL in bottom waters at the western end of the AMZ, up to 143 CFU/100mL in mid-waters to the north, and up to 173 CFU/100mL at the surface to the north-east, suggesting a non-linear, dynamic dispersion and dilution affected by winds and subsurface currents (Figure 2-50), but with no exceedances of guideline values;
- Very low FIB counts at all sites in the bay (including nearshore sites), as well as at Dungeons, with no evidence of plume advection into the bay on this date;

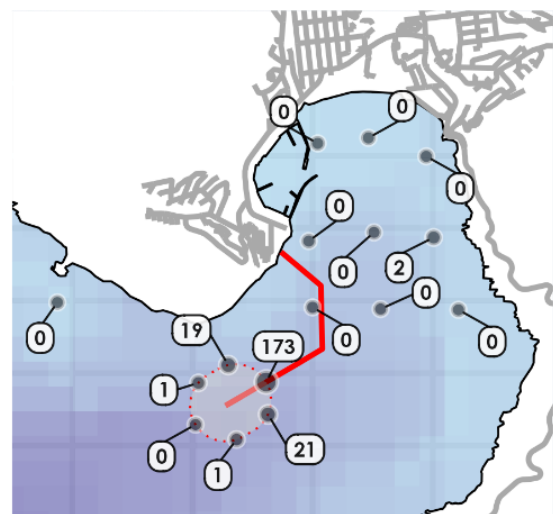


Figure 2-50. Hout Bay enterococci counts in cfu/100ml at the surface in February 2025.

- High average fertilisation success rates in sea urchin toxicity tests on water from the AMZ at all depths, although Chapman's Peak reference site had very low fertilisation success at mid-depth, at only 8.3% average fertilisation;
- Low, but non-zero turbidity in bottom waters at sites in the bay, highest at nearshore sites;
- High salinities and temperatures were observed at the surface at nearshore sites, suggesting limited mixing in the inner bay; lower salinities were apparent in bottom waters near the river mouth, while outer bay and offshore sites had clear haloclines and thermoclines with depth; and
- Clear vertical stratification was evident in the low oxygen saturations recorded in mid and bottom waters throughout the bay, with saturation falling below 50% at deeper sites.

Key observations from samples collected around the **Hout Bay** outfall on **18 March 2025**, during strong southerly winds and warm temperatures with 3.6 mm of rainfall in the past three days, include:

- Elevated FIB counts in bottom waters and at mid-depth on the boundary of the AMZ, extending through the outer and mid-bay sites, with up to 68 CFU/100ml in the mid-bay screen in bottom waters, and up to 71 CFU/100ml on the western boundary of the AMZ, suggesting wide dispersal of the diluted effluent plume within the bay; no sites exceeded recreational water quality guidelines, however;
- Widespread plume dispersion was likely driven by the strong southerly winds, and did not result in elevated enterococci counts at the screen of sites nearest the beach;
- Reduced sea urchin fertilisation success was observed in samples from two of the AMZ sites, on the north-western (offshore) boundary of the AMZ in bottom waters (71.3% average success) and the western boundary of the AMZ at the surface (72.5% average success); all other sites and depths had no evidence of acute toxicity; no elevated FIB were found in the samples with lower fertilisation success;
- Zero turbidity at all AMZ sites, but very slightly elevated (<6 NTU) turbidity at nearshore sites; and
- Salinity and temperature data indicative of the standard thermocline and inverse haloclines and at most sites throughout the bay.

Key observations from samples collected around the **Hout Bay** outfall on **15 April 2025**, during south-westerly and southerly winds, cool temperatures and with 23.4 mm of rainfall in the preceding three days, include:

- Non-zero enterococci counts at sites throughout Hout Bay at all depths, with notable elevations at the Hout Bay Harbour (219 CFU/100mL at the surface; 193 at mid-depth, and 181 CFU/100mL at the bottom), and lower at the outer boundary of the AMZ (138 and 73 CFU/100mL at mid-depth) (Figure 2-51);
- The Hout Bay Harbour values, coupled with much lower counts (up to a maximum of 43 CFU/100mL) at sites between these two points, suggests multiple confounding sources of faecal contamination - the outfall, the Hout Bay River, and other stormwater flows following a significant rainfall event;
- Acute toxicity in the sea urchin toxicity test was found for a sample from one site on the northern boundary of the AMZ in bottom waters (0.5% average fertilisation) in contrast to good (>98%) average fertilisation success at all other sites and depths; the same site had a very low FIB count (3 CFU/100mL) and no anomalies in salinity, temperature or TSS;

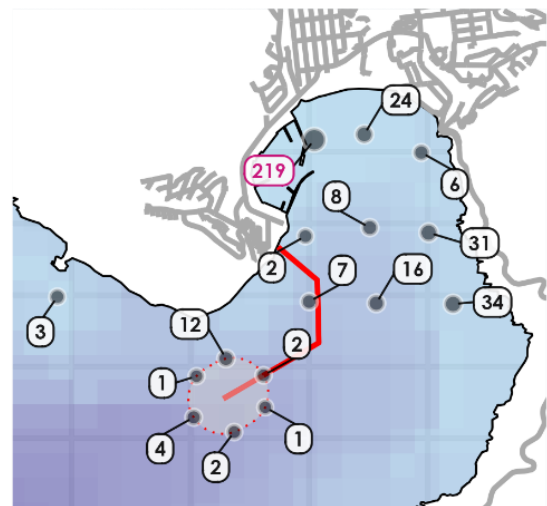


Figure 2-51. Hout Bay enterococci counts in cfu/100ml at the surface in April 2025.

- Slightly elevated turbidity in mid-depth and bottom waters at the nearshore sites, closest to the river mouth;
- Strong stratification in dissolved oxygen with depth, with evidence of supersaturation in surface waters in the nearshore (>130% saturation), and relatively low saturation in bottom waters in the deepest offshore sites (<60% saturation); and
- A clear thermocline and halocline at offshore sites; sites around the AMZ appeared to have fresher bottom water, possibly as a result of larger volumes of stormwater-augmented wastewater being discharged from the outfall.

Key observations from samples collected around the **Hout Bay** outfall on **13 May 2025**, during strong north-westerly winds, cool temperatures and with 31.5 mm of rainfall in the past three days, include:

- FIB counts at the surface were near zero at all sites (<10 CFU/100mL); counts were low at mid-depth around the AMZ (up to 65 CFU/100mL, while bottom waters showed the highest counts (up to 159 CFU/100mL), suggesting plume movement near the seafloor;
- Low enterococci counts (>20 CFU/100mL) were detected across all AMZ, outer bay and mid-bay screens of sites; nearshore sites had negligible FIB counts (<15 CFU/100mL); although the plume was likely a key contributor to the presence of detectable levels of enterococci in the bay on this day, it was diluted to well below guideline thresholds and did not reach the surface or the shoreline in concentrations posing detectable risks to recreational users;
- High average fertilisation success in sea urchin toxicity tests at all AMZ sites and at all depths sampled (>90%) indicating there was no acute toxicity in seawater at the boundary of the AMZ around the outfall;
- Stratification in oxygen saturation with depth, with surface saturations above 100% throughout the bay, dropping to around 95% at mid-depth, and below 60% (5.8 mg/L) in bottom waters at the deepest offshore sites;
- No apparent change in temperature or salinity with depth at most sites, although the deepest offshore sites on the AMZ were colder at between 10 and 11°C, and slightly less saline.

Key observations from samples collected around the **Hout Bay** outfall on **11 June 2025**, during strong southerly winds, cold temperatures and with 24.6 mm of rainfall in the past three days, include:

- Enterococci counts on the southern boundary of the AMZ at mid-depth of up to 119 CFU/100mL, but only 9 - 31 CFU/100mL at the surface, suggesting that the plume either did not reach the surface, or was effectively diluted before doing so;
- Detectable levels of FIB in bottom waters in the bay, and in surface waters adjacent to the Hout Bay Harbour – well below thresholds of concern for recreational water use, but suggesting either advection of diluted wastewater into the bay, or contributions of sewage-contaminated flows from the river or vessels in the harbour, or a combination thereof;
- Elevated turbidity of up to 20 NTU at nearshore sites, and zero readings at all offshore and mid-bay sites;
- Acceptable average fertilisation success in sea urchin toxicity tests at all AMZ sites and at all depths sampled (>88%) indicating there was no acute toxicity in seawater at the boundary of the AMZ around the outfall;
- Generally low salinities, relatively warm temperatures, and no apparent change in temperature or salinity with depth at most sites, although the deepest offshore sites on the AMZ were colder at below 12°C and slightly less saline.
- Clear stratification in oxygen saturations with depth, with no supersaturation recorded, but not dropping below 60% saturation at any site.

2.5.3 Effluent plume and dispersion model comparisons

The City of Cape Town undertook detailed, three-dimensional dispersion modelling for the effluent plume at each of the three outfalls, to inform an understanding of the movement of contaminants from the outfall in space and time. The model outputs are reported on in PRDW (2020b).^{††}

The modelled effluent plume movement was reported to be extremely dynamic, but key patterns and trends include:

- » The AMZ is spread parallel to the diffuser where it usually becomes entrained in the predominantly northward longshore currents (typically with southerly winds) or spreads offshore to the south-west (typically with northerly winds).
- » During stratified conditions the surface and sub-surface plumes often exhibit different flow directions, e.g. showing offshore advection at the surface and onshore advection at mid-depth. The effluent plume rises due to its buoyancy and usually becomes passive at mid-depth due to mixing with the ambient currents or trapping by stratification.
- » Occasional surfacing of the plume happens during periods of high effluent flows or stagnant hydrodynamic conditions.
- » The bacteria plumes have the highest concentrations at mid depth where the plume usually becomes trapped.
- » Currents driven by wave breaking at the southern or northern entrance of the bay (near the Dungeons surf spot) often advect the plume towards Hout Bay, but due to dispersion and decay the bacteria concentrations are significantly reduced by the time the plume reaches the beach or harbour.

FIB counts from 2024/2025 suggest that the Hout Bay plume was detected at the boundary of the AMZ on several occasions during the year of monitoring:

- » In winter and spring, at mid-depth at all AMZ sites, and highest at the inshore site (July 2024 and September 2024 in north-westerly winds, October 2024 in southerly winds, and November 2024 in south-easterly winds);
- » In both summer and winter, at mid-depth at the southern boundary of the AMZ (December 2024 in south-westerly winds, and June 2025 in southerly winds); and
- » In autumn, at mid-depth at several sites around the AMZ (March 2025 in southerly winds and May 2025 in north-westerly winds) and at the offshore boundary of the AMZ (April 2025 in southerly winds).

These findings align well with modelled conditions, in particular relating to the trapped effluent plume at mid-depth and the reduction in bacterial counts with distance inshore as well as at the surface, where no exceedances of recreational water quality guidelines were recorded. Elevated FIB counts at the sites closest to the shore coupled with low counts at the screens of sites between the outfall and the shore suggest that there are multiple sources of contamination in Hout Bay and that the contribution from the outfall at the sites where recreational activity is most intense (i.e. near the shore) is not significant.

^{††} Available for download at the time of writing at:

https://resource.capetown.gov.za/cityassets/Media%20Centre%20Assets/B_Numerical_Dispersion_Modelling_Reports_Marine_Outfalls.zip

2.5.4 Compliance with Permit Conditions

Section 4 of the CWDP for the Hout Bay outfall specifies target values for the boundary of the AMZ as set out in Table 2-1.

Table 2-1. Receiving water quality substance/parameters and target values for the natural environment at the end of the Hout Bay outfall mixing zone.

Substance / parameter	Target value / Concentration
pH	7.3 – 8.6
Salinity	$33 \times 10^{-3} - 36 \times 10^{-3}$
Temperature	The maximum acceptable variation in ambient temperature is 1°C
Total suspended solids	Not increased by more than 10% of the ambient concentration
Turbidity / Colour	Turbidity and colour acting simply or in combination should not reduce the depth of the euphotic zone by more than 10% of background levels
Dissolved oxygen	Should not fall below 5 mg/L (99% of the time) and below 6 mg/L (95% of the time)

Hout Bay has two reference sites, with one closer to the AMZ (Chapmans Peak, CP001) and one further away (Crayfish Factory, CF001). The Chapmans Peak site has more similar hydrodynamic conditions to the AMZ, but is potentially within the zone of influence of the outfall under certain conditions. The Crayfish Factory site is approximately 13 km to the south, and not in an area likely to be influenced by the Hout Bay outfall, but may have very different background conditions.

2.5.4.1 Temperature

The Hout Bay coastal waters discharge permit (CWDP), aligned with the 1995 Guidelines, specifies that the temperature in the receiving environment should not exceed 1°C above or below the ambient temperature. The 2022 draft Guidelines also set the temperature range relative to the ambient temperature of the environment but specify that the temperature should not fall outside the 20th and 80th percentiles of a suitable reference data set.

As described in §2.5.1.1, sea temperature is highly variable seasonally across all depths. Compliance assessments therefore utilised mean temperature values as a better comparator for highly variable data.

The annual mean temperatures at all of the AMZ sites fell within 1°C of both of the reference sites (Figure 2-52) and both the mean and median values fell within the target between the 20th and 80th percentiles of both the reference sites, as seen in Figure 2-52.

Compliance statement: Sea temperatures at all Hout Bay AMZ sites at all depths were compliant with the permit limits and with the 1995 Guidelines and 2022 draft Guidelines.

2.5.4.2 Salinity

Salinity is measured against a target range of values, relevant to the coastal zone of South Africa. The CWDP for Hout Bay specifies that the target range for salinity is between 33×10^{-3} and 36×10^{-3} , corresponding to the 33-36 ppt range indicated in the 1995 guidelines. The 2022 guidelines for salinity indicate that values should be measured against a range defined by the 20th and 80th percentiles of a suitable reference data set.

All annual mean salinity values at the Hout Bay marine outfall fell within permit limits (min: 34.79 PSU at bottom of water column for HB015, max: 35.89 PSU at surface for HB011). The median salinity values for the AMZ fell within the overlapping region of the 20th and 80th percentiles of both reference sites for all but two median site/depth combinations, while these two median values still fell within the range for one of the reference sites.

Compliance statement: Salinity at all Hout Bay AMZ sites at all depths was compliant with the permit limits and with the 1995 Guidelines. They also complied with the 2022 draft Guidelines when compared against at least one of the two reference sites sampled.

2.5.4.3 Dissolved oxygen

Target values and ranges for dissolved oxygen are generally specified according to lower limits. The 1995 guidelines have specific lower thresholds for the south- and east coasts, while for the west coast oxygen concentrations are required not to fall below 10% of 'established natural variation'. The Hout Bay CWDP specifies that values should not fall below 5 mg/L 99% of the time, or below 6 mg/L 95% of the time. In the 1995 guidelines, these are the criteria applicable to the south and east coasts, although Hout Bay is on the west coast. According to the 2022 guidelines, dissolved oxygen concentrations should not fall below the 20th percentile of an appropriate reference data set.

Single-sample, one-sided t-tests were conducted to determine whether the mean oxygen concentration was significantly lower than the threshold values at the specified confidence levels. No sites in Hout Bay had annual mean values less than 5 mg/L at the 99% confidence level at any depth (all $p > 0.3$, $df = 11$). There was also no evidence from the data that the mean dissolved oxygen concentration was less than 6 mg/L at the 95% confidence level for any surface and middle water column sites at the boundary of the AMZ (all $p > 0.99$, $df = 11$). For the bottom water samples, however, the dissolved oxygen concentrations were generally lower (min = 5.99 mg/L, max = 6.64 mg/L) but there was still no evidence that any of the sites had mean dissolved oxygen concentrations that were significantly less than 6 mg/L (**HB011B**: $t_s = 1.54$, $df = 11$, $p = 0.92$, **HB012B**: $t_s = 0.86$, $df = 11$, $p = 0.80$, **HB013B**: $t_s = 1.12$, $df = 11$, $p = 0.86$, **HB014B**: $t_s = -0.29$, $df = 11$, $p = 0.39$, **HB015B**: $t_s = 0.94$, $df = 11$, $p = 0.82$ and **HB016B**: $t_s = -0.004$, $df = 11$, $p = 0.50$).

With respect to the 1995 guidelines specifying that values should not fall below 10% of natural variation, no annual mean dissolved oxygen values were more than 10% lower than either of the reference sites. The lowest value was found at the bottom of the water column at HB014 (5.91 mg/L) which was still within 10% of the reference site mean values (CP001: 6.22 mg/L and CF001: 6.27 mg/L). Finally, the mean and median dissolved oxygen across the year exceeded the 20th percentile values of both reference sites at all sites on the boundary of the AMZ, throughout the water column.

Compliance statement: Dissolved oxygen concentrations at all Hout Bay AMZ sites in surface waters and at mid-depth were compliant with the permit limits of 6.0 mg/L at the 99% confidence level, and 5.0 mg/L at the 95% confidence level. In bottom waters, both the 5.0 mg/L and the 6.0 mg/L thresholds were met but mean dissolved oxygen concentrations were generally lower than at the surface and at mid-depth. The guidelines do not specify whether these thresholds must be met at all depths; at depths of >30 m below sea level, oxygen concentrations would normally be lower than at the surface. All AMZ oxygen concentrations were within the target ranges calculated in terms of the 2022 draft Guidelines.

2.5.4.4 Turbidity

In both the CWDP for Hout Bay, and the 1995 guidelines, turbidity guidelines are specified according to the impact that turbidity has on the depth of the euphotic zone. The 2022 guidelines specify that the upper limit of acceptable turbidity should be set by the 80th percentile of the suitable reference data set, as well as requiring that the natural depth of the euphotic zone should not be changed by more than 10% relative to a reference site. Turbidity data were measured as absolute values at various depths in nephelometric turbidity units, which can only be assessed in terms of the 2022 draft Guidelines and compared to the 80th percentile of the reference data.

Because turbidity values at sites in Hout Bay, and at the reference site, included a large number of zero values (refer to footnote on page 40), median values at most sites are zero, thus mean data are used for comparison purposes. The reference sites in Hout Bay differed in their mean turbidity values over the sampling year, with the Crayfish Factory (CF001) reference site having lower turbidity at the surface and middle of the water column, while the Chapmans Peak (CP001) site typically had lower turbidity at the bottom of the water column. As a conservative approach, the AMZ values were therefore compared to the lower of the two reference site values.

The median values for the AMZ sites did not exceed the more conservative (lower) of the 80th percentile values for any of the sites, throughout the water column.

Annual mean values at most AMZ sites were similar to the mean values at the lower of the two reference site values. Two mean values from the bottom of the water column were slightly higher than both the reference sites, namely HB012 (1.03 NTU compared to 0.74 (CF001) and 0.44 NTU (CP001) and HB014 (2.12 NTU compared to 0.74 and 0.44 NTU) (Figure 2-52).

The mean turbidity values for the surface samples collected at the boundary of the AMZ were all higher than the lower of the 80th percentile reference values, but none exceeded the larger of the 80th percentile reference values. For the middle of the water column, all the sites had higher mean turbidity values than both reference site 80th percentile values. For the bottom of the water column, all sites but one (HB015) exceeded both of the reference site 80th percentile values; the mean for this site (HB015: 0.24 NTU) was higher than the Chapmans Peak 80th percentile value (0.17 NTU) but lower than the Crayfish Factor 80th percentile value (0.264 NTU). Although the mean values exceeded the 80th percentile of the reference sites, the absolute values were low.

Compliance statement: Mean turbidity at Hout Bay AMZ sites exceeded reference site values by more than 10% at two sites at the bottom of the water column. Absolute values were low, and averages were skewed by elevated turbidity during a few sampling events and particularly at the bottom and mid-depths. Mid-depth turbidity elevations may be reflective of the effluent plume trapped at this depth. Surface samples were compliant with respect to the 2022 draft Guidelines.

2.5.4.5 Total suspended solids

The recommended concentration of TSS in the receiving environment is specified as an upper limit against a background concentration. The 1995 guidelines (as well as the Hout Bay CWDP) state that the concentration of TSS should not be increased by more than 10% of the ambient concentration. The 2022 guidelines recommend that the TSS be measured against a suitable reference data set, and that the concentration should not exceed the 80th percentile of a suitable reference data set.

In a similar pattern to that of turbidity, the Hout Bay reference sites had different mean TSS concentrations, especially at the surface and in the middle of the water column. Comparing to the more conservative (lower) reference site (CF001: 21.35 mg/L), all but two (HB011, HB013) mean TSS concentrations at the surface exceeded the 10% upper limit specified by the 1995 guidelines but

compared to the less conservative reference site (CF001: 25.85 mg/L), all values fell below the upper limit.

A similar picture emerged for the 80th percentile values of the reference site – only HB011 and HB013 had mean concentrations below both reference 80th percentile values, but all concentrations were below the higher of the two reference 80th percentiles. For the middle of the water column, all values exceeded the 10% upper target relative to the more conservative reference site (CF001, 17.58 mg/L) but only one value (HB012) exceeded the upper 10% guideline value relative to the less conservative reference site (CP001, 23.17 mg/L). The 80th percentile of the reference data for the middle of the water column showed that all mean concentration values but one (HB016) exceeded both reference concentrations. For the bottom of the water column, no values were more than 10% higher than either of the reference sites, and all values fell below the more conservative 80th percentile.

Compliance statement: *The Hout Bay permit does not specify a TSS limit. Mean TSS did not exceed the less conservative of the two reference site values by more than 10%, with a few exceptions. Mid-depth elevations in TSS may be reflective of the effluent plume trapped at this depth. Surface samples were compliant with respect to the 2022 draft Guidelines, as were bottom samples.*

2.5.4.6 pH

The Coastal Waters Discharge Permit for Hout Bay specifies the range of acceptable pH values for the end of the AMZ as 7.3 to 8.6. The 1995 water quality guidelines specify a narrower range of pH values, as 7.3 to 8.2. The 2022 guidelines specify that a range needs to be calculated from the 20th and 80th percentiles of a reference data set suitable to the discharge location. Additionally, the guidelines specify that any deviations of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated.

All pH annual median values for the Hout Bay marine outfall fell within the range of pH values specified in the 1995 guidelines, which have a narrower range than the CWDP for Hout Bay. All values fell between the 20th and 80th percentiles of both reference sites, and there were no values that exceeded the seasonal maximum or minimum of either of the reference sites.

Compliance statement: *Median pH values across the sites and throughout the water column did not fall outside the permit range, or outside the guideline range based on data from the Crayfish Factory and Chapman's Peak reference sites.*

2.5.4.7 Concluding statement on compliance

The Hout Bay marine outfall was compliant at the boundary of its AMZ with permit conditions for temperature, salinity, dissolved oxygen (at the surface and mid-depth) and pH. Dissolved oxygen in bottom waters was low but still compliant, and this is likely due to the depth of the sites and not an indicator of impact. Turbidity was compliant with permit conditions based on reference site comparisons at the sea surface, but not at mid-depth or (at two of six sites) in bottom waters. Absolute values were low, and permit limit exceedances may be due to environmental, rather than anthropogenic, causes. Contributions of the outfall wastewater to elevations in turbidity at mid-depth are not, however, ruled out. FIB counts suggested that recreational activity on the boundary of the AMZ (were this to take place, although the AMZ is not recommended for full-contact recreation) would not have posed a risk to human health on any of the dates monitored, and Hazen-based categories calculated for the AMZ sites were 'Excellent' at five sites, and 'Good' at one of the six sites monitored. These categorisations are however strongly influenced by the low sample count (n=12), and are less valuable as measures of risk to beach users than the recreational water quality sampling carried out at a higher frequency by the CCT and reported in §2.6, which indicates that the Hout Bay beach is in winter regularly exposed to faecal contamination from the Hout Bay River at levels that would pose a risk to recreational users.

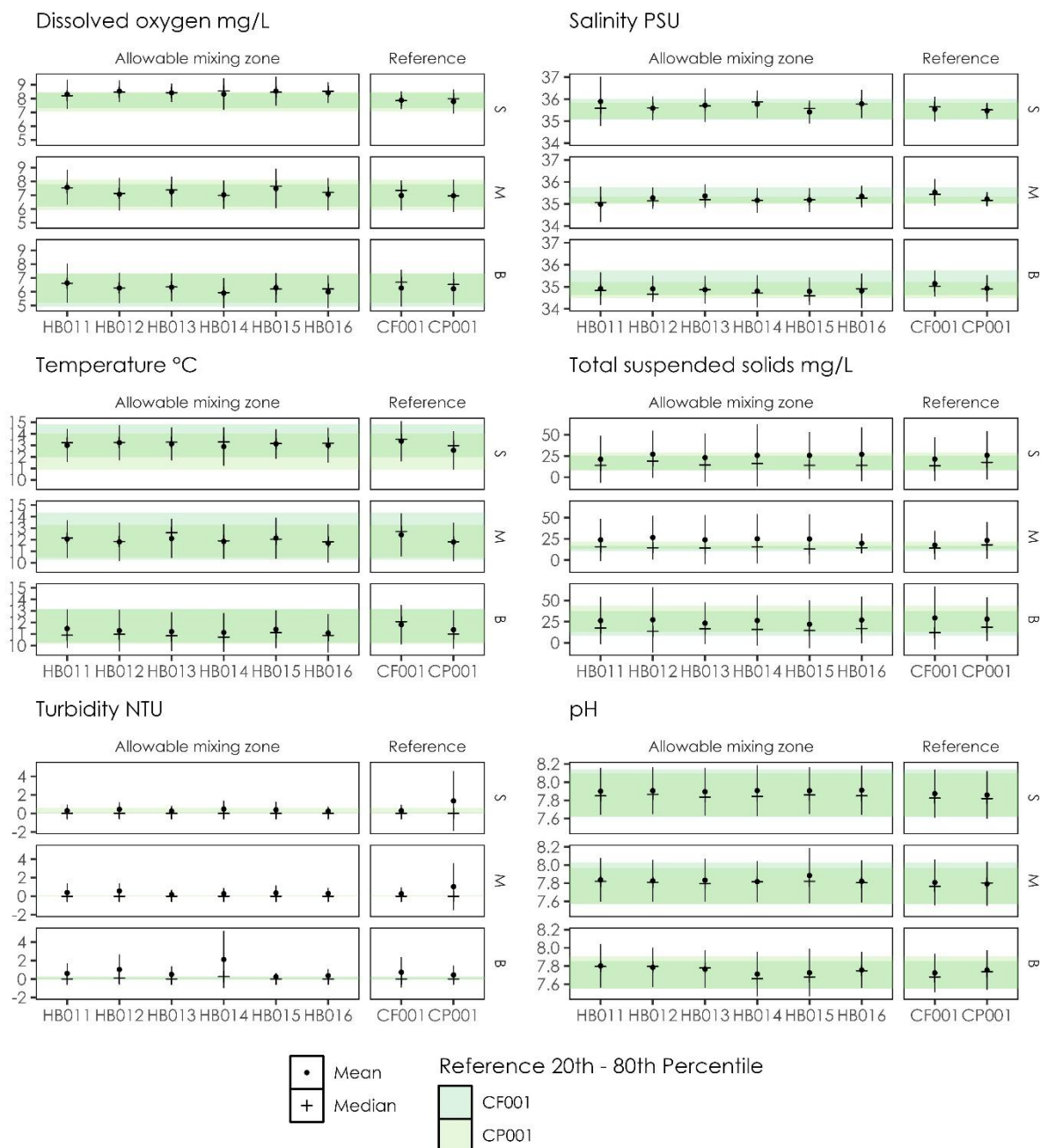


Figure 2-52. Annual median values for six of the parameters required to be monitored by the Hout Bay Coastal Waters Discharge Permit, relative to the reference site. Annual mean $\pm$ SD (points + error bars) is also shown for sites on the boundary of the allowable mixing zone for the Hout Bay marine outfall, shown against the 20th and 80th percentiles of the values from the Crayfish Factory and Chapmans Peak reference sites. For pH, the error bars show IQR, not standard deviation.

2.6 Recreational Water Quality

2.6.1 Recreational Water Quality Guidelines: Approach to assessments

FIB are measured as a surrogate for a complex suite of pathogens (bacteria, viruses, and others) present in sewage and used to estimate the risk of gastrointestinal and other health effects in humans using recreational waters. These FIB are not themselves the causative agents of illness, but counting FIB in recreational waters allows for determination of the level of risk to users, based on epidemiological studies that provide a clear dose-response relationship with gastrointestinal illnesses (Wade et al., 2010). Intestinal enterococci, a group of bacteria that includes the common species *E. faecalis* and *E. faecium*, is the most commonly used measure in various recreational water quality guidelines and criteria globally (Wade et al., 2006, 2010; WHO, 2021). Intestinal enterococci in samples collected from outfall monitoring sites were enumerated using accredited membrane filtration methods (ISO/IEC, 2017). These counts are provided as colony-forming units (CFU) per 100 ml of sample.

South African Recreational Water Quality Guidelines (DEA, 2012) recommend determining the 95th and 90th percentiles of intestinal enterococci counts to determine the recreational water quality of a given beach. The guideline thresholds are as follows:

- 95th Percentile should be ≤ 100 CFU for Excellent water quality
- 95th Percentile should be ≤ 200 CFU for Good water quality
- 90th Percentile should be ≤ 185 CFU for Sufficient water quality

The Hazen method is a statistical approach used to analyse enterococci levels in water quality data. It is generally a very conservative way of determining water quality (i.e., it will err on the side of poorer water quality estimates), and is applied as follows:

- All FIB counts are arranged in order from the smallest to the largest value.
- The method identifies the value below which a specified percentage of the data lies (e.g., the 90th or 95th percentile).
- To achieve greater precision, the Hazen method uses interpolation. This means it calculates a value that might fall between two actual measurements to give a more accurate percentile estimate.

The guideline categories listed above are applicable specifically to recreational waters where recreational activities involving full immersion in the water are regularly practised. Not all sites monitored as part of this 2024 Receiving Environment Monitoring Programme are commonly used for recreation, and areas in the AMZ would not be recommended for recreation. The risk categories in **Figure 2-54** should be interpreted with this in mind. The figure also shows risk categories calculated based on weekly data from the shoreline sampling conducted by the CCT, for sites along the coast.

It is important to also note that with small datasets, the Hazen method of interpolation is particularly vulnerable to the influence of large outliers. In this case, since each site was sampled once per month for 12 months, the dataset for each site only has 12 values. The effect is evident in the case of the Green Point marine outfall in July 2024. 18 out of the 21 sites sampled around the Green Point marine outfall had high enterococci values (>150 CFU per 100 mL) primarily due to river and stormwater runoff. Since there are only 12 data points for each site, a single high value can increase both the 90th and 95th percentile values to fall into the Poor category, while the other 11 values for the year would result in better water quality. As the monitoring programme continues and more data are collected, the effect of these outliers will be diminished. Rainfall data in relation to sampling dates between July 2024 and June 2025 are presented in Figure 2-53.

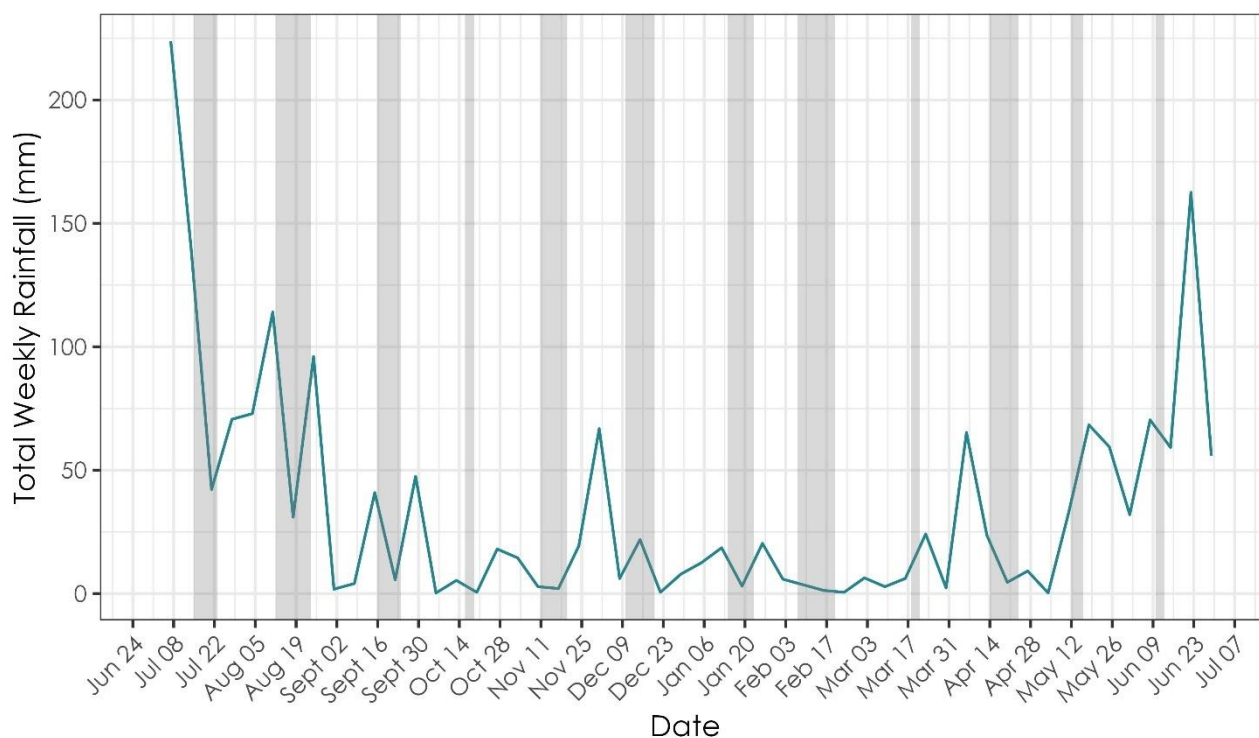


Figure 2-53. Plot showing the range of sampling dates during each month for the first completed year of monitoring (indicated in grey vertical boxes). Total weekly rainfall is plotted on the y-axis to provide context for interpreting all water quality results in the context of urban riverine and surface stormwater runoff as potential sources of cumulative and other impacts on coastal water quality.

2.6.2 Outfall-specific trends in recreational water quality

Trends are apparent in the recreational risk category data (**Figure 2-54**) are set out below.

In **Camps Bay**:

- One site on the offshore boundary of the AMZ was in the Poor category;
- All other AMZ sites and all nearshore screen sites were in the Excellent category. One site directly to the north of the AMZ, offshore of Maidens Cove, was in the Sufficient category;
- In terms of the national Recreational Water Quality Guidelines, all nearshore sites between the outfall and the shore would generally be considered low to very low risk for full-contact recreation;
- Shoreline sites were all in the Good or Excellent categories with the exceptions of Saunders Rocks, Bakoven and Barley Bay beaches (refer to §2.6.3.1 for explanations of likely causes); and
- The Karbonkelberg reference site was in the Excellent category.

Overall, given how recreational activity is distributed in the vicinity of the Camps Bay outfall and the generally low FIB counts at the surface at the boundary of the AMZ for this outfall and at other sites between the outfall and the shoreline, risks to human health due to pathogens originating from this outfall are considered to be very low.

The contribution of faecal pathogens from other land-based sources (stormwater outflows) in this area is significant, especially in winter, and because of their proximity to the shoreline where recreational activity is most intense, does pose a risk to human health at times, especially following heavy rainfall (refer to §2.6.3.1 below).

At Green Point:

- Five of six sites on the AMZ were in the Poor category, and the sixth (the offshore site) was in the Sufficient category for the twelve-month period. This is due to high FIB counts at all of these sites in August 2024 (ranging from 67 CFU/100mL to 230 CFU/100mL) and to counts in excess of the upper limit of quantification (>150 CFU/100mL) in the July 2024 survey which occurred on the day following a major rainfall event.
- Three of the five sites located roughly midway between the outfall and the shoreline were in the Poor category for similar reasons – in August 2024 these samples had enterococci counts between 77 and 280 CFU/100mL, and in July 2024 they exceeded the upper limit of quantification applied by the laboratory in that month (>150 CFU/100mL); it is likely that the missed samples from two of these sites in July 2024 would also have exceeded this quantification limit and that the difference in the category is due primarily to this omission rather than to any actual local difference in conditions;
- Of the five nearshore sites located just seaward of the surf zone, two were in the Sufficient category, and three were in the Poor category;
- The two sites in Table Bay, distant from the outfall and closer to the Diep and Salt River mouths and the Port of Cape Town, were in the Poor category;
- The reference sites at Robben Island was in the Excellent category;
- Based on the national Recreational Water Quality Guidelines, all sites between the outfall and the shore would generally be considered to be in unacceptable risk ranges for full-contact recreation, noting that these categorisations are strongly influenced by the low sample count (n=12); three of the five shoreline sites, and two of the five nearshore screen sites, would be in the acceptable risk ranges, and sites distant from the outfall in Table Bay would also be in the unacceptably Poor risk range;
- These data demonstrate the conservative nature of the Hazen calculation, which determines a higher risk category based on guideline exceedances on two [one confirmed and one assumed based on an upper limit of quantification] sample dates;
- Shoreline data based on more frequent sampling on this coastline indicates three sites are in the Good category and two (Green Point Pump Station and Three Anchor Bay) in the Poor category (refer to §2.6.3.1 for explanations of likely causes).

Overall, given how full-contact recreational activity is distributed in the vicinity of the Green Point outfall, risks to human health due to discharges from this outfall are considered low provided that full-contact recreation does not take place within the AMZ. Contributions from other land-based sources (Salt River, Diep River, stormwater outfalls) in this area are significant (more details on this in §2.6.3.2 below), especially in winter and pose an equal if not larger risk to human health especially in areas close to the shoreline where recreational activity is most intense.

In Hout Bay:

- One site on the inshore side of the AMZ was in the Good category;
- All other sites on the AMZ and in mid-bay and nearshore, as well as the Dungeons surf site, were in the Excellent category;
- In terms of the national Recreational Water Quality Guidelines, all sites around and near the outfall AMZ would generally be considered low to very low risk for full-contact recreation; and
- Nearshore and mid-bay screen sites close to the Hout Bay Harbour and Hangberg were in the Good category;
- Beach sites at the Chapmans Peak and harbour sides of the beach were both in the Poor category; the low FIB counts at sites between the beach and the outfall, coupled with the relatively high number of elevated FIB data on the beach itself, suggests a stormwater and river

runoff source for the faecal contamination evident in coastal waters, particularly during winter, as explained in §2.6.3.3 below; and

- The two reference sites at Chapman's Peak and Crayfish Factory were both in the Excellent category.

Overall, given how full-contact recreational activity is distributed in the vicinity of the Hout Bay outfall and overall low level of FIB on the boundary of the AMZ and other sites in close proximity to the outfall, risks to human health due to discharges from this outfall are considered very low. Contributions from other land-based sources (Disa River, stormwater outfalls) in this area are significant (more details on this in §2.6.3.3 below), especially in winter and likely pose a much larger risk to human health especially in areas close to the shoreline where recreational activity is most intense.

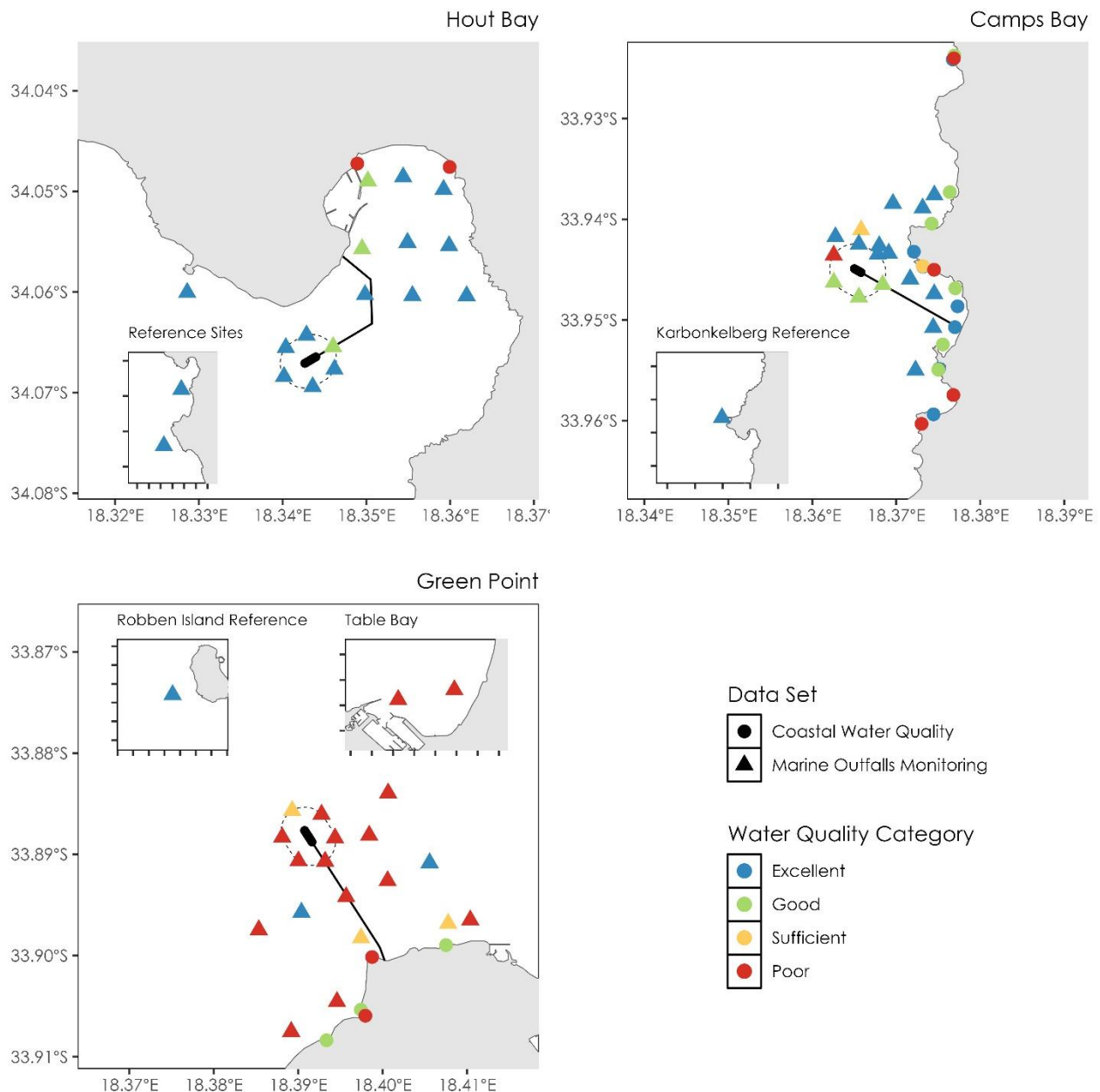


Figure 2-54. Categories of risk to human health from full-contact recreation, based on surface water samples collected monthly around the marine outfalls (n = 12 for most sites), as well as weekly, biweekly or monthly at coastal water quality monitoring stations from July 2024 to June 2025. Percentiles were calculated using the Hazen method. The categories are calculated based on the risk of gastrointestinal illness as a result of full-contact recreation, as set out in the National Water Quality Guidelines for Recreational Use (DEA, 2012). Excellent – 2.9% gastrointestinal illness (GI) risk; Good – 5% GI risk, Sufficient – 8.5% GI risk and Poor – >8.5% GI risk.

2.6.3 Land-based sources of pollution

Stormwater and river runoff to the coastal environment are an important source of faecal contamination in recreational water bodies in Cape Town. While the water quality is generally good along the Atlantic seaboard, a few point sources of pollution are well-known and well-documented. Both coastal monitoring sites (beaches, tidal pools, known discharges) as well as inland water quality sites (rivers, stormwater drains) are monitored frequently for faecal contamination.

While the marine outfalls are certainly a source of faecal contamination into the marine environment, land-based sources are often contributors to, and in some cases the primary causes of, poor recreational water quality at popular recreational nodes. Some of the well-known point discharges of faecal pollution are problematic year-round, including stormwater drains at Three Anchor Bay and Saunders Beach as well as river mouths at Hout Bay and Lagoon Beach (CSIR, 2017a). Other point sources become problematic after periods of high rainfall, especially if these occur after periods of little rainfall. Some occasional point sources are a result of periodic or episodic pump station failures or sewer spills rather than predictable flows.

2.6.3.1 Camps Bay

The coastline between Three Anchor Bay beach and Queen's Beach rarely experiences problems with faecal contamination from land-based sources. Slightly further south, however, Saunders Rocks commonly experiences impaired water quality. While the tidal pool ('Excellent' classification, $n = 34$) and Saunders Rocks beach ('Good' classification, $n = 18$) generally had good water quality between July 2024 and June 2025, the gully outside the tidal pool ('Poor', $n = 52$) consistently had bacterial counts indicative of faecal contamination and associated health risks during this period. The stormwater discharge at Saunders Rocks is a known source of pollution throughout the year, and has resulted in impaired coastal water quality for several years.^{§§} Between July 2024 and June 2025, the median *E. coli* count in the stormwater discharge was 111 990 CFU per 100 mL, with the maximum value reaching 24 million CFU per 100 mL on 23 April 2025. On 24 April 2025, a day later, the counts of enterococci outside the Saunders Rocks tidal pool spiked at 12 400 CFU per 100 mL. Even excluding this sample, the water quality at Saunders Rocks outside the tidal pool would still have been classified as Poor ($n = 51$). Eleven of 52 samples collected during this period exceeded the single-sample threshold for enterococci of 240 CFU per 100 mL. The stormwater discharge is a consistent source of pollution into the coastal environment.

The twelve coastal monitoring sites nearest the Camps Bay marine outfall (Clifton Second Beach to Camps Bay Tidal Pool Outside) generally have good water quality, with a few notable exceptions. Clifton Second Beach experienced no FIB threshold exceedances between July 2024 and June 2025 and was classified as 'Excellent'. Similarly, Clifton Fourth Beach was classified as Excellent, with two samples exceeding the single-sample threshold for Enterococci in July 2024. These samples were collected during and after a period of very high rainfall (see **Figure 2-53**).

The rocks, beaches and tidal pools around Maidens Cove are the nearest points along the shoreline to the Camps Bay marine outfall. North Sandy Cove and the western tidal pool had Excellent water quality and no exceedances between July 2024 and June 2025. Samples from one date (10 April 2025) exceeded thresholds, and resulted in classifications of 'Sufficient' outside the western tidal pool, and 'Poor' inside the eastern tidal pool. These samples were collected after a period of high rainfall that was preceded by a few months of little or no rainfall, and demonstrate the conservative nature of the guidelines and Hazen-based classification – without this sample, the sites would have had annual classifications of 'Excellent' and 'Good' respectively.

^{§§} Based on coastal water quality data supplied by the CCT

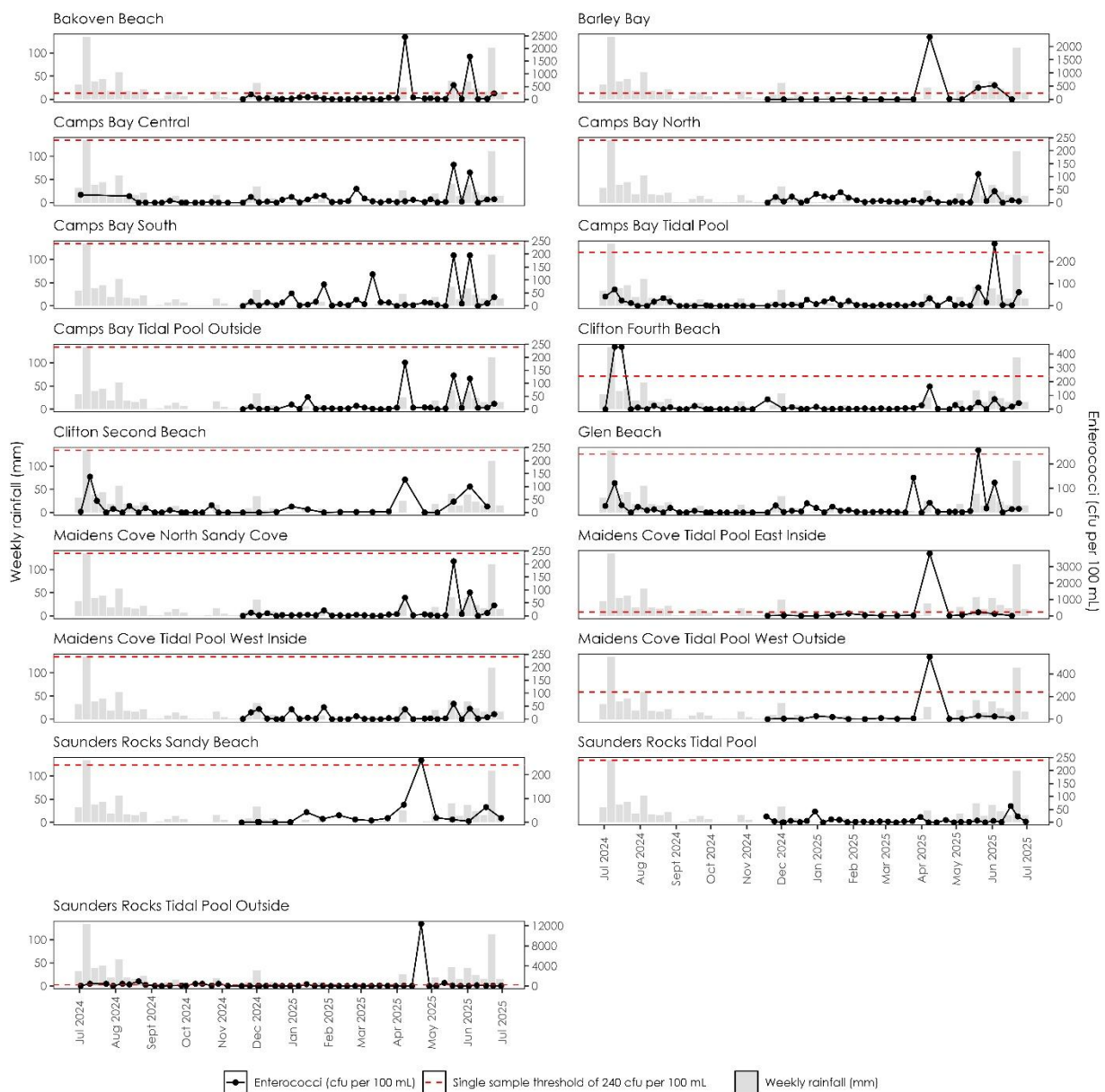


Figure 2-55. Enterococci counts (CFU per 100 mL) and weekly total rainfall (mm) shown for coastal monitoring sites near the Camps Bay marine outfall for the period between July 2024 and June 2025. Rainfall data are from the Molteno rainfall station. Note that vertical scales differ.

The beaches from Glen Beach through Camps Bay have been studied and monitored intensively, including higher-frequency sampling during the period reported on here. The water at these beaches was classified as 'Excellent' (Camps Bay Central and Camps Bay North) or 'Good' (Camps Bay South, Glen Beach) between July 2024 and June 2025 and only one sample (Glen Beach, 22 May 2025, 256 CFU per 100 mL) exceeded the single-sample threshold for enterococci indicative of pathogenic risks to human health. The tidal pool at Camps Bay had Excellent water quality and no samples exceeded the single-sample threshold, while coastal waters outside the tidal pool were classified as 'Good'.

A stormwater pipeline discharges into the sea near the southern end of the Camps Bay beach. While this site is rarely sampled, a single sample taken in March 2025 had an *E. coli* count of 98 040 CFU/100mL. Very limited data from this site suggest that stormwater flows constitute a further source

of pollution into the marine environment near popular swimming beaches; however, low discharge volumes may account for what appears to be a very limited impact on the recreational water quality in the area.

Barley Bay and Bakoven beaches, to the south of Camps Bay, both had water quality classified as 'Poor' between July 2024 and June 2025 with three samples exceeding the single-sample threshold for enterococci on the same days at each site (10 April 2025, 22 May 2025 and 5 June 2025). These samples were all collected during and after high rainfall events. Many points along the Atlantic seaboard experienced poor water quality on 10 April 2025, and the widespread nature of these impacts suggest that the high rainfall preceding this date was a key driver of the deterioration in water quality. These episodes of poor water quality were associated with high rainfall events that followed a period of little or no rainfall, and were not reflective of longer-term averages.

In summary, the coastal water quality at beaches near the Camps Bay marine outfall is generally very good when compared against recreational water quality guidelines for FIB. A known point source of pollution at Saunders Rocks contributes to poor water quality, as well as high rainfall events, especially when these follow periods of little or no rainfall.

2.6.3.2 Green Point

The Table Bay and Green Point sections of Cape Town's coastline are impacted by a few significant sources of wastewater contamination. The Diep River, with its mouth just south of the Milnerton Lighthouse, is highly polluted and is frequently found to have high levels of the faecal indicator bacterium *Escherichia (E.) coli* at the river mouth (median 4788 CFU per 100 mL, maximum 677 000 CFU per 100 mL between January 2024 and June 2025, n = 38 samples)^{***}. This is reflected in the enterococci counts from Lagoon Beach (at the mouth of the Diep River) where the recreational water quality was consistently classified as Poor between 2020 and 2024, and 37% of samples exceeded the 240 CFU per 100 mL single-sample guideline for enterococci in recreational waters (*Coastal Water Quality Dashboard*). Similarly, the Salt River – discharging to the north of the port of Cape Town – is frequently found to have high *E. coli* levels (15 out of 17 of the samples at the Marine Drive bridge at the mouth of the Salt River exceeded 100 000 CFU per 100 mL between January 2024 and June 2025) and conveys treated wastewater from several wastewater treatment works. The coast near the mouth of the river is not used for recreation and is therefore not regularly monitored for FIBs, but flows from the Salt River contribute to poor water quality in Table Bay. These sites have consistently high FIB counts throughout the year, with episodes of further deterioration of water quality after high rainfall (e.g. two enterococci counts of >1500 CFU per 100 mL occurred at Lagoon Beach in July 2024 after heavy rainfall: Figure 2-56).

Nearer to the Green Point marine outfall, sites such as Mouille Point generally do not experience problems with poor water quality (category: Good; zero FIB single-sample threshold exceedances between July 2024 and June 2025). The coastal monitoring point directly offshore of the Green Point pump station, however, was classified as having Poor water quality between July 2024 and June 2025, due to three samples (out of 32) that exceeded the 240 CFU per 100 mL single-sample limit. The remainder of the samples collected at this site did not indicate a risk to human health. This does not point to a pattern of poor water quality but rather to episodic pollution events not correlated with high rainfall.

Another documented (CSIR, 2017a) point source of pollution near the Green Point marine outfall is the stormwater discharges from the sea wall into Three Anchor Bay. The beach at this site has a history of impaired water quality, which has previously been attributed to the effects of these stormwater drains coupled with limited circulation and flushing within the bay. Over the period November 2024

^{***} Data from [CCT Inland Water Quality Dashboard](#)

to June 2025 [this site was not sampled between July 2024 and November 2024], 12% of samples exceeded 240 enterococci CFU/100mL, resulting in a classification of Poor for this site. These stormwater drains have been found to convey flows with clear indicators of wastewater contamination in CCT coastal water quality monitoring (*E. coli* - median: 48 840 CFU per 100 mL, max: 4.6 million CFU per 100 mL on September 25, 2024). Lending support to a land-based cause of these impacts, a sampling point on the rocks on the northwestern side of Three Anchor Bay had only 1 out of 37 samples in excess of the single-sample threshold of 240 CFU per 100 mL between July 2024 and June 2025 and was classified in the 'Good' category. Since the stormwater drains discharge on the southeastern side, this highlights that although the impact of the stormwater discharge is significant within the sheltered bay, the spatial extent of the impact may be limited.

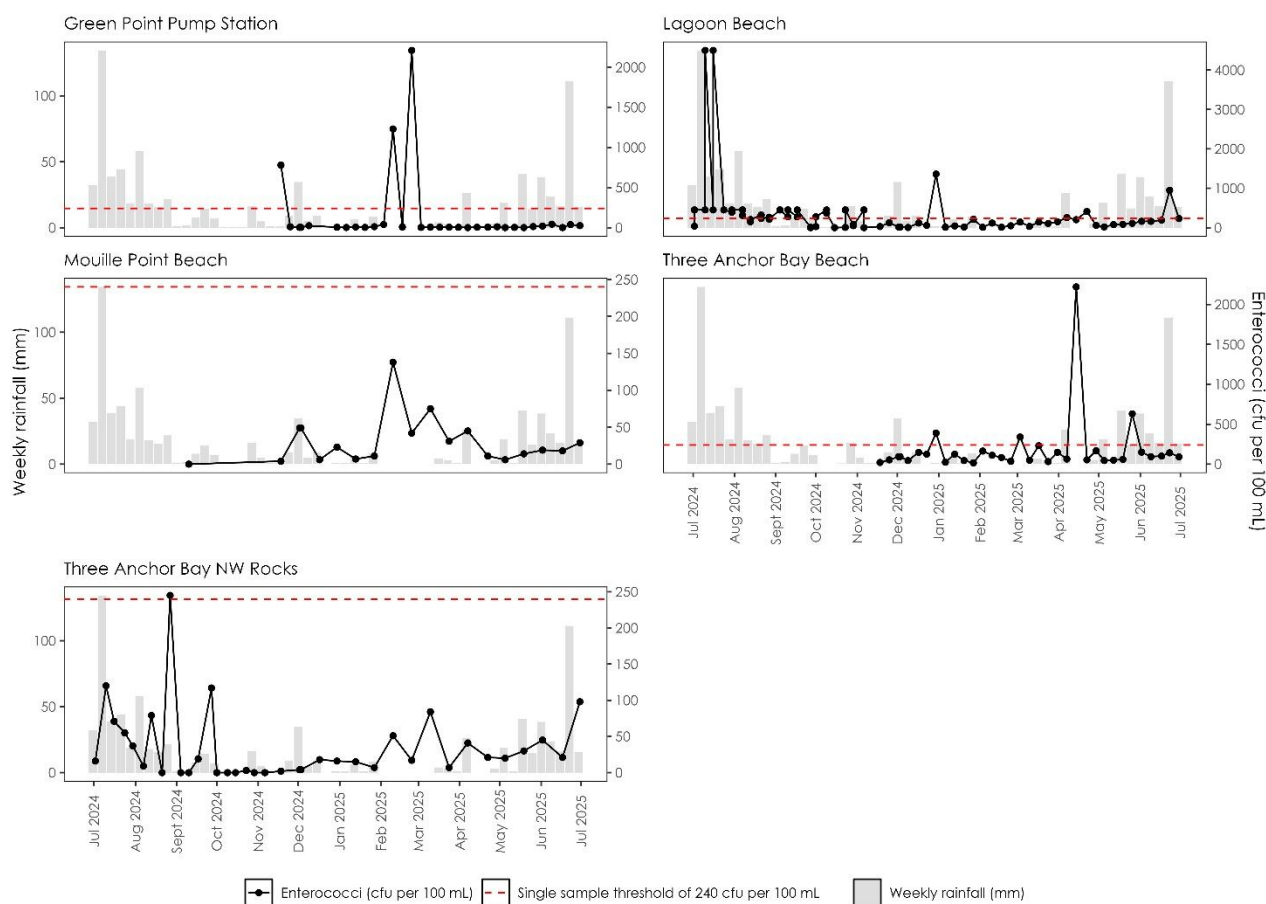


Figure 2-56. Enterococci counts (CFU per 100 mL) and weekly total rainfall (mm) shown for coastal monitoring sites near the Green Point marine outfall for the period between July 2024 and June 2025. Rainfall data are from the Molteno rainfall station.

2.6.3.3 Hout Bay

Due to the nature of the coastline around Hout Bay, there is very little anthropogenic input of faecal contamination into the marine environment to the north and the south of the bay. Llandudno has a small wastewater treatment works at Logies Bay which rarely contributes to poor water quality (one of 18 samples during the year exceeded FIB thresholds). Further to the south, Noordhoek Beach has mostly pristine water quality and even the outflow of the Wildevölvlei Wastewater Treatment Works further to the south (via the Noordhoek wetlands and estuary) has no discernible detrimental effect on the water quality in the area. The primary inputs of sewage contamination into Hout Bay,

therefore, are the Disa/Hout Bay River and the Hout Bay marine outfall. Other smaller sources include the stormwater culvert flowing past the Yacht Club on the western side of the beach, vessels in the harbour, and other more minor discharges of sewage via stormwater systems or overland flow.

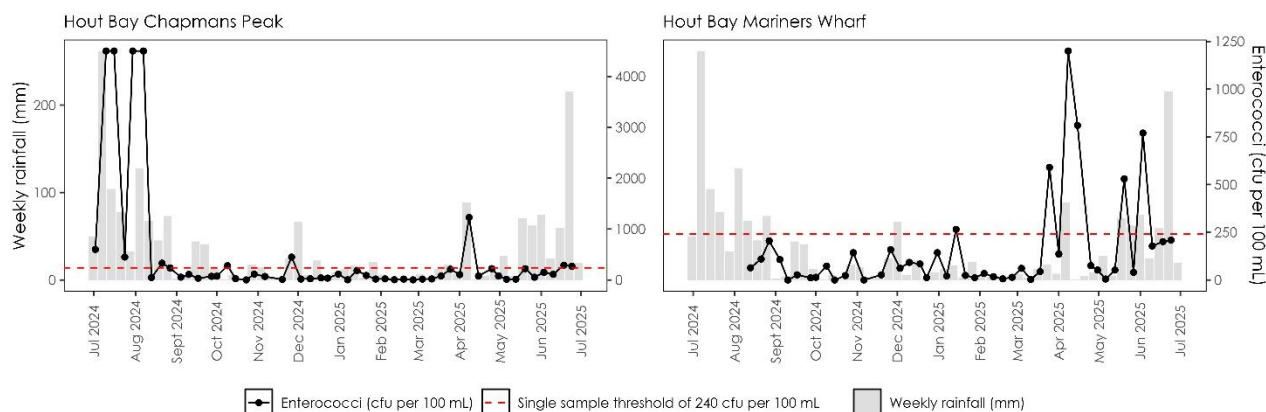


Figure 2-57. Enterococci counts (CFU per 100 mL) and weekly total rainfall (mm) shown for coastal monitoring sites near the Hout Bay marine outfall for the period between July 2024 and June 2025. Rainfall data are from the Constantiaberg rainfall station.

Two coastal monitoring sampling sites on Hout Bay Beach (Mariner's Wharf and Chapmans Peak) are frequently sampled and have some of the worst water quality along the Atlantic coast in terms of recreational guidelines. Long-term coastal monitoring data shows that the Chapmans Peak site has not had a year where the water quality was rated Good or Excellent since 2007 (CCT Know your Coast Report, 2025). The Chapmans Peak site, on the eastern side of the beach, had 12 samples exceeding the single-sample threshold of 240 CFU per 100 mL and also had Poor water quality. At the Mariner's Wharf site, on the western side of the beach, 6 out of 45 samples exceeded the single-sample threshold of 240 CFU per 100 mL between July 2024 and June 2025, and the water quality was classified as Poor. For both sites, water tends to deteriorate with high rainfall, especially after periods of little or no rainfall (Figure 2-57). The data also seem to show improvements in water quality after sustained periods of heavy rainfall, suggesting that the 'first flush' effect is a significant contributor to coastal water quality impairment.

The Hout Bay River (also commonly referred to as the Disa River) is sampled monthly for *E. coli*. Between July 2024 and June 2025, the *E. coli* counts were very high (median: 106 974 CFU per 100 mL; max: 363 000 CFU per 100 mL). The Hout Bay Beach receives a consistent flow of highly polluted water from the Hout Bay River – increasing during periods of high rainfall – contributing to the deterioration of recreational water quality at the beach. As described in §2.5.2 and 2.5.3, wastewater from the outfall is expected to reach the shoreline under certain sea conditions, but only after significant dilution and die-off of faecal bacteria. Based on available data, the impairment of microbiological water quality indicators at the beach is much more strongly associated with the Hout Bay River and other land-based sources, than with the marine outfall.

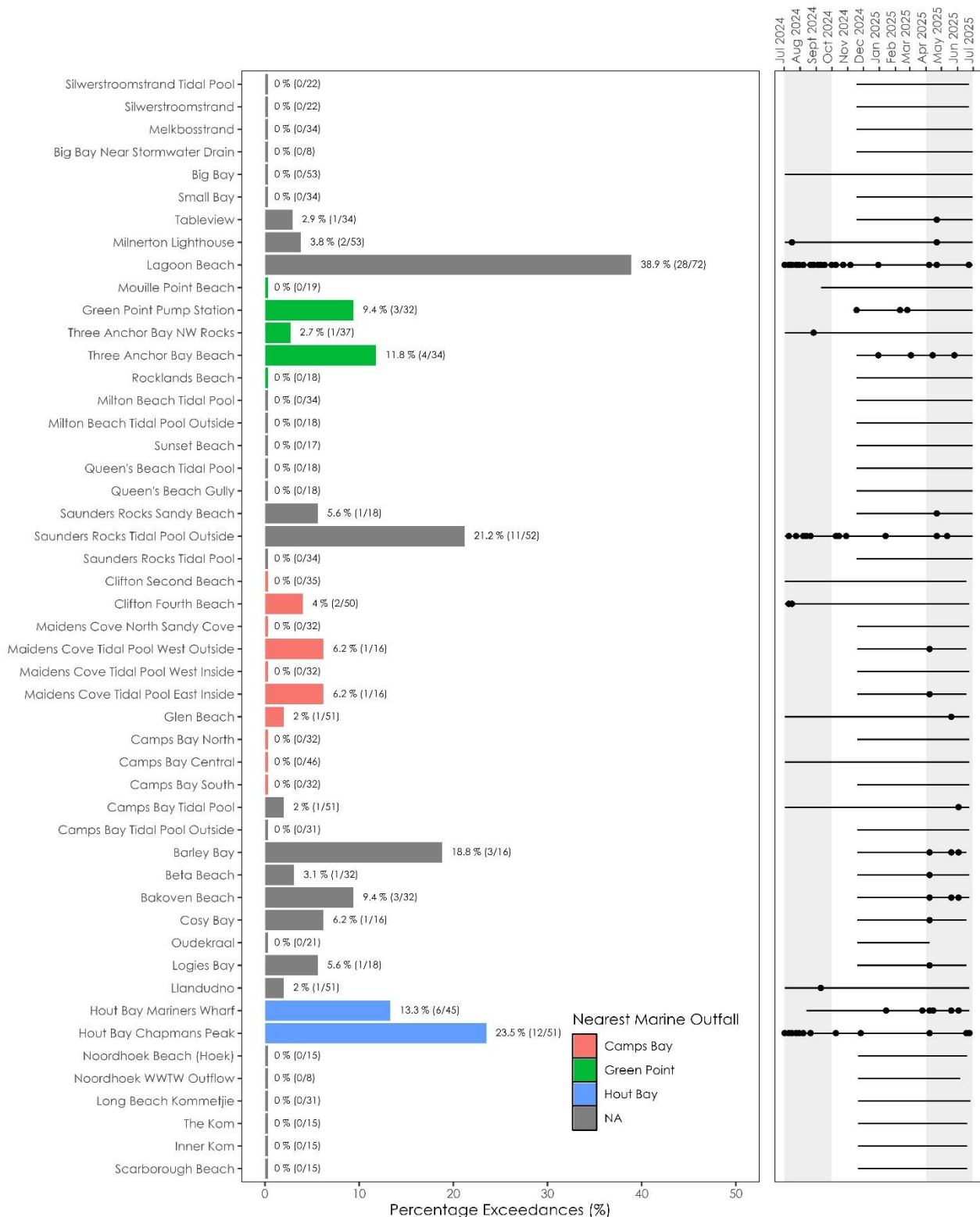


Figure 2-58. Percentage of samples that exceeded the single-sample threshold of 240 CFU per 100 mL by site across the Atlantic coastline (from north to south), from July 2024 to June 2025. Sites are highlighted that are near the three marine outfalls, and the distribution of the exceedances over the monitoring period is shown on the right of the plot. The shaded regions show the winter rainfall months in Cape Town, April to September.

2.7 Conclusions

The first twelve months of water quality monitoring in the vicinity of the Green Point, Camps Bay, and Hout Bay outfalls under the approved 2024 Receiving Environment Monitoring Programme provide some insights into the behaviour of the outfall effluent plumes, the impacts of wastewater disposal on the marine and coastal environment, and the potential risks to human health.

2.7.1 Impacts on recreational water quality

Previous monitoring programmes (CLS, 2021, 2022b; CSIR, 2017a; Lwandle, 2020) have found that water quality on the boundary of the AMZ of the three outfalls is, at least periodically, not compliant with South African Water Quality Guidelines for Coastal Marine Waters (DWAf, 1995). Outfall design cannot rule out the likelihood of effluent reaching the sea surface under certain sea states. Evidence of the effluent plume reaching the sea surface was present on at least three occasions at the Green Point outfall, six occasions at Camps Bay, and once at Hout Bay – in most of these cases at concentrations not posing a significant risk to human health when measured in terms of guidelines for recreational use. On one occasion at Camps Bay and three occasions at Green Point when FIB counts at the surface were linked to wastewater discharge, the counts were high enough that pathogenic organisms in the seawater would likely have posed a risk to human health at these offshore locations, in terms of recreational water quality guidelines.

FIB counts at the sea surface decreased rapidly with distance from the outfall diffusers. The data collected do not provide any evidence that wastewater reached the shoreline in surface waters at Hout Bay. At Green Point, a single episode of water quality impairment in the nearshore could not be clearly attributed either to the marine outfall or to land-based sources. In Camps Bay, there is some evidence for very diluted wastewater reaching the nearshore at the surface (behind the surf zone) on occasion under certain weather conditions, but with bacterial counts well below guideline values indicative of a risk to the health of recreational water users. Although the data collected cannot be used to identify sources of faecal bacteria, there was no evidence that wastewater discharged through the Green Point, Camps Bay and Hout Bay outfalls resulted in microbiological impairment of shoreline water quality on the days sampled.

Some beaches in the vicinity of the marine outfalls were, periodically during the year, characterised by FIB counts that indicate there would have been a health risk associated with swimming or participating in other recreational activities in coastal waters. Around the Green Point outfall, Mouille Point Beach was assigned a recreational water quality category of 'Excellent', not having any documented exceedances of guideline FIB counts during the year. Three Anchor Bay Beach, in contrast, had four such exceedances and is assigned a 'Poor' classification, due to impacts attributed to the stormwater drains discharging into the bay. The coastal water quality at beaches near the Camps Bay marine outfall was generally very good, with some of the lowest FIB guideline exceedance rates in Cape Town over the period. A known point source of pollution at Saunders Rocks contributes to poor water quality at this site, and episodes of rainfall-related deterioration in water quality resulted in lower classifications for the Bakoven and Barley Bay beaches. In Hout Bay, beach water quality remained severely impaired during the study period, but is most directly affected by the highly polluted Hout Bay River, rather than by significant impacts associated with the marine outfall.

2.7.2 Permit compliance

Water quality at the Green Point marine outfall was compliant at the boundary of the AMZ with permit conditions for temperature, salinity, dissolved oxygen, and pH during the study period. Turbidity and TSS were not compliant with permit limits based on reference site comparisons, due to increases during winter sampling events that are attributed to environmental, rather than

anthropogenic, causes. FIB counts suggested that recreational activity on the boundary of the AMZ – if this were to take place – would have posed a risk to human health on at least three occasions, and Hazen-based categories calculated for the AMZ sites were 'Poor' at five, and 'Sufficient' at one of the six sites monitored. The exceedances resulting in this classification occurred during winter flood events and are not believed to relate to the marine outfall specifically.

Water quality at the Camps Bay marine outfall was compliant at the boundary of the AMZ with permit conditions for salinity, dissolved oxygen, and pH. Temperature was not compliant with permit limits based on comparisons with the Karbonkelberg reference site, but this is attributed to environmental differences between the more exposed reference site and the generally shallower and more stratified AMZ sites around the outfall rather than to pollution impacts. Turbidity and TSS were also not compliant with permit limits based on reference site comparisons, due to increases during winter sampling events that are attributed to environmental, rather than anthropogenic, causes, and to a sandy seafloor around the outfall compared with a rocky reference site. FIB counts suggested that recreational activity at or near the boundary of the AMZ – if this were to take place – would have posed a risk to human health on two occasions, and Hazen-based categories calculated for the AMZ sites were 'Poor' at one (offshore) site, 'Excellent' at two, and 'Good' at three of the six sites monitored.

Water quality at the Hout Bay marine outfall was compliant at the boundary of its AMZ with permit conditions for temperature, salinity, dissolved oxygen (at the surface and mid-depth) and pH. Dissolved oxygen in bottom waters was low, but still compliant. This is likely due to the depth of the sites and not an indicator of impact. Turbidity was compliant with permit conditions based on reference site comparisons at the sea surface, but not at mid-depth or (at two of six sites) in bottom waters. Absolute values were low, and permit limit exceedances may be due to environmental, rather than anthropogenic, causes. Contributions of the outfall wastewater to elevations in turbidity at mid-depth are not, however, ruled out. FIB counts suggested that recreational activity on the boundary of the AMZ – if this were to take place – would not have posed a risk to human health on of the dates monitored, and Hazen-based categories calculated for the AMZ sites were 'Excellent' at five sites, and 'Good' at one of the six sites monitored.

2.7.3 Effluent plume behaviour

The data collected enabled estimations of the direction and approximate amount of dilution of the effluent plume at all three outfalls on most dates, although some sampling events found no evidence of the plume reaching the boundary of the AMZ. For example, at Green Point, the plume was frequently detected moving in a north-easterly direction at mid-depth; in Hout Bay, the plume was frequently detected at mid-depth moving either into or out of the bay, and at Camps Bay, the effluent plume was detected at high levels of dilution at the surface to the south of the outfall, or at depth, to the north of the outfall. The Green Point outfall plume exhibited the behaviour expected of a buoyant effluent plume discharged at the sea floor: initial rapid vertical ascent, stalling or dispersing in the middle waters, and reaching the surface in reduced, though still periodically significant concentrations. The Hout Bay outfall plume tended to stall and disperse in middle waters, and reached the surface only after sufficient dilutions to meet recreational guidelines.

These data are consistent with the findings of the dispersion modelling studies conducted for the CCT in 2020-2021, and suggest that the model outputs are a valuable management tool in determining the impacts of the outfalls on coastal water quality.

2.7.4 Toxicity testing

Toxicity testing quantifies the aggregate toxic effect of an aqueous sample (in this case, seawater) as measured by an organism's response upon exposure to the sample (e.g. lethality, impaired growth, or impaired reproduction). While the concentrations of known individual contaminants/pollutants within sewage can be used to estimate toxicity to the receiving environment, these analyses alone are mostly inadequate for assessing the risk once these constituents are all mixed/combined and diluted in the receiving environment. This information on toxicity is not available for all chemicals, and many chemicals with known toxicity have unknown additive, antagonistic or synergistic toxic effects when present in complex mixtures. Toxicity testing measures the effect of a mixture of contaminants regardless of its physical and chemical properties and accounts for antagonistic, additive, and synergistic effects of the potentially thousands of constituents in a pollution source. Toxicity testing also puts chemical analytical data into perspective, as it directly assesses biological availability of all chemical substances in the effluent/pollution source, and their effects on reproductive success. This is important since the mere presence of a chemical in water or sediment does not imply it is in a bioavailable form (i.e. a form that can cross biological membranes). Only if it is in a bioavailable form can a chemical exert an effect (adverse or beneficial). Metals bound in the crystal lattice of sediment grains, for example, are in a non-bioavailable form, while metals dissolved in the water column are generally in a bioavailable form. To further complicate matters, because a chemical is in a bioavailable form does not mean it will exert an effect. This can only occur if there is exposure, that is, an organism actually comes into contact with the chemical. Toxicity testing takes these complexities into account. Sea urchin fertilisation toxicity tests investigate effects that directly inhibit fertilisation, but cannot exclude the presence of other toxicants acting through different mechanisms. Nonetheless, the assay remains a sensitive and widely recognised method for assessing sublethal toxicity in marine environments.

A total of 571 seawater samples from around all three outfalls and reference sites were collected and toxicity testing conducted during the July 2024 – June 2025 monitoring campaign. This is equivalent to 144 samples from the AMZ boundary at the Green Point and Hout Bay outfalls (each), and 141 samples from the AMZ boundary at the Camps Bay outfall (one site was missed due to bad weather in August 2024), 36 samples at the Karbonkelberg, Chapman's Peak and Crayfish Factory reference sites and 34 samples at the Robben Island Reference site. Acute toxicity to urchin gametes i.e. an average fertilisation success rate of less than 70%, occurred in only 10 of the samples tested. The toxicity testing of 178 seawater samples collected from the Green Point area (including reference site) revealed only a single account of toxicity to sea urchin gametes, in the midwater of the Robben Island References site (RI001 M in September 2024). Only three samples from the Hout Bay area were toxic, including a single bottom water sample in the AMZ (KB001 in April 2025), and a sample from each of the two reference sites; a bottom water sample at CF001 and a midwater sample at CP001 both in April this year. Samples from the Camps Bay area had the highest number of acute toxicity events, with three toxic samples in bottom waters of CB007 in February, March and April 2025, and three samples at the Karbonkelberg Reference site, including bottom and surface samples in February and a midwater sample in April 2025.

Guideline values for sea urchin fertilisation success range from 70% to 100%, which is a large range. Therefore, statistical tests were conducted for each month's data to determine if the fertilisation success of any AMZ sample differed significantly from the equivalent reference sample. The percentage fertilisation success of an AMZ surface sample was compared with the surface sample at its corresponding reference site, using non-parametric tests. The majority of AMZ samples did not differ significantly from the reference samples, with the expected exceptions being where acute toxicity occurred at a small number of sites in September 2024, February, March and April 2025. This low incidence of toxicity events across the board, along with the occurrence of toxicity events at reference sites, suggests that discharge of wastewater through the outfalls is not resulting in

concerning levels of impact on biota through acute toxicity, and also that toxicity events occur naturally at sites across the Atlantic seaboard.

2.7.5 Comparison with previous studies

Water quality data reported above were broadly consistent with data and impacts reported by previous authors (CLS, 2021, 2022a; CSIR, 2017a). A greater degree of variability, particularly in physical and chemical parameters, may be attributed to the intentional increase in tolerance for more variable (less 'ideal') weather and sea conditions during sampling than in previous surveys. With the benefit of dispersion model outputs (PRDW, 2020a, 2020b, 2021), this study has been able to better compare periodic data against expected effluent plume behaviour under various conditions, and to draw conclusions on the likely explanations for observed data in relation to weather and sea state.

Certain outlier data require further investigation; specifically:

- the three toxicity events reported in bottom waters at a site near the Camps Bay outfall and at the Karbonkelberg reference site in summer / autumn 2025, the potential frequency of which will be monitored in the form of continued monthly toxicity analyses at Camps Bay sites despite a reduction in frequency to quarterly sampling at the other two outfalls; and
- recurring high FIB counts in coastal waters at Green Point Pump Station and Three Anchor Bay, indicative of sources of sewage contamination in these areas.

2.7.6 Ecological impacts

Water quality data presented here do not provide evidence of any risk posed by the marine outfalls to marine biota or ecology. Chapters 4, 5 and 6 respectively include more relevant reporting on sediment quality, ecological effects, and bioaccumulation data respectively.

3 EMERGING CONTAMINANTS: MICROPLASTICS

3.1 Introduction

The primary, secondary, and even tertiary treatment of wastewater does not effectively remove all contaminants arising from human activities. Dubbed ‘contaminants of emerging concern’ (CECs) (Yang et al., 2021) these include a wide array of chemicals from pharmaceuticals and personal care products to per- and polyfluoroalkyl substances (PFAS) and microplastics. CECs are not necessarily new contaminants, but rather contaminants which may have already been in the environment but have only recently been found to be of concern, or successfully detected (i.e. hazardous ecologically, environmentally, and/or to humans). The 2024 Receiving Environment Monitoring Programme has two components: three-yearly monitoring of a suite of pharmaceuticals and personal care products [PPCPs] and herbicides, and quarterly monitoring of microplastics.

Microplastics have been identified as a marine contaminant and pollutant potentially posing an ecological threat to marine organisms and to humans who consume these marine species. Microplastics are small to microscopic pieces of plastic (<5 mm) which result from the breakdown of plastic debris (secondary microplastics); small plastic particles, i.e. nurdles, which are specifically manufactured to be used in plastic production; or microbeads which are used in cosmetics and detergents (primary microplastics).

Microplastics have been found in all parts of the ocean including at the bottom of the Mariana Trench (the deepest point in the ocean), (Zhao et al., 2025) as well as in a wide range of marine species, including sardines (Bakir et al., 2020) and hake (Sparks & Immelman, 2020) off the coast of South Africa. Microplastic levels were recorded as 12.08 ± 1.3 particles/L (Sparks et al., 2023) in the Port of Cape Town, compared to studies in Port of Durban Harbour which recorded levels of between 0.007 to 1.20 particles/L of seawater (as summarised in Sparks et al. (2023)). Ingestion of microplastics by marine organisms can cause mechanical impacts, such as the clogging of the digestive tract or smothering of breathing apparatus, or ecological effects, such as hepatic stress and slowed growth rates (Gall & Thompson, 2015).

Microplastics can enter the ocean from land-based sources, such as stormwater runoff, sewer overflows, marine and coastal outfalls, or marine-based activities such as harbour dredging, the fishing industry or mining. Runoff entering the ocean through stormwater systems has been identified as a significant source of microplastics within South Africa, with high levels of polymers that had a high associated ecological risk factor (see Julius et al. (2023) for more information), found in sediments around Cape Town, especially near Mouille Point (Granger Bay: 234.67 ± 31.42 particles/kg of sediment vs 149.71 ± 21.17 particles/kg in False Bay (Julius et al., 2023)). Other studies have found that wastewater (both treated and untreated) forms a significant source of microplastic pollution in the ocean, with marine outfalls mentioned as potentially being a significant contributor (Bhikhoo et al., 2024; Julius et al., 2023; Verster & Bouwman, 2020a).

Another type of microplastic associated with sewage discharge is a type of primary microplastic, known as microbeads, which are commonly used in cosmetics and personal care products (e.g. toothpastes and facial scrubs). Many countries, such as the England, the USA and New Zealand, have banned the use of these microbeads. They have not yet been banned in South Africa, but the DFFE has issued draft regulations for public comment for the banning of the use and production of microbeads (DFFE, 2025) and the cosmetic industry in this country has implemented some initiatives to develop a more environmentally friendly substitute for microbeads (Verster & Bouwman, 2020a). Microbeads typically range from 1-1000 µm in size and are predominantly made from polyethylene which is less dense than seawater (Pereao et al., 2020).

Other potential sources of microplastics include litter and untreated wastewater entering the marine environment via rivers, stormwater drains and industries, such as the fishing industry. From the fishing industry, secondary microplastics are expected: predominantly fibres and fragments, from the degradation of fishing equipment, such as nets and ropes etc., which are composed primarily of polyamide (nylon) (Verster & Bouwman, 2020b). From the degradation of larger single-use plastic items into microplastics, fragments made up of polymers such as polyethylene (high and low density), polystyrene and polylactic acid are expected (Verster & Bouwman, 2020a). Single-use plastic items can enter the ocean through stormwater drains, especially during periods of heavy rainfall, and also from rivers which can carry plastics from the terrestrial environment into the marine environment. Approximately 80% of plastic pollution (of all sizes) is from land-based sources (Andrady, 2011).

As mentioned above, microplastics can be harmful to marine life, causing mechanical impacts such as reducing the ability of organisms to feed, by obstructing the digestive tract, or their ability to breathe, by smothering their gills, leading to a loss of overall health and fecundity (Gall & Thompson, 2015). In addition, microplastics are made from, and have the ability to, adsorb potentially harmful chemicals, which are then distributed widely on the buoyant plastic particles with ocean currents. Chemicals, such as flame retardants, antioxidants and catalysts, are often added to plastics during production to improve performance. Other chemicals, such as PAH, DDTs, DDEs, PCBs and HCHs, can be absorbed by the plastic particles at much more concentrated levels than the surrounding seawater (Pereao et al., 2020). These chemicals consist of unreacted raw materials and additives which can then leach into the environment or be ingested by organisms which can lead to severe and adverse health effects. These toxins can then be transferred up the food chain and bioaccumulate in species which may, in turn, be consumed by humans with associated health consequences, such as cancer or reproductive abnormalities (as summarised in Pereao (2020)).

As microplastics are a contaminant of emerging concern, and have not previously been monitored when assessing potential impacts of the marine outfalls, it was considered relevant to include a microplastics component in the monitoring of impacts on the receiving environment in the vicinity of CCT marine outfalls. Although there are no regulations or guidelines regarding microplastic contamination from outfalls, monitoring will contribute to an understanding of impacts and changes in the receiving environment over time.

3.2 Methods

Microplastic pollution research is a relatively new and emerging field, with limited studies (40 publications) having been conducted within a South African context (Dahms & Greenfield, 2024). There are currently no regulations or guidelines regarding the quantity of microplastics discharged through WWTW, as microplastics have only become identified as a concern or potential health risk within the last decade. As such, there are no standardised protocols for quantifying microplastic pollution from outfalls in South Africa and little to no information on what levels would be considered harmful. There is also as yet no requirement within Coastal Water Discharge Permits to monitor microplastic contamination, instead authorities aim to reduce plastic pollution at its source. This is done through Regulations such as the Extended Producer Responsibility Regulations, 2020 (Government Notice 1184 of 2020) which is published under the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008). The aim of this Regulation is to reduce waste and improve waste management by making businesses responsible for what happens to their products after they have been used. Additionally, as mentioned above, the DFFE is proposing to ban the production and utilization of microbeads in cosmetics in an effort to reduce microplastic particles entering South Africa's water systems (DFFE, 2025).

Given the deficit of local information on microplastics and the contribution of the marine outfalls to microplastic pollution on the CCT coastline, the CCT has been proactive in including microplastics

as a potential contaminant of emerging concern in its outfall monitoring programme. Given the lack of standardised protocols in South Africa for marine outfalls, the sampling methodology for this programme is based on the NOAA Marine Debris Program's *Technical Memorandum NOS-OR&R-48* (NOAA Marine Debris Program, 2015), with substantial modifications to match the requirements of this monitoring programme, as well as available scientific literature and consultations with microplastic experts in South Africa. This survey is the first of its kind in South Africa and is a preliminary look at microplastic counts in the marine waters around the CCT, especially around the outfalls. As a baseline study it aims to establish the presence and quantity of microplastics and to inform future work.

Microplastic samples were collected from the water column surrounding the outfalls in September 2024, December 2024, March 2025 and June 2025. For each outfall, four sites were sampled around the boundary of the AMZ, one site was sampled at the associated reference site and additional samples were collected near river mouths/stormwater drains to assess the relative contribution from other potential sources of contamination (Figure 3-1). In Hout Bay, additional samples were collected at site HB005, as this is where the Disa River flows into to the bay. Additional samples in Green Point were also collected at GP018 and GP019 to account for contributions from the Diep and Salt Rivers and at GP004 to account for the stormwater outflows at Three Anchor Bay.

At each sampling site, samples were collected at three different depths: the surface (1 m below the surface), mid-depth (total depth/2) and bottom (1 m above the ocean floor). While the NOAA methodology suggests using a manta net for the collection of microplastics, the collection of water samples from three different depths at each site meant this was not feasible, as manta nets are generally only used on the surface and are dragged over a considerable distance, whereas this monitoring programme required sampling at specific points around the outfall. Instead of a manta net, an innovative system consisting of a deck wash pump and a series of pipes fitted with a 5 mm filter at the end (microplastics < 5 mm), was used to pump 100 litres of water, from each depth, through a set of nylon filters (1000 µm, 500 µm, 100 µm and 50 µm) held within a tower structure to keep the mesh in place (Figure 3-2). Between each depth and site, site water is pumped through the pipes to flush out and clear them of any seawater and potential microplastic contamination, from the previous sample, before the pipe is connected to the filter tower. At each site, the surface was sampled first to prevent contamination of the surface waters with mid and bottom waters.

The size of the mesh filters was chosen to sample a range of microplastic sizes from 5 mm to as small as reasonably possible. Microplastic research is still an emerging field, and the protocols are not yet standardized. The NOAA Marine Debris Program's *Technical Memorandum NOS-OR&R-48* (NOAA Marine Debris Program, 2015) only uses 1 mm (1000 µm) and 0.3 mm (300 µm) sized mesh. This is because manta nets usually have a mesh size of 0.3 mm, which limits the minimum size of particles that can be sampled. Based on reviews of microplastic literature (Preston-Whyte et al., 2021; Yang et al., 2021), and because the method was not limited by the size of the manta net, this study included more filters and sampled to a smaller minimum size (50 µm).

While some other studies measure each microplastic length under the microscope, this was considered impractical given the large numbers of samples being processed and, instead, the number of microplastic particles was counted on each filter and assigned to the size class of that filter. Originally a fifth filter of 20 µm was included in the tower, which is one of the smallest mesh sizes used, based on available literature, but because it clogged up so quickly with suspended particles in the water column, it was discarded in favour of sampling larger volumes of seawater to obtain a more accurate estimate of microplastic count.

Given the corrosive nature of seawater, the microplastic tower is made of sturdy and resilient polyvinylchloride (PVC) cylinders (not stainless steel), the same material used in the NOAA manual to build microplastic filters (NOAA Marine Debris Program, 2015), due to the lack of microplastic

shedding associated with this material. Nylon filters were chosen based on the NOAA Marine Debris Program's *Technical Memorandum NOS-OR&R-48* (NOAA Marine Debris Program, 2015).

The microplastic filters from the tower were then collected, carefully stored in sealed containers which had been cleaned and rinsed with distilled water and taken back to the laboratory for counting and identification. While the NOAA method uses a digestion step, to dissolve organic matter, and separation step, to remove sediment and heavier particles from the sample, the seawater samples for the 2024 Receiving Environment Monitoring Programme are generally very clear (unlike river and harbour samples) and had much lower quantities of debris and sediment in them. In addition, the 5 mm first filter is used in the field to remove larger particles before the storage of each sample. Density separation is also more commonly used in sediment sampling of microplastics, not usually for water samples (Dahms & Greenfield, 2024). In the interest of financial considerations and time, as well as the risks associated with using hydrogen peroxide to dissolve organic matter, the implementers of this monitoring programme opted to simplify the approach by excluding these steps.

At the laboratory, microplastics were classified as either fragments, fibres, films or nodules, and counted under a dissecting microscope (Figure 3-3). Occasionally, bundles of fibres were found on the filters. As bundles could easily contain hundreds to thousands of fibres, and counting each individual strand is a time-consuming process, the number of fibres per bundle was estimated and multiplied by the number of bundles. Precautions including working in a clean laboratory, wearing nitrile gloves and lab coats when counting samples, keeping filters covered in foil when not being actively counted and storing filters in individual sealed containers immediately after preparation were taken to avoid contamination of filters prior to collection and during the counting process. Field control filters (i.e. filters that were cut and taken into the field, but were not exposed to seawater) were also taken each day that samples were collected in the field, in order to account for any possible contamination - as microplastics are ubiquitous and any exposure to air can lead to potential contamination despite the precautions undertaken. Numbers of microplastics detected on the field control filters were subtracted from the final count of microplastics by type to account for this. As controls were not used for the first survey, the control values for the first survey were calculated by taking an average of the subsequent surveys' controls.

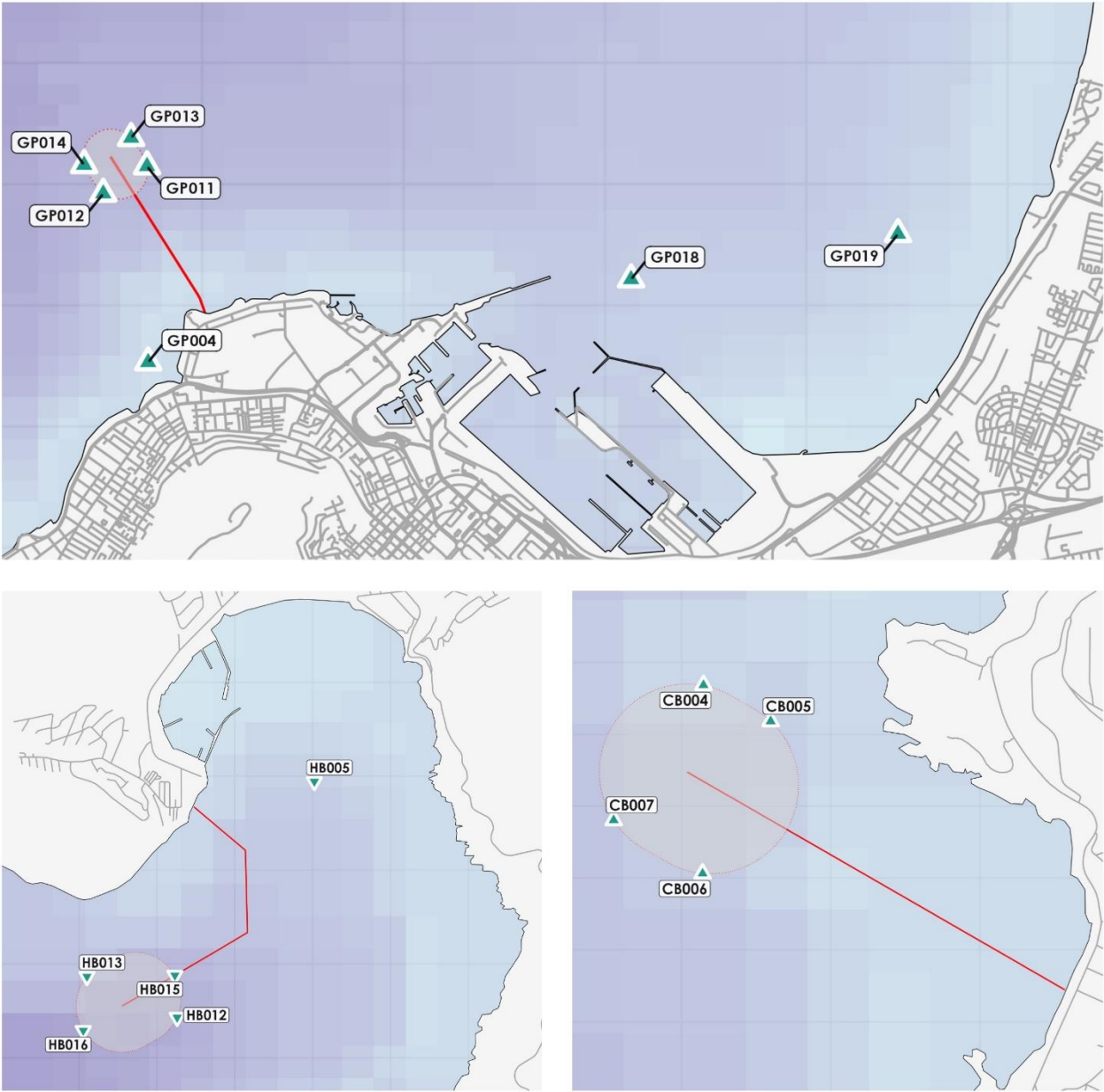


Figure 3-1. Monitoring sites for microplastics in seawater.

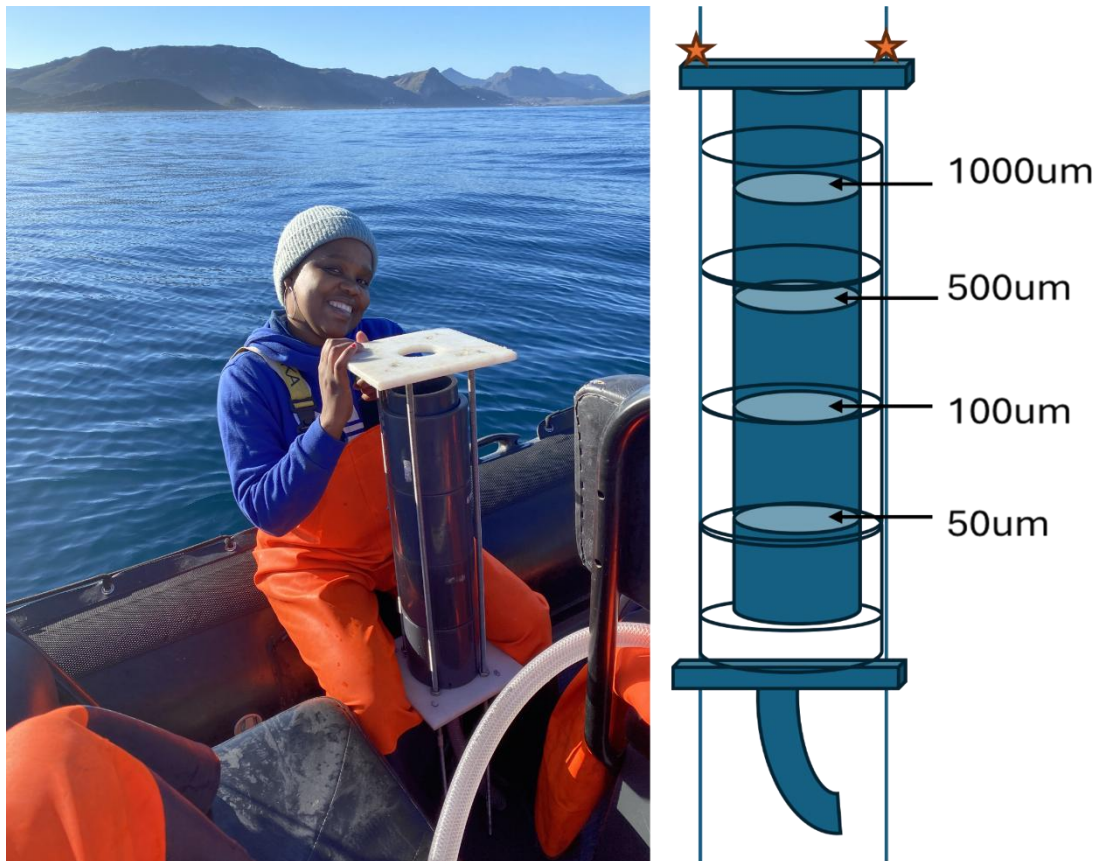


Figure 3-2. Filter Tower

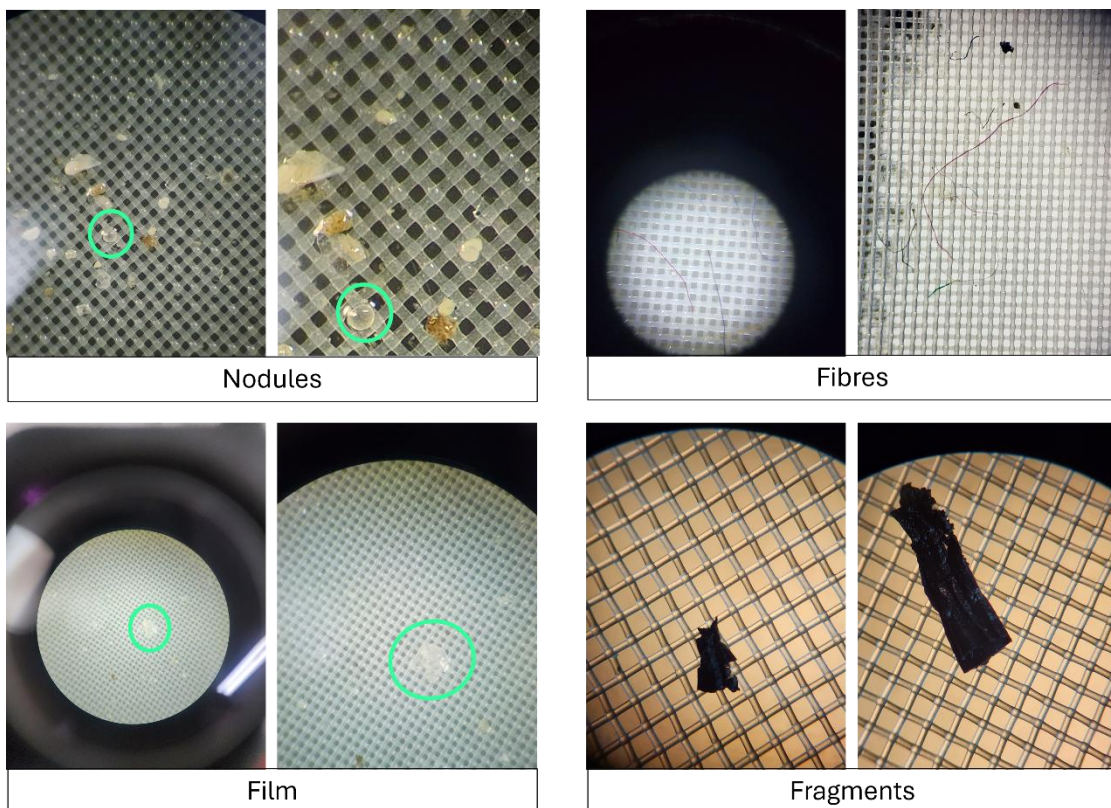


Figure 3-3. Microplastic types commonly found in the CCT samples.

3.3 Results

Microplastic data were collected every three months between September 2024 and June 2025. The results from the 2024/2025 sampling period for the three different outfalls, Camps Bay, Green Point and Hout Bay, are shown below. Microplastics were found both around the outfall sites and at their respective reference sites. The data are presented in Figure 3-4, Figure 3-5 and Figure 3-6 by type and size class.

The vast majority of microplastics found in the surveys were fibres, which is in line with global trends (Yang et al., 2021). In particular, very high numbers of fibres were occasionally found on the boundary of the AMZ at each outfall, frequently in the form of bundles of fibres (Figure 3-4, Figure 3-5, & Figure 3-6). These bundles were made up of large numbers of fibres which had clumped together and contributed to the very high numbers of microplastics recorded at CB007, CB004, GP013, GP014, HB012 and HB016 on the respective sampling surveys (Table 3-1). Aside from these eight instances, the number of microplastic particles per litre of seawater was <10, which was similar to concentrations of 12.08 ± 1.3 particles/L found in the Cape Town Harbour (Sparks et al., 2023).

Table 3-1. Sites with high numbers of microplastics (>10 particles/L).

Outfall	Site	Impact	Depth	Survey Month	Total Count per litre
Camps Bay	CB007	AMZ	Surface	September 2024	29.6
Camps Bay	CB004	AMZ	Surface	June 2025	35.3
Greenpoint	GP014	AMZ	Mid	September 2024	20.5
Greenpoint	GP014	AMZ	Mid	March 2025	128.6
Greenpoint	GP013	AMZ	Surface	June 2025	11.3
Hout Bay	HB012	AMZ	Bottom	September 2024	11.6
Hout Bay	HB012	AMZ	Bottom	March 2025	89.3
Hout Bay	HB016	AMZ	Mid	September 2024	9.3

3.3.1 Seasonal Patterns

3.3.1.1 Camps Bay

Around the Camps Bay outfall, the highest number of microplastics was recorded on the surface at site CB004, at the boundary of the AMZ, during the winter months (35.6 particles/L). The lowest microplastic count during the winter surveys was observed at the reference site, KB001 at the bottom depth (0.2 particles/L) (Figure 3-4).

During the summer months, the highest microplastic count was lower than recorded in winter and was observed at the CB006 surface site, located at the boundary of the AMZ (6.3 particles/L). The lowest summer count was again recorded at the reference site, KB001, at the middle depth and was lower than those recorded in the winter months (0.03 particles/L) (Figure 3-4).

3.3.1.2 Green Point

At the Green Point outfall, the highest microplastic count recorded across all three outfalls and survey months was measured during a summer survey at site GP014, at the middle depth, on the boundary

of the AMZ (128.6 particles/L). The lowest count of microplastics during summer surveys was recorded at the surface of GP012 at the boundary of the AMZ (0.00 particles/L) (Figure 3-5).

During the Green Point winter surveys, the maximum microplastic count was observed at the middle sampling depth of GP014, at the boundary of the AMZ (21.2 particles/L). The minimum count was recorded at the surface of GP004, near the stormwater outlets at Three Anchor Bay (0.4 particles/L) (Figure 3-5). While it is possible that increased rainfall and subsequent runoff, during the rainy winter season would likely result in higher stormwater discharge volumes (and theoretically pollution/litter/microplastic contamination), this would be dependent on the frequency and timing of rainfall events relative to the sampling date.

3.3.1.3 Hout Bay

Similarly to the Green Point outfall, the highest number of microplastics (89.3 particles/L) was recorded during the summer season around the boundary of the AMZ at bottom depth of site HB012. During summer, there were no microplastics of any type recorded at several of the Hout Bay sites, including: HB005 bottom (Disa River contamination control), HB012 surface (AMZ), HB013 bottom (AMZ) and HB016 middle (AMZ) (Figure 3-6).

In winter, microplastic counts were lower than in the summer season, with a maximum count (12.3 particles/L) observed at the bottom depth of HB012 at the boundary of the AMZ, and a minimum count (0.1 particles/L) observed at the surface of the reference site, CF001 (Figure 3-6).

3.3.2 Quarterly data summaries

3.3.2.1 Camps Bay

For the first microplastic sampling survey in September 2024, the highest count was 32.5 particles/L for Camps Bay at the surface for site CB007. This is a very high count for microplastics and was one of the samples in which bundles of fibres were found. The lowest count was recorded at CB006 middle sampling depth (0.8 particles/L). Both sites are situated at the boundary of the AMZ.

In December 2024, both the highest microplastic count, recorded at the surface of CB006 (6.3 particles/L), and the lowest, recorded at the bottom depth of CB004 (0.1 particles/L), were recorded at sites around the boundary of the AMZ.

Microplastic counts were low overall at Camps Bay in the March 2025 survey and there were no bundles observed. The highest count was only 1.4 particles/L, which was recorded at the surface of CB005, and the lowest count of 0.03 particles/L was recorded at the reference site, KB001, at the middle sampling depth.

In June 2025, there were once again bundles of fibres picked up and the maximum count was very high (35.6 particles/L) and recorded at CB004 at the surface, around the boundary of the AMZ. The lowest count was again picked up at the reference site, but at the bottom depth for KB001 (0.2 particles/L).

3.3.2.2 Green Point

For the Green Point outfall, the maximum count for microplastics in the June survey 2024 was recorded at one of the AMZ sites, GP014 at the middle sampling depth (21.2 particles/L). The minimum count was recorded at GP004 at the bottom sampling depth, which is the control site as there might be potential contamination from Three Anchor Bay (0.4 particles/L).

The December 2024 survey had the lowest overall microplastic numbers, with the highest count being recorded again at GP014, but at the bottom depth (4.2 particles/L), and the lowest count being recorded at another site around the boundary of the AMZ, GP012 at the surface (0.00 particles/L).

Bundles of fibres were recorded during the March 2025 sampling surveys at Green Point. The highest microplastic concentration was once again detected at GP014 at the middle depth, where 128 particles/L were measured. This was the greatest value recorded across all outfall sites throughout the entire survey period. Similarly to the December survey, the lowest microplastic count was recorded at the bottom depth of the site GP012 (0.1 particles/L).

For the June 2025 survey, the highest microplastic count was observed at the boundary of the AMZ at GP013 at the surface. The lowest count was observed at the reference site RI001 at the bottom sampling depth (0.8 particles/L). Interestingly, the surface sample from GP014 was predominantly made up of fragments, as opposed to microfibrils which are the most numerous types of microplastic found across the surveys.

3.3.2.3 Hout Bay

For the September 2024 survey of Hout Bay, the maximum concentration of microplastics was found at one of the sites at the boundary of the AMZ, HB012 at the bottom sampling depth (12.3 particles/L). The lowest count was at another site around the AMZ, HB013, at the middle sampling depth (0.02 particles/L).

For the December 2025 survey, the overall microplastic counts were low. The highest microplastic count was at one of the reference sites, CP001, at the middle sampling depth (2.3 particles/L). The lowest count was found at HB005 at the bottom sampling depth (0.1 particles/L), which is the control site for the Disa River as another source of potential contamination. The HB005 surface results were also interesting in that there were more fragments and films than microfibrils.

Similarly to the Green Point outfall, the highest microplastic count was found during the March 2025 survey. In September, the highest microplastic count was found at the bottom sampling depth of HB012 (89.3 particles/L), while at several sites: HB005 Bottom, HB012 Surface, HB013 Bottom & HB016 Middle, no microplastics were recorded.

Overall microplastic counts were low in the June 2025 survey, similarly to the December 2024 survey. The maximum count was 2.94 particles/L which was observed at the bottom depth of HB016, around the boundary of the AMZ. The lowest count of 0.28 particles/L was observed at the same site, HB016, but at the middle sampling depth.



Figure 3-4. Camps Bay microplastic results from the 2024/2025 sampling period. The AMZ sites are shown in the orange panels, with the reference sites shown in white. Y-axis upper limit set at 10 particles/L.

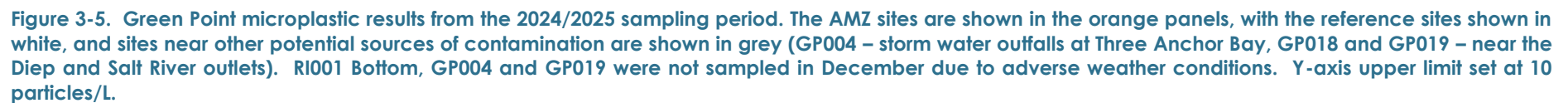




Figure 3-6. Hout Bay microplastics results from the 2024/2025 sampling period. The AMZ sites are shown in the orange panels, with the reference sites shown in white, and sites near other potential sources of contamination are shown in grey (HB005 – Disa River). Y-axis upper limit set at 10 particles/L.

3.4 Discussion

Higher numbers of microplastics in the marine environment have been shown to be associated with areas where coastal population densities are higher. Microfibres are known to enter the marine environment from sewage (Browne et al., 2011; de Villiers, 2018; Verster & Bouwman, 2020b), as they have been shown to be released in high quantities from synthetic clothing and carpets when they are machine washed (Maciel et al., 2022; Napper & Thompson, 2016). Microfibres from laundry mostly consist of fibres made from polyester and acrylic, while polyamide garments shed fewer plastics (Maciel et al., 2022). Wastewater from the laundry then enters the municipal drainage systems and is carried to the subsequent treatment plants (Maciel et al., 2022; Napper & Thompson, 2016).

Land-based WWTWs have been shown to remove around 99% of microplastics entering the treatment plant from the influent water compared to the effluent water (Carr et al., 2016; Magnusson & Norén, 2014). Depending on the WWTW and the treatment of the wastewater, microplastics may be removed via surface skimming, as well as by settling in the sludge which is then removed. A large portion of the microplastics is thereby removed from the wastewater, although some may subsequently be released to the environment in waste sludges. Despite this, domestic washing machine use is likely still a potentially significant source of microplastic pollution, given the high volumes of treated wastewater that are discharged into the environment and the 1% of microplastics that remain in final effluent (Verster & Bouwman, 2020b). Note that wastewater discharged from the outfalls at Green Point, Camp Bay and Hout Bay undergoes preliminary treatment only, which comprises screening (12 mm and 3 mm mesh sizes) designed to remove larger inorganic and non-degradable constituents only, and thus wastewater released from these outfalls potentially contains higher concentrations of microplastics than does wastewater treated at a WWTW which undertakes secondary or tertiary treatment. Not all of Cape Town's land-based WWTWs operate within their design parameters, however, and significant flows of sewage and washwater are also discharged directly into rivers or the sea, via the stormwater system or overland runoff, from spills and surcharges, and from areas without sufficient formal sewerage systems where greywater and sewage are discharged directly to stormwater and rivers. While it is likely that fibres found in the marine environment originate from some combination of the outfalls, stormwater and river inputs, the occurrence of elevated numbers of fibres at AMZ sites suggests that many of these may originate in wastewater introduced via the outfalls (Figure 3-4, Figure 3-5 & Figure 3-6).

Very few microbeads were found during microplastic sampling in this study, however, which is consistent with other studies undertaken in South Africa which found lower densities of this class of microplastics than what is found in more developed countries (Verster & Bouwman, 2020a). Overall, microbeads were the least numerous type of microplastic recorded across the different outfalls and the reference sites (Figure 3-4, Figure 3-5 & Figure 3-6).

There were also relatively similar numbers and compositions of microplastics found at the reference sites and sites of known alternative pollution sources, highlighting the ubiquity of this form of pollution around Cape Town. There were no obvious trends with regards to seasonality and rainfall, and no significant differences between the different outfalls or between the different depths.

As mentioned above, there are no regulations or limits specifying the quantities of microplastics being released from outfalls in South Africa. There are also no protocols for quantifying and monitoring the release of microplastics from outfalls, and as discussed, microplastics were also found at reference sites and throughout the coastal waters of Cape Town and it is currently inconclusive as to whether the outfalls are the primary source of these microplastics. These surveys are a preliminary analysis of this contaminant of emerging concern and confirm that microplastics are indeed ubiquitous in coastal waters around Cape Town and not just in areas around the AMZ of the outfalls, that

microfibres are the most abundant, and that total counts of microplastics per litre are not high in global terms. Microplastic research is still an emerging field, and while microplastics have been suggested to have negative implications for humans and marine fauna, more research needs to be done to determine what concentrations and exposure are considered harmful to marine organisms, the marine environment and human health. Additionally, more research needs to be conducted within a South African context, with long-term studies to provide more informative baseline data from which to inform policy and environmental management. Should microplastic monitoring be continued at the outfalls, testing of the raw effluent for microplastics and, if practicable, FTIR analysis of polymers should be undertaken to determine the type of plastic and provide insight into sources of microplastics.

4 SEDIMENT QUALITY

4.1 Introduction

Sediment is the combined term for mud, sand, gravel, and organic detritus, and when accumulated on the seafloor, provides essential habitat for many bottom-dwelling marine organisms. Contaminants introduced to the marine environment may accumulate in these sediments due to their physical properties, causing sediment to act as a type of reservoir or sink for contaminants (Kuznetsova & Timerbaev, 2022). Marine outfalls discharge high volumes of suspended particles, of which some are dispersed by currents while others settle on the seafloor in the benthic environment. Sediment contamination may pose risks to individual organisms and overall ecosystem health, whilst also serving as a potential pathway for bioaccumulation (Chiaia-Hernández et al., 2022). The tendency for sediment to act as a reservoir for contaminants makes it a powerful tool for marine outfall impact monitoring programmes.

Additionally, sediment provides a temporally integrated measure of pollutant loading in the receiving environment, making it a better indicator of long-term pollution than water samples, which only provide a once off snapshot in time. The accumulation of contaminants in sediment is not uniform though, with several factors influencing accumulation rates – including particle size (finer silts, clays, and organic matter bind contaminants more effectively than coarse sands), sediment deposition rates (high natural sedimentation can 'dilute' contaminant concentrations), and water flow (high-energy environments may resuspend and disperse sediments and attached contaminants more readily than low-energy environments like harbours or estuaries, where accumulation dominates). Sediment and contaminant chemical properties, as well as environmental conditions such as salinity, pH and temperature, also affect the binding or adsorption of contaminants, while biological processes such as bioturbation (mixing of sediments by organisms) and microbial activity can also impact on sediment contamination rates.

Multiple previous sediment quality investigations have been conducted around the three marine outfalls in Cape Town, with the CSIR having conducted sampling in 2003, 2005/06, 2011, and 2015/16. The 2003 study (CSIR, 2003) involved the collection of sediment from 97 sites across Table Bay, Camps Bay and Hout Bay, and the 2015/16 study successfully sampled 40 of 67 target sites. The most recent reporting (CSIR, 2017a) recommended that the sampling sites for sediment quality should ideally be informed by simulations of the fate of effluent through numerical modelling. Dispersion modelling (PRDW, 2020a, 2020b, 2021) confirmed the conclusion by the CSIR that the accumulation of sediments and associated contaminants in the nearfield coastal environment is unlikely, due to the high-energy nature of the environment near the outfalls. The only areas found in the models to be significant depositional zones were the two harbours (the Port of Cape Town and Hout Bay Harbour).

This chapter discusses the results of the physical and chemical analysis of sediment collected in the Green Point, Camps Bay and Hout Bay areas in 2024/2025. The data are compared to findings of previous studies in these areas, where possible.

4.1.1 Structure of this chapter

- **Methods** relating to this sediment quality monitoring effort are described in §4.2;
- **Results and Discussion** are presented in §4.3 for particle size, metals, hydrocarbons, and organic pollutants; and
- Brief **conclusions** are drawn based on these results in §4.4.

Data tables are included in **Appendix IV**.

4.2 Methods

4.2.1 Sediment sampling site selection

Sediment monitoring sites were selected to respond to the objectives of the broader 2024 Receiving Environment Monitoring Programme (Clark et al., 2024), which include the assessment of potential impacts of the marine outfalls, as well as the collection of long-term data from fixed points to assist in assessing environmental change over time. Compared to 2015/2016 monitoring efforts, fewer sites were planned in Green Point and Hout Bay, whilst additional sites were sampled in the Camps Bay area. Hydrodynamic modelling of suspended solid deposition (PRDW, 2020a, 2020b, 2021) and historic data (CSIR, 2017a) informed site selection. Figure 4-1 shows the location of all the sample sites for the present study. For ease of interpretation:

- **Sites on the AMZ** are identified in **bold** (**CB017** is a Camps Bay AMZ site);
- Reference sites are *italicised* (*KB001* is the Karbonkelberg reference site);
- Sites selected to characterise known or suspected point sources of pollution are underlined; (HB034 is a site in the Hout Bay Harbour); and
- All other sites proximal to the outfalls are in plain text.

4.2.2 Fieldwork and laboratory analyses

Sediment samples were collected in February 2025. Sampling was scheduled for the end of the dry summer season on the premise that this is when wastewater discharged via the outfalls would be expected to have the most concentrated flows of solids in the absence of stormwater additions. In other words, sampling was scheduled to coincide with the expected “worst case” scenario, in line with the precautionary principle.

A total of 41 sites around the outfalls were selected for sampling, in addition to four reference sites. Triplicate samples were collected at each reference site, making for a total of 53 planned sediment samples. A stainless steel Van Veen grab was used to collect all sediment samples (surface area 0.1207 m²). In contrast to previous monitoring programmes, SCUBA divers were not used to collect sediment from small pockets in rocky reef areas – it was decided that samples collected in this way would be of limited value given their very localised nature and low representativity.

The previous assessment in 2015/2016 targeted 67 sites for sediment collection but was only able to collect samples at 40 of these sites, despite the use of SCUBA divers for sampling in rocky bottomed/reef ecosystems (CSIR, 2017a). A total of 45 sediment sites were selected for annual sampling for the sediment assessment aspect of this 2024 Receiving Environment Monitoring Programme. Sediment sampling was largely successful at Hout Bay, which has a generally sandy/soft-bottomed benthic environment. Due to the rocky reef substrate found off the Green Point and Camps Bay outfalls, not all planned sites could be sampled for sediment. Of the 45 planned sites (including four reference sites), only 29 sites were successfully sampled using a Van Veen grab sampler, with the remainder not having sufficient sediment for sampling. The 29 sites included:

- Seven of the 11 sites in Camps Bay (three in the nearshore, two offshore, and two on the AMZ);
- 15 of the 17 sites in Hout Bay (five on the AMZ, three around the outfall diffuser, five in the bay, and two in the harbour, selected to enable characterisation of a known point source of pollution);
- Only three of the 14 sites in Green Point / Table Bay (one near the shoreline, and two distant from the outfall in Table Bay, selected to enable characterisation of known point sources of pollution); and
- Four reference sites, of which one (Robben Island) was relocated to the northeastern side of the island to locate soft substrates.

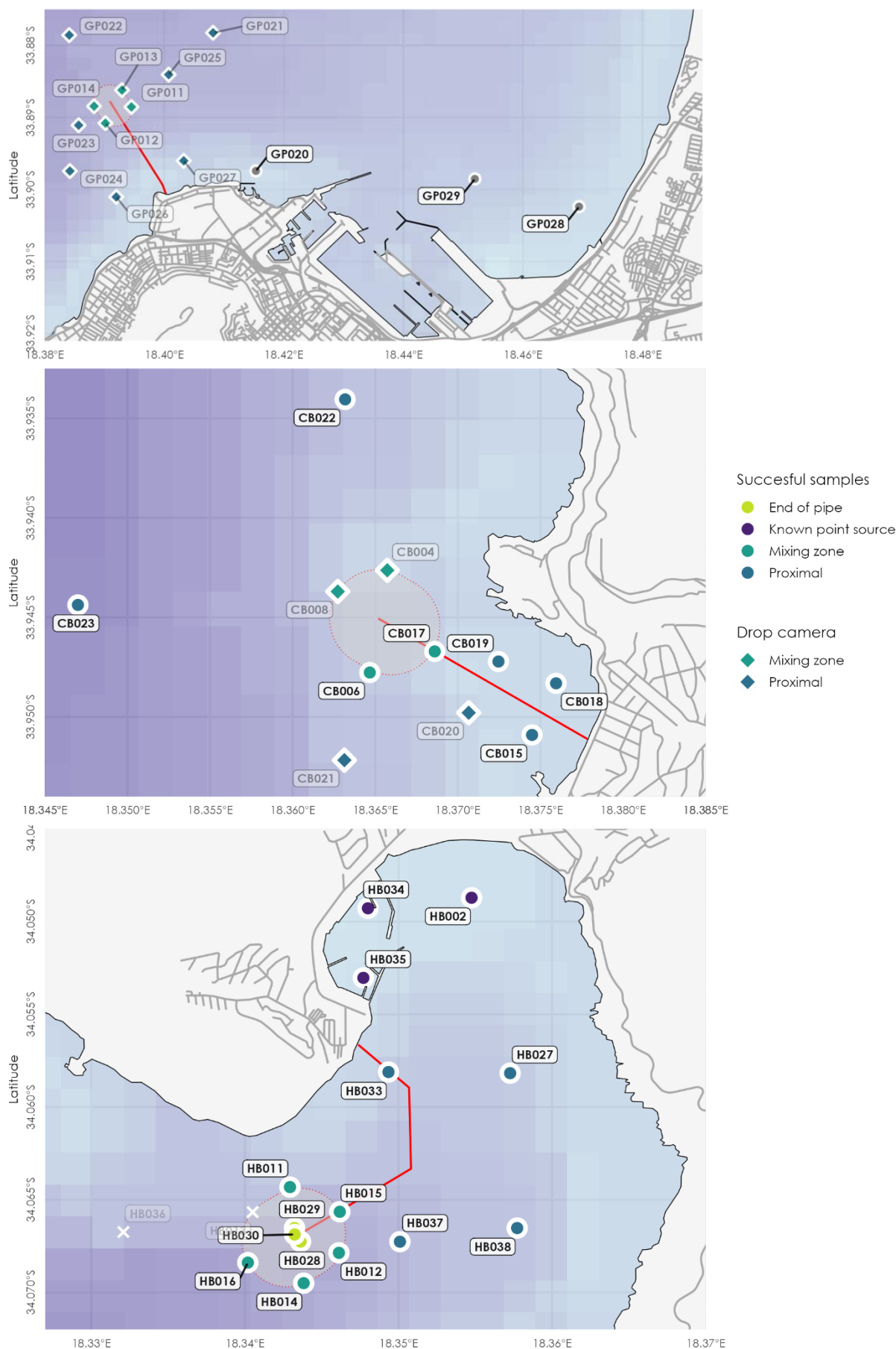


Figure 4-1. Sediment sampling success at planned sediment monitoring sites. Locations that were not successfully sampled were later confirmed to be rocky reef substrate through the use of a drop camera setup. Hout Bay sites HB036 and HB013 were not successfully grab sampled and were not surveyed with a drop camera

Where a sample could not be collected after three grab attempts, the team relocated and attempted to sample again. Where a second area and third area could not be successfully sampled for a given site, this site was considered unsuccessful. At the Camps Bay and Green Point outfalls, these sites were later photographed using a drop-camera rig – refer to Chapter 7. **Figure 4-1** provides an overview of successful sediment sampling sites and **Appendix I** provides further details on the differences between planned sample sites and actual sample sites for the sediment monitoring aspect of this programme.

Samples were submitted to the CSIR for metals analysis, Element Laboratories (UK) for organics, and a geotechnical laboratory for particle size distribution (PSD) analyses. Samples collected for metal and PSD analysis were stored frozen until laboratory submission. Metal analyses were undertaken using ICP-OES, with the exception of mercury, which was analysed using Direct Mercury Analysis. Sediment analysed for organic contaminants was collected in amber glass jars with no headspace and refrigerated overnight before being couriered on ice to the UK for analysis. Total organic carbon was analysed by combustion in an Eltra TOC furnace/analyser in the presence of oxygen, and by quantification of the CO₂ generated using infra-red detection. Table 4-1 lists all parameters analysed for in sediment samples, and their respective limits of detection.

Table 4-1. Parameters monitored in sediment and their respective limits of detection (LoD)

Group	Parameter	LoD	Parameter	LoD
Metals	Aluminium (mg/kg)	100	Lead (mg/kg)	3
	Arsenic (µg/kg)	2	Mercury (µg/kg)	10
	Cadmium (µg/kg)	100	Nickel (µg/kg)	1
	Chromium (mg/kg)	1	Vanadium (mg/kg)	1
	Copper (mg/kg)	2	Zinc (mg/kg)	2
Polycyclic aromatic hydrocarbons (mg/kg)	Acenaphthene	0.05	Chrysene	0.02
	Acenaphthylene	0.03	Dibenzo(ah)anthracene	0.04
	Anthracene	0.04	Fluoranthene	0.03
	Benzo(a)anthracene	0.06	Fluorene	0.04
	Benzo(a)pyrene	0.04	Indeno(123cd)pyrene	0.04
	Benzo(b)fluoranthene	0.05	Naphthalene	0.04
	Benzo(ghi)perylene	0.04	Phenanthrene	0.03
	Benzo(k)fluoranthene	0.02	Pyrene	0.03
			Total PAH 16 (individual listed above)	0.6
Petroleum hydrocarbons (mg/kg)	EPH >C10-C12	10	EPH >C35-C40	10
	EPH >C12-C16	10	EPH >C8-C10	5
	EPH >C16-C21	10	EPH >C8-C40	30
	EPH >C21-C35	10		
Phenols (mg/kg)	Total Phenols	0.15		
TOC (%)	Total Organic Carbon	0.02		
Organic pollutants (µg/kg)	1,1,1,2-Tetrachloroethane	3	Chlorobenzene	3
	1,1,1-Trichloroethane	3	Chloroethane	2
	1,1,2,2-Tetrachloroethane	3	Chloroform	3
	1,1,2-Trichloroethane	3	Chloromethane	3
	1,1-Dichloroethane	3	cis-1-2-Dichloroethene	3
	1,1-Dichloroethene (1,1 DCE)	6	cis-1-3-Dichloropropene	4
	1,1-Dichloropropene	3	Dibromochloromethane	3
	1,2,3-Trichlorobenzene	7	Dibromomethane	3
	1,2,3-Trichloropropane	4	Dichlorodifluoromethane	2
	1,2,4-Trichlorobenzene	7	Dichloromethane (DCM)	7
	1,2,4-Trimethylbenzene	6	Ethylbenzene	3
		4	Hexachlorobutadiene	4

Group	Parameter	LoD	Parameter	LoD
	1,2-Dibromo-3-chloropropane	3	Isopropylbenzene	3
	1,2-Dibromoethane	4	Methyl Tertiary Butyl Ether	2
	1,2-Dichlorobenzene	4	m/p-Xylene	5
	1,2-Dichloroethane	6	Naphthalene	27
	1,2-Dichloropropane	3	n-Butylbenzene	4
	1,3,5-Trimethylbenzene	4	o-Xylene	3
	1,3-Dichlorobenzene	3	Propylbenzene	4
	1,3-Dichloropropane	4	sec-Butylbenzene	4
	1,4-Dichlorobenzene	4	Styrene	3
	2,2-Dichloropropane	3	tert-Butylbenzene	5
	2-Chlorotoluene	3	Tetrachloroethene (PCE)	3
	4-Chlorotoluene	4	Toluene	3
	4-Isopropyltoluene	3	trans-1-2-Dichloroethene	3
	Benzene	2	trans-1-3-Dichloropropene	3
	Bromobenzene	3	Trichloroethene (TCE)	
	Bromochloromethane	3	Trichlorofluoromethane	3
	Bromodichloromethane		Vinyl Chloride	2
	Bromoform	1		2
	Bromomethane	4		
	Carbon tetrachloride			

4.2.3 Approach to data presentation and statistical analyses

Mud accumulates at a higher rate in more sheltered environments such as estuaries or harbours, where fine materials may settle out of the water column; these are known as depositional areas. In a low to medium energy environment, the discharge of wastewater via marine outfalls may alter the particle size distribution of sediments in the receiving environment, since it contributes a disproportionately high amount of fine solids to the system. In addition to local current strength and turbulence throughout the water column, seabed morphology can also affect the transport and accumulation of sediments – especially in rocky bottomed and reef covered areas such as Camps Bay and Green Point.

Determining the relationship between metal concentration in sediment and whether the sediment has actually been contaminated by a given metal is not straightforward. Metal concentrations in sediment are influenced by numerous factors, including local underlying geology, particle size, and organic content. In a geologically homogeneous area, grain size is the main determinant of natural metal content as the grain size distribution of a given sample directly affects how contaminants interact and may accumulate in sediment. High surface area to volume ratios and electrically charged surfaces make fine sediments more reactive, increasing the affinity of particle-reactive and hydrophobic contaminants alike to adsorb onto them. As such, muds are generally found to have higher levels of a given contaminant than sand (assuming that the same concentration of a given contaminant is present in the overlying water). In addition, the association of metals with aluminosilicate minerals, which are mostly found in clays, can also play an important role. Sand, on the other hand, is composed mainly of quartz, which is a very metal-deficient mineral. Particulate organic matter also acts as a site of adsorption for certain trace metals.

To distinguish between natural variability and anthropogenic enrichment, these physical and geochemical characteristics must be accounted for. Geochemical normalisation is one of the most common approaches (Kersten & Smedes, 2002), carried out by relating each metals concentration to a conservative reference element (Loring, 1991) – frequently, aluminium. This conservative

reference element serves as a tracer of natural variability of the metal composition of the aluminosilicate (metal-heavy) fraction of sediment. Aluminium is commonly used as it is stable, highly refractory, and is not generally associated with anthropogenic contamination.

Historic data were used to generate baseline models, against which geochemically normalised values could be compared to identify enriched samples. Details on the generation and use of baseline models to discern between natural variation and artificial enrichment of metals in sediment are provided below.

4.2.3.1 Analyses

4.2.3.1.1 TOC

Pearson correlation tests were used to assess the linearity of the relationship between TOC and mud fraction at Camps Bay, Hout Bay and Green Point. This approach was applied as a simple means of identifying possible organically enriched samples. If removing outliers meaningfully improved the correlation coefficient, this could indicate the sample was organically enriched (or deficient).

4.2.3.1.2 Enrichment Factors

Baseline or background models provide an equation for the linear relationship between the concentration of aluminium, and the corresponding concentration of a given metal under natural circumstances (Birch, 2017). Once defined, a baseline model can be used to determine whether the ratio of a given metal to aluminium falls within the expected range of natural variation. When a given value falls above the expected baseline range, this suggests the sample is enriched.

By definition, a baseline model should be based on a set of sediment samples collected from a wide range of undisturbed sites as close to the study area as possible. Where this is not practical, as was the case for this study, simple linear regression and the use of confidence intervals (and associated prediction limits) can be used to estimate a baseline model for each metal based on available local data. Baseline models were constructed for each metal, in line with the CSIR's methodology (CSIR, 2017a). As the 2015/2016 CSIR sediment survey had a greater sample size, and was more spatially extensive around each outfall, their sediment metal concentration data were used to generate baseline models for use in the present study. This also allowed for the direct comparison of enrichment factors between the two studies.

Baseline models were constructed for each metal by generating 99% prediction limits, based on the modelled linear relationship between aluminium and each respective metal. Modelled relationships were generated using simple linear regression. Outliers were then iteratively excluded by removing values above the upper 99% prediction limit for each metal. Each model was then refitted and the process repeated until all values fell below the 99% upper prediction limit. Once this was achieved, the regression line and associated 99% prediction limits were used as the baseline model for the given metal.

The metal-aluminium concentrations were plotted against the respective baseline models for each metal. Data points above the upper prediction limit were classified as enriched. The classification of samples into 'enriched' and 'not enriched', however, does not give an approximation of the extent to which the samples are enriched. To address this, Enrichment Factors (EFs) were used. An EF represents the ratio of measured metal-to-aluminium ratio to the theoretical 99% upper metal-to-aluminium ratio. As this has been modelled using a linear regression, the aluminium terms cancel out, making the EF equivalent to the quotient of the measured metal concentration divided by the modelled concentration at the upper 99% upper prediction limit.

This provides a unitless value that represents the amount by which a given metal is enriched when compared against the expected baseline model. Using a 99% prediction limit means that one in 100

samples would be expected to exceed the prediction limit as a result of natural environmental variation. Thus, the magnitude of enrichment and number of enriched metals at a given site should also be taken into account to identify the likelihood of the EFs representing anthropogenic contamination.

EFs provide a useful way to identify and quantify potential anthropogenic influences, although enrichment does not necessarily equate to ecological risk. Ecological impacts depend not only on whether a metal is elevated above background concentrations, but also on its bioavailability, chemical form, and the sensitivity of organisms in the immediate environment (Paller & Knox, 2013; Zhang et al., 2014). Certain metals such as cadmium, mercury, and lead are toxic at relatively low concentrations and may pose an acute risk when enriched, while others such as zinc and copper are essential micronutrients, but can become toxic at higher concentrations. Importantly, sediment quality guidelines that provide “threshold effect” and “probable effect” concentrations (see §4.2.3.2 and Table 4-2 below) are based on absolute values. These guidelines are useful for screening but can be misleading in dynamic systems such as coastal sediments, where natural variation in grain size, mineralogy, and background geochemistry strongly influence metal concentrations. This makes it challenging to distinguish natural enrichment from anthropogenic contamination based on absolute thresholds alone.

By contrast, the baseline model approach accounts for natural geochemical and physical variability and therefore provides a more refined tool for detecting anomalies suggestive of contamination. The use of EFs to determine the degree of exceedance above what would be expected naturally, complements the assessment of possible ecological or toxicological concern using guideline-based assessments.

4.2.3.2 Sediment Quality Guidelines

There are no official sediment quality guidelines published for the South African marine environment, and it is necessary to adopt international guidelines when screening sediment metal concentrations. The Benguela Current Large Marine Ecosystem (BCLME) programme reviewed international sediment quality guidelines in order to develop a common set of sediment quality guidelines for the coastal zone of the BCLME (Angola, Namibia and west coast of South Africa). These guidelines include recommended values and Probable Effect Concentrations (PEC) for metals and toxic organic compounds (Table 4-2). These guidelines cover a broad concentration range and still need to be refined to meet the specific requirements of each country within the BCLME region; however, they were the only available values for the southern hemisphere (developed for Australia and New Zealand) while others were all developed for the Northern Hemisphere (e.g. for USA, Canada and Europe) (CSIR 2006). The National Oceanic and Atmospheric Administration (NOAA) have published a series of sediment screening values which cover a broad spectrum of concentrations from toxic to non-toxic levels.

The BCLME Probable Effects Concentration (PEC) represents the concentration of individual chemicals above which adverse effects in sediments are expected to frequently occur, while the Recommended guideline value represents the highest recorded concentration at which organisms presented no observable effect (No-Observable-Effects-Concentration (NOEC)). For NOAA data the Effects Range Low (ERL) represents the concentration at which toxicity may begin to be observed in sensitive species. The ERL is calculated as the 10th percentile of sediment concentrations reported in literature that co-occur with any observable biological effect. The Effects Range Median (ERM) is the median concentration of available toxicity data. It is calculated as the 50th percentile of sediment concentrations reported in literature that co-occur with a biological effect (Buchman 1999, 2008). The BCLME Recommended Guidelines values represent the most conservative screening concentrations for sediment toxicity proposed for the southern hemisphere.

Table 4-2 Recommended sediment quality guidelines for toxic substances for the protection of marine aquatic ecosystem in the BCLME (CSIR, 2006b) and proposed by NOAA (Long et al., 1995). Recommended sediment quality guidelines for toxic substances for the protection of marine aquatic ecosystem in the BCLME (CSIR, 2006b) and proposed by NOAA (Long et al., 1995). Recommended sediment quality guidelines for toxic substances for the protection of marine aquatic ecosystem in the BCLME (CSIR, 2006b) and proposed by NOAA (Long et al., 1995).

BCLME region (South Africa. Namibia. Angola)			NOAA	
TOXIC SUBSTANCES	Recommended guideline Value	Probable concentration	effect	ERL ERM
METALS (ppm, mg/kg dry weight)				
Arsenic, As	7.24	41.6	8.2	70.0
Cadmium, Cd	0.68	4.21	1.2	9.6
Chromium, Cr	52.3	160	81.0	370.0
Copper, Cu	18.7	108	34.0	270.0
Lead, Pb	30.2	112	46.7	218.0
Mercury, Hg	0.13	0.7	0.15	0.71
Nickel, Ni	15.9	42.8	20.9	51.6
Zinc, Zn	124	271	150.0	410.0
TOXIC ORGANIC COMPOUNDS (µg/kg dry weight normalized to 1% organic carbon for BCLME guidelines)				
Total PAHs	1684	16770	4022	44792
Low Molecular Weight PAHs	312	1442	-	-
Acenaphthene	6.71	88.9	16	500
Acenaphthalene	44	640	44	640
Anthracene	46.9	245	85.3	1100
Fluorene	21.2	144	19	540
2-methyl naphthalene	-	-	70	670
Naphthalene	34.6	391	160	2100
Phenanthrene	86.7	544	240	1500
High Molecular Weight PAHs	655	6676	1700	9600
Benzo(a)anthracene	74.8	693	261	1600
Benzo(a) pyrene	88.8	763	430	1600
Dibenzo(a,h)anthracene	6.22	135	63.4	260
Chrysene	108	846	384	2800
Fluoranthene	113	1494	600	5100
Pyrene	153	1398	665	2600

4.3 Results and Discussion

A total of 45 sediment sites were planned to be sampled on an annual basis for the sediment assessment aspect of this 2024 Receiving Environment Monitoring Programme. Of the 45 planned sites (including four reference sites), only 29 sites were successfully sampled using a Van Veen grab sampler, with the remainder not having sufficient sediment for sampling. Four of these sites were located to enable characterisation of known point sources of pollution, and four were distant reference sites.

4.3.1 Particle size

The particle size distribution (PSD) of sediment provides important information about potential for contaminant accumulation, hydrodynamic conditions of the sample site, and the potential influence of the marine outfalls. Coarse-grained sand and gravel typically dominate in high-energy environments, such as that of the Atlantic seaboard in Cape Town, where dispersion and resuspension limit the accumulation of fine material.

Of the 29 unique sites sampled, almost all were composed of greater than 90% sand – characteristic of a high energy coastal environment. Two samples, both from the Hout Bay Harbour, comprised more than 10% mud (18% and 35% respectively). The other 27 samples were mainly sand; nine samples contained over 10% gravel. The size classification used to define these categories is found in Table 4-3.

Table 4-3. Details of the sediment size classification used for the current study according to the Wentworth Scale.

Broad Sediment Size Classes	Specific Sediment Size Classes	Sediment Size Ranges (mm)
Mud	Mud	< 0.063
Sand	Very fine-grained sand	0.063 – 0.125
	Fine-grained sand	0.125 – 0.250
	Medium-grained sand	0.25 – 0.50
	Coarse-grained sand	0.5 – 1.0
	Very coarse-grained sand	1.0 – 2.0
Gravel	Gravel	> 2.0

Hout Bay displayed the highest degree of variability in PSD, with individual sites displaying both the highest and lowest median particle sizes. Most sites from Hout Bay were composed of gravelly sand. Of the seven samples collected in Camps Bay, two were majority gravel (>75%), whilst the other five samples were over 90% sand, with gravel and mud combined to make up the remaining 5-10 % (**Figure 4-2**). The Green Point sample closest to the Port of Cape Town had nearly 100% sand, whilst the point closest to the Diep River Estuary and the Black River had a slightly higher gravel content.

Total organic carbon (TOC) in sediment is a key indicator of ecosystem functioning because it is an indication of the amount of particulate organic matter, which is the main food source for benthic organisms and underpins energy flow in the benthic food web. Moderate levels of TOC support diverse communities, but excessive accumulation can lead to oxygen depletion through microbial respiration, reducing species diversity and favouring only a few tolerant taxa. Under anoxic conditions, further organic matter breakdown shifts to sulphate reduction, which produces toxic sulphides that can stress or eliminate sensitive organisms. TOC content also tends to show a strong linear relationship with the proportion of fine-grained sediment (mud), since smaller particles trap and retain more organic material. This makes TOC a useful metric for assessing organic enrichment and

potential ecological risks in sedimentary environments. As there is normally a linear relationship between the amount of organic content and mud, any sample exhibiting particularly elevated organic content in relation to mud content may be indicative of anthropogenic organic enrichment (Mayer, 1994, 1994).

A Pearson correlation test was conducted to assess the linearity of the relationship between TOC and mud fraction of each area. Hout Bay displayed a strong linear relationship ($r = 0.972$, $p < 0.001$), suggesting no samples were notably enriched in organic content. Three sediment samples from Hout Bay with the highest organic content (Figure 4-3) were removed (both individually and collectively), and the correlation analyses were re-run to determine whether these anomalously high TOC values near the harbour were skewing the overall relationship, and masking the fact that these samples were enriched. In all cases, removing these samples produced a weaker relationship between TOC and mud fraction within Hout Bay, and thus it was concluded that none of the sites were organically enriched. The relatively small sample size (after removal of the suspected enriched samples) may have contributed to these findings. Camps Bay displayed a significant, though weaker, linear relationship ($r = 0.768$, $p < 0.01$) between the two parameters; removing possible outliers did not improve the Pearson coefficient, suggesting a more variable trend than Hout Bay, without any clearly organically enriched or depleted samples disproportionately affecting the correlation coefficient. Green Point did not have sufficient samples to conduct a meaningful correlation test. Notably, the Robben Island reference site generally had less mud but similar TOC concentrations to the Table Bay samples. TOC concentrations across all three survey areas were less than 2%, representing conditions typical of the high energy coastal environments on the Atlantic seaboard (Figure 4-3).

Both samples collected in Table Bay were found to be over 95% sand, and the mud they did contain showed no evidence of organic enrichment (i.e., both sites had low TOC levels - Figure 4-3). Table Bay, which is sheltered in comparison to most other sediment monitoring sites in this programme, is subjected to high levels of fine sediment inputs from both the Black and Diep Rivers. Table Bay samples were composed of less than 5% mud – a finding that suggests little of the organic material and fine solids entering the sea in the Table Bay area is being retained in the sediment. These data also suggest the Green Point marine outfall is not contributing significantly to organic loading of sediments in Table Bay.

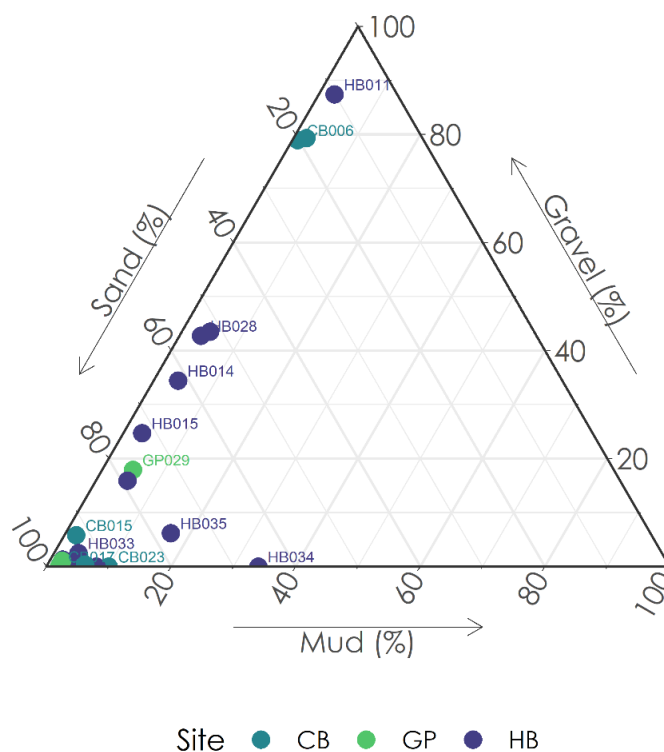


Figure 4-2. Ternary plot illustrating the percent contributions of gravel, sand and mud to sediment samples collected at each site.

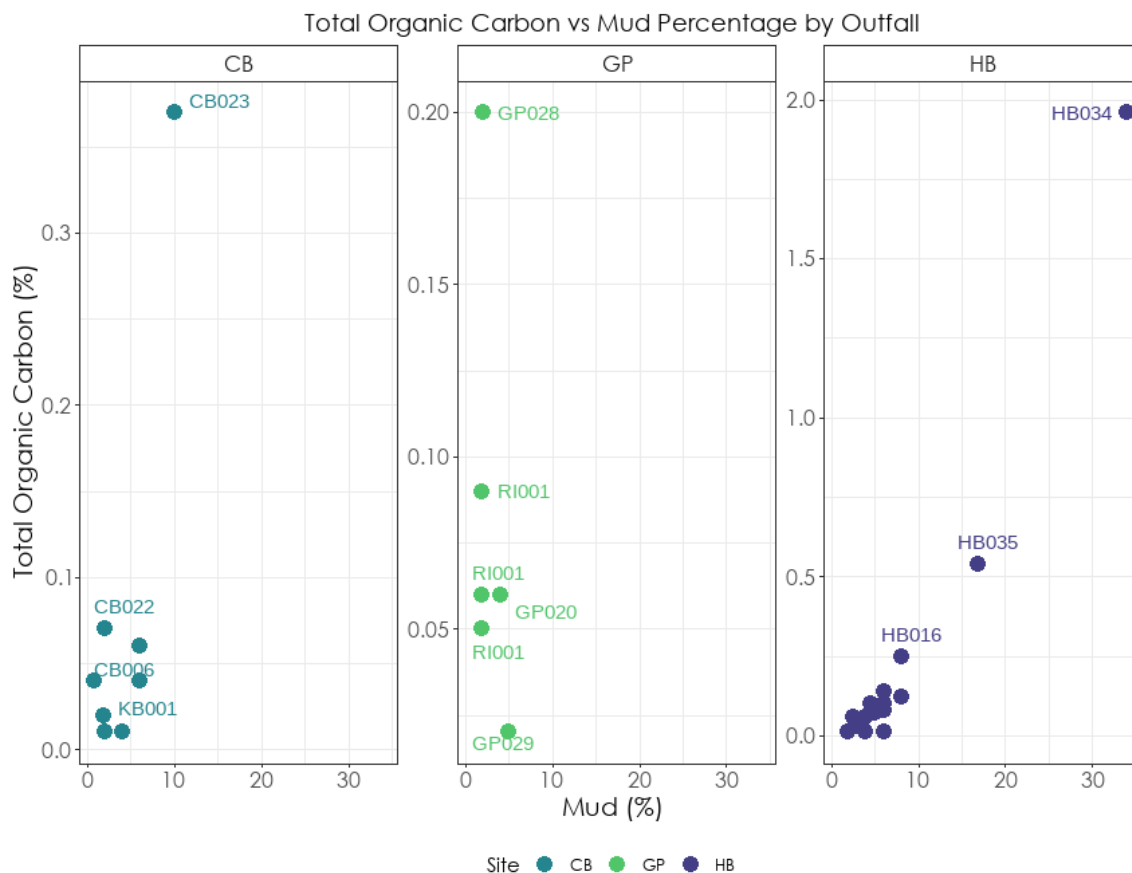


Figure 4-3. Proportion of Total Organic Carbon to the mud fraction of each sediment sample. The first year of sampling did not provide enough data to fit a regression to reliably identify organically enriched samples using prediction intervals.

4.3.2 Sediment metals

The metal concentrations at most sites fell within the baseline model prediction ranges for the various metals analysed (**Figure 4-4**). In other words, metal concentrations from samples from most sites were found to fall within the expected natural range of metal concentrations, based on the amount of aluminium found in each sample. This indicates there was minimal anthropogenic metal contamination prevalent at most sites sampled.

When comparing the sediment metals concentrations to that of the BCLME region recommended guideline values, only two sites had metal concentrations above the Recommended Guideline Value, both in the Hout Bay Harbour (**HB034** and **HB035**). At **HB034**, arsenic (8.0 mg/kg), cadmium (1.225 mg/kg), and zinc (161 mg/kg) exceeded the Recommended Guideline Values and copper (121.0 mg/kg) exceeded the Probable Effect value. The Recommended Guideline Value threshold represents the highest recorded concentration at which organisms present no observable effects, while the Probable Effect concentration suggests likely adverse negative effects on organisms. Copper at **HB035** also exceeded the Recommended Guideline Value. The BCLME guideline values are more conservative than the NOAA ERL and ERM guideline values and no NOAA thresholds were exceeded in the present study.

Five of 29 sites were found to have enriched metal content:

- two sites in Table Bay (**GP028** and **GP029**);
- two sites in the Hout Bay Harbour (**HB034** and **HB035**); and
- one site offshore of the Camps Bay outfall (**CB022**).

Of the five sites where metal enrichment was detected, four had been specifically targeted as sites known to be affected by point sources of pollution other than the marine outfalls, in an attempt to distinguish between possible impacts attributable specifically to the outfalls, and those from other sources. **GP028** and **GP029**, both in Table Bay, were sampled to account for the inflow and possible deposition of pollutants from the Diep River, Salt River, and Port of Cape Town. All metals apart from nickel and mercury were found to be enriched in sediment from at least one of these five sites.

The metals most often at a higher than expected concentration were (in order) zinc (four sites); arsenic, copper, and lead (two sites each); and chromium and vanadium (one site each) (**Figure 4-4**). The more frequent detection of copper and zinc at higher than expected concentrations could reflect the impact of wastewater discharge, considering these metals were detected in all effluent samples in the 2015/2016 effluent characterisation by the CSIR and were then at a relatively high concentration in Green Point and Camps Bay effluent. However, the most frequently enriched metals are also common contaminants of stormwater in urban areas, and as discussed below the sediment that was most contaminated by copper and zinc was at sites situated in the Hout Bay Harbour, a considerable distance from the outfall and subject to other marine and land-based contamination sources. At least two metals were found to be elevated at each of the enriched sites (**Figure 4-6**), with zinc being the only metal to be enriched across all five sites. None of the other 20 sites sampled displayed enrichment for any of the eight metals tested for. The fifth site where trace metal enrichment was evident was in Camps Bay. This is discussed in more detail in the next section.

4.3.3 Camps Bay

Site **CB022**, a site roughly 1 km north of the Camps Bay outfall diffuser section, had the largest number of metals at a higher than expected concentration: arsenic, lead, vanadium and zinc. However, all four of these metals were found at concentrations only slightly above the 99% prediction limits, with enrichment factors of between 1.09 and 1.56. Although there is no defined guideline for metal enrichment values in sediment, previous studies by the CSIR around Cape Town's coast have defined an enrichment factor of below 1 as good (or baseline), 1 – 2.5 as “fair”, and values above 2.5 as

“poor”. This means sediment at CB022 would be classified as possibly reflecting anthropogenic contamination, albeit at a low level.

The CSIR (2017a, 2017a) concluded that sediment in the Camps Bay area was rarely enriched for metals, and concluded that metals in wastewater discharged through the Camps Bay outfall were not accumulating to excessive concentrations in sediment in the Camps Bay area. They attributed this to the predominantly coarse-grained nature of sediment at sites in the Camps Bay area. The CSIR in 2015/2016 sampled fewer sites offshore than did the present study, so historic data in Camps Bay can be compared only on a descriptive basis. The previous study did not find arsenic or lead to be enriched at any sites around the Camps Bay outfall. Vanadium was found to be enriched at one site, whilst zinc was enriched at numerous sites in the study area. EFs for both metals were <1.5 at all sites in Camps Bay where they were present in 2015/16. Vanadium and zinc were found to be enriched at a site 1200 m north of the Camps Bay outfall diffuser section. Mercury, chromium, copper, and barium were also found in 2015 at this site; in the most recent sampling effort, mercury, chromium and copper were all found at concentrations that fell within the baseline model. Barium was not included in the analysis suite for the present study.

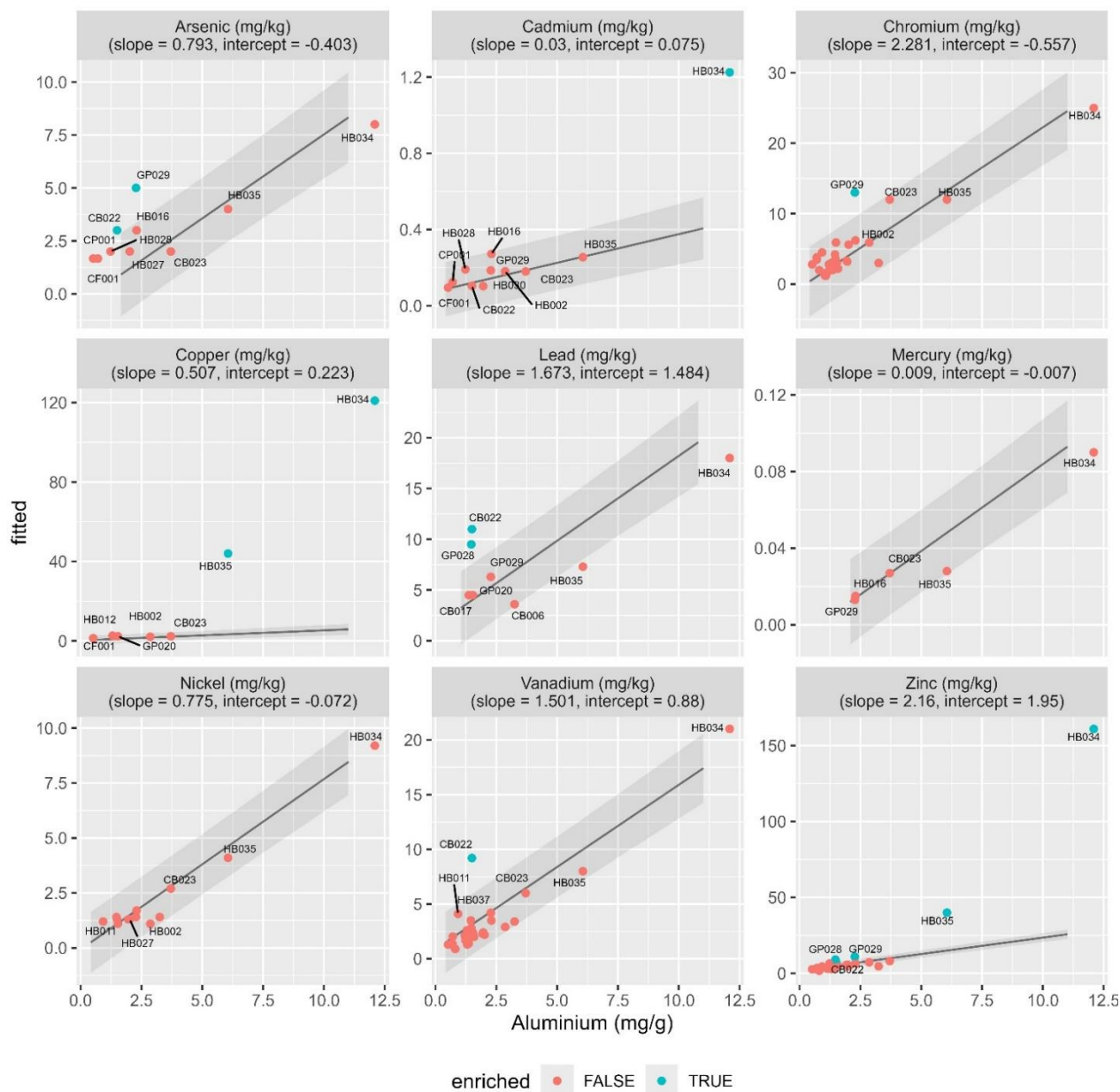


Figure 4-4 Sediment metal content plotted against aluminium content, shown against the baseline model calculated from CSIR data collected in 2015/2016 around Camps Bay, Hout Bay and Green Point. The regression line and the 99% prediction intervals are shown.



Figure 4-5. Sediment metal enrichment factors from Green Point, Hout Bay and Camps Bay in 2025. Non-faded bars exceeded the 99% upper prediction interval of the CSIR baseline model (red dashed line), signifying likely anthropogenic enrichment. Where a metal was below the laboratory lower detection limit, the site was not included on the plot.

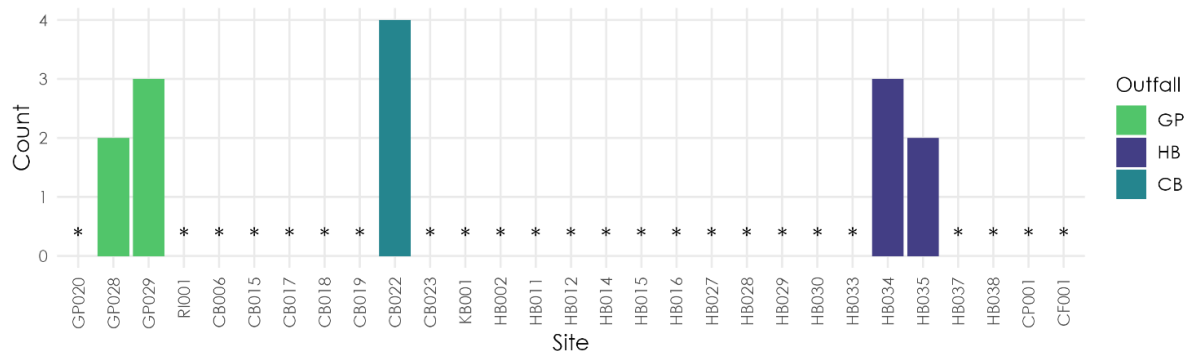


Figure 4-6. Number of enriched metals per sample site relative to CSIR background model.

4.3.4 Green Point

Site GP028 in Table Bay, near the Port of Cape Town, was found to be enriched for both zinc and lead. GP029 near the mouths of the Diep and Salt rivers was enriched for zinc, cadmium and arsenic. Zinc and lead at GP028 had EFs of 1.2 and 1.3 respectively, whilst GP029 generally had slightly higher enrichment factors of 1.5 for arsenic, 1.4 for chromium and 1.2 for zinc. Similar to Camps Bay, while these EF values may be indicative of anthropogenic influence, they do not reflect a highly polluted system. By way of comparison, enrichment factors calculated by the CSIR (2017) for samples collected within the Port of Cape Town had enrichment factors of up to 12 for zinc, up to 2.4 for cadmium, and up to 1.7 for arsenic (CSIR, 2017b).

4.3.5 Hout Bay

Sites HB034 and HB035 are located in the Hout Bay Harbour. In addition to the pollution sources ordinarily associated with a harbour, including boat building, servicing, painting, refuelling and general operation and breakdowns of vessel engines, the highly polluted Hout Bay River (Day et al., 2024) discharges onto the shoreline of the Hout Bay Beach approximately 750m east of the harbour's breakwater. The Hout Bay marine outfall discharges 1850 m south-southeast of the harbour entrance.

Both sites in the Hout Bay Harbour displayed high EFs for various metals – at HB034, zinc and copper were highly enriched with EFs of 5.2 and 13.1 respectively; cadmium was also enriched, with an EF of 2.0. Likewise, HB035 had high EFs for both copper and zinc (7.9 and 2.3 respectively). These EF values are indicative of a heavily polluted system, consistent with the findings of previous studies in the Port of Cape Town (CSIR, 2011a, 2014, 2016, 2017b). The historic industrial activities and current servicing and operation of boats are likely to be the main source of pollution in the Hout Bay Harbour, although one specific source cannot be isolated.

The CSIR (2017a) also found that the metals enriched to the highest magnitude in sediment collected in and near Hout Bay Harbour in 2003 and 2015/2016 were copper and zinc, noting that these metals are perhaps the most common and significant metal contaminants of sediment in ports, primarily due to their use as active agents in antifouling coatings applied to the hulls of vessels. The hydrodynamic modelling by PRDW (2020b) concluded that approximately 256 kg of solids transported from the Hout Bay outfall would settle in the Hout Bay Harbour annually, comprising 0.1% of all solids discharged from the outfall. Potential contributions by the Hout Bay marine outfall, the Hout Bay River, stormwater drains, and other land-based runoff cannot be excluded, but harbour operations are likely to be a significant source of the metal enrichment in sediments within the harbour. Hout Bay sediment sites outside the harbour (n=12) did not show similar enrichment.

4.3.6 Effluent contribution to metal enrichment

The CSIR (2017a, 2017a) undertook analyses of effluent from each of the three marine outfalls to characterise it in terms of water quality, including metal concentrations. Although effluent characterisation does not form part of the present monitoring programme, the CCT does undertake regular analyses of metal concentrations in the effluent, and external auditors are also appointed to do so on a regular basis. In the CSIR's 2015/2016 effluent characterisation, copper and zinc were consistently found in the effluent of all three outfalls, with the study finding higher concentrations in effluent at the Green Point and Camps Bay outfalls than in effluent from the Hout Bay outfall (CSIR, 2017a). These patterns were repeated, albeit in different concentrations, in the CCT's 2024/2025 data. Zinc and copper are two of the most common and significant metal contaminants found in stormwater in urban areas, with copper being a constituent in many car parts, and zinc being commonly used in car tyres, and across the construction industry. They are also common in wastewater, particularly in industrial effluents.

4.3.7 Hydrocarbons

Petroleum hydrocarbons were detected in samples from nine sites on the Atlantic Seaboard – at eight sites in Hout Bay, and one at the Chapmans Peak (Hout Bay) reference site (**Figure 4-7**). Sites in the Hout Bay Harbour (HB034 and HB035) had notably higher hydrocarbon contamination than any other sites. Longer-chain hydrocarbons were detected at both Hout Bay Harbour sites, with both sites including detectable quantities of C12-C16, C16-C21, C21-C35 and C35-C40 hydrocarbons.^{†††} At all other sites where hydrocarbons were present, only very long-chain hydrocarbons (C21-C35) were found. C21-C35 were also most prevalent in the harbour, accounting for over 50% of extractable petroleum hydrocarbons (EPH) by concentration at both sites.

By far the most common petroleum hydrocarbon found in this monitoring programme was the C21-C35 class, which includes hydrocarbons common in the marine industry – lubricating oils, motor oils, and heavy fuels (bunker fuel). The C21-C35 class of EPH is generally not considered acutely toxic; however, they are known to pose risks to benthic organisms due to their long residence time and resultant chronic exposure. The C12-C16 range includes compounds such as kerosene and light diesels, while C16-C21 would be considered typical for diesel and light engine oils/lubricants. The presence of a variety of hydrocarbon chain lengths from light, highly volatile compounds to heavier more stable petrochemicals in the Hout Bay Harbour is suggestive of ongoing contamination from the operations within the harbour.

An oil spill was reported (Engel, 2025) to have occurred in the Hout Bay area on or before 22 January 2025, approximately two weeks before sediment sampling for this study on 7 February 2025. Although the source and nature of this spill appears not to have been traced, it is possible that some of the hydrocarbons detected in sediments in this study may result from this event.

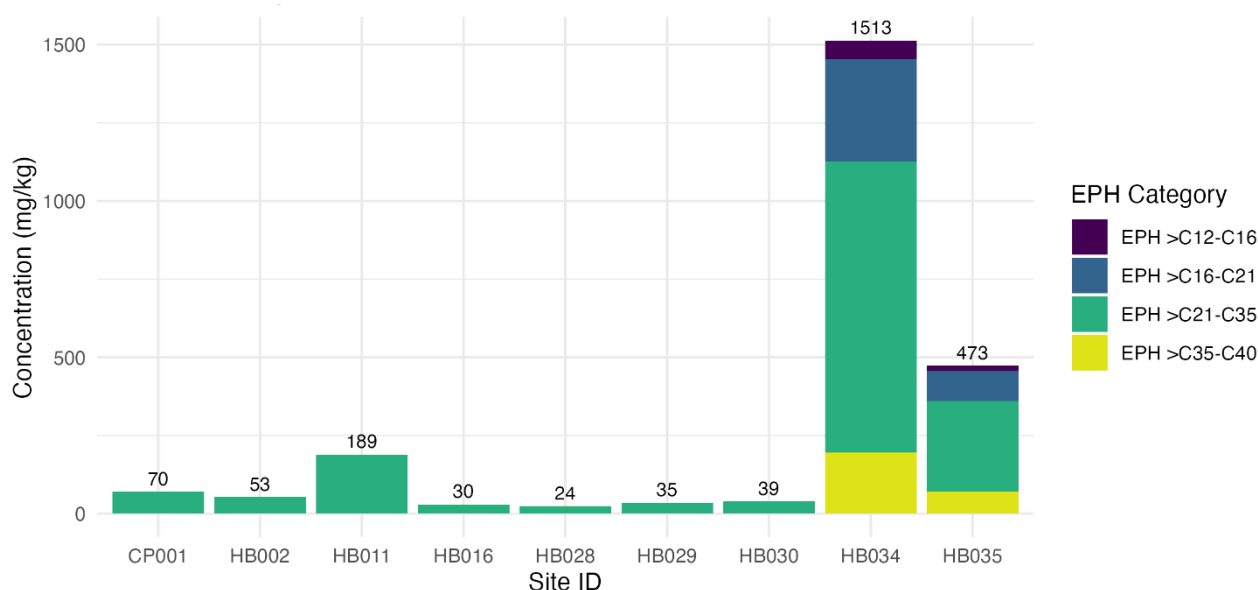


Figure 4-7. Total extractable petroleum hydrocarbon concentration in sediment at each site. Only sites where EPH's were detected are included in the plot.

^{†††} The numbers refer to the number of carbon atoms in a hydrocarbon's molecular chain. The more carbon atoms in the molecular chain, the heavier and generally less volatile the compound. As heavier EPHs are generally less volatile, they are also more persistent in the environment – that is they are both more resistant to natural weathering processes, and less likely to evaporate once released.

4.3.8 Organic pollutants

Other organic contaminants detected (from a set of 80 compounds analysed for – refer to **Table 4-1**) were limited to:

- the volatile organic compound **styrene**, found at four sites (GP020: 4 µg/kg; HB034: 17 µg/kg; HB035: 9 µg/kg; and the reference site RI001 at 9 µg/kg) – no other volatile organic compounds were detected at any sites sampled;
- **phenols**, which were detected at two sites (total phenols 1.34 mg/kg at site CB023; 0.43 mg/kg at site HB027); and
- the polycyclic aromatic hydrocarbon (PAH) **fluoranthene**, one of 16 common PAHs analysed for but detected only at one site, GP020, at 0.04 mg/kg).

Organic contaminant concentrations were either below BCLME recommended guideline values and NOAA thresholds for sediment quality, or (in the case of acenaphthene, fluorene and naphthalene) were not detected, albeit at limits of detection which were higher than the BCLME recommended guideline values, meaning that the data did not allow for a determination in respect of guideline exceedances for these three PAHs.

Previous environmental monitoring work by the CSIR in 2015/16, found various phenolic compounds in samples of effluent from the Green Point, Camps Bay and Hout Bay outfalls. However, samples of sediment collected from around the outfalls (n = 40) during the same monitoring programme did not yield any phenols. The CSIR attributed this to the “low organic carbon/water partition coefficient and a low octanol/water partition coefficient”, noting this means that phenols are not expected to readily adsorb to TSS in the water column or on the seafloor (CSIR, 2017a). (CSIR, 2017a). (CSIR, 2017a). (CSIR, 2017a).

Styrene, a volatile, aromatic hydrocarbon used in the production of plastic polymers such as polystyrene, was found at four sites, including two in Hout Bay Harbour, one at Granger Bay near the shoreline at Green Point, and one at the Robben Island reference site. Styrene may be introduced to the marine environment through a number of pathways, including the leaching and breakdown of expanded polystyrene foam into microplastics in the environment (Turner, 2020). Its presence in the environment does not appear to be related to wastewater discharged from the marine outfalls., and one at the Robben Island reference site., and one at the Robben Island reference site.

Fluoranthene was found at the same site at Granger Bay where styrene was recorded; like other PAHs, it is a product of incomplete combustion of organic materials like coal and petroleum, and may be introduced into the marine environment by atmospheric deposition, urban runoff, or by shipping. Its presence at Granger Bay is unlikely to be related to wastewater discharge from the Green Point outfall.

4.4 Conclusions

The first annual survey of sediment quality in the vicinity of the Green Point, Camps Bay, and Hout Bay outfalls under the approved 2024 Receiving Environment Monitoring Programme provides some insights into the potential long-term accumulation of wastewater derived contaminants in benthic sediments.

At the 29 sites sampled, sediments were primarily sandy (>90%) at most sites, reflecting high-energy coastal conditions. The only exceptions were in Hout Bay Harbour, where two sites ([HB034](#) and [HB035](#)) had notable mud fractions of 18% and 35%. Particle size variability was greatest in Hout Bay, with both the coarsest and finest sediments recorded there. Camps Bay sites were mostly gravel-rich and sand-dominated, while Table Bay sediments were almost entirely sand, suggesting that fine particulates

from the Diep and Black Rivers are not accumulating in the shallow parts of the bay. No evidence of organic enrichment was observed in relation to mud content at any site, and total organic carbon (TOC) levels were consistent with natural sediment composition.

Even when sediment enrichment for particular metals is detected, the sources can usually not be definitively identified. Metals in sediments may arise from a mixture of natural processes (such as mineral weathering, sediment transport, or upwelling inputs) and anthropogenic activities (such as stormwater discharges, shipping, or effluent from wastewater treatment). Consequently, enrichment observed in this dataset cannot be directly attributed to any one source, nor can it be conclusively linked to the marine outfalls specifically. Rather, the enrichment analyses identify sites where metal concentrations are elevated above what would be expected based on natural background conditions, highlighting areas where anthropogenic contributions are likely. Most sites fell within natural baseline ranges for metals, but five sites displayed enrichment: GP028 and GP029 in Table Bay, CB022 in Camps Bay, and HB034 and HB035 in Hout Bay Harbour. Zinc was enriched at all five sites, with low-level enrichment of arsenic, lead, vanadium, and chromium also observed. Camps Bay and Table Bay showed only slight enrichment. The strongest evidence for metal contamination was in Hout Bay Harbour, where copper and zinc were highly enriched (EFs >5), consistent with potential harbour-based sources of these metals. Sites outside the harbour showed no enrichment.

Petroleum hydrocarbons were detected at nine sites, with the Hout Bay Harbour samples showing the highest contamination and widest range (C12–C40). Outside the harbour, only long-chain fractions (C21–C35, common in lubricants, heavy oils, and bunker fuels) were detected. Shorter-chain hydrocarbons were found only in harbour sediments.

Other organic contaminants were rare, with few contaminants detected at any sites. Styrene was detected in low concentrations at four sites, including two in Hout Bay Harbour, one at Green Point, and one at Robben Island. Phenols were found at two sites (CB023 and HB027). The PAH fluoranthene was detected only once (at GP020, Green Point). Organic contaminants were not present in significant concentrations or at any of the outfall AMZ sites, suggesting that the outfalls are not the likely source of these contaminants.

There was no relationship between contaminant concentrations in sediment and proximity to the outfalls. The most contaminated sediment was found at a considerable distance from the outfalls, and usually at or near other potential sources of contaminants to the marine environment. These include the Port of Cape Town and Hout Bay Harbour. It is not possible, based on these data, to determine if contaminants in the sediment were derived from outfall discharge, but samples from sites close to the outfall diffusers were not found to be significantly contaminated in this study.

Where contaminants were found outside of harbours, the concentrations of these chemicals in the sediment were low. This implies that metals, polycyclic aromatic hydrocarbons, and, by inference, other chemicals in wastewater discharged through the Green Point, Camps Bay and Hout Bay outfalls that have a propensity for adsorbing onto sediment are not accumulating at measurable levels in sediment across most of the Cape Town outfalls study area, at least not in the long-term. This conclusion is consistent with the findings of previous surveys in the Cape Town outfalls study area (CSIR, 2017a).

Despite the very long history of wastewater discharge into the marine environment off Cape Town, this study did not find evidence for significant chemical contamination of sediment in the Table Bay, Camps Bay and Hout Bay areas that might be associated with wastewater discharge from the marine outfalls. The potential for contaminants derived from effluent and/or other land-based sources in sediment to impact sediment/bottom-dwelling organisms through chronic toxicity is further explored in the ecological effects study (refer to **Chapter 5**).

5 ECOLOGICAL EFFECTS

5.1 Introduction

Ecological monitoring is an essential component of the outfall monitoring programme, and is directed at identifying if there are any adverse impacts that effluent from the marine outfalls is causing to ecological function and community structure in the environment. While chemical and biological monitoring (e.g. taking measurements of water quality) can determine pollutant concentrations and track potential contamination in the environment, ecological monitoring gives insight into whether pollutants may be causing adverse impacts on marine organisms and habitats irrespective of whether they are present at detectable levels or not. These impacts may be associated with negative physiological or behavioural changes due to the long-term impacts of contaminated effluent. Ecological monitoring often makes use of sensitive sentinel species that can provide a warning of emerging or existing health hazards in the ocean (P. M. Chapman et al., 2003; Schwacke et al., 2012). Marine sentinel species can provide an indication of adverse effects and insight into the mechanisms of a toxic or hazardous contaminant or species that are sensitive to any biological toxin or pathogen and/or chemical contaminant due to their ability to bioaccumulate or incorporate the contaminant into their food web or ecosystem (Schwacke et al., 2012).

Benthic marine species and ecosystems are often used as indicators of pollution (Rees et al., 1991) as they are usually quick to respond to environmental changes from events including storms and sewage discharges (Desrosiers et al., 2013; Mallin et al., 2007; Rees et al., 1991; Valente et al., 1992). Most benthic organisms are sessile or sedentary, meaning they are either fixed to the substratum or have very limited ability to move, which prevents them from evading poor environmental conditions and make them particularly useful for studying or understanding local pollution patterns (Calabretta & Oviatt, 2008; Ruhí et al., 2016). Benthic organisms are mostly long-lived (> 1 year) permitting sufficient time for them to respond to pollution and to provide an indication of the integrated impacts of pollution over time (Rees et al., 1991).

Historically, the CSIR (1993, 1994) have sampled soft sediment benthic macrofauna communities surrounding the Green Point, Camps Bay and Hout Bay outfalls in an effort to assess impacts of the outfalls on marine biodiversity. More recently, CLS (2022c) attempted to assess whether discharge from the outfall at Camps Bay has had any measurable effects on sessile biota on rock surfaces, rock lobster or fish. More recently, CLS (2022c) attempted to assess whether discharge from the outfall at Camps Bay has had any measurable effects on sessile biota on rock surfaces, rock lobster or fish. the study considered percentage cover and species diversity of rocky reef fauna in a series of 0.25 m² quadrat observations spanning different depth ranges, totalling 15 m². Percentage cover and biomass did not differ significantly between sites in close proximity to the outfalls compared with those further afield, and the composition of primary producers, grazers, detritus and filter feeders, and carnivores were considered as being “characteristic of the greater Table Bay and West Coast kelp forest”. No measurable effects on percentage cover or species diversity of invertebrates and macroalgae were evident that could be attributed to the effluent from the Camps Bay outfall. Additionally, data on rock lobster numbers and sizes, and abundance of Cape bream *Patchymetopon blochii* at different localities and depths around the outfall were similar to one another, and the researchers concluded that no measurable effect on the abundance of rock lobster or fish could be attributed to wastewater discharged from the Camps Bay outfall.

5.2 Approach

Assessment of the ecological effects of wastewater discharge from the CCT marine outfalls on marine fauna and flora adjacent to each of the outfalls utilised surveys of soft-bottom benthic infauna and/or reef epifaunal communities for each outfall. Where possible, sediment survey methods were similar in design to historic surveys conducted by CSIR, Lwandle and CLS. Diver surveys were based on those conducted by CMS and Anchor Environmental for the Table Mountain National Park long-term environmental monitoring programme (Hutchings et al., 2024; Kock, 2024; Mayfield et al., 2001) and was tailored to suit the nature of the environment adjacent to each outfall (i.e. soft sediment or rocky reef). Thus, for the Hout Bay outfall the ecological effects surveys focused on soft-bottom benthic infauna communities only, while those at Green Point and Camps Bay covered both soft-bottom benthic infauna and reef epifaunal communities.

5.2.1 Sites and Methods

Soft bottom benthic infauna communities were surveyed using a Van Veen grab, while reef epifaunal communities and reef fish were surveyed by divers on SCUBA and using a drop camera setup. Further details on the methods employed for each of these surveys are provided in the subsections below.

The survey design included sites of various types, categorised as follows:

- **AMZ (Allowable Mixing Zone):** Sites were sampled at the boundary of the designated mixing zone.
- **Proximal Zone:** Sites located outside the mixing zone but still near the outfall.
- **Reference Zone:** Control sites positioned further away from the outfall and assumed to be unaffected by its influence.
- **End of Pipe Zone:** (Hout Bay only) Sites located at the marine outfall diffuser.

5.3 Benthic Infauna Monitoring

5.3.1 General overview

Benthic macrofauna, also known as infauna, are commonly used as bio-indicators for monitoring the health of marine and estuarine environments (Feebarani et al., 2016; Kenny & Rees, 1996; Lewis et al., 2001; Simbora & Zenetos, 2002). Specific characters that underline their functionality as indicators include:

- **Mobility:** Many benthic macrofauna are non-mobile and cannot move away from disturbed or contaminated areas. As a result, they are strongly influenced by local conditions, making their abundance and distribution reliable indicators of spatial variation in water and sediment quality (Dutertre et al., 2013).
- **Differential responses:** Species vary in their sensitivity to environmental impacts, with some more tolerant and others highly vulnerable. These differences provide valuable information on the nature and intensity of disturbances (Dean, 2008; Kress et al., 2004; Raymond, 2022).
- **Short life span:** Most species have relatively short generation times, ranging from months to a few years. This allows them to reflect temporal changes in response to disturbances or pollutants (Raymond, 2022).
- **Sediment association:** As benthic macrofauna predominantly inhabit soft sediments, they can be sampled quantitatively. Their abundance is typically measured as the density (number) of organisms per unit area, providing standardized data for monitoring.

Community structure is also strongly influenced by sediment grain size, organic content, and water column characteristics (e.g., salinity). Therefore, their community structure, including species richness (i.e., total number of taxa), abundance, and functional traits, can be used to assess overall ecosystem health and identify specific types of disturbance.

Additionally, macrofaunal responses often precede chemical detection of impacts (Cranford et al., 2006). These responses include declines in biomass, reduced individual body size, and shifts in trophic dominance (Black et al., 2008; Cranford et al., 2012). It is, therefore, suggested that monitoring surveys should always include the determination of species biomass, to be used to construct Cumulative Abundance-Biomass dominance curves (ABC plots) and provide information on the level of disturbance, if any, within an anthropogenically influenced area. These curves provide a means of detecting the effects of anthropogenic perturbations on community assemblages.

5.3.2 Methods

5.3.2.1 Sample collection and processing

Soft bottom benthic infauna communities were sampled using a Van Veen grab (Figure 5-2). A single grab sample was collected from designated sites surrounding each outfall, which were designated into the following zones: AMZ, Proximal Zone, Reference Zone, with three replicates for each reference site (and in Hout Bay only) end of Pipe samples (Figure 5-2). A table summary of each site sampled at each outfall is presented in Table 5-1.

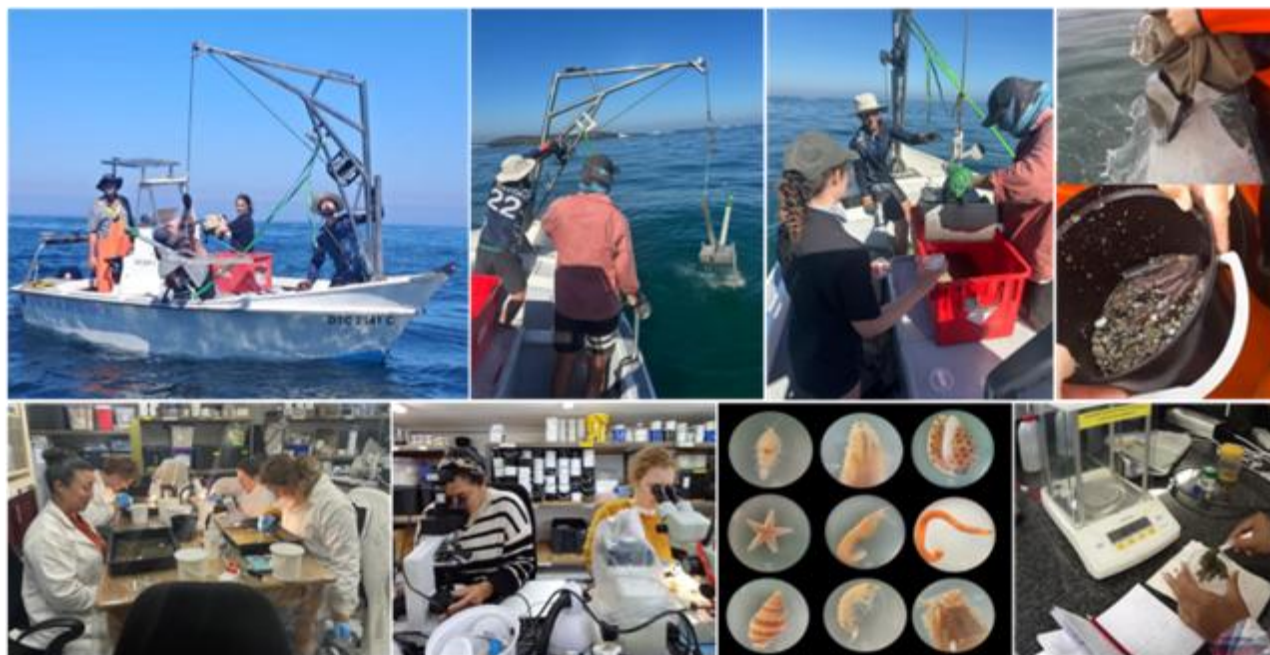


Figure 5-1. Benthic macrofauna sampling using a Van Veen grab on a small boat. Samples are sieved, preserved, sorted, identified to the highest taxonomic level and weighed.

At the Hout Bay outfall, an additional sampling zone, the End of Pipe Zone, was included, where samples were collected directly at the discharge point of the outfall pipe. Due to the presence of a rocky reef habitat at the Green Point outfall's AMZ and proximal sites, benthic infaunal sampling was not possible at that location. Instead, the epifaunal reef communities were surveyed to assess potential outfall impacts on local biota.

The contents of each grab sample were sieved using a 1 mm mesh sieve bag, and the retained macrofauna extracted and preserved in formalin. In the laboratory, samples were rinsed in a 1.0 mm

sieve to remove formalin and, if necessary, stained with Rose Bengal to aid sorting of biological from non-biological matter. The macrofauna were identified to the highest possible taxonomic resolution using available keys, dissecting and compound microscopes. The identification of each taxon was then checked on The World Register of Marine Species (WoRMS, www.marinespecies.org). Biomass (blotted wet mass to four decimal places) and abundance (individual counts) of species was recorded for each sample. Individuals that were too damaged to accurately place into an existing taxon were discarded to prevent artificially increasing diversity by the addition of ambiguous species names of damaged individuals.

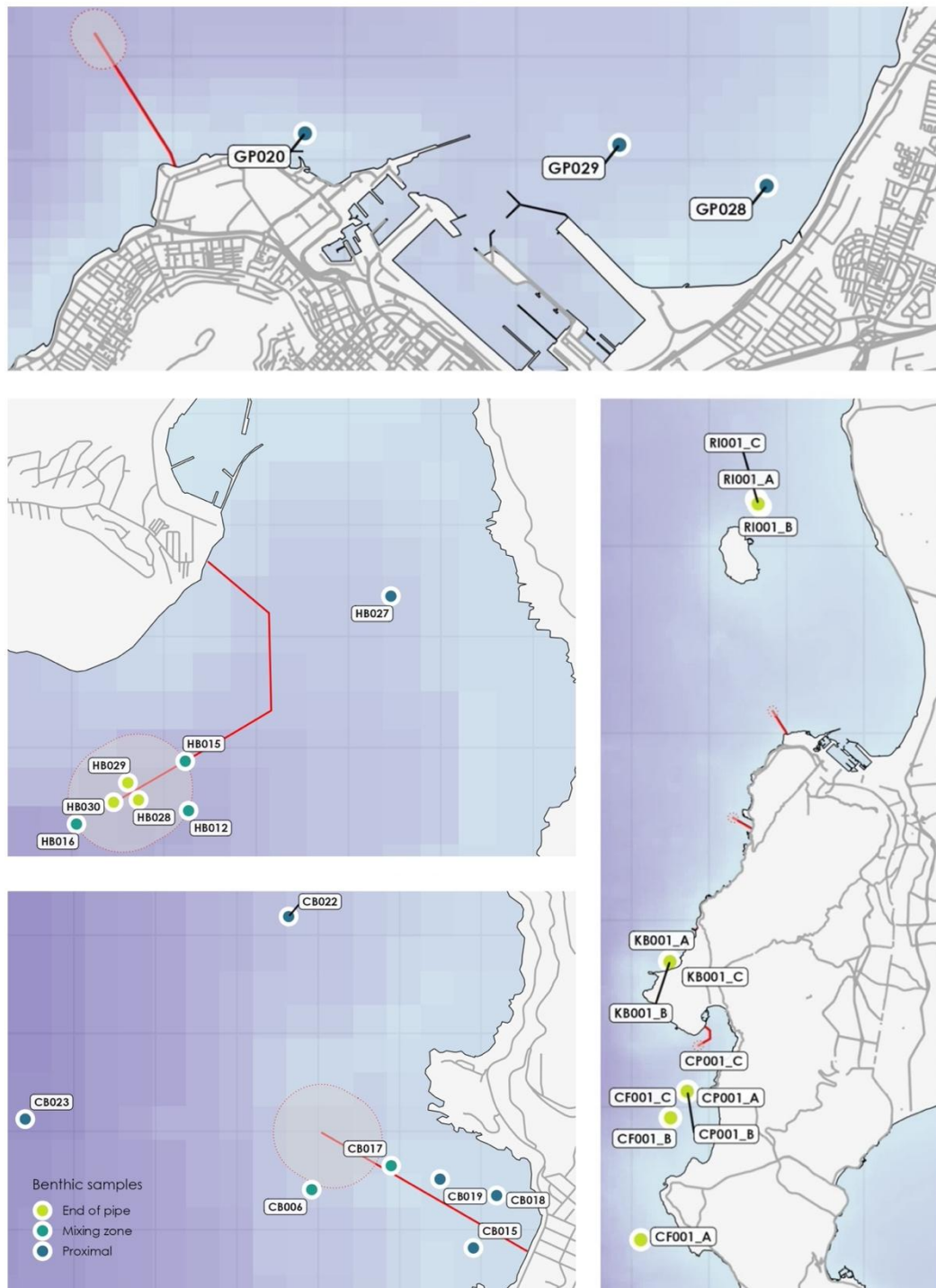


Figure 5-2. Ecological monitoring sites for benthic infauna at marine outfalls and reference sites.

Table 5-1. Benthic infaunal sampling sites at the Atlantic outfalls. CB: Camps Bay, GP: Green Point, HB: Hout Bay, AMZ: Allowable Mixing Zone.

Outfall	Site Zone	Site Name	Longitude	Latitude
CB	AMZ	CB006	18.3646	-33.948
CB	Proximal	CB015	18.37453	-33.9509
CB	AMZ	CB017	18.36948	-33.9468
CB	Proximal	CB018	18.37595	-33.9483
CB	Proximal	CB019	18.37248	-33.9474
CB	Proximal	CB022	18.36318	-33.9341
CB	Proximal	CB023	18.347	-33.9444
CB	Reference	KB001A	18.32458	-34.0218
CB	Reference	KB001B	18.32477	-34.022
CB	Reference	KB001C	18.3249	-34.0221
GP	Table Bay	GP020	18.41539	-33.8974
GP	Table Bay	GP028	18.46914	-33.9025
GP	Table Bay	GP029	18.45198	-33.8985
GP	Reference	RI001_A	18.3807	-33.7751
GP	Reference	RI001_B	18.38323	-33.7787
GP	Reference	RI001_C	18.38185	-33.7774
HB	Reference	CF001A	18.306	-34.1708
HB	Reference	CF001B	18.32495	-34.1058
HB	Reference	CF001C	18.32533	-34.1057
HB	Reference	CP001A	18.33622	-34.0916
HB	Reference	CP001B	18.33618	-34.0916
HB	Reference	CP001C	18.33603	-34.0915
HB	AMZ	HB012	18.34633	-34.0678
HB	AMZ	HB015	18.34615	-34.0656
HB	AMZ	HB016	18.34027	-34.0684
HB	Proximal	HB027	18.3573	-34.0582
HB	End_of_Pipe	HB028	18.34363	-34.0674
HB	End_of_Pipe	HB029	18.34305	-34.0666
HB	End_of_Pipe	HB030	18.34228	-34.0675

5.3.2.2 Statistical Analysis

Univariate (i.e., diversity indices) and multivariate statistical techniques were used to compare community structure of the infauna assemblages at the boundary of the AMZ, the Proximal Zone and at appropriate reference sites to evaluate impacts of the outfalls on the marine environment.

5.3.2.2.1 Diversity indices and community descriptors

Macrofaunal community descriptors (number of taxa, abundance, and diversity) were calculated using the DIVERSE function in PRIMER V6 (Clarke & Warwick, 2001). Diversity indices provide a measure of diversity (i.e., the way in which the total number of individuals are divided up among different species). Understanding changes in benthic diversity is important because increasing levels of environmental stress generally decreases diversity. Community diversity is influenced by two main aspects: species richness (the total number of species present) and evenness (how evenly individuals are distributed among species). A community with greater evenness is considered to be more diverse.

The Shannon Diversity index [$H'(\log_e)$] was calculated for each sampling location using PRIMER V6:

$H' = -\sum_{i=1}^S p_i \ln p_i$ Where p_i is the proportion of the total count represented by species i . This measurement is the most used diversity measure, as it incorporates both species richness and equability.

The H' index considers both species richness and evenness of the species' abundance, providing a single number that reflects the distribution of individuals among species in a community. A higher H' value indicates a more diverse community, with greater evenness and a larger number of species.

Taxonomic richness (alpha diversity or total number of species/taxa), total abundance, and biomass were also calculated. Community descriptors were plotted for all three of the outfall regions.

PRIMER software was also used to generate a Michaelis-Menten species accumulation curve to determine whether the sampling effort at Camps Bay and Hout Bay had been sufficient to accurately document the benthic macrofauna diversity.

5.3.2.2.2 Community structure and composition

The statistical programme, PRIMER V6 (Clarke & Warwick, 2001) was used to analyse benthic macrofauna data. Abundance and biomass data were converted from values within a single grab sample to per m^2 . All data were fourth root transformed and converted to a similarity matrix using the Bray-Curtis similarity coefficient. Spatial variability in macrofaunal community structure (based on abundance and biomass data) was visually assessed using non-metric multidimensional scaling (nMDS) plots, to find 'natural groupings' between the sites. The nMDS plots aim to maintain the rank order of dissimilarities between points (samples), utilizing a resemblance measure within the constraints of a limited number of dimensions (i.e., a non-parametric approach). To assess the effectiveness of the two-dimensional representation in capturing the sample relationship, a stress value is assigned to nMDS plots. A stress value exceeding 0.25 suggests that a higher-dimensional projection might be more suitable.

PERMANOVA (Permutational Multivariate Analysis of Variance) was used to assess the statistical significance of infaunal community structure for each outfall using site zone as an *a priori* defined group. The PERMANOVA routine (in the PERMANOVA+ software package in PRIMER V6), tests the simultaneous responses of one or more variables to one or more factors in an analysis of variance (ANOVA) experimental design on the basis of a resemblance measure (e.g., Bray-Curtis similarity), using permutation methods (Anderson et al., 2008). (Anderson et al., 2008). In this study, this routine was applied to test for statistically significant differences of a particular variable, such as abundance or biomass, among (*a priori* defined) groups of samples (e.g., site zone). In essence, the routine

performs a partitioning of the total sum of squares according to the specified experimental design, including appropriate treatment of factors that are fixed or random, crossed, or nested, and all interaction terms. A distance-based pseudo-F statistic was calculated in a fashion that is analogous to the construction of the F-statistic for multi-factorial ANOVA models. P-values were subsequently obtained using an appropriate permutation procedure for each term. Following the main overall test, pair-wise comparisons were also conducted. The significance level for the PERMANOVA routine was set to $p < 0.05$.

5.3.2.2.3 Cumulative abundance-biomass plot

Cumulative Abundance–Biomass plots (Warwick, 1993), also known as k-dominance curves, were used to visually assess whether benthic communities exhibited signs of disturbance or not. These plots compare the cumulative contribution of species to overall abundance and biomass on the same graph (Figure 5-3). In undisturbed communities (Figure 5-3A), the biomass curve typically lies above the abundance curve along its entire length. This pattern reflects the dominance of k-selected species, which typically includes larger, long-lived organisms that contribute significantly to community biomass but are usually less numerous. At the same time, many smaller, r-selected, opportunistic species with shorter lifespans are present, and often dominate in numbers but contribute little to biomass (Warwick, 1993). With slight disturbance (Figure 5-3B), competitive k-selected species are reduced or eliminated, narrowing the gap between the abundance and biomass curves. In some cases, the curves overlap or even cross, indicating a shift in community structure and moderate disturbance (Figure 5-3C). Under high disturbance (Figure 5-3D), larger species are displaced or die off, and r-selected species dominate. This results in high abundances but low overall biomass, with the abundance curve lying above the biomass curve for most or all of its length (Warwick, 1993).

For macrofauna, the DOMINANCE function in Primer was used to construct ABC curves and calculate W-statistics, in order to investigate if the communities currently show any signs of disturbance. The W-statistic of this test can move from neutral ($W \geq 0$) towards negative ($W < 0$), with the latter suggesting a disturbed or stressed condition.

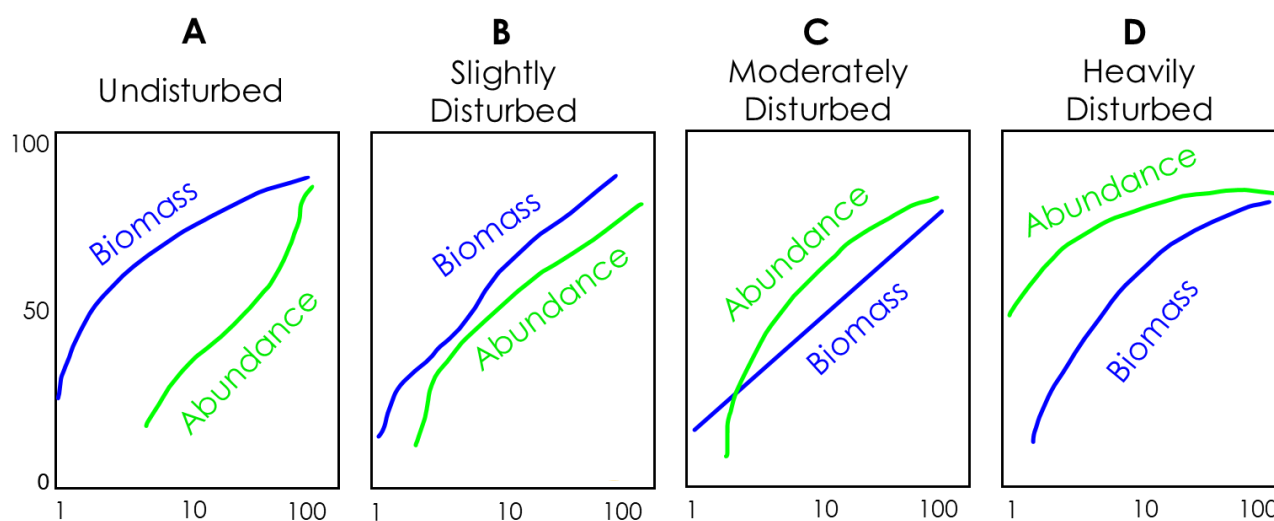


Figure 5-3. Hypothetical Abundance-Biomass Comparison (ABC) curves for species biomass and abundance showing A) undisturbed, B) moderately disturbed, and C) grossly disturbed conditions (after Warwick 1993).

5.3.3 Results and Discussion

5.3.3.1 Camps Bay Benthic Infauna

5.3.3.1.1 Diversity indices and community descriptors

A total of 70 benthic macrofauna taxa were identified from 10 samples collected at the Camps Bay survey sites, these span across seven phyla, including Nemertea (ribbon worms), Mollusca (gastropods and bivalves), Echinodermata (sea cucumbers and sea stars), Cnidaria (sea anemones), Chordata (sea squirts), Arthropoda (amphipods, isopods and true crabs), and Annelida (segmented worms and peanut worms).

The lowest average biomass and Shannon diversity were recorded at the boundary of the AMZ (9.8 ± 10.1 g/m², 0.6 ± 0.7 Shannon diversity), compared to the Proximal (23.5 ± 27.1 g/m², 1.7 ± 0.8) and Reference zones (39 ± 24.7 g/m², 2.2 ± 0.2) (Figure 5-4). Conversely, the average number of taxa was lowest at proximal sites (10.4 ± 5.6 taxa), increasing at AMZ sites (12.0 ± 8.5 taxa) and was highest at reference sites (15.7 ± 2.3). High abundance and low biomass as present at the AMZ of Camps Bay is indicative of a disturbed habitat. By favouring smaller, short-lived opportunistic taxa, the habitat is accompanied by a loss of larger, longer-lived taxa. Although lower diversity at the AMZ is visually evident, high variability in the data at Proximal sites, resulted in few statistically significant differences, with only Shannon diversity at the AMZ being significantly lower than at the reference zone. Given the limited replication and unequal sample sizes (AMZ: $n = 2$; Proximal: $n = 5$; Reference: $n = 3$), these patterns should be interpreted with caution as it currently stands.

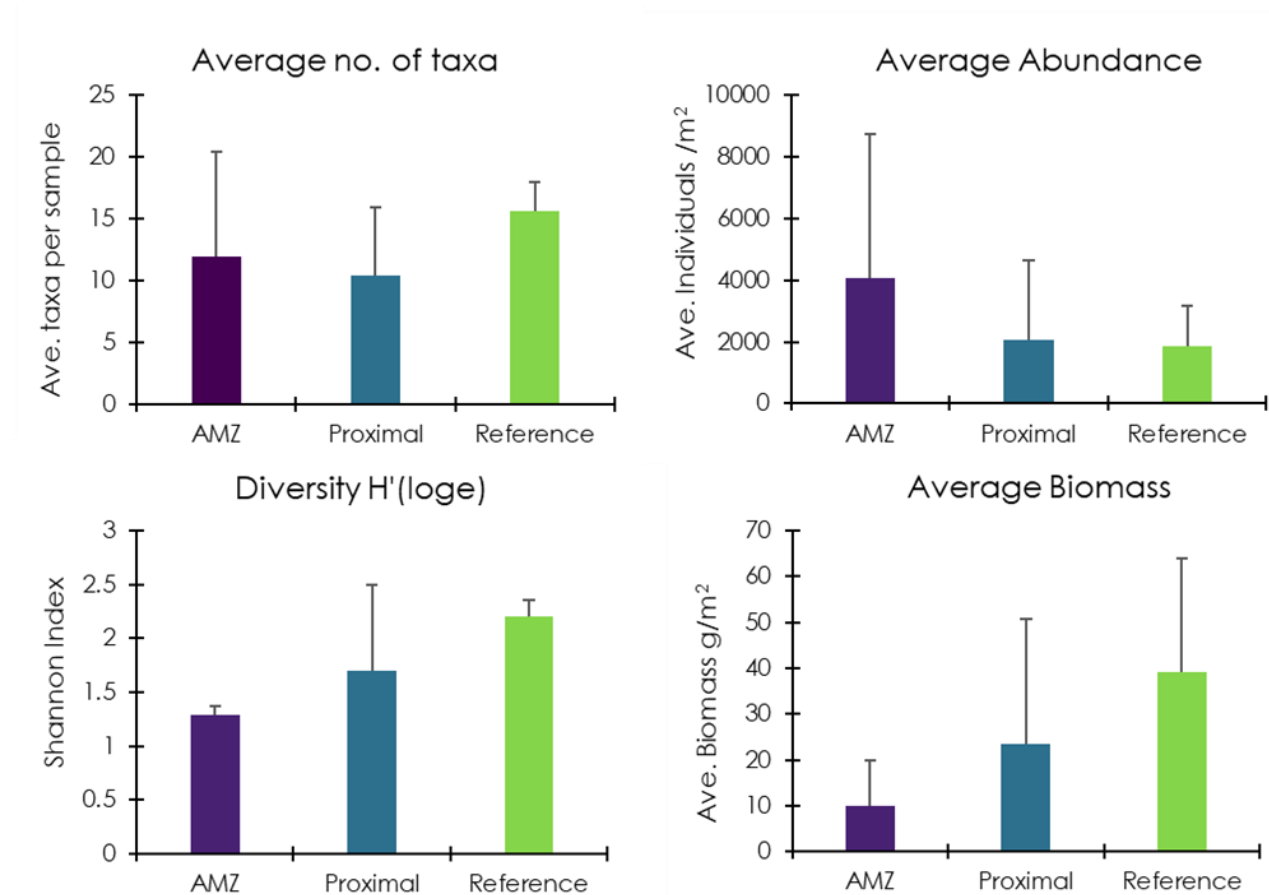


Figure 5-4. Means ± one standard deviation of Average number of Taxa (per m²), abundance (per m²), biomass (g/m²) and Diversity for benthic infauna sampled across three zones at the Camps Bay outfall in February 2025, including the Allowable Mixing Zone (AMZ), the Proximal zone and the Reference zone.

High macrofaunal abundances were recorded at the AMZ boundary (site CB006: 7382 individuals/m²) and within the Proximal zone (site CB018: 6636 individuals/m²) (Figure 5-5). At CB006, this was driven by exceptionally high densities of Oligochaeta (> 4900 individuals/m²). Proximal zone communities were dominated by arthropods, especially amphipods, including high numbers of the endemic isopod *Eurydice longicornis* at CB018 (> 5700 individuals/m²). By contrast, Reference zone sites showed moderate abundances with higher biomass, mainly composed of Nemertea, and no Oligochaetes.

Oligochaetes are well-known pollution-tolerant taxa, capable of thriving in environments with high levels of organic matter and low dissolved oxygen, compared to more sensitive species (P. M. Chapman et al., 1982; Lin & Yo, 2008; Martins et al., 2008; Rashid & Pandit, 2014). Their dominance combined with the absence of taxa at some sites, largely indicate ecological disturbance at the boundary of the Camps Bay AMZ.

Water quality surveys conducted in February 2025 did not detect elevated organic loading or TSS at any depth layer (refer to §2.3.2). However, moderate to low oxygen saturation was recorded at some AMZ sites, particularly at CB006, where bottom water oxygen saturation was 51.5% and dissolved oxygen was 4.6 mg/L. Interestingly, sediment data shows that this site (CB006) has some of the coarsest sediment within Camps Bay, making it less likely to be trapping/retaining organic matter than areas with finer particle size (Figure 4-2). These conditions, rather than effluent discharge, likely contributed to the proliferation of Oligochaetes and the concurrent loss of sensitive taxa at this site.

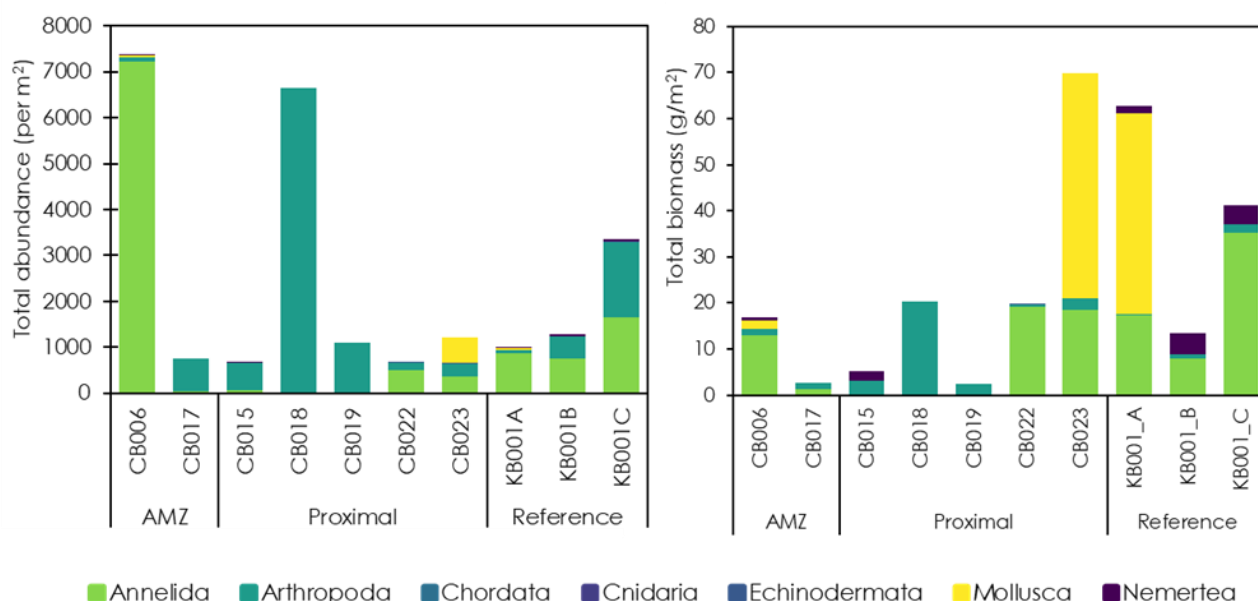


Figure 5-5. Total abundance (no. individuals per m²) (left) and total biomass (g/m²) (right) of major benthic infaunal phyla at each site sampled for the Camps Bay outfall.

5.3.3.1.2 Benthic infauna community structure

An ordination plot, that displays samples based on similarities in their macrofaunal community composition in two-dimensional space (samples with similar communities are closer together), prepared from macrofaunal abundance data, is presented in Figure 5-6. Visually, there was some separation in the benthic infaunal communities between the Reference sites and those in the AMZ and Proximal zones. This pattern was not supported by PERMANOVA results, which showed non-significant differences in benthic community composition between zones (pseudo-F = 1.4049, p =

0.061). Meaning that although it may look like there is separation, this was not statistically supported and communities were in fact similar.

These findings are consistent with results from the 2022 Camps Bay outfall survey by CLS, which also observed distinct species composition near the outfall, attributed to high abundances of *E. longicornis* and finer sediment grain sizes (0.25–0.425 mm) compared to other sites (CLS, 2022c).

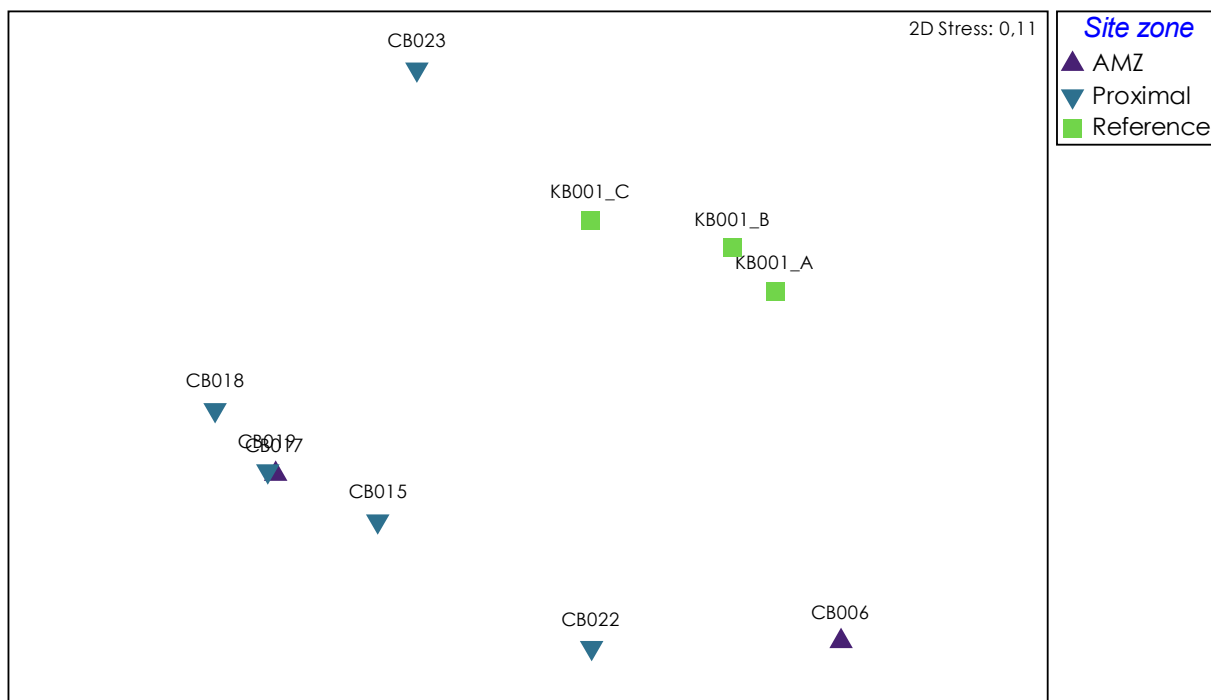


Figure 5-6. Non-metric multidimensional scaling (nMDS) for the benthic infaunal communities sampled at the Camps Bay outfall in February 2025 based on three zones, including the Allowable Mixing Zone (AMZ), the Proximal Zone and the Reference Zone.

The ABC curve for AMZ sites in Camps Bay showed that the biomass curve plotted consistently below the abundance curve across its entire length, with a negative W-statistic (Figure 5-7). This pattern, typical of disturbed habitats, likely reflects a high-energy environment influenced by wave action and sediment abrasion rather than the outfall itself, as the AMZ was characterised by coarser sediment and dominance by *Oligochaetes*. At the proximal site, the biomass curve plotted above the abundance curve for most of its length, but the initial crossing point suggests moderate disturbance, consistent with the low positive W-statistic observed. By contrast, at the Reference sites the biomass curve remained above the abundance curve throughout, accompanied by a strongly positive W-statistic, indicating undisturbed and stable habitat conditions.

Species accumulation curves were plotted for samples collected in the AMZ, Proximal and Reference zones at Camps Bay to evaluate whether the survey has adequately captured the local biodiversity. These curves plot the cumulative number of new species discovered against the amount of sampling effort. The curve typically shows a steep initial slope as new species are found rapidly, followed by a decreasing slope and eventual plateau as fewer new species are discovered with increased effort, indicating saturation. The curves show an increase in taxa with each additional sample; however, none reached a clear plateau, suggesting that the sampling effort may be insufficient to reliably represent benthic macrofaunal diversity across all zones and that more sites should be added to accurately account for all species present (Figure 5-8).

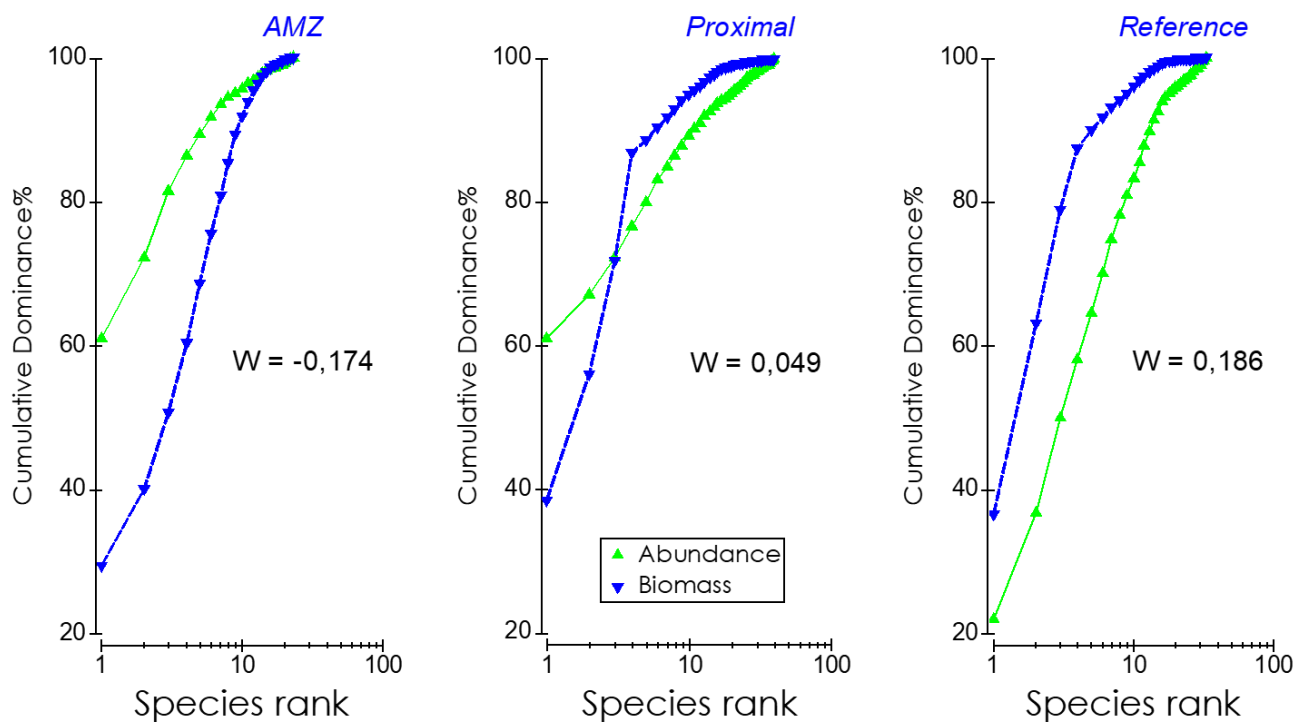


Figure 5-7. Abundance Biomass Comparison (ABC) curves for the AMZ, Proximal and Reference sites surveyed at Camps Bay in February 2025.

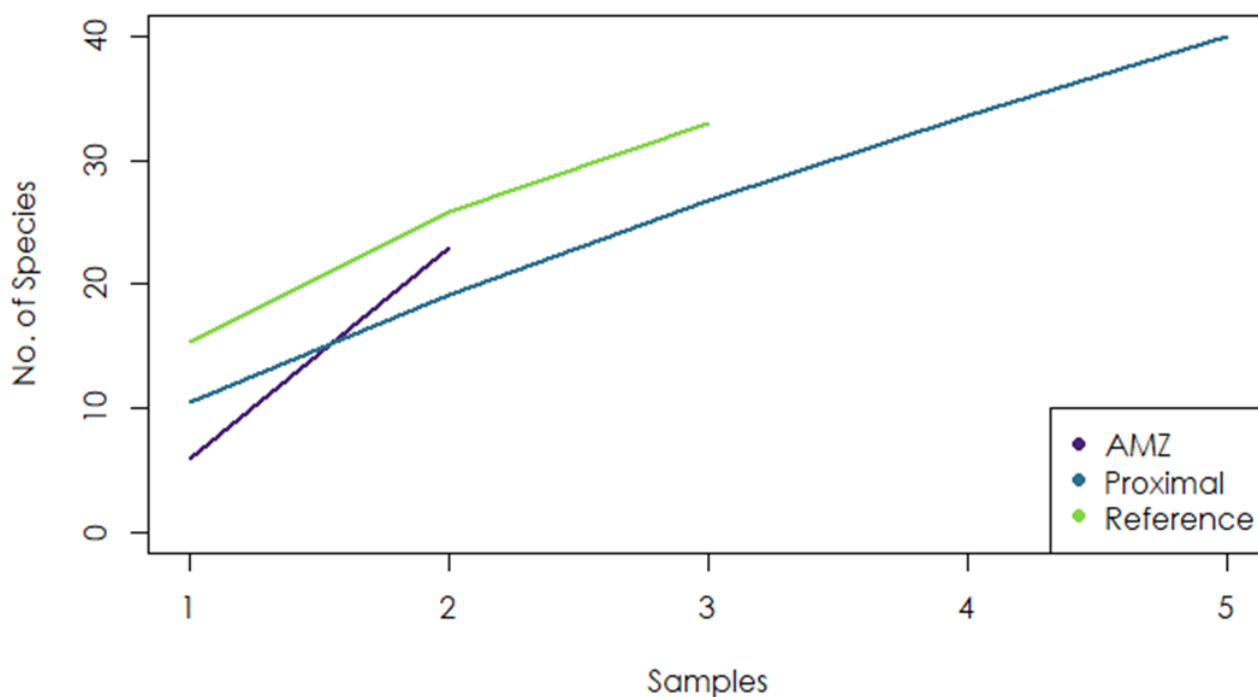


Figure 5-8. Michaelis-Menten species accumulation curves for the AMZ, Proximal and Reference sites collected at Camps Bay.

Overall, the combination of lower than reference diversity, high abundance, and low biomass, together with elevated densities of *Oligochaetes* and a reduced presence of other macrofaunal groups at the AMZ sites, suggests that there are ecological differences between sites around the Camps Bay outfall and those further away. However, the lack of organic sediment enrichment and the coarser sediment particle size, suggests that this disturbance likely reflects disturbance by the naturally high-energy environment influenced by wave action and sediment abrasion, rather than effects of wastewater discharge.

5.3.3.2 Hout Bay Benthic Infauna

5.3.3.2.1 Diversity indices and community descriptors

A total of 103 benthic macrofauna taxa were identified from 13 samples collected at the Hout Bay survey sites. These span seven phyla, including Nemertea (ribbon worms), Mollusca (gastropods and bivalves), Echinodermata (sea cucumbers and sea stars), Cnidaria (sea anemones), Chordata (sea squirts), Arthropoda (amphipods, isopods and true crabs), and Annelida (segmented worms and peanut worms). The number of taxa, abundance and Shannon diversity were statistically similar at the end of the outfall pipe, on the boundary of the AMZ and at the Reference sites (Figure 5-9). Biomass was higher at the Proximal site, but as this zone was represented by only a single sample, the result should be interpreted with caution. While biomass was lower at the Reference sites, it was not statistically different from the AMZ and End of Pipe sites. Abundance was also lower at the Proximal site, likely due to the presence of only a single replicate.

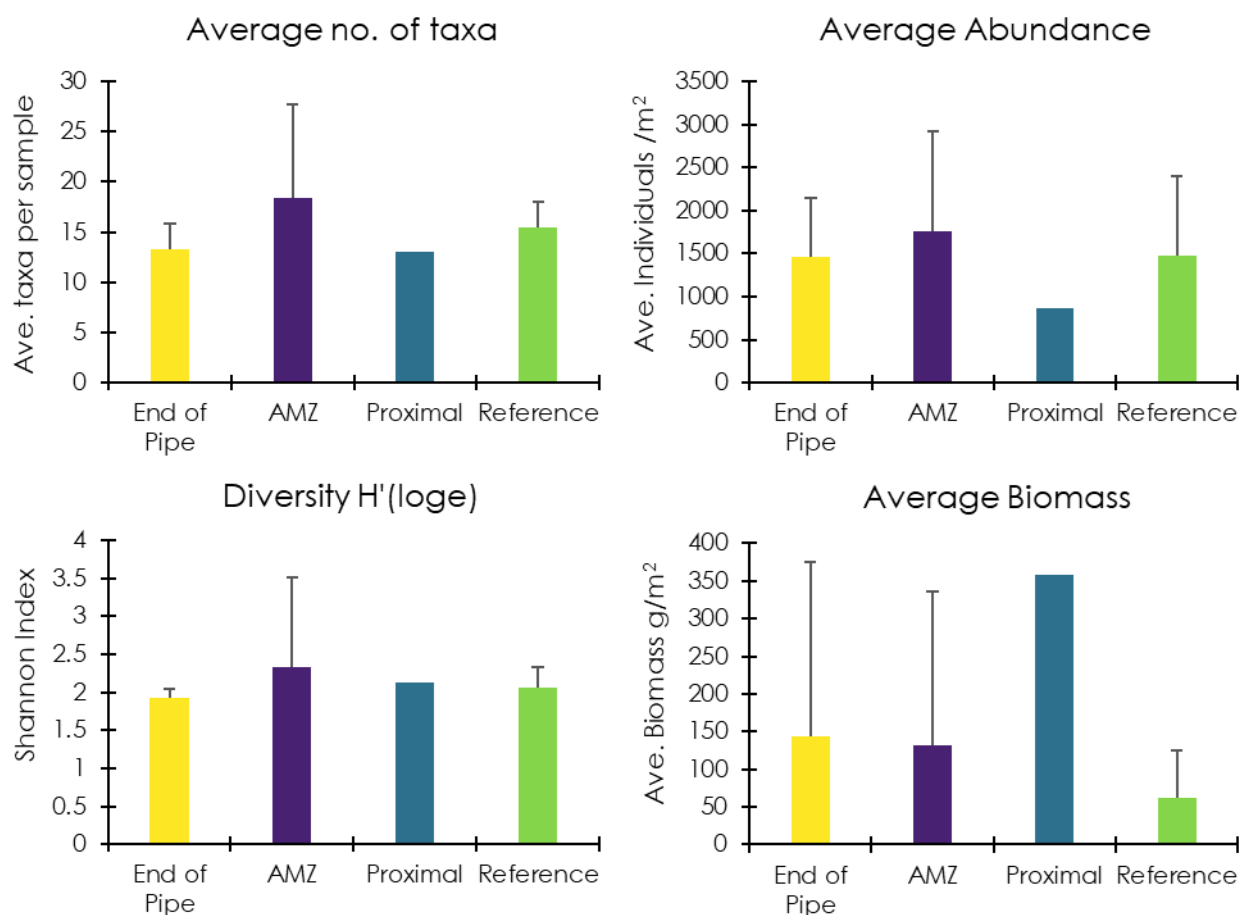


Figure 5-9. Means $\pm$ one standard deviation of Average number of Taxa, abundance, biomass (g/m²) and Diversity for benthic infauna sampled across four zones at the Hout Bay outfall in February 2025, including the End of the Pipe, Allowable Mixing Zone, the Proximal zone and the Reference zone.

Macrofaunal abundances were variable but broadly overlapping across all four zones (Figure 5-10). Biomass reflected a similar pattern, apart from elevated values recorded at HB30, HB16 and HB27, attributed to the presence of a Masked crab *Mursia cristata*, a starfish *Astroidea* sp. and the flat plough shell *Bullia laevissima*, respectively, all of which occur on the sediment surface rather than being true infaunal species. An alien species, the fat-feeler amphipod *Monocorophium acherusicum*, was detected at the end of the outfall pipe (HB012). This globally invasive species is known for its tolerance to a wide range of salinities and for constructing fragile but conspicuous U-shaped tubes (Mead et al., 2011). *M. acherusicum* was also recorded at the reference site CP001, however, suggesting its presence is unlikely to be linked to the outfall.

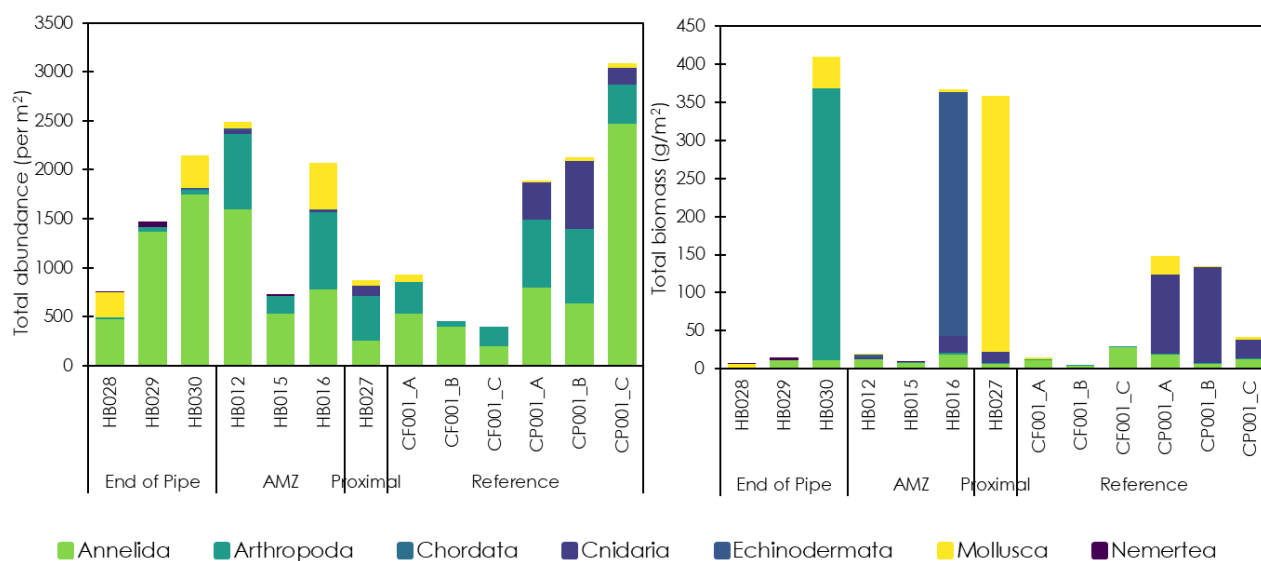


Figure 5-10. Total abundance (no. individuals per m²) (left) and total biomass (g/m²) (right) of major benthic infaunal phyla at each site sampled for the Hout Bay outfall.

5.3.3.2.2 Benthic infauna community structure

Visually, there was some separation in the benthic infaunal communities at the Crayfish Factory Reference site, CF001, relative to other Hout Bay sites, with the exception of one outlier site at the boundary of the AMZ (HB015) (Figure 5-11). This pattern/separation is likely based on locality, as samples located near each other grouped closer together, including the Chapman's Peak Reference sites, suggesting natural abiotic variability causing slight variation in the community structure. These differences were not statistically significant (PERMANOVA: pseudo-F = 1.6708, $p = 0.072$).

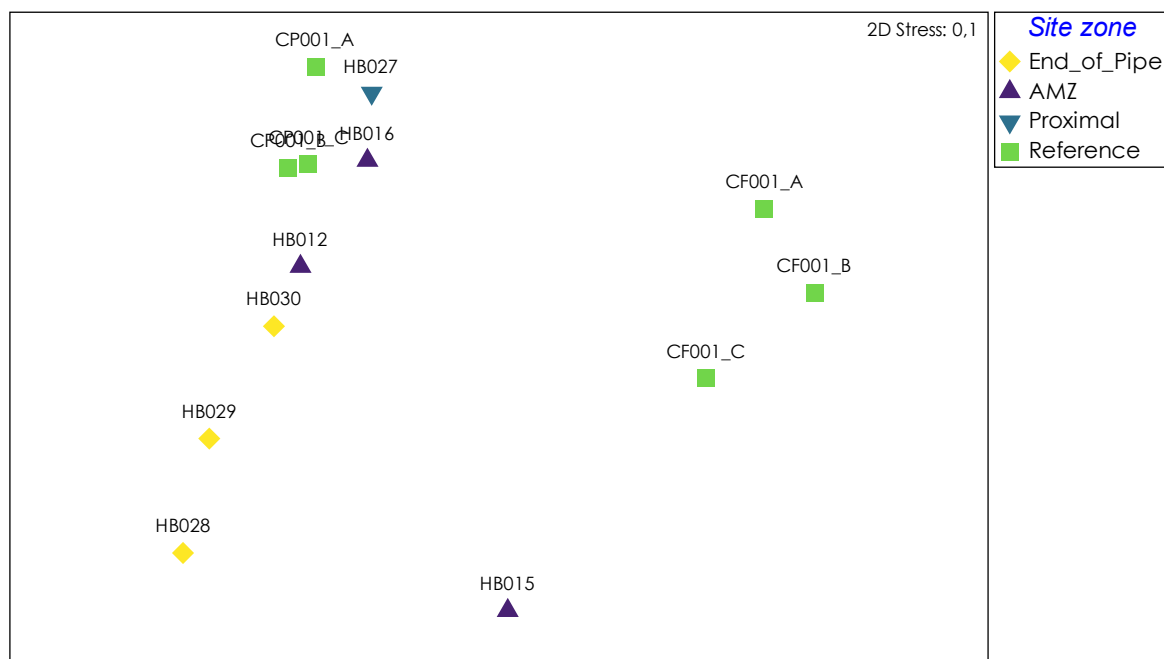


Figure 5-11. Non-metric multidimensional scaling (nMDS) for the benthic infaunal communities sampled at the Hout Bay outfall in February 2025 based on four site zones, including the End of the Pipe, Allowable Mixing Zone, the Proximal zone and the Reference zone.

The biomass curve on the ABC curves for all Hout Bay zones consistently plotted above the abundance curve across its entire length, with positive W-statistics recorded for all zones, indicating undisturbed and stable habitat conditions across all sites (Figure 5-12). These findings align with both the univariate and multivariate analyses, which suggest that the Hout Bay outfall has no detectable effects on the ecological health of benthic infaunal communities surrounding the outfall.

Species accumulation curves for the End of Pipe, AMZ, and Reference zones revealed a similar initial increase in taxa for the AMZ and reference sites, whereas the End of Pipe zone showed a more gradual increase (Figure 5-8). The reference zone had the greatest number of samples collected, with the curve nearly reaching a plateau and indicating that local diversity was more fully captured. By contrast, the AMZ and End of Pipe sites did not approach a clear plateau, suggesting that the sampling effort was insufficient to reliably represent benthic macrofaunal diversity in these zones, similar to results from Camps Bay. A plateau would likely be achieved with the addition of three to four further samples per zone.

Overall, at Hout Bay, there was no evidence from the benthic infaunal species diversity or community composition to suggest that the discharge from the outfall is having any ecological impacts on the health of the benthic ecosystem within or near the AMZ.

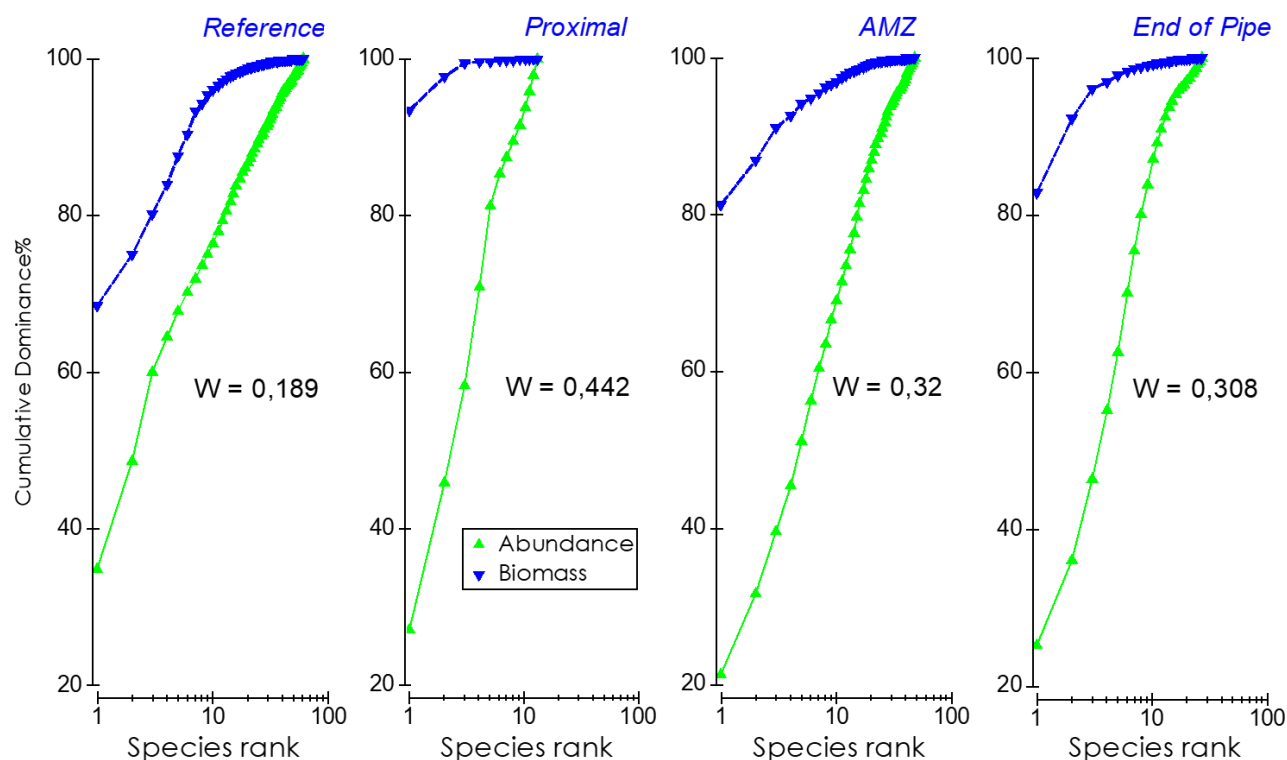


Figure 5-12. Abundance Biomass Comparison (ABC) curves for species biomass and abundance for the End of Pipe, AMZ, Proximal and Reference sites surveyed at Hout Bay in February 2025.

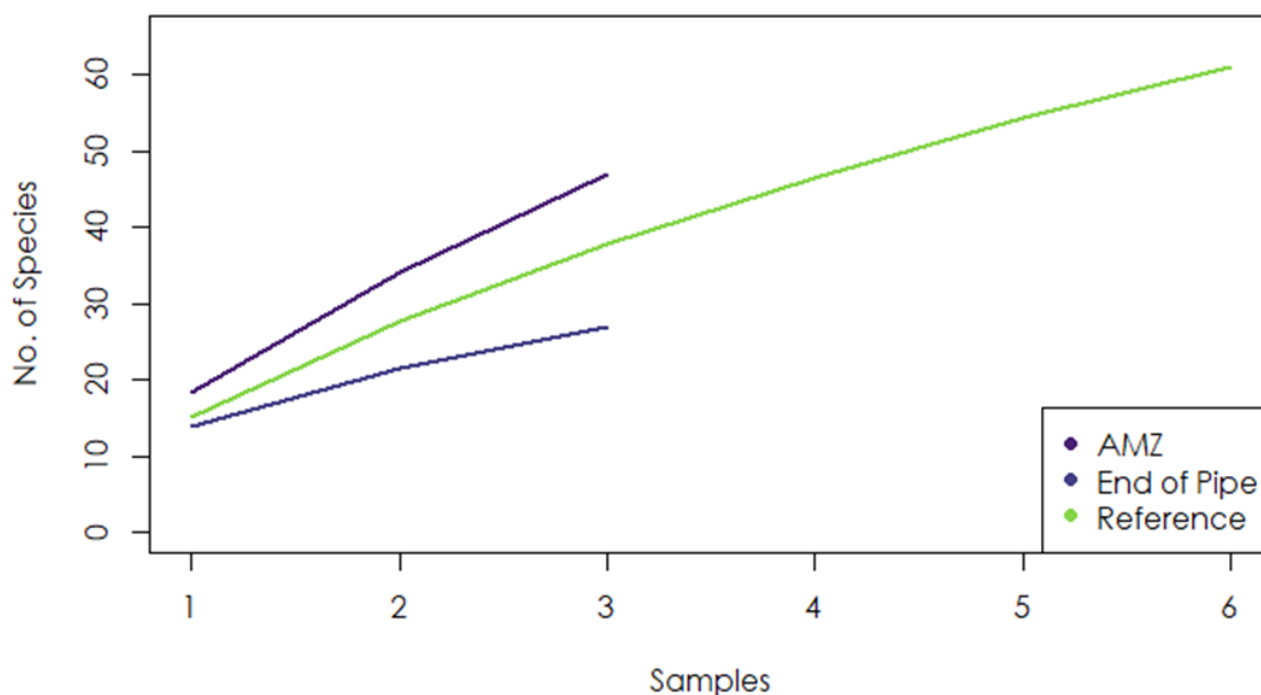


Figure 5-13. Michaelis-Menten species accumulation curve for the End of Pipe, AMZ and Reference sites collected at Hout Bay. The Proximal zone is not plotted here as there is only data for one site.

5.3.3.3 Green Point Benthic Infauna

5.3.3.3.1 Diversity indices and community descriptors

A total of 54 benthic macrofauna taxa were identified from six samples collected at the Green Point survey sites. These span seven phyla, including Nemertea (ribbon worms), Mollusca (gastropods and bivalves), Echinodermata (sea cucumbers and sea stars), Cnidaria (sea anemones), Chordata (sea squirts), Arthropoda (amphipods, isopods and true crabs), and Annelida (segmented worms and peanut worms). It is noteworthy that, due to the abundance of rocky reef habitats in Table Bay, it was only possible to collect sediment samples from three sites to the east of the outfall – in front of Cape Town Harbour and three reference sites around Robben Island.

None of the variations between community descriptors were statistically different, however some patterns were evident in the data. The number of taxa, and Shannon diversity were lower at the sites in Table Bay to the east of the outfall (9.3 ± 4 taxa, 1.2 ± 0.3 Shannon diversity) compared to the Reference zone (15.3 ± 3.1 taxa, 2.3 ± 0.3) (Figure 5-14). However, this is likely due to differences in environmental conditions, as the reference sites were collected near Robben Island, which experience different oceanographical conditions compared to the area in front of the harbour. Consequently, the reference sites may be more suitable for assessing trends over time rather than for direct comparison of absolute values.

The abundance and biomass were more variable at sites in Table Bay to the east of the outfall (382 to 2018 individuals/m²), compared to the Reference sites (872 to 1290 individuals/m²) (Figure 5-15). However, these largely overlapped with no major differences detected apart from the elevated abundance at site GP020 and biomass at GP028. The former is due to high abundances of the polychaete *Caulleriella acicula* (1636 individuals/m²), while the latter was due to the presence of the finger plough shell *Bullia digitalis* (54.3 g/m²).

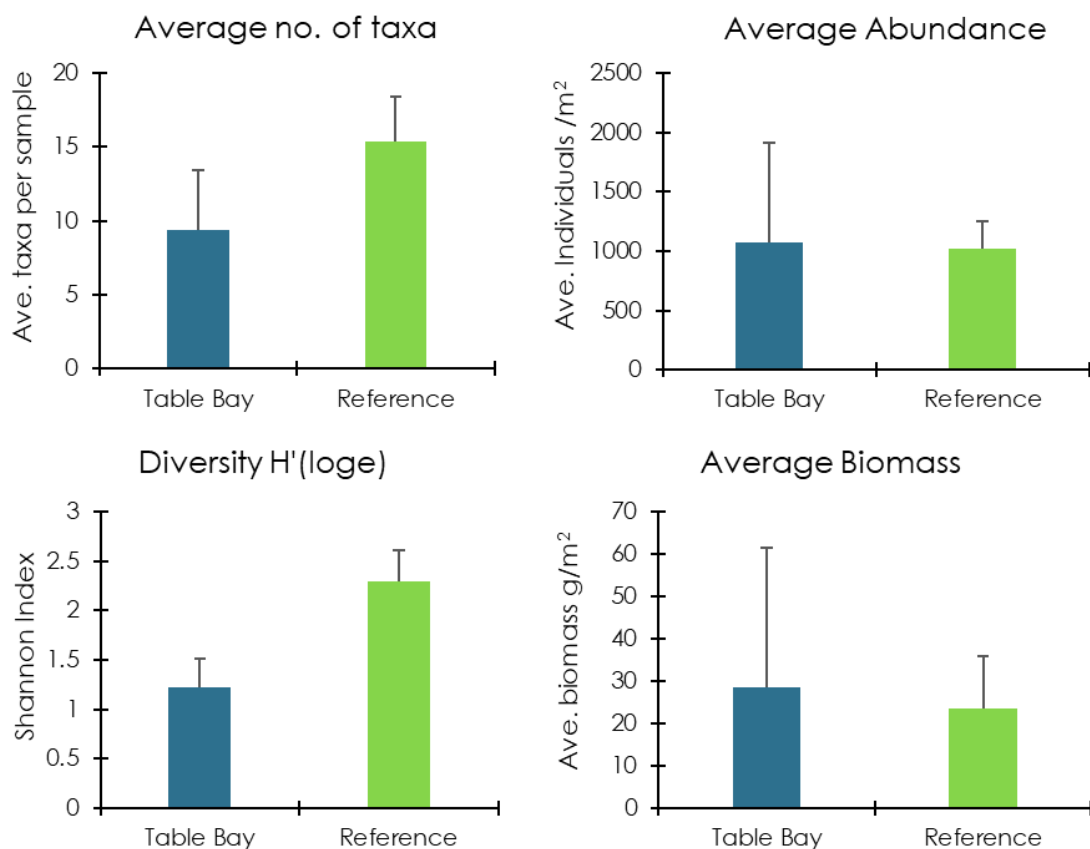


Figure 5-14. Means $\pm$ one standard deviation of Average number of Taxa, abundance, Diversity and biomass (g/m²) for benthic infauna sampled across two zones at the Green Point outfall in February 2025, including the sites in Table Bay to the east of the outfall and the Reference zone.

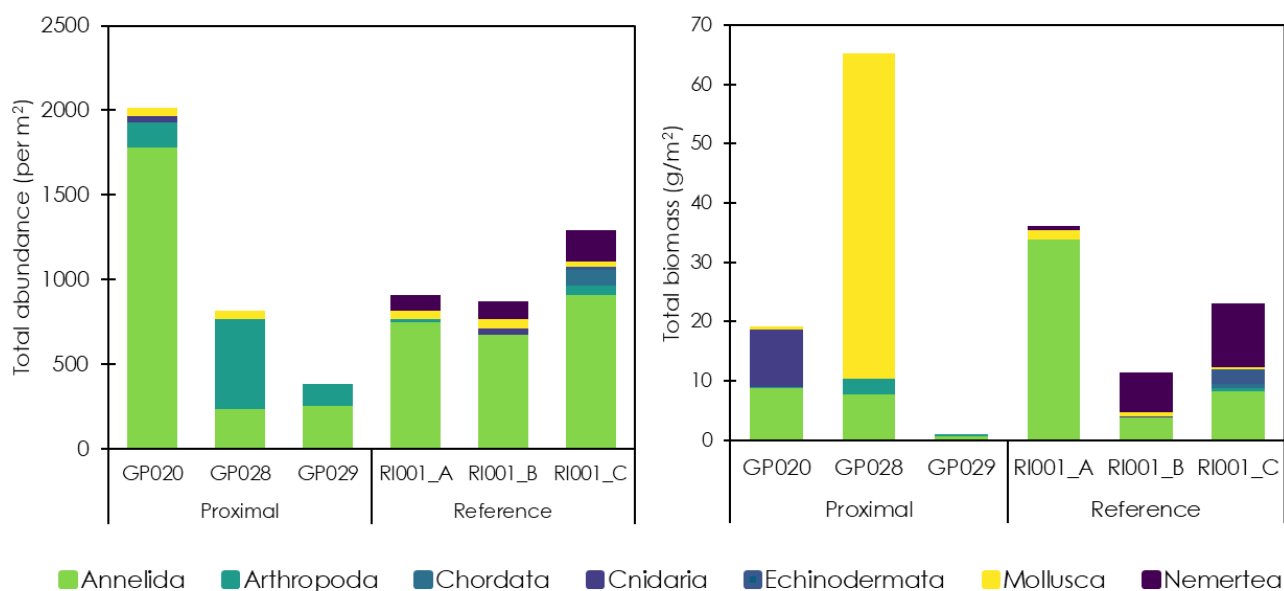


Figure 5-15. Total abundance (no. individuals per m²) (top) and total biomass (g/m²) (bottom) of major benthic infaunal phyla at Table Bay and Green Point reference sites sampled.

5.3.3.3.2 Benthic infauna community structure

Visually, there appears to be separation between the benthic infaunal communities at the Reference and Proximal sites, but this was not statistically significant (PERMANOVA: pseudo-F = 1.3398, $p = 0.074$) (Figure 5-16). It is likely that this is due to low number of sample replicates, causing the data to not be statistically robust. Nevertheless, slight differences in communities between the Proximal sites collected near the harbour mouth and the Reference sites at Robben Island are expected due to the exposure to different environmental conditions.



Figure 5-16. Non-metric multidimensional scaling (nMDS) for the benthic infaunal communities sampled at the Green Point outfall in February 2025 based on two zones: the sites in Table Bay to the east of the outfall and the Reference zone.

The ABC curves for Green Point showed that the biomass curve consistently plotted above the abundance curve across its entire length, with a positive W-statistic recorded in the sites to the east of the outfall and those in the Reference area. These lines were closer together than those of Hout Bay, and come close to touching in the proximal sites, suggesting some slight disturbance in this zone (Figure 5-17). This is likely due to the proximity of these sites to the Black and Diep Rivers and the Port of Cape Town rather than due to their proximity to the Green Point outfall.

Overall, the data collected during the benthic infaunal survey at Green Point are insufficient to allow any conclusive inferences on the ecological impacts of the discharge from the outfall. Epifaunal communities were surveyed using a drop camera at Green Point to compensate for the lack of infauna data at the boundary of the AMZ. Results from this survey can be found in §5.4.2.

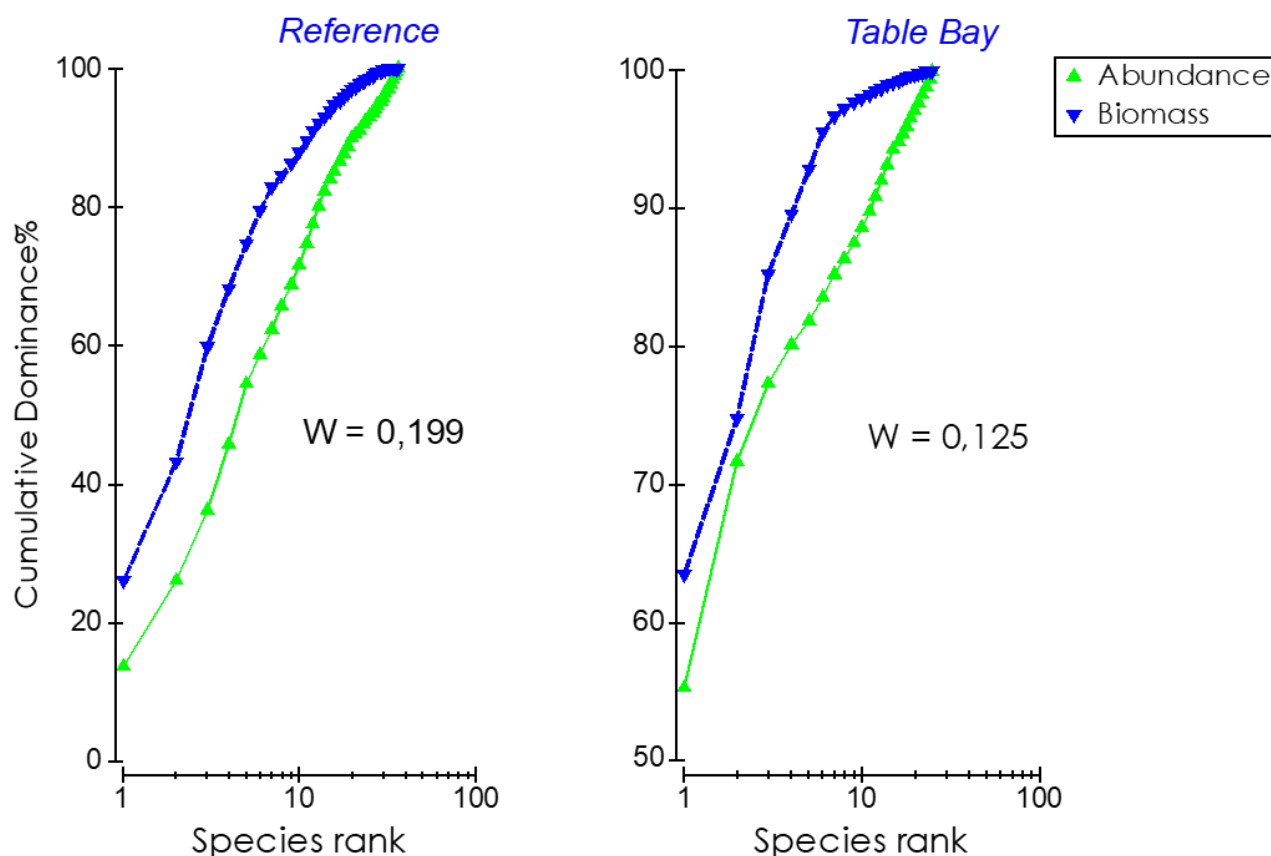


Figure 5-17. Abundance Biomass Comparison (ABC) curves for the Reference and Table Bay sites surveyed for the Green Point outfall in February 2025.

5.4 Benthic Epifauna monitoring: Drop Camera surveys

At the Camps Bay and Green Point outfall monitoring sites benthic infauna sampling was unsuccessful due to the presence of rocky reef in these areas. For this reason, the monitoring strategy was changed at these sites, and a drop camera survey was employed.

5.4.1 Methods

5.4.1.1 Drop camera

Hard bottom benthic epifauna communities were sampled using a drop camera system. This included a GoPro Hero 7 camera and white light torch mounted within a stainless-steel frame and set to record video (Figure 5-18). The frame, once lowered onto the seafloor, provides a recording of a known area and records a standardised field of view. The system was lowered to settle on the seafloor 10 times along a transect at each site and allowed to rest for a few seconds to enable clear focus. Site videos were processed into stills using DaVinci Resolve and then analysed using photographic analysis software, Transect Measure. Organisms were identified to species and pseudo-species level within an overlaid grid used to calculate area cover of each species. Higher order groups were retained and used for the analysis, because there is higher confidence in correct identification to functional group level.

The drop camera was unable to find rock at the Proximal sites GP021 and GP042 at Green Point, and the Camps Bay reference site KB001C, and as a result they were excluded from the analysis (Figure 5-19).

Sites were designated into the following zones: AMZ, Proximal zone, and Reference zone (Figure 5-20.). At the Camps Bay outfall three sites were sampled at the AMZ, three at the Proximal zone, and two were sampled at the Reference zone at Karbonkelberg. For the Green Point outfall three sites were sampled at the AMZ, five at the Proximal zone, and three samples were taken at the Reference zone at Robben Island.



Figure 5-18. Sampling team deploying the Drop camera frame off Green Point (left) and examples of still images extracted from the video footage (right).

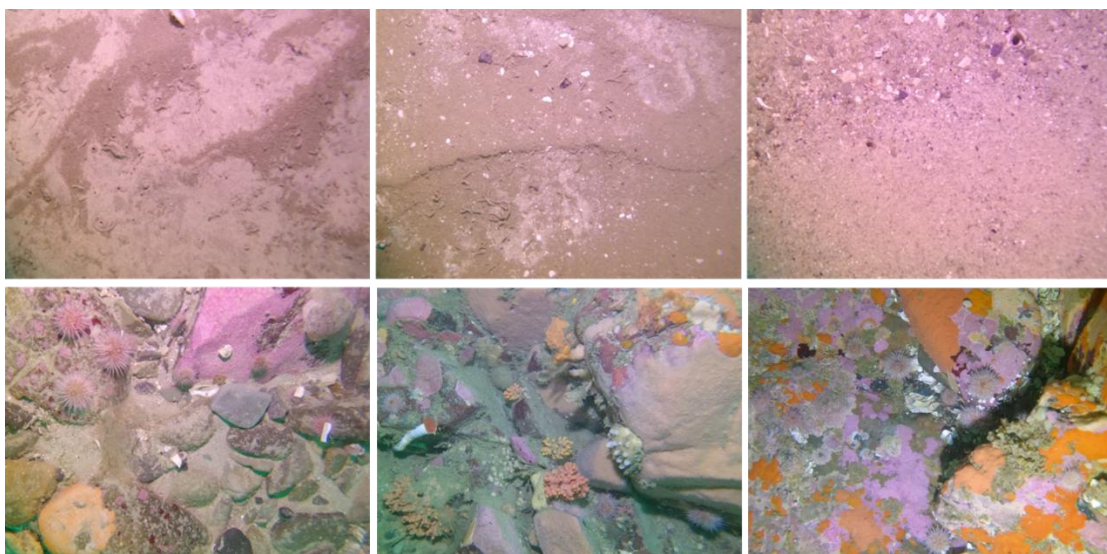


Figure 5-19. Comparisons of samples with no reef/rock, only unconsolidated sediment (top) and examples of stills of rocky reef substrate (bottom).

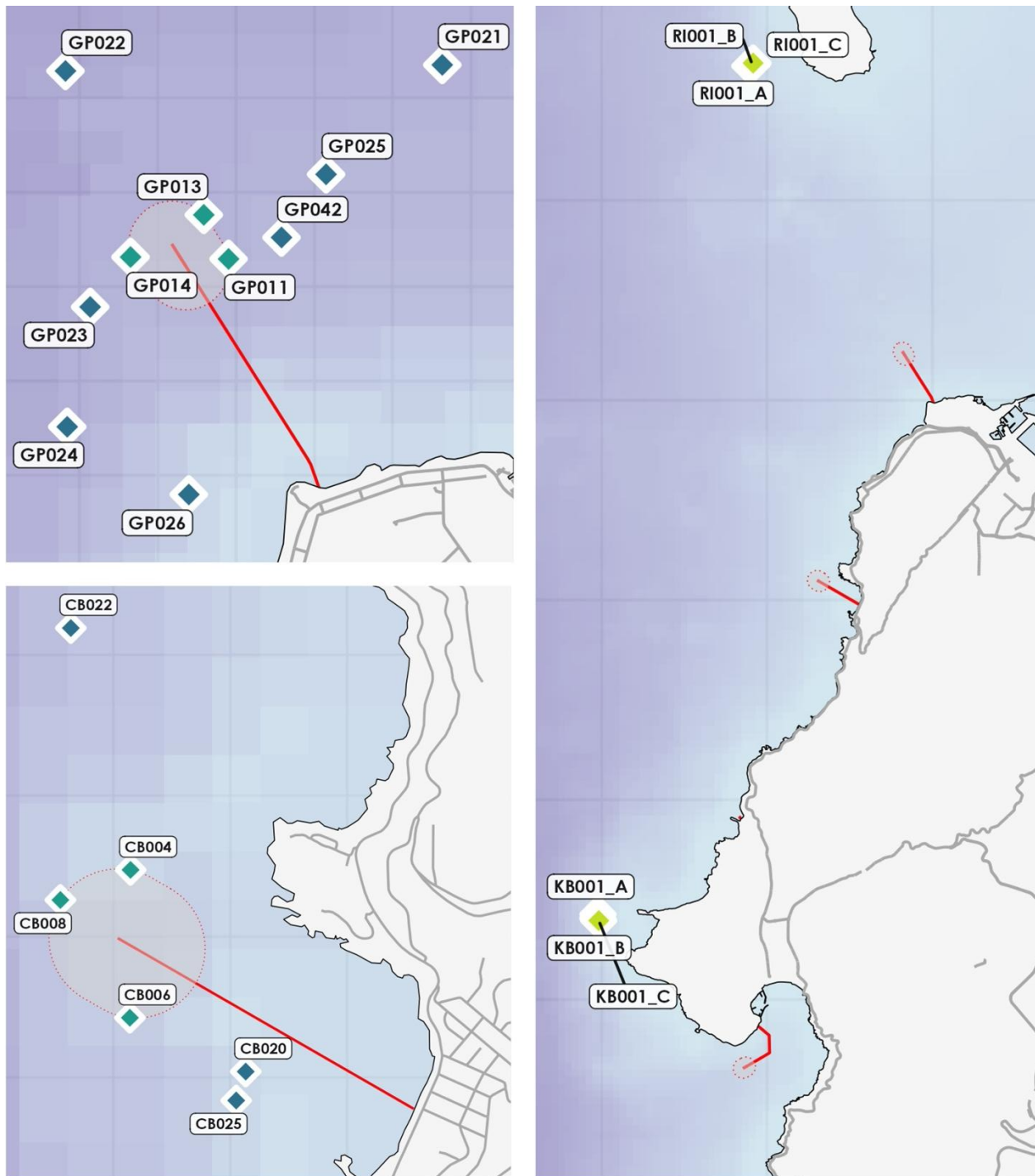


Figure 5-20. Drop camera survey sites for ecological effects monitoring.

5.4.1.2 Statistical analysis

The data for each outfall were analysed independently. Each site had ten images for which species groundcover was averaged. Data were analysed using Primer 6 and Permanova+. Descriptive statistics of Species Richness, Abundance (groundcover), Evenness, and Shannon Diversity metrics were calculated individually for the three zones (AMZ, Proximal, Reference). The data were 4th root transformed as is standard for ecological data, as this transformation copes with extreme variability. Non-metric multidimensional scaling plots (nMDS) were created to visualise site variability, and a PERMANOVA test was run to test for significant differences in community composition.

5.4.2 Results and Discussion: Drop Camera

5.4.2.1 Green Point Benthic Epifauna

A total of 56 taxa were identified from 11 sites for the Green Point survey which span across 9 phyla, including Annelida (segmented worms), Bryozoa, Chordata (ascidians and crustaceans) Cnidaria (sea anemones, corals, seafans), Echinodermata (seastars, sea cucumbers, brittlestars, sea urchins), Mollusca (snails and bivalves), Porifera (sea sponges), Algae (red, green, and brown), and Other (Table 5-2). The category marked 'Other' in Table 5-2 includes whelk eggs, a sea pig, chitons, limpets, and unknown encrusting organisms. Porifera was the most diverse group.

Across the AMZ, Proximal and Reference sites, respectively, the average number of taxa (21.0 ± 7.0 , 21.0 ± 3.3 and 23.0 ± 2.6), Abundance (133 ± 10.6 , 139 ± 26.2 , and 126 ± 7.2), Evenness ($58.5\% \pm 3.6\%$, $58.6\% \pm 5.8\%$, and $58.4\% \pm 5.4\%$), and Shannon Diversity (1.76 ± 0.24 , 1.78 ± 0.25 , and 1.83 ± 0.23) were highly similar for all zones (Figure 5-21.). The variability in these indices was also comparable between the zones. None of the zones were significantly different from each other suggesting impact of the outfall on rocky reef epifauna is not significant.

Table 5-2. Taxonomic groups used in benthic epifauna assessment and the number of species/pseudo species that contributed to those groups at Green Point

Phyla	Analysis Group	No species
Algae	Algae	6
Annelida	Worm	3
Bryozoa	Bryozoa	3
Chordata	Ascidian	5
	Crustacean	1
Cnidaria	Anemone	3
	Coral	7
	Seafan	2
Echinodermata	Echinoderm	9
Mollusca	Mollusc	2
Porifera	Sponge	10
Other	Other	5

A species accumulation curve is used to check whether sufficient sampling was conducted to reasonably cover the species present in an area. These curves plot the cumulative number of new species discovered against the amount of sampling effort. The curve typically shows a steep initial slope as new species are found rapidly, followed by a decreasing slope and eventual plateau as fewer new species are discovered with increased effort, indicating saturation. A species accumulation curve was checked for the three zones and shows that sufficient sampling was conducted at Green Point to run these analyses, as all three graphs move towards a plateau (Figure 5-22.).

Green Point sites were dominated by algae and echinoderms, with consistent appearances from sponges, Bryozoa and cold water corals. The average cover for all sites sampled was similar, ranging

between 10 and 20 cm² (Figure 5-23.). One Proximal site (GP022) and one Reference site (RI001A) had a higher average cover, due to the high numbers of Molluscs present. In both cases, this was due to the drop camera landing on a bed of South African ribbed mussel, *Aulacomya atra*, where faunal cover is higher on average due to the clustered nature of these organisms. Reference sites had lower cover of echinoderms and higher cover of sponges than the Proximal sites, which had higher cover of Bryozoa (Figure 5-23.).

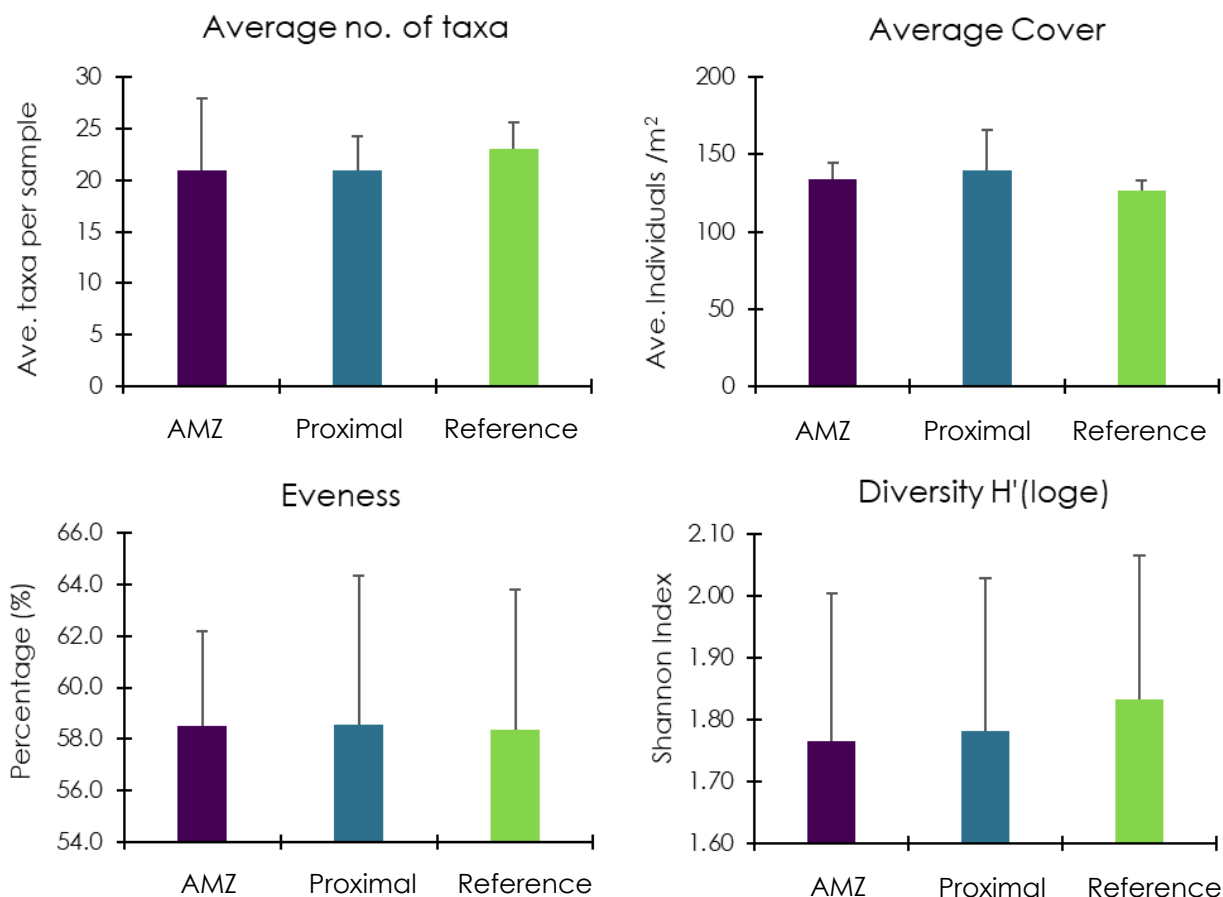


Figure 5-21. Means ± one standard deviation of Average number of Taxa, Abundance, Evenness and Diversity for benthic epifauna sampled across three zones at the Green Point outfall in February 2025, including the Mixing Zone, Proximal zone, and the Reference zone.

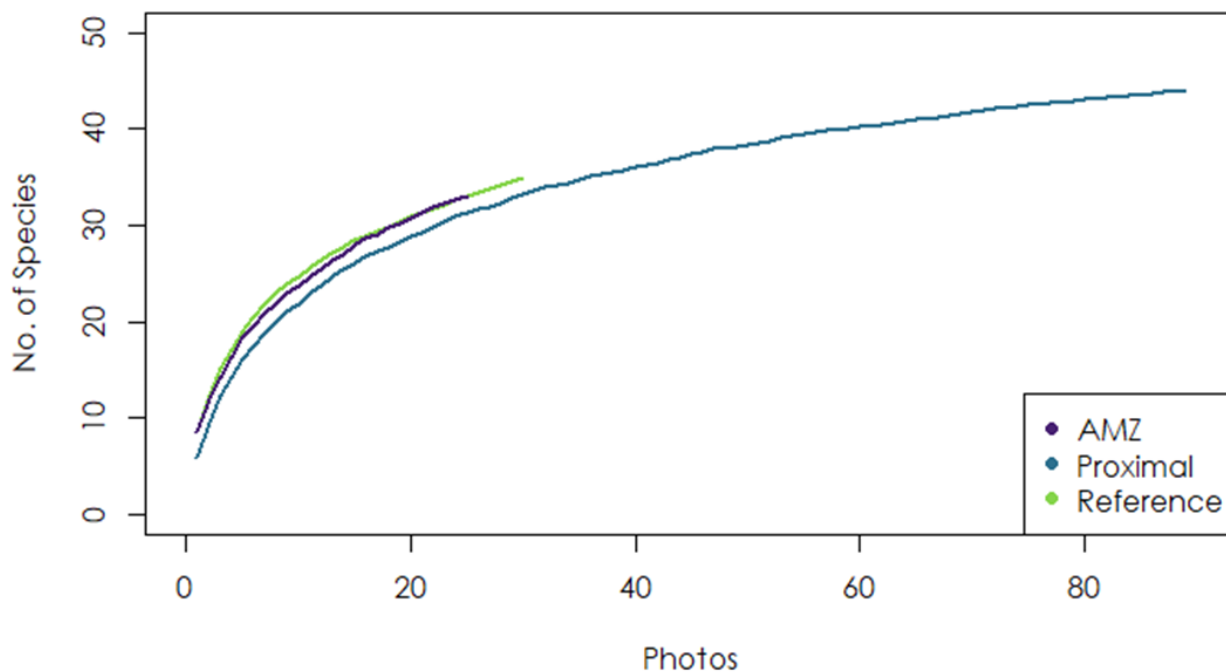


Figure 5-22. Species accumulation curve for the Mixing Zone, Proximal zone, and the Reference zone samples collected at Green Point in February 2025.

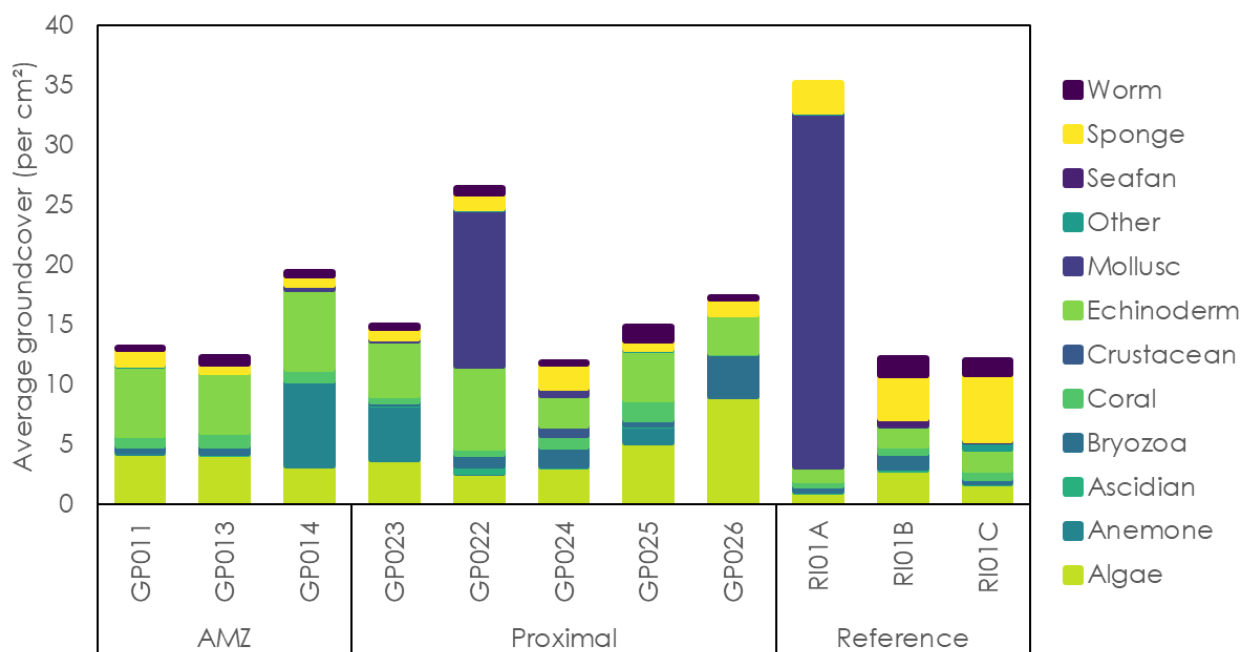


Figure 5-23. Average groundcover (per cm²) of major benthic epifauna phyla at each site sampled in February 2025 based on three site zones, Allowable Mixing Zone, Proximal zone, and the Reference zone.

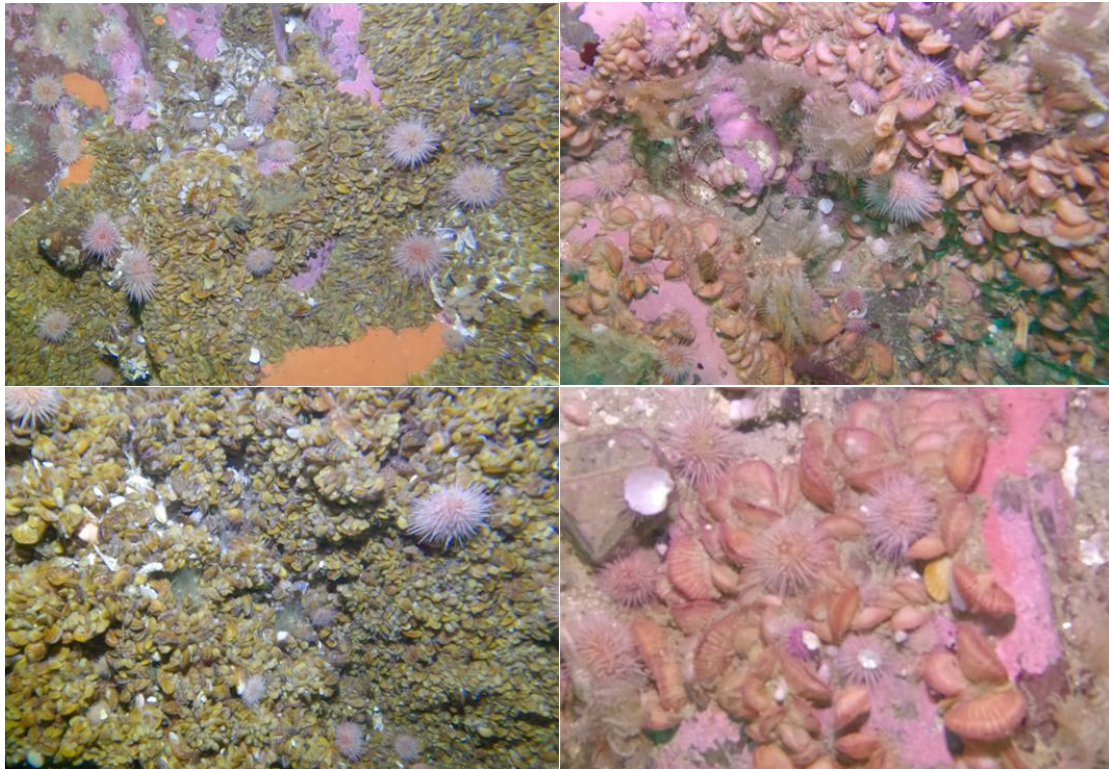


Figure 5-24. Dense beds of the South African ribbed mussel, *Aulacomya atra*, found in GP022 and RI001A, which account for the higher-than-average abundance of molluscs in Figure 5-23.

An ordination plot showing similarities in epifaunal community composition and abundance displays that reference sites appear to be more similar to each other than to the Proximal and AMZ sites, as they cluster closer to each other (Figure 5-25.). Although this pattern was partially supported statistically by PERMANOVA results, which showed significant differences in epifaunal communities (pseudo-F = 2.2518, $p = 0.025$), pairwise comparisons, showed no significant differences between any zone pairings (AMZ- References $t = 1.667$, $p = 0.100$; AMZ -Proximal $t = 1.219$, $p = 0.215$; Proximal-Reference $t = 1.6924$, $p = 0.098$). Because the pairwise comparisons are not significant, the PERMANOVA results should be treated with caution. This means that the differences between the communities was not substantial enough to be statistically significant and communities only had natural variation and not variation as a result of the outfalls.

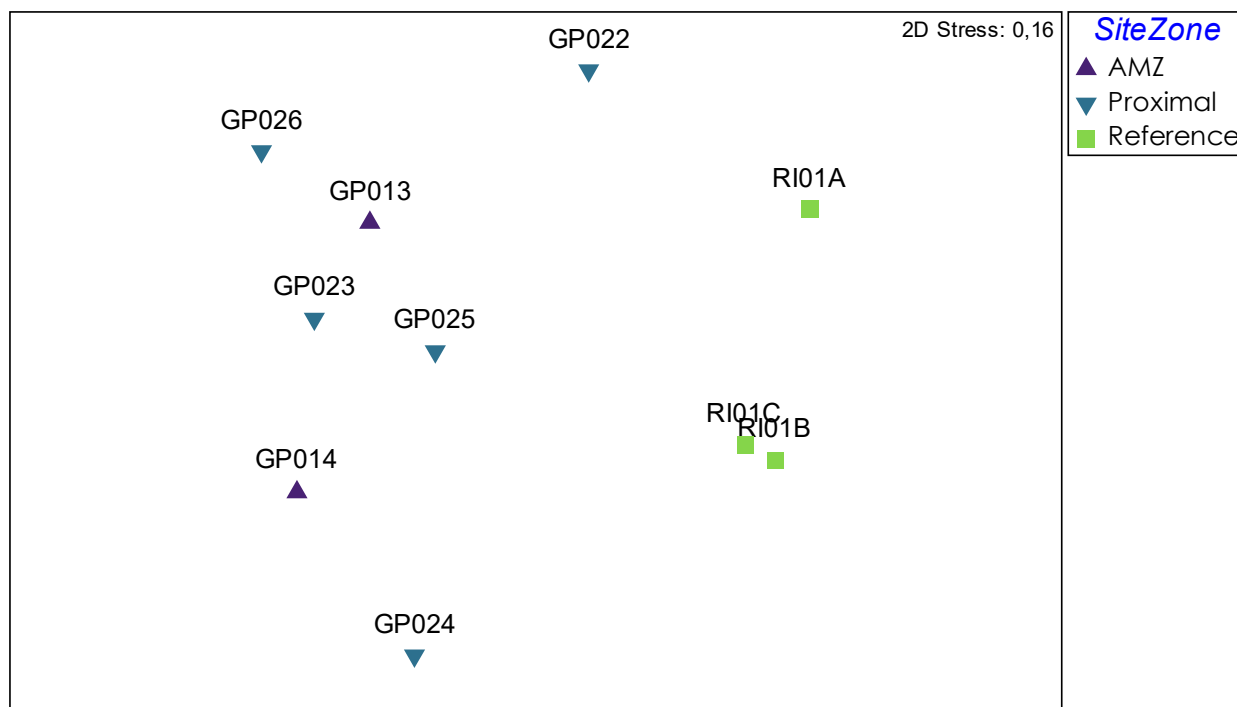


Figure 5-25. Non-metric multidimensional scaling (nMDS) for the benthic epifaunal communities sampled at the Green Point outfall in February 2025 based on three site zones, Allowable Mixing Zone, Proximal zone and the Reference zone.

5.4.2.2 Camps Bay Benthic Epifauna

A total of 50 taxa were identified from 8 sites sampled at Camps Bay which span 10 phyla, including Annelida (segmented worms), Bryozoa, Chordata (ascidians and crustaceans), Cnidaria (sea anemones and corals), Echinodermata (seastars, sea cucumbers, brittlestars, sea urchins), Mollusca (snails and bivalves), Porifera (sea sponges), Algae (red, green, and brown), and Other (Table 5-3). The category marked 'Other' in Table 5-3 included whelk eggs and chitons.

The average number of taxa, abundance, evenness, and Shannon diversity were similar across all three zones, although proximal sites exhibited slightly lower average number of taxa, evenness and Diversity, and somewhat higher average abundance (Figure 5-26.). None of these differences were statistically significant, however. The variability in these statistics was also comparable between the sites.

Table 5-3. Taxonomic groups used in benthic epifauna assessment and the number of species/pseudo species that contributed to those groups at Camps Bay.

Phyla	Analysis Group	No species
Algae	Algae	11
Annelida	Worm	2
Bryozoa	Bryozoa	3
Chordata	Ascidian	4
	Crustacean	2
Cnidaria	Anemone	1
	Coral	4
Echinodermata	Echinoderm	4

Phyla	Analysis Group	No species
Mollusca	Mollusc	2
Porifera	Sponge	14
Other	Other	2

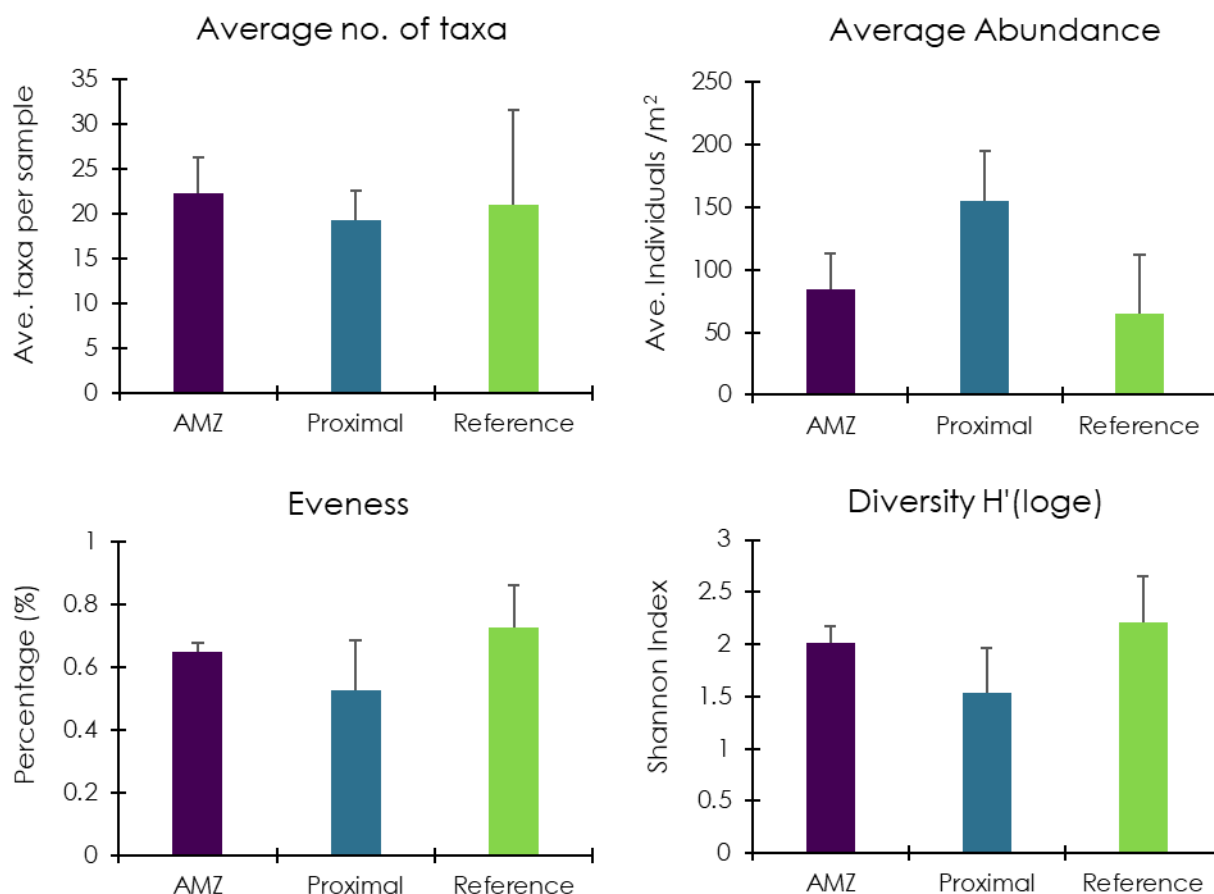


Figure 5-26. Means ± one standard deviation of Average number of Taxa, Abundance, Evenness and Diversity for benthic epifauna sampled across three zones at the Camps Bay outfall in February 2025, including the Allowable Mixing Zone, the Proximal zone and the Reference zone.

Species accumulation curves were used to check whether sufficient sampling had been conducted to reasonably cover the species present in each area. These curves were assessed for the three zones and suggest that sufficient sampling was conducted at Camps Bay to run these analyses (Figure 5-27.). It shows that species accumulated slightly faster at the Reference zone when compared to the two impact zones. This is linked to higher Shannon diversity in this zone, which is evident in the Diversity H' (loge) part of Figure 5-26.

The average cover occupied by each phylum at each site is shown in Figure 5-28. Epifaunal communities at Camps Bay were dominated by molluscs and algae. The Proximal zone also had higher cover of echinoderms at two sites, and anemones at one site. There was high variability in ground cover within the Proximal zone, which was driven by the presence of mussel beds in CB022 and CB020.

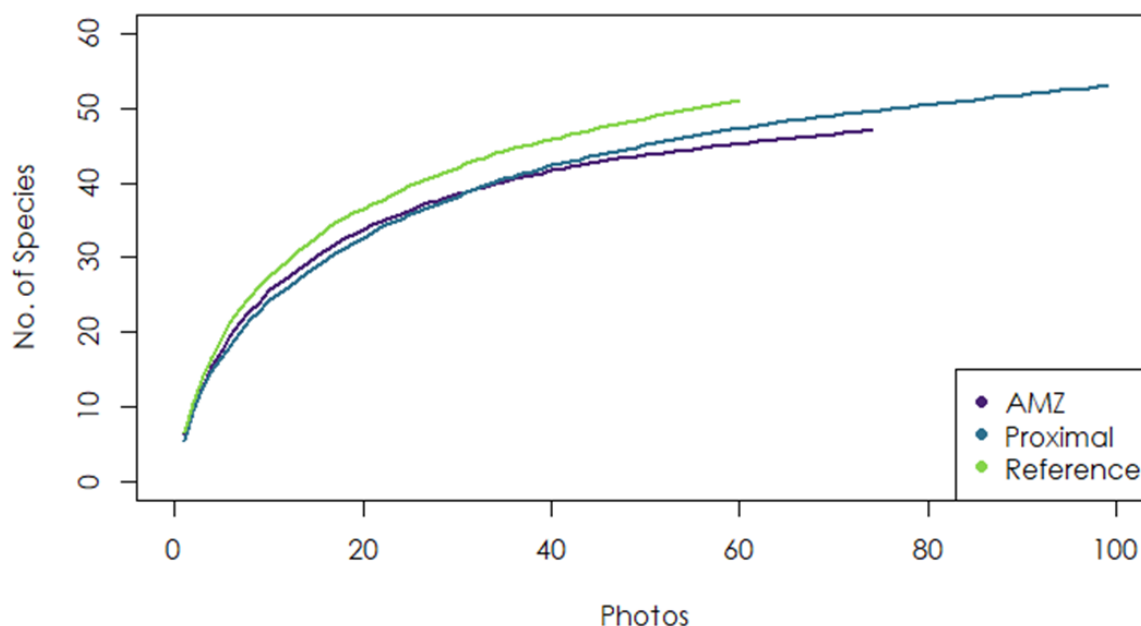


Figure 5-27. Species accumulation curves for the AMZ (purple), Proximal (orange), and Reference (green) zone samples collected at Camps Bay in February 2025

The ordination plot showing similarities in benthic epifaunal community composition and abundance suggests that there is slight clustering within zones, but no strong dissimilarities between zones (Figure 5-29.). This pattern was supported by PERMANOVA results, which showed low-magnitude, but statistically significant differences in epifaunal communities (pseudo-F = 2.2518, $p = 0.02$). Pairwise comparisons, however, showed no significant differences between any zone pairings (AMZ-Reference $t = 1.6669$, $p = 0.099$; AMZ-Proximal $t = 1.2188$, $p = 0.188$; Proximal-Reference $t = 1.6924$, $p = 0.113$). This makes sense for benthic epifauna, which are mostly comprised of sessile species that broadcast spawn, therefore enabling taxa to be distributed over large areas by currents and wave action.

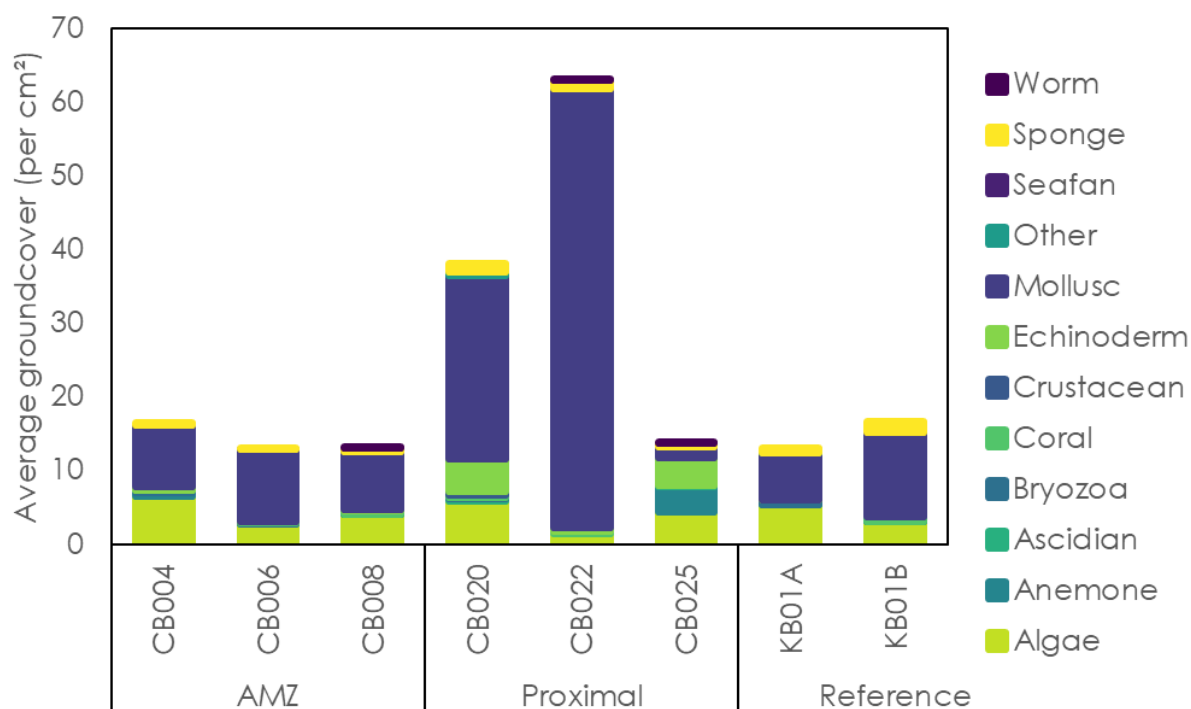


Figure 5-28. Average groundcover (per cm²) of major benthic epifauna phyla at each site at Camps Bay sampled in February 2025 based on three site zones, Allowable Mixing Zone, Proximal zone and the Reference zone.



Figure 5-29. Non-metric multidimensional scaling (nMDS) for the benthic epifaunal communities sampled at the Camps Bay outfall in February 2025 based on three site zones, Allowable Mixing Zone, Proximal zone and the Reference zone.

5.5 Benthic Epifauna monitoring: Reef Surveys

5.5.1 General overview

An essential outcome of any outfall biomonitoring programme is to determine if wastewater discharge is significantly and negatively impacting on the ecology of the receiving environment and/or is posing a risk to the health of humans that use the receiving environment (CSIR, 2017a). (CSIR, 2017a). This is a critical objective of the 2024 Receiving Environment Monitoring Programme and as part of this programme, an epifauna reef survey was undertaken to evaluate the ecological condition of reef communities and to detect any potential effects attributable to the marine wastewater outfalls.

The survey focused on key species of commercial concern such as West Coast rock lobster (*Jasus lalandii*, hereafter referred to as rock lobster), abalone, alikreukel and reef-associated fish communities. These species were selected as rock lobster populations are commercially exploited species (DFFE, 2020) that are highly sensitive to habitat degradation and pollution while reef-associated fish communities provide insights into broader ecological integrity across multiple trophic levels.

5.5.1.1 West coast rock lobster

Rock lobster is recognised as a sensitive bioindicator due to its mid-trophic level, habitat specificity and vulnerability to environmental stressors. Its life history traits including slow growth rates, complex planktonic larval phase and reliance on reef structures (e.g., caves) for shelter make it highly responsive to water quality issues (e.g., heavy metals, toxins, hypoxia), temperature fluctuations and habitat modification. These species play a pivotal role in the regulation of prey populations (e.g., sea urchins) and are prey for higher trophic level (order) predators (e.g., sharks, rays). Changes in

rock lobster populations can therefore trigger trophic cascades that alter the broader ecosystem functioning (Mayfield et al., 2001; Mayfield & Branch, 2000).

Despite conservation efforts, rock lobster stocks remain severely depleted due to historical overexploitation and ongoing illegal harvesting (i.e., poaching) (DFFE, 2020). While rock lobster sanctuaries have been established along the West Coast, their efficacy has been questioned (Centre for Marine Studies, 2001).

5.5.1.2 Reef-associated fish communities

Fish communities were surveyed concurrently due to their ecological and diagnostic value. Fish species occupy a broad range of trophic levels, from herbivores controlling algal growth to apex predators that structure reef food webs. Their mobility and physiological sensitivity make them effective early indicators of ecosystem stress, with signs such as avoidance behaviours or gill damage often linked to pollution events. Additionally, commercially important species (e.g., Cape seabream / linefish) may act as vectors for human health risks through the bioaccumulation of pollutants. As such, shifts in fish diversity, abundance and community structure provide complementary insights to those derived from rock lobster data, capturing both benthic and pelagic ecosystem responses.

5.5.2 Methods

5.5.2.1 Dive survey

During February 2025, underwater visual census (UVC) surveys were conducted to collect data on commercially and ecologically important indicator species (rock lobster, abalone, alikreukel, kelp, sea urchins and fish species) at designated CCT marine outfall sites. Ten sites were surveyed (three reference sites and six AMZ sites) with four transects per site (Figure 5-30 and Figure 5-31).

Three transect sites were positioned on the boundary of the AMZ of the Camps Bay and Green Point outfalls (Figure 5). Two reference sites outside the AMZ were sampled for each region (Figure 5). The Hout Bay outfall was not surveyed because the sandy substrate and greater depth (>30 m) are not conducive habitat for most of the target species, and benthic infauna monitoring is of greater relevance (refer to §5.3). At each site, two SCUBA divers independently surveyed two 10 m transects (four in total per site) (Figure 5-31). Data were recorded on printed waterproof datasheets and captured digitally by the dive team within one week of each diving day.

During each of the transects, the numbers of rock lobster, abalone, and alikreukel within an area of 0.5 m on either side of each transect were recorded. The rock lobster and abalone were further distinguished by the number of individuals estimated as being above or below legal-harvest size, which is 80 mm carapace length for rock lobster and 114 mm minimum shell diameter for abalone. This distinction was not made for alikreukel as juveniles are found primarily in the shallower intertidal zone. In addition, the water depth, water temperature, habitat structure (reef, boulders and/or sand), and abundance of urchins and kelp fronds present were recorded. The urchin and kelp abundance were recorded according to a rating scale of 0–3 (Table 5-4). A total of 40 SCUBA transects were completed over two days. At the outer end of each transect the diver would spend up to one minute identifying and counting fish and classifying each individual into size classes.

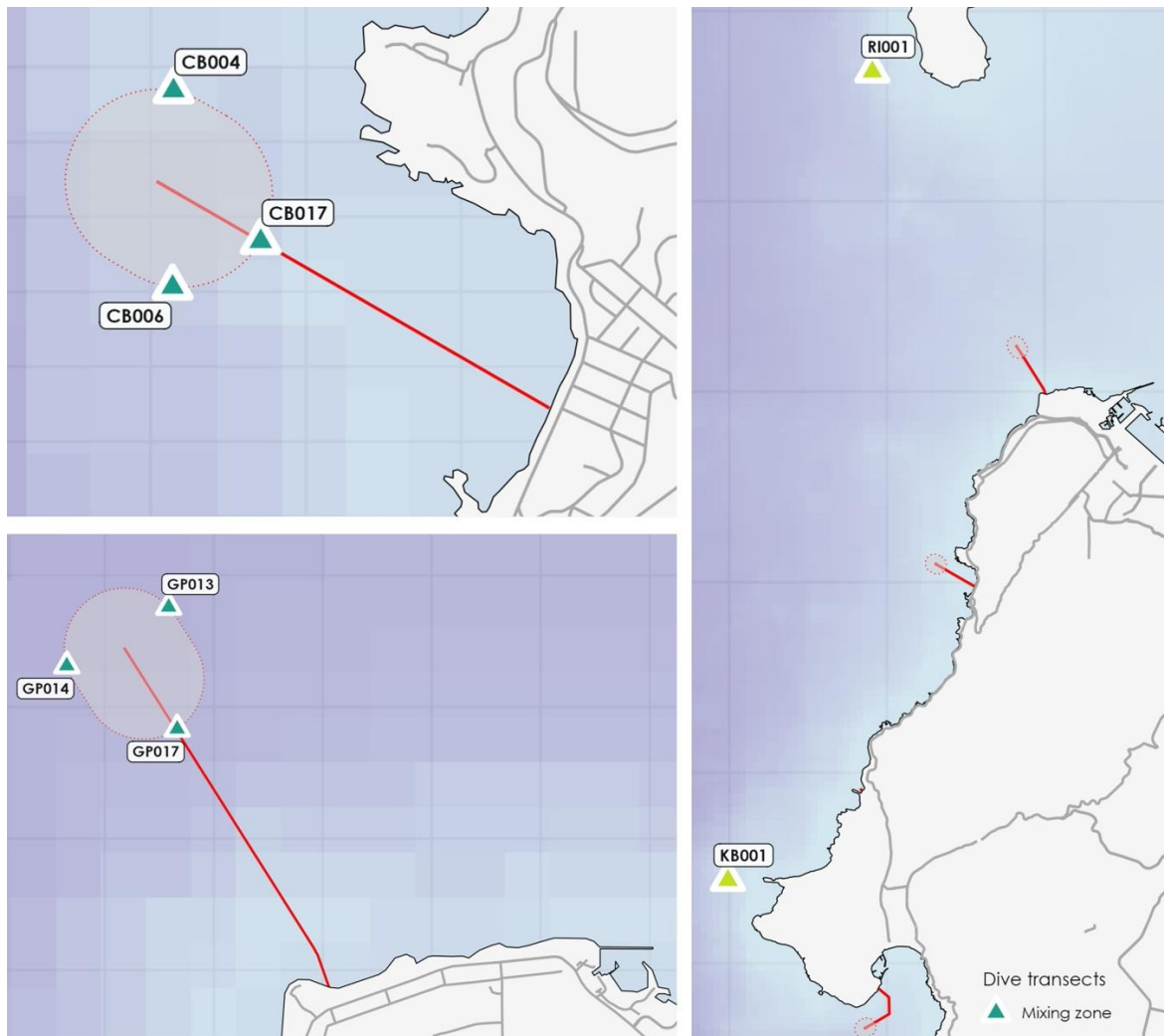


Figure 5-30. Epifaunal dive survey sites for ecological effects monitoring.

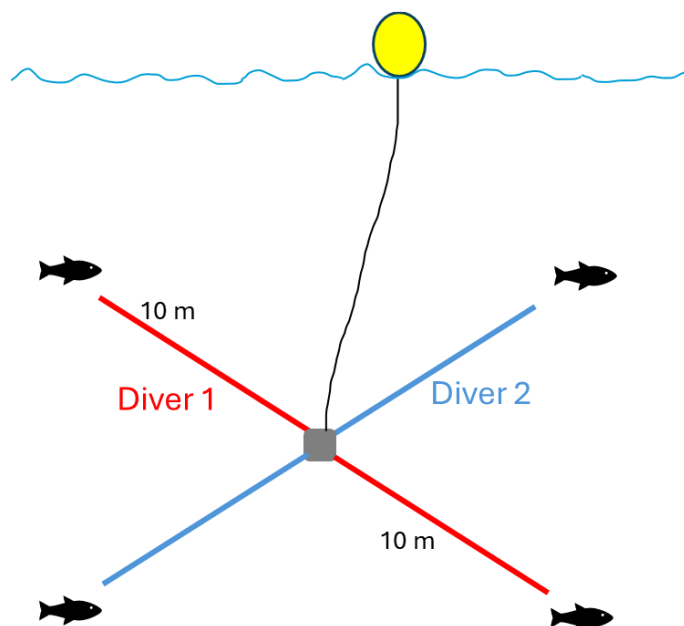


Figure 5-31. Underwater visual census survey procedure for each diving pair at site. Yellow balloon is representative of the surface marker buoy.

Table 5-4. The categorical scoring system used in the SCUBA surveys to represent the estimated number of urchins and kelp fronds found within a 1 m² area.

Score	Number of individuals	
	Urchins (m ⁻²)	Kelp (m ⁻²)
0	0	0
1	1–9	1–2
2	10–50	3–5
3	> 50	> 5

5.5.2.2 Statistical analysis

Due to the limited dataset obtained from the transect surveys, analyses were restricted to descriptive statistics. Total counts of observed species were aggregated for each site to assess broad trends in species distribution. Additionally, species abundance was evaluated in relation to categorical kelp and urchin density scores (Table 5-4) to identify potential ecological associations.

Mean species densities (per 10 m²) were calculated and compared across sites (grouped by region). Bar graphs were used to visualise these mean densities relative to region with error bars indicating $\pm$ standard error (SE). A ranked Kruskal-Wallis (non-parametric) test was performed to determine any significant differences within regions.

No multivariate or parametric statistical tests (e.g., regression, ANOVA) were applied, as sample sizes were too small for hypothesis testing. Findings are, therefore, interpreted descriptively, focusing on observable spatial and density-dependent patterns in species abundance.

5.5.3 Results and Discussion

A total of 40 transects (covering 400 m² of reef habitat) were surveyed across the Camps Bay and Green Point outfall regions in February 2025.

5.5.3.1 Reef epifauna observations

5.5.3.1.1 Rock lobster

A total of 109 rock lobsters were recorded across all transects, while no abalone (*Haliotis midae*) or alikreukel (*Turbo sarmaticus*) were observed. The absence of these species is likely attributable to their cryptic behaviour, patchy distribution and preference for shallower intertidal habitats beyond the surveyed depth range (20–30 m) (Branch et al., 2017). Abundance of rock lobster was notably higher at Camps Bay (n = 93) compared to Green Point (n = 16), accounting for 85% of total observations (Table 5-5).

Table 5-5. Summary of total observations of rock lobster, abalone and alikreukel from Camps Bay and Green Point dive survey data collected in February 2025.

Region/Status	Rock Lobster	Abalone	Alikreukel
Camps Bay	93	0	0
AMZ	51	0	0
Reference	42	0	0

Region/Status	Rock Lobster	Abalone	Alikreukel
Green Point	16	0	0
AMZ	14	0	0
Reference	2	0	0
Grand Total	109	0	0

At both regions, rock lobster counts were marginally higher at the AMZ sites compared to reference sites; however, these differences are not statistically significantly different ($H_{10} = 13.07$, $p = 0.22$) (Figure 5-32 and Table 5-5). The highest abundance recorded at Camps Bay was AMZ site CB004 and at Green Point site GP014 (Figure 5-32). Green Point sites generally exhibited lower or negligible abundances (Figure 5-32 and Table 5-5). Due to the small sample sizes and descriptive analyses, these patterns should be interpreted with caution.

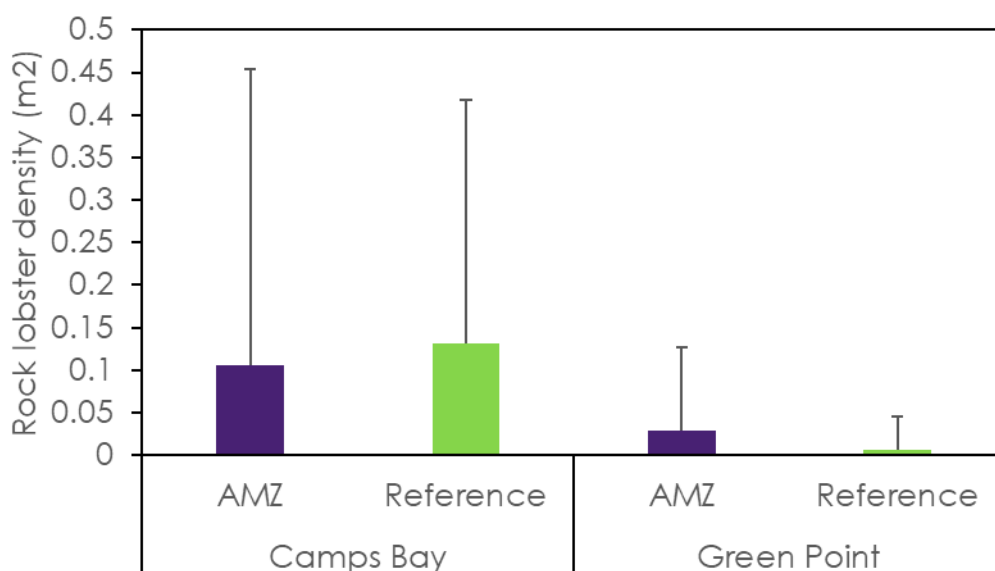


Figure 5-32. Rock lobster density per m² (+SE) on the seafloor for the Allowed Mixing Zone (AMZ) and Reference sites off Camps Bay and Green Point.

The observed disparity in rock lobster populations between Camps Bay and Green Point may be strongly linked to differences in reef habitat (Figure 5-33). Camps Bay outfall sites are characterised by complex, heterogenous reef formations with many crevices, overhangs and shelters which are preferred habitats of rock lobster (Figure 5-33). Contrastingly, reef structures at Green Point are dominated by low relief ridges with minimal available shelter, offering little to no suitable conditions for lobster occupancy (Figure 5-33). This pattern is consistent with the established knowledge that rock lobster exhibits strong habitat specificity, preferring structurally complex reef environments that provide refuge from predation and facilitates their life history behaviours such as moulting and brooding (Cockcroft et al., 2000; Hutchings et al., 2024; Mayfield & Branch, 2000).

The low overall rock lobster densities recorded during the survey align with national assessments indicating that these populations remain in a collapsed state, with biomass levels estimated at less than 5% of pristine historical levels (Figure 5-32 and Figure 5-34). These findings are representative of the region and further emphasise the heavily depleted status of these species (Figure 5-34) (DFFE, 2023; Hutchings et al., 2024). Management measures including restricted commercial rights, quotas, and Marine Protected Areas (MPAs and no take zones) are in place. However, the persistence of

illegal harvesting continues to compromise population recovery (Brill & Raemaekers, 2013; DFFE, 2020; Hutchings et al., 2024; Okes et al., 2018). In these results, it is important to consider the clear influence of habitat complexity in interpreting the distribution patterns of the observed rock lobster communities.

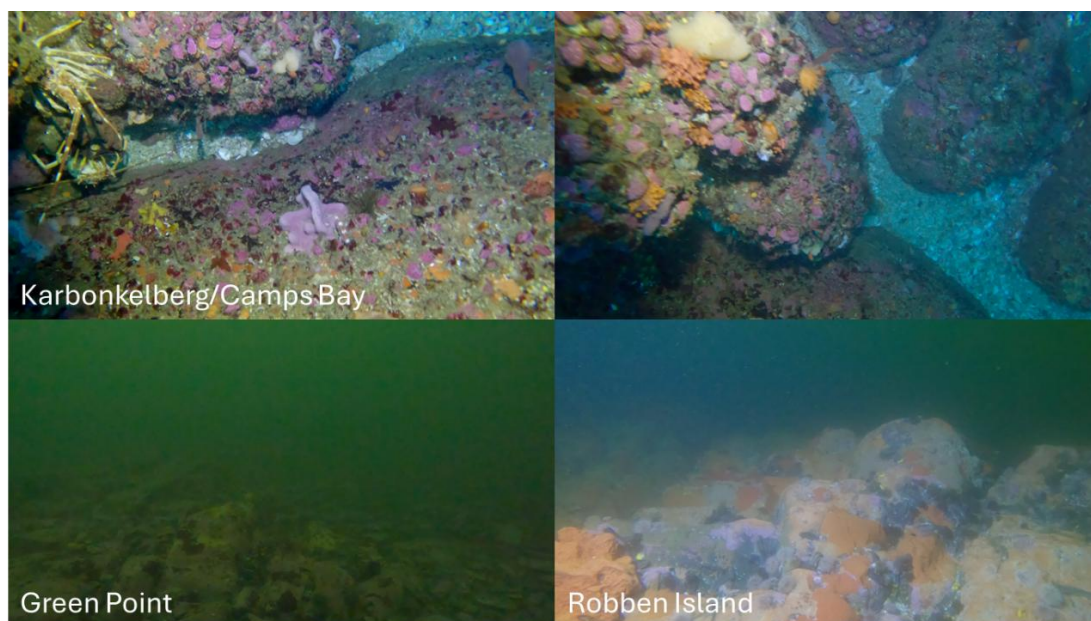


Figure 5-33. Reef profiles from Camps Bay and Green Point sampling sites displaying the high ridge presence versus low profile reef habitats.

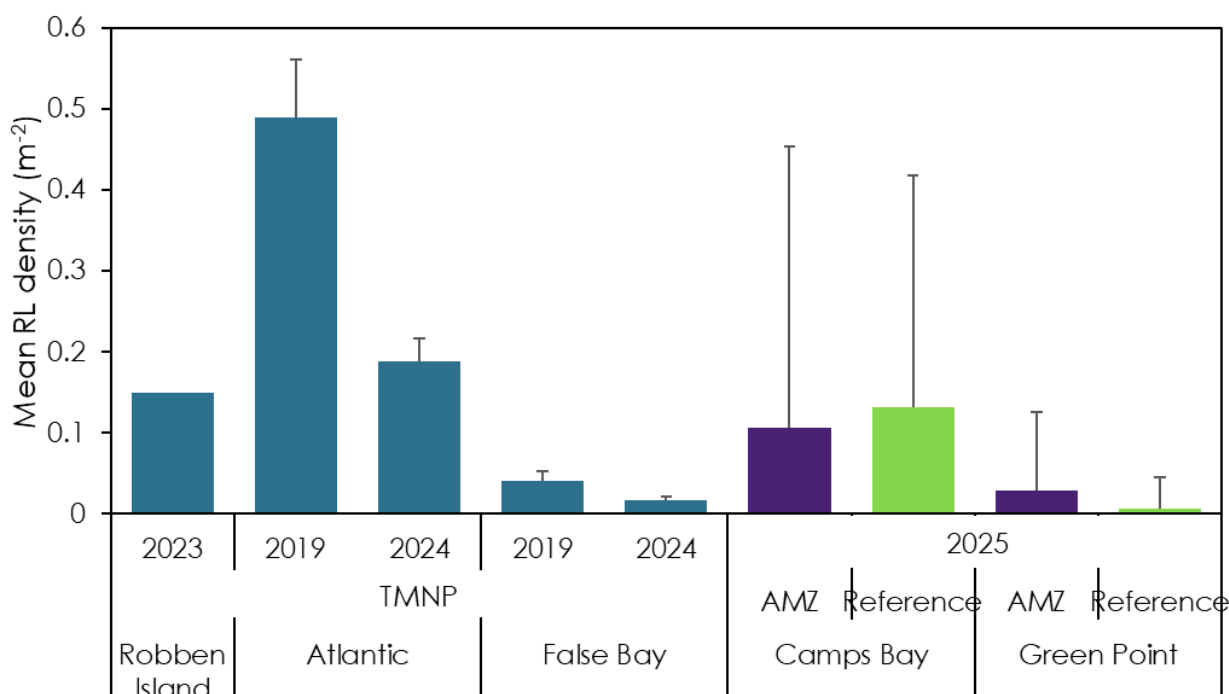


Figure 5-34. Mean rock lobster (RL) density per m² (± SE) on the seafloor from surveys conducted for Table Mountain National Park (TMNP) marine invertebrate surveys displayed in dark blue (Hutchings et al., 2024) with the mean densities per m² collected in this epifauna reef survey for regional context. Mean rock lobster (RL) density per m² (± SE) on the seafloor from surveys conducted for Table Mountain National Park (TMNP) marine invertebrate surveys displayed in dark blue (Hutchings et al., 2024) with the mean densities per m² collected in this epifauna reef survey for regional context.

5.5.4 Fish assemblages

Visual assessments of reef-associated fish communities were conducted during the February 2025 reef dive surveys to complement concurrent epifaunal observations. Reef fish are considered valuable ecological indicators due to their trophic diversity, mobility, and responsiveness to environmental change. Variations in species composition, abundance, and size-class distribution can reveal habitat degradation or broader ecosystem shifts, particularly in areas subject to anthropogenic pressures such as wastewater outfalls.

A total of 171 Cape seabream (also known as hottentot seabream, *Pachymetopon blochii*) and two klipfish (Clinidae spp.) were recorded across the 400 m² of reef habitat surveyed (40 transects spanning 10 m of the seafloor). Observed fish were categorised into size classes to provide insights into population structure and potential habitat use (Table 5-6). Cape seabream emerged as the dominant species of these subtidal reef communities, while other species, such as klipfish (Clinidae spp.), typically associated with intertidal or shallow subtidal habitats, and are therefore, less frequently observed on deeper subtidal reefs hence the very low numbers.

The distribution of seabream showed regional and zonal differences where most individuals in Camps Bay were observed at the reference sites (n = 140 of 144 Camps Bay observations), while all individuals were observed at the AMZ sites in Green Point (n = 27 of 27 Green Point observations) (Table 5-6). The largest size class (21–30 cm) was rarely encountered. The scarcity of these large individuals may be attributed to fisheries-related pressures as fish within this size class approach and/or exceed the minimum legal-size limit permitted for retention under South Africa's fishing regulations as outlined by DFFE (DFFE, 2020; Attwood & Farquhar, 1999). As larger individuals are likely targeted and removed by fishers, their limited presence in the survey area suggests a potential cumulative fishing impact over time (Attwood & Farquhar, 1999). Therefore, the abundance of smaller individuals (<20 cm) implies that Camps Bay's reference site (Karbonkelberg) may serve as important nursery or juvenile recruitment habitat for Cape seabream.

Table 5-6. Summary of Cape seabream (*Pachymetopon blochii*) and Klipfish (Clinidae spp.) observations from Camps Bay and Green Point dive survey data (February 2025). Size classes for each fish species are included.

Region/ Status	Cape seabream <i>Pachymetopon blochii</i>			Klipfish Clinidae spp.		
	0–10 cm	11–20 cm	21–30 cm	0–10 cm	11–20 cm	21–30 cm
Camps Bay	80	60	4	0	0	0
AMZ	2	2	0	0	0	0
Reference	78	58	4	0	0	0
Green Point	20	7	0	0	0	0
AMZ	20	7	0	0	0	0
Reference	0	0	0	2	0	0
Grand Total	100	67	4	2	0	0

The Atlantic seaboard of the Cape Peninsula supports a distinct, temperate reef fish assemblage, shaped by the influence of the cold Benguela Current and associated upwelling systems (Turpie et al., 2000). Water temperatures in this region typically range between 11–16°C, with seasonal

fluctuations strongly influencing these communities. Only 27 Cape seabream were observed at Green Point, cold water conditions ($<12^{\circ}\text{C}$) likely influenced the species spatial distributions (Kock, 2024). Scientific divers recorded water temperatures as low as 10°C during the survey period, which may have led to avoidance behaviour among thermally sensitive species, such as Cape seabream. Previous studies have noted that the diversity and abundance of reef-associated fish tend to decline under such cold-water conditions, favouring a narrower assemblage of cold-tolerant species (Attwood & Farquhar, 1999; Hutchings et al., 2024; Kock, 2024; Turpie et al., 2000).

Spatial variability in epifaunal and fish communities was observed between Camps Bay and Green Point, with higher fish and epifaunal abundances recorded at Camps Bay. However, no immediate or ecological impacts associated with wastewater discharge were detected. It is important to note that the limited sample size, unbalanced representation of AMZ and reference sites, and inherent habitat variability constrain the capacity to identify statistically robust patterns or discernible differences between outfall sites. Consequently, while some differences in assemblage composition were observed, the similarities between AMZ and reference sites within each region suggest there is no evidence that wastewater discharges are having an adverse ecological impact on reef fish communities.

5.6 Conclusions and Recommendations

5.6.1 Benthic infauna

The first annual survey of benthic infauna in the vicinity of the Green Point, Camps Bay, and Hout Bay outfalls under the approved 2024 Receiving Environment Monitoring Programme provides some insights into the potential biological impacts of the outfalls on the benthic infaunal communities.

Soft bottom benthic infauna communities were sampled using a Van Veen grab at 29 sites in total, which were separated into the following categories: AMZ, Proximal Zone or Table Bay, Reference Zone, with three replicates for each reference site, and in Hout Bay only, end of Pipe samples. Due to the presence of a rocky reef habitat at the Green Point outfall's AMZ and proximal sites, benthic infaunal sampling was not possible and epifaunal reef communities were surveyed instead to assess potential outfall impacts on local biota instead.

A total of 70 benthic macrofauna taxa, were identified from 10 samples collected at the Camps Bay survey sites, 103 benthic macrofauna taxa, were identified from 13 samples collected at Hout Bay sites, and 54 benthic macrofauna taxa were identified from six samples collected at the Green Point reference sites and sites in Table Bay to the east of the outfall.

Univariate community indices such as number of taxa, abundance, biomass and Shannon diversity did not reveal any strong patterns at either Hout Bay or the Green Point outfalls. While, in Camps Bay, although diversity was on average lower at the AMZ than at the proximal or reference sites, high variability among samples resulted in few statistically significant differences. Multivariate data also showed no significant differences in community structure for Hout Bay, Green Point, or Camps Bay.

Abundance Biomass (ABC) curves used as indicators of the level of disturbance experienced by a community suggest that the Hout Bay outfall has no detectable effects on the ecological health of benthic infaunal communities surrounding the outfall. Robben Island reference sites may be considered slightly disturbed, while the Table Bay sites exhibit a more marked, and yet still slightly disturbed community, the latter is likely due to the proximity of these sites to the Black and Diep rivers and the Port of Cape Town rather than due to their proximity to the Green Point outfall.

By contrast, in Camps Bay the ABC curves suggest that while the Karbonkelberg sites exhibit no signs of disturbance, proximal sites are moderately disturbed and sites from the AMZ consistently have the

biomass curve below the abundance curve across its entire length, which along with a negative *W*-statistic indicated a heavily disturbed community. However, this disturbance likely reflects the naturally high-energy environment influenced by wave action and sediment abrasion, rather than effects from the outfall itself, as supported by the lack of organic enrichment (TOC) and coarse particle size.

While species accumulation curves for Camps Bay and Hout Bay do show an increase in taxa with each additional sample, none reached a clear plateau, suggesting that the sampling effort may be insufficient to reliably represent benthic macrofaunal diversity across all zones at these outfalls and increased sampling effort is recommended to adequately capture local biodiversity and improve confidence in the findings of the infaunal monitoring surveys.

5.6.2 Benthic epifauna: Drop Camera surveys

Drop camera surveys were used to assess epifaunal reef community structure at sites where benthic infaunal sampling was not possible due to the presence of rocky reef in these areas. A total of 56 taxa, from 9 phyla, were identified from 11 sites at Green Point and a total of 50 taxa, from 10 phyla, were identified from 8 sites sampled at Camps Bay. At both Green Point and Camps Bay, the average number of taxa, abundance, evenness, and Shannon diversity of reef epifauna were similar across all three zones.

Green Point sites were dominated by algae and echinoderms, with consistent appearances from sponges, Bryozoa and cold water corals. Examples of higher average cover seen at one Proximal and one Reference site was due to the drop camera landing on a bed of South African ribbed mussel, *Aulacomya atra*, where faunal cover is higher on average due to the clustered nature of the organisms. Epifaunal communities at Camps Bay were dominated by molluscs and algae and high variability in cover within the Proximal zone, was driven by the presence of mussel beds at two sites.

Neither univariate nor multivariate tests found any significant differences between treatments/zones suggesting that the outfalls have a negligible impact on rocky reef epifauna.

5.6.3 Reef epifauna survey

The epifaunal and fish surveys in February 2025 at the Camps Bay and Green Point marine outfall sites provide a snapshot of reef community structure at the boundary of and outside the AMZs. Rock lobster densities were generally low, consistent with larger regional stock assessments, but were higher at Camps Bay, owing to higher structural complexity at this site. No abalone or alikreukel were observed, likely reflecting habitat preferences below the surveyed depth range. Fish assemblages were dominated by juvenile Cape seabream, with few individuals approaching the minimum legal size. Findings were consistent with work done by CLS previously (CLS, 2022a, 2022b). While no clear evidence of effluent-related ecological deterioration was detected, the low representation of mature individuals and limited species richness highlight the vulnerability of these reef systems and the need for continued, long-term monitoring to detect potential cumulative impacts.

6 BIOACCUMULATION

6.1 Background

The contamination of water or sediment (assessed in chapters 2 and 4 of this report) is of concern primarily if the contaminants adversely affect ecosystems and organisms, or if they pose a risk to human health. A challenge with measuring contaminant levels in water or sediment is that we rarely know what fraction of a given contaminant is in a bioavailable form – that is, able to cross cell membranes and interact with biological systems. The measurement of pollutant concentrations directly in the tissues of indicator organisms allows for an absolute measurement of bioavailability which cannot be obtained by measuring chemical concentrations in water or sediment. This technique also provides a measure of potential human health risks related to the consumption of marine species by people.

Contaminants derived from wastewater and other anthropogenic sources, once in the marine environment, disperse in the water column and sediment and may be taken up by organisms through respiration or feeding (Borgå, 2013). After being taken up by an organism, contaminants can accumulate to concentrations higher than in the surrounding environment, through a process known as bioaccumulation. This occurs when an organism accumulates contaminants more quickly than it eliminates or depurates them (Borgå, 2013; Wang, 2016), and is therefore the sum of contaminant uptake (indirectly through respiration and directly through feeding) and losses (through metabolism, egestion, passive diffusion, growth, and transfer to offspring) in an organism (Borgå, 2013).

Besides acute and chronic toxicity to organisms themselves, an implication of bioaccumulation is biomagnification, which occurs when there is an increase in the internal concentration of a contaminant in organisms at a higher trophic level through feeding (Gray, 2002). The amount of bioaccumulation of metals in tissue depends on a multitude of factors including ambient environmental conditions such as pH, temperature and salinity; the duration of exposure; the metal concentration in the environment; the organism's feeding ecology and habitat; and the physiology and life history of the organism itself (Borgå, 2013; Zeitoun & Mehana, 2014), but is often many hundreds or thousands of times higher than that seen in the environment. The amount of bioaccumulation of metals in tissue depends on a multitude of factors including ambient environmental conditions such as pH, temperature and salinity; the duration of exposure; the metal concentration in the environment; the organism's feeding ecology and habitat; and the physiology and life history of the organism itself.

Species previously utilised as biomonitoring sentinel species for assessing impacts of wastewater discharge at the Green Point, Camps Bay and Hout Bay outfalls (CSIR, 2017a) were Mediterranean mussels (*Mytilus galloprovincialis*) and west coast rock lobsters (*Jasus lalandii*). Both species, with the addition of the resident reef fish Cape seabream (*Pachymetopon blochii*), form part of the bioaccumulation monitoring programme for the Cape Town marine outfalls. Contaminant concentrations in mussels near contaminant sources, such as urban and industrial areas, are often higher and decrease with distance from the sources (Phillips & Rainbow, 1993). Mediterranean mussels have a high environmental tolerance and readily bioaccumulate a wide range of contaminants including metals. They are also abundant along rocky shores as well as being an invasive species, and are sessile, all of which makes them valuable indicators of spatial trends in contaminant distributions. Mussels in the family Mytilidae are commonly used bioindicator species globally, and have historically formed part of pollution monitoring programmes in South Africa, including the DFFE Mussel Watch programme (Sparks et al., 2014) and various targeted assessments including of the CCT marine outfalls (CLS, 2022b; e.g., CSIR, 2017a). Mussels are regularly consumed by humans and can therefore be used to indicate human health risks associated with contaminant

uptake. Both species, with the addition of the resident reef fish Cape seabream (*Pachymetopon blochii*), form part of the bioaccumulation monitoring programme. Mediterranean mussels have a high environmental tolerance and readily bioaccumulate a wide range of contaminants including metals. They are also abundant along rocky shores as well as being an invasive species, and are sessile, all of which makes them valuable indicators of spatial trends in contaminant distributions.

West Coast Rock Lobster (*Jasus lalandii*) is a spiny lobster species that inhabits rocky reefs between Namibia and East London (Barkai & Davis, 1996). *J. lalandii* prey on fish and invertebrates, and although not sedentary, tend to remain within a fairly restricted home range as adults. The CSIR (2017a) measured trace metal, polycyclic aromatic hydrocarbon, polychlorinated biphenyl, and pharmaceutical compound concentrations in West Coast Rock Lobster sampled along the Atlantic Seaboard in Cape Town, finding metals in tissue from lobster at all sites. This species is also harvested commercially and by subsistence and recreational fishers, and its propensity to accumulate contaminants is relevant to human health hazard and risk assessments.

Cape seabream (*Pachymetopon blochii*) is an omnivorous endemic, and highly resident fish species that inhabits rocky reefs and kelp forests near the coast (Branch, 1994). It is targeted by recreational and small scale commercial line fisheries and the population is able to sustain harvesting for research purposes, as well as allowing for assessment of potential hazards to the health of humans consuming this species. *Pachymetopon blochii* are considered a reef associate fish species which are known for their small home range sizes and site fidelity, meaning they could be exposed to contamination over a long period in a relatively localised area during their ~20 year lifespan.

The two key objectives of this component of the monitoring programme were (1) to assess whether metal concentrations in organisms close to any of the marine outfalls are elevated relative to reference stations distant from the outfalls, and (2) whether such elevation poses any risk to the health of people who may be consuming these organisms.

This chapter presents the annual environmental bioaccumulation data from sampling conducted in February 2025. The annual environmental bioaccumulation monitoring consists of sampling resident seabream (*Pachymetopon blochii*), rock lobsters (*Jasus lalandii*), and Mediterranean mussels (*Mytilus galloprovincialis*) from sites close to and distant from (reference sites) each outfall to detect any trace metal bioaccumulation, and associated risks to human health (as consumers). The rationale behind the bioaccumulation monitoring plan design is set out in the 2024 Receiving Environment Monitoring Programme (Clark et al., 2024), and is based on previous environmental monitoring programmes (e.g., CSIR, 2017a), as well as guidelines published by the USEPA (USEPA, 2000b, 2000c).

The monitoring of metal bioaccumulation in mussels, lobster and fish (reported on here) is the only component of the bioaccumulation monitoring plan which fell within the 2024/2025 period. This survey takes place annually. Deployment of mussels in bags around the marine outfalls to further investigate any relationships between proximity to the outfalls and bioaccumulation rates is scheduled for 2025/2026, and sampling for pharmaceuticals and other non-metal contaminants in tissue is scheduled for 2026/2027.

Note: The assessment of human health hazards and risks presented in this chapter reflects only the metals analysed and detected, and only for the three target species (West Coast rock lobster, Cape seabream, and Mediterranean mussels). It is not intended to provide a comprehensive assessment of hazards and risks associated with consuming seafood, as this would require the analysis of a much more comprehensive suite of chemical analytes and a range of other seafoods commonly consumed by humans.

6.2 Methods

6.2.1 Fieldwork and laboratory analyses

6.2.1.1 Sample collection and handling

Tissue samples were collected over a three-week period during February 2025. Tissue samples were collected using free diving techniques, with fish being captured using a speargun, rock lobster caught by hand and mussels collected by scraping/breaking them off the rock at shoreline or nearshore outcrops. The only lobster samples collected near the Hout Bay diffuser were collected using SCUBA, from the Aster shipwreck. Sample sites are shown in Figure 6-1, Figure 6-2, and Figure 6-3. Sampling was conducted under a permit from SANParks dated 26 June 2024 for 'Cape Town outfalls marine discharge monitoring', and a permit from DFFE with reference number RES2025/37.

The aim was to collect a minimum of three individuals for each replicate station, so that samples were a composite of tissue from more than one individual. While this was possible for mussel tissue, which usually included ~10 individuals, it was not always possible in the case of fish and crayfish samples. Numerous fish samples included tissue from between one and three individuals, however, crayfish proved very difficult to find and, in most cases, only a single individual was used for each sample. In the field, specimens were stored in separate, site labelled Ziploc bags, and kept on ice in a cooler box before being taken to the Anchor laboratory, to be frozen.

Processing of these samples was done using nitrile gloves and a ceramic knife to avoid any contamination of tissues. In fish, muscle tissue from the fillet just below the dorsal fin was extracted and stored in a 30 ml sample vial. Similarly, for crayfish muscle tissue from the tail was extracted for analysis. The tissue of entire mussel individuals was extracted from the shells. In each case, where multiple replicates were available, the tissue was combined within the sample vial to be homogenised at the testing laboratory.

6.2.1.2 Metal analysis

Metal concentrations in composite tissue samples were analysed using ICP-OES by the CSIR's laboratory in Stellenbosch. Mercury was quantified using Direct Mercury Analysis. Nine metals were chosen for this study: aluminium, arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.

6.2.1.3 Statistical analyses

6.2.1.3.1 Local spatial trends

The potential accumulation of metals in the tissue of rock lobsters, mussels, and seabream was quantified by comparing metal concentrations in tissue samples collected from each area to metal concentrations in tissue samples collected from four reference sites (Figure 6-1, Figure 6-3). The four reference sites (Figure 6-1) were as close to those used for sediment and water quality as possible.

Because replicate samples were collected only at reference sites, all samples from each area of interest (Green Point, Camps Bay, Hout Bay) were aggregated (on a per species basis) to form replicates reasonably representative of each overall area. Comparisons of each species in each area to the reference samples were made using permutation tests with 20 000 resamples. This test evaluated the null hypothesis that the mean metal concentration in a given tissue type in a given impact area did not differ significantly from the mean concentration at the reference sites. A permutation test was necessary due to the small sample size of each tissue type at each area (generally 3 to 5 samples for each species per impact area). This allowed for a robust assessment of statistical significance, despite the fact the data were not normally distributed and did not display equal variances.

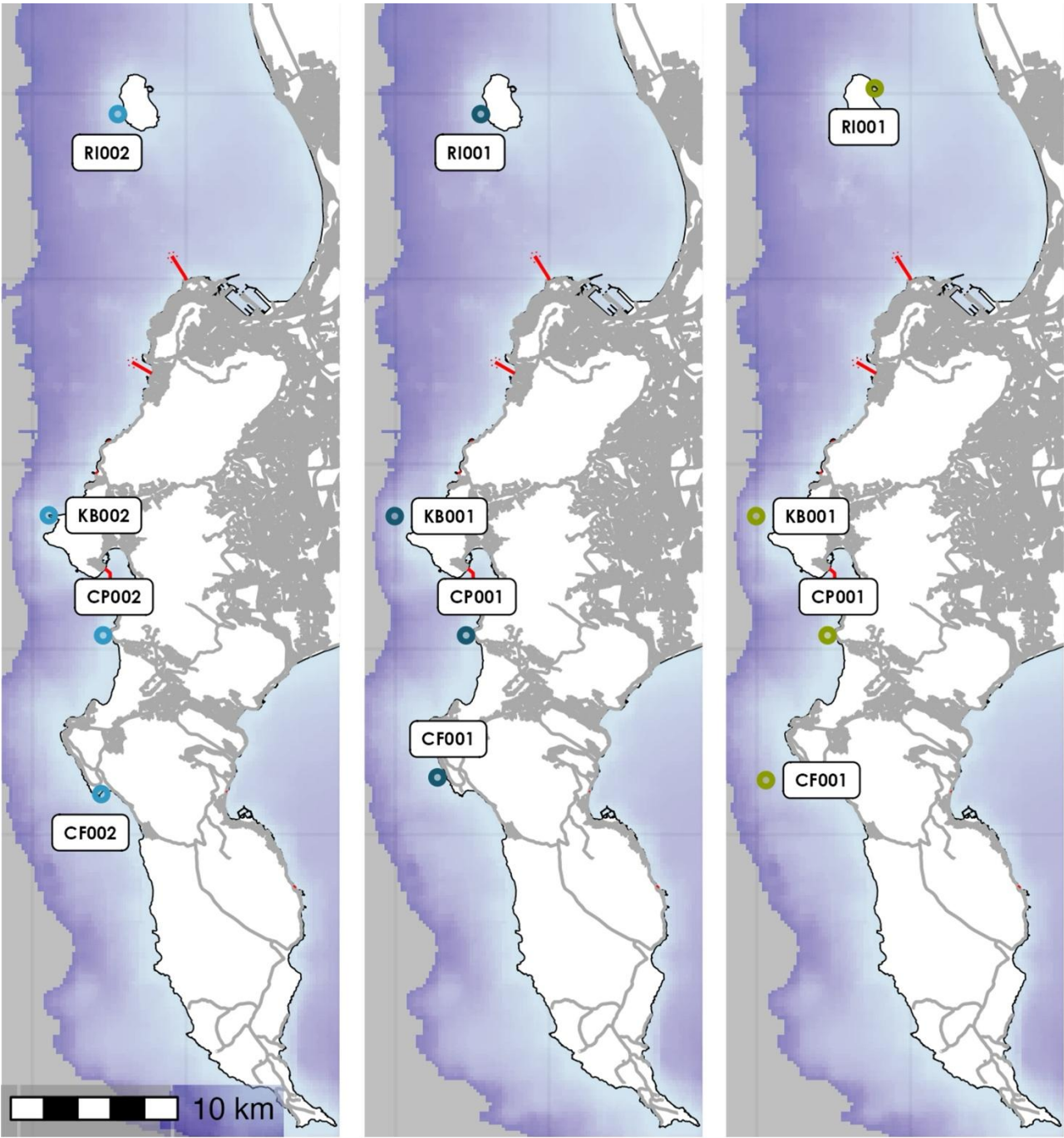


Figure 6-1. Reference site sample locations for rock lobster (green), mussels (light blue), and seabream (dark blue) collected during February 2025.

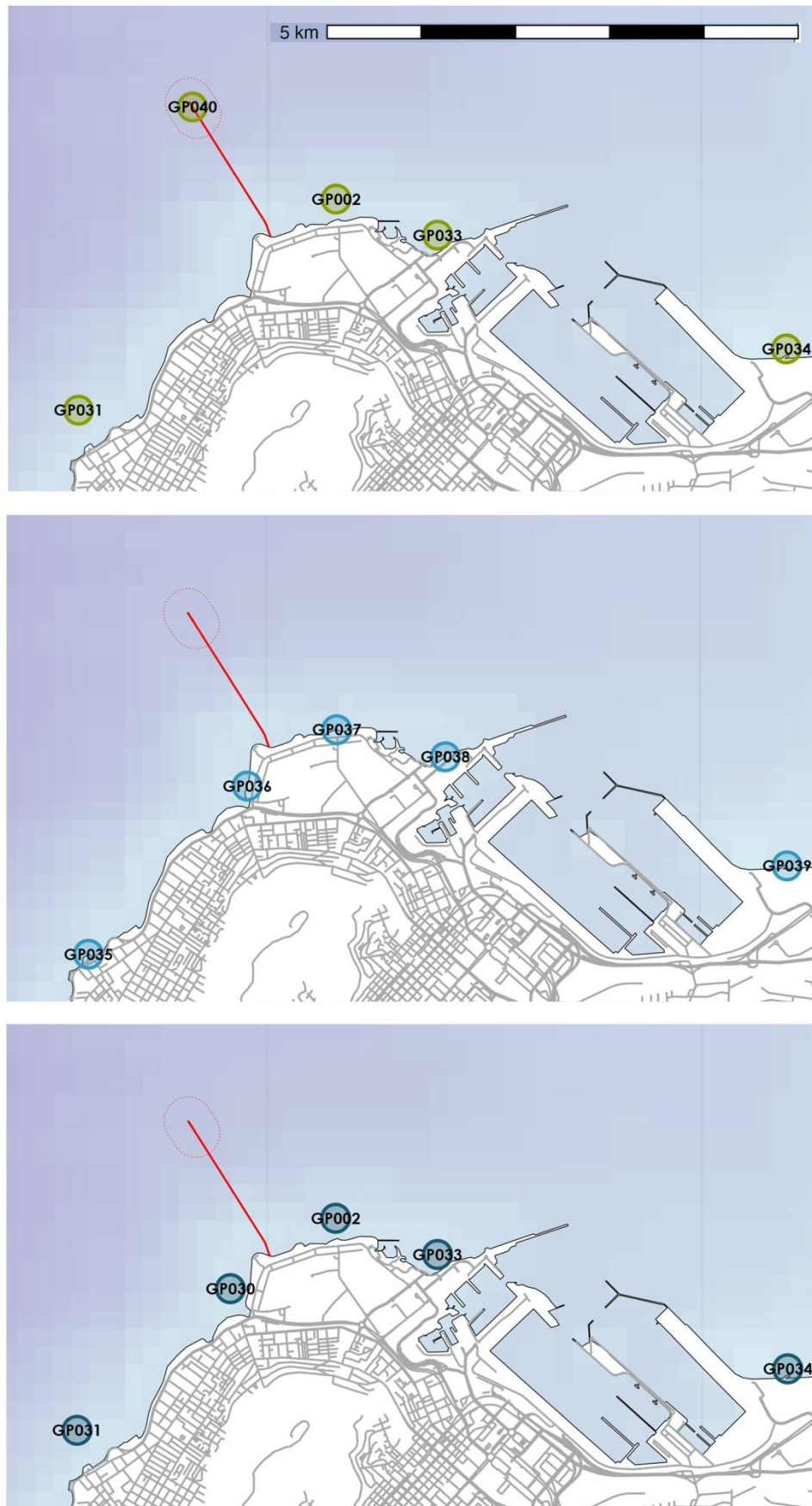


Figure 6-2. Sample locations for rock lobster (green), mussels (light blue), and seabream (dark blue) collected from Green Point area in February 2025.

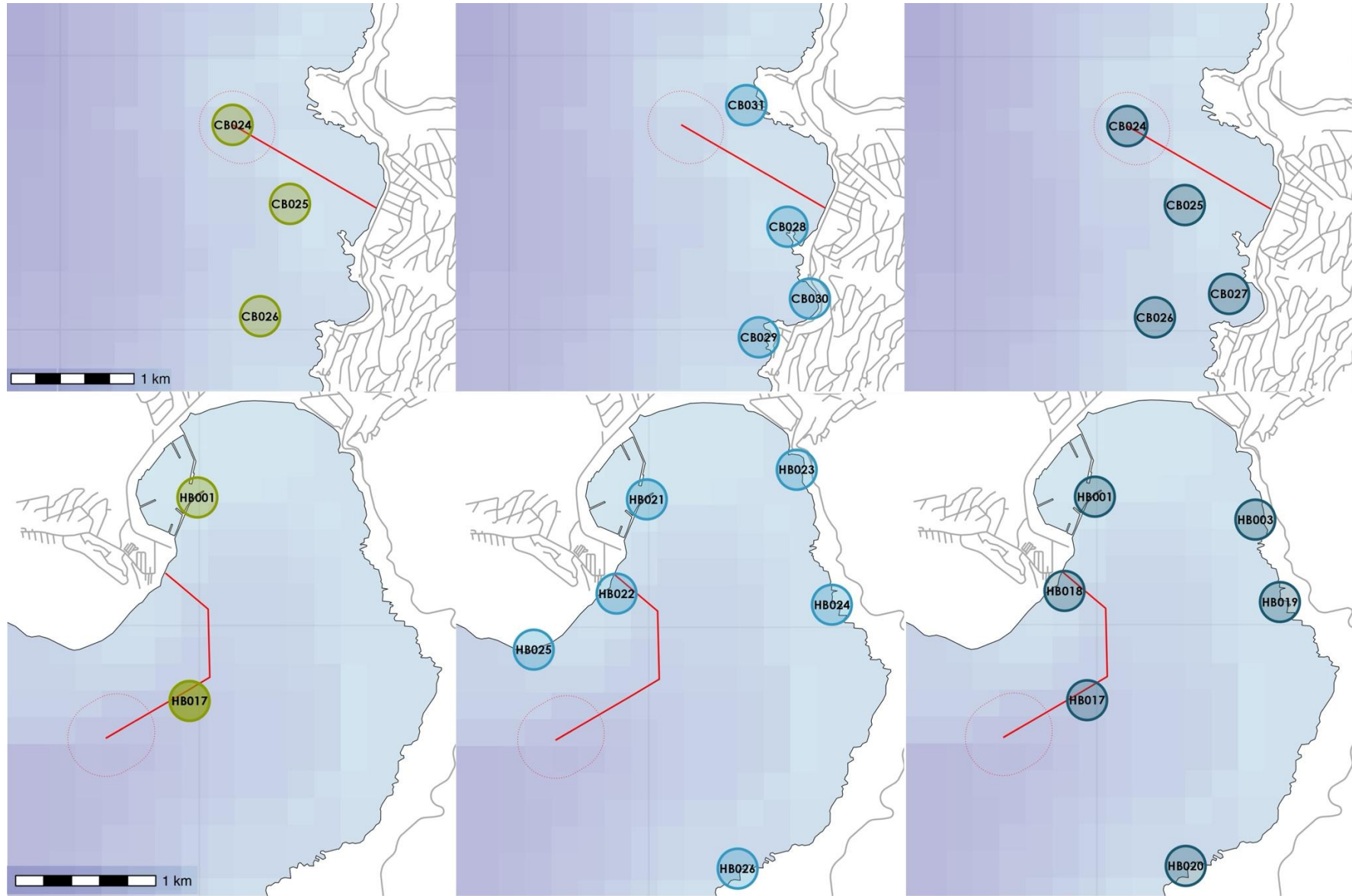


Figure 6-3. Sample locations for rock lobster (green), mussels (light blue), and seabream (dark blue) collected from Camps Bay and Hout Bay in February 2025.

6.2.1.3.2 Influence of proximity to outfall

In order to investigate a possible link between each outfall and bioaccumulation in tissue, Spearman's rank correlation was used to explore the association between proximity to outfall and metal concentration. Distances from each impact site to their respective outfall (middle of diffuser section) were calculated and assigned to each sample. Sites GP034 and GP039, located just east of the Port of Cape Town, were removed prior to analysis as they were selected to assess the impact of other known point sources of contamination, including the Diep and Salt Rivers and the Port of Cape Town.

Due to concerns over small sample size, data from all three areas were combined into one dataset with metal concentration and distance from nearest outfall (reference sites excluded), and re-evaluated. Spearman's rank correlation was used as it does not assume a linear relationship between the data, and does not assume normally distributed data, thus making it appropriate for assessing the monotonic relationship between distance from outfall and tissue metal content. Given the small sample sizes, permutation (20 000 resamples) was used to evaluate significance of the results.

Permutation was necessary to limit the risk of Type I errors (false positive) due to small sample size, however it also increases the likelihood of Type II error (false negative). With just one year of data, further analyses are not possible at this time. That being said, were there to be a clear link between outfall proximity and the concentration of a given metal, this test would most likely detect it. Additionally, metal concentration was plotted against distance from outfall, and a simple linear model was fitted to each plot in order to highlight general trends.

Analyses were also conducted on data from each outfall area individually in order to investigate localised effects, however it was not included in the results due to concerns over reliability as a result of small sample size. No statistically significant relationships were found.

6.2.2 Risk Assessment

The assessment of risk is based on the determination of the hazard posed by a specific chemical, combined with a determination of the level of exposure of ecosystems and humans to this hazard.

The outcome of this assessment may help determine whether there is a need for risk management, that is, prevention or control measures to reduce the risk. In the context of seafood this could include an advisory on the consumption of fish or shellfish caught or collected in a particular area due to high contaminant concentrations in their tissue, in addition to measures for the identification, control and reduction of contaminants at their source. Risk assessments repeated over time can be a valuable tool to comprehend the long-term environmental impact of pollution.

The approach described below follows the United States Environmental Protection Agency's (US EPA) recommended approach for evaluating risks to human health from exposure to chemicals in fish and shellfish (USEPA, 2000a, 2014a, 2014b). This study also draws on the methods of the most recent Cape Town Outfalls Monitoring Report that investigated environmental bioaccumulation (CSIR, 2017a) to allow direct comparison with previous data.

Note that although conducted as part of the marine outfalls receiving environment monitoring effort, the risk assessment reported here does not incorporate any differentiation between the many sources of metal contamination in the nearshore and coastal environment and is not intended as a measure of the effects of the discharge of wastewater through the marine outfalls.

A risk assessment is made up of four stages, namely Hazard Identification, Dose-Response Assessment, Exposure Assessment, and Risk Characterisation (USEPA, 2000a, 2014b, 2014a).

6.2.2.1 Hazard Identification and exposure assessment

Hazard identification seeks to identify contaminants in a given medium that have the potential to increase the risk of negative health effects in humans, and to determine the likelihood of these negative health outcomes (USEPA, 2000a, 2014b, 2014a).

Screening values were calculated for two sections of the South African population, high- and low-end consumers. High and low-end consumer scenarios are included to account for the variable seafood intake by individuals across the population. In other words, a high-end consumer was included as a “worst-case” scenario, to determine risk level posed to the individuals in the population who consume a much greater amount of seafood on a daily basis than the average South African. As the high-end consumer scenario is still a generalisation, and based on population wide trends, caution must be exercised when interpreting the results of this risk assessment. The low-end consumer can be taken as a more representative scenario for the average person.

Assumptions on the amount of seafood consumed by a high- and low-end consumer were based on the figures used in the 2017 CSIR report to ensure comparability. These were originally derived by (Steyn et al., 2003). A brief search was undertaken to identify updated seafood consumption estimates for South Africa, but none were found.

In terms of exposed populations, the US EPA methods account for both sensitive and non-sensitive segments of the population when deriving relevant chemical specific toxicological constants to be used in risk assessments. Sensitive segments of the population are defined by the US EPA as females of childbearing age, infants, and children (USEPA, 2000b). As this assessment assumed consumption rates to be proportional to body weight, it should account for children and infants reasonably well, in addition to the standard population. As such, sensitive populations were not assessed separately in this risk assessment.

6.2.2.1.1 Dose-response

The relationship between a given chemical dose and resultant risk to humans forms the basis of a risk assessment. Constant values that mathematically link the incidence of both non-carcinogenic and carcinogenic risk to a given chemical concentration were obtained from the United States Environmental Protection Agency (US EPA) Integrated Risk Information System (IRIS).

6.2.2.2 Assumptions for this specific assessment

6.2.2.2.1 Exposure Pathway and Quantification

This risk assessment assumes that the consumption of seafood was the only pathway of exposure to a given metal of interest. This is of course not the case; however, a more detailed assessment is beyond the scope of this study. Other pathways for exposure may include but are not limited to other contaminated food and water sources, air pollution and occupational exposure.

An individual's exposure to a given contaminant via seafood depends on a multitude of factors, including:

- Contaminant concentration in seafood;
- Amount of seafood consumed;
- Frequency of seafood consumption;
- Duration of seafood consumption; and
- Consumer's bodyweight

The contaminant concentration, seafood amount, and frequency of consumption can be multiplied to calculate a total lifetime contaminant exposure level. Dividing this by a unit of time (normally in days), and the consumers body weight, this gives an average exposure rate per day as a function

of body weight (IPSC, 2004; USEPA, 2000a, 2014a). This is referred to as an Average Daily Dose (*ADD*) (Equation 1).

$$\text{Equation 1: } ADD = \frac{C_{\text{medium}} * IngR * EF * ED}{BW * AT}$$

Where:

ADD = Average daily dose (mg/kg-day)

C_{medium} = Concentration of contaminant in medium (mg/kg in this risk assessment)

IngR = Ingestion rate (mg/day in this risk assessment)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

6.2.2.2.2 Consumption Rate and Chemical Absorption

Based on Steyn *et al.* (2003) and CSIR (2017a), a consumption rate of 15.35 g of fish per day was assumed for the low-end consumer scenario. Steyn *et al.* note that only a fraction of the population actually reported consuming fish, meaning the estimate of daily fish intake per capita is too low for those who generally consume fish, and too high for those who do not. A high-end consumer scenario was thus based on the mean daily per capita fish intake of only those South Africans who reported that they eat fish. This resulted in an assumed consumption rate of 125.44 g of fish per day for the high-end consumer scenario.

This risk assessment assumed that the full concentration of metals present in seafood tissue was absorbed by the consumer.

Arsenic and mercury are not necessarily highly toxic to humans in all forms, however their toxic forms – methylmercury and inorganic arsenic – are difficult and costly to quantify. As such, total mercury and arsenic were measured, and then converted to their respective toxic forms for the risk assessment. In line with literature, and the previous risk assessment (CSIR, 2017a; USEPA, 2000a), arsenic was converted to inorganic arsenic using a 2% conversion factor, and all mercury was assumed to be methylmercury.

6.2.2.2.3 Exposure Frequency, Duration and Averaging Time

The exposure frequency for the calculation of chemical-specific average daily dose was set at 365 days per year, following standard practices for human health assessments (USCDC, 2025; USEPA, 2000a, 2014a).

Exposure duration is necessary to inform how long an individual would be exposed to the contaminant of interest in a given risk assessment. In line with the previous study (CSIR 2017) and standard practice for health risk assessments, an exposure duration of 30 years was assumed. This is to say that it was assumed an individual will live in and consume seafood harvested in the same area for 30 years, before likely relocating.

Human exposure to contaminants in seafood generally occurs at low levels over a long period of time. Thus, total exposure can be divided by the time period of interest in days, to determine a mean rate of exposure per day. When divided by body weight, the result is an average daily exposure rate per kilogram of body weight – referred to as the Average Daily Dose (*ADD*), expressed in milligrams of contaminant per kilogram (kg) of bodyweight per day. A life expectancy of 70 years was selected

for this risk assessment, in line with both the CSIR's report (2017a), and the US EPA's assumption of life expectancy for the determination of Cancer Slope Factors. This equates to an averaging time of 25 550 days.

6.2.2.2.4 Human Body Weight

In line with the CSIR's assumption of bodyweight, 70 kg was used to provide a conservative risk estimate. The actual calculated average body weight of South Africans of 15 years of age and older was 68.2 kg, with a mean of 67.3 kg for males and 72.2 kg for females (Shisana et al., 2014 cited in CSIR, 2017a).

6.2.2.2.5 Loss of Contaminants

This assessment assumed that all contaminants detected in the raw samples will be consumed by a human. This was done to be as conservative as possible, as cooking seafood can remove at least a portion of the contaminants present. For metals specifically, their concentrations are often reduced significantly due to loss during the cooking process (Metian et al., 2009). It should be noted that metals may also be concentrated when cooking seafood due to fluid loss, however even if concentrated, the heating process can decrease a metals bioavailability (i.e. it will not be absorbed by the consumer).

6.2.2.3 Non-Carcinogenic

Non-carcinogenic risk was determined based on chemical specific oral reference doses (*RfD*), obtained from the US EPA IRIS database. A chemical specific reference dose is based on the premise that humans consuming a contaminated food, or seafood in this case, are exposed to said contaminant at low concentrations over an extended time period, rather than being exposed to high concentrations on an irregular basis (i.e. acute toxicity). As such, an *RfD* represents the highest chemical specific daily dose considered to pose no increased risk of non-cancer related negative health impacts. A key assumption, and possible limitation, of *RfDs* is that they assume there is a daily consumption limit below which there are likely to be no "discernible risk of deleterious effects to the general population" during a lifetime of exposure (Agency for Toxic Substances and Disease Registry, 2025). As *RfDs* are an estimate, safety factors are included in their determination.

By calculating the chemical specific average daily dose (*ADD*) in each sample (were it to be consumed by a human), one then gets a value which can be directly compared to the specific chemical's *RfD*. The most common method of comparison is the use of a ratio (Equation 2). This gives a unitless value, referred to as the Hazard Quotient (*HQ*). When less than one, the *HQ* indicates minimal risk of non-carcinogenic health impacts, and when greater than one it means humans consuming the given organism may be at risk (as the *ADD* exceeded the *RfD*). The degree of hazard to human health can then be determined based on the magnitude of the *HQ*. Importantly, the hazard does not increase in a linear manner with the *HQ*.

$$\text{Equation 2: } HQ = \frac{ADD}{RfD}$$

Where:

HQ = Hazard Quotient (unitless)

ADD = Average daily dose (mg/kg-day)

RfD = Oral reference dose for non-carcinogenic health impacts (mg/kg-day)

6.2.2.4 Carcinogenic Risk

The health risk as a result of a specific detected carcinogenic metal in seafood can be estimated as an increased probability that a person will develop cancer in their lifetime due to exposure to that

specific chemical. This is referred to as an excess cancer risk (ECR). ECRs only refer to the increased probability of developing cancer as a result of the chemical exposure, rather than the risk of developing cancer in general (i.e. an ECR does not include the baseline population wide cancer rates). Cancer risk is expressed in terms of probabilities, where 1×10^{-4} would represent a risk of 1 in 10 000 people developing cancer during their lifetime. According to the latest data^{†††} the age-standardised incidence of cancer amongst South African males is 129.07 per 100 000 and for females is 111 per 100 000. An ECR of 1×10^{-4} thus means that an additional 10 incidences of cancer could occur per 100 000.

ECR was calculated using Cancer Slope Factors (CSF) determined by the US EPA (IRIS, 2025), as shown in equation 3. The CSF is the upper estimate of the 95 percent confidence limit of the probability that a person will develop cancer over their lifetime as a result of an arbitrary dose of a defined carcinogen.

$$\text{Equation 3: } ECR = ADD * CSF$$

Where:

ECR = Excess cancer risk (unitless)

ADD = Average daily dose (mg/kg-day)

CSF = Cancer slope factor (mg/kg-day)

Note that in contrast to the development of oral reference doses for non-carcinogenic hazard assessment, the EPA assumes there is no threshold dose below which a carcinogen does not have an effect (USEPA, 2000a). This means that as long as a contaminant considered to be a carcinogen is present, there will be an associated cancer risk (as a probability). The mere fact that an ECR is greater than zero does not imply that a contaminant is present in “dangerous” or even unnatural concentrations, and nor does it imply that the ECR is as a result of anthropogenic impact (USEPA, 2000a, 2014a). To this end, public health and environmental agencies, like the EPA and the CDC, define “acceptable” risk levels. In other words, a probability of cancer developing in a population below which the risk is deemed acceptable. For ECR, this threshold is usually at 1×10^{-5} or 1×10^{-6} , although the CSIR noted that due to the health benefits associated with seafood consumption, some authorities accept a higher risk tolerance of 1×10^{-4} . This was the value used by the CSIR in their previous report on the Marine Outfalls. The present study has not selected a singular risk level to deem acceptable; all results are presented and discussed, and maximum monthly meal limits for seafood from different parts of Cape Town were calculated based on a conservative risk level of 1×10^{-6} .

6.3 Results

6.3.1 Morphological Measurements

6.3.1.1 Size variability

Average wet weight and length of each organism is presented in Figure 6-4. It was not always possible during the surveys undertaken for this study to obtain specimens of the target size range. Inter-site variability of organism size must therefore be taken into account when reading findings on contaminant levels. Figure 6-4 shows a clear relationship between organism length and weight. The correction of tissue contaminant content based on an organism's size or weight is very inexact, since all methods for such correction suffer from one or more limitations such as smaller individuals accumulating disproportionately higher metal burdens. As such, this study first contextualises the size

^{†††} https://www.nicd.ac.za/wp-content/uploads/2024/04/NCR_ASRTables_2022_final.pdf

and weight range of specimens collected (per species), and then plots each metal concentration against length. Whilst this does not provide a correction factor, it is helpful in a purely qualitative manner to explore any trends that may exist between body size and levels of metal bioaccumulation.

Mediterranean mussels have been documented to bioaccumulate metals at significantly different rates, dependent on their body size (Blackmore & Wang, 2003). Juvenile mussels accumulate metals to higher levels than larger, mature, mussels – the mechanisms behind this process are not fully understood, and vary on a per-metal basis, but in general it is thought that due to the larger surface area to volume ratio, more contaminant is able to be absorbed per unit of water pumped through each mussel. Additionally, the higher metabolic rates of juvenile mussels (due to the growth phase of their lifecycle) likely expose them to more seawater with a given contaminant than a mature mussel.

West coast rock lobster sizes were fairly evenly distributed between 40 to 120 mm in length (carapace length). This variability is attributed to a low abundance of target species at several sites, particularly in the Hout Bay area. Mussel length ranged between 35 to 90 mm (total length), with most mussels falling between 35 to 75 mm. Bream length (total) was generally between 220 to 350 mm, although a few large individuals were collected where smaller ones could not be speared due to poor visibility.

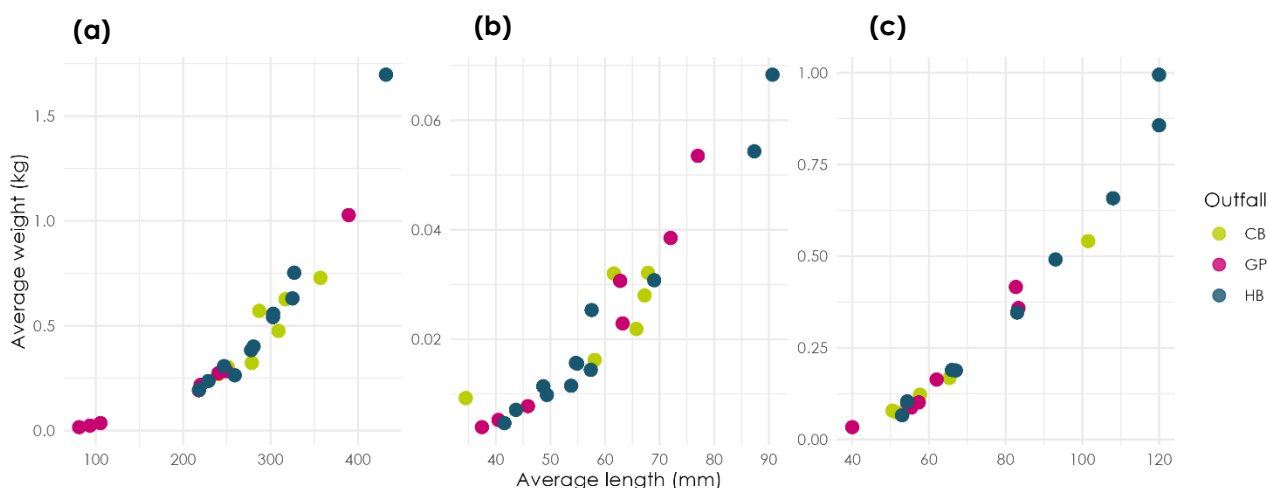


Figure 6-4. The distribution of the average wet weight (kg) - average length (mm) relationship for each composite sample of organisms from each site, (a) Seabream, (b) Mussel and (c) Rock Lobster.

6.3.1.2 Length and weight: Relationship to contaminant concentrations

Plots of metal concentration vs. weight were used to explore possible trends indicating a relationship between body weight and contaminant concentration for each metal in each species. Cape seabream showed no clear relationship between body weight and metal concentration in tissue (Figure 6-5). In contrast, Mediterranean mussels showed a reasonably clear inverse relationship between body weight and metal concentration for most metals, except mercury and cadmium (Figure 6-6) – as body weight increased, metal concentrations decreased. West Coast rock lobster appeared to have an association between body weight and mercury; with mercury concentration increasing with body weight (Figure 6-7).



Figure 6-5. Metal concentrations vs seabream weight at Camps Bay, Green Point and Hout Bay.



Figure 6-6. Metal concentrations vs mussel weight at Camps Bay, Green Point and Hout Bay.



Figure 6-7. Metal concentrations vs rock lobster weight at Camps Bay, Green Point and Hout Bay.

6.3.2 Metal concentrations in mussels, rock lobsters, and Cape seabream

6.3.2.1 Distribution of Metal Concentrations

Metals occur naturally in marine systems and therefore in the tissues of organisms. Some, like copper, are essential for normal cellular function, though only at trace levels. Others, such as mercury, have no known physiological role but still occur naturally in biological material. The presence of metals in mussels, seabream, and rock lobster does not automatically indicate exposure to contaminated seawater or prey; it may simply reflect natural background levels in water, sediment, and food. The challenge in this survey is therefore to distinguish between concentrations that represent natural uptake and those that point to bioaccumulation from contaminated sources. This is complicated by natural variability: tissue concentrations can differ between sites, between sampling times at the same site, and between individuals due to factors such as size (age), sex, and species-specific differences in how metals and other chemicals are accumulated.

All nine metals were found at concentrations that exceeded laboratory lower detection limits in mussels at all sites sampled. With the exception of lead and nickel, all metals were detected in west coast rock lobster samples from all sites. Arsenic, chromium, mercury and zinc were the only metals detected in seabream from all sites in this study (Figure 6-5). Mussels were found to have the highest concentrations of aluminium, cadmium, chromium, lead, nickel and zinc (Figure 6-8). Rock lobster had the highest concentrations of arsenic, copper and mercury.

High-level spatial trends are summarised below, with the caveat that replicate sample collection and analysis from each site was outside the scope of this project, thus statistical analyses could only compare metal concentrations of each tissue type in each area to background values of tissue metal concentrations, obtained from four reference sites along the coast. See §6.2.1.3 for further details on analysis. Additionally, metal concentrations in all tissue types were generally highly variable at reference sites, often exhibiting much more variability than around each outfall study area, further complicating analyses.

In mussels collected from Green Point, aluminium, chromium, lead, and zinc concentrations were significantly higher than in mussels collected from reference sites (p-values: Al $p = 0.025$, Cr $p < 0.01$, Pb $p < 0.001$, Zn $p < 0.001$). In contrast, cadmium was significantly lower than at reference sites ($p = 0.05$). In Hout Bay, no metals in mussel tissue were found to be significantly elevated above reference values, while arsenic, cadmium, chromium and nickel were found at significantly lower concentrations in Hout Bay than at reference sites (p-values: As $p < 0.01$, Cd $p < 0.01$, Cr $p = 0.018$, Ni $p = 0.022$). In Camps Bay, the only statistically significant finding in mussels was that arsenic was significantly lower than at reference sites (p-value = 0.028).

The elevated levels of aluminium, chromium, lead and zinc in Green Point are indicative of an area under high anthropogenic pressure, likely from numerous sources. As discussed in §4, aluminium is generally of crustal origin, suggesting a large portion of the elevated metals in the mussels may be associated with the input of terrestrial sediment, likely via the Diep and Salt rivers. These rivers have been shown to carry numerous metal pollutants at high concentrations, including nickel, lead, and zinc (Gilbert, 2015). Additionally, the Port of Cape Town has been found to have high metal contamination in sediment, although the authors of these studies did note there were questions around the bioavailability of the metal in sediment (CSIR, 2016, 2017b). Metal concentrations, including zinc, lead, and chromium, in mussels collected near the port were comparable to those previously found inside the Port of Cape Town (CSIR, 2017b).

In rock lobster, aluminium, chromium, mercury and nickel were found at significantly higher concentrations in Hout Bay than at reference sites (Al $p < 0.01$, Cr $p < 0.01$, Hg $p = 0.0127$, Ni $p < 0.01$). In Green Point, arsenic was significantly lower (p -value = 0.014), whilst lead was significantly higher than reference sites (p -value = 0.034). There were no significant differences in metal concentrations observed in rock lobsters between Camps Bay and reference sites.

Seabream did not display any statistically significant differences in metal concentrations between reference sites and impact areas.

This differential distribution of metals in tissue between species highlights the importance of using multiple sentinel species for bioaccumulation monitoring.

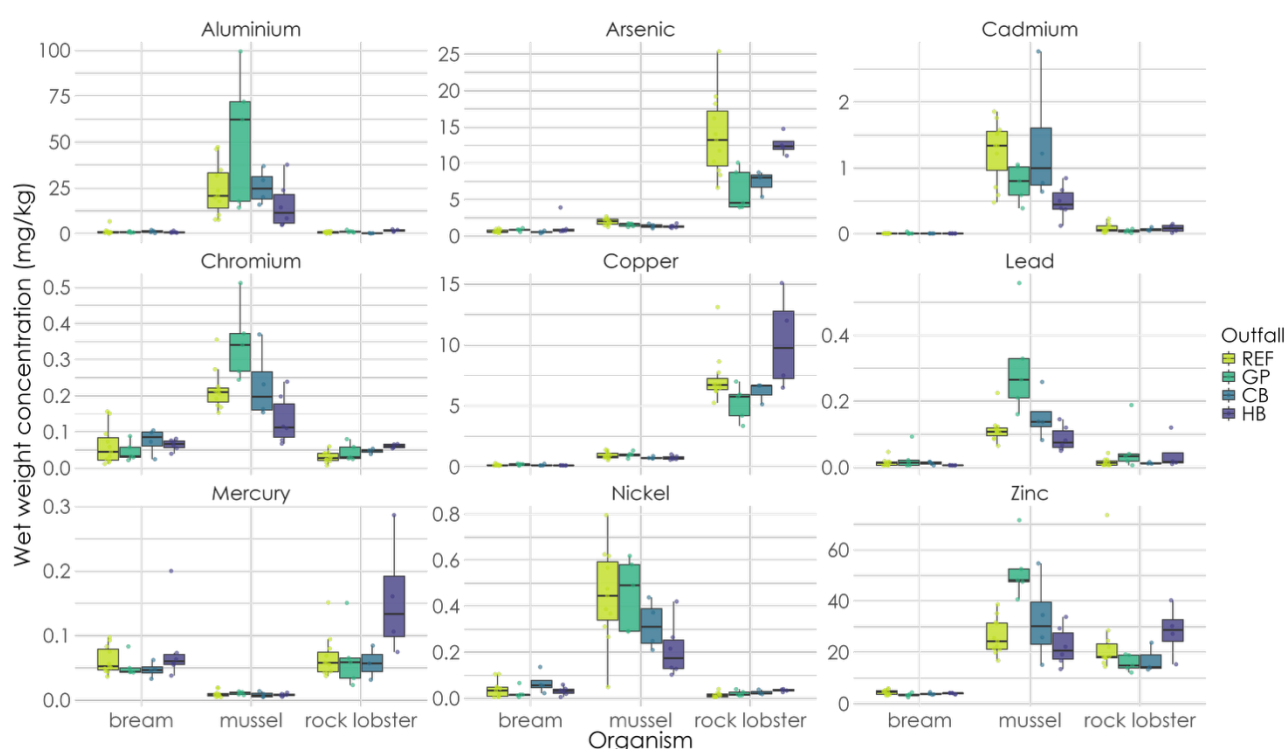


Figure 6-8. Boxplots summarising the concentration of metals in the tissue of target organisms collected from the Green Point, Camps Bay and Hout Bay areas, as well as from reference sites. Reference sites include samples collected from the Crayfish Factory (Soetwater), base of Chapmans Peak (near Noordhoek Long beach), Karbonkelberg and western shore of Robben Island.

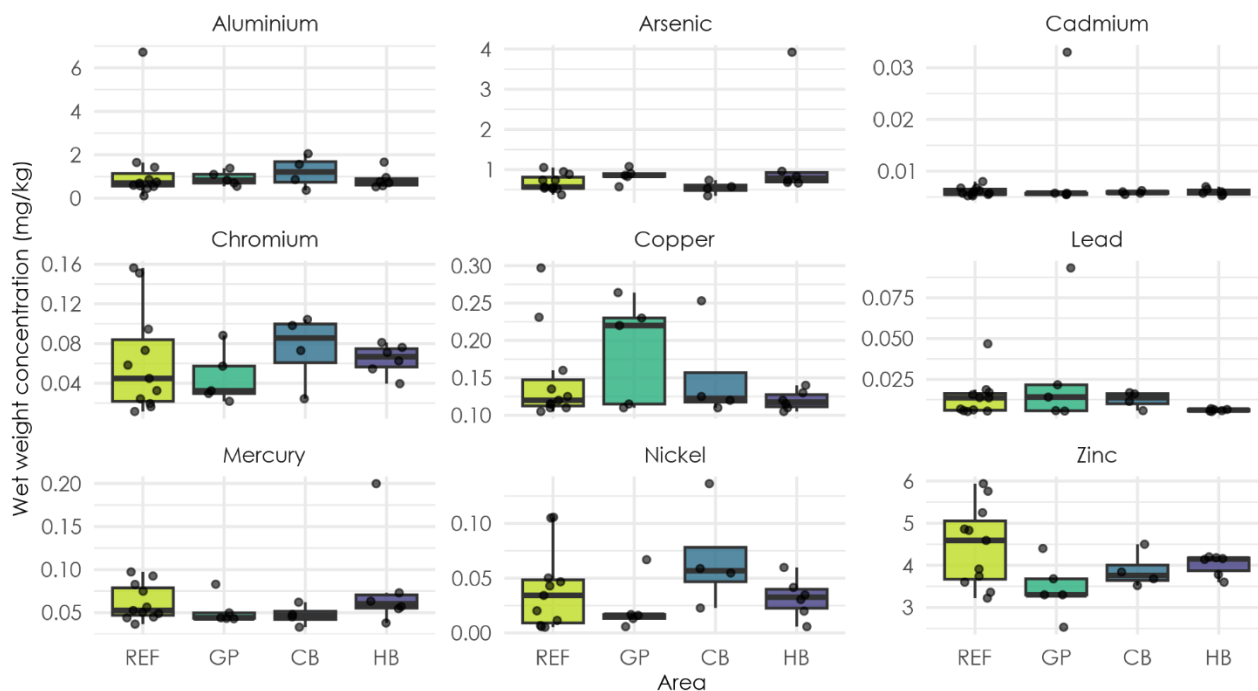


Figure 6-9. Boxplots summarising metal concentrations in Cape seabream tissue collected from the Green Point, Camps Bay and Hout Bay areas, as well as from reference sites. Reference sites include samples collected from the Crayfish Factory (Soetwater), base of Chapmans Peak (near Noordhoek Long beach), Karbonkelberg and western shore of Robben Island.

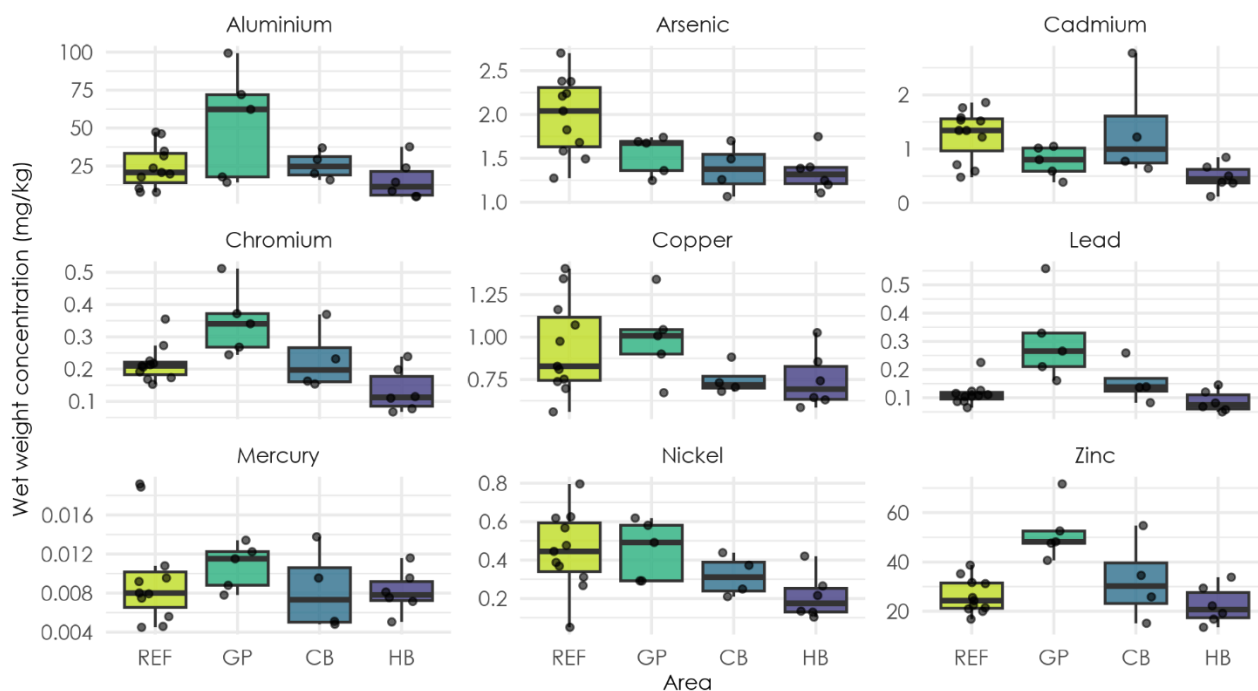


Figure 6-10. Boxplots summarising metal concentrations in mussel tissue collected from the Green Point, Camps Bay and Hout Bay areas, as well as from reference sites. Reference sites include samples collected near the Crayfish Factory (Soetwater), near the base of Chapmans Peak (near Noordhoek Long beach), Karbonkelberg and western shore of Robben Island.

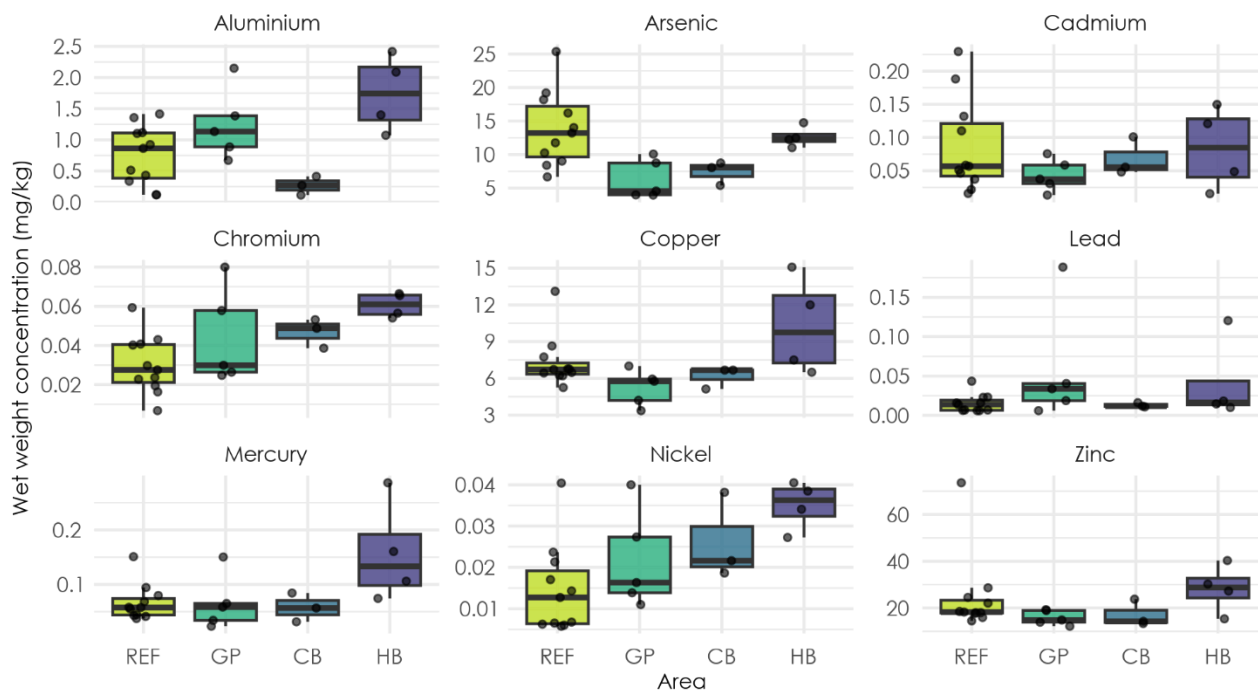


Figure 6-11. Boxplots summarising metal concentrations in rock lobster tissue collected from the Green Point, Camps Bay and Hout Bay areas, as well as from reference sites. Reference sites include samples collected from the Crayfish Factory (Soetwater), base of Chapmans Peak (near Noordhoek Long beach), Karbonkelberg and western shore of Robben Island.

6.3.2.2 Metal concentrations and proximity to outfall

As this report aims to address three central questions of the 2024 Receiving Environment Monitoring Programme, investigating the relationship between proximity to outfalls and metal concentrations in tissue is of particular relevance. The only way to conduct such an analysis was to look for a relationship between distance from outfall to each impact site, and metal concentration in each species. Statistical methods are discussed in §6.2.1.3. General trends in metal concentrations as distance from outfall increases (per species) are illustrated in Figure 6-12, Figure 6-13, and Figure 6-14, where some relationships appeared neutral, some positive, and others negative. This variability reflects a system influenced by numerous anthropogenic pressures, as well as variation in trace metal inputs (and accumulation) from natural sources. The fitted lines are presented only to illustrate general trends, and should not be interpreted as true relationships; due to the low sample size, and likely non-linear relationship, outliers at either end of the distance spectrum may disproportionately affect slope (and subsequent interpretation).

Correlations between metal concentration and distance from outfall were not found to be statistically significant in any of the three species sampled. The results did not provide evidence that the outfalls are a detectable driver of the bioaccumulation of metals, at least at the scale of this investigation. Analyses were limited by the fact that this report is based only on a single year of data. The statistical analyses above were conducted to ensure as thorough and conservative an assessment as possible; had the outfalls been substantially contributing to metal bioaccumulation in the marine sentinel species used in this assessment, these analyses would have likely detected this impact. While these results provide no evidence of the three marine outfalls contributing to bioaccumulation along the Atlantic coastline of Cape Town, they also cannot be excluded as contributors.

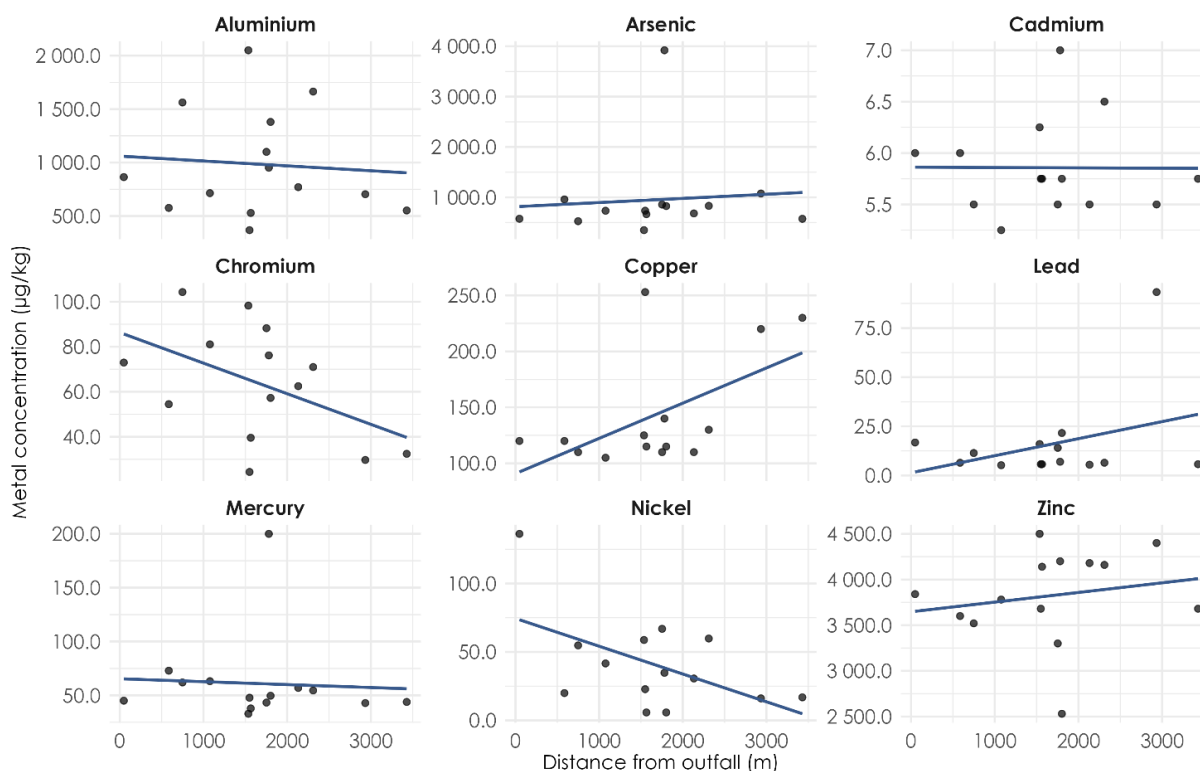


Figure 6-12. Scatterplots showing the relationship between distance from outfall and metal concentration in bream. Distance from outfall was calculated for each area, and combined into one dataset for analysis and plotting. A simple linear model was fitted solely as an indicator of how metal concentration changed with distance.

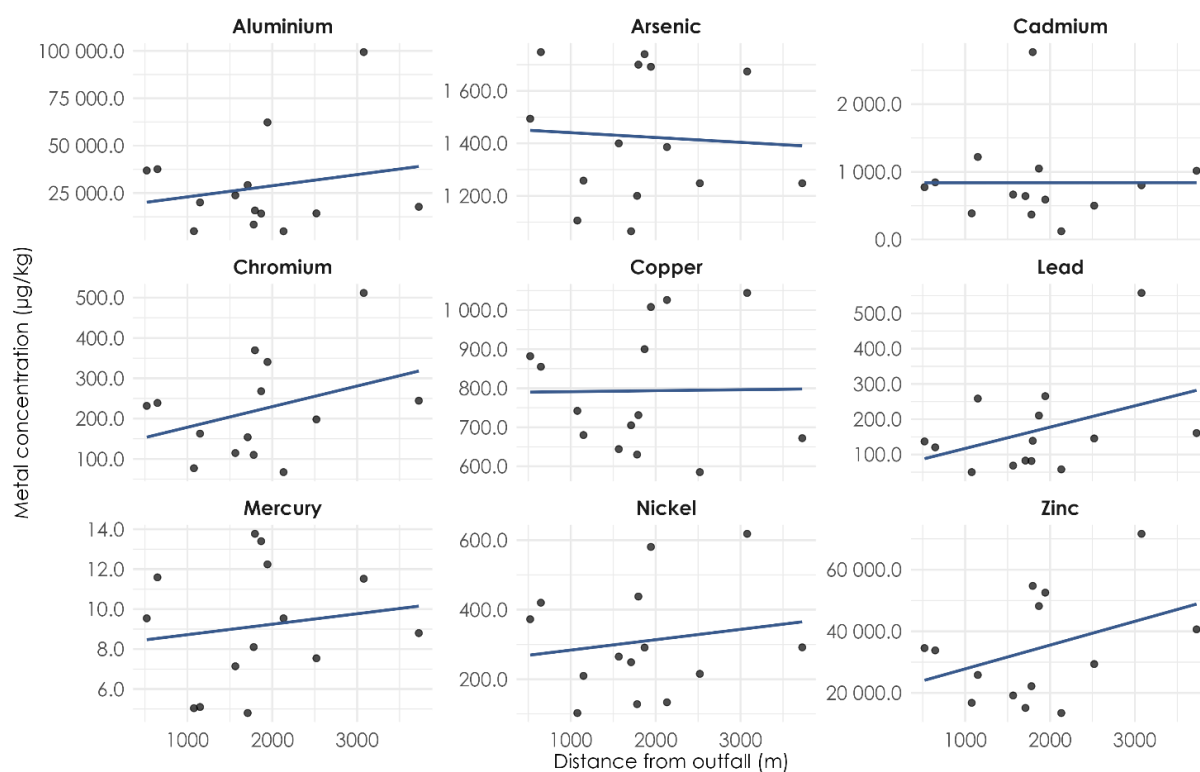


Figure 6-13. Scatterplots showing the relationship between distance from outfall and metal concentration in mussels. Distance from outfall was calculated for each area, and combined into one dataset for plotting. A simple linear model was fitted solely as an indicator of how metal concentration changed with distance.

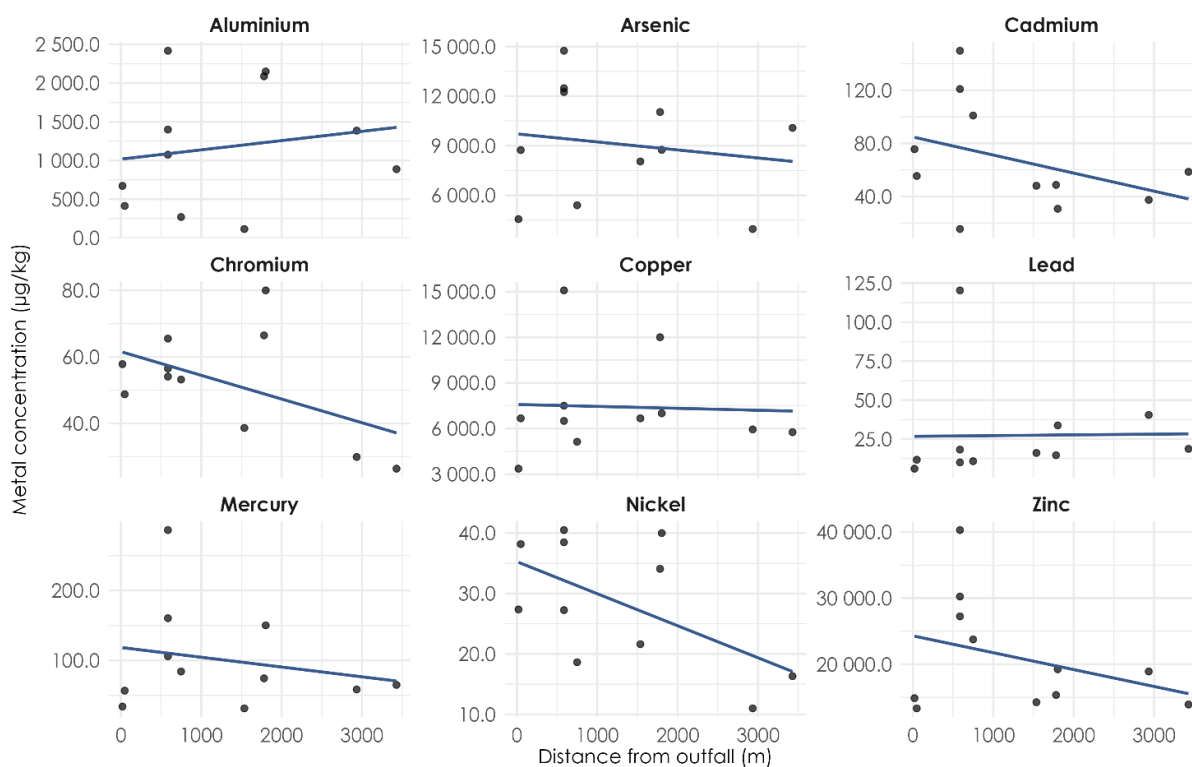


Figure 6-14. Scatterplots showing the relationship between distance from outfall and metal concentration in rock lobsters. Distance from outfall was calculated for each area, and combined into one dataset for plotting. A simple linear model was fitted solely as an indicator of how metal concentration changed with distance.

6.3.2.3 Tissue Quality

In previous Cape Town area studies, the CSIR defined guidelines for dry-weight metal concentrations in mussels, based on available data from the USEPA's Mussel Watch Programme (CSIR, 2011a, 2014, 2016, 2017b). These guidelines classify mussel tissue metal concentrations into low, moderate and high levels of contamination for each metal. Based on the high variability in bioaccumulation rates across different species, only mussel tissue results have been compared to these guidelines.

- All mussel samples collected were classified as having "low" levels of chromium, copper and mercury accumulation.
- Lead was generally found in "low" concentrations, with the exception of one sample, GP038, which was classified as having a "moderate" lead concentration.
- For arsenic, five samples were classified as "moderate"; all five of these samples were collected at reference sites (two at KB002, three at CF002), selected to represent background values of metals in tissue, and not expected to be impacted directly by effluent from the marine outfalls. All other samples, including those from nearest the outfall diffusers, had "low" concentrations of arsenic.
- Zinc concentrations generally fell within the "moderate" category, with one sample from Green Point (GP038) and one from Camps Bay (CB029) falling into the "high" category for zinc contamination. Almost all other samples from Green Point and Camps Bay were classified as moderate, whilst the majority of samples from Hout Bay fell into the "low" category.
- Cadmium exceeded the "high" threshold in three samples, two of which were collected at Robben Island – a reference site. The third sample with "high" cadmium was collected in Camps Bay at site CB029. Most other sites fell within the "moderate" category.
- Nickel was by far the "worst" metal in terms of contaminant levels when compared to the guidelines set out by the CSIR. 17 out of 26 samples were categorised as having "high" nickel

concentrations, with no particular spatial trend between the three outfalls. Almost all reference sites exhibited elevated nickel levels, with most reference sites (7 out of 11) being classified as having “high” nickel levels. Ten out of 15 sites nearer the marine outfalls also had “high” levels of nickel.

- No guidelines were specified for aluminium. Concentrations were highest in the Green Point and Table Bay areas. Hout Bay and Camps Bay had comparable levels of aluminium in mussels.

Overall, mussel tissue results indicate that most metals fell within the low to moderate range of metal concentrations measured in mussels in the USA, with a few localised or site-specific exceptions. Elevated arsenic and cadmium at reference sites suggest the possibility of naturally elevated background levels of these metals since these sites had specifically been chosen as being at a distance from potential sources of anthropogenic pollution. Isolated higher concentrations of zinc (GP038, CB029), cadmium (CB029), and lead (GP038) at impact sites suggest possible localised point sources of pollution associated with urban runoff and wastewater discharged from the outfalls. Nickel concentrations were high at nearly all sites, reflecting possible regional enrichment. Nickel was particularly elevated at sites in Green Point (GP037, GP038, and GP039), Camps Bay (CB029, CB030, and CB031), and Hout Bay (HB022, HB025, and HB026), as well as at Karbonkelberg and Crayfish Factory reference sites.

As described in §4.3, sediment at sites in Table Bay near the Port of Cape Town was enriched for lead and zinc, at sites where bioaccumulation of these metals was also found in marine organisms. Sites where arsenic was elevated in tissue were not found to have sediment enriched with this metal, and most other spatial trends detected in sediment metal concentrations were not aligned with spatial trends in biota.



6.3.3 Risk Assessment

In line with the methods in §6.2.2, a risk assessment was conducted for two separate consumer exposure scenarios – a high-end and a low-end consumer. As the high-end consumer scenario represents a worse case than the low-end, it is presented first. Where the high-end consumer scenario found no notable hazard or risk, the same can be concluded for the low-end consumer scenario.

6.3.3.1 High-end consumer scenario

6.3.3.1.1 Non-carcinogenic Risk

Under the high-end consumer scenario, **Cape seabream** had hazard quotients (HQ) of well below 1.0 (all below 0.25) for all metals assessed, with the exception of mercury (Figure 6-16). The HQ of mercury was >1.0 in fish at one site, Hout Bay Harbour (HB001, $HQ \sim 1.55$). No metals in Cape seabream exceeded a HQ of 1.0 under the low-end consumer scenario (**Appendix V**).

HQ s for **rock lobster** samples were well below 1.0 for all metals except arsenic and mercury; One sample had a $HQ >1.0$ for arsenic, and four samples had a $HQ >1.0$ for mercury ($n = 23$). The only sample to have a $HQ >1.0$ for arsenic ($HQ \sim 1.25$) was collected at the Crayfish Factory reference site (CF001, replicate C). This site is not near any known point sources of contamination. The HQ for mercury was elevated in two out of three samples from the Aster shipwreck in Hout Bay (HB017, replicates A and C; $HQ \sim 2.20$, $HQ \sim 1.25$); at one site in Green Point (GP002; $HQ \sim 1.15$); and in one of two samples from the Chapmans Peak reference site (CP001, replicate C; $HQ \sim 1.15$).

With the exception of cadmium, **mussels** did not exceed a HQ of 1.0 for metals included in this assessment (Figure 6-17) under the high-end consumer scenario. Cadmium had a $HQ >1.0$ in eight mussel samples ($n = 26$), from four sites ($n = 19$). Exceedances were at:

- three reference sites (CP001A, B, C; KB002B; RI002A, B, C; all $HQ < 1.5$); and
- one site in Camps Bay (CB029; $HQ \sim 2.1$).

While a $HQ >1.0$ indicates the possibility of increased non-carcinogenic health effects occurring, the magnitude of the HQ should also be considered. As the HQ increases, so too does the risk of chronic adverse health effects as a result of sustained consumption of the contaminated seafood in question, albeit not in a linear manner. The US EPA notes that due to built-in safety-factors in the determination of daily dose limits, HQ s just above 1.0 are generally not a cause for immediate concern, although results must be interpreted on a case-by-case basis. See §6.2.2 for further details on HQ s.

The non-carcinogenic risk assessment shows that for the majority of sites sampled, Mediterranean mussels, Cape seabream, and west coast rock lobster can be consumed with little cause for concern with regard to the metals included in this study. The only exceptions were:

- Mussels collected from around the Bakoven beach area, where cadmium concentrations were higher;
- Seabream caught at the Hout Bay harbour, where mercury concentrations were higher; and
- West coast rock lobster caught around the Aster Shipwreck in Hout Bay, where mercury concentrations were higher.

These were the only three samples that had HQ s >1.5 . While seafood collected at all three of these sites would be deemed safe under the low-end consumer scenario, out of an abundance of caution it is recommended that seafood not be consumed at a rate approaching the high-end consumer scenario from these three sites specifically.

Mussels collected from the rocks around Bakoven beach were found to pose the greatest hazard to human health out of all mussel sites sampled across the Atlantic Seaboard. Of the sites sampled near

the Camps Bay outfall, this site is furthest from the outfall, not including the reference site. Mussels from the two sites nearest the outfall had a cadmium concentration more than two times lower than at Bakoven. This suggests that the outfall is not the main driver of elevated cadmium concentrations in mussels around Bakoven. Interestingly, mercury, nickel, zinc, chromium, and arsenic were also found at their highest concentrations (in the Camps Bay area) at site CB029, suggesting a possible unknown point source of metals entering the marine environment near Bakoven.

Rock lobster collected from the Aster shipwreck, about 900 meters from the Hout Bay outfall diffuser section, had the highest mercury concentrations and HQs for mercury across all sites. As rock lobster was found in only two locations in Hout Bay, likely due to poaching, no meaningful conclusion can be drawn about whether proximity to the outfall was a driver of mercury accumulation in rock lobster in Hout Bay. Additionally, the fact that rock lobsters could be found only at the harbour and on a shipwreck makes interpretation of spatial trends and isolation of possible sources difficult – shipwrecks have been well documented to contribute to bioaccumulation in marine organisms (Vieira et al., 2023).

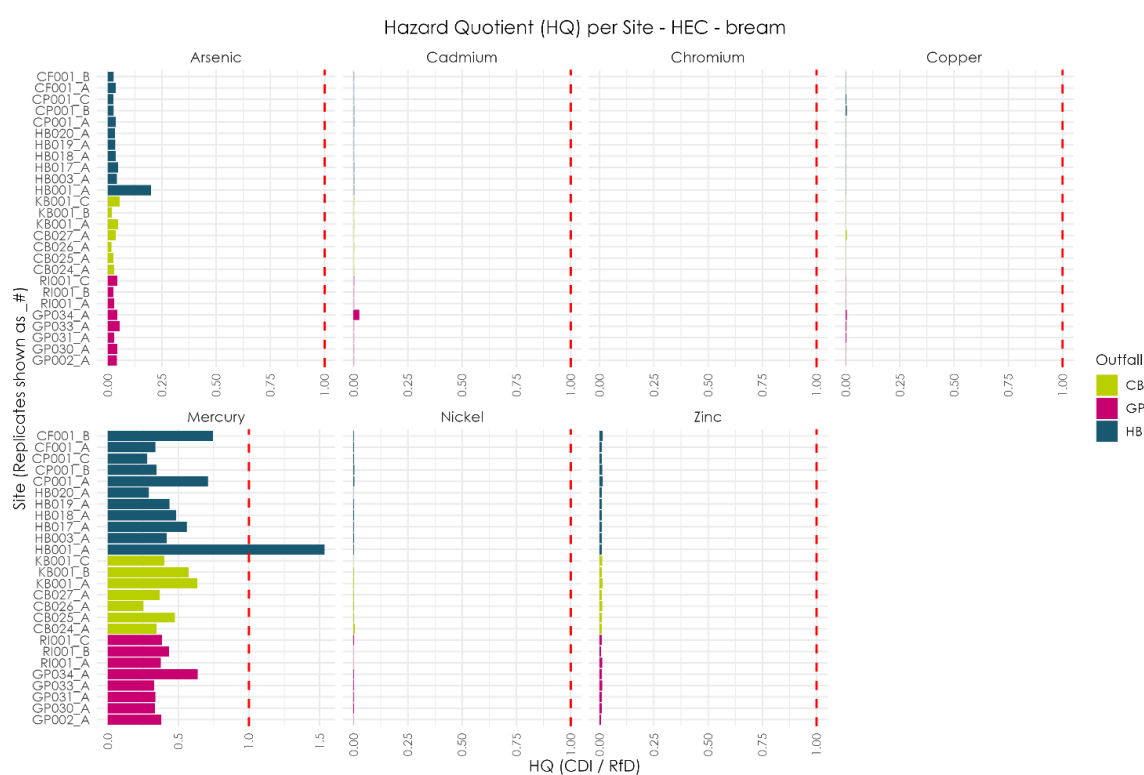


Figure 6-16. Hazard Quotient for each metal in Cape seabream tissue for which a daily chemical specific reference dose has been determined by the US EPA and published on the IRIS database. The red line denotes a hazard quotient of 1.0. The x-axis is variable to emphasize spatial variation on a per metal basis.

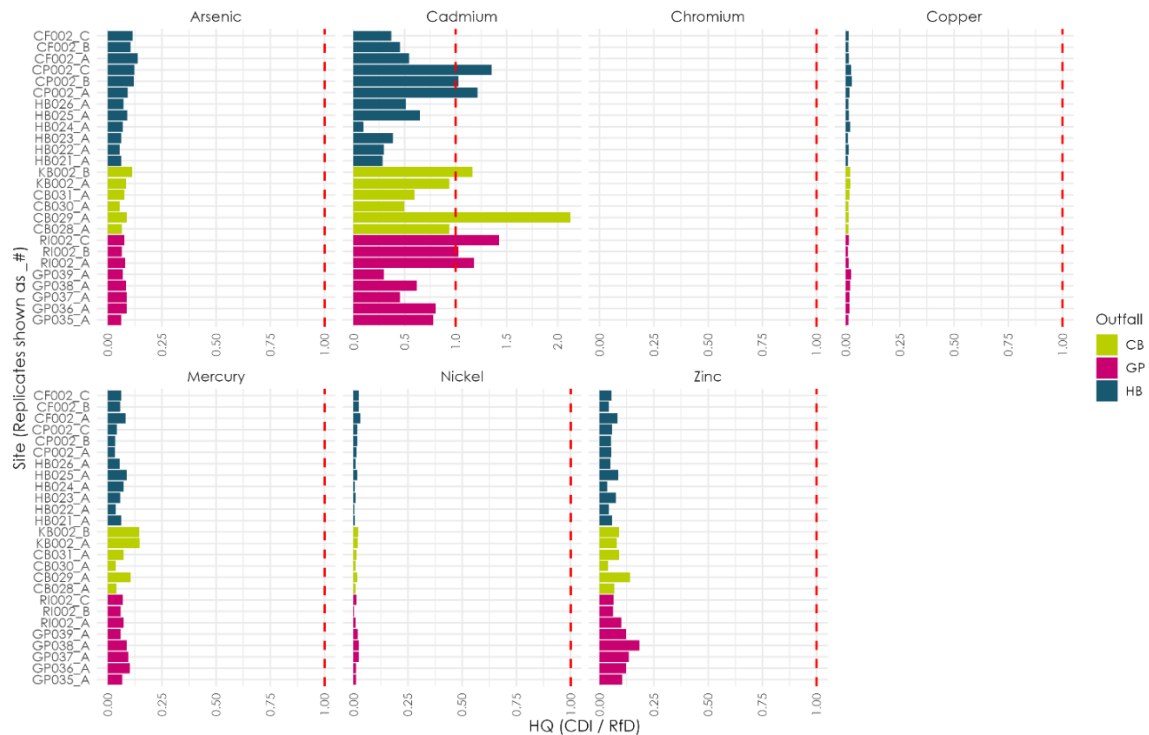


Figure 6-17. Hazard Quotient for each metal in Mediterranean mussel tissue for which a daily chemical specific reference dose has been determined by the US EPA and published on their IRIS database. The red line denotes a hazard quotient of 1.0. The x-axis is variable to emphasize spatial variation on a per metal basis.

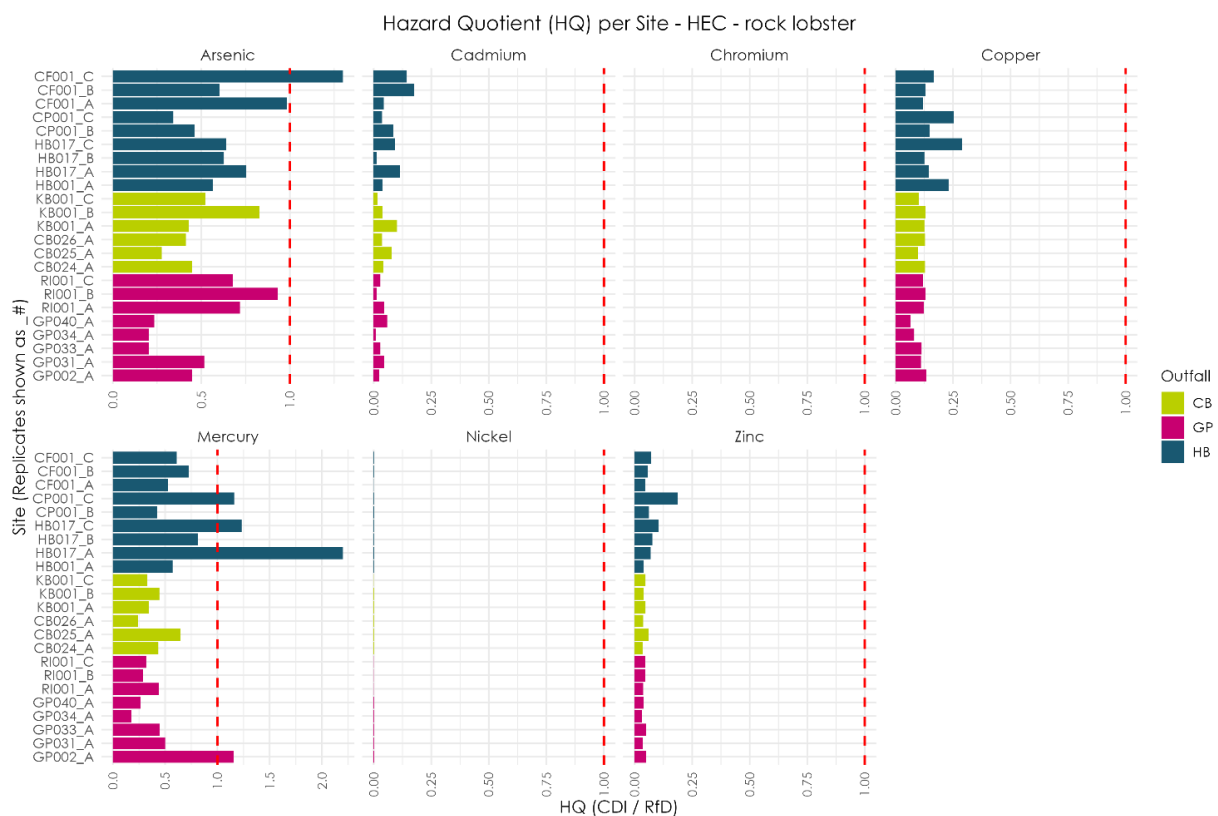


Figure 6-18. Hazard Quotient for each metal in rock lobster tissue for which a daily chemical specific reference dose has been determined by the US EPA and published on their IRIS database. The red line denotes a hazard quotient of 1.0. The x-axis is variable to emphasize spatial variation on a per metal basis.

6.3.3.1.2 Excess Cancer Risk

Excess cancer risk (ECR) was only calculated for inorganic arsenic and lead, as the US EPA has not yet determined oral cancer slope factors for the ingestion of the other metals included in this study. Arsenic accounted for the majority of total elevated cancer risk, while lead contributed minimally across all three species (Figure 6-19, Figure 6-20, Figure 6-21).

Rock lobster had the highest ECRs, mainly driven by elevated total arsenic concentrations (and consequently, inorganic arsenic). Under the high-end consumer scenario, the lowest calculated cancer risk for arsenic in rock lobster was 1.93×10^{-4} , collected from the breakwater in Granger Bay (GP033). This equates to an additional 1.93 cancer cases per 10 000 people who consume rock lobster at rates matching the high-end consumer scenario. The samples with the four highest ECRs were collected at reference sites – two from Crayfish factory (CF001A - 1.24×10^{-3} , CF001B - 9.35×10^{-4} , RI001B - 8.86×10^{-4} , and KB001B - 7.89×10^{-4}). These ECR values are higher than what is normally considered an acceptable risk level (US EPA, 2008; US CDC, 2025). An acceptable ECR is normally defined as 1.0×10^{-6} or lower, although it may sometimes be defined as 1×10^{-4} (see §6.2.2 for further details).

Mussels had arsenic-related ECRs between 5.19×10^{-5} and 1.31×10^{-4} , with the highest ECR in mussels slightly below the lowest rock lobster ECR (1.93×10^{-4}).

Cape seabream had the lowest arsenic-specific ECRs (1.7×10^{-5} to 5.25×10^{-5}) except for a single outlier collected at the Hout Bay Harbour (1.91×10^{-4}), comparable to the upper ECR range of mussels.

The apparent increase in arsenic-related ECRs compared to the CSIR report (2017) was mainly due to the updated oral Cancer Slope Factor (CSF) published by the US EPA in 2025 (USEPA, 2025). The CSF was increased from $1.5 \text{ mg/kg day}^{-1}$ to $3.17 \times 10^1 \text{ mg/kg day}^{-1}$. Both studies also used a worst-case scenario in the conversion of arsenic to inorganic arsenic – two percent of total arsenic was used to approximate inorganic arsenic concentrations. However, some studies of other lobster species suggest that inorganic arsenic may account for as little as 0.01% of all arsenic in lobsters (Peshut et al., 2008 cited in CSIR, 2017a; Greene & Crecelius, 2006; Schoof & Yager, 2007). If this were the case in this study, it would decrease the highest ECR by two orders of magnitude to 5.19×10^{-5} , a much more acceptable level of risk. Further investigations would be required to determine the actual proportion of inorganic arsenic to total arsenic in seafood tissue around Cape Town. This may not be immediately possible due to the technical complexities and costs associated with the quantification of inorganic arsenic in tissue. Across all species, no consistent spatial trends in arsenic ECR were observed.

Lead made negligible contributions to ECR in comparison to arsenic across all three species tested. The maximum ECR for lead in rock lobster was low (3.92×10^{-8} and 1.23×10^{-6}). There was just one value in the range of 10^{-6} , with all other values $< 3.1 \times 10^{-7}$. Lead specific ECRs in mussels were higher than in rock lobster, with the exception of a few outliers. Values ranged between 3.26×10^{-7} and 3.64×10^{-6} , still one to three orders of magnitude lower than arsenic related ECRs. Cape seabream had consistently low lead ECRs (3.43×10^{-8} to 6.09×10^{-7}). Lead ECRs, although much lower than arsenic, exhibited similar spatial patterns among all three species, indicative of specific point sources of lead pollution.

Lead ECRs were elevated in the vicinity of the Port of Cape Town. Rock lobster collected just east of the port (GP034) had an ECR almost two times greater than at any other site. Bream and mussels collected just west of the port also had lead ECRs approximately two times higher than samples from any other site (Figure 6-19 and Figure 6-20).

Regardless of risk levels, a key question for this survey is whether any of the three marine outfall pipelines contributed to the observed elevated ECR from arsenic and lead in rock lobster, mussels, and seabream. There is no indication that ECR values are higher close to any of the outfalls. The highest ECRs were actually found in tissue samples collected from reference sites, so these data do not provide evidence that the discharge of wastewater through the three marine outfalls is contributing to elevated ECRs in the immediate vicinity as a result of arsenic and lead bioaccumulation. This is not to say that localised bioaccumulation of metals in organisms near the three outfalls can be ruled out; however, the present study did not detect any consistent relationship between outfall proximity and metal accumulation in the three species sampled.

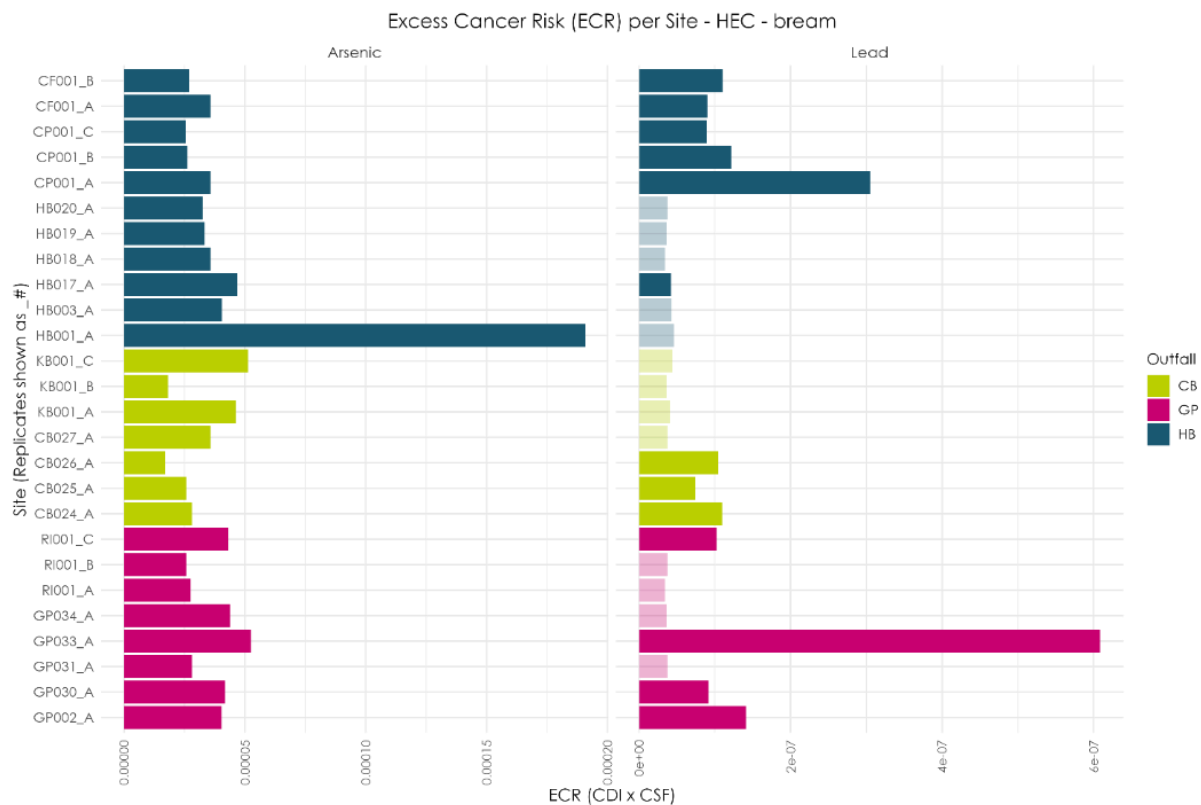


Figure 6-19. Excess cancer risk for arsenic and lead in Cape seabream under a high-end consumer scenario.

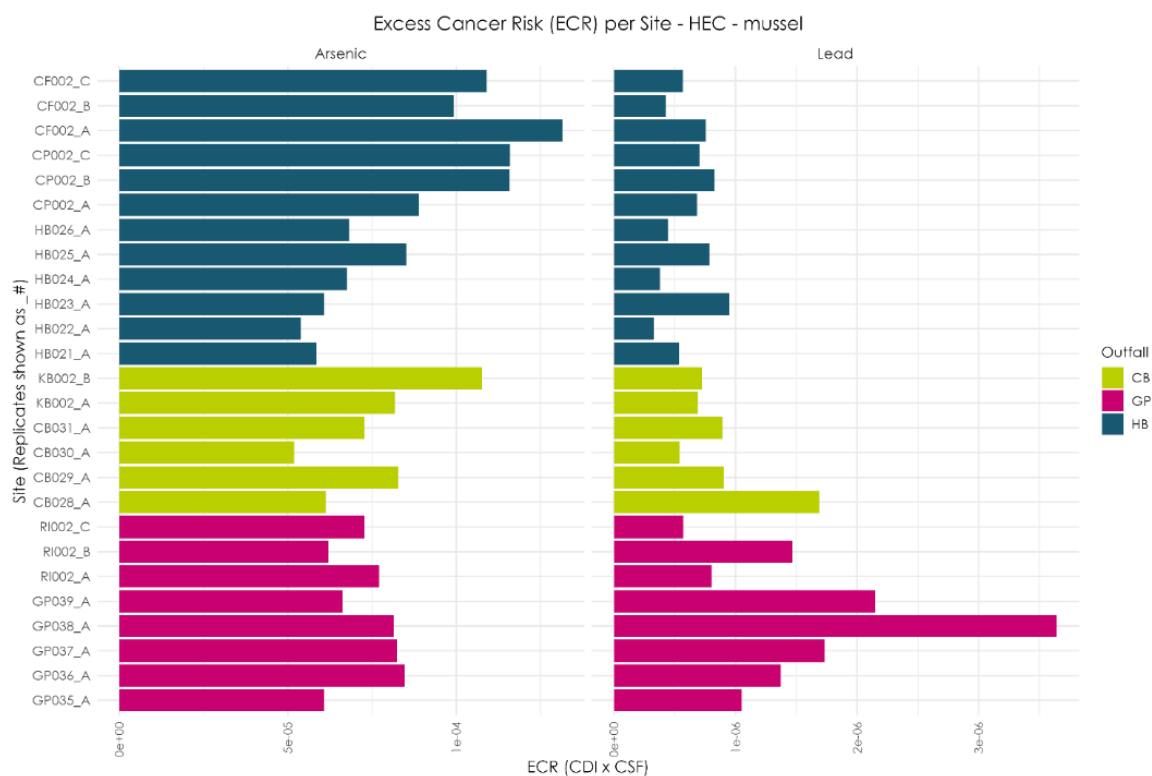


Figure 6-20. Excess cancer risk for arsenic and lead in Mediterranean mussels under a high-end consumer scenario.

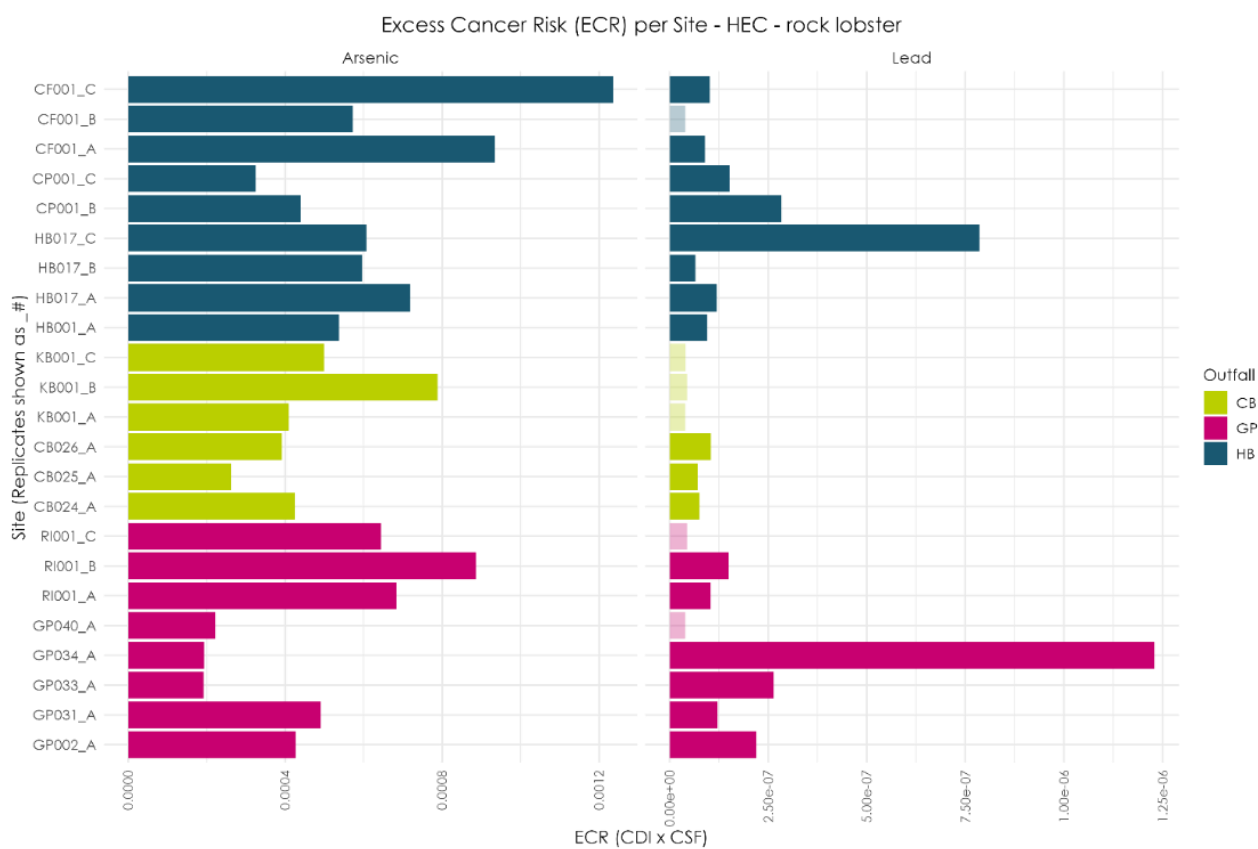


Figure 6-21 Excess cancer risk for arsenic and lead in rock lobster under a high-end consumer scenario.

6.3.3.2 Low-end consumer scenario

6.3.3.2.1 Excess Cancer Risk

All HQs for the low-end consumer scenario were well below 1.0. All ECRs for mussels and bream were found to be less than 1×10^{-4} , falling into an acceptable range. Three rock lobster samples from reference sites exceeded this risk threshold for inorganic arsenic ECRs (CF001A – 1.1×10^{-4} , CF001C – 1.5×10^{-4} , RI001B – 1.1×10^{-4}). All inter-site trends were the same as for the High-end consumer ratio, just with lower magnitudes, so discussion of these results has not been repeated; See §6.3.3.1.2 for further details on arsenic and lead associated ECR.

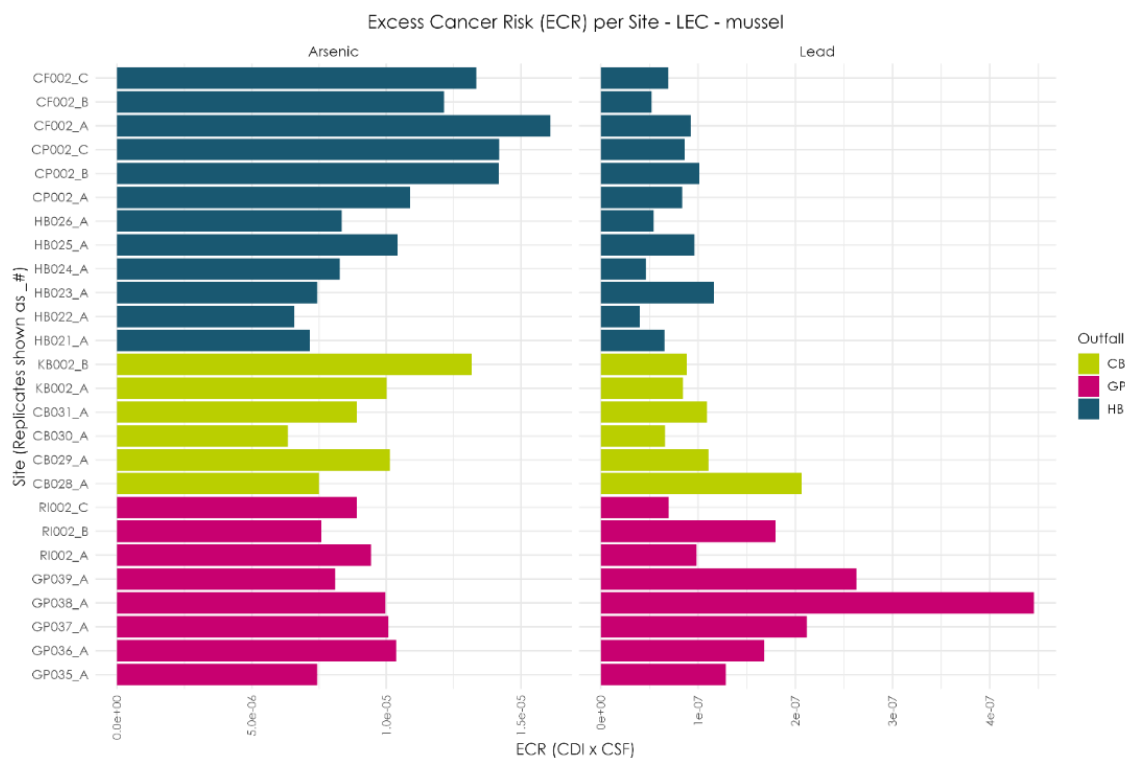


Figure 6-22 Excess cancer risk for arsenic and lead in Mediterranean mussels under a low-end consumer scenario.

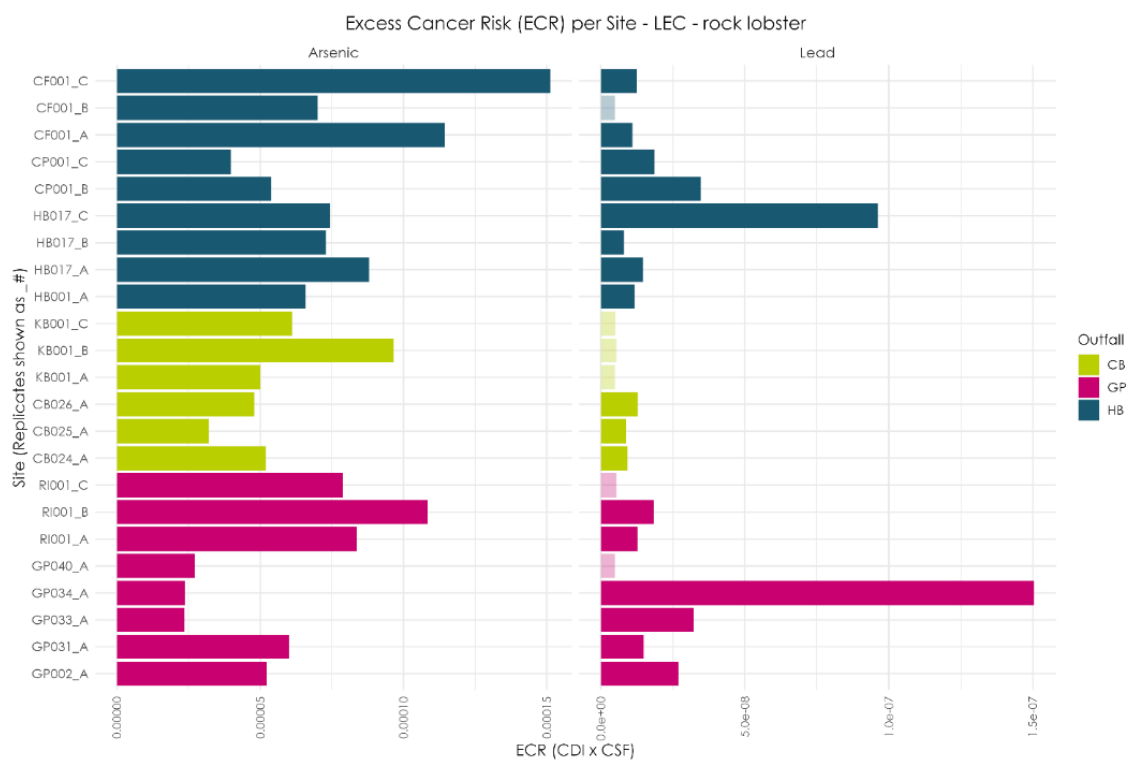


Figure 6-23 Excess cancer risk for arsenic and lead in rock lobster under a low-end consumer scenario.

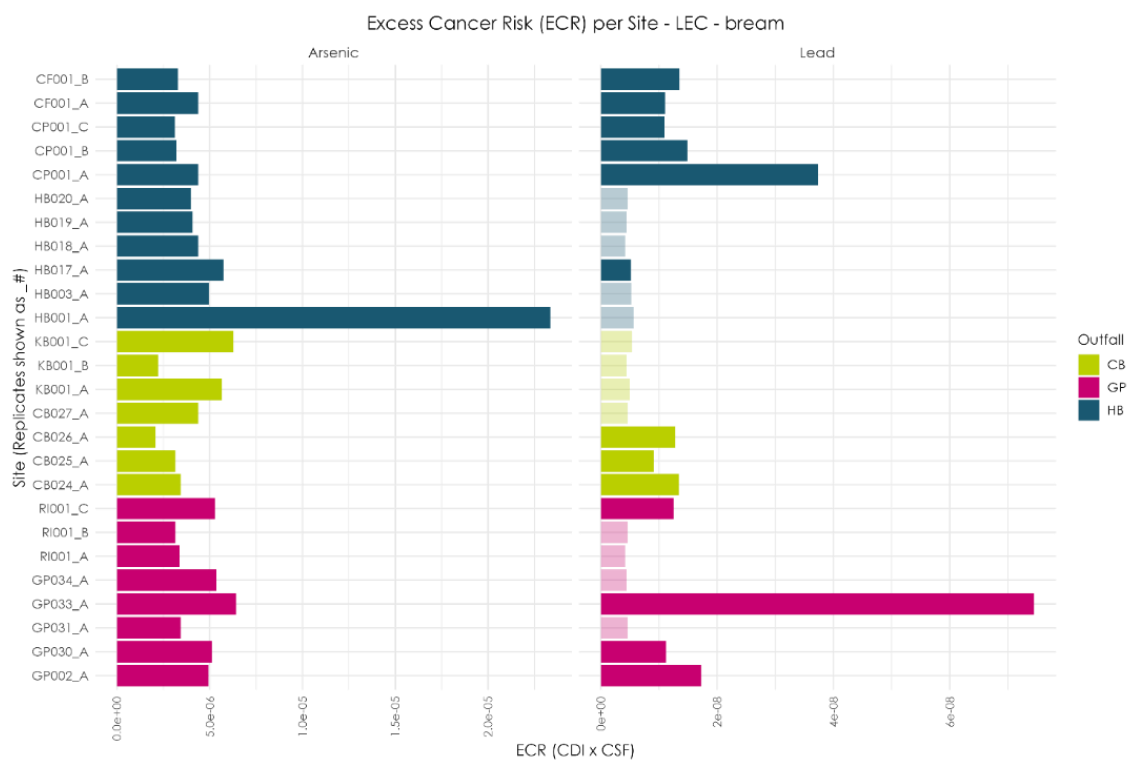


Figure 6-24 Excess cancer risk for arsenic and lead in Cape seabream under a low-end consumer scenario.

6.3.4 Historic comparisons

6.3.4.1 Temporal trends in the distribution of metals in Mussels and West Coast Rock Lobster

The CSIR (2017) previously found that aluminium, iron, nickel, and cadmium concentrations were highest in Mediterranean mussel tissue, whilst arsenic, copper and mercury were highest in rock lobster tissue. These trends were reflected in the recent data, except that iron was not included as part of the analyses in 2025. The CSIR study did not include Cape seabream as an indicator species, and thus it is not discussed further in this section. Trends in metal concentrations are described below for mussels and rock lobster (Figure 6-25 and Figure 6-26).

6.3.4.1.1 Mussels

Copper and nickel were generally higher across most sites in 2025 than in 2015/16. Zinc was elevated at Green Point and certain Camps Bay sites, with minimal changes observed in Green Point. Arsenic was found at similar concentrations in both studies, though reference sites in 2025 had higher values than any recorded in 2015/16. Mercury concentrations were largely comparable or lower in 2025, except at the Karbonkelberg reference sites. Hout Bay Harbour had notably lower mercury and arsenic concentrations in mussels in 2025. Nickel was found in greater concentrations in tissue samples across all three impact areas in 2025. Cadmium concentrations in Green Point were lower in 2025, but showed no notable change in Camps Bay except at CB029 (Bakoven), which was elevated in the present study. Cadmium accumulation in tissue was higher in Hout Bay in 2025 than in 2015/16. Finally, chromium tissue concentrations increased in Hout Bay and Green Point, while most sites in Camps Bay remained at similar levels, with the exception of CB029 which increased over time.

6.3.4.1.2 Rock lobster

Arsenic and cadmium were found at elevated levels in 2025, and cadmium was detected more frequently than in 2015/16. Chromium concentrations remained stable, or decreased slightly, except at the Hout Bay Harbour where concentrations dropped markedly. Copper concentrations were higher in Camps Bay, and at reference sites; elsewhere, copper concentrations remained stable. Mercury generally decreased over time, except for GP002 and HB017 which were approximately double previous recorded concentrations. It is worth noting HB017 is a site at a shipwreck near the Hout Bay outfall (not sampled in 2015/16), and the nearest sites that could be used for comparison from the 2015/16 report were collected near the Hout Bay beach. Nickel showed a substantial increase, from mainly non-detects in 2015/16 to reasonably elevated levels in 2025. Zinc concentrations were reasonably stable, with the exception of those at HB017 which were higher in the present study than any previous findings.

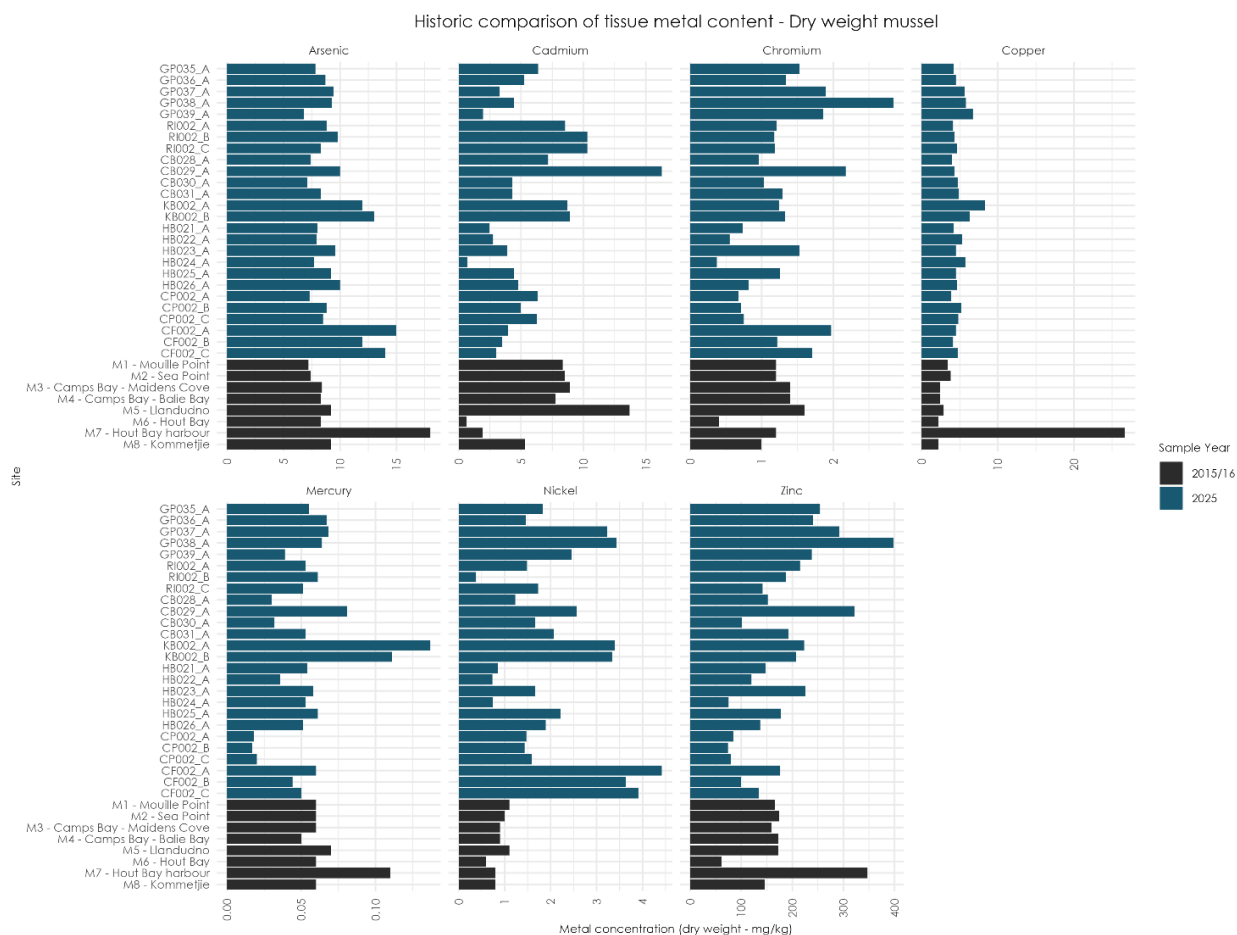


Figure 6-25 Historic comparison of metal concentrations (dry weight) in Mediterranean mussels across the Atlantic Seaboard of Cape Town. Black bars show data collected in 2015/16 by the CSIR and blue bars show data collected in February 2025 during the present study.

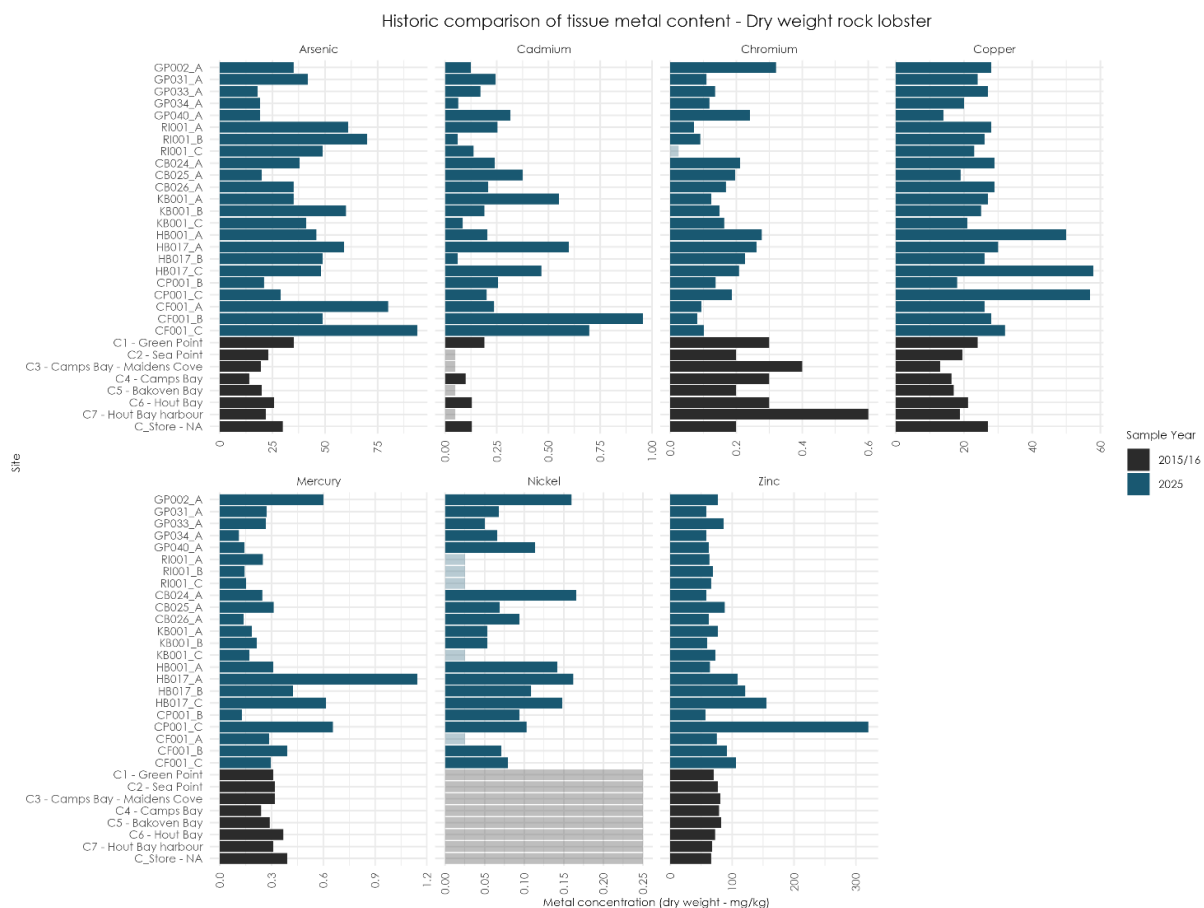


Figure 6-26 Historic comparison of metal concentrations (dry weight) in West Coast Rock Lobsters across the Atlantic Seaboard of Cape Town. Black bars show data collected in 2015/16 by the CSIR and blue bars show data collected in February 2025 during the present study.

6.3.4.2 Risk assessment

HQs and ECR factors were re-calculated for the 2015/16 dataset of metals in tissue, to allow for direct comparison of results between the two sampling events (Figure 6-27, Figure 6-28). The present study used different RfDs and CSFs for certain metals, in line with the most recent values provided by the US EPA (IRIS 2025). See Table 6-1 for a comparison of values used in each study.

No tissue samples collected in 2015/16 were found to exceed a HQ of 1.0 using the most recent RfD and CSF values from the US EPA IRIS database (2025) (Figure 6-27, Figure 6-28). As discussed in detail in §6.3.3, 2025 sampling found eight mussel samples exceeded HQs of one for cadmium, four rock lobster samples exceeded an HQ of one for mercury, and one rock lobster sample exceeded an HQ of 1 for arsenic.

This suggests that mercury, arsenic and cadmium concentrations in mussel and rock lobster tissue were higher in localised areas in the most recent survey. However, metal content in tissue may vary seasonally (Azizi et al., 2018; Bennaoum et al., 2025), so further sampling must be undertaken before definite conclusions can be drawn.

Similar to the non-carcinogenic risk assessment findings, carcinogenic risk was generally elevated in 2025 samples compared to 2015/16 samples. ECR could only be calculated for lead and arsenic, as there are not currently USEPA defined CSF values for the other metals in this study.

In mussels, ECRs for lead were very similar between Camps Bay and Hout Bay in both 2015/16 and 2025. Lead ECRs in Green Point were markedly elevated in tissue samples collected during 2025 (albeit still within acceptable limits). Rock lobster lead ECRs remained similar in Camps Bay between the two studies, but were elevated in both Hout Bay and Green Point during the recent sampling effort.

As discussed in §6.3.2 and 6.3.3, higher arsenic concentrations were found in rock lobster and mussels across the Atlantic Seaboard during the 2025 survey than in 2015/16. In 2015/16, the highest arsenic ECR in mussels was 7.89×10^{-5} , compared to 1.3×10^{-4} in samples collected during recent sampling. Arsenic ECRs were also higher in rock lobster than in mussels during the 2015/16 sampling, with a maximum ECR of 4×10^{-4} . This is essentially an order of magnitude lower than the highest ECR recorded during 2025 sampling, which was 1.24×10^{-3} . As discussed in §6.3.3, the highest arsenic concentrations were found at reference sites in recent sampling, making interpretation of the results in relation to pollution sources challenging.

Table 6-1. Comparison of RfDs and CSFs used in the 2015/16 study and the present (2025) study.

Metal	RfD – Used by CSIR mg/kg-day	RfD – used in present study mg/kg-day	CSF – Used by CSIR (mg/kg-day) ⁻¹	CSF – used in present study (mg/kg-day) ⁻¹
Arsenic (inorganic)	3.0×10^{-3}	3.0×10^{-4}	1.5	3.17×10^1
Cadmium	5.0×10^{-3}	1.0×10^{-3}	Not available	Not available
Chromium (III)	1.5	1.5	Not available	Not available
Copper	4.0×10^{-2}	4.0×10^{-2}	Not available	Not available
Lead	Not available	Not available	Not available	8.5×10^{-3}
Mercury (methylmercury)	3.0×10^{-4}	1.0×10^{-4}	Not available	Not available
Nickel	2.0×10^{-2}	2.0×10^{-2}	Not available	Not available
Zinc	3.0×10^{-1}	3.0×10^{-1}	Not available	Not available

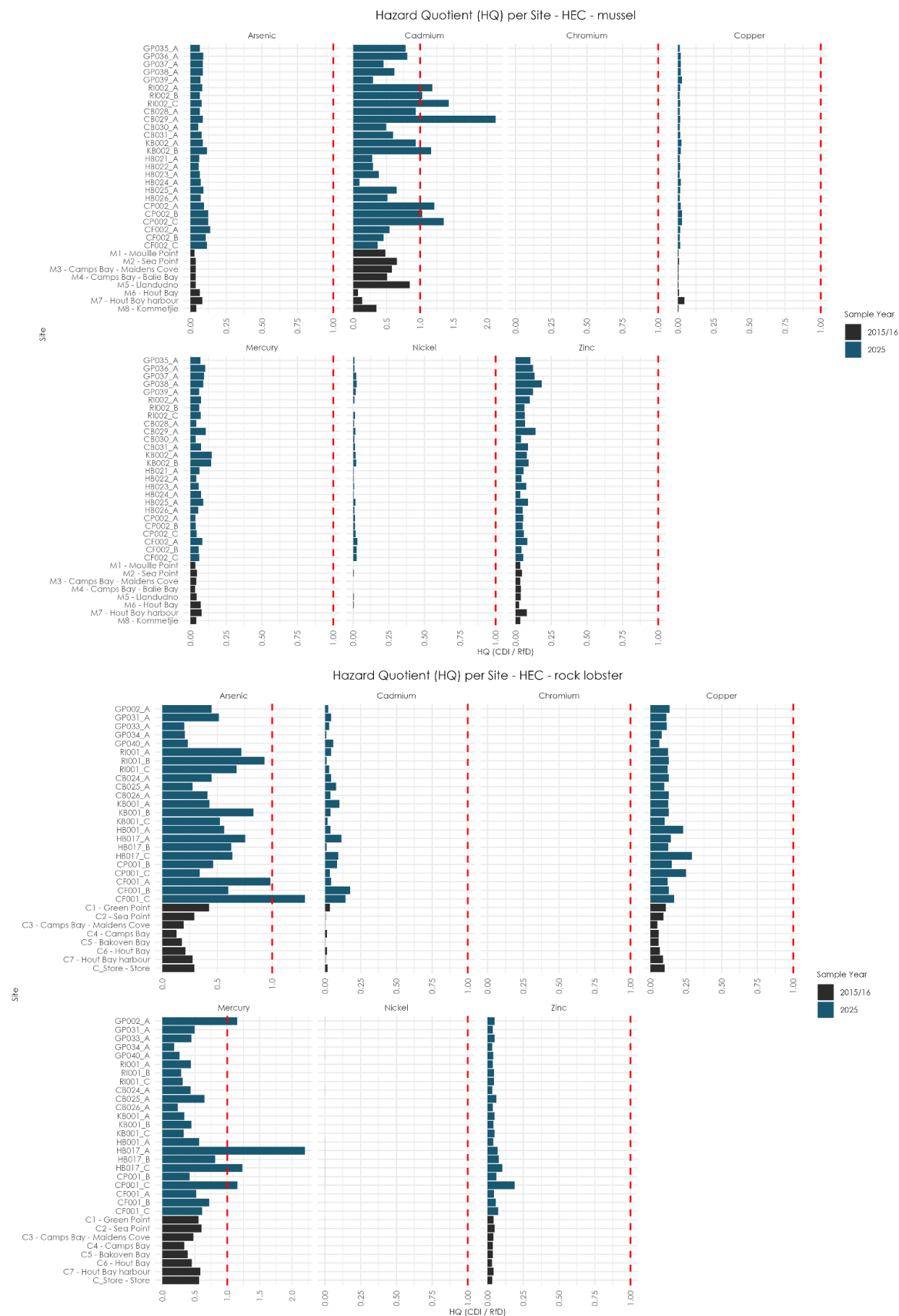
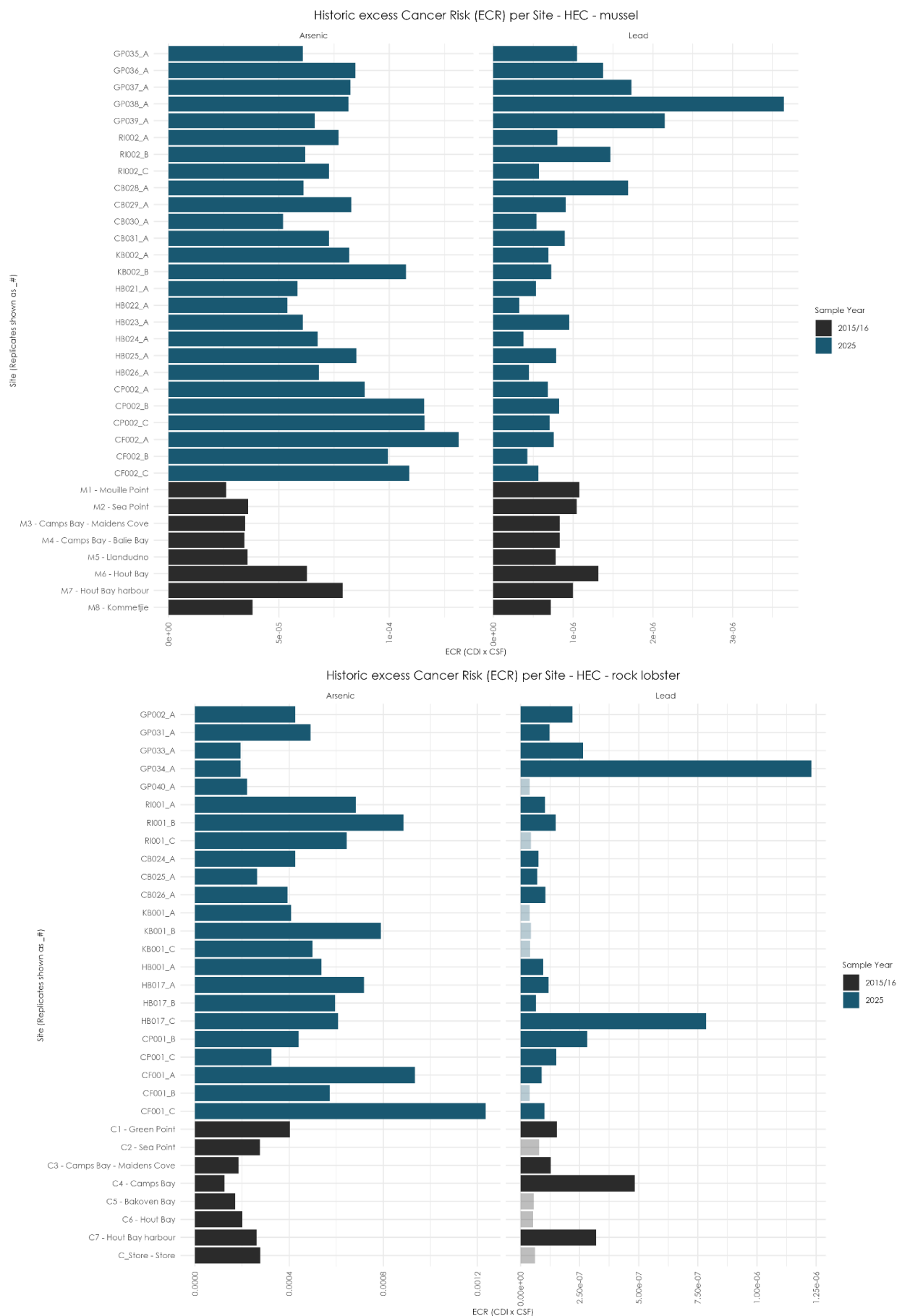


Figure 6-27. Comparisons of 2024/2025 (blue) hazard quotient values for high-end consumers of mussels (top) and rock lobster (bottom) with 2015/2016 values for the same species (black). Where RfD values have changed, 2015/16 excess cancer risk was recalculated with the most recent RfD for comparison purposes.



6.4 Conclusions

A survey of metal accumulation in the tissues of commonly harvested mollusc, crustacean, and fish species in the nearshore and shoreline environment provided some insight into spatial distribution of bioavailable metals in the receiving environment, as well as the level of risk associated with regular consumption of seafood harvested from the urban shoreline.

Increased human health risks associated with the regular consumption of these species were most strongly associated with elevated arsenic concentrations in the tissue of some organisms. There was no evidence of any spatial relationship between the location of specimens with higher arsenic levels and the marine outfalls, however. Rock lobster tissue posed the highest risk calculated in terms of the number of excess cancer cases expected in human consumers, due to their accumulation of arsenic. Risk factors were calculated using a very conservative ('worst-case') assumption of the ratio of inorganic arsenic compounds to total arsenic.

For consumers of low to moderate amounts of seafood, no non-carcinogenic risk was determined based on the specific metals and organisms analysed in this survey. For high-end consumers (those who consume on average 125 g of seafood per day), at the sites with the highest levels of bioaccumulation, risk levels were within tolerable limits for mussels and fish, but exceeded acceptable risk levels for rock lobsters. It is unlikely in the extreme that this represents a common level of consumption of rock lobster, given their relatively high cost and the seasonal restrictions on harvesting this species.

The findings of the 2025 survey were comparable to those of the CSIR's survey approximately 10 years before in 2015/16 (CSIR, 2017a), with a few exceptions. In both studies, the calculated excess cancer risk and non-carcinogenic risk to human consumers were driven primarily by the concentrations of arsenic in tissue. The highest arsenic concentrations in the present survey were found at reference sites, making interpretation of the results in relation to pollution sources challenging.

Although the above analyses necessarily focus on those areas where assessed risks appear to be higher than in previous studies, the present study also found some metals to be present at lower concentrations than in the 2015/16 surveys, and assessed many samples to be of sufficiently low concentrations not to pose human health risks in either study.

The data presented here are subject to several limitations, some of which will be addressed through the continued implementation of annual surveys. Bioaccumulation is strongly affected by the size and age of the organism sampled, and difficulty in sourcing specimens of similar size ranges requires a greater sampling effort in future surveys. In particular, rock lobster were scarce in the Hout Bay vicinity, presumably due to the effects of poaching on this population – this may have an effect on the reported results in relation to metal concentrations in the tissue of the few specimens which could be collected. Greater sample sizes will also enable the use of statistical analyses to compare data between and among sites. Given the significance of the assumptions regarding the relative concentrations of (unmeasured) inorganic arsenic compounds including arsenic trioxide, arsenite, and arsenate to (measured) total arsenic, the quantification of this ratio in the subject species would be beneficial to future health risk assessments.

7 SUMMARY AND CONCLUSIONS

Data from the first year (2024/2025) of a three-year monitoring programme for the receiving environment around the CCT marine outfalls are analysed in this report. In addition to reporting on compliance with permit conditions, the study set out to provide responses to three guiding questions:

- Whether there is a **measurable change in the physicochemical environment** attributable to one or more of the marine outfalls;
- Whether this change is relevant to ecological health and **results in ecological responses** beyond the AMZ of each outfall; and
- Whether there are any measurable **risks to human health** arising from recreational or extractive uses of the coastal and marine environment in the vicinity of the outfalls.

Monitoring of the physical, chemical and microbiological characteristics of seawater found that the effluent plume from each marine outfall was regularly detectable in the water column. Bacteria and TSS originating from wastewater discharge were most often detected at the bottom or in mid-water samples, but also periodically reached the surface, particularly at the Green Point outfall. Conclusions that could be drawn from water quality data on the movement of the effluent plume were consistent with the findings of the dispersion modelling studies conducted in 2020-2021, and provide support for the model outputs as a valuable management tool in determining the impacts of the outfalls on coastal water quality on a finer timescale than environmental monitoring is able to achieve. Changes in water quality around the outfalls, even where these were attributable to wastewater discharge, were largely within the range of variation in the natural environment measured at unimpacted reference sites.

Data further suggest that most constituents of the effluent are sufficiently diluted within the area designated as an AMZ to meet water quality targets protective of marine ecosystems and human health. Exceptions to this included FIB at the Green Point outfall, which regularly exceeded target values at the sea surface to the northeast of the outfall, in line with modelled plume behaviour. At the Camps Bay outfall, only two recreational guideline exceedances occurred during the twelve monthly surveys, one at the surface to the north of the outfall and one on the offshore boundary of the AMZ. The Camps Bay effluent plume was usually either not detectable or had been sufficiently diluted to reduce the risks of gastrointestinal and other illnesses among recreational users to acceptable guideline levels. In Hout Bay, surface water quality in the bay was not impaired in terms of recreational water quality guidelines during surveys for this study.

At times when FIB were detected on the sea's surface around the outfall AMZ at Camps Bay, there was no evidence from screens of sample sites between the outfall and the beach that indicator bacteria (and by extension other constituents of outfall effluent) reached the shoreline at concentrations which would indicate a risk to people using the shoreline and nearshore waters. At Green Point, FIB were elevated near the shoreline on two occasions, one of which may have been attributable to a shoreward movement of the effluent plume. During and following heavy rainfall events, there was evidence of widespread contamination of nearshore waters by sewage, particularly in Table Bay where bacterial counts were periodically elevated across the entire bay. Although the data collected cannot be used to identify sources of faecal bacteria, there was no evidence that wastewater discharged through the Green Point, Camps Bay and Hout Bay outfalls resulted in risks to recreational use of the beaches on the days sampled.

Some beaches in the vicinity of the marine outfalls were, periodically during the year, characterised by FIB counts that indicate there would have been an unacceptable health risk associated with swimming or other recreational activities in coastal waters. Around the Green Point outfall, Mouille

Point Beach was assigned a recreational water quality category of 'Excellent', not having any documented exceedances of guideline FIB counts during the year. Three Anchor Bay Beach, in contrast, had four such exceedances and was assigned a 'Poor' classification, due to impacts attributed to the stormwater drains discharging into the bay. The coastal water quality at beaches near the Camps Bay marine outfall was generally very good, with some of the lowest FIB guideline exceedance rates in Cape Town over the period. A known point source of pollution at Saunders Rocks contributes to poor water quality at this site, and episodes of rainfall-related deterioration in water quality resulted in lower classifications for the Bakoven and Barley Bay beaches. In Hout Bay, beach water quality remained severely impaired during the study period, but is believed based on data collected at nearshore and mid-bay sites to be most directly affected by the polluted Hout Bay River, rather than the marine outfall.

The toxicity testing of seawater samples collected on the boundary of the AMZ of the outfalls found no incidences of acute toxicity (defined as less than 70% fertilisation success in sea urchin gametes exposed to sample) at the surface, even though some seawater samples were collected in the effluent plume. Acute toxicity to sea urchin gametes was however detected in samples collected at one site at the bottom in Camps Bay (three occasions) and at one site in bottom waters in Hout Bay (one occasion). Reduced fertilisation success just above the 70% threshold was also detected on a separate occasion in mid-water and at the surface in Hout Bay. A level of variability in fertilisation success is expected, and in most cases when acute toxicity occurred near an outfall, a sample from a nearby reference site also had the same effects on sea urchin gametes. Toxicity testing supports the conclusion that contaminants in the wastewater are being sufficiently diluted within the AMZ to limit the incidence of acute toxicity to marine organisms, and that the discharge of wastewater is in general not resulting in impacts on the reproduction of sensitive marine species.

Monitored for the first time as part of a marine outfalls monitoring programme in Cape Town, microplastics were detected at all sites monitored both around the marine outfalls and at distant reference sites. Fibres were the predominant class of plastics detected in the surveys, which may indicate a wastewater origin related to the release of fibres from synthetic clothing when washed. There were however relatively similar numbers and compositions of microplastics found at reference sites and in the nearshore. No clear trends were detectable with regard to seasonality and rainfall, and nor were major differences found between the different outfalls or at different depths in the water column, highlighting the ubiquity of plastic pollution along South Africa's coastline.

While water quality monitoring typically presents a limited 'snapshot' of impacts, contaminants may accumulate in sediments and affect marine organisms through both acute and chronic toxic effects. Sediment was sampled for metals, hydrocarbons, and organic pollutants, and found evidence of low-level enrichment of arsenic, lead, vanadium, and chromium at sites near the Port of Cape Town in Table Bay, at a site offshore of Clifton near Camps Bay, and at sites in the Hout Bay Harbour. Camps Bay and Table Bay showed only slightly elevated metal concentrations, and the strongest contamination was in Hout Bay Harbour, where copper and zinc were detected in high concentrations, along with petroleum hydrocarbons. In general, organic contaminants were spatially limited and not present in significant concentrations. There appears to be no significant acute toxic risk posed by chemical concentrations in sediment in the Table Bay, Camps Bay and Hout Bay areas, other than within the Hout Bay Harbour where one sediment sample exceeded guideline values for copper. There was no relationship between contaminant concentrations in sediment and proximity to the outfall diffuser sections. The most contaminated sediment was situated a considerable distance from the outfall diffuser sections, and usually at or near other known sources of contaminants to the marine environment off Cape Town.

Surveys of invertebrate ecology within sediments on the seafloor at and near the outfalls found that, at Camps Bay, sites in very close proximity to the outfall diffuser section tended to have lower diversity

than sites further away. However, this disturbance likely reflects the naturally high-energy environment influenced by wave action and sediment abrasion, rather than effects from the outfall itself. In Hout Bay, there was no evidence in the benthic infaunal species diversity or community composition to suggest that the discharge from the outfall has any ecological impacts on the overall health of the benthic ecosystem near the outfall. Ecological surveys of reef flora and fauna at Green Point found no significant difference between sites in close proximity to the outfall and those further away, suggesting that there was no discernible ecological impact in this area. Similarly, ecological surveys of reef communities in the Camps Bay region found no significant differences between sites in close proximity to the outfall and those further away.

Mussels, rock lobsters and seabream collected from the shoreline and nearshore along the Atlantic seaboard of the Cape Peninsula were found to be accumulating metals in their tissue in variable quantities, but there were no clear trends in spatial distribution to suggest that this was due to wastewater discharge through the outfalls. Increased human health risks associated with the regular consumption of seafood were identified in relation to elevated arsenic concentrations in the tissue of some organisms. Rock lobster tissue analytes posed an increased risk, calculated in terms of the number of excess cancer cases expected in human consumers. Risk factors were calculated using a conservative ('worst-case') assumption of the ratio of inorganic arsenic compounds to total arsenic. No significant spatial relationship found between the location of specimens with higher metal content (including arsenic) and the marine outfalls. The highest arsenic concentrations in the present survey were found at reference sites distant from the outfalls.

Compliance with the permit conditions, which involves comparison to suitable reference sites, was achieved for most parameters during the study period. Many of the more significant differences between the outfall AMZs and reference sites were attributed to environmental, rather than anthropogenic, causes.

Wastewater discharge through the Green Point, Camps Bay and Hout Bay outfalls was not found in these surveys to be having a major ecological impact, nor to have posed significant additional risks to beneficial users within the study area. This does not mean that there are no impacts associated with the offshore discharge of wastewater, but only that the assimilative capacity of the marine receiving environments for the Camps Bay, Green Point, and Hout Bay marine outfalls has not, at this time, been exceeded for the analytes and indicators investigated.

This report presents the first year of monitoring data from an integrated monitoring programme that will repeat certain monitoring on a seasonal or annual basis, as well as examining parameters not yet assessed during the 2024/2025 surveys.

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APPENDICES

Appendix I: Methodology and Metadata

Appendix II: Water Quality Guidelines, Data Tables and Supplementary Figures

Appendix III: Microplastics Data Tables and Supplementary Figures

Appendix IV: Sediment Data Tables

Appendix V: Bioaccumulation Data Tables

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APPENDIX I: METHODOLOGY AND METADATA

BACKGROUND

The Monitoring Programme was developed based on desktop data from previous monitoring studies (CSIR, 2017; Lwandle, 2020; CLS, 2021, 2022), effluent dispersion modelling (PRDW, 2020a, 2020b, 2021), permit conditions and environmental legislation, and environmental conditions including coastal bathymetry and the distribution of stormwater outlets and other infrastructure. This section describes adjustments and adaptations to methods set out in the approved Monitoring Programme made during implementation, in response to variable onsite conditions and other factors.

WATER QUALITY MONITORING METHODS

Water quality sampling was conducted in line with the approved Monitoring Programme, comprising boat-based in-field measurements of physico-chemical parameters and the collection of water samples for analysis by accredited analytical laboratories. Methods of implementation are described in detail in the Monitoring Programme (Clark *et al.*, 2024) and listed briefly in Chapter 2 of this report.

Planned Sampling Sites

Table 1 Planned sampling sites for water quality around the Camps Bay marine outfall and the Karbonkelberg reference site

Site ID	Site Type	Longitude	Latitude
CB001	Offshore screen	18.36295	-33.94187
CB002	Mid-shore screen	18.36602	-33.94121
CB003	Near-shore screen	18.36816	-33.94279
CB004	Allowable mixing zone	18.36573	-33.94263
CB005	Allowable mixing zone	18.36798	-33.94364
CB006	Allowable mixing zone	18.36570	-33.94788
CB007	Allowable mixing zone	18.36272	-33.94639
CB008	Allowable mixing zone	18.36273	-33.94370
CB009	Near-shore screen	18.37476	-33.93779
CB010	Near-shore screen	18.37335	-33.93907
CB011	Near-shore screen	18.36983	-33.93860
CB012	Near-shore screen	18.36929	-33.94354
CB013	Near-shore screen	18.37182	-33.94611
CB014	Near-shore screen	18.37468	-33.94760
CB015	Near-shore screen	18.37453	-33.95094
CB016	Near-shore screen	18.37239	-33.95516
CB017	Allowable mixing zone	18.36854	-33.94666
KB001	Reference	18.29961	-34.02821

Table 2 Planned sampling sites for water quality around the Green Point marine outfall and the Robben Island reference site

Site ID	Site Type	Longitude	Latitude
GP001	Near-shore screen	18.41047	-33.89672
GP002	Near-shore screen	18.40786	-33.89705
GP003	Near-shore screen	18.39753	-33.89843
GP004	Near-shore screen	18.39463	-33.90471
GP005	Near-shore screen	18.38919	-33.90763
GP006	Mid-shore screen	18.40570	-33.89105
GP007	Mid-shore screen	18.40071	-33.89280
GP008	Mid-shore screen	18.39579	-33.89436
GP009	Mid-shore screen	18.39049	-33.89586
GP010	Mid-shore screen	18.38543	-33.89757
GP011	Allowable mixing zone	18.39452	-33.88854
GP012	Allowable mixing zone	18.39016	-33.89079
GP013	Allowable mixing zone	18.39293	-33.88620
GP014	Allowable mixing zone	18.38826	-33.88843
GP015	Allowable mixing zone	18.38946	-33.88582
GP016	Offshore screen	18.39856	-33.88829
GP017	Allowable mixing zone	18.39333	-33.89084
GP018	Other point source	18.44260	-33.89786
GP019	Other point source	18.46912	-33.89412
GP043	Offshore screen	18.40083	-33.88413
RI001	Reference	18.34543	-33.81599

Table 3 Planned sampling sites for water quality around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites

Site ID	Site Type	Longitude	Latitude
CF001	Reference	18.30600	-34.17078
CP001	Reference	18.33635	-34.09141
HB001	Near-shore screen	18.35043	-34.04915
HB002	Near-shore screen	18.35465	-34.04877
HB003	Near-shore screen	18.35946	-34.05005
HB004	Mid-shore screen	18.34969	-34.05589
HB005	Mid-shore screen	18.35511	-34.05529
HB006	Mid-shore screen	18.36007	-34.05564
HB007	Near-shore screen	18.32878	-34.06012
HB008	Outer-bay screen	18.35000	-34.06046
HB009	Outer-bay screen	18.35566	-34.06058
HB010	Outer-bay screen	18.36213	-34.06063
HB011	Allowable mixing zone	18.34299	-34.06444
HB012	Allowable mixing zone	18.34630	-34.06785
HB013	Allowable mixing zone	18.34051	-34.06567
HB014	Allowable mixing zone	18.34368	-34.06957
HB015	Allowable mixing zone	18.34615	-34.06561
HB016	Allowable mixing zone	18.34027	-34.06854

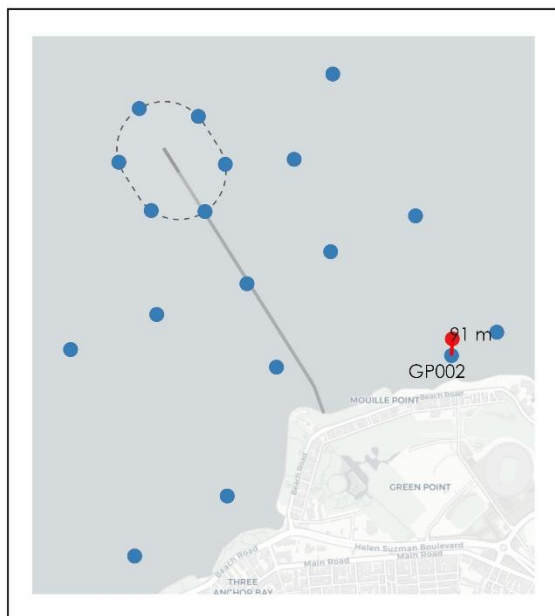
Sampling site location adjustments

During the first sampling efforts in July 2024, various minor amendments to the sampling sites were required to fit them to conditions encountered in-field. Most notably, sampling sites in Camps Bay were adjusted to avoid subsurface reefs and other hazards to boat-based sampling in the complex nearshore environment of this coastline. Inshore sites at Green Point were also adjusted to avoid very shallow conditions encountered during low tide. Outfall area sites were adjusted by between 49 and 149 metres relative to the approved Monitoring Programme, but within the general area and achieving the same intended outcomes. Reference sites were moved between 373 and 1053 m after the first two months of monitoring to ensure depths were similar to their respective outfalls. Finalised sampling stations are mapped in Figure 1 to Figure 3 and the details of the relocated sites are listed in Table 1, Table 2 and Table 3.

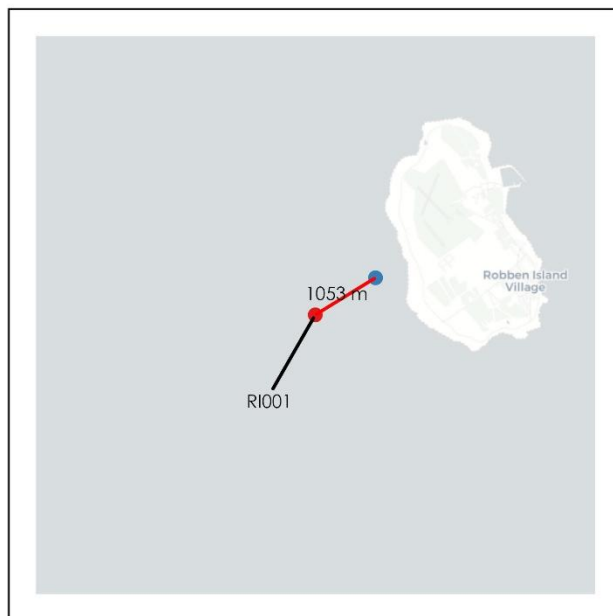
Table 4 Water quality monitoring sites that were moved relative to the original monitoring plan submitted to DFFE.

Outfall	Site ID	Site Type	Distance moved (m)	Reason	Month Changed
CB	CB005	Allowable mixing zone	94	Navigation danger due to rocks	Jul 2024
CB	CB012	Allowable mixing zone	49	Navigation hazard	Jul 2024
CB	KB001	Reference	373	Adjustment to depth	Sep 2024
GP	GP002	Near-shore screen	91	Navigation hazard due to reef	July 2024
GP	RI001	Reference	1053	Adjustment to depth	Sep 2024
HB	CF001	Reference	487	Adjustment to depth	Oct 2024
HB	CP001	Reference	690	Adjustment to depth	Oct 2024
HB	HB007	Near-shore screen	149	Navigation hazard due to surf	Jul 2024

Green Point



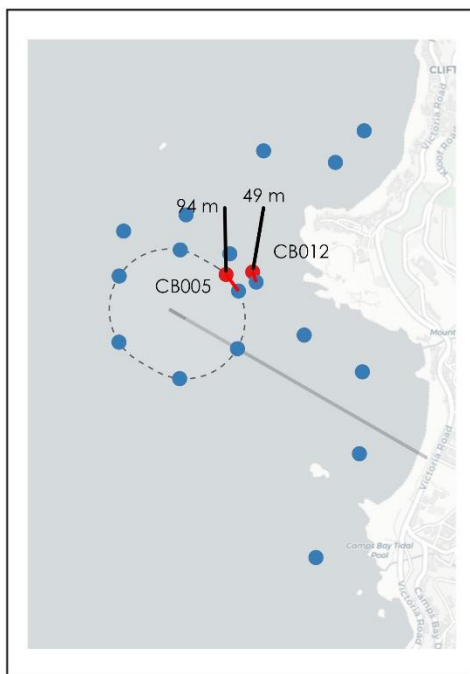
Robben Island



Moved
 Original

Figure 1. Sampling sites around the Green Point marine outfall for water quality, showing the sites that were moved relative to the monitoring plan.

Camps Bay



Moved
 Original

Karbonkelberg

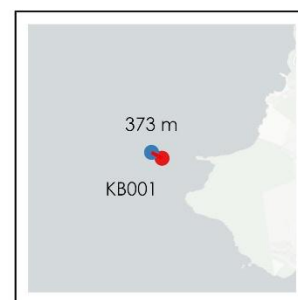


Figure 2. Sampling sites around the Camps Bay marine outfall for water quality, showing the sites that were moved relative to the monitoring plan.

HB: Reference



HB

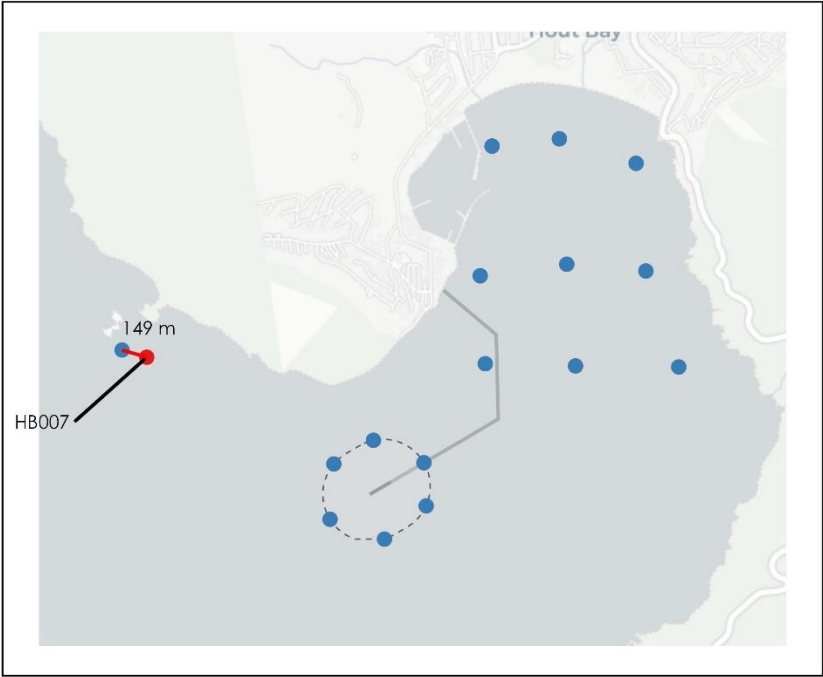


Figure 3. Sampling sites around the Hout Bay marine outfall for water quality, showing the sites that were moved relative to the monitoring plan.

Missed samples

During the 12 months reported on here, a total of 2044 samples of seawater were collected and analysed in line with the monitoring programme. A total of 11 samples were not successfully collected, due either to sampler error (9 cases) or weather, rough seas and other navigational hazards preventing safe access to a sample site (2 cases). Data for these 11 analyses are therefore excluded from the reporting.

The reference site KB001 was sampled twice in August 2024 (three additional samples). This was because the Camps Bay outfall was sampled over two days due to bad weather, and it was decided to resample the reference site on both days so that the reference site samples would provide valid comparisons to samples on both days.

Table 5. 11 out of the planned 2364 samples were not collected during the first year of the marine outfalls monitoring plan.

Month	Site ID	Depth Level	Reason
July 2024	GP006	B	Sampler error
July 2024	GP006	M	
July 2024	GP006	S	
July 2024	GP009	B	Sampler error
July 2024	GP009	M	
July 2024	GP009	S	

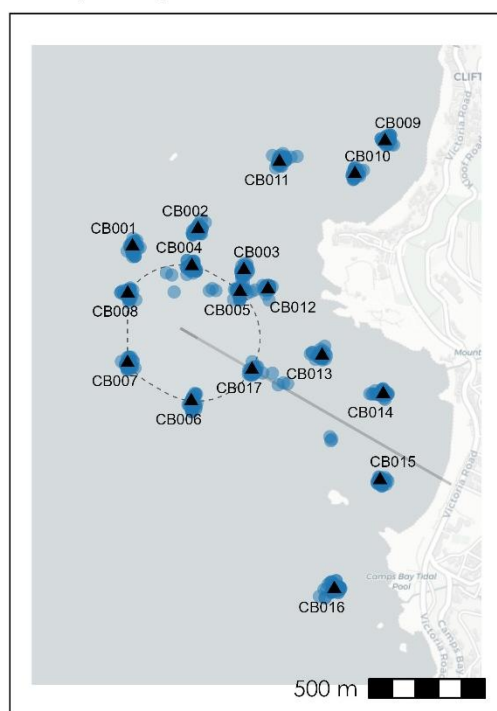
Month	Site ID	Depth Level	Reason
August 2024	RI001	B	Unsafe conditions
August 2024	RI001	M	
October 2024	CB002	B	Sampler error
October 2024	CB002	M	
October 2024	CB002	S	

Site location accuracy

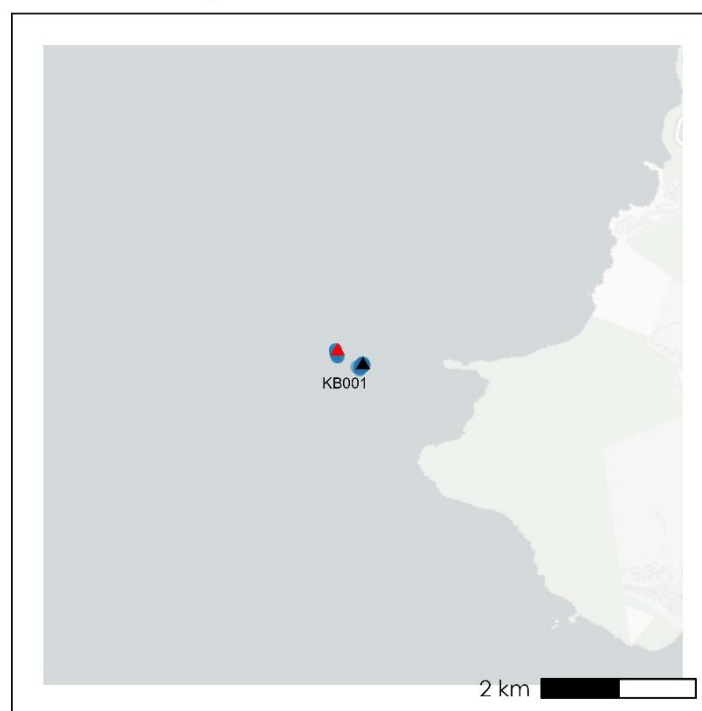
Sampling was conducted from a small (6 or 8 metre) rigid inflatable craft. Operational safety limits established for sampling were that forecasted swell should not exceed 4 metres and winds should not be in excess of 25 knots.

These operational limits still often encompassed rainy conditions, rough seas and strong winds, in an effort to ensure that the data reflect a representative range of sea conditions.

Camps Bay



Karbonkelberg



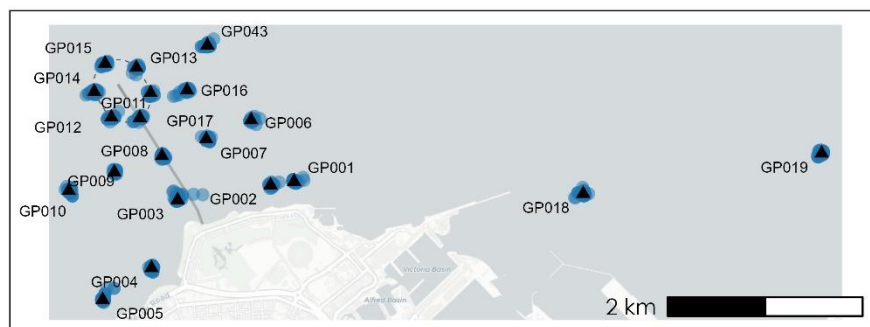
Actual
 Original
 Planned

Figure 4. Actual sampling locations of all samples around the Camps Bay marine outfall and Karbonkelberg reference site, relative to approved monitoring programme. Red triangles show the locations of sites that were moved.

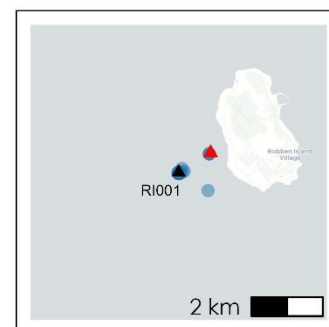
Sampling was carried out from small vessels equipped with basic geographic positioning systems (GPS) and sampling station accuracy was therefore affected both by the absolute accuracy of these systems ($\pm 3\text{m}$) and more significantly, by the effects of wind and currents during the time elapsed between deploying and retrieving instruments and sampling vessels at depths of up to 40 metres. An accuracy threshold of 30 metres was established for determining whether to re-sample a site in the event of substantial drift. Actual GPS coordinates for each sample were collected on every occasion and form part of the database. On some occasions it was not possible to collect a sample

at the actual GPS location due to weather conditions. In these cases the sample was collected at the nearest safe location.

Green Point



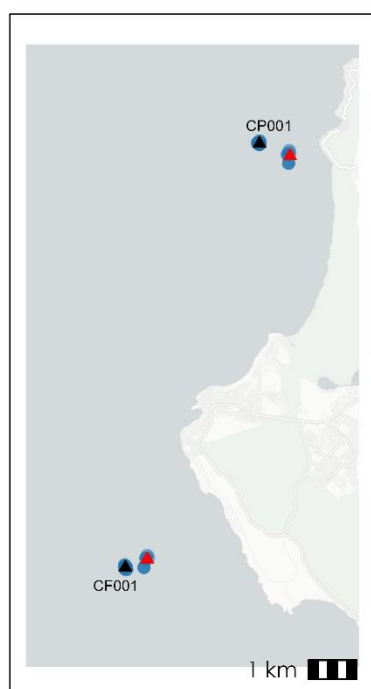
Robben Island



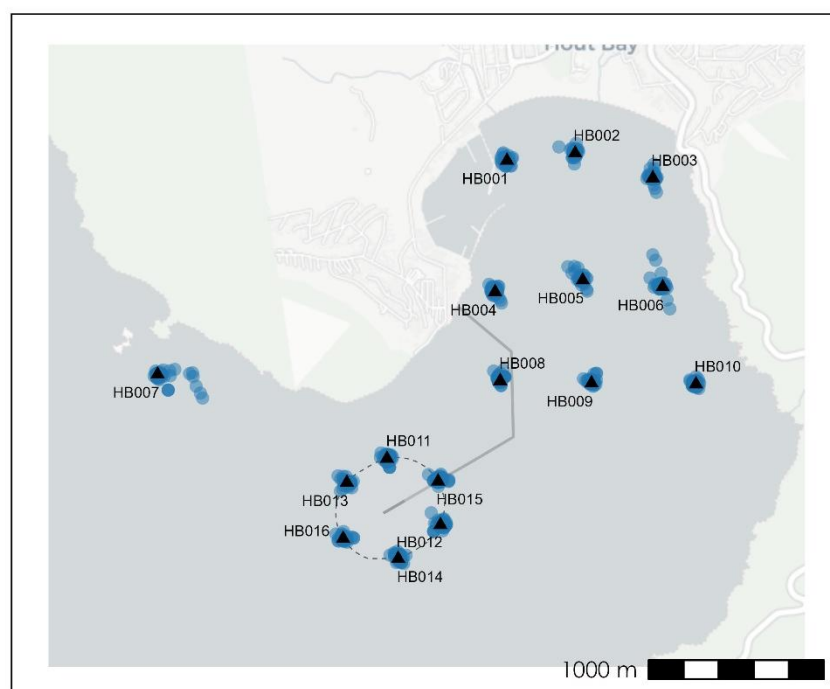
Actual Original Planned

Figure 5. Planned vs actual sampling locations for water samples collected from around the Green Point marine outfall from July 2024 to June 2025. Red triangles show the locations of sites that were moved. GP005 and GP003 are subject to breaking waves during big swell, hence the variability in these sites. The one far-off sample from Robben Island was collected there due to unsafe conditions as a result of large swell.

Chapmans Peak & Crayfish Factory



Hout Bay



Actual Original Planned

Figure 6. Planned vs actual sampling locations for water samples collected from around the Hout Bay marine outfall from July 2024 to June 2025. Red triangles show the locations of sites that were moved. HB007 is a well-known surf spot – as such, sampling is very challenging during big swell. HB005 and HB006 are particularly difficult to sample during strong south-easterly wind conditions.

Depths

The Monitoring Programme requires the collection of data and water samples from three depths at each site: surface, middle, and bottom. Because of the influence of exact sample locations, tide, and weather, depth to bottom was re-measured on each sampling date at each site. The 'bottom' sample was collected at a depth of one metre from the seabed, the 'middle' sample from half of the total depth, rounded up to the nearest half metre, and the 'surface' sample was collected from a consistent one metre below the surface. At inshore sites where depths are less than 4 metres, this sometimes resulted in samples from 1 m, 2m, and 3m depth, with naturally very little distinction in the data among these depths.

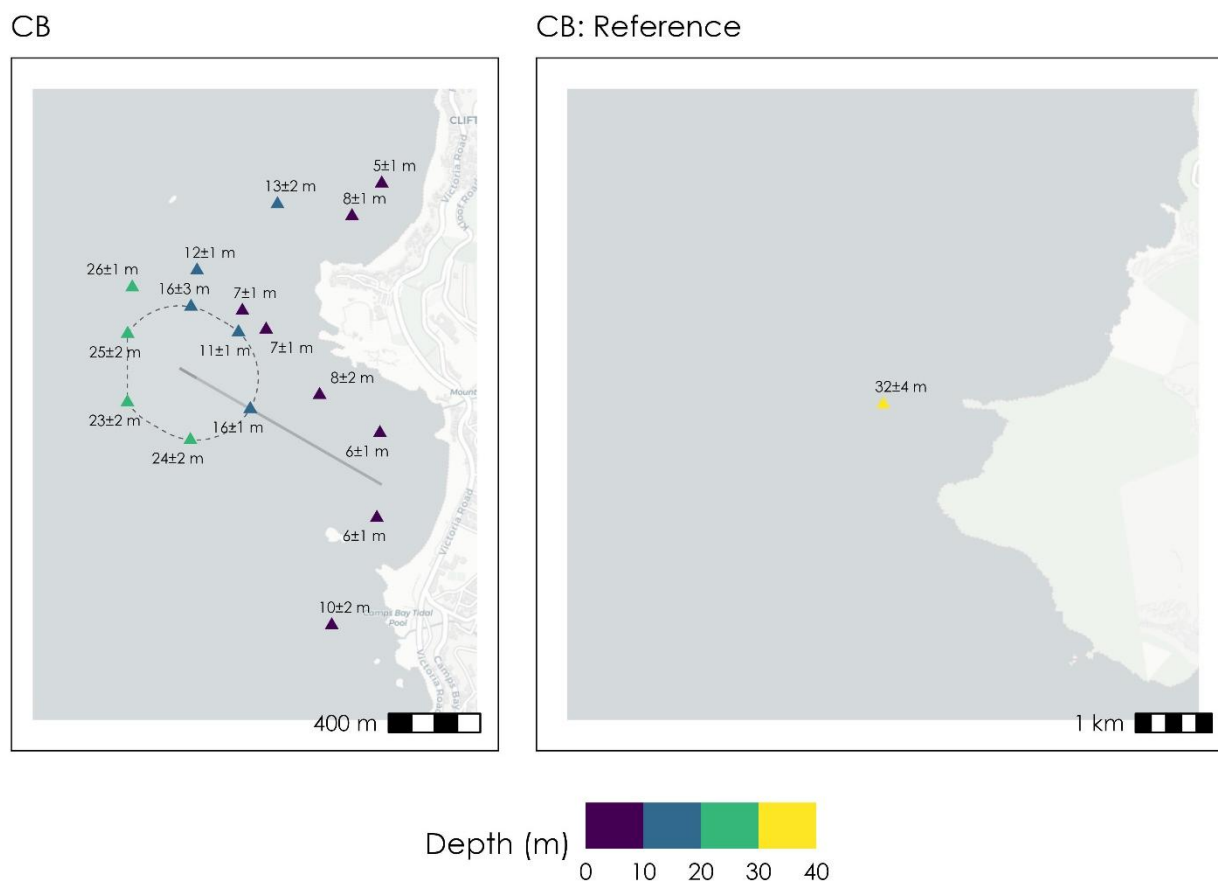


Figure 7. Mean (+SD) depth of samples collected from July 2024 to June 2025 around the Camps Bay marine outfall. The Camps Bay reference site at Karbonkelberg is also shown.

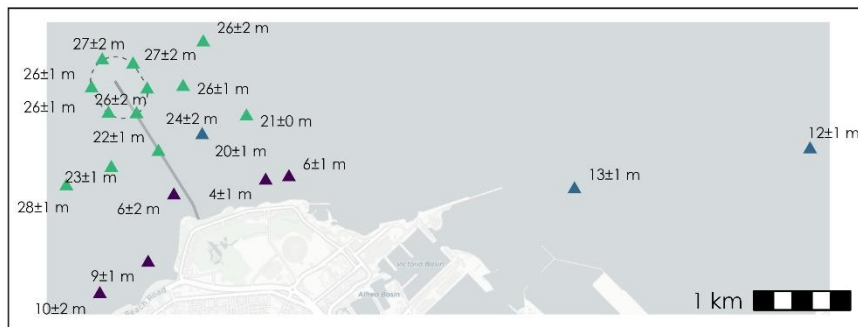
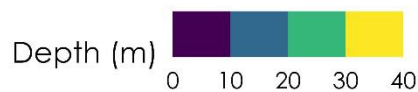
GP**GP: Reference**

Figure 8. Mean (+SD) depth of samples collected from July 2024 to June 2025 around the Green Point marine outfall. The Green Point reference site at Robben Island is also shown.

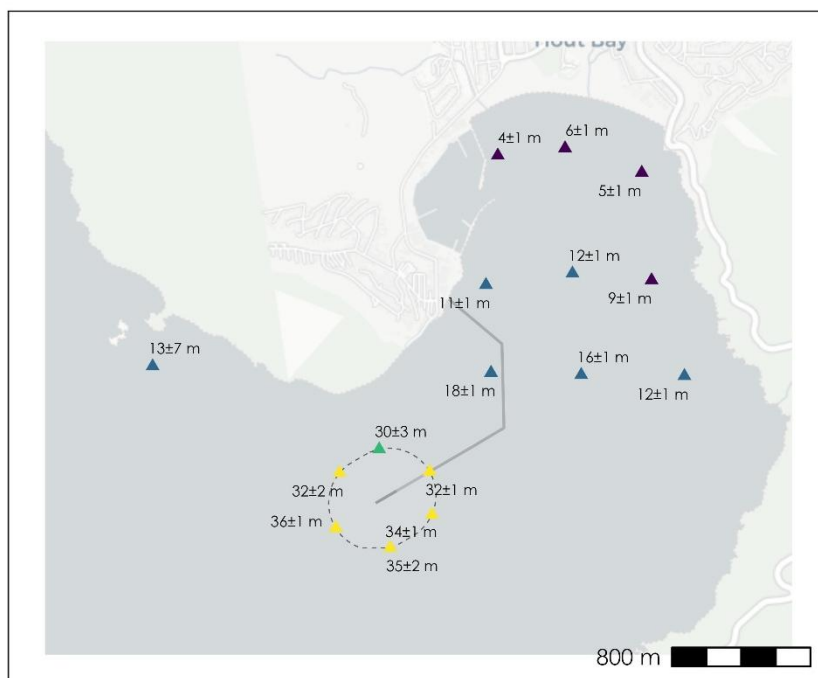
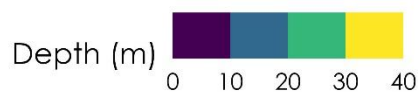
HB**HB: Reference**

Figure 9. Mean (+SD) depth of samples collected from July 2024 to June 2025 around the Hout Bay marine outfall. The Hout Bay reference sites at Chapman's Peak and Crayfish Factory are also shown.

SEDIMENT METHODS

Sediment sampling was conducted in line with the approved Monitoring Programme, comprising boat-based and diver collection of sediments, and analysis by accredited laboratories for physical parameters and sediment chemistry. Methods of implementation are described in Chapter 4 of the Annual Report.

Missed/moved samples

A comprehensive set of sediment sampling stations was located around each outfall, and efforts were made to sample sediment at the planned sites through both boat-based grab sampling and diver surveys. For sites around the Camps Bay and Hout Bay outfalls, one or more of these methods was successful in obtaining sufficient sample volume in most cases. At Green Point, however, substrates are solid bedrock or boulders with very limited or no fine sediment accumulation. Most sites at Green Point were therefore not successfully sampled for sediment quality analysis, and only those stations further east in Table Bay near the mouths of the Diep and Salt Rivers, and near the entrance of the Port of Cape Town, were successfully sampled for sediment. Where repeated failures occurred at a site, sampling stations were in some cases relocated to obtain sediment from a site near the intended location. The Monitoring Programme was also adjusted during implementation by the addition of sample replicates for sediment collected at environmental control / reference sites. Triplicate samples were collected from the Robben Island, Karbonkelberg, Chapman's Peak, and Crayfish Factory reference sites to allow for statistical comparisons between impact sites and reference sites. Refer to Table 6 to Table 10 and Figure 10 to Figure 12.

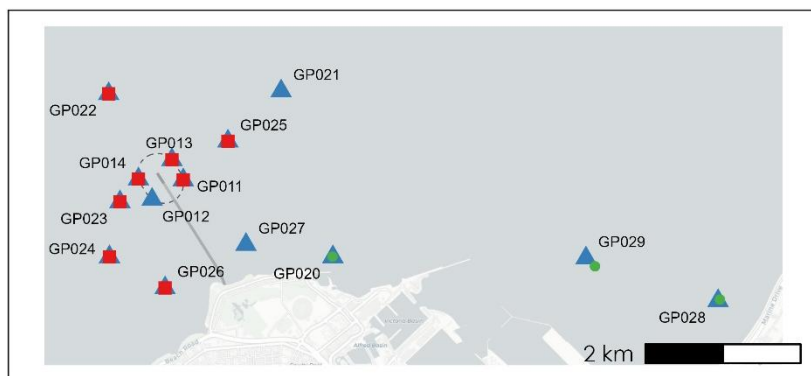
Table 6 List of planned sediment sample sites around the Green Point marine outfall showing which sites were successfully sampled for sediment, at which sites a drop camera was deployed, which sites were moved and how far, as well as comments regarding the collection and movement of sites.

Site ID	Outfall	Replicate	Sampled	Drop Camera	Distance Moved (km)	Comments
GP011	GP	A		✓		No sediment found
GP012	GP	A		✓		No sediment found
GP013	GP	A		✓		No sediment found
GP014	GP	A		✓		No sediment found
GP020	GP	A	✓	✓		
GP021	GP	A		✓		No sediment found
GP022	GP	A		✓		No sediment found
GP023	GP	A		✓		No sediment found
GP024	GP	A		✓		No sediment found
GP025	GP	A		✓		No sediment found
GP026	GP	A		✓		No sediment found
GP027	GP	A				No sediment found
GP028	GP	A	✓			
GP029	GP	A	✓			
RI001	GP	A	✓	✓	6.52	No sediment found at original location
RI001	GP	B	✓	✓	6.53	No sediment found at original location
RI001	GP	C	✓	✓	6.57	No sediment found at original location

Table 7 Planned and actual locations, as well as depth, of sediment samples collected in February 2025 near the Green Point marine outfall and the Robben Island reference sites.

Site ID	Replicate	Planned		Actual		Depth (m)
		Longitude	Latitude	Longitude	Latitude	
GP020	A	18.41539	-33.89743	18.41534	-33.89741	10.7
GP028	A	18.46914	-33.90250	18.46940	-33.90237	10.2
GP029	A	18.45070	-33.89757	18.45196	-33.89852	14.4
RI001	A	18.34543	-33.81599	18.38387	-33.77929	33.2
RI001	B	18.34543	-33.81599	18.38314	-33.77862	33.5
RI001	C	18.34543	-33.81599	18.38205	-33.77755	31.6

Green Point



Robben Island

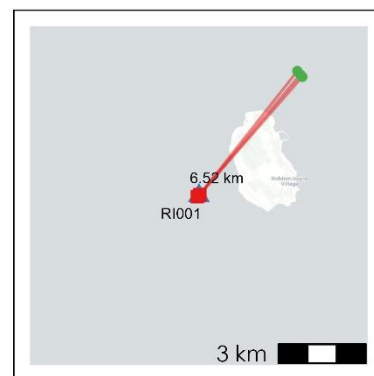


Figure 10. Locations of planned sediment samples, actual sediment samples and drop camera deployments (where sediment samples could not be collected) near the Green Point marine outfall and the Robben Island reference site. Samples were collected in February 2025.

Table 8 List of planned sediment sample sites around the Camps Bay marine outfall showing which sites were successfully sampled for sediment, at which sites a drop camera was deployed, which sites were moved and how far, as well as comments regarding the collection and movement of sites.

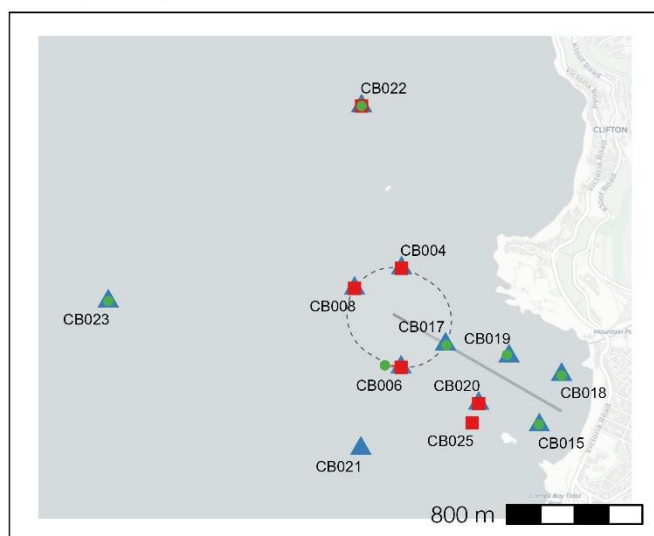
Site ID	Outfall	Replicate	Sampled	Drop Camera	Distance Moved (km)	Comments
CB004	CB	A		✓		No sediment found
CB006	CB	A	✓	✓		
CB008	CB	A		✓		No sediment found
CB015	CB	A	✓			
CB017	CB	A	✓			
CB018	CB	A	✓			
CB019	CB	A	✓			
CB020	CB	A		✓		No sediment found
CB021	CB	A				No sediment found
CB022	CB	A	✓	✓		
CB023	CB	A	✓	✓		
KB001	CB	A	✓		2.91	No sediment found at original location

Site ID	Outfall	Replicate	Sampled	Drop Camera	Distance Moved (km)	Comments
KB001	CB	B	✓		2.92	No sediment found at original location
KB001	CB	C	✓		2.93	No sediment found at original location

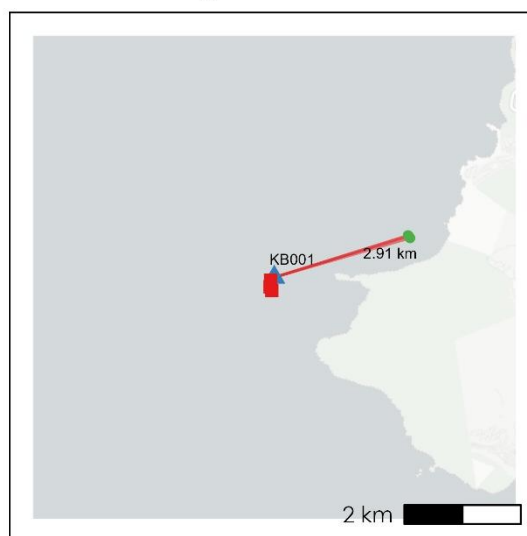
Table 9 Planned and actual locations, as well as depth, of sediment samples collected in February 2025 near the Camps Bay marine outfall and the Karbonkelberg reference site

Site ID	Replicate	Planned		Actual		Depth (m)
		Longitude	Latitude	Longitude	Latitude	
CB006	A	18.36570	-33.94788	18.36467	-33.94777	28.7
CB015	A	18.37453	-33.95094	18.37450	-33.95090	9.2
CB017	A	18.36854	-33.94666	18.36860	-33.94671	17.7
CB018	A	18.37595	-33.94827	18.37595	-33.94831	5.9
CB019	A	18.37260	-33.94729	18.37246	-33.94722	11.0
CB022	A	18.36318	-33.93405	18.36318	-33.93405	28.6
CB023	A	18.34700	-33.94437	18.34700	-33.94437	50.3
KB001	A	18.29961	-34.02821	18.32453	-34.02173	26.0
KB001	B	18.29961	-34.02821	18.32465	-34.02182	23.1
KB001	C	18.29961	-34.02821	18.32492	-34.02214	20.8

Camps Bay



Karbonkelberg



Drop Camera
 Planned
 Sediment

Figure 11 Locations of planned sediment samples, actual sediment samples and drop camera deployments (where sediment samples could not be collected) near the Camps Bay marine outfall and the Karbonkelberg reference site. Samples were collected in February 2025.

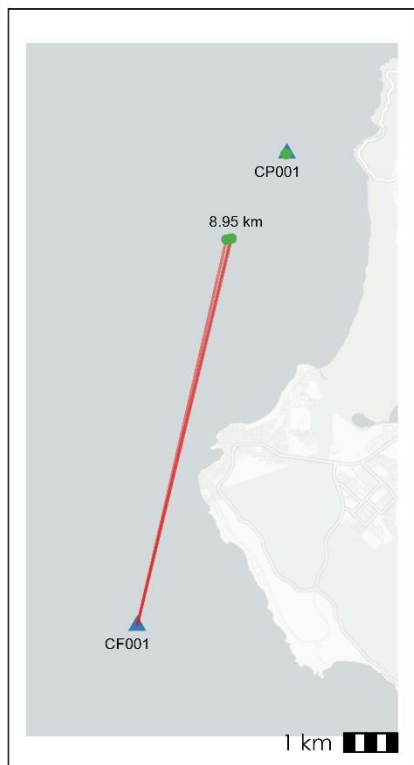
Table 10 List of planned sediment sample sites around the Camps Bay marine outfall showing which sites were successfully sampled for sediment, at which sites a drop camera was deployed, which sites were moved and how far, as well as comments regarding the collection and movement of sites.

Site ID	Outfall	Replicate	Sampled	Drop Camera	Distance Moved (km)	Comments
CF001	HB	A	✓		8.95	No sediment found at original location
CF001	HB	B	✓		8.99	No sediment found at original location
CF001	HB	C	✓		9.00	No sediment found at original location
CP001	HB	A	✓			
CP001	HB	B	✓			
CP001	HB	C	✓			
HB002	HB	A	✓			
HB011	HB	A	✓			
HB012	HB	A	✓			
HB013	HB	A				
HB014	HB	A	✓			
HB015	HB	A	✓			
HB016	HB	A	✓			
HB027	HB	A	✓			
HB028	HB	A	✓			
HB029	HB	A	✓			
HB030	HB	A	✓			
HB033	HB	A	✓			
HB034	HB	A	✓			
HB035	HB	A	✓			
HB036	HB	A				
HB037	HB	A	✓			
HB038	HB	A	✓			

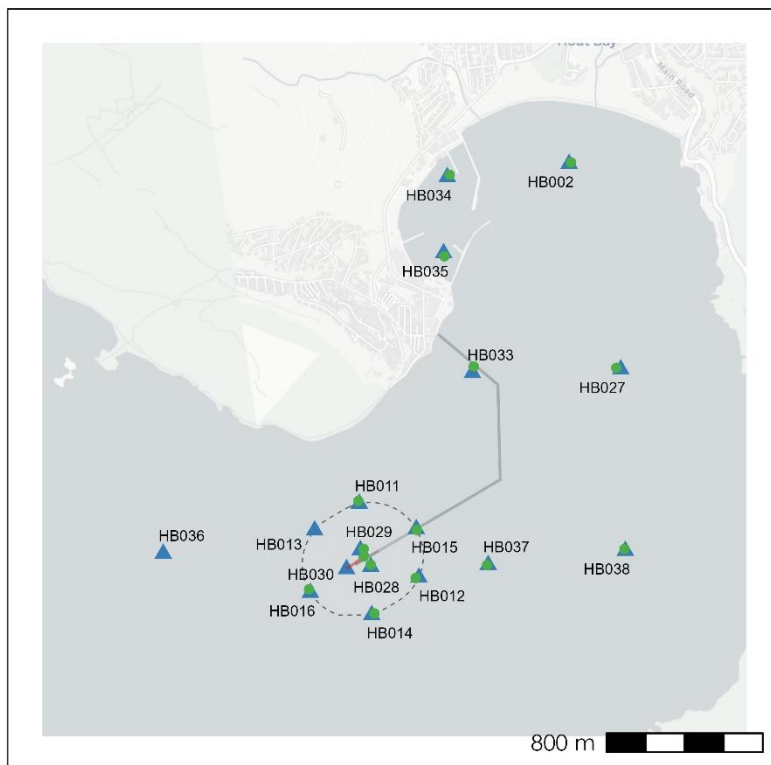
Table 11 Planned and actual locations, as well as depth, of sediment samples collected in February 2025 near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites.

Site ID	Replicate	Planned		Actual		Depth (m)
		Longitude	Latitude	Longitude	Latitude	
CF001	A	18.30600	-34.17078	18.32409	-34.10590	42.1
CF001	B	18.30600	-34.17078	18.32492	-34.10577	40.7
CF001	C	18.30600	-34.17078	18.32515	-34.10573	40.5
CP001	A	18.33635	-34.09141	18.33625	-34.09156	36.5
CP001	B	18.33635	-34.09141	18.33620	-34.09154	38.0
CP001	C	18.33635	-34.09141	18.33607	-34.09151	36.0
HB002	A	18.35465	-34.04877	18.35476	-34.04871	7.6
HB011	A	18.34299	-34.06444	18.34293	-34.06432	32.4
HB012	A	18.34630	-34.06785	18.34612	-34.06787	38.6
HB014	A	18.34368	-34.06957	18.34383	-34.06950	39.7
HB015	A	18.34615	-34.06561	18.34618	-34.06565	34.0
HB016	A	18.34027	-34.06854	18.34019	-34.06839	39.7
HB027	A	18.35752	-34.05825	18.35727	-34.05818	16.1
HB028	A	18.34363	-34.06735	18.34362	-34.06726	41.3
HB029	A	18.34305	-34.06658	18.34323	-34.06653	42.1
HB030	A	18.34228	-34.06745	18.34324	-34.06688	40.2
HB033	A	18.34927	-34.05842	18.34935	-34.05811	10.0
HB034	A	18.34788	-34.04938	18.34801	-34.04928	5.4
HB035	A	18.34767	-34.05289	18.34771	-34.05304	7.7
HB037	A	18.35015	-34.06727	18.35009	-34.06727	29.9
HB038	A	18.35777	-34.06661	18.35772	-34.06653	20.9

Chapmans Peak & Crayfish Factory



Hout Bay



Drop Camera
 Planned
 Sediment

Figure 12. Locations of planned sediment samples, actual sediment samples and drop camera deployments (where sediment samples could not be collected) near the Hout Bay marine outfall as well as the Chapmans Peak and Crayfish Factory reference sites. Samples were collected in February 2025.

Summary of implementation data for sediment monitoring

Table 12 Total number of sediment samples collected per outfall, broken down by sampling station type. Reference sites were sampled in triplicate.

Outfall	Mixing Zone	Proximal	Reference	Known Point Source	End Of Pipe
CB	4	3	3	-	-
GP	-	1	3	2	-
HB	5	4	6	3	3

Summary of implementation data for bioaccumulation monitoring

Table 13 Sampling locations for bream, rock lobster and mussels near the Camps Bay marine outfall and the Karbonkelberg reference site. Sampling took place in February 2025.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
CB024	A	18.36519	-33.94505	18.36519	-33.94505	-	-
CB025	A	18.37025	-33.95082	18.37025	-33.95082	-	-

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
CB026	A	18.36762	-33.95902	18.36762	-33.95902	-	-
CB026	B	18.36762	-33.95902	-	-	-	-
CB027	A	18.37416	-33.95730	-	-	-	-
CB028	A	-	-	-	-	18.37455	-33.95248
CB029	A	-	-	-	-	18.37202	-33.96056
CB030	A	-	-	-	-	18.37652	-33.95773
CB031	A	-	-	-	-	18.37091	-33.94362
KB001	A	18.29961	-34.02821	18.29961	-34.02821	-	-
KB001	B	18.29961	-34.02821	18.29961	-34.02821	-	-
KB001	C	18.29961	-34.02821	18.29961	-34.02821	-	-
KB002	A	-	-	-	-	18.31075	-34.02778
KB002	B	-	-	-	-	18.31075	-34.02778
KB002	C	-	-	-	-	-	-

Table 14 Sampling locations for bream, rock lobster and mussels near the Green Point marine outfall and the Robben Island reference site. Sampling took place in February 2025.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
GP002	A	18.40786	-33.89705	18.40786	-33.89705	-	-
GP019	A	-	-	-	-	-	-
GP030	A	18.39575	-33.90376	18.39575	-33.90376	-	-
GP031	A	18.37813	-33.91725	18.37813	-33.91725	-	-
GP033	A	18.41957	-33.90050	18.41957	-33.90050	-	-
GP034	A	18.45982	-33.91139	18.45982	-33.91139	-	-
GP035	A	-	-	-	-	18.37946	-33.92047
GP036	A	-	-	-	-	-	-
GP037	A	-	-	-	-	18.40811	-33.89898
GP038	A	-	-	-	-	18.42065	-33.90157
GP039	A	-	-	-	-	18.46008	-33.91201
GP040	A	-	-	18.39126	-33.88824	-	-
RI001	A	18.35572	-33.81103	18.37687	-33.79714	-	-
RI001	B	18.35572	-33.81103	18.37687	-33.79714	-	-
RI001	C	18.35572	-33.81103	18.37687	-33.79714	-	-
RI002	A	-	-	-	-	18.35572	-33.81103
RI002	B	-	-	-	-	18.35572	-33.81103
RI002	C	-	-	-	-	18.35572	-33.81103

Table 15 Sampling locations for bream, rock lobster and mussels near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Sampling took place in February 2025.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
CF001	A	18.32748	-34.16930	18.30600	-34.17078	-	-
CF001	B	18.32748	-34.16930	18.30600	-34.17078	-	-
CF001	C	-	-	18.30600	-34.17078	-	-
CF002	A	-	-	-	-	18.34490	-34.17831
CF002	B	-	-	-	-	18.34490	-34.17831
CF002	C	-	-	-	-	18.34490	-34.17831
CP001	A	18.34614	-34.09259	-	-	-	-
CP001	B	18.34614	-34.09259	18.34614	-34.09259	-	-
CP001	C	18.34614	-34.09259	18.34614	-34.09259	-	-
CP002	A	-	-	-	-	18.34614	-34.09259
CP002	B	-	-	-	-	18.34614	-34.09259
CP002	C	-	-	-	-	18.34614	-34.09259
HB001	A	18.34985	-34.05179	18.34985	-34.05179	-	-
HB003	A	18.36230	-34.05326	-	-	-	-
HB017	A	18.34925	-34.06485	18.34925	-34.06485	-	-
HB017	B	-	-	18.34925	-34.06485	-	-
HB017	C	-	-	18.34925	-34.06485	-	-
HB018	A	18.34750	-34.05783	-	-	-	-
HB019	A	18.36420	-34.05855	-	-	-	-

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
HB020	A	18.35690	-34.07548	-	-	-	-
HB021	A	-	-	-	-	18.34985	-34.05179
HB022	A	-	-	-	-	18.34750	-34.05783
HB023	A	-	-	-	-	18.36147	-34.04989
HB024	A	-	-	-	-	18.36420	-34.05855
HB025	A	-	-	-	-	18.34107	-34.06143
HB026	A	-	-	-	-	18.35690	-34.07548

City of Cape Town Marine Wastewater Outfalls:
Receiving Environment Monitoring Report 2024/2025

APPENDIX II: WATER QUALITY GUIDELINES, DATA TABLES AND SUPPLEMENTARY FIGURES

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Guidelines and Permit Conditions for Water Quality

Table 1. Receiving water quality substance/parameters and target values for the natural environment at the end of the Hout Bay outfall mixing zone [Permits for Green Point and Camps Bay do not specify limits]

Substance / parameter	Target value / Concentration
pH	7.3 – 8.6
Salinity	$33 \times 10^{-3} - 36 \times 10^{-3}$
Temperature	The maximum acceptable variation in ambient temperature is 1°C
Total suspended solids	Not increased by more than 10% of the ambient concentration
Turbidity / Colour	Turbidity and colour acting singly or in combination should not reduce the depth of the euphotic zone by more than 10% of background levels
Dissolved oxygen	Should not fall below 5 mg/l (99% of the time) and below 6 mg/l (95% of the time)

Table 2. South African Water Quality Guidelines for Coastal Marine Waters: Summary of Recommended Target Values for Recreational Use

INDICATOR	RECOMMENDED TARGET
Objectionable Matter	Water should not contain litter, floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance. Water should not contain materials from non-natural land-based sources which will settle to form objectionable deposits. Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use. Water should not contain substances producing objectionable colour, odour, taste, or turbidity.
INDICATOR	RECOMMENDED TARGET
pH	pH of water should be within the range 5.0-9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.
Temperature	For prolonged exposure, temperatures should be in the range 15 - 35 °C
INDICATOR	RECOMMENDED TARGET
pH	pH of water should be within the range 5.0-9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.
Temperature	For prolonged exposure, temperatures should be in the range 15 - 35 °C

Table 2 cont. Risk-based ranges for intestinal enterococci (microbiological indicator organisms)

CATEGORY	ESTIMATED RISK PER EXPOSURE	ENTEROCOCCI (Count per 100 ml)
Excellent	2.9% gastrointestinal (GI) illness risk	≤ 100 (95 percentile)
Good	5% GI illness risk	≤ 200 (95 percentile)
Sufficient or Fair (minimum requirement)	8.5% GI illness risk	≤ 185 (95 percentile)
Poor (unacceptable)	>8.5% GI illness risk	> 185 (95 percentile)

Table 3. Water quality guidelines for physico-chemical properties of seawater as contained in the 1995 DWAF guidelines for the Natural Environment (DWAF 1995b) and the draft 2022 Water Quality Guidelines for Coastal Marine Waters: Volume 1: Natural Environment and Mariculture Use (DEA 2024).

Category	Parameter	DWAF (1995) Guideline	DEA (2022) Guideline
Objectionable matter	Objectionable matter	Water should not contain floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance; Water should not contain materials from non-natural land-based sources which will settle to form putrescence; Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use	Coastal and marine waters should not contain - - floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance; - materials from non-natural land-based sources which will settle to form putrescence; - submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use
Physico-chemical properties	Temperature (°C)	The maximum acceptable variation in ambient temperature is + or - 1° C.	Guideline values must be derived from a reference system (data set) that is appropriate to the discharge locality and should be determined as the range defined by the 20 th and 80 th %iles of the seasonal and/or event-driven distributions for the reference system. Test data: Median concentration for the period. If sufficient data do not exist for the discharge locality, data such be extrapolated from the closest or most appropriate alternative point and effort must be made to accumulate necessary data as soon as discharge commences.
	Salinity	The target range for the South African coastal zone is 33-36 ppt.	Human activities should not cause the salinity (expressed as, parts per thousand) of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth.

Category	Parameter	DWAF (1995) Guideline	DEA (2022) Guideline
	pH	The target range for the South African coastal zone is 7.3-8.2	Guideline values must be derived from a reference system (data set) that is appropriate to the discharge locality and should be determined as the range defined by the 20 th and 80 th %iles of the of seasonal and/or event-driven distributions for the reference system. pH changes of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated. Test data: Median concentration for the period
	Total suspended solids (TSS)	The concentration of total suspended solids should not be increased by more than 10% of the ambient concentration.	Guideline values must be derived from a reference system (data set) that is appropriate to the discharge locality and should not exceed the 80 th %ile of the seasonal and/or event-driven distributions. Test data: Median concentration for period. Additionally, the natural euphotic depth (Z_{eu}) should not be permitted to change by more than 10%.
	Turbidity (including colour and euphotic zone)	Turbidity and colour acting singly or in combination should not reduce the depth of the euphotic zone by more than 10 % of background levels measured at a comparable control site. The colour (substances in solution) of water should not exceed background levels by more than 35 Hazen units.	Guideline values must be derived from a reference system (data set) that is appropriate to the discharge locality and should not exceed the 80 th %ile of seasonal and/or event-driven distributions. Additionally, the natural euphotic depth (Z_{eu}) should not be permitted to change by more than 10%. Test data: Median concentration for period.
	Dissolved Oxygen	For the south and east coasts, the dissolved oxygen should not fall below 5 mg/L (99 % of the time) and below 6 mg/L (95 % of the time). For the west coast, the dissolved oxygen should not fall below 10% of the established natural variation.	Guideline values must be derived from a reference system (data set) that is appropriate to the discharge locality and should not be allowed to drop below the 20 th %ile of the daily, seasonal and/or event-driven distributions. Where possible, guideline values should be obtained during low flow and high temperature periods when DO concentrations are likely to be at their lowest. Test data: Median DO concentration for the period, calculated separately for diurnal and nocturnal periods and different seasons, where appropriate.
Nutrients	Ammonium (NH ₄ ⁺) and ammonia (NH ₃) Measured as total ammonia nitrogen (TAN)	0.02 mg N as NH ₃ 0.60 mg N as NH ₃ + NH ₄ ⁺	As a <i>nutrient</i> : Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/or dissolved oxygen levels that are outside the recommended water quality guideline range. This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, total ammonia nitrogen (TAN) (i.e. NH ₃ and NH ₄ ⁺) concentrations can be derived using the reference system data approach: where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80 th %ile of the reference system(s) distribution.

Category	Parameter	DWAF (1995) Guideline	DEA (2022) Guideline
			Where insufficient or no reference data exists, single guideline values could be derived from available data based on professional judgement, as an interim measure. Toxicity: 600 µg/L
	Nitrate (NO ₃ ⁻)	Waters should not contain concentrations of dissolved nutrients that are capable of causing excessive or nuisance growth of algae or other aquatic plants or reducing dissolved oxygen concentrations below the target range indicated for Dissolved oxygen	As a <i>nutrient</i> : Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/or dissolved oxygen levels that are outside the recommended water quality guideline range. This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the <i>reference system data approach</i> : Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80 th %ile of the reference system(s) distribution. Where insufficient or no reference data exists, single guideline values could be derived from available data based on professional judgement, as an interim measure. Toxicity: Nitrate (NO ₃) = 200 000 µg/L, Nitrate as nitrogen (NO ₃ -N) = 45 000 µg/L
	Nitrite (NO ₂ ⁻)	Waters should not contain concentrations of dissolved nutrients that are capable of causing excessive or nuisance growth of algae or other aquatic plants or reducing dissolved oxygen concentrations below the target range indicated for Dissolved oxygen	As a <i>nutrient</i> : Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/or dissolved oxygen levels that are outside the recommended water quality guideline range. This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the <i>reference system data approach</i> : Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80 th %ile of the reference system(s) distribution. Where insufficient or no reference data exists, single guideline values could be derived from available data based on professional judgement, as an interim measure.
	Phosphorus (P)	Waters should not contain concentrations of dissolved nutrients that are capable of causing excessive or nuisance growth of algae or other aquatic plants or reducing dissolved oxygen concentrations below the target range indicated for Dissolved oxygen	As a <i>nutrient</i> : Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/ or dissolved oxygen levels that are outside the recommended water quality guideline range. This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the <i>reference system data approach</i> : Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80 th %ile of the reference system(s) distribution. Where insufficient or no reference data exists, single guideline values could be derived from available data based on professional judgement, as an interim measure.
	Silicon (Si) as reactive silicate	Waters should not contain concentrations of dissolved	As a <i>nutrient</i> : Nutrient concentrations in the water column should not result in chlorophyll a, turbidity

Category	Parameter	DWAF (1995) Guideline	DEA (2022) Guideline
		nutrients that are capable of causing excessive or nuisance growth of algae or other aquatic plants or reducing dissolved oxygen concentrations below the target range indicated for Dissolved oxygen	and/or dissolved oxygen levels that are outside the recommended water quality guideline range. This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the <i>reference system data approach</i> : Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80 th percentile of the reference system(s) distribution. Where insufficient or no reference data exists, single guideline values could be derived from available data based on professional judgement, as an interim measure.
Toxic substances – Metals	Arsenic (As)	12 µg/L	8 µg/L
	Cadmium (Cd)	4 µg/L	0.12 µg/L
	Chromium (Cr)	8 µg/L	2 µg/L
	Copper (Cu)	5 µg/L	3 µg/L
	Lead (Pb)	12 µg/L	2 µg/L
	Mercury (Hg)	0.30 µg/L	0.016 µg/L
	Nickel (Ni)	25 µg/L	5 µg/L
	Silver (Ag)		0.7 µg/L
	Zinc (Zn)	25 µg/L	20 µg/L
Toxic substances – Inorganic constituents	Chlorine (Cl)	-	3 µg/L
	Fluoride (F ⁻)	5 000 µg/L	5000 µg/L
	Cyanide (CN ⁻)	12 µg/L	1 µg/L
	Sulphide (S ²⁻)	-	2 µg/L
Toxic substances – Organic constituents	Aldrin	-	0.003 µg/L
	Dieldrin	-	0.002 µg/L
	Total DDT ((DDT + DDE + DDD)	-	0.025 µg/L
	Endosulfan	-	0.0005 µg/L
	Acenaphthene	-	20 µg/L
	Anthracene	-	0.1 µg/L
	Benzo(a)pyrene	-	0.00017 µg/L
	Fluoranthene	-	0.0063 µg/L
	Naphthalene	-	2 µg/L
	2,4-Dichlorophenol	-	0.42 µg/L
	2,4,6-Trichlorophenol	-	6.5 µg/L
	Pentachlorophenol	-	0.4 µg/L
	Polychlorinated biphenyls (PCBs)	-	0.000045 µg/L
	Tributyltin	-	0.0002 µg/L

Water Quality Data Tables

Table 4 Water quality parameters measured *in situ*, or soon after sampling, for the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference site.

Site ID	Date	Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
		B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB001	2024-07-22	25.0	13.0	1	7.47	7.59	9.16	89.00	91.00	110.00	54417.00	54250.00	54170.00	35.97	35.85	35.80	8.24	8.24	9.08	13.95	13.98	14.16	1.91	1.05	0.64
CB002	2024-07-22	10.5	6.0	1	7.45	7.87	8.78	89.00	94.00	106.00	54375.00	54114.00	54143.00	35.94	35.75	35.77	8.22	8.24	8.28	13.91	13.87	13.87	1.23	0.66	1.97
CB003	2024-07-22	8.0	4.5	1	8.02	8.43	9.05	96.00	101.00	109.00	54189.00	54070.00	54034.00	35.80	35.72	35.70	8.23	8.26	8.29	13.93	14.00	14.13	2.02	1.37	1.22
CB004	2024-07-22	16.0	8.5	1	7.53	8.45	8.97	90.00	101.00	108.00	54328.00	54020.00	54224.00	35.90	35.68	35.84	8.23	8.27	8.30	13.90	13.98	14.13	2.04	0.89	1.48
CB005	2024-07-22	12.0	6.5	1	7.55	8.13	8.94	90.00	98.00	108.00	54171.00	54046.00	54063.00	35.79	35.70	35.72	8.23	8.24	8.28	13.89	13.95	14.18	2.93	1.58	0.76
CB006	2024-07-22	21.0	11.0	1	7.50	7.72	8.13	90.00	92.00	97.00	54452.00	54256.00	53912.00	35.99	35.85	35.59	8.20	8.21	8.19	13.90	13.86	13.72	0.85	1.14	1.14
CB007	2024-07-22	22.0	11.5	1	7.55	7.78	8.21	90.00	93.00	98.00	54541.00	54346.00	54015.00	36.06	35.92	35.67	8.20	8.21	8.20	13.94	13.87	13.77	1.97	1.10	1.61
CB008	2024-07-22	26.0	13.5	1	7.43	7.60	8.75	89.00	91.00	106.00	54367.00	54340.00	54276.00	35.93	35.91	35.88	8.24	8.25	8.31	13.94	13.91	14.14	1.05	0.40	0.00
CB009	2024-07-22	5.5	4.0	1	7.95	8.05	8.43	95.00	97.00	102.00	54414.00	54237.00	54276.00	35.97	35.84	35.88	8.19	8.20	8.21	13.79	13.99	14.24	6.21	5.04	1.55
CB010	2024-07-22	10.0	5.5	1	7.39	8.61	8.61	88.00	102.00	104.00	54448.00	54229.00	54232.00	35.99	35.83	35.85	8.21	8.24	8.23	13.74	13.90	14.19	4.52	1.51	3.16
CB011	2024-07-22	14.0	7.5	1	7.56	7.49	9.01	90.00	90.00	108.00	54406.00	54209.00	54139.00	35.96	35.82	35.78	8.22	8.22	8.26	13.86	13.85	14.09	1.12	1.86	1.44
CB012	2024-07-22	8.0	4.5	1	8.39	8.43	8.83	100.00	101.00	106.00	54203.00	54192.00	54183.00	35.82	35.81	35.81	8.24	8.25	8.28	13.99	14.04	14.23	1.91	0.32	1.10
CB013	2024-07-22	7.5	4.5	1	8.14	8.18	8.27	97.00	97.00	98.00	54178.00	54178.00	53970.00	35.86	35.79	35.64	8.13	8.13	8.14	13.72	13.73	13.71	5.74	8.19	3.46
CB014	2024-07-22	5.0	3.0	1	8.22	8.25	8.28	98.00	98.00	98.00	54142.00	54105.00	54022.00	35.76	35.73	35.67	8.14	8.14	8.14	13.68	13.68	13.67	6.35	7.06	4.68
CB015	2024-07-22	8.0	4.5	1	8.46	8.47	8.48	100.00	101.00	101.00	53987.00	53948.00	53952.00	35.64	35.62	35.62	8.09	8.10	8.10	13.63	13.66	13.60	0.19	2.89	4.14
CB016	2024-07-22	8.0	4.5	1	7.97	8.29	8.23	95.00	99.00	98.00	54118.00	54062.00	53919.00	35.75	35.71	35.61	8.21	8.23	8.23	13.77	13.83	13.95	9.85	3.80	6.01
CB017	2024-07-22	14.0	7.5	1	7.55	7.88	8.20	90.00	94.00	97.00	54422.00	54182.00	53873.00	35.97	35.79	35.56	8.20	8.19	8.21	13.84	13.77	13.68	1.50	3.32	1.34
KB001	2024-07-22	38.0	19.5	1	5.64	7.40	8.79	65.00	88.00	105.00	54244.00	54459.00	53992.00	35.78	35.99	35.66	8.12	8.23	8.29	12.67	13.62	13.82	2.40	2.74	2.80
CB001	2024-08-23	24.0	12.5	1	7.08	7.83	7.95	85.41	95.75	97.27	54319.00	54709.00	54356.00	35.90	36.20	35.95	7.53	7.55	7.55	14.17	14.44	14.44	0.41	1.67	2.64
CB002	2024-08-23	10.0	5.5	1	7.75	7.92	7.87	94.61	97.04	94.49	54466.00	54384.00	54384.00	36.03	35.97	35.98	7.53	7.55	7.54	14.45	14.54	14.63	2.43	1.70	2.64
CB003	2024-08-23	8.5	5.0	1	7.52	7.44	7.42	92.14	91.45	91.08	54814.00	54866.00	54937.00	36.28	36.33	36.38	7.51	7.51	7.51	14.45	14.46	14.56	0.00	1.44	0.00
CB004	2024-08-20	19.0	10.0	1	7.62	8.05	8.29	93.18	98.19	102.21	54210.00	55092.00	55282.00	35.84	36.49	36.64	7.54	7.53	7.53	14.71	14.54	14.44	13.28	8.08	13.90
CB005	2024-08-20	12.0	6.5	1	8.09	8.43	8.53	100.29	102.57	103.97	53942.00	54346.00	54213.00	35.66	35.95	35.85	7.52	7.52	7.52	15.22	14.66	14.53	10.44	16.15	15.67
CB006	2024-08-23	25.0	12.5	1	7.55	7.96	8.12	92.12	97.63	99.52	54625.00	54821.00	54767.00	36.13	36.29	36.26	7.51	7.54	7.53	14.32	14.49	14.52	0.88	0.00	0.75
CB007	2024-08-20	23.0	12.0	1	7.72	7.97	8.11	93.75	97.12	99.37	55297.00	54384.00	54565.00	36.64	35.97	36.11	7.54	7.54	7.53	14.65	14.64	14.66	5.65	2.46	3.79
CB008	2024-08-20	21.0	12.0	1	7.80	7.98	8.14	95.27	97.26	99.46	54412.00	54555.00	54546.00	35.99	36.09	36.09	7.54	7.54	7.53	14.58	14.51	14.54	5.24	1.61	5.77
CB009	2024-08-23	6.0	3.5	1	7.78	7.81	7.83	95.40	95.55	96.54	54506.00	54547.00	54614.00	36.06	36.09	36.15	7.54	7.54	7.54	14.51	14.57	14.74	1.21	2.95	0.87
CB010	2024-08-23	6.0	3.0	1	7.81	7.70	7.78	95.51	94.48	95.51	54288.00	54255.00	54450.00	35.90	35.88	36.02	7.54	7.54	7.54	14.56	14.61	14.63	1.70	1.62	2.63
CB011	2024-08-23	9.0	4.5	1	7.77	7.82	7.92	95.01	95.73	97.42	54217.00	54222.00	54135.00	35.85	35.86	35.80	7.54	7.54	7.54	14.58	14.77	14.77	3.37	0.83	2.31
CB012	2024-08-23	7.0	4.0	1	7.40	7.63	7.38	90.47	90.26	90.23	54777.00	54778.00	54839.00	36.26	36.26	36.31	7.50	7.51	7.51	14.40	14.46	14.44	0.00	0.00	0.00
CB013	2024-08-20	13.0	6.5	1	8.30	8.30	8.47	101.55	102.34	103.44	54294.00	54325.00	54371.00	35.91	35.93	35.97	7.51	7.51	7.52	14.69	14.66	14.70	11.77	12.18	3.53
CB014	2024-08-23	6.0	3.5	1	7.76	7.90	7.91	94.81	97.04	97.19	54757.00	54771.00	54729.00	36.25	36.26	36.23	7.48	7.49	7.49	14.50	14.60	14.59	0.50	1.02	0.26
CB015	2024-08-20	8.0	4.5	1	8.16	8.17	8.22	99.60	99.40	100.21	54451.00	54387.00	54490.00	36.02	35.97	36.05	7.51	7.51	7.51	14.46	14.53	14.63	12.57	7.31	10.26
CB016	2024-08-20	9.0	4.5	1	8.12	8.34	8.26	98.32	101.69	100.91	54538.00	54493.00	54512.00	36.08	36.05	36.07	7.50	7.50	7.50	14.44	14.59	14.59	5.19	7.74	5.26

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB017	2024-08-23	17.0	9.0	1	7.58	7.90	8.04	92.44	96.93	98.76	54783.00	54793.00	54846.00	36.26	36.27	36.31	7.53	7.54	7.53	14.42	14.49	14.54	1.15	0.00	0.08
KB001	2024-08-20	36.0	18.5	1	7.84	8.01	8.20	95.44	97.68	99.77	54839.00	54919.00	54762.00	36.29	36.36	36.25	7.52	7.54	7.53	14.44	14.62	14.53	0.36	1.52	0.26
KB001*	2024-08-23	41.0	21.0	1	7.82	8.27	8.43	95.51	101.44	103.76	54736.00	54921.00	54983.00	36.21	36.36	36.42	7.56	7.57	7.58	14.33	14.57	14.65	0.00	0.42	0.00
CB001	2024-09-23	25.5	13.0	1	7.49	8.53	8.81	85.01	96.41	101.99	51719.00	52937.00	52962.00	33.89	34.75	34.84	7.55	7.59	7.60	11.80	11.19	12.39	0.00	0.00	0.00
CB002	2024-09-23	9.5	5.0	1	8.14	8.27	8.44	92.22	92.59	94.73	52694.00	53204.00	53617.00	34.61	34.91	35.22	7.57	7.58	7.57	11.80	10.64	10.78	0.00	0.00	0.00
CB003	2024-09-23	5.5	3.0	1	8.18	8.01	8.03	91.52	89.24	89.35	52706.00	53487.00	53546.00	34.57	35.11	35.15	7.54	7.53	7.54	11.03	10.46	10.46	0.00	0.00	0.00
CB004	2024-09-23	10.0	5.5	1	8.15	8.60	9.19	91.00	96.27	103.02	53107.00	53409.00	53871.00	34.81	35.05	35.40	7.54	7.58	7.63	10.29	10.50	10.57	0.00	0.00	0.00
CB005	2024-09-23	11.0	6.0	1	7.81	8.28	8.67	86.48	91.97	96.94	53247.00	53511.00	53745.00	34.89	35.11	35.30	7.54	7.56	7.58	9.97	10.34	10.46	0.00	0.00	0.00
CB006	2024-09-23	23.5	12.0	1	7.27	8.21	9.30	80.37	91.76	105.76	52687.00	53043.00	53899.00	34.50	34.78	35.46	7.54	7.55	7.60	10.28	10.46	11.15	0.00	0.00	0.00
CB007	2024-09-23	23.0	12.0	1	7.83	8.47	9.00	87.63	94.80	102.73	52731.00	53155.00	54043.00	34.54	34.87	35.57	7.54	7.57	7.58	10.32	10.64	11.37	0.00	0.00	0.02
CB008	2024-09-23	25.0	13.0	1	7.39	8.42	8.98	81.70	94.13	102.01	52710.00	53288.00	53760.00	34.52	34.96	35.35	7.54	7.58	7.59	10.27	10.55	11.11	0.00	0.00	0.00
CB009	2024-09-23	4.5	2.0	1	7.80	8.34	8.51	88.36	95.03	97.63	52748.00	53722.00	54133.00	34.61	35.33	35.65	7.56	7.56	7.57	11.22	11.24	11.53	0.00	0.00	0.02
CB010	2024-09-23	7.0	4.0	1	7.95	8.28	8.84	89.64	93.00	101.41	52672.00	53430.00	54592.00	34.55	35.07	35.98	7.56	7.57	7.58	11.02	10.59	11.35	0.00	0.00	0.00
CB011	2024-09-23	13.5	7.0	1	7.77	8.12	8.48	86.98	90.77	95.78	53023.00	53319.00	53945.00	34.75	34.98	35.47	7.55	7.57	7.57	10.33	10.49	10.91	0.00	0.00	0.00
CB012	2024-09-23	7.0	4.0	1	7.75	8.06	8.32	86.66	89.61	92.85	53161.00	53448.00	53631.00	34.85	35.07	35.21	7.53	7.54	7.54	10.17	10.36	10.44	0.00	0.00	0.00
CB013	2024-09-23	6.0	3.5	1	8.27	8.64	8.75	92.30	96.80	98.51	53223.00	53586.00	53742.00	34.93	35.19	35.32	7.55	7.57	7.56	10.76	10.63	10.82	0.00	0.00	0.00
CB014	2024-09-23	4.5	2.5	1	8.12	8.76	8.81	90.52	98.18	98.97	53394.00	53625.00	53704.00	35.04	35.22	35.29	7.55	7.57	7.57	10.46	10.65	10.87	0.00	0.00	0.00
CB015	2024-09-23	6.0	3.5	1	8.51	8.79	8.97	94.27	98.71	101.19	52912.00	53460.00	53725.00	34.69	35.11	35.32	7.54	7.56	7.56	10.60	10.76	10.97	0.00	0.00	1.37
CB016	2024-09-23	12.5	6.5	1	8.01	8.91	9.32	87.90	100.37	105.44	53157.00	53456.00	53686.00	34.85	35.10	35.30	7.52	7.59	7.60	10.25	10.78	11.11	0.00	0.00	0.00
CB017	2024-09-23	16.0	8.5	1	7.60	8.31	8.92	84.03	92.66	100.26	52476.00	53217.00	53679.00	34.38	34.91	35.27	7.54	7.56	7.58	10.66	10.48	10.77	0.00	0.00	0.00
KB001	2024-09-23	30.0	15.5	1	8.51	8.76	9.13	93.50	96.79	102.99	53056.00	53201.00	53807.00	34.76	34.89	35.37	7.53	7.55	7.60	10.24	10.46	10.92	0.00	0.00	0.00
CB001	2024-10-16	25.0	13.0	1	6.25	6.55	7.36	70.40	74.69	89.38	53395.00	53606.00	55052.00	35.06	35.25	36.24	7.58	7.59	7.60	10.95	11.48	10.26	0.02	0.00	0.00
CB003	2024-10-16	6.0	3.5	1	7.72	7.78	7.64	90.70	91.61	89.85	52954.00	53328.00	53316.00	34.84	35.13	35.14	7.59	7.60	7.60	12.69	12.93	13.32	0.00	0.00	0.02
CB004	2024-10-16	13.0	7.0	1	6.64	7.21	7.36	75.88	83.53	85.90	53791.00	54443.00	53868.00	35.40	35.91	35.52	7.56	7.88	7.59	11.56	12.08	12.73	0.45	0.00	0.12
CB005	2024-10-16	13.0	7.0	1	6.97	7.42	7.79	80.01	85.21	91.07	53113.00	53919.00	54148.00	34.91	35.51	35.73	7.57	7.56	7.59	11.84	11.84	12.77	1.02	0.92	0.00
CB006	2024-10-16	25.0	13.0	1	6.47	6.93	7.41	73.13	79.66	85.48	53339.00	53424.00	53847.00	35.04	35.14	35.49	7.54	7.57	7.59	11.19	11.85	12.45	3.57	0.02	0.00
CB007	2024-10-16	23.0	12.0	1	6.60	6.76	7.24	72.95	76.99	84.02	53233.00	53951.00	54252.00	34.96	35.50	35.78	7.56	7.57	7.59	11.26	11.37	12.22	0.13	1.74	0.00
CB008	2024-10-16	26.0	13.5	1	6.35	6.64	7.56	71.72	75.54	88.42	53671.00	54009.00	55058.00	35.27	35.54	36.41	7.57	7.58	7.60	11.09	11.35	12.99	0.00	0.00	0.00
CB009	2024-10-16	4.5	2.5	1	7.23	7.53	7.68	84.09	88.26	91.75	53793.00	53576.00	54231.00	35.44	35.31	35.82	7.59	7.60	7.62	12.22	12.82	13.48	1.18	0.09	0.02
CB010	2024-10-16	9.0	5.0	1	6.91	7.20	7.66	79.34	82.94	92.30	53513.00	53694.00	54272.00	35.21	35.36	35.90	7.58	7.58	7.62	11.84	12.22	14.75	1.38	0.00	0.00
CB011	2024-10-16	14.5	7.5	1	6.51	6.84	8.35	74.05	78.51	99.75	53513.00	53748.00	54007.00	35.18	35.37	35.66	7.59	7.57	7.63	11.39	11.67	13.52	0.00	0.00	0.00
CB012	2024-10-16	6.5	3.5	1	7.74	7.53	7.56	89.88	87.81	88.51	53772.00	54069.00	54141.00	35.43	35.66	35.71	7.56	7.58	7.58	12.41	12.54	12.53	0.00	1.34	0.00
CB013	2024-10-16	6.0	3.5	1	7.82	7.83	7.78	89.64	89.69	89.22	53403.00	53977.00	54224.00	35.13	35.55	35.77	7.53	7.54	7.54	11.76	11.71	12.49	2.08	0.37	0.89
CB014	2024-10-16	4.0	2.5	1	7.73	7.71	7.73	88.74	88.20	88.49	53510.00	53817.00	53919.00	35.22	35.42	35.51	7.54	7.53	7.54	12.03	11.65	11.81	2.76	0.32	0.98
CB015	2024-10-16	4.5	2.0	1	8.25	8.34	8.27	95.14	95.58	95.25	53644.00	53801.00	53901.00	35.31	35.43	35.50	7.53	7.54	7.54	11.85	11.87	11.94	3.17	5.83	4.46
CB016	2024-10-16	8.0	4.0	4	7.23	7.22	7.24	83.86	83.84	84.19	53990.00	54225.00	54214.00	35.58	35.76	35.75	7.57	7.58	7.58	12.25	12.26	12.36	0.23	0.00	0.00
CB017	2024-10-16	15.0	8.0	1	7.33	7.26	7.26	83.88	84.33	84.81	52987.00	53511.00	53772.00	34.84	35.24	35.44	7.54	7.58	7.59	12.22	12.41	12.55	1.33	0.32	0.27
KB001	2024-10-16	31.0	16.0	1	6.49	6.62	6.56	72.40	73.49	72.91	53372.00	53554.00	53668.00	35.02	35.15	35.24	7.15	7.52	7.52	10.55	10.49	10.39	0.02	0.00	0.02
CB001	2024-11-11	26.0	13.5	1	7.35	7.78	8.76	82.78	87.83	100.31	53580.00	53705.00	53754.00	35.20	35.30	35.39	7.57	7.59	7.63	11.07	11.08	11.78	0.00	0.00	0.00

* KB001 (Karbonkelberg reference site) was sampled twice in August because the sampling for Camps Bay marine outfall was split over two days due to poor weather conditions.

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB002	2024-11-11	11.5	6.0	1	7.81	8.20	8.63	88.31	92.95	100.10	53383.00	53519.00	54434.00	35.08	35.19	35.90	7.60	7.61	7.63	11.30	11.35	12.07	0.00	0.00	0.00
CB003	2024-11-11	6.5	4.0	1	8.10	8.44	8.63	92.25	96.10	98.74	53459.00	53744.00	53825.00	35.15	35.36	35.43	7.61	7.61	7.61	11.54	11.52	11.58	0.00	0.00	0.00
CB004	2024-11-11	17.0	9.0	1	7.83	8.05	8.51	88.61	91.13	98.31	53560.00	53488.00	54289.00	35.21	35.16	35.79	7.59	7.60	7.63	11.28	11.38	11.95	0.00	0.00	0.00
CB005	2024-11-11	11.5	6.0	1	7.82	8.18	8.46	89.00	93.41	96.95	53120.00	53757.00	54557.00	34.90	35.37	35.98	7.60	7.60	7.61	11.54	11.57	11.79	0.00	0.00	0.00
CB006	2024-11-11	25.0	13.0	1	7.41	8.10	8.98	83.66	92.31	106.61	53304.00	53644.00	54159.00	35.01	35.26	35.75	7.61	7.62	7.67	11.17	11.14	13.16	0.00	0.00	0.00
CB007	2024-11-11	25.5	13.5	1	7.36	8.36	9.19	82.90	94.64	107.26	53580.00	53186.00	54471.00	35.20	34.94	35.95	7.60	7.62	7.67	11.02	11.43	12.53	0.00	0.00	0.00
CB008	2024-11-11	26.5	13.5	1	7.37	8.07	8.87	83.24	91.15	104.85	53179.00	53616.00	54281.00	34.92	35.24	35.83	7.60	7.61	7.66	11.27	11.13	12.81	0.00	0.00	0.00
CB009	2024-11-11	5.5	3.5	1	8.80	9.14	9.41	103.69	108.33	114.18	53164.00	54456.00	54620.00	35.00	35.99	36.12	7.67	7.71	7.71	12.69	13.49	13.84	0.02	0.00	0.00
CB010	2024-11-11	7.5	4.5	1	8.49	9.28	9.20	97.90	108.66	109.90	52888.00	53832.00	54222.00	34.77	35.49	35.82	7.64	7.68	7.70	12.21	12.67	13.56	0.00	0.00	0.00
CB011	2024-11-11	14.0	7.5	1	8.26	8.99	9.72	94.61	105.51	115.51	52748.00	53466.00	54287.00	34.65	35.21	35.85	7.64	7.67	7.71	11.86	12.51	13.24	0.00	0.00	0.00
CB012	2024-11-11	7.0	4.0	1	8.41	8.67	8.76	95.92	99.10	100.03	53658.00	53506.00	53714.00	35.30	35.20	35.35	7.62	7.62	7.63	11.53	11.73	11.67	0.00	0.00	0.00
CB013	2024-11-11	7.0	4.0	1	8.42	8.65	9.13	96.62	101.07	108.17	53218.00	53307.00	54263.00	35.00	35.09	35.83	7.64	7.64	7.67	11.88	12.50	13.13	0.00	0.00	0.00
CB014	2024-11-11	5.5	3.5	1	8.39	8.56	8.81	95.95	98.05	102.24	53309.00	53779.00	54016.00	35.05	35.40	35.60	7.63	7.63	7.65	11.73	11.71	12.15	0.00	0.00	0.00
CB015	2024-11-11	7.0	4.0	1	8.39	8.87	8.98	96.69	101.72	103.65	52803.00	53472.00	53651.00	34.70	35.18	35.32	7.63	7.64	7.64	12.04	11.76	12.03	0.00	0.00	0.00
CB016	2024-11-11	9.5	5.5	1	8.01	8.13	8.31	91.21	92.37	95.50	53066.00	53577.00	54072.00	34.87	35.23	35.63	7.63	7.63	7.62	11.60	11.43	11.92	0.00	0.00	0.00
CB017	2024-11-11	16.5	9.0	1	7.92	7.63	8.25	89.52	95.03	95.22	53456.00	53711.00	53275.00	35.13	35.32	35.05	7.62	7.63	7.62	11.27	11.30	12.08	0.00	0.00	0.00
KB001	2024-11-11	33.0	17.0	1	6.71	7.41	7.85	73.19	82.83	88.38	53584.00	53515.00	53507.00	35.10	35.14	35.18	7.50	7.55	7.58	9.60	10.70	11.28	0.00	0.00	0.00
CB001	2024-12-19	25.0	13.0	1	5.66	6.02	7.50	62.29	66.29	85.52	52512.00	53685.00	53030.00	34.36	35.21	34.85	7.56	7.56	7.62	10.10	10.01	11.77	0.00	0.00	0.00
CB002	2024-12-19	11.0	6.0	1	6.31	6.78	7.53	70.27	76.62	87.99	52554.00	53789.00	54815.00	34.43	35.35	36.18	7.58	7.61	7.61	10.66	10.86	12.08	0.00	0.00	0.00
CB003	2024-12-19	6.0	3.5	1	7.83	8.02	8.61	87.54	89.82	96.26	53451.00	53364.00	53556.00	35.10	35.04	35.18	7.60	7.59	7.59	10.78	10.80	10.80	1.15	0.00	0.00
CB004	2024-12-19	17.5	9.0	1	5.60	5.93	7.33	61.06	65.19	83.11	52639.00	53679.00	53460.00	34.45	35.21	35.15	7.56	7.56	7.62	10.08	9.95	11.39	0.12	0.00	0.00
CB005	2024-12-19	11.0	6.0	1	7.79	7.90	7.27	86.18	87.65	81.81	53270.00	53622.00	54180.00	34.94	35.20	35.66	7.58	7.58	7.59	10.47	10.47	11.05	1.38	0.00	0.00
CB006	2024-12-19	24.5	13.0	1	5.59	5.74	7.11	60.70	62.94	80.76	53252.00	52503.00	55005.00	34.86	34.36	36.28	7.55	7.55	7.59	9.61	10.20	11.26	0.00	0.00	0.00
CB007	2024-12-19	25.0	13.0	1	5.64	5.95	7.68	61.51	65.11	87.20	53150.00	53263.00	54068.00	34.80	34.89	35.61	7.55	7.55	7.61	9.77	9.85	11.57	0.00	0.00	0.00
CB008	2024-12-19	25.0	13.0	1	5.68	5.60	7.70	61.97	61.01	88.03	53036.00	53667.00	54192.00	34.72	35.17	35.69	7.55	7.55	7.61	9.87	9.57	11.42	0.00	0.00	0.00
CB009	2024-12-19	5.0	3.0	1	8.35	8.54	8.47	95.44	99.08	98.74	52065.00	54002.00	53233.00	34.14	35.59	35.05	7.62	7.63	7.63	11.67	12.09	12.63	0.00	0.24	0.00
CB010	2024-12-19	7.5	5.0	1	7.15	7.96	9.16	81.09	90.20	105.40	52288.00	53446.00	53985.00	34.28	35.12	35.56	7.62	7.62	7.64	11.20	11.16	11.85	0.00	0.00	0.67
CB011	2024-12-19	13.0	7.0	1	6.93	7.07	7.28	77.62	79.50	82.01	53361.00	52914.00	53619.00	35.04	34.74	35.24	7.61	7.60	7.62	10.89	11.26	11.07	0.47	0.00	0.00
CB012	2024-12-19	7.5	4.5	1	9.46	9.44	9.41	105.31	105.02	104.68	53402.00	53572.00	53629.00	35.05	35.17	35.22	7.63	7.63	7.62	10.60	10.52	10.51	0.00	0.61	0.00
CB013	2024-12-19	7.5	4.0	1	8.23	8.26	8.74	90.76	90.82	96.34	53165.00	53590.00	53984.00	34.85	35.15	35.45	7.56	7.55	7.56	10.20	10.01	10.12	1.35	1.12	1.59
CB014	2024-12-19	5.5	3.0	1	7.66	8.31	8.58	84.45	91.44	95.11	53110.00	53477.00	53759.00	34.82	35.07	35.29	7.55	7.55	7.55	10.25	10.05	10.29	0.97	0.00	0.64
CB015	2024-12-19	6.5	3.5	1	7.34	8.50	8.97	80.74	93.82	99.70	52998.00	52295.00	53882.00	34.72	34.22	35.39	7.54	7.56	7.57	10.08	10.22	10.40	0.86	0.84	0.00
CB016	2024-12-19	8.5	5.0	1	7.31	7.71	7.65	80.35	85.19	87.14	53394.00	53696.00	54053.00	35.01	35.24	35.58	7.55	7.56	7.57	10.04	10.18	11.39	0.41	0.25	0.02
CB017	2024-12-19	15.5	8.0	1	5.71	6.47	7.02	62.25	70.60	78.31	52955.00	53699.00	53415.00	34.66	35.20	35.08	7.55	7.55	7.57	9.81	9.67	10.85	0.00	0.35	1.02
KB001	2024-12-19	30.0	15.5	1	5.69	5.86	6.16	61.85	63.30	66.37	53371.00	53103.00	53437.00	35.08	34.77	35.01	7.46	7.48	7.49	9.41	9.71	9.63	0.00	0.00	0.00
CB001	2025-01-14	26.0	13.5	1	5.05	4.99	6.39	55.35	54.57	68.02	53198.00	53655.00	53312.00	34.83	35.14	35.00	7.76	7.76	7.79	9.69	9.38	10.81	0.00	0.00	0.00
CB002	2025-01-14	13.0	7.0	1	5.21	5.64	6.20	56.35	61.13	69.91	52920.00	53431.00	53816.00	34.67	35.03	35.26	7.76	7.77	7.78	10.18	9.95	9.27	0.00	0.00	0.00
CB003	2025-01-14	5.0	3.0	1	5.66	5.85	6.51	62.54	64.85	76.82	53148.00	53508.00	53707.00	34.83	35.09	35.26	7.78	7.78	7.79	10.11	10.08	10.28	0.00	0.00	0.00
CB004	2025-01-14	17.0	9.0	1	4.93	5.02	6.22	54.02	55.09	67.72	53389.00	53356.00	53539.00	34.96	34.95	35.13	7.74	7.72	7.77	9.52	9.71	10.29	0.00	0.00	0.00
CB005	2025-01-14	12.0	6.5	1	5.22	5.11	6.80	55.40	56.29	76.88	53108.00	53615.00	53907.00	34.77	35.14	35.44	7.72	7.72	7.77	9.71	9.71	10.82	0.00	0.00	0.00
CB006	2025-01-14	23.0	12.0	1	5.18	5.46	6.81	56.62	58.21	74.40	53245.00	53457.00	53853.00	34.88	35.03	35.39	7.77	7.77	7.82	9.93	9.80	10.64	0.00	0.00	0.00
CB007	2025-01-14	21.0	11.0	1	5.01	5.18	6.55	54.81	56.46	74.86	53440.00	53429.00	53947.00	34.99	35.01	35.46	7.75	7.75	7.80	9.49	9.75	10.75	0.00	0.00	0.00
CB008	2025-01-14	25.0	13.0	1	5.05	4.98	6.39	55.06	54.54	72.00	53535.00	53672.00	53253.00	35.05	35.16	34.97	7.75	7.74	7.79	9.41	9.38	10.92	0.00	0.00	0.00
CB009	2025-01-14	5.0	3.0	1	5.67	6.22	7.20	63.60	70.30	82.65	52711.00	53527.00	53320.00	34.57	35.17	35.06	7.73	7.79	7.79	10.88	10.91	11.60	0.00	0.00	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB010	2025-01-14	8.0	4.5	1	4.88	5.63	6.23	54.24	61.42	72.54	52824.00	53142.00	54019.00	34.60	34.86	35.56	7.75	7.73	7.80	10.22	10.55	11.36	0.00	0.00	0.00
CB011	2025-01-14	13.0	7.0	1	4.61	5.03	7.05	51.61	57.22	80.90	52314.00	52939.00	54268.00	34.25	34.68	35.73	7.73	7.71	7.81	10.59	10.11	11.26	0.00	0.00	0.00
CB012	2025-01-14	6.0	3.5	1	5.85	6.66	7.07	64.88	74.82	79.90	53722.00	53732.00	53752.00	35.25	35.28	35.32	7.74	7.76	7.76	10.03	10.44	10.76	0.00	0.00	0.00
CB013	2025-01-14	9.5	4.5	1	5.60	6.30	6.83	60.17	69.59	77.44	53082.00	53552.00	53801.00	34.78	35.16	35.37	7.73	7.75	7.78	10.05	10.49	11.01	0.00	0.00	0.00
CB014	2025-01-14	5.0	3.0	1	6.62	6.51	7.00	73.68	73.20	79.75	53049.00	53517.00	53797.00	34.82	35.15	35.38	7.76	7.77	7.78	10.97	10.78	11.20	0.00	0.00	0.00
CB015	2025-01-14	5.0	3.0	1	6.70	7.53	7.71	74.56	86.93	88.42	52815.00	53151.00	54096.00	34.65	34.90	35.62	7.75	7.75	7.77	11.07	11.09	11.54	0.00	0.00	0.00
CB016	2025-01-14	10.0	5.5	1	4.84	5.40	6.55	52.37	59.58	74.85	53393.00	53608.00	53542.00	34.97	35.15	35.17	7.67	7.70	7.74	9.63	9.80	10.79	0.00	0.00	0.00
CB017	2025-01-14	15.0	8.0	1	5.17	5.08	6.75	56.42	55.86	73.49	53204.00	53521.00	54087.00	34.83	35.06	35.58	7.76	7.76	7.83	9.63	9.57	10.94	0.00	0.00	0.00
KB001	2025-01-14	30.0	15.5	1	5.34	5.39	6.78	58.46	59.08	76.84	53615.00	53606.00	53406.00	35.12	35.11	35.07	7.61	7.65	7.73	9.52	9.47	10.81	0.00	0.00	0.00
CB001	2025-02-12	25.0	13.0	1	5.86	6.78	8.69	66.60	80.80	86.33	51229.00	51128.00	53104.00	33.54	33.53	35.03	7.89	7.99	8.35	12.07	13.33	14.68	0.00	0.00	0.18
CB002	2025-02-12	13.0	7.0	1	6.63	8.62	8.52	76.41	107.72	108.50	50902.00	52466.00	52641.00	33.33	34.52	34.68	7.89	8.27	8.31	12.50	13.56	14.47	0.00	0.00	0.00
CB003	2025-02-12	6.0	3.5	1	7.95	8.29	8.96	91.41	95.70	105.53	56627.00	53221.00	53813.00	37.51	35.03	35.51	8.06	8.09	8.17	11.89	12.50	13.56	0.00	0.00	0.00
CB004	2025-02-12	14.5	8.0	1	7.16	8.32	8.93	87.89	112.33	117.90	51183.00	52077.00	52544.00	33.60	34.29	34.63	8.07	8.34	8.37	14.37	15.40	15.21	0.25	0.11	1.01
CB005	2025-02-12	12.0	6.5	1	5.83	9.13	10.75	65.41	106.46	129.14	53625.00	53250.00	53224.00	35.19	35.05	35.07	7.93	8.14	8.31	10.32	12.40	13.30	0.00	0.00	0.00
CB006	2025-02-12	24.5	12.0	1	4.57	8.28	8.28	51.46	109.15	99.26	53393.00	52643.00	52952.00	35.24	34.67	34.93	7.81	8.25	8.36	14.75	14.17	15.03	0.00	0.00	1.38
CB007	2025-02-12	23.0	11.0	1	6.22	8.06	8.02	71.29	97.63	105.65	50300.00	52114.00	52647.00	32.92	34.27	34.68	7.85	8.17	8.36	13.23	13.78	14.17	0.00	0.02	0.00
CB008	2025-02-12	21.5	13.0	1	6.00	8.05	9.18	76.16	96.62	110.54	50233.00	51242.00	52726.00	32.88	33.66	34.70	7.91	8.24	8.36	13.54	14.90	13.23	0.00	0.00	0.96
CB009	2025-02-12	4.5	2.5	1	10.60	11.77	11.83	128.90	143.24	144.73	52925.00	53977.00	54279.00	34.88	35.66	35.89	8.34	8.33	8.39	14.22	14.23	14.41	0.00	0.00	0.54
CB010	2025-02-12	9.5	5.0	1	6.81	10.56	11.29	76.96	127.44	136.86	53552.00	54480.00	54415.00	35.18	35.98	35.97	8.04	8.33	8.35	10.94	12.99	13.90	0.00	0.02	0.02
CB011	2025-02-12	11.0	6.0	1	7.24	8.07	9.33	68.29	93.01	110.89	53033.00	54009.00	54419.00	34.78	35.56	35.93	7.93	8.15	8.25	10.57	11.66	12.92	0.00	0.00	0.00
CB012	2025-02-12	6.0	3.5	1	8.53	9.01	9.02	97.19	103.19	103.68	53361.00	53593.00	53742.00	35.08	35.25	35.37	8.00	8.04	8.07	11.45	11.50	11.57	0.00	0.00	0.00
CB013	2025-02-12	6.0	3.5	1	8.28	8.39	8.36	95.71	95.73	97.27	53642.00	53344.00	53905.00	35.27	35.06	35.53	7.96	7.96	7.96	11.29	11.32	12.32	0.00	0.00	0.00
CB014	2025-02-12	5.0	3.0	2	7.70	8.14	8.20	87.70	93.36	93.93	53391.00	53657.00	53499.00	35.09	35.29	35.18	7.96	8.00	7.98	11.30	11.30	11.49	0.00	0.00	0.00
CB015	2025-02-12	6.0	3.0	1	7.55	7.78	7.91	85.88	91.23	92.95	53190.00	52979.00	53666.00	34.93	34.79	35.30	7.88	7.80	7.92	11.03	11.29	11.47	0.00	0.20	0.00
CB016	2025-02-12	9.0	5.0	1	6.46	7.21	7.98	72.50	81.29	90.12	53554.00	53560.00	53729.00	35.15	35.18	35.33	7.84	7.92	7.93	10.39	10.76	11.13	0.00	0.00	0.03
CB017	2025-02-12	15.0	8.0	1	5.85	9.96	10.09	65.86	117.91	119.77	52036.00	53575.00	53459.00	34.07	35.31	35.24	7.85	8.20	8.23	10.91	13.04	13.18	0.48	0.00	0.37
KB001	2025-02-12	25.0	13.0	1	5.93	6.46	7.35	65.33	71.53	82.73	53333.00	53715.00	53910.00	34.94	35.24	35.43	7.86	7.90	7.99	9.88	10.08	10.60	0.00	0.00	0.00
CB001	2025-03-20	26.5	13.5	1	3.59	6.70	8.19	39.20	78.56	99.73	52989.00	54826.00	54982.00	34.75	36.22	36.41	7.86	8.06	8.18	10.74	12.63	14.31	0.00	0.00	0.00
CB002	2025-03-20	13.0	7.0	1	7.56	8.19	8.41	90.30	99.10	102.65	53708.00	54410.00	54992.00	35.44	35.98	36.43	8.11	8.18	8.19	13.69	14.14	14.62	0.57	0.67	0.75
CB003	2025-03-20	7.0	4.0	1	7.71	7.80	7.98	91.24	93.19	96.37	53667.00	54199.00	54609.00	35.39	35.80	36.12	8.07	8.12	8.16	13.21	13.49	14.07	0.51	0.48	0.51
CB004	2025-03-20	18.0	9.5	1	7.10	7.84	8.04	83.27	94.14	97.30	53322.00	54257.00	54529.00	35.12	35.85	36.07	8.02	8.15	8.17	12.92	13.77	14.16	0.49	0.71	0.32
CB005	2025-03-20	12.0	6.5	1	7.10	7.54	7.97	82.79	89.57	95.81	52100.00	54192.00	54349.00	34.23	35.78	35.93	8.01	8.10	8.15	13.00	13.23	13.97	0.33	0.12	0.56
CB006	2025-03-20	24.5	13.0	1	4.14	7.29	8.21	45.83	86.92	100.50	53012.00	54620.00	55053.00	34.79	36.08	36.47	7.91	8.11	8.18	11.10	12.94	14.53	0.04	0.47	0.00
CB007	2025-03-20	22.5	12.0	1	5.00	7.35	8.17	57.07	87.12	99.62	53465.00	54294.00	54762.00	35.16	35.85	36.25	7.97	8.12	8.18	11.62	13.18	14.40	0.00	0.08	0.51
CB008	2025-03-20	24.0	12.5	1	3.76	7.13	8.22	42.21	85.68	100.19	53059.00	54497.00	54755.00	34.82	35.99	36.25	7.91	8.11	8.18	11.06	12.97	14.54	0.32	0.02	0.41
CB009	2025-03-20	4.0	2.5	1	8.34	8.35	8.44	100.37	102.01	103.27	54192.00	54410.00	54467.00	35.81	35.99	36.04	8.15	8.20	8.20	13.99	14.61	14.67	0.00	0.02	0.04
CB010	2025-03-20	7.5	4.5	1	7.96	8.20	8.38	95.79	98.75	102.22	53827.00	54276.00	54558.00	35.54	35.87	36.10	8.16	8.19	8.19	14.02	13.96	14.51	0.58	0.02	0.00
CB011	2025-03-20	13.5	8.0	1	7.56	8.25	8.23	89.39	99.30	100.59	53647.00	54450.00	54301.00	35.37	35.99	35.91	8.04	8.15	8.19	13.22	13.75	14.55	0.00	0.08	0.31
CB012	2025-03-20	5.0	3.0	1	7.46	7.67	7.78	88.04	91.27	93.07	53769.00	54212.00	54282.00	35.46	35.80	35.86	8.06	8.11	8.13	13.09	13.40	13.62	0.35	0.00	0.49
CB013	2025-03-20	7.0	4.0	1	7.12	7.33	7.48	83.11	85.06	87.66	53389.00	53952.00	53815.00	35.16	35.58	35.48	8.00	8.03	8.03	12.59	12.67	12.77	0.00	0.00	0.00
CB014	2025-03-20	7.0	4.0	1	6.85	7.11	7.63	80.03	83.80	90.17	53557.00	53998.00	53964.00	35.28	35.62	35.60	8.02	8.05	8.05	12.62	12.77	12.98	0.69	0.00	0.00
CB015	2025-03-20	7.0	4.0	1	6.85	7.63	7.84	80.59	89.41	92.96	53082.00	53905.00	54136.00	34.94	35.54	35.73	7.99	7.99	8.04	12.82	12.72	13.03	0.00	0.00	0.15
CB016	2025-03-20	13.0	6.5	1	6.41	7.41	7.68	74.44	87.25	91.99	53557.00	54085.00	54403.00	35.27	35.69	35.94	7.99	8.06	8.11	12.37	12.93	13.31	0.00	0.04	0.00
CB017	2025-03-20	16.5	8.5	1	6.67	7.37	7.89	77.96	86.90	94.71	53472.00	54045.00	53917.00	35.22	35.66	35.61	8.01	8.08	8.15	12.69	12.99	14.13	0.00	0.00	0.36

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
KB001	2025-03-20	35.5	18.5	1	4.41	6.38	7.74	48.66	71.38	91.31	53046.00	53634.00	54715.00	34.74	35.21	36.14	7.95	8.11	8.09	10.00	10.46	12.66	0.00	0.00	0.00
CB001	2025-04-23	27.0	14.0	1	4.80	5.79	6.68	53.26	64.98	76.47	53153.41	53437.77	53332.69	34.86	35.10	35.09	7.91	8.01	8.05	10.62	11.04	11.94	0.00	0.00	0.00
CB002	2025-04-23	12.0	6.5	1	5.42	6.13	6.55	60.42	69.04	74.95	52684.00	53328.01	53600.34	34.56	35.04	35.28	7.95	8.03	8.06	11.16	11.21	11.86	0.00	0.00	0.00
CB003	2025-04-23	6.0	3.5	1	6.44	6.51	6.71	72.51	73.07	75.46	52718.54	53089.19	53212.11	34.60	34.86	34.95	7.97	7.96	7.96	11.36	11.12	11.19	0.00	0.00	0.00
CB004	2025-04-23	16.0	8.5	1	5.28	5.32	6.22	59.13	59.43	70.12	52779.31	53170.87	53360.30	34.63	34.90	35.07	7.90	7.92	7.97	11.11	10.90	11.28	0.00	0.00	0.00
CB005	2025-04-23	10.0	5.5	1	5.43	5.67	5.67	60.30	63.17	65.56	53574.00	53471.17	53992.00	35.17	35.12	35.52	7.94	7.95	7.95	10.55	10.77	11.14	0.00	0.00	0.00
CB006	2025-04-23	22.0	11.5	1	5.39	5.58	5.84	59.48	62.14	65.78	53168.60	53240.46	53332.69	34.85	34.94	35.05	7.86	7.92	7.99	10.29	10.76	11.35	0.00	0.00	0.00
CB007	2025-04-23	23.0	12.0	1	4.86	5.41	6.61	53.72	60.38	74.72	53010.54	53207.88	53305.27	34.75	34.93	35.04	7.87	7.96	8.02	10.47	10.87	11.41	0.00	0.00	0.00
CB008	2025-04-23	26.0	13.5	1	4.77	5.87	6.40	52.88	65.90	72.60	53171.18	53283.93	53434.50	34.87	34.99	35.14	7.90	7.99	8.03	10.53	11.09	11.51	0.00	0.00	0.00
CB009	2025-04-23	6.0	3.5	1	5.50	5.77	6.86	61.67	64.74	78.27	52720.93	53121.36	53373.14	34.59	34.88	35.10	7.96	7.99	8.03	11.14	11.05	11.73	0.00	0.00	0.00
CB010	2025-04-23	8.0	4.5	1	5.42	6.11	6.81	60.64	68.59	77.64	52928.68	53037.59	53374.99	34.73	34.82	35.10	7.95	7.98	7.99	11.00	11.13	11.73	0.00	0.00	0.00
CB011	2025-04-23	14.0	7.5	1	5.25	5.73	6.28	58.73	64.22	71.02	52278.45	53162.72	53235.57	34.27	34.90	34.98	7.93	7.98	8.00	11.20	11.01	11.41	0.00	0.00	0.00
CB012	2025-04-23	8.0	4.5	1	5.94	6.04	6.57	66.22	67.27	73.31	53398.29	53599.29	53704.44	35.06	35.21	35.29	7.93	7.93	7.92	10.83	10.74	10.79	0.00	0.00	0.00
CB013	2025-04-23	8.0	4.5	1	7.04	6.88	6.54	77.81	76.28	72.71	53238.58	53579.93	53698.05	34.92	35.18	35.27	7.89	7.91	7.94	10.48	10.50	10.63	0.00	0.00	0.00
CB014	2025-04-23	6.0	3.5	1	6.86	6.51	6.37	76.22	72.31	70.94	53530.38	53701.37	53759.33	35.15	35.27	35.32	7.93	7.93	7.95	10.60	10.60	10.69	0.00	0.00	0.00
CB015	2025-04-23	7.0	4.0	1	6.91	6.51	6.42	76.76	72.31	71.37	53378.94	53629.76	53595.94	35.04	35.22	35.20	7.90	7.92	7.92	10.64	10.60	10.62	0.00	0.00	0.00
CB016	2025-04-23	11.0	6.0	1	6.21	5.97	5.95	69.39	66.67	66.50	53139.02	53571.23	53662.46	34.88	35.19	35.26	7.92	7.95	7.97	10.97	10.83	10.88	0.00	0.00	0.00
CB017	2025-04-23	16.0	8.5	1	5.20	5.92	5.88	57.37	65.62	65.58	53473.90	53680.48	53786.64	35.08	35.25	35.35	7.90	7.92	7.95	10.29	10.49	10.74	0.00	0.00	0.00
KB001	2025-04-23	29.0	15.0	1	5.07	5.23	5.63	55.27	56.91	61.33	53383.68	53471.57	53457.91	34.97	35.03	35.03	7.80	7.82	7.82	9.77	9.71	9.76	0.00	0.00	0.00
CB001	2025-05-15	23.5	12.0	1	7.69	9.84	10.53	89.93	117.75	127.46	53644.00	54852.03	55340.96	35.35	36.28	36.67	8.13	8.31	8.38	12.89	13.67	14.18	5.50	1.19	3.08
CB002	2025-05-15	13.0	7.0	1	9.11	9.28	9.80	107.67	109.94	119.28	53375.00	53803.06	56391.96	35.18	35.50	37.43	8.21	8.25	8.38	13.52	13.46	13.59	0.00	2.83	3.24
CB003	2025-05-15	7.0	4.0	1	8.75	9.17	9.19	103.57	108.18	108.40	53450.31	53855.02	53973.00	35.24	35.53	35.62	8.21	8.22	8.72	13.53	13.26	13.22	1.18	2.19	6.26
CB004	2025-05-15	12.5	6.5	1	8.66	9.38	10.72	101.83	110.47	102.39	53804.26	54025.00	53212.00	35.49	35.65	35.08	8.18	8.23	8.28	13.14	13.16	13.68	12.36	14.58	19.60
CB005	2025-05-15	9.0	5.0	1	8.54	8.58	8.64	100.00	100.44	101.15	53716.74	53850.00	53892.37	35.42	35.51	35.54	8.09	8.09	8.10	12.99	12.91	12.88	0.00	1.29	0.40
CB006	2025-05-15	20.0	10.0	1	6.17	8.02	9.05	70.99	93.59	106.77	53036.25	54265.15	54614.27	34.88	35.80	36.09	7.90	8.13	8.35	12.27	12.66	13.13	0.00	1.72	12.02
CB007	2025-05-15	19.5	10.0	1	7.52	8.83	9.52	87.56	103.45	113.32	53445.33	54084.76	55154.21	35.20	35.68	36.49	8.05	8.18	8.38	12.76	12.91	13.18	0.00	2.59	5.13
CB008	2025-05-15	26.0	13.5	1	4.30	8.63	10.32	48.09	100.81	122.78	53532.00	54276.63	53261.78	35.18	35.81	35.12	7.79	8.17	8.38	11.25	12.72	13.76	0.00	0.00	0.52
CB009	2025-05-15	5.0	3.0	1	8.71	9.10	9.10	102.69	107.78	107.80	53785.69	53993.48	53971.00	35.48	35.64	35.63	8.12	8.16	8.16	13.22	13.44	13.41	0.70	1.26	2.53
CB010	2025-05-15	7.0	4.0	1	8.29	8.60	8.93	97.36	101.00	105.91	53506.47	53803.87	54217.00	35.27	35.49	35.81	8.06	8.11	8.14	13.12	13.05	13.41	2.53	0.02	1.83
CB011	2025-05-15	12.0	6.5	1	10.00	10.32	10.67	118.12	122.21	126.91	53469.06	53968.38	54122.89	35.25	35.62	35.74	8.25	8.32	8.35	13.44	13.38	13.59	1.21	3.47	5.99
CB012	2025-05-15	8.0	4.5	1	8.50	8.56	8.69	99.58	100.24	101.77	53525.22	53813.75	53954.42	35.28	35.49	35.59	8.08	8.09	8.11	13.04	12.89	12.88	7.32	0.03	0.00
CB013	2025-05-15	6.0	3.5	1	8.42	8.38	8.26	98.77	98.16	96.66	53591.98	53860.71	53871.11	35.33	35.52	35.53	8.06	8.06	8.07	13.09	12.93	12.90	9.00	6.65	5.74
CB014	2025-05-15	6.5	3.0	1	8.33	8.50	8.46	97.32	98.80	98.94	53683.42	51639.55	53840.57	35.39	33.90	35.51	8.07	8.07	8.07	12.83	13.05	12.87	1.11	4.40	2.56
CB015	2025-05-15	6.0	3.5	1	8.32	8.64	8.65	97.14	100.79	100.91	53548.45	53817.23	53900.41	35.29	35.48	35.54	8.04	8.02	8.05	12.86	12.79	12.76	2.25	5.25	3.70
CB016	2025-05-15	11.0	6.0	1	6.36	8.06	8.04	73.39	93.85	93.70	53765.68	53849.40	53997.72	35.42	35.50	35.61	7.95	8.04	8.03	12.27	12.67	12.67	0.69	0.00	0.00
CB017	2025-05-15	18.0	9.5	1	6.46	7.56	9.01	72.22	88.13	106.23	53623.00	54187.64	54674.74	35.30	35.75	36.13	7.96	8.11	8.32	12.10	12.66	12.95	0.50	5.71	17.13
KB001	2025-05-15	30.0	15.5	1	6.33	7.23	10.20	72.15	83.38	120.26	53151.43	53857.30	54265.53	34.93	35.48	35.83	7.80	7.96	8.29	11.81	12.21	13.13	0.00	0.00	5.02
CB001	2025-06-10	28.0	14.5	1	5.91	7.41	8.21	70.43	88.24	98.37	52774.00	52868.00	53013.00	34.73	34.83	34.96	8.05	8.18	8.14	13.45	14.15	14.67	0.00	0.00	0.00
CB002	2025-06-10	13.0	7.0	1	7.63	7.95	7.85	91.65	85.21	94.08	53330.00	52915.00	52918.00	35.19	34.89	34.89	8.11	8.10	8.17	14.67	14.81	14.69	1.08	2.72	0.00
CB003	2025-06-10	7.0	4.0	1	7.65	7.80	7.96	91.04	93.53	95.20	53656.00	52738.00	52874.00	35.44	34.76	34.86	8.11	8.09	8.07	14.72	14.58	14.68	0.00	0.00	0.00
CB004	2025-06-10	17.0	9.0	1	7.08	7.91	7.88	84.46	93.89	94.08	52792.00	52363.00	52822.00	34.79	34.47	34.82	8.11	8.11	8.09	14.47	14.43	14.59	0.00	0.00	0.00
CB005	2025-06-10	12.0	6.5	1	7.62	7.78	7.86	90.76	93.15	93.78	52544.00	52795.00	52928.00	34.61	34.79	34.90	8.06	8.08	8.09	14.51	14.50	14.55	0.00	0.00	0.00
CB006	2025-06-10	25.0	13.0	1	6.34	7.68	8.06	74.22	91.16	96.42	52561.00	52883.00	53040.00	34.58	34.85	34.98	8.04	8.13	8.22	13.44	14.34	14.62	0.00	0.00	0.00
CB007	2025-06-10	25.0	13.0	1	6.69	8.05	8.02	79.00	96.06	96.52	52679.00	52710.00	52815.00	34.68	34.73	34.81	8.10	8.21	8.26	13.92	14.57	14.59	0.00	0.00	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB008	2025-06-10	26.0	13.5	1	6.03	7.88	8.28	70.46	94.03	99.12	52622.00	52972.00	52968.00	34.62	34.92	34.93	8.05	8.17	8.23	13.51	14.42	14.63	0.00	0.00	0.00
CB009	2025-06-10	7.0	4.0	1	7.46	7.78	7.94	89.10	92.86	95.18	52881.00	52925.00	52937.00	34.85	34.89	34.91	8.07	8.08	8.05	14.37	14.55	14.70	0.00	0.00	0.00
CB010	2025-06-10	8.0	4.5	1	7.54	7.66	8.01	89.57	91.18	95.11	52934.00	52910.00	52942.00	34.89	34.88	34.91	8.09	8.11	8.07	14.23	14.37	14.54	0.00	0.00	0.00
CB011	2025-06-10	13.0	7.0	1	7.48	7.43	7.78	89.18	88.64	92.84	52760.00	52893.00	52918.00	34.76	34.87	34.89	8.10	8.11	8.10	14.39	14.46	14.53	0.00	0.00	0.00
CB012	2025-06-10	7.0	4.0	1	8.23	8.12	8.23	96.88	96.42	97.71	50865.00	52965.00	52667.00	33.37	34.92	34.70	8.07	8.06	8.04	14.40	14.38	14.42	0.00	0.00	0.00
CB013	2025-06-10	7.0	4.0	1	8.22	8.21	8.12	97.52	97.43	96.55	54889.00	52866.00	52787.00	36.34	34.84	34.79	8.03	8.02	8.04	14.28	14.34	14.43	0.00	0.00	0.00
CB014	2025-06-10	6.0	3.5	1	7.79	7.84	7.77	92.69	93.40	92.73	52857.00	52840.00	52873.00	34.84	34.83	34.86	8.10	8.10	8.12	14.47	14.49	14.60	0.00	0.00	0.00
CB015	2025-06-10	7.0	4.0	1	8.21	7.94	8.18	98.40	94.47	96.80	52833.00	52859.00	51112.00	34.82	34.84	33.56	8.06	8.08	8.06	14.29	14.45	14.43	0.00	0.00	0.00
CB016	2025-06-10	9.0	5.0	1	10.62	10.19	7.72	98.10	97.94	91.58	NA	52764.00	52412.00	NA	34.78	34.52	8.11	8.12	8.03	14.46	14.59	14.53	0.00	0.00	0.00
CB017	2025-06-10	16.0	8.5	1	7.78	7.71	7.74	92.70	92.18	92.37	52892.00	52764.00	52715.00	34.86	34.77	34.74	8.18	8.12	8.13	14.31	14.56	14.59	0.00	0.00	0.00
KB001	2025-06-10	29.0	15.0	1	6.54	10.17	8.68	74.31	98.52	102.50	50564.00	50277.95	51411.00	33.10	32.95	33.78	7.90	8.14	8.25	13.17	14.77	14.69	0.00	0.00	0.00

Table 5 Water quality parameters measured *in situ*, or soon after sampling (in the case of turbidity), for the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site.

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP001	2024-07-15	3.0	2.0	1	7.97	8.06	8.05	95.00	96.00	96.00	53915.00	53842.00	51074.00	35.60	35.55	33.51	8.22	8.23	8.22	13.81	13.86	13.91	5.63	4.87	6.51
GP002	2024-07-15	3.0	2.0	1	7.76	7.83	7.98	93.00	93.00	95.00	54225.00	53936.00	51906.00	35.83	35.62	34.13	8.21	8.21	8.22	13.80	13.86	14.04	17.03	8.90	14.06
GP003	2024-07-15	5.0	2.5	1	7.45	7.91	7.94	89.00	94.00	94.00	54085.00	53544.00	51714.00	35.73	35.33	33.99	8.19	8.21	8.20	13.86	13.86	14.06	9.35	6.38	5.87
GP004	2024-07-15	7.0	3.5	1	8.05	8.08	8.27	96.00	96.00	98.00	54186.00	54183.00	48182.00	35.80	35.80	31.42	8.23	8.23	8.18	13.86	13.87	14.34	19.70	3.96	12.33
GP005	2024-07-15	11.0	3.5	1	7.70	8.12	8.55	92.00	97.00	100.00	54176.00	54049.00	49080.00	35.79	35.70	32.07	8.21	8.24	8.20	13.86	13.94	14.26	3.45	4.50	17.36
GP007	2024-07-15	18.0	10.0	1	8.42	8.49	8.07	100.00	101.00	95.00	54300.00	54307.00	49660.00	35.88	35.89	32.48	8.25	8.25	8.20	13.79	13.80	13.87	18.91	3.12	3.44
GP008	2024-07-15	21.0	11.0	1	8.41	8.47	7.96	100.00	101.00	94.00	54302.00	54276.00	52467.00	35.88	35.86	34.53	8.25	8.25	8.20	13.81	13.80	13.86	3.02	18.91	15.41
GP010	2024-07-15	27.0	13.5	1	7.92	8.36	9.11	94.00	100.00	107.00	54349.00	54302.00	50136.00	35.91	35.88	32.82	8.27	8.25	8.23	13.95	13.79	13.78	11.86	5.03	12.63
GP011	2024-07-15	24.0	12.0	1	8.20	8.39	8.84	98.00	100.00	101.00	54371.00	54307.00	51258.00	35.93	35.88	33.64	8.19	8.24	8.25	13.77	13.77	13.78	3.54	2.85	21.90
GP012	2024-07-15	25.0	12.5	1	8.32	8.39	9.43	99.00	100.00	97.00	54378.00	54388.00	50734.00	35.93	35.94	33.26	8.23	8.24	8.17	13.77	13.77	13.72	4.75	1.73	12.86
GP013	2024-07-15	26.0	13.0	1	8.14	8.32	8.53	97.00	99.00	99.00	54367.00	54286.00	49324.00	35.92	35.87	32.23	8.22	8.24	8.21	13.74	13.77	13.77	2.94	1.31	15.01
GP014	2024-07-15	24.0	13.0	1	8.21	8.31	8.21	98.00	99.00	97.00	54334.00	54341.00	53114.00	35.90	35.91	35.01	8.23	8.23	8.20	13.79	13.78	13.78	3.40	1.28	9.32
GP015	2024-07-15	26.5	14.0	1	8.03	8.20	8.15	96.00	98.00	95.00	54382.00	54346.00	50741.00	35.93	35.91	33.26	8.21	8.23	8.29	13.78	13.77	13.64	4.05	1.18	14.56
GP016	2024-07-15	25.0	13.0	1	8.36	8.43	8.03	99.00	100.00	95.00	54562.00	54394.00	52574.00	36.07	35.95	34.61	8.22	8.23	8.22	13.76	13.77	13.77	5.37	2.83	26.20
GP017	2024-07-15	23.0	11.0	1	8.35	8.46	8.82	99.00	101.00	100.00	54381.00	54281.00	42880.00	35.93	35.86	27.58	8.23	8.24	8.16	13.77	13.78	13.49	5.85	1.98	15.01
GP018	2024-07-15	13.0	7.0	1	8.12	7.81	8.12	97.00	NA	90.00	54343.00	53893.00	38017.00	35.91	35.58	24.14	8.12	8.11	8.00	13.77	13.77	13.21	7.63	13.51	41.90
GP019	2024-07-15	12.0	6.0	1	7.66	8.23	8.26	91.00	97.00	90.00	54110.00	53806.00	38838.00	35.74	35.51	24.71	8.13	8.16	8.06	13.77	13.66	13.02	15.98	6.83	38.50
GP043	2024-07-15	25.0	13.0	1	8.22	8.34	8.69	98.00	99.00	97.00	54311.00	54303.00	44684.00	35.88	35.88	28.87	8.21	8.22	8.24	13.77	13.78	13.45	2.57	1.37	14.61
RI001	2024-07-15	17.0	8.5	1	7.87	7.96	8.06	93.00	94.00	96.00	54300.00	54315.00	54319.00	35.87	35.89	35.89	8.18	8.18	8.19	13.68	13.68	13.68	1.00	1.03	1.61

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP001	2024-08-12	5.0	3.0	1	7.92	7.95	8.23	95.12	95.42	98.68	54170.00	53715.00	52932.00	35.80	35.46	34.89	7.55	7.55	7.54	14.11	14.18	14.21	6.81	3.01	2.98
GP002	2024-08-12	5.0	2.5	1	8.10	7.94	8.30	96.53	95.35	99.12	53593.00	53910.00	53077.00	35.37	35.61	34.99	7.53	7.54	7.54	14.06	14.13	14.04	7.91	6.79	7.20
GP003	2024-08-12	8.0	4.5	1	8.50	8.59	9.04	102.09	102.46	108.22	54038.00	54182.00	51819.00	35.70	35.81	34.08	7.37	7.58	7.58	14.04	14.13	14.45	3.74	1.04	9.52
GP004	2024-08-12	9.5	5.0	1	8.23	8.39	8.65	99.06	100.96	103.48	54190.00	53561.00	52669.00	35.81	35.35	34.69	7.54	7.53	7.55	14.22	14.28	14.17	25.90	6.62	14.08
GP005	2024-08-12	15.5	8.0	1	8.10	8.34	8.65	97.49	99.65	103.75	54317.00	54173.00	52509.00	35.90	35.80	34.58	7.55	7.55	7.55	14.18	14.25	14.31	23.60	4.88	8.60
GP006	2024-08-12	20.5	10.5	1	8.07	8.12	8.73	96.98	99.05	104.18	54448.00	52860.00	50478.00	35.99	34.86	33.10	7.57	7.58	7.57	14.00	15.01	14.58	6.09	0.64	9.91
GP007	2024-08-12	18.0	9.5	1	8.28	8.43	8.78	99.71	101.33	105.01	54110.00	54194.00	51282.00	35.75	35.82	33.68	7.56	7.58	7.57	14.24	14.22	14.40	13.10	2.78	11.50
GP008	2024-08-12	21.0	11.0	1	8.43	8.35	9.03	100.78	100.50	108.01	54086.00	54140.00	51671.00	35.73	35.78	33.97	7.56	7.58	7.59	14.26	14.27	14.45	38.70	1.04	8.93
GP009	2024-08-12	22.0	11.5	1	8.15	8.62	8.89	97.51	103.35	106.49	54319.00	54191.00	52075.00	35.90	35.82	34.26	7.56	7.58	7.59	14.05	14.27	14.40	41.30	0.78	7.36
GP010	2024-08-12	27.0	13.5	1	8.35	8.40	8.86	99.82	100.70	106.06	54291.00	54615.00	52706.00	35.88	36.12	34.72	7.57	7.58	7.59	14.18	14.01	14.25	79.80	5.81	5.48
GP011	2024-08-12	23.0	12.0	1	8.00	8.08	8.49	95.97	96.82	99.56	54551.00	54586.00	51996.00	36.07	36.10	34.20	7.57	7.57	7.54	14.00	13.97	14.18	9.06	1.53	10.87
GP012	2024-08-12	26.0	13.5	1	7.97	8.06	8.67	95.48	96.42	102.09	54668.00	53134.00	50992.00	36.15	35.02	33.46	7.56	7.57	7.54	13.96	13.99	14.14	34.20	20.40	9.77
GP013	2024-08-12	27.0	13.5	1	8.02	8.15	8.50	95.68	97.78	100.37	54630.00	54713.00	50126.00	36.12	36.19	32.83	7.57	7.57	7.54	14.00	14.05	14.23	4.20	0.21	11.55
GP014	2024-08-12	25.0	13.0	1	8.00	8.08	8.82	96.07	97.64	104.26	54571.00	54589.00	52181.00	36.08	36.10	34.34	7.57	7.57	7.58	14.02	14.04	14.32	2.64	0.11	6.40
GP015	2024-08-12	22.0	11.5	1	8.06	8.09	9.14	96.73	97.20	110.13	54612.00	54680.00	52131.00	36.11	36.17	34.31	7.58	7.55	7.51	14.04	14.08	14.40	3.85	1.05	5.42
GP016	2024-08-12	25.0	13.0	1	8.02	8.08	8.13	96.03	96.89	95.98	54644.00	54670.00	51524.00	36.13	36.16	33.85	7.55	7.55	7.51	13.95	13.99	14.04	24.70	2.41	10.28
GP017	2024-08-12	22.0	11.5	1	7.96	8.10	8.58	95.22	97.08	100.74	54576.00	54638.00	49709.00	36.08	36.14	32.52	7.55	7.56	7.52	13.95	14.00	14.09	34.80	1.98	13.89
GP018	2024-08-12	13.0	6.5	1	7.86	8.01	8.30	94.18	95.88	94.67	54685.00	54422.00	54377.00	36.17	35.98	35.94	7.47	7.48	7.42	14.00	14.02	13.81	17.10	8.08	28.90
GP019	2024-08-12	12.0	6.5	1	7.27	8.19	8.55	87.15	98.47	99.98	54518.00	54137.00	49709.00	36.05	35.77	32.52	7.47	7.52	7.49	14.06	14.05	14.00	23.50	3.14	15.20
GP043	2024-08-12	23.5	12.0	1	8.08	8.12	8.42	96.85	97.43	97.26	54683.00	54706.00	47143.00	36.16	36.19	30.65	7.56	7.56	7.50	13.99	14.01	13.91	6.26	0.95	19.40
RI001	2024-08-12	NA	NA	1	NA	NA	8.44	NA	NA	101.49	NA	NA	54861.00	NA	NA	36.31	NA	NA	7.53	NA	NA	14.00	NA	NA	3.30
GP001	2024-09-16	6.0	3.5	1	12.09	13.04	13.71	140.39	150.66	158.81	53013.00	53302.00	53411.00	34.89	35.09	35.19	7.78	7.79	7.84	12.68	12.54	12.81	0.00	0.00	0.00
GP002	2024-09-16	6.0	3.5	1	11.30	12.88	14.66	131.23	148.58	171.28	53157.00	53261.00	53412.00	34.98	35.06	35.19	7.76	7.79	7.88	12.54	12.49	12.86	2.11	2.75	0.45
GP003	2024-09-16	7.0	4.0	1	10.96	12.17	13.39	127.51	140.34	156.42	52767.00	53263.00	53174.00	34.71	35.06	35.01	7.75	7.81	7.87	12.72	12.45	12.86	2.39	2.51	1.01
GP004	2024-09-16	7.5	4.5	1	9.88	10.13	10.97	113.31	119.70	127.96	53351.00	52785.00	53299.00	35.10	34.73	35.09	7.70	7.75	7.79	11.97	12.97	12.58	2.71	2.16	1.49
GP005	2024-09-16	8.0	4.5	1	11.72	13.78	10.81	134.24	159.23	124.80	53405.00	53559.00	52431.00	35.14	35.27	34.44	7.74	7.83	7.76	12.01	12.37	12.29	0.20	0.16	0.00
GP006	2024-09-16	21.0	11.0	1	8.02	15.20	13.60	91.65	178.15	161.17	52960.00	54173.00	54387.00	34.82	35.75	35.95	7.58	7.91	7.92	12.27	13.01	13.94	0.36	0.00	0.00
GP007	2024-09-16	20.0	10.5	1	11.17	14.88	14.17	127.62	172.99	168.25	52251.00	53727.00	54448.00	34.31	35.40	35.98	7.58	7.91	7.94	12.40	12.59	13.41	1.11	0.00	0.00
GP008	2024-09-16	21.0	11.0	1	8.11	15.16	16.00	91.56	177.16	190.36	52203.00	53064.00	54268.00	34.24	34.93	35.86	7.57	7.87	7.95	11.77	12.81	13.77	0.27	0.00	0.00
GP009	2024-09-16	22.0	11.5	1	7.95	8.59	15.69	89.77	98.74	186.76	52065.00	52144.00	54313.00	34.15	34.23	35.88	7.57	7.64	7.94	11.94	12.33	13.41	0.34	0.00	0.00
GP010	2024-09-16	27.0	14.0	1	9.24	11.10	15.09	103.28	124.86	179.07	53017.00	52477.00	54189.00	34.81	34.44	35.78	7.36	7.57	7.93	11.40	11.77	13.24	0.00	1.32	0.00
GP011	2024-09-16	27.0	14.0	1	9.80	11.78	15.15	110.66	134.44	180.35	53097.00	53180.00	54089.00	34.86	34.97	35.73	7.56	7.60	7.94	11.30	11.90	13.72	1.19	0.40	0.00
GP012	2024-09-16	25.0	13.0	1	9.13	9.76	15.83	102.02	110.60	187.58	53369.00	53118.00	54397.00	35.05	34.90	35.94	7.55	7.59	7.95	11.11	11.53	13.42	0.02	0.00	0.00
GP013	2024-09-16	28.0	14.5	1	9.31	10.13	14.59	104.85	113.87	187.77	53001.00	53167.00	54568.00	34.79	34.93	36.07	7.56	7.60	7.92	11.31	11.48	13.58	0.57	0.00	0.00
GP014	2024-09-16	25.0	13.0	1	9.24	11.11	12.16	102.47	127.20	146.81	53103.00	53237.00	54296.00	34.86	35.01	35.89	7.55	7.64	7.93	11.15	11.89	14.15	2.81	0.02	0.00
GP015	2024-09-16	28.0	14.5	1	8.60	9.41	15.08	97.11	104.42	180.80	52896.00	53160.00	54413.00	34.73	34.92	35.97	7.55	7.57	7.92	11.46	11.42	13.91	0.00	0.00	0.00
GP016	2024-09-16	27.0	14.0	1	7.35	10.16	15.02	89.33	115.43	179.91	54314.00	53525.00	54097.00	35.77	35.21	35.73	7.88	7.66	7.94	11.54	11.75	13.77	0.33	0.00	0.00
GP017	2024-09-16	24.0	12.5	1	9.40	11.46	13.37	104.74	129.81	163.41	51996.00	53064.00	54201.00	34.07	34.88	35.81	7.58	7.65	7.95	11.53	11.85	13.76	0.22	0.00	0.00
GP018	2024-09-16	12.0	6.5	1	10.90	12.28	11.89	120.42	137.40	134.58	53227.00	53441.00	53438.00	34.95	35.13	35.14	7.54	7.67	7.70	11.09	11.39	11.57	0.05	1.10	0.69
GP019	2024-09-16	10.5	5.5	1	10.38	12.12	13.40	115.05	136.47	153.43	53113.00	53250.00	53746.00	34.90	35.01	35.40	7.54	7.66	7.78	11.52	11.69	12.06	0.00	0.25	0.00
GP043	2024-09-16	25.0	13.0	1	8.51	11.42	14.98	95.04	129.91	179.02	53495.00	53625.00	54254.00	35.15	35.28	35.85	7.56	7.71	7.92	11.20	11.72	13.86	0.00	0.26	0.00
RI001	2024-09-16	23.5	12.5	1	9.62	10.78	12.81	109.59	123.94	148.92	53876.00	54188.00	54147.00	35.48	35.74	35.72	7.60	7.66	7.80	12.07	12.44	12.65	0.40	0.00	0.53
GP001	2024-10-17	5.5	3.0	1	6.10	6.22	6.29	70.88	72.13	73.73	53427.00	53924.00	54083.00	35.19	35.55	35.67	7.47	7.49	7.50	12.66	12.43	12.54	1.37	0.00	0.00
GP002	2024-10-17	3.0	2.0	1	6.19	6.32	6.35	71.75	73.58	74.40	54136.00	54109.00	54280.00	35.70	35.68	35.82	7.50	7.51	7.50	12.39	12.44	12.57	2.81	0.00	1.06

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP003	2024-10-17	6.0	3.5	1	6.12	6.40	6.90	71.01	75.61	81.30	53904.00	54964.00	54312.00	35.53	36.32	35.84	7.50	7.52	7.57	12.50	12.49	12.68	0.62	0.02	0.00
GP004	2024-10-17	8.0	4.5	1	6.98	6.87	6.99	80.85	79.41	81.45	53913.00	54092.00	54289.00	35.53	35.66	35.82	7.57	7.57	7.57	12.27	12.30	12.54	0.00	0.11	0.23
GP005	2024-10-17	8.0	4.5	1	7.03	6.91	6.96	81.11	80.31	81.65	53903.00	53953.00	54290.00	35.31	35.56	35.82	7.53	7.54	7.58	12.50	12.40	12.58	0.00	0.00	0.00
GP006	2024-10-17	21.0	11.0	1	5.96	6.67	8.03	67.29	78.72	91.46	53337.00	54469.00	54102.00	35.04	35.93	35.73	7.56	7.62	7.62	11.33	12.09	13.52	0.00	0.00	0.00
GP007	2024-10-17	20.0	10.5	1	6.41	6.94	7.56	72.77	81.59	89.86	52909.00	54150.00	53770.00	34.77	35.70	35.49	7.58	7.63	7.62	11.94	12.35	13.77	0.00	0.00	0.00
GP008	2024-10-17	22.0	11.5	1	6.21	7.29	7.49	70.24	85.10	88.33	53490.00	53484.00	54567.00	35.17	35.23	36.05	7.57	7.63	7.62	11.50	12.78	13.13	0.00	0.00	0.00
GP009	2024-10-17	23.5	12.0	1	6.54	7.15	7.51	74.02	83.00	88.88	52930.00	53429.00	54593.00	34.79	35.18	36.08	7.59	7.63	7.62	12.16	12.49	13.32	0.23	0.00	0.00
GP010	2024-10-17	27.5	14.0	1	6.33	6.98	7.58	71.77	79.53	89.93	53231.00	53978.00	53735.00	34.98	35.55	35.44	7.58	7.62	7.62	11.65	11.86	13.19	0.00	0.00	0.00
GP011	2024-10-17	28.0	14.5	1	6.20	7.34	7.20	70.48	85.00	91.74	53270.00	53990.00	54393.00	34.98	35.59	35.94	7.58	7.64	7.62	11.17	12.38	13.50	0.00	0.00	0.21
GP012	2024-10-17	27.0	14.0	1	6.35	7.22	7.59	71.85	83.51	91.24	53506.00	53758.00	55206.00	35.17	35.42	36.55	7.59	7.63	7.62	11.39	12.49	13.57	0.00	0.02	0.00
GP013	2024-10-17	29.0	15.0	1	6.69	6.96	7.72	73.17	80.79	91.58	52998.00	54325.00	54598.00	34.79	35.81	36.11	7.58	7.63	7.30	11.33	11.99	13.86	0.00	0.00	0.00
GP014	2024-10-17	25.0	13.0	1	6.36	7.22	7.61	72.39	83.74	91.60	52996.00	54122.00	54446.00	34.80	35.67	36.00	7.59	7.63	7.63	11.49	12.17	14.13	0.00	0.00	0.00
GP015	2024-10-17	27.0	14.0	1	6.32	7.21	7.70	71.19	83.38	92.38	53465.00	53678.00	54830.00	35.13	35.35	36.29	7.59	7.63	7.63	11.20	12.27	14.04	0.00	0.00	0.00
GP016	2024-10-17	27.0	14.0	1	6.21	7.25	7.72	72.75	85.19	92.40	53129.00	53408.00	54119.00	34.89	35.17	35.75	7.48	7.64	7.63	11.27	12.70	13.83	0.00	0.00	0.00
GP017	2024-10-17	23.0	12.0	1	6.64	7.35	7.51	75.61	85.49	89.76	53006.00	53455.00	53821.00	34.86	35.21	35.54	7.61	7.63	7.62	12.38	12.74	14.05	0.00	0.00	0.00
GP018	2024-10-17	12.0	6.5	1	6.23	6.45	7.67	70.29	77.13	91.37	53062.00	53869.00	53616.00	34.85	35.46	35.35	7.56	7.59	7.60	11.30	11.61	13.07	0.00	0.72	1.55
GP019	2024-10-17	11.5	6.0	1	5.79	7.30	7.26	65.49	84.10	84.98	53656.00	53302.00	54065.00	35.28	35.09	35.67	7.55	7.59	7.60	11.20	12.57	12.81	0.00	0.00	1.60
GP043	2024-10-17	31.0	16.0	1	6.36	7.35	7.72	71.82	85.84	92.15	53116.00	53969.00	54598.00	34.88	35.58	36.10	7.59	7.64	7.64	11.30	12.58	13.63	0.00	0.00	0.00
RI001	2024-10-17	24.0	12.5	1	6.35	7.13	8.24	72.75	83.22	99.54	53816.00	54404.00	55420.00	35.43	35.90	36.73	7.56	7.60	7.68	11.97	12.63	14.13	0.00	0.00	0.00
GP001	2024-11-19	5.0	3.0	1	8.49	9.79	10.51	99.48	115.04	128.67	51504.00	53503.00	54735.00	33.82	35.29	36.23	7.70	7.74	7.78	13.61	13.63	14.40	0.00	0.36	0.00
GP002	2024-11-19	2.0	1.5	1	9.89	10.15	10.47	120.80	123.41	131.32	53776.00	54085.00	54184.00	35.53	35.77	35.86	7.75	7.78	7.82	14.85	15.24	15.79	0.00	0.00	0.00
GP003	2024-11-19	5.0	3.0	1	9.40	8.57	10.78	111.56	114.16	127.98	53618.00	53280.00	54184.00	35.36	35.13	35.80	7.73	7.77	7.80	13.31	13.92	13.76	0.00	0.00	0.00
GP004	2024-11-19	11.0	6.0	1	7.41	8.31	9.10	82.10	92.68	107.20	NA	53777.00	53865.00	NA	35.33	35.49	7.61	7.67	7.67	10.46	10.61	12.24	0.02	0.00	0.00
GP005	2024-11-19	8.0	4.5	1	7.67	8.56	9.86	86.51	95.14	115.89	51961.00	53402.00	54165.00	34.07	35.08	35.76	7.63	7.65	7.69	11.83	10.99	13.16	0.00	0.00	0.00
GP006	2024-11-19	20.0	10.5	1	6.01	8.08	11.30	67.80	90.48	132.38	52031.00	52898.00	54201.00	34.02	34.71	35.79	7.56	7.63	7.84	10.30	11.06	13.34	0.00	0.00	0.00
GP007	2024-11-19	20.0	10.5	1	5.88	7.99	11.33	64.80	89.36	133.74	52420.00	52051.00	54343.00	34.29	34.08	35.89	7.56	7.63	7.83	10.10	10.92	13.25	0.00	0.00	0.00
GP008	2024-11-19	22.0	11.5	1	5.89	7.70	10.65	64.73	86.55	124.47	52398.00	52963.00	53260.00	34.26	34.70	35.10	7.56	7.63	7.81	9.86	10.15	13.41	0.00	0.00	0.00
GP009	2024-11-19	23.0	12.0	1	5.66	7.83	11.12	62.29	87.37	130.09	52031.00	52648.00	55481.00	34.02	34.51	36.70	7.56	7.63	7.82	10.22	10.76	12.60	0.00	0.00	0.00
GP010	2024-11-19	29.0	15.0	1	5.55	6.19	9.27	61.92	68.48	106.03	52525.00	52613.00	53958.00	34.35	34.44	35.56	7.56	7.57	7.71	9.84	10.19	12.12	0.00	0.00	0.00
GP011	2024-11-19	25.0	13.0	1	6.29	7.60	10.91	70.77	85.21	124.72	51463.00	52407.00	54363.00	33.62	34.37	35.91	7.55	7.62	7.83	10.48	11.45	13.20	0.00	0.00	0.00
GP012	2024-11-19	25.0	13.0	1	5.81	7.62	11.00	63.24	84.69	131.48	52703.00	53343.00	54228.00	34.45	35.00	35.81	7.55	7.61	7.81	9.47	10.52	13.20	0.00	0.00	0.00
GP013	2024-11-19	27.0	14.0	1	5.70	7.61	11.48	62.20	84.92	136.41	52116.00	53024.00	54029.00	34.07	34.78	35.66	7.55	7.61	7.83	10.05	10.69	13.21	0.00	0.00	0.00
GP014	2024-11-19	27.0	14.0	1	6.04	7.64	11.20	66.75	85.02	131.22	52177.00	53116.00	55628.00	34.13	34.84	36.84	7.55	7.61	7.81	10.28	10.61	13.05	0.00	0.00	0.00
GP015	2024-11-19	27.0	14.0	1	5.72	7.58	11.37	61.60	84.52	133.57	53216.00	52970.00	54335.00	34.80	34.75	35.89	7.54	7.61	7.82	9.23	10.84	13.32	0.00	0.00	0.00
GP016	2024-11-19	26.0	13.5	1	5.81	7.75	11.64	63.33	87.32	138.40	52644.00	52958.00	54023.00	34.42	34.74	35.67	7.56	7.62	7.84	9.68	10.88	13.47	0.00	0.00	0.00
GP017	2024-11-19	22.0	11.5	1	6.13	7.67	11.17	66.74	84.88	131.79	52688.00	53592.00	53711.00	34.46	35.17	35.45	7.55	7.61	7.82	9.72	10.32	13.74	0.00	0.00	0.00
GP018	2024-11-19	12.0	6.5	1	6.29	7.42	8.73	75.44	85.66	100.30	48447.00	51282.00	53260.00	31.63	33.62	35.06	7.55	7.60	7.96	15.16	12.84	12.53	0.00	0.00	0.00
GP019	2024-11-19	14.0	7.5	1	7.62	8.02	7.63	88.02	91.62	89.65	51580.00	53174.00	50781.00	33.85	NA	33.31	7.61	7.61	7.60	13.22	NA	14.40	0.00	0.00	0.00
GP043	2024-11-19	25.0	13.0	1	5.87	7.41	11.19	65.50	85.17	130.32	50934.00	52794.00	54068.00	33.28	34.62	35.69	7.56	7.62	7.84	11.16	10.91	13.32	0.00	0.00	0.00
RI001	2024-11-19	25.0	13.0	1	8.63	10.01	11.41	98.58	115.87	134.10	53245.00	53645.00	53853.00	35.05	35.33	35.53	7.61	7.70	7.78	12.80	12.41	13.23	0.00	0.00	0.13
GP001	2024-12-15	6.0	3.5	1	8.05	9.01	9.06	99.46	116.16	115.01	53393.00	54484.00	54356.00	35.27	36.09	36.00	7.75	7.79	7.78	15.78	16.30	16.39	1.02	0.24	0.02
GP002	2024-12-15	4.0	2.5	1	8.99	9.10	9.09	114.39	114.97	115.62	54274.00	54350.00	54284.00	35.93	35.99	35.93	7.76	7.77	7.77	16.25	16.17	15.78	0.00	0.37	0.29
GP003	2024-12-15	4.5	3.0	1	8.93	9.05	9.50	113.96	113.85	119.58	54449.00	52845.00	52874.00	36.06	34.88	34.90	7.77	7.76	7.76	16.22	16.29	16.29	0.21	0.22	2.07
GP004	2024-12-15	10.0	5.5	1	6.41	8.38	9.32	73.01	110.05	116.04	51042.00	55412.00	55160.00	33.39	36.74	36.57	7.48	7.74	7.76	11.72	14.80	15.45	0.27	0.34	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP005	2024-12-15	9.0	5.0	1	6.42	7.18	8.59	74.80	99.44	113.06	52864.00	54741.00	54391.00	34.77	36.22	36.00	7.59	7.71	7.74	12.52	14.15	15.43	2.59	0.00	0.00
GP006	2024-12-15	22.0	11.5	1	3.86	3.96	9.33	42.61	42.92	113.47	51882.00	53239.00	55175.00	33.92	34.89	36.53	7.47	7.48	7.74	10.30	10.03	13.69	1.85	0.00	0.24
GP007	2024-12-15	19.5	10.0	1	4.04	4.55	8.88	44.63	50.20	105.75	51894.00	53185.00	55726.00	33.94	34.85	36.92	7.48	7.50	7.72	10.47	10.01	13.21	1.45	0.63	0.00
GP008	2024-12-15	20.0	13.5	1	4.06	4.41	9.02	43.67	48.60	110.55	50797.00	53092.00	56114.00	33.11	34.82	37.23	7.48	7.50	7.75	10.00	10.51	13.89	4.37	0.00	0.66
GP009	2024-12-15	26.0	13.5	1	4.02	4.13	9.54	45.28	45.34	117.18	51662.00	53452.00	55081.00	33.76	35.04	36.50	7.48	7.48	7.78	10.38	9.94	14.80	4.00	0.69	0.93
GP010	2024-12-15	26.0	13.5	1	4.37	4.77	9.46	47.43	50.84	117.83	52880.00	52638.00	54968.00	34.59	34.45	36.41	7.51	7.50	7.77	9.56	10.05	14.83	2.76	0.58	0.15
GP011	2024-12-15	29.0	15.0	1	4.96	6.07	8.83	53.27	61.74	105.21	52121.00	52856.00	54189.00	34.06	34.58	35.79	7.51	7.50	7.71	9.90	9.65	13.56	3.44	0.00	0.34
GP012	2024-12-15	28.0	14.5	1	4.57	4.83	9.05	49.21	50.25	108.58	53368.00	52795.00	54156.00	34.93	34.53	35.77	7.51	7.49	7.74	9.42	9.52	13.68	0.00	0.69	0.73
GP013	2024-12-15	29.0	15.0	1	4.47	4.53	8.61	53.33	49.31	105.85	52620.00	53416.00	54620.00	34.42	34.96	36.11	7.52	7.52	7.70	9.94	9.32	13.41	1.64	0.00	0.61
GP014	2024-12-15	28.0	14.5	1	5.71	5.42	8.83	58.41	59.48	104.59	52549.00	53657.00	54389.00	34.37	35.16	35.93	7.53	7.52	7.69	9.95	9.62	13.32	0.69	0.00	0.02
GP015	2024-12-15	28.0	14.5	1	5.56	6.76	8.94	59.51	74.61	106.07	52777.00	53239.00	53899.00	34.53	34.90	35.58	7.54	7.59	7.71	9.81	10.22	13.54	0.00	0.39	0.46
GP016	2024-12-15	26.0	13.5	1	4.68	4.09	9.01	50.03	44.58	108.50	51822.00	53061.00	54777.00	33.89	34.73	36.23	7.50	7.49	7.73	10.57	9.68	13.72	2.38	0.60	0.28
GP017	2024-12-15	28.0	14.5	1	4.32	5.11	8.86	47.30	53.93	106.69	52206.00	53484.00	53733.00	34.10	35.05	35.47	7.50	7.46	7.72	9.62	9.77	13.89	2.14	0.00	0.67
GP018	2024-12-15	15.0	8.0	1	3.48	6.11	8.30	39.02	71.72	100.56	52471.00	52983.00	54440.00	34.40	34.85	36.00	7.46	7.60	7.71	11.10	12.51	14.04	0.67	1.34	1.52
GP019	2024-12-15	15.0	8.0	1	3.53	9.34	9.52	40.06	114.58	117.07	52598.00	54329.00	54228.00	34.51	35.93	35.88	7.45	7.77	7.79	11.39	14.72	15.23	4.59	0.26	0.62
GP043	2024-12-15	29.0	15.0	1	4.61	5.34	9.51	50.51	64.46	118.29	51411.00	54765.00	54364.00	33.53	36.05	35.97	7.52	7.58	7.77	9.80	10.67	14.96	0.05	0.00	0.00
RI001	2024-12-15	27.0	14.0	1	4.90	4.61	8.93	51.61	52.72	111.12	51404.00	53801.00	55939.00	33.58	35.34	37.15	7.44	7.50	7.73	10.51	10.54	15.22	0.00	0.00	0.00
GP001	2025-01-17	4.0	2.5	1	5.75	6.11	8.59	62.95	67.76	96.32	53062.00	52976.00	53618.00	34.75	34.69	35.21	7.81	7.81	7.99	9.89	9.89	10.60	0.44	0.02	2.19
GP002	2025-01-17	3.0	2.0	1	6.18	7.52	8.19	68.87	83.95	92.08	52375.00	53033.00	53370.00	34.30	34.77	35.05	7.85	7.88	8.03	10.50	10.38	10.83	0.63	0.62	0.51
GP003	2025-01-17	4.0	2.5	1	6.39	6.28	6.39	71.16	69.70	71.22	53247.00	53455.00	53662.00	34.93	35.07	35.22	7.83	7.81	7.83	10.41	10.24	10.30	0.00	0.00	0.00
GP004	2025-01-17	9.0	5.0	1	6.15	6.11	7.69	67.93	67.09	86.10	52710.00	53529.00	53549.00	34.50	35.09	35.16	7.80	7.80	7.87	9.93	9.86	10.59	0.00	0.00	0.00
GP005	2025-01-17	10.0	5.5	1	5.61	5.82	7.46	61.80	63.90	82.61	52536.00	52725.00	53520.00	34.38	34.49	35.11	7.81	7.80	7.82	10.11	9.71	10.13	0.10	0.00	0.20
GP006	2025-01-17	21.0	11.0	1	5.31	5.53	6.55	57.97	60.11	73.43	52091.00	52521.00	53262.00	34.02	34.32	34.96	7.80	7.79	7.82	9.60	9.42	10.66	0.00	0.00	0.00
GP007	2025-01-17	20.0	10.5	1	5.47	5.78	6.26	59.68	63.29	69.58	52750.00	52999.00	53781.00	34.50	34.70	35.31	7.79	7.80	7.80	9.62	9.80	10.26	0.00	0.00	0.00
GP008	2025-01-17	21.0	11.0	1	5.43	5.83	6.41	58.93	63.74	71.47	52697.00	52963.00	53485.00	34.44	34.66	35.10	7.79	7.80	7.80	9.38	9.70	10.34	0.00	0.00	0.00
GP009	2025-01-17	22.0	11.5	1	5.46	5.82	6.13	59.44	63.58	67.77	53236.00	53424.00	53784.00	34.83	34.99	35.29	7.79	7.80	7.80	9.34	9.52	10.01	0.00	0.00	0.00
GP010	2025-01-17	27.0	14.0	1	5.37	5.78	6.33	58.36	63.19	69.97	53068.00	53116.00	53080.00	34.70	34.77	34.81	7.79	7.80	7.80	9.25	9.67	10.51	0.00	0.00	0.00
GP011	2025-01-17	24.0	12.5	1	5.31	5.72	5.86	57.49	62.53	64.32	53619.00	53662.00	53618.00	35.09	35.14	35.14	7.76	7.77	7.78	9.13	9.28	9.66	0.00	0.00	0.00
GP012	2025-01-17	25.0	13.0	1	5.37	5.94	7.05	59.14	64.99	80.29	52312.00	53500.00	53327.00	34.24	35.06	35.03	7.80	7.81	7.82	10.46	9.76	11.01	0.00	0.00	0.00
GP013	2025-01-17	23.0	12.0	1	5.38	5.99	7.02	59.04	65.39	78.95	52534.00	53565.00	54152.00	34.38	35.12	35.61	7.79	7.81	7.84	10.10	9.85	10.73	0.00	0.00	0.00
GP014	2025-01-17	26.0	13.5	1	5.52	5.99	7.03	60.17	65.35	81.96	52945.00	53709.00	52975.00	34.64	35.20	34.80	7.79	7.81	7.83	9.66	9.66	11.61	0.00	0.00	0.00
GP015	2025-01-17	27.0	14.0	1	5.33	5.76	7.18	58.45	62.55	82.10	52453.00	53452.00	53308.00	34.33	35.01	35.04	7.79	7.79	7.85	10.31	9.57	11.41	0.00	0.00	0.00
GP016	2025-01-17	26.0	13.5	1	5.45	5.65	6.34	61.24	61.43	70.02	51786.00	53280.00	53961.00	33.87	34.89	35.45	7.77	7.77	7.80	10.65	9.59	10.33	0.00	0.00	0.00
GP017	2025-01-17	24.0	12.5	1	5.38	5.89	6.95	59.38	64.53	79.00	51100.00	53107.00	53166.00	33.36	34.80	34.93	7.79	7.80	7.83	10.58	10.06	11.27	0.00	0.00	0.00
GP018	2025-01-17	13.0	7.0	1	5.46	5.52	5.88	59.39	60.10	65.71	53553.00	53604.00	54331.00	35.06	35.10	35.72	7.74	7.74	7.70	9.32	9.32	10.36	0.00	0.00	1.21
GP019	2025-01-17	11.0	6.0	1	5.99	6.08	6.66	66.08	66.91	74.39	53077.00	53423.00	53062.00	34.77	35.02	34.78	7.73	7.73	7.71	9.99	9.89	10.19	0.00	0.00	0.00
GP043	2025-01-17	27.0	14.0	1	5.45	5.63	7.21	60.45	60.89	80.84	53143.00	53668.00	54458.00	34.77	35.15	35.83	7.75	7.76	7.84	9.53	9.32	10.67	0.00	0.00	0.00
RI001	2025-01-17	29.0	15.0	1	5.54	6.87	9.40	60.57	76.84	109.95	52065.00	53666.00	54214.00	34.06	35.24	35.74	7.62	7.75	7.94	10.59	10.59	12.08	0.00	0.00	0.00
GP001	2025-02-19	7.0	4.0	1	5.68	5.58	7.13	63.06	61.79	78.42	52686.00	53326.00	53059.00	34.53	34.99	34.83	7.92	7.89	7.92	10.56	10.47	11.01	0.00	0.29	0.00
GP002	2025-02-19	3.0	2.0	1	5.76	6.30	6.73	65.26	70.51	78.30	52072.00	52975.00	53700.00	34.13	34.76	35.31	7.90	7.94	8.00	11.41	10.84	11.20	0.00	0.00	0.00
GP003	2025-02-19	3.0	2.0	1	8.22	8.26	8.92	94.18	94.85	95.23	53488.00	53697.00	53711.00	35.19	35.34	35.35	8.11	8.11	8.11	11.81	11.67	11.71	0.00	0.00	0.00
GP004	2025-02-19	10.0	5.5	1	6.89	7.32	7.53	77.09	82.02	85.15	52812.00	53693.00	53728.00	34.64	35.27	35.31	7.96	8.03	8.03	10.95	10.62	10.83	0.00	0.00	0.00
GP005	2025-02-19	10.0	4.0	1	7.29	7.53	8.13	80.87	85.48	93.70	53203.00	53878.00	53899.00	34.90	35.40	35.48	7.97	8.05	8.11	10.48	10.60	11.52	0.00	0.00	0.00
GP006	2025-02-19	21.0	11.0	1	4.23	5.60	7.55	46.14	60.98	85.45	53031.00	53205.00	53674.00	34.70	34.86	35.28	7.87	7.89	8.06	9.52	9.97	10.95	0.00	0.00	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP007	2025-02-19	19.0	11.0	1	4.59	4.96	7.84	50.28	53.35	89.63	53307.00	53497.00	54438.00	34.89	35.05	35.85	7.88	7.88	8.12	9.48	9.67	11.08	0.00	0.00	0.00
GP008	2025-02-19	23.0	12.0	1	5.61	7.01	8.46	60.22	77.04	97.51	52836.00	53202.00	54247.00	34.58	34.88	35.75	7.92	8.00	8.13	9.88	10.30	11.80	0.00	0.00	0.00
GP009	2025-02-19	23.0	12.0	1	4.67	6.68	7.90	50.69	73.33	90.47	53414.00	53467.00	54724.00	34.95	35.06	36.08	7.91	7.99	8.14	9.24	10.03	11.43	0.00	0.00	0.00
GP010	2025-02-19	28.0	14.0	1	5.13	6.35	8.24	54.82	69.74	93.56	53019.00	53352.00	53882.00	34.67	34.96	35.45	7.91	7.99	8.13	9.38	9.86	11.20	0.00	0.00	0.00
GP011	2025-02-19	26.0	13.5	1	5.18	6.24	8.14	55.51	68.42	92.00	53198.00	53400.00	53512.00	34.80	34.99	35.17	7.92	7.97	8.12	9.32	9.85	11.20	0.00	0.00	0.00
GP012	2025-02-19	26.0	13.5	1	5.62	6.69	8.19	60.80	73.41	92.48	53241.00	53375.00	53906.00	34.82	34.98	35.45	7.93	7.97	8.11	9.20	9.85	11.02	0.02	0.00	0.00
GP013	2025-02-19	27.0	14.0	1	5.61	6.96	8.26	60.02	76.54	94.46	52991.00	53203.00	53999.00	34.66	34.86	35.55	7.93	7.98	8.12	9.45	9.93	11.57	0.00	0.00	0.00
GP014	2025-02-19	26.0	13.5	1	5.58	6.49	8.34	58.11	69.99	93.32	53181.00	53388.00	54173.00	34.78	34.97	35.65	7.94	7.99	8.10	9.28	9.71	11.00	0.00	0.00	0.00
GP015	2025-02-19	27.0	14.0	1	5.84	6.03	8.11	59.20	65.91	90.59	52915.00	53450.00	54864.00	34.60	35.01	36.14	7.95	7.97	8.10	9.42	9.62	10.82	0.00	0.00	0.00
GP016	2025-02-19	25.0	13.0	1	5.16	6.25	8.03	56.09	68.45	89.06	53021.00	53435.00	53776.00	34.68	35.02	35.34	7.92	7.97	8.05	9.44	9.81	10.70	0.00	0.00	0.00
GP017	2025-02-19	23.0	12.0	1	5.24	6.68	8.11	57.05	71.64	91.61	52924.00	53487.00	53744.00	34.61	35.06	35.33	7.92	7.98	8.11	9.47	9.87	10.99	0.00	0.00	0.00
GP018	2025-02-19	13.0	7.0	1	4.56	5.04	6.66	50.09	55.24	74.70	52252.00	52869.00	53420.00	34.17	34.61	35.09	7.88	7.88	7.87	10.05	9.85	10.89	0.00	0.00	0.00
GP019	2025-02-19	13.0	7.0	1	5.05	5.63	6.57	55.39	62.67	73.20	53440.00	52907.00	52632.00	35.02	34.68	34.51	7.84	7.84	7.84	9.75	10.41	10.80	0.00	0.00	0.00
GP043	2025-02-19	26.0	13.5	1	5.37	6.21	7.20	57.37	68.73	79.64	52888.00	52513.00	53509.00	34.59	34.38	35.13	7.94	7.96	8.02	9.50	10.32	10.55	0.00	0.00	0.00
RI001	2025-02-19	27.0	14.0	1	3.94	5.12	7.90	42.14	57.18	90.21	52560.00	53196.00	53626.00	34.37	34.90	35.30	7.81	7.89	8.10	9.82	10.64	11.95	0.00	0.00	0.00
GP001	2025-03-19	5.0	3.0	1	5.90	6.34	7.07	68.24	73.61	83.22	53300.00	53490.00	53975.00	35.08	35.23	35.61	7.98	7.99	8.07	12.27	12.52	12.95	0.50	0.02	0.55
GP002	2025-03-19	3.0	2.0	1	6.85	6.84	7.25	80.31	80.36	86.24	53658.00	53789.00	54001.00	35.37	35.47	35.64	8.03	8.04	8.11	12.77	12.83	13.17	0.43	0.60	0.40
GP003	2025-03-19	7.5	4.0	1	6.24	6.79	7.51	72.95	80.03	90.01	53357.00	53694.00	54247.00	35.14	35.41	35.84	7.98	8.01	8.08	12.70	13.13	13.59	0.29	0.00	0.46
GP004	2025-03-19	8.0	4.5	1	6.83	7.62	7.49	80.04	90.70	96.07	53007.00	53867.00	54236.00	34.90	35.55	35.83	7.99	8.05	8.16	13.18	13.41	13.74	0.53	0.06	0.37
GP005	2025-03-19	9.0	5.0	1	7.15	7.18	7.99	84.96	84.45	95.81	53299.00	53533.00	54176.00	35.11	35.29	35.79	7.99	8.01	8.12	13.09	13.10	13.67	0.26	0.00	0.00
GP006	2025-03-19	21.5	11.0	1	5.25	6.22	6.97	59.17	71.33	83.37	52328.00	52810.00	54210.00	34.34	34.72	35.80	7.90	7.97	8.06	12.04	12.43	13.47	0.00	0.29	0.32
GP007	2025-03-19	21.0	11.0	1	5.00	6.40	6.99	56.16	74.94	83.48	52711.00	53002.00	53994.00	34.61	34.88	35.64	7.90	8.00	8.05	11.69	12.76	13.47	0.00	0.00	0.02
GP008	2025-03-19	23.0	12.0	1	5.78	6.45	7.70	64.99	75.50	92.63	51946.00	53012.00	54163.00	34.08	34.89	35.78	7.89	8.00	8.13	12.40	12.87	13.75	0.21	0.00	0.00
GP009	2025-03-19	23.0	12.0	1	4.88	7.19	7.59	57.87	84.97	92.16	50916.00	53164.00	54250.00	33.38	35.01	35.86	7.90	8.04	8.14	13.70	13.07	14.18	0.02	0.00	0.00
GP010	2025-03-19	25.0	13.0	1	4.34	6.92	7.75	49.03	82.04	94.91	51269.00	52915.00	54408.00	33.56	34.83	35.99	7.88	8.07	8.14	11.78	13.21	14.60	0.02	0.00	0.00
GP011	2025-03-19	24.5	12.5	1	3.03	5.21	6.20	33.50	60.39	73.92	52978.00	53911.00	54441.00	34.71	NA	35.96	7.81	7.98	7.97	10.23	NA	13.05	0.00	0.00	0.19
GP012	2025-03-19	28.0	14.5	1	4.12	7.04	7.50	45.38	83.15	90.42	52026.00	53425.00	54159.00	34.09	35.21	35.78	7.84	8.06	8.12	11.42	13.20	13.88	0.00	0.37	0.19
GP013	2025-03-19	27.0	14.0	1	5.23	6.90	7.61	57.70	79.93	91.13	51145.00	53366.00	54309.00	33.49	35.15	35.88	7.82	8.00	8.11	12.22	12.86	13.56	0.00	0.00	0.10
GP014	2025-03-19	28.0	14.5	1	5.83	6.98	7.19	63.50	82.63	86.52	51520.00	53121.00	54332.00	33.76	34.98	35.91	7.84	8.05	8.11	12.22	13.10	13.77	0.43	0.14	0.00
GP015	2025-03-19	26.5	14.0	1	5.51	7.21	7.45	59.70	85.39	90.35	51653.00	53327.00	54379.00	33.85	35.14	35.95	7.82	8.05	8.13	11.98	13.36	14.13	0.27	0.00	0.30
GP016	2025-03-19	26.5	14.0	1	2.49	4.32	5.57	27.12	49.60	56.92	53343.00	53341.00	54554.00	34.96	35.04	36.02	7.80	7.94	7.96	9.99	11.13	12.60	0.13	0.13	0.15
GP017	2025-03-19	25.0	13.0	1	4.29	6.80	7.49	48.73	80.39	90.41	52093.00	53101.00	54162.00	34.14	34.96	35.79	7.86	8.02	8.11	11.49	12.95	13.95	0.00	0.14	0.67
GP018	2025-03-19	13.5	7.0	1	4.95	5.93	5.99	56.34	68.16	69.41	53099.00	53544.00	53274.00	34.87	35.25	35.05	7.88	7.90	7.91	11.29	12.12	12.14	0.59	0.21	0.42
GP019	2025-03-19	11.5	6.0	1	3.85	4.69	5.69	43.30	54.88	65.41	53503.00	53878.00	53821.00	35.13	35.44	35.39	7.84	7.92	7.93	10.69	11.15	11.07	0.02	0.15	0.26
GP043	2025-03-19	26.0	13.5	1	2.60	4.96	6.18	27.02	56.98	72.95	53377.00	53661.00	54090.00	34.97	35.28	35.69	7.80	7.94	7.90	9.80	11.20	12.86	0.80	0.00	0.19
RI001	2025-03-19	26.0	13.5	1	4.06	5.94	6.94	43.94	69.99	84.90	54425.00	54324.00	54731.00	35.84	35.85	36.19	7.90	8.02	7.80	11.37	12.74	13.56	1.28	0.00	0.00
GP001	2025-04-14	6.0	3.5	1	7.94	7.99	8.52	97.93	97.85	105.65	54128.16	54167.00	54377.43	35.81	35.84	36.00	8.28	8.21	8.32	15.52	15.60	15.76	1.73	1.58	3.12
GP002	2025-04-14	4.0	2.5	1	9.25	9.31	9.58	113.79	114.91	118.51	54272.03	54260.26	54181.23	35.91	35.91	35.85	8.30	8.33	8.34	15.40	15.57	15.66	2.73	0.02	2.25
GP003	2025-04-14	6.0	3.5	1	9.47	8.97	8.64	116.56	110.26	106.22	54194.86	54224.82	54208.81	35.86	35.88	35.87	8.34	8.33	8.29	15.41	15.39	15.35	0.36	0.52	0.64
GP004	2025-04-14	9.0	5.0	1	7.99	8.86	9.84	97.56	108.73	120.94	54110.46	54315.62	54237.77	35.78	35.94	35.89	8.20	8.34	8.38	15.03	15.26	15.37	4.21	1.77	1.59
GP005	2025-04-14	9.0	5.0	1	8.02	8.32	8.97	97.71	101.75	109.99	54075.32	54306.64	54344.42	35.75	35.93	35.96	8.21	8.23	8.33	14.98	15.12	15.26	0.00	2.05	1.27
GP006	2025-04-14	21.0	11.0	1	3.48	8.84	10.58	39.23	108.46	131.08	53270.00	54326.50	54451.27	35.04	35.95	36.06	7.27	8.29	8.45	12.16	15.31	15.76	4.77	0.00	0.86
GP007	2025-04-14	20.0	10.5	1	5.42	8.13	9.89	62.43	97.83	122.05	52156.90	54311.00	54400.62	34.26	35.93	36.01	7.76	8.26	8.39	12.82	15.19	15.53	1.05	0.02	0.03
GP008	2025-04-14	21.0	11.0	1	6.04	8.40	9.58	70.14	102.15	118.36	52821.60	54542.59	54447.50	34.75	36.09	36.05	7.82	8.20	8.45	12.96	14.74	15.58	1.00	0.00	0.99

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP009	2025-04-14	24.0	12.5	1	3.89	7.05	9.22	44.48	83.99	113.33	52601.40	53912.36	54611.05	34.56	35.60	36.16	7.75	8.06	8.41	12.31	13.93	15.29	3.58	0.00	0.00
GP010	2025-04-14	29.0	15.0	1	3.57	6.46	9.78	40.74	76.05	120.21	52701.66	53691.69	55011.46	34.62	35.41	36.46	7.73	8.02	8.44	12.10	13.42	15.17	0.00	0.00	0.00
GP011	2025-04-14	25.0	13.0	1	4.02	7.15	10.48	46.08	86.37	129.58	53311.14	55072.00	54579.83	35.07	36.47	36.15	7.79	8.15	8.40	12.21	14.31	15.63	0.58	0.00	0.00
GP012	2025-04-14	26.0	13.5	1	3.65	5.59	10.72	41.63	65.03	132.25	52949.85	53984.52	54701.32	34.80	35.60	36.23	7.75	7.95	8.44	12.15	12.81	15.48	0.48	0.00	1.33
GP013	2025-04-14	25.0	13.0	1	3.89	4.62	9.73	44.55	53.35	119.32	53180.57	53931.06	55293.31	34.98	35.55	36.66	7.78	7.88	8.40	12.20	12.48	15.02	1.22	3.36	0.00
GP014	2025-04-14	26.0	13.5	1	3.74	6.20	10.51	42.76	72.35	130.14	53278.09	54459.00	54801.50	35.04	35.98	36.31	7.78	8.03	8.41	12.12	13.33	15.60	0.00	1.56	0.18
GP015	2025-04-14	27.0	14.0	1	3.68	6.36	9.79	41.98	72.72	120.54	53236.52	53699.00	54926.00	35.01	35.40	36.40	7.77	7.92	8.39	12.04	12.98	15.53	0.00	0.00	0.20
GP016	2025-04-14	26.0	13.5	1	3.34	6.63	10.23	38.00	77.28	126.10	53077.45	52743.13	54773.43	34.89	34.70	36.29	7.72	7.91	8.39	12.01	13.14	15.43	1.14	0.00	0.82
GP017	2025-04-14	24.0	12.5	1	4.26	5.31	10.54	48.97	61.81	129.62	53463.13	53931.55	55202.59	35.19	35.57	36.60	7.80	7.91	8.44	12.32	12.86	15.22	0.95	0.00	0.00
GP018	2025-04-14	13.0	7.0	1	5.94	8.24	8.65	69.91	99.86	104.95	52745.51	53950.74	53722.29	34.72	35.65	35.49	7.75	8.08	8.17	13.55	14.70	14.86	0.00	0.00	0.57
GP019	2025-04-14	11.0	6.0	1	6.11	7.47	8.92	72.52	89.89	108.96	53770.37	53802.32	53729.60	35.49	35.54	35.51	7.89	8.01	8.29	13.77	14.41	15.20	1.09	0.00	0.00
GP043	2025-04-14	26.0	13.5	1	3.33	7.07	10.19	37.81	83.94	127.43	52607.43	54345.91	54870.00	34.55	35.91	36.36	7.70	8.09	8.41	12.00	13.73	15.62	1.19	0.00	0.00
RI001	2025-04-14	26.0	13.5	1	4.43	8.85	8.82	51.06	109.23	109.28	52357.03	54428.76	54388.60	34.40	36.03	36.01	7.77	8.26	8.28	12.74	15.58	15.74	0.00	0.00	0.00
GP001	2025-05-12	5.0	3.0	1	8.69	8.69	10.29	101.62	101.62	121.82	53501.64	53501.64	53395.83	35.27	35.27	35.22	8.19	8.19	8.28	13.23	13.23	13.81	7.28	11.92	21.60
GP002	2025-05-12	3.0	2.0	1	8.79	8.79	9.16	103.49	103.49	108.59	53526.78	53526.78	53600.56	35.30	35.30	35.37	8.16	8.16	8.24	13.56	13.56	13.90	17.58	15.68	18.08
GP003	2025-05-12	9.0	5.0	1	8.59	9.12	11.44	100.29	106.46	134.91	53668.30	53730.88	53841.57	35.39	35.43	35.54	8.17	8.23	8.45	13.13	13.10	13.56	6.49	7.16	19.05
GP004	2025-05-12	8.0	4.5	1	8.27	8.46	8.45	96.44	98.71	98.96	53804.09	53858.90	53978.32	35.48	35.53	35.62	8.12	8.11	8.09	13.04	13.04	13.17	7.23	8.01	4.13
GP005	2025-05-12	9.0	5.0	1	8.62	8.80	9.22	100.69	102.90	108.68	53953.26	53859.27	54117.88	35.60	35.53	35.74	8.16	8.18	8.21	13.09	13.16	13.46	4.53	3.56	6.94
GP006	2025-05-12	21.0	11.0	1	8.54	10.08	10.88	99.01	117.59	129.03	53683.99	53912.23	53762.03	35.38	35.56	35.49	8.18	8.31	8.33	12.81	13.04	13.85	14.71	2.42	11.53
GP007	2025-05-12	19.0	10.0	1	8.27	9.71	10.36	96.02	113.14	121.54	53604.88	53823.00	53654.61	35.33	35.53	35.39	8.15	8.27	8.28	12.94	13.98	13.36	15.72	3.57	22.90
GP008	2025-05-12	22.0	11.5	1	6.57	9.19	10.69	75.48	107.00	125.38	53563.58	53976.61	53621.05	35.27	35.60	35.37	8.00	8.23	8.37	12.44	12.93	13.41	20.60	4.75	9.76
GP009	2025-05-12	23.0	12.0	1	5.32	9.25	11.45	60.25	107.50	134.29	53587.02	54124.42	53727.67	35.25	35.71	35.44	7.88	8.25	8.40	11.76	12.81	13.32	12.36	8.76	11.26
GP010	2025-05-12	28.0	14.5	1	3.62	9.25	11.34	40.31	107.58	133.27	53537.79	53926.01	53855.69	35.17	35.56	35.54	7.71	8.24	8.42	11.02	12.88	13.38	1.75	2.49	14.65
GP011	2025-05-12	25.0	13.0	1	6.57	9.25	10.56	75.16	107.32	123.47	53642.85	54116.42	53819.93	35.32	35.70	35.51	7.99	8.23	8.35	12.23	12.77	13.20	11.30	2.81	21.80
GP012	2025-05-12	26.0	13.5	1	4.80	8.73	10.79	54.05	100.96	126.54	53348.75	54255.40	53827.61	35.07	35.79	35.52	7.82	8.21	8.36	11.57	12.58	13.32	8.52	4.51	4.45
GP013	2025-05-12	25.0	13.0	1	5.73	9.35	10.91	65.04	108.61	127.75	53515.39	53950.74	54032.15	35.20	35.58	35.66	7.92	8.21	8.36	11.85	12.86	13.22	4.67	0.00	21.30
GP014	2025-05-12	26.0	13.5	1	5.95	9.30	10.30	67.49	107.88	120.50	53433.57	53847.19	53832.57	35.14	35.50	35.52	7.91	8.22	8.35	11.85	12.83	13.23	5.56	2.53	17.88
GP015	2025-05-12	28.0	14.5	1	5.18	9.28	10.59	58.41	107.60	124.03	53406.93	53904.13	53955.50	35.11	35.54	35.61	7.84	8.20	8.37	11.62	12.79	13.23	4.28	2.34	4.28
GP016	2025-05-12	25.0	13.0	1	6.85	9.55	10.31	78.57	110.97	120.56	53740.20	53961.19	53793.41	35.39	35.59	35.49	8.00	8.22	8.30	12.29	12.88	13.19	12.16	1.83	22.60
GP017	2025-05-12	23.0	12.0	1	5.99	9.50	10.92	68.40	110.64	128.03	53485.96	53922.92	53688.87	35.20	35.57	35.42	7.95	8.24	8.35	12.14	12.96	13.36	11.29	5.61	18.33
GP018	2025-05-12	12.0	6.5	1	8.86	9.42	9.11	103.43	110.06	108.02	53817.00	53869.00	53677.00	35.50	35.54	35.41	8.10	8.06	8.12	13.16	13.27	13.49	11.33	8.43	10.66
GP019	2025-05-12	11.0	6.0	1	9.41	9.43	8.98	110.85	111.02	105.26	54355.00	54335.88	53386.73	35.91	35.89	35.19	8.19	8.20	8.16	13.42	13.42	13.41	6.89	17.71	21.30
GP043	2025-05-12	25.0	13.0	1	6.45	9.22	10.08	73.62	107.10	118.12	53710.52	53992.79	53796.25	35.36	35.61	35.49	7.95	8.18	8.32	12.12	12.88	13.31	7.33	0.00	18.12
RI001	2025-05-12	25.0	13.0	1	7.57	8.82	9.00	84.01	101.77	103.92	53842.00	53991.34	54006.13	35.46	35.59	35.61	7.95	8.12	8.12	12.12	12.50	12.58	0.00	0.00	0.00
GP001	2025-06-12	8.5	4.5	1	7.32	8.66	8.56	87.19	103.60	103.70	52569.00	52650.00	50956.00	34.62	34.68	33.45	8.10	8.25	8.26	14.17	14.31	14.49	0.00	2.68	6.80
GP002	2025-06-12	4.0	2.0	1	8.07	8.24	8.32	96.30	97.69	99.80	52448.00	49065.00	52496.00	34.54	32.06	34.58	8.10	8.10	8.20	14.47	14.47	14.49	0.00	0.00	6.60
GP003	2025-06-12	6.0	3.0	1	7.89	8.20	8.41	93.53	98.44	99.53	50863.00	52477.00	52422.00	33.38	34.56	34.52	8.10	8.18	8.20	14.53	14.55	14.59	0.00	10.27	14.88
GP004	2025-06-12	10.0	5.0	1	7.62	8.31	8.26	89.47	99.30	97.62	52502.00	51986.00	51408.00	34.57	34.20	33.78	8.03	8.20	8.18	14.38	14.49	14.73	0.00	3.91	0.00
GP005	2025-06-12	9.0	4.5	1	7.95	8.30	8.20	94.92	100.10	99.43	52612.00	52488.00	52602.00	34.66	34.57	34.66	8.04	8.16	8.21	14.41	14.51	14.78	0.00	0.00	0.00
GP006	2025-06-12	21.0	10.5	1	6.15	7.74	8.61	72.59	92.64	102.60	52476.00	52873.00	52374.00	34.51	34.85	34.49	8.03	8.18	8.25	13.15	14.38	14.47	0.00	0.00	4.76
GP007	2025-06-12	20.0	10.5	1	6.41	7.38	8.51	75.72	88.15	101.80	52596.00	52642.00	52382.00	34.62	34.67	34.50	8.07	8.11	8.22	13.74	14.25	14.61	15.61	0.00	0.00
GP008	2025-06-12	22.0	11.5	1	6.54	7.25	8.12	77.42	86.26	96.98	52609.00	52687.00	52488.00	34.62	34.70	34.57	8.10	8.05	8.19	13.61	14.22	14.44	0.00	0.00	6.88
GP009	2025-06-12	22.0	11.5	1	6.92	8.41	8.36	82.46	100.50	100.00	52655.00	52748.00	52465.00	34.67	34.76	34.56	8.09	8.25	8.22	14.03	14.44	14.59	0.00	0.00	5.66
GP010	2025-06-12	30.0	15.0	1	6.46	8.48	8.36	74.94	101.20	99.07	52304.00	52948.00	54496.00	34.39	34.90	36.06	7.98	8.30	8.23	13.58	14.48	14.53	0.00	0.00	11.80

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP011	2025-06-12	26.0	13.0	1	6.78	7.48	8.30	66.20	87.54	98.43	52509.00	52855.00	52591.00	34.51	34.81	34.64	7.91	8.09	8.19	12.86	13.84	14.22	0.00	0.00	0.00
GP012	2025-06-12	25.0	12.5	1	7.08	7.97	8.20	78.46	94.40	98.94	52544.00	52839.00	52365.00	34.55	34.81	34.47	7.96	8.17	8.20	13.14	14.12	14.32	0.00	0.00	9.59
GP013	2025-06-12	28.0	14.0	1	6.14	7.69	8.34	68.92	90.87	100.20	52304.00	52762.00	53342.00	34.37	34.76	35.20	7.92	8.14	8.22	13.07	14.14	14.60	0.00	0.00	0.00
GP014	2025-06-12	27.0	13.5	1	6.98	8.50	8.04	78.13	92.57	96.29	52343.00	52521.00	52228.00	34.41	34.58	34.39	7.96	8.13	8.19	13.26	14.13	14.77	0.00	0.00	0.00
GP015	2025-06-12	28.0	14.0	1	6.53	7.87	8.26	74.48	94.29	99.59	53318.00	52505.00	52267.00	35.13	34.58	34.41	7.96	8.17	8.22	13.28	14.53	14.65	0.00	0.00	0.00
GP016	2025-06-12	26.0	13.0	1	6.58	7.21	8.37	75.74	81.83	99.22	52571.00	51417.00	52720.00	34.57	33.74	34.73	7.94	8.03	8.19	13.04	13.26	14.04	0.00	0.00	0.00
GP017	2025-06-12	23.0	11.5	1	6.92	7.52	8.31	80.68	88.25	98.88	52682.00	52837.00	52594.00	34.66	34.80	34.64	8.05	8.11	8.20	13.33	13.77	14.19	0.00	0.00	3.34
GP018	2025-06-12	14.0	7.0	1	7.53	7.76	8.31	87.55	88.92	97.80	53129.00	52570.00	52002.00	35.01	34.61	34.19	8.09	8.03	8.14	13.61	13.85	13.78	0.00	0.00	1.64
GP019	2025-06-12	12.0	6.0	1	7.57	8.08	8.59	89.03	94.86	98.90	52933.00	50923.00	52490.00	34.87	33.43	34.55	8.06	8.11	8.10	13.87	14.84	13.94	0.00	0.00	0.00
GP043	2025-06-12	28.0	14.0	1	6.68	7.50	8.24	74.62	87.16	96.62	52722.00	50369.00	52571.00	34.67	32.97	34.62	7.91	8.01	8.15	12.85	13.32	14.11	0.00	0.00	0.00
RI001	2025-06-12	26.0	13.0	1	6.68	8.70	8.64	76.59	103.30	102.80	52191.00	52792.00	52939.00	34.28	34.74	34.85	7.60	8.09	8.13	12.88	13.09	13.09	0.00	0.00	1.15

Table 6 Water quality parameters measured *in situ*, or soon after sampling (in the case of turbidity), for the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites.

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CF001	2024-07-17	25.0	12.5	1	7.38	8.31	8.45	88.00	99.00	101.00	54133.00	53746.00	53636.00	35.75	35.47	35.39	8.23	8.28	8.28	13.77	13.73	13.70	4.60	0.98	1.63
CP001	2024-07-17	25.0	13.0	1	7.27	8.71	8.87	87.00	104.00	106.00	54429.00	53557.00	53390.00	35.97	35.33	35.21	8.23	8.29	8.29	13.72	13.72	13.71	1.82	3.96	10.83
HB001	2024-07-17	3.5	2.0	1	8.40	8.42	8.00	100.00	101.00	96.00	53553.00	53574.00	53312.00	35.33	35.35	35.15	8.26	8.26	8.24	13.73	13.77	13.80	2.47	0.92	1.86
HB002	2024-07-17	5.0	3.0	1	8.15	8.59	8.61	98.00	103.00	103.00	53582.00	53507.00	53420.00	35.35	35.30	35.24	8.25	8.28	8.28	13.72	13.80	13.84	1.91	2.86	2.46
HB003	2024-07-17	5.0	3.0	1	7.69	8.52	8.66	92.00	102.00	104.00	53648.00	53543.00	52988.00	35.40	35.32	34.92	8.23	8.28	8.28	13.73	13.76	13.82	8.93	2.28	2.04
HB004	2024-07-17	11.5	6.0	1	7.33	8.53	8.57	88.00	102.00	103.00	53824.00	53568.00	53560.00	35.52	35.34	35.34	8.21	8.28	8.28	13.71	13.73	13.78	3.38	1.81	2.32
HB005	2024-07-17	12.0	6.5	1	7.55	8.34	8.99	90.00	99.00	108.00	54049.00	53580.00	52865.00	35.69	35.35	34.83	8.21	8.28	8.31	13.70	13.71	13.86	5.89	1.05	1.91
HB006	2024-07-17	9.0	5.0	1	6.79	8.82	9.08	82.00	105.00	108.00	53619.00	53304.00	52835.00	35.37	35.14	34.80	8.20	8.30	8.31	13.72	13.73	13.81	6.43	2.36	1.51
HB007	2024-07-17	12.0	6.0	1	8.45	8.13	8.17	101.00	97.00	97.00	53770.00	53703.00	53661.00	35.48	35.44	35.41	8.18	8.20	8.20	13.70	13.68	13.68	1.06	1.75	1.18
HB008	2024-07-22	17.0	9.0	1	7.92	7.99	8.62	94.00	95.00	103.00	54161.00	53937.00	53575.00	35.77	35.61	35.35	8.23	8.24	8.25	13.78	13.80	13.91	1.24	0.51	1.59
HB009	2024-07-22	15.0	8.0	1	7.84	8.54	8.03	93.00	102.00	103.00	54194.00	53738.00	53298.00	35.80	35.46	35.15	8.22	8.25	8.04	13.77	13.68	14.04	2.08	1.97	1.90
HB010	2024-07-22	12.0	6.5	1	6.81	7.93	8.62	81.00	96.00	102.00	54031.00	53576.00	53650.00	35.68	35.34	35.40	8.13	8.25	8.03	13.77	13.65	13.62	1.43	2.25	2.62
HB011	2024-07-17	34.0	17.5	1	6.96	7.59	8.99	83.00	91.00	108.00	54363.00	54247.00	53554.00	35.91	35.83	35.33	8.21	8.24	8.30	13.68	13.73	13.77	2.61	3.45	1.38
HB012	2024-07-17	34.0	17.5	1	7.27	7.50	9.38	87.00	90.00	112.00	54347.00	54167.00	53480.00	35.90	35.78	35.28	8.22	8.24	8.33	13.68	13.72	13.75	5.39	1.54	2.08
HB013	2024-07-17	32.0	16.0	1	7.24	7.64	8.82	87.00	91.00	106.00	54402.00	54118.00	53184.00	35.94	35.74	35.06	8.22	8.22	8.31	13.68	13.71	13.72	0.73	1.79	1.78
HB014	2024-07-17	34.0	17.0	1	6.97	7.59	9.33	83.00	91.00	112.00	54499.00	54117.00	53510.00	36.01	35.74	35.30	8.21	8.23	8.34	13.63	13.71	13.72	9.25	1.85	2.91
HB015	2024-07-17	32.0	16.5	1	7.34	7.41	9.06	88.00	89.00	109.00	54343.00	54044.00	53465.00	35.90	35.68	35.27	8.23	8.23	8.31	13.68	13.70	13.77	0.47	2.83	2.36
HB016	2024-07-17	36.0	18.0	1	6.81	7.46	9.20	81.00	90.00	110.00	54468.00	54256.00	53499.00	35.99	35.84	35.29	8.18	8.24	8.33	13.63	13.72	13.72	2.40	1.81	1.55
CF001	2024-08-15	25.0	13.0	1	7.42	7.49	7.79	89.89	90.75	94.75	54697.00	54532.00	54700.00	36.19	36.08	36.21	7.55	7.55	7.55	14.43	14.50	14.61	3.89	2.22	1.76

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CP001	2024-08-15	11.0	6.0	1	7.57	8.18	8.49	95.95	98.60	102.54	54416.00	54356.00	54330.00	35.98	35.94	35.93	7.55	7.54	7.54	14.18	14.23	14.36	3.16	8.27	4.44
HB001	2024-08-15	5.0	2.5	1	8.15	8.06	8.14	97.22	96.16	96.67	54278.00	53720.00	52019.00	35.87	35.46	34.21	7.46	7.47	7.48	13.96	13.97	13.91	3.37	2.89	2.47
HB002	2024-08-15	7.0	4.0	1	7.87	8.37	8.13	94.48	99.77	96.66	54472.00	53948.00	52961.00	36.01	35.62	34.90	7.49	7.50	7.49	13.86	13.86	13.95	4.40	2.93	3.37
HB003	2024-08-15	4.0	2.5	1	8.32	8.35	8.34	99.51	99.42	99.08	54101.00	53370.00	53171.00	35.74	35.20	35.05	7.51	7.50	7.49	13.93	13.90	13.86	1.87	8.70	8.52
HB004	2024-08-15	10.0	6.0	1	7.94	8.26	8.54	95.92	98.81	102.01	54403.00	54362.00	53377.00	35.97	35.94	35.21	7.52	7.52	7.53	14.09	14.09	14.08	3.44	0.82	0.95
HB005	2024-08-15	11.0	6.0	1	8.16	8.25	8.35	97.98	99.10	99.88	54619.00	54096.00	53485.00	36.12	35.74	35.29	7.53	7.52	7.52	14.00	14.13	14.15	2.45	4.16	2.39
HB006	2024-08-15	8.0	4.0	1	8.27	8.41	8.40	99.32	100.39	99.92	54559.00	53790.00	52929.00	36.08	35.51	34.88	7.52	7.52	7.51	14.03	14.00	14.01	2.89	2.42	1.64
HB007	2024-08-15	7.0	4.0	1	8.64	8.60	8.60	104.46	103.99	104.07	54786.00	54807.00	54640.00	36.26	36.28	36.16	7.57	7.57	7.57	14.31	14.31	14.39	0.00	0.17	0.00
HB008	2024-08-15	18.0	9.0	1	8.19	8.37	8.63	98.17	101.03	103.61	54684.00	54561.00	53739.00	36.17	36.09	35.48	7.55	7.55	7.54	14.06	14.22	14.13	3.33	1.26	2.86
HB009	2024-08-15	17.0	9.0	1	8.24	8.27	8.50	99.51	99.72	102.03	54550.00	54521.00	53259.00	36.08	36.06	35.13	7.55	7.55	7.53	14.20	14.22	14.33	6.59	2.15	2.69
HB010	2024-08-15	11.0	6.0	1	8.28	8.54	8.69	99.82	102.51	104.21	54503.00	54183.00	53839.00	36.05	35.81	35.56	7.55	7.54	7.54	14.22	14.17	14.13	3.27	0.59	2.77
HB011	2024-08-15	29.0	15.0	1	8.02	8.30	8.67	96.77	100.40	105.15	54532.00	54367.00	54008.00	36.06	35.95	35.70	7.58	7.56	7.56	14.27	14.40	14.62	3.07	0.02	2.01
HB012	2024-08-15	33.0	17.0	1	8.02	8.37	8.75	96.93	101.08	106.27	54688.00	54483.00	53987.00	36.18	36.03	35.68	7.58	7.56	7.55	14.35	14.40	14.65	1.64	2.67	1.96
HB013	2024-08-15	32.0	16.0	1	8.07	8.28	8.50	97.42	100.14	103.25	54557.00	54447.00	54496.00	36.08	36.01	36.06	7.58	7.56	7.55	14.27	14.39	14.64	2.08	0.00	0.88
HB014	2024-08-15	37.0	17.0	1	7.85	8.09	8.56	94.63	97.87	104.21	54579.00	54520.00	54198.00	36.09	36.06	35.84	7.57	7.58	7.55	14.31	14.38	14.74	2.94	0.00	1.48
HB015	2024-08-15	30.0	15.0	1	8.27	8.32	8.64	99.75	100.54	104.45	54519.00	54445.00	53940.00	36.05	36.00	35.64	7.57	7.56	7.55	14.22	14.32	14.43	1.35	0.85	2.03
HB016	2024-08-15	34.0	17.0	1	8.08	8.09	8.53	97.21	97.58	103.24	54609.00	54547.00	54548.00	36.11	36.08	36.09	7.59	7.58	7.57	14.22	14.31	14.40	0.00	1.05	0.91
CF001	2024-09-17	26.0	13.5	1	8.00	7.82	8.83	93.17	91.20	103.42	54317.00	54214.00	54476.00	35.84	35.76	35.98	7.55	7.55	7.59	12.67	12.64	12.95	0.00	0.00	0.00
CP001	2024-09-17	14.0	7.5	1	7.63	8.23	8.45	84.58	91.60	94.34	53670.00	53774.00	53837.00	35.24	35.33	35.38	7.54	7.56	7.56	10.55	10.75	10.75	0.00	0.00	0.00
HB001	2024-09-17	3.0	2.0	1	11.00	10.95	10.97	127.09	127.02	127.17	53661.00	53749.00	53805.00	35.35	35.42	35.46	7.75	7.75	7.75	12.49	12.49	12.45	0.96	0.23	0.03
HB002	2024-09-17	3.0	1.0	5	11.31	10.90	10.96	131.03	128.23	127.56	53878.00	53008.00	53638.00	35.52	34.91	35.35	7.78	7.77	7.73	12.59	13.31	12.72	0.00	0.00	0.35
HB003	2024-09-17	4.5	3.0	1	9.94	10.03	9.48	116.57	117.42	111.91	53158.00	53069.00	52588.00	35.02	34.96	34.61	7.73	7.75	7.74	13.21	13.34	13.59	0.79	1.76	3.16
HB004	2024-09-17	10.0	5.5	1	10.86	12.12	11.38	124.80	139.63	131.44	53582.00	53764.00	53867.00	35.27	35.41	35.50	7.70	7.78	7.79	12.04	12.18	12.29	1.42	0.00	0.54
HB005	2024-09-17	11.0	6.0	1	10.01	10.91	11.75	114.92	125.55	136.76	53226.00	53668.00	53815.00	35.00	35.34	35.47	7.54	7.70	7.79	11.90	12.14	12.58	1.65	1.49	1.42
HB006	2024-09-17	8.0	4.5	1	10.62	10.96	11.36	122.08	126.81	131.90	53511.00	53580.00	53854.00	35.22	35.29	35.50	7.71	7.73	7.78	12.13	12.40	12.63	1.43	0.81	0.16
HB007	2024-09-17	12.0	6.5	1	9.20	9.15	9.08	103.15	102.59	101.97	53605.00	53685.00	53499.00	35.23	35.29	35.17	7.60	7.60	7.60	11.04	11.06	11.30	0.00	0.00	0.00
HB008	2024-09-17	18.0	9.5	1	8.60	10.36	11.66	96.92	118.05	134.36	53503.00	53591.00	53850.00	35.15	35.26	35.48	7.58	7.66	7.77	11.10	11.69	12.16	0.00	0.00	0.35
HB009	2024-09-17	17.0	9.0	1	8.77	10.21	11.59	99.20	116.21	133.79	53203.00	53599.00	53896.00	34.95	35.27	35.52	7.60	7.66	7.77	11.39	11.76	12.25	0.00	0.00	0.00
HB010	2024-09-17	12.0	6.5	1	9.09	10.45	10.19	103.13	119.57	117.13	53510.00	53651.00	53842.00	35.18	35.31	35.48	7.61	7.71	7.74	11.48	11.85	12.22	1.09	1.01	0.92
HB011	2024-09-17	24.0	12.5	1	8.15	8.98	10.72	91.34	101.32	122.51	53567.00	53522.00	53895.00	35.19	35.18	35.49	7.58	7.61	7.71	10.96	11.25	11.76	0.00	0.13	0.00
HB012	2024-09-17	35.0	18.0	1	7.33	8.84	10.10	80.96	99.14	114.94	53536.00	53702.00	53995.00	35.13	35.30	35.56	7.55	7.60	7.68	10.53	11.04	11.63	1.62	0.00	0.45
HB013	2024-09-17	36.0	18.5	1	7.77	8.30	9.17	86.60	93.06	103.77	53092.00	53606.00	53870.00	34.83	35.22	35.45	7.56	7.58	7.63	10.83	10.97	11.39	0.00	0.00	0.00
HB014	2024-09-17	34.0	17.5	1	7.26	8.24	9.73	86.33	92.29	110.28	53452.00	53724.00	53769.00	35.07	35.31	35.38	7.52	7.57	7.64	10.48	10.98	11.48	6.98	0.00	0.00
HB015	2024-09-17	33.0	18.0	1	7.54	8.59	10.89	83.46	96.23	124.61	NA	53616.00	53914.00	NA	35.24	35.51	7.56	7.60	7.72	10.81	11.11	11.83	0.10	0.00	0.00
HB016	2024-09-17	36.0	18.5	1	7.43	8.32	9.41	82.49	93.29	106.32	53421.00	53691.00	53824.00	35.06	35.28	35.41	7.54	7.58	7.64	10.73	10.93	11.34	1.01	0.00	0.28
CF001	2024-10-18	32.0	16.5	1	7.03	7.20	8.23	82.17	83.28	97.53	53146.00	54169.00	54793.00	34.95	35.71	36.23	7.56	7.58	7.64	12.14	12.24	13.35	0.00	0.00	0.00
CP001	2024-10-18	34.0	17.5	1	6.66	7.61	7.78	74.49	88.90	90.90	53253.00	54061.00	54322.00	34.97	35.65	35.86	7.57	7.62	7.62	11.19	12.71	12.80	0.00	0.00	0.00
HB001	2024-10-18	5.0	3.0	1	8.28	8.29	8.47	99.82	99.50	102.59	54294.00	54143.00	52890.00	35.89	35.78	34.87	7.64	7.64	7.63	14.09	14.04	14.76	0.00	0.27	0.68
HB002	2024-10-18	8.0	4.5	1	8.28	8.24	8.29	98.99	99.09	99.95	54509.00	54542.00	54457.00	36.04	36.07	36.01	7.65	7.65	7.65	13.88	13.95	14.13	1.00	0.10	0.00
HB003	2024-10-18	6.0	3.5	1	8.21	8.27	8.33	98.49	98.86	99.49	54378.00	54426.00	54609.00	35.94	35.98	36.11	7.65	7.65	7.65	13.77	13.77	13.68	0.59	0.63	0.00
HB004	2024-10-18	12.0	6.5	1	7.63	8.15	8.22	85.14	97.82	98.44	53201.00	55064.00	54748.00	34.98	36.44	36.21	7.61	7.66	7.66	11.93	13.59	13.73	0.00	0.00	0.00
HB005	2024-10-18	12.0	6.5	1	7.54	8.28	8.21	83.19	98.11	97.90	52573.00	54445.00	54471.00	34.52	35.98	36.00	7.62	7.65	7.65	11.96	13.54	13.60	0.00	0.00	0.00
HB006	2024-10-18	11.0	6.0	1	7.04	7.84	8.18	78.41	91.59	98.01	53309.00	54373.00	53806.00	35.04	35.91	35.52	7.59	7.64	7.65	11.53	13.12	13.81	1.99	0.00	0.00
HB007	2024-10-18	14.0	7.5	1	7.76	8.69	8.42	89.47	102.17	99.53	54200.00	54282.00	54467.00	35.77	35.84	35.99	7.62	7.62	7.66	13.05	13.04	13.37	0.00	0.00	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
HB008	2024-10-18	19.0	10.0	1	6.41	7.17	8.40	71.61	83.42	100.32	53214.00	54154.00	54799.00	34.92	35.70	36.25	7.58	7.68	7.67	10.81	12.24	13.76	0.00	0.00	0.00
HB009	2024-10-18	18.0	9.5	1	6.57	7.12	8.02	73.55	81.75	96.99	52547.00	53977.00	55017.00	34.45	35.54	36.39	7.59	7.61	7.66	11.06	11.62	13.31	0.00	0.00	0.00
HB010	2024-10-18	14.0	7.5	1	6.78	7.78	8.18	76.05	89.42	97.33	52133.00	53236.00	54436.00	34.19	35.06	35.97	7.60	7.65	7.66	11.78	12.97	13.53	0.00	0.00	0.00
HB011	2024-10-18	25.0	13.0	1	6.34	6.97	7.97	70.60	77.35	94.33	53385.00	52430.00	54909.00	35.04	34.40	36.31	7.57	7.58	7.64	10.71	11.58	13.31	0.00	0.00	0.00
HB012	2024-10-18	34.5	18.0	1	6.29	7.15	8.08	70.97	81.11	95.99	52075.00	53205.00	54974.00	34.11	34.97	36.37	7.58	7.60	7.65	11.17	11.69	13.44	0.00	0.00	0.00
HB013	2024-10-18	32.0	16.5	1	6.36	6.98	8.15	70.88	78.21	96.32	53321.00	53294.00	54486.00	34.99	35.12	36.01	7.57	7.59	7.65	10.78	13.41	13.41	0.00	0.00	0.00
HB014	2024-10-18	36.0	18.5	1	6.26	6.98	7.97	70.53	79.39	94.13	51525.00	53914.00	54681.00	33.73	35.48	36.14	7.58	7.61	7.64	11.67	11.57	13.18	0.00	0.00	0.00
HB015	2024-10-18	33.0	17.0	1	6.37	6.52	8.28	71.45	74.17	98.94	52741.00	53924.00	54849.00	34.59	35.46	36.29	7.58	7.60	7.65	11.04	11.05	13.73	0.00	0.00	0.00
HB016	2024-10-18	36.0	18.5	1	6.26	6.95	7.99	69.48	78.77	94.18	53080.00	53686.00	54372.00	34.82	35.30	35.91	7.57	7.59	7.64	10.79	11.33	13.23	0.00	0.00	0.00
CF001	2024-11-12	29.0	15.0	1	7.20	7.60	8.36	79.44	84.91	95.81	52790.00	53886.00	52523.00	34.59	35.41	34.49	7.53	7.57	7.61	10.55	10.65	11.91	0.00	0.00	0.10
CP001	2024-11-12	34.0	17.5	1	7.35	7.89	8.21	80.62	88.71	93.39	53378.00	53294.00	53274.00	34.98	35.00	35.02	7.55	7.60	7.62	10.07	11.01	11.49	0.00	0.00	0.00
HB001	2024-11-12	4.0	2.5	1	9.81	9.36	8.90	112.76	108.93	103.71	52965.00	53682.00	53345.00	34.86	35.37	35.13	7.70	7.65	7.65	12.78	12.44	12.60	0.00	0.71	0.74
HB002	2024-11-12	6.0	3.5	1	9.19	9.31	8.80	106.55	108.12	103.80	52436.00	53426.00	53215.00	34.45	35.19	35.07	7.68	7.68	7.63	12.47	12.68	13.40	0.66	0.78	1.25
HB003	2024-11-12	6.0	3.5	1	9.00	9.07	9.02	104.64	105.00	105.48	52538.00	52865.00	53133.00	34.54	34.76	35.00	7.63	7.66	7.65	12.68	12.34	13.27	0.00	0.85	1.61
HB004	2024-11-12	13.0	7.0	1	7.71	8.49	8.88	87.96	97.59	101.08	51398.00	53310.00	53631.00	33.67	35.06	35.30	7.58	7.68	7.63	11.99	11.78	11.81	0.52	0.35	0.29
HB005	2024-11-12	13.0	7.0	1	8.26	9.14	9.17	89.63	104.19	105.19	52781.00	53928.00	53758.00	34.65	35.51	35.40	7.63	7.67	7.65	11.41	11.71	11.94	0.00	0.00	0.00
HB006	2024-11-12	10.0	5.5	1	7.87	9.02	9.19	88.76	103.39	105.77	52142.00	53662.00	53847.00	34.18	35.32	35.47	7.60	7.65	7.65	11.38	11.77	11.98	0.00	0.00	0.24
HB007	2024-11-12	11.0	6.0	1	8.99	9.37	9.53	100.13	106.09	108.31	53109.00	53616.00	53686.00	34.88	35.27	35.33	7.64	7.67	7.68	11.24	11.55	11.59	0.02	0.00	0.00
HB008	2024-11-12	20.0	10.0	1	7.24	8.61	9.12	79.93	98.26	105.54	53206.00	53472.00	53792.00	34.87	35.14	35.44	7.57	7.64	7.66	10.08	11.15	12.18	0.00	0.00	0.00
HB009	2024-11-12	18.0	9.5	1	7.35	8.70	9.60	80.88	106.67	106.67	53507.00	53574.00	53998.00	35.12	35.24	35.60	7.59	7.65	7.69	10.48	11.52	12.45	0.68	0.02	0.32
HB010	2024-11-12	13.0	7.0	1	7.50	8.98	8.74	83.18	102.77	99.79	52340.00	54133.00	53001.00	34.29	35.64	34.85	7.55	7.67	7.60	10.80	11.47	12.01	0.19	0.00	0.23
HB011	2024-11-12	30.5	16.0	1	7.03	8.17	8.73	76.49	90.24	101.53	53601.00	53649.00	53559.00	35.12	35.24	35.26	7.57	7.61	7.63	9.68	10.83	12.13	0.31	0.00	0.00
HB012	2024-11-12	36.0	18.5	1	6.28	7.82	8.90	67.76	86.53	102.76	53168.00	53279.00	54088.00	34.77	34.95	35.65	7.56	7.60	7.64	9.29	10.51	12.12	0.94	0.67	0.02
HB013	2024-11-12	35.0	18.0	1	6.35	8.02	8.49	68.81	89.11	96.89	52900.00	53228.00	53424.00	34.59	34.94	35.14	7.57	7.62	7.65	9.44	10.86	11.67	0.75	0.00	0.00
HB014	2024-11-12	35.0	18.0	1	6.12	7.74	8.55	65.89	85.71	99.81	53040.00	53443.00	54833.00	34.67	35.07	36.20	7.55	7.61	7.62	9.20	10.50	12.03	0.52	0.02	0.00
HB015	2024-11-12	31.5	16.0	1	6.71	8.30	8.74	72.90	92.69	100.76	52860.00	52978.00	54168.00	34.60	34.78	35.71	7.57	7.64	7.62	9.99	11.30	12.16	0.36	0.00	0.00
HB016	2024-11-12	36.0	18.5	1	6.34	7.69	8.54	68.18	84.69	96.90	52858.00	53705.00	53971.00	34.54	35.24	35.51	7.56	7.60	7.66	9.26	10.26	11.22	0.00	0.05	0.00
CF001	2024-12-10	34.5	18.0	1	6.22	7.20	8.55	70.07	84.26	105.07	52396.00	53617.00	53114.00	34.35	35.33	35.04	7.55	7.60	7.69	11.30	12.77	14.87	0.00	0.00	0.00
CP001	2024-12-10	36.0	18.5	1	6.43	6.66	8.38	71.39	76.09	103.52	51941.00	52974.00	53984.00	34.02	34.82	35.68	7.56	7.50	7.69	11.32	12.06	14.51	0.11	0.00	0.00
HB001	2024-12-10	5.0	3.0	1	8.95	9.56	9.36	114.41	122.94	125.38	53581.00	53848.00	53495.00	35.42	35.62	35.38	7.74	7.77	7.79	16.47	16.61	19.25	0.11	0.00	1.28
HB002	2024-12-10	6.0	3.5	1	8.52	9.47	10.17	110.81	121.16	130.30	51622.00	53139.00	53650.00	33.99	35.10	35.48	7.73	7.78	7.77	18.05	16.91	16.96	1.63	0.03	0.00
HB003	2024-12-10	6.0	3.5	1	8.64	9.75	9.37	108.11	123.67	121.44	50505.00	53180.00	52909.00	33.15	35.14	34.94	7.75	7.76	7.77	16.35	17.11	17.90	1.20	2.51	2.04
HB004	2024-12-10	12.0	6.5	1	7.09	7.20	8.15	82.14	91.85	109.20	51142.00	53590.00	53733.00	33.56	35.37	35.52	7.62	7.72	7.73	13.92	14.14	15.68	4.13	0.10	0.43
HB005	2024-12-10	14.0	7.5	1	7.00	8.72	8.40	79.17	106.53	122.10	52215.00	52842.00	54136.00	34.27	34.84	35.82	7.62	7.72	7.77	12.13	14.77	15.63	0.00	1.79	0.00
HB006	2024-12-10	9.0	5.0	1	8.77	9.64	10.20	109.33	120.18	130.24	50744.00	53802.00	54695.00	33.31	35.57	36.26	7.74	7.76	7.77	15.35	15.60	17.07	0.00	0.22	0.00
HB007	2024-12-10	12.0	6.5	1	7.60	7.90	8.66	97.09	99.59	107.42	52220.00	52626.00	53998.00	34.43	34.72	35.71	7.70	7.70	7.70	17.37	16.54	15.35	0.00	0.00	0.00
HB008	2024-12-10	19.5	10.5	1	7.43	8.32	9.10	86.03	100.31	118.33	52303.00	53163.00	52807.00	34.36	35.05	34.85	7.65	7.68	7.77	12.76	14.14	16.19	0.02	0.00	0.00
HB009	2024-12-10	17.0	9.0	1	7.11	8.95	9.40	81.20	109.48	114.83	52148.00	53437.00	54234.00	34.22	35.26	35.86	7.62	7.72	7.73	12.13	14.30	14.60	0.00	0.00	0.00
HB010	2024-12-10	12.0	6.5	1	6.66	8.50	9.85	77.53	107.95	127.16	50907.00	54581.00	55294.00	33.35	36.12	36.69	7.61	7.72	7.78	12.86	14.69	16.10	0.38	0.25	0.16
HB011	2024-12-10	30.5	16.0	1	6.24	7.48	8.25	69.80	87.01	104.25	52585.00	53115.00	55609.00	34.46	34.96	36.89	7.57	7.62	7.71	10.84	12.69	14.76	0.00	0.00	0.00
HB012	2024-12-10	35.0	18.0	1	6.04	6.91	8.71	67.64	82.88	110.95	52661.00	54076.00	55100.00	34.51	35.63	36.54	7.59	7.63	7.75	10.79	11.99	16.01	0.00	0.00	0.04
HB013	2024-12-10	32.0	16.5	1	6.15	6.72	9.33	68.91	81.72	118.33	52481.00	54912.00	56000.00	34.39	36.27	37.20	7.58	7.65	7.73	10.88	12.51	15.60	0.00	0.02	0.38
HB014	2024-12-10	36.5	18.0	1	6.02	6.98	9.45	66.51	81.31	117.77	53059.00	53387.00	55703.00	34.76	35.13	36.97	7.58	7.62	7.74	10.18	12.23	15.03	2.89	0.00	0.22
HB015	2024-12-10	34.0	17.5	1	6.20	7.89	9.41	69.66	91.77	117.98	52598.00	51890.00	53971.00	34.49	34.08	35.69	7.60	7.64	7.75	11.19	13.23	15.39	0.00	0.00	0.31

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
HB016	2024-12-10	36.0	18.5	1	6.16	7.84	8.92	69.26	90.02	117.09	51572.00	54215.00	56217.00	33.74	35.75	37.37	7.59	7.63	7.75	11.27	12.31	15.74	0.00	0.00	0.00
CF001	2025-01-22	34.0	17.5	1	5.87	6.48	7.21	63.87	71.32	79.81	53550.00	53165.00	53089.00	35.04	34.83	34.81	7.69	7.72	7.76	9.23	9.92	10.32	0.00	0.00	0.00
CP001	2025-01-22	33.0	17.0	1	5.49	5.56	6.15	56.62	60.71	69.50	53170.00	53551.00	53575.00	34.76	35.04	35.09	7.73	7.74	7.72	9.20	9.10	9.41	0.00	0.00	0.00
HB001	2025-01-22	3.0	2.0	1	7.55	9.44	10.58	87.98	109.85	129.95	51504.00	54172.00	54579.00	33.78	35.74	36.09	7.91	8.12	8.15	12.68	12.63	13.86	0.64	0.63	0.63
HB002	2025-01-22	5.5	3.0	1	6.45	7.57	9.12	74.11	85.21	108.44	49510.00	52367.00	54152.00	32.36	34.40	35.74	7.85	7.88	8.01	13.58	12.41	13.03	0.02	1.02	0.95
HB003	2025-01-22	5.0	3.0	1	6.44	7.79	7.99	71.35	88.80	91.72	52751.00	52595.00	53483.00	34.56	34.53	35.17	7.84	7.88	7.89	10.36	11.70	11.56	0.19	0.86	0.00
HB004	2025-01-22	10.0	5.5	1	5.88	6.22	8.52	65.10	68.58	100.61	51585.00	53187.00	52815.00	33.72	34.86	34.76	7.81	7.80	7.96	10.54	10.08	13.10	0.65	0.00	0.82
HB005	2025-01-22	12.0	6.5	1	5.80	6.67	8.22	63.32	74.05	95.65	52795.00	52600.00	53735.00	34.55	34.47	35.37	7.81	7.83	7.90	9.77	10.65	11.75	0.00	0.18	0.52
HB006	2025-01-22	9.0	5.0	1	5.96	7.22	7.68	65.43	80.70	86.51	52432.00	52673.00	53631.00	34.29	34.52	35.24	7.81	7.85	7.89	9.90	10.55	10.78	0.00	0.00	0.00
HB007	2025-01-22	14.0	7.0	1	6.12	5.99	6.60	66.49	65.52	74.68	52825.00	53377.00	53874.00	34.56	34.95	35.34	7.75	7.75	7.75	9.62	9.42	9.71	0.00	0.00	0.00
HB008	2025-01-22	19.5	10.5	1	5.78	6.61	7.94	62.69	74.29	90.68	53058.00	52247.00	54289.00	34.71	34.21	35.77	7.79	7.81	7.93	9.46	10.59	11.52	0.00	0.00	0.25
HB009	2025-01-22	17.0	9.0	1	5.51	6.19	7.94	59.83	67.05	89.87	52611.00	53414.00	53459.00	34.39	34.96	35.10	7.78	7.80	7.91	9.47	9.31	10.66	0.03	0.40	0.00
HB010	2025-01-22	12.0	6.5	1	5.60	6.62	8.32	61.07	72.74	94.21	52404.00	53319.00	53412.00	34.25	34.92	35.10	7.79	7.82	7.87	9.67	9.61	11.21	0.00	0.00	0.02
HB011	2025-01-22	30.0	15.5	1	5.81	5.98	6.61	63.07	65.53	74.26	52621.00	53405.00	58788.00	34.39	34.95	38.98	7.77	7.79	7.79	9.54	9.25	9.98	0.00	0.00	0.02
HB012	2025-01-22	33.0	17.0	1	5.67	5.95	8.10	61.41	64.65	88.25	52998.00	53520.00	53625.00	34.63	35.02	35.23	7.75	7.77	7.79	9.14	9.14	10.76	0.00	0.00	0.00
HB013	2025-01-22	32.0	16.0	1	5.72	5.89	8.36	62.04	63.89	90.01	53421.00	53576.00	52167.00	34.94	35.06	34.15	7.74	7.75	7.77	9.05	9.07	10.59	0.00	0.02	0.00
HB014	2025-01-22	36.0	18.0	1	5.83	6.68	6.32	63.44	71.16	70.23	52557.00	52845.00	53656.00	34.34	34.55	35.17	7.74	7.78	7.79	9.44	9.44	9.61	0.00	0.00	0.00
HB015	2025-01-22	31.0	16.0	1	5.83	6.04	7.63	63.02	65.81	85.01	52931.00	53454.00	52531.00	34.59	34.98	34.45	7.76	7.78	7.79	9.23	9.23	11.02	0.00	0.00	0.00
HB016	2025-01-22	37.0	18.0	1	5.89	5.81	8.05	62.35	62.97	90.15	52701.00	53488.00	53531.00	34.42	34.99	35.15	7.73	7.76	7.78	9.14	9.05	10.61	0.00	0.00	0.00
CF001	2025-02-07	33.0	17.0	1	4.06	5.66	6.67	44.31	62.63	77.58	53487.00	53380.00	54275.00	35.01	35.00	35.73	7.73	7.81	7.89	9.33	10.14	11.11	0.00	0.00	0.00
CP001	2025-02-07	33.0	17.0	1	4.36	5.08	7.23	47.54	55.96	79.63	53244.00	53736.00	53533.00	34.82	35.21	35.16	7.83	7.87	7.92	9.23	9.54	10.78	0.00	0.13	0.73
HB001	2025-02-07	3.0	2.0	1	6.61	6.54	7.95	73.90	89.34	105.48	51548.00	56883.00	54399.00	33.81	37.87	36.05	7.88	8.08	8.07	12.68	16.02	17.68	2.28	3.22	4.21
HB002	2025-02-07	5.0	4.0	1	5.85	6.28	6.98	65.68	73.51	86.70	50874.00	53195.00	56369.00	33.26	35.01	37.45	7.88	7.92	8.06	11.45	12.40	14.73	4.38	2.94	3.96
HB003	2025-02-07	4.0	2.0	1	5.90	7.58	7.97	66.93	88.09	100.27	52940.00	52492.00	55124.00	34.74	34.48	36.53	7.89	7.94	8.04	11.05	12.20	14.86	6.63	2.71	2.84
HB004	2025-02-07	11.0	6.0	1	4.69	6.99	7.60	47.22	71.83	94.87	52317.00	52760.00	52274.00	34.24	34.59	34.40	7.81	7.88	8.05	10.38	10.76	14.03	3.15	1.68	1.36
HB005	2025-02-07	11.0	6.0	1	5.51	5.58	10.46	61.29	62.64	97.96	52942.00	53540.00	53138.00	34.69	35.13	35.03	7.86	7.88	8.01	10.28	10.21	13.86	4.18	2.80	2.48
HB006	2025-02-07	9.0	5.0	1	5.87	7.02	6.68	63.91	79.31	80.57	52408.00	52044.00	55602.00	34.32	34.10	36.79	7.86	7.88	7.98	10.47	11.16	12.59	2.79	0.72	1.22
HB007	2025-02-07	14.0	7.5	1	5.17	6.51	8.15	57.03	73.50	92.72	53132.00	53253.00	53578.00	34.80	34.91	35.17	7.83	7.87	7.94	9.84	10.12	10.36	1.51	0.00	0.00
HB008	2025-02-07	18.0	9.5	1	4.36	5.54	6.90	48.23	61.01	82.58	53318.00	53119.00	55399.00	34.92	34.81	36.67	7.84	7.85	7.95	9.66	10.17	13.11	0.40	0.00	2.15
HB009	2025-02-07	16.0	8.5	1	4.85	5.15	7.66	53.78	57.22	90.89	51996.00	53713.00	54148.00	33.99	35.22	35.72	7.84	7.87	7.97	10.17	9.75	12.54	1.75	0.36	2.26
HB010	2025-02-07	12.0	6.5	1	5.45	5.48	7.95	60.32	60.30	90.86	52269.00	53549.00	53050.00	34.21	35.12	34.88	7.86	7.87	7.94	10.46	9.97	11.89	0.02	0.45	0.62
HB011	2025-02-07	30.0	16.0	1	4.17	5.44	7.50	45.84	58.52	86.67	52064.00	53085.00	53527.00	34.00	34.75	35.22	7.83	7.85	7.91	9.68	9.72	11.81	1.12	0.00	0.00
HB012	2025-02-07	34.0	17.5	1	4.38	4.61	7.46	47.60	50.83	86.12	53055.00	53654.00	53614.00	34.70	35.14	35.28	7.87	7.85	7.94	9.41	9.38	11.63	2.62	0.00	0.73
HB013	2025-02-07	33.0	17.0	1	4.85	4.98	7.14	50.49	54.69	85.52	52691.00	53040.00	55257.00	34.45	34.71	36.54	7.82	7.84	7.90	9.57	9.61	12.54	2.47	0.02	0.00
HB014	2025-02-07	36.0	18.5	1	4.32	5.00	6.59	47.04	55.44	75.33	52969.00	52449.00	53542.00	34.63	34.31	35.17	7.82	7.85	7.90	9.30	9.97	10.80	2.80	0.17	1.00
HB015	2025-02-07	31.0	16.0	1	4.35	4.72	7.27	47.42	52.40	84.01	52730.00	53732.00	53020.00	34.46	35.22	34.86	7.23	7.86	7.93	9.41	9.62	11.96	0.63	0.00	0.00
HB016	2025-02-07	36.0	18.5	1	4.32	4.94	6.95	47.27	54.23	80.37	52823.00	53517.00	54111.00	34.53	35.04	35.64	7.82	7.85	7.92	9.41	9.33	11.67	0.63	0.02	0.02
CF001	2025-03-18	33.0	17.0	1	4.03	4.48	7.06	44.49	49.43	83.92	53012.00	53638.00	54551.00	34.72	35.18	36.00	7.86	7.91	8.12	10.15	9.99	12.27	0.33	0.02	0.00
CP001	2025-03-18	31.0	16.0	1	5.13	5.94	6.68	56.64	65.78	80.19	52269.00	53509.00	54073.00	34.22	35.11	35.64	7.97	7.99	8.04	10.70	10.37	12.13	0.19	0.04	0.22
HB001	2025-03-18	5.0	3.0	1	6.99	7.14	7.14	83.29	86.29	90.52	53132.00	54342.00	54012.00	35.00	35.92	NA	8.08	8.09	8.10	13.29	13.84	NA	0.50	0.13	0.08
HB002	2025-03-18	6.0	3.5	1	6.73	7.33	7.70	78.32	87.71	93.87	52951.00	54003.00	53975.00	34.82	35.66	35.65	8.09	8.08	8.13	12.35	13.61	14.10	0.00	0.00	0.00
HB003	2025-03-18	6.0	3.5	1	5.76	7.76	7.83	65.20	91.96	93.05	51732.00	53574.00	54121.00	33.89	35.31	35.74	8.04	8.11	8.12	11.62	12.98	13.46	0.00	0.00	0.00
HB004	2025-03-18	11.0	6.0	1	5.41	6.90	7.38	60.61	79.29	89.00	53425.00	54078.00	54283.00	35.08	35.62	35.86	8.05	8.11	8.11	10.78	11.79	13.52	0.00	0.04	0.00
HB005	2025-03-18	13.0	7.0	1	5.63	6.40	7.59	52.91	74.67	89.72	52814.00	54101.00	53938.00	34.63	35.64	35.58	8.05	8.06	8.11	10.81	11.85	12.95	0.00	0.04	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
HB006	2025-03-18	10.0	5.5	1	6.17	7.13	7.71	70.01	82.89	92.28	52485.00	53979.00	54722.00	34.43	35.57	36.20	8.05	8.12	8.14	11.42	12.09	13.96	0.02	0.24	0.59
HB007	2025-03-18	13.0	7.0	1	6.44	7.67	8.96	72.42	87.50	103.86	53100.00	53628.00	53835.00	34.84	35.28	35.46	8.00	8.07	8.13	10.79	11.57	12.00	0.00	0.00	0.00
HB008	2025-03-18	19.0	10.0	1	5.95	6.84	7.21	66.25	78.36	85.58	53269.00	53600.00	54332.00	34.96	35.27	35.89	8.03	8.09	8.09	10.78	11.76	13.31	0.00	0.54	0.00
HB009	2025-03-18	15.0	8.0	1	5.20	6.42	7.22	57.60	73.50	85.62	53087.00	53766.00	53766.00	34.81	35.36	35.41	8.01	8.06	8.10	10.45	11.20	12.17	0.00	0.43	0.00
HB010	2025-03-18	13.0	7.0	1	5.47	7.68	7.44	64.40	89.59	87.86	52951.00	53757.00	54224.00	34.71	35.43	35.80	8.02	8.13	8.12	10.52	12.58	13.13	1.08	0.09	0.00
HB011	2025-03-18	31.0	16.0	1	4.81	6.55	7.21	53.02	74.47	83.98	52886.00	53524.00	54112.00	34.64	35.19	35.68	7.98	8.05	8.09	10.21	11.35	12.39	0.00	0.02	0.12
HB012	2025-03-18	35.0	18.0	1	5.00	6.17	7.45	54.76	69.28	87.60	52900.00	53488.00	53040.00	34.64	35.15	34.91	7.99	8.04	8.11	10.15	11.16	12.73	0.19	0.79	0.00
HB013	2025-03-18	32.0	16.0	1	4.77	6.48	7.59	52.63	73.90	89.70	53277.00	53616.00	54150.00	34.91	35.26	35.74	7.99	8.05	8.12	10.01	11.43	13.03	0.00	0.27	0.00
HB014	2025-03-18	36.0	18.5	1	4.77	6.11	7.15	52.53	68.94	83.38	53197.00	53584.00	54647.00	34.85	35.21	36.08	7.97	8.03	8.11	10.10	11.02	12.36	0.00	0.00	0.00
HB015	2025-03-18	33.0	17.0	1	5.30	6.55	7.29	58.29	74.64	84.21	52998.00	53480.00	53350.00	34.72	35.16	35.13	7.99	8.05	8.10	10.28	11.45	12.54	0.00	0.53	0.00
HB016	2025-03-18	38.0	19.0	1	4.63	5.99	7.39	50.96	67.51	87.37	53576.00	53481.00	54513.00	35.09	35.13	36.01	7.96	8.01	8.11	9.59	10.92	13.04	0.34	0.67	0.12
CF001	2025-04-15	19.0	11.0	1	4.69	6.07	7.91	53.42	70.41	94.00	54118.00	53888.00	54288.00	35.66	35.53	35.87	7.67	8.03	8.15	12.00	12.77	13.77	0.00	0.00	0.00
CP001	2025-04-15	24.0	12.5	1	5.79	6.39	7.38	67.12	72.95	87.30	52634.00	53247.00	54033.00	34.63	35.08	35.68	7.88	7.88	8.07	13.40	13.14	13.68	0.00	0.00	0.00
HB001	2025-04-15	4.0	2.5	1	8.50	8.48	9.07	108.28	106.53	115.57	54006.00	54909.00	53600.00	35.72	36.40	35.43	8.46	8.47	8.47	15.76	15.78	16.16	6.72	6.06	5.98
HB002	2025-04-15	6.0	3.5	1	8.89	8.33	10.69	110.78	106.34	132.03	52993.00	54126.00	53959.00	34.96	35.80	35.68	8.36	8.42	8.46	15.25	15.35	15.35	4.32	2.61	3.01
HB003	2025-04-15	6.0	3.5	1	8.44	8.76	10.58	108.44	113.20	131.27	54284.00	54234.00	54121.00	35.91	35.88	35.80	8.38	8.43	8.43	15.04	15.26	15.33	0.97	0.79	1.34
HB004	2025-04-15	10.0	5.5	1	8.33	8.25	8.33	101.35	99.18	101.35	53910.00	54059.00	53910.00	35.61	35.73	35.62	8.23	8.22	8.23	14.40	14.40	14.40	1.38	1.86	1.55
HB005	2025-04-15	12.0	6.5	1	10.20	10.21	8.19	92.84	96.23	98.65	53148.00	52717.00	53889.00	35.01	34.72	35.59	7.99	8.12	8.20	13.28	14.05	14.09	0.00	0.69	0.02
HB006	2025-04-15	11.0	6.0	1	7.76	7.81	7.76	90.60	90.61	90.60	53725.00	53231.00	53725.00	35.45	35.10	35.46	8.14	8.05	8.14	13.76	13.89	13.76	3.58	1.39	2.65
HB007	2025-04-15	5.0	3.0	1	8.12	8.50	8.62	94.76	97.97	99.58	57543.00	52860.77	52978.14	38.26	34.77	34.86	7.91	7.90	7.92	13.14	12.58	12.66	0.00	0.00	0.00
HB008	2025-04-15	17.0	6.0	1	5.29	7.71	9.96	64.07	87.47	92.74	53162.00	53285.00	53305.00	34.99	35.12	35.12	7.93	8.03	8.05	12.59	13.56	13.16	0.00	0.00	0.00
HB009	2025-04-15	13.0	6.5	1	7.10	7.17	6.32	82.62	79.75	68.47	52455.00	52880.00	53053.00	34.50	34.81	34.89	7.93	7.95	7.93	13.32	13.13	12.09	1.56	0.00	0.00
HB010	2025-04-15	12.0	6.5	1	6.46	6.93	5.21	76.55	77.11	59.25	51695.00	52247.00	53182.00	33.96	34.33	35.15	7.88	7.87	7.89	13.80	12.78	17.74	0.00	0.00	0.36
HB011	2025-04-15	34.0	17.5	1	6.90	9.68	8.17	74.02	93.13	97.60	51606.00	50258.00	53352.00	33.84	32.90	35.19	7.82	7.95	8.18	12.65	13.46	14.04	0.00	0.00	0.00
HB012	2025-04-15	33.0	17.0	1	7.44	7.11	8.22	87.01	86.46	98.00	52637.00	52630.00	54044.00	34.64	34.63	35.73	7.95	7.95	8.15	13.68	13.51	14.75	0.00	0.00	0.00
HB013	2025-04-15	28.0	14.5	1	6.58	7.94	8.22	71.23	91.73	97.86	51591.00	53332.00	53942.00	33.85	35.16	35.62	7.82	8.03	8.18	12.96	13.76	13.88	0.00	0.00	0.00
HB014	2025-04-15	32.0	16.5	1	5.01	6.16	8.72	56.00	70.00	105.09	51572.00	52578.00	54920.96	33.81	34.56	36.36	7.29	7.85	8.23	12.46	12.67	14.18	0.00	0.00	0.00
HB015	2025-04-15	33.0	17.0	1	6.19	10.26	7.94	71.88	99.73	94.52	51746.17	52913.00	54049.00	33.96	34.88	35.67	7.85	8.52	8.17	13.14	14.58	13.17	0.00	0.00	0.00
HB016	2025-04-15	35.0	18.0	1	5.19	6.05	8.85	59.07	70.90	105.78	51002.00	52649.00	54577.71	33.38	34.61	36.09	7.84	7.88	8.24	12.32	12.69	13.90	0.00	0.00	0.00
CF001	2025-05-13	32.0	16.5	1	6.59	7.86	7.79	76.56	96.81	97.43	53369.80	55821.14	53767.36	35.15	37.05	35.56	7.95	8.09	8.15	12.89	15.13	16.35	0.00	0.00	0.00
CP001	2025-05-13	32.0	15.5	1	4.31	6.00	8.77	47.93	67.85	103.01	53499.29	53595.11	54482.32	35.13	35.25	35.99	7.75	7.86	8.14	10.83	11.58	13.14	0.00	0.00	0.00
HB001	2025-05-13	5.0	3.0	1	8.23	8.23	8.39	97.11	97.11	98.60	53581.05	53581.05	53740.20	35.34	35.34	35.45	8.09	8.09	8.09	13.45	13.45	13.25	1.80	2.07	0.45
HB002	2025-05-13	5.0	3.0	1	9.13	9.13	9.44	107.64	107.64	111.32	53520.82	53520.82	54003.09	35.29	35.29	35.65	8.15	8.15	8.17	13.46	13.46	13.36	2.33	2.79	3.26
HB003	2025-05-13	5.0	3.0	1	8.64	8.75	8.75	101.58	103.29	103.29	53686.62	53932.81	53932.81	35.41	35.60	35.60	8.08	8.09	8.09	13.28	13.41	13.41	6.59	0.67	3.66
HB004	2025-05-13	12.0	6.5	1	8.47	8.99	8.85	99.78	105.70	105.40	53380.70	53856.71	54258.39	35.19	35.53	35.85	8.12	8.16	8.14	13.43	13.23	13.71	0.43	1.97	0.00
HB005	2025-05-13	12.0	6.5	1	7.49	8.86	9.60	87.33	103.86	114.19	53422.67	53886.75	54421.93	35.20	35.55	35.97	8.05	8.12	8.18	12.98	13.10	13.64	1.58	1.49	0.39
HB006	2025-05-13	10.0	5.5	1	7.64	7.64	8.72	89.17	89.17	102.39	53413.12	53413.12	54066.48	35.20	35.20	35.69	8.01	8.01	8.14	13.12	13.12	13.17	1.19	2.97	3.72
HB007	2025-05-13	12.0	6.5	1	8.93	9.01	9.02	104.79	105.51	105.78	54012.16	54150.40	54227.00	35.64	35.74	35.80	8.12	8.12	8.12	13.23	13.10	13.08	0.00	0.00	0.00
HB008	2025-05-13	17.0	9.0	1	6.97	8.81	8.95	80.31	103.01	105.24	53936.18	54313.04	54401.56	35.54	35.85	35.93	7.99	8.12	8.12	12.33	12.95	13.17	0.21	0.00	0.16
HB009	2025-05-13	16.0	8.5	1	6.68	8.56	9.02	76.82	99.93	106.00	53662.49	54372.56	54528.44	35.34	35.89	36.03	7.98	8.10	8.14	12.30	12.85	13.13	0.00	0.00	0.60
HB010	2025-05-13	12.0	6.5	1	9.22	9.25	9.26	107.99	108.57	109.30	54220.97	54202.00	54432.00	35.79	35.78	35.97	8.14	8.14	8.13	13.04	13.08	13.40	2.29	0.00	0.16
HB011	2025-05-13	28.0	14.5	1	9.27	8.70	9.13	109.11	101.72	107.16	54312.00	54157.25	54351.90	35.86	35.74	35.90	8.18	8.11	8.18	13.18	13.00	13.14	0.12	1.13	0.00
HB012	2025-05-13	33.0	17.0	1	5.25	8.15	9.23	59.06	94.52	108.26	53549.23	54584.79	54576.32	35.19	36.03	36.06	7.84	8.07	8.16	11.28	12.52	13.06	0.00	1.13	0.00
HB013	2025-05-13	31.0	16.0	1	5.67	8.73	9.34	63.71	101.64	109.63	53431.85	54661.53	54487.14	35.11	36.10	35.99	7.82	8.10	8.16	11.30	12.70	13.13	0.00	0.00	0.00

		Depth (m)			Dissolved oxygen concentration (mg/L)			Dissolved oxygen saturation (%)			Specific conductivity (µS/cm)			Salinity (PSU)			pH			Temperature (°C)			Turbidity (NTU)		
Site ID	Date	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
HB014	2025-05-13	38.0	19.5	1	4.64	8.37	9.47	51.24	97.46	111.80	53460.00	54358.93	54364.64	35.11	35.87	35.92	7.78	8.07	8.21	10.99	12.75	13.40	0.00	1.21	0.00
HB015	2025-05-13	31.0	16.0	1	5.56	8.24	9.33	62.71	95.78	109.57	53043.60	54455.26	54466.57	34.84	35.94	35.98	7.84	8.08	8.16	11.62	12.63	13.13	0.00	0.00	0.00
HB016	2025-05-13	36.0	18.0	1	4.37	8.85	9.18	48.72	103.71	107.93	53334.19	54660.00	54603.42	35.01	36.10	36.08	7.77	8.11	8.19	10.97	12.79	13.14	0.00	0.00	0.00
CF001	2025-06-11	33.0	17.0	1	6.78	7.53	7.67	78.40	90.03	92.80	52433.00	53042.00	53339.00	34.47	34.97	35.21	7.82	8.01	8.06	13.28	14.57	15.07	0.00	0.00	0.00
CP001	2025-06-11	33.0	17.0	1	6.63	7.24	7.01	74.01	84.63	93.46	52460.00	53023.00	53106.00	34.44	34.92	35.01	7.91	8.05	8.10	12.07	13.33	14.11	0.00	0.00	0.00
HB001	2025-06-11	4.0	2.5	1	7.28	6.72	7.40	87.05	80.87	88.80	52704.00	52579.00	51294.00	34.73	34.64	33.71	8.10	8.05	8.05	14.47	14.76	15.02	1.05	2.09	13.94
HB002	2025-06-11	5.0	3.0	1	5.47	7.74	7.00	65.77	93.30	84.29	52731.00	52725.00	51998.00	34.74	34.75	34.22	7.96	8.11	8.05	14.30	14.83	14.86	19.58	6.59	7.69
HB003	2025-06-11	5.0	3.0	1	7.10	7.93	7.75	85.10	95.19	92.91	52745.00	52790.00	52385.00	34.76	34.80	34.50	8.09	8.13	8.07	14.55	14.76	14.74	18.80	0.00	1.83
HB004	2025-06-11	11.0	6.0	1	6.49	7.45	7.51	76.10	88.41	89.66	52403.00	52771.00	52810.00	34.47	34.77	34.81	8.05	8.11	8.10	13.45	14.23	14.41	0.00	0.00	0.02
HB005	2025-06-11	12.0	6.5	1	6.10	7.25	7.46	70.74	85.94	89.50	52467.00	52860.00	52592.00	34.49	34.83	34.66	8.00	8.09	8.10	12.81	14.00	14.78	0.00	0.00	0.00
HB006	2025-06-11	9.0	5.0	1	6.00	7.58	7.93	69.41	90.38	94.90	52310.00	52871.00	52579.00	34.38	34.85	34.64	7.99	8.12	8.10	13.00	14.35	14.62	0.00	0.00	0.00
HB007	2025-06-11	33.0	17.0	1	5.90	7.37	7.88	65.57	84.05	90.62	52672.00	53996.00	52847.00	34.61	35.64	34.82	7.89	8.00	8.04	12.41	13.51	13.93	0.00	0.00	0.00
HB008	2025-06-11	17.0	9.0	1	6.20	7.29	7.80	71.70	86.17	92.97	52467.00	52839.00	52867.00	34.49	34.81	34.85	8.00	8.10	8.12	12.99	13.89	14.42	0.00	0.00	0.00
HB009	2025-06-11	16.0	8.5	1	6.01	6.45	7.96	69.21	75.27	94.87	52367.00	52608.00	52822.00	34.41	34.61	34.81	7.99	8.04	8.14	12.80	13.13	14.40	0.00	0.00	2.73
HB010	2025-06-11	12.0	6.5	1	6.42	7.40	7.93	74.81	87.76	94.79	52495.00	52819.00	52054.00	34.53	34.80	34.26	8.03	8.09	8.10	13.20	14.12	14.62	0.00	0.00	0.00
HB011	2025-06-11	29.0	15.0	1	5.93	6.99	7.78	67.15	81.34	92.31	52493.00	52773.00	52775.00	34.48	34.74	34.77	7.96	8.06	8.11	12.33	13.38	14.26	0.00	0.00	0.00
HB012	2025-06-11	32.0	16.5	1	6.30	6.20	8.02	70.07	71.73	94.66	52575.00	52721.00	52775.00	34.52	34.67	34.77	7.94	8.00	8.12	12.03	12.68	14.18	0.00	0.00	0.00
HB013	2025-06-11	32.0	16.5	1	6.41	7.11	7.91	70.14	81.49	92.73	52421.00	52831.00	53968.00	34.39	34.75	35.64	7.92	8.01	8.10	11.70	12.73	13.91	0.00	0.00	0.00
HB014	2025-06-11	34.0	17.5	1	5.86	6.39	8.02	62.75	72.85	94.58	52629.00	52730.00	52701.00	34.55	34.68	34.72	7.93	8.01	8.12	11.86	12.93	14.12	0.00	0.00	0.00
HB015	2025-06-11	30.0	15.5	1	5.83	7.04	7.96	65.68	81.64	94.55	52495.00	52767.00	52827.00	34.47	34.73	34.81	7.94	8.06	8.12	12.21	13.42	14.32	0.00	0.00	0.00
HB016	2025-06-11	36.0	18.5	1	6.50	6.90	8.11	71.30	78.11	95.61	53379.00	52907.00	52943.00	35.09	34.80	34.89	7.92	8.02	8.12	11.61	12.71	14.04	0.00	0.00	0.00

Table 7 Enterococci counts (cfu per 100 mL) in samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference site between July 2024 and June 2025.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CB001	B	ND	ND	3	2	ND	1	1	ND	2	ND	2	7
CB001	M	ND	ND	18	2	ND	1	1	ND	ND	ND	ND	3
CB001	S	ND	ND	13	ND	ND	ND	52	36	ND	ND	ND	ND
CB002	B	ND	ND	ND	NA	ND	ND	11	2	ND	1	2	51
CB002	M	ND	ND	ND	NA	ND	ND	72	8	ND	ND	3	140
CB002	S	ND	ND	ND	NA	ND	ND	44	5	ND	ND	1	256
CB003	B	ND	ND	ND	1	ND	ND	45	1	2	ND	1	21
CB003	M	ND	ND	ND	ND	ND	ND	2	6	2	ND	1	9
CB003	S	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	2	1
CB004	B	ND	ND	2	6	ND	ND	2	8	5	1	5	18
CB004	M	ND	ND	1	ND	ND	ND	4	4	ND	ND	4	22
CB004	S	ND	11	ND	ND	ND	ND	65	17	ND	ND	1	2
CB005	B	ND	ND	1	6	ND	ND	5	10	12	2	6	2

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CB005	M	ND	ND	1	1	ND	ND	7	2	ND	1	4	3
CB005	S	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
CB006	B	ND	ND	ND	7	ND	5	ND	4	29	15	16	8
CB006	M	ND	ND	2	7	ND	4	1	58	26	68	26	4
CB006	S	ND	40	ND	115	ND	22	1	7	ND	2	1	ND
CB007	B	ND	ND	ND	5	2	ND	1	6	62	7	12	15
CB007	M	ND	ND	ND	7	ND	ND	2	45	ND	ND	1	ND
CB007	S	ND	ND	1	140	ND	ND	ND	15	ND	ND	2	ND
CB008	B	ND	ND	ND	3	1	ND	ND	2	16	ND	1	5
CB008	M	ND	26	8	7	ND	ND	12	42	ND	ND	3	7
CB008	S	ND	43	225	ND	ND	ND	168	39	ND	ND	1	ND
CB009	B	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	2
CB009	M	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	1	ND
CB009	S	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND
CB010	B	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	3
CB010	M	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
CB010	S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
CB011	B	ND	ND	ND	1	ND	ND	ND	ND	ND	1	1	5
CB011	M	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	10
CB011	S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	6
CB012	B	ND	ND	ND	1	ND	ND	ND	1	2	ND	15	ND
CB012	M	ND	ND	ND	ND	ND	ND	ND	ND	2	1	11	ND
CB012	S	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	9	ND
CB013	B	ND	ND	ND	1	ND	ND	5	ND	16	4	3	ND
CB013	M	ND	ND	ND	1	ND	ND	3	ND	19	ND	5	2
CB013	S	ND	ND	ND	ND	ND	ND	4	ND	10	1	1	ND
CB014	B	ND	ND	ND	7	1	ND	1	1	39	ND	ND	1
CB014	M	ND	ND	ND	3	ND	ND	5	1	12	5	4	ND
CB014	S	ND	ND	ND	ND	ND	ND	15	1	22	2	3	ND
CB015	B	ND	ND	ND	3	ND	ND	6	28	43	6	4	ND
CB015	M	ND	ND	2	3	ND	1	ND	2	17	5	1	ND
CB015	S	ND	ND	ND	1	1	2	4	ND	1	4	4	ND
CB016	B	ND	ND	ND	4	ND	ND	ND	36	9	23	1	1
CB016	M	ND	ND	2	ND	ND	2	ND	27	16	28	ND	1
CB016	S	ND	ND	ND	ND	ND	ND	8	14	12	4	1	2
CB017	B	ND	ND	1	2	ND	3	ND	42	9	11	32	ND
CB017	M	ND	ND	ND	2	ND	1	4	63	12	2	18	1
CB017	S	ND	ND	ND	ND	ND	ND	2	49	ND	2	181	1
KB001	B	ND	ND	1	ND	ND	ND	1	ND	ND	ND	ND	ND
KB001	M	ND	ND	1	ND	ND	ND	ND	ND	ND	1	1	ND
KB001	S	ND	ND	ND	ND	1	ND	ND	ND	ND	1	3	1

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
KB001†	B		ND										
KB001	M		ND										
KB001	S		ND										

Table 8 Enterococci counts (cfu per 100 mL) in samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites between July 2024 and June 2025.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CF001	B	ND	ND	ND	ND	2	ND	2	ND	ND	ND	ND	ND
CF001	M	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND
CF001	S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CP001	B	ND	1	ND	ND	ND	12	ND	ND	4	2	13	4
CP001	M	ND	ND	1	7	ND	ND	ND	ND	8	1	25	7
CP001	S	ND	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	ND
HB001	B	16	8	ND	1	ND	2	2	ND	ND	181	6	15
HB001	M	ND	38	3	ND	ND	ND	ND	ND	ND	193	14	8
HB001	S	ND	27	ND	ND	ND	ND	ND	ND	ND	219	7	29
HB002	B	ND	26	1	ND	ND	ND	6	1	9	16	3	43
HB002	M	16	24	ND	ND	ND	ND	ND	1	ND	22	1	ND
HB002	S	26	63	1	ND	ND	1	ND	ND	ND	24	3	10
HB003	B	29	17	1	ND	ND	ND	3	2	13	20	7	6
HB003	M	ND	41	2	ND	ND	ND	ND	ND	2	22	10	2
HB003	S	90	36	46	ND	1	ND	ND	ND	ND	6	8	2
HB004	B	>150	25	16	ND	5	44	11	6	68	21	20	46
HB004	M	78	20	7	48	8	6	ND	2	3	11	6	8
HB004	S	121	38	1	ND	13	10	ND	ND	6	2	4	ND
HB005	B	>150	25	62	11	ND	269	5	2	47	27	24	65
HB005	M	>150	36	ND	1	1	26	1	ND	1	12	3	3
HB005	S	44	17	ND	ND	ND	ND	ND	ND	ND	8	ND	2
HB006	B	27	57	5	34	1	ND	6	1	31	52	4	56
HB006	M	42	57	ND	ND	ND	ND	1	1	3	43	5	18
HB006	S	40	38	ND	ND	ND	ND	ND	2	ND	31	1	1
HB007	B	ND	ND	ND	ND	ND	1	15	ND	ND	5	8	11
HB007	M	ND	ND	ND	ND	ND	ND	36	ND	ND	3	5	2
HB007	S	ND	ND	1	ND	ND	ND	11	ND	ND	3	2	2
HB008	B	13	2	14	5	184	46	18	5	31	34	66	58
HB008	M	ND	24	41	18	30	ND	12	2	12	15	21	29
HB008	S	ND	16	2	17	ND	ND	ND	ND	ND	7	6	ND
HB009	B	31	13	44	40	24	29	4	7	30	11	64	94

† KB001 (Karbonkelberg reference site) was sampled twice in August 2024 because sampling was spread over two days for the Camps Bay marine outfall.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
HB009	M	15	26	33	4	2	2	6	1	16	9	9	36
HB009	S	ND	14	2	ND	ND	ND	2	ND	1	16	ND	ND
HB010	B	34	22	25	90	2	15	14	16	3	27	21	82
HB010	M	43	27	5	ND	ND	ND	4	1	ND	43	5	30
HB010	S	ND	18	ND	1	ND	ND	ND	ND	1	34	ND	ND
HB011	B	ND	ND	6	1	ND	2	6	8	ND	5	43	6
HB011	M	>150	18	310	14	ND	ND	17	143	19	23	36	91
HB011	S	ND	ND	ND	6	ND	ND	6	19	ND	12	ND	9
HB012	B	ND	1	18	1	17	11	7	9	12	52	124	27
HB012	M	47	2	17	6	890	4	3	55	15	14	28	101
HB012	S	ND	2	5	ND	28	ND	13	21	ND	1	ND	23
HB013	B	ND	ND	9	1	2	28	12	188	ND	3	159	3
HB013	M	81	13	5	16	ND	2	35	94	27	16	7	18
HB013	S	ND	ND	8	10	ND	ND	1	1	ND	1	3	31
HB014	B	ND	ND	38	ND	8	6	2	3	33	5	76	1
HB014	M	54	ND	4	6	2	186	ND	1	25	138	65	88
HB014	S	ND	24	31	ND	ND	ND	9	1	ND	2	1	13
HB015	B	ND	7	10	1	3	10	6	12	7	5	42	11
HB015	M	62	27	20	240	10	37	7	17	22	19	30	47
HB015	S	ND	8	1	1	ND	ND	6	173	ND	2	2	14
HB016	B	ND	ND	3	1	ND	15	9	1	49	1	42	2
HB016	M	35	1	9	3	1	ND	9	15	71	73	18	119
HB016	S	ND	ND	17	ND	ND	ND	17	ND	1	4	2	12

Table 9 Enterococci counts (cfu per 100 mL) in samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site between July 2024 and June 2025.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP001	B	28	54	15	ND	ND	ND	1	ND	ND	ND	30	15
GP001	M	16	59	13	ND	ND	ND	1	ND	ND	1	63	17
GP001	S	66	505	15	ND	ND	ND	ND	ND	1	ND	12	10
GP002	B	69	405	7	2	ND	ND	ND	ND	ND	2	6	2
GP002	M	59	130	7	1	ND	ND	ND	ND	ND	ND	9	9
GP002	S	71	295	6	3	ND	ND	ND	ND	ND	2	3	5
GP003	B	78	29	6	10	ND	1	ND	ND	ND	ND	7	1
GP003	M	67	28	7	390	ND	1	ND	ND	ND	ND	5	6
GP003	S	79	76	13	380	ND	2	ND	ND	ND	1	1	1
GP004	B	>150	17	9	80	1	1	ND	ND	ND	15	6	2
GP004	M	13	ND	10	50	3	ND	ND	ND	ND	3	5	5
GP004	S	>150	37	3	320	ND	ND	ND	ND	ND	ND	1	ND
GP005	B	10	ND	20	31	2	2	ND	ND	ND	ND	1	7
GP005	M	19	ND	13	108	1	ND	ND	ND	ND	ND	1	6

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP005	S	>150	ND	6	320	ND	1	ND	ND	ND	ND	ND	1
GP006	B	NA	ND	37	16	15	31	11	ND	2	17	16	26
GP006	M	NA	ND	105	5	5	251	4	ND	ND	4	5	34
GP006	S	NA	ND	2	ND	1	3	ND	ND	ND	ND	16	3
GP007	B	24	ND	44	8	ND	35	13	ND	9	14	21	23
GP007	M	13	6	30	1	3	56	1	ND	10	24	6	5
GP007	S	>150	280	ND	ND	ND	4	ND	ND	ND	1	15	8
GP008	B	19	34	44	9	1	15	2	ND	6	6	24	36
GP008	M	>150	14	8	ND	ND	10	13	ND	12	3	8	13
GP008	S	>150	138	ND	1	ND	7	1	ND	ND	ND	6	4
GP009	B	NA	17	30	70	1	11	6	ND	9	ND	24	3
GP009	M	NA	19	5	78	2	127	5	ND	5	11	13	10
GP009	S	NA	95	ND	ND	ND	4	ND	ND	ND	ND	5	1
GP010	B	39	17	8	11	ND	16	ND	ND	ND	1	16	12
GP010	M	10	19	20	124	2	152	ND	ND	2	1	18	1
GP010	S	>150	77	ND	ND	ND	2	ND	ND	1	2	4	4
GP011	B	40	ND	6	24	27	2	2	11	4	6	27	6
GP011	M	13	ND	170	77	6	27	ND	149	3	13	4	25
GP011	S	>150	124	2	460	ND	3	23	46	21	ND	9	4
GP012	B	24	10	16	9	ND	2	53	ND	1	1	16	15
GP012	M	8	ND	40	ND	ND	1	32	ND	11	11	30	6
GP012	S	>150	230	ND	ND	ND	ND	136	ND	ND	ND	6	10
GP013	B	13	ND	2	2	2	6	ND	27	15	26	61	18
GP013	M	ND	ND	890	200	96	2	ND	560	68	980	1	219
GP013	S	>150	81	15	1	2	1	ND	6	3	34	3	3
GP014	B	31	ND	4	125	2	2	ND	2	40	ND	6	34
GP014	M	35	ND	4	ND	3	360	ND	36	126	1	63	286
GP014	S	>150	148	ND	ND	ND	12	ND	ND	ND	37	450	59
GP015	B	21	ND	ND	5	1	2	ND	ND	19	2	41	31
GP015	M	13	ND	ND	ND	15	410	ND	20	7	410	30	33
GP015	S	>150	67	1	ND	1	13	ND	ND	ND	8	ND	2
GP016	B	13	ND	36	8	2	12	7	1	7	13	30	14
GP016	M	ND	ND	50	77	17	39	82	ND	3	12	ND	22
GP016	S	>150	150	ND	30	1	9	51	ND	39	6	31	9
GP017	B	35	ND	18	30	ND	2	3	1	2	4	31	44
GP017	M	ND	ND	5	24	ND	1	96	ND	5	ND	15	23
GP017	S	>150	137	11	310	ND	1	19	ND	ND	ND	4	21
GP018	B	33	116	23	3	37	1	6	2	9	14	82	7
GP018	M	44	149	52	7	30	2	1	5	38	7	77	73
GP018	S	>150	345	74	61	4	11	25	1	88	135	400	247
GP019	B	44	21	3	ND	10	ND	37	44	10	2	20	11
GP019	M	34	24	40	2	49	ND	46	49	51	7	5	3
GP019	S	>150	141	22	6	56	10	68	56	22	760	130	16

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP043	B	ND	190	56	3	4	19	ND	23	20	32	51	8
GP043	M	ND	ND	540	27	162	4	ND	19	2	6	1	52
GP043	S	>150	ND	2	ND	1	1	ND	93	15	2	11	33
RI001	B	ND	NA	ND	2	ND	ND	1	ND	ND	ND	ND	ND
RI001	M	ND	NA	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
RI001	S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 10 Total suspended solids (mg/L) measured from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference site.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CB001	B	163	104	13	18	15	28	5	15	9	8	11	11
CB001	M	160	11	9	21	13	26	15	26	8	6	9	12
CB001	S	108	6	13	13	11	19	10	24	7	6	11	8
CB002	B	142	33	14	NA	9	14	8	14	12	<4.5	9	11
CB002	M	145	31	5	NA	15	98	13	17	9	16	9	10
CB002	S	112	15	16	NA	15	17	6	19	7	10	11	5
CB003	B	11	12	33	8	17	<4.5	10	25	11	11	10	13
CB003	M	7	12	16	27	18	26	17	17	11	13	9	14
CB003	S	13	11	14	37	24	18	17	20	12	11	9	17
CB004	B	80	99	18	15	37	15	7	22	5	12	6	17
CB004	M	114	24	18	35	15	23	13	24	13	8	10	10
CB004	S	114	25	13	11	32	6	9	22	16	26	15	14
CB005	B	26	35	28	17	18	12	6	28	12	21	14	11
CB005	M	156	118	17	15	17	<4.5	<4.5	22	17	6	15	8
CB005	S	144	27	15	18	19	7	<4.5	17	13	6	15	10
CB006	B	82	16	21	24	21	<4.5	<4.5	14	16	8	10	9
CB006	M	58	12	22	12	28	7	7	10	18	14	14	6
CB006	S	54	9	16	7	16	<4.5	8	11	19	10	6	11
CB007	B	62	33	9	11	8	9	9	13	10	14	12	11
CB007	M	87	24	18	19	15	6	9	22	12	12	10	10
CB007	S	54	23	17	11	11	<4.5	9	18	19	10	7	5
CB008	B	28	48	31	13	13	5	12	20	6	13	13	18
CB008	M	127	88	21	10	32	<4.5	8	31	18	14	5	9
CB008	S	138	40	13	16	10	5	10	27	16	18	13	7
CB009	B	91	13	39	26	16	16	13	25	13	10	14	11
CB009	M	12	12	14	19	55	15	7	33	14	9	10	11
CB009	S	6	7	13	37	57	13	16	15	13	15	7	14

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CB010	B	14	11	18	14	56	7	13	19	8	15	14	5
CB010	M	9	9	22	26	25	17	14	23	10	5	16	7
CB010	S	13	11	31	17	14	17	15	36	12	14	17	12
CB011	B	44	10	18	11	23	5	<4.5	19	19	10	14	6
CB011	M	141	13	22	14	14	7	<4.5	25	20	12	12	6
CB011	S	44	35	58	8	20	7	10	35	27	35	10	6
CB012	B	11	7	22	27	11	21	<4.5	25	9	12	16	16
CB012	M	90	10	17	13	10	25	11	30	10	12	12	16
CB012	S	17	36	24	20	44	13	11	27	8	19	16	14
CB013	B	17	26	16	29	11	<4.5	15	32	11	10	18	19
CB013	M	55	58	12	21	13	24	17	37	7	14	15	13
CB013	S	45	34	12	17	25	11	11	30	5	14	14	10
CB014	B	32	22	22	15	23	16	18	44	8	23	16	7
CB014	M	43	14	18	13	106	8	11	29	9	13	16	11
CB014	S	94	31	12	16	21	11	11	26	5	11	16	13
CB015	B	46	97	16	19	15	15	11	31	8	12	21	11
CB015	M	105	145	20	19	24	13	9	13	5	7	14	13
CB015	S	50	35	17	14	41	17	<4.5	29	11	10	16	13
CB016	B	29	109	21	14	10	16	7	14	22	13	23	8
CB016	M	42	90	11	14	8	7	<4.5	27	15	20	15	12
CB016	S	33	41	28	23	11	<4.5	9	24	24	7	16	14
CB017	B	43	16	14	20	10	7	6	37	17	<4.5	14	8
CB017	M	53	16	25	19	12	6	5	31	14	<4.5	16	5
CB017	S	15	9	6	12	12	12	6	27	9	21	9	6
KB001	B	68	27	27	17	<4.5	18	18	20	12	14	13	6
KB001	M	33	31	11	18	7	18	11	30	17	16	18	8
KB001	S	24	15	16	24	16	24	14	26	19	17	7	<4.5
KB001†	B		84										
KB001	M		10										
KB001	S		9										

† KB001 (Karbonkelberg reference site) was sampled twice in August 2024 because sampling was spread over two days for the Camps Bay marine outfall.

Table 11 Total suspended solids (mg/L) measured from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
CF001	B	122	86	40	6	11	10	8	26	10	13	16	5
CF001	M	70	18	7	15	12	17	10	13	12	15	17	5
CF001	S	98	27	8	8	10	10	13	34	18	14	14	<4.5
CP001	B	96	50	47	13	13	13	12	31	21	22	16	<4.5
CP001	M	90	21	25	22	16	10	21	19	14	13	17	10
CP001	S	107	50	22	18	8	22	8	31	17	17	8	<4.5
HB001	B	99	23	17	10	16	39	7	223	11	18	5	11
HB001	M	95	26	19	20	6	28	12	65	18	21	12	13
HB001	S	62	18	19	11	13	21	8	25	8	21	12	<4.5
HB002	B	105	13	15	12	10	23	17	19	8	22	6	14
HB002	M	105	25	18	17	19	23	16	17	14	22	10	14
HB002	S	105	12	19	10	26	14	11	15	13	13	8	12
HB003	B	113	35	27	20	11	15	5	29	13	9	15	14
HB003	M	105	33	18	21	17	14	7	45	17	18	9	15
HB003	S	115	29	34	16	50	19	8	27	17	18	13	8
HB004	B	113	30	41	8	11	13	26	21	9	17	10	8
HB004	M	136	35	28	9	12	10	16	14	10	14	9	11
HB004	S	98	58	32	17	34	8	27	14	10	33	6	6
HB005	B	92	32	19	16	15	25	9	20	9	14	7	<4.5
HB005	M	106	42	21	13	12	23	10	11	8	17	15	6
HB005	S	92	30	14	15	14	38	8	15	13	17	9	7
HB006	B	108	20	15	34	16	14	10	9	13	16	9	8
HB006	M	104	24	22	31	16	35	12	13	10	22	13	11
HB006	S	113	27	13	22	19	32	6	16	13	15	9	13
HB007	B	99	30	17	7	8	21	13	52	13	24	13	18
HB007	M	117	37	20	5	10	12	10	31	8	16	16	6
HB007	S	101	52	29	14	8	36	17	11	12	15	9	6
HB008	B	63	45	25	18	13	96	<4.5	25	11	18	11	5
HB008	M	91	39	8	25	53	12	11	19	14	19	11	9
HB008	S	107	26	12	14	12	15	8	15	12	27	11	9
HB009	B	121	42	17	19	20	19	8	14	12	34	5	8
HB009	M	53	31	28	31	12	<4.5	9	19	14	30	9	14
HB009	S	47	32	32	39	10	18	8	27	20	16	7	13
HB010	B	49	40	35	49	12	23	10	10	<4.5	19	13	10
HB010	M	47	34	24	33	7	40	9	8	11	17	17	17

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
HB010	S	65	51	19	23	8	17	29	18	7	16	12	13
HB011	B	111	37	25	14	11	17	26	26	8	18	9	13
HB011	M	94	37	15	16	41	11	<4.5	21	11	16	7	15
HB011	S	107	30	11	16	5	15	<4.5	13	11	20	9	15
HB012	B	145	42	19	31	8	13	13	16	14	8	11	7
HB012	M	99	48	32	14	12	8	12	30	15	30	8	11
HB012	S	103	53	25	10	<4.5	10	26	37	6	22	15	16
HB013	B	95	40	28	18	6	10	7	23	5	16	17	14
HB013	M	106	52	30	16	11	16	<4.5	14	14	13	10	<4.5
HB013	S	113	23	22	14	5	16	13	22	11	15	14	9
HB014	B	116	44	26	14	6	20	14	20	12	15	17	12
HB014	M	109	54	25	11	6	16	13	19	8	18	7	15
HB014	S	142	21	23	10	11	16	7	20	16	17	12	14
HB015	B	109	30	18	<4.5	17	11	8	19	13	15	14	7
HB015	M	114	31	11	9	30	11	7	27	12	21	14	11
HB015	S	108	40	21	6	14	19	11	37	14	14	12	12
HB016	B	108	37	17	26	17	16	7	40	16	20	10	9
HB016	M	49	35	19	22	15	13	12	24	14	14	13	7
HB016	S	122	32	48	14	12	14	10	22	17	12	11	10

Table 12 Total suspended solids (mg/L) measured from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site.

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP001	B	89	71	43	15	11	16	14	14	11	36	19	14
GP001	M	89	48	18	6	7	20	9	16	17	31	19	11
GP001	S	91	27	27	14	8	17	16	16	12	23	17	5
GP002	B	93	44	43	18	11	13	12	19	8	20	24	9
GP002	M	94	61	22	12	11	17	11	17	18	30	26	7
GP002	S	88	44	60	14	11	17	13	25	14	23	28	12
GP003	B	91	28	29	11	10	19	14	22	14	22	25	12
GP003	M	95	25	26	5	12	18	30	21	15	11	15	8
GP003	S	64	18	55	11	13	13	15	19	19	12	12	6
GP004	B	79	47	43	10	16	36	13	26	14	14	21	7
GP004	M	94	44	22	10	17	12	12	17	16	17	17	9
GP004	S	50	133	23	17	15	19	12	21	18	13	16	9
GP005	B	98	19	25	10	25	24	13	34	16	10	21	7

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP005	M	93	28	35	11	16	17	9	27	15	14	18	5
GP005	S	92	15	64	14	14	18	12	23	19	13	13	13
GP006	B	NA	32	26	17	17	14	16	17	19	14	25	8
GP006	M	NA	23	28	22	14	18	13	15	18	9	20	8
GP006	S	NA	53	28	11	92	14	<4.5	18	12	17	16	7
GP007	B	95	50	23	23	9	9	14	26	16	18	18	10
GP007	M	86	12	18	14	18	15	5	18	12	9	10	13
GP007	S	95	23	12	10	9	16	7	22	15	16	13	10
GP008	B	86	45	32	7	13	19	6	20	22	12	27	5
GP008	M	49	99	25	23	14	16	10	21	32	14	16	13
GP008	S	93	19	13	13	16	19	<4.5	14	23	10	11	11
GP009	B	NA	93	18	18	13	23	7	20	20	19	22	9
GP009	M	NA	34	31	19	15	18	<4.5	27	26	12	11	9
GP009	S	NA	15	31	12	13	22	11	15	10	11	12	11
GP010	B	113	115	25	16	21	22	12	28	14	12	14	9
GP010	M	130	9	29	19	12	16	8	23	13	11	13	7
GP010	S	109	<4.5	23	22	15	15	<4.5	23	15	11	14	6
GP011	B	114	16	17	19	12	24	<4.5	16	14	17	35	6
GP011	M	104	9	22	15	16	16	11	24	13	17	18	10
GP011	S	69	18	6	10	12	16	13	24	12	13	15	9
GP012	B	73	25	14	15	26	19	5	26	14	18	29	11
GP012	M	87	14	18	12	29	14	7	23	12	23	12	<4.5
GP012	S	78	14	21	10	21	9	9	30	16	15	12	10
GP013	B	123	10	26	12	39	14	6	29	16	12	17	15
GP013	M	116	5	20	9	25	19	12	32	16	12	11	5
GP013	S	83	18	21	7	16	13	9	29	17	13	15	10
GP014	B	140	13	16	11	28	11	13	12	14	13	15	11
GP014	M	104	17	30	24	23	17	8	23	17	11	13	8
GP014	S	36	14	23	6	21	9	11	19	14	15	11	8
GP015	B	297	11	14	11	15	17	8	11	18	10	21	9
GP015	M	80	9	13	9	26	15	14	16	10	11	13	<4.5
GP015	S	107	10	14	12	16	18	10	14	21	11	10	15
GP016	B	123	43	28	73	28	16	9	13	21	15	21	8
GP016	M	93	33	20	13	13	13	9	19	15	8	11	8
GP016	S	86	40	17	10	14	20	14	24	17	10	12	7
GP017	B	123	71	23	8	17	13	13	26	22	12	26	10
GP017	M	96	31	21	10	18	11	9	20	15	13	14	8
GP017	S	76	37	22	12	15	10	7	18	20	12	9	5

Site ID	Position	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
GP018	B	111	26	35	24	15	19	6	16	11	15	15	9
GP018	M	111	28	31	20	11	19	8	14	13	14	16	9
GP018	S	0	47	40	18	9	98	12	18	15	14	11	10
GP019	B	74	53	53	17	20	30	6	15	18	13	13	8
GP019	M	120	38	<4.5	23	10	111	8	14	11	19	16	8
GP019	S	115	30	22	18	14	11	15	18	14	22	21	5
GP043	B	105	32	13	18	12	9	8	13	19	14	31	11
GP043	M	109	24	24	33	26	15	12	12	15	5	8	12
GP043	S	46	37	23	10	10	38	9	10	9	13	8	14
RI001	B	109	NA	21	15	17	21	13	10	17	11	14	10
RI001	M	123	NA	40	5	5	13	15	11	14	19	14	14
RI001	S	103	19	18	18	16	14	6	13	8	16	14	14

Table 13 Ecotoxicity results (% fertilisation of urchin gametes) obtained from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference site, between July 2024 and June 2025.

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
CB004	B	1	98	99	99	100	99	99	91	87	93	97	99	88	97
CB004	B	2	100	98	100	98	96	96	96	86	94	100	98	91	96
CB004	B	3	95	97	100	98	98	98	99	82	99	100	96	91	93
CB004	B	4	100	97	NR	95	99	99	94	81	95	99	96	98	97
CB004	M	1	100	94	NR	96	98	98	95	90	94	100	97	96	92
CB004	M	2	100	97	97	95	99	99	98	94	96	100	98	82	96
CB004	M	3	99	98	99	93	97	97	98	82	94	99	97	94	96
CB004	M	4	97	99	98	90	96	96	92	87	88	94	95	98	97
CB004	S	1	99	96	94	96	98	98	98	91	98	99	96	90	93
CB004	S	2	99	93	100	98	94	94	92	81	96	99	99	89	97
CB004	S	3	100	97	99	93	99	99	98	90	91	100	96	88	94
CB004	S	4	95	100	96	95	97	97	98	92	94	100	98	98	96
CB005	B	1	99	96	97	95	95	95	97	90	97	100	97	75	98
CB005	B	2	97	98	98	100	98	98	95	87	96	100	97	89	95
CB005	B	3	98	97	98	96	99	99	98	89	89	100	100	94	97
CB005	B	4	97	95	91	96	96	96	90	85	95	98	96	94	98
CB005	M	1	98	99	94	98	93	93	96	88	96	100	98	94	91
CB005	M	2	100	98	99	95	98	98	94	82	96	96	93	98	96
CB005	M	3	99	97	97	97	96	96	98	85	94	98	98	98	94

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
CB005	M	4	98	96	94	99	98	98	89	84	94	99	97	98	98
CB005	S	1	99	98	99	96	98	98	98	92	99	100	94	95	98
CB005	S	2	100	98	98	96	95	95	99	85	98	97	100	99	95
CB005	S	3	99	98	99	96	98	98	97	92	94	98	98	93	96
CB005	S	4	100	99	89	98	99	99	98	93	93	99	98	94	90
CB006	B	1	98	NR	98	96	99	99	95	84	96	97	97	92	98
CB006	B	2	100	NR	100	95	97	97	98	89	99	97	97	99	97
CB006	B	3	100	NR	97	95	93	93	98	94	95	99	100	98	94
CB006	B	4	98	NR	97	96	99	99	97	90	96	100	96	86	98
CB006	M	1	99	NR	98	88	97	97	98	91	96	100	98	89	98
CB006	M	2	99	NR	99	95	97	97	98	85	95	99	97	91	94
CB006	M	3	100	NR	99	97	98	98	99	86	95	99	97	91	96
CB006	M	4	97	NR	95	98	98	98	99	85	98	100	95	93	95
CB006	S	1	99	NR	99	92	94	94	92	92	98	100	99	88	95
CB006	S	2	98	NR	98	88	98	98	97	89	99	100	98	88	92
CB006	S	3	99	NR	92	98	96	96	96	86	98	99	99	83	91
CB006	S	4	100	NR	94	92	96	96	99	88	95	100	97	93	98
CB007	B	1	99	96	96	97	97	97	94	63	97	98	95	94	98
CB007	B	2	100	98	99	97	98	98	95	0	0	100	98	97	97
CB007	B	3	99	97	100	92	99	99	88	0	20	6	95	95	81
CB007	B	4	98	99	98	97	98	98	97	0	0	36	95	93	96
CB007	M	1	99	96	98	96	98	98	98	87	98	100	97	94	93
CB007	M	2	100	99	94	95	92	92	94	85	100	97	95	94	97
CB007	M	3	98	94	91	93	95	95	94	89	98	98	98	93	94
CB007	M	4	100	99	98	94	98	98	97	89	92	99	97	86	95
CB007	S	1	99	100	98	97	100	100	97	87	95	99	98	71	95
CB007	S	2	97	97	89	97	99	99	100	89	97	100	96	91	97
CB007	S	3	98	97	88	92	97	97	95	90	98	100	96	87	96
CB007	S	4	99	100	97	95	97	97	100	84	97	98	99	96	94
KB001	B	1	99	99	96	98	94	94	97	94	95	98	91	95	98
KB001	B	2	100	99	100	98	98	98	96	0	87	99	100	96	94
KB001	B	3	98	97	94	98	96	96	98	0	98	100	94	98	97
KB001	B	4	99	99	99	98	99	99	100	0	100	98	99	89	94
KB001	M	1	99	96	95	95	98	98	98	90	98	3	97	93	92
KB001	M	2	96	100	95	96	96	96	96	91	93	72	97	87	96
KB001	M	3	99	99	92	95	100	100	97	94	92	76	97	84	93
KB001	M	4	97	99	98	97	99	99	99	87	0	96	96	97	92

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
KB001	S	1	98	98	95	93	98	98	99	83	100	100	98	97	94
KB001	S	2	99	98	95	96	99	99	97	84	93	97	98	90	99
KB001	S	3	100	99	91	91	98	98	97	0	98	100	97	100	90
KB001	S	4	100	97	100	96	96	96	100	0	0	2	97	78	93

Table 14 Ecotoxicity results (% fertilisation of urchin gametes) obtained from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site, between July 2024 and June 2025.

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
GP011	B	1	96	100	98	100	96	96	97	100	91	100	99	97	84
GP011	B	2	97	99	95	97	92	92	98	100	96	99	96	88	92
GP011	B	3	87	100	91	94	98	98	96	93	97	99	95	90	90
GP011	B	4	81	99	96	98	94	94	94	100	98	100	87	92	87
GP011	M	1	94	100	97	99	96	96	98	95	99	97	90	93	80
GP011	M	2	92	100	96	96	98	98	98	99	96	100	96	86	88
GP011	M	3	74	89	NR	94	94	94	94	99	91	98	90	90	94
GP011	M	4	63	93	92	99	98	98	95	96	99	100	94	94	83
GP011	S	1	83	99	94	98	97	97	94	99	91	98	95	88	95
GP011	S	2	73	100	93	97	97	97	99	100	95	99	94	90	90
GP011	S	3	88	100	95	98	98	98	91	100	95	99	93	93	87
GP011	S	4	89	100	100	96	94	94	99	96	97	100	84	83	88
GP012	B	1	97	100	95	98	92	92	97	100	97	98	94	87	93
GP012	B	2	96	99	95	97	95	95	95	99	95	97	97	98	89
GP012	B	3	94	99	99	99	94	94	98	93	100	98	97	93	93
GP012	B	4	92	100	100	97	97	97	99	100	99	96	88	88	84
GP012	M	1	97	100	96	98	98	98	95	96	95	99	94	86	89
GP012	M	2	91	99	93	100	96	96	93	96	97	100	90	89	82
GP012	M	3	97	100	90	98	95	95	96	96	99	100	91	83	92
GP012	M	4	96	99	98	93	93	93	98	100	99	98	95	84	87
GP012	S	1	88	100	92	97	96	96	98	96	97	98	98	95	89
GP012	S	2	88	97	94	99	98	98	98	99	96	99	90	86	83
GP012	S	3	93	99	93	96	94	94	100	96	99	98	90	92	91
GP012	S	4	96	100	96	97	96	96	97	98	98	99	98	87	91
GP013	B	1	96	98	97	96	98	98	99	98	95	97	98	94	90
GP013	B	2	81	100	97	97	92	92	98	97	96	100	88	89	91

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
GP013	B	3	91	100	95	94	94	94	98	100	95	97	90	91	94
GP013	B	4	97	99	95	97	91	91	97	96	94	99	94	97	95
GP013	M	1	93	100	93	98	100	100	97	100	98	98	90	96	89
GP013	M	2	89	97	94	96	96	96	99	97	96	99	90	89	98
GP013	M	3	69	100	86	98	97	97	96	98	97	97	87	89	90
GP013	M	4	73	98	NR	100	97	97	96	96	96	99	85	92	94
GP013	S	1	90	100	100	99	96	96	97	99	97	100	87	81	84
GP013	S	2	75	99	93	97	97	97	91	100	98	99	100	88	97
GP013	S	3	82	100	95	96	96	96	96	99	96	99	86	85	85
GP013	S	4	94	99	96	99	97	97	97	97	96	100	97	86	90
GP014	B	1	96	100	96	99	97	97	97	97	95	99	95	90	88
GP014	B	2	92	100	92	98	97	97	95	97	97	100	98	83	87
GP014	B	3	90	100	98	94	92	92	94	97	99	100	93	78	88
GP014	B	4	89	97	97	98	98	98	98	97	94	96	89	91	89
GP014	M	1	85	100	96	95	95	95	98	99	97	98	97	88	96
GP014	M	2	93	99	97	99	94	94	99	97	99	99	91	92	92
GP014	M	3	81	99	98	97	90	90	96	97	96	96	96	93	93
GP014	M	4	90	96	100	94	97	97	98	93	97	99	93	89	94
GP014	S	1	93	99	96	97	98	98	98	97	96	99	95	90	0
GP014	S	2	79	100	95	95	95	95	97	87	96	100	98	91	0
GP014	S	3	96	99	94	98	96	96	96	96	97	100	87	94	0
GP014	S	4	95	98	94	96	98	98	98	97	96	98	94	84	0
RI001	B	1	88	NR	99	93	89	89	98	98	96	98	100	91	85
RI001	B	2	94	NR	98	99	99	99	98	82	97	100	97	83	88
RI001	B	3	88	NR	94	99	94	94	95	79	98	94	93	82	93
RI001	B	4	96	NR	96	99	94	94	99	99	96	99	91	86	89
RI001	M	1	81	NR	11	91	97	97	96	97	96	100	95	89	91
RI001	M	2	79	NR	1	97	97	97	97	97	93	99	92	85	82
RI001	M	3	94	NR	3	99	97	97	93	95	100	95	97	86	83
RI001	M	4	96	NR	35	95	95	95	95	93	100	99	96	81	93
RI001	S	1	92	98	96	97	97	97	99	95	93	99	90	92	83
RI001	S	2	79	100	96	95	96	96	100	97	98	99	95	94	90
RI001	S	3	76	99	90	100	98	98	98	99	96	99	97	87	91
RI001	S	4	74	96	93	97	99	99	97	87	96	100	97	90	85

Table 15 Ecotoxicity results (% fertilisation of urchin gametes) obtained from water samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites, between July 2024 and June 2025.

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
CF001	B	1	100	100	98	92	93	93	94	89	96	100	97	92	92
CF001	B	2	89	100	97	98	95	95	93	97	97	100	93	84	91
CF001	B	3	100	100	92	96	96	96	97	92	99	98	95	100	85
CF001	B	4	94	100	95	96	98	98	90	0	94	98	98	94	91
CF001	M	1	97	98	100	100	97	97	90	89	97	100	94	83	95
CF001	M	2	99	99	97	99	97	97	93	94	99	99	95	95	93
CF001	M	3	98	98	97	99	94	94	95	94	99	100	92	93	86
CF001	M	4	100	95	95	95	91	91	91	89	100	100	97	98	86
CF001	S	1	97	99	97	95	97	97	94	91	100	99	94	85	92
CF001	S	2	100	100	99	99	94	94	96	92	97	99	96	98	88
CF001	S	3	97	92	96	98	98	98	91	90	98	98	94	80	86
CF001	S	4	99	99	97	98	95	95	96	93	100	98	96	86	80
CP001	B	1	97	96	99	99	98	98	91	94	99	99	93	96	80
CP001	B	2	99	100	98	99	94	94	95	92	99	100	96	94	94
CP001	B	3	100	99	96	97	97	97	90	91	96	99	95	90	85
CP001	B	4	100	98	97	93	95	95	91	89	95	99	94	86	83
CP001	M	1	80	100	94	93	95	95	91	33	100	100	99	78	82
CP001	M	2	97	100	97	98	98	98	92	0	97	99	97	72	85
CP001	M	3	99	100	81	95	97	97	88	0	99	99	95	86	90
CP001	M	4	100	100	96	99	97	97	83	0	99	99	96	75	79
CP001	S	1	98	95	97	96	100	100	89	93	98	100	94	99	87
CP001	S	2	100	98	99	98	96	96	89	94	72	99	91	94	85
CP001	S	3	99	100	96	98	98	98	90	91	97	98	98	96	87
CP001	S	4	98	100	98	98	98	98	96	93	98	100	91	83	81
HB012	B	1	94	99	100	99	99	99	84	97	96	99	88	97	91
HB012	B	2	95	100	99	97	98	98	89	97	98	97	84	95	63
HB012	B	3	99	100	95	100	98	98	94	99	93	99	92	92	88
HB012	B	4	99	99	94	96	93	93	86	88	97	99	99	94	64
HB012	M	1	96	99	97	99	95	95	89	97	100	99	89	96	95
HB012	M	2	98	100	98	96	91	91	85	93	100	100	85	95	87
HB012	M	3	96	99	100	94	94	94	85	97	100	99	96	93	90
HB012	M	4	99	100	98	98	89	89	85	96	99	96	98	95	90
HB012	S	1	100	99	98	98	95	95	86	97	100	99	94	96	87
HB012	S	2	98	100	95	96	96	96	86	91	97	99	97	86	92
HB012	S	3	95	99	92	97	97	97	88	98	94	99	95	93	92

Site ID	Position	Lab Replicate	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Jul 2025
HB012	S	4	100	99	97	96	94	94	88	93	98	99	94	94	85
HB013	B	1	98	99	100	95	90	90	93	93	95	1	93	94	88
HB013	B	2	94	100	97	97	95	95	83	97	97	0	100	94	87
HB013	B	3	92	100	94	93	95	95	93	94	0	0	94	96	83
HB013	B	4	99	99	95	95	89	89	92	90	93	1	97	94	91
HB013	M	1	96	100	98	98	96	96	84	89	96	97	94	95	89
HB013	M	2	98	100	97	96	93	93	90	81	99	99	98	97	92
HB013	M	3	99	97	97	99	97	97	88	92	89	100	89	97	86
HB013	M	4	97	98	99	98	95	95	95	96	94	97	94	93	91
HB013	S	1	99	100	96	99	96	96	92	97	99	100	87	92	90
HB013	S	2	99	100	98	99	95	95	92	93	96	99	100	93	93
HB013	S	3	99	99	99	98	91	91	95	95	94	99	93	90	91
HB013	S	4	99	100	99	95	89	89	84	95	99	99	87	94	88
HB015	B	1	98	97	100	98	96	96	82	95	100	98	93	92	94
HB015	B	2	98	100	95	96	90	90	82	94	98	99	96	92	89
HB015	B	3	100	100	94	97	98	98	92	91	92	98	91	92	93
HB015	B	4	94	98	98	98	98	98	86	99	95	98	92	83	91
HB015	M	1	98	100	98	99	97	97	86	93	100	96	93	92	88
HB015	M	2	96	99	99	94	100	100	90	92	98	98	95	96	98
HB015	M	3	99	98	100	97	99	99	84	92	100	99	88	87	93
HB015	M	4	93	97	100	99	93	93	91	93	99	100	91	94	87
HB015	S	1	98	99	98	99	95	95	94	90	97	98	92	86	0
HB015	S	2	100	99	96	100	92	92	95	95	98	98	97	86	0
HB015	S	3	100	99	96	99	97	97	89	95	94	98	86	91	0
HB015	S	4	98	98	97	98	88	88	90	92	98	98	96	99	0
HB016	B	1	90	99	100	98	96	96	76	93	94	99	93	93	78
HB016	B	2	98	99	98	98	95	95	83	93	86	97	93	84	89
HB016	B	3	98	99	97	97	94	94	87	94	93	100	95	88	89
HB016	B	4	100	99	93	98	99	99	86	98	97	99	97	88	87
HB016	M	1	100	100	100	100	95	95	84	92	99	98	94	88	87
HB016	M	2	100	100	97	95	97	97	88	99	99	100	96	93	94
HB016	M	3	95	100	97	98	99	99	91	94	92	100	94	79	90
HB016	M	4	93	100	99	99	98	98	82	97	97	100	89	95	91
HB016	S	1	95	99	92	98	98	98	87	89	100	99	85	87	92
HB016	S	2	98	100	100	99	99	99	92	96	96	99	97	85	88
HB016	S	3	96	99	99	97	97	97	87	93	94	98	96	99	84
HB016	S	4	98	100	95	100	97	97	88	93	0	97	94	84	81

Table 16 Nutrient concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference site.

Site ID	Month	Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
		B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB001	2024-07	0.304	0.235	0.228	<0.194	0.317	0.209	<0.065	<0.065	<0.065	<0.009	0.21	0.93	NA	NA	NA	0.207	0.333	0.222	0.01	0.008	0.009
CB002	2024-07	0.23	0.233	0.213	0.21	0.223	<0.194	<0.065	<0.065	<0.065	0.08	0.04	0.05	NA	NA	NA	0.226	0.239	<0.194	0.008	0.008	0.009
CB004	2024-07	0.222	0.214	0.221	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.03	<0.009	<0.009	NA	NA	NA	<0.194	<0.194	<0.194	0.009	0.008	0.011
CB005	2024-07	0.235	0.493	0.208	<0.194	0.197	8.79	<0.065	<0.065	<0.065	0.11	0.06	0.06	NA	NA	NA	0.201	0.212	8.8	0.009	0.019	0.008
CB006	2024-07	0.219	0.218	0.221	7.63	5.87	3.27	<0.065	<0.065	<0.065	0.11	0.09	0.11	NA	NA	NA	7.65	5.89	3.29	0.008	0.008	0.008
CB007	2024-07	0.227	0.218	0.217	0.368	0.346	0.309	<0.065	<0.065	<0.065	<0.009	0.01	0.06	NA	NA	NA	0.385	0.362	0.326	0.009	0.008	0.008
CB008	2024-07	0.212	0.225	0.219	0.242	0.281	0.32	<0.065	<0.065	<0.065	0.05	<0.009	<0.009	NA	NA	NA	0.259	0.297	0.337	0.01	0.009	0.008
CB011	2024-07	0.227	0.225	0.218	0.401	0.221	<0.194	<0.065	<0.065	<0.065	0.08	0.02	0.04	NA	NA	NA	0.418	0.238	<0.194	0.009	0.009	0.008
CB016	2024-07	0.234	0.234	0.234	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.08	0.21	<0.009	NA	NA	NA	<0.194	<0.194	0.209	0.009	0.009	0.009
CB017	2024-07	0.226	0.23	0.59	0.226	0.208	0.236	<0.065	<0.065	<0.065	0.08	0.02	0.04	NA	NA	NA	0.226	0.271	0.314	0.009	0.009	0.023
KB001	2024-07	0.272	0.23	0.213	0.32	0.24	<0.194	<0.065	<0.065	<0.065	0.02	0.06	0.06	NA	NA	NA	0.338	0.259	0.205	0.01	0.009	0.008
CB001	2024-10	1.72	1.28	2.46	3.62	3.38	3.64	0.100	0.100	0.120	0.610	0.350	0.180	0.980	0.839	0.751	3.72	3.48	3.76	0.081	0.060	0.143
CB004	2024-10	2.72	0.94	1	3.38	3.40	3.24	0.120	0.120	0.100	0.070	0.040	0.010	0.937	0.843	0.725	3.50	3.52	3.34	0.128	0.044	0.058
CB005	2024-10	0.92	1.06	3.7	3.48	3.42	3.68	0.100	0.100	0.140	0.140	<0.009	<0.009	0.852	0.879	0.789	3.58	3.52	3.82	0.043	0.050	0.216
CB006	2024-10	1.66	1.76	3.14	3.40	3.50	3.74	0.120	0.120	0.140	0.050	0.080	0.090	1.12	0.879	0.888	3.52	3.62	3.88	0.078	0.083	0.147
CB007	2024-10	3.02	2.46	2.46	3.40	3.44	3.58	0.160	0.140	0.140	<0.009	0.130	0.010	0.828	10.7	0.828	3.56	3.58	3.72	0.142	0.115	0.143
CB008	2024-10	2.26	2.64	2.44	3.74	3.56	3.92	0.140	0.140	0.140	0.100	<0.009	0.050	0.809	0.875	0.695	3.88	3.70	4.06	0.140	0.164	0.152
CB011	2024-10	2.2	1.68	2.6	3.86	3.48	3.64	0.140	0.140	0.140	<0.009	0.050	0.020	0.822	0.864	0.770	4.00	3.62	3.78	0.137	0.079	0.152
CB016	2024-10	1.4	2.56	1.96	3.46	3.30	3.42	0.140	0.140	0.140	0.010	<0.009	0.070	0.745	0.768	0.697	3.60	3.44	3.56	0.066	0.149	0.114
CB017	2024-10	3.38	2.76	1.94	3.36	2.88	3.48	0.140	0.580	0.120	0.050	0.130	0.080	0.864	0.760	0.751	3.50	3.46	3.60	0.159	0.129	0.073
KB001	2024-10	3.14	2.54	1.44	4.00	4.06	3.84	0.140	0.120	0.120	<0.009	0.020	0.030	0.789	0.826	0.819	4.14	4.18	3.96	0.147	0.119	0.068
CB001	2025-01	5.16	6.66	2.96	3.66	3.52	3.28	0.140	0.120	0.160	0.410	0.580	0.470	3.75	3.77	3.32	3.80	3.64	3.44	0.257	0.312	0.139
CB002	2025-01	5.02	4.2	3.68	4.38	3.58	3.54	0.140	0.140	0.140	0.720	0.560	0.580	3.71	3.55	3.34	4.52	3.72	3.68	0.235	0.197	0.173
CB004	2025-01	3.68	3.72	5.4	3.70	3.80	3.78	0.140	0.120	0.140	0.640	0.500	0.550	3.76	3.79	3.24	3.84	3.92	3.92	0.148	0.149	0.269
CB005	2025-01	4.94	4.64	3.44	3.84	3.90	3.58	0.140	0.120	0.120	0.540	0.500	0.450	3.77	3.68	3.22	3.98	4.02	3.70	0.232	0.218	0.161
CB006	2025-01	5.2	3.54	4.1	3.42	3.78	3.40	0.140	0.120	0.120	0.390	0.560	1.36	3.32	3.55	3.24	3.56	3.90	3.52	0.244	0.166	0.239
CB007	2025-01	4.62	6	5.24	3.90	4.18	4.92	0.120	0.120	0.140	0.470	0.370	0.520	3.59	3.64	3.27	4.02	4.30	5.06	0.217	0.281	0.305
CB008	2025-01	5.62	5.3	3.66	3.54	3.52	4.10	0.140	0.140	0.120	0.520	0.550	0.520	3.58	3.64	3.37	3.68	3.66	4.22	0.264	0.249	0.198
CB011	2025-01	4.68	3.14	3.24	3.96	4.12	3.84	0.120	0.120	0.120	0.280	0.250	0.180	3.93	3.95	3.20	4.08	4.24	3.96	0.219	0.137	0.162
CB016	2025-01	4.14	4.14	4.12	11.6	3.54	3.50	0.120	0.140	0.120	0.610	0.190	0.200	3.87	3.57	3.44	11.8	3.68	3.62	0.194	0.207	0.206
CB017	2025-01	3.76	3.56	5.4	3.44	3.68	3.36	0.100	0.120	0.120	0.200	0.220	0.190	3.52	3.53	3.27	3.54	3.80	3.48	0.176	0.178	0.315
KB001	2025-01	5.54	5.12	4.8	3.78	3.78	3.78	0.120	0.120	0.120	0.290	0.240	0.210	4.91	3.41	3.23	3.90	3.90	3.90	0.276	0.240	0.280
CB001	2025-04	1.12	0.72	1.16	3.40	4.54	3.76	0.820	<0.065	0.260	0.050	0.040	0.020	NA	NA	NA	4.22	4.54	4.02	0.037	0.023	0.047
CB002	2025-04	0.34	0.66	0.34	4.06	3.00	3.96	0.140	0.420	0.100	0.600	0.100	<0.009	NA	NA	NA	4.20	3.42	4.06	0.011	0.022	0.011
CB004	2025-04	0.24	1.08	0.66	3.40	3.28	3.28	0.120	0.100	0.100	0.040	<0.009	0.020	NA	NA	NA	3.52	3.38	3.38	0.006	0.028	0.022
CB005	2025-04	0.92	0.28	0.24	3.26	3.30	3.24	0.100	0.100	0.100	0.070	0.040	<0.009	NA	NA	NA	3.36	3.40	3.34	0.024	0.007	0.006
CB006	2025-04	0.5	0.54	0.46	3.38	3.24	3.52	0.100	0.140	0.340	<0.009	0.020	0.060	NA	NA	NA	3.48	3.38	3.86	0.013	0.018	0.015
CB007	2025-04	0.72	0.12	0.5	3.56	3.50	4.26	0.120	0.120	0.100	0.110	0.030	0.110	NA	NA	NA	3.68	3.62	4.36	0.019	<0.005	0.016

		Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
Site ID	Month	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CB008	2025-04	0.74	0.86	0.6	3.38	3.38	3.36	0.100	0.100	0.120	0.040	0.010	0.030	NA	NA	NA	3.48	3.48	3.48	0.019	0.028	0.020
CB011	2025-04	0.3	0.36	0.4	6.10	3.20	3.44	0.100	0.100	0.220	0.050	0.040	0.040	NA	NA	NA	6.20	3.30	3.66	0.008	0.012	0.013
CB016	2025-04	0.22	0.84	1.24	3.52	3.22	4.02	0.100	0.480	0.120	0.070	0.030	0.060	NA	NA	NA	3.62	3.70	4.14	0.007	0.027	0.040
CB017	2025-04	0.62	0.36	0.44	3.82	4.00	3.72	0.100	0.100	0.100	0.050	0.020	0.060	NA	NA	NA	3.92	4.10	3.82	0.016	0.012	0.014
KB001	2025-04	0.48	0.38	0.36	5.98	3.48	3.34	0.100	0.120	0.120	0.050	0.070	<0.009	NA	NA	NA	6.08	3.60	3.46	0.013	0.010	0.009

Table 17 Nutrient concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site.

		Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
Site ID	Month	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP011	2024-07	0.231	0.239	0.441	0.397	0.321	1.05	<0.065	<0.065	<0.065	0.11	0.03	0.17	NA	NA	NA	0.411	0.334	1.1	0.008	0.008	0.009
GP012	2024-07	0.231	0.231	0.307	0.869	0.552	0.747	<0.065	<0.065	<0.065	0.08	<0.009	0.07	NA	NA	NA	0.882	0.565	0.768	0.008	0.008	0.008
GP013	2024-07	0.223	0.233	0.443	<0.194	<0.194	0.655	<0.065	<0.065	<0.065	0.06	0.07	0.05	NA	NA	NA	<0.194	<0.194	0.694	0.007	0.008	0.009
GP014	2024-07	0.236	0.233	0.302	<0.194	<0.194	0.267	<0.065	<0.065	<0.065	0.07	0.12	<0.009	NA	NA	NA	<0.194	<0.194	0.29	0.008	0.008	0.008
GP015	2024-07	0.229	0.245	0.351	<0.194	<0.194	0.537	<0.065	<0.065	<0.065	0.06	0.02	0.06	NA	NA	NA	<0.194	<0.194	0.569	0.008	0.008	0.009
GP016	2024-07	0.234	0.237	0.445	<0.194	0.198	0.687	<0.065	<0.065	<0.065	0.11	0.07	0.15	NA	NA	NA	0.203	0.211	0.728	0.008	0.008	0.009
GP017	2024-07	0.231	0.237	0.394	<0.194	<0.194	0.538	<0.065	<0.065	<0.065	0.32	0.07	0.07	NA	NA	NA	0.194	<0.194	0.576	0.008	0.008	0.008
GP018	2024-07	0.235	0.265	0.545	<0.194	<0.194	2.17	<0.065	<0.065	129	0.04	0.08	0.34	NA	NA	NA	<0.194	<0.194	2.3	0.008	0.007	0.011
GP019	2024-07	0.271	0.259	0.935	<0.194	<0.194	0.455	<0.065	<0.065	<0.065	0.08	<0.009	0.22	NA	NA	NA	0.205	<0.194	0.514	0.009	0.008	0.008
GP043	2024-07	0.242	0.24	0.415	0.214	0.22	0.506	<0.065	<0.065	<0.065	0.08	0.05	0.16	NA	NA	NA	0.228	0.234	0.535	0.008	0.008	0.009
RI001	2024-07	0.23	0.235	0.239	0.389	<0.194	0.21	<0.065	<0.065	<0.065	0.07	0.09	0.05	NA	NA	NA	0.404	0.194	0.224	0.008	0.008	0.008
GP011	2024-10	1.48	2.82	2.7	3.62	3.40	3.44	0.120	0.140	0.120	<0.009	<0.009	0.030	0.901	0.839	0.824	3.74	3.54	3.56	0.086	0.164	0.127
GP012	2024-10	2.28	1.9	2.4	3.42	3.42	3.30	0.120	0.120	0.120	0.050	0.040	0.080	0.963	0.785	0.730	3.54	3.54	3.42	0.107	0.118	0.149
GP013	2024-10	2.16	2.7	1.76	3.44	3.50	3.36	0.120	0.120	0.120	0.080	<0.009	0.050	0.986	0.869	0.770	3.56	3.62	3.48	0.134	0.168	0.109
GP014	2024-10	3.38	1.9	1.2	3.60	3.44	3.68	0.140	0.120	0.100	<0.009	<0.009	0.030	0.888	0.691	0.809	3.74	3.56	3.78	0.159	0.111	0.070
GP015	2024-10	1.94	2.72	2	3.66	3.96	3.44	0.120	0.140	0.120	0.030	0.080	<0.009	0.941	0.742	0.760	3.78	4.10	3.56	0.113	0.169	0.124
GP016	2024-10	3.6	3.18	2.6	3.38	3.30	3.74	0.140	0.140	0.120	0.050	0.010	0.030	1.07	0.800	0.789	3.52	3.44	3.86	0.224	0.197	0.161
GP017	2024-10	3.2	1.76	1.76	3.38	6.28	3.52	0.140	0.120	0.120	0.080	0.130	0.060	0.875	0.828	0.877	3.52	6.40	3.64	0.199	0.109	0.109
GP018	2024-10	1.22	1.58	1.32	3.56	3.64	3.58	0.120	0.120	0.120	0.060	0.080	0.090	0.276	0.888	0.815	3.68	3.76	3.70	0.076	0.098	0.082
GP019	2024-10	2.44	1.66	3.66	3.94	3.96	3.98	0.140	0.120	0.140	<0.009	<0.009	<0.009	1.22	0.802	0.854	4.08	4.08	4.12	0.122	0.103	0.227
GP043	2024-10	1.2	1.48	1.28	3.74	3.80	3.58	0.120	0.120	0.120	<0.009	<0.009	<0.009	0.939	0.753	0.704	3.86	3.92	3.70	0.070	0.092	0.079
RI001	2024-10	1.66	2.04	1.68	5.56	5.38	4.80	0.140	0.140	0.120	<0.009	0.050	0.030	0.967	0.768	0.567	5.70	5.52	4.92	0.078	0.119	0.121
GP011	2025-01	5.04	5.24	6.5	4.44	3.96	5.02	0.100	0.100	0.100	0.210	0.230	0.260	3.63	3.48	3.36	4.54	4.06	5.12	0.219	0.228	0.283
GP012	2025-01	7.12	5.42	4.06	6.28	3.90	3.94	0.100	0.100	0.100	0.350	0.190	0.270	3.68	3.39	3.23	6.38	4.00	4.04	0.310	0.293	0.203
GP013	2025-01	3.78	3.76	7.54	3.78	3.86	4.36	0.100	0.100	0.100	0.190	0.250	0.230	3.17	3.25	2.90	3.88	3.96	4.46	0.189	0.188	0.468
GP014	2025-01	4.14	6.58	5	4.22	4.66	4.12	0.100	0.100	0.100	0.220	0.250	0.120	3.68	3.44	3.18	4.32	4.76	4.22	0.207	0.409	0.250
GP015	2025-01	4.4	4.66	6.24	4.28	4.12	6.00	0.100	0.100	0.100	0.190	0.250	0.270	3.55	3.36	3.04	4.38	4.22	6.10	0.220	0.233	0.388
GP016	2025-01	5.18	7.16	4.34	4.00	4.08	4.00	0.100	0.120	0.100	0.220	0.240	0.150	3.73	3.60	3.12	4.10	4.20	4.10	0.258	0.357	0.217

		Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
Site ID	Month	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
GP017	2025-01	5.38	4.74	3.62	4.12	4.14	4.14	0.100	0.100	0.100	0.220	0.140	0.160	3.59	3.47	2.96	4.22	4.24	4.24	0.268	0.237	0.181
GP018	2025-01	6.26	4.36	5.84	4.48	4.36	3.94	0.120	0.100	0.120	0.290	0.190	0.250	3.61	3.50	4.65	4.60	4.46	4.06	0.312	0.218	0.291
GP019	2025-01	4.32	5.64	6.46	4.20	3.94	5.08	0.100	0.120	0.100	0.210	0.280	0.260	3.59	3.44	4.01	4.30	4.06	5.18	0.216	0.281	0.322
GP043	2025-01	4.56	4.98	6.1	3.86	3.86	3.66	0.100	0.100	0.100	0.200	0.240	0.120	3.60	3.38	2.79	3.96	3.96	3.76	0.228	0.249	0.379
RI001	2025-01	4.58	4.6	3.32	2.32	1.72	3.06	0.100	0.100	0.080	0.170	0.180	0.160	3.89	3.00	2.59	2.42	1.82	3.14	0.215	0.268	0.240
GP011	2025-04	1.14	0.34	0.7	4.00	3.96	3.94	<0.065	<0.065	0.220	0.040	0.020	0.040	NA	NA	NA	4.06	3.96	4.16	0.028	0.014	0.035
GP012	2025-04	0.48	0.12	0.38	4.40	3.84	4.10	<0.065	0.460	0.100	0.060	0.100	0.040	NA	NA	NA	4.46	4.30	4.20	0.018	<0.005	0.019
GP013	2025-04	0.52	0.2	1.12	4.40	3.76	4.32	<0.065	0.680	0.380	0.100	0.100	<0.009	NA	NA	NA	4.42	4.44	4.70	0.014	0.005	0.057
GP014	2025-04	0.58	0.52	0.24	5.26	4.50	3.96	<0.065	<0.065	0.340	0.050	0.070	0.020	NA	NA	NA	5.26	4.50	4.30	0.015	0.014	0.012
GP015	2025-04	0.16	0.22	1.94	4.44	4.24	25.4	0.340	<0.065	0.260	0.090	0.120	0.080	NA	NA	NA	4.78	4.26	25.7	<0.005	0.008	0.079
GP016	2025-04	0.38	0.46	0.36	4.40	4.14	4.20	<0.065	0.180	0.180	0.060	0.050	<0.009	NA	NA	NA	4.42	4.32	4.38	0.010	0.022	0.018
GP017	2025-04	0.12	0.4	0.92	4.52	4.38	4.20	0.080	<0.065	0.420	0.060	0.050	0.010	NA	NA	NA	4.60	4.40	4.62	<0.005	0.010	0.047
GP018	2025-04	1.42	0.68	0.86	4.24	4.04	4.00	<0.065	0.200	<0.065	0.170	0.060	0.030	NA	NA	NA	4.24	4.24	4.00	0.054	0.028	0.035
GP019	2025-04	0.62	0.48	0.84	3.70	4.18	3.92	0.240	<0.065	<0.065	0.030	0.070	0.160	NA	NA	NA	3.94	4.18	3.92	0.024	0.016	0.034
GP043	2025-04	0.24	0.46	0.48	4.02	4.08	4.28	<0.065	<0.065	<0.065	0.070	0.080	0.060	NA	NA	NA	4.02	4.08	4.28	0.006	0.019	0.024
RI001	2025-04	1.14	0.8	0.92	3.84	3.52	4.26	<0.065	0.260	<0.065	0.050	0.050	0.020	NA	NA	NA	3.84	3.78	4.28	0.058	0.033	0.047

Table 18 Nutrient concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish factory and Chapmans Peak reference sites.

		Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
Site ID	Month	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
CF001	2024-07	0.245	0.258	0.284	0.295	0.261	0.199	<0.065	<0.065	<0.065	0.18	0.14	0.17	NA	NA	NA	0.277	0.215	0.373	0.006	0.008	0.009
CP001	2024-07	0.244	0.272	0.334	0.357	<0.194	0.215	<0.065	<0.065	<0.065	0.1	0.03	0.07	NA	NA	NA	<0.194	0.231	0.501	0.008	0.009	0.009
HB007	2024-07	0.269	0.265	0.268	0.224	<0.194	<0.194	<0.065	<0.065	<0.065	0.05	0.09	0.07	NA	NA	NA	0.241	0.2	<0.194	0.007	0.007	0.009
HB011	2024-07	0.229	0.262	0.272	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.05	0.03	0.04	NA	NA	NA	<0.194	<0.194	<0.194	0.008	0.009	0.009
HB012	2024-07	0.225	0.246	0.289	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.03	0.07	0.05	NA	NA	NA	0.196	<0.194	0.204	0.007	0.008	0.009
HB013	2024-07	0.264	0.244	0.276	0.244	<0.194	<0.194	<0.065	<0.065	<0.065	0.03	0.14	0.07	NA	NA	NA	0.26	<0.194	<0.194	0.009	0.006	0.011
HB014	2024-07	0.226	0.239	0.367	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.19	0.01	0.1	NA	NA	NA	0.196	<0.194	<0.194	0.007	0.008	0.01
HB015	2024-07	0.239	0.251	0.275	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.08	0.13	<0.009	NA	NA	NA	<0.194	<0.194	<0.194	0.008	0.008	0.009
HB016	2024-07	0.275	0.241	0.287	<0.194	<0.194	<0.194	<0.065	<0.065	<0.065	0.06	0.03	0.12	NA	NA	NA	<0.194	<0.194	0.195	0.007	0.008	0.009
CF001	2024-10	2.84	3.26	2.66	3.46	3.44	3.74	0.140	0.140	0.140	0.020	<0.009	0.040	0.689	0.747	0.610	3.60	3.58	3.88	0.166	0.190	0.192
CP001	2024-10	3.4	2.84	1.24	3.54	3.58	3.66	0.140	0.140	0.120	<0.009	0.020	<0.009	0.849	0.674	0.608	3.68	3.72	3.78	0.159	0.205	0.072
HB002	2024-10	2.54	1.6	1.54	3.62	3.68	3.66	0.140	0.120	0.120	<0.009	<0.009	<0.009	0.719	0.770	0.670	3.76	3.80	3.78	0.158	0.099	0.090
HB004	2024-10	1.62	3.3	1.7	3.70	3.72	3.40	0.120	0.140	0.120	<0.009	<0.009	<0.009	0.888	0.646	0.665	3.82	3.86	3.52	0.076	0.192	0.099
HB007	2024-10	1.9	2.14	5.42	3.92	3.94	56.5	0.120	0.140	0.160	<0.009	<0.009	<0.009	0.749	0.576	0.603	4.04	4.08	56.6	0.089	0.125	0.316
HB011	2024-10	3.18	3.52	1.4	4.22	4.62	3.80	0.140	0.360	0.120	<0.009	<0.009	<0.009	0.920	0.871	0.659	4.36	4.98	3.92	0.149	0.165	0.082
HB012	2024-10	3.16	3.06	3.48	4.24	4.62	4.48	0.140	0.140	0.140	<0.009	<0.009	<0.009	0.903	0.890	0.646	4.38	4.76	4.62	0.148	0.144	0.268
HB013	2024-10	3.4	3.24	1.3	3.90	3.80	3.16	0.140	0.140	0.120	<0.009	<0.009	<0.009	0.781	0.922	0.614	4.04	3.94	3.28	0.211	0.189	0.076

		Ammonium (NH ₄) as N (mg/L)			Nitrate (NO ₃) as N (mg/L)			Nitrite (NO ₂) as N (mg/L)			Orthophosphate (PO ₄) as P (mg/L)			Silica (SiO ₂) (mg/L)			Total oxidised nitrogen as N (mg/L)			Un-ionized Ammonia (NH ₃) as N (mg/L)		
Site ID	Month	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S	B	M	S
HB014	2024-10	1.68	1.6	1.44	5.72	3.34	3.78	0.120	0.320	0.120	<0.009	<0.009	<0.009	0.939	0.768	0.715	5.84	3.66	3.90	0.079	0.093	0.089
HB015	2024-10	3.12	5.04	3.38	4.38	3.56	3.50	0.140	0.160	0.140	<0.009	0.010	<0.009	0.965	0.839	0.682	4.52	3.72	3.64	0.194	0.313	0.260
HB016	2024-10	3.62	2.76	3.16	3.80	4.18	3.92	0.140	0.140	0.140	<0.009	<0.009	0.060	0.837	0.680	0.599	3.94	4.32	4.06	0.225	0.171	0.196
CF001	2025-01	3.78	4.68	4.48	3.82	4.36	4.30	0.100	0.100	0.100	0.220	0.200	0.200	3.33	3.46	3.05	3.92	4.46	4.40	0.189	0.273	0.278
CP001	2025-01	5.88	5.96	5.38	4.14	10.1	4.14	0.120	0.100	0.120	0.500	0.270	0.140	3.74	3.57	3.99	4.26	10.2	4.26	0.293	0.370	0.268
HB002	2025-01	3.38	3.76	4.56	4.18	3.30	3.62	0.100	0.100	0.120	0.210	0.240	0.210	4.07	3.26	2.87	4.28	3.40	3.74	0.169	0.188	0.283
HB004	2025-01	3.92	4.44	4	3.76	4.16	3.30	<0.065	0.120	0.100	0.160	0.230	0.280	3.81	3.87	3.22	3.80	4.28	3.40	0.196	0.222	0.248
HB007	2025-01	3.34	3.7	2.32	3.66	3.46	3.52	0.100	0.120	0.100	0.250	0.140	0.260	4.10	3.91	3.83	3.76	3.58	3.62	0.167	0.185	0.116
HB011	2025-01	5.24	3.64	2.4	4.46	3.74	3.78	0.100	0.100	0.100	0.220	0.180	0.450	4.30	3.96	3.85	4.56	3.84	3.88	0.261	0.182	0.120
HB012	2025-01	4.32	5.98	5.44	5.18	4.22	4.00	0.100	0.100	0.100	0.260	0.200	0.230	4.16	3.96	3.88	5.28	4.32	4.10	0.216	0.298	0.294
HB013	2025-01	4.68	6.02	5.7	4.06	4.08	4.20	0.100	0.100	0.120	0.430	0.180	0.220	4.40	3.93	3.68	4.16	4.18	4.32	0.219	0.282	0.332
HB014	2025-01	4.82	7.08	6.46	5.32	3.82	4.42	0.100	0.120	0.120	0.250	0.190	0.200	4.20	3.94	3.79	5.42	3.94	4.54	0.226	0.308	0.281
HB015	2025-01	7.58	5.84	3.7	4.60	4.10	4.12	0.120	0.100	0.100	0.160	0.210	0.180	4.25	3.98	3.91	4.72	4.20	4.22	0.410	0.340	0.200
HB016	2025-01	7.62	7.28	8.58	4.08	4.64	4.40	0.120	0.100	0.100	0.190	0.220	0.250	4.07	3.93	3.84	4.20	4.74	4.50	0.357	0.317	0.402
CF001	2025-04	0.3	0.5	0.52	2.72	4.06	3.62	0.300	0.120	0.120	0.070	0.070	0.010	NA	NA	NA	3.02	4.18	3.74	0.010	0.016	0.021
CP001	2025-04	0.32	0.9	0.32	6.42	3.72	3.40	0.120	0.120	0.460	0.100	0.060	0.060	NA	NA	NA	6.54	3.84	3.86	0.008	0.023	0.010
HB002	2025-04	2.3	2.7	2.12	32.3	24.6	19.0	0.220	<0.065	<0.065	0.060	<0.009	0.020	NA	NA	NA	32.5	24.7	19.0	0.094	0.137	0.107
HB004	2025-04	2.24	2.08	2.16	14.2	11.5	10.3	<0.065	<0.065	0.080	0.030	0.080	0.070	NA	NA	NA	14.2	11.6	10.4	0.073	0.085	0.088
HB007	2025-04	4.42	2.54	2.5	8.88	10.2	5.48	<0.065	0.320	<0.065	0.090	0.050	0.060	NA	NA	NA	8.92	10.5	5.54	0.115	0.066	0.082
HB011	2025-04	2.72	0.14	0.48	4.76	3.70	3.52	<0.065	<0.065	0.180	0.090	0.060	0.020	NA	NA	NA	4.82	3.70	3.70	0.071	0.005	0.020
HB012	2025-04	0.94	0.7	1.26	3.72	3.80	3.86	<0.065	<0.065	<0.065	0.010	0.060	<0.009	NA	NA	NA	3.72	3.82	3.86	0.031	0.018	0.051
HB013	2025-04	1.98	0.1	0.5	3.98	3.90	4.08	<0.065	0.100	<0.065	0.060	0.060	0.050	NA	NA	NA	3.98	4.00	4.08	0.052	<0.005	0.020
HB014	2025-04	0.68	0.18	0.2	4.00	3.90	3.50	0.260	0.080	<0.065	0.060	0.110	0.020	NA	NA	NA	4.26	3.98	3.52	0.018	0.005	0.008
HB015	2025-04	0.58	0.1	0.1	3.74	3.64	3.62	<0.065	<0.065	<0.065	0.010	0.040	0.040	NA	NA	NA	3.74	3.66	3.62	0.015	<0.005	<0.005
HB016	2025-04	0.6	0.1	0.38	5.14	3.74	4.38	<0.065	0.640	<0.065	0.070	0.080	0.100	NA	NA	NA	5.14	4.38	4.38	0.016	<0.005	0.015

See §2.2.3.6 in the Monitoring Report for more information about nutrient analyses conducted in this monitoring programme.

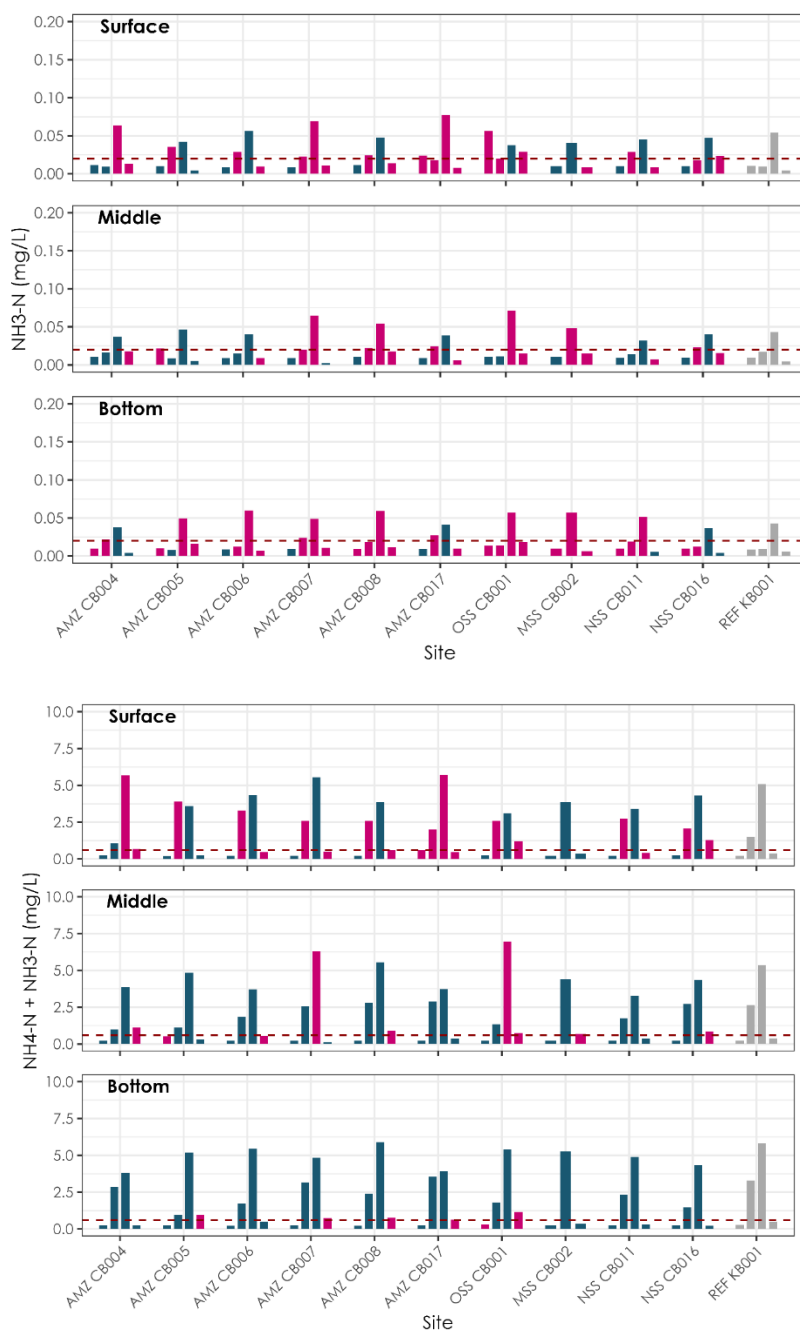


Figure 1. Nitrogen nutrients at the Camps Bay outfall, showing un-ionised ammonia concentrations (top) and total ammonia nitrogen (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025 and where only two are present these are for January 2025 and April 2025.

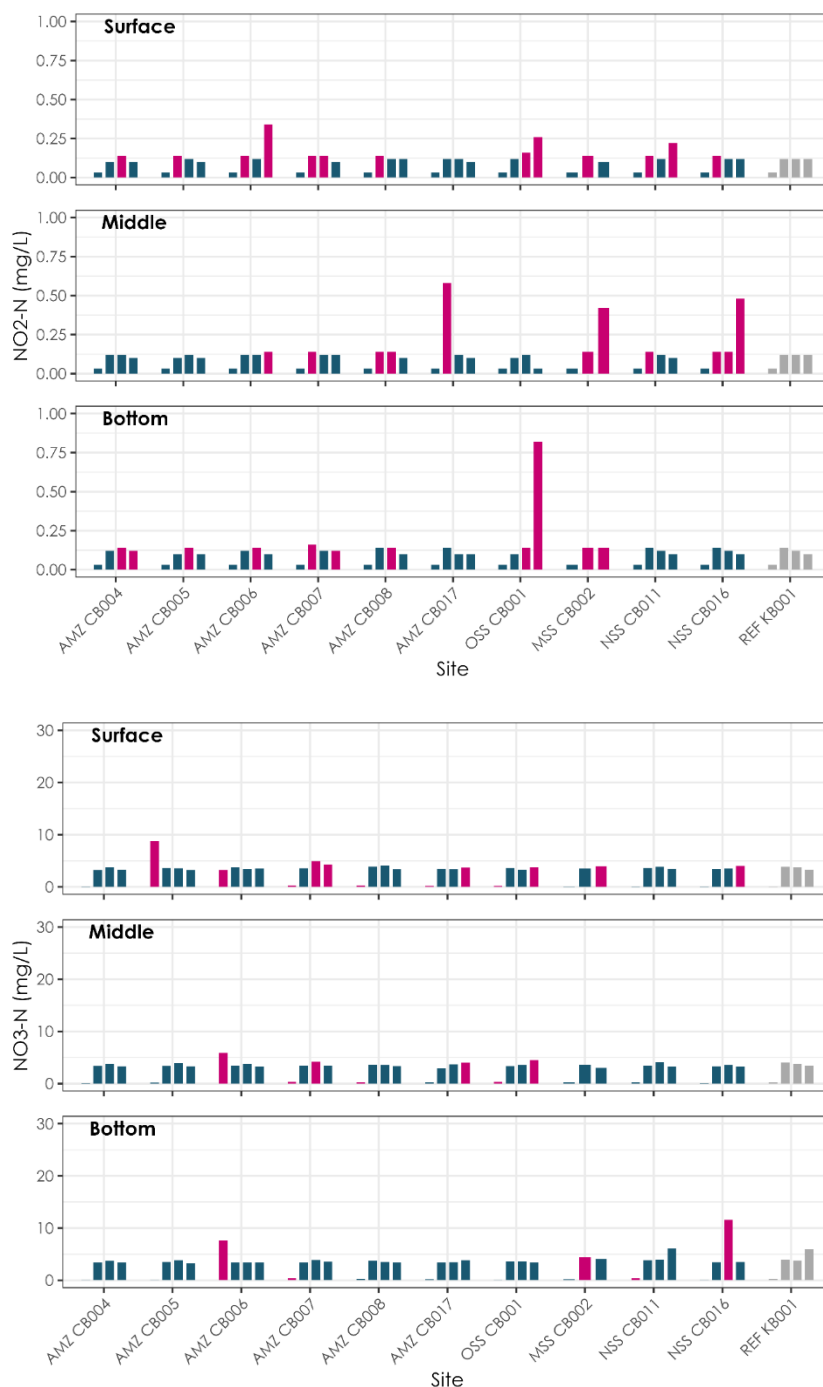


Figure 2. Nitrogen nutrients at the Camps Bay outfall, showing nitrite concentrations (top) and nitrate concentrations (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025 and where only two are present these are for January 2025 and April 2025.

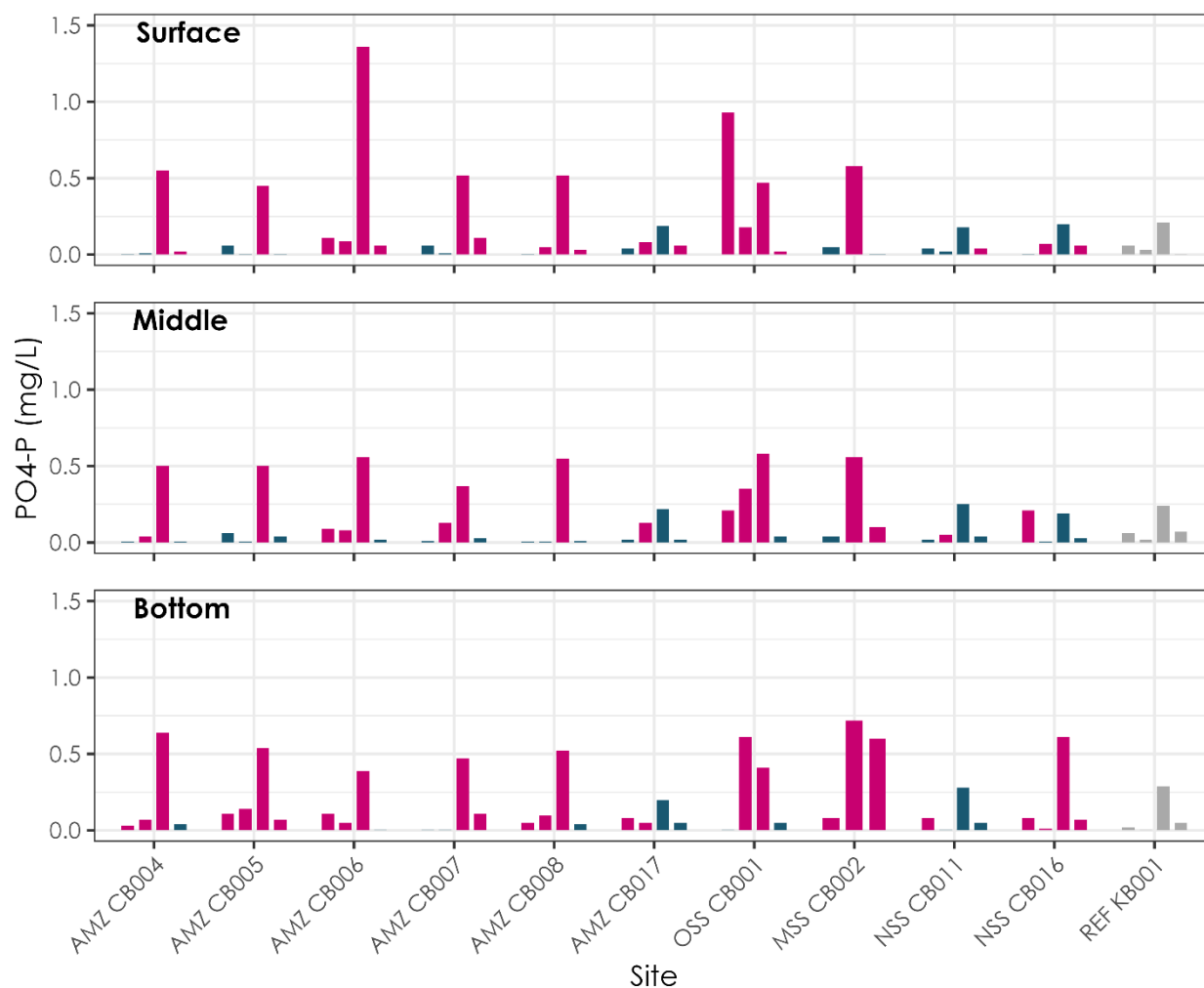


Figure 3. Nutrients at the Camps Bay outfall, showing orthophosphate concentrations in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025 and where only two are present these are for January 2025 and April 2025.

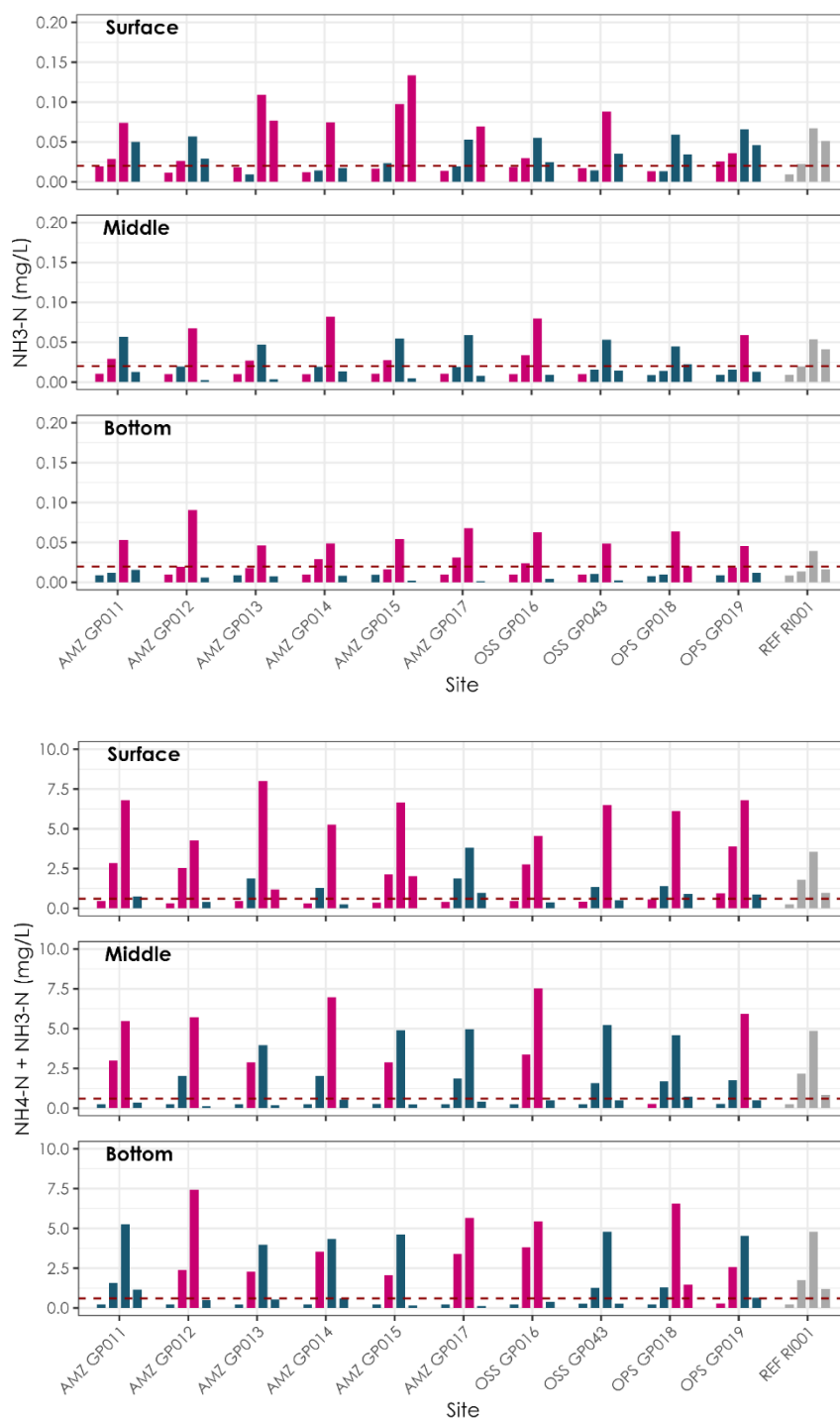


Figure 4. Nitrogen nutrients at the Green Point outfall, showing un-ionised ammonia concentrations (top) and total ammonia nitrogen (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively.

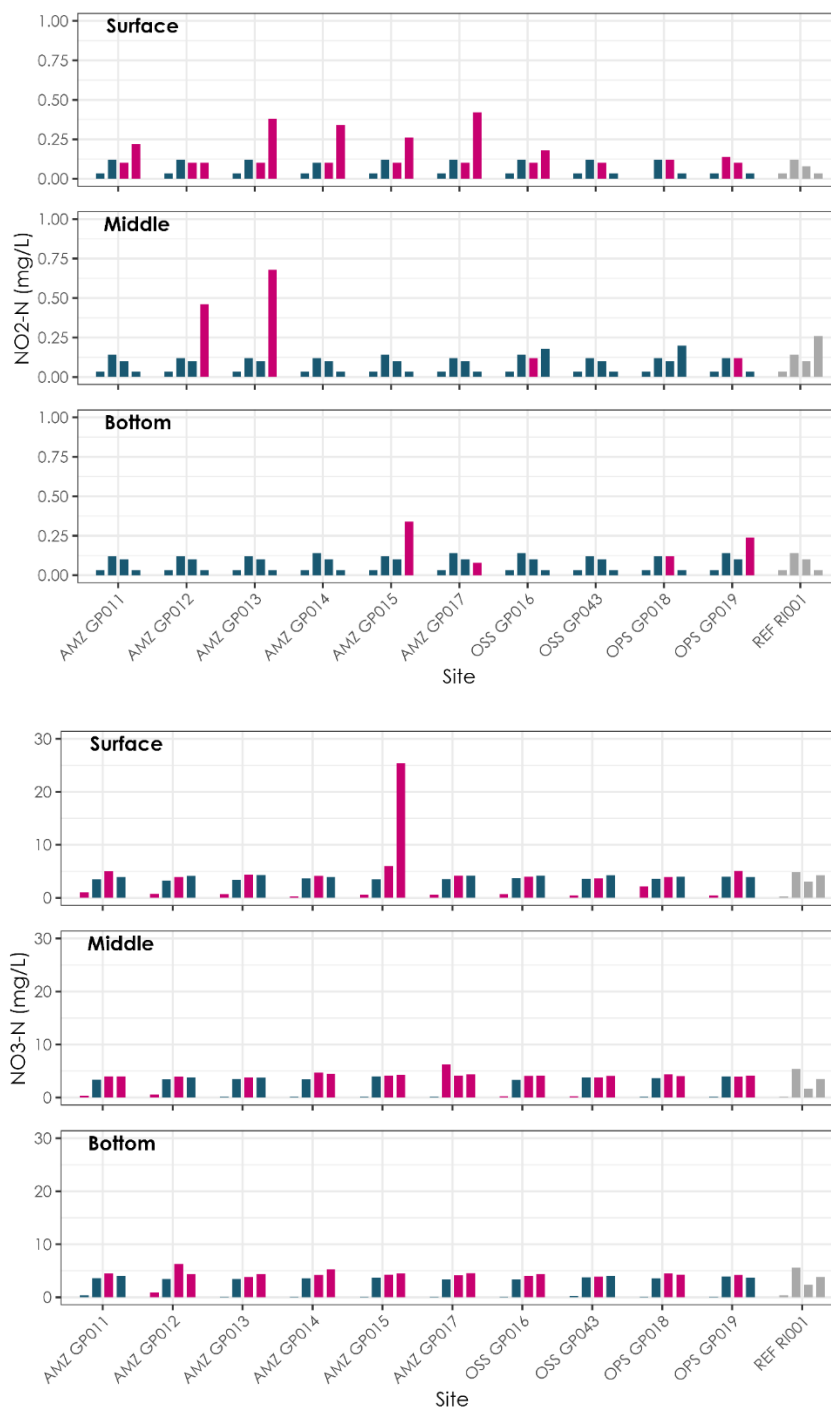


Figure 5. Nitrogen nutrients at the Green Point outfall, showing nitrite concentrations (top) and nitrate concentrations (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively.

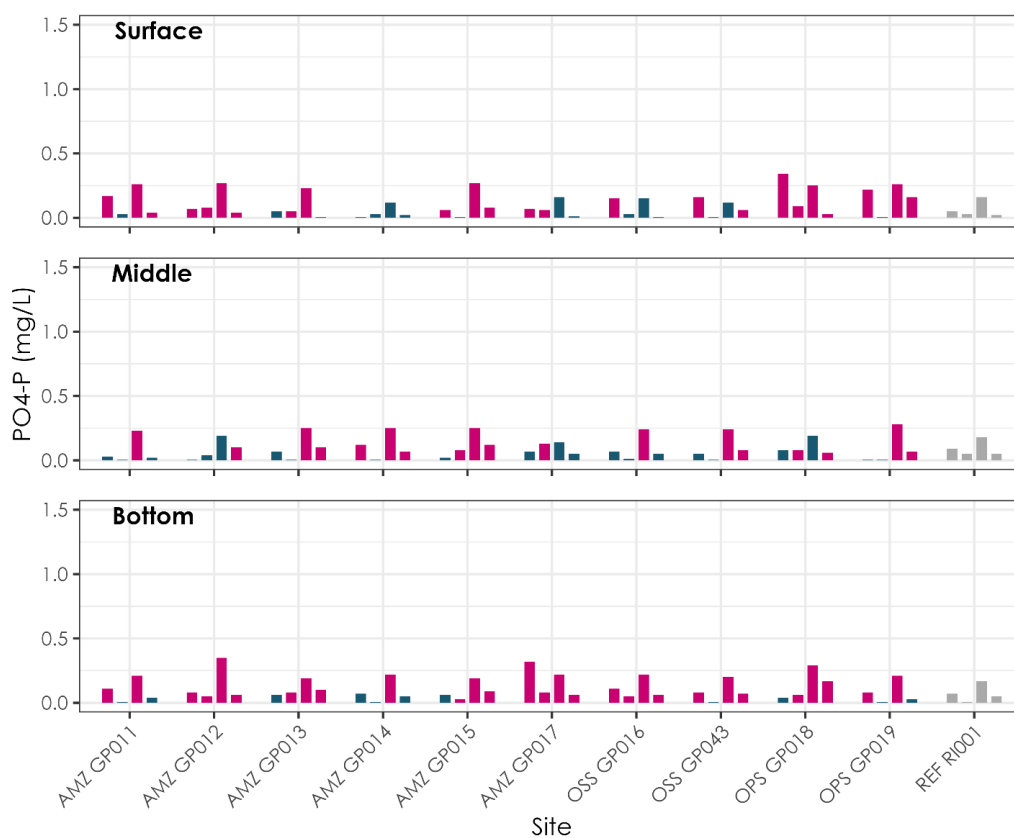


Figure 6. Nutrients at the Green Point outfall, showing orthophosphate concentrations in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively.

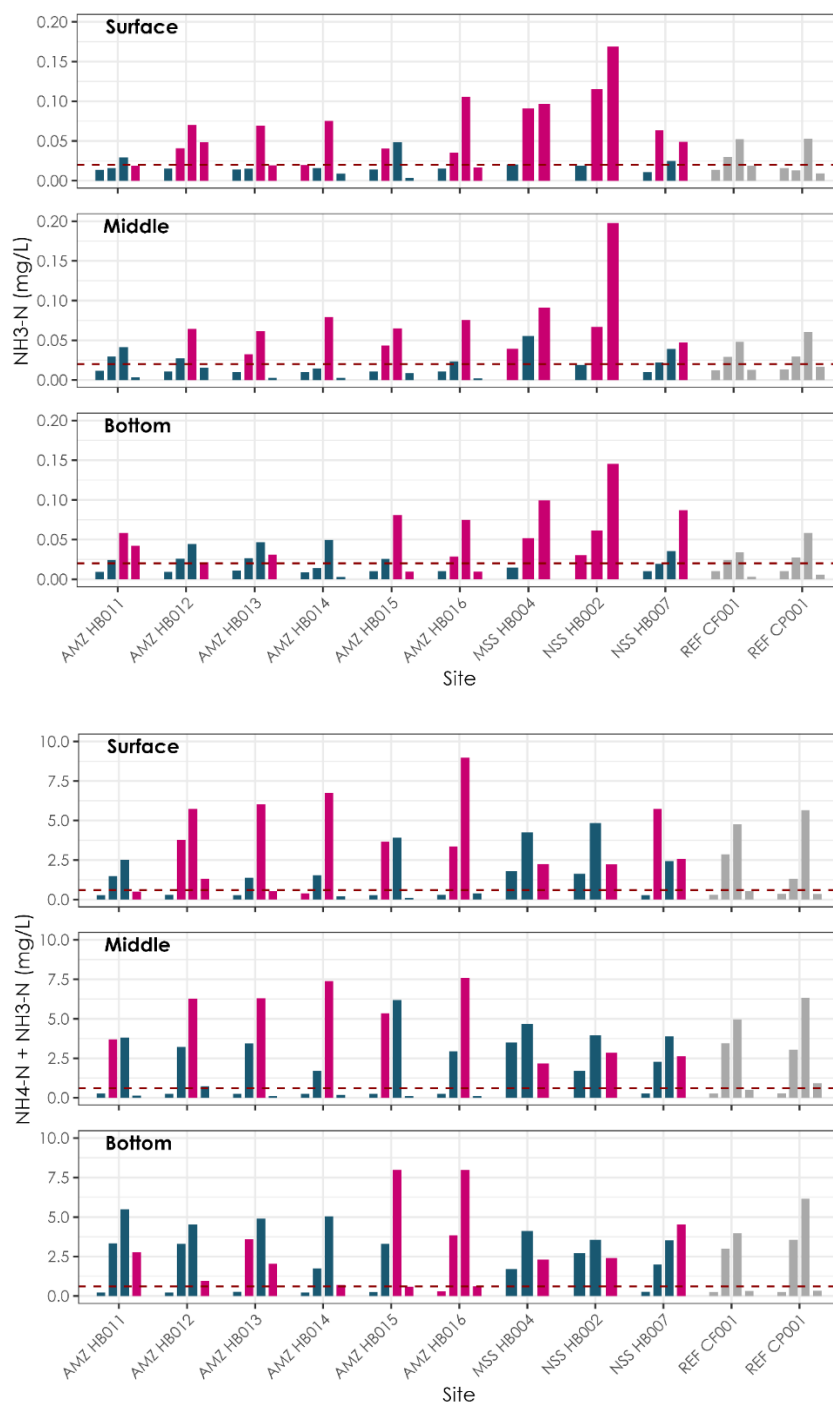


Figure 7. Nitrogen nutrients at the Hout Bay outfall, showing un-ionised ammonia concentrations (top) and total ammonia nitrogen (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025.

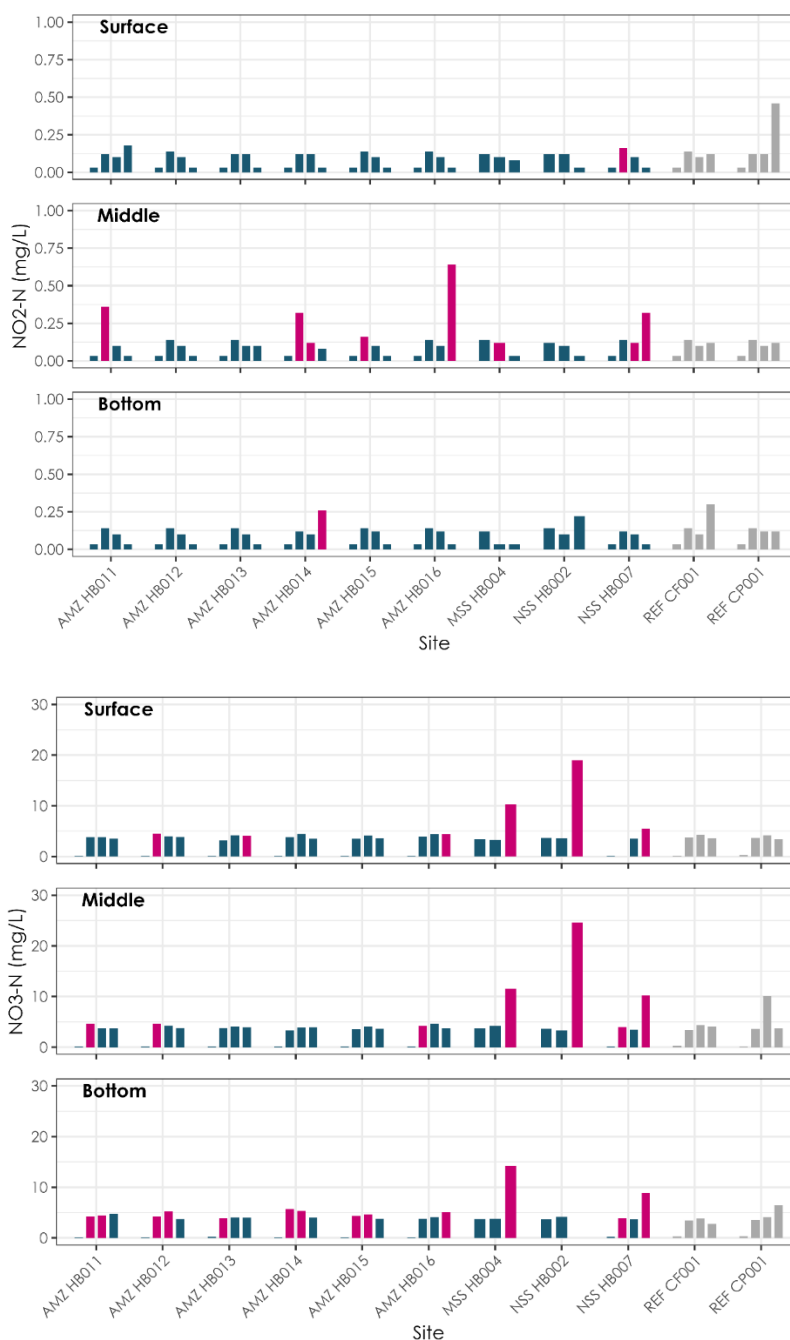


Figure 8. Nitrogen nutrients at the Hout Bay outfall, showing nitrite concentrations (top) and nitrate concentrations (bottom) in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025 and where only two are present these are for January 2025 and April 2025.

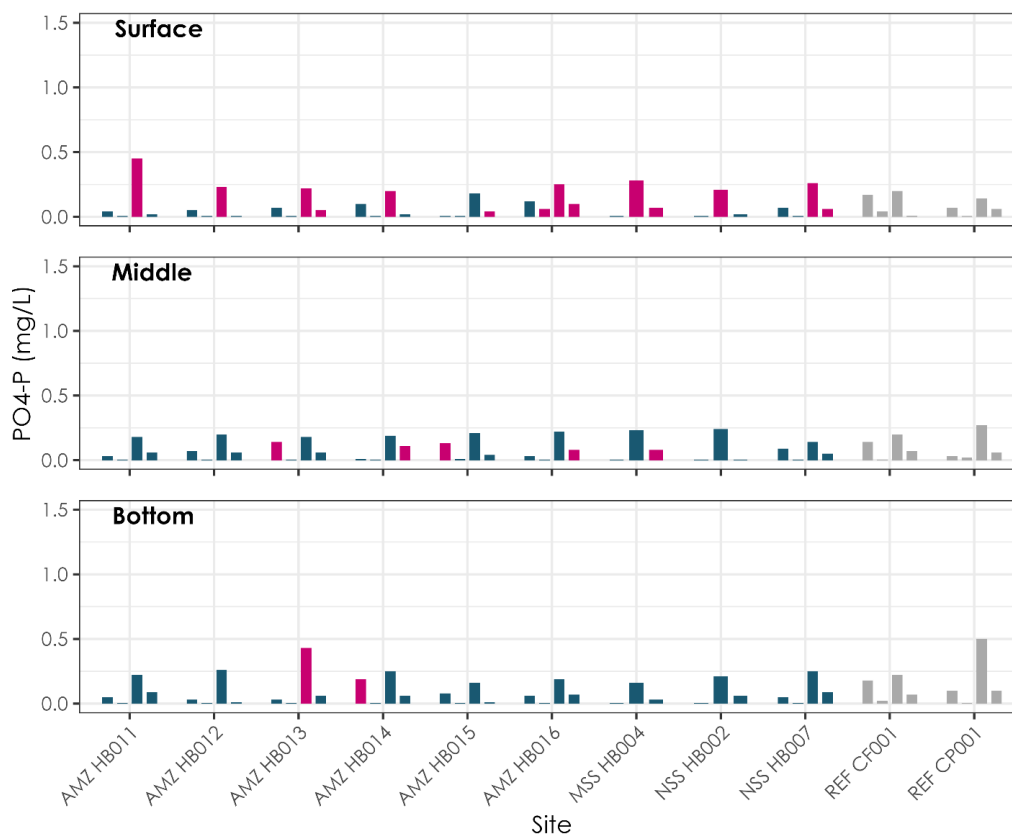


Figure 9. Nutrients at the Hout Bay outfall, showing orthophosphate concentrations in mg/L. Grey bars are reference site data from the same date, blue denotes concentrations less than 10% different from the reference site value, and pink denotes concentrations more than 10% greater than the reference site. Four bars per site are for July 2024, October 2024, January 2025, and April 2025 respectively – where only three bars are present these denote surveys in October 2024, January 2025, and April 2025.

Table 19 Metal concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Camps Bay marine outfall and the Karbonkelberg reference sites between July 2024 and June 2025.

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
CB001	B	2024-07	0.04	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
CB001	M	2024-07	0.059	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	NA	<0.002
CB001	S	2024-07	0.036	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB002	B	2024-07	0.096	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	NA	<0.002
CB002	M	2024-07	0.052	0.002	0.007	<0.002	0.023	0.016	<0.002	NA	<0.002
CB002	S	2024-07	0.112	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB004	B	2024-07	0.038	<0.002	0.006	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB004	M	2024-07	0.105	<0.002	<0.003	<0.002	<0.004	0.023	<0.002	NA	<0.002
CB004	S	2024-07	0.066	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	NA	<0.002
CB005	B	2024-07	0.128	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
CB005	M	2024-07	0.099	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB005	S	2024-07	0.077	<0.002	<0.003	<0.002	<0.004	0.014	<0.002	NA	<0.002
CB006	B	2024-07	0.102	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB006	M	2024-07	0.082	<0.002	<0.003	<0.002	<0.004	0.017	<0.002	NA	<0.002
CB006	S	2024-07	0.034	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	NA	<0.002
CB007	B	2024-07	0.065	<0.002	<0.003	<0.002	<0.004	0.026	<0.002	NA	<0.002
CB007	M	2024-07	0.13	<0.002	<0.003	<0.002	<0.004	0.008	<0.002	NA	<0.002
CB007	S	2024-07	0.096	<0.002	<0.003	<0.002	<0.004	0.024	<0.002	NA	<0.002
CB008	B	2024-07	0.107	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	NA	<0.002
CB008	M	2024-07	0.104	<0.002	<0.003	<0.002	0.011	0.018	<0.002	NA	<0.002
CB008	S	2024-07	0.072	<0.002	<0.003	<0.002	<0.004	0.009	<0.002	NA	<0.002
CB011	B	2024-07	<0.006	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
CB011	M	2024-07	0.109	<0.002	<0.003	<0.002	<0.004	0.014	<0.002	NA	<0.002
CB011	S	2024-07	0.11	<0.002	<0.003	<0.002	<0.004	0.014	<0.002	NA	<0.002
CB016	B	2024-07	0.125	<0.002	0.006	<0.002	<0.004	0.023	<0.002	NA	<0.002
CB016	M	2024-07	0.109	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
CB016	S	2024-07	0.055	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	NA	<0.002
CB017	B	2024-07	0.118	<0.002	<0.003	<0.002	<0.004	0.012	<0.002	NA	<0.002
CB017	M	2024-07	0.072	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	NA	<0.002
CB017	S	2024-07	0.103	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
KB001	B	2024-07	0.014	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
KB001	M	2024-07	0.057	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
KB001	S	2024-07	0.049	<0.002	<0.003	<0.002	<0.004	0.02	<0.002	NA	<0.002
CB001	B	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.458	0.012
CB001	M	2024-10	0.026	0.002	<0.003	<0.002	0.013	<0.005	<0.002	0.392	<0.002
CB001	S	2024-10	0.015	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.351	<0.002
CB004	B	2024-10	0.076	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.438	<0.002
CB004	M	2024-10	0.019	<0.002	<0.003	<0.002	0.012	<0.005	<0.002	0.394	<0.002
CB004	S	2024-10	0.010	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.339	<0.002

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
CB005	B	2024-10	0.014	<0.002	<0.003	<0.002	0.009	<0.005	<0.002	0.398	<0.002
CB005	M	2024-10	0.033	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.411	<0.002
CB005	S	2024-10	0.082	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.369	<0.002
CB006	B	2024-10	0.052	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.522	<0.002
CB006	M	2024-10	0.077	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.411	<0.002
CB006	S	2024-10	0.037	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.415	<0.002
CB007	B	2024-10	0.071	<0.002	<0.003	<0.002	0.017	<0.005	<0.002	0.387	<0.002
CB007	M	2024-10	0.037	0.002	<0.003	<0.002	0.008	<0.005	<0.002	4.99	<0.002
CB007	S	2024-10	0.065	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.387	<0.002
CB008	B	2024-10	0.060	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.378	<0.002
CB008	M	2024-10	0.023	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.409	<0.002
CB008	S	2024-10	0.026	<0.002	<0.003	<0.002	<0.004	0.005	<0.002	0.325	<0.002
CB011	B	2024-10	0.024	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.384	<0.002
CB011	M	2024-10	0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.404	<0.002
CB011	S	2024-10	0.127	0.003	<0.003	<0.002	<0.004	<0.005	<0.002	0.360	<0.002
CB016	B	2024-10	0.066	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.348	<0.002
CB016	M	2024-10	0.034	0.003	<0.003	<0.002	<0.004	<0.005	<0.002	0.359	<0.002
CB016	S	2024-10	0.014	<0.002	<0.003	<0.002	0.015	<0.005	<0.002	0.326	<0.002
CB017	B	2024-10	0.083	<0.002	<0.003	<0.002	0.010	<0.005	<0.002	0.404	<0.002
CB017	M	2024-10	0.070	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.355	<0.002
CB017	S	2024-10	0.010	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.351	<0.002
KB001	B	2024-10	0.039	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.369	0.004
KB001	M	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.386	<0.002
KB001	S	2024-10	0.058	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.383	<0.002
CB001	B	2025-01	0.153	<0.002	<0.003	<0.002	<0.004	0.035	<0.002	1.75	0.048
CB001	M	2025-01	0.086	<0.002	<0.003	0.021	0.010	1.02	<0.002	1.76	0.069
CB001	S	2025-01	<0.006	<0.002	<0.003	0.002	0.006	0.014	<0.002	1.55	0.049
CB002	B	2025-01	0.095	<0.002	<0.003	0.029	<0.004	0.020	<0.002	1.73	0.056
CB002	M	2025-01	0.095	<0.002	0.004	0.023	<0.004	0.010	<0.002	1.66	0.055
CB002	S	2025-01	0.043	<0.002	<0.003	<0.002	<0.004	0.012	<0.002	1.56	0.081
CB004	B	2025-01	0.090	<0.002	<0.003	0.014	0.016	0.035	<0.002	1.76	0.042
CB004	M	2025-01	0.122	<0.002	<0.003	0.005	<0.004	<0.005	<0.002	1.77	0.030
CB004	S	2025-01	0.025	<0.002	<0.003	<0.002	<0.004	0.032	<0.002	1.51	0.016
CB005	B	2025-01	0.112	<0.002	<0.003	<0.002	0.005	0.010	<0.002	1.76	0.020
CB005	M	2025-01	0.080	<0.002	<0.003	<0.002	0.011	0.041	<0.002	1.72	0.024
CB005	S	2025-01	0.070	<0.002	0.004	<0.002	<0.004	0.024	<0.002	1.51	0.027
CB006	B	2025-01	0.093	<0.002	<0.003	0.043	0.005	0.013	<0.002	1.55	0.069
CB006	M	2025-01	0.041	<0.002	<0.003	0.004	0.033	0.050	<0.002	1.66	0.028
CB006	S	2025-01	0.075	<0.002	<0.003	0.009	0.007	0.019	<0.002	1.52	0.028
CB007	B	2025-01	0.156	<0.002	<0.003	<0.002	0.018	0.034	<0.002	1.68	0.052
CB007	M	2025-01	0.057	<0.002	<0.003	0.004	<0.004	0.041	<0.002	1.70	0.040
CB007	S	2025-01	0.065	<0.002	<0.003	<0.002	<0.004	0.017	<0.002	1.53	0.059

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
CB008	B	2025-01	0.104	<0.002	<0.003	0.006	<0.004	0.012	<0.002	1.67	0.068
CB008	M	2025-01	0.023	<0.002	<0.003	0.008	0.018	0.018	<0.002	1.70	0.036
CB008	S	2025-01	0.073	<0.002	<0.003	<0.002	<0.004	0.011	<0.002	1.58	0.030
CB011	B	2025-01	0.064	<0.002	0.003	<0.002	<0.004	0.020	<0.002	1.84	0.007
CB011	M	2025-01	0.119	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.85	0.036
CB011	S	2025-01	0.071	<0.002	0.006	0.048	0.010	0.016	<0.002	1.50	0.030
CB016	B	2025-01	0.110	<0.002	<0.003	0.002	<0.004	0.035	<0.002	1.81	0.048
CB016	M	2025-01	0.106	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.67	0.065
CB016	S	2025-01	0.088	<0.002	<0.003	0.003	<0.004	0.051	<0.002	1.61	0.050
CB017	B	2025-01	0.114	<0.002	<0.003	0.002	<0.004	0.019	<0.002	1.64	0.048
CB017	M	2025-01	0.143	<0.002	<0.003	0.012	<0.004	0.041	<0.002	1.65	0.088
CB017	S	2025-01	0.106	<0.002	<0.003	0.008	0.008	0.030	<0.002	1.53	0.048
KB001	B	2025-01	0.069	<0.002	<0.003	0.006	<0.004	0.018	<0.002	2.30	0.023
KB001	M	2025-01	0.087	<0.002	<0.003	<0.002	0.004	0.019	<0.002	1.59	0.019
KB001	S	2025-01	0.035	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	1.51	0.013
CB001	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB001	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB001	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB002	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB002	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB002	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB004	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB004	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB004	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB005	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB005	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB005	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB006	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB006	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB006	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB007	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB007	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB007	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB008	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB008	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB008	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB011	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB011	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB011	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB016	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB016	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB016	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
CB017	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB017	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CB017	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
KB001	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
KB001	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
KB001	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03

Table 20 Metal concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Green Point marine outfall and the Robben Island reference site between July 2024 and June 2025.

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
GP011	B	2024-07	0.063	<0.002	<0.003	<0.002	<0.004	0.027	<0.002	NA	<0.002
GP011	M	2024-07	0.012	<0.002	<0.003	<0.002	<0.004	0.024	<0.002	NA	<0.002
GP011	S	2024-07	0.057	<0.002	<0.003	<0.002	0.03	0.033	<0.002	NA	<0.002
GP012	B	2024-07	0.065	<0.002	<0.003	<0.002	<0.004	0.028	<0.002	NA	<0.002
GP012	M	2024-07	0.094	<0.002	0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
GP012	S	2024-07	0.071	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
GP013	B	2024-07	0.007	<0.002	<0.003	<0.002	<0.004	0.027	<0.002	NA	<0.002
GP013	M	2024-07	0.111	<0.002	<0.003	<0.002	<0.004	0.023	<0.002	NA	<0.002
GP013	S	2024-07	0.072	<0.002	0.012	<0.002	<0.004	0.017	<0.002	NA	<0.002
GP014	B	2024-07	0.063	<0.002	<0.003	<0.002	<0.004	0.026	<0.002	NA	<0.002
GP014	M	2024-07	0.051	<0.002	<0.003	<0.002	<0.004	0.023	<0.002	NA	<0.002
GP014	S	2024-07	0.075	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
GP015	B	2024-07	0.103	<0.002	<0.003	<0.002	<0.004	0.023	<0.002	NA	<0.002
GP015	M	2024-07	0.045	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
GP015	S	2024-07	0.107	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
GP016	B	2024-07	0.119	<0.002	<0.003	<0.002	<0.004	0.025	<0.002	NA	<0.002
GP016	M	2024-07	0.111	<0.002	<0.003	<0.002	<0.004	0.022	<0.002	NA	<0.002
GP016	S	2024-07	0.097	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	NA	<0.002
GP017	B	2024-07	0.087	<0.002	<0.003	<0.002	<0.004	0.028	<0.002	NA	<0.002
GP017	M	2024-07	0.073	<0.002	<0.003	<0.002	<0.004	0.026	<0.002	NA	<0.002
GP017	S	2024-07	0.143	<0.002	0.006	<0.002	<0.004	0.024	<0.002	NA	<0.002
GP018	B	2024-07	0.16	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	NA	<0.002
GP018	M	2024-07	0.127	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
GP018	S	2024-07	0.137	<0.002	<0.003	<0.002	<0.004	0.02	<0.002	NA	<0.002
GP019	B	2024-07	0.108	<0.002	<0.003	<0.002	<0.004	0.02	<0.002	NA	<0.002

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
GP019	M	2024-07	0.075	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
GP019	S	2024-07	0.141	<0.002	<0.003	<0.002	0.018	0.022	<0.002	NA	<0.002
GP043	B	2024-07	<0.006	<0.002	0.017	<0.002	<0.004	0.015	<0.002	NA	<0.002
GP043	M	2024-07	0.092	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
GP043	S	2024-07	0.141	<0.002	0.008	<0.002	<0.004	0.017	<0.002	NA	<0.002
RI001	B	2024-07	0.132	<0.002	0.007	<0.002	<0.004	0.013	<0.002	NA	<0.002
RI001	M	2024-07	0.07	<0.002	<0.003	<0.002	<0.004	0.024	<0.002	NA	<0.002
RI001	S	2024-07	0.077	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
GP011	B	2024-10	0.020	<0.002	<0.003	<0.002	0.026	<0.005	<0.002	0.421	<0.002
GP011	M	2024-10	0.061	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.392	<0.002
GP011	S	2024-10	0.026	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.385	<0.002
GP012	B	2024-10	0.073	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.450	<0.002
GP012	M	2024-10	0.059	<0.002	<0.003	<0.002	0.012	<0.005	<0.002	0.367	<0.002
GP012	S	2024-10	0.018	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.341	<0.002
GP013	B	2024-10	0.090	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.461	<0.002
GP013	M	2024-10	0.097	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.406	0.004
GP013	S	2024-10	0.046	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.360	<0.002
GP014	B	2024-10	0.076	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.415	<0.002
GP014	M	2024-10	0.098	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.323	<0.002
GP014	S	2024-10	0.022	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.378	<0.002
GP015	B	2024-10	0.053	<0.002	<0.003	<0.002	0.024	<0.005	<0.002	0.440	<0.002
GP015	M	2024-10	0.012	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.347	<0.002
GP015	S	2024-10	0.012	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.355	<0.002
GP016	B	2024-10	0.027	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.500	<0.002
GP016	M	2024-10	<0.006	0.005	<0.003	<0.002	<0.004	<0.005	<0.002	0.374	<0.002
GP016	S	2024-10	0.090	0.005	<0.003	<0.002	<0.004	<0.005	<0.002	0.369	<0.002
GP017	B	2024-10	0.063	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.409	<0.002
GP017	M	2024-10	0.056	<0.002	<0.003	<0.002	0.020	<0.005	<0.002	0.387	<0.002
GP017	S	2024-10	0.037	<0.002	<0.003	<0.002	0.005	<0.005	<0.002	0.410	0.002
GP018	B	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	0.129	<0.002
GP018	M	2024-10	0.067	<0.002	<0.003	<0.002	0.017	<0.005	<0.002	0.415	<0.002
GP018	S	2024-10	0.078	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.381	<0.002
GP019	B	2024-10	0.058	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.569	<0.002
GP019	M	2024-10	0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.375	<0.002
GP019	S	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.399	<0.002
GP043	B	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.439	<0.002
GP043	M	2024-10	0.030	<0.002	<0.003	<0.002	0.028	<0.005	<0.002	0.352	<0.002

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
GP043	S	2024-10	0.085	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.329	<0.002
RI001	B	2024-10	0.116	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.452	<0.002
RI001	M	2024-10	0.037	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.359	<0.002
RI001	S	2024-10	0.069	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.265	<0.002
GP011	B	2025-01	0.159	<0.002	<0.003	<0.002	0.021	0.022	<0.002	1.70	0.036
GP011	M	2025-01	0.134	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.63	0.019
GP011	S	2025-01	0.062	<0.002	<0.003	<0.002	0.023	0.022	<0.002	1.57	0.017
GP012	B	2025-01	0.106	<0.002	<0.003	<0.002	0.020	0.026	<0.002	1.72	0.011
GP012	M	2025-01	0.048	<0.002	<0.003	0.020	<0.004	0.018	<0.002	1.58	0.026
GP012	S	2025-01	0.077	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	1.51	0.011
GP013	B	2025-01	0.029	<0.002	<0.003	<0.002	<0.004	0.012	<0.002	1.48	<0.002
GP013	M	2025-01	0.045	<0.002	<0.003	<0.002	0.015	0.025	<0.002	1.52	0.053
GP013	S	2025-01	0.091	<0.002	<0.003	<0.002	<0.004	0.017	<0.002	1.36	0.045
GP014	B	2025-01	0.080	<0.002	<0.003	0.019	0.026	0.011	<0.002	1.72	0.011
GP014	M	2025-01	0.045	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	1.61	<0.002
GP014	S	2025-01	0.034	<0.002	<0.003	0.016	<0.004	0.012	<0.002	1.48	0.004
GP015	B	2025-01	0.071	<0.002	0.003	<0.002	0.020	0.019	<0.002	1.66	<0.002
GP015	M	2025-01	0.109	<0.002	<0.003	<0.002	0.023	0.014	<0.002	1.57	0.010
GP015	S	2025-01	0.068	<0.002	0.012	<0.002	0.026	0.011	<0.002	1.42	0.044
GP016	B	2025-01	0.102	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.74	0.008
GP016	M	2025-01	0.128	<0.002	<0.003	<0.002	<0.004	0.020	<0.002	1.68	<0.002
GP016	S	2025-01	0.101	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	1.46	0.004
GP017	B	2025-01	0.080	<0.002	<0.003	0.002	<0.004	0.016	<0.002	1.68	0.038
GP017	M	2025-01	0.064	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.62	<0.002
GP017	S	2025-01	0.080	<0.002	<0.003	<0.002	0.015	0.014	<0.002	1.38	0.009
GP018	B	2025-01	0.111	<0.002	<0.003	0.005	<0.004	0.025	<0.002	1.69	<0.002
GP018	M	2025-01	0.087	<0.002	<0.003	<0.002	<0.004	0.009	<0.002	1.64	0.023
GP018	S	2025-01	0.057	<0.002	<0.003	<0.002	<0.004	0.020	<0.002	2.18	0.019
GP019	B	2025-01	0.106	<0.002	<0.003	<0.002	<0.004	0.016	<0.002	1.68	0.013
GP019	M	2025-01	0.077	<0.002	<0.003	0.007	0.009	0.023	<0.002	1.61	0.058
GP019	S	2025-01	0.064	<0.002	<0.003	0.004	0.036	<0.005	<0.002	1.87	<0.002
GP043	B	2025-01	0.098	<0.002	0.006	<0.002	0.014	0.014	<0.002	1.68	<0.002
GP043	M	2025-01	0.051	<0.002	<0.003	0.002	<0.004	0.008	<0.002	1.58	<0.002
GP043	S	2025-01	0.095	<0.002	<0.003	<0.002	<0.004	0.030	<0.002	1.31	0.018
RI001	B	2025-01	0.051	<0.002	<0.003	<0.002	0.033	0.007	<0.002	1.82	0.008
RI001	M	2025-01	0.069	<0.002	<0.003	<0.002	0.024	0.015	<0.002	1.40	0.013
RI001	S	2025-01	0.092	<0.002	<0.003	<0.002	0.004	0.020	<0.002	1.21	0.008

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
GP011	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP011	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP011	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP012	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP012	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP012	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP013	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP013	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP013	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP014	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP014	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP014	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP015	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP015	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP015	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP016	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP016	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP016	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP017	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP017	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP017	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP018	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP018	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP018	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP019	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP019	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP019	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP043	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP043	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
GP043	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
RI001	B	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
RI001	M	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
RI001	S	May 2025	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03

Table 21 Metal concentrations in seawater samples collected from the bottom (B), middle (M) and surface (S) of the water column around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites between July 2024 and June 2025.

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
CF001	B	2024-07	0.008	<0.002	<0.003	<0.002	<0.004	0.028	<0.002	NA	<0.002
CF001	M	2024-07	0.086	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
CF001	S	2024-07	0.079	<0.002	<0.003	<0.002	<0.004	0.026	<0.002	NA	<0.002
CP001	B	2024-07	0.096	<0.002	<0.003	<0.002	<0.004	0.024	<0.002	NA	<0.002
CP001	M	2024-07	<0.006	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
CP001	S	2024-07	0.023	<0.002	<0.003	<0.002	<0.004	0.034	<0.002	NA	<0.002
HB007	B	2024-07	0.091	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
HB007	M	2024-07	0.124	<0.002	<0.003	<0.002	<0.004	0.019	<0.002	NA	<0.002
HB007	S	2024-07	0.069	<0.002	<0.003	<0.002	<0.004	0.024	<0.002	NA	<0.002
HB011	B	2024-07	0.117	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
HB011	M	2024-07	0.099	<0.002	<0.003	<0.002	<0.004	0.02	<0.002	NA	<0.002
HB011	S	2024-07	0.125	<0.002	<0.003	<0.002	<0.004	0.021	<0.002	NA	<0.002
HB012	B	2024-07	0.109	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	NA	<0.002
HB012	M	2024-07	0.082	<0.002	<0.003	<0.002	<0.004	0.017	<0.002	NA	<0.002
HB012	S	2024-07	0.111	<0.002	<0.003	<0.002	<0.004	0.018	<0.002	NA	<0.002
HB013	B	2024-07	0.064	<0.002	<0.003	<0.002	<0.004	0.016	<0.002	NA	<0.002
HB013	M	2024-07	0.119	<0.002	<0.003	<0.002	<0.004	0.01	<0.002	NA	<0.002
HB013	S	2024-07	0.059	<0.002	<0.003	<0.002	<0.004	0.023	<0.002	NA	<0.002
HB014	B	2024-07	0.047	<0.002	<0.003	<0.002	<0.004	0.015	<0.002	NA	<0.002
HB014	M	2024-07	0.037	<0.002	<0.003	<0.002	<0.004	0.017	<0.002	NA	<0.002
HB014	S	2024-07	0.093	<0.002	<0.003	<0.002	<0.004	0.016	<0.002	NA	<0.002
HB015	B	2024-07	0.087	<0.002	<0.003	<0.002	<0.004	0.026	<0.002	NA	<0.002
HB015	M	2024-07	0.124	<0.002	<0.003	<0.002	<0.004	0.013	<0.002	NA	<0.002
HB015	S	2024-07	0.077	<0.002	0.003	<0.002	<0.004	0.013	<0.002	NA	<0.002
HB016	B	2024-07	0.057	<0.002	<0.003	<0.002	<0.004	0.016	<0.002	NA	<0.002
HB016	M	2024-07	0.009	<0.002	<0.003	<0.002	<0.004	0.014	<0.002	NA	<0.002
HB016	S	2024-07	0.068	<0.002	<0.003	<0.002	<0.004	0.012	<0.002	NA	<0.002
CF001	B	2024-10	0.027	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.322	<0.002
CF001	M	2024-10	0.041	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.349	<0.002
CF001	S	2024-10	0.028	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.285	<0.002
CP001	B	2024-10	0.030	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.397	<0.002
CP001	M	2024-10	0.076	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.315	<0.002
CP001	S	2024-10	<0.006	0.002	<0.003	<0.002	0.013	<0.005	<0.002	0.284	<0.002
HB002	B	2024-10	0.014	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.336	<0.002

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
HB002	M	2024-10	0.032	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.360	<0.002
HB002	S	2024-10	0.017	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.313	<0.002
HB004	B	2024-10	0.020	0.002	<0.003	<0.002	0.005	<0.005	<0.002	0.415	0.007
HB004	M	2024-10	0.036	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.302	<0.002
HB004	S	2024-10	0.059	<0.002	<0.003	<0.002	0.021	<0.005	<0.002	0.311	<0.002
HB007	B	2024-10	0.085	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.350	<0.002
HB007	M	2024-10	<0.006	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.269	<0.002
HB007	S	2024-10	0.013	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.282	<0.002
HB011	B	2024-10	0.094	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.430	<0.002
HB011	M	2024-10	0.090	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.407	<0.002
HB011	S	2024-10	0.066	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.308	<0.002
HB012	B	2024-10	0.039	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.422	<0.002
HB012	M	2024-10	0.100	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.416	<0.002
HB012	S	2024-10	0.091	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.302	<0.002
HB013	B	2024-10	0.051	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.365	<0.002
HB013	M	2024-10	0.059	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.431	0.760
HB013	S	2024-10	0.100	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.287	<0.002
HB014	B	2024-10	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.439	<0.002
HB014	M	2024-10	0.017	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.359	<0.002
HB014	S	2024-10	<0.006	<0.002	<0.003	<0.002	0.015	<0.005	<0.002	0.334	<0.002
HB015	B	2024-10	0.096	<0.002	<0.003	<0.002	0.022	<0.005	<0.002	0.451	<0.002
HB015	M	2024-10	0.051	<0.002	<0.003	<0.002	0.022	<0.005	<0.002	0.392	<0.002
HB015	S	2024-10	0.044	0.002	<0.003	<0.002	0.010	<0.005	<0.002	0.319	<0.002
HB016	B	2024-10	0.102	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.391	<0.002
HB016	M	2024-10	0.103	0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.318	<0.002
HB016	S	2024-10	0.056	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	0.280	<0.002
CF001	B	2025-01	0.079	<0.002	<0.003	<0.002	<0.004	0.028	<0.002	1.56	0.007
CF001	M	2025-01	0.072	<0.002	<0.003	<0.002	0.030	0.010	<0.002	1.62	0.030
CF001	S	2025-01	0.021	<0.002	0.008	<0.002	<0.004	0.011	<0.002	1.43	0.021
CP001	B	2025-01	0.069	<0.002	<0.003	0.017	<0.004	0.008	<0.002	1.75	0.025
CP001	M	2025-01	0.074	<0.002	0.004	<0.002	0.018	0.015	<0.002	1.67	0.032
CP001	S	2025-01	0.047	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.87	<0.002
HB002	B	2025-01	0.121	<0.002	0.010	0.015	<0.004	0.022	<0.002	1.90	0.051
HB002	M	2025-01	0.065	<0.002	<0.003	<0.002	0.015	0.028	<0.002	1.53	0.044
HB002	S	2025-01	0.033	<0.002	<0.003	<0.002	0.011	0.041	<0.002	1.34	0.037
HB004	B	2025-01	0.118	<0.002	<0.003	<0.002	<0.004	0.022	<0.002	1.78	0.017
HB004	M	2025-01	0.059	<0.002	<0.003	<0.002	<0.004	0.007	<0.002	1.81	0.031

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
HB004	S	2025-01	0.073	<0.002	<0.003	<0.002	<0.004	0.083	<0.002	1.51	<0.002
HB007	B	2025-01	0.062	<0.002	<0.003	0.014	0.010	0.024	<0.002	1.92	0.055
HB007	M	2025-01	0.053	<0.002	<0.003	0.022	0.007	0.047	<0.002	1.83	0.077
HB007	S	2025-01	0.057	<0.002	<0.003	0.028	<0.004	0.013	<0.002	1.79	0.070
HB011	B	2025-01	0.034	<0.002	<0.003	0.002	<0.004	<0.005	<0.002	2.01	0.064
HB011	M	2025-01	0.065	<0.002	<0.003	0.003	<0.004	0.035	<0.002	1.85	0.044
HB011	S	2025-01	0.128	<0.002	<0.003	0.038	<0.004	0.016	<0.002	1.80	0.051
HB012	B	2025-01	0.062	<0.002	<0.003	0.023	<0.004	0.036	<0.002	1.95	0.071
HB012	M	2025-01	0.083	<0.002	<0.003	<0.002	<0.004	0.036	<0.002	1.85	0.028
HB012	S	2025-01	0.104	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.81	<0.002
HB013	B	2025-01	0.099	<0.002	<0.003	<0.002	0.011	0.011	<0.002	2.06	0.034
HB013	M	2025-01	0.027	<0.002	<0.003	<0.002	0.019	0.007	<0.002	1.84	<0.002
HB013	S	2025-01	0.076	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.72	0.011
HB014	B	2025-01	0.107	<0.002	<0.003	0.011	0.031	0.019	<0.002	1.96	0.043
HB014	M	2025-01	<0.006	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.84	0.069
HB014	S	2025-01	0.122	<0.002	<0.003	0.025	0.010	0.029	<0.002	1.77	0.043
HB015	B	2025-01	0.006	<0.002	<0.003	0.018	<0.004	0.011	<0.002	1.99	0.057
HB015	M	2025-01	0.045	<0.002	<0.003	<0.002	<0.004	<0.005	<0.002	1.86	0.075
HB015	S	2025-01	0.115	<0.002	<0.003	0.007	<0.004	0.025	<0.002	1.83	0.047
HB016	B	2025-01	0.080	<0.002	<0.003	0.030	<0.004	0.019	<0.002	1.90	0.057
HB016	M	2025-01	0.104	<0.002	<0.003	<0.002	0.012	0.017	<0.002	1.84	0.006
HB016	S	2025-01	0.100	<0.002	<0.003	<0.002	<0.004	0.042	<0.002	1.80	0.022
CF001	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CF001	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CF001	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CP001	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CP001	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
CP001	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB002	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB002	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB002	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB004	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB004	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	0.037
HB004	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB007	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB007	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB007	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	0.05

Site ID	Position	Month	Arsenic (As) (mg/L)	Cadmium (Cd) (mg/L)	Chromium (Cr) (mg/L)	Copper (Cu) (mg/L)	Lead (Pb) (mg/L)	Mercury (Hg) (mg/L)	Nickel (Ni) (mg/L)	Silicon (Si) (mg/L)	Zinc (Zn) (mg/L)
HB011	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB011	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB011	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB012	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB012	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB012	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB013	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB013	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB013	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB014	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB014	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB014	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB015	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB015	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB015	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB016	B	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB016	M	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03
HB016	S	2025-05	<0.025	<0.005	<0.015	<0.07	<0.05	<0.01	<0.02	<1	<0.03

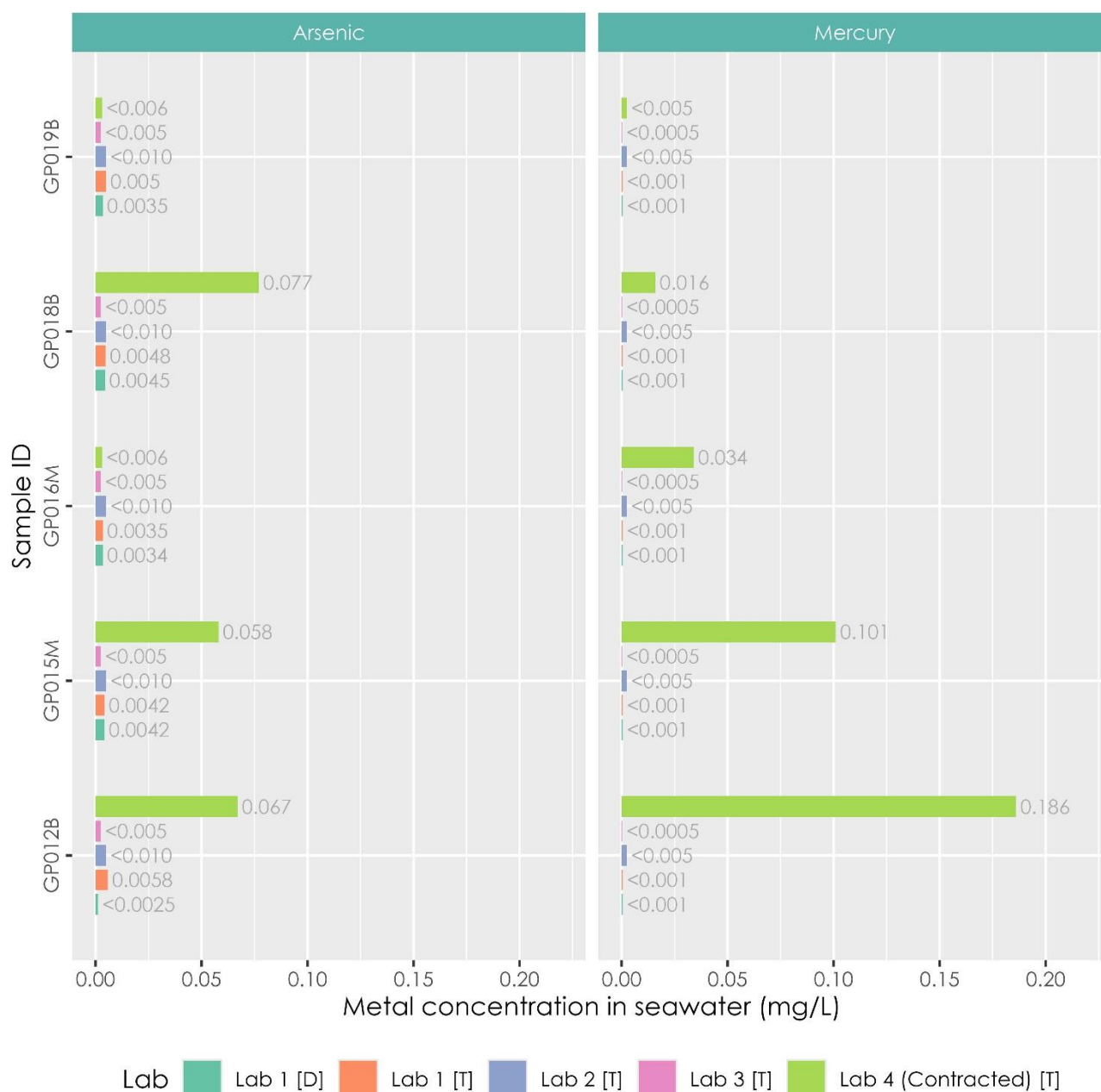


Figure 10 Results of a split-sampling trial to determine the reliability of analysis for metal concentrations in seawater from different analytical laboratories. Five samples collected on 19 February 2025 from the Green Point marine outfall were split and sent to four different analytical laboratories. The letters D and T in square brackets denote labs that filtered the seawater before testing to determine the concentration of dissolved metals (D) as compared to total metals (T) in the seawater sample. Lab 4 was the lab contracted by Infinity Environmental for the analysis of seawater metal concentrations in the marine outfall monitoring programme.

Table 22 Analytical laboratories included in the split sampling trial. Shown below are the method(s) implemented by each laboratory as well as the limit of detection of each laboratory for Mercury and Arsenic.

Laboratory	Method	Limit of detection
Lab 1	ICP-OES	0.0025 mg/L
Lab 2	ICP-OES	0.010 mg/L
Lab 3	ICP-MS	0.005 mg/L
Lab 4 (Contracted)	ICP-OES	0.006 mg/L

Water Quality Compliance Data

Allowable mixing zone							Reference	Dissolved oxygen mg/L
S -	8.14	8.11	7.94	8.03	8.23	7.92	7.77	
M -	7.51	7.68	7.25	7.35	7.24	7.42	7.09	
B -	6.96	7.15	6.13	6.5	5.99	6.74	6.21	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Salinity PSU
S -	35.43	35.55	35.64	35.62	35.53	35.45	35.34	
M -	35.3	35.35	35.26	35.21	35.29	35.38	35.11	
B -	35.02	35.04	35.06	34.99	34.9	35.05	34.98	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Temperature °C
S -	12.87	12.62	12.96	12.89	12.97	12.58	11.86	
M -	12.48	12.2	12.22	12.24	12.21	12.12	11.36	
B -	12.28	12	11.85	11.87	11.69	11.85	10.92	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Turbidity NTU
S -	3.04	1.45	1.27	0.92	0.64	1.71	0.66	
M -	2.03	1.67	0.28	0.67	0.17	0.81	0.31	
B -	2.42	1.34	0.44	0.65	0.55	0.41	0.22	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	pH
S -	7.87	7.86	7.91	7.91	7.91	7.89	7.78	
M -	7.9	7.83	7.84	7.85	7.87	7.84	7.73	
B -	7.82	7.82	7.79	7.8	7.77	7.8	7.7	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Total suspended solids mg/L
S -	25.25	24.44	14.1	15.52	26.08	12	16.77	
M -	25.58	32.96	17.33	20.33	30.44	17.02	17.29	
B -	27.75	19	18.79	16.75	18.33	16.19	22.56	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	

Figure 0-11 Annual mean values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Camps Bay marine outfall. The median is used for pH, while the mean is used for all other parameters.

Allowable mixing zone							Reference	Dissolved oxygen mg/L
S -	8.16	8.21	8.12	8.07	8.25	7.96	7.8	
M -	7.98	8.02	7.7	7.88	7.74	7.59	6.92	
B -	7.13	7.59	6.26	6.65	6.02	7	6.13	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Salinity PSU
S -	35.27	35.6	35.54	35.64	35.52	35.39	35.3	
M -	35.19	35.29	35.09	34.98	35.2	35.28	35.14	
B -	35.04	34.93	34.88	34.98	34.9	34.97	34.99	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Temperature °C
S -	13.2	12.82	13.14	12.86	13.11	12.75	11.1	
M -	12.62	12.12	12.25	12.17	12.04	12.53	10.48	
B -	12.24	11.69	11.18	11.44	11.17	11.68	10.12	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Total suspended solids mg/L
S -	15.5	15	10.5	11	14.5	10.5	16.5	
M -	16.5	16	13	13.5	16	15	17.5	
B -	16	17.5	15	11	13	14	17.5	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	Turbidity NTU
S -	0.06	0	0	0	0	0.18	0	
M -	0	0	0	0.01	0	0	0	
B -	0.18	0	0	0	0	0	0	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	
Allowable mixing zone							Reference	pH
S -	7.87	7.86	7.91	7.91	7.91	7.89	7.78	
M -	7.9	7.83	7.84	7.85	7.87	7.84	7.73	
B -	7.82	7.82	7.79	7.8	7.77	7.8	7.7	
	CB004	CB005	CB006	CB007	CB008	CB017	KB001	

Figure 0-12 Annual median values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Camps Bay marine outfall. The median is used for pH, while the mean is used for all other parameters.

Allowable mixing zone							Reference	Dissolved oxygen mg/L
S -	9.08	9.5	9.27	9.02	9.31	9.22	9.05	
M -	7.53	7.32	7.27	7.6	7.48	7.49	7.71	
B -	6.19	6.07	6.19	6.43	6.2	6.24	6.33	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Salinity PSU
S -	35.31	35.27	35.3	35.55	35.4	34.59	35.92	
M -	35.33	35.19	35.3	35.33	35.22	35.25	35.5	
B -	34.92	34.94	34.77	34.83	34.94	34.72	34.89	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Temperature °C
S -	13.24	13.4	13.4	13.56	13.55	13.5	13.49	
M -	12.11	12.01	11.95	12.07	12.12	12.08	12.44	
B -	11.38	11.42	11.6	11.59	11.51	11.69	11.87	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Turbidity NTU
S -	4.61	3.24	4.05	2.82	2.1	4.33	0.56	
M -	0.63	2.31	0.41	0.47	0.41	0.81	0.09	
B -	2.43	4	1.27	1.29	1.04	4.6	0.24	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	pH
S -	7.96	8.03	8.02	8.02	8.01	8.03	7.87	
M -	7.87	7.88	7.85	7.9	7.86	7.86	7.89	
B -	7.77	7.78	7.79	7.79	7.78	7.8	7.62	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Total suspended solids mg/L
S -	18.08	20.42	20.92	15.58	21.5	20.25	21.58	
M -	22.92	21.1	23.5	24.58	18.19	22.17	24.82	
B -	24.35	22.92	26.58	24.75	36.83	30.33	23.45	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	

Figure 0-13 Annual mean values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Green Point marine outfall. The median is used for pH, while the mean is used for all other parameters.

Allowable mixing zone							Reference	Dissolved oxygen mg/L
S -	8.66	8.86	8.52	8.58	8.6	8.7	8.73	
M -	7.41	7.42	7.28	7.43	7.39	7.43	7.96	
B -	6.24	5.72	5.72	6	5.78	6.06	6.35	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Salinity PSU
S -	35.62	35.64	35.66	35.77	35.75	35.43	35.82	
M -	35.14	35.04	35.13	35.18	35.08	35.11	35.59	
B -	34.92	34.87	34.73	34.79	34.91	34.64	35.05	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Temperature °C
S -	13.53	13.62	13.57	13.77	13.78	13.82	13.39	
M -	12.38	12.53	12.23	12.5	12.53	12.8	12.5	
B -	11.23	11.41	11.59	11.67	11.54	11.83	12.07	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Total suspended solids mg/L
S -	13	14.5	15.5	14	14	13.5	15	
M -	16	14	14	17	13	14.5	14	
B -	16.5	18.5	15.5	13	12.5	19.5	15	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	Turbidity NTU
S -	0.1	0.46	0	0	0.1	0.34	0	
M -	0	0.01	0	0.01	0	0	0	
B -	0.29	0.01	0.28	0.22	0	0.11	0	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	
Allowable mixing zone							Reference	pH
S -	7.96	8.03	8.02	8.02	8.01	8.03	7.87	
M -	7.87	7.88	7.85	7.9	7.86	7.86	7.89	
B -	7.77	7.78	7.79	7.79	7.78	7.8	7.62	
	GP011	GP012	GP013	GP014	GP015	GP017	RI001	

Figure 0-14 Annual median values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Green Point marine outfall. The median is used for pH, while the mean is used for all other parameters.

Allowable mixing zone							Reference		Dissolved oxygen mg/L
S -	8.31	8.53	8.42	8.32	8.54	8.43	7.88	7.78	
M -	7.57	7.06	7.26	7.03	7.49	7.07	6.98	6.96	
B -	6.64	6.27	6.33	5.91	6.29	6	6.27	6.22	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Salinity PSU
S -	35.89	35.59	35.72	35.77	35.42	35.79	35.54	35.47	
M -	34.98	35.27	35.36	35.17	35.18	35.35	35.53	35.22	
B -	34.92	34.91	34.87	34.8	34.79	34.81	35.14	34.93	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Temperature °C
S -	13	13.23	13.13	12.89	13.12	13	13.36	12.57	
M -	12.05	11.81	12.1	11.85	12.14	11.7	12.42	11.8	
B -	11.48	11.29	11.21	11.13	11.4	11.08	11.81	11.37	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Turbidity NTU
S -	0.29	0.44	0.25	0.47	0.39	0.24	0.29	1.35	
M -	0.4	0.57	0.18	0.27	0.35	0.3	0.27	1.03	
B -	0.6	1.03	0.5	2.12	0.24	0.36	0.74	0.44	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		pH
S -	7.85	7.86	7.84	7.85	7.86	7.85	7.82	7.82	
M -	7.82	7.81	7.8	7.81	7.82	7.8	7.76	7.8	
B -	7.8	7.8	7.78	7.66	7.68	7.75	7.68	7.74	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Total suspended solids mg/L
S -	21.19	27.1	23.08	25.75	25.67	27	21.35	25.85	
M -	23.85	26.58	23.88	25.08	24.83	19.75	17.58	23.17	
B -	26.25	27.25	23.25	26.33	21.94	26.92	29.42	28.02	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	

Figure 0-15 Annual mean values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Hout Bay marine outfall. The median is used for pH, while the mean is used for all other parameters.

Allowable mixing zone							Reference		Dissolved oxygen mg/L
S -	8.21	8.46	8.43	8.55	8.46	8.54	7.85	8	
M -	7.54	7.13	7.38	6.98	7.65	7.2	7.35	6.95	
B -	6.62	6.28	6.36	5.94	6.19	6.21	6.69	6.53	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Salinity PSU
S -	35.59	35.6	35.69	35.88	35.57	35.78	35.65	35.51	
M -	35.07	35.14	35.19	35.17	35.19	35.26	35.44	35.16	
B -	34.84	34.67	34.87	34.71	34.59	34.91	35.02	34.89	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Temperature °C
S -	13.23	13.25	13.27	13.29	13.15	13.19	13.52	12.97	
M -	12.13	11.84	12.6	11.9	12.04	11.82	12.7	11.82	
B -	10.9	10.98	10.86	10.73	11.11	10.88	12.07	11.01	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Total suspended solids mg/L
S -	14	19	14.5	16	14	14	13.5	17.5	
M -	15.5	14.5	14	15.5	13	14.5	14	18	
B -	17.5	13.5	16.5	16	14.5	17	12	18.5	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		Turbidity NTU
S -	0	0.01	0	0	0	0	0	0	
M -	0	0	0	0	0	0	0	0	
B -	0	0.1	0	0.26	0	0	0	0	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	
Allowable mixing zone							Reference		pH
S -	7.85	7.86	7.84	7.85	7.86	7.85	7.82	7.82	
M -	7.82	7.81	7.8	7.81	7.82	7.8	7.76	7.8	
B -	7.8	7.8	7.78	7.66	7.68	7.75	7.68	7.74	
	HB011	HB012	HB013	HB014	HB015	HB016	CF001	CP001	

Figure 0-16 Annual median values for five of the parameters required to be monitored by the Coastal Waters Discharge Permits for marine outfalls in Cape Town. Values are shown for sites on the edge of the mixing zone, as well as reference sites, for the Hout Bay marine outfall. The median is used for pH, while the mean is used for all other parameters.

APPENDIX III: MICROPLASTICS DATA TABLES AND SUPPLEMENTARY FIGURES

Table 1 Microplastic counts per L of seawater, sampled at the bottom (B), middle (M) and surface (S) of the water column near the Camps Bay marine outfall and the Karbonkelberg reference site. Counts shown are raw counts for September 2024 but adjusted for contamination for December 2024 and March 2025.

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Sept 2024	CB004	B	23.0	5.0	13.0	0.0	42.0	5.0	18.0	0.0	57.0	0.0	14.0	0	8.0	4.0	6.0	0
Sept 2024	CB004	M	115.0	12.0	48.0	0.0	38.0	9.0	18.0	3.0	15.0	11.0	5.0	0	137.0	2.0	8.0	0
Sept 2024	CB004	S	65.0	9.0	33.0	0.0	31.0	10.0	9.0	0.0	8.0	3.0	5.0	0	5.0	2.0	3.0	0
Sept 2024	CB005	B	96.0	1.0	6.0	0.0	140.0	4.0	20.0	0.0	43.0	10.0	2.0	0	64.0	0.0	4.0	0
Sept 2024	CB005	M	107.0	6.0	24.0	0.0	62.0	15.0	29.0	0.0	8.0	2.0	4.0	0	16.0	0.0	2.0	0
Sept 2024	CB005	S	114.0	15.0	33.0	0.0	22.0	6.0	8.0	0.0	0.0	1.0	3.0	0	0.0	0.0	0.0	0
Sept 2024	CB006	B	55.0	16.0	28.0	0.0	54.0	16.0	14.0	1.0	2.0	2.0	3.0	0	9.0	2.0	2.0	0
Sept 2024	CB006	M	48.0	18.0	26.0	6.0	36.0	4.0	11.0	0.0	9.0	1.0	1.0	0	0.0	0.0	0.0	0
Sept 2024	CB006	S	180.0	3.0	22.0	0.0	80.0	6.0	18.0	1.0	46.0	0.0	2.0	0	0.0	0.0	0.0	0
Sept 2024	CB007	B	249.0	8.0	46.0	1.0	197.0	9.0	30.0	0.0	28.0	0.0	3.0	0	0.0	0.0	0.0	0
Sept 2024	CB007	M	127.0	3.0	41.0	0.0	76.0	0.0	11.0	0.0	11.0	2.0	4.0	0	18.0	4.0	2.0	0
Sept 2024	CB007	S	80.0	0.0	3.0	0.0	125.0	0.0	6.0	0.0	18.0	1.0	9.0	0	3425.0	51.0	285.0	0
Sept 2024	KB001	B	135.0	0.0	5.0	2.0	144.0	3.0	2.0	1.0	335.0	7.0	5.0	0	38.0	0.0	11.0	0
Sept 2024	KB001	M	129.0	0.0	26.0	0.0	76.0	2.0	13.0	0.0	137.0	0.0	0.0	0	0.0	0.0	1.0	0
Sept 2024	KB001	S	98.0	12.0	25.0	0.0	56.0	16.0	27.0	11.0	19.0	0.0	0.0	0	26.0	0.0	0.0	0
Dec 2024	CB004	B	0.0	1.2	0.0	0.0	4.0	3.2	0.0	0.0	1.0	1.2	3.5	0	0.0	0.0	0.0	0
Dec 2024	CB004	M	14.0	1.2	3.5	0.0	26.0	2.2	3.5	0.0	21.0	0.2	0.0	0	0.0	0.0	2.5	0
Dec 2024	CB004	S	133.0	4.2	10.5	0.0	71.0	2.2	10.5	0.0	0.0	0.0	0.0	0	63.0	4.2	15.5	0
Dec 2024	CB005	B	5.0	0.0	4.5	0.0	10.0	0.0	3.5	0.0	0.0	0.0	0.5	0	0.0	0.0	0.0	0
Dec 2024	CB005	M	112.0	8.2	10.5	0.0	50.0	10.2	19.5	0.0	89.0	3.2	6.5	0	15.0	4.2	6.5	0
Dec 2024	CB005	S	6.0	1.2	5.5	0.0	0.0	2.2	2.5	1.0	0.0	0.0	1.5	0	0.0	0.0	0.0	0
Dec 2024	CB006	B	36.0	0.0	1.5	0.0	19.0	14.2	0.5	0.0	20.0	8.2	0.0	0	0.0	0.0	0.0	0
Dec 2024	CB006	M	25.0	1.2	9.5	0.0	2.0	2.2	3.5	1.0	0.0	1.2	0.0	0	-	-	-	-
Dec 2024	CB006	S	206.0	2.2	8.5	0.0	408.0	0.0	6.5	0.0	108.0	0.0	2.5	0	13.0	0.0	0.0	0
Dec 2024	CB007	B	52.0	1.2	5.5	1.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	CB007	M	40.0	5.2	21.5	0.0	26.0	14.2	6.5	0.0	5.0	1.2	5.5	0	0.0	0.0	0.0	0
Dec 2024	CB007	S	0.0	1.2	1.5	1.0	0.0	1.2	4.5	0.0	16.0	0.2	0.0	0	0.0	0.0	0.0	0
Dec 2024	KB001	B	24.0	8.2	11.5	0.0	0.0	1.2	6.5	0.0	0.0	1.2	2.5	0	0.0	0.0	0.0	0
Dec 2024	KB001	M	43.0	3.2	15.5	3.0	16.0	1.2	1.5	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	KB001	S	48.0	2.2	6.5	0.0	11.0	2.2	5.5	0.0	3.0	0.0	0.0	0	0.0	0.0	0.5	0
Mar 2025	CB004	B	33.9	0.4	10.1	0.0	28.9	1.4	8.1	0.0	35.9	8.4	1.1	0	0.0	1.4	2.1	0
Mar 2025	CB004	M	2.9	0.0	2.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	CB004	S	30.9	2.4	3.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.1	0
Mar 2025	CB005	B	37.9	1.4	0.0	0.0	19.9	1.4	0.1	0.0	5.9	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	CB005	M	24.9	0.4	0.0	0.0	1.9	4.4	0.0	0.0	91.9	3.4	4.1	0	11.9	0.0	0.0	0
Mar 2025	CB005	S	27.9	4.4	13.1	1.6	19.9	7.4	1.1	0.0	53.9	2.4	0.0	0	11.9	0.0	0.1	0
Mar 2025	CB006	B	7.9	1.4	3.1	0.0	10.9	0.4	5.1	0.0	0.9	0.4	1.1	0	0.0	0.0	0.1	0
Mar 2025	CB006	M	10.9	0.4	5.1	0.0	46.9	0.0	4.1	0.0	37.9	0.0	2.1	0	0.0	0.0	1.1	0
Mar 2025	CB006	S	25.9	3.4	0.0	0.0	16.9	1.4	0.0	0.0	10.9	1.4	0.0	0	0.9	0.0	0.0	0

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Mar 2025	CB007	B	10.9	0.4	2.1	0.6	8.9	0.0	0.1	0.0	0.0	2.4	1.1	0	0.0	0.0	0.1	0
Mar 2025	CB007	M	54.9	1.4	8.1	0.0	7.9	5.4	3.1	0.0	24.9	9.4	1.1	0	5.9	0.0	1.1	0
Mar 2025	CB007	S	40.9	0.0	0.0	0.0	2.9	1.4	0.1	0.0	17.9	0.4	0.0	0	4.9	1.4	0.0	0
Mar 2025	KB001	B	33.9	1.4	3.1	0.0	0.0	1.4	1.1	0.0	3.9	0.0	0.1	0	0.0	0.4	0.1	0
Mar 2025	KB001	M	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	1.1	0	0.0	0.0	1.1	0
Mar 2025	KB001	S	6.9	3.4	6.1	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0	0.0	0.0	0.1	0
Jun 2025	CB004	B	15.5	0.0	1.5	0.0	16.5	0.8	8.5	0.0	7.5	0.0	0.5	0	1.5	0.0	0.0	0
Jun 2025	CB004	M	3.5	0.0	0.0	0.0	134.5	2.8	1.5	0.0	0.0	0.0	0.0	0	3.5	0.0	0.0	0
Jun 2025	CB004	S	773.5	8.8	7.5	0.0	2737.5	5.8	0.0	0.0	16.5	0.0	7.5	0	0.0	0.0	0.0	0
Jun 2025	CB005	B	116.5	4.8	0.0	0.0	74.5	6.8	0.0	9.2	15.5	2.8	9.5	0	0.0	0.0	17.5	0
Jun 2025	CB005	M	10.5	0.0	0.0	0.0	3.5	0.0	6.5	0.0	19.5	0.0	0.5	0	0.0	0.0	3.5	0
Jun 2025	CB005	S	9.5	0.0	0.0	0.0	8.5	0.0	0.0	0.0	1.5	0.0	3.5	0	0.0	0.0	1.5	0
Jun 2025	CB006	B	6.5	0.8	0.0	0.0	22.5	0.0	0.5	0.0	2.5	2.8	3.5	0	0.0	0.0	0.5	0
Jun 2025	CB006	M	9.5	0.0	1.5	0.0	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CB006	S	24.5	0.0	1.5	0.0	81.5	2.8	1.5	0.0	42.5	0.8	0.5	0	12.5	0.0	0.0	0
Jun 2025	CB007	B	17.5	0.0	1.5	0.0	1.5	0.0	3.5	0.0	12.5	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CB007	M	19.5	0.0	3.5	0.0	5.5	2.8	6.5	0.0	4.5	0.0	0.5	0	0.0	0.0	0.0	0
Jun 2025	CB007	S	4.5	0.0	0.0	0.0	50.5	0.0	0.0	0.0	47.5	0.0	1.5	0	6.5	0.0	0.0	0
Jun 2025	KB001	B	18.5	0.0	3.5	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	KB001	M	46.5	2.8	5.5	0.0	19.5	0.8	3.5	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	KB001	S	22.5	0.0	0.5	0.0	83.5	0.0	0.5	0.0	61.5	0.0	0.0	0	7.5	0.0	0.0	0

Table 2 Microplastic counts per L of seawater, sampled at the bottom (B), middle (M) and surface (S) of the water column near the Green Point marine outfall and the Robben Island reference site. Counts shown are raw counts for September 2024 but adjusted for contamination for December 2024 and March 2025.

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Sept 2024	GP004	B	24.0	0.0	5.0	0	12.0	1.0	4.0	0	41.0	1.0	0.0	0	12.0	0.0	3.0	0
Sept 2024	GP004	M	58.0	8.0	24.0	2	32.0	46.0	12.0	0	18.0	4.0	5.0	0	0.0	0.0	0.0	0
Sept 2024	GP004	S	53.0	0.0	5.0	2	37.0	0.0	3.0	0	117.0	0.0	2.0	0	17.0	0.0	0.0	0
Sept 2024	GP011	B	29.0	15.0	23.0	2	27.0	10.0	14.0	12	47.0	7.0	9.0	0	18.0	0.0	2.0	0
Sept 2024	GP011	M	33.0	0.0	2.0	1	46.0	3.0	5.0	0	29.0	1.0	17.0	0	10.0	0.0	2.0	0
Sept 2024	GP011	S	64.0	2.0	18.0	0	10.0	0.0	0.0	0	16.0	0.0	3.0	0	5.0	1.0	0.0	0
Sept 2024	GP012	B	67.0	0.0	22.0	2	143.0	2.0	22.0	0	7.0	0.0	1.0	0	3.0	0.0	0.0	0
Sept 2024	GP012	M	22.0	0.0	21.0	0	56.0	0.0	5.0	0	9.0	2.0	2.0	0	9.0	1.0	5.0	0
Sept 2024	GP012	S	49.0	1.0	11.0	0	15.0	3.0	11.0	3	10.0	0.0	4.0	1	12.0	0.0	10.0	0
Sept 2024	GP013	B	30.0	0.0	0.0	0	5.0	11.0	1.0	0	159.0	36.0	2.0	0	0.0	0.0	0.0	0
Sept 2024	GP013	M	38.0	2.0	8.0	0	94.0	6.0	9.0	0	8.0	0.0	1.0	0	13.0	0.0	5.0	0
Sept 2024	GP013	S	128.0	8.0	21.0	0	22.0	8.0	13.0	9	3.0	0.0	1.0	0	11.0	0.0	5.0	0
Sept 2024	GP014	B	83.0	1.0	5.0	0	164.0	0.0	7.0	1	71.0	2.0	3.0	0	64.0	0.0	4.0	0
Sept 2024	GP014	M	89.0	6.0	18.0	1	163.0	5.0	13.0	0	69.0	6.0	11.0	0	219.0	0.0	27.0	0

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Sept 2024	GP014	S	141.0	0.0	4.0	1	97.0	0.0	1.0	0	50.0	0.0	3.0	0	18.0	0.0	4.0	0
Sept 2024	GP018	B	37.0	0.0	8.0	0	65.0	0.0	14.0	0	14.0	0.0	2.0	0	19.0	1.0	6.0	0
Sept 2024	GP018	M	94.0	0.0	9.0	0	37.0	0.0	8.0	0	6.0	0.0	2.0	0	14.0	0.0	3.0	0
Sept 2024	GP018	S	325.0	4.0	13.0	0	188.0	2.0	6.0	0	63.0	2.0	1.0	0	14.0	0.0	0.0	0
Sept 2024	GP019	B	5.0	0.0	20.0	0	65.0	5.0	16.0	0	26.0	0.0	2.0	0	11.0	1.0	4.0	0
Sept 2024	GP019	M	48.0	2.0	8.0	0	100.0	2.0	14.0	0	14.0	0.0	4.0	0	20.0	2.0	4.0	0
Sept 2024	GP019	S	80.0	0.0	14.0	0	110.0	0.0	5.0	0	22.0	4.0	3.0	0	23.0	0.0	0.0	0
Sept 2024	RI001	B	71.0	13.0	11.0	8	58.0	8.0	10.0	6	38.0	3.0	4.0	0	35.0	0.0	4.0	0
Sept 2024	RI001	M	211.0	2.0	16.0	0	203.0	1.0	8.0	0	125.0	0.0	12.0	0	55.0	0.0	1.0	0
Sept 2024	RI001	S	152.0	2.0	23.0	3	16.0	0.0	21.0	4	8.0	0.0	4.0	0	8.0	2.0	7.0	0
Dec 2024	GP011	B	105.0	3.5	0.0	0	50.0	0.0	0.0	0	1.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP011	M	23.0	0.5	0.5	0	35.0	0.5	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP011	S	0.0	0.0	0.0	0	329.0	0.5	5.5	2	146.0	1.5	10.5	0	0.0	0.0	0.0	0
Dec 2024	GP012	B	0.0	3.5	7.5	0	285.0	46.5	45.5	2	0.0	3.5	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP012	M	3.0	0.0	0.0	0	2.0	2.5	1.5	0	0.0	0.0	0.0	0	0.0	0.5	0.0	0
Dec 2024	GP012	S	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP013	B	133.0	3.5	0.5	0	182.0	3.5	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP013	M	10.0	0.0	0.0	0	169.0	4.5	0.5	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP013	S	23.0	0.0	11.5	0	40.0	3.5	0.0	1	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP014	B	270.0	0.0	0.0	0	227.0	2.5	1.5	0	0.0	5.5	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP014	M	15.0	0.5	0.0	0	96.0	3.5	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	GP014	S	11.0	0.0	0.0	0	0.0	0.5	0.0	0	0.0	1.5	0.0	1	0.0	0.0	0.0	0
Dec 2024	GP018	B	0.0	0.5	0.0	0	0.0	0.5	0.0	0	0.0	0.0	0.0	0	-	-	-	-
Dec 2024	GP018	M	16.0	0.5	0.0	0	31.0	1.5	0.0	0	31.0	2.5	1.5	0	0.0	2.5	0.0	0
Dec 2024	GP018	S	34.0	7.5	12.5	3	0.0	1.5	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	RI001	M	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.5	0.5	0	0.0	0.0	0.0	0
Dec 2024	RI001	S	59.0	0.5	1.5	0	5.0	0.5	0.0	0	0.0	0.0	0.0	0	0.0	0.5	0.0	0
Mar 2025	GP004	B	24.6	0.6	1.8	0	26.6	0.6	2.8	0	7.6	6.6	0.0	0	0.6	0.0	0.0	0
Mar 2025	GP004	M	11.6	0.0	2.8	0	0.0	0.6	2.8	0	0.0	0.0	0.8	0	0.0	0.0	0.0	0
Mar 2025	GP004	S	27.6	0.0	4.8	0	1.6	0.0	2.8	0	5.6	0.0	0.8	0	0.0	0.0	0.0	0
Mar 2025	GP011	B	2.6	0.6	0.0	0	112.6	1.6	4.8	0	8.6	0.6	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP011	M	27.6	0.0	0.8	0	9.6	0.6	1.8	0	20.6	0.6	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP011	S	28.6	1.6	4.8	0	109.6	1.6	0.0	0	3.6	0.6	1.8	0	0.0	0.0	0.0	0
Mar 2025	GP012	B	5.6	0.0	2.8	0	1.6	1.6	0.0	0	0.0	0.6	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP012	M	24.6	0.0	9.8	0	0.0	0.0	3.8	0	0.0	0.0	0.0	0	1.6	0.0	0.8	0
Mar 2025	GP012	S	25.6	0.0	1.8	0	12.6	0.0	0.8	0	19.6	3.6	0.0	0	0.0	0.0	1.8	0
Mar 2025	GP013	B	11.6	3.6	0.8	0	31.6	2.6	4.8	0	0.0	0.6	0.0	0	7.6	0.0	0.0	0
Mar 2025	GP013	M	154.6	0.0	14.8	2	108.6	5.6	0.8	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP013	S	17.6	0.0	1.8	0	0.0	1.6	0.0	0	7.6	1.6	0.0	0	0.0	3.6	0.0	0
Mar 2025	GP014	B	10.6	0.0	2.8	0	13.6	3.6	0.0	0	30.6	1.6	0.0	0	3.6	0.0	0.0	0
Mar 2025	GP014	M	1735.6	1.6	5.8	0	7985.6	0.0	0.8	0	2785.6	0.6	2.8	0	335.6	5.6	0.0	0
Mar 2025	GP014	S	23.6	1.6	0.0	0	26.6	3.6	0.0	0	13.6	0.0	0.0	0	0.0	0.0	0.0	0

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Mar 2025	GP018	B	23.6	0.0	0.0	0	4.6	6.6	0.0	0	20.6	1.6	0.0	0	5.6	0.0	0.0	0
Mar 2025	GP018	M	16.6	0.6	0.0	0	27.6	2.6	3.8	0	14.6	0.0	1.8	0	37.6	0.0	0.0	0
Mar 2025	GP018	S	13.6	0.0	0.8	0	14.6	0.0	1.8	0	285.6	1.6	0.0	0	0.0	0.0	0.8	0
Mar 2025	GP019	B	32.6	0.0	1.8	0	6.6	0.0	3.8	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP019	M	7.6	0.0	0.0	0	3.6	0.0	0.0	0	5.6	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	GP019	S	49.6	0.0	0.8	0	0.0	0.0	0.0	0	0.0	0.0	0.8	0	0.0	0.0	0.0	0
Mar 2025	RI001	B	6.6	0.0	0.8	0	0.0	3.6	0.8	0	8.6	0.0	2.8	0	0.0	0.0	0.8	0
Mar 2025	RI001	M	30.6	0.0	1.8	0	11.6	0.6	0.8	0	2.6	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	RI001	S	10.6	0.0	0.0	0	1.6	0.6	0.0	0	4.6	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	GP004	B	114.2	4.0	6.0	0	64.2	5.0	10.0	0	7.2	4.0	4.0	0	7.2	1.0	2.0	0
Jun 2025	GP004	M	32.2	4.0	0.0	0	47.2	5.0	10.0	0	22.2	4.0	0.0	0	0.0	1.0	0.0	0
Jun 2025	GP004	S	16.2	0.0	1.0	0	54.2	7.0	12.0	0	8.2	0.0	0.0	0	5.2	0.0	1.0	0
Jun 2025	GP011	B	60.2	0.0	0.0	0	38.2	0.0	2.0	0	10.2	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	GP011	M	46.2	1.0	3.0	0	36.2	0.0	0.0	0	23.2	0.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	GP011	S	50.2	1.0	5.0	0	32.2	1.0	14.0	0	7.2	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	GP012	B	197.2	0.0	3.0	0	134.2	0.0	6.0	0	28.2	0.0	0.0	0	5.2	0.0	0.0	0
Jun 2025	GP012	M	71.2	0.0	3.0	0	84.2	2.0	6.0	0	3.2	0.0	2.0	0	0.2	0.0	0.0	0
Jun 2025	GP012	S	114.2	1.0	4.0	1	79.2	0.0	2.0	0	9.2	1.0	2.0	0	0.0	0.0	1.0	0
Jun 2025	GP013	B	149.2	0.0	0.0	0	127.2	0.0	2.0	0	18.2	0.0	0.0	0	0.0	0.0	1.0	0
Jun 2025	GP013	M	69.2	2.0	4.0	1	77.2	3.0	3.0	0	4.2	2.0	2.0	0	0.0	0.0	0.0	0
Jun 2025	GP013	S	36.2	1.0	3.0	0	79.2	0.0	13.0	0	20.2	0.0	0.0	0	993.2	0.0	1.0	0
Jun 2025	GP014	B	277.2	0.0	0.0	0	45.2	1.0	2.0	0	9.2	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	GP014	M	277.2	5.0	1.0	0	45.2	0.0	4.0	0	9.2	2.0	3.0	0	0.0	0.0	2.0	0
Jun 2025	GP014	S	0.0	0.0	84.0	0	0.0	0.0	108.0	0	0.0	0.0	8.0	0	0.0	0.0	0.0	0
Jun 2025	GP018	B	74.2	7.0	0.0	0	38.2	9.0	0.0	0	26.2	12.0	0.0	0	0.2	0.0	0.0	0
Jun 2025	GP018	M	31.2	0.0	0.0	0	30.2	0.0	0.0	0	9.2	0.0	1.0	0	9.2	0.0	0.0	0
Jun 2025	GP018	S	34.2	0.0	4.0	0	35.2	0.0	0.0	0	7.2	0.0	3.0	0	0.2	0.0	0.0	0
Jun 2025	GP019	B	49.2	0.0	1.0	0	39.2	0.0	0.0	0	15.2	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	GP019	M	105.2	2.0	4.0	0	49.2	0.0	3.0	0	0.2	1.0	2.0	0	0.0	0.0	1.0	0
Jun 2025	GP019	S	65.2	0.0	0.0	0	66.2	0.0	0.0	0	0.2	0.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	RI001	B	21.2	0.0	6.0	0	30.2	1.0	7.0	0	8.2	1.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	RI001	M	127.2	1.0	3.0	0	47.2	0.0	0.0	0	5.2	0.0	2.0	0	0.0	0.0	0.0	0
Jun 2025	RI001	S	36.2	0.0	6.0	0	75.2	0.0	2.0	0	4.2	1.0	2.0	0	0.0	0.0	0.0	0

Table 3 Microplastic counts per L of seawater, sampled at the bottom (B), middle (M) and surface (S) of the water column near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Counts shown are raw counts for September 2024 but adjusted for contamination for December 2024 and March 2025.

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Sept 2024	CF001	B	102.0	0.0	3.0	0	33.0	3.0	0.0	0	-	-	-	-	85.0	0.0	4.0	0

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Sept 2024	CF001	M	419.0	0.0	4.0	0	9.0	22.0	14.0	0	-	-	-	-	1.0	0.0	0.0	0
Sept 2024	CF001	S	25.0	0.0	2.0	0	31.0	1.0	7.0	0	-	-	-	-	12.0	0.0	4.0	0
Sept 2024	CP001	B	57.0	0.0	3.0	0	20.0	2.0	6.0	0	-	-	-	-	5.0	0.0	0.0	0
Sept 2024	CP001	M	34.0	0.0	4.0	0	32.0	6.0	7.0	0	-	-	-	-	28.0	0.0	1.0	0
Sept 2024	CP001	S	44.0	0.0	0.0	0	20.0	16.0	35.0	0	-	-	-	-	0.0	0.0	0.0	0
Sept 2024	HB005	B	85.0	2.0	7.0	0	108.0	5.0	15.0	0	-	-	-	-	0.0	0.0	0.0	0
Sept 2024	HB005	M	101.0	0.0	5.0	0	52.0	0.0	9.0	0	23.0	0.0	4.0	0	3.0	0.0	0.0	0
Sept 2024	HB005	S	40.0	0.0	6.0	0	22.0	0.0	4.0	0	9.0	0.0	1.0	0	4.0	0.0	1.0	0
Sept 2024	HB012	B	228.0	9.0	39.0	2	155.0	6.0	18.0	2	37.0	0.0	9.0	0	17.0	1.0	3.0	0
Sept 2024	HB012	M	47.0	0.0	6.0	0	35.0	0.0	6.0	0	67.0	0.0	3.0	0	4.0	0.0	3.0	0
Sept 2024	HB012	S	165.0	1.0	16.0	0	21.0	1.0	7.0	0	31.0	0.0	3.0	0	8.0	0.0	1.0	0
Sept 2024	HB013	B	149.0	0.0	28.0	0	451.0	10.0	42.0	6	-	-	-	-	12.0	2.0	4.0	0
Sept 2024	HB013	M	31.0	0.0	2.0	0	34.0	1.0	4.0	0	-	-	-	-	4.0	0.0	2.0	0
Sept 2024	HB013	S	66.0	4.0	6.0	3	71.0	0.0	3.0	0	-	-	-	-	0.0	0.0	0.0	0
Sept 2024	HB015	B	69.0	0.0	5.0	0	33.0	1.0	8.0	0	16.0	0.0	3.0	0	2.0	0.0	4.0	0
Sept 2024	HB015	M	65.0	0.0	7.0	0	82.0	0.0	6.0	0	33.0	0.0	4.0	0	35.0	0.0	3.0	0
Sept 2024	HB015	S	42.0	0.0	8.0	0	20.0	0.0	6.0	0	1.0	0.0	1.0	0	3.0	0.0	1.0	0
Sept 2024	HB016	B	231.0	0.0	29.0	0	61.0	4.0	13.0	0	48.0	0.0	0.0	0	0.0	0.0	0.0	0
Sept 2024	HB016	M	252.0	12.0	33.0	0	775.0	13.0	15.0	0	139.0	4.0	20.0	0	97.0	7.0	23.0	0
Sept 2024	HB016	S	93.0	1.0	10.0	0	90.0	2.0	5.0	0	43.0	0.0	0.0	0	5.0	0.0	0.0	0
Dec 2024	CF001	B	46.2	2.0	2.8	2	22.2	8.0	3.8	0	7.2	0.0	0.0	0	0.0	1.0	0.0	0
Dec 2024	CF001	M	17.2	2.0	6.8	0	25.2	2.0	5.8	0	6.2	0.0	5.8	0	0.0	0.0	0.0	0
Dec 2024	CF001	S	46.2	5.0	11.8	0	21.2	2.0	2.8	0	0.0	0.0	1.8	0	0.0	0.0	2.8	0
Dec 2024	CP001	B	27.2	2.0	1.8	1	32.2	0.0	3.8	0	4.2	0.0	1.8	0	0.0	0.0	0.0	0
Dec 2024	CP001	M	62.2	4.0	4.8	0	90.2	21.0	13.8	4	46.2	18.0	8.8	0	0.0	0.0	0.0	0
Dec 2024	CP001	S	21.2	2.0	2.8	0	0.0	2.0	4.8	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	HB005	B	0.0	0.0	0.0	0	0.0	1.0	0.0	0	8.2	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	HB005	M	45.2	5.0	13.8	1	24.2	4.0	10.8	0	5.2	0.0	2.8	0	0.0	0.0	0.8	0
Dec 2024	HB005	S	10.2	16.0	44.8	0	3.2	52.0	12.8	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	HB012	B	51.2	2.0	4.8	1	62.2	3.0	7.8	0	0.2	0.0	0.0	0	6.2	1.0	1.8	0
Dec 2024	HB012	M	19.2	0.0	16.8	0	44.2	7.0	11.8	0	5.2	3.0	2.8	0	0.0	0.0	0.0	0
Dec 2024	HB012	S	102.2	8.0	34.8	0	49.2	11.0	19.8	2	0.0	2.0	0.0	0	0.0	0.0	0.0	0
Dec 2024	HB013	B	50.2	2.0	4.8	2	50.2	0.0	1.8	0	0.2	0.0	0.8	0	0.0	0.0	0.0	0
Dec 2024	HB013	M	70.2	2.0	3.8	0	5.2	0.0	3.8	0	0.0	0.0	2.8	0	0.0	0.0	0.0	0
Dec 2024	HB013	S	71.2	0.0	11.8	2	31.2	13.0	4.8	4	0.0	3.0	1.8	0	0.0	2.0	0.0	0
Dec 2024	HB015	B	22.2	2.0	0.0	0	28.2	6.0	0.8	1	26.2	8.0	5.8	0	0.0	0.0	0.0	0
Dec 2024	HB015	M	97.2	1.0	0.8	0	59.2	4.0	3.8	0	0.0	0.0	6.8	0	3.2	0.0	0.0	0
Dec 2024	HB015	S	24.2	27.0	44.8	6	16.2	1.0	0.0	0	35.2	0.0	1.8	0	0.0	1.0	0.8	0
Dec 2024	HB016	B	10.2	0.0	0.0	9	34.2	1.0	0.0	4	63.2	2.0	3.8	0	0.0	0.0	0.0	0
Dec 2024	HB016	M	127.2	1.0	8.8	0	100.2	0.0	6.8	0	0.0	0.0	0.8	0	0.0	0.0	0.0	0
Dec 2024	HB016	S	18.2	1.0	0.0	0	51.2	3.0	6.8	0	115.2	1.0	0.0	0	5.2	1.0	0.0	0
Mar 2025	CF001	B	0.0	0.0	1.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	1.8	0.0	0

Month	Site ID	Position	50 µm				100 µm				500 µm				1000 µm			
			Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules	Fibres	Film	Fragments	Nodules
Mar 2025	CF001	M	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.8	0.0	0	0.0	0.0	0.0	0
Mar 2025	CF001	S	92.2	2.8	1.2	0	21.2	3.8	0.0	0	0.0	1.8	0.0	0	0.0	0.0	0.0	0
Mar 2025	CP001	B	6.2	0.0	0.0	0	0.0	1.8	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	CP001	M	0.0	4.8	1.2	0	0.0	1.8	0.0	0	0.0	1.8	0.0	0	0.0	0.0	0.0	0
Mar 2025	CP001	S	0.2	1.8	3.2	0	0.0	0.0	1.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB005	B	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB005	M	0.0	1.8	0.0	0	0.0	1.8	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB005	S	10.2	6.8	0.0	0	1.2	0.8	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB012	B	0.0	0.0	0.2	0	7963.2	0.0	0.0	0	0.0	0.0	0.0	0	963.2	0.0	0.0	0
Mar 2025	HB012	M	4.2	0.0	0.0	0	0.0	0.0	3.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB012	S	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB013	B	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB013	M	0.0	1.8	0.0	0	2.2	0.0	2.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB013	S	10.2	0.0	0.0	0	0.0	0.0	1.2	0	0.0	0.8	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB015	B	11.2	0.8	0.0	0	0.2	1.8	5.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB015	M	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	1.8	0.0	0
Mar 2025	HB015	S	83.2	3.8	15.2	0	0.0	3.8	9.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB016	B	0.2	0.0	0.0	0	0.0	0.0	0.0	0	0.0	1.8	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB016	M	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Mar 2025	HB016	S	4.2	0.0	1.2	0	0.0	0.8	1.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CF001	B	20.5	0.0	0.0	0	33.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CF001	M	25.5	0.0	0.0	0	26.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CF001	S	55.5	2.0	14.0	0	5.5	0.0	2.0	0	0.0	4.0	4.0	0	0.0	0.0	0.0	0
Jun 2025	CP001	B	42.5	0.0	0.0	0	39.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CP001	M	73.5	0.0	0.0	0	25.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	CP001	S	16.5	3.0	7.0	0	4.5	0.0	1.0	0	7.5	0.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	HB005	B	157.5	0.0	3.0	0	102.5	2.0	23.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB005	M	43.5	0.0	2.0	0	30.5	0.0	2.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB005	S	36.5	0.0	3.0	0	14.5	0.0	2.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB012	B	26.5	3.0	2.0	0	9.5	0.0	2.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB012	M	22.5	0.0	0.0	0	149.5	0.0	2.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB012	S	23.5	0.0	0.0	0	12.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB013	B	49.5	0.0	0.0	0	48.5	0.0	0.0	0	3.5	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB013	M	87.5	0.0	0.0	0	42.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB013	S	40.5	2.0	16.0	0	8.5	0.0	4.0	0	0.0	0.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	HB015	B	130.5	0.0	1.0	0	48.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB015	M	59.5	0.0	0.0	0	73.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB015	S	35.5	0.0	4.0	0	5.5	0.0	1.0	0	0.0	0.0	1.0	0	0.0	0.0	0.0	0
Jun 2025	HB016	B	152.5	0.0	2.0	0	139.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB016	M	14.5	0.0	11.0	0	2.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Jun 2025	HB016	S	35.5	0.0	0.0	0	41.5	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0

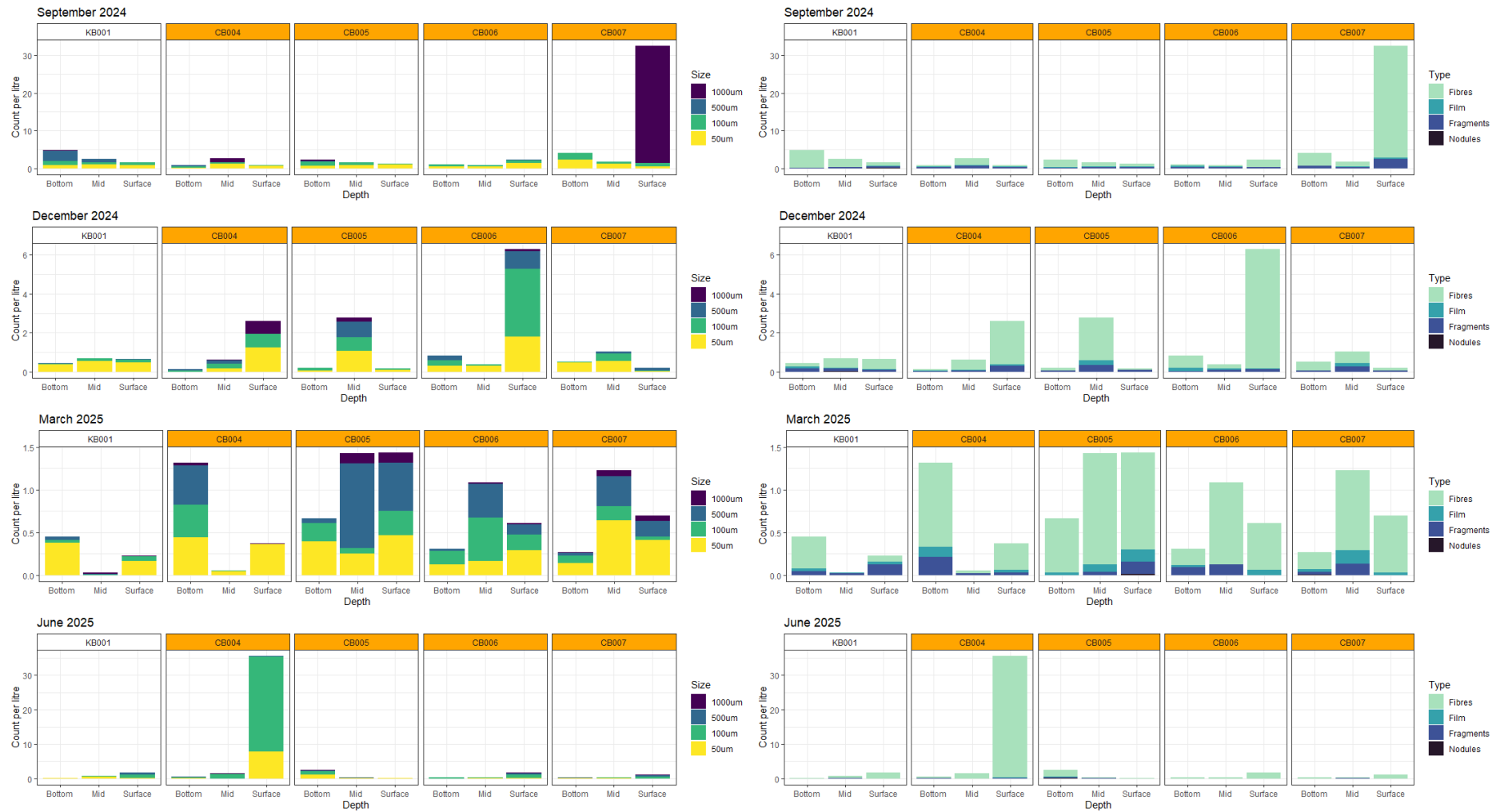


Figure 1. Camps Bay microplastic results from the 2024/2025 sampling period with unrestricted axes. The AMZ sites are shown in the orange panels, with the reference sites shown in white.



Figure 2. Greenpoint microplastic results from the 2024/2025 sampling period with unrestricted axes. The AMZ sites are shown in the orange panels, with the reference sites shown in white, and sites near other potential sources of contamination are shown in grey (GP004 – stormwater outfalls at Three Anchor Bay, GP018 and GP019 – near the Diep and Salt River outlets). RI001 Bottom, GP004 and GP019 were not sampled in December due to adverse weather conditions.



Figure 3. Hout Bay microplastics results from the 2024/2025 sampling period with unrestricted axes. The AMZ sites are shown in the orange panels, with the reference sites shown in white, and sites near other potential sources of contamination are shown in grey (HB005 – Disa River).

APPENDIX IV: SEDIMENT DATA TABLES

Table 1 Results of sediment chemistry analyses from sediment samples collected at sites near the Camps Bay marine outfall and the Karbonkelberg reference site. Replicate samples are indicated by the letters A, B and C. Sediment samples were collected in February 2025.

Parameter	Unit	Method	Detection Limit	CB006	CB015	CB017	CB018	CB019	CB022	CB023	KB001		
				A	A	A	A	A	A	A	A	B	C
EPH >C10-C12	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
EPH >C12-C16	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
EPH >C16-C21	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
EPH >C21-C35	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
EPH >C35-C40	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
EPH >C8-C10	mg/kg	TM5/PM8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EPH >C8-C40	mg/kg	TM5/PM8	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Natural Moisture Content	%	PM4/PM0	<0.1	18.1	24	24.5	27.1	25.6	29.3	51.9	28	25.1	31.5
Acenaphthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Anthracene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(a)anthracene	mg/kg	TM4/PM8	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(b)fluoranthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(bk)fluoranthene	mg/kg	TM4/PM8	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Benzo(ghi)perylene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(k)fluoranthene	mg/kg	TM4/PM8	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	mg/kg	TM4/PM8	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dibenzo(ah)anthracene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Fluoranthene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Fluorene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Indeno(123cd)pyrene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Naphthalene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
PAH 16 Total	mg/kg	TM4/PM8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
PAH Surrogate % Recovery	%	TM4/PM8	<0	106	109	106	108	108	107	97	107	106	107
Phenanthrene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Pyrene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total Phenols HPLC	mg/kg	TM26/PM21B	<0.15	<0.30	<0.15	<0.15	<0.15	<0.15	<0.15	1.34	<0.15	<0.15	<0.15
Total Organic Carbon	%	TM21/PM24	<0.02	0.04	0.02	<0.02	<0.02	<0.02	0.07	0.37	0.06	0.04	0.06
1,1,1,2-Tetrachloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,1,1-Trichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,1,2,2-Tetrachloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,1,2-Trichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,1-Dichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,1-Dichloroethene (1,1 DCE)	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
1,1-Dichloropropene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,2,3-Trichlorobenzene	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
1,2,3-Trichloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
1,2,4-Trichlorobenzene	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
1,2,4-Trimethylbenzene	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
1,2-Dibromo-3-chloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
1,2-Dibromoethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,2-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
1,2-Dichloroethane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4

Parameter	Unit	Method	Detection Limit	CB006	CB015	CB017	CB018	CB019	CB022	CB023	KB001		
				A	A	A	A	A	A	A	A	B	C
1,2-Dichloropropane	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
1,3,5-Trimethylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,3-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
1,3-Dichloropropane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
1,4-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
2,2-Dichloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
2-Chlorotoluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
4-Chlorotoluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
4-Isopropyltoluene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Bromobenzene	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Bromochloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Bromodichloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Bromoform	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Bromomethane	µg/kg	TM15/PM10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbon tetrachloride	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Chlorobenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chloroethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chloroform	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
cis-1-2-Dichloroethene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
cis-1-3-Dichloropropene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Dibromochloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dibromomethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dichlorodifluoromethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dichloromethane (DCM)	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Hexachlorobutadiene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Isopropylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Methyl Tertiary Butyl Ether	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
m/p-Xylene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Naphthalene	µg/kg	TM15/PM10	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27
n-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
o-Xylene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Propylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
sec-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Styrene	µg/kg	TM15_A/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Surrogate Recovery 4-Bromofluorobenzene	%	TM15/PM10	<0	102	100	105	103	103	102	106	104	102	104
Surrogate Recovery Toluene D8	%	TM15/PM10	<0	83	81	84	82	82	82	79	83	82	83
tert-Butylbenzene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene (PCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Toluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
trans-1-2-Dichloroethene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
trans-1-3-Dichloropropene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Trichloroethene (TCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Trichlorofluoromethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Vinyl Chloride	µg/kg	TM15_A/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Table 2 Results of sediment chemistry analyses from sediment samples collected at sites near the Green Point marine outfall and the Robben Island reference site. Replicate samples are indicated by the letters A, B and C. Sediment samples were collected in February 2025.

Parameter	Unit	Method	Detection Limit	GP020	GP028	GP029	RI001		
				A	A	A	A	B	C
EPH >C10-C12	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10
EPH >C12-C16	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10
EPH >C16-C21	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10
EPH >C21-C35	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10
EPH >C35-C40	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10
EPH >C8-C10	mg/kg	TM5/PM8	<5	<5	<5	<5	<5	<5	<5
EPH >C8-C40	mg/kg	TM5/PM8	<30	<30	<30	<30	<30	<30	<30
Natural Moisture Content	%	PM4/PM0	<0.1	32.4	33.6	20.3	29.3	42.5	28.3
Acenaphthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Anthracene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(a)anthracene	mg/kg	TM4/PM8	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(b)fluoranthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(bk)fluoranthene	mg/kg	TM4/PM8	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Benzo(ghi)perylene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(k)fluoranthene	mg/kg	TM4/PM8	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	mg/kg	TM4/PM8	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dibenzo(ah)anthracene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Fluoranthene	mg/kg	TM4/PM8	<0.03	0.04	<0.03	<0.03	<0.03	<0.03	<0.03
Fluorene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Indeno(123cd)pyrene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Naphthalene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
PAH 16 Total	mg/kg	TM4/PM8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
PAH Surrogate % Recovery	%	TM4/PM8	<0	94	105	105	96	100	92
Phenanthrene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Pyrene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total Phenols HPLC	mg/kg	TM26/PM21B	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Total Organic Carbon	%	TM21/PM24	<0.02	0.06	0.2	0.02	0.06	0.05	0.09
1,1,1,2-Tetrachloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,1,1-Trichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,1,2,2-Tetrachloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,1,2-Trichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,1-Dichloroethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,1-Dichloroethene (1,1 DCE)	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6
1,1-Dichloropropene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,2,3-Trichlorobenzene	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7
1,2,3-Trichloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
1,2,4-Trichlorobenzene	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7
1,2,4-Trimethylbenzene	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6
1,2-Dibromo-3-chloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
1,2-Dibromoethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,2-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
1,2-Dichloroethane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
1,2-Dichloropropane	µg/kg	TM15/PM10	<6	<6	<6	<6	<6	<6	<6

Parameter	Unit	Method	Detection Limit	GP020	GP028	GP029	RI001		
				A	A	A	A	B	C
1,3,5-Trimethylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,3-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
1,3-Dichloropropane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
1,4-Dichlorobenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
2,2-Dichloropropane	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
2-Chlorotoluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
4-Chlorotoluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
4-Isopropyltoluene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
Benzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Bromobenzene	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2
Bromochloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Bromodichloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Bromoform	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Bromomethane	µg/kg	TM15/PM10	<1	<1	<1	<1	<1	<1	<1
Carbon tetrachloride	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
Chlorobenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Chloroethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2
Chloroform	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Chloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
cis-1-2-Dichloroethene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
cis-1-3-Dichloropropene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
Dibromochloromethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Dibromomethane	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Dichlorodifluoromethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2
Dichloromethane (DCM)	µg/kg	TM15/PM10	<7	<7	<7	<7	<7	<7	<7
Ethylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Hexachlorobutadiene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
Isopropylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Methyl Tertiary Butyl Ether	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2
m/p-Xylene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5
Naphthalene	µg/kg	TM15/PM10	<27	<27	<27	<27	<27	<27	<27
n-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
o-Xylene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Propylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
sec-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4
Styrene	µg/kg	TM15_A/PM10	<3	4	<3	<3	<3	4	5
Surrogate Recovery 4-Bromofluorobenzene	%	TM15/PM10	<0	100	102	103	102	101	119
Surrogate Recovery Toluene D8	%	TM15/PM10	<0	66	83	85	70	73	81
tert-Butylbenzene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene (PCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Toluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
trans-1-2-Dichloroethene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
trans-1-3-Dichloropropene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Trichloroethene (TCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3
Trichlorofluoromethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2
Vinyl Chloride	µg/kg	TM15_A/PM10	<2	<2	<2	<2	<2	<2	<2

				CF001			CP001			HB002	HB011	HB012	HB014	HB015	HB016	HB027	HB028	HB029	HB030	HB033	HB034	HB035	HB037	HB038
Parameter	Unit	Method	Detection Limit	A	B	C	A	B	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
EPH >C10-C12	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
EPH >C12-C16	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	59	17	<10	<10
EPH >C16-C21	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	328	96	<10	<10
EPH >C21-C35	mg/kg	TM5/PM8	<10	<10	<10	<10	70	<10	<10	53	189	<10	<10	<10	30	<10	24	35	39	<10	931	289	<10	<10
EPH >C35-C40	mg/kg	TM5/PM8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	195	71	<10	<10
EPH >C8-C10	mg/kg	TM5/PM8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EPH >C8-C40	mg/kg	TM5/PM8	<30	<30	<30	<30	70	<30	<30	53	189	<30	<30	<30	30	<30	<30	35	39	<30	1513	473	<30	<30
Natural Moisture Content	%	PM4/PM0	<0.1	29	34.3	27.1	45.3	45.1	43.5	61.1	256.1	41.8	41.5	41.2	55.6	43.2	42.7	39.8	33	26.6	137.6	57.7	30.1	31.8
Acenaphthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	mg/kg	TM4/PM8	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Anthracene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(a)anthracene	mg/kg	TM4/PM8	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzo(b)fluoranthene	mg/kg	TM4/PM8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(bk)fluoranthene	mg/kg	TM4/PM8	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Benzo(ghi)perylene	mg/kg	TM4/PM8	<0.04	<0.04	<0.04	<0.0																		

[illegible]

Parameter	Unit	Method	Detection Limit	CB001			CP001			HB002	HB011	HB012	HB014	HB015	HB016	HB027	HB028	HB029	HB030	HB033	HB034	HB035	HB037	HB038
				A	B	C	A	B	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Isopropylbenzene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Methyl Tertiary Butyl Ether	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
m/p-Xylene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Naphthalene	µg/kg	TM15/PM10	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27	<27
n-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
o-Xylene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Propylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
sec-Butylbenzene	µg/kg	TM15/PM10	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Styrene	µg/kg	TM15_A/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	17	9	<3	<3
Surrogate Recovery 4-Bromofluorobenzene	%	TM15/PM10	<0	105	103	96	103	ME	ME	104	100	104	102	108	102	102	94	105	105	106	87	91	104	100
Surrogate Recovery Toluene D8	%	TM15/PM10	<0	79	76	64	76	ME	ME	71	76	76	77	78	76	73	62	82	81	80	68	68	79	68
tert-Butylbenzene	µg/kg	TM15/PM10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene (PCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Toluene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
trans-1-2-Dichloroethene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
trans-1-3-Dichloropropene	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Trichloroethene (TCE)	µg/kg	TM15/PM10	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Trichlorofluoromethane	µg/kg	TM15/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Vinyl Chloride	µg/kg	TM15_A/PM10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Table 4 Metal concentrations in sediment samples collected around the Camps Bay marine outfall and the Karbonkelberg reference site in February 2025.

Site ID	Replicate	Aluminium (mg/kg)	Cadmium (µg/kg)	Nickel (mg/kg)	Mercury (µg/kg)	Arsenic (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
CB006	A	3250	<100	1.4	<10	<2	3	<2.0	3.6	3.4	4.7
CB015	A	1042	<100	<1.0	<10	<2	1.2	<2.0	<3.0	<1.0	<2.0
CB017	A	1368	<100	<1.0	<10	<2	2	<2.0	4.5	1.4	3.2
CB018	A	1147	<100	<1.0	<10	<2	1.7	<2.0	<3.0	<1.0	3.0
CB019	A	1087	<100	<1.0	<10	<2	1.2	<2.0	<3.0	<1.0	<2.0
CB022	A	1498	104	1.3	<10	3	5.9	<2.0	11	9.2	7.7
CB023	A	3708	180	2.7	27	2	12	2.3	<3.0	6.0	8.1
KB001	A	814	<100	<1.0	<10	<2	2	<2.0	<3.0	1.1	2.2
KB001	B	861	<100	<1.0	<10	<2	2	<2.0	<3.0	1.1	2.1

Site ID	Replicate	Aluminium (mg/kg)	Cadmium (µg/kg)	Nickel (mg/kg)	Mercury (µg/kg)	Arsenic (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
KB001	C	760	<100	<1.0	<10	<2	1.9	<2.0	<3.0	<1.0	<2.0

Table 5 Metal concentrations in sediment samples collected around the Green Point marine outfall and the Robben Island reference site in February 2025.

Site ID	Replicate	Aluminium (mg/kg)	Cadmium (µg/kg)	Nickel (mg/kg)	Mercury (µg/kg)	Arsenic (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
GP020	A	1532	<100	1.1	<10	<2	3	2.3	4.5	2.4	4.2
GP028	A	1472	<100	1.4	<10	<2	3.6	<2.0	9.5	2.8	9.1
GP029	A	2275	186	1.4	13	5	13	<2.0	6.3	4.2	11
RI001	A	732	<100	<1.0	<10	<2	3.9	<2.0	<3.0	1.7	3.7
RI001	B	737	<100	<1.0	<10	<2	3.7	<2.0	<3.0	1.9	3.3
RI001	C	670	<100	<1.0	<10	<2	3.8	<2.0	<3.0	2.5	3.5

Table 6 Metal concentrations in sediment samples collected around the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites in February 2025.

Site ID	Replicate	Aluminium (mg/kg)	Cadmium (µg/kg)	Nickel (mg/kg)	Mercury (µg/kg)	Arsenic (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
CF001	A	301	<100	<1.0	<10	<2	1.9	<2.0	<3.0	1.3	2.1
CF001	B	983	186	<1.0	<10	3	4.4	2.0	<3.0	1.5	3.7
CF001	C	274	<100	<1.0	<10	<2	2.1	<2.0	<3.0	1.1	2.3
CP001	A	972	165	<1.0	<10	2	4.3	<2.0	<3.0	1.4	3.8
CP001	B	293	<100	<1.0	<10	<2	2	<2.0	<3.0	1.3	<2.0
CP001	C	862	157	<1.0	<10	2	4.1	<2.0	<3.0	1.3	3.1
HB002	A	2865	181	1.1	<10	<2	5.9	2.1	<3.0	2.9	7.3
HB011	A	927	<100	1.2	<10	<2	4.5	<2.0	<3.0	4.1	4.5
HB012	A	1309	<100	<1.0	<10	<2	3	2.6	<3.0	1.3	2.9
HB014	A	1293	<100	<1.0	<10	<2	2.6	<2.0	<3.0	2.6	3.8
HB015	A	1321	<100	<1.0	<10	<2	3	<2.0	<3.0	2.0	3.2
HB016	A	2301	272	1.7	15	3	6.2	<2.0	<3.0	3.5	6.5
HB027	A	2018	<100	1.3	<10	2	5.6	<2.0	<3.0	2.2	4.6
HB028	A	1228	191	<1.0	<10	2	2.7	<2.0	<3.0	1.7	6.5
HB029	A	1934	<100	<1.0	<10	<2	3.3	<2.0	<3.0	2.3	5.5
HB030	A	1961	103	1.3	<10	<2	3.2	<2.0	<3.0	2.4	5.7
HB033	A	1585	<100	<1.0	<10	<2	2.2	<2.0	<3.0	2.0	4.6
HB034	A	12093	1225	9.2	90	8	25	121	18	21	161
HB035	A	6058	255	4.1	28	4	12	44	7.3	8.0	40
HB037	A	1454	<100	<1.0	<10	<2	4.2	<2.0	<3.0	3.5	4.3
HB038	A	1207	<100	<1.0	<10	<2	2.8	<2.0	<3.0	2.1	3.4

Table 7 Particle size distribution (cumulative %) of sediment samples collected around the Camps Bay marine outfall and Karbonkelberg reference site in February 2025.

C8022	C8019	C8018	C8017	C8015	C8006	Particle size (mm)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						Site ID	Replicate	0.001	0.002	0.003	0.004	0.005	0.007	0.023	0.024	0.025	0.05	0.051	0.052	0.053	0.07	0.072	0.073	0.074	0.075	0.15	0.3	0.425	0.6	1.18	2.36	4.75	6.7	9.5	13.2	19	26.5	37.5	53	63	75	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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KB001	KB001	KB001	CB023	Site ID	
				Replicate	
C	A	6	0.001		
1.992	3.968	-	0.002		
-	-	6/6	0.003		
1.992/3.984	3.968/3.968	-	0.004		
-	-				
3.984	3.984	6	0.005		
3.984	5.952	8	0.007		
3.984	5.952	8	0.023		
-	-	-	0.024		
-	-	-	0.025		
-	-	-	0.05		
3.984	5.976	10	0.051		
-	-	-	0.052		
-	-	-	0.053		
-	-	16	0.07		
-	-	-	0.072		
3.984	5.976	-	0.073		
-	-	-	0.074		
4.1	6	17.8	0.075		
5	7	95	0.15		
60	38	99	0.3		
87	72	99	0.425		
97	90	100	0.6		
99.6	99.2	100	1.18		
100	100	100	2.36		
100	100	100	4.75		
100	100	100	6.7		
100	100	100	9.5		
100	100	100	13.2		
100	100	100	19		
100	100	100	26.5		
100	100	100	37.5		
100	100	100	53		
100	100	100	63		
100	100	100	75		
100	100	100	100		

Table 8 Particle size distribution (cumulative %) for sediment samples collected around the Green Point marine outfall and Robben Island reference site in February 2025.

R001	R001	R001	GP029	GP028	GP020	Particle size (mm)	
						Site ID	Replicate
C	B	A	A	A	A	0.001	0.001
1.932	1.978	1.692	4.926	2	0.998	0.002	0.002
-	-	-	-	-	-	0.003	0.003
1.932/1.932	1.978/1.978	1.692/1.692	4.926/4.926	2/2	1.996/1.996	0.004	0.004
-	-	-	-	-	-	0.005	0.005
1.932	1.978	1.692	4.926	2	3.992	0.007	0.007
1.932	1.978	1.692	4.926	2	3.992	0.023	0.023
-	1.978	1.692	4.926	2	3.992	0.024	0.024
1.932	-	-	-	-	-	0.025	0.025
-	-	-	-	-	-	0.05	0.05
-	-	-	-	-	-	0.051	0.051
-	1.978	-	4.926	-	3.992	0.052	0.052
-	-	1.692	-	2	-	0.053	0.053
1.932	-	-	-	-	-	0.07	0.07
-	-	-	-	-	-	0.072	0.072
-	-	-	6.568	-	5.988	0.073	0.073
-	1.978	-	-	2	-	0.074	0.074
-	-	1.692	-	-	-	0.075	0.075
3.1/2.898	3.1	2.2	7.2	3.2	6.2	0.15	0.15
4	5	4	63	6	11	0.3	0.3
10	34	26	76	22	46	0.425	0.425
43	55	34	78	45	77	0.6	0.6
69	77	44	80	73	92	1.18	1.18
96.6	98.9	84.6	82.1	100	99.8	2.36	2.36
100	100	98	88	100	100	4.75	4.75
100	100	100	94	100	100	6.7	6.7
100	100	100	96	100	100	9.5	9.5
100	100	100	99	100	100	13.2	13.2
100	100	100	100	100	100	19	19
100	100	100	100	100	100	26.5	26.5
100	100	100	100	100	100	37.5	37.5
100	100	100	100	100	100	53	53
100	100	100	100	100	100	63	63
100	100	100	100	100	100	75	75
100	100	100	100	100	100	100	100

Table 9 Particle size distribution (cumulative %) for sediment samples collected around the Hout Bay marine outfall and Crayfish Factory and Chapmans Peak reference sites in February 2025.

CP001	CF001	CP001	CF001	CF001	CF001	CF001	Particle size (mm)																																					
							Site ID	Replicate																																				
C	B	A	C	B	A	C	0.001	0.002	0.003	0.004	0.005	0.007	0.023	0.024	0.025	0.05	0.051	0.052	0.053	0.07	0.072	0.073	0.074	0.075	0.15	0.3	0.425	0.6	1.18	2.36	4.75	6.7	9.5	13.2	19	26.5	37.5	53	63	75	100			
2	2	1.956	1.966	1.952	2	2	0.001	-	-	2/2	-	-	4	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
-	-	-	-	-	-	-	0.002	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/4	2/2	3.912/3.912	3.932/1.966	1.952/1.952	2/2	2/2	0.003	-	-	-	-	-	4	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
-	-	-	-	-	-	-	0.004	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	4	3.912	3.932	1.952	4	4	0.005	-	-	4	-	-	4	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
6	4	3.912	3.932	1.952	4	4	0.007	-	-	-	-	-	4	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
6	4	3.912	3.932	1.952	4	4	0.023	-	-	-	-	-	4	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
-	-	-	-	-	-	-	0.024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	0.025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
6	6	3.912	-	1.952	6	6	0.051	-	-	-	-	-	6	-	-	-	6	-	-	-	8	-	-	8.2	49	98	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
-	-	-	3.932	-	-	-	0.052	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	0.053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	8	3.912	-	-	-	8	0.072	-	-	-	-	-	8	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	-	-	3.932	1.952	-	-	0.073	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	0.074	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6.4	8.4	4	4	2.3	8.2	8.2	0.075	-	-	-	-	-	8.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
44	48	5	4	4	4	49	0.15	-	-	-	-	-	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
98	98	6	5	5	5	98	0.3	-	-	-	-	-	98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
99	99	26	30	29	99	99	0.425	-	-	-	-	-	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
99	100	71	73	72	100	100	0.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	97.8	98.3	97.6	100	100	1.18	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	99	100	100	100	2.36	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	4.75	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	6.7	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	9.5	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	13.2	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	19	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	26.5	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	37.5	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	53	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	63	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	75	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
100	100	100	100	100	100	100	100	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

HB016	HB015	HB014	HB012	HB011	HB002	Site ID	Particle size (mm)									
							Replicate									
A	A	A	A	A	A											
4	1.506	1.312	1.994	1.008	4	0.001										
-	-	-	-	-	-	0.002										
6/6	3.012/3.012	2.624/2.624	3.988/3.988	1.008/1.26	4/4	0.003										
-	-	-	-	-	-	0.004										
6	3.012	2.624	3.988	1.26	4	0.005										
6	3.012	2.624	3.988	1.26	4	0.007										
8	3.012	2.624	3.988	1.764	6	0.023										
-	-	-	-	-	-	0.024										
-	-	-	-	-	-	0.025										
-	-	-	-	2.52	-	0.05										
-	-	3.936	3.988	-	-	0.051										
8	3.012	-	-	-	6	0.052										
-	-	-	-	-	-	0.053										
-	-	-	-	3.024	-	0.07										
16	-	-	-	-	-	0.072										
-	3.012	3.936	3.988	-	-	0.073										
-	-	-	-	-	8	0.074										
16.2	3.5	4.2	4.3	3.5	9.7	0.075										
62	4	5	5	4	86	0.15										
92	10	6	49	4	99	0.3										
98	28	11	90	5	99	0.425										
99	45	21	98	6	100	0.6										
100	75.3	65.6	99.7	12.6	100	1.18										
100	86	84	100	44	100	2.36										
100	93	91	100	78	100	4.75										
100	95	94	100	87	100	6.7										
100	99	96	100	94	100	9.5										
100	100	98	100	99	100	13.2										
100	100	100	100	100	100	19										
100	100	100	100	100	100	26.5										
100	100	100	100	100	100	37.5										
100	100	100	100	100	100	53										
100	100	100	100	100	100	63										
100	100	100	100	100	100	75										
100	100	100	100	100	100	100										

HB034	HB033	HB030	HB029	HB028	HB027	Particle size (mm)	
						Site ID	Replicate
A	A	A	A	A	A		
-	1.95	5.046	1.13	2.292	4	0.001	
10	-	-	-	-	-	0.002	
12	1.95/1.95	5.046/5.046	2.26/2.26	2.292/2.292	4/4	0.003	
12	-	-	-	-	-	0.004	
14	1.95	5.046	3.39	3.438	6	0.005	
16	3.9	5.046	3.39	3.438	6	0.007	
-	3.9	5.046	3.39	3.438	-	0.023	
-	-	-	-	-	6	0.024	
18	-	-	-	-	-	0.025	
-	-	-	-	-	-	0.05	
-	3.9	5.046	-	3.438	-	0.051	
-	-	-	4.52	-	-	0.052	
34	-	-	-	-	8	0.053	
-	-	-	-	-	-	0.07	
-	3.9	6.728	-	-	-	0.072	
42	-	-	4.52	3.438	-	0.073	
-	-	-	-	-	10	0.074	
43.5	4.5	8.1	5	3.5	10.2	0.075	
82	10	10	5.5	4	58	0.15	
98	70	13	7	7	98	0.3	
99	88	21	11	16	99	0.425	
100	94	38	20	28	100	0.6	
100	97.5	84.1	56.5	57.3	100	1.18	
100	99	90	75	68	100	2.36	
100	100	94	87	80	100	4.75	
100	100	96	92	85	100	6.7	
100	100	98	97	91	100	9.5	
100	100	99	100	92	100	13.2	
100	100	100	100	94	100	19	
100	100	100	100	100	100	26.5	
100	100	100	100	100	100	37.5	
100	100	100	100	100	100	53	
100	100	100	100	100	100	63	
100	100	100	100	100	100	75	
100	100	100	100	100	100	100	

		Particle size (mm)																													
HB038	HB037	HB035	Site ID																												
A	A	A	Replicate																												
1.952	1.974	5.628	0.001																												
-	-	-	0.002																												
1.952/1.952	1.974/1.974	7.504/7.504	0.003																												
-	-	-	0.004																												
1.952	1.974	9.38	0.005																												
3.904	1.974	11.26	0.007																												
3.904	1.974	13.13	0.023																												
-	-	-	0.024																												
-	-	-	0.025																												
-	-	-	0.05																												
3.904	1.974	16.88	0.051																												
-	-	-	0.052																												
-	-	-	0.053																												
-	-	-	0.07																												
-	3.948	20.64	0.072																												
3.904	-	-	0.073																												
-	-	-	0.074																												
4	4	21.8	0.075																												
5	6	33	0.15																												
30	19	65	0.3																												
61	61	80	0.425																												
79	84	88	0.6																												
97.6	98.7	93.8	1.18																												
100	100	96	2.36																												
100	100	98	4.75																												
100	100	98	6.7																												
100	100	98	9.5																												
100	100	100	13.2																												
100	100	100	19																												
100	100	100	26.5																												
100	100	100	37.5																												
100	100	100	53																												
100	100	100	63																												
100	100	100	75																												
100	100	100	100																												

Table 10 Moisture content and specific gravity of sediment samples collected near the Camps Bay marine outfall and the Karbonkelberg reference site in February 2025. Replicate samples are shown as A, B and C.

		CB006	CB015	CB017	CB018	CB019	CB022	CB023	KB001		
Parameter	Unit	A	A	A	A	A	A	A	A	B	C
Moisture content	%	17.400	22.200	28.200	22.600	21.700	74.900	30.500	26.400	23.700	24.800
Specific gravity		2.626	2.629	2.624	2.631	2.631	2.518	2.621	2.601	2.597	2.621

Table 11 Moisture content and specific gravity of sediment samples collected near the Green Point marine outfall and the Robben Island reference site in February 2025. Replicate samples are shown as A, B and C.

		GP020	GP028	GP029	RI001		
Parameter	Unit	A	A	A	A	B	C
Moisture content	%	22.600	37.300	24.100	24.500	34.000	32.100
Specific gravity		2.626	2.614	2.626	2.601	2.649	2.535

Table 12 Moisture content and specific gravity of sediment samples collected near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Replicate samples are shown as A, B and C.

		CF001			CP001			HB002	HB011	HB012	HB014	HB015	HB016	HB027	HB028	HB029	HB030	HB033	HB034	HB035	HB037	HB038
Parameter	Unit	A	B	C	A	B	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Moisture content	%	50.200	29.500	27.800	38.100	39.100	55.000	48.700	62.00	24.70	43.600	33.800	53.200	39.100	35.200	45.000	37.400	31.000	28.800	61.400	27.600	25.600
Specific gravity		2.643	2.641	2.615	2.638	2.611	2.608	2.544	2.57	2.62	2.601	2.605	2.548	2.519	2.602	2.565	2.622	2.648	2.248	2.504	2.645	2.632

Table 13 Depths and locations of drop camera deployments around the Camps Bay marine outfall, mostly in cases where sediment was unable to be collected to lack rocky substrate.

Site ID	Replicate	Depth (m)	Planned		Actual	
			Longitude	Latitude	Longitude	Latitude
CB004	A	18.5	18.36573	-33.94263	18.36595	-33.94286
CB006	A	28.1	18.36570	-33.94788	18.36590	-33.94784
CB008	A	27.7	18.36273	-33.94370	18.36264	-33.94361
CB020	A	13.8	18.37066	-33.94979	18.37081	-33.94965
CB022	A	27.6	18.36318	-33.93405	18.36323	-33.93405
CB023	A	50.3	18.34700	-33.94437	18.34700	-33.94437

Table 14 Depths and locations of drop camera deployments around the Green Point marine outfall and the Robben Island reference site, mostly in cases where sediment was unable to be collected due to rocky substrate.

Site ID	Replicate	Depth (m)	Planned		Actual	
			Longitude	Latitude	Longitude	Latitude
GP011	A	26.8	18.39452	-33.88854	18.39438	-33.88846
GP012	A	27.6	18.39016	-33.89079	18.39011	-33.89086
GP013	A	28.1	18.39293	-33.88620	18.39289	-33.88617
GP014	A	27.5	18.38826	-33.88843	18.38855	-33.88840
GP020	A	10.7	18.41539	-33.89743	18.41534	-33.89741
GP021	A	32.4	18.40817	-33.87825	18.40679	-33.87931
GP022	A	37.3	18.38411	-33.87857	18.38424	-33.87859
GP023	A	30.2	18.38568	-33.89108	18.38583	-33.89100
GP024	A	33.2	18.38422	-33.89743	18.38456	-33.89751
GP025	A	28.4	18.40075	-33.88405	18.39999	-33.88417
GP026	A	20.1	18.39198	-33.90102	18.39206	-33.90094
RI001	A	31.2	18.34543	-33.81599	18.34565	-33.81634
RI001	B	33.2	18.34543	-33.81599	18.34514	-33.81629
RI001	C	30.4	18.34543	-33.81599	18.34589	-33.81565

APPENDIX V: BIOACCUMULATION DATA TABLES

Table 1 Metal content in tissue of rock lobster, bream and mussels collected near the Camps Bay marine outfall and the Karbonkelberg reference site. Replicate samples were collected at the reference sites, labelled A-C.

		CB024		CB025		CB026		CB027	CB028	CB029	CB030	CB031	KB001						KB002	
		A		A		A		A	A	A	A	A	A		B		C		A	B
Parameter	Unit	Bream	Rock Lobster	Bream	Rock Lobster	Bream	Rock Lobster	Bream	Mussel	Mussel	Mussel	Mussel	Bream	Rock Lobster	Bream	Rock Lobster	Bream	Rock Lobster	Mussel	Mussel
Zinc as Zn Total (dry)	mg/kg	16	58	16	88	18	62	16	152	322	101	192	21	77	17	59	17	73	223	207
Nickel as Ni Total (dry)	µg/kg	568	166	249	69	235	94	99	1233	2576	1659	2070	137	53	52	53	<50	<50	3397	3338
% Moisture	%	76	77	78	73	75	77	77	83	83	85	82	75	76	78	73	73	75	86	83
Mercury as Hg (dry)	µg/kg	188	247	282	312	132	137	208	30	81	32	53	331	186	340	215	194	172	137	111
Lead as Pb Total (dry)	µg/kg	70	51	52	40	64	70	<50	1521	816	551	761	<50	<50	<50	<50	<50	<50	754	652
Arsenic as As Total (dry)	mg/kg	2.4	38	2.4	20	1.4	35	3.2	7.4	10	7.1	8.3	3.8	35	1.7	60	3.9	41	12	13
Copper as Cu Total (dry)	mg/kg	<1.0	29	<1.0	19	<1.0	29	1.1	4.0	4.3	4.7	4.9	<1.0	27	<1.0	25	<1.0	21	8.3	6.3
Aluminium as Al Total (dry)	mg/kg	3.6	1.8	7.1	1.0	8.2	<1.0	1.6	118	93	195	205	3.0	5.9	2.6	3.2	1.7	3.7	148	139
Chromium as Cr Total (dry)	µg/kg	304	212	474	197	393	168	106	958	2174	1026	1287	97	124	148	149	72	163	1238	1325
Cadmium as Cd Total (dry)	µg/kg	<50	241	<50	374	<50	209	<50	7180	16292	4285	4302	<50	550	<50	190	<50	87	8716	8921

Table 2 Metal content in tissue of rock lobster, bream and mussels collected near the Green Point marine outfall and the Robben Island reference site. Replicate samples were collected at the reference sites, labelled A-C.

		GP002		GP030	GP031		GP033		GP034		GP035	GP036	GP037	GP038	GP039	GP040	RI001						RI002		
		A		A	A		A		A		A	A	A	A	A	A	A		B		C		A	B	C
Parameter	Unit	Bream	Rock Lobster	Bream	Bream	Rock Lobster	Bream	Rock Lobster	Bream	Rock Lobster	Mussel	Mussel	Mussel	Mussel	Mussel	Rock Lobster	Bream	Rock Lobster	Bream	Rock Lobster	Bream	Rock Lobster	Mussel	Mussel	Mussel
Lead as Pb Total (dry)	µg/kg	94	135	64	<50	78	424	184	<50	897	1005	1052	1474	3100	1646	<50	<50	69	<50	88	65	<50	683	1732	485
Aluminium as Al Total (dry)	mg/kg	6.0	8.6	5.0	2.4	3.7	3.2	6.3	3.8	5.4	111	71	346	552	360	2.8	2.6	4.8	<1.0	1.3	2.9	1.6	57	59	43
Arsenic as As Total (dry)	mg/kg	3.6	35	3.9	2.5	42	4.9	18	4.1	19	7.8	8.7	9.4	9.3	6.8	19	2.7	61	2.3	70	3.7	49	8.8	9.8	8.3
Cadmium as Cd Total (dry)	µg/kg	<50	123	<50	<50	244	<50	170	150	64	6356	5248	3283	4460	1941	315	<50	253	<50	61	<50	138	8530	10313	10318
Chromium as Cr Total (dry)	µg/kg	249	320	401	141	110	135	136	99	118	1528	1340	1892	2843	1860	241	55	71	71	91	187	<50	1208	1177	1188
Copper as Cu Total (dry)	mg/kg	<1.0	28	<1.0	1.0	24	1.0	27	1.2	20	4.2	4.5	5.6	5.8	6.7	14	<1.0	28	<1.0	26	<1.0	23	4.1	4.3	4.6
Mercury as Hg (dry)	µg/kg	216	601	197	191	271	195	266	377	111	55	67	68	64	39	142	233	251	245	144	209	153	53	61	51
% Moisture	%	77	75	78	77	76	78	78	78	79	84	80	82	82	80	76	79	77	77	74	76	73	82	87	82
Nickel as Ni Total (dry)	µg/kg	<50	160	304	73	68	73	50	60	66	1823	1455	3226	3435	2456	114	<50	<50	<50	<50	179	<50	1484	382	1730
Zinc as Zn Total (dry)	mg/kg	11	77	15	16	58	20	86	15	58	254	241	292	398	238	62	23	63	14	69	15	66	215	187	142

Table 3 Metal content in tissue of rock lobster, bream and mussels collected near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Replicate samples were collected at the reference sites as well as at HB017, labelled A-C.

		CF001					CF002			CP001					CP002			HB001		HB003	HB017				HB018	HB019	HB020	HB021	HB022	HB023	HB024	HB025	HB026
		A		B		C	A	B	C	A		B		C	A	B	C	A		A	A		B	C	A	A	A	A	A	A	A	A	A
Parameter	Unit	Bream	Rock Lobster	Bream	Rock Lobster	Rock Lobster	Mussel	Mussel	Mussel	Bream	Bream	Rock Lobster	Bream	Rock Lobster	Mussel	Mussel	Mussel	Bream	Rock Lobster	Bream	Bream	Rock Lobster	Rock Lobster	Rock Lobster	Bream	Bream	Bream	Mussel	Mussel	Mussel	Mussel	Mussel	Mussel
% Moisture	%	77	76	78	76	73	82	83	84	68	73	57	79	77	75	73	72	72	76	74	76	75	75	74	79	78	77	85	86	87	82	81	86
Zinc as Zn Total (dry)	mg/kg	17	75	27	92	106	176	99	134	18	18	57	16	320	84	74	80	15	64	16	15	109	121	155	18	19	18	148	120	226	75	178	137
Aluminium as Al Total (dry)	mg/kg	2.6	<1.0	3.9	<1.0	1.9	176	104	123	21	6.1	2.6	6.8	5.9	139	171	169	3.4	8.7	6.4	2.4	5.6	4.3	9.3	3.4	3.5	2.3	56	35	110	27	198	170
Arsenic as As Total (dry)	mg/kg	3.2	80	2.5	49	94	15	12	14	2.3	2.0	21	2.5	29	7.3	8.8	8.5	14	46	3.2	4.0	59	49	48	3.5	3.1	2.9	8.0	7.9	9.6	7.7	9.2	10
Cadmium as Cd Total (dry)	µg/kg	<50	237	<50	956	697	3939	3476	2996	<50	<50	256	<50	202	6318	4969	6291	<50	203	<50	<50	599	62	465	<50	<50	<50	2468	2770	3857	685	4453	4754
Chromium as Cr Total (dry)	µg/kg	318	95	265	81	102	1972	1214	1707	472	350	138	744	187	673	711	750	272	277	273	227	262	226	208	386	284	172	734	550	1524	374	1257	819
Copper as Cu Total (dry)	mg/kg	<1.0	26	<1.0	28	32	4.5	4.1	4.7	<1.0	1.1	18	1.1	57	3.9	5.2	4.8	<1.0	50	<1.0	<1.0	30	26	58	<1.0	<1.0	<1.0	4.2	5.3	4.5	5.7	4.5	4.6
Lead as Pb Total (dry)	µg/kg	60	57	77	<50	58	642	384	541	146	69	101	65	101	418	468	385	<50	61	<50	27	73	40	463	<50	<50	<50	544	357	1119	321	633	489
Mercury as Hg (dry)	µg/kg	191	285	442	393	295	60	44	50	289	166	128	174	656	18	17	20	714	310	210	304	1146	424	617	301	259	165	54	36	58	53	61	51

		CF001					CF002			CP001					CP002			HB001		HB003	HB017			HB018	HB019	HB020	HB021	HB022	HB023	HB024	HB025	HB026	
		A		B		C	A	B	C	A	B		C		A	B	C	A		A	A		B	C	A	A	A	A	A	A	A	A	
Parameter	Unit	Bream	Rock Lobster	Bream	Rock Lobster	Rock Lobster	Mussel	Mussel	Mussel	Bream	Bream	Rock Lobster	Bream	Rock Lobster	Mussel	Mussel	Mussel	Bream	Rock Lobster	Bream	Bream	Rock Lobster	Rock Lobster	Rock Lobster	Bream	Bream	Bream	Mussel	Mussel	Mussel	Mussel		
Nickel as Ni Total (dry)	µg/kg	203	<50	92	71	79	4422	3636	3905	330	389	94	239	103	1473	1434	1589	124	142	230	83	162	109	148	198	139	<50	855	734	1657	742	2211	1893

Table 4 Morphological measurements of rock lobster, bream and mussels collected near the Camps Bay marine outfall and the Karbonkelberg reference site. Replicate samples were collected at reference sites, labelled A-C.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
CB024	A	322 / 229 / 202	580 / 194 / 135	55 / 57 / 51	92 / 92 / 75	-	-
CB025	A	227 / 245 / 389	216 / 281 / 1216	107 / 96	580 / 502	-	-
CB026	A	359 / 275	867 / 386	48 / 53	67 / 90	-	-
CB026	B	291	467	-	-	-	-
CB027	A	197 / 261 / 263	138 / 316 / 352	-	-	-	-
CB028	A	-	-	-	-	59 / 62 / 72 / 60 / 53 / 62 / 76 / 49	30 / 28 / 44 / 33 / 23 / 27 / 59 / 12
CB029	A	-	-	-	-	60 / 53 / 68 / 66 / 64 / 68 / 67 / 80	17 / 12 / 21 / 24 / 25 / 23 / 23 / 30
CB030	A	-	-	-	-	64 / 71 / 43 / 78 / 80 / 65 / 68 / 74	25 / 30 / 7 / 49 / 48 / 25 / 30 / 43
CB031	A	-	-	-	-	59 / 65 / 57 / 59 / 51 / 60 / 63 / 55 / 54	17 / 19 / 14 / 20 / 12 / 17 / 21 / 12 / 14
KB001	A	283 / 274	336 / 310	51 / 74 / 71	79 / 214 / 210	-	-
KB001	B	375 / 339	854 / 603	51 / 51 / 53	73 / 72 / 74	-	-
KB001	C	332 / 286	576 / 375	65 / 55 / 53	178 / 99 / 89	-	-
KB002	A	-	-	-	-	66 / 31 / 19 / 24 / 22 / 18 / 22 / 74	24 / 3 / 1 / 2 / 1 / 1 / 1 / 41
KB002	B	-	-	-	-	79 / 58 / 60 / 67 / 68 / 73 / 72 / 61	33 / 20 / 21 / 31 / 31 / 33 / 33 / 22

Table 5 Morphological measurements of rock lobster, bream and mussels collected near the Green Point marine outfall and the Robben Island reference site. Replicate samples were collected at reference sites, labelled A-C.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
GP002	A	98 / 111 / 107	29.1 / 40.1 / 38.2	76 / 78 / 96	246 / 300 / 529	-	-
GP030	A	81 / 88 / 74	16.7 / 22.5 / 10.2	102 / 38 / 55	620 / 39 / 123	-	-
GP031	A	201 / 241 / 212	131 / 272 / 174	48 / 54 / 61	64 / 95 / 141	-	-
GP033	A	274 / 252 / 195	387 / 301 / 133	139 / 54 / 55	1062 / 85 / 101	-	-
GP034	A	376 / 440 / 352	945 / 1320 / 819	41 / 37 / 46 / 36	30 / 30 / 49 / 25	-	-
GP035	A	-	-	-	-	89 / 79 / 51 / 57 / 54 / 48 / 78 / 63 / 50	56 / 36 / 11 / 15 / 13 / 11 / 34 / 21 / 9
GP037	A	-	-	-	-	43 / 46 / 37 / 41 / 34 / 34 / 40 / 44 / 41 / 41 / 44 / 41	4 / 8 / 4 / 6 / 4 / 3 / 6 / 5 / 5 / 6 / 7 / 5
GP038	A	-	-	-	-	47 / 43 / 53 / 49 / 55 / 42 / 41 / 43 / 40	7 / 8 / 13 / 8 / 8 / 8 / 6 / 7 / 5
GP039	A	-	-	-	-	37 / 33 / 35 / 33 / 36 / 37 / 34 / 40 / 40 / 43 / 40 / 38 / 41 / 32 / 39 / 44 / 35	3 / 3 / 3 / 3 / 3 / 5 / 3 / 5 / 5 / 6 / 3 / 5 / 5 / 2 / 5 / 5 / 3
GP040	A	-	-	54 / 54 / 55 / 58	86 / 89 / 98 / 111	-	-
RI001	A	203 / 212 / 245	139 / 177 / 338	51 / 81 / 54	69 / 332 / 89	-	-
RI001	B	95 / 80 / 105	26.2 / 14.6 / 30.7	63 / 49 / 60	139 / 55 / 109	-	-
RI001	C	227 / 241 / 281	190 / 252 / 409	56 / 53 / 57	83 / 78 / 99	-	-
RI002	A	-	-	-	-	81 / 50 / 35 / 75 / 62 / 78 / 71 / 53 / 60	60 / 13 / 4 / 47 / 23 / 55 / 31 / 20 / 23
RI002	B	-	-	-	-	86 / 76 / 87 / 66 / 74 / 78 / 78 / 71	59 / 59 / 63 / 41 / 54 / 52 / 59 / 41
RI002	C	-	-	-	-	77 / 86 / 65 / 64 / 71 / 69	31 / 73 / 31 / 30 / 31 / 35

Table 6 Morphological measurements of rock lobster, bream and mussels collected near the Hout Bay marine outfall and the Crayfish Factory and Chapmans Peak reference sites. Replicate samples were collected at reference sites and at HB017, labelled A-C.

Site ID	Replicate	Bream		Rock Lobster		Mussel	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
CF001	A	259	264	86 / 59 / 53	358 / 129 / 81	-	-
CF001	B	215 / 271 / 171 / 240 / 195	194 / 300 / 99 / 247 / 141	93	491	-	-
CF001	C	-	-	67	188	-	-
CF002	A	-	-	-	-	44 / 45 / 43 / 41 / 43 / 41 / 37 / 39 / 37 / 38 / 48 / 43	7 / 5 / 6 / 5 / 5 / 5 / 3 / 4 / 2 / 3 / 6 / 5
CF002	B	-	-	-	-	55 / 55 / 59 / 64 / 55 / 61 / 53 / 53 / 59 / 60	13 / 11 / 18 / 20 / 12 / 15 / 10 / 15 / 15 / 15
CF002	C	-	-	-	-	43 / 42 / 39 / 41 / 41 / 61 / 36 / 46 / 43 / 45	6 / 5 / 4 / 4 / 6 / 22 / 4 / 8 / 5 / 7
CP001	A	321 / 329	591 / 670	-	-	-	-
CP001	B	302 / 259	499 / 303	53	66	-	-
CP001	C	256 / 350	296 / 818	120	995	-	-
CP002	A	-	-	-	-	52 / 40 / 44 / 52 / 47 / 46 / 52 / 51 / 57 / 46	12 / 7 / 7 / 12 / 8 / 10 / 11 / 14 / 23 / 10
CP002	B	-	-	-	-	61 / 54 / 57 / 52 / 56 / 52 / 57 / 47 / 58	15 / 19 / 17 / 12 / 25 / 14 / 14 / 7 / 17
CP002	C	-	-	-	-	33 / 50 / 65 / 32 / 53 / 68 / 33 / 37 / 61 / 57 / 54	3 / 9 / 16 / 3 / 8 / 20 / 3 / 4 / 17 / 14 / 11
HB001	A	443 / 421	1847 / 1548	53 / 56 / 54	103 / 106 / 102	-	-
HB003	A	183 / 275	107 / 367	-	-	-	-
HB017	A	397 / 349 / 235	1142 / 858 / 259	120	857	-	-
HB017	B	-	-	108	658	-	-
HB017	C	-	-	83	346	-	-
HB018	A	208 / 289 / 243	159 / 475 / 288	-	-	-	-
HB019	A	273 / 284 / 276	358 / 397 / 396	-	-	-	-
HB020	A	312 / 270 / 339 / 290	511 / 374 / 815 / 464	-	-	-	-
HB021	A	-	-	-	-	43 / 45 / 54 / 71 / 70 / 60 / 58 / 46 / 71	12 / 9 / 23 / 47 / 37 / 30 / 21 / 9 / 40
HB022	A	-	-	-	-	98 / 79 / 75 / 104 / 92 / 96	81 / 60 / 38 / 76 / 77 / 78
HB023	A	-	-	-	-	57 / 52 / 43 / 44 / 49 / 69 / 53 / 72 / 53	13 / 11 / 8 / 8 / 11 / 28 / 20 / 29 / 13
HB024	A	-	-	-	-	83 / 93 / 86	49 / 58 / 56
HB025	A	-	-	-	-	56 / 59 / 50 / 44 / 66 / 52 / 54 / 51 / 49 / 57	13 / 12 / 13 / 9 / 19 / 9 / 14 / 7 / 7 / 12
HB026	A	-	-	-	-	51 / 40 / 59 / 78 / 88 / 80 / 68 / 77 / 80	11 / 5 / 18 / 38 / 43 / 48 / 27 / 43 / 44



30 October 2025

Mr Gregg Oelofse
Manager: Coastal Management, Environmental Management
Spatial Planning and Environment
City of Cape Town
South Africa

Dear Mr Oelofse,

**Review comments for City of Cape Town Marine Wastewater Outfalls: Receiving Environment
Monitoring Report 2024/2025**

Preamble

I was appointed by the City of Cape Town to provide an independent review of the abovementioned report, including its appendices. The purpose of this letter is to inform you that I have completed the review. Key comments arising from my review are summarised below. I have also provided annotations directly within the report, which is returned under the cover of this letter. This letter and the annotated report should be considered jointly. The review comments are my own and do not necessarily represent the views of the CSIR. It remains at the discretion of the City of Cape Town and/or the survey team whether to adopt the recommendations I have made in the context of the report and study.

General

The report is generally well presented, clearly written, and follows a logical format in terms of the survey sections. However, there are several general aspects that, in my opinion, warrant attention.

- The report contains numerous grammatical errors and inconsistencies in terminology. I have highlighted many of these within the report, but I did not attempt to identify every instance. While these issues do not detract from the scientific rigour of the study, they may be distracting to a discerning reader. I appreciate that different specialist scientists contributed to various chapters or sections of the report, which likely accounts for inconsistencies in terminology, presentation, and style. I recommend that a single scientist, or technical editor, be tasked with ensuring consistency in terminology, presentation, and style throughout the report.
- The figures, graphs, and tables generally convey the survey findings in a clear format. One criticism is that axis labels for numerous graphs include technical inaccuracies, such as not superscripting the '2' in m^2 , or subscripting the number of oxygen molecules ('4') in nutrient chemical formulas, such as PO_4-P rather than PO_4-P . As above, this may be distracting for a more discerning reader and technical audience. Some information in axis labels is, in my

opinion, also superfluous or redundant, such as 'Ave. taxa per sample' if the same information (Ave. in this case) is included in the figure caption.

- Numerous figure captions require attention. I have pointed out several incidences within the report.
- I recommend that in addition to the appendices provided, the report that outlines the monitoring programme scope of work and survey designs, and the Coastal Waters Discharge Permits for the three outfalls, also be included as appendices for ease of reference. Alternately, where these are first mentioned in the report a hyperlink to the report or permits on the City of Cape Town website could be provided for ease of reference, if this is a simpler process.

Water quality

Uncertainties surrounding the validity of reported total suspended solids, metal, and nutrient concentrations is unfortunate, as nothing can be concluded from the data. I appreciate the survey team has been transparent about these limitations. However, a decision needs to be made on whether these measurements are retained and interpreted in the report or are withdrawn entirely—if there is no confidence in the measurements then there can be no confidence in conclusions drawn from the data analysis and interpretation, in my opinion. The survey team, in consultation with the City of Cape Town, will need to decide on whether these data should be retained in the report, assuming they can be interpreted with some confidence in a relative rather than absolute context.

Other comments on this part of the report include:

- Large variations in sea urchin gamete fertilisation success in replicate treatments for some toxicity tests suggest a methodological issue that needs to be addressed.
- I disagree that a sea urchin gamete fertilisation success of 70% should be used to delineate toxic from non-toxic water samples. I appreciate that this is a limit of acceptability used in some parts of the world. I also appreciate that comparisons were made to the reference site data, but a control sample fertilisation success should be the point of comparison. This is especially the case when toxicity was detected at some reference sites. I suspect that a fertilisation success of 95%, or at least 90%, can be regarded as the limit for test acceptability—but enough control treatments should have been generated to date to define a test acceptance limit and threshold for toxicity.
- Toxicity tests are valuable but have limitations. These should be briefly expounded upon in the report. I raise this point as the results of toxicity tests are, in my opinion, a good impact indicator.
- The salinity reported at numerous sites in some surveys seems anomalously high. Although I did not perform a detailed review of the scientific literature pertaining to salinities in nearshore marine waters off Cape Town and thus stand to be corrected, a salinity above 36, and especially above 37 seems high for this area of the South African coast. Indeed, salinities above 35.5 may well be high. Calibration of the salinity sensor should be done regularly, if this is not already the case, and should be verified against seawater standards. If so, it might be worthwhile including a very brief review of the literature in support of these high salinities.
- A turbidity of 0 NTU was a common occurrence in the water quality surveys. I question the validity of these measurements—there should in my opinion never be zero turbidity in marine waters such as those off Cape Town. Even the clearest water to the naked eye, including drinking water, will have some turbidity. Calibration of the turbidity sensor should be done

regularly, if this is not already the case, and checked. I recommend that the resolution of the *in situ* instrument be investigated. It may well be that a turbidity of 0 NTU is being reflected by the instrument, but this is simply because the resolution is too wide to effectively measure a very low turbidity. The turbidity should thus not be considered as 0 NTU, but rather too low to measure accurately. The turbidity could in this instance be presented as 0 NTU but should be caveated by a statement on the instrument's measurement resolution and that a turbidity of 0 NTU represents a very low (but unmeasurable) turbidity.

- The survey team might wish to investigate the relationship between pH and dissolved oxygen. They are frequently very closely related and deviations from such a relationship by one or both might be informative on effluent discharge related impacts on water quality.
- I recommend that, if the opportunity arises during normally scheduled water quality surveys, that water samples be collected within the most intense part of surfacing effluent plumes. This will provide a measure for 'calibrating' measurements made at the AMZ boundary, and will obviously provide information on water quality within a surface water plume.

Emerging contaminants

I question the necessity of microplastic studies in the context of the effluent discharges, or at least whether this study needs to be taken forward. While I do not question that microplastics are contaminants in municipal effluent and will be reaching the sea via effluents discharged through the outfalls since this is well-documented in the scientific literature and it would be surprising if this was not also the case in Cape Town, the only conclusions that can be reached from the study is that effluent is a probable source of microplastics to coastal waters in Cape Town. There were no specific concentration trends that allude to effluent as being more or less important than other potential microplastic sources. Also, if there are higher microplastic counts near the outfalls, what does this mean from an ecological perspective? We know too little about the ecological impacts of microplastics to reach a conclusion on whether they are exerting a major effect on the local ecology, regardless of the fact the body of evidence does point to some ecological impacts of these contaminants. That said, it is the prerogative of the City of Cape Town and/or survey team to decide on the future value of this component of the monitoring programme. I also appreciate that future surveys could provide spatial trends that allude to the importance of the discharges.

Sediment quality

The survey findings confirm the findings of earlier surveys on the Cape Town outfalls, or surveys in the outfall areas. These studies have consistently pointed to low contaminant concentrations in sediment near the outfalls, and in Table Bay, reflecting the combined effects of numerous receiving environment properties.

The Limits of Detection for polycyclic aromatic hydrocarbons are high relative to the concentrations that can be expected in sand dominated sediment such as that near the Cape Town outfalls. This probably accounts for the almost complete failure to detect these compounds in sediment. A lower Limit of Detection is necessary to detect these compounds in sandy sediment, but whether this is necessary is debatable since even at the used Limits of Detection there is no evidence for the significant accumulation of these hydrocarbons in sediment.

Ecological effects

The findings of the ecological effects surveys also provide no clear evidence that effluent derived material is accumulating on the seabed near the outfalls, nor is effluent in the water column impinging on the seabed, to a degree that this is adversely affecting benthic invertebrate

communities. This supports the findings of recent surveys for the Cape Town outfalls monitoring programme. The present survey on sediment benthic macrofauna concludes that there is some evidence for impacts to these communities near the Camps Bay outfall, but there are uncertainties in the data to either doubt this is the case, or to preclude a confident conclusion until additional information is generated. Indeed, the report appears to be somewhat contradictory in this sense, sometimes appearing to allude to an impact to sediment benthic macrofauna near the Camps Bay outfall while at other times alluding to uncertainties that make it impossible to conclude this is the case. I support the report conclusion that a more intensive sampling effort is required to resolve this issue, perhaps at the expense of sediment benthic macrofauna surveys at the Green Point outfall and in Table Bay.

Rocky substrate epifauna and fish surveys also did not provide clear evidence for measurable community level impacts of the effluent discharges.

Bioaccumulation

The small size of the West Coast Rock Lobster specimens collected for the survey, in combination with the collapsed fishery for this species and the findings of the present study and an earlier study that provided no evidence lobsters are accumulating metal contaminants in their tissue to a degree that this poses significant health risks to humans, calls into question the ethics of continuing to use this species as a contaminant monitoring sentinel. The City of Cape Town and survey team might thus wish to consider the long-term use of this animal as a contaminant monitoring sentinel. However, discontinuing the use of West Coast Rock Lobster as a contaminant monitoring sentinel is not a specific recommendation I make as there are valid reasons for its identification and use in this context.

Spearfishing was used to sample fish, but this is not a recommended method. I appreciate the rationale for using this collection method, but it restricts the analysis of tissue to a specific, undamaged part of the fish fillet. Ideally, an entire fillet should be processed from each fish. I nevertheless appreciate that the survey team will need to make a trade-off between time spent in the field collecting fish using other methods, and the number of samples that can be analysed.

The bioaccumulation component of the study should, to the extent practical, standardise the size of animals analysed amongst sites. It is the common difficulty in collecting animals of a standard size amongst sites that makes these studies expensive, as long-periods must often be spent in the field for this purpose. However, non-standardised fish, lobster, and mussel sizes complicates comparisons amongst sites, and limits human health hazard and risk assessment. I nevertheless appreciate that the survey team will need to make a trade-off between time spent in the field collecting organisms of a standard size, and the number of samples that can be analysed. That said, the study was valuable in confirming that, despite variations in animal size, there was no evidence for anomalously high metal concentrations in the targeted organisms.

The hazard and risk assessment findings support earlier studies that metals are not being bioaccumulated to such high concentrations in the targeted organisms that this is posing unacceptably high hazards and risks to human health of seafood consumers in Cape Town. This conclusion is of course restricted to metals in the context of this survey, but future surveys for the monitoring programme will identify if this extends to other contaminants that these organisms might be accumulating in their tissue.

Conclusions

The monitoring programme uses a diverse array of monitoring techniques and environmental indicators for assessing the impact of the effluent discharges on the marine receiving environments. The survey team is commended for completing the many surveys required, in what would appear sometimes to be trying weather conditions.

The diverse array of monitoring techniques and environmental indicators is a strength of the monitoring programme and contributes confidence that the conclusion reached by the survey team that there was no clear evidence for major ecological impacts in the receiving environments beyond the allowable mixing zones in the survey period is reliable, within the constraints of the techniques, some challenges experienced in the measurement of certain environmental indicators, and the survey design. Based on the information made available to me for the review, I concur with the conclusion reached by the survey team.

The absence of evidence for major ecological impacts is due either to physical, chemical, and biological processes in the receiving environments effectively dispersing, diluting, and degrading effluent derived contaminants to such a degree that possible effects of the discharges are subsumed by natural variability beyond the allowable mixing zones, or there are no effects. However, there can never be no effect in the context of effluent discharge. Other monitoring techniques and environmental indicators might detect more subtle ecological impacts and effects of the discharges, but whether these will materially alter the conclusions reached in terms of the extent of ecological and human health risks when compared to the current survey findings is open to debate. These techniques could, however, be considered in future iterations of the monitoring programme, if necessary.

Segments of the public might not appreciate, nor accept, that there was no clear evidence for major ecological impacts related to effluent discharges beyond the allowable mixing zones in the survey period. This is, however, a logical conclusion based on the available results for the monitoring techniques and environmental indicators used for the survey. However, as noted above it would be incorrect to conclude that the effluent discharges are not having an impact—there can never be no impact in the context of the discharges—and the public thus has a right to express concerns on this practice.

The contradiction between the findings of this first year of the current outfalls monitoring programme cycle and conclusions reached by other investigators who have pointed to effluent discharge as posing major ecological and human health risks in the coastal marine environment in Cape Town may reflect different indicators used in the studies. However, I am aware the current City of Cape Town outfalls monitoring programme will use some of the indicators used by other investigators in forthcoming surveys, so further conclusions on the nature and extent of impacts associated with the effluent discharges will need to wait until the future survey information is available.

I recommend that the City of Cape Town make a stronger point of explaining to the public that alternative wastewater management options, such as transferring wastewater discharged through the outfalls to inland wastewater treatment works will ultimately involve the discharge of treated wastewater into a river/estuary and eventually the sea. Not only will this come at a significant additional financial cost, but the ecological costs of treated wastewater discharges

into rivers and estuaries might supersede the impacts of discharges of preliminarily treated effluent into the sea. Nonetheless, the City should continue to explore opportunities to improve effluent quality and address public concerns.

Closure

The role of a reviewer is to critically evaluate a report, which often necessitates highlighting areas of concern relative to reported conclusions. In doing so, the positive aspects of the work can be overlooked. As noted above, the existing monitoring programme involves a large volume of work, and the survey team is commended for completing it within acknowledged weather and other typical and sometimes uncontrollable survey constraints that inevitably arise. The City of Cape Town is also commended for supporting the surveys, to a degree that more information was generated than that ordinarily required in Coastal Water Discharge Permits. The surveys completed in the first year make an important contribution to the understanding of effluent discharge impacts in the Cape Town area. I look forward to the opportunity to review further reports as the monitoring programme progresses.

In closing, I welcome the opportunity to discuss the comments that I have made in this letter and the annotated report with the City of Cape Town and/or the survey team, should you consider this useful.

Your sincerely,

A handwritten signature in black ink that reads "Brent Newman". The script is cursive and fluid, with the first letters of "Brent" and "Newman" being capitalized and prominent.

Brent Newman



18 November 2025

Brent Newman
Coastal Systems Research Group
CSIR
[REDACTED]

RE: External review of the draft City of Cape Town Marine Wastewater Outfalls Receiving Environment Monitoring Annual Report 2024/2025

Dear Brent,

Our thanks for your efforts as external reviewer of a draft version of the City of Cape Town Marine Outfalls Monitoring Annual Report 2024/2025 prepared by Infinity and Anchor. Your inputs have been exceptionally valuable, and we believe the final report has been strengthened significantly in response to your review comments.

A copy of the final report is provided herewith for your records, along with a brief response to your review comments overleaf.

Thank you once again for your work on this – it has certainly improved the final report and we appreciate your willingness to contribute.

Please feel free to get in touch with any further feedback or to discuss any of the above responses.

Regards,

A handwritten signature in black ink, appearing to read "Barry Clark", with a stylized, sweeping flourish at the end.

Barry Clark

Anchor Environmental

A handwritten signature in black ink, appearing to read "Jeremy Rose", with a stylized, sweeping flourish at the end.

Jeremy Rose

Infinity Environmental

Comments by Reviewer: Dr Brent Newman (CSIR)	Response by authors
Preamble I was appointed by the City of Cape Town to provide an independent review of the abovementioned report, including its appendices. The purpose of this letter is to inform you that I have completed the review. Key comments arising from my review are summarized below. I have also provided annotations directly within the report, which is returned under the cover of this letter. This letter and the annotated report should be considered jointly. The review comments are my own and do not necessarily represent the views of the CSIR. It remains at the discretion of the City of Cape Town and/or the survey team whether to adopt the recommendations I have made in the context of the report and study.	Thank you. We believe the final report has been strengthened significantly in response to your review comments.
General The report is generally well presented, clearly written, and follows a logical format in terms of the survey sections. However, there are several general aspects that, in my opinion, warrant attention. - The report contains numerous grammatical errors and inconsistencies in terminology. I have highlighted many of these within the report, but I did not attempt to identify every instance. While these issues do not detract from the scientific rigour of the study, they may be distracting to a discerning reader. I appreciate that different specialist scientists contributed to various chapters or sections of the report, which likely accounts for inconsistencies in terminology, presentation, and style. I recommend that a single scientist, or technical editor, be tasked with ensuring consistency in terminology, presentation, and style throughout the report. - The figures, graphs, and tables generally convey the survey findings in a clear format. One criticism is that axis labels for numerous graphs include technical inaccuracies, such as not superscripting the '2' in m², or subscripting the number of oxygen molecules ('4') in nutrient chemical formulas, such as PO₄-P rather than PO₄-P. As above, this may be distracting for a more discerning reader and technical audience. Some information in axis labels is, in my opinion, also superfluous or redundant, such as 'Ave. taxa per sample' if the same information (Ave. in this case) is included in the figure caption. - Numerous figure captions require attention. I have pointed out several incidences within the report. - I recommend that in addition to the appendices provided, the report that outlines the monitoring programme scope of work and survey designs, and the Coastal Waters Discharge Permits for the three outfalls, also be included as appendices for ease of reference. Alternately, where these are first mentioned in the report a hyperlink to the report or permits on the City of Cape Town website could be provided for ease of reference, if this is a simpler process.	Inconsistencies in terminology, presentation of units, referencing errors, grammar, formatting problems, figure captions, etc. in the draft document are acknowledged and have been rectified – thank you for highlighting these. The final version of the report has incorporated your comments, and been edited for consistency. While we have not responded in detail to each of these, we appreciated the time taken to highlight them.
Water quality Uncertainties surrounding the validity of reported total suspended solids, metal, and nutrient concentrations is unfortunate, as nothing can be concluded from the data. I appreciate the survey team has been transparent about these limitations. However, a decision needs to be made on whether these measurements are retained and interpreted in the report or are withdrawn entirely—if there is no confidence in the measurements then there can be no confidence in conclusions drawn from the data analysis and interpretation, in my opinion. The survey team, in consultation with the City of Cape Town, will need to decide on whether these data should be retained in the report, assuming they can be interpreted with some confidence in a relative rather than absolute context. Other comments on this part of the report include:	- Uncertainties surrounding the validity of reported total suspended solids, metal, and nutrient concentrations are acknowledged in the report. We have elected in the final report not to include assessments based on these data while the necessary laboratory quality control measures are pursued. Data are reported in

Comments by Reviewer: Dr Brent Newman (CSIR)	Response by authors
- Large variations in sea urchin gamete fertilisation success in replicate treatments for some toxicity tests suggest a methodological issue that needs to be addressed. - I disagree that a sea urchin gamete fertilisation success of 70% should be used to delineate toxic from non-toxic water samples. I appreciate that this is a limit of acceptability used in some parts of the world. I also appreciate that comparisons were made to the reference site data, but a control sample fertilisation success should be the point of comparison. This is especially the case when toxicity was detected at some reference sites. I suspect that a fertilisation success of 95%, or at least 90%, can be regarded as the limit for test acceptability—but enough control treatments should have been generated to date to define a test acceptance limit and threshold for toxicity. - Toxicity tests are valuable but have limitations. These should be briefly expounded upon in the report. I raise this point as the results of toxicity tests are, in my opinion, a good impact indicator. - The salinity reported at numerous sites in some surveys seems anomalously high. Although I did not perform a detailed review of the scientific literature pertaining to salinities in nearshore marine waters off Cape Town and thus stand to be corrected, a salinity above 36, and especially above 37 seems high for this area of the South African coast. Indeed, salinities above 35.5 may well be high. Calibration of the salinity sensor should be done regularly, if this is not already the case, and should be verified against seawater standards. If so, it might be worthwhile including a very brief review of the literature in support of these high salinities. - A turbidity of 0 NTU was a common occurrence in the water quality surveys. I question the validity of these measurements—there should in my opinion never be zero turbidity in marine waters such as those off Cape Town. Even the clearest water to the naked eye, including drinking water, will have some turbidity. Calibration of the turbidity sensor should be done regularly, if this is not already the case, and checked. I recommend that the resolution of the in situ instrument be investigated. It may well be that a turbidity of 0 NTU is being reflected by the instrument, but this is simply because the resolution is too wide to effectively measure a very low turbidity. The turbidity should thus not be considered as 0 NTU, but rather too low to measure accurately. The turbidity could in this instance be presented as 0 NTU but should be caveated by a statement on the instrument's measurement resolution and that a turbidity of 0 NTU represents a very low (but unmeasurable) turbidity. - The survey team might wish to investigate the relationship between pH and dissolved oxygen. They are frequently very closely related and deviations from such a relationship by one or both might be informative on effluent discharge related impacts on water quality. - I recommend that, if the opportunity arises during normally scheduled water quality surveys, that water samples be collected within the most intense part of surfacing effluent plumes. This will provide a measure for 'calibrating' measurements made at the AMZ boundary, and will obviously provide information on water quality within a surface water plume.	appendices only for the sake of completeness and to confirm the attempts to comply with the DFFE-approved monitoring programme. - We have also reviewed data for fertilisation toxicity tests and reworded conclusions and analyses in relation to the 70% threshold included in Standard Methods. The final report avoids any averaging of toxicity data across tests or dates, but retains the threshold in the absence of a locally determined success threshold for the time being. - Some of the limitations of toxicity testing have been expanded on in the relevant sections of the report. - Higher salinities and lower turbidity data will be investigated with the supplier of the sensors, but we can confirm that all necessary calibrations are regularly performed. The turbidity data have been qualified where they appear in the report. - The suggestion to consider the relationship between dissolved oxygen and pH is an interesting one, and will be pursued in the next reporting period. - Sampling of the visible part of surfacing effluent plumes is already conducted on an ad hoc basis – data for this will be considered for incorporation in the next reporting period.
Emerging contaminants I question the necessity of microplastic studies in the context of the effluent discharges, or at least whether this study needs to be taken forward. While I do not question that microplastics are contaminants in municipal effluent and will be reaching the sea via effluents discharged through the outfalls since this is well-documented in the scientific literature and it would be surprising if this was not also the case in Cape Town, the only conclusions that can be reached from the study is that effluent is a probable source of microplastics to coastal waters in Cape Town. There were no specific concentration trends that allude to effluent as being more or less important than other potential	The conclusions of the microplastics chapter have been reviewed and revised to clarify the exploratory nature of the study.

Comments by Reviewer: Dr Brent Newman (CSIR)	Response by authors
microplastic sources. Also, if there are higher microplastic counts near the outfalls, what does this mean from an ecological perspective? We know too little about the ecological impacts of microplastics to reach a conclusion on whether they are exerting a major effect on the local ecology, regardless of the fact the body of evidence does point to some ecological impacts of these contaminants. That said, it is the prerogative of the City of Cape Town and/or survey team to decide on the future value of this component of the monitoring programme. I also appreciate that future surveys could provide spatial trends that allude to the importance of the discharges.	
Sediment quality The survey findings confirm the findings of earlier surveys on the Cape Town outfalls, or surveys in the outfall areas. These studies have consistently pointed to low contaminant concentrations in sediment near the outfalls, and in Table Bay, reflecting the combined effects of numerous receiving environment properties. The Limits of Detection for polycyclic aromatic hydrocarbons are high relative to the concentrations that can be expected in sand dominated sediment such as that near the Cape Town outfalls. This probably accounts for the almost complete failure to detect these compounds in sediment. A lower Limit of Detection is necessary to detect these compounds in sandy sediment, but whether this is necessary is debatable since even at the used Limits of Detection there is no evidence for the significant accumulation of these hydrocarbons in sediment.	We concur that the findings are well-aligned with previous work. Limits of detection were below guideline thresholds for all but three of the PAHs, but we agree that there is no evidence for the accumulation of these in sediment.
Ecological effects The findings of the ecological effects surveys also provide no clear evidence that effluent derived material is accumulating on the seabed near the outfalls, nor is effluent in the water column impinging on the seabed, to a degree that this is adversely affecting benthic invertebrate communities. This supports the findings of recent surveys for the Cape Town outfalls monitoring programme. The present survey on sediment benthic macrofauna concludes that there is some evidence for impacts to these communities near the Camps Bay outfall, but there are uncertainties in the data to either doubt this is the case, or to preclude a confident conclusion until additional information is generated. Indeed, the report appears to be somewhat contradictory in this sense, sometimes appearing to allude to an impact to sediment benthic macrofauna near the Camps Bay outfall while at other times alluding to uncertainties that make it impossible to conclude this is the case. I support the report conclusion that a more intensive sampling effort is required to resolve this issue, perhaps at the expense of sediment benthic macrofauna surveys at the Green Point outfall and in Table Bay. Rocky substrate epifauna and fish surveys also did not provide clear evidence for measurable community level impacts of the effluent discharges.	The conclusions of the ecological effects chapter have been strengthened and clarified based on this feedback. No evidence was found for ecological effects at the community level.
Bioaccumulation The small size of the West Coast Rock Lobster specimens collected for the survey, in combination with the collapsed fishery for this species and the findings of the present study and an earlier study that provided no evidence lobsters are accumulating metal contaminants in their tissue to a degree that this poses significant health risks to humans, calls into question the ethics of continuing to use this species as a contaminant monitoring sentinel. The City of Cape Town and survey team might thus wish to consider the long-term use of this animal as a contaminant monitoring sentinel. However, discontinuing the use of West Coast Rock Lobster as a contaminant monitoring sentinel is not a specific recommendation I make as there are valid reasons for its identification and use in this context. Spearfishing was used to sample fish, but this is not a recommended method. I appreciate the rationale for using this collection method, but it restricts the	- Rock lobster is currently included primarily to allow for assessment of human health impacts given that this species is regularly harvested for consumption along Cape Town's coastline. - The logistical aspects of sampling have been balanced against the costs of the programme in determining the methods,

Comments by Reviewer: Dr Brent Newman (CSIR)	Response by authors
analysis of tissue to a specific, undamaged part of the fish fillet. Ideally, an entire fillet should be processed from each fish. I nevertheless appreciate that the survey team will need to make a trade-off between time spent in the field collecting fish using other methods, and the number of samples that can be analysed. The bioaccumulation component of the study should, to the extent practical, standardise the size of animals analysed amongst sites. It is the common difficulty in collecting animals of a standard size amongst sites that makes these studies expensive, as long-periods must often be spent in the field for this purpose. However, non-standardised fish, lobster, and mussel sizes complicates comparisons amongst sites, and limits human health hazard and risk assessment. I nevertheless appreciate that the survey team will need to make a trade-off between time spent in the field collecting organisms of a standard size, and the number of samples that can be analysed. That said, the study was valuable in confirming that, despite variations in animal size, there was no evidence for anomalously high metal concentrations in the targeted organisms. The hazard and risk assessment findings support earlier studies that metals are not being bioaccumulated to such high concentrations in the targeted organisms that this is posing unacceptably high hazards and risks to human health of seafood consumers in Cape Town. This conclusion is of course restricted to metals in the context of this survey, but future surveys for the monitoring programme will identify if this extends to other contaminants that these organisms might be accumulating in their tissue.	but we acknowledge this limitation. - We concur with this assessment of the conclusions.
Conclusions The monitoring programme uses a diverse array of monitoring techniques and environmental indicators for assessing the impact of the effluent discharges on the marine receiving environments. The survey team is commended for completing the many surveys required, in what would appear sometimes to be trying weather conditions. The diverse array of monitoring techniques and environmental indicators is a strength of the monitoring programme and contributes confidence that the conclusion reached by the survey team that there was no clear evidence for major ecological impacts in the receiving environments beyond the allowable mixing zones in the survey period is reliable, within the constraints of the techniques, some challenges experienced in the measurement of certain environmental indicators, and the survey design. Based on the information made available to me for the review, I concur with the conclusion reached by the survey team. The absence of evidence for major ecological impacts is due either to physical, chemical, and biological processes in the receiving environments effectively dispersing, diluting, and degrading effluent derived contaminants to such a degree that possible effects of the discharges are subsumed by natural variability beyond the allowable mixing zones, or there are no effects. However, there can never be no effect in the context of effluent discharge. Other monitoring techniques and environmental indicators might detect more subtle ecological impacts and effects of the discharges, but whether these will materially alter the conclusions reached in terms of the extent of ecological and human health risks when compared to the current survey findings is open to debate. These techniques could, however, be considered in future iterations of the monitoring programme, if necessary. Segments of the public might not appreciate, nor accept, that there was no clear evidence for major ecological impacts related to effluent discharges beyond the allowable mixing zones in the survey period. This is, however, a logical conclusion based on the available results for the monitoring techniques and environmental indicators used for the survey. However, as	Thank you for this feedback – we appreciate the constructive inputs and have incorporated revisions in response to the detailed in-text comments in addition to these summaries.

Comments by Reviewer: Dr Brent Newman (CSIR)	Response by authors
noted above it would be incorrect to conclude that the effluent discharges are not having an impact– there can never be no impact in the context of the discharges–and the public thus has a right to express concerns on this practice. The contradiction between the findings of this first year of the current outfalls monitoring programme cycle and conclusions reached by other investigators who have pointed to effluent discharge as posing major ecological and human health risks in the coastal marine environment in Cape Town may reflect different indicators used in the studies. However, I am aware the current City of Cape Town outfalls monitoring programme will use some of the indicators used by other investigators in forthcoming surveys, so further conclusions on the nature and extent of impacts associated with the effluent discharges will need to wait until the future survey information is available. I recommend that the City of Cape Town make a stronger point of explaining to the public that alternative wastewater management options, such as transferring wastewater discharged through the outfalls to inland wastewater treatment works will ultimately involve the discharge of treated wastewater into a river/estuary and eventually the sea. Not only will this come at a significant additional financial cost, but the ecological costs of treated wastewater discharges into rivers and estuaries might supersede the impacts of discharges of preliminarily treated effluent into the sea. Nonetheless, the City should continue to explore opportunities to improve effluent quality and address public concerns.	
Closure The role of a reviewer is to critically evaluate a report, which often necessitates highlighting areas of concern relative to reported conclusions. In doing so, the positive aspects of the work can be overlooked. As noted above, the existing monitoring programme involves a large volume of work, and the survey team is commended for completing it within acknowledged weather and other typical and sometimes uncontrollable survey constraints that inevitably arise. The City of Cape Town is also commended for supporting the surveys, to a degree that more information was generated than that ordinarily required in Coastal Water Discharge Permits. The surveys completed in the first year make an important contribution to the understanding of effluent discharge impacts in the Cape Town area. I look forward to the opportunity to review further reports as the monitoring programme progresses. In closing, I welcome the opportunity to discuss the comments that I have made in this letter and the annotated report with the City of Cape Town and/or the survey team, should you consider this useful.	Thank you for this feedback.

Stavanger 11th November 2025



To Mr. Gregg Oelofse
Manager of the Coastal Management
Spatial Planning and Environment
City of Cape Town
South Africa

Objective: External Review of the CCT Marine Outfalls Report 2024-2025

As a reviewer of the City of Cape Town Marine Outfalls Monitoring Report 2025, I would like to commend the City and its consultants for the considerable effort and dedication invested in this first year of the monitoring programme.

The study presents a well-designed and multidisciplinary approach to assessing the environmental performance of marine wastewater outfalls, reflecting a genuine commitment to responsible coastal management and evidence-based decision-making. This work provides a strong foundation for understanding the condition of the receiving environment and for guiding future improvements in wastewater management.

The comments and recommendations below are offered to support the continued refinement and strengthening of this important programme.

Sincerely,


Prof. Daniela M. Pampanin

Daniela M. Pampanin PhD.

Professor
Faculty of Science and Technology
Department of Chemistry, Bioscience and Environmental Engineering

[Redacted]

[Redacted]

[Redacted]

General Evaluation

The first-year report of the City of Cape Town's three-year marine outfalls monitoring programme (2024–2025) constitutes a thorough and well-structured environmental assessment, demonstrating substantial effort, technical competence, and multidisciplinary integration. The programme is comprehensive in scope, encompassing six key areas: (1) water quality (physico-chemical parameters, nutrients, and metals); (2) ecotoxicity using sea urchin fertilisation bioassays; (3) sediment quality (VOCs, PAHs, TPHs, TOC, and phenols); (4) bioaccumulation studies in resident and caged biota (bream, rock lobsters, and black mussels); (5) monitoring of contaminants of emerging concern (pharmaceuticals, personal care products, and herbicides) and microplastics; and (6) assessment of ecological effects through surveys of benthic and reef communities.

The report provides an extensive dataset collected between July 2024 and June 2025, and it presents findings with a commendable level of detail and scientific rigour. The integration of field observations, laboratory analyses, and model validation enhances the overall credibility of the results. Notably, the report confirms that while effluent plumes from the Green Point, Camps Bay, and Hout Bay marine outfalls are frequently detectable, their physical and chemical effects remain largely confined within the allowable mixing zones (AMZs), and compliance with permit conditions has generally been achieved. The confirmation of dispersion model predictions from earlier studies (2020–2021) is a particularly valuable outcome, strengthening confidence in these models as management tools for temporal and spatial interpretation of effluent dynamics.

The breadth of the monitoring design reflects a well-considered, ecosystem-based approach, ensuring that both acute and chronic impacts are captured. The inclusion of bioassays (sea urchin fertilisation), sediment toxicity testing, and bioaccumulation analyses provides a solid foundation for assessing ecological risk beyond simple compliance monitoring. Furthermore, the consistency between observed plume behaviour and modelled outputs demonstrates sound integration between empirical and predictive approaches. The documentation of faecal indicator bacteria (FIB) exceedances primarily following rainfall events highlights the programme's sensitivity to distinguishing between outfall-derived and land-based contamination sources.

The study's finding that most water quality parameters, including suspended solids and metals, remain within natural variability limits at reference sites is encouraging. The lack of major acute toxicity in seawater samples and the absence of significant ecological degradation in benthic and reef communities suggest that the assimilative capacity of the marine receiving environments has not been exceeded under current discharge regimes. The incorporation of microplastic monitoring, though qualitative at this stage, is a valuable addition, demonstrating responsiveness to emerging global environmental concerns.

Specific comments and recommendations for improvement

1. Study purpose

- While the report highlights the role of dilution and dispersion in mitigating immediate pollutant concentrations, it would be advisable to rephrase the paragraph in line 65 to avoid possible misunderstanding. Dilution and dispersion should not be interpreted as sustainable solutions to pollution management, since continuous discharge may still lead to gradual accumulation of contaminants in the marine environment. It is recommended that the text clarify that long-term environmental protection depends on ensuring that wastewater discharges contain pollutant concentrations low enough to pose no risk to ecosystems or human health.

2. Methodological clarity and standardisation

- In Section 2.2 (Bioaccumulation), it should be clearly specified whether analyses were performed on wild or caged organisms, and at what distance from the outfalls the samples were collected. This information is critical for interpreting exposure gradients.
- In the microbiology section (line 556), details on sample transport and storage conditions should be added to ensure traceability and comparability with subsequent analyses (as is done for ecotoxicity samples in Section 2.2.3.2).
- For the metals analysis (line 647), greater transparency is required regarding laboratory selection and quality assurance procedures. The rationale for choosing the UK laboratory should be stated explicitly, and data on inter-laboratory variability, analytical recovery, and the use of internal standards should be presented. Spiking with known concentrations and inclusion of certified reference materials would further support data integrity. With the introduction of a new laboratory for the 2025–2026 cycle (line 676), measures to ensure inter-laboratory comparability must be outlined, as analytical discrepancies can arise from instrument sensitivity and detection limits (LOD/LOQ).

3. Nutrient and temperature data interpretation

- The reported nutrient concentrations, which were two to three orders of magnitude higher than in previous surveys (line 1200), require detailed scrutiny. These anomalies could stem from methodological inconsistencies, instrument calibration issues, or environmental drivers such as changing water temperature regimes (line 739; 9.4°C–15.4°C range). Comparative testing using both the old and new laboratories for a subset of samples would allow for verification and improve confidence in the nutrient dataset before continuing the full monitoring cycle.

4. Ecotoxicity and variability

- The whole effluent toxicity tests using sea urchin fertilisation assays indicate no detectable contaminants that directly inhibit fertilisation. However, they cannot exclude the presence of other toxicants acting through different mechanisms. This limitation should be clearly stated. Nonetheless, the assay remains a sensitive and widely recognised method for assessing sublethal toxicity in marine environments.
- The variability in sea urchin fertilisation success between samples raises questions about sample homogeneity and replication. The report should specify how water samples were homogenised before testing and how many replicates were analysed per site. Additionally, while the test is robust for detecting reproductive toxicity, the report

should clarify that it does not exclude the potential presence of contaminants acting via other toxicological pathways.

5. Microplastics analysis

- The microplastic study remains qualitative due to the selected approach. To align with current international publication standards, future monitoring analysis should include:
A detailed sampling and preparation protocol;
Polymer identification using FTIR, Raman, or pyrolysis-GC-MS;
Quantification in standardised units (items/L or items/kg)
Comparison with global datasets
Discussion of discrepancies exceeding one order of magnitude with published literature justified by sampling gear or mesh size differences.

6. Sediment and bioaccumulation results

- The report correctly notes that sediment contamination does not correlate with proximity to outfalls and is more pronounced near known anthropogenic sources (e.g., Hout Bay Harbour). However, sediment metal enrichment (e.g., Cu, Zn, As, Pb) should be discussed in light of potential cumulative impacts over time, especially where concentrations approach guideline thresholds.
- Bioaccumulation results (Figure 6–8) indicate no statistically significant correlation between metal concentrations and distance from outfalls. This conclusion is well-supported, yet the discussion could be strengthened by including potential confounding factors such as species-specific bioaccumulation kinetics and habitat variability.

7. Hydrodynamics and plume behaviour

- The section on plume dynamics (line 1151) should be expanded, as the modelled effluent plume behaviour provides a crucial interpretive framework. The dynamic nature of plume dispersion, particularly under variable current and temperature conditions, should be presented as central to understanding short-term exceedances and potential seasonal effects.

In conclusion, this report reflects a highly professional and scientifically robust monitoring programme. The data collected provide a sound foundation for assessing the impacts of marine wastewater discharges on Cape Town's coastal environments. The work demonstrates strong alignment with international best practices in environmental monitoring and offers an evidence-based framework for adaptive management. To further enhance the scientific credibility and policy utility of the subsequent reports, methodological transparency, inter-laboratory standardisation, and improved quantification of microplastics and nutrient dynamics are recommended.



18 November 2025

Prof Daniela Pampanin
University of Stavanger

[REDACTED]

[REDACTED]

RE: External review of the draft City of Cape Town Marine Wastewater Outfalls Receiving Environment Monitoring Annual Report 2024/2025

Dear Daniela,

Our thanks for your efforts as external reviewer of a draft version of the City of Cape Town Marine Outfalls Monitoring Annual Report 2024/2025 prepared by Infinity and Anchor. Your inputs have been exceptionally valuable, and we believe the final report has been strengthened significantly in response to your review comments.

A copy of the final report is provided herewith for your records, along with a response to your review comments overleaf.

Thank you once again for your work on this – it has certainly improved the final report and we appreciate your willingness to contribute.

Please feel free to get in touch with any further feedback or to discuss any of the above responses.

Regards,

A handwritten signature in black ink, appearing to read "Barry Clark".

Barry Clark

Anchor Environmental

A handwritten signature in black ink, appearing to read "Jeremy Rose".

Jeremy Rose

Infinity Environmental

Comments by Reviewer: Prof Daniela Pampanin (University of Stavanger)	Response by authors
Objective: External Review of the CCT Marine Outfalls Report 2024-2025 As a reviewer of the City of Cape Town Marine Outfalls Monitoring Report 2025, I would like to commend the City and its consultants for the considerable effort and dedication invested in this first year of the monitoring programme. The study presents a well-designed and multidisciplinary approach to assessing the environmental performance of marine wastewater outfalls, reflecting a genuine commitment to responsible coastal management and evidence-based decision-making. This work provides a strong foundation for understanding the condition of the receiving environment and for guiding future improvements in wastewater management. The comments and recommendations below are offered to support the continued refinement and strengthening of this important programme.	Thank you. We believe the final report has been strengthened significantly in response to your review comments.
General Evaluation The first-year report of the City of Cape Town's three-year marine outfalls monitoring programme (2024–2025) constitutes a thorough and well-structured environmental assessment, demonstrating substantial effort, technical competence, and multidisciplinary integration. The programme is comprehensive in scope, encompassing six key areas: (1) water quality (physicochemical parameters, nutrients, and metals); (2) ecotoxicity using sea urchin fertilisation bioassays; (3) sediment quality (VOCs, PAHs, TPHs, TOC, and phenols); (4) bioaccumulation studies in resident and caged biota (breem, rock lobsters, and black mussels); (5) monitoring of contaminants of emerging concern (pharmaceuticals, personal care products, and herbicides) and microplastics; and (6) assessment of ecological effects through surveys of benthic and reef communities. The report provides an extensive dataset collected between July 2024 and June 2025, and it presents findings with a commendable level of detail and scientific rigour. The integration of field observations, laboratory analyses, and model validation enhances the overall credibility of the results. Notably, the report confirms that while effluent plumes from the Green Point, Camps Bay, and Hout Bay marine outfalls are frequently detectable, their physical and chemical effects remain largely confined within the allowable mixing zones (AMZs), and compliance with permit conditions has generally been achieved. The confirmation of dispersion model predictions from earlier studies (2020–2021) is a particularly valuable outcome, strengthening confidence in these models as management tools for temporal and spatial interpretation of effluent dynamics. The breadth of the monitoring design reflects a well-considered, ecosystem-based approach, ensuring that both acute and chronic impacts are captured. The inclusion of bioassays (sea urchin fertilisation), sediment toxicity testing, and bioaccumulation analyses provides a solid foundation for assessing ecological risk beyond simple compliance monitoring. Furthermore, the consistency between observed plume behaviour and modelled outputs demonstrates sound integration between empirical and predictive approaches. The documentation of faecal indicator bacteria (FIB) exceedances primarily following rainfall events highlights the programme's sensitivity to distinguishing between outfall-derived and land-based contamination sources. The study's finding that most water quality parameters, including suspended solids and metals, remain within natural variability limits at reference sites is encouraging. The lack of major acute toxicity in seawater samples and the absence of significant ecological degradation in benthic and reef communities suggest that the assimilative capacity of the marine receiving environments has not been	Thank you – we concur with this summary of the annual report, and note the

Comments by Reviewer: Prof Daniela Pampanin (University of Stavanger)	Response by authors
exceeded under current discharge regimes. The incorporation of microplastic monitoring, though qualitative at this stage, is a valuable addition, demonstrating responsiveness to emerging global environmental concerns.	
Study purpose - While the report highlights the role of dilution and dispersion in mitigating immediate pollutant concentrations, it would be advisable to rephrase the paragraph in line 65 to avoid possible misunderstanding. Dilution and dispersion should not be interpreted as sustainable solutions to pollution management, since continuous discharge may still lead to gradual accumulation of contaminants in the marine environment. It is recommended that the text clarify that long-term environmental protection depends on ensuring that wastewater discharges contain pollutant concentrations low enough to pose no risk to ecosystems or human health.	Thank you for highlighting this – the description of the functioning and purpose of marine outfalls in the Introduction has been strengthened and clarified on this basis.
Methodological clarity and standardisation - In Section 2.2 (Bioaccumulation), it should be clearly specified whether analyses were performed on wild or caged organisms, and at what distance from the outfalls the samples were collected. This information is critical for interpreting exposure gradients. - In the microbiology section (line 556), details on sample transport and storage conditions should be added to ensure traceability and comparability with subsequent analyses (as is done for ecotoxicity samples in Section 2.2.3.2). - For the metals analysis (line 647), greater transparency is required regarding laboratory selection and quality assurance procedures. The rationale for choosing the UK laboratory should be stated explicitly, and data on inter-laboratory variability, analytical recovery, and the use of internal standards should be presented. Spiking with known concentrations and inclusion of certified reference materials would further support data integrity. With the introduction of a new laboratory for the 2025–2026 cycle (line 676), measures to ensure inter-laboratory comparability must be outlined, as analytical discrepancies can arise from instrument sensitivity and detection limits (LOD/LOQ).	Section 2.2 has been updated to clarify that wild organisms were used, and distances from the outfalls is plotted. The sections on metals in water has been substantially revised. Data on interlaboratory variability has been incorporated into Appendix II. Recommendations for quality assurance in future monitoring are appreciated and will be incorporated.
Nutrient and temperature data interpretation - The reported nutrient concentrations, which were two to three orders of magnitude higher than in previous surveys (line 1200), require detailed scrutiny. These anomalies could stem from methodological inconsistencies, instrument calibration issues, or environmental drivers such as changing water temperature regimes (line 739; 9.4°C– 15.4°C range). Comparative testing using both the old and new laboratories for a subset of samples would allow for verification and improve confidence in the nutrient dataset before continuing the full monitoring cycle.	- Uncertainties surrounding the validity of reported and nutrient concentrations are acknowledged in the report. We have elected in the final report not to include assessments based on these data while the necessary laboratory quality control measures are pursued. Data are reported in appendices only for the sake of completeness and to confirm the attempts to comply with the DFFE-approved monitoring programme.
Ecotoxicity and variability - The whole effluent toxicity tests using sea urchin fertilisation assays indicate no detectable contaminants that directly inhibit fertilisation. However, they cannot exclude the presence of other toxicants acting through different mechanisms. This limitation should be clearly	- Some of the limitations of toxicity testing have been expanded on in the

Comments by Reviewer: Prof Daniela Pampanin (University of Stavanger)	Response by authors
stated. Nonetheless, the assay remains a sensitive and widely recognised method for assessing sublethal toxicity in marine environments. - The variability in sea urchin fertilisation success between samples raises questions about sample homogeneity and replication. The report should specify how water samples were homogenised before testing and how many replicates were analysed per site. Additionally, while the test is robust for detecting reproductive toxicity, the report 4 should clarify that it does not exclude the potential presence of contaminants acting via other toxicological pathways.	relevant sections of the report. - Additional details as suggested here have been incorporated into the relevant methodology descriptions in the final report.
Microplastics analysis – - The microplastic study remains qualitative due to the selected approach. To align with current international publication standards, future monitoring analysis should include: - o A detailed sampling and preparation protocol; Polymer identification using FTIR, Raman, or pyrolysis-GC-MS; - o Quantification in standardised units (items/L or items/kg); - o Comparison with global datasets; and - o Discussion of discrepancies exceeding one order of magnitude with published literature justified by sampling gear or mesh size differences.	The conclusions of the microplastics chapter have been reviewed and revised to clarify the exploratory nature of the study. Recommendations for future work are appreciated, and will be considered in light of available resources.
Sediment and bioaccumulation results – - The report correctly notes that sediment contamination does not correlate with proximity to outfalls and is more pronounced near known anthropogenic sources (e.g., Hout Bay Harbour). However, sediment metal enrichment (e.g., Cu, Zn, As, Pb) should be discussed in light of potential cumulative impacts over time, especially where concentrations approach guideline thresholds. - Bioaccumulation results (Figure 6–8) indicate no statistically significant correlation between metal concentrations and distance from outfalls. This conclusion is well supported, yet the discussion could be strengthened by including potential confounding factors such as species-specific bioaccumulation kinetics and habitat variability.	We concur with this summary, and comparisons with available historic data are already included, but statistical analyses are challenging with current sample sizes. The three-year assessment will have more potential to consider cumulative effects over time. Some additional information in relation to the species selected, their habitats and other potential confounding factors has been included.
7. Hydrodynamics and plume behaviour - The section on plume dynamics (line 1151) should be expanded, as the modelled effluent plume behaviour provides a crucial interpretive framework. The dynamic nature of plume dispersion, particularly under variable current and temperature conditions, should be presented as central to understanding short-term exceedances and potential seasonal effects.	The plume dispersion modelling conducted by PRDW is better described in the source reports, links to which have now been incorporated into the final report.
In conclusion, this report reflects a highly professional and scientifically robust monitoring programme. The data collected provide a sound foundation for assessing the impacts of marine wastewater discharges on Cape Town's coastal environments. The work demonstrates strong alignment with international best practices in environmental monitoring and offers an evidence-based framework for adaptive management. To further enhance the scientific credibility and policy utility of the subsequent reports, methodological transparency, interlaboratory standardisation, and improved quantification of microplastics and nutrient dynamics are recommended.	Thank you for this feedback – we appreciate the constructive inputs and have incorporated revisions in response to your suggestions.