Marine Biodiversity Assessment

CAMPS BAY OUTFALL

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1 Introduction

The City of Cape Town (CCT) treats most household and industrial liquid waste at 17 wastewater treatment works (WWTW) and six smaller facilities (CCT, 2018). At the WWTWs wastewater undergoes secondary treatment processes, including chemical or ultraviolet disinfection, before being discharged into rivers, canals, vleis, aquifers or the sea. However, as in other South African coastal cities and elsewhere globally, the CCT's wastewater management strategy includes discharging preliminarily treated wastewater into the marine environment via three marine outfalls located in Green Point, Camps Bay, and Hout Bay.

Preliminarily treatment includes sand and grit removal followed by screening to remove plastic, paper, and larger foreign materials. No chemicals are used in this process. The screened effluent is then pumped and discharged through underwater pipelines and discharged through offshore diffusers. Diffusers at the end of the pipeline have multiple ports that discharge effluent in alternating horizontal directions to aid dispersion and dilution. While preliminary treatment reduces the suspended solids load and removes objects such as plastic, rags and paper, there is inefficient removal of other contaminants related to wastewater. However, well-designed, maintained, and effective outfalls using preliminary treatment processes are considered to pose a low human health risk (WHO, 2003).

Camps Bay was chosen for this initial biodiversity assessment as of the three sites it is least affected by either other major sources of pollution or known marine extraction activities. At Hout Bay there is substantial ongoing nearshore wastewater pollution from the Disa and Baviaans Rivers, pollution from the harbour and significant marine resource extraction (fishing, harvesting, poaching) on the seaward side of the Sentinel. Similarly, Green Point is close to the Port of Cape Town, as well as Black River and the Diep River, the latter both heavily polluted and discharging substantial daily volumes of contaminated water into Table Bay.

As part of the CCT's environmental monitoring efforts, CLS Southern Africa (CLS SA) was contracted to conduct a once off biodiversity assessment at the Camps Bay outfall. The outfall was commissioned in 1977 and is the oldest of the three systems. The outfall itself is 1.5 km long and is designed for a discharge of 5.5 million litres (ML) of effluent per day at a depth of 23 m (Figure 1.1). The objective of this initial assessment was to investigate whether the discharge from the outfall has had any measurable effects on sessile biota on rock surfaces, rock lobster or fish. This document provides the methods, results and discussion related to this assessment.

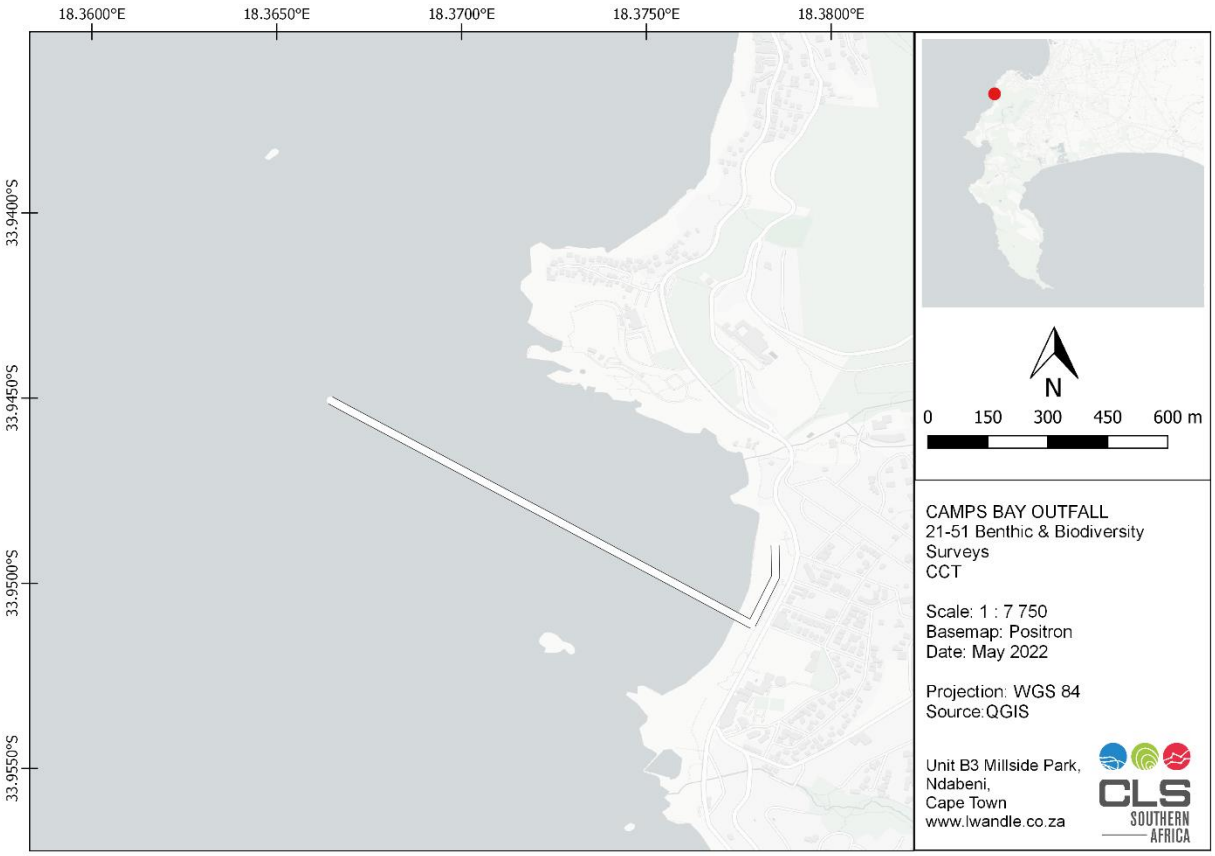

Figure 1.1: Map of the Camps Bay outfall.

2 Approach

The biodiversity assessment utilised a control-impact survey design, with replicate surveys being conducted at the outfall (impact area) and three comparable control areas. It is best practice to compare biodiversity against multiple control areas as conclusions can be confounded by natural variation (Underwood, 1992; Underwood, 1993; Stewart-Oaten & Bence, 2001). It is also important that these control areas represent environments that are comparable to the impact area in terms of habitat, geomorphology, seabed topography, and oceanographic parameters but are also geographically distant from, in this case, the discharge being investigated. The biodiversity of sessile biota within each area was assessed by quadrat imagery and species counts, including rock lobster counts, by scuba divers, and deployments of baited remote underwater video systems (BRUVS) for fish. Collected data underwent suitable quality controls, processing and statistical analyses where required. Field work and data analyses protocols are detailed in Section 5.

3 Site Description

Camps Bay is a small embayment (~850 m wide) located on the west coast of the Cape peninsula. The surrounding coastline is characterised by rocky headlands and shores with sandy pocket beaches in between. Camps Bay beach itself is bounded by rocky headlands with Maidens Cove to the north and the rocky shores below Camps Bay drive to the south. Nearshore subtidal rocky substrate at these headlands is dominated by kelp (*Ecklonia maxima & Laminaria pallida*) and related biological communities. The seafloor inshore of the diffusers is mainly medium to coarse grained sand, however at the diffusers, and

to the north and south of the diffusers, there are extensive underwater granite boulders and exposed bedrock (Eagle *et al.,*1977; CSIR, 2017). Between these reef structures there are pockets of sand which range in size. These reported characteristics were confirmed by drop camera footage collected by CLS SA during a site visit prior to field work.

Wave action is strong within Camps Bay, with waves generally propagating from the south-west direction throughout the year (PRDW, 2020). The southern corner of the bay is more protected from this than the northern edge of the bay. Water column measurements recorded during summer and winter in 2021 show seawater temperatures ranging from 9.6 °C to 15.1 °C within Camps Bay (CLS SA, 2021). This is within the expected range for the greater Table Bay region (Quick & Roberts, 1993; Lwandle, 2007).

Camps Bay falls within the large Table Mountain National Park (TMNP) multi-use Marine Protected Area (MPA). Commercial and recreational fishing and shellfish harvesting are allowed with associated permits within the MPA. There are however several 'no-take' zones, for example the Karbonkelberg sanctuary south of Camps Bay. The entirety of Table Bay falls within a West Coast rock lobster (*Jasus lalandii)* closed area in which no lobsters may be caught recreationally or commercially.

The sandy beach at Camps Bay is a tourist attraction and is popular among beachgoers, swimmers, kayakers, divers, and surfers, mostly in the summer months.

4 Survey Design

This assessment included survey activities at the outfall (impact area, within 500 m distance) and three comparable far field control areas (control areas, respectively at ~3 600 m, 4 600 m, and 10 000 m distance). The mixing zone distance required to meet water quality guidelines has been estimated by dispersion modelling to be a maximum of 260 m from the outfall for enterococci and suspended solids (PRDW, 2020). Drop camera imagery, bathymetry data, marine charts, and satellite imagery, were used to select three suitable control areas along the coastline adjacent to Camps Bay. These were then shifted in the field based on in-situ observations where required. The selected locations areal extent is similar to that of the corresponding impact area (Figure 4.1). Ecoregions, MPA zonation and other anthropogenic disturbances were also considered when selecting locations to ensure comparability between surveyed areas. However, two of the control areas fall within the TMNP MPA no-take zone. Additionally, the study area is urbanised, and the surrounding coastal waters are exposed to anthropogenic disturbances from multiple sources and activities. This includes substantial urban runoff including but not limited to stormwater drain outlets as shown in Figure 4.1.

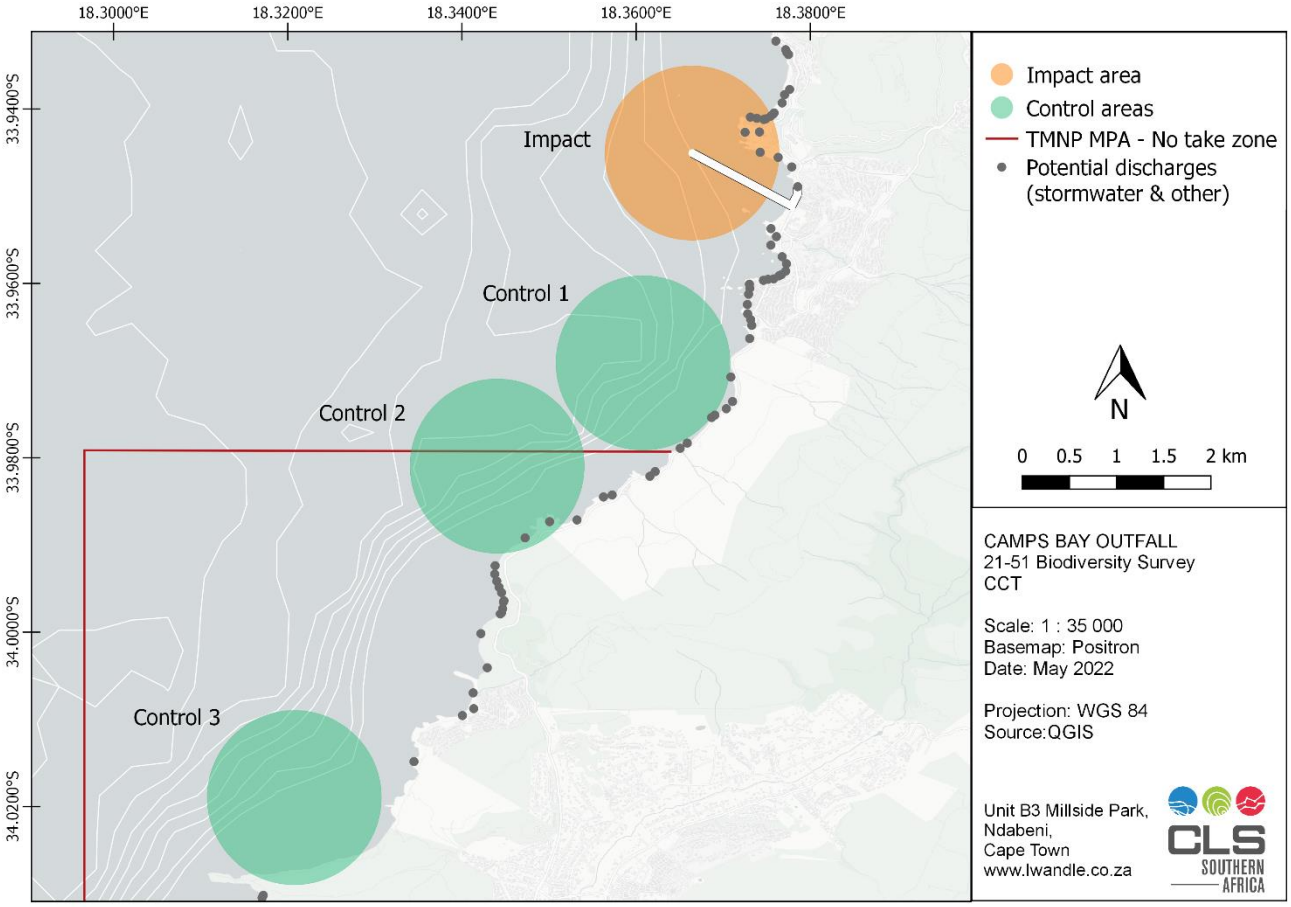

Figure 4.1: Map showing the four sampling areas included in this assessment (Impact, Control 1, Control 2, Control 3), in relation to the TMNP MPA no-take zone and other potential discharge sources (stormwater drains etc., provided by CCT).

In each of the four sampling areas (Impact, Control 1, Control 2, Control 3), three reef sites were selected to cover the depth strata 5-9 m (shallow), 10-14 m (mid-depth) and 15-25 m (deep), respectively. In total, 12 depth stratified reefs were surveyed (Table 4.1).

At each of these reef sites, scuba divers estimated the percentage cover of invertebrate and macroalgae species within five randomly placed quadrats. These quadrats were also photographed. Additionally, scuba divers conducted rock lobster counts along three radial 10 m transects, recording the number of juveniles, sub-adult and adult sized rock lobsters observed. At the 10-14 m reef sites three BRUVs were deployed sequentially to assess the fish community structure and abundance. The Control 3 area is an exception as here only two BRUV deployments were completed due to camera battery constraints.

Table 4.1: Summary of the sampling activities completed within each sampling area.

Sampling Area & Activity	Shallow reef site 5-9 m	Mid-depth reef site 10-14 m	Deep reef site 15-25 m	Total
Impact				
Quadrat observations	5	5	5	**15**
Lobster counts	3	3	3	**9**
BRUVs	-	3	-	**3**
Control 1				
Quadrat observations	5	5	5	**15**
Lobster counts	3	3	3	**9**
BRUVs	-	3	-	**3**
Control 2				
Quadrat observations	5	5	5	**15**
Lobster counts	3	3	3	**9**
BRUVs	-	3	-	**3**
Control 3				
Quadrat observations	5	5	5	**15**
Lobster counts	3	3	3	**9**
BRUVs	-	2	-	**2**

The resulting metrics from this survey for each sampling area (Impact, Control 1, Control 2, Control 3) are thus:

Quadrat Observations

- Percentage cover of invertebrate species per quadrat
- Percentage cover macroalgae species per quadrat
- Number of taxa per quadrat

Lobster Counts

- Size classified rock lobster counts per reef site

BRUVs (fish)

- Max number of individuals of a species in any one video frame (MaxN)
- Relative abundance of each species

5 Methods

This section details the field work and data analyses protocols that were followed for each of the survey components. The sampling plan for this survey is included in Appendix A.

The biodiversity survey was conducted over three days (4th, 5th, and 12th of April 2022) by a team of experienced scuba divers from University of Cape Town's Research Dive Unit (UCT RDU). CCT provided the vessels and skippers for this work. A commercial dive supervisor was always present to record individual dive times and ensure the recommended no decompression limits were adhered to.

On arrival to each sampling area, three suitable depth stratified reefs were selected and marked by shot lines with surface marker buoys. Figure 5.1 shows the location of each of the reef sites, and Table 5.1

lists the site depths and distances away from the discharge. At each reef site, all observations were made within a 10 m radius of the shot line.

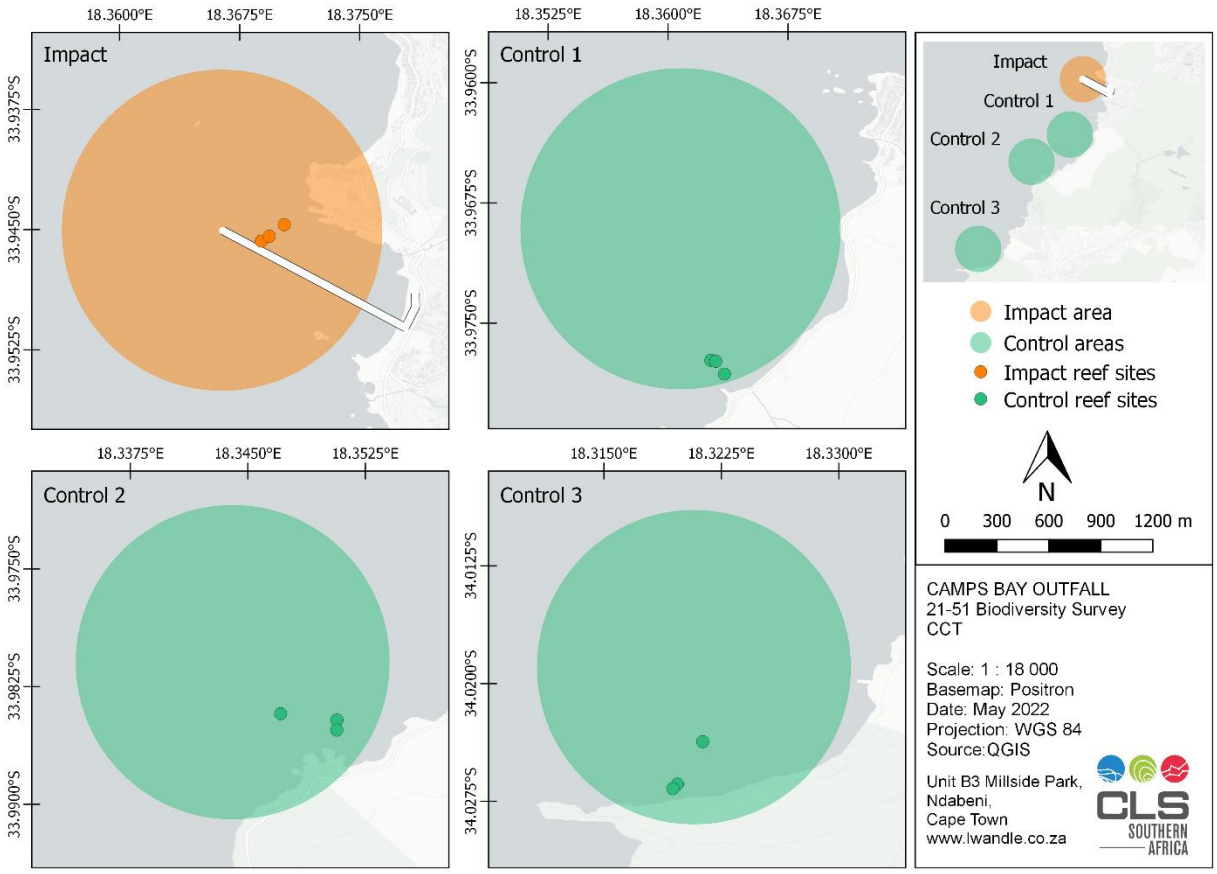

Figure 5.1: Map showing the locations of the three depth-stratified reef sites within the Impact, Control 1, Control 2, and Control 3 sampling areas.

Table 5.1: Site depths and approximate distances away from the outfall discharge.

Site name	Depth (m)	Distance from outfall (m)	Site name	Depth (m)	Distance from outfall (m)
Impact shallow	6	352	**Control 2 shallow**	6	4685
Impact mid-depth	14	270	**Control 2 mid-depth**	10	4618
Impact deep	18	235	**Control 2 deep**	16	4690
Control 1 shallow	9	3680	**Control 3 shallow**	8	10050
Control 1 mid-depth	13	3595	**Control 3 mid-depth**	13	10000
Control 1 deep	16	3590	**Control 3 deep**	24	9660

5.1 Field Work

5.1.1 Quadrat Observations

After descending at the shot line, divers randomly placed a 0.25 m^2 quadrat on the reef area within 10 m of the shot line. Divers then recorded the percentage cover of all sessile species and macroalgae species present in the quadrat on a dive slate. Cover is defined as the fraction of the total quadrat area that is obscured by a particular species when viewed directly from above. A total of five randomly placed

quadrats were assessed at each reef. Divers carried a GoPro Hero 8 video camera and recorded footage of the quadrats as well as the surrounding reef. After each field day, data recorded on dive slates were transcribed to electronic data sheets. The above process was conducted at the three depth stratified reef sites in each of the four sampling areas.

5.1.2 Rock Lobster Counts

After descending at the shot line, divers laid out three 10 m long metered chains in outward radial directions from the shot line. Divers then swam along the transects and recorded the number of juvenile, sub-adult and adult rock lobster individuals present per metre of transect. Counts were restricted to 0.5 m either side of the transect chain, therefore transects were 1 m wide. Lobsters were size classed based on carapace length (CL). The following size classes were used: juvenile (less than 50 mm CL), sub-adult (50-75 mm CL), adult (>75 mm CL). Divers used a video camera to record footage of the transects as well as the surrounding reef. After each field day, data recorded on dive slates were transcribed to electronic data sheets. The above process was conducted at the three depth stratified reef sites in each of the four sampling areas.

5.1.3 BRUVs

BRUV deployments were conducted on a different day to the quadrat observations and rock lobster counts to ensure that divers did not impact fish behaviour. Three sequential (separate), replicate BRUV deployments were conducted at the mid-depth reef sites in each sampling area except for Control Area 3 where two deployments were achieved. The deployments in each area ran concurrently as far as possible (i.e., deployment 1 in the impact area overlapped with deployment 1 in each of the control areas, and similarly for deployments 2 and 3). This was done so that environmental conditions were the same during replicate deployments across areas. The mono BRUVs consist of one horizontally mounted GoPro Hero 8 video camera, secured on a stainless-steel landing frame together with an extended arm (1.5 m) that holds the bait canister (~200 mm x 100 mm). Previously frozen, crushed sardines (*Sardinops sagax*) were divided into ~800 g partitions and used for bait in each deployment. A temperature logger (HOBO TidbiT) was attached to each BRUV frame to record temperature at minute intervals during the deployments. Deployment locations were randomly placed adjacent to the mid-depth reef sites.

BRUVs were baited onboard the vessel and the GoPro was switched on to video mode. A surface marker buoy and rope were attached to the frame for easy deployment and retrieval. Once ready for deployment, the BRUV frame was held perpendicular to the boat and lowered to the seafloor. BRUVs were left down for a minimum of 50 minutes soak periods.

5.2 Data Analyses

5.2.1 Quadrat Observations

Diver observations of percentage cover were confirmed using the obtained video footage. The total percentage cover and taxa per quadrat was calculated and the mean and standard deviations were calculated across the various reef site and depth ranges.

Average Shannon-Wiener indices were calculated per sampling area as a measure of species diversity. Non-parametric statistical analysis methods were applied due to departures from normal distributions. Kruskal-Wallis tests were used to test the null hypothesis that percentage cover and species diversity are equal across sampling areas and depth ranges. Dunn's test was used post-hoc following the Kruskal-Wallis tests to conduct multiple pairwise comparisons and identify the significantly different sample means.

5.2.2 Rock Lobster Counts

A stacked histogram was generated to display the size classed lobster count data at each reef site. Counts from the three transects conducted at each reef site were summed for the histogram and analyses.

Non-parametric statistical analysis methods were applied due to departures from normal distributions. A Kruskal-Wallis test was used to test the null hypothesis that lobster abundance at all sampling areas (Impact, Control 1, Control 2, Control 3) are equal. A Dunn's test was conducted post-hoc. This test generates multiple pairwise comparisons between sampling areas. Count data collected within the three different depth strata were also compared using this approach. Both the Kruskal-Wallis and Dunn's tests were also conducted for total lobster numbers at each reef site, irrespective of size class. This was done as incorporating size class in the analysis greatly reduced the power of the statistical tests due to the low numbers of rock lobster in each of the size classes.

5.2.3 BRUVs

Videos were standardised to 45 minutes and analysed using VideoLan VLC Media Player. All species in each video were identified and a MaxN measure was obtained for each species for every deployment. MaxN is the maximum number of individuals of a species in any one frame for the duration of a video (Cappo et al. 2003). Relative frequency of occurrence for each species was calculated as the number of deployments in which a species was recorded, as a fraction of all deployments. Relative abundance for each species was calculated as the sum of all MaxN values for each species divided by the total number of deployments. These metrics were calculated per sampling area.

Species richness, meaning the number of species identified per deployment, was calculated. Shannon-Wiener indices were computed as it is the most widely used diversity index and is sensitive to small scale differences in diversity. The mean and standard deviation of the Shannon-Wiener indices were calculated for each deployment and per sampling area. Non-parametric statistical analysis methods were applied due to departures from normal distributions. The Kruskal-Wallis test was used to test the null hypothesis that species diversity is equal at all sampling areas. A post-hoc Dunn's test was used to conduct the pairwise comparisons between each site.

Data were square root transformed to reduce the effect of outliers. A Bray-Curtis dissimilarity matrix was used to determine the relationship between the MaxN values recorded for each deployment, and a Non-metric Multi-dimensional Scaling (NMDS) plot was generated using this matrix. A Shepard's plot was used to determine whether the ordination was appropriate. An ANOSIM, followed by a SIMPER analysis were conducted to identify the species that contributed the most to the dissimilarity within or between groupings.

6 Results

6.1 Quadrat Observations

A total of 26 taxa were observed across the reef sites, with the most being observed at the shallow reef sites (20). A species list is included in Appendix B. The quadrats recorded at the deep reef sites had a higher average percentage cover (94.30 % SD = 24.45 %) compared to that at the shallower reefs. The quadrats recorded at mid-depth reefs displayed the lowest overall mean percentage cover (78.70 %, SD = 20.22 %). However, there were no statistically significant differences in percentage cover between depth ranges ($X^2 = 2.87$, df = 2, p = 0.238) or between sampling areas ($X^2 = 3.911$, df = 3, P = 0.271).

Black mussels (*Choromytilus meridionalis*) contributed the highest percentage cover and were found in all sampling areas except Control 2. Red macroalgae and encrusting algae also contributed to a high

percentage cover and were widespread across the sampling areas and depth ranges. Stellar sponges (*Crambe acuata*) and Cape Urchins (*Parechinus angulosus*) were also found across the depth ranges however, they were not recorded in sampling area Control 1 quadrats. Black mussels were observed at most reef sites in the shallow and mid depth ranges however few mussels were observed at the deeper reefs. It is expected that the percentage cover values of the large kelps (predominantly *Laminaria pallida*) are underestimated as quadrats could not be placed over the long stipes. All reef sites surveyed were located within kelp forests. An example of the environment is displayed in Figure 6.1.

Figure 6.1: Example of the kelp forest environment with long Laminaria pallida *stipes characteristic of all reef sites surveyed.*

Average Shannon Wiener diversity indices and box plots for each sampling area are listed and shown in Table 6.1 and Figure 6.2, respectively. Control area 2 had the highest index and the Impact area had the lowest index, however there was no significant difference in species diversity between the four areas (X^2 = 3.275, df = 3, p = 0.351). This is supported by the overlapping box plots in Figure 6.2.

Table 6.1: Average quadrat count Shannon-Wiener diversity indices for each sampling area.

Sampling area	Average Shannon-Wiener Indices	Standard deviations
Impact	0.98	0.21
Control 1	0.96	0.40
Control 2	1.18	0.44
Control 3	1.12	0.39

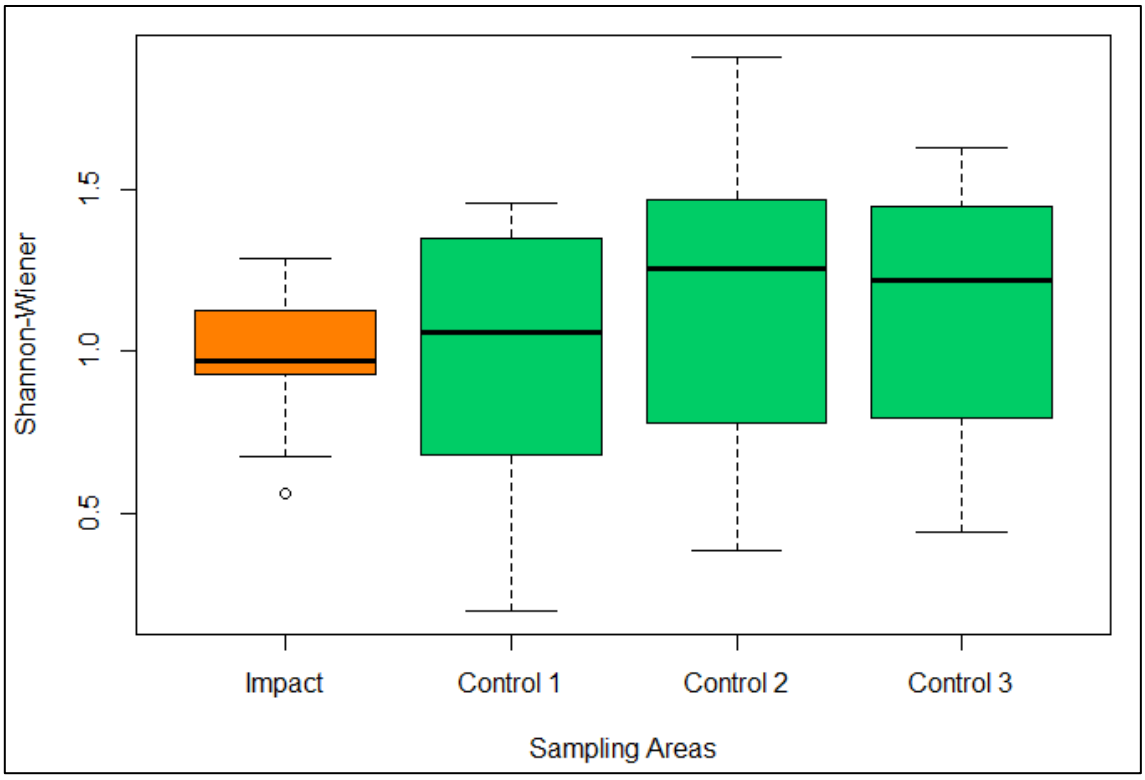

Figure 6.2: Box plots of quadrat count Shannon-Wiener diversity indices for each sampling area.

Table 6.2: Average percentage cover of identified taxa for each reef site. Taxa were idenitied to the lowest possible level and ordered alphabetically.

Taxa	Common name	Impact			Control 1			Control 2			Control 3		
		Shallow	Mid-depth	Deep	Shallow	Mid-depth	Deep	Shallow	Mid-depth	Deep	Shallow	Mid-depth	Deep
Number of quadrats (0.25 m²)		5	5	5	5	5	5	5	5	5	5	5	5
Annelida	Segmented Worm					2%							
Ascidian	Ascidian	1%					5%						
Brachyura	True Crab	1%							5%				
Callopatiria granifera	Red Starfish		1%	4%							2%	1%	
Chaetomorpha linum	Hair Weed		1%										
Choromytilus meridionalis	Black Mussel	42%	25%		14%				31%	35%	30%		13%
Crambe acuata	Stellar Sponge	5%		3%	11%	2%	1%	12%	7%	27%	5%	2%	5%
Ecklonia maxima	Bamboo Kelp				1%				10%				
Unknown	Encrusting Algae	37%	30%	65%	19%	17%	34%	20%	14%	38%	22%	64%	58%
Haliotis midae	Abalone											8%	
Holothuroidea	Sea Cucumber									8%			5%
Hydrozoa	Hyrdoids				13%	5%	11%		10%	13%			5%
Laminaria pallida	Split Frond Kelp	5%	2%	5%		5%			3%	10%		3%	
Marthasterias glacialis	Spiny Starfish		1%				5%		8%	1%	9%	10%	7%
Unknown	Mussel Spat			50%				44%	5%	5%			
Ophiuroidea	Brittle Star										1%		
Opisthobranchia	Nudibranch	1%									5%		
Parechinus angulosus	Cape Urchin	1%	4%	1%	2%			4%	2%	15%	13%	7%	11%
Polymastia mamillaris	Teat Sponge		2%	15%				50%	2%				
Porifera	Sponge (Black)		2%	15%		25%				10%	2%	10%	
Rhodophyte	Red Algae	30%	7%	8%	19%	32%	18%	5%	27%		25%	50%	5%
Sabellidae	Fan Worm										5%		
Spirobis	Tube Worm									18%			
Tethya aurantium	Golf Ball Sponge			20%	70%	35%	64%	24%	10%			18%	5%
Turbo sarmaticus	Alikreukel												
Whelk	Whelk	3%		1%	2%	3%	1%				5%	3%	1%
Sum Biological Cover		**95%**	**66%**	**95%**	**75%**	**66%**	**96%**	**98%**	**89%**	**100%**	**96%**	**95%**	**86%**
Estimated bare substrate (rock/sand)		**5%**	**34%**	**5%**	**25%**	**34%**	**4%**	**2%**	**11%**	**0%**	**4%**	**5%**	**14%**
Total Number of Taxa		**6**	**5**	**4**	**5**	**4**	**4**	**5**	**6**	**5**	**7**	**5**	**5**

6.2 Rock Lobster Counts

A total of 80 rock lobster were counted over the 360 m^2 surveyed during this assessment. There was an average of 4.11 (SD = 4.51) individuals observed across the three depth stratified reefs at the Impact sampling area (per 90 m^2). Control 1, Control 2, and Control 3 sampling areas displayed much lower average counts of 1.78 (SD = 3.29), 1.11 (SD = 2.81) and 1.90 (SD = 2.47) per 90 m^2 respectively (Figure 6.3). These averages have high standard deviations due to the variation in counts between reefs. There was no significant difference between the abundance of lobster at any of the four sampling areas (X^2 = 4.53, df = 3, p = 0.21), therefore we accept the null hypothesis.

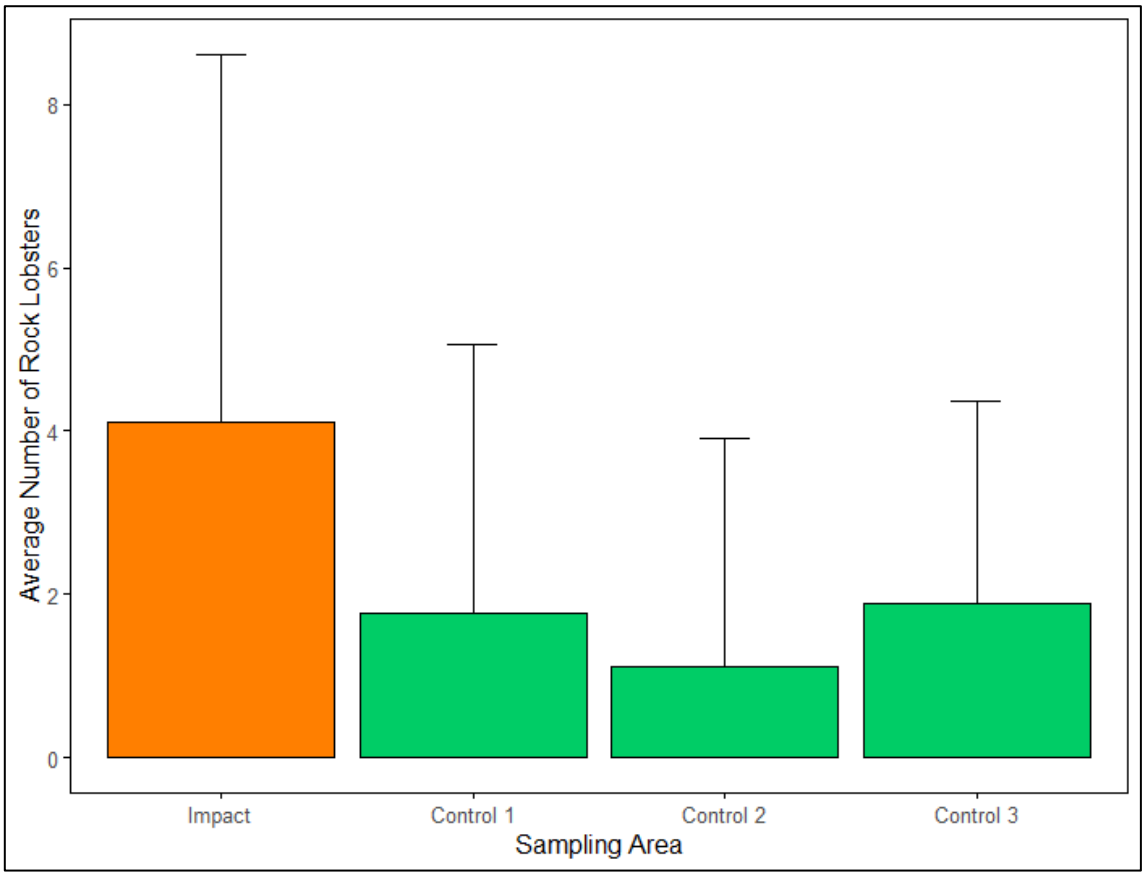

Figure 6.3: Average number of rock lobster counted in each sampling area. Error bars show the upper standard deviations related to each average.

Figure 6.4 shows the rock lobster counts at each reef site. The shallow reef in the designated impact area had the highest rock lobster count which were exclusively juveniles. Rock lobsters observed at the Impact, Control 1 and Control 2 sampling areas were majority juveniles, with only two sub-adults and no adult rock lobsters observed in these areas. Adult and sub-adult size classes were mainly restricted to mid-depth and below in the Control 3 area. There was no significant difference in the abundance of rock lobster between the different depth ranges, irrespective of sampling area and size class (X^2 = 1.13, df = 2, p = 0.57).

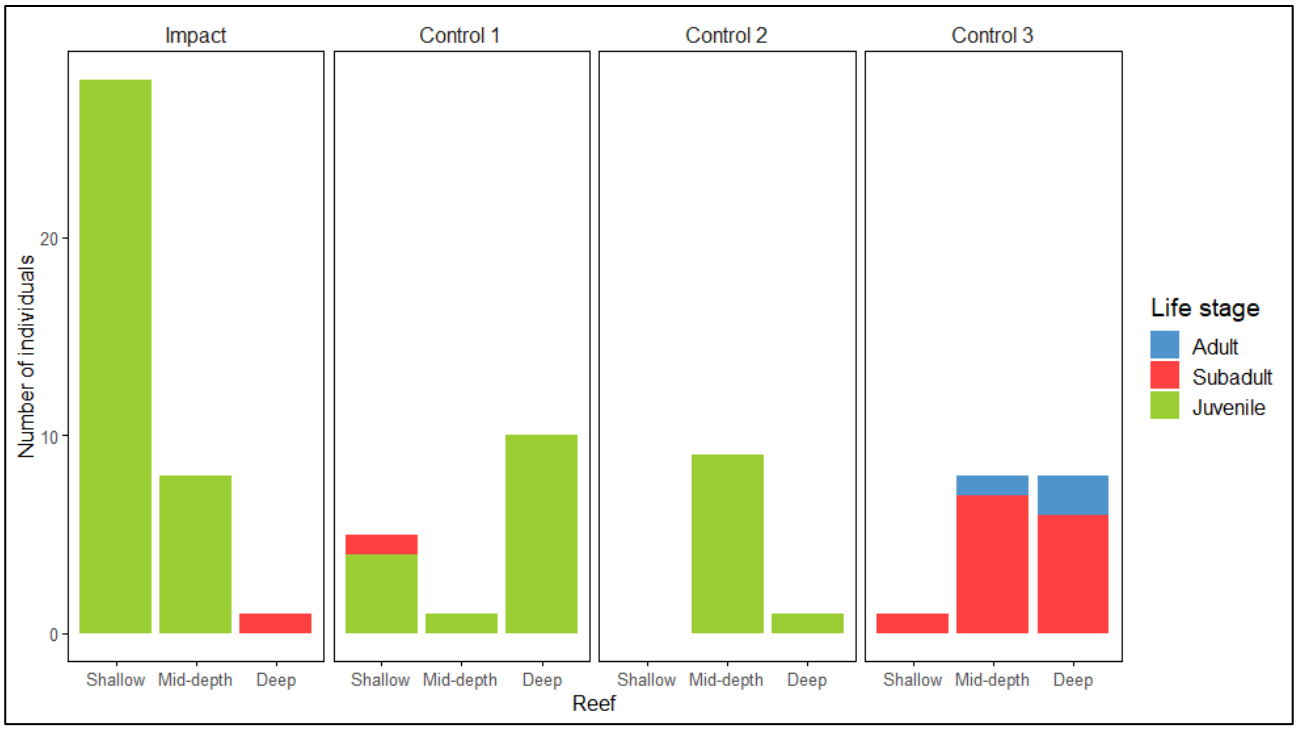

Figure 6.4: The total number of juvenile, sub-adult and adult rock lobster observed at each reef site. Shallow = 5-9 m, Mid-depth = 10-14 m and Deep = 15-25 m. Counts are a sum of three 10 m x 1 m transects at each reef, therefore are per 30 m².

6.3 BRUVs

A total of 11 species from eight different taxonomic families were observed in this assessment (Table 6.4). A species list is included in Appendix B. There were high numbers (100-200) of small, likely juvenile, fish (1-2 cm) observed during deployments in Control 1 and Control 2. These could not be identified.

The most taxa were observed during deployments at Control 1 and the least were observed at Control 2. Despite only two deployments, Control 3 had the highest average species richness (4.0, SD = 1.0) (Table 6.3). According to the Shannon-Wiener index, Control 3 also displayed the highest level of species diversity, while the lowest species diversity was observed in Control 2 (Table 6.3, Figure 6.5). There was no significant difference in the species diversity (Shannon-Wiener indices) between the 4 sampling areas (X^2=4.12, df=3, p=0.25). We therefore accept the null hypothesis.

Table 6.3: Species richness and Shannon-Wiener indices for each BRUV deployment, and averages for each sampling area. SD = standard deviation.

Sampling Area	Deployment	Species richness		Shannon-Wiener	
		Index	Average (SD)	Index	Average (SD)
Impact	D1	2.00	3.00 (0.82)	0.29	0.56 (0.19)
	D2	3.00		0.72	
	D3	4.00		0.66	
Control 1	D1	4.00	3.67 (1.25)	0.42	0.52 (0.30)
	D2	2.00		0.22	
	D3	5.00		0.93	
Control 2	D1	2.00	2.00 (0.82)	0.21	0.26 (0.05)
	D2	3.00		0.31	
	D3	1.00		-	
Control 3	D1	5.00	4.00 (1.00)	0.58	0.79 (0.22)
	D2	3.00		1.01	

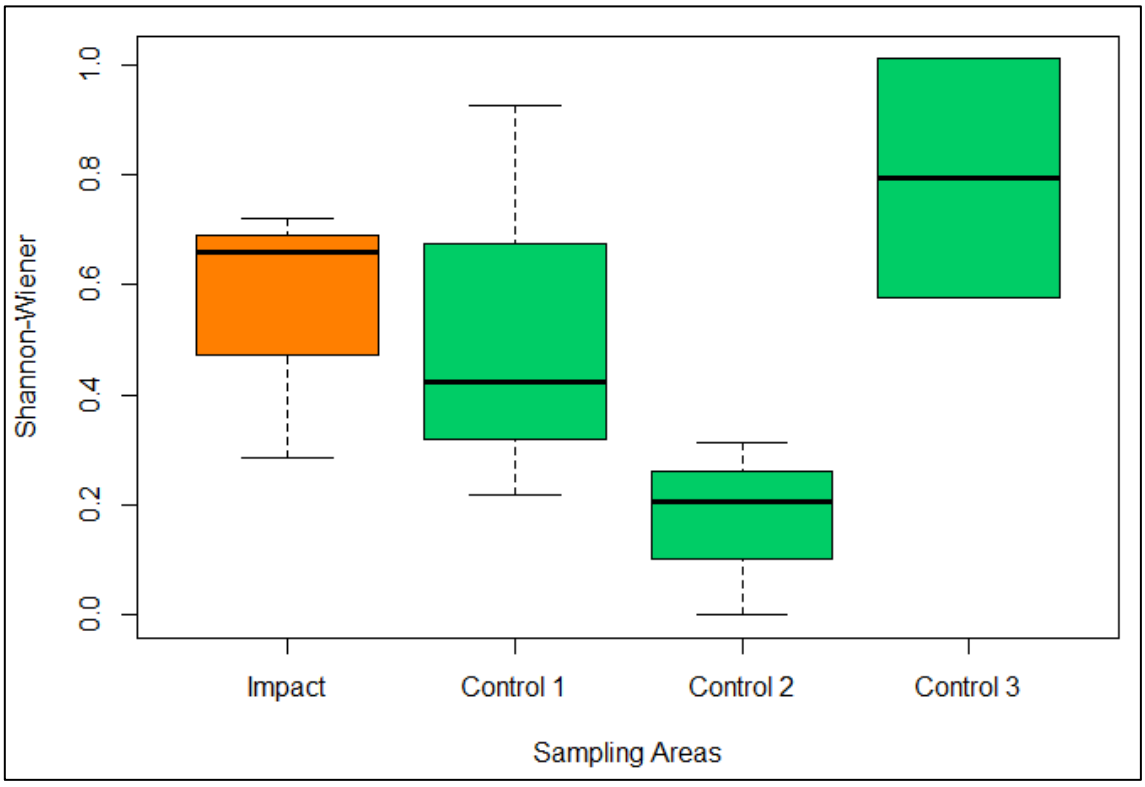

Figure 6.5: Box plots of Shannon-Wiener diversity indices for BRUV counts in each sampling area.

The most frequently recorded species was Cape Bream (*Pachymetapon blonchii)*, which was observed during every deployment (Figure 6.6). Super Klipvis (*Clinus superciliosus)* were also common and were observed within every sampling area (Figure 6.6). Relative abundance for this species was lowest at the impact area, and highest in Control 2 (Table 6.5).

The NMDS plot did not reveal any groupings between any of the sites or deployments (not shown). The ANOSIM supported this (R = -0.06, P=0.5781). The very low and negative R statistic means that there

was slightly more variation within the sites than between sites and therefore we can conclude that the sites are not significantly different from one another. The SIMPER analysis revealed that the presence of abundant, unidentified juvenile fish and Cape Bream were mostly responsible for the differences between sites, but not to the degree to yield a significant result.

Average seawater temperatures recorded during all deployments ranged from 10.4 to 12.1 °C (data not shown). The lowest temperature was observed at Control 3, but there is no apparent effect on fish abundance or diversity.

Figure 6.6: TOP: Cape Bream recorded at sampling area Control 1. BOTTOM: *Cape Bream* and Super Klipvis (*Clinus superciliosus*) (circled) recorded at sampling area Control 2.

Table 6.4: MaxN of each species identified in BRUV deployments per sampling area and deployment (D) number. MaxN is the maximum number of individuals of a species in any one frame for the duration of each deployment. Species are ordered alphabetically.

Species name	Common name	Impact			Control 1			Control 2			Control 3	
		D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2
Arctocephalus pusillus	Cape Fur Seal	-	-	1	-	-	1	-	-	-	-	-
Clinus cottoides	Bluntnose Klipvis	-	2	-	-	-	-	-	-	-	-	-
Clinus superciliosus	Super Klipvis	-	1	1	1	-	-	1	1	-	1	3
Diplodus capensis	Blacktail	-	-	-	1	-	1	-	-	-	-	-
Galeichthys feliceps	White Catfish	-	-	1	-	-	1	-	-	-	1	-
Haploblepharus pictus	Dark Shyshark	-	-	-	-	-	-	-	-	-	1	-
Jasus lalandii	West Coast Rock Lobster	-	-	-	-	-	2	-	-	-	-	-
Pachymetopon blochii	Cape Bream	11	9	14	28	12	14	18	8	36	26	7
Plagusia chabrus	Cape Rock Crab	1	-	-	1	-	-	-	-	-	-	3
Sebastes capensis	False Jacopever	-	-	-	-	-	-	-	-	-	1	-
Unknown	Unidentified juvenile fish	-	-	-	-	200	-	-	100	-	-	-

Table 6.5: Relative frequency and abundance of each species (as defined in text) per each sampling area. Species are ordered alphabetically.

Common name	Species name	Frequency	Relative frequency				Relative abundance			
			Impact	Control 1	Control 2	Control 3	Impact	Control 1	Control 2	Control 3
Cape Fur Seal	*Arctocephalus pusillus*	2	0.33	0.33	-	-	0.33	0.33	-	-
Bluntnose Klipvis	*Clinus cottoides*	1	0.33	-	-	-	0.67	-	-	-
Super Klipvis	*Clinus superciliosus*	7	0.67	0.33	0.67	1.00	0.67	0.33	0.67	2
Blacktail	*Diplodus capensis*	2	-	0.67	-	-	-	0.67	-	-
White Catfish	*Galeichthys feliceps*	3	0.33	0.33	-	0.50	0.33	0.33	-	0.5
Dark Shyshark	*Haploblepharus pictus*	1	-	-	-	0.50	-	-	-	0.5
West Coast Rock Lobster	*Jasus lalandii*	1	-	0.33	-	-	-	0.67	-	-
Cape Bream	*Pachymetopon blochii*	11	1.00	1.00	1.00	1.00	11.33	18	20.67	16.5
Cape Rock Crab	*Plagusia chabrus*	3	0.33	0.33	-	0.50	0.33	0.33	-	1.5
False Jacopever	*Sebastes capensis*	1	-	-	-	0.50	-	-	-	0.5
Unidentified juvenile fish	Unknown	2	-	0.33	0.33	-	-	66.67	33.33	-

7 Discussion

A total area of 15 m^2 was assessed via 0.25 m^2 quadrat observations across depth ranges and sampling areas. The average percentage cover and species diversity did not differ significantly between the four sampling areas. The composition of primary producers, grazers, detritus and filter feeders, and carnivores identified are characteristic of the greater Table Bay and West Coast kelp forest communities (Velimirov *et al.,*1977; Field *et al.,*1980; Quick & Roberts, 1993; Branch, 2017). It is expected that the abundance and cover of large kelps are underestimated in this study as quadrats could not be placed over the long stipes. Historic surveys show that kelp forests in this region are composed of *Ecklonia maxima* in the shallower regions (<5 m) with the presence *Laminaria pallida* increasing rapidly with depths greater than 5 m (Velimirov *et al.,*1977; Field *et al.,*1980). This distribution pattern aligns with non-quantitative field observations and video footage. Based on data collected during this assessment, no measurable effects on the percentage cover or species diversity of invertebrates and macroalgae were evident that could be attributed to the effluent from the Camps Bay outfall.

In southern Africa, West Coast rock lobster occur inshore (<200 m depth) from, just north of Walvis Bay in Namibia to East London on the south east coast. This species is an important predator in shallow marine systems, strongly influencing prey density and population structure (Velimirov *et al.,*1977; Barkai and Branch 1988, Branch, 2018). West Coast rock lobster are slow growing, long-lived animals. They are listed in the National Environmental Management Biodiversity Act of 2004, as a threatened and protected species, which means that it is a species of high conservation value. Despite this, and the stock status being categorised as 'heavily depleted' by the Department of Forestry, Fisheries, and the Environment (DFFE), legal and illegal extraction levels remain high. The current harvestable biomass is estimated at 2-3% of the pre-exploitation levels in the 19th century (Johnston & Butterworth, 2018). This decline has been attributed to large, unsustainable catches taken particularly during the mid-1900s, a substantial reduction in the somatic growth rate over the last thirty years, and increasingly uncontrolled poaching (Johnston & Butterworth, 2018). The entire survey area included in this assessment falls within a designated West Coast rock lobster sanctuary, therefore commercial and recreational removal of this species should not take place.

A total area of 360 m^2 was assessed across depth ranges and sampling areas during the rock lobster counts. Most rock lobsters observed in this study were juvenile sized (<50 mm CL), however control area 3 contained only sub-adult and adult rock lobsters. The high number of juveniles is due to successful recruitment from the post-larval puerulus life stage. Puerulus settlement generally occurs nearshore in shallow waters and juveniles move into deeper waters as they grow. Thus, in shallow areas more juveniles than larger adult/subadult stages are expected. As water depth increases, this changes to a higher dominance of older, larger rock lobster. The abundance in the discharge location does not suggest that the species is influenced by the discharge. Although the highest number of rock lobster were observed at the impact sampling area, there was no significant difference in the abundance of rock lobsters recorded between the four sampling areas assessed. There was also no significant difference in the abundance of rock lobsters recorded within the three depth ranges. This statistical outcome is attributable to the highly variable counts between sites. Based on data collected during this assessment, no measurable effect on the abundance of rock lobster can be attributed to the effluent from the Camps Bay outfall.

Cape Bream dominated the observations during the BRUV survey. This species is a small sized sparid endemic to southern Africa. They are resident reef fish that occur primarily between Port Nolloth and Cape Agulhas (Nepgen, 1977; van der Elst, 1977 referenced by Farthing *et al.,*2018). Based on the Shannon-Weiner indices, sampling area Control 3 had the highest species diversity. This sampling area is located within the TMNP MPA no-take zone, therefore added protection could account for the higher diversity recorded here. However, no significant difference in the species diversity between the four sampling areas recorded during the BRUV survey was identified. Based on data collected during this assessment, no measurable effect on fish diversity can be attributed to the effluent from the Camps Bay outfall.

8 Limitations

One of the predominant limitations to this assessment is the comparable data from the study area over time. As a result, comparisons were made with existing data and literature from the greater Table Bay and West Coast regions too. Additionally, as this was a once off survey, it presents a snapshot in time and no seasonal or interannual inferences on biodiversity patterns could be made.

Another challenge was identifying suitable control areas with comparable benthic habitats and oceanographic conditions to the impact area, but that are also geographically distant enough to not be affected by the disturbance. This challenge is not unique to this assessment but does increase the risk of confounding results. There are many sources of urban runoff and anthropogenic disturbances across the entire coastline included in this assessment (Figure 4.1). It is impossible to quantify the impact of this and differentiate this from impacts directly related to the Camps Bay outfall. Another layer of added complexity of site selection in this study was the location of the TMNP MPA no-take zone, which encompasses most of the coastline south of Camps Bay to Hout Bay. In theory, this area should act as a sanctuary to West Coast Rock Lobster and reef fish, however one cannot ignore the occurrence of illegal fishing and poaching of lobsters.

9 Conclusion

In conclusion, no measurable effects attributable to the effluent from the Camps Bay outfall were identified during this initial assessment. These results show no significant differences in the percentage cover and species diversity of invertebrates and macroalgae, abundance of rock lobster, or fish diversity between the four sampling areas (Impact, Control 1, Control 2, and Control 3) were identified.

A once off survey can only provide a snapshot in time. This should not be considered a definitive study; it is recommended that CCT employ regular monitoring of the biodiversity in these environments by repeatable and comparable surveys. This will allow interannual and seasonal comparisons of the biological communities and will increase sample size, improving the statistical robustness and our understanding of the ecosystem over time.

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Appendix A - Sampling Plan

Sampling Plan

Camps Bay Outfall: Biodiversity Survey

Prepared for:

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Reference: CLS-SA-21-51 BIODIVERSITY SAMPLING PLAN

V1.0 – 28/03/2022

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CHRONOLOGY ISSUES

Version	Date	Reference	Written by	Checked by
1	28/03/2022	CLS-SA-21-51 BIODIVERSITY SAMPLING PLAN V1.0	A. McGrath	L. Holton R. Carter

DISTRIBUTION

Company	Means of distribution	Names
CCT	Electronic	G. Oelofse, J. Du Toit

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1 INTRODUCTION

The City of Cape Town (CCT) operates three marine outfalls that discharge wastewater offshore of Camps Bay, Green Point and Hout Bay. At all outfalls, the effluent moves through a 3 mm mesh which removes solids and general litter from the waste stream before being discharged. At the end of the outfalls, diffusers rapidly dilute the effluent as it is discharged. The Camps Bay outfall was commissioned in 1977 and is the oldest of the three systems. The outfall itself is 1.5 km long and discharges 5.5 million litres (Ml) of effluent per day at a depth of 23 m (Figure 1.1).

As part of the CCT's environmental monitoring efforts, CLS Southern Africa (CLS SA) has been contracted to conduct a once off biodiversity survey at the Camps Bay outfall to investigate whether the discharge is significantly impacting marine vertebrate and invertebrate diversity, relative abundance and community composition. This document provides a detailed sampling plan that will be followed to complete the scope of work for the survey.

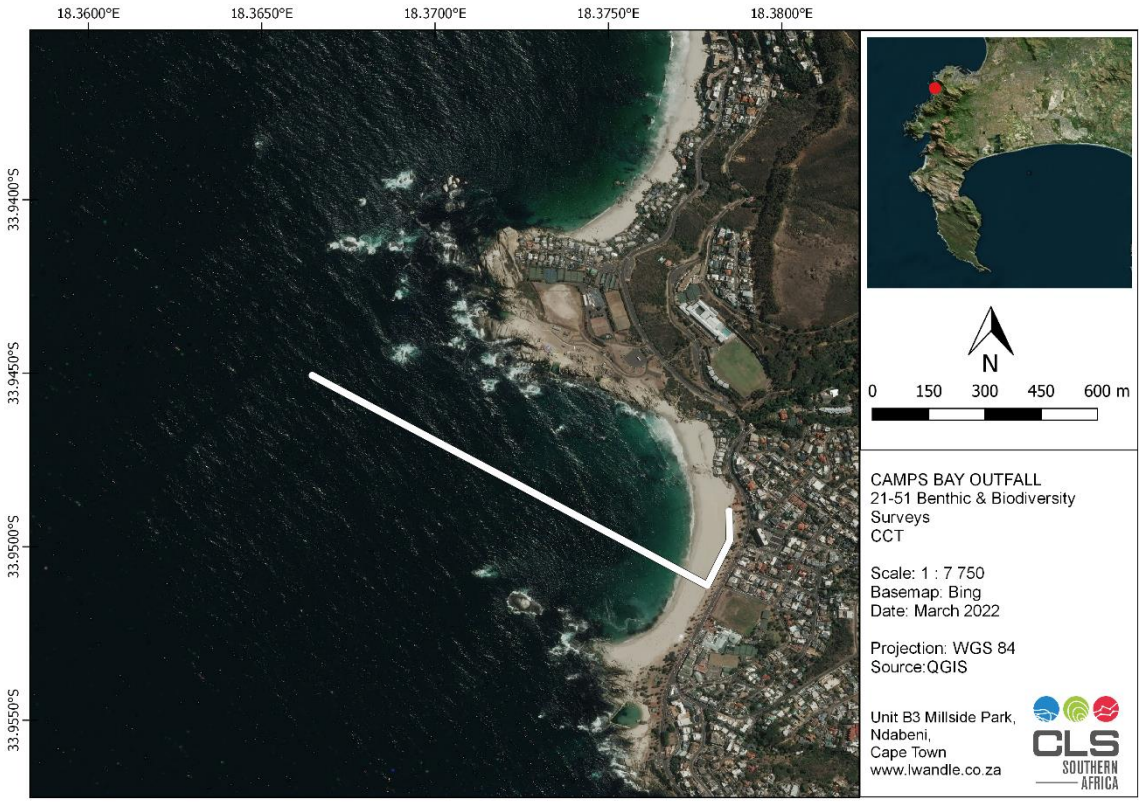

Figure 1.1: Map of the Camps Bay outfall.

2 SURVEY DESIGN

A control-impact survey design will be implemented, with replicate surveys being conducted at the outfall (impact area) and three comparable control areas with no wastewater influence. It is best practice to compare biodiversity against multiple control areas as conclusions can be confounded by natural variation. It is also important that these control areas represent environments that are comparable to the impact area in terms of habitat, geomorphology, and oceanographic parameters, but are also geographically distant. The biodiversity within each area will be assessed by quadrat imagery and species counts by scuba divers, as well as deployments of baited remote underwater video systems (BRUVS). The sections below provide details of the site selection, survey design and statistical analyses approach.

2.1 Site selection

Drop camera imagery, bathymetry data, marine charts and satellite imagery, were used to select three control areas along the coastline adjacent to Camps Bay. The selected locations areal cover is of similar to that of the corresponding impact area. Ecoregions, Marine Protected Area (MPA) zonation and other anthropogenic disturbances were also considered when selecting locations to ensure comparability between surveyed areas. However, two of the control areas fall within the Table Mountain National Park (TNPA) No-Take Zone. Any differences between the control areas and the impact area will be explicitly discussed when interpreting survey results and all limitations to this study will be stated.

In each area (impact area and control areas), three depth stratified reef sites will be selected to cover the depth strata 5-9 m, 10-14 m and 15-25 m, respectively. Additionally, all sites selected will be less than 30 m deep to remain within non-decompression scuba diving limits.

Figure 1.1 displays the planned sampling areas.

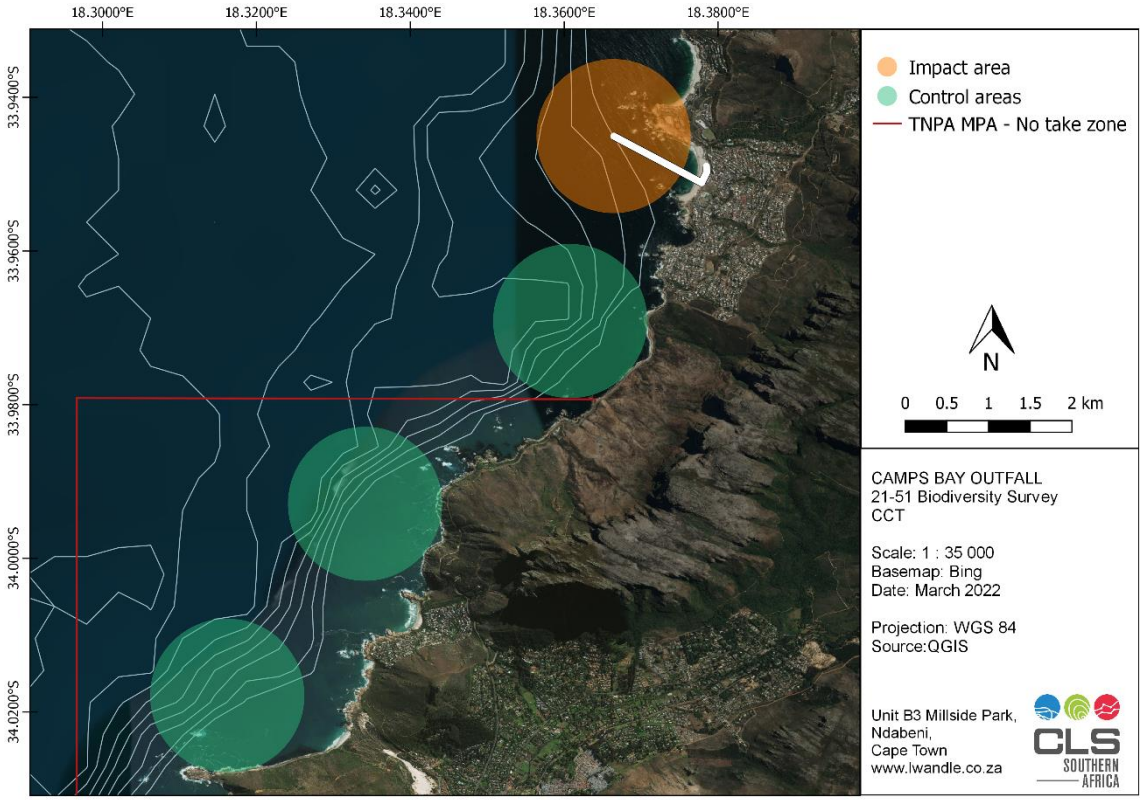

Figure 2.1: Map showing the planned impact and control areas. Note that suitable depth stratified reef areas will be selected in the field.

2.2 Survey design

The survey includes a total of 12 depth stratified reef sites: three in the impact area and three in each of the control areas (Table 2.1). At each of these reef sites, five randomly placed quadrats will be videoed and surveyed by divers. Additionally, divers will conduct West Coast rock lobster (*Jasus lalandii*) species counts along three radial transects, recording the number of juvenile, sub-adult and adult size class rock lobster observed. At the 10-14 m reef sites only, three BRUVs will be deployed sequentially to assess the fish community structure and abundance.

Table 2.1: Summary of the number of sites within each sampling area.

Sampling Area	No. of reef sites	No. of quadrats	No. of lobster counts	No. of BRUVs
Impact	3	15 (5 x 3)	9 (3 x 3)	3
Control 1	3	15 (5 x 3)	9 (3 x 3)	3
Control 2	3	15 (5 x 3)	9 (3 x 3)	3
Control 3	3	15 (5 x 3)	9 (3 x 3)	3
TOTAL	**12**	**60**	**36**	**12**

The mono BRUVs consist of one horizontally mounted GoPro HD camera, secured on a stainless steel landing frame together with an extended arm (1.5 m) that holds the bait canister. Bait will be 800 g of crushed sardines (*Sardinops sagax*). Deployment locations will be randomly placed adjacent to the mid-depth reef site. Deployments will be standardised to 40 minutes. The resulting video data will be analysed to obtain a fish species list and index of relative abundance for the sites that are being assessed. As the device acts as an aggregation device, special care must be taken to avoid the repeated counting of fish attracted to the bait during video analysis. To do this, relative abundance is estimated from a single frame during the video period where the number of individuals from a species is highest (MaxN) (Cappo et al., 2003). Deployment and processing methods employed by De Vos et al. (2015) will be followed.

The resulting metrics from this survey for each sampling area (impact, control 1, control 2, control 3) will be:

- Percentage cover of invertebrate and vertebrate species per quadrat
- Percentage cover macroalgae species per quadrat
- Size classified rock lobster counts per m^2
- Max number of individuals of a species in any one video frame (MaxN)
- Relative abundance of each species

Appendix A - lists all site IDs.

2.3 Statistical analyses

Statistical analyses will be computed using R version 4.1.1.

Diver Observations

Percentage cover of sessile organisms and macroalgae species will be assessed and compared between sampling areas using a one-way ANOVA with the alternative hypothesis (H_1) that percentage cover is dissimilar in the impact, control 1, control 2 and control 3 sampling areas (p-value of >0.05 indicating statistical significance). Additionally, rock lobster counts will be assessed and compared in the same way. Post hoc analyses (e.g Tukey's test) will be conducted as suitable.

BRUVS

Using MaxN as a measure of abundance, the Shannon-Wiener diversity index (H') will be calculated for each site. Shannon-Wiener diversity index is commonly used in ecology, it is a measurement of the biodiversity within a sample, considering both the abundance and evenness of each species. A one-way ANOVA will be used to test the alternate hypothesis (H_1) that species diversity is related to sampling area (p-value of >0.05 indicating statistical significance).

The initial composition and spatial changes in composition of species will be assessed by Non-Metric Multidimensional Scaling (NDMS) based on a Bray-Curtis dissimilarity matrix using appropriately

transformed data. NDMS ordination plots will be generated which are non-parametric and two-dimensional. Both Analysis of Similarity (ANOSIM) and Similarity Percentage (SIMPER) analyses will be calculated as supplementary analyses to the ordination to quantify the relationships between and among the groupings.

3 EQUIPMENT

The following equipment is required to conduct this survey:

- Scuba dive gear for dive team
- Quadrats
- Underwater cameras and tripod frame
- Dive slates
- BRUVS
- Sardine bait

4 PERSONNEL

The survey team will consist of the following personnel:

- CLS SA survey lead
- Skipper/ dive supervisor
- Six divers (incl. standby diver)

5 SURVEY PROTOCOLS

The following protocols and work procedures will be followed by the survey team. A Toolbox Talk meeting and diver briefing will be conducted by the CLS SA survey lead and dive supervisor to discuss the planned operations, related risks and mitigation measures. The dive supervisor will keep a log of the dive times and manage the dive operations throughout the survey.

5.1 Biodiversity survey: Diver observations

Quadrats

Quadrat positions will be randomly distributed within each reef site; however, overly rugose areas will be avoided so divers may shift quadrats to more suitable locations nearby in the field. At each of the confirmed reef sites, the following steps must be followed:

1. Deploy a shot line with small surface marker buoys at the reef location.
2. Record a waypoint, as indicated by surface marker buoys, on the handheld GPS.
3. Once dive buddy gear checks have been completed, the divers should enter the water on instruction from the dive supervisor.
4. Descend at the shotline with quadrats, slates, and an underwater camera on tripod frame.
5. At five randomly selected locations, place the quadrat on the seafloor in an area that is not overly rugose.
6. Turn the camera is on video mode and place over the quadrat ensuring that the entire quadrat is visible. The tripod standardises the height above the seafloor at each site.
7. Divers are to take note of the following observations, which will be complimented by further analysis of the videos by CLS SA personnel.
    a. Percentage cover[1] of all sessile organism species in quadrat.

[1] Cover in this study is defined as the fraction of the total quadrat area that is obscured by a particular species when viewed directly from above.

b. Percentage cover of macroalgae species

Rock lobster transects

Three 10 m transects will be conducted across the reef area. At each transect location, the following steps must be followed:

1. Deploy a shot line with small surface marker buoy at the reef.
2. Record the waypoints on the handheld GPS.
3. Once dive buddy gear checks have been completed, the divers should enter the water on instruction from the dive supervisor.
4. Lay out a metered chain on the seafloor in a radial direction away from the shotline.
5. Swim the length of the transect slowly, recording the per metre count of rock lobster present 0.5 m either side of the chain.
6. Classify each rock lobster as either juvenile, sub-adult or adult if possible.
7. Return to the start point, filming the benthic habitat over length of the transect chain from 1 m above the seafloor.
8. Each replicate will follow the steps above, chains laid out in a radial fashion from the shotline.

5.2 Biodiversity survey: BRUVS

There are three BRUV deployments at the mid-depth reef within each sampling area (Impact, Control 1, Control 2 and Control 3). The deployments in each area should run concurrently as far as possible (i.e deployment 1 in the impact area should overlap with deployment 1 in the control areas, and similarly for deployments 2 and 3). The deployment positions will be randomly distributed within each reef site; however, the BRUV needs to land flat so sites may be shifted to more suitable locations in the field. The following steps must be followed during each BRUV deployment:

Deployment

1. Ensure the BRUV has been baited with 800 g of crushed sardines, and that the bait canister is secured.
2. Ensure the GoPro has sufficient battery and memory for the deployment. Camera settings are listed in Appendix B.
3. Attach the surface marker buoy's rope to the BRUV frame using a bowline and two half hitches. The rope should be at least 1.5 x the water depth.
4. Switch the GoPro on to start recording and display site number to the lens.
5. Holding the frame perpendicular to the boat, lower it steadily to the seafloor, ensuring that it does not tip over to either side.
6. Once on the seafloor, quickly pay out the remaining rope and toss the buoy overboard.
7. Record site name, deployment time, waypoint, memory card number and depth on the datasheet.
8. Move to the next BRUV site and allow BRUV to record for 45 minutes.

Retrieval

1. Approach from the downwind side of the buoy and bring buoy onto the vessel.
2. Slowly retrieve the line to pick up slack so that the vessel is directly above the BRUV (you can check vessel position against recorded waypoint). Do not drag the BRUV along the seafloor.
3. Lift the BRUV on to the vessel.
4. Check that the GoPro is still recording and turn off.
5. Record retrieval time on the datasheet.

6 SCHEDULE

The biodiversity survey is expected to take 4 days and will be scheduled according to the most suitable weather conditions.

7 REFERENCES

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Appendix A - Sample IDs

Sampling Area	Site	Activity	Sample ID
Impact	Shallow reef (reef 1) 1-6 m	Quadrat 1	I-R1Q1
		Quadrat 2	I-R1Q2
		Quadrat 3	I-R1Q3
		Quadrat 4	I-R1Q4
		Quadrat 5	I-R1Q5
	Mid reef (reef 2) 7-12 m	Quadrat 1	I-R2Q1
		Quadrat 2	I-R2Q2
		Quadrat 3	I-R2Q3
		Quadrat 4	I-R2Q4
		Quadrat 5	I-R2Q5
	Deep reef (reef 3) 15-20 m	Quadrat 1	I-R3Q1
		Quadrat 2	I-R3Q2
		Quadrat 3	I-R3Q3
		Quadrat 4	I-R3Q4
		Quadrat 5	I-R3Q5
	Shallow reef (reef 1) 1-6 m	Transect 1	I-R1T1
		Transect 2	I-R1T2
		Transect 3	I-R1T3
	Mid reef (reef 2) 7-12 m	Transect 1	I-R2T1
		Transect 2	I-R2T2
		Transect 3	I-R2T3
	Deep reef (reef 3) 15-20 m	Transect 1	I-R3T1
		Transect 2	I-R3T2
		Transect 3	I-R3T3
	Mid reef (reef 2) 7-12 m	BRUV 1	I-R2B1
		BRUV 2	I-R2B2
		BRUV 3	I-R2B3

Sampling Area	Site	Activity	Sample ID
Control 1	Shallow reef (reef 1) 1-6 m	Quadrat 1	C1-R1Q1
		Quadrat 2	C1-R1Q2
		Quadrat 3	C1-R1Q3
		Quadrat 4	C1-R1Q4
		Quadrat 5	C1-R1Q5
	Mid reef (reef 2) 7-12 m	Quadrat 1	C1-R2Q1
		Quadrat 2	C1-R2Q2
		Quadrat 3	C1-R2Q3
		Quadrat 4	C1-R2Q4
		Quadrat 5	C1-R2Q5
	Deep reef (reef 3) 15-20 m	Quadrat 1	C1-R3Q1
		Quadrat 2	C1-R3Q2
		Quadrat 3	C1-R3Q3
		Quadrat 4	C1-R3Q4
		Quadrat 5	C1-R3Q5
	Shallow reef (reef 1) 1-6 m	Transect 1	C1-R1T1
		Transect 2	C1-R1T2
		Transect 3	C1-R1T3
	Mid reef (reef 2) 7-12 m	Transect 1	C1-R2T1
		Transect 2	C1-R2T2
		Transect 3	C1-R2T3
	Deep reef (reef 3) 15-20 m	Transect 1	C1-R3T1
		Transect 2	C1-R3T2
		Transect 3	C1-R3T3
	Mid reef (reef 2) 7-12 m	BRUV 1	C1-R2B1
		BRUV 2	C1-R2B2
		BRUV 3	C1-R2B3

Sampling Area	Site	Activity	Sample ID
Control 2	Shallow reef (reef 1) 1-6 m	Quadrat 1	C2-R1Q1
		Quadrat 2	C2-R1Q2
		Quadrat 3	C2-R1Q3
		Quadrat 4	C2-R1Q4
		Quadrat 5	C2-R1Q5
	Mid reef (reef 2) 7-12 m	Quadrat 1	C2-R2Q1
		Quadrat 2	C2-R2Q2
		Quadrat 3	C2-R2Q3
		Quadrat 4	C2-R2Q4
		Quadrat 5	C2-R2Q5
	Deep reef (reef 3) 15-20 m	Quadrat 1	C2-R3Q1
		Quadrat 2	C2-R3Q2
		Quadrat 3	C2-R3Q3
		Quadrat 4	C2-R3Q4
		Quadrat 5	C2-R3Q5
	Shallow reef (reef 1) 1-6 m	Transect 1	C2-R1T1
		Transect 2	C2-R1T2
		Transect 3	C2-R1T3
	Mid reef (reef 2) 7-12 m	Transect 1	C2-R2T1
		Transect 2	C2-R2T2
		Transect 3	C2-R2T3
	Deep reef (reef 3) 15-20 m	Transect 1	C2-R3T1
		Transect 2	C2-R3T2
		Transect 3	C2-R3T3
	Mid reef (reef 2) 7-12 m	BRUV 1	C2-R2B1
		BRUV 2	C2-R2B2
		BRUV 3	C2-R2B3

Sampling Area	Site	Activity	Sample ID
Control 3	Shallow reef (reef 1) 1-6 m	Quadrat 1	C3-R1Q1
		Quadrat 2	C3-R1Q2
		Quadrat 3	C3-R1Q3
		Quadrat 4	C3-R1Q4
		Quadrat 5	C3-R1Q5
	Mid reef (reef 2) 7-12 m	Quadrat 1	C3-R2Q1
		Quadrat 2	C3-R2Q2
		Quadrat 3	C3-R2Q3
		Quadrat 4	C3-R2Q4
		Quadrat 5	C3-R2Q5
	Deep reef (reef 3) 15-20 m	Quadrat 1	C3-R3Q1
		Quadrat 2	C3-R3Q2
		Quadrat 3	C3-R3Q3
		Quadrat 4	C3-R3Q4
		Quadrat 5	C3-R3Q5
	Shallow reef (reef 1) 1-6 m	Transect 1	C3-R1T1
		Transect 2	C3-R1T2
		Transect 3	C3-R1T3
	Mid reef (reef 2) 7-12 m	Transect 1	C3-R2T1
		Transect 2	C3-R2T2
		Transect 3	C3-R2T3
	Deep reef (reef 3) 15-20 m	Transect 1	C3-R3T1
		Transect 2	C3-R3T2
		Transect 3	C3-R3T3
	Mid reef (reef 2) 7-12 m	BRUV 1	C3-R2B1
		BRUV 2	C3-R2B2
		BRUV 3	C3-R2B3

Appendix B - Camera Settings

Mode	Video (set as default start mode)
Frame rate	25 FPS
Pixels	1080p
View	Wide angle, 11 MP
Protune	Off
Loop recording	Off
Broadcast format	NTSC
Front screen display	On
Back screen display	Off
Lights (LEDs)	Off
Sound	Off

Appendix B - Species Lists

Taxa identified in Quadrat Observations		Taxa identified in BRUVs	
Taxa	Common name	Taxa	Common name
Annelida	Segmented Worm	*Arctocephalus pusillus*	Cape Fur Seal
Ascidian	Ascidian	*Clinus cottoides*	Bluntnose Klipvis
Brachyura	True Crab	*Clinus superciliosus*	Super Klipvis
Callopatiria granifera	Red Starfish	*Diplodus capensis*	Blacktail
Chaetomorpha linum	Hair Weed	*Galeichthys feliceps*	White Catfish
Choromytilus meridionalis	Black Mussel	*Haploblepharus pictus*	Dark Shyshark
Crambe acuata	Stellar Sponge	*Jasus lalandii*	West Coast Rock Lobster
Ecklonia maxima	Bamboo Kelp	*Pachymetopon blochii*	Cape Bream
Unknown	Encrusting Algae	*Plagusia chabrus*	Cape Rock Crab
Haliotis Midae	Abalone	*Sebastes capensis*	False Jacopever
Holothuroidea	Sea Cucumber	Unknown	Unidentified juvenile fish
Hydrozoa	Hyrdoids		
Laminaria pallida	Split Frond Kelp		
Marthasterias glacialis	Spiny Starfish		
Unknown	Mussel Spat		
Ophiuroidea	Brittle Star		
Opisthobranchia	Nudibranch		
Parechinus angulosus	Cape Urchin		
Polymastia mamillaris	Teat Sponge		
Porifera	Sponge (Black)		
Rhodophyte	Red Algae		
Sabellidae	Fan Worm		
Spirobis	Tube Worm		
Tethya aurantium	Golf Ball Sponge		
Turbo sarmaticus	Alikreukel		
Whelk	Whelk		