forestry, fisheries
& the environment

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

INVITATION TO BID

BID REFERENCE NUMBER: MLRF200/23

TO APPOINT A SERVICE PROVIDER (SP) TO CONDUCT SPECIALIST MONITORING IN ACCORDANCE WITH THE ENVIRONMENTAL AUTHORISATION, ENVIRONMENTAL MANAGEMENT PROGRAMME AND SAMPLING PLAN AT THE SEA-BASED AQUACULTURE DEVELOPMENT ZONE LOCATED WITHIN SALDANHA BAY IN THE WESTERN CAPE FOR A PERIOD OF THIRTY-SIX (36) MONTHS.

Contact person:
Name: Ms Talitha Bikani/ Mr Lwandisa Hoza
Office Telephone No: (021) 402 3260/ (021) 402 3425
E-Mail: MLRFTENDERS@DFFE.GOV.ZA

NATIONAL TREASURY CENTRAL SUPPLIER DATABASE (CSD) REGISTRATION INFORMATION

Company name	Supplier registration number	Unique reference number

CLOSING DATE OF THE BID: 29 SEPTEMBER 2023 AT 11H00

Briefing session:

A compulsory briefing session will be held on the 20th of September 2023 (Wednesday) at 10:00. Link can be requested from MLRFTENDERS@DFFE.GOV.ZA

MS TEAMS DETAILS ARE AS FOLLOWS:

Meeting ID: 346 461 668 445
Passcode: 85hVE4

DROP OFF ADDRESS:
The location of the drop off is: Tender Box, Ground Floor, Foretrust Building, 2 Martin Hammerschlag Way, Foreshore, Cape Town, 8001

PART A
INVITATION TO BID

YOU ARE HEREBY INVITED TO BID FOR REQUIREMENTS OF THE *(NAME OF DEPARTMENT/ PUBLIC ENTITY)*					
BID NUMBER:	**MLRF200/23**	CLOSING DATE:	**29 SEPTEMBER 2023**	CLOSING TIME:	**11:00**
DESCRIPTION	**TO APPOINT A SERVICE PROVIDER (SP) TO CONDUCT SPECIALIST MONITORING IN ACCORDANCE WITH THE ENVIRONMENTAL AUTHORISATION, ENVIRONMENTAL MANAGEMENT PROGRAMME AND SAMPLING PLAN AT THE SEA-BASED AQUACULTURE DEVELOPMENT ZONE LOCATED WITHIN SALDANHA BAY IN THE WESTERN CAPE FOR A PERIOD OF THIRTY-SIX (36) MONTHS.**				
BID RESPONSE DOCUMENTS MAY BE DEPOSITED IN THE BID BOX SITUATED AT *(STREET ADDRESS)*					
GROUND FLOOR, FORETRUST BUILDING					
MARTIN HAMMERSCHLAG WAY					
FORESHORE, CAPE TOWN, 8001					

BIDDING PROCEDURE ENQUIRIES MAY BE DIRECTED TO		**TECHNICAL ENQUIRIES MAY BE DIRECTED TO:**	
CONTACT PERSON	**Ms. Talitha Bikani**	CONTACT PERSON	**Mr Lwandisa Hoza**
TELEPHONE NUMBER	**021-402 3260**	TELEPHONE NUMBER	**021-402 3425**
E-MAIL ADDRESS	**MLRFtenders@dffe.gov.za**	E-MAIL ADDRESS	**MLRFtenders@dffe.gov.za**

SUPPLIER INFORMATION					
NAME OF BIDDER					
POSTAL ADDRESS					
STREET ADDRESS					
TELEPHONE NUMBER	CODE		NUMBER		
CELLPHONE NUMBER					
FACSIMILE NUMBER	CODE		NUMBER		
E-MAIL ADDRESS					
VAT REGISTRATION NUMBER					
SUPPLIER COMPLIANCE STATUS	TAX COMPLIANCE SYSTEM PIN:		**OR**	CENTRAL SUPPLIER DATABASE No:	MAAA

ARE YOU THE ACCREDITED REPRESENTATIVE IN SOUTH AFRICA FOR THE GOODS /SERVICES /WORKS OFFERED?	☐Yes ☐No [IF YES ENCLOSE PROOF]	ARE YOU A FOREIGN BASED SUPPLIER FOR **THE GOODS /SERVICES /WORKS OFFERED?**	☐Yes ☐No [IF YES, ANSWER THE QUESTIONNAIRE BELOW]

QUESTIONNAIRE TO BIDDING FOREIGN SUPPLIERS

IS THE ENTITY A RESIDENT OF THE REPUBLIC OF SOUTH AFRICA (RSA)?	☐ YES ☐ NO
DOES THE ENTITY HAVE A BRANCH IN THE RSA?	☐ YES ☐ NO
DOES THE ENTITY HAVE A PERMANENT ESTABLISHMENT IN THE RSA?	☐ YES ☐ NO
DOES THE ENTITY HAVE ANY SOURCE OF INCOME IN THE RSA?	☐ YES ☐ NO
IS THE ENTITY LIABLE IN THE RSA FOR ANY FORM OF TAXATION?	☐ YES ☐ NO

IF THE ANSWER IS "NO" TO ALL OF THE ABOVE, THEN IT IS NOT A REQUIREMENT TO REGISTER FOR A TAX COMPLIANCE STATUS SYSTEM PIN CODE FROM THE SOUTH AFRICAN REVENUE SERVICE (SARS) AND IF NOT REGISTER AS PER 2.3 BELOW.

PART B
TERMS AND CONDITIONS FOR BIDDING

1. BID SUBMISSION:

1.1. BIDS MUST BE DELIVERED BY THE STIPULATED TIME TO THE CORRECT ADDRESS. LATE BIDS WILL NOT BE ACCEPTED FOR CONSIDERATION.

1.2. **ALL BIDS MUST BE SUBMITTED ON THE OFFICIAL FORMS PROVIDED–(NOT TO BE RE-TYPED) OR IN THE MANNER PRESCRIBED IN THE BID DOCUMENT.**

1.3. THIS BID IS SUBJECT TO THE PREFERENTIAL PROCUREMENT POLICY FRAMEWORK ACT, 2000 AND THE PREFERENTIAL PROCUREMENT REGULATIONS, 2022, THE GENERAL CONDITIONS OF CONTRACT (GCC) AND, IF APPLICABLE, ANY OTHER SPECIAL CONDITIONS OF CONTRACT.

1.4. **THE SUCCESSFUL BIDDER WILL BE REQUIRED TO FILL IN AND SIGN A WRITTEN CONTRACT FORM (SBD7).**

2. TAX COMPLIANCE REQUIREMENTS

2.1 BIDDERS MUST ENSURE COMPLIANCE WITH THEIR TAX OBLIGATIONS.

2.2 BIDDERS ARE REQUIRED TO SUBMIT THEIR UNIQUE PERSONAL IDENTIFICATION NUMBER (PIN) ISSUED BY SARS TO ENABLE THE ORGAN OF STATE TO VERIFY THE TAXPAYER'S PROFILE AND TAX STATUS.

2.3 APPLICATION FOR TAX COMPLIANCE STATUS (TCS) PIN MAY BE MADE VIA E-FILING THROUGH THE SARS WEBSITE WWW.SARS.GOV.ZA.

2.4 BIDDERS MAY ALSO SUBMIT A PRINTED TCS CERTIFICATE TOGETHER WITH THE BID.

2.5 IN BIDS WHERE CONSORTIA / JOINT VENTURES / SUB-CONTRACTORS ARE INVOLVED, EACH PARTY MUST SUBMIT A SEPARATE TCS CERTIFICATE / PIN / CSD NUMBER.

2.6 WHERE NO TCS PIN IS AVAILABLE BUT THE BIDDER IS REGISTERED ON THE CENTRAL SUPPLIER DATABASE (CSD), A CSD NUMBER MUST BE PROVIDED.

2.7 NO BIDS WILL BE CONSIDERED FROM PERSONS IN THE SERVICE OF THE STATE, COMPANIES WITH DIRECTORS WHO ARE PERSONS IN THE SERVICE OF THE STATE, OR CLOSE CORPORATIONS WITH MEMBERS PERSONS IN THE SERVICE OF THE STATE."

NB: FAILURE TO PROVIDE / OR COMPLY WITH ANY OF THE ABOVE PARTICULARS MAY RENDER THE BID INVALID.

SIGNATURE OF BIDDER: ……………………………………………

CAPACITY UNDER WHICH THIS BID IS SIGNED: ……………………………………………
(Proof of authority must be submitted e.g. company resolution)

DATE: ……………………………………………

SARS

TAX CLEARANCE

TCC 001

Application for a Tax Clearance Certificate

Purpose

Select the applicable option .... Tenders ☐ Good standing ☐

If "Good standing", please state the purpose of this application

Particulars of applicant

Name/Legal name (Initials & Surname or registered name)

Trading name (if applicable)

ID/Passport no

Company/Close Corp. registered no

Income Tax ref no

PAYE ref no 7

VAT registration no 4

SDL ref no L

Customs code

UIF ref no U

Telephone no

Fax no

E-mail address

Physical address

Postal address

Particulars of representative (Public Officer/Trustee/Partner)

Surname

First names

ID/Passport no

Income Tax ref no

Telephone no

Fax no

E-mail address

Physical address

Particulars of tender (If applicable)

Tender number

Estimated Tender amount R ,

Expected duration of the tender year(s)

Particulars of the 3 largest contracts previously awarded

Date started	Date finalised	Principal	Contact person	Telephone number	Amount

Audit

Are you currently aware of any Audit investigation against you/the company?.. YES NO

If "YES" provide details

Appointment of representative/agent (Power of Attorney)

I the undersigned confirm that I require a Tax Clearance Certificate in respect of Tenders or Goodstanding.

I hereby authorise and instruct ______ to apply to and receive from SARS the applicable Tax Clearance Certificate on my/our behalf.

Signature of representative/agent

Date

Name of representative/ agent

Declaration

I declare that the information furnished in this application as well as any supporting documents is true and correct in every respect.

Signature of applicant/Public Officer

Date

Name of applicant/ Public Officer

Notes:

1. It is a serious offence to make a false declaration.
2. Section 75 of the Income Tax Act, 1962, states: Any person who
   - (a) fails or neglects to furnish, file or submit any return or document as and when required by or under this Act; or
   - (b) without just cause shown by him, refuses or neglects to-
     - (i) furnish, produce or make available any information, documents or things;
     - (ii) reply to or answer truly and fully, any questions put to him ...

   As and when required in terms of this Act ... shall be guilty of an offence ...
3. **SARS will, under no circumstances, issue a Tax Clearance Certificate unless this form is completed in full.**
4. Your Tax Clearance Certificate will only be issued on presentation of your South African Identity Document or Passport (Foreigners only) as applicable.

PRICING SCHEDULE
(Professional Services)

NAME OF BIDDER: ………………………………………………………	BID NO.: **MLRF200/23**
CLOSING TIME 1**1H00**	CLOSING DATE: **29 SEPTEMBER 2023**

OFFER TO BE VALID FOR **120 DAYS** FROM THE CLOSING DATE OF BID.

ITEM NO	DESCRIPTION	BID PRICE IN RSA CURRENCY **(ALL APPLICABLE TAXES INCLUDED)

TO APPOINT A SERVICE PROVIDER (SP) TO CONDUCT SPECIALIST MONITORING IN ACCORDANCE WITH THE ENVIRONMENTAL AUTHORISATION, ENVIRONMENTAL MANAGEMENT PROGRAMME AND SAMPLING PLAN AT THE SEA-BASED AQUACULTURE DEVELOPMENT ZONE LOCATED WITHIN SALDANHA BAY IN THE WESTERN CAPE FOR A PERIOD OF THIRTY-SIX (36) MONTHS.

1. The accompanying information must be used for the formulation of proposals.

2. Bidders are required to indicate a ceiling price based on the total estimated time for completion of all phases and including all expenses inclusive of all applicable taxes for the project. R……………………………………………………………

3. PERSONS WHO WILL BE INVOLVED IN THE PROJECT AND RATES APPLICABLE (CERTIFIED INVOICES MUST BE RENDERED IN TERMS HEREOF)

4. PERSON AND POSITION

PERSON AND POSITION	HOURLY RATE	DAILY RATE
--	R-------------------------	-------------------------
--	R-------------------------	-------------------------
--	R-------------------------	-------------------------
--	R-------------------------	-------------------------
--	R-------------------------	-------------------------

5. PHASES ACCORDING TO WHICH THE PROJECT WILL BE COMPLETED, COST PER PHASE AND MAN-DAYS TO BE SPENT

--	R-------------------------	--------------------- days
--	R-------------------------	--------------------- days
--	R-------------------------	--------------------- days
--	R-------------------------	--------------------- days

5.1 Travel expenses (specify, for example rate/km and total km, class of airtravel, etc). Only actual costs are recoverable. Proof of the expenses incurred must accompany certified invoices.

DESCRIPTION OF EXPENSE TO BE INCURRED	RATE	QUANTITY	AMOUNT
--	………………	………………	R………………
--	………………	………………	R………………
--	………………	………………	R………………
--	………………	………………	R………………

TOTAL: R……………………………………………………

Bid No.: ......MLRF200/23...................................

Name of Bidder: ....

** "all applicable taxes" includes value- added tax, pay as you earn, income tax, unemployment insurance contributions and skills development levies.

5.2 Other expenses, for example accommodation (specify, eg. Three star hotel, bed and breakfast, telephone cost, reproduction cost, etc.). On basis of these particulars, certified invoices will be checked for correctness. Proof of the expenses must accompany invoices.

DESCRIPTION OF EXPENSE TO BE INCURRED	RATE	QUANTITY	AMOUNT
--	....	....	R....................
--	....	....	R....................
--	....	....	R....................
--	....	....	R....................

TOTAL: R...

6. Period required for commencement with project after acceptance of bid ....

7. Estimated man-days for completion of project ....

8. Are the rates quoted firm for the full period of contract? *YES/NO

9. If not firm for the full period, provide details of the basis on which adjustments will be applied for, for example consumer price index. ....

....

....

....

***[DELETE IF NOT APPLICABLE]**

Any enquiries regarding bidding procedures may be directed to the –

DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT

Contact Person: Ms. Talitha Bikani
Contact Number: 021 402 3260
E-Mail: MLRFtenders@dffe.gov.za

Or

Contact Person: Mr. Lwandisa Hoza
Contact Number: 021 402 3425
E-Mail: MLRFtenders@dffe.gov.za

BIDDER'S DISCLOSURE

1. PURPOSE OF THE FORM

Any person (natural or juristic) may make an offer or offers in terms of this invitation to bid. In line with the principles of transparency, accountability, impartiality, and ethics as enshrined in the Constitution of the Republic of South Africa and further expressed in various pieces of legislation, it is required for the bidder to make this declaration in respect of the details required hereunder.

Where a person/s are listed in the Register for Tender Defaulters and / or the List of Restricted Suppliers, that person will automatically be disqualified from the bid process.

2. Bidder's declaration

2.1 Is the bidder, or any of its directors / trustees / shareholders / members / partners or any person having a controlling interest1 in the enterprise, employed by the state? **YES/NO**

2.1.1 If so, furnish particulars of the names, individual identity numbers, and, if applicable, state employee numbers of sole proprietor/ directors / trustees / shareholders / members/ partners or any person having a controlling interest in the enterprise, in table below.

Full Name	Identity Number	Name of State institution

2.2 Do you, or any person connected with the bidder, have a relationship

1 the power, by one person or a group of persons holding the majority of the equity of an enterprise, alternatively, the person/s having the deciding vote or power to influence or to direct the course and decisions of the enterprise.

with any person who is employed by the procuring institution? **YES/NO**

2.2.1 If so, furnish particulars:
……………………………………………………………………………………………
……………………………………………………………………………………………

2.3 Does the bidder or any of its directors / trustees / shareholders / members / partners or any person having a controlling interest in the enterprise have any interest in any other related enterprise whether or not they are bidding for this contract? **YES/NO**

2.3.1 If so, furnish particulars:
……………………………………………………………………………………
……………………………………………………………………………………

3 DECLARATION

I, the undersigned, (name)…………………………………………………………………… in submitting the accompanying bid, do hereby make the following statements that I certify to be true and complete in every respect:

3.1 I have read and I understand the contents of this disclosure;
3.2 I understand that the accompanying bid will be disqualified if this disclosure is found not to be true and complete in every respect;
3.3 The bidder has arrived at the accompanying bid independently from, and without consultation, communication, agreement or arrangement with any competitor. However, communication between partners in a joint venture or consortium2 will not be construed as collusive bidding.
3.4 In addition, there have been no consultations, communications, agreements or arrangements with any competitor regarding the quality, quantity, specifications, prices, including methods, factors or formulas used to calculate prices, market allocation, the intention or decision to submit or not to submit the bid, bidding with the intention not to win the bid and conditions or delivery particulars of the products or services to which this bid invitation relates.
3.4 The terms of the accompanying bid have not been, and will not be, disclosed by the bidder, directly or indirectly, to any competitor, prior to the date and time of the official bid opening or of the awarding of the contract.

3.5 There have been no consultations, communications, agreements or arrangements made by the bidder with any official of the procuring

2 Joint venture or Consortium means an association of persons for the purpose of combining their expertise, property, capital, efforts, skill and knowledge in an activity for the execution of a contract.

institution in relation to this procurement process prior to and during the bidding process except to provide clarification on the bid submitted where so required by the institution; and the bidder was not involved in the drafting of the specifications or terms of reference for this bid.

3.6 I am aware that, in addition and without prejudice to any other remedy provided to combat any restrictive practices related to bids and contracts, bids that are suspicious will be reported to the Competition Commission for investigation and possible imposition of administrative penalties in terms of section 59 of the Competition Act No 89 of 1998 and or may be reported to the National Prosecuting Authority (NPA) for criminal investigation and or may be restricted from conducting business with the public sector for a period not exceeding ten (10) years in terms of the Prevention and Combating of Corrupt Activities Act No 12 of 2004 or any other applicable legislation.

I CERTIFY THAT THE INFORMATION FURNISHED IN PARAGRAPHS 1, 2 and 3 ABOVE IS CORRECT.
I ACCEPT THAT THE STATE MAY REJECT THE BID OR ACT AGAINST ME IN TERMS OF PARAGRAPH 6 OF PFMA SCM INSTRUCTION 03 OF 2021/22 ON PREVENTING AND COMBATING ABUSE IN THE SUPPLY CHAIN MANAGEMENT SYSTEM SHOULD THIS DECLARATION PROVE TO BE FALSE.

……………………………… ………………………………………………
Signature Date

……………………………… ………………………………………………
Position Name of bidder

PREFERENCE POINTS CLAIM FORM IN TERMS OF THE PREFERENTIAL PROCUREMENT REGULATIONS 2022

This preference form must form part of all tenders invited. It contains general information and serves as a claim form for preference points for specific goals.

NB: BEFORE COMPLETING THIS FORM, TENDERERS MUST STUDY THE GENERAL CONDITIONS, DEFINITIONS AND DIRECTIVES APPLICABLE IN RESPECT OF THE TENDER AND PREFERENTIAL PROCUREMENT REGULATIONS, 2022

---

1. GENERAL CONDITIONS

1.1 The following preference point systems are applicable to invitations to tender:

- the 80/20 system for requirements with a Rand value of up to R50 000 000 (all applicable taxes included); and
- the 90/10 system for requirements with a Rand value above R50 000 000 (all applicable taxes included).

1.2 **To be completed by the organ of state**

(*delete whichever is not applicable for this tender*).

a) The applicable preference point system for this tender is the 90/10 preference point system.

b) The applicable preference point system for this tender is the 80/20 preference point system.

c) Either the 90/10 or 80/20 preference point system will be applicable in this tender. The lowest/ highest acceptable tender will be used to determine the accurate system once tenders are received.

1.3 Points for this tender (even in the case of a tender for income-generating contracts) shall be awarded for:

(a) Price; and

(b) Specific Goals.

1.4 **To be completed by the organ of state:**

The maximum points for this tender are allocated as follows:

	POINTS
PRICE	**80**
SPECIFIC GOALS	**20**
Total points for Price and SPECIFIC GOALS	**100**

1.5 Failure on the part of a tenderer to submit proof or documentation required in terms of this tender to claim points for specific goals with the tender, will be interpreted to mean that preference points for specific goals are not claimed.

1.6 The organ of state reserves the right to require of a tenderer, either before a tender is adjudicated or at any time subsequently, to substantiate any claim in regard to preferences, in any manner required by the organ of state.

2. DEFINITIONS

(a) **"tender"** means a written offer in the form determined by an organ of state in response to an invitation to provide goods or services through price quotations, competitive tendering process or any other method envisaged in legislation;

(b) **"price"** means an amount of money tendered for goods or services, and includes all applicable taxes less all unconditional discounts;

(c) **"rand value"** means the total estimated value of a contract in Rand, calculated at the time of bid invitation, and includes all applicable taxes;

(d) **"tender for income-generating contracts"** means a written offer in the form determined by an organ of state in response to an invitation for the origination of income-generating contracts through any method envisaged in legislation that will result in a legal agreement between the organ of state and a third party that produces revenue for the organ of state, and includes, but is not limited to, leasing and disposal of assets and concession contracts, excluding direct sales and disposal of assets through public auctions; and

(e) **"the Act"** means the Preferential Procurement Policy Framework Act, 2000 (Act No. 5 of 2000).

3. FORMULAE FOR PROCUREMENT OF GOODS AND SERVICES

3.1. POINTS AWARDED FOR PRICE

3.1.1 THE 80/20 OR 90/10 PREFERENCE POINT SYSTEMS

A maximum of 80 or 90 points is allocated for price on the following basis:

80/20 or **90/10**

$$Ps = 80\left(1 - \frac{Pt - P\,min}{P\,min}\right) \quad \text{or} \quad Ps = 90\left(1 - \frac{Pt - P\,min}{P\,min}\right)$$

Where

Ps = Points scored for price of tender under consideration

Pt = Price of tender under consideration

Pmin = Price of lowest acceptable tender

3.2. FORMULAE FOR DISPOSAL OR LEASING OF STATE ASSETS AND INCOME GENERATING PROCUREMENT

3.2.1. POINTS AWARDED FOR PRICE

A maximum of 80 or 90 points is allocated for price on the following basis:

80/20 **or** **90/10**

$$Ps = 80\left(1 + \frac{Pt - P\,max}{P\,max}\right) \quad \text{or} \quad Ps = 90\left(1 + \frac{Pt - P\,max}{Pmax}\right)$$

Where

Ps	=	Points scored for price of tender under consideration
Pt	=	Price of tender under consideration
Pmax	=	Price of highest acceptable tender

4. POINTS AWARDED FOR SPECIFIC GOALS

4.1. In terms of Regulation 4(2); 5(2); 6(2) and 7(2) of the Preferential Procurement Regulations, preference points must be awarded for specific goals stated in the tender. For the purposes of this tender the tenderer will be allocated points based on the goals stated in table 1 below as may be supported by proof/ documentation stated in the conditions of this tender:

4.2. In cases where organs of state intend to use Regulation 3(2) of the Regulations, which states that, if it is unclear whether the 80/20 or 90/10 preference point system applies, an organ of state must, in the tender documents, stipulate in the case of—

(a) an invitation for tender for income-generating contracts, that either the 80/20 or 90/10 preference point system will apply and that the highest acceptable tender will be used to determine the applicable preference point system; or

(b) any other invitation for tender, that either the 80/20 or 90/10 preference point system will apply and that the lowest acceptable tender will be used to determine the applicable preference point system,

then the organ of state must indicate the points allocated for specific goals for both the 90/10 and 80/20 preference point system.

Table 1: Specific goals for the tender and points claimed are indicated per the table below.

(Note to organs of state: Where either the 90/10 or 80/20 preference point system is applicable, corresponding points must also be indicated as such.

Note to tenderers: The tenderer must indicate how they claim points for each preference point system.)

The specific goals allocated points in terms of this tender	Number of points allocated (90/10 system) (To be completed by the organ of state)	Number of points allocated (80/20 system) (To be completed by the organ of state)	Number of points claimed (90/10 system) (To be completed by the tenderer)	Number of points claimed (80/20 system) (To be completed by the tenderer)
51% Black ownership	**N/A**	**8**	**N/A**	
50% Women ownership	**N/A**	**4**	**N/A**	
Youth ownership	**N/A**	**4**	**N/A**	
Disability	**N/A**	**4**	**N/A**	
Non-compliant contributor	**N/A**	**0**	**N/A**	

DECLARATION WITH REGARD TO COMPANY/FIRM

4.3. Name of company/firm………………………………………………………………………..

4.4. Company registration number: ……………………………………………………………....

4.5. TYPE OF COMPANY/ FIRM

Partnership/Joint Venture / Consortium
One-person business/sole propriety
Close corporation
Public Company
Personal Liability Company
(Pty) Limited
Non-Profit Company
State Owned Company
[TICK APPLICABLE BOX]

4.6. I, the undersigned, who is duly authorised to do so on behalf of the company/firm, certify that the points claimed, based on the specific goals as advised in the tender, qualifies the company/ firm for the preference(s) shown and I acknowledge that:

i) The information furnished is true and correct;

ii) The preference points claimed are in accordance with the General Conditions as indicated in paragraph 1 of this form;

iii) In the event of a contract being awarded as a result of points claimed as shown in paragraphs 1.4 and 4.2, the contractor may be required to furnish documentary proof to the satisfaction of the organ of state that the claims are correct;

iv) If the specific goals have been claimed or obtained on a fraudulent basis or any of the conditions of contract have not been fulfilled, the organ of state may, in addition to any other remedy it may have –

(a) disqualify the person from the tendering process;

(b) recover costs, losses or damages it has incurred or suffered as a result of that person's conduct;

(c) cancel the contract and claim any damages which it has suffered as a result of having to make less favourable arrangements due to such cancellation;

(d) recommend that the tenderer or contractor, its shareholders and directors, or only the shareholders and directors who acted on a fraudulent basis, be restricted from obtaining business from any organ of state for a period not exceeding 10 years, after the *audi alteram partem* (hear the other side) rule has been applied; and

(e) forward the matter for criminal prosecution, if deemed necessary.

	…………………………………………
	SIGNATURE(S) OF TENDERER(S)
SURNAME AND NAME:	………………………………………………………
DATE:	………………………………………………………
ADDRESS:	………………………………………………………
	………………………………………………………
	………………………………………………………
	………………………………………………………

THE NATIONAL TREASURY

Republic of South Africa

GOVERNMENT PROCUREMENT:

GENERAL CONDITIONS OF CONTRACT

July 2010

GOVERNMENT PROCUREMENT

GENERAL CONDITIONS OF CONTRACT
July 2010

NOTES

The purpose of this document is to:

(i) Draw special attention to certain general conditions applicable to government bids, contracts and orders; and

(ii) To ensure that clients be familiar with regard to the rights and obligations of all parties involved in doing business with government.

In this document words in the singular also mean in the plural and vice versa and words in the masculine also mean in the feminine and neuter.

- The General Conditions of Contract will form part of all bid documents and may not be amended.

- Special Conditions of Contract (SCC) relevant to a specific bid, should be compiled separately for every bid (if (applicable) and will supplement the General Conditions of Contract. Whenever there is a conflict, the provisions in the SCC shall prevail.

TABLE OF CLAUSES

General Conditions of Contract

1. Definitions

1. The following terms shall be interpreted as indicated:

1.1 "Closing time" means the date and hour specified in the bidding documents for the receipt of bids.

1.2 "Contract" means the written agreement entered into between the purchaser and the supplier, as recorded in the contract form signed by the parties, including all attachments and appendices thereto and all documents incorporated by reference therein.

1.3 "Contract price" means the price payable to the supplier under the contract for the full and proper performance of his contractual obligations.

1.4 "Corrupt practice" means the offering, giving, receiving, or soliciting of any thing of value to influence the action of a public official in the procurement process or in contract execution.

1.5 "Countervailing duties" are imposed in cases where an enterprise abroad is subsidized by its government and encouraged to market its products internationally.

1.6 "Country of origin" means the place where the goods were mined, grown or produced or from which the services are supplied. Goods are produced when, through manufacturing, processing or substantial and major assembly of components, a commercially recognized new product results that is substantially different in basic characteristics or in purpose or utility from its components.

1.7 "Day" means calendar day.

1.8 "Delivery" means delivery in compliance of the conditions of the contract or order.

1.9 "Delivery ex stock" means immediate delivery directly from stock actually on hand.

1.10 "Delivery into consignees store or to his site" means delivered and unloaded in the specified store or depot or on the specified site in compliance with the conditions of the contract or order, the supplier bearing all risks and charges involved until the supplies are so delivered and a valid receipt is obtained.

1.11 "Dumping" occurs when a private enterprise abroad market its goods on own initiative in the RSA at lower prices than that of the country of origin and which have the potential to harm the local industries in the

RSA.

1.12 "Force majeure" means an event beyond the control of the supplier and not involving the supplier's fault or negligence and not foreseeable. Such events may include, but is not restricted to, acts of the purchaser in its sovereign capacity, wars or revolutions, fires, floods, epidemics, quarantine restrictions and freight embargoes.

1.13 "Fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of any bidder, and includes collusive practice among bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the bidder of the benefits of free and open competition.

1.14 "GCC" means the General Conditions of Contract.

1.15 "Goods" means all of the equipment, machinery, and/or other materials that the supplier is required to supply to the purchaser under the contract.

1.16 "Imported content" means that portion of the bidding price represented by the cost of components, parts or materials which have been or are still to be imported (whether by the supplier or his subcontractors) and which costs are inclusive of the costs abroad, plus freight and other direct importation costs such as landing costs, dock dues, import duty, sales duty or other similar tax or duty at the South African place of entry as well as transportation and handling charges to the factory in the Republic where the supplies covered by the bid will be manufactured.

1.17 "Local content" means that portion of the bidding price which is not included in the imported content provided that local manufacture does take place.

1.18 "Manufacture" means the production of products in a factory using labour, materials, components and machinery and includes other related value-adding activities.

1.19 "Order" means an official written order issued for the supply of goods or works or the rendering of a service.

1.20 "Project site," where applicable, means the place indicated in bidding documents.

1.21 "Purchaser" means the organization purchasing the goods.

1.22 "Republic" means the Republic of South Africa.

1.23 "SCC" means the Special Conditions of Contract.

1.24 "Services" means those functional services ancillary to the supply of the goods, such as transportation and any other incidental services, such as installation, commissioning, provision of technical assistance, training, catering, gardening, security, maintenance and other such obligations of the supplier covered under the contract.

1.25 "Written" or "in writing" means handwritten in ink or any form of electronic or mechanical writing.

2. Application

2.1 These general conditions are applicable to all bids, contracts and orders including bids for functional and professional services, sales, hiring, letting and the granting or acquiring of rights, but excluding immovable property, unless otherwise indicated in the bidding documents.

2.2 Where applicable, special conditions of contract are also laid down to cover specific supplies, services or works.

2.3 Where such special conditions of contract are in conflict with these general conditions, the special conditions shall apply.

3. General

3.1 Unless otherwise indicated in the bidding documents, the purchaser shall not be liable for any expense incurred in the preparation and submission of a bid. Where applicable a non-refundable fee for documents may be charged.

3.2 With certain exceptions, invitations to bid are only published in the Government Tender Bulletin. The Government Tender Bulletin may be obtained directly from the Government Printer, Private Bag X85, Pretoria 0001, or accessed electronically from www.treasury.gov.za

4. Standards

4.1 The goods supplied shall conform to the standards mentioned in the bidding documents and specifications.

5. Use of contract documents and information; inspection.

5.1 The supplier shall not, without the purchaser's prior written consent, disclose the contract, or any provision thereof, or any specification, plan, drawing, pattern, sample, or information furnished by or on behalf of the purchaser in connection therewith, to any person other than a person employed by the supplier in the performance of the contract. Disclosure to any such employed person shall be made in confidence and shall extend only so far as may be necessary for purposes of such performance.

5.2 The supplier shall not, without the purchaser's prior written consent, make use of any document or information mentioned in GCC clause 5.1 except for purposes of performing the contract.

5.3 Any document, other than the contract itself mentioned in GCC clause 5.1 shall remain the property of the purchaser and shall be returned (all copies) to the purchaser on completion of the supplier's performance under the contract if so required by the purchaser.

5.4 The supplier shall permit the purchaser to inspect the supplier's records relating to the performance of the supplier and to have them audited by auditors appointed by the purchaser, if so required by the purchaser.

6. Patent rights

6.1 The supplier shall indemnify the purchaser against all third-party claims of infringement of patent, trademark, or industrial design rights arising from use of the goods or any part thereof by the purchaser.

7. Performance security

7.1 Within thirty (30) days of receipt of the notification of contract award, the successful bidder shall furnish to the purchaser the performance security of the amount specified in SCC.

7.2 The proceeds of the performance security shall be payable to the purchaser as compensation for any loss resulting from the supplier's failure to complete his obligations under the contract.

7.3 The performance security shall be denominated in the currency of the contract, or in a freely convertible currency acceptable to the purchaser and shall be in one of the following forms:

(a) a bank guarantee or an irrevocable letter of credit issued by a reputable bank located in the purchaser's country or abroad, acceptable to the purchaser, in the form provided in the bidding documents or another form acceptable to the purchaser; or

(b) a cashier's or certified cheque

7.4 The performance security will be discharged by the purchaser and returned to the supplier not later than thirty (30) days following the date of completion of the supplier's performance obligations under the contract, including any warranty obligations, unless otherwise specified in SCC.

8. Inspections, tests and analyses

8.1 All pre-bidding testing will be for the account of the bidder.

8.2 If it is a bid condition that supplies to be produced or services to be rendered should at any stage during production or execution or on completion be subject to inspection, the premises of the bidder or contractor shall be open, at all reasonable hours, for inspection by a representative of the Department or an organization acting on behalf of the Department.

8.3 If there are no inspection requirements indicated in the bidding documents and no mention is made in the contract, but during the contract period it is decided that inspections shall be carried out, the purchaser shall itself make the necessary arrangements, including payment arrangements with the testing authority concerned.

8.4 If the inspections, tests and analyses referred to in clauses 8.2 and 8.3 show the supplies to be in accordance with the contract requirements, the cost of the inspections, tests and analyses shall be defrayed by the purchaser.

8.5 Where the supplies or services referred to in clauses 8.2 and 8.3 do not comply with the contract requirements, irrespective of whether such supplies or services are accepted or not, the cost in connection with these inspections, tests or analyses shall be defrayed by the supplier.

8.6 Supplies and services which are referred to in clauses 8.2 and 8.3 and which do not comply with the contract requirements may be rejected.

8.7 Any contract supplies may on or after delivery be inspected, tested or analyzed and may be rejected if found not to comply with the requirements of the contract. Such rejected supplies shall be held at the cost and risk of the supplier who shall, when called upon, remove them immediately at his own cost and forthwith substitute them with supplies which do comply with the requirements of the contract. Failing such removal the rejected supplies shall be returned at the suppliers cost and risk. Should the supplier fail to provide the substitute supplies forthwith, the purchaser may, without giving the supplier further opportunity to substitute the rejected supplies, purchase such supplies as may be necessary at the expense of the supplier.

8.8 The provisions of clauses 8.4 to 8.7 shall not prejudice the right of the purchaser to cancel the contract on account of a breach of the conditions thereof, or to act in terms of Clause 23 of GCC.

9. Packing

9.1 The supplier shall provide such packing of the goods as is required to prevent their damage or deterioration during transit to their final destination, as indicated in the contract. The packing shall be sufficient to withstand, without limitation, rough handling during transit and exposure to extreme temperatures, salt and precipitation during transit, and open storage. Packing, case size and weights shall take into consideration, where appropriate, the remoteness of the goods' final destination and the absence of heavy handling facilities at all points in transit.

9.2 The packing, marking, and documentation within and outside the packages shall comply strictly with such special requirements as shall be expressly provided for in the contract, including additional requirements, if any, specified in SCC, and in any subsequent instructions ordered by the purchaser.

10. Delivery and documents

10.1 Delivery of the goods shall be made by the supplier in accordance with the terms specified in the contract. The details of shipping and/or other documents to be furnished by the supplier are specified in SCC.

10.2 Documents to be submitted by the supplier are specified in SCC.

11. Insurance

11.1 The goods supplied under the contract shall be fully insured in a freely convertible currency against loss or damage incidental to manufacture or acquisition, transportation, storage and delivery in the manner specified in the SCC.

12. Transportation

12.1 Should a price other than an all-inclusive delivered price be required, this shall be specified in the SCC.

13. Incidental services

13.1 The supplier may be required to provide any or all of the following services, including additional services, if any, specified in SCC:

(a) performance or supervision of on-site assembly and/or commissioning of the supplied goods;
(b) furnishing of tools required for assembly and/or maintenance of the supplied goods;
(c) furnishing of a detailed operations and maintenance manual for each appropriate unit of the supplied goods;

(d) performance or supervision or maintenance and/or repair of the supplied goods, for a period of time agreed by the parties, provided that this service shall not relieve the supplier of any warranty obligations under this contract; and

(e) training of the purchaser's personnel, at the supplier's plant and/or on-site, in assembly, start-up, operation, maintenance, and/or repair of the supplied goods.

13.2 Prices charged by the supplier for incidental services, if not included in the contract price for the goods, shall be agreed upon in advance by the parties and shall not exceed the prevailing rates charged to other parties by the supplier for similar services.

14. Spare parts

14.1 As specified in SCC, the supplier may be required to provide any or all of the following materials, notifications, and information pertaining to spare parts manufactured or distributed by the supplier:

(a) such spare parts as the purchaser may elect to purchase from the supplier, provided that this election shall not relieve the supplier of any warranty obligations under the contract; and

(b) in the event of termination of production of the spare parts:

(i) Advance notification to the purchaser of the pending termination, in sufficient time to permit the purchaser to procure needed requirements; and

(ii) following such termination, furnishing at no cost to the purchaser, the blueprints, drawings, and specifications of the spare parts, if requested.

15. Warranty

15.1 The supplier warrants that the goods supplied under the contract are new, unused, of the most recent or current models, and that they incorporate all recent improvements in design and materials unless provided otherwise in the contract. The supplier further warrants that all goods supplied under this contract shall have no defect, arising from design, materials, or workmanship (except when the design and/or material is required by the purchaser's specifications) or from any act or omission of the supplier, that may develop under normal use of the supplied goods in the conditions prevailing in the country of final destination.

15.2 This warranty shall remain valid for twelve (12) months after the goods, or any portion thereof as the case may be, have been delivered to and accepted at the final destination indicated in the contract, or for eighteen (18) months after the date of shipment from the port or place of loading in the source country, whichever period concludes earlier, unless specified otherwise in SCC.

15.3 The purchaser shall promptly notify the supplier in writing of any claims arising under this warranty.

15.4 Upon receipt of such notice, the supplier shall, within the period specified in SCC and with all reasonable speed, repair or replace the defective goods or parts thereof, without costs to the purchaser.

15.5 If the supplier, having been notified, fails to remedy the defect(s) within the period specified in SCC, the purchaser may proceed to take such remedial action as may be necessary, at the supplier's risk and expense and without prejudice to any other rights which the purchaser may have against the supplier under the contract.

16. Payment

16.1 The method and conditions of payment to be made to the supplier under this contract shall be specified in SCC.

16.2 The supplier shall furnish the purchaser with an invoice accompanied by a copy of the delivery note and upon fulfillment of other obligations stipulated in the contract.

16.3 Payments shall be made promptly by the purchaser, but in no case later than thirty (30) days after submission of an invoice or claim by the supplier.

16.4 Payment will be made in Rand unless otherwise stipulated in SCC.

17. Prices

17.1 Prices charged by the supplier for goods delivered and services performed under the contract shall not vary from the prices quoted by the supplier in his bid, with the exception of any price adjustments authorized in SCC or in the purchaser's request for bid validity extension, as the case may be.

18. Contract amendments

18.1 No variation in or modification of the terms of the contract shall be made except by written amendment signed by the parties concerned.

19. Assignment

19.1 The supplier shall not assign, in whole or in part, its obligations to perform under the contract, except with the purchaser's prior written consent.

20. Subcontracts

20.1 The supplier shall notify the purchaser in writing of all subcontracts awarded under this contracts if not already specified in the bid. Such notification, in the original bid or later, shall not relieve the supplier from any liability or obligation under the contract.

21. Delays in the supplier's performance

21.1 Delivery of the goods and performance of services shall be made by the supplier in accordance with the time schedule prescribed by the purchaser in the contract.

21.2 If at any time during performance of the contract, the supplier or its subcontractor(s) should encounter conditions impeding timely delivery of the goods and performance of services, the supplier shall promptly notify the purchaser in writing of the fact of the delay, its likely duration and its cause(s). As soon as practicable after receipt of the supplier's notice, the purchaser shall evaluate the situation and may at his discretion extend the supplier's time for performance, with or without the imposition of penalties, in which case the extension shall be ratified by the parties by amendment of contract.

21.3 No provision in a contract shall be deemed to prohibit the obtaining of supplies or services from a national department, provincial department, or a local authority.

21.4 The right is reserved to procure outside of the contract small quantities or to have minor essential services executed if an emergency arises, the supplier's point of supply is not situated at or near the place where the supplies are required, or the supplier's services are not readily available.

21.5 Except as provided under GCC Clause 25, a delay by the supplier in the performance of its delivery obligations shall render the supplier liable to the imposition of penalties, pursuant to GCC Clause 22, unless an extension of time is agreed upon pursuant to GCC Clause 21.2 without the application of penalties.

21.6 Upon any delay beyond the delivery period in the case of a supplies contract, the purchaser shall, without canceling the contract, be entitled to purchase supplies of a similar quality and up to the same quantity in substitution of the goods not supplied in conformity with the contract and to return any goods delivered later at the supplier's expense and risk, or to cancel the contract and buy such goods as may be required to complete the contract and without prejudice to his other rights, be entitled to claim damages from the supplier.

22. Penalties

22.1 Subject to GCC Clause 25, if the supplier fails to deliver any or all of the goods or to perform the services within the period(s) specified in the contract, the purchaser shall, without prejudice to its other remedies under the contract, deduct from the contract price, as a penalty, a sum calculated on the delivered price of the delayed goods or unperformed services using the current prime interest rate calculated for each day of the delay until actual delivery or performance. The purchaser may also consider termination of the contract pursuant to GCC Clause 23.

23. Termination for default

23.1 The purchaser, without prejudice to any other remedy for breach of contract, by written notice of default sent to the supplier, may terminate this contract in whole or in part:

(a) if the supplier fails to deliver any or all of the goods within the period(s) specified in the contract, or within any extension thereof granted by the purchaser pursuant to GCC Clause 21.2;

(b) if the Supplier fails to perform any other obligation(s) under the contract; or

(c) if the supplier, in the judgment of the purchaser, has engaged in corrupt or fraudulent practices in competing for or in executing the contract.

23.2 In the event the purchaser terminates the contract in whole or in part, the purchaser may procure, upon such terms and in such manner as it deems appropriate, goods, works or services similar to those undelivered, and the supplier shall be liable to the purchaser for any excess costs for such similar goods, works or services. However, the supplier shall continue performance of the contract to the extent not terminated.

23.3 Where the purchaser terminates the contract in whole or in part, the purchaser may decide to impose a restriction penalty on the supplier by prohibiting such supplier from doing business with the public sector for a period not exceeding 10 years.

23.4 If a purchaser intends imposing a restriction on a supplier or any person associated with the supplier, the supplier will be allowed a time period of not more than fourteen (14) days to provide reasons why the envisaged restriction should not be imposed. Should the supplier fail to respond within the stipulated fourteen (14) days the purchaser may regard the intended penalty as not objected against and may impose it on the supplier.

23.5 Any restriction imposed on any person by the Accounting Officer / Authority will, at the discretion of the Accounting Officer / Authority, also be applicable to any other enterprise or any partner, manager, director or other person who wholly or partly exercises or exercised or may exercise control over the enterprise of the first-mentioned person, and with which enterprise or person the first-mentioned person, is or was in the opinion of the Accounting Officer / Authority actively associated.

23.6 If a restriction is imposed, the purchaser must, within five (5) working days of such imposition, furnish the National Treasury, with the following information:

(i) the name and address of the supplier and / or person restricted by the purchaser;
(ii) the date of commencement of the restriction
(iii) the period of restriction; and
(iv) the reasons for the restriction.

These details will be loaded in the National Treasury's central database of suppliers or persons prohibited from doing business with the public sector.

23.7 If a court of law convicts a person of an offence as contemplated in sections 12 or 13 of the Prevention and Combating of Corrupt Activities Act, No. 12 of 2004, the court may also rule that such person's name be endorsed on the Register for Tender Defaulters. When a person's name has been endorsed on the Register, the person will be prohibited from doing business with the public sector for a period not less than five years and not more than 10 years. The National Treasury is empowered to determine the period of restriction and each case will be dealt with on its own merits. According to section 32 of the Act the Register must be open to the public. The Register can be perused on the National Treasury website.

24. Anti-dumping and countervailing duties and rights

24.1 When, after the date of bid, provisional payments are required, or anti-dumping or countervailing duties are imposed, or the amount of a provisional payment or anti-dumping or countervailing right is increased in respect of any dumped or subsidized import, the State is not liable for any amount so required or imposed, or for the amount of any such increase. When, after the said date, such a provisional payment is no longer required or any such anti-dumping or countervailing right is abolished, or where the amount of such provisional payment or any such right is reduced, any such favourable difference shall on demand be paid forthwith by the contractor to the State or the State may deduct such amounts from moneys (if any) which may otherwise be due to the contractor in regard to supplies or services which he delivered or rendered, or is to deliver or render in terms of the contract or any other contract or any other amount which may be due to him

25. Force Majeure

25.1 Notwithstanding the provisions of GCC Clauses 22 and 23, the supplier shall not be liable for forfeiture of its performance security, damages, or termination for default if and to the extent that his delay in performance or other failure to perform his obligations under the contract is the result of an event of force majeure.

25.2 If a force majeure situation arises, the supplier shall promptly notify the purchaser in writing of such condition and the cause thereof. Unless otherwise directed by the purchaser in writing, the supplier shall continue to perform its obligations under the contract as far as is reasonably practical, and shall seek all reasonable alternative means for performance not prevented by the force majeure event.

26. Termination for insolvency

26.1 The purchaser may at any time terminate the contract by giving written notice to the supplier if the supplier becomes bankrupt or otherwise insolvent. In this event, termination will be without compensation to the supplier, provided that such termination will not prejudice or affect any right of action or remedy which has accrued or will accrue thereafter to the purchaser.

27. Settlement of Disputes

27.1 If any dispute or difference of any kind whatsoever arises between the purchaser and the supplier in connection with or arising out of the contract, the parties shall make every effort to resolve amicably such dispute or difference by mutual consultation.

27.2 If, after thirty (30) days, the parties have failed to resolve their dispute or difference by such mutual consultation, then either the purchaser or the supplier may give notice to the other party of his intention to commence with mediation. No mediation in respect of this matter may be commenced unless such notice is given to the other party.

27.3 Should it not be possible to settle a dispute by means of mediation, it may be settled in a South African court of law.

27.4 Mediation proceedings shall be conducted in accordance with the rules of procedure specified in the SCC.

27.5 Notwithstanding any reference to mediation and/or court proceedings herein,

(a) the parties shall continue to perform their respective obligations under the contract unless they otherwise agree; and
(b) the purchaser shall pay the supplier any monies due the supplier.

28. Limitation of liability

28.1 Except in cases of criminal negligence or willful misconduct, and in the case of infringement pursuant to Clause 6;
(a) the supplier shall not be liable to the purchaser, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the supplier to pay penalties and/or damages to the purchaser; and

(b) the aggregate liability of the supplier to the purchaser, whether under the contract, in tort or otherwise, shall not exceed the total contract price, provided that this limitation shall not apply to the cost of repairing or replacing defective equipment.

29. Governing language	29.1	The contract shall be written in English. All correspondence and other documents pertaining to the contract that is exchanged by the parties shall also be written in English.
30. Applicable law	30.1	The contract shall be interpreted in accordance with South African laws, unless otherwise specified in SCC.
31. Notices	31.1	Every written acceptance of a bid shall be posted to the supplier concerned by registered or certified mail and any other notice to him shall be posted by ordinary mail to the address furnished in his bid or to the address notified later by him in writing and such posting shall be deemed to be proper service of such notice
	31.2	The time mentioned in the contract documents for performing any act after such aforesaid notice has been given, shall be reckoned from the date of posting of such notice.
32. Taxes and duties	32.1	A foreign supplier shall be entirely responsible for all taxes, stamp duties, license fees, and other such levies imposed outside the purchaser's country.
	32.2	A local supplier shall be entirely responsible for all taxes, duties, license fees, etc., incurred until delivery of the contracted goods to the purchaser.
	32.3	No contract shall be concluded with any bidder whose tax matters are not in order. Prior to the award of a bid the Department must be in possession of a tax clearance certificate, submitted by the bidder. This certificate must be an original issued by the South African Revenue Services.
33. National Industrial Participation (NIP) Programme	33.1	The NIP Programme administered by the Department of Trade and Industry shall be applicable to all contracts that are subject to the NIP obligation.
34 Prohibition of Restrictive practices	34.1	In terms of section 4 (1) (b) (iii) of the Competition Act No. 89 of 1998, as amended, an agreement between, or concerted practice by, firms, or a decision by an association of firms, is prohibited if it is between parties in a horizontal relationship and if a bidder (s) is / are or a contractor(s) was / were involved in collusive bidding (or bid rigging).
	34.2	If a bidder(s) or contractor(s), based on reasonable grounds or evidence obtained by the purchaser, has / have engaged in the restrictive practice referred to above, the purchaser may refer the matter to the Competition Commission for investigation and possible imposition of administrative penalties as contemplated in the Competition Act No. 89 of 1998.

34.3 If a bidder(s) or contractor(s), has / have been found guilty by the Competition Commission of the restrictive practice referred to above, the purchaser may, in addition and without prejudice to any other remedy provided for, invalidate the bid(s) for such item(s) offered, and / or terminate the contract in whole or part, and / or restrict the bidder(s) or contractor(s) from conducting business with the public sector for a period not exceeding ten (10) years and / or claim damages from the bidder(s) or contractor(s) concerned.

Js General Conditions of Contract (revised July 2010)

MARINE LIVING RESOURCES FUND

Foretrust Building ,Martin Hammerschlag Way ,Foreshore, Cape Town, 8001 or Private Bag X2 ,ROGGEBAAI,8012(FASCMILE NO.021-4023228)

MLRF ENTITY MAINTENANCE AND CREDIT ORDER INSTRUCTION

(Please complete or mark with a "X" in black ink where applicable. A bank stamp is required to verify your banking details. In case of a cheque account a cancelled cheque must be included. Please return form by post or by hand delivery or by facsimile.)

TAKE-ON	NEW	UPDATE	ENTITY TYPE	BUSINESS	DEPARTMENT	EMPLOYEE	OTHER

FROM: CREDITOR / ENTITY (DETAILS)

TITLE	
SURNAME	
FIRST NAME/S	
BUSINESS NAME	
TRADING NAME	
BUSINESS REG No.	
VAT REGISTERED	Y N
VAT REGISTRATION NO.	
ID NO.	
DEPARTMENT NAME	
PERSAL NO.*	* For employees only

CONTACT DETAILS

STREET / PHYSICAL ADDRESS	POSTAL CODE
POSTAL ADDRESS	POSTAL CODE
BUSINESS TELEPHONE No.	DIALLING CODE
BUSINESS FACSIMILE No.	DIALLING CODE
NAME OF CONTACT PERSON	
E-MAIL ADDRESS	
CELLULAR TELEPHONE No.	

DETAILS OF FINANCIAL INSTITUTION FOR ELECTRONIC BANKING TRANSFERS:

BANK NAME:	
BRANCH NAME & CITY/TOWN	
BRANCH NUMBER/CODE	
ACCOUNT NUMBER	
ACCOUNT TYPE	CURRENT / SAVINGS / TRANSMISSION

BANK DATE STAMP (COMPULSORY)

I / We hereby request, instruct and authorise you to pay any amounts which may accrue to me / us to the credit of my / our account with the abovementioned bank.

I / we understand that the credit transfers hereby authorised will be processed electronically through a system known as the "ACB ELECTRONIC FUNDS TRANSFER SERVICE", and I/we also understand that no additional advice of payment will be provided by my/our bank. Details of each payment will be printed on my/our bank statement or any accompanying voucher.

I / We understand that a payment advice will be supplied by the Marine Living Resource Fund in the normal way, and that it will indicate the date on which funds will be available in my / our account.

This authority may be cancelled / changed by giving prior written notice, by way of registered post or facsimile.

SIGNATURE OF AUTHORISED PERSON		POSITION HELD	
PRINT NAME OF AUTHORISED PERSON		DATE (DD/MM/YYYY):	

forestry, fisheries
& the environment

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

THE MARINE LIVING RESOURCES FUND, A SCHEDULE 3A PUBLIC ENTITY ESTABLISHED IN TERMS OF THE PUBLIC FINANCE MANAGEMENT ACT, 1999 (ACT NO 1 of 1999) AND THE DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT ("DFFE") (IN ITS COMMITMENT TO THE PRINCIPLES ENSHRINED IN THE CONSTITUTION OF THE REPUBLIC OF SOUTH AFRICA, 1996) ADHERES TO THE PROVISIONS OF THE BROAD BASED BLACK ECONOMIC EMPOWERMENT ACT, 2003 (Act No. 53 OF 2003) (B-BBEE), THE PREFERENTIAL PROCUREMENT POLICY FRAMEWORK ACT, 2000 (Act No. 5 OF 2000) ("PPPF") AND THE PREFERENTIAL PROCUREMENT REGULATIONS, 2022.

TERMS OF REFERENCE

MLRF200/23:TO APPOINT A SERVICE PROVIDER (SP) TO CONDUCT SPECIALIST MONITORING IN ACCORDANCE WITH THE ENVIRONMENTAL AUTHORISATION, ENVIRONMENTAL MANAGEMENT PROGRAMME AND SAMPLING PLAN AT THE SEA-BASED AQUACULTURE DEVELOPMENT ZONE LOCATED WITHIN SALDANHA BAY IN THE WESTERN CAPE FOR A PERIOD OF THIRTY-SIX (36) MONTHS.

TABLE OF CONTENTS

1. PURPOSE

1.1 The Marine Living Resource Fund (MLRF), Fisheries Management Branch of the Department of Forestry, Fisheries, and the Environment as the holder of the Environmental Authorisation (EA) for the Saldanha Bay Aquaculture Development Zone (ADZ) requires the services of a suitably qualified Service Provider (SP) to conduct specialist monitoring according to the environmental Sampling Plan for the sea based ADZ located within Saldanha Bay in the Western Cape, in compliance with the stipulations in the Environmental Authorisation (EA) and the Environmental Management Plan (EMP) for the ADZ, for a period of thirty-six (36) months

2. INTRODUCTION AND BACKGROUND

2.1 The Aquaculture Development Zone (ADZ) is an area that has been earmarked specifically for aquaculture activities with the purpose of encouraging investor and consumer confidence; creating incentives for industry development, to provide marine aquaculture services; to manage the risks associated with aquaculture; as well as to provide skills development and employment for coastal communities. The development of ADZs supports the Policy for the Development of a Sustainable Marine Aquaculture sector in South Africa (2007) aimed at creating an enabling environment that will promote growth and sustainability of the marine aquaculture sector in South Africa, as well as to enhance the industry's contribution to South Africa's economic growth.

2.2 Saldanha Bay is the primary area for bivalve production in South Africa, with the majority of oyster and mussel production to date originating from the bay. As a result of improved opportunities for local mussel import substitution, the opening up of export markets for oysters, and improved access to water and land space through the Oceans Economy Operation Phakisa initiative, there is a renewed interest in expanding and fully utilizing the bay for further oyster and mussel production, as well as exploring potential for finfish production in the outer more exposed parts of the bay.

2.3 The MLRF undertook an Environmental Impact Assessment (EIA) for the establishment of an ADZ in Saldanha Bay in 2016/2017 and the EA was granted on the 8th January 2018. Appeals against the authorisation were lodged to the "then Minister of Environmental Affairs" and the authorisation was upheld as per the letter dated 7th June 2018.

2.4 The Branch Fisheries Management appointed a specialist service provider in August 2021 for a contract period. However this contract is set to expire in October 2023. It is important that ongoing environmental monitoring continues for the project to ensure that the Branch, as the custodian of the authorisation, continues to comply with the EA and EMPr for the ADZ.

2.5 The MLRF seeks to appoint a service provider for specialist monitoring, which includes the servicing of bottom moored oxygen sensors every eight (8) weeks (deployment and retrieval of oceanographic instrumentation and data collection etc.); drafting of technical reports and the undertaking of field surveys as required by the Sampling Plan in compliance with the stipulations in the EA and the EMP for the sea based ADZ located within the Saldanha Bay in the Western Cape, for a period of thirty six (36) months.

3. VIRTUAL COMPULSORY BRIEFING SESSION

3.1 To ensure that service providers understand what is required from them with regards to this tender, bidders must attend of a compulsory Briefing Session. The Briefing Session will take place as follows:

- 20 September 2023 at 10h00 – 12h00

The link for the Briefing Session can be requested via email:

Name	Email address
Mr Lwandisa Hoza	MLRFtenders@dffe.gov.za
Ms Talitha Bikani	

**Bidders should use "MLRF200/23: Briefing Session" as the subject of the email of requesting link for the briefing session.*

4. SCOPE AND EXTENT OF WORK

4.1 Benthic macrofauna survey

The Sampling Plan for the Saldanha Bay Aquaculture Development Zone outlines the requirements for conducting the benthic macrofauna survey. This survey includes a full macrofauna analyses (both infauna and epifauna), TOC/N, granularity and porosity at shellfish and finfish monitoring sites/sampling stations indicated in the Sampling Plan, with three samples taken from the finfish sites which will also be taken for analysis of the metals Al, Cu and Zn. These surveys are to be undertaken once every three years, the last survey was completed in April 2021, the next survey is required in April 2024 for 26 sites. Refer to 2021 report (Annexure A) and the amended Sampling Plan (Annexure B) regarding the specific required methodologies. It is highly recommended that all bidders read through the annexure documents in order to get detailed information on the scope and extent of work.

4.2 Annual benthic chemical survey

Annual chemical transect survey of sulfide (S2-) to establish the status of the oxygen environment of the aquaculture lease areas. Chemical characteristics to be collected during sampling by divers along a transect (0m; 30m; and 60m) to reflect farm impact over a total of 30 sites, seventeen (17) sites in Big Bay, seven (7) in Outer Bay North and six (6) within Small Bay. In instances where farming structures fall over hard substrata, alternative means for monitoring the health of the benthic environment in these areas (e.g. assessment of visual or photo-quadrats) should be implemented. Statistical analysis of data collected in the 2021 and 2022 surveys should be taken into consideration as well as the amended Sampling Plan (Annexure B) when planning and analysing the samples for this survey. It is highly recommended that all bidders read through the annexure documents in order to get detailed information on the scope and extent of work

4.3 Caltrate platform survey

Full extent of Caltrate platform to be determined through the undertaking of a once off mapping process to assess the habitat type through the hydrographic mapping of the Big Bay precinct. The recent hydrographic survey conducted by the South African Hydrographic office in 2021/22 excluded the extent of the Big Bay precinct due to the presence of the aquaculture infrastructure. Since this data was omitted from the recent survey the mapping of the Big Bay precinct needs to be undertaken and incorporated into the SA hydrographic survey results (data to be shared on appointment). Estimated area to be surveyed is 409ha within the Big Bay precinct. Find attached the Hard Substrate Survey Report of August 2022 (Annexure C). It is highly recommended that all bidders read through the annexure documents in order to get detailed information on the scope and extent of work.

4.4 Epifauna reef community surveys

Reef community surveys to determine the species community composition and diversity found on hard substrata in Big Bay and to determine the potential impact of aquaculture on these communities to be undertaken every three years, the last survey was conducted in 2022, the next survey is required in 2025. Please see the Sampling Plan (Annexure A) for the details regarding the required methodologies.

The number of replicates taken within a site should be sufficient to address natural spatial variability and patchiness such that a degree of reliability can be placed on the results. This is of particular relevance where comparison with a reference or baseline condition is intended. Reference stations need to be defined for each location. Stations of similar depth and substratum type to the sites within the proposed aquaculture operation should be chosen. Reference stations should be positioned away from the probable zone of influence of the operation (e.g., upstream of dominant current direction) but within the same broad vicinity (Noble-James et al. 2017). Under no circumstances should reference stations be located close to the aquaculture site, even if they are believed to be 'upstream' (Fernandes et al. 2001).

It is highly recommended that all bidders read through the annexure documents in order to get detailed information on the scope and extent of work.

4.5 Servicing of bottom moored instruments

Deployment, retrieval and servicing (cleaning of the instrument of biofouling organisms and changing of the batteries if required) of bottom moorings by means of qualified and Department of Employment and Labour compliant scuba divers for the below mentioned oceanographic equipment, every eight (8) weeks (estimated eighteen (18) servicing intervals) over the thirty-six (36) months contract period. Service providers should provide credible references of previous work which is in line with servicing and retrieval of the below type of equipment and are to cost for the insurance of all sensors (please also note that the MLRF is not responsible for the appointed service provider's personal liability insurance or equipment to be used in the undertaking of this work). Deployment, retrieval and servicing will be coordinated in consultation with the DFFE scientists and oceanographic technicians to facilitate data download:

- Four oxygen sensors (JFE Advantech Rinko-W Oxygen optical sensors) to be serviced in conjunction with the DFFE scientists. Nylon stocking to be replaced at each service interval, which encases the oxygen sensors. The servicing includes procurement and replacement of CR-V3 lithium batteries (16 batteries to be replaced every sixteen (16) weeks i.e. at nine (9) of the estimated 18 service intervals). Moorings for each sensor should be supplied by the appointed service provider.
- One nitrate sensor (SUNA) to be serviced during each service interval along with the collection of a 100ml water sample. A suitable mooring (height 1m above the seafloor) to be supplied for redeployment of a nitrate sensor.

4.6 Biofouling Management Strategy

Draft a Biofouling Management Strategy for disposal of biofouling waste, to be implemented by the operators and to include a review of the current reporting format on the Farm Monitoring Report template and update if required. There are existing biofouling species identification reports (non-quantitative data) available which will be shared upon appointment to guide the development of the strategy. International examples should be used to inform the development of strategy. The control of biofouling in aquaculture is achieved through the avoidance of natural recruitment, physical removal and the use of antifoulants.

4.7 Quarterly Environmental reporting

Draft a Quarterly Environmental Sampling Report based on the current monitoring being undertaken in line with the scope of these ToR and submit to the Aquaculture Management Committee (AMC) in a format approved by the MLRF.

4.8 Amend the Sampling Plan (as required)

Update the Sampling Plan (Annexure B) in consultation with the DFFE scientists, to allow for flexibility to add or remove indicators based on the evolution of the state of knowledge on the project to date. The Sampling plan was amended in 2022 and will require review and amendment in 2025.

4.9 Validation of finfish model (subject to the establishment of a finfish farm within the ADZ)

Collection of raw data (water samples) for laboratory analysis for the validation process of the initial finfish dispersion model (desktop model) as documented in Annexure B, developed by PRDW Consulting Port and Coastal Engineers. This should include near field effects and the interactions between neighbouring aquaculture operations. The appointed service provider should cater for collaborative efforts with PRDW who developed the model which is to be updated with real time monitoring (such as water quality monitoring). Raw data has been collected since September 2021 to September 2022 and a draft report is available of the data collected to date. Ongoing data may be required if a finfish farm is to be established in the ADZ.

4.10 Digital invertebrate taxonomic reference library

Maintain and update an existing digital invertebrate taxonomic reference library that was collected from the previous contracts to allow comparison between service providers for the lifespan of the ADZ. The reference library should be presented in an electronic and hard copy booklet format and should allow for continued updating.

4.11 Project management duties

Bi-monthly (every two months) progress meetings will be held virtually with the exception of the project inception and close out meetings which will be held physically in DFFE's Cape Town offices. Progress meeting minutes to be drafted by the service provider and approved by the MLRF Project Manager. Bi - monthly progress reports should be submitted to the MLRF Project Manager.

4.12 Endangered, Threatened and Protected species data

Visual survey of the presence or absence of Endangered, Threatened and Protected species (as per the Endangered, Threatened and Protected species lists) to be recorded in existing excel spread sheet template. Visual survey to be conducted every eight (8) weeks within the four precincts of the ADZ from a boat, during the servicing of the bottom moored instruments. Data to be summarised into text and findings to be reported in the Quarterly Environmental reporting. Species identification to be facilitated by the use of existing species ID cards reference material, templates for species counts will be made available on appointment.

5. EXPECTED DELIVERABLES / OUTCOMES

	Deliverable	Frequency
5.1	Benthic Macrofauna survey and report every three (3) years	Two (2) surveys to be conducted (2024), samples to be analysed, report to be drafted and presentation to be given to the Saldanha Bay

		Aquaculture Management Committee (virtual platform) and the Consultative Forum (virtual meeting) for their noting.
5.2	Annual benthic chemical survey	Three (3) surveys to be conducted (2024, 2025 and 2026), samples to be analysed, reports to be drafted and presentations to be given to the Saldanha Bay Aquaculture Management Committee (virtual platform) and the Consultative Forum (virtual meeting) for their noting.
5.3	Caltrate platform survey	Hydrographic survey (once off) of caltrate platform to be conducted, data to be analysed, report to be drafted and presentation to be given to the Saldanha Bay Aquaculture Management Committee (virtual platform) and the Consultative Forum (virtual meeting) for their noting.
5.4	Epifauna reef community survey	One survey (2025) to be conducted, samples to be analysed, reports to be drafted and presentation to be given to the Saldanha Bay Aquaculture Management Committee (virtual platform) and the Consultative Forum (virtual meeting) for their noting
5.5	Servicing of bottom moored instruments	Eighteen (18) surveys of servicing bottom moored instruments, progress to be reported in the quarterly environmental reports as well as the bi-monthly progress reports. Insurance of instruments to be covered by service provider. Mooring to be supplied by service provider.
5.6	Biofouling Management Strategy	One report to be drafted for the management of biofouling on aquaculture infrastructure. Review and amendment if required, of the existing Farm Monitoring report template where the biofouling data is reported by the operators.
5.7	Quarterly Environmental reporting	Four quarterly reports drafted per year of appointment depending on the start date.
5.8	Amended the Sampling Plan (as required)	One amendment of the Sampling plan during the thirty six (36) months period possibly in 2025.
5.9	Validation of finfish model	Raw data collection surveys to be conducted at every service interval for the duration of the appointment. Data to be analysed and fed into the desk top model developed by PRDW for validation of the model.
5.10	Digital invertebrate taxonomic reference library	Electronic and hard copy data base to be maintained during the lifetime of the appointment period.
5.11	Project management duties	One inception meeting and minutes, project closure meeting and minutes, then bi-monthly meetings attended virtually, meeting minutes drafted, bi-monthly progress reports to be submitted along with an invoice for payment.
5.12	Endangered, Threatened and Protected species monitoring	Existing data base to be maintained and species data to be collected every eight (8) weeks during the servicing of the bottom moored instruments, via survey of all precincts within the ADZ while on the water. The reporting of ETP species data to be reported in the Quarterly Environmental reporting.

6. PERIOD / DURATION OF APPOINTMENT

6.1. The contract with the appointed Service Provider (SP) will run for a period of thirty-six (36) months and will commence as agreed in the Memorandum of Agreement (MOA) and upon the issuing of the purchase order.

7. COSTING / COMPREHENSIVE BUDGET

7.1. A comprehensive costing must be provided in a separate envelope inclusive of all disbursement costs and related expenditures inclusive of Value Added Tax (VAT). Refer to additional pricing schedule for further detail and SBD 3.3 to be completed. The SP must quote for all activities and should be quoted in South African currency.

7.2. The MLRF shall not pay for any unproductive or duplicated time spent by the SP on any assignment because of staff changes, outsourcing or re-drafting of reports due to errors, corrections or incorrect/incomplete findings.

7.3. The MLRF reserves the right to negotiate with one or more preferred bidder(s) identified in the evaluation process, regarding any terms and conditions, including prices without offering the same opportunity to any other bidder(s) who have not been awarded the status of the preferred bidder(s).

7.4. The DFFE / MLRF reserves the right to negotiate with one or more preferred bidder(s) identified in the evaluation process, regarding any terms and conditions, including prices without offering the same opportunity to any other bidder(s) who have not been awarded the status of the preferred bidder(s).

7.5. Prices should be quoted as per the pricing schedule below:

Costing Activity	**Unit of measure**	**Cost per unit**	**Total Costs**
1.Project inception meeting and report	1 meeting and report		
2.Servicing of bottom moored instruments	18 service intervals		
3. Quarterly progress meeting and minutes	12 meetings and minutes		
4.Quarterly Environmental Sampling reports	12 reports		
5. Benthic Macrofauna survey and report	1 survey and report		
6. Annual benthic chemical survey and report	3 surveys and reports		
7. Caltrate platform survey	1 one survey and report		
8. Epifauna reef community surveys	1 survey and report		
9. Amended the Sampling Plan	1 report		
10. Validation of finfish model	1 report		
11. Digital invertebrate taxonomic reference library	1 report		

12. Biofouling Management Strategy and amendment of the Farm Monitoring Report template	1 report		
13. Project management and progress report	12 reports		
14. ETP species data collection	18 surveys		
ESTIMATED TOTAL AMOUNT FOR THE PROJECT			

8. EVALUATION METHOD

8.1 The evaluation for this bid will be carried out in four (4) phases:

- Phase 1: Pre-compliance or Initial screening
- Phase 2: Mandatory Requirement
- Phase 3: Due Diligence
- Phase 4: Price and Specific goals

8.2 PHASE 1: PRE-COMPLIANCE OR INITIAL SCREENING

8.2.1 During this phase bid documents will be reviewed to determine the compliance with Supply Chain Management Standard Bidding Documents and any other required returnable, tax matters and whether the Central Data Base (CSD) report has been submitted with the bid documents at the closing date and time of the bid. Bids which do not satisfy the compliance criteria will not be evaluated further.

8.2.2 The bid proposal will be screened for compliance with administrative requirements as indicated below:

Item No.	Administrative Requirements	Check/Compliance	Non-submission may result in disqualification?
1	SCM - SBD 1 - Invitation to Bid	Completed and signed	**NO
2	SCM - SBD 2 - Tax Clearance Certificate Requirements	CSD registration number/SARS PIN and CSD summary report	**NO
3	SCM - SBD 3.3 – Pricing Schedule	Completed and signed	**NO
4	SCM – NEW SBD 4 - Declaration of Interest	Completed and signed	**NO

Item No.	Administrative Requirements	Check/Compliance	Non-submission may result in disqualification?
5	SCM - NEW SBD 6.1 - Preference Points Claim Form in terms of the Preferential Procurement Regulations 2022	Completed and signed.	**NO
6	In case of bids where Consortia / Joint Ventures, Consortia agreement signed by both parties must be submitted with bid proposal	JV agreement completed and signed, if applicable	**NO

**NO – MLRF reserves the right to send a request for information (RFI) to the service provider in the event of non-submission or incomplete documentation and to request a response within seven (7) days after the date of sending the RFI. If the documents are not submitted or completed in full within seven (7) days the MLRF will reject proposals and will these will not be further evaluated for Phase 2.

8.3. PHASE 2: MANDATORY REQUIREMENTS

8.3.1. The following table must be completed by the bidder by answering YES OR NO and attach proof.

8.3.2. Only bidders who achieve a "Yes" and attach required proof for all mandatory requirements will proceed for evaluation to Phase 3.

REQUIREMENT	REQUIRED PROOF TO BE SUBMITTED WITH BID	COMPLY: YES OR NO
The Project leader is registered with the South African Council for Natural Scientific Professionals (SACNASP) as an Aquatic science professional (marine science) or relevant field of practise covering the scope of work outlined in SECTION 4 above.	SACNASP registration number, certificate / annual subscription	
The Bidder has conducted at least two marine environmental monitoring projects of a multi stakeholder nature with experience as a senior Project manager/ Senior natural marine scientist.	Company Profile/ CV of Project leader	
The Project Teams members or individuals have demonstrable knowledge in marine environmental monitoring and aquaculture projects required to draft and draft the reports listed above or be supported by a team with the required skills.	CV of Project team members	
The Project leader has at least a MSc in Marine Natural Sciences.	MSc Degree	
Certified Scientific Dive Team of at least five (5) people, one supervisor, one designated medical practitioner (level 2: on call) and three (3) divers with minimum Class 4 Registration. Note pricing should be equivalent to a Class registration for all divers.	Dive certificates	

Full compliance with labour requirements e.g. Medicals up to date etc.		
Verifiable experience with development of monitoring protocols in aquaculture and conducting dispersion modelling	At least 3 signed reference letters from a client on successfully completed work on the dispersion modelling and development of monitoring protocols in aquaculture	

8.4. PHASE 3: DUE DILIGENCE

8.4.1 The Department shall have the right to perform due-diligence exercise during the evaluation process of this bid and to reject proposals that do not comply with the requirements.

8.4.2 Only bid proposals that meet Phase one (1) and two (2) will be considered to be evaluated for due diligence.

8.4.3 The MLRF will perform due diligence on the areas of the bidders:

8.4.3.1 Mandatory requirements in 8.3.2

8.4.3.2 Premises of the bidder

8.4.4 Live demonstrations and/or site inspections will be performed to confirm the ability of the bidder to execute the project and the availability of sufficient personnel, working equipment, and other resources to deliver the required services.

8.4.5 The MLRF will communicate the dates to the bidder/s beforehand. Bidders must

8.4.5.1 To have the personnel who will be responsible for the demonstrations that will be required to be available.

8.4.5.2 To have any other information or staff required for MLRF to successfully perform the due diligence.

8.4.5.3 To provide the MLRF before the date of the due diligence with the contact details of two people that will be contacted on the day of the due diligence.

8.4.5.4 To reserve two (2) parking bays for the representative of the MLRF.

8.5 PHASE 4: PRICING AND SPECIFIC GOALS

8.5.1 An evaluation of Price and Specific Goals Preference points on the suppliers that have successfully qualified to this stage of evaluation.

8.5.2 Calculation of points for price - The Preferential Procurement Policy Framework Act (PPPFA) prescribes that the lowest acceptable bid will score 80 points (for tenders under R50m) or 90 points (for tenders above R50m) for price. Suppliers that quoted higher prices will score lower points for price on a pro-rata basis.

8.5.3 The 80/20 as an appropriate preference point system will be used in the evaluation and adjudication of this quote. However, it must be extended that the lowest acceptable quote will be used to determine the applicable preference point system as per regulation (Section 3(2)(b) of the Preferential Procurement Regulations (PPR) 2022, which states: "If it is unclear which preference point system will be applicable, that either the 80/20 or 90/10 preference point system will apply and that the lowest acceptable proposal will be used to determine the applicable preference point system". Therefore, either 80 or 90 points, depending on the rand value of the proposal, will be awarded to the suppliers who offers the lowest price, and proportionately fewer points are awarded to those with higher prices. Either 20 or 10 points are then available as preference points for Specific Goals, as applicable. The contract will be awarded to the supplier that scores the highest total number of adjudication points per category.

8.5.4 Points will be awarded to a supplier for specific goals in accordance with the table below:

A.	**PRICE**	**80**
B.	**Specific Goal**	**Number of points (20)**
	51% black ownership	8
	50% women ownership	4
	Youth ownership	4
	Disability	4
	Non–compliant contributor	0

*The definitions of the above specific goals are as per the PPR policy of the MLRF.

8.5.5 The SCM unit of the MLRF will allocate preferential points (Specific Goals) to each company for its contribution towards empowerment of the black designated groups as prescribed in the Preferential Procurement Regulations of 2022, women, people with disabilities, youth as well as local economic development.

8.5.6 A supplier will not be disqualified from the quotation process if the suppliers does not submit supporting documents substantiating the specific goals preference points claimed or is a non-compliant contributor. Such some suppliers will score 0 for Specific Goals.

8.5.7 Suppliers will be subject to SCM conditions of the Department – MLRF and the Preferential Procurement Regulations, 2022 issued in terms of section 5 of the Preferential Procurement Policy Framework Act (Act No 5 of 2000) (PPPFA).

8.5.8 The PPPFA prescribes that the lowest acceptable bid will score 80 or 90 points for price (as explained above, depending on whether the bid prices is more or less than R50million). Suppliers that quoted higher prices will score lower points for price on a pro-rata basis.

8.5.9 The contract will be awarded to the supplier scoring the highest points subject to section 2(1) (f) of the PPPFA, 2000.

9. BID SUBMISSION REQUIREMENTS

9.1 **All completed documentation must be returned to the Marine Living Resources Fund (MLRF), the entity of the Department of Forestry, Fisheries and the Environment (DFFE) before 11:00 on the 29th of September 2023. The location of the drop off is: Tender Box, Ground Floor, Foretrust Building, 2 Martin Hammerschlag Way, Cape Town, 8000.**

9.2 Bidders should ensure that the following submission requirements, which will be needed for evaluation purposes are included in their bid proposal and are as follows:

9.2.1. The SP must draft a table of content which will indicate where each document is located in the proposal.

9.2.2 The proposal shall consist of two parts, namely the technical bid and the pricing bid (master and copies).

9.2.3 Add documents that are required to be submitted with the bids. These documents include those included in Phase one (1) and Phase two (2) of the evaluation criteria.

9.2.4 Completed table of mandatory requirements, as set out in the table in paragraph 8.3. 2 of this document, together with all necessary supporting documents and required documentary proof.

9.2.5 Standard bidding documents (SBD1, 2, 3.3, 4, and 6.1) completed and signed. A valid copy of the Tax Clearance Certificate/ Tax Compliance Status Pin issued by SARS to the supplier/copy of Central Supplier Database (CSD)/ MA supplier Number must be submitted together with the bid.

9.2.6 In case of bids where Consortia / Joint Ventures / Sub-contractors are involved; such must be clearly indicated and each party must submit a separate copy of a valid Tax Clearance Certificate or copy of Tax Compliance Status Pin or CSD/ MAAA supplier Number together with the bid.

9.2.7 Certified copies of identity documents of directors and shareholders of the company.

9.2.8 Entity registration Certificate (e.g. CK1).

9.2.9 Letter of Authority to sign documents on behalf of the company.

10. SPECIAL CONDITIONS OF CONTRACT

10.1 On appointment, the performance measures for the delivery of the agreed services will be closely monitored by Department / MLRF.

10.2 The Department / MLRF will not be held responsible for any costs incurred by the SPs during the preparation, presentation and submission of the proposal.

10.3 The Project Manager will be responsible for the management of the Memorandum of Agreement (MOA).

10.4 All the conditions specified in the General Conditions of Contract (GCC) will apply and where the conditions in the special conditions of contract contradict the conditions in the general conditions of contract, the special conditions of contract will prevail.

10.5 The bid proposals should be submitted with all required information containing technical information.

10.6 Travelling costs and time spent or incurred between home and office of the SP and the MLRF office will not be for the account of MLRF.

10.7 Poor or non-performance by the bidder will result in cancellation of the order and the MOA.

10.8 Should the service provider fail to perform, the MLRF reserves the right to cancel the appointment of such service provider immediately and without any notice.

11. PAYMENT TERMS

11.1 The MLRF undertakes to pay out in full or as per deliverables within 30 (thirty) days all valid claims for work done to its satisfaction upon presentation of a substantiated claim and the required reports stipulated in special conditions. No payment will be made where there is outstanding information/work not submitted by the Service Provider/s until that outstanding information is submitted.

11.2 Payment by the MLRF shall be made by means of an electronic transfer into the SP's bank account.

11.3 Payment requirements

- The successful Service Provider shall render services to the MLRF in accordance with the Project Plan and Project Scope.
- The amounts are inclusive of VAT and all disbursements shall be paid in South African Rands.
- The MLRF reserves the right to, after consultation with the successful Service Provider, increase, reduce or cancel the budget.
- Disbursements of project funding will be agreed on for each project and disbursements will be made on agreed and verified deliverables and indicators (targets) that are included in the Project Plan
- The successful Service Provider shall provide the MLRF with an original tax invoice for the services rendered. Once the MLRF has approved such an invoice and is satisfied with the services rendered as

outlined in the Project Plan, it will make payment to the successful Service Provider within 30 days of approval of such a request.

- The successful Service Provider is required to submit the following documents with each invoice;

    - Acting letter of the manager of SP (if applicable)
    - Monthly/Period Project Progress Report

- The MLRF requires that a new order number be raised after 1 April of each of the financial years of the contract period.
- ALL INVOICES MUST ADDRESSED TO THE MLRF.

12. ENQUIRIES

12.1 Should you require any further information in this regard, please do not hesitate to email:

Name	**Email address**
Mr Lwandisa Hoza	MLRFtenders@dffe.gov.za
Ms Talitha Bikani	

**Bidders should use "MLRF200/23: Enquiries" as the subject of the email of requesting link for the briefing session.*

ANNEXURE A

SALDANHA BAY SEA BASED AQUACULTURE DEVELOPMENT ZONE

2021 BENTHIC MONITORING SURVEY FINAL REPORT

July 2021

ANCHOR research & monitoring

Anchor Research and Monitoring Report No. 1937/3

SALDANHA BAY SEA BASED AQUACULTURE DVELOPMENT ZONE 2021 BENTHIC MONITORING SURVEY DRAFT REPORT

July 2021

Made through the Ocean Stewardship Fund (OSF) program
of Marine Stewardship Council

and the
World Wide Fund for Nature

Report Prepared by:
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EXECUTIVE SUMMARY

Introduction

The Marine Stewardship Council (MSC) has appointed the WWF as the implementing partner to undertake Project Pre-Assessments (PPA) of small-scale fisheries, and coastal fishers based on country-specific analyses under the 'Fish for Good' initiative funded by the Dutch Postcode Lottery. One of the key stages of the PPAs is the development and implementation of improvement action plans through Fishery Improvement Projects (FIPs).

The primary area for bivalve production in South Africa is Saldanha Bay, with the majority of oyster and mussel production originating here. The opening up of the export market for oysters and the substituting imported mussels with locally farmed alternatives in conjunction with improved access to water and land space through Operation Phakisa has led to renewed interest in expanding and fully utilizing the bay for further oyster and mussel production, as well as exploring potential finfish production. One of the fisheries chosen for the FIP stage is the Rope Grown Mussels fishery based in Saldanha Bay. Collaboration between the WWF and aquaculture industry aims to improve fishing practices and management allowing the Rope Grown Mussel fishery to reach a level consistent with an unconditional pass against the MSC standard.

The Branch Fisheries Management appointed an independent specialist to compile a Sampling Plan for the ADZ which was reviewed by local and international stakeholders and experts (DAFF 2018). Further work conducted for the ADZ by independent specialists include Dispersion modelling completed by PRDW, baseline macrofauna sampling done by Capricorn Fisheries Monitoring and macrofauna and physicochemical properties of the sediment analysed by Steffani Marine Environmental Consultant. In 2020, the Branch Fisheries Management appointed Anchor Research and Monitoring (ARM) to compile the ADZ baseline benthic survey report and to conduct the annual redox survey and compile the resulting report. The WWF South Africa through its Fish for Good initiative is currently implementing a Fisheries Improvement Project with the Saldanha Bay mussel sector (which is designated as a "catch and grow" fishery by the Marine Stewardship Council). WWF (SA) appointed ARM to undertake the 2021 benthic monitoring survey and conduct the annual benthic chemical surveys of the Saldanha Bay ADZ in 2021 and 2022 in an effort to support the development of the ADZ by fulfilling the requirements as per the Sampling Plan.

The ADZ sampling plan requires a full benthic macrofauna survey to be undertaken every 3-5 years, the first such survey was conducted in 2019. Each survey includes the collection of benthic macrofauna samples and sediment samples for the analyses of Total Organic Carbon, Total Organic Nitrogen and particle size distribution. Additionally, trace metals analyses (Aluminium, Copper and Zinc) must be collected in the finfish precinct. This report provides the results of the second benthic monitoring survey which was undertaken by ARM at the end of March 2021. Data from samples collected at the impact sites within the ADZ boundaries and reference sites falling outside the ADZ boundaries in Big Bay and Outer Bay North are assessed and compared to the results of the 2019 baseline survey results to determine whether the aquaculture operations in these areas are having measurable benthic impacts.

Sediment Quality

The particle size composition of the sediments occurring in Saldanha Bay are strongly influenced by wave energy and circulation patterns in the Bay. Under natural circumstances, the prevailing high wave energy and strong currents would have flushed fine sediment and mud particles out of the Bay, leaving behind the heavier, coarser sand and gravel fractions. However, obstructions to current flow and wave energy can result in increased deposition of finer sediment (mud). Higher proportions of mud, relative to sand or gravel, can lead to high organic loading and trace metal contamination and can have a negative impact on the environment when they are re-suspended. Baseline (2019) and subsequent monitoring (2021) data collected across the precincts in Big Bay, Outer Bay North and Outer Bay South (Baseline only) all had sand as the dominant particle size composition. While some finer (mud) and coarser sediment (gravel) constituents were detected; these were minimal. The sediment granulometry findings were in the line with the sediment trace metal and organic matter content measured. Zinc (Zn) and Copper (Cu) were the only two metals measured in the designated finfish farming sites and three reference sites in Big Bay during the recent monitoring survey. Zn had greater concentrations compared Cu, however, both Cu and Zn fell significantly below their Effects Range Low (ERL) threshold of 34 and 150 mg/kg, respectively. Total sediment organic carbon and nitrogen at all three precincts were similar to those recorded at other sites sampled in the State of the Bay 2021 survey. Furthermore, levels of TOC and TON were also not significantly different between the reference and impact sites across the precincts, indicating that sediments in these areas are not being enriched by farming operations. Importantly, both the low trace metal content and organic matter loading is largely influenced by the low mud content recorded at these sites suggesting they are naturally well flushed. Overall, the data collected from the two monitoring surveys for sediment quality is comparable between impact and reference sites, as well as sites sampled elsewhere in the Bay, and anthropogenic disturbances to the physico-chemical nature of the sediments were not detected.

Benthic macrofauna

Soft-bottom benthic macrofauna (animals living in the sediment that are larger than 1 mm) are frequently used as a measure to detect changes in the health of the marine environment as a result of anthropogenic disturbance and are often used for monitoring aquaculture impacts. Indeed, some research has shown that benthic macrofauna are more sensitive to stressor impacts than other benthic organisms, resulting in macrofauna being widely used as environmental indicators. This is largely because these species are short lived and, as a consequence, their community composition responds rapidly to environmental changes.

Benthic macrofauna in sediment samples collected from reference and impact sites in the Big Bay and Outer Bay North precincts were identified to the lowest possible taxonomic level, enumerated and the blotted, wet biomass recorded. Statistical analyses were performed on these data to assess spatial variability in the benthic macrofauna community structure and composition (1) between the baseline and monitoring sampling surveys, (2) between the two precincts, (3) between reference and impact sites within each area, and (4) between samples collected in Big Bay for the annual Saldanha State of the Bay report and those collected for the purposes of ADZ monitoring in this area. In addition, values of biological indices were compared to recommended threshold values to determine if aquaculture activities are causing a detectable disturbance in macrofaunal communities.

Multivariate statistical analyses comparing the 2019 baseline survey, 2021 monitoring survey and two State of the Bay monitoring surveys (2019 & 2020) indicate that macrofaunal communities vary amongst all sampling surveys, suggesting natural variation in macrofaunal communities as a result of spatial and temporal changes. With the exception of sites in Big Bay during the 2021 monitoring survey, no significant differences between Impact and Reference sites were detected. The differences in macrofaunal community composition in Big Bay 2021 was likely the result of a greater spread in the variance of reference sites in this precinct as multivariate dispersion tests showed that the presence of aquaculture operations (impact sites) decreased variability in macrofaunal assemblages relative to areas without aquaculture operations (reference sites).

Univariate analyses indicate no significant differences between the baseline and monitoring surveys for comparisons of four community indices (Shannon Weiner Diversity, Total number of species, Abundance per sample and Pielou's Evenness) at both Big Bay and Outer Bay North precincts. Similarly, Reference and Impact sites of both precincts were not significantly different for most comparisons. Outer Bay North impact sites showed a significant decrease in species evenness relative to reference sites in the 2021 monitoring survey, suggesting some impact of shellfish aquaculture operations in this precinct. Aquaculture operations had no significant impact on the macrofaunal biomass in either Big Bay or Outer Bay North for the 2021 monitoring survey.

The Infaunal Trophic Index (ITI) and AZTI Marine Biotic Index (AMBI) scores show some level of agreement and generally indicate that current aquaculture operations are having a limited effect on benthic macrofauna in the two precincts. The ITI index showed a slightly increased level of community change in the monitoring survey than the baseline in both precincts, while the average AMBI community classification was considered slightly disturbed at the Outer Bay North sites but undisturbed at the Big Bay sites.

In contrast, based on Cumulative abundance-biomass plots, in Outer Bay North Reference sites were undisturbed, with low to moderate levels of disturbance occurring at Impact sites. In Big Bay, all sites (regardless of treatment) show a low level of disturbance, with 2019 and 2020 SOB macrofaunal communities indicating a higher level of disturbance than those of the ADZ monitoring. Therefore, suggesting that all sites within Big Bay are experiencing some, low levels of disturbance (natural and/or anthropogenic).

Qualitative description of reef epifauna in the Big Bay precinct

The presence of low-lying reef was noted during the baseline surveys and deployment of monitoring instruments in the finfish area. The potential effects of aquaculture on patches of this habitat type and its associated epifaunal communities has not previously been assessed in the Big Bay precinct beyond Lynch Blinder. The reef has been described as low-profile reef, roughly < 1m in height from the sea floor, which may be subject to periodic, natural sand inundation. Additionally, substantial outcrops >1m in height are present in places and may form habitat for a well-established epifaunal community. Given this information, the 2021 monitoring survey included the collection of video footage of the reef at any sampling site where hard substrate was encountered. Footage was collected at two sites in Big bay where reef was encountered and this was used to provide a qualitative description of the epifaunal species present at each site. A total of 21 species were recorded with common species including: the West Coast rock lobster *Jasus lalandii*, red *Patiria granifera* and reticulated starfish *Henricia ornata*, cape urchins *Parechinus angulosus*, and beds of the common feather star *Comanthus wahlbergii.* Given the identification of reef in the Big Bay precinct it is recommended that further studies be conducted to provide a quantitative assessment of the epifaunal reef communities present. In addition, the extent of the reef in Big Bay is yet to be determined and a detailed bathymetry survey should be undertaken.

Findings Summary

Based on the above comparison of the baseline survey data and the 2021 monitoring survey data, which included two brief video surveys of confirmed rocky reef areas within the Big Bay ADZ precinct, the following provides a summary of key findings:

1. Despite high abundance and species richness in Saldanha Bay, the natural occurrence of certain dominant species causes the Shannon-Weiner Diversity index to fall below the stipulated threshold of H' = 3 throughout both ADZ precincts. However, the diversity values at the impact sites were not significantly lower when compared to the revised H' statistic threshold calculated from the baseline and reference sites. Supporting the suggestion made in the baseline report that a locally applicable threshold value should be used.
2. The collection of biomass data for the 2021 monitoring survey enabled the production of Cumulative abundance-biomass plots of macrobenthic communities (Warwick 1993), also called k-dominance curves. These curves provided an additional tool with which to assess the level of disturbance within the aquaculture sites relative to the reference sites. Highlighting low to moderate levels of disturbance in Outer Bay North and a low level of disturbance in Big Bay, although the latter was consistent across all treatments as well as SOB sites suggesting that Big Bay is experiencing natural and anthropogenic disturbances not specific to the aquaculture activities.
3. Updates to the species lists of the AZTI Marine Biotic Index (AMBI), and the software which enables users to allocate species groups independent of the species list suggests an improvement to the accuracy of this index for use in the southern hemisphere. However, only half the listed species could be assigned for use in the determination of the Infaunal Trophic Index (ITI). Improved applicability of these indices in the South African context would be highly beneficial for marine environmental monitoring in general, and for monitoring impacts of current and future ADZs in particular. This would require collaboration between local South African marine scientists with taxonomic expertise (an expert workshop) to produce a more comprehensive list of the feeding modes and functional groups of species, to both standardise the assignment of groups to species and to ensure that more species are included in the calculation of both indices. This is beyond the scope of monitoring obligations of the Saldanha ADZ alone, but DFFE should give consideration to initiating and supporting such an initiative in the future if the use of these indices is specified in approved and updated ADZ sampling plans.
4. The identification of a moderately disturbed site in Outer Bay North and data from ABC curves indicating that all communities within Big Bay are already experiencing low levels of disturbance - regardless of the presence or absences of aquaculture activities – suggests the need to maintain the interval between monitoring surveys at least every 3 years (and not allow gaps of up to 5 years between surveys). Thus, ensuring that any impacts associated with the ADZ operations are detected timeously and do not compound the natural/existing disturbance

within the bay and that the cumulative impacts within the bay do not push these sites towards detrimental levels of disturbance.

5. The extent of the reef abrasion platform present in Big Bay is currently unquantified and the proportion of this habitat type impacted by current and future mariculture activities unknown, especially in view of the fact that the dispersion model shows strong scouring here. A detailed bathymetry survey using side scan sonar or multibeam echosounder of the ADZ precinct and historical extent of the abrasion platform would map the current extent of the abrasion platform in Big Bay allowing calculation of the proportion of this habitat type potentially impacted by mariculture operations.
6. Video footage taken by ARM divers during the monitoring survey allowed for a qualitative description of the epifaunal community on the reef habitat which included a total of 21 species. The reef appears to be mostly low profile <1m in height and may be periodically inundated with sand, however, outcrops of reef >1m in height were evident. This is a poorly/unstudied habitat type within Saldanha Bay and there is a dearth of information on its extent, and the nature and type of biotic communities present. The ADZ Sampling Plan should be updated to include suitable reef surveys for monitoring potential aquaculture impacts on this habitat type. This is being addressed and the DFFE are considering proposals to undertake this work.
7. Suitable reef impact sites (n=3) in the finfish area and suitable reference sites (n=3) should be surveyed by scientific divers using transect or quadrat surveys to quantify key biotic components of this reef habitat. An alternative approach could be the use of underwater visual survey by means of divers with cameras, drop cameras or a Remote Operated Vehicle (ROV). All methods of surveying this habitat will rely on acceptable underwater visibility which is not common in Big Bay. In situ benthic surveys by divers, however, may be more easily undertaken than underwater video surveys in conditions of reduced visibility, but all options should be considered. It is critical that whichever survey method is employed, it must be repeatable for ongoing future monitoring. Ideally this monitoring should (as per the soft sediment monitoring programme) follow a 'Before-after-control-impact' (BACI) design. The pilot finfish cages have not yet moved into the ADZ and monitoring is planned in the coming months.
8. Analysis and interpretation of the results of the bathymetric and underwater reef habitat surveys must provide practical advice to support the ongoing adaptive management of the Big Bay ADZ precinct.

TABLE OF CONTENTS

GLOSSARY

Abundance	Refers to the number of individuals of a specific species.
Aquatic	Relating to or living in water.
Benthic	Pertaining to the environment inhabited by organisms living on or in the sediment bottom of the bay.
Biodiversity	The variety of plant and animal life in a particular habitat.
Biomass	The mass of living biological organisms in a given area or ecosystem.
Bivalve	A large class of molluscs that have a hard shell made of two parts or 'valves'.
Community	A naturally occurring group of native animals/plants that interact in a unique habitat.
Cumulative impacts	Direct and indirect impacts that act together with current or future potential impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.
Diversity	The number of different species that are represented in a given community.
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.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Gastropod/a	Molluscs (e.g. snails and slugs).
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.
Invertebrate	An animal without a backbone (e.g. a starfish, crab, or worm).
Polychaete (Polychaeta)	Segmented worms with many bristles (i.e. bristle worms).
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.
Species richness	The number of different species represented in an ecological community. It is simply a count of species and does not take into account the abundance of species.

LIST OF ABBREVIATIONS

ARM	Anchor Research and Monitoring (a subsidiary of Anchor Environmental Consultants)
ADZ	Aquaculture Development Zone
AMBI	AZTI Marine Biotic Index
BB	Big Bay
Cu	Copper
DAFF	Department of Agriculture, Forestry and Fisheries
DEFF	Department of Environment, Forestry and Fisheries
DFFE	Department of Forestry, Fisheries and the Environment
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
EQS	Ecological Quality Status
FIP	Fishery Improvement Project
FF	Finfish
ICMA	Integrated Coastal Management Act (No. 24 of 2008)
ITI	Infaunal Trophic Index
MSC	Marine Stewardship Council
NEMA	National Environmental Management Act (No. 107 of 1998, as amended)
OBN	Outer Bay North
PPA	Project Pre-Assessments
SBWQT	Saldanha Bay Water Quality Trust
SOB	State of the Bay
TOC	Total organic carbon
TON	Total organic Nitrogen
WWF	World Wide Fund for Nature
Zn	Zinc

1 BACKGROUND

The Marine Stewardship Council (MSC) has appointed the WWF as implementing partner to undertake Project Pre-Assessments (PPA) of small-scale fisheries, and coastal fishers based on country-specific analyses under the Fish For Good initiative funded by the Dutch Postcode Lottery. The initiative aims to contribute to sustainable fisheries infrastructure and improve environmental sustainability while socioeconomically benefiting fishing communities. The MSC has shown that its fishery certification and eco-labelling programme can drive improvements amongst fisheries leading to healthier oceans by leveraging market incentives on offer by the MSC programme and utilises PPA as a way of introducing the MSC programme to small-scale fisheries, and coastal fishers.

PPAs are divided into three key stages: 1) mapping and selection of fisheries for pre-assessment; 2) pre-assessment of selected fisheries; and 3) development and implementation of improvement action plans through Fishery Improvement Projects (FIPs).

In addressing deficiencies in the fishery, FIPs are considered a key tool for achieving targets, improving overall fishing practices, enhancing the overall management of the fishery, establishing critical partnerships, generating community support to inspire change in other fisheries in South Africa and improving accessibility of the MSC standard in the southern hemisphere.

So far in South Africa, the Fish for Good Project has mapped fifteen (15) fisheries, conducted nine (9) pre-assessments and selected five (5) fisheries to go for development of action plans and implementation through FIPs. One of the fisheries chosen for the FIP stage is the Rope Grown Mussels fishery based in Saldanha Bay. Collaboration between the WWF and aquaculture industry aims to improve fishing practices and management allowing the Rope Grown Mussel fishery to reach a level consistent with an unconditional pass against the MSC standard.

The Branch Fisheries Management in the then Department of Agriculture, Forestry and Fisheries (now Department of Forestry, Fisheries and the Environment; DFFE), obtained Environmental Authorisation (EA) on 8 January 2018 to establish a sea-based Aquaculture Development Zone (ADZ) in Saldanha Bay. An ADZ is an area that has been earmarked specifically for aquaculture activities with the purpose of encouraging investor and consumer confidence, creating incentives for industry development, to provide marine aquaculture services, manage the risks associated with aquaculture, as well as to provide skills development and employment for coastal communities. The development of ADZs supports the Policy for the Development of a Sustainable Marine Aquaculture sector in South Africa (2007) objective aimed at creating an enabling environment that will promote growth and sustainability of the marine aquaculture sector in South Africa, as well as to enhance the industry's contribution to economic growth. The Branch Fisheries Management has created an enabling environment for the sustainable expansion within the ADZ operations in the existing aquaculture areas in Small Bay, Big Bay and outer Bay North and will further extend operations into Outer Bay South/Entrance Channel. The authorized species for cultivation include both alien and indigenous species of finfish and shellfish, and seaweeds.

Saldanha Bay is the primary area for bivalve production in South Africa, with the majority of national oyster and mussel production to date originating here. As a result of improved opportunities for local mussel import substitution, the opening up of export markets for oysters, and improved access to water and land space through Operation Phakisa Oceans Economy, there is a renewed interest in expanding and fully utilizing the bay for further oyster and mussel production, as well as exploring potential finfish production in the outer, more exposed parts of the bay.

The then DAFF (now DFFE) appointed an Environmental Assessment Practitioner (EAP) to undertake an Environmental Impact Assessment for the establishment of an Aquaculture Development Zone in Saldanha Bay in 2016/2017. Appeals against the authorisation were lodged to the then Minister of Environmental Affairs and the authorisation was upheld as per the letter dated 7th June 2018. As required in terms of the EA, the Branch Fisheries Management appointed an Environmental Control Officer in 2018 and set up a Consultative Forum (CF – a public and industry forum), which has grown to 140 members thus far [1]. The Aquaculture Management Committee (AMC – a government committee) meets every two months to ensure that the implementation of the ADZ occurs in line with the requirements specified in the EA and Environmental Management Programme (EMPr). The Branch Fisheries Management recently published a "Guideline for Bivalve Production Estimates for the Saldanha Bay Aquaculture Development Zone". This document ensures that the production per annum as specified in the EA are upheld by the operators in the ADZ for the first two years after which this will be reviewed and amended based on environmental monitoring. Coupled with environmental monitoring, the adherence to the authorised tonnages should facilitate adaptive environmental management of the ADZ as a whole.

The Branch Fisheries Management appointed an independent specialist to compile a Sampling Plan for the ADZ which was reviewed by local and international stakeholders and experts (DAFF 2018). Further work conducted for the ADZ by independent specialists include, Dispersion modelling completed by PRDW, baseline macrofauna sampling done by Capricorn Fisheries Monitoring and macrofauna and physicochemical properties of the sediment analysed by Steffani Marine Environmental Consultant. In 2020, the Branch Fisheries Management appointed Anchor Research and Monitoring (ARM) to compile the ADZ baseline benthic survey report (Mostert *et al.* 2020a) and to conduct the annual redox survey and compile the resulting report (Mostert *et al.* 2020b). The WWF South Africa through its Fish for Good initiative is currently implementing a Fisheries Improvement Project with the Saldanha Bay mussel sector (which is designated as a “catch and grow” fishery by the Marine Stewardship Council). WWF (SA) appointed ARM to undertake the 2021 benthic monitoring survey and conduct the annual benthic chemical surveys of the Saldanha Bay ADZ in 2021 and 2022 in an effort to support the development of the ADZ by fulfilling the requirements as per the Sampling Plan.

The ADZ sampling plan requires a full benthic macrofauna survey to be undertaken every 3-5 years, the first such survey was conducted in 2019. Each survey includes the collection of benthic macrofauna samples and sediment samples for the analyses of Total Organic Carbon, Total Organic Nitrogen and particle size distribution. Additionally, trace metals analyses (Aluminium, Copper and Zinc) must be collected in the finfish precinct. This report provides the results of the second benthic monitoring survey which was undertaken by ARM at the end of March 2021. Data from samples

[1] Clark BM, Massie V, Hutchings K, Biccard A, Brown E, Laird M, Gihwala K, Swart C, Makhosonke A, Sedick S, Turpie J. and Vermaak N. 2019. The State of Saldanha Bay and Langebaan Lagoon 2019, Technical Report. Report No. AEC 1841/1 prepared by Anchor Environmental Consultants (Pty) Ltd for the Saldanha Bay Water Quality Forum Trust, September 2019.

collected at the impact sites within the ADZ boundaries and reference sites falling outside the ADZ boundaries in Big Bay and Outer Bay North are assessed and compared to the results of the 2019 baseline survey results to determine whether the aquaculture operations in these areas are having measurable benthic impacts.

2 INTRODUCTION

Aquaculture is defined as the propagation, improvement, rearing, regular stocking, feeding or protection from predators and harvesting of aquatic organisms (plant and animal) in controlled or selected aquatic environments (fresh, sea or brackish waters, on land or at sea) for any commercial, subsistence, recreational or other public or private purposes (DEA&T 2007, South African Aquaculture Development Bill 2018). Marine aquaculture, or mariculture, is the process of cultivating and harvesting sea based aquatic organisms. Marine aquaculture includes the commercial farming of all marine organisms such as finfish, shellfish (i.e. abalone, mussels, prawns or oysters) and seaweed. Operations generally involve some form of intervention in the rearing process to enhance production (i.e. regular stocking, feeding, and protection from predators).

Saldanha Bay is a highly productive marine environment and constitutes the only natural sheltered embayment in South Africa (Stenton-Dozey *et al.* 2001). These favourable conditions have facilitated the establishment of an aquaculture industry in the Bay. In January 2018 the then Department of Agriculture, Forestry and Fisheries was granted Environmental Authorisation to establish a sea-based Aquaculture Development Zone (ADZ) in Saldanha Bay and expand the total area available for aquaculture in the Bay to 884 ha, which is located within four precincts (Small Bay, Big Bay, Outer Bay North and South). In 2018, it was reported that of the new established area, 151 ha was being actively farmed. By the end of December 2019, approximately 36% of the ADZ had been leased, but less than 60% of the actively leased area was being utilised and this value is constantly changing as new leases are being granted, new farms start, current lease holders expand their areas, or alternatively shrink in size, based on economic factors. As of March 2020, 28 companies within the Saldanha Bay ADZ were registered on the Marine Aquaculture Right Register, of which only 15 companies were actively operational.

The impacts of aquaculture on the marine environment are generally well studied globally, with several studies indicating that, unless suitably managed, aquaculture can have a negative impact on the environment (Borja *et al.* 2009). One of the primary impacts of finfish mariculture cage farming is that untreated wastes resulting mainly from uneaten food and faeces of fish in sea cages are discharged directly into the sea and represent a potentially significant source of nutrients (Brooks *et al.* 2002, Staniford 2002a). Studies have documented increased dissolved nutrients and particular components (POC and PON) both below, and in plumes downstream, of fish cages (Pitta *et al.* 2005). The impacts of shellfish mariculture include the effects of waste products such as pseudofaeces, dissolved and particulate nutrients, chemicals and medicines on benthic and planktonic communities, the transmission of genes, parasites and diseases between wild and cultured species, and the possible introduction of and invasion by the non-indigenous species used in shellfish aquaculture (Borja *et al.* 2009).

Organic matter is one of the most universal pollutants affecting marine life and it can lead to significant changes in community composition and abundance, particularly in semi-enclosed or closed bays where water circulation is restricted, such as Saldanha Bay. High organic loading typically leads to eutrophication, which can lead to a range of different community responses amongst the benthic macrofauna. These include increased growth rates, disappearance of species due to anoxia, changes in community composition and reduction in the number of species following repeat hypoxia and even complete disappearance of benthic organisms in severely eutrophic and anoxic sediments (Warwick

1993). The community composition of benthic macrofauna is also likely to be impacted by increased levels of other contaminants such as trace metals and hydrocarbons in the sediments. Furthermore, areas that are frequently disturbed by mechanical means (e.g. through dredging, anchoring) are likely to be inhabited by a greater proportion of smaller, opportunistic pioneer species as opposed to larger, longer lived species.

Copper (Cu) and Zinc (Zn) are two metals that are commonly monitored in finfish growing areas (DAFF 2018). Copper is the primary active agent in most antifouling products applied to submerged farm structures and Zinc is a fish health additive included in feed. Additionally, some antifoulants also include Zinc as active agent (Macleod and Erikson 2009). These metals are ubiquitous in the environment and are essential trace elements for nearly all organisms (DAFF 2018). However, when these trace elements accumulate in high concentrations of bioavailable forms, they become toxic (DAFF 2018). Antifoulants leeching Cu results in this metal primarily being present in the dissolved phase, however, due to its low solubility, Cu is rapidly partitioned to suspended particulate matter and ultimately deposited in the sediments. Although copper and zinc based antifoulants are commonly used internationally to reduce biofouling of finfish cage infrastructure this is not appropriate in ecologically sensitive areas such as Saldanha Bay where there is also extensive bivalve farming (filter feeding bivalves can bioaccumulate trace metals to levels dangerous for human consumption). Molapong therefore does not use copper-based paints and prefers to manage biofouling with *in situ* net cleaning. The bioavailable fraction of Cu in the dissolved phase can be orders of magnitude lower than the total Cu concentration because of binding to naturally occurring organic material (Clement *et al.* 2010). Zn in uneaten feed and fish faeces will also rapidly settle to the seabed. Thus, sediments are the primary concern in the accumulation of Cu and Zn and both are consistently associated with finfish farming at environmentally significant levels beneath and adjacent to fish cages (Clement *et al.* 2010). It is noteworthy that there are currently existing sources of trace metal contamination due to the activities associated with a bulk ore export port. Sediment analyses conducted for the Annual State of the Bay monitoring report provides some evidence (spatial correlation) linking existing sources of trace metal contamination within the bay (specifically Cu) to the ore shipping activities at the multipurpose quay as well as at the Saldanha Bay Harbour and Yacht club (Clark *et al.* 2020).

The accumulation of both metals is mediated by settlement processes and as a result may be expected to follow the pattern predicted for organic matter (Keeley *et al.* 2014). Metals, however, are neither broken down over time or utilized by biota at any significant rate (DAFF 2018). Consequently, they may persist for long periods in environments where physical dispersion is limited. Although model simulations for the finfish site suggest very little accumulation of particulate matter and their associated contaminants into benthic sediments (PRDW 2017), Cu and Zn should be monitored until sufficient data are collected to validate model predictions.

It is important to monitor biological components of the ecosystem in addition to physico-chemical and eco-toxicological variables, as biological indicators provide a direct measure of the state of the ecosystem at a selected point in space and time. Benthic macrofauna are the biotic component most frequently monitored to detect changes in the health of the marine environment. This is largely because these species are short lived and, as a consequence, their community composition responds rapidly to environmental changes (Warwick 1993). Given that they are also relatively non-mobile (as compared with fish and birds) they tend to be directly affected by pollution and they are easy to sample quantitatively (Warwick 1993). Furthermore, they are scientifically well-studied compared with other sediment-dwelling components (e.g. meiofauna and microfauna), and taxonomic keys are available for most groups. In addition, benthic community responses to a number of anthropogenic influences have been well documented.

The main aim of monitoring the health of an area is to detect the effects of stress, as well as to monitor recovery after an environmental perturbation. There are numerous indices, based on benthic invertebrate fauna information, which can be used to reveal conditions and trends in the state of ecosystems. These indices include those based on community composition, diversity and species abundance and biomass. Given the complexity inherent in environmental assessment it is recommended that several indices be used (Salas *et al.* 2006).

3 METHODS

3.1 Site selection

Baseline sample site selection and the sampling requirements are described in the sampling report compiled by Capricorn Fisheries Monitoring (2019).

3.2 Benthic sampling

The monitoring survey of the Saldanha Bay ADZ was conducted from 21st March to 1st April 202, with sampling sites matching those used in the Baseline benthic survey report. A total of eight sampling sites were selected in Big Bay and three in the finfish area, relative positions and geographical coordinates are shown in Table 1 and Figure 1. At two sites (numbers B5 and F2) the seabed consisted of sediment inundated rock for a radius of 25 m from the selected sample position. Therefore, no macrofauna sample was collected, however, sediment samples were scraped off the rock and divers collected video footage of the surrounding reef to provide a qualitative description of the reef epibenthos. Three reference (control) sites were sampled within Big Bay. Given that there is currently no finfish farming occurring within the finfish sites, F1-F3 were also treated as reference sites.

In the Outer Bay North area, four impact sites and three reference sites were sampled. Reference site NBC3 was moved to a new location at a depth more representative of the impact sites. The relative positions and geographical coordinates of all sites are shown in Table 1 and Figure 1, including the Big Bay sites sampled for the annual State of the Bay report.

Table 1. **Co-ordinates of the macrofauna monitoring survey sites from Big Bay and Outer Bay North in decimal degrees.**

Area	Site	Latitude	Longitude	Comments
Big Bay	B 1	-33.028808	18.019161	
	B 2	-33.030550	18.022083	
	B 3	-33.039167	18.021183	
	B 4	-33.035367	18.010983	
	B 5	-33.044667	18.014917	No macrofauna collected. Sediment scraped off the calcrete rock and video footage captured of surrounding reef.
	B 6	-33.043950	18.009850	
	B 7	-33.040983	18.013033	New site selected - 8th May 2020
	B 8	-33.040497	18.015473	New site selected - 8th May 2020
	BC 1	-33.029733	18.007400	
	BC 2	-33.048633	18.001550	
	BC 3	-33.065414	18.020089	
	F 1	-33.039056	18.002878	
	F 2	-33.040681	18.007119	No macrofauna collected. Sediment scraped off the calcrete rock and video footage captured of surrounding reef.
	F 3	-33.042911	18.004736	
Outer Bay North	NB 1	-33.032617	17.943633	
	NB 2	-33.034417	17.948867	
	NB 3	-33.038433	17.945633	
	NB 4	-33.045200	17.942067	
	NB C1	-33.037283	17.960267	
	NB C2	-33.042167	17.953733	
	NB C3	-33.038339	17.963950	New site selected - 30th March 2021

Figure 1. **Map of Saldanha Bay showing the sites sampled during the macrofaunal monitoring survey of the Saldanha ADZ, reference (control) sites are indicated with blue arrows while impact sites are indicated with red arrows, finfish sites are marked with yellow arrows and treated as baseline data/reference sites, while grey arrows indicate original sites that have been moved due to hard substrate (B7 & B8) or to reduce depth (NB C3). The sites sampled during the annual State of the Bay (SOB) surveys are also shown.**

Macrofauna samples were collected using a diver-operated suction sampler, which sampled an area of 0.08 m^2 to a depth of 30 cm and retained benthic macrofauna in a 1 mm mesh sieve bag. Benthic macrofauna have been sampled at more than 30 sites in Big Bay (9 sites), Small Bay (10 sites) and Langebaan Lagoon (12 sites) since the inception of the State of the Bay monitoring programme in 2004. The data collected during the Saldanha ADZ monitoring survey was compared with data from the Baseline survey (samples collected in 2019, Mostert *et al.* 2020a) and further compared to the Big Bay sites sampled during the 2019 and 2020 Saldanha Bay Water Quality Trust (SBWQT) State of the Bay monitoring programme, (hereafter referred to as SOB 2019 and SOB 2020). Sample identification and data from the SOB 2021 survey has not yet been completed and could not be included here. For the SOB 2019 & 2020, samples were also collected using a diver-operated suction sampler, which sampled an area of 0.08 m^2 to a depth of 30 cm and retained benthic macrofauna (>1 mm in size) in a 1 mm mesh sieve bag. Three samples are taken at each site and pooled, resulting in a total sampling surface area of 0.24 m^2 per site (cf. 0.39m^2 for the ADZ baseline sampling). Samples were stored in plastic bottles and preserved with 5% formalin. All macrofauna abundance and biomass data were standardised per unit area (m^2) prior to analysis.

3.3 Sampling procedure to collect sediment for TOC/N, and granularity and trace metals

Two sediment samples were collected in 400 ml plastic bottles by a diver at each of the sites shown in Figure 1. In the field the samples were stored in an insulated cooler box with ice packs. On shore the samples were transferred to a freezer and stored at -18°C. One of these samples was delivered to the CSIR for the analysis of total organic carbon (TOC) and total organic nitrogen (TON). The second sample was sent to Scientific Services where the sample was homogenised and separated into two portions: one for the analysis of trace metals and one for the determination of particle size distribution.

3.4 Particle Size Analysis

Sediment particle size was analysed by weighing dry sediment samples to the nearest 0.1g. The material was dry sieved through graded sieves on a mechanical shaker for 20 minutes. The weight of each fraction on each sieve was recorded to the nearest 0.1 g. Grain size fraction data was analysed using GRADISTAT v8.0 (Blott, 2010) and divided into ten size classes as follows: gravel (>2000 µm), sand (subdivided into very coarse 1000-2000 µm, coarse 850-1000, 710-850 and 500-710 µm, medium 425-500, 300-425 µm, fine 212-300 µm, very fine 63-212 µm), and mud (< 63 µm).

3.5 Trace Metals

Trace metal analysis was undertaken by Scientific Services and were analysed as per the methods described by Steffani (2019). The sediment was first freeze dried and ball milled. Approximately 1 g of dried sediment was weighed and digested with HNO_3 in either an open vessel or microwave assisted digestion. This method was derived from USEPA method 3050B. This 'total' digestion method dissolves all elements that could become 'environmentally available'. The digestate was made up to volume using distilled water. After settling a clear solution was quantified using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) for concentrations of various major, minor and trace metals. Mercury was analysed using a vapour generation unit (VGU). Precision and extraction efficiency of the digestion and metal determination procedures was evaluated by analysing marine sediment reference standard TH-2 (National Research Council of Canada). All recoveries were within acceptable tolerance and precision limits for quality assurance and quality control purposes. Quality assurance and quality control procedures were run with batches of samples. This included the analysis of laboratory blanks, laboratory duplicates, spiked blanks, and duplicate samples.

3.6 Total Organic Carbon (TOC) and Nitrogen (TON)

Total Organic Carbon (TOC) and Nitrogen (TON) analyses were undertaken by the CSIR the methods described by Steffani (2019). For the analysis of total organic carbon (TOC) and nitrogen (TON), approximately 5 -10g of dried and homogenised sample is acidified with 0.1N HCl and agitated to remove inorganic carbonates as volatile CO_2. The sample is copiously washed with Milli Q water after acidification and dried. A dry sub-sample is weighed and analysed for TOC and nitrogen via thermo-catalytic combustion in a VARIO Elementar.

3.7 Macrofauna Analysis

Macrofauna were analysed as per the analysis report prepared for the Branch Fisheries Management by Nina Steffani (Steffani 2019) to ensure constancy between baseline and monitoring surveys. In the laboratory, samples were rinsed of formalin and stained with Rose Bengal to aid sorting of biological from non-biological matter. All fauna were removed and preserved in 1% phenoxetol (Ethyleneglycolmonophenylether) solution. The macrofauna were then identified to species level where possible, but at least to family level in all instances. The validity of each species was then checked on The World Register of Marine Species (WoRMS, www.marinespecies.org). The biomass (blotted wet mass to four decimal places) and abundance of each species was recorded for each sample.

Information on species-specific feeding modes was sourced from a range of literature, (e.g. scientific publications, web databases (e.g. MarLIN 2006), general field books and technical papers (e.g. Macdonald *et al.* 2010). In the event that no information of a feeding mode at the species level was available, a search was conducted at the genus level, and if still no information was found, then at the family level. Information sourced at such higher level is marked by a question mark. For taxa that could only be identified at a high taxonomic level, (e.g. Brachyura), feeding modes were omitted. Macrofaunal species can have several feeding modes, and can switch between them in response to environmental conditions. A number of species have therefore more than one feeding mode allocated.

3.7.1 Statistical Analyses

The statistical program, PRIMER 6 (Clarke and Warwick 1993), was used to analyse benthic macrofauna abundance data. Data were root-root (fourth root) transformed and converted to a similarity matrix using the Bray-Curtis similarity coefficient. Multidimensional Scaling (MDS) plots were constructed in order to find 'natural groupings' for the precincts. Data collected during the 2019 and 2020 SOB annual survey for Big Bay was included for further comparisons in the Big Bay precinct. Multivariate dispersion of samples within treatments was calculated using the PERMDISP function. The DOMINANCE function in Primer 6 was used to construct ABC (abundance biomass comparison) curves and to calculate W-statistics in order to determine if any of the treatments (impact or reference) within each precinct are currently showing signs of disturbance.

Diversity indices provide a measure of diversity, i.e. the way in which the total number of individuals is divided up among different species. Understanding changes in benthic diversity is important because increasing levels of environmental stress generally decreases diversity. Two different aspects of community structure contribute to community diversity, namely species richness and equability (evenness). Species richness refers to the total number of species present while equability or evenness expresses how evenly the individuals are distributed among different species. A sample with greater evenness is considered to be more diverse. It is important to note when interpreting diversity values that predation, competition and disturbance all play a role in shaping a community. For this reason, it is important to consider physical parameters as well as other biotic indices when drawing a conclusion from a diversity index.

The *Shannon-Weiner diversity index* (H') was calculated for each sampling location using PRIMER V 6:

$H' = - \Sigma i p_i (\ln p_i)$ [2]

The mean Shannon-Weiner diversity index calculated for each of the precincts (Big Bay - BB and Outer Bay North - OBN also known as North Bay - NB) was statistically compared to a revised H' threshold (H' = 2.1) separating the Oxic B category from the Hypoxic A. The original value, given in the Sample Plan (DAFF 2018), was based on previous papers (Hansen *et al.* 2001, Warwick *et al.* 2008 & Borja *et al.* 2009) which used Log2 in the above equation not the natural log (ln) used during this study. The threshold of 3 (log2) is equivalent to 2.1 (ln), the latter should therefore be used going forward.

Average H' for each precinct was tested for a Hypoxic A decrease in diversity below the Oxic B category by a 1-sample t-test, with a reference constant set at the adjusted threshold value (Table 2):

$H_0: \mu \geq 2.1$; $H_A: \mu < 2.1$ Shannon-Weiner Index (1-tailed)

If there was evidence of a sub-optimal diversity an ANOVA was undertaken to test the following hypotheses:

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[2] Where p_i is the proportion of the total count arising from the *i*th species. This is the most commonly used diversity measure and it incorporates both species richness and equability.

H_0: there is no interaction between farm (impact)/reference site and baseline/operational; H_A: there is an interaction (2-tailed).

Table 2. Ranges of biological indices in various Ecological Quality Status (EQS) classifications for five sediment organic enrichment categories. * Denotes values that have been adjusted to natural log (Pers. Comm. Trevor Probyn).

Geochemical	Oxic A	Oxic B	Hypoxic A	Hypoxic B	Anoxic
Disturbance	Undisturbed	Slightly disturbed	Moderately disturbed	Heavily disturbed	Extremely disturbed
EQS	High	Good	Moderate	Poor	Bad
Biological:					
*Adjusted Shannon-Weiner diversity index (H')	>4	2.8 – 2.1	2.1 – 1.4	1.4 -1.7	<0.7
Infaunal Trophic Index (ITI)	>50	50 - 25	<25	<25	<5
AZTI Marine Biotic Index (AMBI)	<1.2	1.2 - 3.3	3.3 - 5	5 - 6	>6
Adjusted AMBI (Cranford *et al.* 2020)	<1.2	1.2 - 3.0	3.0 - 4.8	4.8 - 6	>6

The Infaunal Trophic Index (ITI) categorises invertebrates into four groups according to their feeding mode: Group 1 – suspension feeders; Group 2 – surface detritus feeders; Group 3 – surface deposit feeders; Group 4 – sub-surface deposit feeders.

The index is then calculated as: ITI = 100-(33.3(n2+2n3+3n4)/(n1+n2+n3+n4))

Where n1 is abundance of individuals in trophic group 1, and so on.

The ITI is a continuous statistic that falls between 0-100 and the relationship between ITI scores and the status of the community with regard to anthropogenic impacts can generally be given as follows: ITI >55 community normal with little anthropogenic effect, ITI between 25-55 community changed or anthropogenically enriched, and ITI <25 community degraded (derived from Somerfield 2009).

Average ITI for each precinct was tested to see if it dropped below the threshold level for Hypoxic A:

H_0: $\mu \geq 25$; H_A: $\mu < 25$ Infaunal Tropic Index (1-tailed).

In addition, ANOVA was undertaken to test the following hypotheses:

H_0: there is no interaction between farm/reference site and baseline/operational; H_A: there is an interaction (2-tailed).

The AZTI's Marine Biotic Index (AMBI) was also calculated for macrofauna samples from different precincts. This biotic indicator was originally designed to assess the health of European estuarine and coastal soft bottom communities and has been widely used elsewhere, e.g. South America's Atlantic coast (Borja et al 2000, Borja 2005, Muniz et al 2005). Individual species are assigned to five ecological groups based on their sensitivity/tolerance to environmental stress/disturbance with the most sensitive assigned to Group I and the most tolerant assigned to Group V. The AMBI is a continuous statistic that falls between 0-7 and is derived from the proportion of individual abundance in the five ecological groups. These are related to the degree of sensitivity to environmental disturbance, with low AMBI scores (0-1.2) reflecting undisturbed benthic communities and high AMBI scores (>5) reflecting heavily disturbed communities that are dominated by species resilient to environmental degradation (Borja et al 2000, Borja 2005). The score is calculated using AMBI software developed by AZTI (https://ambi.azti.es/). The new (December 2020) AMBI species list, consisting of 10 638 taxa, was used to analysis both the 2019 baseline data and the 2021 monitoring data. The 2019 data were reassessed using the updated species list – though the changes were insignificant.

Average AMBI for each precinct was tested for a Hypoxic A decrease in score above the Oxic B category by a 1-sample t-test. The threshold value was decreased from 3.3 to 3.0 based on a recent update provided by Cranford *et al.* 2020.

H_0: $\mu \leq 3.0$; H_A: $\mu > 3.0$ AMBI (1-tailed)

In addition, ANOVA was undertaken to test the following hypotheses:

H_0: there is no interaction between farm/reference site and baseline/operational; H_A: there is an interaction (2-tailed).

4 RESULTS AND DISCUSSION

4.1 Sediment physico-chemical properties

4.1.1 Particle Size Analysis

The particle size composition of the sediments occurring in Saldanha Bay are strongly influenced by wave energy and circulation patterns in the Bay (Clark *et al.* 2020). Coarser or heavier sand and gravel particles are typically found in areas with high wave energy and strong currents as the movement of water in these areas suspends fine particles (mud and silt) and flushes these out of these areas. Disturbances to the wave action and current patterns, which reduce the movement of water, can result in the deposition of mud in areas where sediments were previously much coarser. The quantity and distribution of different sediment grain particle sizes (gravel, sand and mud) through Saldanha Bay influences the status of biological communities and the extent of contaminant loading that may occur in Saldanha Bay. Contaminants such as metals and organic toxic pollutants are predominantly associated with fine sediment particles (mud and silt). This is because fine grained particles have a relatively larger surface area for pollutants to adsorb and bind to. Higher proportions of mud, relative to sand or gravel, can thus lead to high organic loading and trace metal contamination.

Currently, there is no active finfish farming operations present at the finfish site within Big Bay ADZ precinct. Thus, FF samples collected within the finfish farming zone during the baseline and monitoring surveys both represent baseline data and are labelled as 'reference' sites. These sites will be reverted to 'impact' sites, once finfish farming commences on the site within the ADZ. Particle size distribution data collected from various precincts during the baseline (2019) and subsequent monitoring (2021) surveys, including sites sampled in Big Bay as part of the SOB monitoring programme, are shown in an ordination plot presented in Figure 2. Data collected from SOB 2019 and 2020 surveys formed its own cluster and revealed some form of dissimilarity to the rest of the sites sampled across the aquaculture precincts. However, the latter pattern was not observed in 2021 where SOB and some of the precincts, particularly in Big Bay, were similar in particle size distribution. Temporal differences were evident between the precincts sampled in 2019 and 2021, and PERMANOVA validated these findings as statistically significant (Pseudo - $F_2 = 4.58$, $p < 0.05$). Despite the latter, differences in sediment distribution between impact and reference sites within the two precincts in Big Bay and Outer North Bay were not found to be significant ($p > 0.05$) across the two surveys. The 2019 survey showcased high inter-sample variability with all the impact and reference sites being dispersed. Interestingly, this variability declined in the recent survey, showcasing the natural perturbations of sedimentation, largely due to the strong influence of wave energy and currents occurring in Saldanha Bay (Clark *et al.* 2020) as opposed to mariculture operations. Furthermore, inter-sample variation was greatest for samples collected at Outer Bay South impact sites (JI in 2019) and Outer Bay North sites, both in 2019 and 2021 as these are situated in the deeper and more exposed outer Bay area.

Particle size composition (gravel, mud and sand) of the impact/reference sites across the three precincts are shown in Figure 3. It is evident that across all three precincts and their impact/reference sites, sand is the dominant component. Big Bay has a higher proportion of mud compared to the other two precincts. Furthermore, mud composition was greater at the impact and reference sites sampled during the 2019 baseline survey compared to those sampled during the SOB surveys in 2019-2021. This may once again be related to the presence of the reef abrasion platform in the ADZ area, with fine (muddy) sediment potentially settling in deeper protected areas between patch reefs. At impact sites some of this fine material could originate from current shellfish operations, but the results indicate that this does not currently exceed rates of natural deposition of fine particles seen at control sites. The low mud composition in the current monitoring survey across all impact/reference sites supports this conclusion. The composition of gravel is prominent across the more exposed Outer Bay North and Outer Bay South precincts sampled in 2019. It is noticeable that gravel is mostly present across the reference sites of all precincts, apart from the impact sites at Outer Bay South, (as there is no mariculture activity within this precinct these sites also represent baseline/reference condition). The gravel component diminished noticeably at the reference sites in the Outer North Bay in the recent monitoring survey (one of the three reference sites was moved to a comparable depth to the impact sites) reflecting the dynamic nature of sediment composition in the outer bay area. While there is variability in particle size composition across the sites and precincts sampled; sand is the major composition of sediment particle size within the Bay. The latter findings are in line with sediment composition recorded in SOB 2021 as well as earlier detailed studies by Flemming (1977a,b); in which he found that sediments in Saldanha Bay were comprised mostly of fine (0.125-0.25 mm) or very fine sand (0.063-0.125 mm)(Clark *et al.* 2020).

Particle size composition is strongly influenced by wave energy and strong currents as well as indirectly by anthropogenic induced disturbance events (e.g. dredging events). The SOB 2019 reports documents that historical dredge events, which re-suspended large amounts of mud from the deeper lying sediments, seem to be a dominant contributor to the elevated mud content in the Bay and results of surveys have shown a general pattern of an increase in mud content following dredge events, followed by a recovery in subsequent years. Any future dredging or other such large-scale disturbance to the sediment in Saldanha Bay are likely to result in similar increases in the mud proportion with accompanying increase in metal content. Mariculture operation can also result in increases in the fine sediment fraction due to the biodeposition of particulate organic matter arising from faeces, pseudofaeces, uneaten food and other particulate matter (Pulfrich 2018). Based on the results of the baseline and monitoring sediment surveys; however, this does not appear to be happening.

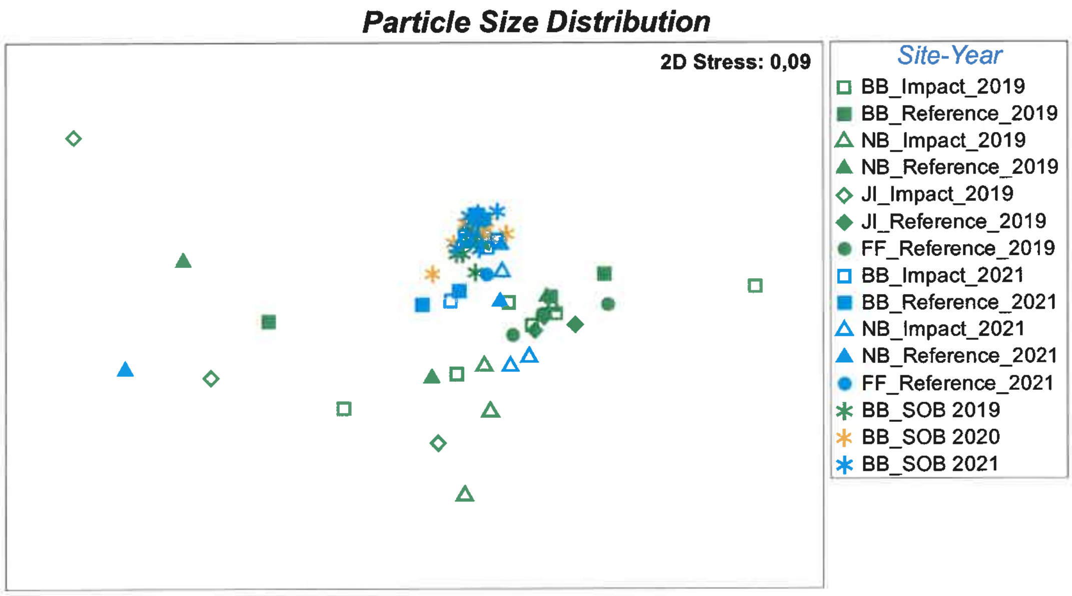

Figure 2. **MDS plot ordination comparing precincts and SOB based on particle size distribution data collected in 2019-2021. Symbols on the ordination plots are as follows: Big Bay (BB), Outer Bay North (NB) and Outer Bay South (JI).**

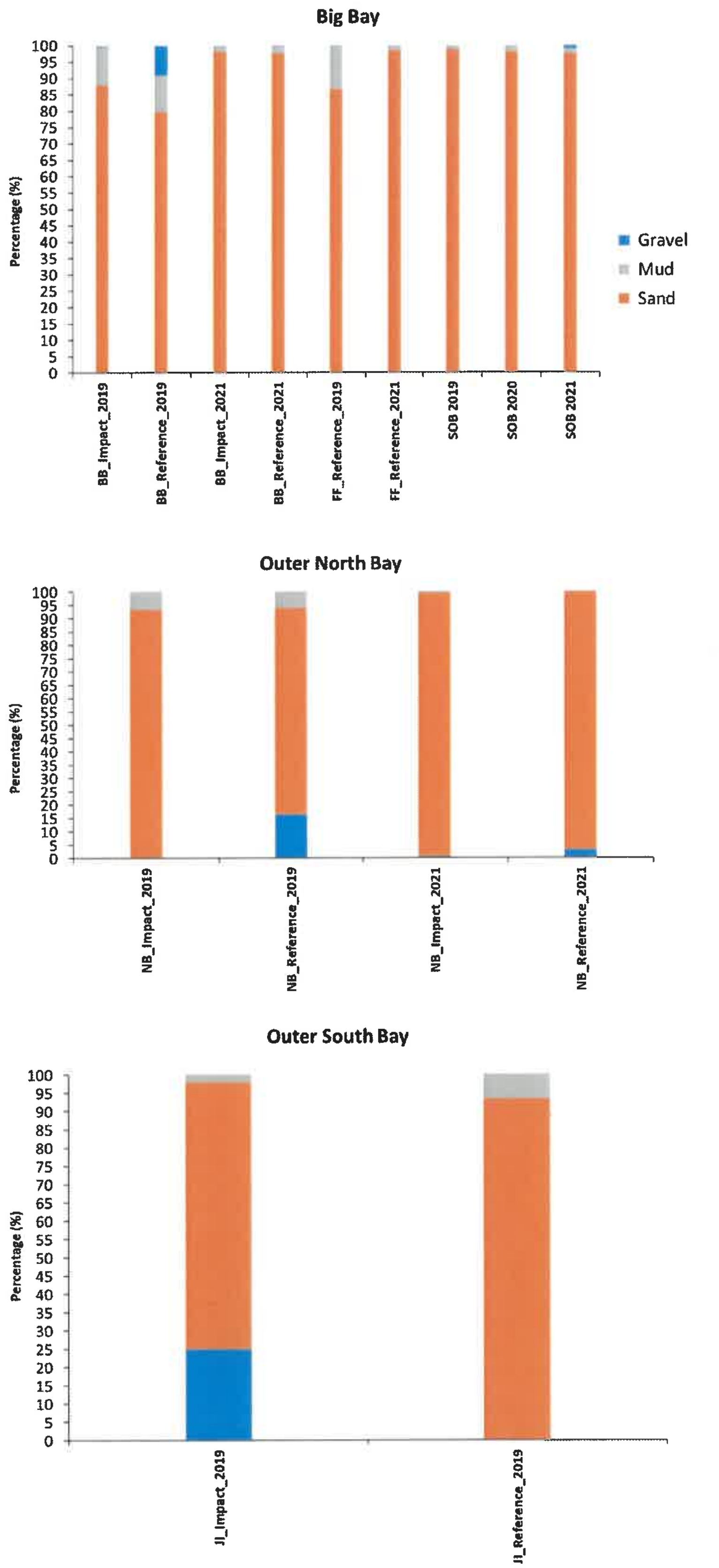

Figure 3. **Particle size composition (percentage gravel, sand and mud) of sediments at various sites within Big Bay, Outer Bay North and Outer Bay South in Saldanha Bay in 2019-2021.**

4.1.2 Trace Metals

Trace metals occur naturally in the marine environment, and some are important in fulfilling key physiological roles. Disturbance to the natural environment by either anthropogenic or natural factors can lead to an increase in metal concentrations occurring in the environment, particularly sediments. An increase in metal concentrations above natural levels, or at least above established safety thresholds, can result in negative impacts on marine organisms, especially filter feeders like mussels that tend to accumulate metals in their flesh. High concentrations of metals can also render these species unsuitable for human consumption. Metals are strongly associated with the cohesive fraction of sediment (i.e. the mud component) and with TOC. Metals occurring in sediments are generally inert (non-threatening) when buried in the sediment but can become toxic to the environment when they are converted to the more soluble form of metal sulphides. Metal sulphides are known to form as a result of natural re-suspension of the sediment (strong wave action resulting from storms) and from anthropogenic induced disturbance events like dredging activities.

The Benguela Current Large Marine Ecosystem (BCLME) program 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) (Table 3). The BCLME guidelines cover a broad concentration range and still need to be refined to meet the specific requirements of each country within the BCLME region (CSIR 2006). There are thus no official sediment quality guidelines that have been published for the South African marine environment as yet, and it is necessary to adopt international guidelines when screening sediment metal concentrations. 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 as shown in Table 3.

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 lower 10th percentile of sediment concentrations reported in literature that co-occur with any biological effect. The Effects Range Median (ERM) is the median concentration of available toxicity data. It is calculated as the lower 50th percentile of sediment concentrations reported in literature that co-occur with a biological effect (Buchman 1999). The ERL values represent the most conservative screening concentrations for sediment toxicity proposed by the NOAA and ERL values have been used to screen the Saldanha Bay sediments.

Table 3. Summary of Benguela Current Large Marine Ecosystem and National Oceanic and Atmospheric Administration metal concentrations in sediment quality guidelines

Metal (mg/kg dry wt.)	BCLME region (South Africa. Namibia. Angola)		NOAA	
	Special care	Prohibited	ERL	ERM
Cu	50 – 500	>500	34.0	270.0
Zn	150 – 750	> 750	150.0	410.0

1(CSIR 2006). 2 (Long *et al.* 1995. Buchman 1999)

Trace metals Cu and Zn were collected at the finfish area and at the reference sites in Big Bay (in the recent survey) and their relative concentrations are shown in Figure 4. It is evident that there are higher concentrations of Zn compared to Cu across all the sites sampled in both surveys. However, both metals were significantly below their ERL threshold (1 sample t-test; Cu: $t = -87.20$, $p < 0.05$; Zn: $t = -50.53$, $p < 0.05$). Comparisons of these same metals were also made across sites sampled in Big Bay (SOB) and are illustrated in Figure 5. Once again, Zn occurred at higher concentrations than Cu, although both metal concentrations were lower in 2019 than in 2021. The latter was noticeably different at the finfish area, despite concentrations of both metals not being significantly different between the two surveys (Mann Whitney U test; Cu: $Z = -1.74$, $p > 0.05$; Zn: $Z = -1.30$, $p > 0.05$). Furthermore, both trace metal concentrations were lower in Big Bay (SOB and reference sites) compared to the finfish precincts for the two monitoring surveys, although these differences were insignificant ($p > 0.05$). No significant differences are expected as finfish farming activities are not currently operational on the site. As previously mentioned, both metals across both areas fell well below their ERL threshold, despite a relative increase in the recent survey (Table 3). This is expected, considering the low mud content found at these sites (refer to Section 4.1.1); effectively reducing the surface area for pollutants to adsorb and bind to.

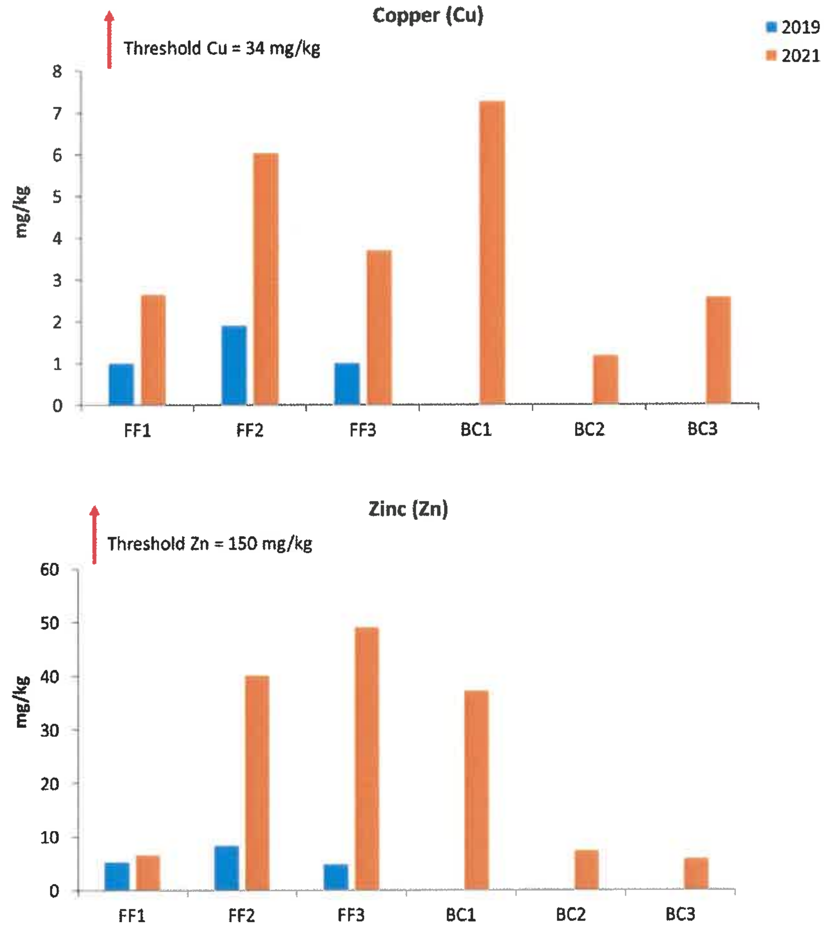

Figure 4. **Total concentrations of Copper (Cu) and Zinc (Zn) in mg/kg recorded within the Finfish area and reference sites of the ADZ in Big Bay of Saldanha Bay in 2019 and 2021.**

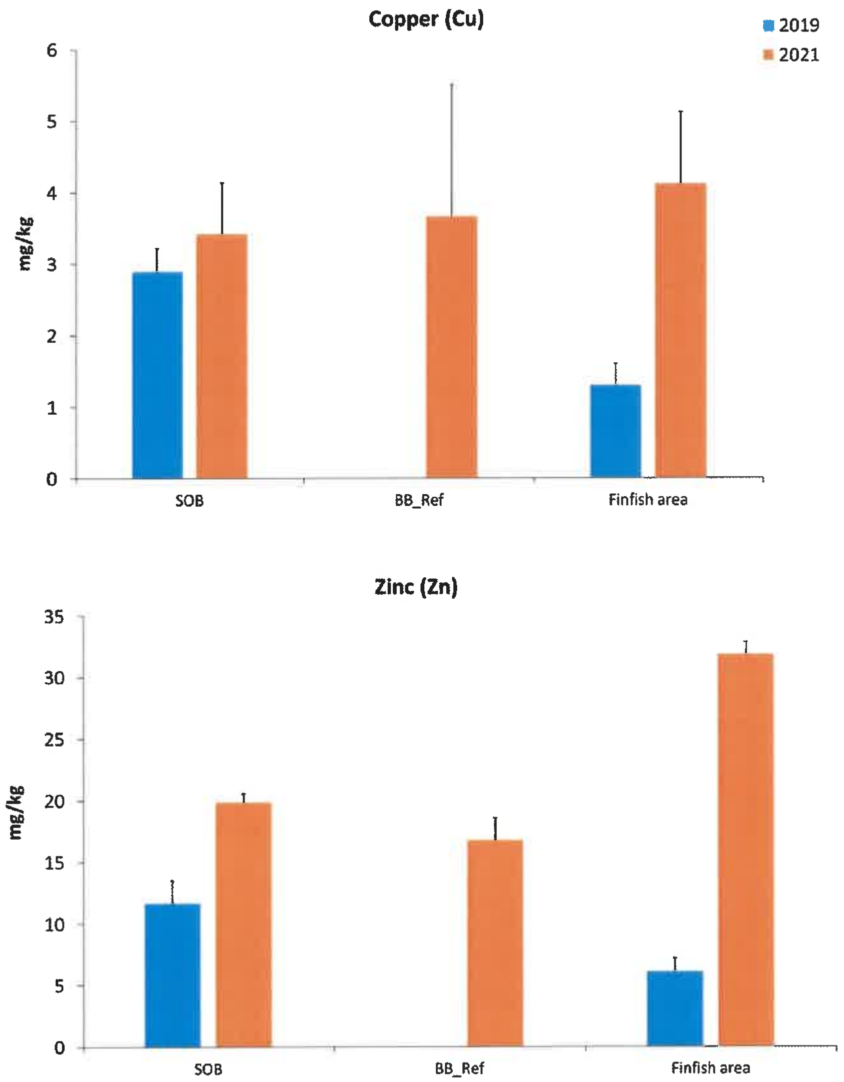

Figure 5. **Mean concentrations of Copper (Cu) and Zinc (Zn) in mg/kg recorded within the Finfish area and reference sites of the ADZ in Big Bay as well as data from SOB in 2019 and 2021.**

4.1.3 Total Organic Carbon (TOC) and Nitrogen (TON)

Total organic carbon (TOC) and total organic nitrogen (TON) accumulates in the same areas as mud as organic particulate matter is of a similar particle size range and density to that of mud particles (size <60 µm) and tends to settle out of the water column together with the mud. The accumulation of organic matter in the sediments doesn't necessarily directly impact the environment but the bacterial breakdown of the organic matter can (and often does) lead to hypoxic (low oxygen) or even anoxic (no oxygen) conditions. Under such conditions, anaerobic decomposition prevails, which results in the formation of sulphides such as hydrogen sulphide (H_2S). Sediments high in H_2S concentrations are characteristically black, foul smelling and toxic for living organisms. The most likely sources of organic matter in Saldanha Bay are from phytoplankton production at sea and the associated detritus that forms from the decay thereof, fish factory waste discharged into the Bay, faecal waste concentrated beneath the mussel and oyster rafts in the Bay, treated sewage effluent discharged into the Bay from the wastewater treatment works (Saldanha & Langebaan) and stormwater.

Total organic carbon and nitrogen concentration in sediments that were collected at impact within the various precincts (Big Bay, Outer Bay North and Outer Bay South) and reference sites within Saldanha Bay are shown in Figure 6. TOC/TON levels appear to be lower in the recent 2021 survey compared to the 2019 baseline survey. Furthermore, TOC/TON levels were found to be greater at the impact sites in comparison to reference sites in 2019, particularly for Big Bay and Outer Bay South, but these differences were not significant (Mann Whitney U tests, $p > 0.05$). Additionally in 2019, no significant difference was found between the impact and reference sites in the Outer Bay North precinct for both TOC (Mann Whitney U test, $Z = -0.53$, $p > 0.05$) and TON (t-test, $t = -0.53$, $p > 0.05$). In the recent survey, it clearly evident that TOC/TON levels are fairly similar across all impact/reference sites in the different precincts as well as to levels recorded during the SOB surveys. These low levels of organic carbon and nitrogen recorded across all three precincts are also related to the low mud content measured at these sites (see Section 4.1.1); as higher proportions of mud are typically found in depositional areas that are also associated with organic loading. Conversely, data recorded in the SOB 2020 report reveal relatively high levels of TOC/TON especially within Small Bay. It was noted that sources of organic carbon and nitrogen in Small Bay include fish factory wastes, biogenic waste from mussel and oyster culture as well as sewage effluent from the wastewater treatment works (Clark *et al.* 2020). The Big Bay and Outer Bay precincts are not subject to the same degree of these anthropogenic inputs, and are more exposed and flushed than Small Bay.

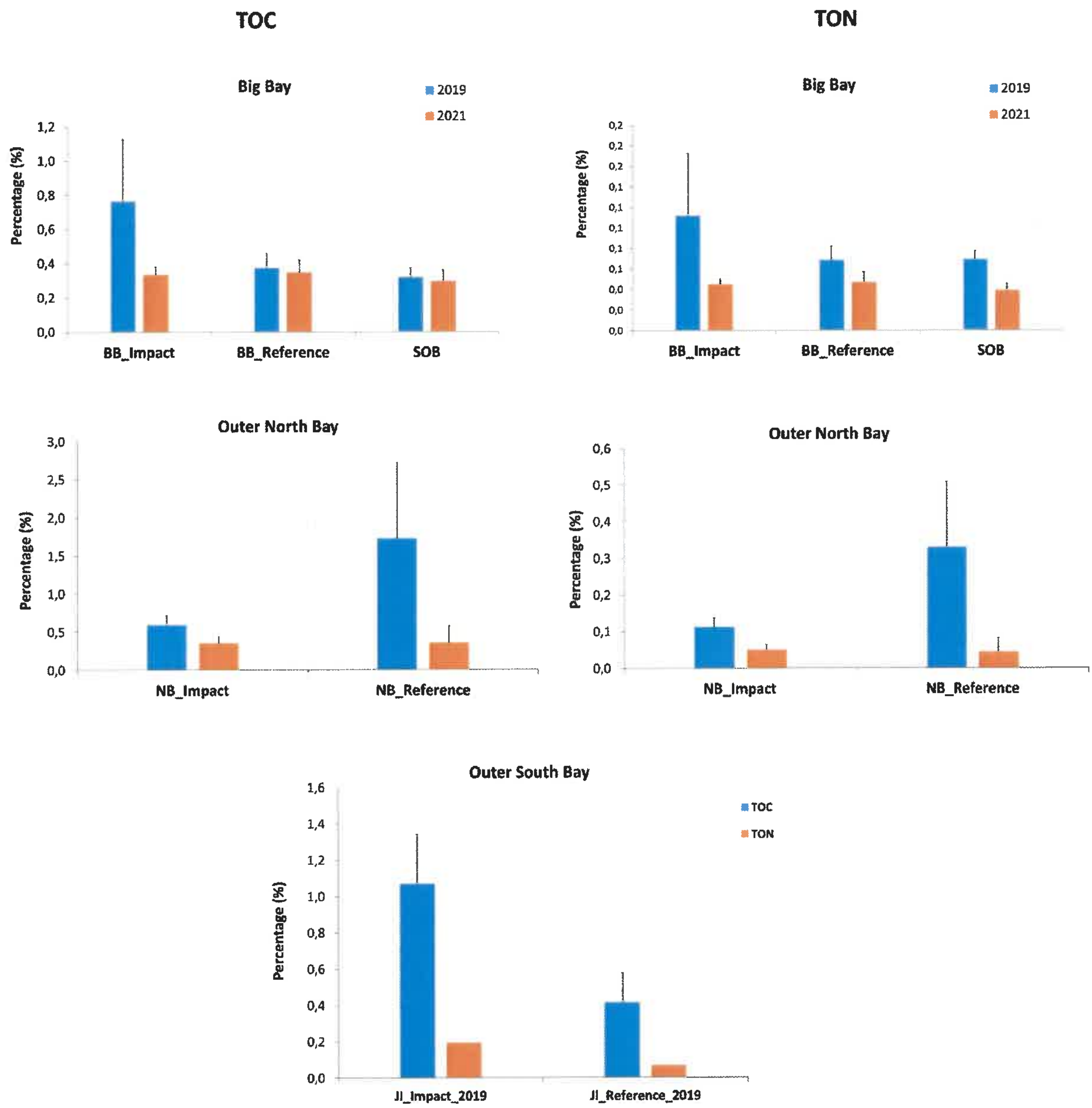

Figure 6. **Total organic carbon (TOC) and nitrogen (TON) in sediments collected at various sites within Big Bay (BB), Outer Bay North (NB), Outer Bay South (JI) and SOB in Saldanha Bay in 2019 and 2021.**

4.2 Benthic Macrofauna

4.2.1 Univariate descriptors of community state

Univariate analyses of macrofaunal community descriptors for Reference and Impact sites within each precinct (Big Bay and Outer Bay North) were calculated and are shown in Figure 7. Fixed effects, full factorial analysis of variance (ANOVA) revealed no statistically significant differences between the Baseline and Monitoring average values for Shannon Weiner Diversity, Abundance and Evenness (ANOVA, $p > 0.05$ for all) in both Big Bay and Outer Bay North (refer to Figure 7). In Big Bay and Outer Bay North, the average number of taxa was lower in both the Impact and Reference sites during the monitoring survey relative to the baseline. Although this decline in the average number of taxa was significantly different between the baseline and monitoring survey in both Big Bay and Outer Bay North ($p = 0.002$ and $p = 0.012$ respectively), the post-hoc Tukey test showed that this difference was between the baseline impact sites and the monitoring reference sites in both precincts, with the impact and monitoring sites of each precinct not showing any significant differences within the respective survey years.

In Big Bay, aquaculture treatment (impact/reference) had no significant effect on Shannon Weiner Diversity, Number of taxa, Abundance or Evenness ($p > 0.05$ for all). In contrast, only the average diversity at Outer Bay North was not significantly affected by treatment. The average number of taxa for impact and reference sites within Outer Bay differed significantly, with post hoc Tukey tests indicating the difference was between the baseline impact sites and the monitoring reference sites. Similarly, the average Evenness for impact and reference sites within Outer Bay differed significantly, however in this case, Tukey tests showed that this was due to a significant difference in the impact and references sites of the monitoring survey, with Evenness being higher in the reference sites. While the ANOVA recorded significant differences in abundance between the impact and reference sites, the post-hoc Tukey test showed no significant difference amongst treatments. Additionally, there was no significant interaction between baseline/monitoring and treatment (impact/reference) for any of the diversity indices. Taken collectively this suggests that the aquaculture activities have a negligible impact on the univariate community descriptors of Big Bay and Outer Bay North.

Macrofaunal biomass was not recorded during the 2019 baseline survey and therefore could not be compared across sampling surveys. However, no treatment effects (Impact/Reference) were detected for biomass in either Big Bay or Outer Bay North for the 2021 monitoring survey (one-way ANOVA, $F_{1,8} = 3.32$, $p = 0.106$ and $F_{1,5} = 0.008$, $p = 0.930$, respectively). Additionally, there was no significant differences in any of the diversity indices between finfish sites across the sampling surveys (Baseline/Monitoring).

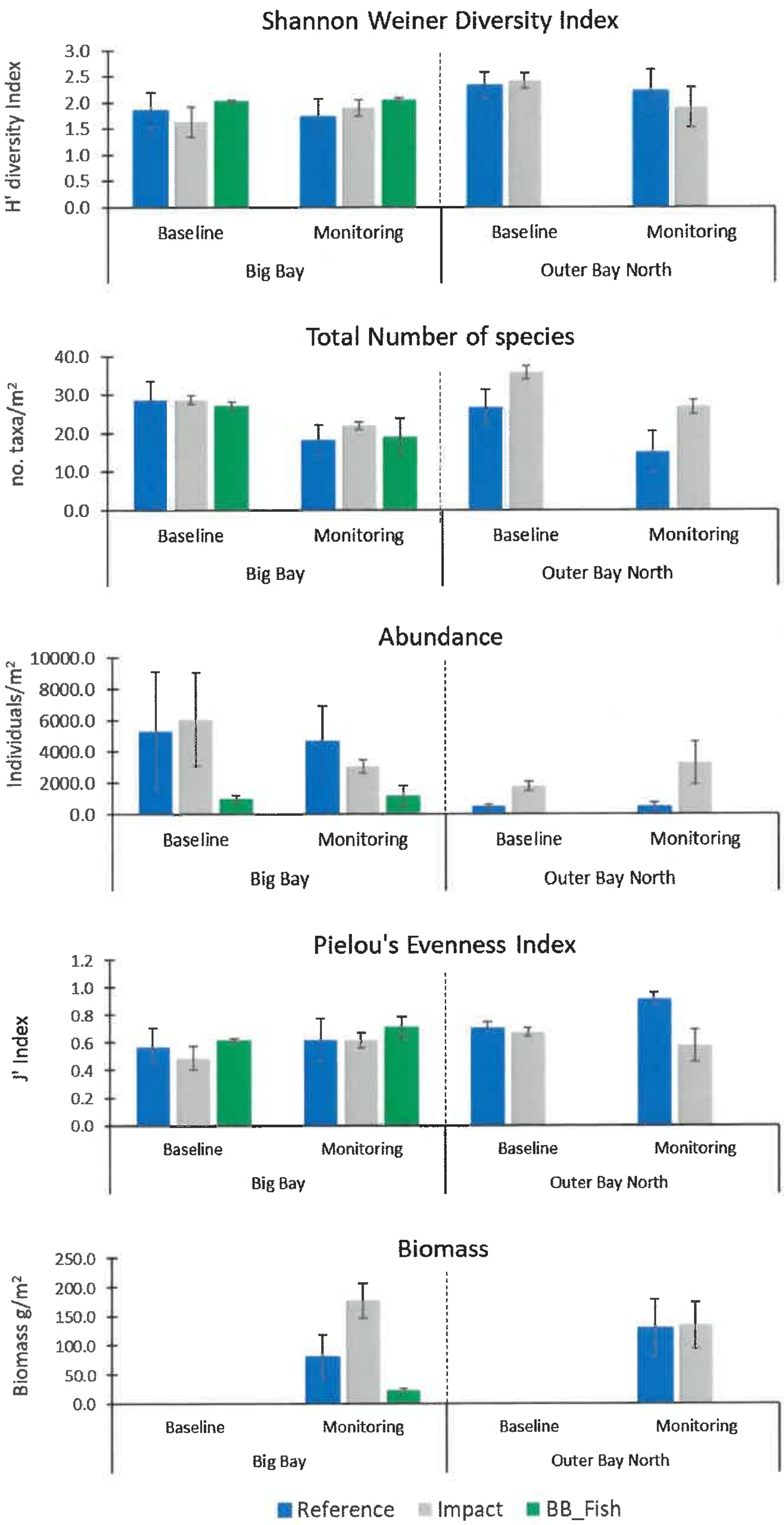

Figure 7. **Variation in macrofaunal community descriptors Diversity, Taxonomic richness (no. of taxa/m2), Abundance (individuals/m²), Evenness and biomass (g/m²) for Impact, Reference and Finfish sites in Big Bay and Outer Bay North, for both the baseline survey (2019) and the monitoring survey (2021). Values are means ± 1 SE.**

The Shannon-Wiener diversity index (H') was calculated for the Big Bay and Outer Bay North precincts and a one-sample t-test used to test the average H' against the adjusted (ln) threshold value as described in section 3.7.1. The average H' for Outer Bay North was not significantly different to the adjusted threshold (average H' = 2.2, 1-sample t-test, $p > 0.05$). However, the average H' for Big Bay precinct was significantly lower (average H' = 1.78, $p = 0.017$) than the prescribed threshold of H' = 2.1 (Table 4). When an ANOVA was preformed comparing the Shannon-Wiener diversity index of impact sites to that of reference sites and that of baseline vs monitoring surveys, no significant difference was detected for either comparison, in both precincts ($p > 0.05$ for all).

In the baseline report it was suggested that H' be statistically compared between impact sites and reference sites to determine if there has been a significant decrease in diversity due to aquaculture activities (none detected as above), and that monitoring values be compared to the reference values of the baseline survey, thus creating a secondary threshold value more reflective of the natural state in Saldanha Bay i.e. the average H' of the baseline reference sites of each precinct was suggested as a suitable threshold, with H' = 1.86 and H' = 2.32 for Big Bay and Outer Bay North respectively (Mostert *et al.* 2020a). One sample t-tests showed that the Shannon-Wiener diversity index (H') for the 2021 monitoring survey impact sites in Big Bay and Outer Bay North were not significantly lower than these revised thresholds recommended by Mostert *et al.* (2020). Future surveys should similarly consider both the adjusted (ln) threshold of H' = 2.1, as well as conducting 1-sided t-tests comparing the H' of impact sites to the average H' of baseline reference sites.

4.2.2 Indices of community health

Based on one sample t-tests the average Infaunal Trophic Index (ITI) of impacted sites for both precincts was significantly above the prescribed threshold value (Table 4, > 25, $p < 0.05$ for both). Additionally, there was no significant difference between the ITI of the 2021 monitoring survey impact and reference sites within either of the precincts when compared using a nested ANOVA (Treatment nested within survey year, $p > 0.05$ for both). Although, the ITI values for the monitoring survey in both Big Bay and Outer Bay North were lower than those recorded during the baseline survey, these declines were not statistically significant ($F_{1,15} = 4.54$, $p > 0.05$ and $F_{1,10} = 3.85$, $p = 0.08$, respectively).

The trophic index community descriptions show that a number of sites previously considered "normal" (ITI > 55) had a lower ITI and are now classed as "changed" (ITI 25-55). In the baseline survey only three out of 18 sites were considered changed, however, during the monitoring survey just over half the sites are classes as "changed" (10 out of 19) with values ranging from 36.2-54.9. It is noteworthy that three of these "changed" sites are reference sites (BB C3, OBN C1 and OBN C3, Table 4), suggesting that the decline in ITI values cannot be solely attributed to aquaculture impacts and sites may also have been impacted by natural events such as large storms or low oxygen events which are common on the West Coast.

Table 4. **Calculated values for three macrofaunal biological indices for all sites. Threshold values prescribed for each index supplied (DAFF 2018). *Cranford *et al.* 2020**

Area	Site	Shannon-Weiner diversity index (H')		Infaunal Trophic Index (ITI)		ITI community description		AZTI Marine Biotic Index (AMBI)		AMBI disturbance category	
		Baseline	Monitoring	Baseline	Monitoring	Baseline	Monitoring	Baseline	Monitoring	Baseline	Monitoring
Threshold		**~1.86**	**~1.71**	**≥ 25**	**≥ 25**			**≤ 3.3**	**≤ 3.0***		
Big Bay	BB 1	2.41	2.13	67.3	50.2	Normal	Changed	0.966	0.392	Undisturbed	Undisturbed
	BB 2	2.02	2.18	57.2	54.5	Normal	Changed	1.067	0.297	Undisturbed	Undisturbed
	BB 3	2.22	1.46	66.1	44.0	Normal	Changed	1.604	0.650	Slightly disturbed	Undisturbed
	BB 4	1.51	1.25	99.2	46.3	Normal	Changed	0.125	0.243	Undisturbed	Undisturbed
	BB 5	0.79	-	99.6	-	Normal	-	0.050	-	Undisturbed	-
	BB 6	0.83	1.83	99.0	95.8	Normal	Normal	0.076	0.239	Undisturbed	Undisturbed
	BB 7	-	2.03	-	64.0	-	Normal	-	0.415	-	Undisturbed
	BB 8	-	2.41	-	63.4	-	Normal	-	1.007	-	Undisturbed
	BB-C1	1.64	1.34	98.4	89.9	Normal	Normal	0.121	0.115	Undisturbed	Undisturbed
	BB-C2	2.52	2.40	63.2	70.9	Normal	Normal	1.518	1.611	Slightly disturbed	Slightly disturbed
	BB-C3	1.4	1.40	98.4	36.2	Normal	Changed	0.163	0.630	Undisturbed	Undisturbed
	BB-F1	2.05	2.08	86.5	97.7	Normal	Normal	0.531	0.551	Undisturbed	Undisturbed
	BB-F2	-	-	-	-	-	-	-	-	-	-
	BB-F3	2.00	2.01	90.3	89.4	Normal	Normal	0.605	1.197	Undisturbed	Undisturbed
Threshold		**~2.32**	**~2.21**	**≥ 25**	**≥ 25**			**≤ 3.3**	**≤ 3.0***		
Outer Bay North	OBN 1	2.12	2.28	65.5	39.1	Normal	Changed	1.045	1.085	Undisturbed	Undisturbed
	OBN 2	2.21	1.99	78.9	40.0	Normal	Changed	1.133	0.715	Undisturbed	Undisturbed
	OBN 3	2.69	0.79	46.9	38.2	Changed	Changed	2.394	4.076	Slightly disturbed	Moderately disturbed
	OBN 4	2.64	2.55	74.4	57.8	Normal	Normal	1.522	1.388	Slightly disturbed	Slightly disturbed
	OBN-C 1	2.39	2.69	53.9	54.9	Changed	Changed	1.752	1.171	Slightly disturbed	Undisturbed
	OBN-C 2	1.85	1.39	87.5	66.7	Normal	Normal	1.412	0.375	Slightly disturbed	Undisturbed
	OBN-C 3	2.71	2.57	51.6	54.8	Changed	Changed	1.488	2.667	Slightly disturbed	Slightly disturbed

The AZTI Marine Biotic Index (AMBI) was calculated for each of the sample sites using the latest AMBI species list (Dec 2020) and a disturbance category assigned to each station, as well as an average AMBI for each treatment within the precincts (Impact/Reference, Table 4, Figure 8). There were no statistically significant differences in either the Big Bay or Outer Bay North AMBI scores between the two sampling surveys (Baseline/Monitoring, Big Bay: $F_{1,15} = 0$, $p = 1.0$ and Outer Bay North: $F_{1,10} = 0.017$, $p = 0.90$). Similarly, the AMBI scores of the two treatments (Impact/Reference) within each survey did not differ significantly (Big Bay: $F_{2,15} = 0.33$, $p = 0.72$ and Outer Bay North: $F_{2,10} = 0.13$, $p = 0.88$).

It was previously suggested that when monitoring the impacts of aquaculture, an AMBI score greater than 3.3 should be flagged as concerning (Table 2, Borja *et al.* 2000, Cranford *et al.* 2006), however, this value has recently been recalibrated and has dropped to 3.0 (Cranford *et al.* 2020). In Big Bay, the AMBI scores for impacted sites were significantly below the revised threshold values (<3.0, t-test, $p = 0.002$), suggesting that aquaculture is not having a significant impact in this precinct. However, impact sites at Outer Bay North were not significantly below the threshold ($p = 0.220$), this is because station OBN3 had an AMBI value of 4.076, therefore categorising this station as "moderately disturbed". The remaining sites had values significantly lower than the threshold, although the reference station OBN C3 also had a fairly high value (2.667). The average AMBI scores indicate that at Outer Bay North the impact and reference sites were slightly disturbed, while in Big Bay the reference, impact and finfish sites were generally undisturbed (Table 4, Figure 8 top). The Outer Bay North area is more exposed to open coast and natural disturbances such as storms, high wave action, temperature fluctuations and sediment movement than sites within Big Bay, which could explain the "changed"/ "slightly disturbed" results for these two outer bay sites.

The ITI appears to show more change occurring in the monitoring survey than in the baseline, while the AMBI scores, with the exception of the OBN3 station, suggest less disturbance in the monitoring survey than in the baseline (Table 4). Given that none of the differences were significant and that the biological indices for all but one site were below the prescribed thresholds, results indicate that the aquaculture operations are having a negligible effect on benthic macrofauna present in the precincts. However, the presence of a "moderately disturbed" site should be noted/flagged, if this condition persists, or should more sites start showing greater levels of disturbance, action may be needed to ensure that the aquaculture does not have negative effects on the ecosystem. Despite the variation in the results of the two indices the fact that both the ITI and AMBI flagged a change and disturbance at site OBN3 indicates some level of agreement between these two methods.

AR&M has previously expressed reservations about the use of both the ITI and AMBI index in South African ecosystems. Both indices were originally developed for use in European waters, and they are therefore not easily applicable to species from South Africa. The ITI assumes that different trophic groups have different sensitivities to disturbance and the majority of species are not included in the provided species list meaning that an informed decision needed to be made depending on the available information of the feeding behaviour of the species. Somerfield (2009) accurately described the assignment of species to trophic groups as frequently being subjective and requiring a detailed knowledge of the biology of the species involved, which is often lacking. In addition, many of the species have been shown to use multiple feeding methods making it difficult to assign them to a single group, for this reason and/or because the taxonomic level identified was too unspecific for the determination of feeding mode only 43% of the species could be assigned to a group to be used in the calculation. Similarly, the AMBI index is calculated using a program developed for European waters.

Although, the number of species on the new list of AMBI species assignments increased from 9 251 (in May 2019) to 10 638 species in December 2020, they are still predominantly for species from geographical areas in the Northern Hemisphere (Europe, North America, Central America, and Asia) While more Southern Hemisphere species have been included in the list the user still has to change the resolution from species level to genera, or else substitute a South African species with a similar species found in the northern hemisphere. The new AMBI 6.0 version of the software now enables the user to choose which group they wish to assign a specific species to. This allows for a more tailored, regional approach to the process, however, still requires the user to have a good understanding of the feeding modes utilised by the species in their geographical region. Improved applicability of these indices in the South African context would be highly beneficial for marine environmental monitoring in general, and for monitoring impacts of current and future ADZs in particular.

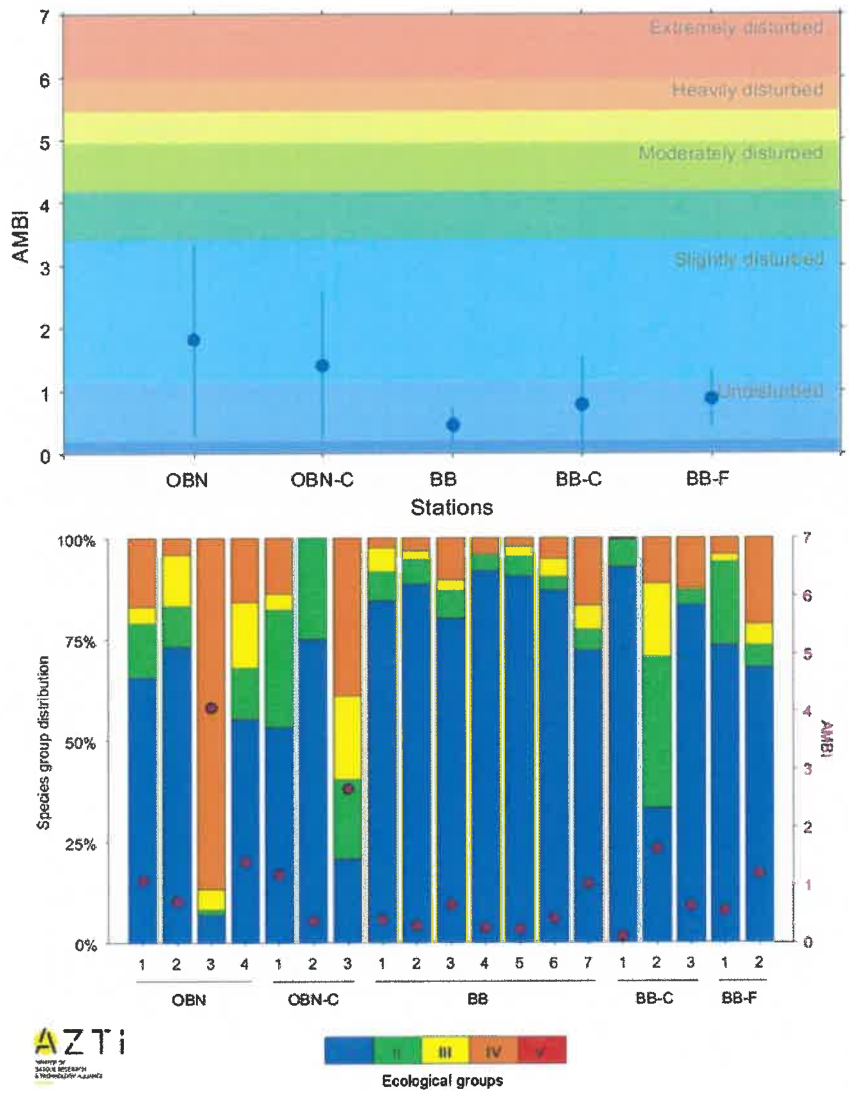

Figure 8. **AMBI scores and disturbance classification for each of the precincts and their control sites (top) and distribution of species ecological groups for all sites (bottom), Outer Bay North (OBN), Outer Bay North Controls (OBN-C), Big Bay (BB), Big Bay Controls (BB-C) and Big Bay Fish (BB-F).**

Macrofaunal species often respond to changes in environmental variables before they are chemically detectable (Cranford *et al.* 2006). These responses include: 1) a reduction in species biomass, 2) a decrease in the average body size of individuals, and 3) a shift in the relative dominance of trophic groups (Black *et al.* 2008, Cranford *et al.* 2012). It was therefore suggested in the baseline report that future monitoring surveys should include the determination of species biomass, to be used to construct ABC dominance curve (Cumulative abundance-biomass plots) and provide information on the level of disturbance within the aquaculture sites relative to the reference sites.

Cumulative abundance-biomass plots of macrobenthic communities (Warwick 1993), also called k-dominance curves are used to visually assess patterns of abundance and biomass to identify if a disturbance is occurring within communities. When cumulative contributions by species to overall abundance and biomass are plotted together on the same graph (Figure 9), in the case of undisturbed communities, the curve for biomass generally lies above the curve for abundance for its entire length. Hypothetically, case A shows the expected response indicative of stable conditions, where the frequency or intensity of disturbance is low. Under these conditions k-selected (larger, long-lived species) make an important contribution to community structure and while they seldom dominate numerically, these species usually provide the largest contribution to biomass (Warwick 1993). Smaller r-selected, opportunistic species with a shorter lifespan are also represented, and usually dominate numerically but make a small (often insignificant) contribution to overall biomass (Warwick 1993). Under moderate or low levels of disturbance, the large competitive species are eliminated and the inequality between abundance and biomass dominants is reduced so that the curves coincide closely and may cross one another such as in hypothetical case B (Figure 9 middle). While in the case of high levels of disturbance, the larger dominant species die off or are displaced and the smaller r-selected, opportunistic species with a shorter lifespan dominate, resulting in a high abundance of individuals but a low total biomass. In the case of highly/grossly disturbed communities, the curve for abundance generally lies above the curve for biomass for its entire length (Figure 9 C right)

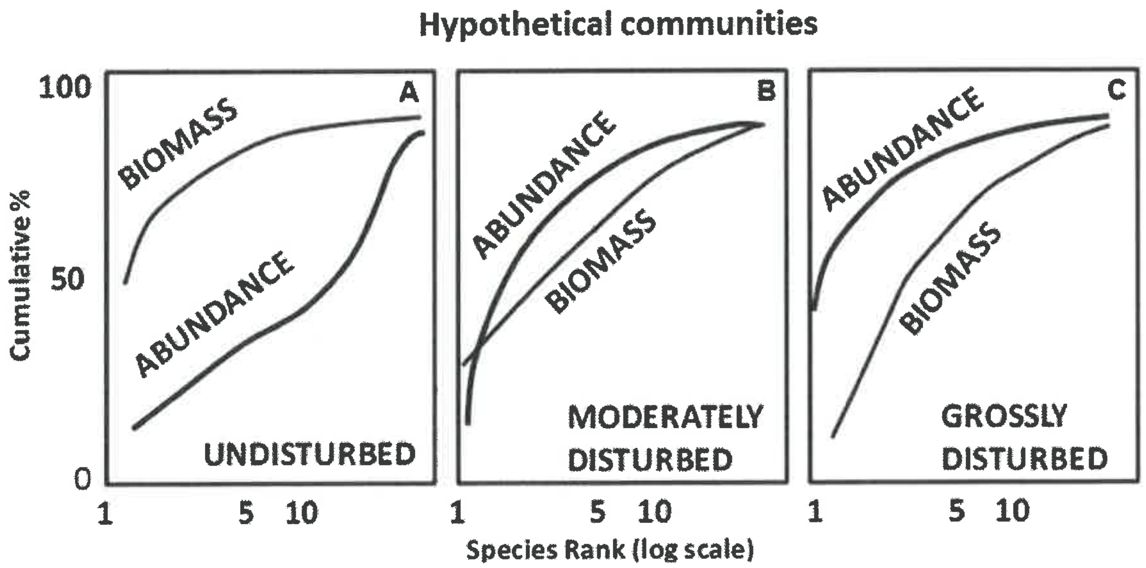

Figure 9. **Hypothetical Abundance-Biomass Comparison (ABC) curves for species biomass and abundance showing undisturbed, moderately disturbed and grossly disturbed conditions (after Warwick 1993)**

The collection of biomass data for the 2021 monitoring survey enabled the production of cumulative abundance-biomass plots (Figure 10 and Figure 11). The ABC curve produced for the reference sites in Outer Bay North provides a textbook example of an undisturbed area, with the biomass curve above the abundance curve for the full length (Figure 10). In contrast, the ONB Impact sites indicate low to moderate levels of disturbance occurring at these Impact sites. The abundance curve lies above the biomass curve to start, before the curves cross with the biomass above abundance in the higher ranked species. These results support those of the AMBI and ITI which reported undisturbed/slightly disturbed references sites, one normal Outer Bay North reference station (>55) and the remaining two reference sites only just changed (54.8 & 54.9). While the impact sites ranged between normal/changed and undisturbed to moderately disturbed.

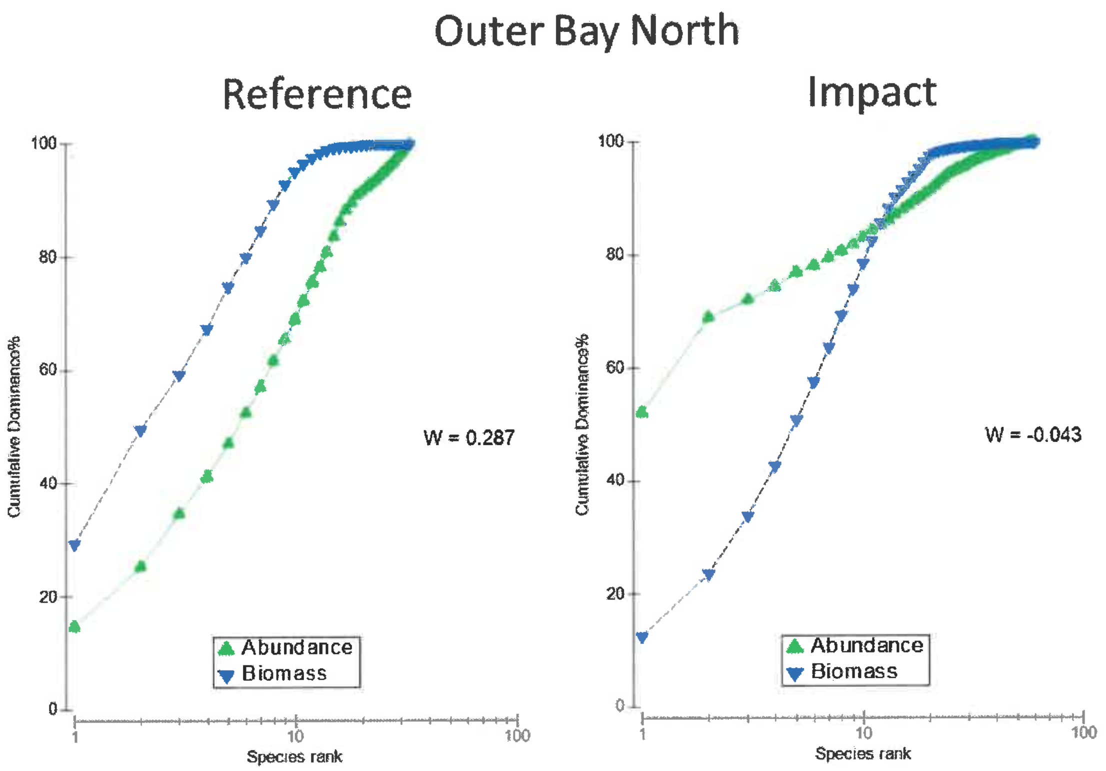

Figure 10. **Abundance-Biomass Comparison (ABC) curves for species biomass and abundance for Reference (left) and Impact (right) sites in the Outer Bay North precinct.**

For all three treatments in Big Bay; Reference, Impact and Finfish (currently considered reference as to-date no fish farming has occurred at these sites) the inequality between abundance and biomass dominants was reduced so that the curves coincided closely, however, the biomass curve was predominantly above the abundance curve, suggesting generally low levels of disturbance (Figure 11). Importantly, the curves for the State of the Bay samples collected in Big Bay in 2019 and 2020 lie very close together, however, the abundance curve dominates, indicating a higher level of disturbance at these sites relative to those of the ADZ monitoring (Figure 11). This suggests that all sites within Big Bay are experiencing some level of disturbance, possibly a combination of natural disturbance due to exposure and/or low oxygen events and anthropogenic disturbance from a combination of human activities occurring within the bay.

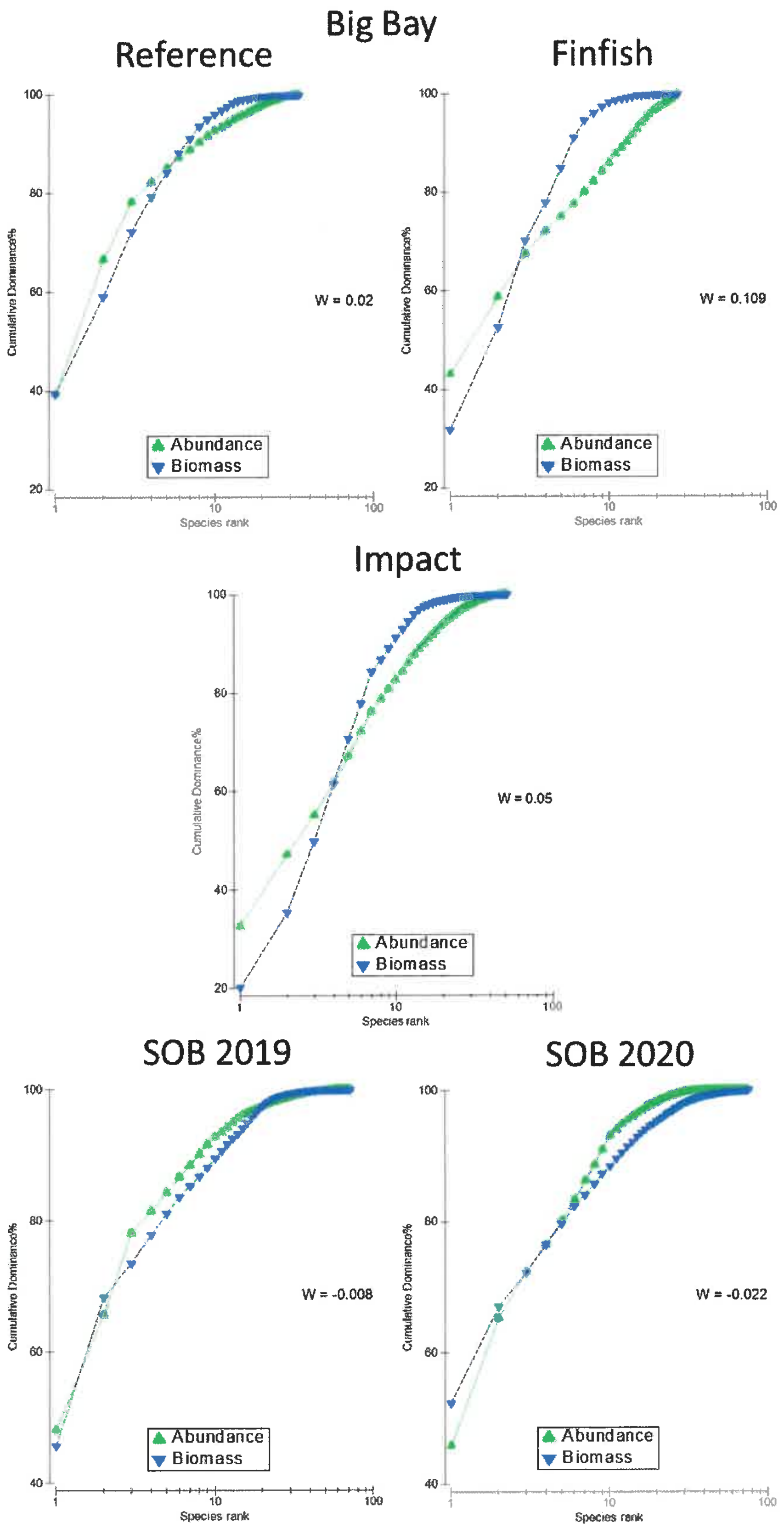

Figure 11. Abundance-Biomass Comparison (ABC) curves for Big Bay Reference (top left), Finfish (top right) and Impact (middle) sites, as well as for the samples collected during the Annual State of the Bay reports in 2019 & 2020 (bottom)

4.2.3 Multivariate analysis

An ordination plot, that displays sites based on similarities in their macrofauna community composition in two-dimensional space (sites with similar communities are closer together) prepared from baseline and monitoring macrofaunal abundance data, is presented in Figure 12. Visually the macrofaunal communities present at the Big Bay sites were separate to those at sites in Outer Bay North and was statistically supported by a significant difference between the two precincts (PERMANOVA pseudo $F_{1,36} = 6.566$; $p = 0.001$). These differences in macrofaunal community structure can largely be explained by variations in the physical and environmental parameters present at each precinct i.e. currents, wave exposure, water quality, sediment granulometry and depth, biological processes such as recruitment, predation, competition etc. can also play a role. These elements are likely to be distinctly different between the Big Bay and Outer Bay North precincts (see section 4.1).

Additionally, communities from the baseline and monitoring surveys formed separate groupings, all four of which were significantly different (PERMANOVA main test, pseudo $F_{3,36} = 4.189$; $p = 0.001$ and pairwise $p < 0.01$ for all). Given the distinction between precincts these have been treated separately for all further analyses.

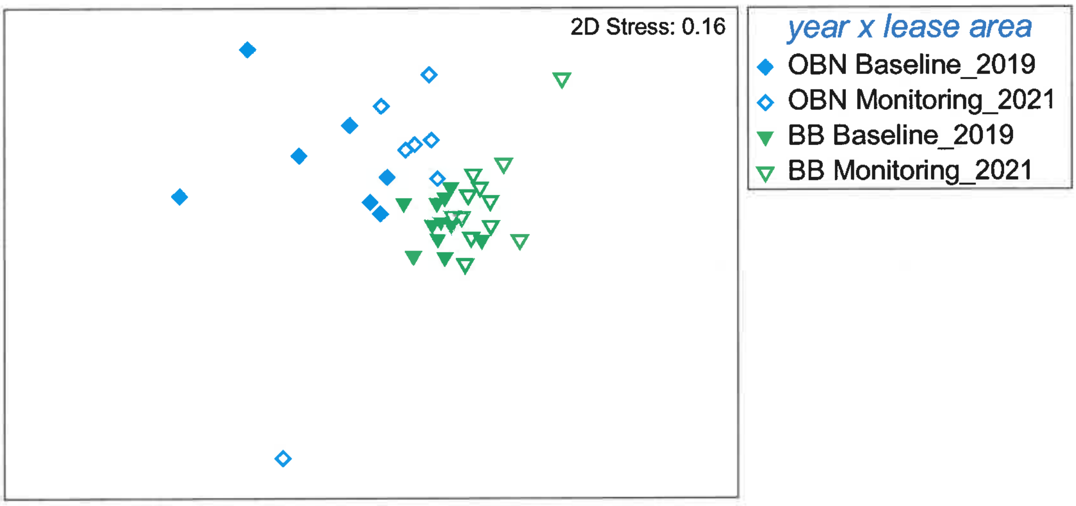

Figure 12. **Ordination plots comparing precincts and sampling surveys based on benthic macrofauna abundance. Symbols on the ordination plots are as follows: Big Bay (BB) and Outer Bay North (OBN), Solid symbols represent the baseline survey and hollow symbols the Monitoring survey.**

A Multidimensional scaling ordination (MDS) based on abundance data from Outer Bay North shows a clear separation between survey years (Baseline survey - 2019 and Monitoring survey 2021), however, there does not appear to be a difference between treatments (Reference/Impact) within each survey (Figure 13). This is statistically supported as PERMANOVA analyses indicated that there was a significant difference between survey year (main test, pseudo $F_{1,13} = 2.1723$; $p = 0.001$), however, pairwise analyses indicated that there was no significant difference between impact and reference sites in either baseline or monitoring surveys ($p > 0.05$). The lack of a significant effect of impact and reference sites within a given survey suggests that the aquaculture activities are not having a significant effect on the community structure and that the differences between survey years is likely due to natural variability in community structure across temporal scales i.e. communities may vary from year to year based on annual changes in physical parameters, such as storms, currents, wave exposure, water quality and natural disturbance events such as algal blooms and the associated low oxygen events.

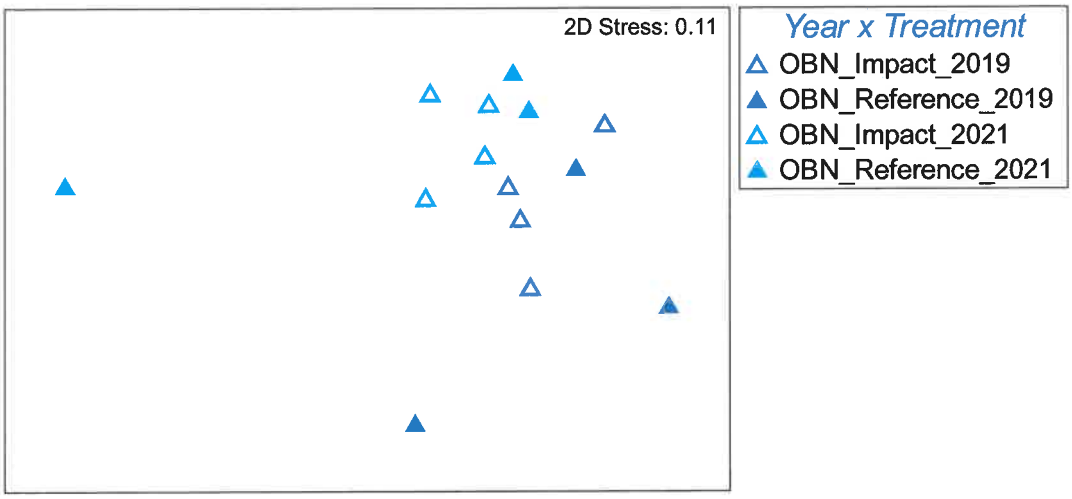

Figure 13. **Ordination plot comparing macrofaunal communities of Outer Bay North (OBN) based on abundance data. Solid symbols represent the reference sites and hollow symbols the Impact sites. Baseline (2019) = dark blue symbols and monitoring (2021) = light blue symbols.**

Multivariate dispersion tests showed that the presence of aquaculture operations (impact sites) decreased variability in macrofaunal assemblages relative to areas without aquaculture operations (reference sites), with the response similar in both baseline treatments (Table 5, PERMDIST, Impact: 37.74 ± 3.8 SE; Reference: 46.35 ± 3.0 SE) and monitoring treatments (PERMDIST, Impact: 36.99 ± 2.2 SE; Reference: 46.06 ± 6.9 SE).

Table 5. **Summary statistics for multivariate dispersion tests showing average variability (+ SE) of macrofaunal communities, based on abundance data, between surveys and treatments at each precinct.**

PERMDISP Macrofaunal Abundance					
Precinct	**Survey**	**Treatment**	**Sample size**	**Average dispersion**	**Standard Error**
Outer Bay North	Baseline	Impact	4	37.74	3.841
		Reference	3	46.35	2.983
	Monitoring	Impact	4	36.99	2.178
		Reference	3	46.06	6.944
Big Bay	Baseline	Impact	6	32.77	2.501
		Reference	5	34.53	2.787
	Monitoring	Impact	7	32.09	1.932
		Reference	5	39.16	3.787
	SOB 2019	Reference	9	41.75	2.994
	SOB 2020	Reference	9	45.11	2.924

In Big Bay, sampling survey has a significant effect on the community structure of macrofaunal assemblages (PERMANOVA main test - pseudo $F_{3,40} = 6.22$; $p = 0.001$), with pairwise tests indicating that all sampling surveys were significantly different (PERMANOVA pairwise - $p = 0.001$ for all). That is, the macrofaunal communities of the ADZ sampling baseline and monitoring surveys differ from each other as well as from both SOB monitoring surveys. As seen in Outer Bay North, sites at which aquaculture operations were underway (impact sites) had a lower level of dispersion, (less variation in community structure) than sites where no aquaculture occurred (reference sites) during both surveys: baseline treatments (Table 5, PERMDIST, Impact: 32.77 ± 2.5 SE; Reference: 34.53 ± 2.8 SE) and monitoring treatments (PERMDIST, Impact: 32.09 ± 1.9 SE; Reference: 39.16 ± 3.8 SE). Additionally, the community dispersion within the SOB sampling surveys was greater than both ADZ surveys (PERMDIST, SOB 2019: 41.75 ± 3.0 SE; Reference: 45.11 ± 2.9 SE).

It is likely that the variation between ADZ and SOB samples is caused by the spatial separation of sampling sites. The SOB samples are generally located on the perimeter of the Bay (see Figure 1) where the substratum is exclusively sandy, and annual diver operated suction sampling for the SOB surveys conducted since 2004 have never encountered rocky substrate. The ADZ samples, however, fall within the centre of the Bay an area where an extensive abrasion platform with emergent patch reef occurs (Mostert *et al.* 2020a). Rocky reef community structure is known to influence macrobenthic distribution and abundance in the adjacent soft bottom habitats, and it has been found that more benthic species occur close to rocky reefs (Barros *et al.* 2001). This suggests that the observed separation of SOB and ADZ sampling sites may be related to differences in habitat between the two areas. Importantly, the SOB macrofaunal communities also differ significantly between years (2019 & 2020[3]) despite the fact that identical sites were sampled, and no aquaculture occurs in the direct vicinity of the SOB sampling sites. This provides support for the statement that the macrofaunal communities within the bay experience natural variability in community structure across temporal scales. Adding to this is the fact that the SOB 2019 samples appear closer to the Baseline 2019 samples than the SOB 2020 samples, suggesting a greater similarity of species composition within years than between years.

As mentioned above, when comparing the macrofaunal community structure of only the ADZ samples in Big Bay, the baseline and monitoring surveys differ significantly, however, this is not obvious in the visual representation of the community structure i.e. the samples appear closely clustered in the MDS plot (Figure 14). Pairwise analyses of the treatments within each survey reveal that the macrofaunal community did not differ between Impact and Reference sites during the baseline survey ($p = 0.653$), however, treatment did have a significant effect on the community structure during the monitoring survey ($p = 0.01$). It is possible that this is due to the increased level of dispersion (greater variation in species composition) in the reference sites of the monitoring survey relative to the impact sites (PERMDIST, Impact: 32.09 ± 1.9 SE; Reference: 39.16 ± 3.8 SE), with a different suite of species found in the reference sites than the impacts sites. However, given that the univariate analyses of all five

[3] Note that, although already collected, the SOB 2021 macrofaunal survey samples have not yet been identified in the laboratory and therefore cannot be included in this analysis, however, the data from 2020 has been added for greater comparison.

Big Bay macrofaunal community descriptors showed no significant differences between Impact and Reference sites it unlikely this variation is an artifact of the aquaculture operations.

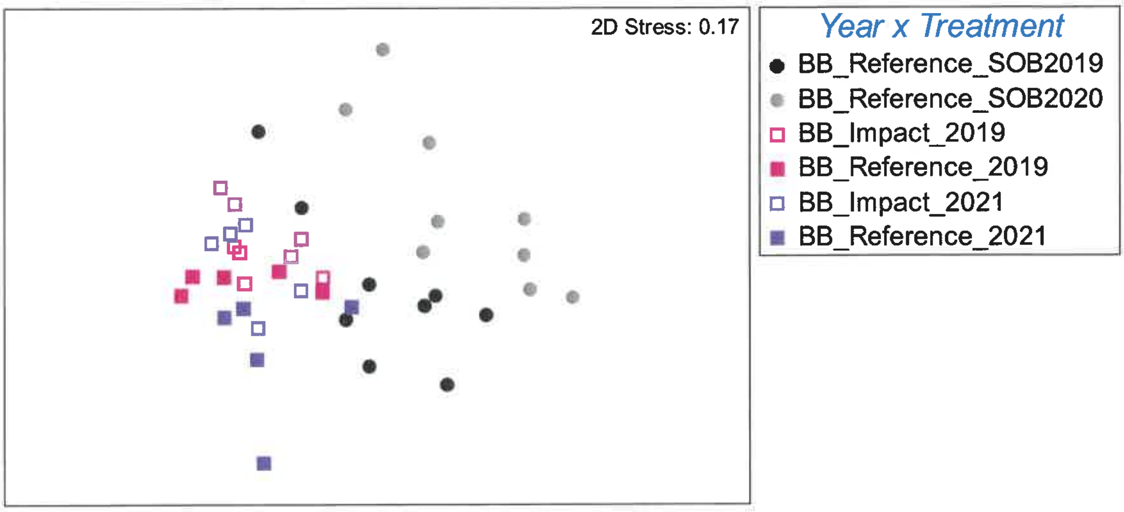

Figure 14. **Ordination plots comparing the 2019 baseline and 2021 monitoring macrofauna data for Big Bay to the data collected during the 2019 and 2020 SOB surveys. Symbols on the ordination plots are as follows: Big Bay (BB) and State of the Bay (SOB). Squares = ADZ surveys, Circles = SOB surveys. Solid symbols represent the Reference sites and hollow symbols the Impact sites.**

Overall, the univariate and multivariate analyses presented here suggest that the aquaculture operations are currently having a negligible effect on soft sediment benthic macrofauna present in the precinct. However, the identification of one impact site in Outer Bay North as "moderately disturbed" and the evidence showing that macrofaunal communities in all areas of Big Bay (SOB, Reference and Impact sites) are experiencing low levels of disturbance (natural and anthropogenic), suggests that it is important to continue to monitor the situation to ensure that operations within the ADZ do not compound this disturbance and that the cumulative effects are not significant enough to cause severe impacts or grossly disturbed benthic communities

4.3 Epifaunal reef species

The Saldanha Bay sea-based Aquaculture Development Zone baseline benthic survey report (Mostert *et al.* 2020a) mentioned that divers encountered calcrete reef at some of the sampling sites during the 2019 baseline survey (Capfish 2019) and that difficulties in obtaining grab samples at several stations were encountered in Big Bay during the 2020 sediment surveys (Mostert *et al.* 2020b). Further to this observation, AR&M divers deploying water quality monitoring instruments during April 2020, indicated the presence of reef in several areas of the Big Bay ADZ precinct. A subsequent literature review revealed the existence of an extensive abrasion platform (areas of exposed calcrete rock) throughout much of Big Bay (Flemming 2015). Additionally, the finfish lease holder provided a bathymetry map of their precinct which indicated extensive low-profile reef throughout the site (Mostert *et al.* 2020a). Underwater video footage obtained from one of the Big Bay finfish lease holders revealed that the depth of sediment varied considerably within their precinct, and was frequently less than 50 cm. Photographs of the benthic environment taken by AR&M indicated that low lying reef occurred, which was possibly periodically inundated with a fine layer of sediment (Mostert *et al.* 2020a, b). The patches of exposed reef provided habitat for upright epifauna (basket stars, sponges, bryozoans etc.) and west coast rock lobster were present (currently unquantified). Overall, the reef was described as low-profile roughly < 1m in height from the sea floor, which may be subject to periodic, natural sand inundation. However, substantial outcrops >1m in height were present which form habitat for a well-established epifaunal community.

During the 2021 monitoring survey AR&M divers collected video footage at two stations where reef was encountered. This footage was then used to provide a qualitative description of the reef epibenthos at each site. A total of 21 species were identified, with more species recorded at site BB5 (20 species) than at the finfish site FF2 (10 species), however, the sites shared a number of common species including the West Coast rock lobster *Jasus lalandii*, red *Patiria granifera* and reticulated starfish *Henricia ornata*, cape urchins *Parechinus angulosus*, and beds of the common feather star *Comanthus wahlbergii* (Table 6), examples of which are shown in Figure 15 and Figure 16.

Table 6. **Species identified using footage collected at rocky ADZ sites in Big Bay.**

			Site	
Phylum/Class	**Scientific Name**	**Common name**	**BB5**	**FF2**
Anthozoa	*Pseudactinia flagellifera*	False Plum anemone	✓	
Ascidiacea	*Pyura stolonifera*	Red Bait	✓	
	Henricia ornata	Reticulated starfish	✓	✓
Asteroidea	*Marthasterias africana*	Spiny starfish	✓	
	Patiria granifera	Red starfish	✓	✓
Bivalvia	*Aulacomya ater*	Ribbed mussel	✓	
Crinoidea	*Comanthus wahlbergii*	Common feather star	✓	✓
Echinoidea	*Parechinus angulosus*	Cape urchin	✓	✓
Gastropoda	*Africofusus ocelliferus*	Long-siphoned whelk	✓	
	Burnupena sp	Whelk	✓	
Gymnolaemata	*Schizoretepora tessellata*	Lacy false coral	✓	
Hydrozoa	*Hydrozoa* sp		✓	✓
Malacostraca	*Jasus lalandii*	West Coast rock lobster	✓	✓
	Palaemon pacificus	Sand shrimp		✓
		Fanworm polychaete	✓	
Polychaeta	*Gunnarea capensis*	Cape reef worm	✓	
		Tangle worm polychaete	✓	
	Haliclona sp	Sponge	✓	
Porifera	*Leucosolenia* sp	Sponge	✓	✓
		Orange sponge	✓	✓
	Tethya sp	Sponge	✓	✓

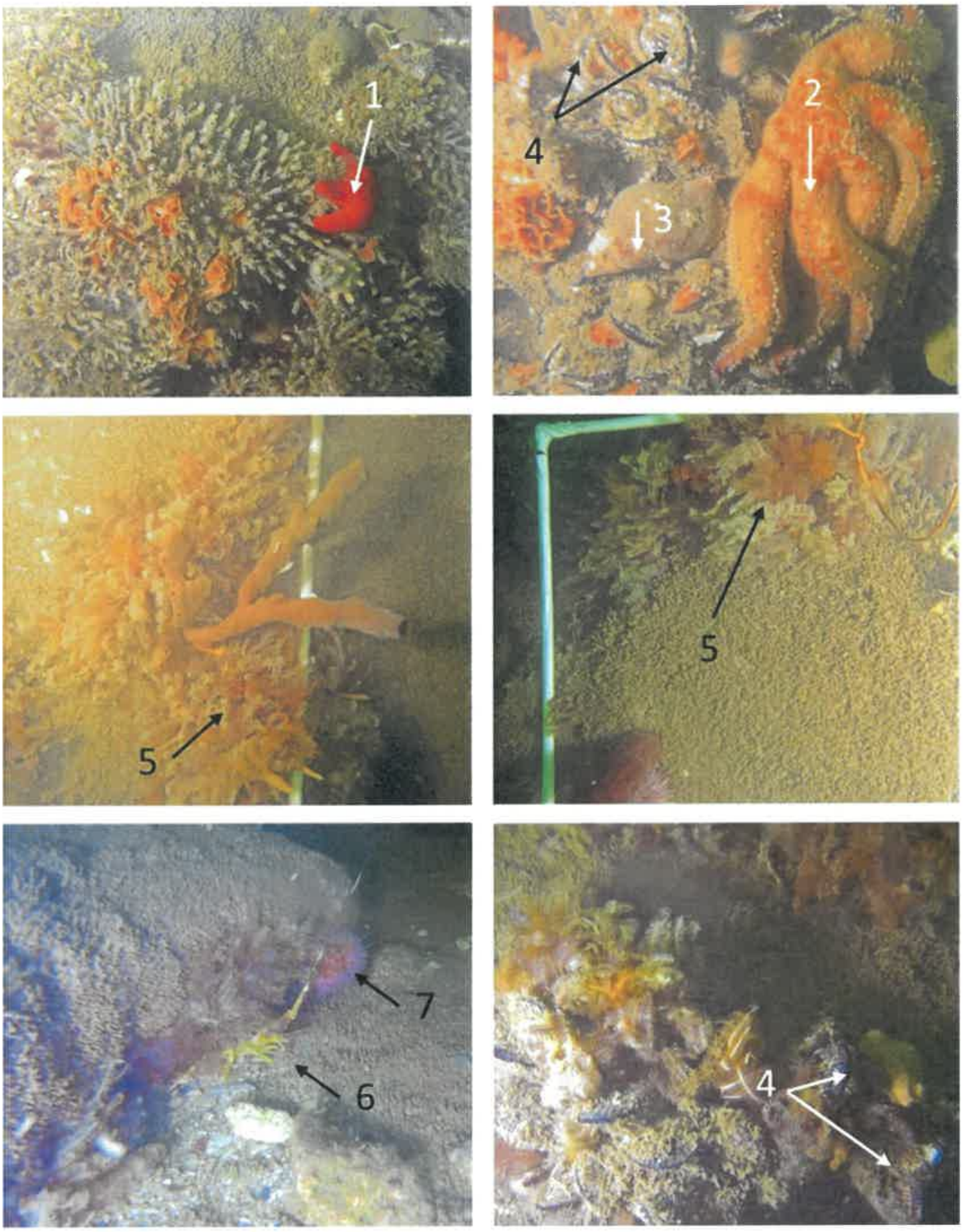

Figure 15. **Stills taken from video footage of Big Bay Site BB5 showing examples of epifaunal reef community. 1) - *Patiria granifera*, 2) - *Marthasterias africana*, 3) - *Burnupena* sp, 4) - *Aulacomya ater*, 5) - *Comanthus wahlbergii*, 6) - *Jasus lalandii*, 7) - *Parechinus angulosus*.**

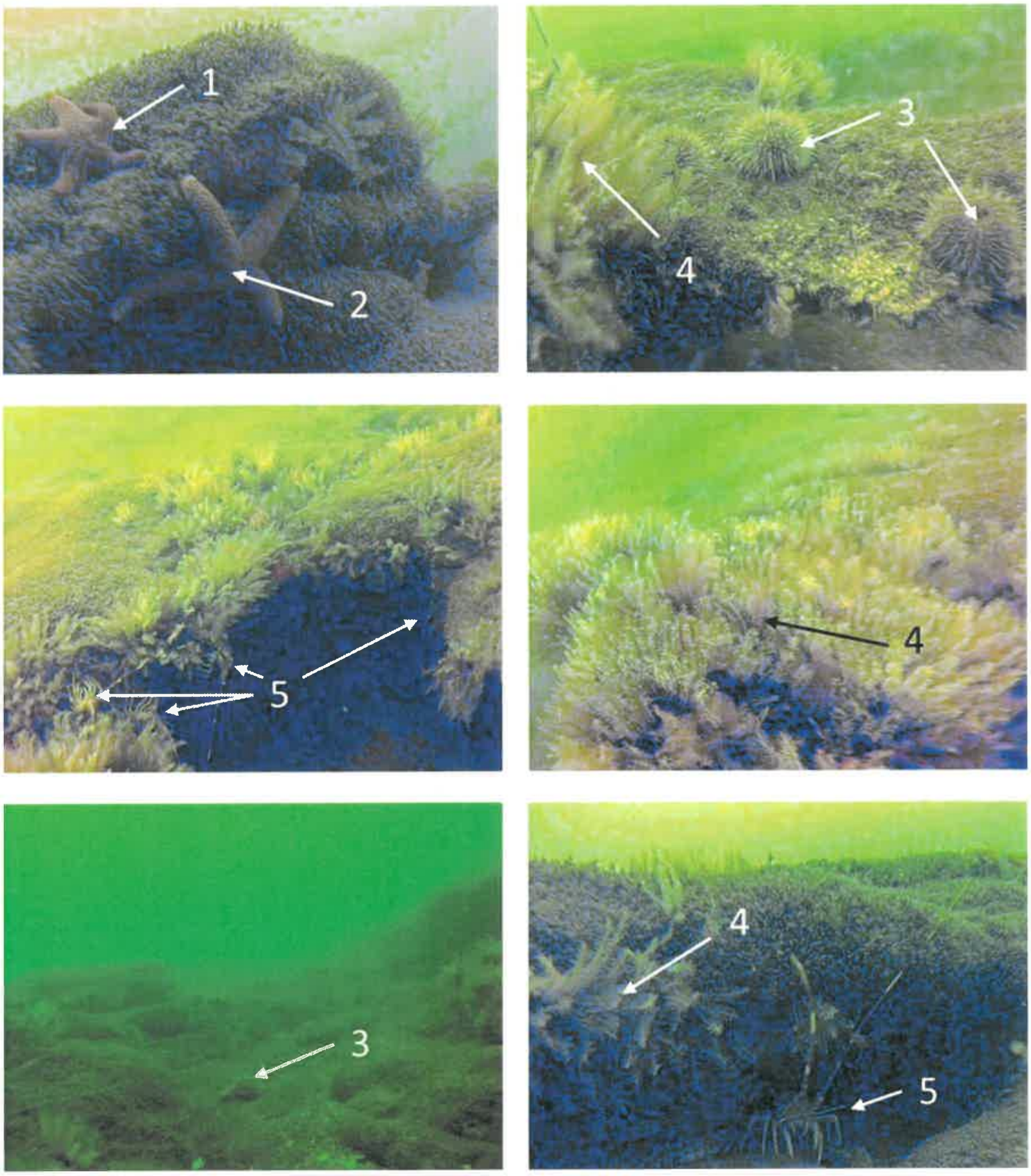

Figure 16. **Stills taken from video footage of Big Bay Site FF2 showing examples epifaunal reef community. 1) - *Patiria granifera*, 2) - *Henricia ornata*, 3) - *Parechinus angulosus*, 4) - *Comanthus wahlbergii*, 5) - *Jasus lalandii*.**

5 FINDINGS AND CONCLUSIONS

Based on the above comparison of the baseline survey data and the 2021 monitoring survey data, which included two brief video surveys of confirmed rocky reef areas within the Big Bay ADZ Precinct, the following provides a summary of key findings:

1. Despite high abundance and species richness in Saldanha Bay, the natural occurrence of certain dominant species causes the Shannon-Weiner Diversity index to fall below the stipulated threshold of H' = 3 throughout both ADZ precincts. However, the diversity values at the impact sites were not significantly lower when compared to the revised H' statistic threshold calculated from the baseline and reference sites. Supporting the suggestion made in the baseline report that a locally applicable threshold value should be used.
2. The collection of biomass data for the 2021 monitoring survey enabled the production of Cumulative abundance-biomass plots of macrobenthic communities (Warwick 1993), also called k-dominance curves. These curves provided an additional tool with which to assess the level of disturbance within the aquaculture sites relative to the reference sites. Highlighting low to moderate levels of disturbance in Outer Bay North and a low level of disturbance in Big Bay, although the latter was consistent across all treatments as well as SOB sites suggesting that Big Bay is experiencing natural and anthropogenic disturbances not specific to the aquaculture activities.
3. Updates to the species lists of the AZTI Marine Biotic Index (AMBI), and the software which enables users to allocate species groups independent of the species list suggests an improvement to the accuracy of this index for use in the southern hemisphere. However, only half the listed species could be assigned for use in the determination of the Infaunal Trophic Index (ITI). Improved applicability of these indices in the South African context would be highly beneficial for marine environmental monitoring in general, and for monitoring impacts of current and future ADZs in particular. This would require collaboration between local South African marine scientists with taxonomic expertise (an expert workshop) to produce a more comprehensive list of the feeding modes and functional groups of species, to both standardise the assignment of groups to species and to ensure that more species are included in the calculation of both indices. This is beyond the scope of monitoring obligations of the Saldanha ADZ alone, but DFFE should give consideration to initiating and supporting such an initiative in the future if the use of these indices is specified in approved and updated ADZ sampling plans.
4. The identification of a moderately disturbed site in Outer Bay North and data from ABC curves indicating that all communities within Big Bay are already experiencing low levels of disturbance - regardless of the presence or absences of aquaculture activities – suggests the need to maintain the interval between monitoring surveys at least every 3 years (and not allow gaps of up to 5 years between surveys). Thus, ensuring that any impacts associated with the ADZ operations are detected timeously and do not compound the natural/existing disturbance within the bay and that the cumulative impacts within the bay do not push these sites towards detrimental levels of disturbance.
5. The extent of the reef abrasion platform present in Big Bay is currently unquantified and the proportion of this habitat type impacted by current and future mariculture activities unknown, especially in view of the fact that the dispersion model shows strong scouring here. A detailed bathymetry survey using side scan sonar or multibeam echosounder of the ADZ precinct and

historical extent of the abrasion platform would map the current extent of the abrasion platform in Big Bay allowing calculation of the proportion of this habitat type potentially impacted by mariculture operations.

6. Video footage taken by ARM divers during the monitoring survey allowed for a qualitative description of the epifaunal community on the reef habitat which included a total of 21 species. The reef appears to be mostly low profile <1m in height and may be periodically inundated with sand, however, outcrops of reef >1m in height were evident. This is a poorly/unstudied habitat type within Saldanha Bay and there is a dearth of information on its extent, and the nature and type of biotic communities present. The ADZ monitoring programme should be updated to include suitable reef surveys for monitoring potential aquaculture impacts on this habitat type. This is being addressed and the DFFE are considering proposals to undertake this work.
7. Suitable reef impact sites (n=3) in the finfish area and suitable reference sites (n=3) should be surveyed by scientific divers using transect or quadrat surveys to quantify key biotic components of this reef habitat. An alternative approach could be the use of underwater visual survey by means of divers with cameras, drop cameras or a Remote Operated Vehicle (ROV). All methods of surveying this habitat will rely on acceptable underwater visibility which is not common in Big Bay. In situ benthic surveys by divers, however, may be more easily undertaken than underwater video surveys in conditions of reduced visibility, but all options should be considered. It is critical that whichever survey method is employed, it must be repeatable for ongoing future monitoring. Ideally this monitoring should (as per the soft sediment monitoring programme) follow a 'Before-after-control-impact' (BACI) design. The pilot finfish farm has not yet moved into the ADZ and monitoring is planned in the coming months.
8. Analysis and interpretation of the results of the bathymetric and underwater reef habitat surveys must provide practical advice to support the ongoing adaptive management of the Big Bay ADZ precinct.

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

Protocols for Environmental Monitoring of the Aquaculture Development Zone in Saldanha Bay, South Africa

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Contents

1. Background to the Aquaculture Development Zone

The then Department of Agriculture Forestry and Fisheries (DAFF) established an Aquaculture Development Zone (ADZ) in January 2018 in Saldanha Bay with the aim of streamlining the expansion of farming operations and promoting investor confidence in the sector. The ADZ expands on existing aquaculture areas in Small Bay and Big Bay and extends operations into Outer Bay (Figure 1). The authorized species for cultivation include both alien and indigenous species of finfish and shellfish, and seaweeds. The proposal has been subject to a Basic Assessment (BA) process and a final Basic Assessment Report was produced (SRK 2017a). Through stakeholder engagement and in mitigation of the proposed scale of operations, the original area considered for new development in the ADZ was reduced considerably from 1 404 ha to 420 ha giving a total area of 884 ha including existing areas allocated for aquaculture. Most of the total area allocated to aquaculture is for shellfish farming as only 29% of the ADZ is regarded as suitable for finfish (SRK 2017a).

Mitigation and monitoring actions during the design, construction, operation and decommissioning phases are clearly specified in the EMPr and will largely be implemented by the developer/farmer and overseen by the Aquaculture Development Zone Management Committee (AMC) constituted according to Section 13 of the Environmental Authorization (EA). A Consultative Forum (CF) was also established to provide a platform for the public to engage on activities within the ADZ. As the holder of the EA, the Department of Forestry, Fisheries, and the Environment (DFFE, previously known as DAFF and as reflected on the EA) is responsible for implementation of recommendations in the Environmental Management Programme (EMPr) and the present monitoring plan. An Environmental Control Officer (ECO) was appointed during the construction and operational phases to ensure compliance with stipulations given in the Environmental Authorization and the EMPr (SRK 2017b).

As specified in section 7.1 of the EMPr (SRK 2017b), monitoring required during the operational phase must be undertaken by:

- a specialist appointed by the Branch Fisheries Management of the DFFE and approved by AMC, and
- individual operators.

The AMC/DFFE has oversight of environmental monitoring and through an Environmental Representative (condition 19 of the EA) will:

- liaise with the appointed specialist(s) to ensure environmental monitoring actions/methods are performed according to the EMPr and additional sampling plans;
- receive and review environmental monitoring results to ascertain compliance of aquaculture operators with conditions of the EMPr and EA;
- receive and review monthly Farm Monitoring Reports from individual operators;
- notify the AMC co-chairpersons of issues that require immediate attention of the committee;

- notify the AMC Secretariat of issues that require immediate attention of other aquaculture operators within the ADZ; and
- report on environmental aspects at AMC meetings.

The Marine Ecology Specialist Study (Pisces 2017) discusses many of the generic impacts associated with finfish and shellfish aquaculture as well as those specific to the Saldanha Bay/Langebaan Lagoon ecosystem which provide the focus for the required monitoring actions. The significance of these potential impacts both with and without mitigation measures are provided in the final Basic Assessment Report (SRK 2017a). Discussion regarding the different impacts with reference to the scientific literature is provided in the specialist study. Very briefly, the significant impacts can be categorized as:

- modification of seabed by biodeposition;
- modification of water column dissolved oxygen and inorganic nitrogen;
- removal of seston by shellfish;
- creation of habitat by farm structures;
- alteration of behaviour and entanglement of seabirds and marine fauna at finfish sites;
- introduction of aliens and spread of pests;
- transmission of diseases to wild population;
- genetic interaction with wild populations by shellfish and finfish; and
- pollution by therapeutants and trace metals.

Management and mitigation measures that address the above concerns for the different phases of the proposed ADZ development are provided in the final Basic Assessment Report (SRK 2017a) and EMPr (SRK 2017b). A number of environmental mitigation measures proposed for the operation phase in the Basic Assessment Report (BAR) are realistically addressed in the design and planning phase and will not be considered in detail in the present recommendations for monitoring. These are concerned mainly with appropriate siting, buffer zones, production limits through phasing and farm footprints, use of predator nets etc.

The scope of this document encompasses a sampling/monitoring plan to address the concerns related to impacts on the marine ecology of the Saldanha Bay/Langebaan Lagoon system during the operational phase of the ADZ, as specified in Section 7.2 of the Environmental Management Plan (SRK 2017b). Mitigation measures related to ecological concerns raised by potential genetic and biosecurity impacts are outlined in the Environmental Management Plan (EMPr) and referred to briefly in Section 11-13. Monitoring actions are intended to address both farm-scale and far-field impacts (Bay scale) and will be guided by the recommendations in the EMPr and the findings of the hydrodynamic model (PRDW 2017).

2. Introduction to the marine ecology monitoring plan

The primary aim of ecologically focused monitoring is to assess whether an activity or activities are having an unacceptable impact on the environment (Fernandes et al. 2001). Ultimately an area designated for aquaculture may be able to be used indefinitely i.e. in a sustainable manner. Potential use of the environment as a means of disposing waste is included under sustainable use of the environment. However, such use must be localized, short-term and reversible (Fernandes et al. 2001). Important in this context is the assimilative capacity or ability of the environment to absorb and process wastes without damage to the ecosystem. GESAMP (1996) suggest a working definition of monitoring as '*the regular collection, generally under regulatory mandate, of biological, chemical or physical data from predetermined locations such that ecological changes attributable to aquaculture wastes can be quantified and evaluated*'. Monitoring should be informed by valid research such that adequate methodologies and appropriate variables are employed. However, situations may arise where the scientific requirements for monitoring are often tempered by practical limitations such as time scale and finances. Ideally the monitoring programme design should be able to distinguish between natural background variability and real change in the indicator variable. Central to most monitoring programmes is the assessment of environmental status against a control or reference condition as an indication of environmental change.

The objectives (purpose) of any monitoring exercise are (Fernandes et al. 2001): '(i) to provide information on the area where the operation will take place (pre-operational); (ii) to provide information on which management guidelines/recommendations can be based (pre-operational); and (iii) to act as a 'temporal and spatial control (operational and post-operational) upon which remedial action might be based'. A key issue is that monitoring actions are not intended solely to document changes as/if they occur but should aim to promote avoidance and mitigation of significant negative impacts on the environment through timely management responses by industry and the regulator (Cranford et al. 2006). A common approach in achieving these goals is the determination of environmental quality objectives so that the environment can be managed in a sustainable manner (Day et al. 2015). Environmental quality standards are then set for specific variables such that the objectives can be attained (GESAMP 1996). Inherent with this approach is the concept of a mixing zone or allowable zone of effect (AZE) where standards may not be met (SEPA 1998, Day et al. 2015).

A monitoring plan should consider the appropriate variables to be sampled for the farming operation and receiving environment. The indicator variables and measurement approach should be able to detect changes over the appropriate temporal and spatial scales. Relevant spatial scales encompass, local (directly at culture structure, lease area, bay (coastal embayment or management area), and regional (broader coastal areas of similar environmental conditions) (Cranford et al. 2006). Temporal conditions should address relevant scales of natural variability and generation times of critical organisms. There are multiple variables that can be sampled, generally falling under three categories: physical (e.g., sediment grain size, wind, currents), chemical (e.g., redox potential, pH, dissolved oxygen), and biological (e.g., species abundance and diversity, productivity). These variables, singly or in combination, form the basis of ecological indicators that aim to provide information on ecosystem status and the impact that aquaculture activities have on ecosystems to regulatory authorities, industry and the public (ICES 2009). Indicators need to be quantifiable and able to detect change over the appropriate temporal and spatial scales, i.e., representative of the system in question. Generally, a suite of environmental impact indicators are considered in industry operational monitoring programmes and the performance of the industry is based on the accumulated evidence ('weight-of-evidence'). Such an approach will require specific thresholds to be predetermined that initiate prompt action on the part of the regulators and operators. Where such thresholds have yet to be determined, an alternative approach (surveillance) attempts to determine if there are detectable differences between aquaculture and control sites, or significant changes over time that cannot be attributed to natural variations (Cranford et al. 2006). Inherent in a recommended monitoring framework is the basic principle that such programmes are reviewed frequently and allow flexibility to add or remove indicators based on the evolution of our state of knowledge.

Certain target areas may require special considerations that could impose specific requirements for variables to be sampled. Sampling design considerations include the number of samples, location and replication. Measurement variation can become a consideration particularly in situations where sampling is difficult to undertake, such as in deep benthic environments. Costly use of time and resources should not be expended on perfecting each measurement, especially where this would lead to a sacrifice in the number of samples taken (Foster et al. 2018). The number and location of sampling sites will depend largely on the hydrography, specific objectives and, as a practical limitation, finances. However, it is essential that important habitats and species are adequately addressed. The number of replicates taken within a site should be sufficient to address natural spatial variability and patchiness such that a degree of reliability can be placed on the results. This is of particular relevance where comparison with a reference or baseline condition is intended. Reference stations need to be defined for each location. Stations of similar depth and substratum type to the sites within the proposed aquaculture operation should be chosen. Reference stations should be positioned away from the probable zone of influence of the operation (e.g., upstream of dominant current direction) but within the same broad vicinity (Noble-James et al. 2017). Under no circumstances should reference stations be located close to the aquaculture site, even if they are believed to be 'upstream' (Fernandes et al. 2001).

Where regular monitoring is intended it is essential that information from each survey is comparable. Methodology and assessment criteria need to be established and, where possible, sampling points/area and in some cases, season, should be fixed. The methodologies to be used including data analyses must be specific for the monitoring design and objectives and allow comparisons to be made. Relatively simple statistics (e.g., regression, analysis of variance) may be employed in combination with specific numerical methods that are standard in environmental data analysis. These encompass univariate summary statistics (e.g., species diversity indices) and multivariate techniques such as cluster analysis and ordination (Fernandes et al. 2001). Power analysis can be used to define how many replicates should be taken in order to assess reliably any potential deviations from the baseline. However, when deciding on the number of replicates practical aspects regarding time and labour demands, as well as the nature of the environment, should also be taken into account. For instance, for benthic subtidal communities it is generally regarded that 3 - 5 replicates are sufficient to provide the necessary information (Fernandes et al. 2001). However, other variables such as water column properties (nutrients, phytoplankton) and physio-chemical parameters could require greater replication to address the inherent short-term spatial and temporal variability that characterizes them.

It should be emphasized that ongoing monitoring programmes need to be responsive to new information concerning environmental impacts and indicators thereof, as well as developments in methodological approaches (Cranford et al. 2006). Some monitoring actions and indicators may prove insensitive to the specific aquaculture impacts they are proposed to target, and as such, a waste of resources. Relatively low-risk practices such as shellfish cultivation in exposed environments may require less frequent monitoring than originally proposed in a monitoring plan. Besides issues of compliance, it is important that regular review of monitoring results is undertaken to facilitate an inclusion or removal of indicators, or amendment of monitoring effort, based on an expanding knowledge base.

3. Sites to be monitored

The ADZ identifies 4 sites within the bay system. The areas allocated for either finfish or shellfish farming in each are shown in Table 1.

Table 1: Areas allocated for the finfish and shellfish farming in the ADZ.

Area	Finfish area (ha)	Bivalve area (ha)
Outer Bay North (OB-N)		217
Outer Bay South (OB-S)	96	
Big Bay (BB)	40	394
Small Bay (SB)		163

The OB and BB sites are largely undeveloped and are earmarked for both finfish and shellfish farming (within OB-N and BB). However, there is little interest by industry in farming finfish in OB-N (A. Bernatzeder, pers. comm.) and as such the area is treated as being allocated for bivalves only (Table 1). Aquaculture in SB is restricted to shellfish farming an activity that has been undertaken for decades. The bivalve industry first developed in Small Bay in the 1980s and research on the impacts of mussel raft culture on benthic macrofauna, water and sediment quality and geochemical processes (dissolved oxygen and nutrient fluxes) was undertaken in the 1990s (Stenton Dozey et al 1999, 2001) and more recently over the period 2009-2013 (Probyn et al. in prep.). This research documented the impacts of bivalve culture on benthic macrofauna in Small Bay and in this plan, the Monitoring actions in SB are addressed separately from the other more recently established ADZ sites.

4. Indicators

Although both benthic and water column effects have been highlighted in the marine ecology specialist study (Pisces 2017), the effect on the benthos will provide the major focus of the monitoring campaign as many studies have shown these to be the more severe. International experience has shown that for both shellfish (review by Keeley et al. 2009) and finfish (review by Forrest et al. 2007) the main environmental impact has been a result of sedimentation of biodeposits. Globally, sea-based aquaculture monitoring has generally focused on organic loading to the benthic habitat in the vicinity of the farm. Sediments generally provide a more stable integrator of near-field past and present activities as well as natural processes that assimilate or disperse particulate wastes than do water column measurements (Cranford et al. 2006, ICES 2009). Understanding of seabed organic enrichment effects are relatively advanced which has resulted in the development of effective environmental indicators and scientifically defensible thresholds. Seabed effects can be particularly pronounced for finfish farming as a result of artificial feed additions. However, a simulation model of finfish farms in Saldanha Bay has shown that none of the sites in OB and BB showed any evidence of organic matter accumulation at the farm site for the specified production tonnages of 1000 - 1500 metric tons (PRDW 2017). The model did identify depositional areas in harbours and along the iron ore and oil jetty, as well near Riet Bay at the entrance to Langebaan Lagoon. Sediment build-up, however, was regarded as negligible in terms of anticipated effects on the benthos (PRDW 2017). Although shellfish feed on naturally occurring plankton populations, the concentration of stock within farm infrastructure results in an 'unnatural' localization of effects on the benthos. However, benthic effects of shellfish are typically of minor influence beyond the boundaries of the farm (NZMPI 2013).

Monitoring of benthic impacts is mandatory in all salmon growing countries (Black et al. 2008) and should be undertaken in Saldanha Bay despite the model predictions of minimal impact. Although there is a wide range of benthic indicators in use by different countries, they all have the primary Environmental Quality Objective of preventing hypoxic or anoxic sediment conditions by maintaining a functional, not necessarily pristine, benthos beneath the culture structures (Black et al. 2008, PNS 2018a). Maintaining functionality is crucial considering the importance of the benthos in promoting organic matter degradation by microbial communities.

Copper (Cu) and zinc (Zn) are two metals that are commonly monitored in finfish growing areas. Copper is the primary active agent in most antifouling products applied to submerged farm structures and Zn is a fish health additive included in feed. Some paint formulations also contain Zn as an antifouling agent (Macleod and Eriksen 2009). Both are ubiquitous in the environment and essential trace nutrients for nearly all organisms. However, toxic effects can occur when they accumulate in high concentrations of bioavailable forms. Copper leaching from antifoulants will primarily be present in the dissolved phase but, as a result of its low solubility, is rapidly partitioned to suspended particulate matter and ultimately incorporated in the sediments. In addition, the actual bioavailable fraction of Cu in the dissolved phase can be orders of magnitude lower than total Cu concentration as a result of binding to naturally occurring organic material (Clement et al. 2010). Zinc in uneaten feed and fish faeces will rapidly settle to the seabed. Thus, sediments are the primary concern in the accumulation of Cu and Zn and both are consistently associated with finfish farming operations at environmentally significant levels beneath and adjacent to fish cages (Clement et al. 2010).

The accumulation of both metals is mediated by settlement processes and as a result may be expected to follow the pattern predicted for organic matter (Keeley et al. 2014). Unlike organic matter, however, metals in sediments are neither broken down over time, nor utilized by biota at appreciable rates. Consequently, they may persist for long periods in environments where physical dispersion is limited. Although model simulations for Saldanha Bay suggest very little accumulation of sediments (and their attendant contaminants) at finfish growing sites (PRDW 2017), Cu and Zn should be monitored until sufficient data are collected to indicate contamination by these two metals within the lease areas is minimal. Generally, studies of metal contamination apply normalization techniques as an aid to interpreting measured concentrations (Ho et al. 2012). Normalization to Aluminium (Al) is common practice and is employed in current monitoring efforts in Saldanha Bay (Clark et al. 2017).

Both finfish and shellfish culture release nutrients to the water column which have putative effects on phytoplankton productivity and community structure. However, numerous studies demonstrate very localized to indiscernible effects of suspended finfish culture on the water column through nutrient enrichment or oxygen depletion (see review by Price et al. 2015). Model simulations of dissolved inorganic Nitrogen (N) release from the proposed finfish farms in Saldanha Bay, support these findings (PRDW 2017). Similarly for shellfish, a meta-analysis of the effects of different aquaculture practices on dissolved nutrient levels has shown no significant effect for bivalve culture (Sarà 2007a). Effects on dissolved oxygen and turbidity have largely been eliminated through better management practices, and near-field nutrient enrichment of the water column is usually not detectable beyond 100 m of the farm. Nutrients as indicators of aquaculture impacts is particularly challenging owing to a high natural variability. A compelling explanation for why increased nutrients are often undetectable around fish farms is that they are being rapidly assimilated by phytoplankton. In fact, measures of chlorophyll or other metrics of phytoplankton production provide useful proxies for hypernutrification (Cranford et al. 2006). Evidence for stimulation of phytoplankton growth around fish cages is variable, though most often a direct causal relationship has not been demonstrated (Price et al. 2015). One possible explanation for the lack of a systematic effect on the water column variables around fish farms, is the presence of strong currents in these areas that promote dilution (Huntington et al. 2006). Alternatively, rapid grazing by microzooplankton could keep stimulation of phytoplankton growth in check (Tett et al. 2003).

Shellfish culture has the added effect of stripping plankton from the water column. Both models (Grant et al. 2008) and field studies (Heasman et al. 1998, Petersen et al. 2008) have shown feeding by intense bivalve culture results in a marked depletion of phytoplankton (and other components of the seston) as water moves through the farmed areas. Larger phytoplankton groups are targeted by mussels and oysters resulting in relative enrichment of smaller size classes with possible ecological costs to other components of the ecosystem 'downstream' of the farm (Cranford et al. 2008). Bivalve filtration could out-compete zooplankton for food potentially redirecting energy flow from pelagic to benthic foodwebs (Cloern 2005). Besides such effects on natural foodwebs, intense shellfish culture may have density-dependent, negative feedback effects within the lease areas (Heasman et al. 1998). Given the potential ecosystem shifts that may arise in areas of intense bivalve culture, indicators of size spectrum changes are perceived as being of high value in monitoring shellfish aquaculture growing areas (Cranford et al. 2006, ICES 2009). Of particular ecological concern is the potential reduction in carrying capacity for other filter feeding organisms in Langebaan Lagoon. The shallow lagoon, exchanges water with the relatively nutrient-poor, upper water column of Big Bay (Monteiro & Largier 1999); a depth range where filtration by cultivated shellfish would be most noticeable. As adequately defined operational, quantitative thresholds are not established for phytoplankton measurements, they fall into the surveillance category of indicators. However, this does not preclude their potential usefulness. Cranford et al. (2006) identifies the possible effects of intensive shellfish feeding on pelagic plankton and foodwebs as of particular concern, particularly at the bay scale.

Based on the above, the ecological indicators chosen for monitoring impacts of aquaculture are:

- benthic macrofaunal community species richness and biomass;
- sediment geochemical variables (total sulfides and/or redox);
- visual and odour characteristics;
- surficial sediment geochemical characteristics (total organic carbon and nitrogen (TOC/N), Al, Cu and Zn);
- sediment geotechnical characteristics (size structure, porosity);
- near-bottom oxygen concentration; and
- upper water column chlorophyll concentration (fluorometer and discrete samples).

Other ecosystem indicators that are presently monitored as part of the State of the Bay programme must also be considered in the context of expansion of aquaculture in the bay. These include:

- fish abundance;
- bird breeding success;
- alien species occurrence.

Together with the ongoing State of the Bay benthic fauna studies in Small Bay, Big Bay and Langebaan Lagoon, these provide useful indicators of the state of the far-field ecosystem relative to aquaculture.

5. Indicators and thresholds

5.1 Benthic oxic-anoxic classification

The primary source of impact on the seabed from finfish and shellfish aquaculture is organic matter input from faeces, pseudofaeces, uneaten artificial feed, and fall-off of culture organisms and fouling organisms (Cranford et al. 2012). Sediment organic enrichment effects are generally less dramatic with bivalve culture than with finfish culture where artificial feed is used. Nevertheless, if organic deposition is sufficiently high, decomposition by sediment bacteria can increase the oxygen demand which, if not balanced by diffusive or advective supply, can lead to anaerobic conditions in the porewaters of the seabed of both finfish and shellfish farms. In severe cases this can lead to oxygen depletion in the water above the sediments that may then have a direct impact on farm operations. Ammonification and sulfate reduction to sulfides follow as typical responses to a lowering of the oxygen reduction (redox) potential. The shift to sulfate reduction is critical because the end-product, sulfide, is toxic (Black et al. 2008). It is important to note that highly organic enriched sediments can occur naturally where inputs from terrestrial or marine sources are large. Periodic oxygen depletion in sediments and overlying water may develop in these areas.

Hargrave (1994) has shown that sediment organic C, redox potential (Eh) and total sulfides (S^{2-}) were effective in describing adverse impacts on the benthos from salmon culture. The two inversely related chemical indicators, Eh and S^{2-}, have been used to classify sediments associated with a salmon farm into 4 organic enrichment groups; normal, oxic, hypoxic and anoxic (Wildish et al. 2001). Subsequently this classification has been expanded into 5 groups, with slight adjustment of the geochemical threshold levels, incorporating two oxic and two hypoxic categories (Cranford et al. 2006, Hargrave et al. 2008a, Hargrave et al. 2008b). The separation of the two hypoxic categories is based on the relative proportion of opportunistic species. Each category has defined Eh and S^{2-} thresholds (Table 2). The maximum S^{2-} threshold level for Oxic B conditions (1500 µM) is slightly higher than previously identified as a maximum S^{2-} concentration for oxic deposits (1300 µM) and the range of Eh potentials characteristic of this enrichment group is slightly broader (+100 to -50 mV) than previously proposed (+100 to 0 mV) in Wildish et al. (2001). This inverse correlation between Eh and S^{2-} has been shown to be similar at both finfish and shellfish aquaculture sites (Cranford et al. 2006). Consequently, these chemical indicators provide an effective means of determining organic matter enrichment and oxic status of seabed deposits at both finfish and shellfish farm sites. In New Brunswick, eastern Canada, an extra category is included by separation into three hypoxic regimes, though the oxic to anoxic transition thresholds remain the same as the 5 category scheme (NBDENV 2012).

Research has shown that the method for classifying the ecological quality status (EQS) of organically enriched marine sediments based on total free sulfide concentrations widely used in monitoring programmes, the ion-selective electrode (ISE) protocol, can produce unreliable data. Therefore, it is suggested that an alternate method proposed by Cranford et al. (2020), is a more suitable approach and should be used preferentially. This method, known as the methylene blue (MB) colorimetric method, provides lower and more consistent readings, and therefore the defined thresholds are lower (Table 2). Monitoring of the Saldanha ADZ to date (2019-2022) in terms of this sampling plan has used the MB colorimetric method and the lower thresholds for assessing sediment health. It is recommended that this is continued, but whichever analytical method is employed to measure suphide concentrations in sediments, it is essential that the appropriate EQS thresholds, as provided in Table 2, are applied.

The statistical program, PRIMER, is widely used to determine benthic macrofaunal community indices, in this program the Shannon-Weiner diversity index (H') is calculated using the follow equation:

$H' = -\Sigma pi(\ln pi)$ 1F

The Shannon-Weiner threshold value of 3.0, given in the original Sampling Plan (DAFF 2018), was based on previous papers (Hansen et al. 2001, Warwick et al. 2008 & Borja et al. 2009) which used Log_2 in the above equation not the natural log (ln) used by PRIMER. The threshold of 3.0 (log_2) is equivalent to 2.1 (ln), the latter threshold value should therefore be used in cases where calculation of the 'H is conducted using the natural log (ln).

Similarly, the threshold values for the AZTI Marine biotic Index (AMBI) have also been revised and values slightly adjusted based on results from Cranford et al. 2020 (Table 2).

Table 2: Ranges of redox potential (Eh) and total sulfides (S^{2-}) in 5 sediment organic enrichment categories Cranford et al. 2006, Hargrave et al. 2008b, Cranford et al. 2020. The Biotic index indicators (Borja et al. 2000, 2003) have been included for comparison.

	Oxic A	Oxic B	Hypoxic A	Hypoxic B	Anoxic
Geochemical:					
Redox (Eh) mV	>100	100 to - 50	-50 to - 100	-100 to – 150	<-150
Sulfides (S^{2-}) µM (ion-selective electrode protocol)	<750	750 to 1500	1500 to 3000	3000 to 6000	>6000
Sulfides (S2-) µM (methylene blue method)	<75	75-250	250-500	500-1100	>1100
Biological:					
Shannon-Wiener (H´)	>4	4 - 3	3 - 2	2 - 1	<1
*Adjusted (Ln) Shannon-Weiner diversity index (H')	>2.8	2.8 – 2.1	2.1 – 1.4	1.4 -1.7	<0.7
Infaunal Trophic Index (ITI)	>50	50 - 25	<25	<25	<5
AZTI Biotic Index	<1.2	1.2 - 3.3	3.3 - 5	5 - 6	>6
Adjusted AMBI (Cranford et al. 2020)	<1.2	1.2 - 3.0	3.0 - 4.8	4.8 - 6	>6
Effect on sediment	Low effects	Low effects	May be causing adverse effects	Likely causing adverse effects	Causing severe damage

Many countries have chemical thresholds for monitoring aquaculture areas, finfish sites in particular, that are aligned with a classification of sediment state into categories similar to those given in Table 2. For example, in Maine S^{2-} levels of 2500 - 6000 µM (Eh 100 to -100 mV) at any sampling station within a salmon AZE (30 m) is treated as a warning level and levels > 6000 µM as unacceptable impact that will require a mitigation plan and schedule for modification of operations (State of Maine 2008). A similar mitigation plan will be required if subsequent monitoring indicates a deterioration in warning level S^{2-} concentrations within the AZE or S^{2-} concentrations >3000 µM at any station beyond the AZE.

Salmon farms on the Pacific coast in British Columbia employ similar regulatory threshold values of 1300 µM and 4500 µM at 125 m and 30 m from the cages (Fisheries and Oceans Canada 2015). If a single sample exceeds the threshold, then an additional survey will be required before re-stocking for the subsequent production cycle (Seafood Watch 2017).

The Irish finfish monitoring thresholds require Eh values to be < -125mV within the AZE and equivalent to reference station values outside the AZE (Irish DAFF 2008). A breach of the required parameters for either chemical or biological indicators will require the operator to provide a benthic amelioration plan that aims to improve the ecology of the benthos in as short a time as possible. Subsequent surveys of the impacted area serve to assess if the amelioration plan has been successful. In Marlborough Sound, New Zealand, proposed S^{2-} thresholds within the zone of maximum effect, i.e., close to fish cages, is < 1700 µM, and for the outer limit of effect (150 - 600 m) concentrations should remain a conservative <290 µM (Keeley et al. 2014). Scotland also applies different thresholds relative to a mixing zone as given in Annex A, SEPA Fish Farm Procedures Manual but, instead of a fixed AZE (25 m), a less arbitrary approach is allowed whereby a site-specific AZE's are determined according to the dispersing nature of the site (Black et al. 2008). This allows larger benthic footprints in areas of high dispersion with the aim of encouraging development in more physically dynamic environments.

Benthic monitoring of finfish culture in the maritime provinces of Canada, Nova Scotia (PNS, 2018a, 2018b) and New Brunswick (NBDENV 2012), does not implement an AZE but is concentrated in the vicinity of cages - along the outside perimeter of cage arrays. If average S^{2-} is < 1500 µM then no further action is required. If S^{2-} falls between 1500 and 3000 µM (hypoxic A) then a mitigation plan will be required by the operator. In the event that S^{2-} exceeds 3000 µM (hypoxic B/anoxic), extra sampling (their Tier II) will be required for an improved spatial delineation of the impacted area and more effectively define the degree of influence. In their scheme, sulfide concentrations indicative of hypoxic (4500 to 6000 µM) or anoxic conditions (>6000 µM) would likely require special authorization (Gomes Consulting Inc. 2010).

5.2 Benthic geochemical indicators

The Aquaculture Stewardship Council specifies a S^{2-} concentration of <1500 µM (or Eh > 0 mV) as the threshold beyond the AZE for salmon farming (ASC 2017). The benthic AZE is defined as 30 m from a cage array unless a site-specific zone of impact has been established. It is proposed that this threshold is adopted for Saldanha Bay fish farm sites as the threshold outside the AZE. It is suggested that an additional S^{2-} threshold concentration of >3000 µM be applied at the position of the finfish cages as is implemented in the Canadian maritime provinces monitoring programmes. Although Eh is still commonly used as an indicator of sediment organic enrichment there are procedural problems with its measurement that led to high variability in certain sediments (Wildish et al. 2004, ACS 2010). Based on these limitations total sulfide should be the variable used to define oxic status. Redox should strictly only be used as a check on S^{2-} measurements - they should be inversely related (Wildish et al. 2004). In the Aquaculture Stewardship Council's monitoring plan for shellfish, an AZE is not specified; sites for measurement of chemical indicators are limited to beneath the farm (ASC 2012). It is recommended that their threshold S^{2-} concentration of >3000 μM is adopted for annual monitoring of site condition in shellfish growing areas (beneath culture areas). This is the Hypoxic A upper limit when measured using the ion selective electrode (ISE) method and is equivalent to 500 μM when measured using the recommended methylene blue (MB) method, as shown in Table 1.

Failure to meet S^{2-} thresholds for classification as Oxic B or higher at the AZE limit for finfish farms; or Hypoxic A or higher at finfish cages or directly below shellfish longlines, will require management intervention and/or additional sampling (see Table 1 for threshold values dependent on measurement technique (ISE or MB). Non-compliance is dependent on the farm or AZE station being significantly greater than levels measured at the reference stations.

While many countries have established sediment quality guidelines for trace metals very few have aquaculture-specific guidelines and sediment monitoring protocols. The Scottish Environmental Protection Agency (SEPA) has derived sediment standards within the AZE that could potentially cause adverse effects (108 mg/kg for Cu and 270 mg/kg for Zn) and probably will have adverse effects (270 mg/kg for Cu and 410 mg/kg for Zn). Outside the AZE the standards are more stringent: 34 mg/kg for Cu and 150 mg/kg for Zn. This approach acknowledges that impacts will be greatest in the vicinity of the farm and is designed to control both the intensity and spatial extent of the impact (Clement et al. 2010). The Australian and New Zealand Environment and Conservation Council (ANZECC 2000) have derived Interim Sediment Quality Guidelines (ISQGs) that are considered appropriate to apply monitoring of benthic conditions at finfish farms (Keeley et al. 2014). The guidelines specify a ISQG-low of 65 mg/kg for Cu and 200 mg/kg for Zn which represents a 10% probability of adverse effects, and a ISQG-high of 270 mg/kg for Cu and 410 for Zn which is regarded as a 50% probability of significant toxicity. These guidelines are applicable to the worst affected areas in the vicinity of a farm (Keeley et al. 2014)

The critical issue regarding the toxicity of metals in the environment is the fraction that is actually bioavailable to organisms. It is likely that the majority of total Cu and Zn in the sediment under fish farms will be bound to sulfides and organic matter rendering them unavailable for uptake by organisms effectively reducing their subsequent toxicity (MPI 2013). Given the likely reduced bioavailabilty of Cu and Zn in the organic rich sediments it is recommended that the SEPA aquaculture-specific probable effects levels (equal to the ANZECC ISQG-high guidelines) are used as guideline limits within the finfish AZE for the total recoverable metal fraction. This is similar to the criteria recommended by Keeley et al. (2014) for finfish in New Zealand and the US National Oceanic and Atmospheric Administration (NOAA) Effects Range Medium for sediments (Macleod & Eriksen 2007). Metal concentrations outside the AZE should conform to the SEPA limits, i.e. 34 mg/kg for Cu and 150 mg/kg for Zn.

Non-conformance of measured values with the above thresholds will trigger additional sampling to facilitate comparison with between baseline data for reference and farm sites with subsequent data. Failure will require management intervention.

5.3 Benthic community impact indicators

A primary objective with farm sediments is that they should contain a high abundance and biomass of bioturbating macrofaunal animals to enhance aeration and carbon degradation (Black et al. 2008). However, the development of oxygen stress within the benthic environment results in well documented responses by the benthic community that acts to reduce the processing of organic matter. These responses by the benthic community to changes in environmental variables such as oxygen supply are often reflected before they are detectable in some chemical properties (Cranford et al. 2006). They form the basis of indicators of benthic environment status and include (Black et al. 2008, Cranford et al. 2012):

- a decrease in species richness and an increase in the total number of individuals,
- a general reduction in most species biomass,
- a decrease in average body size of species,
- a constriction of that portion of the sediment occupied by infauna, and
- a shift in the relative dominance of trophic groups.

Away from the farm, organic input and oxygen demand decrease, benthic faunal assemblages are typified by increased diversity and functionality (Black et al. 2008, Keeley et al. 2014).

Some of the benthic community indicators that are commonly used are given in Table 3. Biodiversity indices are in common usage to describe the diversity of macrofaunal assemblages. However, they should be interpreted with caution and require a good understanding of what these indicator results actually reveal about community changes (Cranford et al. 2012). They should not be employed in isolation but as part of a suite of indices to interpret changes in benthic fauna and the probable causes. Indicator species or trophic indices have been shown to be extremely useful in situations of high organic loading which result in shifts in community structure from filter feeders to deposit feeders and scavengers or from sensitive to more tolerant opportunistic feeders (McKindsey et al. 2011). Studies conducted by Stenton-Dozey et al. (1999) and Stenton-Dozey et al. (2001) showed that mussel rafts in Small Bay, Saldanha Bay, attracted opportunistic deposit feeders and carnivores while stations away from the aquaculture sites had an increased presence of suspension feeders.

Table 3: Indicators of the intensity of benthic community impacts from organic matter deposition from suspended aquaculture (after Cranford et al. 2012).

Indicator category	Indicators
Biodiversity metrics	Index of the number and abundance of species. Includes the Shannon-Wiener diversity index (*H´*) Pielou's evenness index (*j*), Simpson's dominance index (*c*), and Margalef's species richness (*d*).
Indicator species	Highly enriched marine sediments are generally dominated by a few opportunistic macrofaunal species that are tolerant of high organic enrichment and low oxygen

	conditions. The AZTI Marine Biotic Index (AMBI) is calculated based on the relative proportion of 5 species groups (previously classed as being sensitive to opportunistic).
Trophic indices	In highly organically enriched areas, benthic communities are dominated by deposit feeders and scavengers, at the expense of filter feeders. For example, the Infaunal Trophic Index provides a categorization of overall species abundance within different trophic groups in soft bottom communities.
Benthic similarity	Comparison of community structure using multivariate statistics such as ordination and cluster analyses.
Size structure	Most species that are tolerant to organic enrichment belong to families such as the Spionidae, and have a small size. Differential sieving allows separation of fauna into size categories.

It is proposed that the biodiversity indices such as Shannon-Wiener diversity index (*H'*), Pielou's eveness index (*j*) and Margalef's species richness index (*d*) form part of the suite of biological indicators because of their common usage in assessing benthic community status. All three have shown significant differences between salmon farm sites and reference sites (Wildish et al. 2001). The Infaunal Trophic Index (ITI), which is based on a functional feeding type for benthic fauna, is 'highly recommended' for monitoring benthic community impacts (Cranford et al. 2012) and should be included as a key indicator. The relationship of these indicators with the chemical thresholds discussed previously is shown in Table 1. Application of the AZTI Marine Biotic Index (AMBI), originally Biotic Coefficient) will require allocation of the different benthic species found in Saldanha Bay sediments to different categories of sensitivity to organic loading and hypoxia/anoxia. The index has been shown to be broadly applicable to a range of impact sources, including aquaculture and hypoxia, in European coastal waters and estuaries (Muxika et al. 2005).

Multivariate methods provide additional tools to the univariate indices mentioned above to describe community composition data. The two most common multivariate techniques for analysis of community data are cluster analysis and ordination. Cluster analysis, usually in the form of a dendrogram, simply groups entities in terms of species composition. Ordination groups similar samples or species, or both, close together and dissimilar entities far apart in a low-dimensional space. Relationships between community and environmental data may be investigated using these techniques to provide further insight to the ecology and environmental degradation of an area. Although a very powerful interpretative tool for environmental managers, multivariate analysis should be applied with caution as interpretation is at least partially subjective. It should always be used in conjunction with other methods such as univariate analysis (Telfer and Beveridge 2001).

Whereas the annual geochemical sampling targets near-field effects from organic loading at the culture structures, the benthic survey gives an indication of the overall health of the broader lease area. Should monitoring actions show that the benthic fauna composition in a lease area does not meet the oxic thresholds of Shannon-Wiener ≥2.1and Infaunal Trophic Index ≥25, or other similar metrics, then mitigatory actions will be required to return the area to an oxic classification.

5.4 Water column indicators

Extensive shellfish and finfish cultivation has two potentially countervailing effects on chlorophyll concentrations. Nutrient enrichment from both finfish and shellfish farming could promote phytoplankton production and biomass, whereas filter feeding by bivalves will reduce phytoplankton biomass. Thus, measures of chlorophyll concentration alone may be ambiguous. An increase in the proportion of small-sized picoplankton in the phytoplankton community, however, is a good indicator of excessive feeding by bivalves. The fluorometer time series of chlorophyll concentration and proportion of picoplankton in size-fractionated discrete samples should be analysed for obvious trends that could be correlated with the expansion of aquaculture in Saldanha Bay. Although operational thresholds for these indicators are difficult to fully define, they remain highly relevant indicators of habitat and ecosystem status (Cranford et al. 2006).

6. Monitoring survey sites

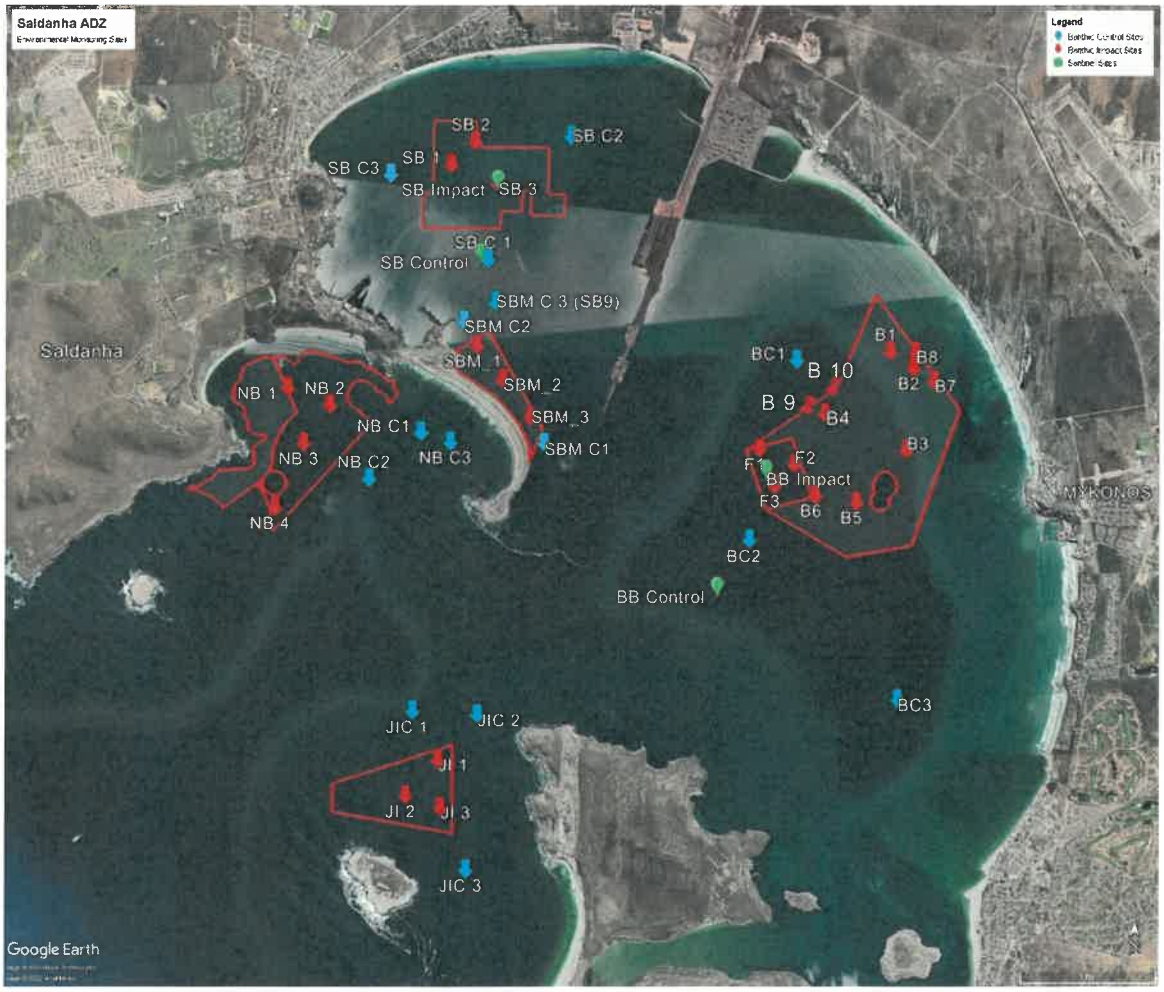

Figure 1: Map of sampling stations for the Saldanha Bay Aquaculture Development Zone showing the benthic chemical (sulphide & redox), sediment (organics, PSD and metals), macrofauna and sentinel (near bottom DO and temperature) sites.

Table 1. Coordinates of the sampling stations for the Saldanha Bay Aquaculture Development Zone.

Area	Site	Latitude	Longitude
Small Bay	SB 1	-33.009100	17.964067
	SB 2	-33.006717	17.967067
	SB 3	-33.011133	17.969850
	SB C1 (North Buoy)	-33.019128	17.968656
	SB C2	-33.006194	17.979093
	SB C3	-33.010171	17.955870
Small Bay (Blue Ocean Mussels)	SBM_1	-33.028207	17.967333
	SBM_2	-33.031754	17.970554
	SBM_3	-33.035732	17.974049
	SBM C1	-33.038483	17.975748
	SBM C2	-33.025602	17.965655
	SB9	-33.023500	17.969833
Big Bay	B 1	-33.028808	18.019161
	B 2	-33.030550	18.022083
	B 3	-33.039167	18.021183
	B 4	-33.035367	18.010983
	B 5	-33.044667	18.014917
	B 6	-33.043950	18.009850
	B 7	-33.040983	18.013033
	B 8	-33.040497	18.015473
	B9	-33.034919°	18.008291°
	B10	-33.032928°	18.011506°
	BC 1	-33.029733	18.007400
	BC 2	-33.048633	18.001550
	BC 3	-33.065414	18.020089
	FF 1	-33.039056	18.002878
	FF 2	-33.040681	18.007119
	FF 3	-33.042911	18.004736
Outer Bay North	NB 1	-33.032617	17.943633
	NB 2	-33.034417	17.948867

Area	Site	Latitude	Longitude
Outer Bay South	NB 3	-33.038433	17.945633
	NB 4	-33.045200	17.942067
	NB C 1	-33.037283	17.960267
	NB C 2	-33.042167	17.953733
	NB C 3	-33.038339	17.963950
	JI 1	-33.071767	17.962450
	JI 2	-33.075517	17.958383
	JI 3	-33.076783	17.962750
	JI C 1	-33.066625	17.959244
	JI C 2	-33.067017	17.967400
	JI C 3	-33.083350	17.965967
Sentinel Sites (Instruments)	SB Control	-33.018900°	17.967750°
	SB Impact	-33.011210°	17.969870°
	BB Impact	-33.041667°	18.003611°
	BB Control	-33.054020°	17.997570°

6.1 Seabed

Although the three-dimensional model simulations for finfish farming in the new areas in BB and OB indicate undetectable accumulation of organic matter at the farm sites (PRDW 2017), these predictions require validation through sampling over the operational phase. An 'ideal' sampling design includes comparison of data from before to after a disturbance that might cause impacts (Underwood & Chapman 2013). A benthic survey should be conducted prior to expansion of aquaculture in OB and BB as a 'before' reference of the area for comparison with the operational or post-operational ('after') phases. Baseline data, if sufficiently detailed and relevant, may be used in place of, or in combination with, reference station data in evaluating results from operational monitoring (State of Maine 2008). Thus, the baseline survey should include replicated, undisturbed control/reference stations that can be used to demonstrate that an impact, if it occurs, is associated with the disturbed area and is not a general phenomenon within the habitat unrelated to the disturbance (Underwood & Chapman 2013). Undisturbed in this instance means isolated from the disturbance being investigated, in the present case organic loading to the seabed from aquaculture, but still exposed to other influences characteristic of the hydrodynamic regime.

Spacing of sampling stations for the baseline study should be stratified random. It is proposed that the number of sample stations should be based on lease area with stratification, i.e. proportional stratification, with a larger sample size (sample unit number) for finfish areas (one per 20 ha) than shellfish areas (one per 50 ha). In this way finfish and shellfish leases are treated as different strata. Currently farmed areas should also be treated as different strata in that at least one station position is located there. If a pre-identified station position is shown to be hard bottomed, the station position should be relocated to the closest point with soft sediment, providing it is within the near vicinity. If large area of rock is found this should be recorded as such. Although confounding the randomness in station positioning, it is deemed necessary as experience has shown that bottom water is often very turbid in the bay precluding reliable photographic/video records - a common means of recording seabed condition in subtidal, hard substratum environments. The rationale for more intensive sampling of finfish sites is based on the reasonable expectation of a potentially greater impact on the benthos from aquaculture in these areas compared to shellfish growing areas. If portions of the lease areas are deemed unsuitable for farming by industry, then sample numbers may be adjusted accordingly. Exclusion of portions of lease areas is most likely for OB where exposure to excessive swell is a practical reality.

The requirement for full macrofauna analyses (both infauna and epifauna), TOC/N, granularity and porosity (Figure 1):

- 10 stations in BB area designated for shellfish farming including at least one in the existing oyster farms (35 ha);
- 3 stations in BB finfish farming area;
- 4 stations in OB-N (based on assumption of only shellfish farming), and
- 3 stations in OB-S. (should this site be developed)
- 6 stations in Small Bay (3 in central area, 3 at rafts along Marcus Island causeway)

Three samples taken from the finfish sites shall also be taken for analysis of the metals Al, Cu and Zn.

Control (reference) stations should be identified; three for each of BB, OB-N,OB-S and six in SB. These should be located in areas where environmental characteristics, such as depth and sediment structure, are as similar as possible to the respective lease areas. They should be located in the same broad vicinity of the farm sites, though at least 100 m from the lease area to minimize potential impact from the farm and at least 100 m apart. Control sites within and/or on the boundary of the marine protected areas around Malgas Island, Jutten Island and Langebaan Lagoon should be considered if they meet the above criteria. Samples must be taken for macrofauna, geochemical (TOC/N, metals) and geotechnical (porosity, granularity) analyses, as above.

Protocols for collecting sediment samples for macrofauna analyses should be maintained within already established monitoring programmes to facilitate comparison with established data-sets (Noble-James et al. 2017). To this end protocols should be aligned with The State of the Bay Programme where 3 replicate samples of 0.08 m^2 and 30 cm deep, where possible, are taken by divers at each station and pooled for subsequent taxonomic analysis of macrofauna in the >1 mm size fraction (Clark et al. 2017). The total sample size is more than double the minimum generally recommended for benthic fauna analysis thereby greatly increasing the likelihood of including rare or sparsely distributed species. Although pooling of replicates for later processing reduces quantification of fine-scale variation, the need to maximize the spatial extent of sampling area in a compliance orientated monitoring programme is prioritized over within station patchiness. This is an acceptable approach (Noble-James et al. 2017) and where resources are adequate should be accompanied by replication at a sub-set of stations (Prezlawski et al. 2018). It is recommended that macrofaunal sampling is replicated at a single station within the three growing areas, BB, OB-N and OB-S. These samples provide information on variability in both small-scale distribution as well as sampling gear performance. While this is not a requirement and depends on practicality, this would equate to three composite samples of approximately 0.2 m^2 at each of the three stations chosen for replication

Sediment geochemical and geotechnical samples should be taken from separate core samples, i.e. they should not be sub-sampled from macrofauna samples. Only the surficial sediment (2 cm) from grabs or diver-collected cores shall be retained for analyses. If multiple samples (replicates) are collected at each station they should be combined and homogenised prior to storing for later analysis (see methods).

This suite of samples is intended to serve as an indication of ecological status at the lease scale prior to major expansion of aquaculture. Significant deterioration at a future date considering both the reference condition and the initial baseline data will initiate a management decision.

In addition to the above, two sentinel stations shall be established one on the boundary of the finfish lease area in Big Bay and one for the intensive shellfish cultivation area in central Small Bay along the main axis of bottom currents. Bottom water oxygen and temperature shall be monitored at sentinel stations and one reference station from each site. Sensors should be moored close to the seabed (<0.5 m off bottom) and programmed for hourly or more frequent readings. Ideally, these stations should be operational prior to development, or as soon thereafter as possible. Significant deterioration in bottom oxygen conditions at either of these sites relative to the reference stations, will initiate further investigation of the extent and magnitude of the effect.

6.2 Water column

As a check on the flow of plankton into Langebaan Lagoon and how it may be affected by aquaculture development (especially shellfish) in the bay, it is proposed that a fluorometer be deployed in the entrance channel. As this is a surveillance approach to monitoring with no specified thresholds, it is important that measures are established prior to major expansion in the bay to assist in interpretation of time series data. These measurements will provide a continuous indicator of phytoplankton abundance (fluorescence) as aquaculture develops within the bay. A long-term commitment to ongoing regular monitoring is critical for establishing time series data which are far superior in identifying directional trends than any combination of independent studies (Noble-James et al. 2017).

It is important that the instrument is readily accessible so that frequent *in situ* calibration samples can be taken at its position for conversion of fluorescence units into chlorophyll concentration. The SAN Parks jetty is a possible option. Calibration will involve regular taking of discrete samples for extracted chlorophyll analyses of both the whole sample and a 2 - 5 µm screened sub-sample. In this way the relative contribution of the small size fraction (picoplankton) to the total phytoplankton community can be measured and the potential far-field effects in the lagoon may be assessed. Sampling should occur during the flood tide to target input to the lagoon.

A minimum of two stations should also be sampled as potential control sites to the SAN Parks jetty site mentioned above for size-fractionated chlorophyll. Frequent water samples (a number of times a week) are currently being taken for phytoplankton identification and enumeration at two sites in the existing shellfish growing areas in the entrance to Small Bay and in North Bay as part of the South African Live Molluscan Shellfish Monitoring and Control Programme. It is recommended that this sampling effort is extended to include discrete samples for size-fractionated chlorophyll analysis. Collection of samples at the three sites should be paired as close as possible in time.

7. Operational surveys

Operational monitoring is to be conducted within the respective lease area following initiation of production. Those areas or sub-areas where farming has not yet started will not need to be surveyed.

7.1 Benthic sampling

a) Chemical investigation (redox (Eh)/sulfides (S^{-2})) at the local scale, three stations; in close proximity to culture structures (0 m), at 30 m which defines the AZE, and at 60 m, along a transect in the direction of prevailing near-bottom currents, i.e., most likely to reflect farm impact. To be conducted annually or during the period of maximum biomass for that production cycle or as close as possible to that time. Additional measurements must be taken at the three reference sites for the respective lease area. A minimum of three replicate grab or core samples are retrieved from each sampling point for S^{-2} (and Eh) measurements in the surficial (upper 2 cm) layer of sediment. Each replicate must be analysed separately, i.e., not composited. Results are tested for significant differences between sample S^{2-} and indicator thresholds and reference station values according to statistical procedures given in the British Columbia, Ministry of Environment, protocols for marine environmental monitoring (BCME 2002).

For finfish stations at 30 m and 60 m determine if there has been a chemical exceedance by a 1-sample t-test:

Redox:	H_0: $\mu \geqslant -50$ mV;	H_A: $\mu < -50$ mV (1-tailed)
ISE:	H_0: $\mu \leqslant 1500$ µM;	H_A: $\mu > 1500$ µM (1-tailed)
MB:	H_0: $\mu \leqslant 250$ µM;	H_A: $\mu > 250$ µM (1-tailed)

For stations at the fish cages (0 m), test the following hypothesis:

Redox:	H_0: $\mu \geqslant -100$ mV;	H_A: $\mu < -100$ mV (1-tailed)
ISE:	H_0: $\mu \leqslant 3000$ µM;	H_A: $\mu > 3000$ µM (1-tailed)
MB:	H_0: $\mu \leqslant 500$ µM;	H_A: $\mu > 500$ µM (1-tailed)

If there is evidence for exceedance at a particular station, do nested 1-way ANOVA to test for farm (F) and reference (R) stations:

H_0: $\mu_F \leq \mu_R$; H_A: $\mu_F > \mu_R$ (1-tailed)

For shellfish, samples are collected under the culture structures and tested as for the finfish 0 m stations:

Redox: H_0: $\mu \geqslant$ -100 mV; H_A: $\mu <$ -100 mV (1-tailed)
ISE: H_0: $\mu \leqslant$ 3000 μM; H_A: $\mu >$ 3000 μM (1-tailed)
MB: H_0: $\mu \leqslant$ 500 μM; H_A: $\mu >$ 500 μM (1-tailed)

In the case of an exceedance perform nested 1-way ANOVA as above.

If a farm station S^{2-} is significantly greater than the reference condition, the exceedance is likely a result of fish farming and management action is required.

b) Sediment characteristics such as colour (e.g., pale/grey, brown/black), visible out-gassing, presence of sulfide oxidising bacteria (e.g., *Beggiatoa* spp.) and smell (e.g., none, medium, strong) must be noted on sample data sheets and photographed. Qualitative assessments are widely employed internationally as a simple, cost-effective means of assessing sediment condition (Keeley et al. 2014). This information should be considered in conjunction with the above statistical analyses in a 'weight-of-evidence' approach to illustrate the status and extent of farm impact. Such assessments could be performed on a regular voluntarily basis by the farmer to complement the annual compliance monitoring.

c) Full macrofaunal analyses shall be conducted at re-randomized sediment station positions with the lease areas every 3 - 5 years. Re-randomization reduces the risk of temporal autocorrelation and is recommended over fixed station positions where the monitoring objective is to assess the overall condition of a habitat (Noble-James et al. 2017). Control positions shall remain fixed providing they comply with the requirements for a control site. Sediment grain size, TOC/N, and porosity analyses shall be performed in parallel with benthic macrofauna sampling. It is more common in environmental monitoring of aquaculture facilities for sampling to be conducted around the period of maximum production. However, it is recommended that it should be aligned with the State of Bay sampling programme to facilitate comparison between the data-sets.

The sampling plan proposed for benthic macrofauna in which data are collected at both farm site stations and reference stations, in both baseline and operational periods is referred to as a beyond BACI (Before After Control Impact) design (Underwood 1992). The rationale for this approach is that organisms may show any pattern of difference between locations (both farm and control sites) before a putative impact (aquaculture). Differences among locations are to be expected but there is no reason to presume that these differences remain constant through time. Thus, there will be statistical interactions between locations (farm and reference) and time of sampling (before and after). An environmental impact is indicated when there is more temporal change in the farm site exposed to a perturbation than is usually the case in similar populations in similar locations where no such disturbance occurs (Underwood 1992). An impact must appear as an interaction between the differences among locations prior to the impact and those differences existing after it begins.

Firstly, determine whether the mean value of the Shannon-Wiener, Infaunal Trophic Indices (ITI) or AZTI Marine biotic Index (AMBI) for a growing area, i.e. BB, OB-N or OB-S, is significantly less than the threshold values by a 1-sample t test:

H_0: $\mu \geq 2.1$; H_A: $\mu < 2.1$ Shannon-Wiener Index (1-tailed)

H_0: $\mu \geq 25$; H_A: $\mu < 25$ Infaunal Trophic Index (1-tailed)

H_0: $\mu \geq 3.0$; H_A: $\mu < 3.0$ AZTI Marine biotic Index (1-tailed)

If there is evidence for exceedance undertake asymmetric ANOVA to test the following hypotheses:

H_0: there is no interaction between farm/reference site and baseline/operational; H_A: there is an interaction (2-tailed).

If a significant interaction is indicated, there is evidence that the exceedance is due to farming activities and management intervention will be required. Alternate metrics may also be used in conjunction with the above indices. Multivariate analyses should also be undertaken to maximize information from the taxonomic data particularly with regard to identifying relationships between different growing areas.

The ITI and AMBI marine biotic indices were originally developed for use in European waters and are therefore not easily applicable to species from South Africa. Presently less than 50% of species found in the ADZ samples can confidently be assigned an ITI group, meaning that the majority of species are not included in the calculations of the biotic coefficients. Similarly, although the number of species on the updated 2020 AMBI species list as increase by 15%, they are still predominantly for species from the Northern Hemisphere. While more Southern Hemisphere species have been included in the list the user still has to change the resolution from species level to genera, or else substitute a South African species with a similar species found in the northern hemisphere. The new AMBI 6.0 version of the software now enables the user to choose which group they wish to assign a specific species to. This allows for a more tailored, regional approach to the process, however, still requires the user to have a good understanding of the feeding modes utilised by the species in their geographical region. Improved applicability of these indices in the South African context would be highly beneficial for marine environmental monitoring in general, and for monitoring impacts of current and future ADZs in particular. Until such time that these indices can be more accurately applied to the majority of species found in the ADZ, it is suggested that results from these indices should be interpreted with caution.

Macrofaunal species often respond to changes in environmental variables before they are chemically detectable (Cranford et al. 2006). These responses include: 1) a reduction in species biomass, 2) a decrease in the average body size of individuals, and 3) a shift in the relative dominance of trophic groups (Black et al. 2008, Cranford et al. 2012). It is therefore suggested that future monitoring surveys include the determination of species biomass, to be used to construct ABC dominance curves (Cumulative abundance-biomass plots) and provide information on the level of disturbance within the aquaculture sites relative to the reference sites. These curves provide an additional tool with which to assess the level of disturbance within the aquaculture sites relative to the reference sites. Protocols should be aligned with the State of the Bay (SOB) Programme in which the blotted wet biomass of all taxa is determined to four decimal places.

Although, monitoring results to date suggest negligible impacts of aquaculture at current production volumes, biotic indices for some sites warrant a precautionary approach. The use of ABC curves on SOB data has shown that much of the bay, including reference sites, are considered moderately disturbed. This is probably a result of cumulative anthropogenic activities in the bay as well as highly variable natural disturbances. Therefore, it is suggested that faunal and metal analyses be undertaken at a more regular interval i.e., every three years not every 3 - 5 years. Thus, ensuring that any impacts associated with the ADZ operations are detected timeously and do not compound the natural/existing disturbance within the bay and that the cumulative impacts within the bay do not push the ecosystem towards detrimental levels of disturbance.

d) As per the biotic indices, asymmetric ANOVA can be performed on TOC/N and geotechnical descriptors (porosity, granularity) to ascertain whether there has been an impact in the growing area. These analyses are provided as supporting information for the above benthic faunal analysis and are not used to initiate management interventions.

e) Samples for metal analyses (Al, Cu and Zn) should be taken at the same time (every 3 years) as the faunal survey at the finfish sites but under cage arrays. Given the dispersive nature of the bottom sediments in the finfish growing areas it is regarded as highly unlikely an exceedance will occur. Should the type of anti-foulants change, this must be updated and considered accordingly. Sampling should be limited to directly under the fish cage structure (the zone of most likely impact) initially and extended should thresholds not be met. Results from replicate cores from each cage group should be tested using a 1-sample t test:

H_0: $\mu \leq 270$ mg/kg; H_A: $\mu > 270$ mg/kg Copper (1-tailed)

H_0: $\mu \leq 410$ mg/kg; H_A: $\mu > 410$ mg/kg Zinc (1-tailed)

Should either metal be shown to exceed the threshold, additional samples will be required incorporating the AZE and reference stations. Three samples should be taken 30 m from cage structures in the direction of residual bottom currents and one at each of the reference stations. Replicate sample stations at the AZE boundary (30 m) should be spaced such that they can be regarded as independent. The AZE boundary samples should be tested for conformance with the beyond AZE thresholds using a 1-sample t test:

H_0: $\mu \leq 34$ mg/kg; H_A: $\mu > 34$ mg/kg Copper (1-tailed)

H_0: $\mu \leq 150$ mg/kg; H_A: $\mu > 150$ mg/kg Zinc (1-tailed)

Should either metal exceed threshold values perform asymmetrical ANOVA to test the following hypotheses:

H_0: there is no interaction between farm/reference site and baseline/operational; H_A: there is an interaction (2-tailed).

If a significant interaction is indicated, there is evidence that the exceedance is due to farming activities and management intervention will be required.

f) Research done to date (2019-2022), diver observations and difficulties in obtaining grab samples at several stations in Big Bay has revealed the presence of patches of exposed reef within Big Bay, particularly in the finfish precinct of the ADZ but also within the bivalve area. The reef is described as being mostly low profile <1m in height and periodically inundated with sand, however, outcrops of reef >1m in height are also reported. It is suggested that the amount of rocky substratum present in Big Bay is likely significantly more expansive than originally thought and that the full extent of the calcrete platform and the proportion of this habitat type impacted by current and future mariculture activities should be more accurately determined. Updated SANHO bathymetry data is available for much of Big Bay, but not for the ADZ precinct itself, and this should be collected by a dedicated survey.

Previously, the benthic monitoring protocols in this sampling plan were appropriate for soft sediment habitats only, and no data was been collected on the potential impacts of mariculture on reef communities. The sampling plan should therefore be expanded to include monitoring on the epifaunal reef community composition. These surveys should take the form of both video and photographic data capture, with the recommended addition of west coast rock lobster counts to monitor the population status of this commercially important species. An initial, qualitative photographic and video survey and analysis was undertaken during 2022 and this should be repeated at least every three years as part of the benthic monitoring. The survey methodology is described below, and survey site locations are provided in the hard substrate survey report (Dawson et al 2022). Given the limitations placed on taxonomic identification by poor visibility within the water column, reference and impact reef sampling surveys should be conducted on the same day. Should diving conditions allow, it would be desirable for analysis to include quantitative abundance or percentage cover data, not just qualitative data.

g) Frequent servicing/calibration of bottom water oxygen sensors must be undertaken, dependent on the rate of fouling and functioning of sensors (e.g., monthly). Both the correlation between oxygen and temperature and the calculated Apparent Oxygen Utilization (which is largely dependent on temperature) should be assessed as indicators of increased oxygen demand by sediments and the near-bottom water column. The time series should be analysed using the Mann Kendall non-parametric statistical test (or similar) to identify whether there is a significant monotonic trend in the data (Pohlert 2018). The Mann Kendall test is used in place of linear regression analysis as it does not require the assumption of a normal distribution of residuals. Change-point detection (Taylor 2000, Killick & Eckley 2014) can then be employed to identify when the change(s) occurred and the statistical confidence thereof. Evidence in the time series for a developing departure in the sentinel site oxygen and temperature relationship relative to the reference site should trigger additional sampling to verify and determine the extent of sediment deterioration. This could take the form of an initial CTD survey of bottom oxygen/temperature. A chemical investigation of S^{2-} may be required to establish the oxic status of the impacted sediments. Management action will be based on this follow-up investigation.

7.2 Water column

a) Frequent (monthly) servicing of the fluorometer is required to maintain proper functioning and calibration. More frequent (e.g., weekly) sampling is required of size-fractionated chlorophyll at both the entrance to the lagoon and reference control sites. Fixed point sampling (Eulerian) as proposed here integrates temporal and spatial variability that typifies the dynamic water movements associated with tidal cycles and currents. The proposed sampling scheme combines high frequency sampling over short time periods relative to phytoplankton generation times, with longer term low frequency sampling, both of which are required to identify putative farm impacts from natural cycles (see Martin-Platero et al. 2018). The data should be subject to trend and change-point analyses as above. Should the time series record of chlorophyll indicate departures from the apparent natural cycles inherent in the embayment, additional sampling may be required. More importantly, if the proportion of picoplankton entering the lagoon is shown to have increased relative to reference sites and in concert with the expansion of shellfish farming (change-point detection), rapid synoptic surveys must be undertaken to identify the source and magnitude of the depletion in large-celled phytoplankton. Management action may be required based on the findings of these surveys.

b) Annual, non-quantitative samples should be taken of fouling organisms on farm infrastructures, preferably in conjunction with the State of the Bay Programme (Clark et al. 2017).

8. Small Bay

Small Bay comprises an area that has been under cultivation for an extended period, and which is subject to many sources of pollution, including aquaculture (see State of the Bay reports e.g. Clark et al. 2017). Despite obvious indications of habitat degradation in the bay, it is often regarded as a 'sacrificial zone' and perhaps even beyond remediation. However, Small Bay is an important nursery ground for finfish, particularly white stumpnose, (Clark et al. 2017) and a popular recreational hub. The bay provides many other crucial ecological services such as assimilative capacity for organic anthropogenic wastes such as fish processing and sewage effluent, as well as a repository for heavy metals and other contaminants in anaerobic sediments. Shellfish aquaculture in the bay has been shown to impact on the ecology of the benthos (Stenton-Dozey et al. 1999, 2001) and the water column (Heasman et al. 1998). Impacts, however, were regarded as very localized and of small concern for the broader bay system. The recent expansion of aquaculture, and scope for further expansion, in the bay does raise new concerns regarding its sustainability, particularly with regard to its assimilative capacity for aquaculture biodeposits.

As an initiation of a monitoring effort in Small Bay it is proposed that a sentinel station is established on the eastern lease boundary of the major longline culture portion in the bay. This position is based on the predominant clockwise circulation within the bay. As with sentinel stations in BB and OB, bottom oxygen and temperature sensors should be moored close to the seabed, and paired with a reference station at North Buoy. North Buoy is currently a monitoring station in the State of the Bay Programme and is outside the putative influence of the shellfish cultivation structures (Stenton-Dozey et al. 2001). Evidence for significant departure from the oxygen temperature relationship indicating oxygen depletion relative to the sentinel site should trigger more extensive sampling. Initially this could be limited to a CTD survey of bottom water oxygen levels over the lease areas. Time series analyses as with the other sentinel stations can be performed to monitor any further deterioration associated with the lease areas.

Irrespective of the sentinel station records, a chemical survey of S^{2-} should be undertaken in the near future to establish the oxic status of the lease areas in Small Bay. The survey should include North Buoy and two other stations as reference conditions. Statistical tests for compliance with S^{2-} thresholds should be performed as outlined earlier and followed up with management interventions should the situation warrant. It is recommended that this survey is preceded by a CTD bottom oxygen survey to map the extent of oxygen depletion associated with the culture area.

9. Sampling procedures

9.1 Macrofauna

Three replicate samples from box-cores, grabs (e.g., Van Veen) or diver-operated suction samples (recommended) are to be taken at each sample site. Sample units should collect at least 0.07 m^2 sediment (diameter 30 cm) and, where possible, to a depth of 30 cm, giving a total surface area of > 0.2 m^2 per site. This is double the minimum recommended area for benthic macrofauna collection by Preslawski et al. (2018). The post-collection procedures given below are based predominantly on Rumohr (1999) and Prezlawski et al. 2018).

a) Gently wash samples with seawater through a 1 mm sieve, avoiding directing flow onto sieve to preserve integrity of fragile organisms. The sieve can be placed in a container into which wash water flows and gently agitated to release light-bodied animals. Continue until all sediment that can pass the sieve is washed through.

b) For grab or box core samples it may be necessary to transfer the sample to the sieve portion by portion as a sediment-water slurry.

c) If re-sieving of samples is carried out a mesh finer than the initial 1 mm must be used.

d) Fragile animals such as some polychaetes, should be picked out by hand during the sieving, to minimize damage. Also stones and large shells should be picked out to avoid a grinding effect during sieving.

e) Once washing is completed remove large-bodied animals that do not float during washing to a sample container.

f) Specimens retained on the sieve are washed off from the underside with a seawater squirt bottle into a funnel and sample container. Minimal amounts of water should be used in this step to ensure adequate preservative concentration.

g) Fix samples with 4 % buffered formaldehyde (1 part 40% formaldehyde plus 9 parts filtered seawater) in tightly sealed containers. Sodium tetraborate at a final concentration of 2 % may be used as a buffering agent. Label both the outside and inside of the container with sample details on durable labels.

h) Staining with e.g., Rose Bengal may be used to facilitate sorting and increase sorting accuracy. The stain can be added to the formaldehyde solution used for fixing.

i) As formalin is toxic and probably carcinogenic it should be handled with great care. Adequate ventilation should be applied for all procedures and thorough rinsing with tap water prior to sorting is mandatory.

j) After sorting into broad taxonomic groups, specimens are identified to the lowest possible taxonomic resolution, weighed, and enumerated. Classification must be undertaken by a qualified professional.

k) After an adequate fixing period samples can be preserved in 70 - 80 % alcohol or saturated propylene phenoxetol for long term storage.

l) It is advisable to store some specimens of each taxon for later taxonomic validation if required.

9.2 Sulfides and redox potential

Sediment samples for chemical measures of oxic status must be taken at three compliance stations: 0 m, 30 m and 60 m along the main axis of residual bottom current flow for finfish areas. For shellfish, samples are limited to directly below the culture structures. Samples must also be taken at three reference stations that were previously established for the particular growing area. It is recommended that, when possible, divers are used in preference to grab sampling for the collection of sediment samples as this carries a lower risk of oxidation.

Recommended sample collection and measurement of S^{2-} and Eh is based on Cranford et al. 2020. Three replicate sulphide and three redox samples must be collected by scuba divers at each site, using new 250ml polyethylene plastic jars. Jars must be completely full and tightly sealed underwater with as little exposed to the water column as possible. S^{2-} samples are to be kept on ice before being frozen and delivered to a certified laboratory to be analysed using the methylene blue colorimetric method. Redox samples must be kept on ice before being measured using a redox probe as per (d) below. A photograph of each redox sediment sample should be taken for a colour assessment.

The alternate method of sample collection and measurement for S^{2-} and Eh is based predominantly on Wildish et al (2004) and Fisheries and Oceans Canada (2015b, 2015b). Samples must be collected by either grab or core with a sampling area of at least 200 cm^2. The device must prevent leakage of water or sediment during retrieval. If a grab is used the sample is suitable for analysis if overlying water is clear indicating minimal disturbance of the sediment. The sample device should have penetrated at least 5 cm. If after 3 attempts no sediment is retrieved in grabs then it is likely the bottom substratum is hard and the sample station should be re-positioned by no more than 3 m, maintaining the required distance from the cages. When a sediment sample cannot be taken that position shall be recorded as hard bottom and not suitable for future sampling. Three replicate grabs or cores must be taken from each sample position and each should be treated separately as outlined below.

a) Perform S^{2-} and Eh (if required) analyses within 5 min after sample retrieval. If it is not possible to make these measurements at sea, the samples may be stored on ice and then refrigerated for up to 72 h prior to analysis (see Wildish et al. 2004). Samples can be held in syringes until later analysis provided they are capped and chilled.

b) Sub-samples are taken of the top 2 cm of the sediment surface by means of a cut-off syringe or spatula and transferred to a suitable glass or plastic container and gently homogenized after removing unrepresentative material (e.g., shells, large worms, stones). A minimum of 25 ml of sediment is required for each Eh and S^{2-} analyses.

c) For S^{2-} measurements, place 10 ml of freshly prepared EDTA/NaOH/ascorbic acid buffer in a graduated container and add homogenized sediment up to 20 ml graduation mark (add buffer first).

    i. Briefly stir mixture and insert electrode below the surface of the slurry.

    ii. Gently move electrode until reading stabilizes, typically 1 - 4 mins. If electrode does not stabilize within a reasonable time re-calibration may be necessary.

    iii. Rinse electrode with distilled water to remove any sediment and gently wipe to remove any oily residue prior to further use.

d) After the 10 ml sub-sample has been removed for S^{2-} measurement, place the redox electrode in the remaining sediment.

    i. The electrode should be held stationary in one position.

    ii. Record the Eh value and sample temperature once a relatively stable reading (< 10 mV/min) is achieved, usually within 3 min. Temperature is required for calculation of a correction factor.

    iii. Rinse electrode with distilled water to remove any sediment and gently wipe to remove any oily residue prior to further use.

Details regarding calibration and electrodes used in the measurement of Eh and S^{2-} are provided in Wildish et al. (2004), Fisheries and Oceans Canada (2015a) and PNS (2018b).

Exceedance of sediment quality thresholds at site B4 in the Big Bay precinct is highlighted as an area of concern. The recommended management action is increased spatial coverage of sediment monitoring. Two-three additional stations should be positioned along the northern boundary of the Big Bay precinct to ascertain if the poor sediment quality at site B4 is due to the bathymetry, or if there are wider spatial scale benthic impacts occurring downwind of the bivalve infrastructure. Two additional benthic stations have therefore been included in this area (Figure 1, Table 1).

9.3 Geotechnical and other geochemical indicators

Collection of sediment for determination of metals (Cu, Zn and Al), TOC/N, porosity and grain size are as described for S^{2-} and Eh. Separate sub-samples of surficial sediment (upper 2 cm) from three replicate cores shall be thoroughly homogenized prior to splitting into separate containers for the different analyses. Caution should be taken to prevent contamination by metallic surfaces. Samples must be kept chilled in the field and stored frozen. The amount of sediment required should be as advised by the analytical laboratories for the respective analyses. Depending on the laboratory, some analyses may be carried out on the same sample, e.g., porosity (water content) and TOC/N. To align with methods currently employed in the State of the Bay Programme, metals should be determined by ICP optical spectrometry after strong acid extraction and microwave digestion (total fraction), TOC/N by elemental analysis (not weight loss on ignition), and sediment particle size distribution by dry sieving (Barry Clark, Anchor Environmental, personal communication). Porosity is calculated from weight loss of wet sediment on drying at 60°C.

9.4 Rapid synoptic surveys

To be undertaken to determine the spatial extent and magnitude of phytoplankton depletion by bivalve cultivation. Depletion of phytoplankton becomes a concern when the scale of cultivation is large enough to remove particles faster than physical re-supply, e.g., through tidal currents, and phytoplankton production (Cranford et al. 2006). This effect has implications for both the production carrying capacity for the cultivated stock and the ecological carrying capacity of other components of the ecosystem (Cranford et al. 2008). A critical additional component of the study is to quantify the biofilter effect of the bivalves on the size structure of the phytoplankton.

The survey involves the rapid, high resolution mapping of chlorophyll with a CTD equipped with a fluorometer. The aim is to collect 3-D data rapidly, within 1 - 2 h, before tidal flushing causes distributional changes (Cranford et al. 2008). Phytoplankton size structure is measured in discrete water samples taken during the survey:

a) Water samples (1 - 2 litre) are collected from 1 m depth and stored chilled, in the dark for processing on return to shore.

b) As soon as possible on return to shore 0.2 litre sub-samples are filtered through a 3 µm Nucleopore (or similar) membrane filter.

c) Screened and unfractionated (100 - 200 ml) sub-samples are then filtered onto Whatman GF/F filters and the filters stored at - 20 °C for later chlorophyll determination by *in vivo* fluorescence or other acceptable method.

9.4 Reef surveys

Epifaunal community surveys of reef habitat within Big Bay should be undertaken during optimal visibility and weather conditions. Three impact sites within the ADZ precinct and three reference sites should be surveyed, with all sites preferably sampled on the same day to minimise confounding weather and visibility effects. A shot-line must be deployed at the identified reef sites and a pair of scientific divers descend to the sea floor. One diver is to slowly swim three 10 m video transects radiating from the shot-line centre with the camera ~50 cm off the seafloor, whilst the other diver conducts at least ten photo-quadrats (0.04 m^2) on reef habitat in the vicinity of the shot-line base. At least 2 - 3 photos must be taken of each quadrat to ensure that the best possible focus is achieved, as well as to account for varying depths of fields of each photograph. Should conditions require the use of the flash or a torch, all photos should be taken using these. Additionally, qualitative collection of biota should be undertaken at all sites to aid in the identification of cryptic biota observed in video transects and photo-quadrats. At a minimum, presence/absence data is to be extracted from the collection, photographs and video footage. However, should conditions and photo quality allow, it is desirable for analysis to include quantitative abundance or percentage cover data. Multivariate statistical analysis should be undertaken to investigate differences between control and impact sites.

Mobile species, such as the economically important west coast rock lobster, are not often captured in photographs as they rapidly retreat when the quadrat is initially dropped and are better represented in video footage. Therefore, it is suggested that lobster counts, to monitor population densities, be included in the reef survey. The diver conducting the video transects should attach a reel to the shot line, holding this reel in front of themselves the diver is to swim the three transects, 10 m in length, counting rock lobsters in the 0.5 m either side of the line (30 m^2 area). The video footage can then be captured as the diver returns to the base of the shot line.

10. Management actions

A breach of the required S^{2-} benthic impact indicators for finfish will require additional sampling to verify and provide greater spatial detail of the magnitude of non-compliance. Sampling should be intensified around the cage/group to accurately map the distribution of non-conformance with the oxic thresholds within the AZE. Based on these findings management actions may include:

a) Extension of the AZE by the AMC. The Scottish EPA allows larger AZE's in dispersive, as opposed to accumulative, environments where supporting information warrants.

b) Reduction in the scale of farming at the site to align with local assimilative capacity. This will involve adjusting on-site stocking levels.

c) Reduction in feed wastage according to a benthic amelioration plan submitted by the operator. Preferable option as it has direct commercial implications for the operator. The plan should include:

i) update of staff training on feeding methods,

ii) installation of submerged video or other device to track feed pellets in real-time to minimize overfeeding (feedback-control).

d) Movement of structures within the lease area to allow recovery on the benthos. Alternatively, investigate whether a re-orientation of cage set-up could take better advantage of dispersive currents. Fallowed sites should be monitored annually to track recovery.

The operator shall be obliged to provide audited (e.g., by certified accountant) information in relation to production and feed input for the implicated entity as deemed necessary by the AMC. If follow-up annual sampling indicates no improvement, further limitation of production levels shall be imposed with attendant reduction in feed. If seabed conditions do not improve in response to production/feed reductions, relocation of the cage structures will be required.

Non-conformance with the shellfish benthic S^{2-} indicator shall require more intensive sampling of an area to verify results and map the zone of negative influence. Based on these findings management actions are limited to:

e) Re-alignment of the culture structures to promote improved dispersion by currents where possible.

f) Reduction in production levels by limiting the number of dropper lines for settlement of mussels or deployment of oyster baskets.

Should these actions prove ineffective at the following annual monitoring campaign, a further decrease in production will be imposed. Additional management actions could require clearing of a site.

Management actions in response to a failure to meet the benthic faunal thresholds are as above but more drastic in that they apply to the whole site, not just ill-performing sub-sets thereof. In the event that the sediment macrofauna oxic thresholds are not achieved, reductions in production feed use/wastage shall be applied as outlined earlier to the whole site. Follow-up benthic fauna surveys shall be carried out on an annual basis until monitoring indicates the benthos has recovered to an oxic status. Continued non-compliance is indicative that the site is unsuitable for aquaculture and it should be de-stocked.

In the event that chlorophyll monitoring and findings of the rapid synoptic survey clearly implicate a bivalve growing area(s) in the depletion and/or alteration of the structure of the phytoplankton community that feeds into Langebaan Lagoon, management action will be required. Bivalve feeding should produce a continuous, press response in the indicators that are clearly distinguishable over the long-term from natural variations. As a first management action, limits on bivalve production should be imposed at certain sites and the level of recovery monitored over time as for the operational phase. As there are no clearly defined thresholds for the phytoplankton indicators (chlorophyll, proportion of picoplankton) it will require a management decision on what level of impact can be regarded as acceptable. Given the sensitivity and ecological importance of the lagoon it would be prudent to apply strict limits such as no significantly detectable change.

Upon establishing that the threshold levels for Cu and/or Zn have been exceeded in potentially bioavailable forms, various management actions shall be imposed that may require (Keeley et al. 2014):

a) Extension of AZE from fixed distance to site specific, e.g. in dispersive environments (SEPA 2000).

b) Reduction of inputs to the system proposed by the operator. Explore alternatives to Cu and Zn based antifoulants and lower levels of nutritional therapeutants such as Zn in feed (Clement et al. 2010).

c) Investigation into the bioavailability of the metal by different extraction protocols, e.g. weak acid extractable fraction as a proxy for bioavailability.

d) Scientific investigation into toxicity of the contamination (see Macleod and Eriksen 2009) and potential adjustment of generic threshold limits with site-specific criteria based on these findings.

Further management imposed reductions in inputs shall be enforced until compliance with thresholds is achieved. Fallowing is a controversial strategy for dealing with metal contaminated sediments as generally much longer time periods are required for metal rehabilitation than for organic enrichment. In addition, there is the potential for metal bioavailability to increase with sediment recovery which in turn might hinder further biological remediation (Clement et al. 2010).

11. Food safety

Farms cultivating molluscan shellfish and finfish are required to comply with the South African Molluscan Shellfish Monitoring and Control Programme (SAMSM&CP), the South African Aquacultured Marine Fish Monitoring and Control Programme (SAAMFM&CP) and the National Residue Control Programme (NRCP) as per the permit conditions contained in the Permit to Engage in Marine Aquaculture. The SAMSM&CP requires that molluscan shellfish farms are classified before marketing their product, a process that could take at least 3 months for a preliminary classification. The SAMSM&CP also requires the testing of Paralytic Shellfish Toxins (PSY), Amnesic Shellfish Toxins (AST), and Diarrhetic Shellfish Toxins (DST) and phytoplankton as well as *E. coli*, *Salmonella* spp., *Vibrio parahaemolyticus* and *V. cholera*. The SAMSM&CP and SAAMFM&CP require that farms furthermore comply with the National Residue Control Programme, which includes the need to test for banned and controlled substances, heavy metals, pesticides and polychlorinated biphenyls (PCBs). Farms exporting product are furthermore required to comply with importing country requirements which could include arsenic, inorganic arsenic, polycyclic aromatic hydrocarbons, dioxins, dioxin-like PCBs and non-dioxin like PCBs. The samples are taken by independent samplers namely the National Regulator for Compulsory Specifications (NRCS) and submitted to the relevant laboratories. Should the concentrations of the contaminants exceed the regulatory limits, the implicated farms are temporarily closed and potentially contaminated products are recalled. The farms remain closed until the regulatory limits are complied with and the reopening protocols are adhered to. The SAMSM&CP and SAAMFM&CP documents are available whereas the National Residue Control Programmes are kept confidential as it deals with banned and controlled veterinary drug residues which are easily manipulated prior to sampling. However, the environmental residue testing requirements are available for distribution.

12. Biosecurity and Aquatic Animal Health Monitoring

The fundamental measures that underpin aquatic animal disease prevention are the application of biosecurity. This paragraph describes the biosecurity principles necessary to mitigate the risks (probability and consequence) associated with the introduction of pathogenic agents into, the spread within or the release from aquaculture facilities in the bay. Biosecurity is a set of physical and management measures which, when used together, cumulatively reduce the risk of infection in aquatic animal populations at an aquaculture facility. Most of the aquaculture activities in the bay can be described as "semi-open systems". In a semi-open aquaculture production system, it is not possible to have control of water entering or exiting the system or of environmental conditions. Some aquatic animals and potential disease vectors may also enter and exit the system. Pathogenic agents can move into, spread within and be released from an aquaculture facility via various transmission pathways. The identification of all potential transmission pathways is essential for the development of an effective biosecurity plan. Since effective isolation of a semi-open system is not possible, the entire bay is regarded as a single epidemiological management unit which will require the coordination of biosecurity measures implemented between different aquaculture operations.

The basic requirements for and effective biosecurity plan are as follows:

Import Control:

1. Only introducing aquatic animals (Seed, juveniles, stock for on-growing) into the aquaculture facility with a known health status, which is of equal or higher status than the animals in the bay (This requires knowing the health or disease status of the aquatic animals in the bay).
2. Ensuring biosecure transport of aquatic animals from the source to the bay to avoid exposure to pathogenic agents.

Early detection and monitoring:

1. Health monitoring of the aquatic animals at the aquaculture facility will include activities like disease surveillance, routine monitoring of stock for important health and production parameters, recording clinical signs of disease, morbidity and mortality rates and their causes.
2. Removing sick or dead aquatic animals from production units as soon as possible and disposing of them in a biosecure manner.

Emergency procedures:

1. Procedures should be developed and implemented to minimize the impact of emergencies, disease events, or unexplained mortality in aquatic animals. These procedures should include clearly defined thresholds that help to identify an emergency incident and activate response protocols, including reporting requirements.

The "Health management procedures for South African bivalves (oysters and mussels) produced for export" document outlines the relevant procedures necessary to support biosecurity and health monitoring in the bay. Similar procedures will need to be developed in conjunction with the department for finfish.

Please also refer to ADZ EMPr for full list of mitigation measures specific to disease management.

13. Genetics

Proposed species for the Saldanha Bay ADZ include the currently cultivated species (*Magallana* Syn *Crassostrea) gigas, Mytilus galloprovincialis* and *Choromytilus meridionalis*); indigenous shellfish (*Haliotis midae* and *Pecten sulcicostatus*) not previously cultured in the bay and finfish species (*Rhabdosargus globiceps, Argyrosomus inodorus* and *Seriola lalandii*); the seaweed *Gracilaria gracilis*; and a number of alien finfish species (*Salmo salar, Oncorhynchus kisutch, O. tshawytscha* and *O. mykiss*).

There are no perceived genetic risks associated with the farming of the proposed alien finfish species. Conversely, farms cultivating indigenous shellfish and finfish. For all farms cultivating indigenous seaweed species in Saldanha ADZ, it is recommended that seed stock are sourced from an area close to where the grow-out will take place. Species should minimize potential genetic impacts on wild populations as much as possible by adhering to the DFFE genetic management guidelines. 'Genetic Best Management Practice Guidelines' already exist for important commercial shellfish species, such as *H. midae*, and for some of the emerging finfish species, including *A. inodorus*, and these guidelines should be strictly adhered to. For all farms cultivating indigenous finfish and shellfish species in the open production systems proposed for the Saldanha ADZ (e.g. rafts, cages and barrels), it is strongly recommended that broodstock or parent fish are sourced from the area in which the grow-out will take place or from the same genetic zone. In order to retain a healthy genetic profile it is recommended that an effective broodstock population size of between 30 and 200 individuals are kept in the hatchery and a rotational breeding program should be implemented. If appropriate broodstock management procedures are used, gene frequencies can be maintained approximating those in the wild stocks.

For additional mitigation measures, please refer to the ADZ EMPr which will be reflected in the site specific EMPr's for individual projects.

Further genetic research between any future farmed indigenous species and wild caught species will be explored when this becomes relevant.

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ANNEXURE C

forestry, fisheries
and the environment

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

SALDANHA BAY SEA BASED AQUACULTURE DEVELOPMENT ZONE SPECIALIST ENVIRONMENTAL MONITORING

HARD SUBSTRATE SURVEY

Draft May 2022

ANCHOR environmental

Anchor Research and Monitoring Report No. 1974/8

SALDANHA BAY SEA BASED AQUACULTURE DEVELOPMENT ZONE SPECIALIST ENVIRONMENTAL MONITORING

HARD SUBSTRATE SURVEY

May 2022

Prepared for:
Department of Forestry, Fisheries and the Environment

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

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EXECUTIVE SUMMARY

Introduction

The Branch Fisheries Management in the then Department of Agriculture, Forestry and Fisheries (now Department of Forestry, Fisheries and the Environment; DFFE), obtained Environmental Authorisation (EA) to establish a sea-based Aquaculture Development Zone in Saldanha Bay on 8 January 2018. In order to ensure appropriate management of the ADZ the Branch Fisheries Management appointed an independent specialist to compile a Sampling Plan for the ADZ and together with other stakeholders have facilitated the completion of numerous monitoring surveys and research projects.

Research done to date, diver observations and difficulties in obtaining grab samples at several stations in Big Bay revealed the presence of patches of exposed reef within Big Bay, specifically in the Finfish precinct of the ADZ. The reef was described as being mostly low profile <1m in height, periodically inundated with sand, however, outcrops of reef >1m in height were also reported. It was suggested that the amount of rocky substratum present in Big Bay was likely significantly more expansive than originally thought and that the full extent of the calcrete platform and the proportion of this habitat type impacted by current and future mariculture activities should be determined.

The Marine Living Resources Fund (MLRF), under the auspices of DFFE, appointed Anchor Research and Monitoring (Pty) Ltd (Anchor) to undertake specialist monitoring in compliance with the environmental Sampling Plan, Environmental Management Program and Environmental Authorisation for the Saldanha Bay ADZ. One of the specific tasks of this appointment was to undertake a study to determine the Big Bay hard substrata species community composition and diversity. This report presents an analysis of available bathymetric data and the findings of diver surveys conducted at three control and three impact sites on the Bay reef platform.

Methodology

The South African Navy Hydrographic Office (SANHO) collected side scan sonar data of Big Bay in 2020 and 2021. However, very little of the ADZ precinct was surveyed leaving a significant gap in the updated bathymetry data within the ADZ. The 2020/2021 SANHO bathymetry data, however, corresponds fairly well with Flemming's (2015) distribution of the abrasion platform created using data from a 1977 side scan survey, and there is a significant amount of overlap/agreement in the extent of reef/hard substate between the two data sets. The georeferenced Flemming image was therefore used to determine the approximate area of reef within the Bay and the ADZ precinct.

During field surveys, when visibility and weather conditions allowed, a shot-line was deployed at identified reef sites and a team of scientific divers descended to the sea floor. One diver swam three 10 m video transects radiating from the shot-line centre, whilst the other diver conducted at least ten photo-quadrats (0.04 m^2) on reef habitat in the vicinity of the shot-line base. At least two photos were taken of each quadrat to ensure that the best possible focus was achieved, as well as to account for varying depths of fields of each photograph. Additionally, qualitative collection of biota was undertaken at all sites to aid in the identification of cryptic biota observed in video transects and photo-quadrats. Presence/absence data was extracted from the collection, photographs and video footage and multivariate statistical analysis was undertaken to investigate differences between control and impacts sites.

Results

Multivariate analysis of the photographic data indicated that there are differences in the community composition between Impact and Control reef sites, and that the community composition of the baseline site location in the undeveloped Finfish precinct is more similar to that of Impact sites. Similar patterns are seen in the results of the video footage multivariate analyses.

Multivariate dispersion tests showed that the presence of aquaculture operations (Impact sites) and close proximity to aquaculture (Finfish baseline) increased the variability in macrofaunal photo quadrat assemblages relative to areas without aquaculture operations (Control sites). Suggesting that the disturbance as a result of aquaculture increases the species diversity at sites within the ADZ.

This pattern of increased diversity at impacted/disturbed sites is consistent with the ecological theory of disturbance on the diversity of tropical reefs. Where a peak in diversity is observed at intermediate levels of disturbance, with diversity dropping at both low and high disturbance pressure due to competition and mortality, respectively.

Findings Summary

Based on the analyses of the existing bathymetry survey data and the reef survey data the following key findings and recommendations are made:

1. Based on available bathymetry data there is approximately 5 047 890.99 m^2 of reef within Big Bay, 29.2% of this reef area falls within the boundaries of the ADZ precinct, i.e. 6.3% of the total Big Bay reef area is found in the finfish precinct and 22.9% in the Bivalve precinct. The majority of the sea floor below the designated Finfish area is covered by reef (~79.9%), while 31.4% of the designated bivalve area consists of hard substrate, this is concentrated in the SW of the section.
2. Due to the fact that the Big Bay ADZ precinct was not surveyed in the recent SANHO data, historical data which appears to have a slightly reduced reef extent as compared to the SANHO data, was used to calculate the reef area and estimates are likely conservative.
3. Confirming the current day reef extent with higher confidence will require a similar resolution bathymetry survey of the ADZ precinct to be conducted in order to tie in with the 2020/2021 SANHO data.
4. The high proportion of reef in the finfish precinct is cause for concern, as finfish aquaculture is known to have a higher impact on the sea floor than bivalve aquaculture. It is therefore suggested that no Finfish aquaculture be undertaken at this site and that the Finfish sites in Outer Bay be utilized.
5. The ability to identify species in both the photographic quadrats and the video footage was dependent on the water visibility. Higher levels of uncertainty occur with higher levels of turbidity. It is suggested that all future survey data be collected on a single day to ensure standardised photo and video quality.
6. Multivariate and univariate data show that the community composition of Control and Impact reef sites differ significantly. Additionally, the benthic community structure at the Baseline reef site, located within the unused Finfish precinct, is more similar to that of impacted reef sites located within the Shellfish ADZ precinct. This suggests that the proximity of this site to the bivalve aquaculture has caused some level of disturbance/alteration of benthic conditions.

7. Community diversity at the Impacted reef sites is higher than at the Control sites, suggesting that at the present level of aquaculture development there is a balance between disruption of competition and mortality as a result of disturbance.
8. The intermediate disturbance hypothesis states that there is a tipping point at which the mortality as a result of disturbance is greater than the benefit of reduced competition. This point has not yet been reached in the Big Bay ADZ, but continuous monitoring of the reef fauna at Control and Impact sites is required to ensure early warning of this point being reached.
9. The use of photograph quadrats informs the identification of video footage and provides better imagery of accurate species identification. However, video transects consistently record higher species diversity, and mobile species such as the economically important west coast rock lobster, which are not often captured in photographs as they retreat when the quadrat is initially dropped, were better represented in video footage. Additionally, video footage provides a more accurate indication of the reef profile.
10. It is suggested that future surveys should include both video and photographic data and that the possible addition of lobster counts be included to monitor the population status of this commercially important species. Should diving conditions allow, it would be desirable for future analysis to include quantitative abundance or percentage cover data.

TABLE OF CONTENTS

GLOSSARY

Abundance	Refers to the number of individuals of a specific species.
Aquatic	Relating to or living in water.
Benthic	Pertaining to the environment inhabited by organisms living on or in the estuary bottom.
Biodiversity	The variety of plant and animal life in a particular habitat.
Biota	Living organisms within a habitat or region.
Bivalve	A large class of molluscs that have a hard shell made of two parts or 'valves'.
Community	A naturally occurring group of native animals/plants that interact in a unique habitat.
Diversity	The number of different species that are represented in a given community.
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.
Invertebrate	An animal without a backbone (e.g., a starfish, crab, or worm).
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.
Species richness	The number of different species represented in an ecological community. It is simply a count of species and does not take into account the abundance of species.
Turbidity	A measure of the loss of transparency of a water column as a result of the total suspended particles within the water

LIST OF ABBREVIATIONS

Anchor	Anchor Research and Monitoring (a subsidiary of Anchor Environmental Consultants)
ADZ	Aquaculture Development Zone
DFFE	Department of Forestry, Fisheries and the Environment
GPS	Global Positioning System
EA	Environmental Authorisation
EMP	Environmental Management Plan
IDH	Intermediate Disturbance Hypothesis
MDS	Multidimensional Scaling
MLRF	Marine Living Resources Fund
SANHO	South African Navy Hydrographic Office
SE	Standard error

1 INTRODUCTION

1.1 Background

An Aquaculture Development Zone (ADZ) comprises areas of land or water selected for their suitability for specific aquaculture sectors. ADZs are intended to boost investor confidence by providing 'investment ready' platforms with strategic environmental approvals and management policies already in place, allowing commercial aquaculture operations to be set up without the need for lengthy, complex and expensive approval processes.

The Branch Fisheries Management in the then Department of Agriculture, Forestry and Fisheries (now Department of Forestry, Fisheries and the Environment; DFFE), obtained Environmental Authorisation (EA) to establish a sea-based ADZ in Saldanha Bay on 8 January 2018. Appeals against the authorisation were lodged to the then "Minister of Environmental Affairs" and the authorisation was upheld as per the letter dated 7th June 2018. The Saldanha ADZ provides opportunities for existing aquaculture operations to expand and new ones to be established, providing economic benefits to the local community through job creation and regional economic diversification.

In order to ensure appropriate management of the ADZ the Branch Fisheries Management appointed an independent specialist to compile a Sampling Plan for the ADZ which was reviewed by local and international stakeholders and experts (DAFF 2018). A substantial body of work has been undertaken in compliance with the stipulations in the EA and the Environmental Management Plan (EMP) for the Saldanha Bay ADZ and work conducted by independent specialists includes, dispersion modelling, baseline macrofauna and physicochemical surveys (2020) and a benthic macrofauna monitoring survey (2021) and annual benthic chemical surveys (2021-2022).

Following the baseline survey, it was shown that patches of exposed reef are present in Big Bay, specifically in the Finfish precinct of the ADZ. The reef was described as being mostly low profile <1m in height, periodically inundated with sand, however, outcrops of reef >1m in height were also reported (Mostert *et al.* 2020). It was reported that the amount of rocky substratum present in Big Bay was likely significantly more expansive than originally thought and that the full extent of the calcrete platform and the proportion of this habitat type impacted by current and future mariculture activities should be determined. Additionally, it was suggested that the ADZ monitoring programme be updated to include suitable methods for monitoring potential aquaculture impacts on this habitat type.

The Marine Living Resources Fund (MLRF) a Schedule 3A Public Entity established in terms of the Public Finance Management Act, 1999 (Act No 1 Of 1999), under the auspices of Department of Forestry, Fisheries and the Environment (DFFE), appointed Anchor Research and Monitoring (Pty) Ltd (Anchor) to undertake specialist monitoring in compliance with the environmental Sampling Plan, Environmental Management Program and Environmental Authorisation for the Saldanha Bay ADZ, for a period of two years (2021/2022). One of the specific tasks of this appointment was to undertake a study to determine the Big Bay hard substrata species community composition and diversity. This report presents the findings of diver surveys conducted at three control and three impact sites on the Bay reef platform.

2 APPROACH & METHODOLOGY

Previous sampling experience and bathymetry data sourced from electronic navigation charts of marine areas (e.g. Navionics), Anchor's library of bathymetry data of Saldanha Bay as well as historical (Flemming 2015) and recent (SANHO) bathymetry charts were used to identify areas of possible hard substrata falling within the ADZ. Hard substrata/reef areas identified outside Big Bay precinct that serve as control sites were confirmed based on data sourced from the South African Navy Hydrographic Office (SANHO) by DFFE (including side scan sonar data collected between 2020 and 2021). A data release agreement was signed on 3 March 2022 for hydrographic data for Big Bay, and the bathymetric data received. This data was processed, and results are displayed below.

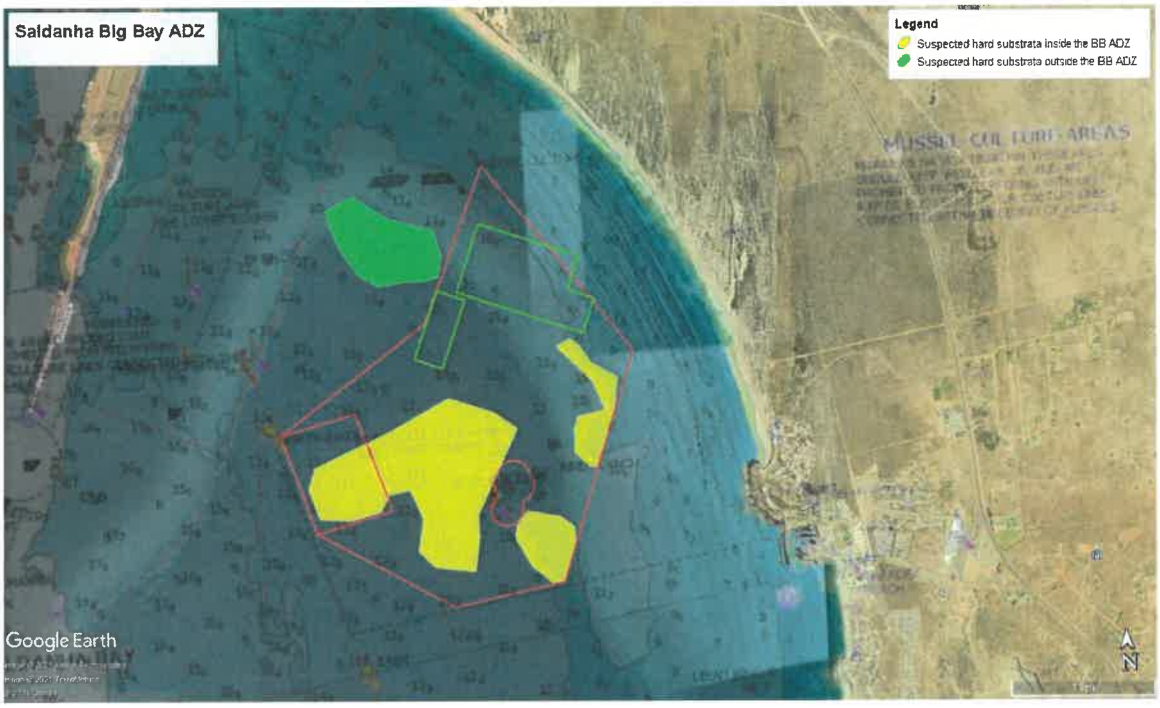

Figure 1. **Navionics overlay showing the changes in depth profile in Big Bay, examples of potential hard substrata as indicated by shallower than expected depths or changes in depth contours for the Big Bay ADZ are highlighted in yellow shading, while potential hard substrata habitat to be surveyed outside the Big Bay ADZ is highlighted with green shading. The shaded areas were targeted for hard substrata sampling by scientific divers.**

During field surveys, when visibility and weather conditions allowed, a shot-line was deployed at identified reef sites and a team of scientific divers descended to the sea floor. If no or only very limited hard substrate was found, divers ascended and moved to another site, but if sufficient hard substrate was encountered sampling was undertaken and the location marked on the GPS. The rocky reef dive survey of three sites located inside the ADZ (Impact sites) took place on 26 November 2021, and the three control sites were surveyed on 11 January 2022 (Table 1). Notably the site initially called Impact 1 due to its location within the ADZ precinct is in fact a control site or a finfish baseline site, as no finfish aquaculture has yet been undertaken.

Table 1. Co-ordinates (in decimal degrees) and naming scheme of the reef monitoring survey sites from Big Bay.

Field name	Corrected Names	Site	Latitude	Longitude	Treatment	Treatment 2
Impact 1	FF Baseline	FF1	-33.040680	18.007110	Control	FF Baseline
Impact 2	Impact 2	I2	-33.040980	18.013030	Impact	Impact
Impact 3	Impact 3	I3	-33.044670	18.014920	Impact	Impact
Control 1	Control 1	C1	-33.034880	18. 003470	Control	Control
Control 2	Control 2	C2	-33.054020	17. 997571	Control	Control
Control 3	Control 3	C3	-33.046700	18.005830	Control	Control

The scientific diver team consisted of two divers, one diver swam three 10 m video transects radiating from the shot-line centre, whilst the other diver conducted at least ten photo-quadrats (0.04 m^2) on reef habitat in the vicinity of the shot-line base (Figure 2). At least two photos were taken of each quadrat to ensure that the best possible focus was achieved, as well as to account for varying depths of fields of each photograph. Additionally, qualitative collection of biota was undertaken at all sites to aid in the identification of cryptic biota observed in video transects and photo-quadrats. Specimens were scraped into sample bags brought to the surface, preserved on ice and then frozen back in the laboratory for later identification.

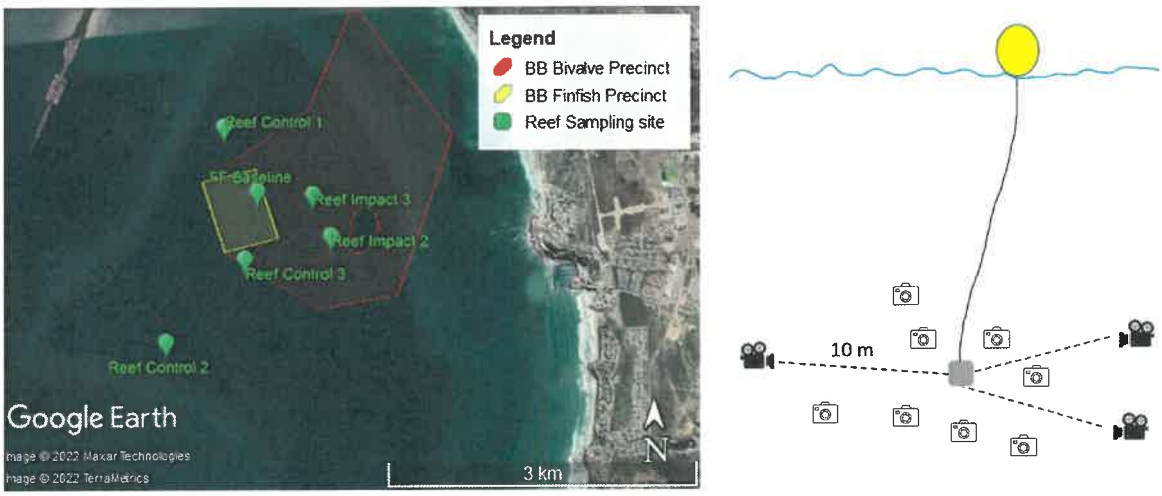

Figure 2. Location of the reef survey sites in Big Bay and diagram of the survey method.

All photographic and video footage species identification was undertaken by a single taxonomist to avoid any identification bias. Any ambiguous identifications were confirmed by a benthic invertebrate and/or a coral taxonomist. For purposes of this initial survey only presence/absence data was recorded and the abundance or percentage cover of species was not determined. The statistical program, PRIMER 6 (Clarke and Warwick 1993), was used to analyse the photographic and video footage presence/absence data separately. Data were converted to a similarity matrix using the Bray-Curtis similarity coefficient. Multidimensional Scaling (MDS) plots were constructed in order to find 'natural groupings' for the treatments (Impact/control). Multivariate dispersion of samples within treatments was calculated using the PERMDISP function.

3 RESULTS

3.1 EXISTING BATHYMETRY DATA

Although the marine specialist report for the Saldanha ADZ EIA considered subtidal reef habitat to be scarce in Saldanha Bay, and only identified Lynch blinder and North Bay blinder as important reef areas (Pulfrich 2017), reports from divers of calcrete rock surrounding sampling sites during the baseline survey (Capfish 2019), difficulties in obtaining grab samples at several stations in Big Bay during 2020 (Anchor) sediment surveys, and observations by Anchor divers deploying water quality monitoring instruments and collecting benthic macrofauna samples, indicated patches of hard substratum/reef in several areas of the Big Bay ADZ precinct. A subsequent literature review revealed the existence of an extensive abrasion platform (areas of exposed calcrete rock) throughout much of Big Bay (Flemming 2015).

Side-scan sonar and seismic data collected in 1977 and supported by *in situ* diver observations indicated the occurrence and distribution of specific seabed features such as rock outcrops on a calcrete abrasion platform (Flemming 1977, 2015) in the centre of what is now Big Bay (Figure 3).

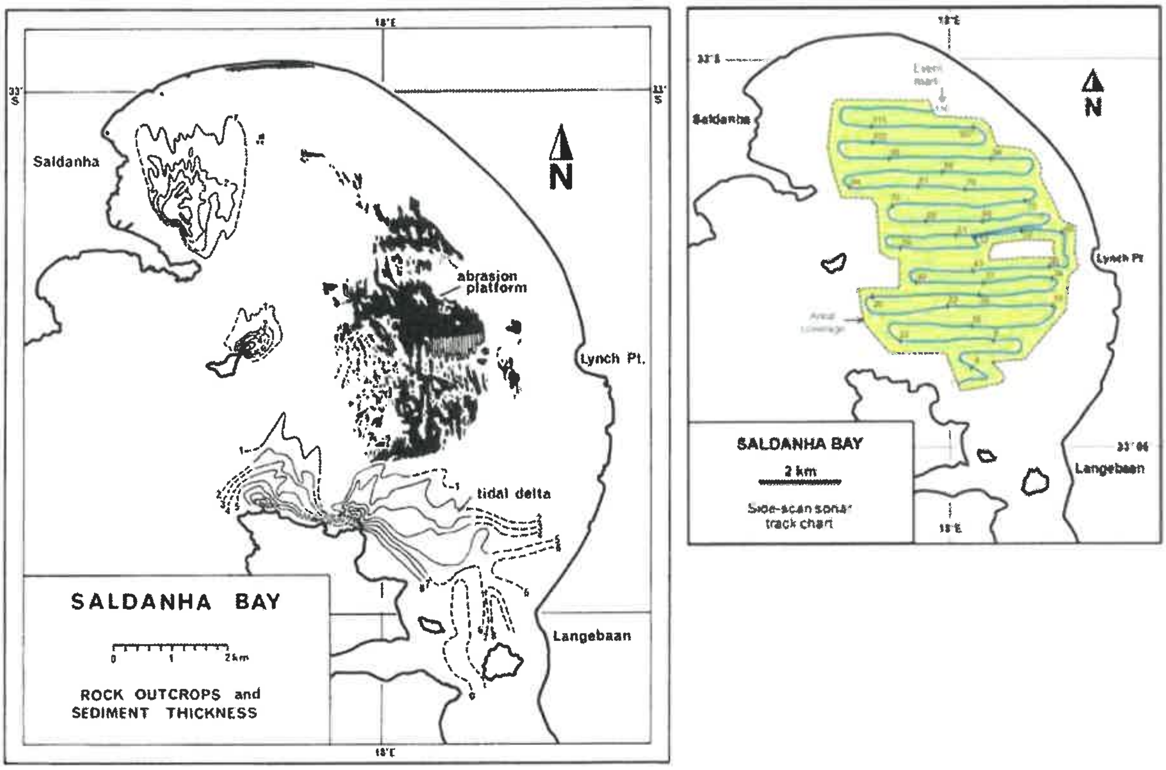

Figure 3. **Location of rock outcrops on the abrasion platform (black, left) determined by the side-scan sonar of Saldanha Bay, taken following the track shown on the right. Source: Flemming (2015).**

More recently, the South African Navy Hydrographic Office (SANHO) collected side scan sonar data of the Bay in 2020 and 2021. However, very little of the ADZ precinct was surveyed, likely because the skipper of the survey vessel was restricted by Bivalve infrastructure and could not navigate through the long lines. Therefore, there is a significant gap in the data within the ADZ precinct (Figure 4).

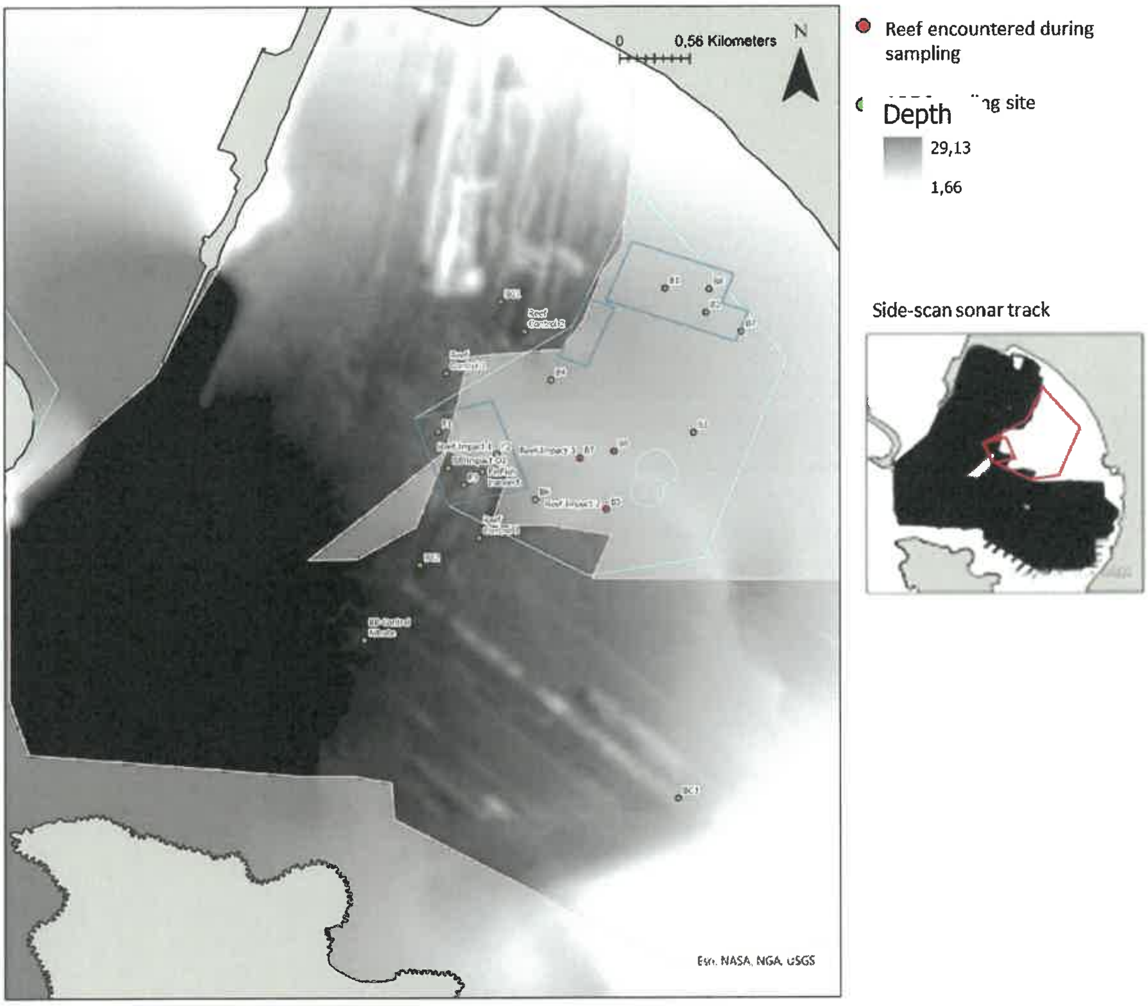

Figure 4. **Bathymetry of Big Bay determined using data sourced from the South African Navy Hydrographic Office (SANHO) collected between 2020 and 2021.**

The available SANHO bathymetry data from Big Bay corresponds well with Flemming's (1977) distribution of the abrasion platform, and if overlain on top of the latter, there is a significant amount of overlap/agreement in the extent of reef/hard substate (Figure 5). Given this, and the lack of recent SANHO data inside the ADZ precinct, Flemming's data was used to calculate the estimated area of reef occurring in both the finfish and Bivalve sections of the Big Bay ADZ precinct. These areas were calculated by first georeferencing Flemmings (2015) image, creating a raster, then extracting per interest area, converting to polygon, projecting using the Projected Coordinate System: Africa_Albers_Equal_Area_Conic and calculating geometry to acquire area in meters squared.

Based on this the total reef area in Big Bay is approximately 5 047 890.99 m2, 29.2% of this reef area falls within the boundaries of the ADZ precinct, i.e. 6.3% of the total Big Bay reef area is found in the finfish precinct and 22.9% of the total Big Bay reef area is in the Bivalve precinct. The majority of the sea floor below the designated Finfish area is covered by reef (~80%, see inset of Figure 5), while 31.% of the designated bivalve area consists of hard substrate, this concentrated in the SW of the section.

It is noteworthy that there appears to be more reef visible in the SANHO data which is not captured in Flemmings 1977 distribution map, particularly the north-south ridges to the North West of the ADZ area and the NW-SE ridge features to the South and SW of the ADZ area (Figure 5). Therefore, it is likely that the calculations of reef areas provided are conservative – i.e. there is probably more reef in Big Bay than Flemming's map indicates, both within and outside the ADZ. Confirming this will require a similar resolution bathymetry survey of the ADZ precinct to be conducted in order to tie in with the 2020/2021 SANHO data.

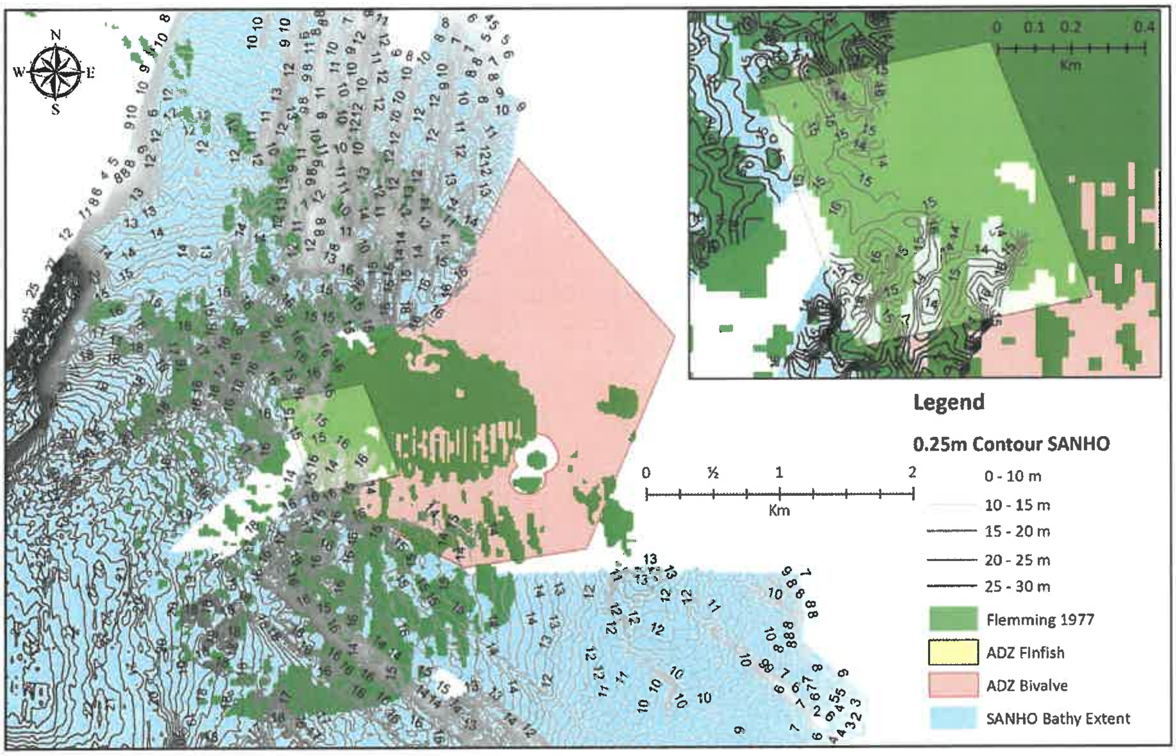

Figure 5. **2020 and 2021 Bathymetry data (SANHO) overlain on top of Flemming's (2015) representation of the abrasion platform based on a 1977 side scan sonar survey. Inset = close up of Finfish section.**

3.2 Reef survey initial observations

The ability to identify species in both the photographic quadrats and the video footage was dependent on the visibility within the water column on the day on which the surveys were conducted. There was greater water clarity on 26 November 2021, while turbidity was higher i.e., there were more suspended particles in the water column, on 11 January 2022. The latter caused more back scatter of torch light in both photos and videos, making identification more difficult with greater uncertainty (Figure 6). To avoid this in future surveys, it is suggested that all six sites be surveyed on the same day, thus standardising photo and video quality. Highly mobile species such as the West Coast rock lobster *Jasus lalandii* were not often captured in photo quadrats as they move away once the quadrat is placed, therefore this species is likely underrepresented in the photographic data, rock lobsters were seen more frequently in the video transects.

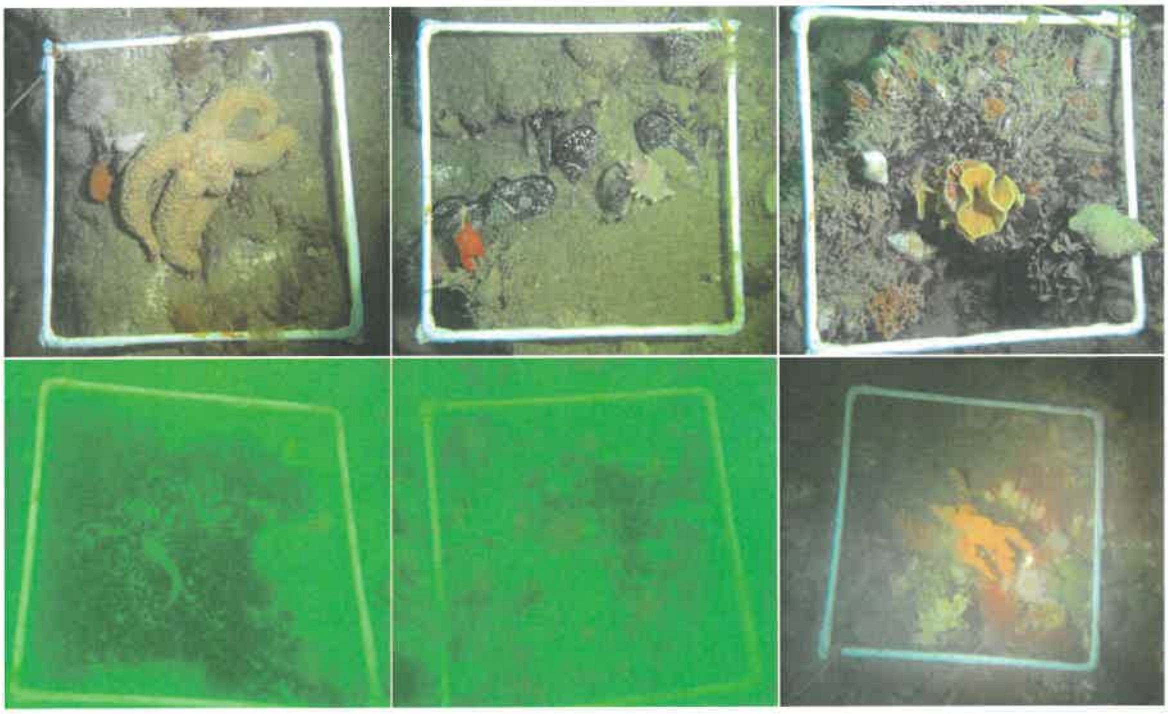

Figure 6. Comparison of image clarity of photos taken in optimal conditions in November 2021 (Top) and images taken in above average visibility for Big Bay taken in January 2022 (bottom).

During the data capture phase, prior to the analysis of the data, it was possible to identify significant differences between photos and videos taken at the control and impact sites. Impact sites appeared more variable with more species than control sites. Additionally, the presence of certain taxa in one or the other treatments (control/impact) were noted i.e., corals and false corals occurred at impact sites while high densities of sea cucumbers occurred at control sites. This interpretation was support by the data analyses.

3.3 Data analysis

An ordination plot, that displays photo quadrats from control and impact sites, based on similarities in their species composition in two-dimensional space (quadrats with similar communities are closer together) prepared from species presence/absence data, is presented in Figure 7. Visually the macrofaunal communities present at the Control sites were separate to those at Impact sites and was statistically supported by a significant difference between the two precincts (PERMANOVA $t_{1,68}$ = 3.3034; p = 0.001).

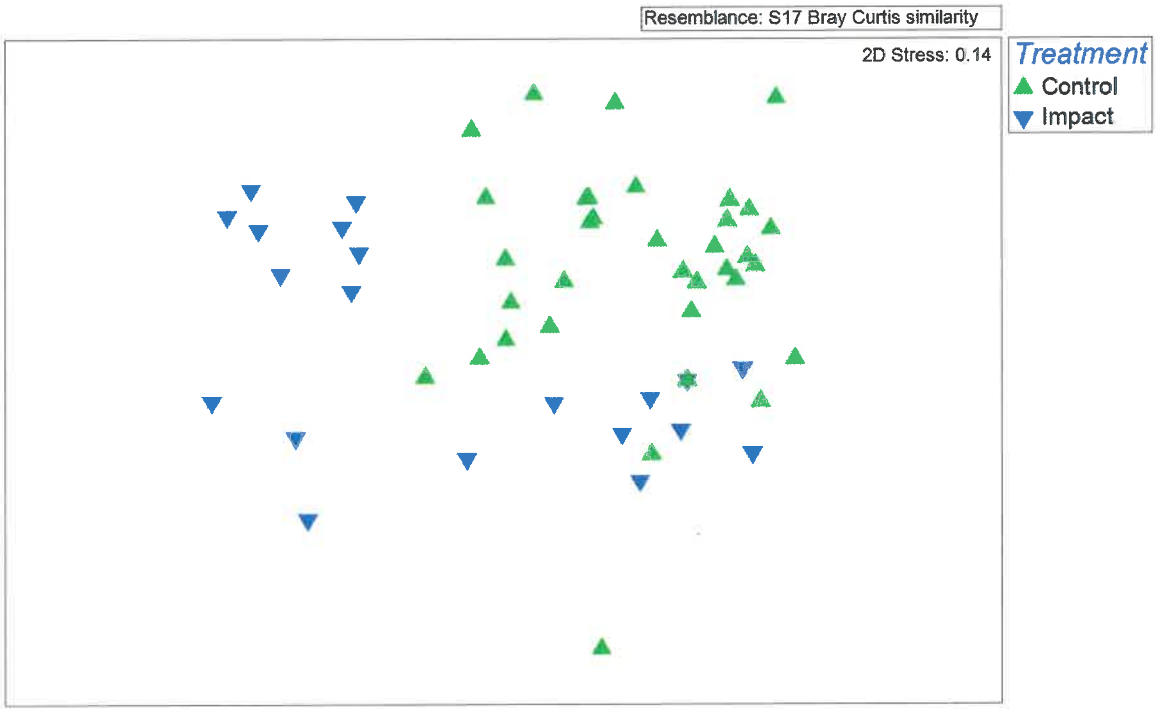

Figure 7. **Ordination plot comparing macrofauna species richness of photographic quadrats from control and impact reef survey sites.**

Given its location on the north-eastern edge of the ADZ Finfish precinct (Figure 2), the FF Baseline site is likely to experience some level of disturbance/deposition of organic matter from the shellfish infrastructure in the adjacent bivalve precinct and photo quadrats from this site are likely to be more similar to those from impact sites. This is supported by the MDS in Figure 8, in which finfish photo quadrats group out in between the quadrats from impact and control sites.

At the species level, the top taxa identified by SIMPER to contribute to the dissimilarity between control and impact sites included, the golden sea cucumber *Thyone aurea*, common feather star *Comanthus wahlbergii*, cape urchin *Parechinus angulosus*, ribbed mussel *Aulacomya ater*, fanworm polychaete, whelks *Burnupena sp.* and lacy false coral *Schizoretepora tessellata*. The average similarity was highest within control sites (54.85%), with a lower average similarity (29.64%) at Finfish baseline sites and the lowest similarity was observed within Impact sites at only 23.97%.

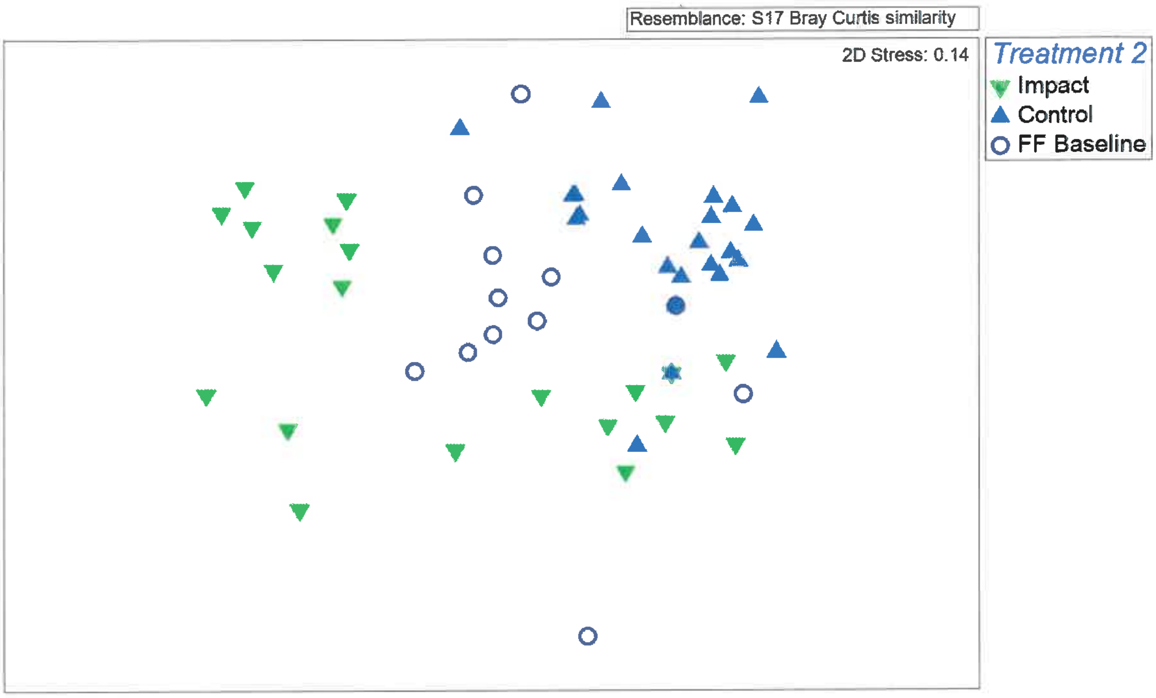

Figure 8. **Ordination plot comparing macrofauna species richness of photographic quadrats from control, Finfish baseline and impact reef survey sites.**

Multivariate dispersion tests showed that the presence of aquaculture operations (impact sites) and close proximity to aquaculture (FF baseline) increased the variability in macrofaunal photo quadrat assemblages relative to areas without aquaculture operations (control sites, Table 1). Suggesting that the disturbance as a result of aquaculture increases the species diversity at sites within the ADZ.

Table 2. **Summary statistics for multivariate dispersion tests showing average variability (+ SE) of macrofaunal communities, based on presence/absence species data, between control and impact reef sites.**

PERMDISP				
Macrofaunal Species composition				
Treatment	**Site**	**Sample size**	**Average dispersion**	**Standard Error**
Baseline	FF1	12	47.668	3.1932
Impact	I2	10	30.876	4.0264
Impact	I3	13	45.466	4.0987
Control	C1	14	24.434	3.7204
Control	C2	11	18.34	2.7564
Control	C3	10	32.602	2.8192

The patterns seen in species composition of video transects are similar to that of the photographic quadrats, however, the finfish baseline transects cluster closer to the impact sites than the control sites (Figure 9).

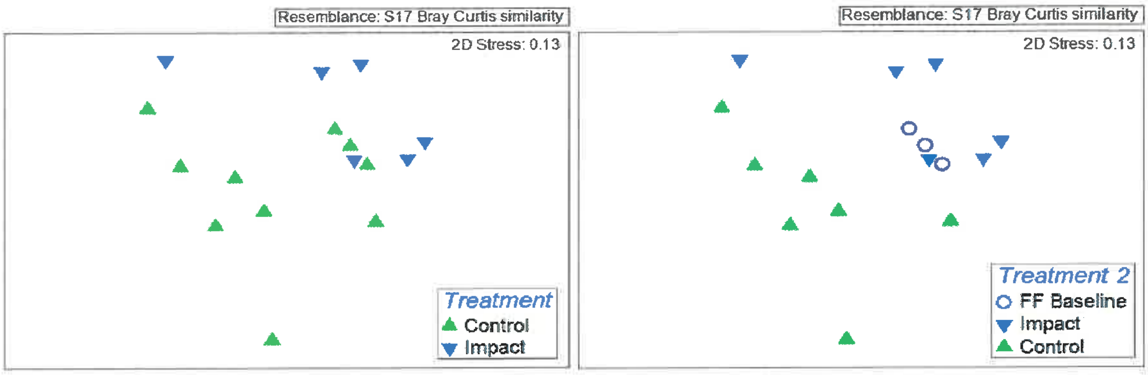

Figure 9. **Ordination plot comparing macrofauna species richness of video footage from control and impact reef survey sites (left) and control, Finfish baseline and impact reef survey sites (right).**

Species counts for both photographic data and video data of Control, Impact and Baseline sites within Big Bay were calculated and are shown in Table 3. Given that the photo quadrat covers an area of only 0.04 m^2, while the video footage covers an estimated area of 5 m^2 is not unexpected that the average number of species per quadrat was lower than the average number of species per video transect. Interestingly, average values at impact sites are consistently higher (more species diversity) than at Control sites.

Table 3. **Species counts for Control and Impact sites within Big Bay. Spp = Species.**

Treatment	Treatment 2	Site	Average		Total species/site		
			Spp/quadrat	Spp/video	Photos only	Videos only	Photos & videos
Impact	Impact	I2	2	8	10	16	19
Impact	Impact	I3	6	18	26	29	35
Average at Impact sites			**4**	**13**	**18**	**23**	**27**
Control	Control	C1	3	6	13	11	18
Control	Control	C2	5	13	10	13	15
Control	Control	C3	3	6	8	10	12
Average at Control sites			**3**	**8**	**10**	**11**	**15**
Baseline	FF Baseline	FF1	6	16	27	23	30

This pattern of increased diversity is consistent with the ecological theory of disturbance on the diversity of tropical reefs (Connell 1978, Huges 1989, Wilkinson 1999). The Intermediate Disturbance Hypothesis predicts a peak in diversity at intermediate levels of disturbance, dropping down at both low and high disturbance pressure due to competition and extreme disturbance conditions (Figure 10).

The effects of disturbance have frequently been explained using the Intermediate Disturbance Hypothesis (IDH, Grime 1973a,b, Connell 1978, Wilkinson 1999) which proposes that diversity peaks at intermediate levels of disturbance (Shea et al. 2004). At low disturbance pressure, dominant species i.e. the golden sea cucumber and common feather star, outcompete sub-dominant species and prevent their co-existence. At high disturbance pressure, all except a few resilient species with high colonization rates are lost. Conversely, intermediate disturbance pressure removes/reduces the abundance of dominant species that cause competitive exclusion and allows for the co-existence and survival of rare/sub-dominant species in the community, i.e, coral and false coral species found in the impact sites. Intermediate intensities of disturbance can also enhance spatial heterogeneity created by patches of different successional communities, enabling early- and late-stage communities to coexist (Connell 1978, Levinton & Stewart 1982, Kelaher et al. 2003).

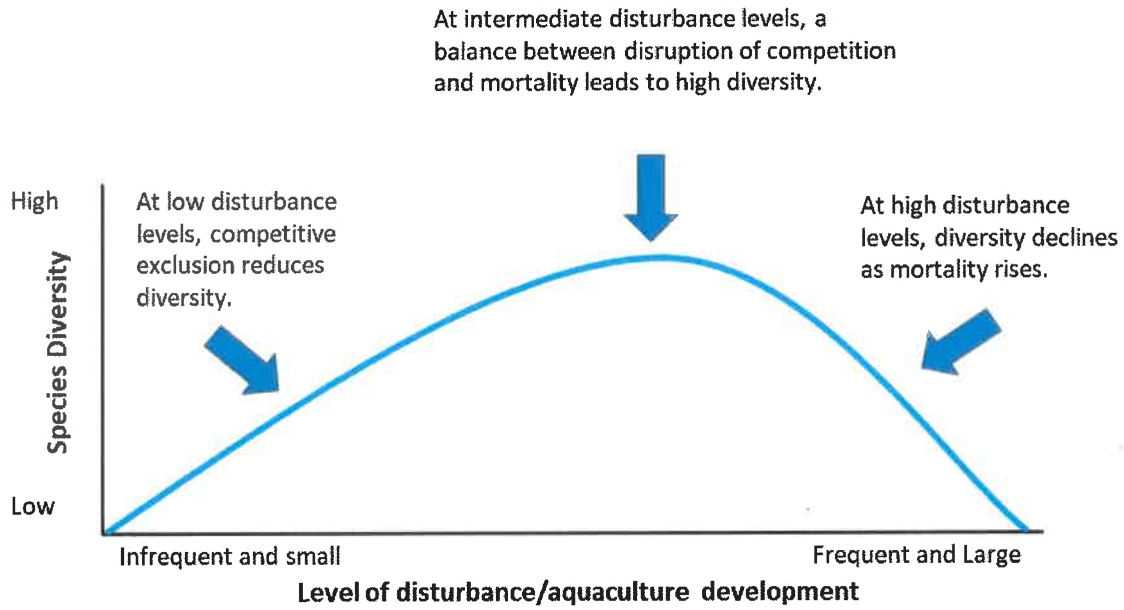

Figure 10. **Graphical representation of the Intermediate Disturbance Hypothesis.**

4 CONCLUSIONS & RECOMMENDATIONS

Based on the analyses of the existing bathymetry survey data and the reef survey data the following key findings and recommendations are made:

1. Based on available bathymetry data there is approximately 5 047 890.99 m^2 of reef within Big Bay, 29.2% of this reef area falls within the boundaries of the ADZ precinct, i.e. 6.3% of the total Big Bay reef area is found in the finfish precinct and 22.9% in the Bivalve precinct. The majority of the sea floor below the designated Finfish area is covered by reef (~79.9%), while 31.4% of the designated bivalve area consists of hard substrate, this is concentrated in the SW of the section.
2. Due to the fact that the Big Bay ADZ precinct was not surveyed in the recent SANHO data, historical data which appears to have a slightly reduced reef extent as compared to the SANHO data, was used to calculate the reef area and estimates are likely conservative.
3. Confirming the current day reef extent with higher confidence will require a similar resolution bathymetry survey of the ADZ precinct to be conducted in order to tie in with the 2020/2021 SANHO data.
4. The high proportion of reef in the finfish precinct is cause for concern, as finfish aquaculture is known to have a higher impact on the sea floor than bivalve aquaculture. It is therefore suggested that no Finfish aquaculture be undertaken at this site and that the Finfish sites in Outer Bay be utilized.
5. The ability to identify species in both the photographic quadrats and the video footage was dependent on the water visibility. Higher levels of uncertainty occur with higher levels of turbidity. It is suggested that all future survey data be collected on a single day to ensure standardised photo and video quality.
6. Multivariate and univariate data show that the community composition of Control and Impact reef sites differ significantly. Additionally, the benthic community structure at the Baseline reef site, located within the unused Finfish precinct, is more similar to that of impacted reef sites located within the Shellfish ADZ precinct. This suggests that the proximity of this site to the bivalve aquaculture has caused some level of disturbance/alteration of benthic conditions.
7. Community diversity at the Impacted reef sites is higher than at the Control sites, suggesting that at the present level of aquaculture development there is a balance between disruption of competition and mortality as a result of disturbance.
8. The intermediate disturbance hypothesis states that there is a tipping point at which the mortality as a result of disturbance is greater than the benefit of reduced competition. This point has not yet been reached in the Big Bay ADZ, but continuous monitoring of the reef fauna at Control and Impact sites is required to ensure early warning of this point being reached.
9. The use of photograph quadrats informs the identification of video footage and provides better imagery of accurate species identification. However, video transects consistently record higher species diversity, and mobile species such as the economically important west coast rock lobster, which are not often captured in photographs as they retreat when the quadrat is initially dropped, were better represented in video footage. Additionally, video footage provides a more accurate indication of the reef profile.
10. It is suggested that future surveys should include both video and photographic data and that the possible addition of lobster counts be included to monitor the population status of this

commercially important species. Should diving conditions allow, it would be desirable for future analysis to include quantitative abundance or percentage cover data.

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6 APPENDIX: Reef species list

Table 4. Species list for control and impact reef sites surveyed in Big Bay, Saldanha Bay.

Group	Scientific name	Common name
Actiniaria	*Bunodactis reynaudi*	Sandy anenome
Anomura		Hermit crab
Ascidiacea	*Pyura stolonifera*	Red Bait
	Ciona intestinalis	Transparnet acsidian
	Styela angularis	Angular ascidian
	Botrylloides leachi	Ladder ascidians
Asteroidea	*Henricia ornata*	Reticulated starfish
	Marthasterias africana	Spiny starfish
	Patiria granifera	Red starfish
Bivalvia	*Aulacomya ater*	Ribbed mussel
	Mytilus galloprvincialis	Black mussel
Brachyura	*Platydromia (Cryptodromiopsis) spongiosa*	Cryptic sponge crab
Bryozoan	*Alcyonidium nodosum*	Nodular Bryozoan
	Cellepora cylindriformis	Cylindrical false coral
	Chaperia sp	Scrolled false coral (yellow/orange)
	Gigantopora polymorpha	Staghorn false coral
	laminopora bimunita	Pore-plated false coral (purple-brown)
	Alcyonidium rhomboidale	Soft False coral
	Schizoretepora tessellata	Lacy false coral
Crinoidea	*Comanthus wahlbergii*	Common feather star
	Tropiometra carinata	Elegant feather star
Cirripedia	*Notomegabalanis*	Barnacles
Echinoidea	*Parechinus angulosus*	Cape urchin
Gastropoda	*Africofusus ocelliferus*	Long-siphoned whelk
	Argobuccinum pustulosum	Pustular Triton
	Burnupena sp	Whelk
	Bullia annulata	Annulated plough shell
	Bullia digitalis	Finger plough shell
	Clionella sinuata	Ribbed turrid
	Nassarius	Dogwhelk
Holothuriodea	*Thyone aurea*	Golden sea cucumber
	Pentacta doliolum	Mauve sea cucumber
Malacostraca	*Jasus lalandii*	West Coast rock lobster
	Palaemon pacificus	Sand shrimp
Opisthobranchia	*Polycera capensis*	Crowned Nudibranch
Pennatulacea	*Virglaria Schultzei*	Feathery sea pen
Phaeophyta	*Colpomenia sinuosa*	Oyster thief
Polychaeta		Fanworm polychaete
	Gunnarea capensis	Cape reef worm
		Tangle worm polychaete
	Spirorbis sp	Spiral fanworms
Porifera	Haliclona sp	Sponge (Blue grey turrets)
	Haplosclerida	Crusting White
	Leucosolenia sp	Sponge (White turrets)
		Orange crusting sponge
	Poeciloscerida	Orange upright sponge
	Tetractinellida	Golf ball/hard round
	Homoscleromorph?	Soft tearing sponge

Group	Scientific name	Common name
	Callyspongia	Tall turret sponge
	Calcarea	yellow sponge
Scleractinia	*Allopora noblis*	Noble coral
Fish		Klipvis
		Pipefish

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