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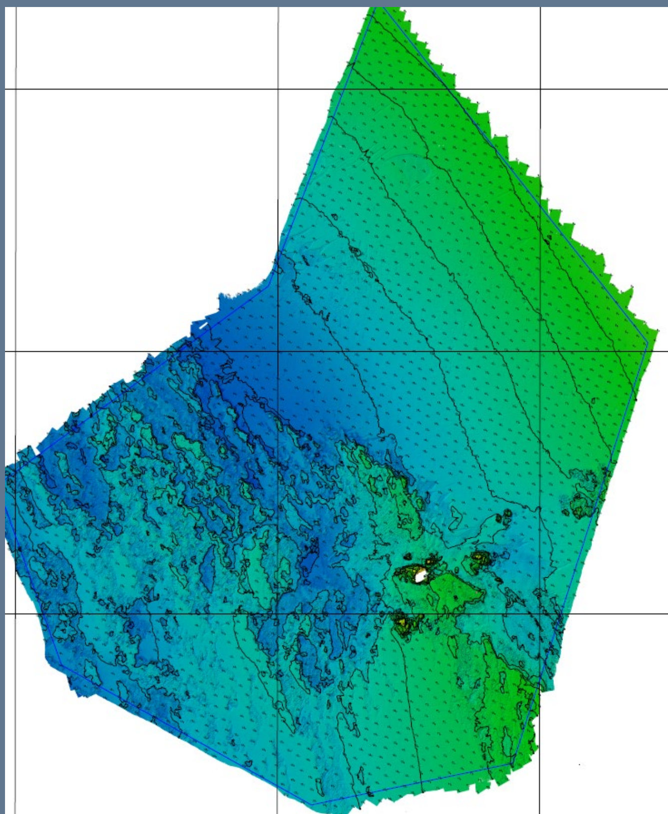
REPUBLIC OF SOUTH AFRICA

SALDANHA BAY AQUACULTURE DEVELOPMENT ZONE ENVIRONMENTAL MONITORING

BATHYMETRIC SURVEY



2024

ANCHOR environmental

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Cover photo: Underwater Survey Multibeam Data

SALDANHA BAY AQUACULTURE DEVELOPMENT ZONE ENVIRONMENTAL MONITORING

BATHYMETRIC SURVEY REPORT

2024

Report prepared for:

Department of Forestry, Fisheries and the Environment

by:

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EXECUTIVE SUMMARY

To comply with the Environmental Authorization (EA) and Environmental Management Programme (EMPr) for the Saldanha Bay Aquaculture Development Zone (ADZ), ongoing independent environmental monitoring is undertaken. The baseline and subsequent environmental monitoring surveys conducted since 2019 identified the presence of exposed reef patches within Big Bay, particularly in the finfish precinct of the ADZ. The reef structure was described as being predominantly low-profile (<1 m in height) and it was proposed that the extent of rocky substratum in Big Bay is likely much greater than initially estimated. These findings emphasized the need to understand the full extent of the calcrete reef platform and its potential vulnerability to current and future aquaculture activities.

Available bathymetry information derived from 1977 side-scan sonar data shows the presence of a calcrete abrasion platform over the central portion of Big Bay. Preliminary, updated side-scan sonar data was also collected in Big Bay by the South African Navy Hydrographic Office (SANHO) in 2020. However, very little of the ADZ precinct was surveyed, leaving a significant gap in the updated bathymetry data. To address this gap in the SANHO data, the current Environmental Monitoring contract specified the requirement of a bathymetry survey and habitat mapping exercise to delineate the full extent of the calcrete platform within the Big Bay ADZ precinct. Further to this, permission to use the SANHO data was subsequently withdrawn by the South African National Hydrographer, and the data is no longer available for use. Therefore, this report makes use of newly collected multibeam bathymetry data from the Big Bay ADZ precinct and the image based on historical side-scan data that was presented in Flemming (2015).

The 2024 multibeam data provides a comprehensive understanding of the habitat within the ADZ precinct, allowing for informed decision-making regarding monitoring methods and management strategies to mitigate potential impacts from aquaculture activities on hard substratum habitats. The 2024 survey confirmed that the earlier analysis of Flemming (1977) was still valid and that reef habitat within the Big Bay ADZ precinct was indeed extensive.

There was good agreement of the extent of reef habitat within the ADZ precinct between the two data sources, with slightly lower estimates for the recent data likely a result of survey tools and processing rather than significant change over time. This allowed for measurement of the proportion of total Big Bay reef habitat within the ADZ precinct, as well as the proportion of the sea floor that is reef within the shellfish only area and the Molapong site (designated finfish area). Measurements made on the georeferenced image made using 1977 side-scan sonar data and from processed 2024 multibeam echo sounder data indicate that 26.2-29.5% of the total Big Bay reef area falls within the boundaries of the Big Bay ADZ precinct. Of the total Big Bay reef area 5.3-6.1% is found within the Molapong site and 20.9-23.4% in the remaining shellfish area. The majority of the sea floor below the Molapong site is covered by reef (64.3-74.4%), while 27.5-30.7% of the remaining designated shellfish area consists of hard substrate.

Potential impacts of finfish cage culture above reef habitat largely relate to the deposition of organic material (mainly faeces, uneaten food and biofouling) are well documented in the literature. Given the high potential impact of finfish cage culture on reef habitat, the high proportion of the finfish area (Molapong site) sea floor that is reef (64.3-74.4%) and the fact that this represent 5.3-6.1% of the total reef habitat within Big Bay, we reiterate the recommendation of previous studies (Dawson et al 2022), that no finfish aquaculture be undertaken at this site and that the finfish sites in Outer Bay be utilized.

The extent to which these potential impacts of bivalve farming on reef habitat may be occurring in the Big Bay precinct are, however, not well understood. Research in Saldanha Bay has demonstrated negative impacts on sediment quality and macrofaunal communities consistent with organic enrichment directly below mussel rafts in Small Bay that have been in production for several decades. Internationally many studies have focused on the role of bivalve biodeposition in changes to the benthos. These largely report that impacts are localised and negligible by comparison to other aquaculture activities, such as finfish cages. Big Bay is also more exposed and therefore better flushed than Small Bay and organic enrichment of benthic habitats does not appear to be taking place at current production levels. Indeed, the first hard substratum ecological survey found functioning reef communities and higher diversity at impact sites compared to control sites (Dawson et al 2022).

Despite the apparent low benthic impacts of shellfish farming on reefs at current production levels, it must however be noted that approximately 31.1-35.0% of all the reef habitat in Big Bay lies within the Big Bay ADZ area. Pending further ecological monitoring results, we recommend that a cautious approach is adopted to any increases in production in the Big Bay shellfish precinct. New infrastructure should preferably be installed over soft substrata (the northeastern part of the precinct) and any mooring block movements in the reef area should be carefully conducted using lifting equipment (crane or air bags) and should not be dragged on the sea floor. Good maintenance (regular inspection and cleaning) of mariculture infrastructure to prevent sinking and subsequent scouring of reef habitat is also a recommended mitigation measure.

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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 sea floor/lagoon bottom.

Biodiversity: The variety of plant and animal life in a particular habitat.

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)

Macrobenthos/macrofauna: Those animals retained by a 1.0-mm-mesh sieve. Macrobenthic invertebrates are defined as organisms that live on or inside the deposit at the bottom of a water body.

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.

LIST OF ABBREVIATIONS

ARM	Anchor Research and Monitoring
ADZ	Aquaculture Development Zone
ASCII	American Standard Code for Information Interchange
CD	Chart Datum
CRP	Centre Reference Point
COG	Centre of Gravity
(Auto)CAD	Computer Aided Design
DFFE	Department of Forestry, Fisheries and the Environment
DTM	Digital Terrain Models
EA	Environmental Authorisation
EMP	Environmental Management Plan
GNSS	Global Navigational Satellite System
GPS	Global Positioning System
INS	Inertial Navigation System
MBES	Multibeam Echo Sounder
MPA	Marine Protected Area
PPK	Post-Processed Kinematic
RTK	Real-Time Kinematic Positioning System
SANHO	South African Navy Hydrographic Office
UTM	Universal Transverse Mercator
WGS 8	World Geodetic System 1984

1 INTRODUCTION

1.1 Background

An Aquaculture Development Zone (ADZ) is a designated area identified for its suitability for specific aquaculture activities. ADZs are designed to encourage investment by providing pre-approved platforms with strategic environmental authorizations and management policies. These provisions enable commercial aquaculture operations to commence with reduced delays and complexities associated with conventional approval processes.

In the Saldanha Bay ADZ, effective management has been ensured through the involvement of independent specialists. The Fisheries Management Branch commissioned a Sampling Plan for the ADZ, which underwent rigorous review by local and international experts (DAFF, 2018). To comply with the Environmental Authorization (EA) and Environmental Management Plan (EMP), substantial efforts have been made, including dispersion modelling, baseline macrofauna and physicochemical surveys (2020), benthic macrofauna monitoring surveys (2021 & 2024), and annual benthic chemical surveys (2021–2024). The baseline survey identified the presence of exposed reef patches within Big Bay, particularly in the Molapong site (which is designated for both finfish and shellfish aquaculture). The reef structure was described as predominantly low-profile (<1 m in height) and intermittently covered by sand. However, notable outcrops exceeding 1 m in height were also reported (Mostert et al. 2020). It was further indicated that the extent of rocky substratum in Big Bay is likely much greater than initially estimated. This finding emphasizes the need to understand the full extent of the calcrete platform and its potential vulnerability to current and future aquaculture activities.

Available bathymetry information derived from 1977 side-scan sonar data shows the presence of a calcrete abrasion platform over the central portion of Big Bay (Flemming 2015). However, very little of the ADZ precinct was surveyed, leaving a significant gap in the updated bathymetry data. In 2022, the georeferenced Flemming image was used to determine the approximate area of reef within the Bay and the ADZ precinct. This analysis, from 2022, indicated that there is approximately 5. 048 km^2 of reef in Big Bay, of which 29.2% falls within the boundaries of the ADZ precinct. Calculations determined that ~6.3% of the total Big Bay reef area is found in the Molapong site and 22.9% in the remaining shellfish only precinct (Dawson et al 2022). It was calculated that the majority of the sea floor below the Molapong site (the only designated finfish and shellfish area) is covered by reef (~79.9%), while only 31.4% of the remaining shellfish only area consists of hard substrate, this concentrated in the South west of the section (2022). Dawson et al (2022) noted that confirming these estimates of reef would require a similar resolution bathymetry survey of the ADZ precinct to be conducted in order to tie in with the data used in their report.

Given these findings, a recommended update to the ADZ environmental monitoring program was proposed to include methods capable of evaluating aquaculture impacts on reef habitat type. Following this recommendation a hard substratum survey that utilized diver collected underwater video and still photographs at impact sites within, and control sites outside of the ADZ precinct was undertaken in 2022 (Dawson et al 2022). A total of 54 taxa were recorded in the survey of the reef habitat within and adjacent to the Big Bay precinct. These included numerous species of attached biota such as false corals, mussels, bryozoans, ascidians, sponges etc as well as mobile taxa such as sea cucumbers, urchins, whelks, rock lobsters and starfish (Dawson et al 2022). These communities are not found on the dominant soft sediment habitats within Saldanha Bay (Dawson et al 2022). Multivariate analysis indicated that there had been a shift in the community composition between Impact and Control reef sites, and that the community composition of the baseline site locations in the as yet undeveloped Finfish precinct (Molapong site) was more similar to that of Impact sites. Similar patterns were 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 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. While this is a common occurrence for communities experiencing low to medium levels of disturbance, at some higher threshold level of disturbance, negative community impacts will occur, suggesting that continued monitoring of the reef community is required. A repeat, hard substratum community monitoring survey of sites within the Big Bay ADZ precinct and control sites is scheduled for 2025.

1.2 RATIONALE FOR CURRENT SCOPE OF WORK

To address the data gap in the SANHO data used in previous reports, the current specialist environmental monitoring specified the requirement of a bathymetry survey and habitat mapping exercise to delineate the full extent of the calcrete platform within the Big Bay ADZ precinct. Further to this, permission to use the SANHO data has been withdrawn by the South African National Hydrographer and is no longer available for use. Therefore, this report makes use of newly collected multibeam bathymetry data from the Big Bay ADZ precinct and the image based on historical side-scan data that was presented in Flemming (2015). The 2024 multibeam data provides a comprehensive understanding of the habitat within the ADZ precinct, allowing for informed decision-making regarding monitoring methods and management strategies to mitigate potential impacts from aquaculture activities on hard substratum habitats. Comparison of the recent 2024 bathymetry data from the ADZ precinct with the historical side-scan data of the whole of Big Bay enhances the assessment of the potential mariculture impacts on reef habitat by providing information on the **scale** of the potential impacts relative to the total amount of reef habitat present in Big Bay. Further information on the **intensity** of potential mariculture impacts on reef habitats will be obtained from the second hard substratum monitoring survey scheduled for 2025.

This expanded scope of work in the Sampling Plan ensures that management strategies are evidence-based and tailored to preserve the ecological integrity of the ADZ, thereby supporting sustainable aquaculture development while minimizing environmental risks.

2 METHODS

2.1 EXISTING SIDE-SCAN DATA FOR BIG BAY PRECINCT (FLEMMING 2015)

The Environmental Impact Assessment (EIA) for the Saldanha Bay Aquaculture Development Zone (ADZ) initially identified subtidal reef habitat as scarce in the region, focusing on Lynch Blinder and North Bay Blinder as the only significant reef areas (Pulfrich, 2017). However, subsequent diver observations and surveys have suggested that this initial assessment underestimated the presence and extent of subtidal reef features, particularly in Big Bay.

During baseline surveys conducted by Capfish in 2019, divers reported encountering calcrete rock around sampling sites within the Big Bay precinct. Similarly, difficulties in obtaining sediment grab samples at several Big Bay stations during Anchor Research and Monitoring's (ARM) 2020 sediment surveys indicated the presence of hard substratum or reef structures in the area. Further in-situ observations by ARM divers while deploying water quality monitoring equipment and collecting benthic macrofauna samples also confirmed patches of hard substratum in various locations within the Big Bay precinct. A subsequent review revealed that an extensive calcrete abrasion platform exists across much of Big Bay. This platform, characterized by areas of exposed calcrete rock, was documented in earlier studies. Notably, side-scan sonar and seismic data collected in 1977 and supported by diver observations indicated the presence of seabed features such as rock outcrops on a calcrete abrasion platform (Flemming, 1977; Flemming, 2015). These findings suggest that the habitat type is more expansive and complex than initially recognized (Figure 1).

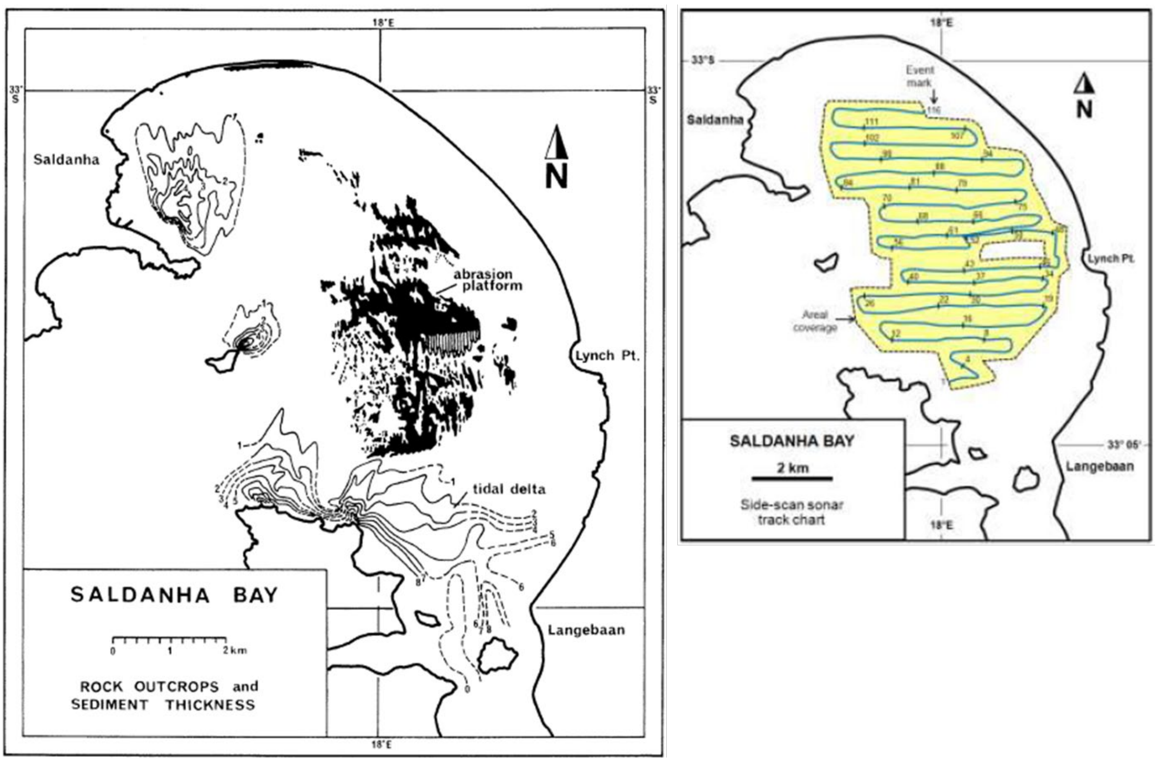


Figure 1. Location of rock outcrops on the abrasion platform (black, left) by the sides-scan sonar data of Saldanha Bay, taken following the track shown on the right (Source: Flemming 2015).

2.2 Underwater surveys Bathymetric Survey

Anchor Research and Monitoring (ARM) sub-contracted Underwater Survey to conduct a hydrographic survey of the Big Bay Precinct, in fulfilment of the scope of works outlined by the DFFE. The primary objective of this survey was to map the extent of the Calcrete platform and assess the reef habitat in the area. This involved a high-resolution multibeam sonar survey to capture bathymetric data. The area surveyed is shown in (Figure 2), covering ~ 409 Ha. The final deliverables included a complete survey report with detailed bathymetric charts, as well as hard and digital copies of all survey data in AutoCAD and PDF formats, along with digital point data in ASCII XYZ format.

Figure 2. Location diagram of multibeam survey extent for the Big Bay Precinct in Saldanha Bay.

2.2.1 SURVEY REQUIREMENTS

A list of equipment and software used is provided below (Table 1), this ensured that an ultra-high resolution focused multibeam echosounder with Real-Time Kinematic (RTK) GPS for positioning, integrated with motion correction sensors (roll, heave, pitch, and heading) could be used and effectively acquire the necessary data.

Table 1. Comprehensive list of equipment used in the bathymetric survey and associated software required to process the multibeam data.

Requirement	Instrument Used
Positioning (Ashore)	Leica 1200 RTK Base Station
Positioning (Ashore)	Leica 1200 RTK Rover
Positioning (Afloat)	SBG Ekinox RTK GPS Antenna 1
Motion Sensor	SBG Systems Ekinox-D INS
Navigation System	QPS Qinsy v9.6.5
Data Acquisition	QPS Qinsy v9.6.5
Sounding System	R2Sonic 2024 Multibeam System (Ultra High Resolution)
Sound Velocity Probe	Valeport SWiFT Sound Velocity Profiler
Sound Velocity Sensor	Valeport Mini SVS Sound Velocity Sensor
Power	220Vac from 1x2.0kVa Honda Generator, inverter and batteries
Software	
Processing / QC	QPS v9.6.5 QIMERA v2.6.2
Data Interpretation	QPS Qinsy v9.6.5 QIMERA v2.6.2
Charting	Bentley MicroStation

The hydrographic survey provided highly accurate depth measurements with a precision of ±0.1 m vertically and ±0.5 m horizontally. Real-time navigational control, online data logging, and post-processing capabilities were utilized to create Digital Terrain Models (DTM) and XYZ files. The survey strictly adhered to IHO S-44 standards (Edition 6.1, October 2022) for SPECIAL ORDER compliance (Figure 3). It is noted that the R2Sonic 2024 MBES system on this project met and exceeded IHO S-44 specifications for SPECIAL ORDER surveys, in terms of feature detection and bathymetric point data uncertainty.

Minimum Standards for Hydrographic Surveys
(To be read in conjunction with the full text set out in this document.)

Reference	Order	Special	1a	1b	2
Chapter 1	Description of areas.	Areas where under-keel clearance is critical	Areas shallower than 100 metres where under-keel clearance is less critical but *features* of concern to surface shipping may exist.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type þf surface shipping expected to transit the area.	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
Chapter 2	Maximum allowable THU 95% *Confidence level*	2 metres	5 metres + 5% of depth	5 metres + 5% of depth	20 metres + 10% of depth
Para 3.2 and note 1	Maximum allowable TVU 95% *Confidence level*	a = 0.25 metre b = 0.0075	a = 0.5 metre b = 0.013	a = 0.5 metre b = 0.013	a = 1.0 metre b = 0.023
Glossary and note 2	*Full Sea floor Search*	Required	Required	Not required	Not required
Para 2.1 Para 3.4 Para 3.5 and note 3	*Feature Detection*	Cubic *features* > 1 metre	Cubic *features* > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Not Applicable	Not Applicable
Para 3.6 and note 4	Recommended maximum Line Spacing	Not defined as *full sea floor search* is required	Not defined as *full sea floor search* is required	3 x average depth or 25 metres, whichever is greater For bathymetric lidar a spot spacing of 5 x 5 metres	4 x average depth
Chapter 2 and note 5	Positioning of fixed aids to navigation and topography significant to navigation. (95% *Confidence level*)	2 metres	2 metres	2 metres	5 metres
Chapter 2 and note 5	Positioning of the Coastline and topography less significant to navigation (95% *Confidence level*)	10 metres	20 metres	20 metres	20 metres
Chapter 2 and note 5	Mean position of floating aids to navigation (95% *Confidence level*)	10 metres	10 metres	10 metres	20 metres

Figure 3. International Hydrographic Organization Standards – S 44, this survey complied with Special Order requirements.

2.2.2 GEODETIC PARAMETERS

An RTK Base Station was established using survey control points with coordinates referenced to the Hartebeesthoek 1994 datum. The primary SBG Ekinox-D internal GPS was set up to transmit geographical coordinates to the Qinsy software via an Ethernet interface. During the survey, the Universal Transverse Mercator (UTM) projection, Zone 34S, with a Central Meridian of 21°E, was applied onboard through the Qinsy software. Unless specified otherwise, all coordinates related to the survey are reported using this projection (Table 2). The following spheroid and projection parameters were utilized:

Table 2. Working Datum & Projection Parameters

Working Spheroid	
Datum	Hartebeeshoek 94
Spheroid	WQS84
Semi-Major, a	6 378 137.0 m
Sem-Minor, b	6 356 752.3 m
Flattening, 1/f	298.25722
Working Projection	
Projection	Universal Transverse Mercator (UTM)
Zone	34 South
Latitude of Origin	0° 00' 00" N
Central Meridian	21° 00' 00" E
False Easting	500 000.00 m
False Northing	10 000 000.00 m
Scale Factor at CM	0.9996

As the Global Positioning System (GPS) and the survey datum are both referenced to the World Geodetic System 1984 (WGS 84) Datum, no datum transformations were required.

The survey was conducted using the Blue Dolphin, a 6.7m Butt-Cat catamaran ski-boat designed for survey operations (Figure 4). The vessel is road transportable and powered by twin Yamaha 70hp 4-stroke motors. It is equipped with a custom multibeam sonar pole mount, enabling accurate bathymetric data collection.

Figure 4. Blue Dolphin survey vessel used for this bathymetric survey and owned by Underwater Surveys.

2.2.3 Survey Preparation

Before the commencement of the survey, all equipment installed on the survey vessel was thoroughly checked and calibrated. Existing sensor offsets relative to the vessel's centre of gravity (COG) were previously established using a total station and verified through manual measurements. These offsets were rechecked prior to the survey to ensure accuracy in data collection. The results of the offset survey, including a vessel offset diagram can be found in the appended Underwater Surveys report (APPENDIX 1).

The primary positioning system for the survey utilized an SBG Systems Equinox-D Inertial Navigation System (INS) integrated with a Real-Time Kinematic (RTK) GNSS. The Leica System 1200 RTK GNSS base station, positioned at a known control point onshore (MYK 1), transmitted real-time RTK corrections to the survey vessel via a high-power radio data link. This system provides a horizontal and vertical accuracy of better than 3 cm at a 95% confidence level. Additionally, raw data from the INS and static GNSS base station were recorded and later processed using Post-Processed Kinematic (PPK) methods. This PPK data was used to enhance the motion compensation accuracy and fill gaps in RTK positioning during periods of signal dropout, particularly in areas with limited line-of-sight. Positioning and height control for the bathymetric survey were based on the RTK/PPK and GNSS system referenced to onshore control points established by Underwater Surveys. RTK verification checks were performed both before the survey began and at the end of each daily survey session to ensure measurement accuracy.

For navigation control, data acquisition, and processing, the QPS Qinsy software package was employed. The survey used Qinsy version 9.6.5 for real-time data acquisition and Qinsy version 9.5.4 for post-survey processing, along with QPS Qimera 2.6.2 for data quality control. The system operates using the WGS-84 geodetic datum, with real-time transformations to local datums as necessary. Continuous quality control checks monitored the positioning system components (e.g., GNSS, sonar, and heading) using online alerts. The data was logged to a hard drive and simultaneously displayed in a live digital terrain model (DTM), allowing the survey operator to monitor coverage and guide the vessel's navigation. A project-specific Qinsy template database was configured with appropriate geodetic parameters, vessel details, and system offsets to ensure proper sensor positioning and data collection.

2.2.4 Multibeam Bathymetric Survey

The multibeam bathymetric survey was conducted using an R2Sonic 2024 400 kHz multibeam sonar system. This system collects bathymetric soundings across the entire swath width as the vessel moves through the survey area. The swath width is determined by the water depth, and the data density depends on the line spacing. No specific line plan was followed, but adjacent swath tracks were overlapped to ensure full coverage of the survey area, with a final data grid resolution of 0.5 m x 0.5 m. Gaps in coverage were filled as necessary. The sonar head was mounted on a rigid stern pole, stabilized with a waterline bracket, and electrically isolated from the pole to avoid interference. Offsets from the acoustic centre of the sonar array to the vessel's centre reference point (CRP) were applied in the acquisition system to ensure precise data alignment. The sonar system was integrated with the navigation computer for precise time tagging of the data, with 1PPS timing provided by the SBG Ekinox-D internal GPS receiver. Before the survey commenced, a sound velocity cast was conducted using a Valeport SWiFT Sound Velocity Profiler to calibrate the speed of sound in the water column. This profile was entered into the acquisition system, where it was applied in real-time during the survey. Continuous comparisons between the real-time sound velocity sensor measurements and the initial sound velocity profile were performed to ensure accurate data collection throughout the survey.

2.3 Data Integration and Analysis

Given the withdrawal of the 2021–2022 SANHO survey data, the approach to accurately delineate the extent of the calcrete platform within Big Bay was adapted. This involved integrating the two available datasets, namely Flemming's Side-Scan Data from 1977 and Underwater Surveys Multibeam Data collected in 2024.

The Flemming side-scan data was overlaid with the multibeam data collected by Underwater Surveys to compare the relative extent of reef habitat within the ADZ precinct. This combined analysis enhanced the accuracy of identifying and characterizing the extent of the calcrete platform within the 409 ha area of the Big Bay ADZ precinct.

The bathymetry survey conducted in 2024 produced 17 million records of depth in the Big Bay ADZ precinct with a resolution (precision) of 0.5 m. These records were digitised to a point feature in ArcPro and pre-processed for use in spatial analyses. To reduce computational processing time due to the high resolution of the data, a generalised slope assessment was conducted. The slope tool uses a 3 x 3 window of cells to fit a plane to (nine) neighbouring cells. This generates a new raster with pixels of a range of values between zero and 90. The slope raster was then reclassified into pre-defined slope classes, and subsequently reprocessed to remove lesser slope values. The result was converted to a polygon feature class, isolated features smaller than 10 m^2 were eliminated, and features with gaps and sinks smaller than 20 m^2 were filled. To compare the rocky outcrop extent as defined by Flemming (1977) with the most recent targeted bathymetric survey, Flemming's figure (Figure 3.1 in Flemming 2015) was georeferenced and overlaid upon the newly created rock feature in ArcPro.

3 RESULTS AND DISCUSSION

3.1 Underwater Surveys Multibeam Results

3.1.1 Survey Results and Data Processing

The survey achieved full coverage of the designated area, with the exception of a pinnacle that remains above water even at high tide known as Lynch Blinder (Figure 5). The areas between the pinnacles were successfully surveyed during high tide, leveraging the higher water levels to obtain maximize coverage. Data collection involved careful navigation through rows of buoys used for bivalve cultivation. However, these buoys, along with the kelp growing on the pinnacles, introduced some noise into the bottom detection.

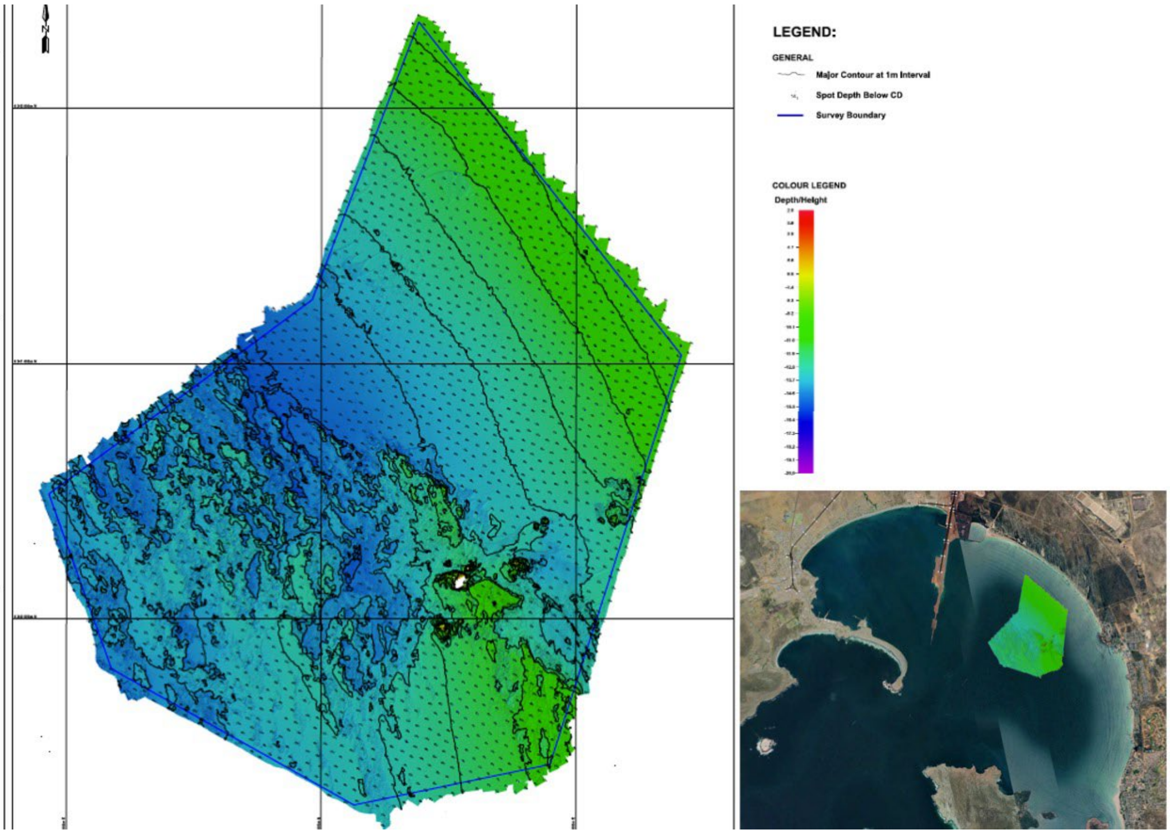


Figure 5. Multibeam survey data for the Big Bay Precinct and data overlayed onto a map of Saldanha Bay.

The Calcrete platform extends from the southern side of the survey area northward, reaching approximately the midpoint of the Big Bay Precinct area. One pinnacle from the platform breaches the water surface. To the north, the seabed gently slopes, transitioning from coarse to fine sediment composition.

3.1.2 Data Processing Procedures

Post-acquisition data processing and quality control (QC) were conducted at the Underwater Surveys offices in Cape Town. The processing workflow for the multibeam bathymetric data included the following steps:

1. SOFTWARE UTILIZED:

- QPS Qimera 2.6.2: Used for data cleaning, calibration, and quality assessment.
- QPS Qinsy v9.6.5: Utilized for final gridding and data output preparation.
- Bentley MicroStation: Employed for chart production.

2. BATHYMETRIC DATA PROCESSING:

- Final Patch Test calibration corrections and true heave observations were applied to all database files in Qimera.
- Various automated filtering and cleaning tools were used to remove suspect data, followed by manual cleaning to eliminate residual spikes.
- The Qimera Cross Check tool was employed to validate data quality by comparing the survey surface to cross-line data. The processed data met the **IHO S-44 Special Order** standards.

3. CHART DATUM ADJUSTMENTS:

- A vertical shift of -0.865 m was applied to all data to reference it to Chart Datum (CD). This adjustment was carried out in Qinsy's Sounding Grid utility.
- All gridded data, TIFF images, contours, and spot soundings were exported for charting purposes.
- An "All-Points" text file corrected to CD was exported from a Qimera dynamic surface (MSL height adjusted by -0.865 m).

4. CHARTING:

- The Bentley MicroStation package was used to create detailed charts. These were prepared at a scale appropriate for the survey area using exported data outputs, including TIFF files, spot soundings, and contour lines.

The final deliverables include fully processed bathymetric datasets, charts, and digital outputs, which provide a comprehensive depiction of the surveyed area (APPENDIX 1). These will be used to help inform the repeat reef community survey to be conducted in 2025.

3.2 Overlay and analysis of historical (1977) and recent 2024 Bathymetry data

Two sets of reef data have been calculated and compared; estimated area of reef based on the historical Flemming data and revised estimated reef area based on the 2024 Bathymetric survey data. Based on a georeferenced image from the Flemming (2015) paper that utilised the 1977 side-scan derived bathymetry data to depict the abrasion platform of calcrete reef in Big Bay, the total reef extent is approximately 4.833 km^2 (Figure 6). The small downwards revision of the total Big Bay reef area from the 5.048 km^2 reported by Dawson et al (2022) was due to updated software and further fine tuning of the image georeferencing.

Measurements made on the georeferenced image of Flemming's data indicate that 29.5% of this reef area falls within the boundaries of the Big Bay ADZ precinct, i.e., 6.1% of the total Big Bay reef area is found in the Molapong site (finfish precinct) and 23.4% in the remaining shellfish precinct (Table 3). The majority of the sea floor below the Molapong site is covered by reef (74.4%), while 30.7% of the remaining shellfish area consists of hard substrate, this is concentrated in the SW of the section (Figure 7).

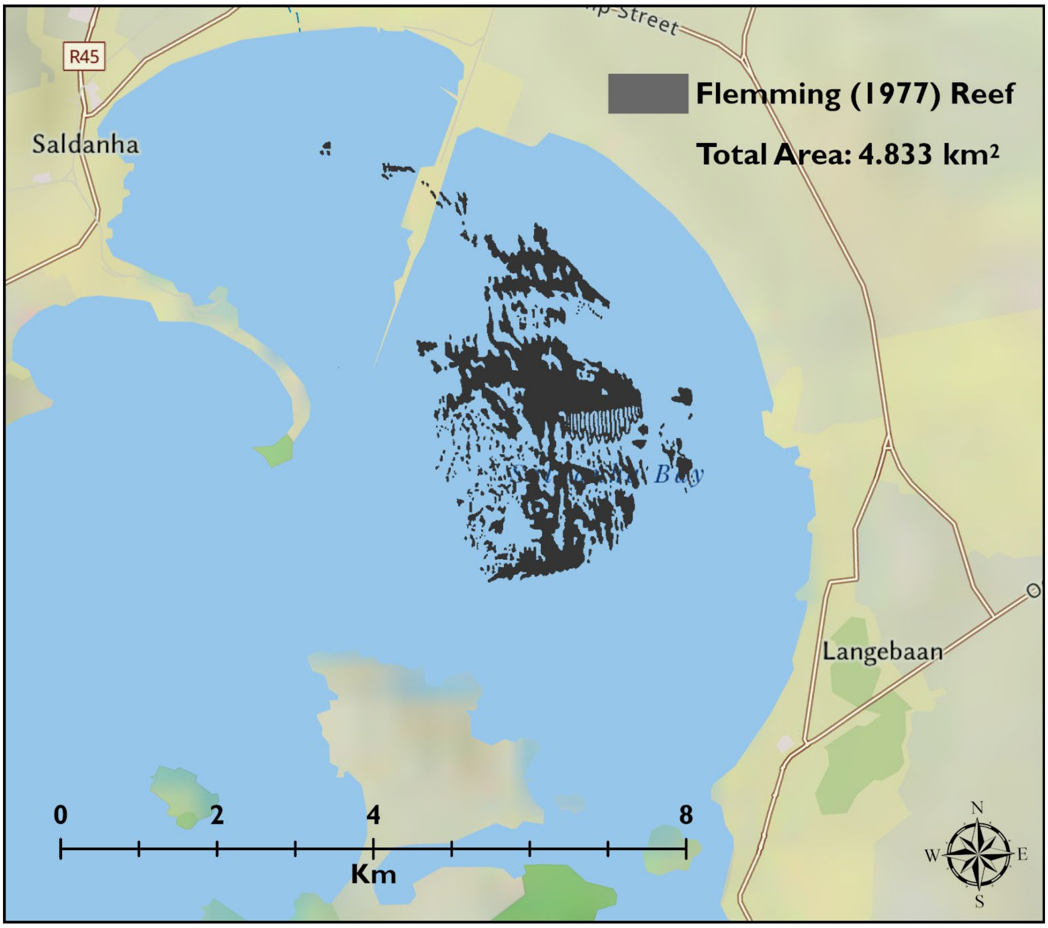


Figure 6. Rock outcrops (black) (Flemming 1977, 2015).

Based on the ArcPro slope analysis of the 2024 bathymetry data, reef habitat within the Big Bay ADZ precinct was delineated and overlaid on the georeferenced Flemming (1977, 2015) abrasion platform (Figure 7). There was good agreement of the extent of reef habitat within the ADZ precinct between the two data sources and this allowed for measurement of the proportion of total Big Bay reef habitat within the ADZ precinct, as well as the proportion of the sea floor that is reef within the Molapong site and the remaining shellfish area (Figure 7, Table 3, Figure 8).

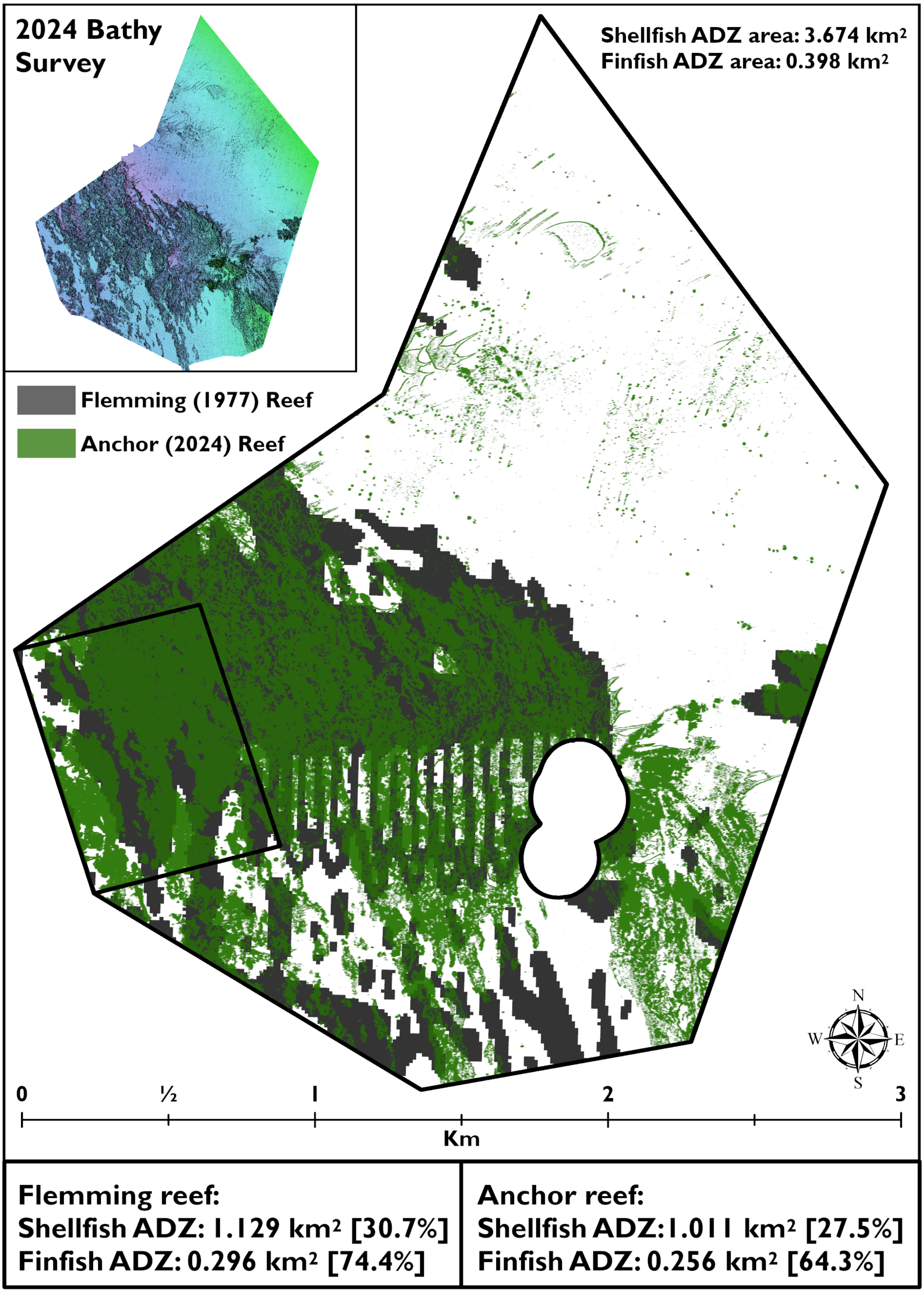
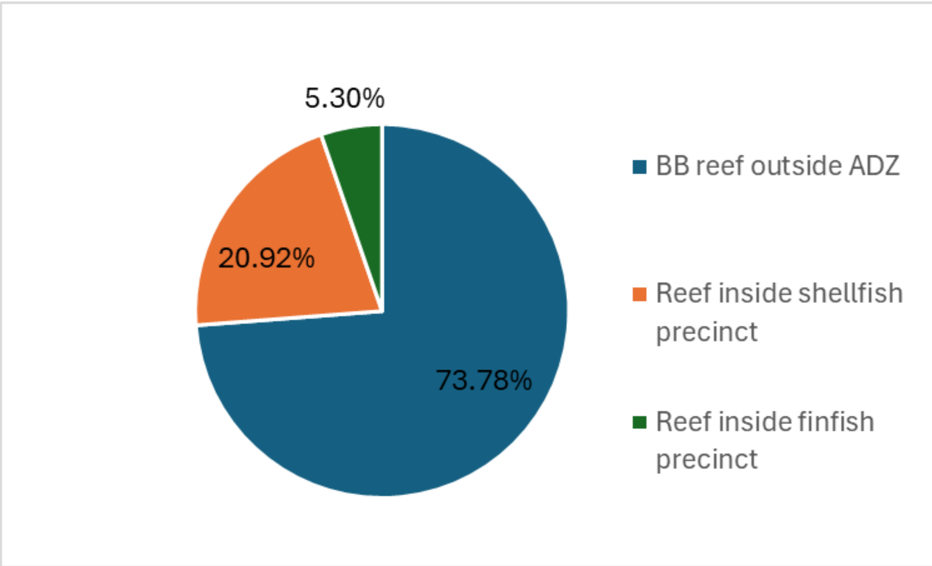


Figure 7. Comparison of rocky features identified by Flemming in 1977, and from the recent bathymetry survey conducted in 2024. Flemming's rocky extent is in grey, while the recent assessment is shown in dark green.

Table 3. Extent of reef habitat (km^2) within Big Bay and ADZ precinct as a proportion of the total reef habitat in Big Bay.

Measurement/ survey year	1977	2024
Total Reef habitat in Big Bay (km^2)	4.833	
Total reef in Big Bay ADZ precinct (km^2)	1.425	1.267
ADZ reef area as % of total reef in Big Bay (1977)	29.5	26.2
% total Big Bay reef habitat in shellfish area	23.4	20.9
% total Big Bay reef habitat in finfish area	6.1	5.3
% of Big Bay ADZ precinct that is reef	35.0	31.1
% of finfish area that is reef	74.4	64.3
% Shellfish area that is reef	30.7	27.5



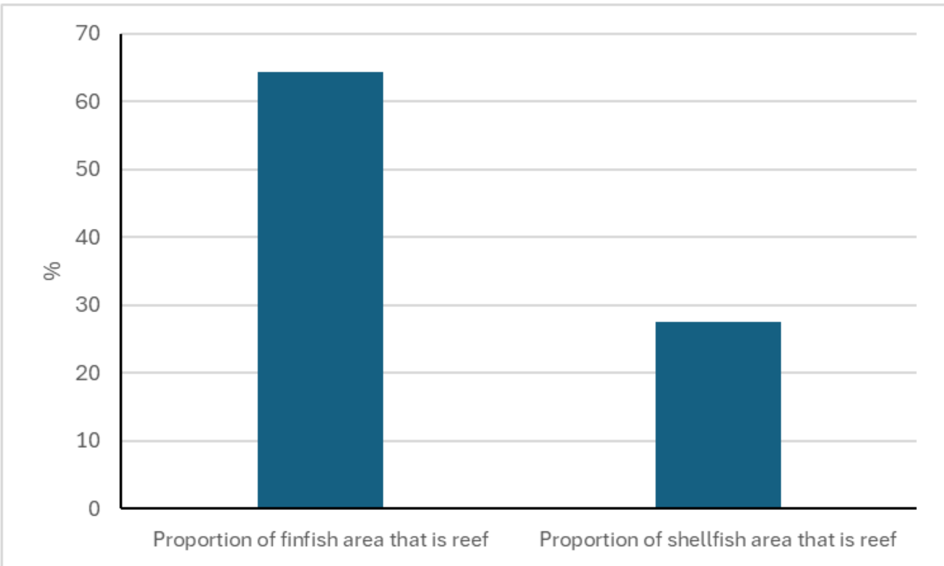


Figure 8. Graphical representation extent of reef habitat within the Big Bay ADZ precincts relative to the total reef habitat (top), as well as the proportion of the finfish and shellfish areas that are reef substratum (bottom).

The high resolution of the 2024 bathymetric data and the high degree of agreement between the data sets evident from the ArcPro analysis confirms that the estimates of reef extent within the Big Bay ADZ by Dawson et al (2022) were realistic. Potential impacts of finfish cage culture above reef habitat largely relate to the deposition of organic material (mainly faeces, uneaten food and biofouling) are well documented in the literature (Staniford 2002, Bannister et al 2016). The initial reef habitat survey revealed a rich epifaunal community including the presence of commercially important west coast rock lobster on the Big Bay reef (Dawson et al 2022). Given the high potential impact of finfish cage culture on reef habitat, the high proportion of the designated finfish area sea floor that is reef (64.3-74.4%) and the fact that this represent 5.3-6.1% of the total reef habitat within Big Bay, we reiterate the recommendation of Dawson et al (2022) that no Finfish aquaculture be undertaken at this site and that the Finfish sites in Outer Bay be utilized. This site is also licensed for the long-line culture of bivalves, the potential impacts of which are briefly discussed below.

The potential impacts of bivalve culture on benthic habitat include those listed by Pulfrich (2017) and others:

- The filter-feeding action of bivalves may result in the benthic sedimentation of organic-rich waste products and the deposition of shells and other fouling biota beneath the mariculture structures during cleaning of infrastructure.

- Accumulation of organic matter and associated changes in physico-chemical properties can create suboptimal conditions within the sediment matrix that can result in changes in the abundance and diversity of benthic micro- and macrobiota.

- Direct effects on the seabed from shellfish farms could, under certain conditions, arise through shading from farm structures, potentially reducing the amount of light reaching the sea floor, with implications for the growth, productivity, survival and depth distribution of ecologically important primary producers (Everett et al. 1995; Huxham et al. 2006).

- Shellfish farm infrastructure could alter hydrodynamics and reduce flow rates and alter current velocities at the farm level.

- Physical damage due to the placement of anchors, mooring blocks and chains on the sea floor and physical damage should infrastructure sink due to poor maintenance.

The extent to which these potential impacts of bivalve farming on reef habitat may be occurring in the Big Bay precinct are, however, not well understood. Research in Saldanha Bay has demonstrated negative impacts on sediment quality and macrofaunal communities consistent with organic enrichment directly below mussel rafts in Small Bay that have been in production for several decades (Stenton-Dozy et al. 2001, Probyn et al 2023). However, since the inception of the ADZ monitoring of both sediment quality and benthic macrofaunal communities inhabiting soft sediments in Big Bay (where Longline culture methods rather than rafts are used), have not detected organic enrichment or significant effects on the macrobenthic communities at impact sites compared to control sites (Dawson et al 2024 $_{a,\,b}$). Many studies have focused on the role of bivalve biodeposition in changes to the benthos. These largely report that impacts are localised and negligible by comparison to other aquaculture activities, such as finfish cages (Forrest et al. 2009). Known as extractive species, the feeding habits of bivalves actually remove waste materials from the water column and generally have a positive influence of the water quality of the surrounding system (National Research Council 2010, FAO 2018).

Mussel farms currently dispose of all fouling material debris into the sea, which results in deposition of fouling material on the benthos within the vicinity of the farm, and this could potentially have significant impacts on affected reefs. Big Bay is however, more exposed and therefore better flushed than Small Bay and organic enrichment of benthic habitats does not appear to be taking place at current production levels (Dawson et al 2024 a, b). The first hard substratum ecological survey found functioning reef communities and higher diversity at impact sites compared to control sites (Dawson et al 2022). This was thought to possibly be a result of intermediate levels of disturbance promoting development of a diverse community. Recent research in the UK demonstrated that the development of mussel longline farming actually facilitated the recovery of reef biota in heavily trawled habitat (Stamp et al 2024). Anchor Research and Monitoring (ARM) scientific divers have, however, also documented the scouring impact of sunken mussel lines on reef habitat in Big Bay where all epifauna was removed from the impacted reef. The recovery of this area, after the removal of sunken lines, will be very slow, as reef communities tend to be long lived, slow growing species. An improved understanding of the intensity of bivalve culture impacts on reef habitats in Big Bay will be developed with ongoing ecological reef surveys (next one scheduled for 2025).

Despite the apparent low benthic impacts of shellfish farming at current production levels, it must however be noted that approximately 20% of all the reef habitat in Big Bay lies within the ADZ shellfish area and a further 5% within the Finfish area where bivalve culture is also permitted. Pending further ecological monitoring results, we recommend that a cautious approach is adopted to any increases in production in the Big Bay shellfish precinct. New infrastructure should preferably be installed over soft substrata (the northeastern part of the precinct) and any mooring block movements in the reef area should be carefully conducted using lifting equipment (crane or air bags) and should not be dragged on the sea floor. Good maintenance (regular inspection and cleaning) of mariculture infrastructure to prevent sinking and subsequent scouring of reef habitat is also a recommended mitigation measure.

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5 APPENDIX 1

UNDERWATER SURVEY MBES REPORT

MULTIBEAM BATHYMETRIC SURVEY

BIG BAY PRECINCT OF THE SALDANHA ADZ

SURVEY OPERATIONS & RESULTS REPORT

Underwater Surveys (Pty) Ltd

Anchor Environmental Consultants (Pty) Ltd

(Project No.: 24-063)

(LOA dated 13/05/2024)

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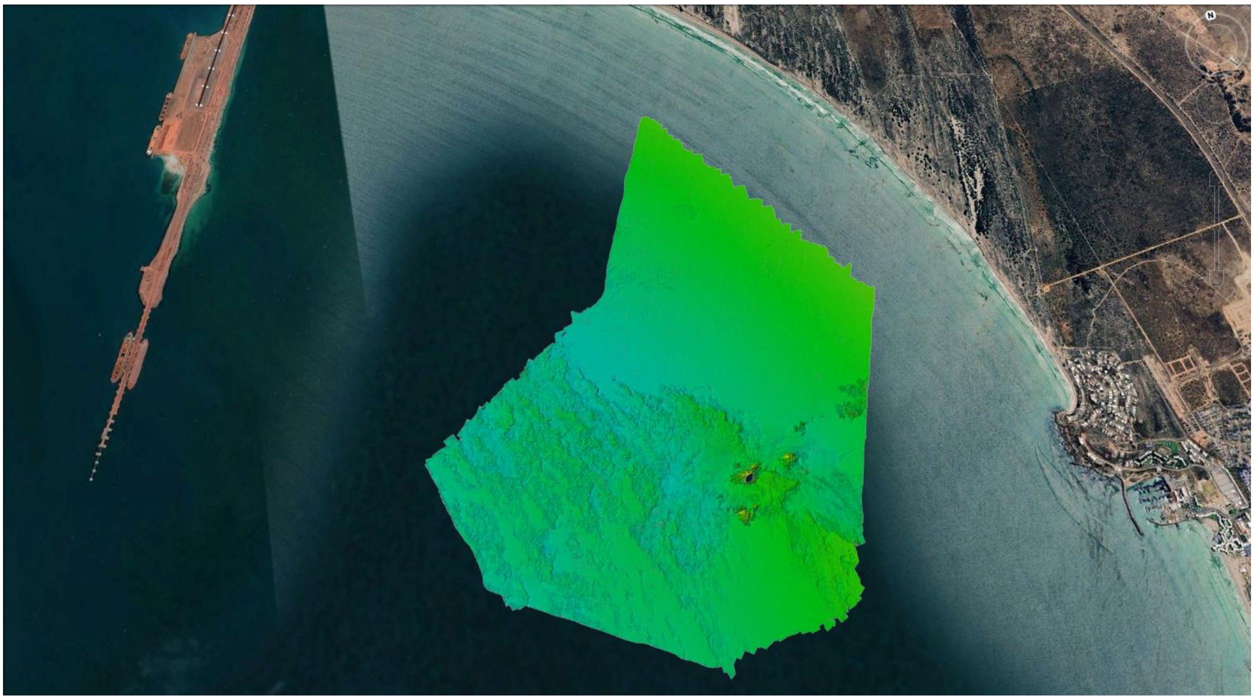
MULTIBEAM BATHYMETRIC SURVEY



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(LOA dated 13/05/2024)

REVISION LOG

1	11 Oct 2024	DRAFT report issued for Client comment.	RK	AJM	PV	-
0	20 Sep 2024	DRAFT report issued for review / QC.	RK	AJM	PV	-
Rev	**Date**	**Reason for Issue**	**ORIG**	**CHK**	**APP**	**APP**
			Underwater Surveys			**AEC**

SUMMARY OF SITE CONDITIONS

ORIGINAL SURVEY AREA – BIG BAY PRECINCT SALDANHA:

APPROXIMATE CENTRE OF SURVEY AREA

GRID (UTM Zone 33S)

Easting = 221318.69m Northing = 6340502.26m

GEOGRAPHIC (WGS84)

Lat = 033° 02’ 18.080” S Long = 018° 00’ 57.690” E

BATHYMETRY (reduced to Chart Datum - CD)

A total of 112 362 612 soundings passed validation checks to make up the 0.5m x 0.5m grid of the Big Bay Precinct Saldanha survey area. The MSL data from the survey were adjusted to the Chart Datum by reducing the depth with a -0.865m CD correction.

Minimum depth in survey area:	2.520 meters below CD
Maximum depth in survey area:	16.533 meters below CD

SEABED HAZARDS AT THE LOCATION

The survey area includes a reef structure with a prominent pinnacle that breaks water at high tide. The pinnacle is situated approximately midway on the South to North direction and East of centre in the survey area. The Northern region of the survey area is in the shelter of Paradise Beach. Within this area there are buoys/markers on which the Bivalve farm is grown. The rows of buoys run approximately perpendicular to the shoreline direction.

CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

CHARTING INDEX

No.	Drawing Number	Drawing Title	Sheet	Scale	Rev.
1	24063_BB ADZ Precincts_Bat_01	Multibeam Bathymetric Survey Big Bay Precinct of the Saldanha ADZ for Habitat Assessment	1	1:5000	01

NOTE: All charts are plotted on A1 paper size at the scale specified above.

DEFINITIONS

The following terms and definitions are used throughout this document:

Client:	Anchor Environmental Consultants Hereinafter called AEC
Survey Contractor:	Underwater Surveys (Pty) Ltd. Hereinafter called UWS
Client Project Reference:	Letter of Appointment dated 13/05/2024
The UWS Project Number is:	24/063

ABBREVIATIONS AND NOMENCLATURE

ASCII	American Standard Code for Information Interchange
BD	“Blue Dolphin” (UWS survey vessel)
CD	Chart Datum (Saldanha)
C-O	Computed minus Observed
COG	Centre of Gravity
CM	Central Meridian
CRP	Common Reference Point
DGNSS	Differential Global Positioning System
DTM	Digital Terrain Model
GNSS	Global Navigation Satellite System
IHO	International Hydrographic Organisation
INS	Inertial Navigation System
LAT	Lowest Astronomical Tide
LLD	Land Levelling Datum
MBES	Multibeam Echosounder
MEMS	Micro Electro Mechanical Systems
MRU	Motion Reference Unit
MSL	Mean Sea Level
NMEA	National Marine Electronics Association
Qinsy	Quality Integrated Navigational System
RTCM	Radio Technical Committee for Maritime
RTK	Real Time Kinematic
SBP	Sub-Bottom Profiler
SSS	Side scan Sonar
SV	Space Vehicle (satellite)
SVP	Sound Velocity Probe
UPS	Uninterruptable Power Supply
UTC	Universal Time Constant
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984

1. INTRODUCTION

1.1. GENERAL PROJECT DESCRIPTION

Anchor Environmental Consultants is currently working on a proposal for a monitoring campaign in Saldanha Bay of which a component of the work will require a hydrographic survey within the Big Bay Precinct.

The purpose of the survey is to determine the full extent of the Caltrate platform through the undertaking for a once-off mapping process to assess the habitat through the hydrographic mapping of the Big Bay Precinct.

Underwater Surveys (Pty) Ltd, based in Cape Town, South Africa, was contracted by AEC to conduct the high-resolution multibeam sonar survey.

The site investigations are required for an area around Big Bay, as shown in Figure 1.1. The requested scope of work for the site investigation includes the following:

- Multibeam Bathymetric Survey of the area as shown in Figure 1.1 - ~409ha.
- A final report, including a complete survey chart, will be produced.
- Hard copies and digital files (AutoCAD and PDF) of all survey drawings and digital point data (ASCII XYZ format) will be submitted to the Client.

Figure 1.1: Location Diagram – Big Bay Precinct Saldanha

This report presents the operational procedures, survey methodology, data acquisition systems, and results obtained during the Multibeam Bathymetric Survey, conducted on September 2nd and 3rd, 2024.

Additional digital data is provided electronically via FTP or flash disc to complement this report.

1.2. SCOPE OF WORK

The scope of services includes the provision of a multibeam bathymetric survey in the specified area west of Mykonos Marina, Big Bay, Saldanha. The survey's primary objective is to obtain accurate data on current seabed levels to be used for habitat assessment and planning of future developments.

The detailed scope of work for this project was as follows:

1.2.1. Multibeam Bathymetric Survey

A continuous multibeam bathymetric survey was to be carried out within the following Client-specified survey areas:

- Within the given KML file polygon supplied by AEC (BB ADZ precincts.kml).

The total area to be surveyed was approximately 409ha.

As a minimum 100% MBES coverage, at 0.5m x 0.5m grid resolution (bin size), was to be acquired for the extent of the Client-specified survey areas.

Requirements for the MBES bathymetric survey were as follows:

- Survey shall be performed using an ultra-high resolution focused multibeam echosounder system with Global Positioning System (GPS) position fixing system utilising Real Time Kinematic (RTK) techniques.
- The system shall include roll, heave, pitch and heading sensors for motion correction of the ship's movements and heading.
- The system shall include a computer for online navigational control during the survey and online acquisition (data logging) of all the above sensor outputs.
- The system shall be capable of measuring depths with an accuracy for seabed elevation measurements better than +/- 0.1m vertical (Z co-ordinates) and 0.5m horizontal (X and Y co-ordinates).
- Conversion of all bathymetry data during post-processing to create digital terrain model (DTM) and XYZ files.
- Produce a survey report with contour maps.

1.2.2. Survey Standards

The multibeam bathymetric survey will comply with the IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44) Edition 6.1, October 2022 (or latest version). The minimum requirements for SPECIAL ORDER surveys as contained in Table 1 of the said IHO standard (see extracted table in Figure 1.2 below) are applicable for this project.

IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44)
5th Edition February 2008

TABLE 1
Minimum Standards for Hydrographic Surveys
(To be read in conjunction with the full text set out in this document.)

Reference	Order	Special	1a	1b	2
Chapter 1	**Description of areas.**	Areas where under-keel clearance is critical	Areas shallower than 100 metres where under-keel clearance is less critical but *features* of concern to surface shipping may exist.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
Chapter 2	**Maximum allowable THU 95% *Confidence level***	2 metres	5 metres + 5% of depth	5 metres + 5% of depth	20 metres + 10% of depth
Para 3.2 and note 1	**Maximum allowable TVU 95% *Confidence level***	a = 0.25 metre b = 0.0075	a = 0.5 metre b = 0.013	a = 0.5 metre b = 0.013	a = 1.0 metre b = 0.023
Glossary and note 2	***Full Sea floor Search***	Required	Required	Not required	Not required
Para 2.1 Para 3.4 Para 3.5 and note 3	***Feature Detection***	Cubic *features* > 1 metre	Cubic *features* > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Not Applicable	Not Applicable
Para 3.6 and note 4	**Recommended maximum Line Spacing**	Not defined as *full sea floor search* is required	Not defined as *full sea floor search* is required	3 x average depth or 25 metres, whichever is greater For bathymetric lidar a spot spacing of 5 x 5 metres	4 x average depth
Chapter 2 and note 5	**Positioning of fixed aids to navigation and topography significant to navigation. (95% *Confidence level*)**	2 metres	2 metres	2 metres	5 metres
Chapter 2 and note 5	**Positioning of the Coastline and topography less significant to navigation (95% *Confidence level*)**	10 metres	20 metres	20 metres	20 metres
Chapter 2 and note 5	**Mean position of floating aids to navigation (95% *Confidence level*)**	10 metres	10 metres	10 metres	20 metres

Figure 1.2: IHO Standards

NOTE: The R2Sonic 2024 MBES system used on this project meets and exceeds IHO SP-44 specifications for Special Order surveys, both in terms of feature detection and bathymetric point data uncertainty.

1.2.3. Survey Deliverables

The deliverables specified by Anchor Environmental Consultants are as follows:

- Comprehensive survey report.
- Processed bathymetry XYZ data in ASCII text format (corrected to CD) all points and gridded at 0.5 x 0.5 m intervals.
- Bathymetric Charts in accordance with specifications:
    - DWG (2013) & PDF Format
    - 1x Paper Copy

A copy of all survey drawings and the digital data (AutoCAD and ASCII format) must be submitted to Anchor Environmental.

1.3. DEFINITION OF SURVEY AREAS

The survey areas, as specified in the RFQ, is defined by the red outer boundary shown in Figure 1.1.

NOTE: The Client-supplied data comprised of a set of boundaries in Google KML format. This was imported directly into the navigation and acquisition software and used as the minimum boundaries of the survey.

2. VESSEL, EQUIPMENT AND PERSONNEL

2.1. VESSEL

The 6.7 m ski-boat, “Blue Dolphin”, was utilised for the multibeam bathymetric data acquisition during this survey. The “Blue Dolphin” is a road transportable Butt-Cat catamaran ski-boat customized for survey operations, based in Cape Town, South Africa. The vessel is equipped with twin Yamaha 70 hp 4-stroke outboard motors and has a purpose-built over-the-stern multibeam sonar pole mount. Power for equipment is provided by a pair of 2.0 kVA inverter petrol generators and invertor battery system.

Figure 2.1: Survey Vessel “Blue Dolphin”

This vessel is ideal for shallow water inshore surveys and protected areas, where water depths range between 3 m and 40 m. Although not ideal, it can be utilised for surveys in open deeper waters, but very good weather conditions are required for the best data quality and safety.

2.2. PERSONNEL

The UWS project personnel are detailed in Table 2-1:

Table 2-1 Personnel

Position	Name
Party Chief / Survey Engineer	Mark Prowse
Project Surveyor	Andrew McClement
Operations Manager (UWS office)	Pierre Vrey
Skipper / Data Processor (UWS office)	Reinhardt Kaufman
QA / QC and Reporting Supervisor (UWS office)	Pierre Vrey

2.3. SURVEY EQUIPMENT

The following equipment was employed on this project:

Positioning (Ashore):	Leica 1200 RTK Base Station
Positioning (Ashore):	Leica 1200 RTK Rover
Positioning (Afloat)	SBG Ekinox RTK GPS Antenna 1
Motion Sensor:	SBG Systems Ekinox-D INS
Navigation System:	QPS Qinsy v9.6.5
Data Acquisition:	QPS Qinsy v9.6.5
Sounding System:	R2Sonic 2024 Multibeam System (Ultra High Resolution)
Sound Velocity Probe:	Valeport SWiFT Sound Velocity Profiler
Sound Velocity Sensor:	Valeport Mini SVS Sound Velocity Sensor
Power:	220Vac from 1x 2.0KVa Honda Generator, inverter and batteries

The following software resources were utilised during the data processing, interpretation, and charting:

Processing / QC:	QPS Qinsy v9.6.5 QIMERA v2.6.2
Data Interpretation:	QPS Qinsy v9.6.5 QIMERA v2.6.2
Charting:	Bentley MicroStation

3. SUMMARY OF EVENTS

The following summary highlights the main events pertaining to this project and provides an overview of preparations, field operations and progress.

All times are referenced to South African local time (GMT +2 hours).

30th August 2024

System mob, tests and verification checks at UWS premises.

Prepare survey vessel for transit and pack equipment.

2nd September 2024

Transit of survey vessel, equipment and personnel from UWS premises to Big Bay, Saldanha work site.

Set up the RTK base station and perform base checks.

Launch survey vessel and perform routine equipment checks/tests on water.

Proceed to survey site, conduct patch test calibration and commence with MBES data acquisition.

At end of day return to mooring at Mykonos Marina.

3rd September 2024

Proceed to survey site and continue with MBES data acquisition.

Complete survey operations, return to Mykonos Marina and recover survey vessel.

Perform RTK base checks and recover RTK base station.

Pack up and proceed back to UWS premises.

09th -18th September 2024

MBES data processing.

Data interpretation.

DTM & chart production.

Report preparation.

02nd - 4th October 2024

QC and submission of DRAFT survey report.

4. SURVEY CONTROL

4.1. UNITS

Linear units are meters.

Angular units are degrees (º), Grid.

Times are South African local time (UTC plus 2 hours).

4.2. GEODETIC PARAMETERS

The RTK Base Station was configured using the survey control points with known coordinates relative to the **Hartebeesthoek 1994** datum. The primary SBG Ekinox-D internal GPS was configured to output geographical coordinates to the Qinsy software via an Ethernet interface. The working projection applied by the online Qinsy software on board the survey vessel was **Universal Transverse Mercator (Zone 34S), Central Meridian 21ºE**. Unless otherwise stated, all coordinates pertaining to the survey are supplied using this projection.

Spheroid and projection parameters are as follows:

Table 4-1 Working Datum & Projection Parameters

Working Spheroid	
Datum:	Hartebeesthoek 94
Spheroid:	WGS84
Semi-Major, a:	6 378 137.0m
Semi-Minor, b:	6 356 752.3m
Flattening, 1/f:	298.25722

Working Projection	
Projection:	Universal Transverse Mercator (UTM)
Zone:	34 South
Latitude of Origin:	0° 00' 00" N
Central Meridian:	21° 00' 00" E
False Easting:	500 000.00 m
False Northing:	10 000 000.00 m
Scale Factor at CM:	0.9996

As the Global Positioning System (GPS) and the survey datum are both referenced to the World Geodetic System 1984 (WGS 84) Datum, no datum transformations were required.

4.3. VERTICAL DATUM

The specified vertical datum for the survey was Chart Datum (CD). CD for Saldanha Bay is -0.865 meters below the Mean Sea Level (MSL), which is equivalent to Land Levelling Datum (LLD).

All depths were recorded using accurate heights from the RTK / SBG Systems Ekinox-D INS system and were therefore collected relative to the height of the onshore survey control points, which are referenced to MSL. All depths have subsequently been reduced to Chart Datum for Saldanha by applying a vertical shift of -0.865m during post-processing, before the export of gridded points.

All depths in this report are given relative to CD.

4.4. SURVEY CONTROL POINTS

The survey was referenced to onshore survey control points, located at the Mykonos Marina. These points were established by UWS relative to existing Town Survey Marks (TSM), using the published coordinates and heights obtained from NGI. The coordinates of the control points used were in the WG19 grid projection and heights are relative to LLD (equivalent to MSL):

Table 4-2 Survey Control Points

Control Point	Hartebeesthoek94 / WG19		LLD / MSL (m)	Description / Remark
	Y (m)	X (m)		
MYK 1	89 707.080	3 658 419.682	2.728	Central Promenade, end Port side mooring (stud in concrete)
MYK 2	89 562.955	3 658 431.651	2.707	Mykonos car park (stud in concrete)
MYK 3	89 720.817	3 658 406.818	2.652	Promenade end hut, Port side mooring (stud in concrete)

4.5. RTK POSITION ACCURACY VERIFICATION

After installation of the RTK base station equipment at control point MYK1, and throughout the survey the integrity of the base station coordinates and RTK positioning accuracy was verified by comparing the rover position measured on benchmarks MYK 2 and MYK 3 to the existing coordinates. The results of these verification checks are shown in the tables below.

Table 4-3 RTK Verification Checks after base installation @ MYK 1

Check Point	WG 19 Y (m)	WG 19 X (m)	LLD / MSL (m)	dXY (m)	dZ (m)
MYK 2	89 562.962	3 658 431.662	2.716	0.013	-0.009
MYK 3	89 720.820	3658406.825	2.662	0.008	-0.007

Table 4-4 RTK Verification Checks PM 02/09/2024

Check Point	WG 19 Y (m)	WG 19 X (m)	Height (m)	dXY (m)	dZ (m)
MYK 2	89 562.965	3 658 431.667	2.719	0.019	-0.012
MYK 3	89 720.823	3658406.828	2.665	0.012	-0.013

Table 4-5 RTK Verification Checks AM 03/09/2024

Check Point	WG 19 Y (m)	WG 19 X (m)	Height (m)	dXY (m)	dZ (m)
MYK 2	89 562.960	3 658 431.675	2.711	0.025	-0.004
MYK 3	89 720.811	3658406.835	2.651	0.018	-0.001

Table 4-6 RTK Verification Checks PM 03/09/2024

Check Point	WG 19 Y (m)	WG 19 X (m)	Height (m)	dXY (m)	dZ (m)
MYK 2	89 562.955	3 658 431.645	2.718	0.006	-0.011

Figure 4.1: RTK Base Station Point (MYK 1)

Figure 4.2: RTK Check Points (MYK 2, MYK 3)

4.6. SYSTEM POSITION ACCURACY VERIFICATION

During the preparation phase of the project the overall dynamic positioning accuracy of the entire survey system, which includes RTK positioning, offset measurements as well as motion and attitude compensation, was verified. This was done at the UWS premises in Cape Town, prior to the mobilisation for the project.

With the survey vessel stationary on its trailer, the Leica 1200 rover receiver was used to determine the position and height of a pre-measured fixed offset mark on the MBES transducer mounting frame. The Qinsy system was brought online and the real-time position and height of the same offset node, as calculated using the primary Ekinox-D INS position solution, was compared to the RTK fix position.

The results of this comparison are shown in Table 4-7**.**

Table 4-7 System Position Accuracy Verification

RTK-Check Mark (Port Frame Offset) – WG19	Y(m)	X(m)	Z(m) - MSL
Qinsy Computation (Ekinox-D RTK position solution)	46,996.192	3,774,268.802	5.184
Leica RTK Rover Check Fix	46,996.191	3,774,268.799	5.194
Difference	-0.001	-0.003	0.010

The excellent correlation observed between the two 3D positions (Table 4-7) is well within specification of the primary positioning source and confirms that the survey system is correctly configured and working to the required accuracy.

5. SURVEY METHODOLOGY

This section describes the methodology for the Multibeam Bathymetric survey undertaken in Big Bay, Saldanha.

The purpose of the survey was to acquire accurate bathymetric data to be used in the planning proposal of a monitoring campaign.

UWS provided the following resources to carry out the required surveys:

- Nearshore survey vessel c/w 4x4 towing vehicle and qualified skipper.
- RTK GNSS Positioning System.
- Navigation and Data Acquisition System.
- Inertial Heading & Motion Sensor (INS).
- Sound Velocity Profiler.
- Multibeam Echosounder.
- Suitably qualified and experienced survey personnel to support 12-hour (daylight) survey operations.

5.1. PREPARATION

Before the commencement of operations, all equipment installed on the survey vessel was checked and tested. Exiting sensor offsets relative to the vessel's COG were previously established using a total station and independently checked by taped measurements. Correct application of these offsets was verified during the preparation for the current survey (refer to section 4.6).

The offset survey results, and vessel offset diagram is presented in Appendix A.

5.2. NAVIGATION SYSTEM

5.2.1. Positioning

An SBG Systems Equinox-D INS with an integrated Real Time Kinematic (RTK) GNSS was used as the primary surface positioning system for the survey. A Leica System 1200 RTK GNSS base station, with a high-power radio data transmitter, located at a known onshore control point MYK 1, provided real-time, dual frequency, RTK corrections to the systems on board the survey vessel. A horizontal and vertical accuracy of better than 3 cm can be expected at a 95% confidence level.

Raw INS observations and static GNSS base station data were also recorded. This data was used for PPK (Post-Process Kinematic) processing to improve the motion compensation accuracy and to fill in any gaps in RTK positioning that may have occurred due to correction signal dropouts in areas where line-of-sight became an issue.

Positioning and level control for the bathymetric survey data was based on accurate positioning and heights obtained from RTK/PPK GNSS. The RTK/PPK positioning was referenced relative to onshore survey control points established by UWS. To ensure accurate depth measurement RTK verification checks were performed before commencement and on completion of daily survey operations.

5.2.2. QPS Qinsy - Navigation System

The Dutch-based company QPS's Qinsy software package was used for navigation control, data acquisition and processing of all external sensor data. QPS Qinsy version 9.6.5 was utilised for online acquisition and Qinsy version 9.5.4 for processing, together with QPS Qimera 2.6.2.

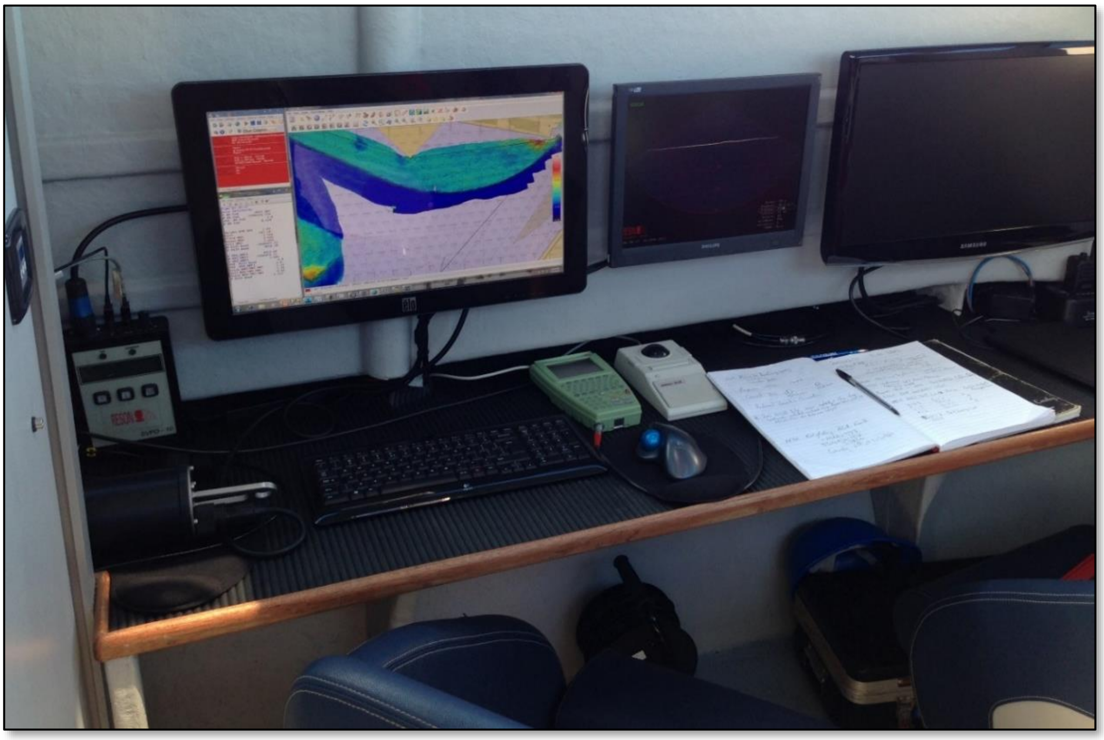


Figure 5.1: QPS Qinsy Survey Acquisition System on board "Blue Dolphin"

Qinsy uses WGS-84 for position calculation. Real-time transformation to local datums is performed using predefined or custom user-defined transformation parameters. All vessel, antenna and system offsets are entered into the system to allow specific sensor positioning. Quality control of all positioning system components (GNSS, Sonar, Heading etc.) is continuous and monitored through a series of online "Alerts." Data is logged to a hard drive and saved in real-time to a live digital terrain model (DTM). This DTM is displayed for the operator to QC and monitor coverage achieved and for the skipper to use as a guide to navigation.

A project-specific Qinsy template database was configured with the appropriate geodetic parameters, vessel details, equipment interfacing parameters and necessary computations. Offsets were entered into the database and background charts were prepared and loaded into the navigation software. The Qinsy template database set-up parameters are presented in Appendix B of this report.

5.3. MOTION AND ORIENTATION SYSTEM

An SBG Systems Ekinox-D INS motion and orientation system was interfaced to the Qinsy navigation system to enable real-time computation of the positions of the survey sensors, using the ship's heading, pitch, roll, heave, layback and transverse offsets to the vessel's origin.

The SBG Systems Ekinox-D INS represents the state of the art in precise, real-time, dynamic positioning and orientation technology. The Ekinox Series is a product range of high-accuracy inertial systems. It has been designed to bring robust, maintenance free and cost-effective MEMS to the tactical grade. Thanks to the selection of high-end MEMS sensors, an advanced calibration procedure and a powerful algorithm design, the Ekinox Series achieves at least 0.05° attitude accuracy.

SBG Systems Ekinox-D INS consists of three separate physical components:

- SBG Systems Ekinox-D INS Inertial Measurement Unit (IMU)
- GNSS Sub-system
- Splitter Box

Figure 5.2: SBG Systems Ekinox-D INS Inertial Measurement Unit

By integrating these Inertial and GPS components the SBG Systems Ekinox-D INS provides the functionality of a GNSS receiver, gyrocompass and conventional motion sensor in a single, user-friendly, turnkey solution. SBG Systems Ekinox-D INS provides an accurate reference for Attitude, Heading, Heave, Position, and Velocity under the most demanding conditions, regardless of vessel dynamics.

The SBG Systems Ekinox-D IMU sensor is installed on the "Blue Dolphin's" deck inside the cabin, as close as possible to the vessel's approximate centre of gravity (COG). The GPS antennae are installed on the port and starboard antenna studs on top of the cabin, which forms a 1.45m baseline approximately perpendicular to the vessel's centreline. A correction of +0.28° is applied to compensate for the baseline misalignment relative to the vessel centreline. The pitch and roll alignment offsets of the Ekinox-D, relative to the vessel reference frame, were derived with the vessel perfectly levelled on its trailer. C-O values of -0.1° and -0.1° for roll and pitch respectively, were applied in the Ekinox-D system configuration.

5.4. BATHYMETRY

Multibeam bathymetric data was acquired using an R2Sonic 2024 400kHz multibeam sonar system to determine the seabed topography. Multibeam bathymetric soundings provide sea bottom topography across the entire swath width along the lines sailed. Swath width is determined by water depth and the amount of information obtained is subject to line density. No specific line plan was used for multibeam acquisition during this survey. Data coverage, at 0.5m x 0.5m grid resolution, was achieved by overlapping adjoining swath tracks and filling in gaps where required.

The sonar head was deployed on a very rigid stern-mounted pole that is stabilised with a waterline bracket. The sonar head was electrically isolated from the pole and accurately measured offsets from the acoustic centre of the sonar array to the CRP were applied by the acquisition system.

The sonar equipment was interfaced with the navigation computer for data control and precise time tagging. 1PPS timing is obtained from a NMEA ZDA time message provided by the SBG Ekinox-D internal GPS receiver and a 1PPS box. For heading, heave, pitch, and roll compensation, the SBG Ekinox-D motion and orientation system was used.

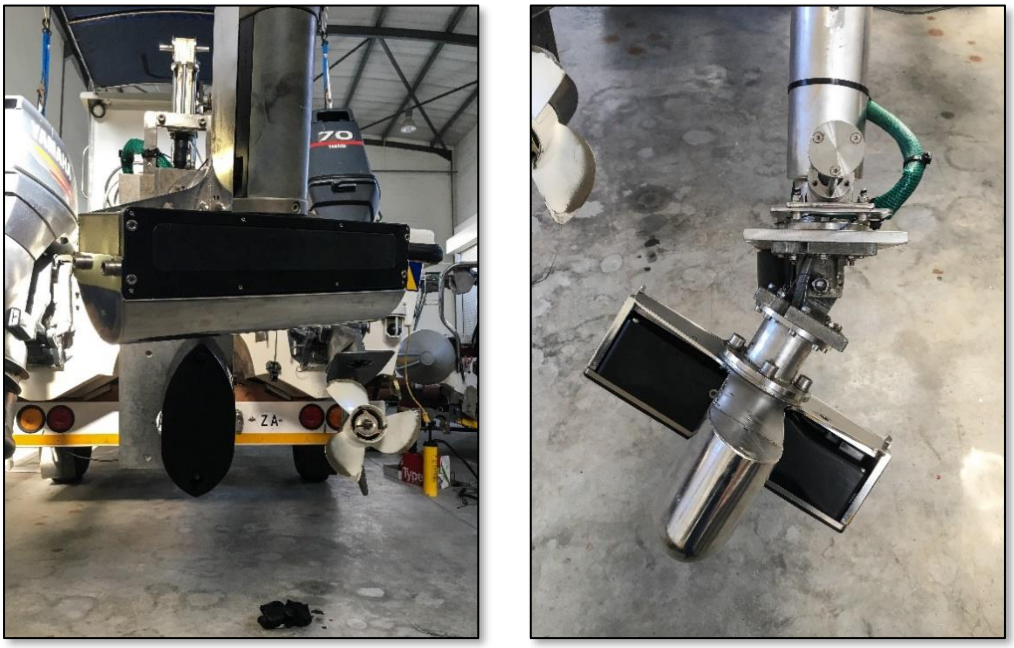


Figure 5.3: MBES tilted Transducer on “Blue Dolphin”

5.4.1. Sound Velocity Calibration

Calibration for the speed of sound was carried out by acquiring a sound velocity cast before transducer alignment calibration or any survey activity, using a Valeport SWiFT Sound Velocity Profiler. The sound velocity profile data was entered into the acquisition system and applied online during the survey. The speed of the sound profile was recorded in the deepest part of the site before the survey commencement. Real-time sound velocity Sensor (SVS) measurements were continuously compared against the SV profile by Qinsy.

Sound velocity profile data is presented in Appendix C to this report.

5.4.2. Transducer Alignment Calibration

To accurately measure the seafloor, the measurements made by the multibeam sonar must be relative to the true vertical as reported by the motion sensor and the heading as reported by the heading sensor. During installation it is not possible to obtain perfect alignment of the sonar on the measured zero axis. Therefore, a standard transducer alignment calibration routine (Patch Test) was performed to derive correction (C-O) values for the Roll, Pitch, and Yaw mounting angles of the sonar head. These values are then applied online to the data to bring the systems into proper alignment.

For the purposes of this survey the sonar head was mounted looking vertically down.

Before transducer alignment calibration, the speed of the sound profile was recorded in the selected patch test area, using a sound velocity cast from a Valeport SWiFT Sound Velocity Profiler. The sound velocity profile data was entered into the acquisition system and applied online during the transducer alignment survey.

For the Patch Test calibration, the following lines were sailed, and DB files were recorded for analysis:

- Roll: two lines over a flat area in opposite directions with the same speed (transducer tracks on top of each other).
- Pitch: two lines over an area with slopes (or an object) in opposite directions with the same speed (transducer tracks on top of each other).
- Heading: two lines over an area with slopes (or an object), the lines need to overlap half a swath width, in the same direction with the same speed.

NOTE: Since PPS timestamping resolves any timing errors, no latency calibration was required.

Known transducer alignment corrections from a previous Patch Test calibration were entered into the template database and applied online during data acquisition for the project. The Patch Test data that was acquired during the survey was processed and variations was applied as relative corrections during post-processing of the data.

The Patch Test calibration values used for the survey are shown in the Table 5-1 below.

Table 5-1 Patch Test Sonar Calibration Results

Description	ROLL	PITCH	YAW	LATENCY
Original template database alignment corrections used during the survey	-1.283°	+9.144°	-1.404°	N/A due to PPS Timing
Patch Test – 2024-09-02	-1.133°	+9.144°	-1.535°	

The Qinsy report for the patch test calibration, conducted on 2nd September 2024, is presented in Appendix D.

6. RESULTS

The multibeam bathymetric data for the Big Bay Precinct survey areas was acquired on 02nd and 03rd September 2024. The figure below shows the total survey coverage.

Figure 6.1: Saldanha Big Bay Precinct - MBES Survey Coverage

6.1. BIG BAY SURVEY AREA

Full coverage of the specified survey area was achieved except for the one pinnacle that is above water level, even at high tide. The area between the pinnacles was surveyed taking advantage of high tide. Once the area was reconnoitred, data was collected while threading through the rows of buoys used to mark and grow bivalves. This and the kelp present on the pinnacles contributed to noise in the bottom detection.

The Calcrete platform extends from the Southern side northwards to approximately midway through the survey area, with one pinnacle breaking surface. On the Northern side the seabed is sloping gently with a mix of course to fine sediment.

6.2. PROCESSING PROCEDURES

Data processing and QC were completed in the UWS offices in Cape Town, after completion of the field data acquisition.

6.2.1. Multibeam Bathymetric Data Processing

Multibeam bathymetric processing was undertaken using the QPS Qimera 2.6.2 and QPS Qinsy v9.6.5 software packages.

Qimera processing involved applying the final Patch Test calibration corrections and true heave observations to all acquired database files. Various filtering and cleaning tools were used to reject suspect data. This was followed by manual cleaning to remove all remaining "spikes".

After all data cleaning had been completed the quality of the data was assessed using the Qimera "Cross Check" tool which assesses the survey surface to data from random cross lines acquired during the survey. An IHO-S44 Special Order was accepted.

The data was imported to Qinsy's Sounding Grid utility where a vertical shift of -0.865m was applied to correct the exported point data to Chart Datum. All gridded data, TIFF images, contouring and spot soundings for charting purposes were exported from this grid. Separately, the All-Points txt file corrected to CD was exported from a QIMERA dynamic surface (MSL) height adjusted by -0.865m.

The following files were exported to comply with the SOW:

- ASCII XYZ (comma delimited)
  - Gridded data 0.5m x 0.5m 24-063-BB ADZ Precinct-XYZ-50cm-UTM34S-CD

- GeoTIFF & KML:
  - Sun-shaded GeoTIFF: 24-063_BB ADZ Precincts-UTM34S-CD

6.2.2. Charting

The Bentley MicroStation software package was used for all charting at an appropriate scale for the size of the survey area, using the exported outputs from the processing stage, including TIFF, spot soundings and contours.

6.3. BATHYMETRIC DATA

6.3.1. Bathymetry Results

A total of 17 796 260 points makes up the 0.5m x 0.5m grid of the Big Bay Precinct survey area. This area includes 112 362 612 accepted soundings, averaged into the 0.5m x 0.5m grid (points accepted after validation checks).

Minimum depth in survey area: 2.520 meters below CD

Maximum depth in survey area: 16.533 meters below CD

A bathymetric chart was produced as an A1 sheet at a scale of 1:5000. Contours are shown at 1m intervals and are overlaid on a colour-scaled GeoTIFF background representing depths. Spot depths are also represented on the chart.

A hard copy of the chart is presented in Appendix E to this report. The chart is also provided in digital format (PDF & DWG) in the accompanying electronic data. A digital version of the data in ASCII XYZ format, exported at 0.5m grid intervals and an all-points format, is also provided.

6.3.2. Data Quality

The quality of the processed data for the survey area was assessed using the QIMERA "Cross Check" tool. A summary of the cross-check results is presented in the table and figure below.

Table 6-1 Big Bay Precinct Cross-Check Results

Description	Value
Survey Order: IHO S-44 Special Order	ACCEPTED
Error Limit	0.266855
Number Rejected	125
P-Statistic	0.000106961
Number Of Points	1 168 645
Grid Cell Size	0.5
Difference Mean	-0.008
Difference Median	-0.007
Difference Std. Dev	0.028
Difference Range	[-0.458, 0.644]
Mean + 2*Stddev	0.063
Median + 2*Stddev	0.062
Data Mean	-13.127
Reference Mean	-13.119
Data Z-Range	[-15.167, 10.891]
Reference Z-Range	[-14.994, 10.924]

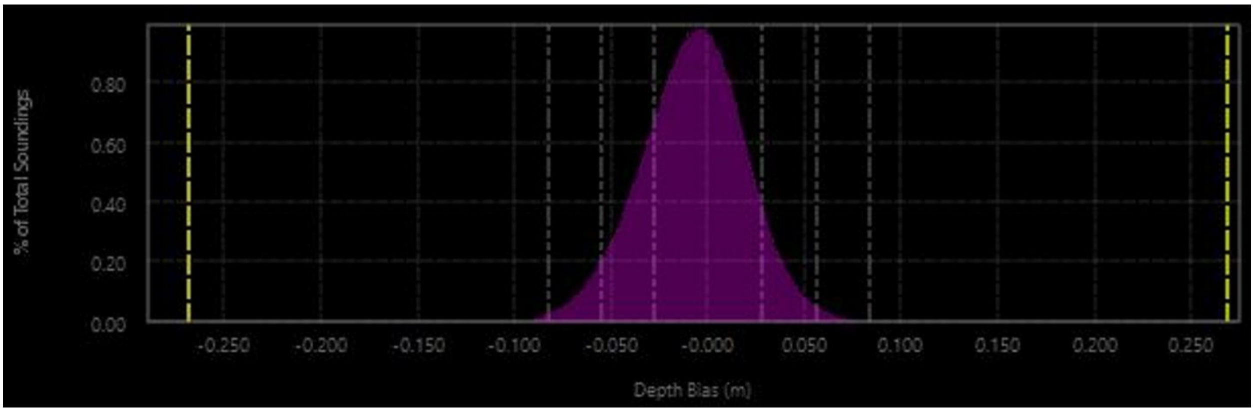


Figure 6.2: Big Bay Precinct Cross-Check Histogram

The results from the cross-check test show that the data sample meets the accuracy requirements specified for this Special-Order survey.

APPENDIX A VDC SURVEY RESULTS & OFFSET DIAGRAM

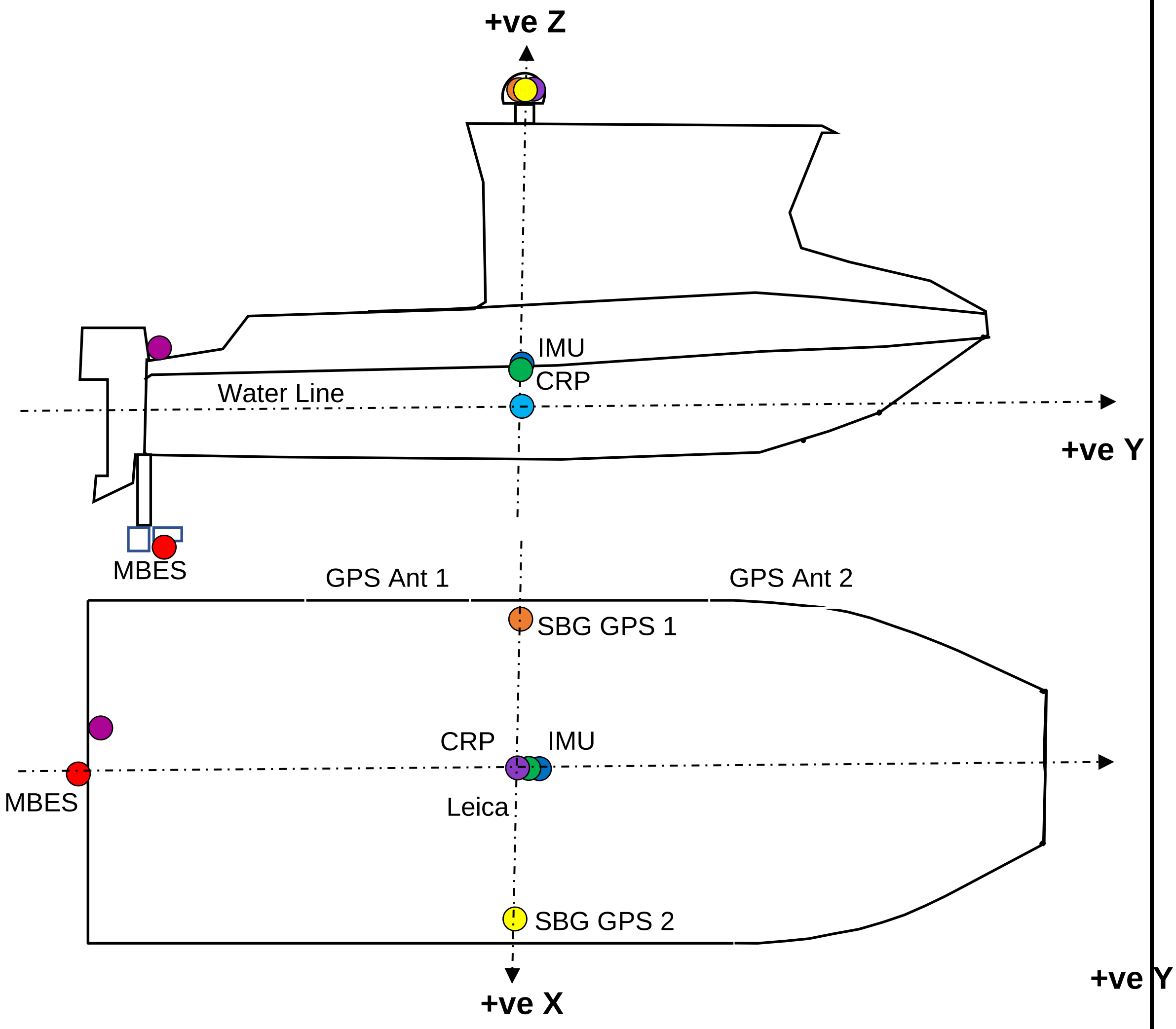
BLUE DOLPHIN – Vessel Dimensional Control Survey Result

Blue Dolphin Offsets For Adjusted Pole | Updated 16/03/2022

Offset	X (m)	Y (m)	Z (m)	Description
COG	0.000	0.000	0.000	Point on deck inside equipment cabinet, approximately below Antenna Stud #3
Antenna Stud #1	-0.728	-0.006	1.898	Ant stud above cabin - port side T/Stud- Ant Flange 7mm Down
Antenna Stud #2	-0.366	0.000	1.903	Ant stud above cabin - 2nd from port side (CDA 3 antenna)- nut 15mmm down
Antenna Stud #3	-0.007	-0.007	1.898	RTK Antenna, approximately on vessel C/L above cabin Ant Flange on Nut - 15mm
Antenna Stud #4	0.359	-0.010	1.901	Ant stud above cabin - 2nd from starboard side. T/Nut below T/Stud 15mm
Antenna Stud #5	0.718	-0.013	1.908	Secondary SBG GPS Ant flange is 7mm below T/Stud
OTS Pole Flange Face	0.024	-2.947	-1.103	Centre of flange face
SBG Ekinox	0.000	0.000	0.036	SBG Ref Point positioned over CRP of thre vessel
Seabat 7125 AC	**0.034**	**-3.083**	**-1.359**	x= Centre of receiver face, Y= centre of projecter, Z= the plane of the receiver face.
7125 AC Vert with Tilt Bracket	0.014	-3.093	-1.488	Tilt Bracket fitted but set facing directly downwards
7125 AC at Angle Tilt Bracket 20	0.129	-3.094	-1.464	Tilt Bracket fitted and tilted to a angle towards the starboard side20 deg
7125 AC at Angle Tilt Bracket 34	0.185	-3.095	-1.441	Tilt Bracket fitted and tilted to a angle towards the starboard side 34 deg
R2Sonic 2024 (UWS)	0.024	-2.745	-1.303	UWS bracket; Tx fwd
R2Sonic 2024 (UWS)	0.024	-3.149	-1.303	UWS bracket; Tx aft
R2Sonic 2024 (UWS)	0.095	-2.759	-1.443	TX FWD UWS Bracket- 22 deg Tilt
T/Pole	0.020	-3.152	-0.026	Temporary Pole
Pole Frame Port	**-0.253**	**-3.036**	**-0.018**	for qinsy check point
Drop Point Stbd	**1.088**	**-0.895**	**0.394**	for qinsy check point
Stbd Bollard	**1.074**	**-2.306**	**0.394**	(Tape)
Seabat 8125 AC				Centre of projector for X & Y and centre of receiver face for Z. (UWS Modified T-Plate)

Qinsy Offsets For Antennas			
GPS 1 - Stud 1	**-0.728**	**-0.006**	**1.891**
GPS 2 - Stud 5	**0.718**	**-0.013**	**1.901**
Leica Ant - Stud 3	**-0.007**	**-0.007**	**1.883**

"BLUE DOLPHIN" SURVEY SENSOR OFFSETS			
Offset	**X Offset (+ve starboard)**	**Y Offset (+ve forward)**	**Z Offset (+ve upward)**
Common Reference Point (CRP)	+0.000m	+0.000m	+0.000m
Leica RTK	-0.007m	-0.007m	+1.883m
GNSS Antenna 2	+0.718m	-0.013m	+1.901m
SBG Ekinox IMU	+0.000m	+0.000m	+0.036m
R2Sonic 2024 Transducer Flat Tx Aft	+0.024m	-3.149m	-1.303m
Water Line	+0.000m	+0.000m	-0.340m
RTK Check Point	-0.253m	-3.036m	-0.018m



Offset Schematic updated 2024/09/10

(not to scale)

APPENDIX B QINSY SETUP PARAMETERS

DbSetup: C:\Users\Reinh\QPS-Data\Projects\202409_Saldanha_34S_24_063\Database\BD TxAft_R2_SBGPage 1 of 16

SURVEY DEFINITIONS

General Definitions

Line name	:	No line name
Line sequence number	:	1
Line description	:	
UTC to GPS time correction	:	18.000 s
Survey unit name	:	meter
Conversion factor to metres	:	1.000000000000000

Geodetic Definitions

Magnetic Variation Information

Undefined

Datum Definitions

Survey Datum	:	WGS 84 (Greenwich)
Spheroid name	:	WGS 84
Prime meridian	:	Greenwich
Prime meridian	:	0;00;00.00000 E
Conversion factor to metres	:	1.0000000000000
Semi-major axis (a)	:	6378137.000000 m
Semi-minor axis (b)	:	6356752.314245 m
Inverse flattening (1/f)	:	298.25722356300
First eccentricity squared (e**2)	:	0.0066943799901
Second eccentricity squared (e'**2)	:	0.0067394967422

Datum Shift Definitions

Undefined

Chart Datum / Vertical Datum Definition

Chart datum	:	WGS 84 (Greenwich)
Height file	:	N/A
Height level	:	No Level Correction
Height file	:	N/A
Height offset	:	0.000000 m
WLR model	:	Horizontal Datum
WLR file	:	N/A
WLR level	:	No Level Correction
WLR file	:	N/A
WLR offset	:	0.000000 m
WLR st.dev.	:	0.000000 m
DTM mode	:	Absolute DTMs
DTM datum	:	WGS 84 (Greenwich)
DTM file	:	N/A
DTM level	:	No Level Correction
DTM file	:	N/A
DTM offset	:	0.000000 m

Projection Definition

Projection type	:	0002
Projection name	:	Universal Transverse Mercator (South Hemisphere)
Conversion factor to metres	:	1.0000000000000
UTM zone number	:	34
UTM central meridian	:	21;00;00.00000 E
Latitude of grid origin	:	0;00;00.00000 N
Longitude of grid origin	:	21;00;00.00000 E
Grid Easting at grid origin	:	500000.000000 m
Grid Northing at grid origin	:	10000000.000000 m
Scale factor at longitude of origin	:	0.999600000000

Local Construction Grid Definition

Not Applicable

Offset Convention

Offset mode	:	Rectangular
Offset distances units	:	Meters
Offset angles units	:	Degrees

OBJECT DEFINITIONS

General Summary Information

Number of survey vessels or objects	:	1
Number of relay vessels or buoys	:	0
Number of external network nodes	:	0
Number of datums/ellipsoids defined	:	1

Vessel Definitions

BD Tx Aft

Streamers	:	0	Gun arrays	:	0
Buoys	:	0	Echosounders	:	1
Satellite receivers	:	3	USBL systems	:	0
Network nodes	:	9	P/R/H sensors	:	1

Correction to GMT (UTC)	:	0.000 h
Correction to master vessel's time	:	0.000 s
Height above draft reference	:	0.000 m
Description of reference point	:	BD Tx Aft CoG

Point	X	Y	Z	Pen	Fill	Style
1	0.000	4.000	0.000	Up	On	Solid
2	1.000	3.000	0.000	Down	On	Solid
3	1.000	-3.000	0.000	Down	On	Solid
4	-1.000	-3.000	0.000	Down	On	Solid
5	-1.000	3.000	0.000	Down	On	Solid
6	0.000	4.000	0.000	Down	On	Solid
7	1.000	0.000	0.000	Up	On	Dash
8	-1.000	0.000	0.000	Down	On	Dash
9	-1.000	-3.000	0.000	Down	On	Dash
10	1.000	-3.000	0.000	Down	On	Dash
11	1.000	0.000	0.000	Down	On	Dash

Gun Array Definitions

NETWORK DEFINITIONS

Fixed Node Definitions

Variable Node Definitions

BD Tx Aft CoG		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.000 m
Leica Ant 3		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	-0.007 m
Y (Bow = Positive):	:	-0.007 m
Z (Up = Positive):	:	1.883 m
A-priori SD	:	0.010 m
Ekinox GPS 1		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	-0.728 m
Y (Bow = Positive):	:	-0.006 m
Z (Up = Positive):	:	1.891 m
A-priori SD	:	0.010 m
SBG_IMU		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.036 m
A-priori SD	:	0.010 m
RTK CheckPortFra		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	-0.253 m
Y (Bow = Positive):	:	-3.036 m
Z (Up = Positive):	:	-0.018 m
A-priori SD	:	0.050 m
R2_AC_FWD		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	0.024 m
Y (Bow = Positive):	:	-2.745 m
Z (Up = Positive):	:	-1.303 m
A-priori SD	:	0.010 m
StbdBol		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	1.074 m
Y (Bow = Positive):	:	-2.306 m
Z (Up = Positive):	:	0.394 m
A-priori SD	:	0.010 m

DbSetup: C:\Users\Reinh\QPS-Data\Projects\202409_Saldanha_34S_24_063\Database\BD TxAft_R2_SBGPage 4 of 16

Variable Node Definitions (continued)

R2SonicCheckNode		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	0.024 m
Y (Bow = Positive):	:	-3.273 m
Z (Up = Positive):	:	-1.159 m
A-priori SD	:	0.010 m
R2_AC_AFT		
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	0.024 m
Y (Bow = Positive):	:	-3.149 m
Z (Up = Positive):	:	-1.303 m
A-priori SD	:	0.010 m

Observation Definitions

DEL_HEAVE0	:	Generic
'At' node	:	Undefined
System description	:	Ekinox Delayed Heave Time(Misc
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000
Variable (C-O)	:	0.000000
A-priori SD	:	1.00
Quality indicator	:	No quality info recorded
SVP-C	:	Generic
'At' node	:	Undefined
System description	:	SVP-C
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000
Variable (C-O)	:	0.000000
A-priori SD	:	1.00
Quality indicator	:	No quality info recorded
Ekinox Nav [Gyro	:	Bearing (True)
'At' node	:	BD Tx Aft CoG
'To' node 1	:	Ship's axis
Measurement unit code	:	Degrees
System description	:	Ekinox Nav [Gyro Compass]
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °
Variable (C-O)	:	0.000000 °
A-priori SD	:	0.08 °
Quality indicator	:	No quality info recorded

Observation Definitions (continued)

Acceleration (Z)	:	Acceleration (Z)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second^2
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s²
Variable (C-O)	:	0.000000 m/s²
A-priori SD	:	0.00 m/s²
Quality indicator	:	No quality info recorded
Acceleration (X)	:	Acceleration (X)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second^2
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s²
Variable (C-O)	:	0.000000 m/s²
A-priori SD	:	0.00 m/s²
Quality indicator	:	No quality info recorded
Acceleration (Y)	:	Acceleration (Y)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second^2
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s²
Variable (C-O)	:	0.000000 m/s²
A-priori SD	:	0.00 m/s²
Quality indicator	:	No quality info recorded
Velocity (Z)	:	Velocity (Z)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s
Variable (C-O)	:	0.000000 m/s
A-priori SD	:	0.10 m/s
Quality indicator	:	No quality info recorded
Velocity (X)	:	Velocity (X)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s
Variable (C-O)	:	0.000000 m/s
A-priori SD	:	0.10 m/s
Quality indicator	:	No quality info recorded

Observation Definitions (continued)

Velocity (Y)	:	Velocity (Y)
'At' node	:	BD Tx Aft CoG
Measurement unit code	:	Meters / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s
Variable (C-O)	:	0.000000 m/s
A-priori SD	:	0.10 m/s
Quality indicator	:	No quality info recorded
Rate-of-Turn (X)	:	Rate-of-Turn (X)
'At' node	:	SBG_IMU
Measurement unit code	:	Degrees / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Squared term factor	:	0.0000000000
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °/s
Variable (C-O)	:	0.000000 °/s
A-priori SD	:	0.00 °/s
Quality indicator	:	No quality info recorded
Rate-of-Turn (Y)	:	Rate-of-Turn (Y)
'At' node	:	SBG_IMU
Measurement unit code	:	Degrees / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Squared term factor	:	0.0000000000
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °/s
Variable (C-O)	:	0.000000 °/s
A-priori SD	:	0.00 °/s
Quality indicator	:	No quality info recorded
Rate-of-Turn (Z)	:	Rate-of-Turn (Z)
'At' node	:	SBG_IMU
Measurement unit code	:	Degrees / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Squared term factor	:	0.0000000000
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °/s
Variable (C-O)	:	0.000000 °/s
A-priori SD	:	0.00 °/s
Quality indicator	:	No quality info recorded
Rate-of-Turn	:	Rate-of-Turn
'At' node	:	SBG_IMU
Measurement unit code	:	Degrees / Second
System description	:	Ekinox_Acc_Vel
Propagation speed	:	0.0000000000 m/s
Squared term factor	:	0.0000000000
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °/s
Variable (C-O)	:	0.000000 °/s
A-priori SD	:	0.50 °/s
Quality indicator	:	No quality info recorded

Reference Station Definitions

ATT Node Definitions

SYSTEM DEFINITIONS

Position Navigation System

Ekinox Nav

Interfacing

Type	:	Position Navigation System		
Driver	:	Network (UDP) - SBG Systems Position (UTC)		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

Satellite System Definition

Position datum	:	WGS 84 (Greenwich)
Satellite system name	:	WGS 84

Satellite Receiver Definition

Receiver number	:	1	
Receiver description	:	Ekinox Nav	
Node identifier	:	SBG_IMU	
Object location	:	BD Tx Aft	
X (Stbd = Positive):	:	0.000 m	
Y (Bow = Positive):	:	0.000 m	
Z (Up = Positive):	:	0.036 m	
A-priori SD	:	0.010 m	
SD latitude	:	0.050000 m	
SD longitude	:	0.050000 m	
SD height	:	0.100000 m	
Measurement unit	:	Meters	
Horizontal datum	:	WGS 84 (Greenwich)	
Vertical datum	:	WGS 84 (Greenwich)	N/A
Height level	:	No Level Correction	N/A
Height offset	:	0.000000 m	

Connected Observations

Connected Nodes

Undefined

Gyro Compass

Ekinox Nav [Gyro Compass]

Interfacing

Type	:	Gyro Compass		
Driver	:	Network (UDP) - SBG Systems Heading (UTC)		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

Connected Observations

Ekinox Nav [Gyro		:	Bearing (True)
Slot 1	:	EULER	

Connected Nodes

BD Tx Aft CoG	:	BD Tx Aft

Pitch Roll Heave Sensor

Ekinox RPH0

Interfacing

Type	:	Pitch Roll Heave Sensor		
Driver	:	Network (UDP) - SBG Systems (R-P-H) (UTC)		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

System Parameters

Ekinox RPH0		
Object	:	BD Tx Aft
Location on object (Lever arm)	:	SBG_IMU
PRH sensor reference number	:	1
Rotation convention pitch	:	Positive bow up
Rotation convention roll	:	Positive heeling to starboard
Angular variable measured	:	HPR (roll first)
Angular measurement units	:	Degrees
Sign convention heave	:	Positive downwards
Measurement unit heave	:	Meters
Conversion factor to degrees decimal	:	1.0000000000000
Conversion factor to metres	:	1.0000000000000
Quality indicator type pitch and roll	:	No quality info recorded
Quality indicator type heave	:	No quality info recorded
Description of quality indicator type	:	
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.036 m
A-priori SD	:	0.010 m
(C-O) pitch offset	:	0.000 °
(C-O) roll offset	:	0.000 °
(C-O) heave offset	:	0.000 m
Heave time delay	:	0.000 s
Heave filter length	:	20.000 s
SD roll and pitch	:	0.020 °
SD heave (fixed)	:	0.050 m
SD heave (variable)	:	5.000 %
SD roll offset	:	0.050 °
SD pitch offset	:	0.050 °
SD heave offset	:	0.050 m
Description of pitch, roll and heave system		
Ekinox RPH0		
Slot		
P/R/H0		

Time Synchronization System

SBG 1PPS

Interfacing

Type	:	Time Synchronization System		
Driver	:	Network (UDP) - SBG Systems UTC		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

PPS Pulse System

PPS Pulse System

Interfacing

Type	:	PPS Pulse System		
Driver	:	QPS PPS Adaptor		
Executable and Cmdline	:	DrvPpsPulseV2.exe		
Port	:	1		
Baud rate	:	1200	Data bits :	8
Parity	:	None	Stop bits :	1
Update rate	:	0.000 s	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	0		

Miscellaneous System

Ekinox Delayed Heave Time(Misc)

Interfacing

Type	:	Miscellaneous System		
Driver	:	Network (UDP) - SBG Systems Delayed Heave UTC		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

Connected Observations

DEL_HEAVE0 : Generic
Slot 1 : DEL_HEAVE0

Connected Nodes

Undefined

Acceleration Velocity Sensor

Ekinox_Acc_Vel

Interfacing

Type	:	Acceleration Velocity Sensor		
Driver	:	Network (UDP) - SBG Systems Vel, Acc, Rot (UTC)		
Executable and Cmdline	:	DrvQPSCountedUDP.exe SBG_EKINOX PPS		
Port	:	5000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	1		

Connected Observations

Acceleration (Z)			: Acceleration (Z)
Slot 1	:	ACC_Z_IMU	
Acceleration (X)			: Acceleration (X)
Slot 1	:	ACC_X_IMU	
Acceleration (Y)			: Acceleration (Y)
Slot 1	:	ACC_Y_IMU	
Velocity (Z)			: Velocity (Z)
Slot 1	:	VEL_D_NAV	
Velocity (X)			: Velocity (X)
Slot 1	:	VEL_N_NAV	
Velocity (Y)			: Velocity (Y)
Slot 1	:	VEL_E_NAV	
Rate-of-Turn (X)			: Rate-of-Turn (X)
Slot 1	:		
Rate-of-Turn (Y)			: Rate-of-Turn (Y)
Slot 1	:		
Rate-of-Turn (Z)			: Rate-of-Turn (Z)
Slot 1	:		
Rate-of-Turn			: Rate-of-Turn
Slot 1	:		

Connected Nodes

SBG_IMU	: BD Tx Aft
BD Tx Aft CoG	: BD Tx Aft

Position Navigation System

Ekinox GNSS 1 - Ant Pos

Interfacing

Type	: Position Navigation System			
Driver	: Network (UDP) - SBG Systems Position			
Executable and Cmdline	: DrvQPSCountedUDP.exe SBG_EKINOX			
Port	: 5000	Latency	:	0.000 s
Acquired by	: [Directly into Qinsy] (No additional time tags)			
Observation time from	: N/A			
Number of slots	: 1			

Satellite System Definition

Position datum	: WGS 84 (Greenwich)
Satellite system name	: WGS 84

Satellite Receiver Definition

Receiver number	: 2	
Receiver description	: Ekinox GNSS 1 - Ant Pos	
Node identifier	: Ekinox GPS 1	
Object location	: BD Tx Aft	
X (Stbd = Positive):	: -0.728 m	
Y (Bow = Positive):	: -0.006 m	
Z (Up = Positive):	: 1.891 m	
A-priori SD	: 0.010 m	
SD latitude	: 0.050000 m	
SD longitude	: 0.050000 m	
SD height	: 0.050000 m	
Measurement unit	: Meters	
Horizontal datum	: WGS 84 (Greenwich)	
Vertical datum	: WGS 84 (Greenwich)	N/A
Height level	: No Level Correction	N/A
Height offset	: 0.000000 m	

Connected Observations

Connected Nodes

Undefined

Output System

ASCII Logger

Interfacing

Type	: Output System
Driver	: Generic ASCII Data Logger (Controller)
Executable and Cmdline	: DrvGenericLogger.exe
Update rate	: 1.000 s

Miscellaneous System

SVP-C

Interfacing

Type	: Miscellaneous System			
Driver	: Generic Serial Input (UWS_SVPC.ini)			
Executable and Cmdline	: DrvInputSerial.exe			
Port	: 11			
Baud rate	: 9600	Data bits	:	7
Parity	: Odd	Stop bits	:	2
Update rate	: 0.000 s	Latency	:	0.000 s
Acquired by	: [Directly into Qinsy] (No additional time tags)			
Observation time from	: N/A			

Number of slots : 1

Connected Observations

SVP-C : Generic
Slot 1 : 0

Connected Nodes

Undefined

Multibeam Echosounder

R2S_2024

Interfacing

Type	:	Multibeam Echosounder
Driver	:	R2Sonic 2000 Series (Network)
Executable and Cmdline	:	DrvR2Sonic.exe
Port	:	4000 Latency : 0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)
Observation time from	:	N/A
Number of slots	:	0

System Parameters

Node name	:	R2_AC_AFT
X (Stbd = Positive):	:	0.024 m
Y (Bow = Positive):	:	-3.149 m
Z (Up = Positive):	:	-1.303 m
A-priori SD	:	0.010 m
Description	:	R2S_2024
Object	:	BD Tx Aft
Number of transducers	:	Single
Transducer node TX	:	R2_AC_AFT
Heading offset	:	-1.535 °
Roll offset	:	-1.133 °
Pitch offset	:	9.144 °
Unit is roll stabilized	:	No
Unit is pitch stabilized	:	No
Unit is heave compensated	:	No
Beam steering (flat transducer)	:	No
Beam angle width along	:	1.000 °
Beam angle width across	:	0.500 °
Maximum number of beams per ping	:	1024
Use sound velocity from unit	:	Yes
Slot	:	1
SD type	:	Pulse, Sampling
SD pulse length	:	0.040 ms
SD sampling length	:	0.050 m
SD roll offset	:	0.050 °
SD pitch offset	:	0.050 °
SD heading offset	:	0.500 °
SD roll stabilization	:	0.000 °
SD pitch stabilization	:	0.000 °
SD heave compensation	:	0.000 m
SD sound velocity	:	0.100 m/s

Sidescan Sonar

R2S_2024 [Sidescan Sonar]

Interfacing

Type	:	Sidescan Sonar		
Driver	:	R2Sonic 2000 series (Network) Truepix		
Executable and Cmdline	:	DrvR2Sonic.exe		
Port	:	4000	Latency :	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)		
Observation time from	:	N/A		
Number of slots	:	0		

System Parameters

Manufacturer	:	R2Sonic
Model	:	R2Sonic Generic
Number of beams	:	1
Number of channels	:	2
Associated multibeam system	:	R2S_2024
Object location	:	BD Tx Aft
Use sound velocity from unit	:	Yes
Node name	:	R2_AC_AFT
Orientation	:	Port
Sidescan Sonar Channel:	:	0
Slot ID	:	0
Roll offset	:	0.000 °
Pitch offset	:	0.000 °
Heading offset	:	0.000 °
Frequency	:	400.000 kHz
Number of beams	:	1
Horizontal beam width	:	1.000 °
Vertical beam width	:	70.000 °
Vertical tilt angle	:	0.000 °
Node name	:	R2_AC_AFT
Orientation	:	Starboard
Sidescan Sonar Channel:	:	1
Slot ID	:	0
Roll offset	:	0.000 °
Pitch offset	:	0.000 °
Heading offset	:	0.000 °
Frequency	:	400.000 kHz
Number of beams	:	1
Horizontal beam width	:	1.000 °
Vertical beam width	:	70.000 °
Vertical tilt angle	:	0.000 °

Position Navigation System

Leica Nav

Interfacing

Type	:	Position Navigation System			
Driver	:	Generic Serial Input (UWS_Leica_GGQ.ini)			
Executable and Cmdline	:	DrvInputSerial.exe			
Port	:	7			
Baud rate	:	38400	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s
Acquired by	:	[Directly into Qinsy] (No additional time tags)			
Observation time from	:	N/A			

Number of slots : 0

Satellite System Definition

Position datum	:	WGS 84 (Greenwich)
Satellite system name	:	WGS 84

Satellite Receiver Definition

Receiver number	:	0
Receiver description	:	Leica Nav
Node identifier	:	Leica Ant 3
Object location	:	BD Tx Aft
X (Stbd = Positive):	:	-0.007 m
Y (Bow = Positive):	:	-0.007 m
Z (Up = Positive):	:	1.883 m
A-priori SD	:	0.010 m
SD latitude	:	0.050000 m
SD longitude	:	0.050000 m
SD height	:	1.000000 m

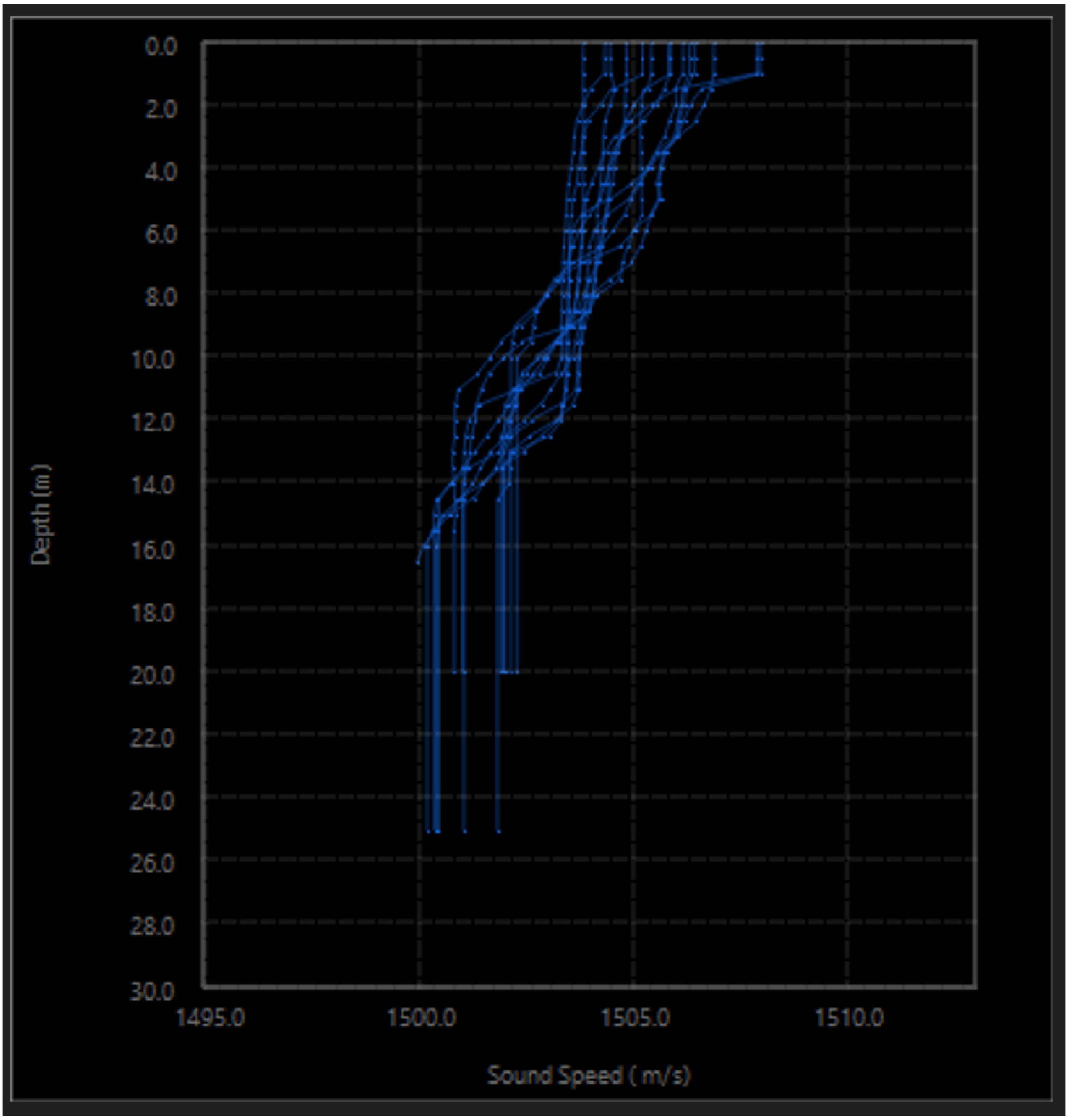
Measurement unit	:	Meters	
Horizontal datum	:	WGS 84 (Greenwich)	
Vertical datum	:	WGS 84 (Greenwich)	N/A
Height level	:	No Level Correction	N/A
Height offset	:	0.000000 m	

Connected Observations

Connected Nodes

Undefined

APPENDIX C SOUND VELOCITY PROFILES


0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
Depth (m)
1495.0
1500.0
1505.0
1510.0
Sound Speed (m/s)

APPENDIX D PATCH TEST CALIBRATION REPORT

Patch Test

Patch Test Information

Project:	C:/Users/Reinh/QPS-Data/Projects/202408_Saldanha
Software:	Qimera v2.6.2
Time of Report:	2024-09-05 07:42:38
Username:	Reinh
Vessel Name:	BD Tx Aft
Lines In Patch Test:	01: 0007 - Patch1 - 0001 (077°, 5.1 kts) 02: 0008 - Patch1 - 0001 (258°, 4.7 kts) 03: 0009 - Patch2 - 0001 (074°, 5.1 kts) 04: 0010 - Patch2 - 0001 (251°, 4.7 kts)

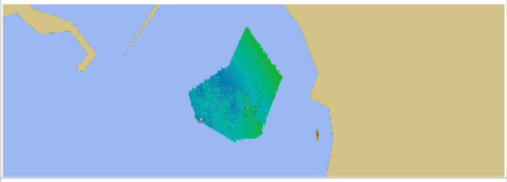
Summary of Calibration Results

System	Parameter	Original	Offset	New
R2S_2024	Roll	-1.283	0.150	-1.133
R2S_2024	Heading	-1.404	-0.131	-1.535

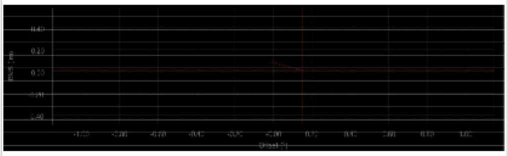
Calibration Step 1

Lines Used:	01: 0007 - Patch1 - 0001 (077°, 5.1 kts) 02: 0008 - Patch1 - 0001 (258°, 4.7 kts)
Calibration Type:	Multibeam Roll
Patch Location:	33°02'40.84"S, 18°00'17.88"E
Patch Heading:	77.0°
Patch Width:	50.17 meters
Patch Height:	2.51 meters
Active Motion System:	Motion
Active Gyro System:	Motion
Active Position System:	Object Track
Calibration System:	R2S_2024
Head Offset Value:	0.150°

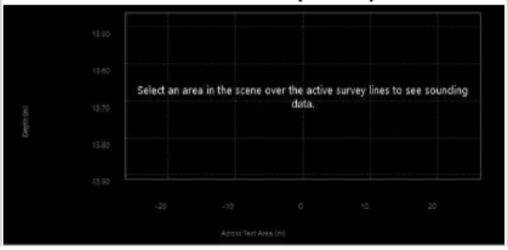
Calibration Area



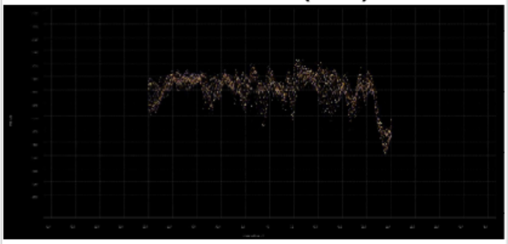
RMS Plot



Calibration Plot (Before)



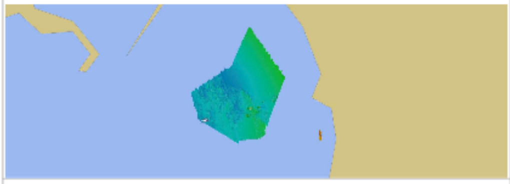
Calibration Plot (After)



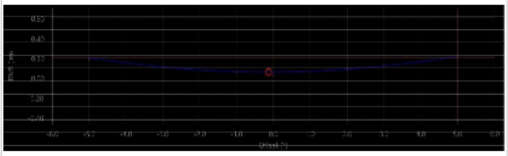
Calibration Step 2

Lines Used:	02: 0008 - Patch1 - 0001 (258°, 4.7 kts) 04: 0010 - Patch2 - 0001 (251°, 4.7 kts)
Calibration Type:	Multibeam Heading
Patch Location:	33°02'40.96"S, 18°00'18.95"E
Patch Heading:	168.0°
Patch Width:	50.17 meters
Patch Height:	2.51 meters
Active Motion System:	Motion
Active Gyro System:	Motion
Active Position System:	Object Track
Calibration System:	R2S_2024
Head Offset Value:	-0.131°

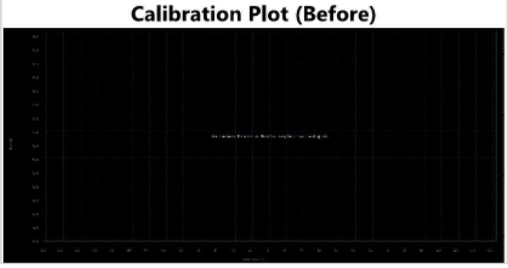
Calibration Area



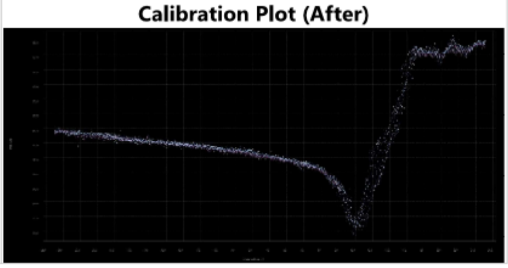
RMS Plot



Calibration Plot (Before)



Calibration Plot (After)



APPENDIX E CHARTS

ANCHOR
environmental