File Name:

Referral Report No. 8 - Boskalis Cambridge Gulf - ANNEXES

Annex A - *Independent Expert Review*

Annex B - *Updated Factual Data Report*

Referral under WA Environmental Protection Act

Proposal: Boskalis Cambridge Gulf Marine Sand Proposal, Western Australia.

Proponent: Boskalis Australia Pty Ltd.

Contacts: steve@eco-strategic.com (040 9909 422), peter.boere@boskalis.com (041 9987 158)

PORT & COASTAL SOLUTIONS

Annex A – Independent Expert Review

Steve Buchan

MetOcean Consulting

40 Gloster Street, Subiaco WA 6008

steve.buchan@metoceanconsulting.com.au

Mobile 040 747 1168

Independent Expert Review
of
Port & Coastal Solutions (PCS) (2024d). *Cambridge Gulf Marine Sand Proposal, Metocean & Sediment Dynamics, Data Analysis & Numerical Modelling Report - Second Draft* (P076-R03V02)

For Boskalis Australia Pty Ltd

Date: 15 January 2025

Responses to standard review questions

CG = Cambridge Gulf. POA = Proposed operational area. HD = Hydrodynamics. SW = Spectral Wave. ST = Sediment Transport. BP = Beach Process. PD = Plume Dispersal.

Review Questions	Reviewer's Comments
Overall Assessment: Quality, comprehensiveness, rigor, accuracy and reliability of the report"	**The report is extremely comprehensive and well-written.** **The supporting data collection and measurement programme was very comprehensive and extensive, although with some elements that could have been stronger. These include the following:** • **No field validation of local winds. Although the resulting modelled waves were shown to calibrate very well for wave heights – in particular, getting the diurnal signal of the daily sea breeze - there are questions about modelled wave directions and periods (particularly in the dry season) which may have been resolved with local wind measurements. However, the hindcasting of winds using the CAWCR model is considered accurate and adequate for the purposes of this study, and wind has been shown to not measurably affect hydrodynamics in CG, which is primarily a tidally driven system.** • **No occupation of a 12-month single AWAC reference site (to set all other measurements in seasonal context). Two of the consequences of this are that the seasonal variation of MSL (and subsequent relation to AHD), and of net drift rates (current residuals) have not (yet) been reliably established. This could be mitigated by further analysis of existing data. However, better resolution of the MSL-AHD relationship will not change the outcomes of this study.** • **The early transition (onset of prevailing southeasterly winds after the northerlies and northwesterlies of the wet season) from wet to dry season in late March 2024, creating an imbalance between wet and dry season measurements. This couldn't have been foreseen, but would have been mitigated if a 12-month reference station had been occupied.** • **Limitations with some wave direction measurements. This is an inherent difficulty associated with the use of AWAC instruments in fetch-limited, intermediate depth waters with a very high tidal range such as CG. It potentially contributed to limitations in modelling of 'old sea' propagation into CG, particularly in the dry season. However – since sediment transport within CG is dominated by tidal currents, this limitation does not impact the outcomes of the study.** **Despite the few questions noted above, because of the tidal dominance of sedimentary processes in CG, the data from BKA's comprehensive and extensive data collection and measurement programme, together with important supplementary data sets from other sources, were sufficient to allow reliable modelling of hydrodynamic and sedimentary processes in CG.**

Review Questions	Reviewer's Comments
	The performance of the modelling is assessed as follows. • **Hydrodynamic modelling is very impressive.** • **Spectral wave modelling is very good (albeit with caveats on measured wave directions and unknown veracity of forcing winds).** • **Sediment transport modelling is sound.** • **Beach Process modelling is sound.** • **Plume Dispersion modelling is adequate.** **Overall:** • **the dominance of the (very well modelled) tidal currents,** • **the general adequacy of the modelled CAWCR winds,** • **the comprehensive and extensive data set collected by BKA and inclusion of a variety of supplementary databases,** • **the absence of any significant benthic communities in CG, and** • **the great variability of natural suspended sediment levels in CG,** **means that predictions from this report can be regarded as reliable.**
1. Supporting Data: Is the full range of data used to support the modelling of sufficient types, spatial scope, temporal scope, volume and quality to support accurate and reliable modelling and prediction of potential changes from the proposed sand-sourcing operation?	
– HD model:	**The measured data are comprehensive and extensive and are more than adequate to support the level of hydrodynamic modelling required to predict the potential impacts of the proposed sand-sourcing operation.** **Setting the data in the context of the prevailing wet and dry seasons was a little compromised by the early (and very rapid) switch of prevailing wind directions from northerlies and northwesterlies to southeasterlies in late March 2024.** **Confidence in the interpretation of the data would have been improved if a single 12-month AWAC reference site had been occupied. However, the wealth of AWAC data collected (11 sites up to 142 days per site and a total combined deployment of 918 days or 30 months), is considered to be sufficient for the purposes of the study, and has allowed very strong calibration and validation of the modelling.**
– SW model:	**The measured data are comprehensive and extensive and more than adequate to support the level of spectral wave modelling required to predict the potential impacts of the proposed sand-sourcing operation.** **Setting the data in the context of the prevailing wet and dry seasons was a little compromised by the early (and very rapid) switch of prevailing wind directions from northerlies and northwesterlies to southeasterlies in late March 2024.** **Confidence in the interpretation of the data would have been improved if a single12-month AWAC reference site had been occupied. However, the wealth of AWAC data collected is considered to be more than adequate for the purposes of the study, and has allowed very strong calibration and validation of the wave height modelling. The wave period validation was not as strong, but was adequate for the purposes of this study.** **There are minor and unavoidable limitations (due to the nature of the physical setting with short fetch, shallow waters etc) in the accuracy of the wave direction measurements, due to the relatively short periods of the prevailing wave climate. This means that wave-induced velocities are rapidly attenuated with depth, making the wave direction measurement susceptible to noise from (unavoidable) side lobe interference of acoustic reflections from the water surface. These limitations do not affect the applicability of the resulting sediment transport modelling.**

Review Questions	Reviewer's Comments
– ST model:	**The measured data are adequate to support the level of sediment transport modelling required to predict the potential impacts of the proposed sand-sourcing operation.** **Measured site-specific turbidity data were supplemented by archived Sentinel 2 sensor imagery, which provided spatial maps of turbidity (up to 50 NTU where it saturated).** **There are potential limitations in the establishment of the NTU-TSS relationships (wet and dry season) upon which model results are dependent. While the relationships are derived from a significant data set (BKA advises that this is much more than is usually collected for similar dredging studies), the range of values used is well less than the full range of values that occur naturally in CG. For example, the highest dry season data point used for the relationship was 140 NTU, and the highest wet season data point was 60 NTU. The measured timeseries turbidity data showed greater variability, with values of up to 600 NTU in both wet and dry seasons, for which corresponding TSS values were not measured. However, it should be noted that periods with the highest NTU and TSS occur during spring tides with extreme currents, when BKA advises that based on site experience, it is extremely difficult and even dangerous to deploy Niskin bottles in vertical profiles to collect water samples for TSS analysis. Overall, the NTU-TSS relationship is considered adequate for the ST modelling.** **Questions about whether turbidity sensors would 'see' sand were somewhat assuaged because the amount of sand found in the PSD analyses of 78 samples, was typically less than 10% of the SSC. While these 78 samples were collected over a very narrow timespan (a few days near peak spring tides), and so not necessarily representative of the full suite of tidal (and river discharge) conditions experienced in CG, the resulting NTU-TSS relationships should be adequate to effectively inform the modelling of the dispersion of silts and clay (the majority of the SSC content).** **From the PSD analyses, it was inferred that sand transport was dominated by bedload transport, the modelling of which was calibrated against one high resolution repeat bathymetric survey over two target areas in CG. Because of the tidal dominance of bedload transport, this calibration data set provided reasonable confidence in the model's ability to simulate bedload transport – sufficient for the purposes of assessment of potential impacts of the proposed sand-sourcing operation.** **Generally, the sediment sampling programme was impressively extensive, and this provides the important ground-truthing of all subsequent sediment transport assessment.**
– BP model:	**The measured data comprised high resolution aerial drone LiDAR and photogrammetry surveys of the 4 known turtle nesting beaches in and around CG.** **The Datum of the surveys was tentatively set to AHD, which was noted as "unknown", but potentially up to 0.2 m below MSL. This was to be confirmed by subsequent analysis of measured tidal data.** **The CoastSat algorithms were also used to extract shoreline positions from archived satellite data, to assist in the assessment of beach stability.** **Crocodile danger precluded the collection of sand samples from any of the nesting beaches, so a median grain size of 0.2 mm was adopted.** **The measured data are adequate to support the level of beach process modelling required to reliably predict the potential impacts of the proposed sand-sourcing operation.**
– PD model:	**The measured data comprised turbidity profiles and Niskin bottle casts at a number of locations over a four week period during the dry season, and a relatively narrow time frame (essentially, hourly profiles over one semi-diurnal tidal cycle near peak spring tides at three site) in the wet season.** **Though the resulting NTU-TSS relationships derived for the wet and dry seasons are based on limited data (in the context of the great variability of turbidity levels in CG), because the ambient turbidity levels in CG are so**

Review Questions	Reviewer's Comments
	high, the data are adequate to support the level of plume dispersion modelling required to reliably predict the potential impacts of the proposed sand-sourcing operation. **Simulation of the sediment inputs generated by the sand-sourcing operation, is dependent on the adequacy of the input data on operational parameters supplied by the project proponent, and it is assumed that these are correct, as described in the report.**
2. Data Analysis: Is the analysis of the supporting data appropriate and adequate to support accurate and reliable modelling and prediction of potential changes from the proposed sand-sourcing operation?	
– HD model:	**Overall – the HD modelling is very sound, is well-calibrated, accurate and reliable and is clearly fit for purpose.** **The data analysis is sufficient to support hydrodynamic modelling and accurate and reliable prediction of the proposed sand-sourcing operation.** **QA-QC of the measured tides and currents included visual inspection of all timeseries data, which provides confidence in the data.** **The major drivers of currents and water levels within CG are clearly identified' and the analyses are sufficient to allow reliable calibration of the HD model.** **There is more that could be done to assess the relationship of MSL to AHD, but it has been established with sufficient accuracy for the purposes of environmental assessment. It is noted that developing the MSL-AHD relationship was not an aim of the study and is not required for the assessment of the proposed project in accordance with EPA guidelines. There are some queries about the oceanographic interpretation of the measured water level and current data, but any differences would not alter the overall environmental impact assessments of the modelled data.** **In particular, it would appear that the role of river outflow has been underestimated in its contribution to what the report describes as "ebb tide dominance".** **Similarly – the strong semi-diurnal signal which remains in much of the analysed current data probably reflects limitations in the harmonic analysis of combined (averaged over several levels), relatively short current data sets, which means that semi-diurnal constituents are not well-resolved. However, the analysis has shown that the residual water levels in CG are small relative to the astronomical tide and this is the key finding required to inform the numerical modelling.** **The Progressive Vector Diagrams generated from selected current data sets do help to elucidate the net current regime, but more useful statistics have been suggested to better illustrate net tidal and drift excursions.**
– SW model:	**Overall – the SW modelling is sound, reliable and fit for purpose.** **The data analysis is sufficient to support spectral wave modelling and reliable prediction of the proposed sand-sourcing operation.** **QA-QC of the measured waves included visual inspection of all timeseries data, which provides confidence in the measured wave height and period data. There is some question about the accuracy of measured wave directions, which are unavoidable because of difficulties in measurement of wave-induced velocities, arising from the fetch-limitations, intermediate water depths and very large tidal range within CG.** **Despite this, the major drivers of waves within CG are clearly identified, and the analyses are sufficient to allow reliable calibration of the SW model.**

Review Questions	Reviewer's Comments
	There are questions about the adequacy of the wave direction data, which may have compromised oceanographic interpretation of the measured wave data, and subsequent efficacy of the wave modelling. In particular, the measurements do not elucidate the propagation of "old sea" into CG as clearly as it might, and consequently the modelling does not simulate this process correctly (particularly in the dry season). However – the wave climate within CG is relatively benign, and any limitations in "old sea" modelling would not alter the overall environmental impact assessments of the modelled data. **In the calibration/validation process, there is a question raised about the adequacy of CAWCR modelled winds for driving the SW model. The apparent limitations arise when comparing modelled and measured wave data, with brief periods of wave height mismatch, and extended period (during the dry season) of wave direction mismatch. Because the seastates in CG (and offshore in Joseph Bonaparte Gulf - JBG) are relatively benign, and because tidal currents are so dominant, these wave modelling mismatches do not alter the overall environmental impact assessment of the proposed sand-sourcing operation.** **Although there was no site-specific calibration of CAWCR winds, it is important to note that the resulting wave modelling did accurately represent the strong diurnal signal of the land/sea breeze, which adds confidence to the applicability of the CAWCR winds.**
– ST model:	**Despite the limitations of the NTU-TSS calibration data set (as described under Item 1. Supporting Data.), the analyses of those data were appropriate to provide sufficient confidence in the subsequent modelling of sediment transport, that would support reliable assessment of the potential environmental impact of the proposed sand-sourcing operation.** **The in-situ turbidity data showed great variability, the sediment sampling programme was extensive (grab samples, vibro-coring, Niskin casts), and subsequent laboratory analyses of retained samples have provided a sound basis to support modelling assessment.** **The Sentinel 2 sensor imagery were processed to estimate Total Suspended Matter (with an upper limit of 50 NTU), which was available for ST model corroboration.**
– BP model:	**Initial QC and analysis of the drone LiDAR data was conducted by Sensorem, to provide a Digital Elevation Model to the BP modelling, with horizontal resolution of 0.05 m, and a RMS vertical accuracy of 0.05 m. This is more than adequate for BP modelling.** **In addition, high resolution orthomosaic imagery was provided to allow identification of areas (e.g. rocky outcrops) which were not sand.** **As outlined above there are questions about the vertical datum (AHD relative to MSL), but this should not affect comparative assessments of the chosen modelling scenarios.**
– PD model:	**The data analyses are adequate to support the level of plume dispersion modelling required to reliably predict the potential impacts of the proposed sand-sourcing operation.** **The PD modelling should also be considered in the context of the fact that CG is largely devoid of benthic life which could potentially be impacted by sediment plumes, principally because of the absence of benthic light, the naturally high and hugely variable turbidity levels, and the very active sediment transport processes (under strong tidal forcing).**
3. Modelling approach & setups: Are the modelling software, modules, approaches and setups appropriate and adequate to support accurate and reliable modelling and prediction of potential changes from the proposed sand-sourcing operation?	

Review Questions	Reviewer's Comments
– HD model:	**Yes.** **The selected HD model (DHI MIKE 3D with flexible mesh) is 'best practice' for this type of project.** **Bathymetric data on which the model is based are highly accurate in the main project area, and fit-for-purpose in peripheral regions.** **The model gridding is comprehensive, and associated time-stepping is in accordance with modelling norms.** **The mixed sigma and Z coordinate scheme for the vertical layers, is appropriate.** **The boundary tidal forcing is comprehensive.** **The driving winds are adequate (noting they are secondary to the tidal driving).** **The river inflow data are adequate (measured for the Ord River, scaled (by relative catchment area) to match King River discharges for other river inputs.**
– SW model:	**Yes.** **The selected wave model (DHI MIKE suite) is widely used and well-accepted for estuarine and coastal wave simulation.** **The nesting structure adopted is appropriate for this domain.** **The bathymetric data are sound.** **The time-stepping and frequency and direction discretization are appropriate.** **The boundary wave data (from the CAWCR hindcast) provide a good representation of the seastates in outer Joseph Bonaparte Gulf (JBG). The CAWCR winds are likely adequate to drive open ocean wave generation. There is some question about the adequacy of CAWCR winds in the coastal zone (where mesoscale influences become important), but it is important that the CAWCR winds have been able to simulate the diurnal signature of the land/sea breeze in coastal wave data.**
– ST model:	**Yes.** **The DHI MIKE ST model is widely used and well-accepted. It meshes seamlessly with the HD and SW models.** **The prime drivers of the model are tidal currents which are very well represented by the HD model.** **The necessary input of river discharge is provided by measured data.** **Local wind-driven currents are insignificant compared to tidal and river discharge currents – so any questions about forcing winds are immaterial.** **The fetch-limitations of CG are such that locally generated waves are of such short period, that they do not contribute significantly to sediment resuspension.**
– BP model:	**Yes.** **The MIKE Littoral Processes LITDRIFT and LITPROF modules have been adopted to model the longshore and cross-shore transport of sediment at the three high-priority turtle-nesting beaches on the seaward coast outside of CG.** **The LITDRIFT and LITPROF modules calculate the propagation, shoaling and breaking of waves, the momentum balance for cross-shore and longshore currents and the resultant longshore and cross-shore sediment transport.**

Review Questions	Reviewer's Comments
	The Littoral Process modules link seamlessly to the HD and SW models. Though there are some questions relating to modelled wave directions within CG, this is less so for the coastline just outside of CG. **For the turtle nesting site within CG (at Barnett Point), the beaches are actually stranded sandbars (cheniers) which are protected by fringing mangroves, and are not amenable to BP modelling by the MIKE suite.** **The satellite-derived shoreline location data provide important corroboration of the interpretation of the beach process modelling.**
– PD model:	**Yes.** **Likely sediment inputs from sand-sourcing operations have been established conservatively, in accordance with advice from the proponent.** **The PD modelling is based on the MIKE ST model, the efficacy of which is addressed above.**
4. Model calibration & validation: Are the calibration and validation of the models appropriate and adequate to support accurate and reliable modelling and prediction of potential changes from the proposed sand-sourcing operation?	
– HD model:	**Yes.** **The calibration and validation of both water levels and current speed and direction are impressive, being supported by a comprehensive and extensive set of field data.** **The introduction of the daily running mean was important in suppressing the semi-diurnal noise introduced into tidal height and current residuals by minor limitations of the (piecemeal) harmonic analyses.** **Given that hydrodynamics are the primary driver of the overall system in CG and the HD model underpins the ST, SW, BP and PD models, the highly accurate and reliable calibration and validation of the HD model underpins the calibration and validation of the other models.**
– SW model:	**Yes.** **Wave heights are well-calibrated and validated.** **Wave periods are less so, with questions about the ability of the SW model to reliably represent the propagation of "old sea" into CG.** **Wave direction validation is uncertain because of unavoidable difficulties with wave direction measurements in the physical setting of CG (short fetch etc).** **Despite this, the dominant influence on sediment transport is tidal currents, so uncertainties in wave modelling do not detract from the overall assessment of the potential environmental impact of the proposed sand-sourcing operation.**
– ST model:	**Yes.** **The relative absence of sand in suspension (less than 10%) indicates that some reliance can be placed on turbidity measurements. While the NTU-SSC calibration data does not cover the extreme upper values of NTU and SSC in CG,, the great variability of ambient levels of turbidity means that highly accurate SSC modelling of the relatively small contributions from the proposed sand-sourcing operation is not required.** **The Total Suspended Matter maps produced from the Sentinel 2 sensor imagery have provided corroboration of the spatial distribution of near-surface sediments.**

Review Questions	Reviewer's Comments
	Bedload transport modelling was calibrated against a repeat bathymetric survey of 2 selected target areas within the POA over a 27-day period covering both spring and neap tides. Because of the tidal dominance of this process, the calibration is sufficient.
– BP model:	**Yes.** **The modelling is supported by aerial LiDAR survey, and inspection of available aerial photography and satellite imagery.** **The results of BP modelling have been checked against shoreline data derived from the CoastSat algorithm, providing qualitative corroboration of the modelling.**
– PD model:	**Yes.** **Calibration of the PD model essentially equates to calibration of the ST model.** **Ambient levels of turbidity are so large, and the CG region so devoid of benthic habitat, that highly accurate plume dispersion modelling is not necessary.** **The potential impacts of plume dispersion will be further mitigated by 'best-practice' to be adopted by the operators during sand-sourcing.**
5. <u>Modelling Results</u>: Are each of the modelling results accurate and reliable, in terms of predicting potential changes from the proposed sand-sourcing operation?	
– HD model:	**Yes, for the reasons stated in the HD model responses to questions 1 to 4 above.** **The selected model scenarios are representative of EPA's requirements, and modelling setups (seabed levels, sea levels, operating levels etc) are well-prescribed.** **The HD model is very well-calibrated.** **The modelling scenarios are not challenging.** **Results can be expected to be accurate and reliable.**
– SW model:	**Yes, for the reasons stated in the SW model responses to questions 1 to 4 above.** **The selected model scenarios are representative of EPA's requirements, and modelling setups (seabed levels, sea levels, operating levels etc) are well-prescribed.** **The SW model is well-calibrated for wave heights, though less so for wave periods and directions.** **The modelling scenarios are not challenging.** **While there are questions about modelling of wave direction and periods, as outlined in the responses above, given the domination of tidal currents in the CG system the results are more than adequate for environmental assessment of the proposed sand-sourcing operation.** **Not much can be inferred from the modelling of TC Marcus. It is only one storm, which was Category 2 when it passed some 80 km north of CG, with a Radius to Maximum Wind of 20 to 30 km. It is not known how well the windfield was parameterized. The modelling does confirm that elevated tropical cyclone seastates from JBG can enter CG, but even-so, the response to a relatively large wave event was (in the context of net sediment transport) very small (insignificant).**
– ST model:	**Yes, for the reasons stated in the ST model responses to questions 1 to 4 above.**

Review Questions	Reviewer's Comments
	The selected model scenarios are representative of EPA's requirements, and modelling setups (seabed levels, sea levels, operating levels etc) are well-prescribed. **Since the sand content of the suspended sediments has been shown to be low, more confidence can be put in the NTU-TSS relationship.** **The natural variability of the sediment regime within CG has been shown to be very large and the changes indicated by the modelled scenarios relatively small. That coupled with the effective absence of benthic life in CG, means that high levels of ST model accuracy are not required.** **The modelling of TC Marcus did indicate that its associated wavefields led to significant increase in sediment transport, but only for a very limited duration.**
– BP model:	**Yes, for the reasons stated in the BP model responses to questions 1 to 4 above.** **The selected model scenarios are representative of EPA's requirements, and modelling setups (seabed levels, sea levels, operating levels etc) are well-prescribed.** **For the coastal beaches just outside CG, the LiDAR data and the sediment sampling which support the BP modelling are very reliable.** **The HD modelling is also very reliable – SW modelling less so – but likely still adequate for simulation of wave breaking processes (which are controlled by wave heights and water levels – both of which are reliably simulated).** **The (partial) corroboration of BP modelling from the shoreline position data derived via CoastSat from satellite imagery, also adds confidence to the BP modelling.** **For the 3 external beaches, the results of the BP modelling scenarios are considered to be reliable.** **Within CG, the beaches at Barnett Point are actually stranded sandbars protected by fringing mangroves. As such – they are not amenable to simulation by the MIKE suite. However, inspection of the results of HD and SW modelling for the selected scenarios, suggests that the sand-sourcing operation is unlikely to have significant impact on these beaches.**
– PD model:	**Yes, for the reasons stated in the PD model responses to questions 1 to 4 above.** **The selected model scenarios are representative of EPA's requirements, and modelling setups (seabed levels, sea levels, operating levels etc) are well-prescribed.**
6. <u>Cumulative Impacts</u>: Are the data analysis and modelling appropriate and adequate to support accurate and reliable modelling of pre-European conditions, changes that have occurred since European settlement (from the Ord River dams), and cumulative changes from the proposal in addition to any changes from the dams?	**Yes.** **The impact of damming the Ord River has had much greater environmental impact than is predicted to occur from the proposed sand-sourcing operation.** **The dominance of the (very well modelled) tidal processes, means that confidence can be placed in the report assessments.**
7. <u>Compliance with Standards & Guidelines</u>: Does the work meet the requirements of the following?	
– Accepted international best practices relating to HD, SW, ST, BP and PD modelling:	**Yes. Port & Coastal Solutions has explicitly followed international best practices as described and recommended in:** – **Becker, J., van Eekelen, E., van Wiechen, J., de Lange, W., Damsma, T., Smolders, T. and van Koningsveld, M., 2015. Estimating source terms**

Review Questions	Reviewer's Comments
	for far field dredge plume modelling. Journal of Environmental Management 149, 282-293. – **GBRMPA, 2012. Guidelines – The use of hydrodynamic numerical modelling for dredging projects in the Great Barrier Reef Marine Park. August 2012.** – **Kemps, H., and Masini, R., 2017. Estimating dredge source terms – a review of contemporary practice in the context of Environmental Impact Assessment in Western Australia. Report of Theme 2 – Project 2.2, prepared for the Dredging Science Node, Western Australian Marine Science Institution (WAMSI). Perth, Western Australia, 29pp.** – **Los, F.J. and Blaas, M., 2010. Complexity, accuracy and practical applicability of different biogeochemical model versions. Journal of Marine Systems 81, 44-74.** – **Sun, C., Shimizu, K., and Symonds, G., 2016. Numerical modelling of dredge plumes: a review. Report of Theme 3 - Project 3.1.3, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 55 pp.** – **WAMSI/CSIRO (Sun et al) 2020 - Guideline on Dredge Plume Modelling for Environmental Impact Assessment.** – **Williams, J.J. and L.S. Esteves (2017). Guidance on setup, calibration and validation of hydrodynamic, wave and sediment models for shelf seas and estuaries. Advances in civil engineering (Volume 2017), 5251902, 25 pages.**
– WA EPA 2016 - Environmental Factor Guideline - Coastal Processes:	**Yes.** **Port & Coastal Solutions has explicitly followed this Guideline as outlined in detail against each of the main requirements of the Guideline in section 8 of the report.**
– WA EPA 2021 - Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals.	**Yes.** **Port & Coastal Solutions has explicitly followed this Guideline as outlined in detail against each of the main requirements of the Guideline in section 8 of the report.**
– WAMSI/CSIRO (Sun et al) 2020 - Guideline on Dredge Plume Modelling for Environmental Impact Assessment.	**Yes.** **Port & Coastal Solutions has explicitly followed this Guideline as listed above and outlined in section 3.7 and section 8 of the report.**

Specific section review comments

In support of the above review, specific comments are included directly on the documents:

Cambridge Gulf Marine Sand Proposal
Metocean and Sediment Dynamics – Factual Data Report
P076_R02v03
PCS Output 3 – December 2024 Update

Cambridge Gulf Marine Sand Proposal
Metocean & Sediment Dynamics
Data Analysis and Numerical Modelling Report
P076_R03v02
PCS Output 4 – Second Draft

Annex B – Updated Factual Data Report

PORT & COASTAL SOLUTIONS

Cambridge Gulf Marine Sand Proposal

Metocean and Sediment Dynamics – Updated Factual Data Report

P076_R02v1.2

PCS Output 3 – January 2025 Update

Boskalis

Technical Report
January 2025

Cambridge Gulf Marine Sand Proposal

Metocean & Sediment Dynamics – Updated Factual Data Report

Report No. P076_R02v1.2

PCS Output 3 - January 2025 Update

January 2025

For Boskalis Australia Pty Ltd

Version	Details	Authorised By	Date
0.1	Draft	Andy Symonds	28/06/2024
0.2	Final	Andy Symonds	29/07/2024
1.1	Updated Draft	Andy Symonds	19/12/2024
1.2	Updated Final	Andy Symonds	20/01/2025

Document Authorisation		Signature	Date
Project Manager	Andy Symonds	[signature]	20/01/2025
Author(s)	Andy Symonds, Claire Conning	[signatures]	20/01/2025
Reviewer	Rachel White	R.E.White	20/01/2025

Disclaimer

PORT AND COASTAL SOLUTIONS PTY LTD
ABN 66 630 775 423

A | 46 Elanora Drive, Burleigh Heads, QLD, 4220
E | info@portandcoastalsolutions.com.au
W | www.portandcoastalsolutions.com.au
M | +61 (0)458 735 747

CONTENTS

APPENDICES

FIGURES

TABLES

ABBREVIATIONS

Abbreviation	Definition
ADCP	Acoustic Doppler Current Profiler
AHD	Australian Height Datum
AHO	Australian Hydrographic Office
AIMS	The Australian Institute of Marine Science
AST	Acoustic Surface Tracking
AWAC	Acoustic Wave and Current
BoM	Bureau of Meteorology
BKA	Boskalis Australia Pty Ltd
CAWCR	Centre for Australian Weather and Climate Research
CG	Cambridge Gulf
CTD	Conductivity, Temperature, and Depth
DEM	Digital Elevation Models
DWER	Department of Water and Environmental Regulation
EDS	Energy Dispersive Spectrometer
GBAD	GBAD Services Pte Ltd
GNSS	Global Navigation Satellite System
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organisation
IMOS	Integrated Marine Observing System
IMSA	Index of Marine Surveys for Assessments
ISO	International Organization for Standardization
JBG	Joseph Bonaparte Gulf
KS	King Shoals
LiDAR	Light Detection and Ranging
MAFRL	Marine and Freshwater Research Laboratory
MSL	Mean Sea Level
NA	Not Available
NATA	National Association of Testing Authorities
NTU	Nephelometric Turbidity Unit
OS	Offshore
PAR	Photosynthetic Active Radiation
PCS	Port and Coastal Solutions Pty Ltd
POA	Proposed Operational Area
PSD	Particle-Size Distribution
PSU	Practical Salinity Unit
QA	Quality Assurance
QC	Quality Control
RMS	Root Mean Squared
SD	Standard Deviation
SE	Standard Error
SEM	Scanning Electron Microscope
SP	Sample Point

Abbreviation	Definition
TSM	Total Suspended Matter
TSS	Total Suspended Solids
UTC	Coordinated Universal Time
UWA	The University of Western Australia
WA EPA	Western Australia Environmental Protection Authority
WQ	Water Quality
WWIII	WAVEWATCH III
YSI	Yellow Springs Instruments

1. Introduction

Boskalis Australia Pty Ltd (BKA) commissioned Port and Coastal Solutions Pty Ltd (PCS) to undertake metocean and sediment data analysis and numerical modelling for the Cambridge Gulf (CG) Marine Sand Proposal (the proposal). The primary aim of this work by PCS is to analyse and interpret metocean and sediment data and undertake detailed numerical modelling to support BKA's environmental impact assessment and regulatory approval applications for the proposal.

The outcomes of this work by PCS are presented in the following three documents:

- PCS (2024a), Cambridge Gulf Marine and Proposal – WA EP Act s38 Referral Report No. 5 *Metocean & Sediment Dynamics – System Understanding, Conceptual Model & Initial Modelling.*
- PCS (2024b), Cambridge Gulf Marine and Proposal – WA EP Act s38 Referral Report No. 5: *Metocean & Sediment Dynamics – System Understanding, Conceptual Model & Initial Modelling.* Annex 1: Supplementary Technical Note.
- PCS (2025a), Cambridge Gulf Marine and Proposal – WA EP Act s38 Referral Report No. 8: *Metocean & Sediment Dynamics – Data Analysis and Numerical Modelling Report.*

This work by PCS is supported by two main data sources:

- BKA-collected data: Data collected from field surveys either commissioned by BKA or undertaken directly by BKA to support the proposal, between February 2023 and 14th August 2024.
- Pre-existing data: Data available from previous studies and external and public sources.

This report describes both the BKA-collected data and pre-existing which have been analysed and used by PCS to inform the metocean and sediment dynamics assessments, as reported to date in PCS (2024a, 2024b & 2025a). This report provides a summary of the data, the quality control and data processing undertaken (where known, as not always available for pre-existing data) and details of the processed data files. For BKA-collected data this report also presents factual results from the data analysis. The report does not provide any interpretation of the data, this is provided in PCS (2024a, 2024b & 2025a).

Where relevant and possible, this report has been developed in accordance with the Western Australia Environmental Protection Authority (WA EPA) instructions for the preparation of data packages for the Index of Marine Surveys for Assessments (IMSA).

Note - Biological data: It should be noted that in addition to the metocean and sediment data presented in this report, BKA has also externally sourced, commissioned collection and directly collected a wide range of biological and related environmental data, to support the environmental impact assessment and regulatory approval applications for the proposal. Those data are not included in this report and are presented in BKA (2024b) Cambridge Gulf Marine Sand Proposal - WA EP Act s38 Referral Report No. 2: *Proposal Setting & Existing Environmental Descriptions.*

1.1. Report Structure

The report herein is set out as follows:

- an introduction to the report is provided in **Section 1 - Introduction**;
- a summary of the data considered in this report, including both the BKA-collected data and pre-existing, is listed in **Section 2 - Data Directory**;
- for the BKA-collected data, details of the instruments used and data collected during the field surveys are presented in **Section 3 - BKA Field Data Details**;
- the quality control and data processing undertaken by PCS is detailed in **Section 4 - Data QA/QC**;
- a list of files of the processed data from the BKA-collected data is provided in **Section 5 - Data Files**;

- an overview of the results from the BKA-collected data is provided in **Section 6 - Results**; and
- a summary of both the BKA-collected and pre-existing data is presented in **Section 7 - Summary**.

The following conventions have been adopted throughout this report:

- water levels are provided relative to mean sea level (MSL);
- depths are provided relative to MSL unless stated otherwise;
- current directions are quoted as directions to; and
- wave directions are quoted as directions from.

2. Data Directory

This section provides a summary of all of the data analysed by PCS up to the 14th August 2024 and reported in PCS (2024a, 2024b & 2025a).

The BKA-collected data are presented in Table 1 and include the following:

- Sand exploration survey February – March 2023, including:
    - Side-scan sonar and sub-bottom profiler for seabed elevation and morphology and sediment type and thickness.
    - Vibrocores for sediment type, particle size distribution (PSD) and thickness.
    - Van Veen Grabs for sediment type.
    - Secchi disc and drop camera for water clarity.
    - Plus, benthic biota was also assessed qualitatively using Van Veen Grab - not part of PCS analysis, see BKA (2024b).
- In-situ oceanographic & water quality data collection June 2023 to August 2024, including:
    - In-situ ADCPs/AWACs for current speed and direction, water levels (tides) and waves using (ADCP = Acoustic Doppler Current Profilers / AWAC = Acoustic Wave & Current profiler).
    - In-situ seabed data loggers for seabed light, turbidity, temperature, salinity, pH and dissolved oxygen.
- Dry-season environmental survey July 2023, including:
    - Water quality profiles with YSI multi-probe for turbidity, chlorophyll-a, temperature, salinity.
    - Water quality Niskin samples for total suspended solids (TSS) and chlorophyll-a.
    - Water clarity using drop camera.
    - Sediment type using Van Veen Grab.
    - Plus a range of biological sampling was also undertaken - not part of PCS analysis, see BKA (2024b).
- Wet-season environmental survey February - March 2024, including:
    - Van Veen Grabs for sediment type, PSD and elemental features using Mastersizer and Scanning Electron Microscope (SEM) feature analysis.
    - Vertical water profiles over 13-hour spring tidal cycle to collect data on currents with Aquadopp, turbidity, chlorophyll-a, temperature, salinity, pH with YSI multi-probe and TSS and suspended sediment PSD and SEM features from Niskin samples.
    - High resolution aerial drone LiDAR and photogrammetry surveys of key turtle nesting beaches to assist coastal process assessment.
    - High resolution hydrographic surveys of the proposed operational area (POA) and 1 km buffer, including repeat surveys over lunar tidal cycle to assess seabed sand dynamics.
    - Plus a range of biological sampling was also undertaken - not part of PCS analysis, see BKA (2024b).

The pre-existing data that were used are presented in Table 2 and include the following:

- AIMS (Australian Institute of Marine Science) hydrodynamics and water quality data 1999 to 2004.

- WA DoT (Department of Transport) water level (tide) data 1985 to 2022.
- AHO (Australian Hydrographic Office) water level (tide) predictions.
- BoM (Bureau of Meteorology) wind and rainfall data 1951 to 2023.
- IMOS (Integrated Marine Observing System) water levels and currents 2010 to 2019.
- CAWCR (Collaboration for Australian Weather and Climate Research) (BoM & CSIRO) waves and wind 1979 to 2024 (hindcast model).
- UWA (University of WA) wind and rainfall November 2013 to August 2014.
- DWER (WA Department of Water & Environmental Regulation) stream gauge data 1967 to 2024.
- Geoscience Australia bathymetric data.
- DEA (Digital Earth Australia) bathymetric data.
- Copernicus satellite imagery 2015 to 2024.
- USGS (US Geological Survey) satellite imagery 1988 to 2024.

Further details of the BKA-collected data are presented in Sections 3, 4 and 5. Further details of the specific pre-existing data collected by AIMS and DWER used in the study are provided in Section 3.5 while the post-processing undertaken by PCS on the USGS and Copernicus satellite imagery is detailed in Section 4.5.

Table 1. BKA-collected data: Summary of data collected from field surveys Feb 2023 to June 2024.

Sampling Activity	Undertaken By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure with data collection sites	Dates Collected	Sampling Equipment	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
SAND EXPLORATION SURVEY FEB-MAR 2023									
Sand profiling:	Metinco for BKA.	Geophysical.	Seabed elevation & morphology. Sediment thickness.	Block 4. -14.872 / 128.233 to -14.772 / 128.350	Figure 1	22 Feb to 6 Mar 2023.	Side-scan sonar. Sub-bottom profiler.	Antenna correction and ground truthing.	Not required.
Vibro-coring:	SEAS with BKA.	Geophysical.	Sediment type. PSD.	35 cores in Block 4. 21 for PSD analyses. -14.872 / 128.233 to -14.772 / 128.350	Figure 2	6 to 14 Mar 2023.	Vibro-corer.	Refer BKA.	Not required.
Van Veen grabs:	SEAS with BKA.	Geophysical.	Sediment type	35 sites in Block 4. -14.872 / 128.233 to -14.772 / 128.350	Figure 2	6 to 14 Mar 2023.	Van Veen grab.	Sieved to 6 mm and then visual assessment of sediment type.	Not required.
Secchi-disc and drop cameras:	EcoStrategic for BKA.	Water Quality.	Water clarity	17 of the 35 sites in Block 4. -14.872 / 128.233 to -14.772 / 128.350	Figure 2	6 to 14 Mar 2023.	Secchi-disc. Drop camera.	Not required	Not required.
IN-SITU OCEANOGRAPHIC & WATER QUALITY JUN 2023 - AUG 2024									
In-situ ADCPs/AWACs:	BKA.	Hydrodynamics. Waves.	Water depth. Currents speed & direction. Wave conditions.	11 sites -15.044 / 128.115 to -14.660 / 128.382	Figure 3	Jun 2023 to Aug 2024 (see Section 3.1.2).	Nortek AWAC 600 kHz. Nortek Signature 500/1000.	See Section 4.1.1.	See Section 4.1.1.
In-situ data-logging light & multi-sonde probes:	BKA.	Water Quality.	Benthic Light (PAR/DLI). Turbidity, temperature,	14 sites, 11 co-located with AWACs above.	Figure 3	Jun 2023 to Aug 2024 (see	LI-COR LI-1500 & Odyssey Xtreem light meters.	See Sections 4.1.2 and 4.1.3.	See Sections 4.1.2 and 4.1.3..

Sampling Activity	Undertaken By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure with data collection sites	Dates Collected	Sampling Equipment	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
			salinity, dissolved oxygen, pH.	-15.044 / 128.115 to -14.660 / 128.382		Section 3.1.2).	Manta/WiMo multi-sonde probes.		
DRY SEASON ENVIRONMENTAL SURVEY JULY 2023									
Water quality profiles with YSI multi-probe:	EcoStrategic for BKA.	Water Quality.	Turbidity, chlorophyll-a, temperature, salinity.	53 sites in Cambridge Gulf (CG). 20 sites at King Shoals (KS). 30 sites offshore. -15.058 / 128.113 to -14.301 / 128.610	Figure 4 & Figure 5	17 to 30 Jul 2023.	YSI EXO-1 multiparameter probe.	See Section 4.3.1.	Not required.
Niskin water samples:	EcoStrategic for BKA.	Water Quality.	TSS. Chlorophyll-a.	31 sites in CG. 3 sites at KS. 20 sites offshore. Figure 4 & Figure 5 -15.044 / 128.169 to -14.301 / 128.609	Figure 4 & Figure 5	17 to 30 Jul 2023.	Niskin water sampler.	See Section 4.3.1.	Not required.
Drop camera profiles:	EcoStrategic for BKA.	Water Quality.	Water clarity. (also benthic biota)	105 sites in CG. 27 sites at KS. 81 sites offshore. -15.058 / 128.113 to -14.301 / 128.610	Figure 4 & Figure 5	17 to 30 Jul 2023.	Drop camera.	Not required.	Not required.
Van Veen grabs:	EcoStrategic for BKA.	Geophysical.	Sediment type.	105 sites in CG. 27 sites at KS. 90 sites offshore. -15.058 / 128.113 to -14.301 / 128.610	Figure 4 & Figure 5	17 to 30 Jul 2023	Van Veen grab.	Visual assessment of samples.	Not required.

Sampling Activity	Undertaken By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure with data collection sites	Dates Collected	Sampling Equipment	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
WET SEASON ENVIRONMENTAL SURVEY FEB - MAR 2024									
Van Veen grabs:	EcoStrategic for BKA. +Microanalysis Labs for sample analysis.	Geophysical.	PSD.	74 sites in CG & KS. -15.651 / 127.822 to -14.668 / 128.484	Figure 6	Feb 2024.	Collection: Van Veen grab. Analysis: Sieved to 500 µm then analysed by Mastersizer.	NATA lab PSD analysis protocols.	Visual check
Van Veen grabs:	EcoStrategic for BKA. +Microanalysis Labs for sample analysis.	Geophysical.	Elemental features.	45 sites in CG & KS. -15.651 / 127.822 to -14.668 / 128.484	Figure 6	Feb 2024.	Collection: Van Veen grab. Analysis: Carl Zeiss EVO 50 SEM fitted with an Oxford INCA X-Max energy dispersive spectrometer (EDS).	Image acquisition & processing and compositional analysis was undertaken using the Oxford Instruments Feature software.	Details provided in Section 4.4.2
Vertical profiles (13 hr tidal cycle):	EcoStrategic for BKA. +Microanalysis Labs for sample analysis.	Hydrodynamics. Water Quality. Geophysical.	Depth & Currents. TSS. Turbidity, chlorophyll-a, temperature, salinity, and pH. Suspended sediment PSD & elemental features.	3 sites in CG. -14.803 / 128.268 -14.761 / 128.242 -14.913 / 128.214	Figure 7	24, 25 and 27 Feb 2024.	Collection: Nortek Aquadopp Deepwater. 2 x Niskins for suspended sediment samples (midwater and near-seabed). YSI Multi-Sonde Probe for water quality. Analysis: TSS - lab methods. PSD - Mastersizer. SEM features -	See Section 4.4.2	See Section 4.4.2

Sampling Activity	Undertaken By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure with data collection sites	Dates Collected	Sampling Equipment	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
							Carl Zeiss EVO 50 SEM as above.		
Aerial drone LiDAR and photogrammetry:	Sensorem for BKA.	Surface Elevation. Aerial Imagery.	Surface Elevation. Aerial Imagery.	4 priority turtle nesting beaches: Cape Domett (main and small beaches). Turtle Bay (Lacrosse Is). Turtle Beach West (west of Cape Dussejour). -14.829 / 128.154 to -14.707 / 128.154	Figure 8	22 to 25 Feb 2024	DJI Matrice 300 RTK with a Zenmuse L2 payload installed. Trimble R12 GNSS Receiver and D-RTK 2 base station.	See Section 4.4.3	Not required
Hydrographic surveys:	BKA.	Geophysical	Seabed Elevation	POA inc. 1 km buffer -14.914 / 128.207 to -14.751 / 128.306	Figure 9	7 to 14 Feb and 3 to 6 Mar 2024	Norbit Multibeam echosounder at 400 kHz	See Section 4.4.4	Not required

Table 2. Pre-existing data: Summary of data sourced from previous studies and external and public sources and analysed as part of the study.

Collected By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure showing data collection sites	Dates Collected	Equipment Specifications	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
AIMS	Hydrodynamic. Water quality.	Water Level. Currents. TSS.	9 sites in CG -15.478 / 128.085 to -14.795 to 128.353	Figure 10	Oct 2000 Jan to Feb 2002	ADCP. Nephelometer.	Unknown.	Visual Check.
AIMS	Water quality.	Salinity. Temperature.	121 sites throughout CG -15.549 / 127.981 to -12.510 / 130.001	Figure 11	1999 to 2004	CTD.	Unknown.	Not required.
WA DoT	Hydrodynamic.	Water Level.	Site at Port of Wyndham -15.453 / 128.101	Figure 10	1985 to 2022	Tide gauge.	Unknown.	Not required.
AHO	Hydrodynamic.	Water Level (Predicted).	Sites at Wyndham and Cape Domett -15.453 / 128.101 -14.833 / 128.383	Figure 10	NA	NA	Unknown.	Not required.
BoM	Meteorological.	Wind. Rainfall.	Wyndham Airport: -15.510 / 128.1503 Port Keats Airport: -14.249 / 129.528	Figure 10 & Figure 13	1951 to 2023 at Wyndham Airport 1996 to 2023 at Port Keats Airport	BoM weather stations.	Standard BoM QA-QC procedures.	Visual Check.
IMOS	Hydrodynamic	Water Level. Currents.	3 sites in Joseph Bonaparte Gulf: -13.610 / 128.965 -12.290 / 128.477 -11.000 / 128.000	Figure 13	2010 to 2019	Sentinel ADCP and Monitor Workhorse ADCP.	Unknown.	Visual Check.
CAWCR	Wave. Meteorological.	Wave Conditions.	2 sites in Joseph Bonaparte Gulf: -14.667 / 128.334	Figure 13	1979 to 2024 (hindcast modelled)	WWIII model.	Not required.	Not required.

Collected By	Data Type	Parameters Measured	Data Location (Lat/Long)	Figure showing data collection sites	Dates Collected	Equipment Specifications	Initial Data Processing & QA-QC	PCS Data Processing & QA-QC
		Wind.	-13.517 / 128.210					
UWA	Meteorological.	Wind. Rainfall.	Site at Cape Domett Beach -14.801 / 128.411	Figure 10	Nov 2013 to Aug 2014	Measurement Engineering Australia Custom Weather Station	Unknown	Visual check and filtering.
DWER	Stream gauging.	River discharge. River level.	5 sites upstream of CG -17.373 / 127.179 to -15.570 / 128.855	Figure 12	1967 to 2024	River Level Gauges and River Discharge Gauges	Unknown	Visual check.
Geoscience Australia	Bathymetric.	Seabed elevation.	CG and JBG -15.402 / 127.192 to -13.515 / 129.885	NA	Unknown	Variable	Unknown	Comparison with other datasets.
Digital Earth Australia	Bathymetric.	Intertidal elevation.	Intertidal areas in CG region -15.479 / 127.910 to -14.510 / 128.799	NA	Unknown	Landsat Satellite Imagery	Unknown	Comparison with other datasets.
Copernicus	Satellite imagery.	NA	CG region -15.250 / 128.050 to -14.250 / 128.750	NA	2015 to 2024	Sentinel-2 sensor	Not required	Processed to derive total suspended matter (TSM) (see Section 4.5).
U.S. Geological Society	Satellite imagery.	NA	CG region -14.950 / 128.150 to -14.675 / 128.425	NA	1988 to 2024	Landsat 5, 7 & 8 sensors, and Sentinel-2 sensor	Not required	Processed to derive shoreline position (see Section 4.5).

PORT & COASTAL
SOLUTIONS

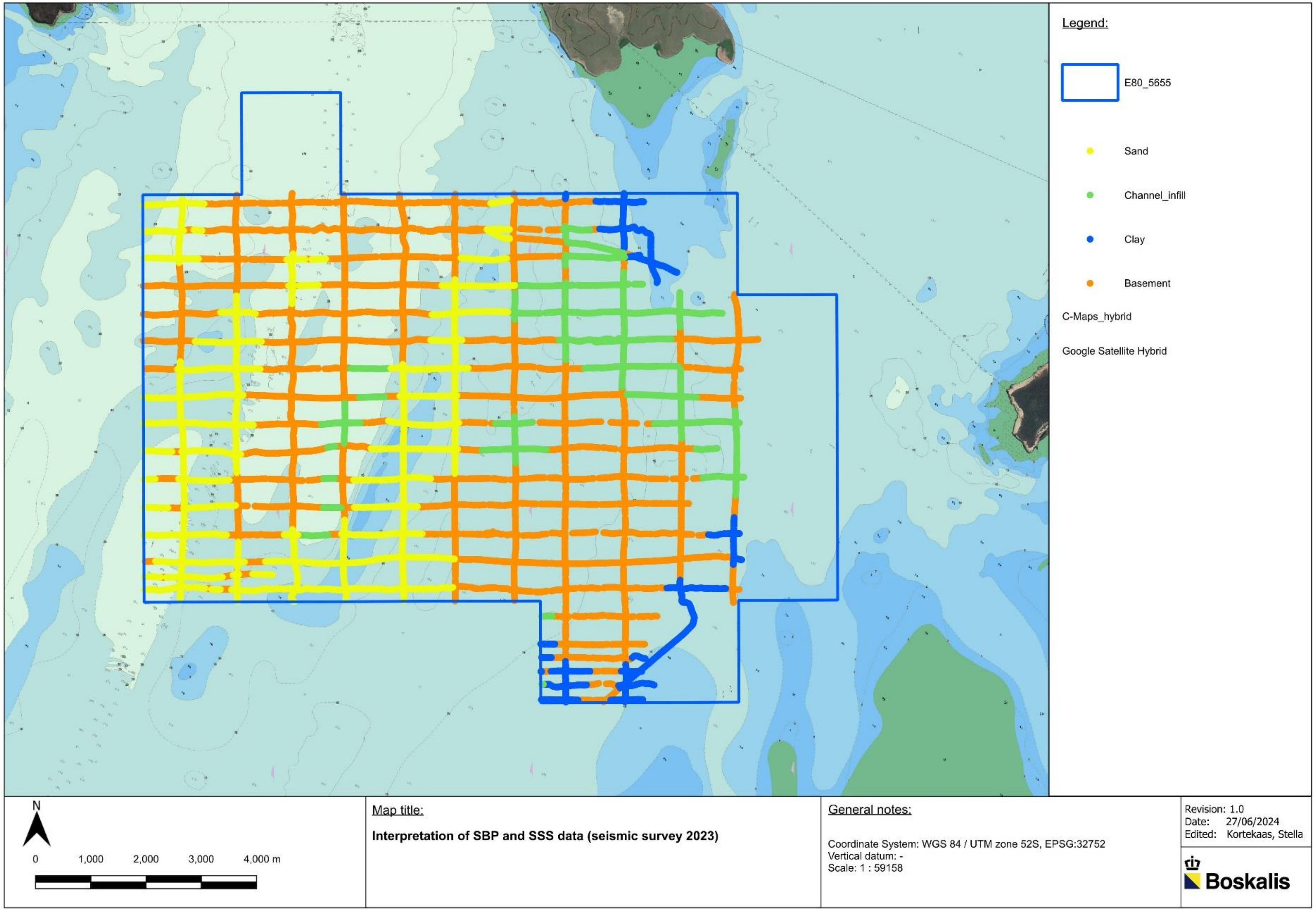


Figure 1. Sub-bottom profiler and sides-scan transects and results from the sand exploration survey in Feb-March 2023 (source: BKA, 2024b).

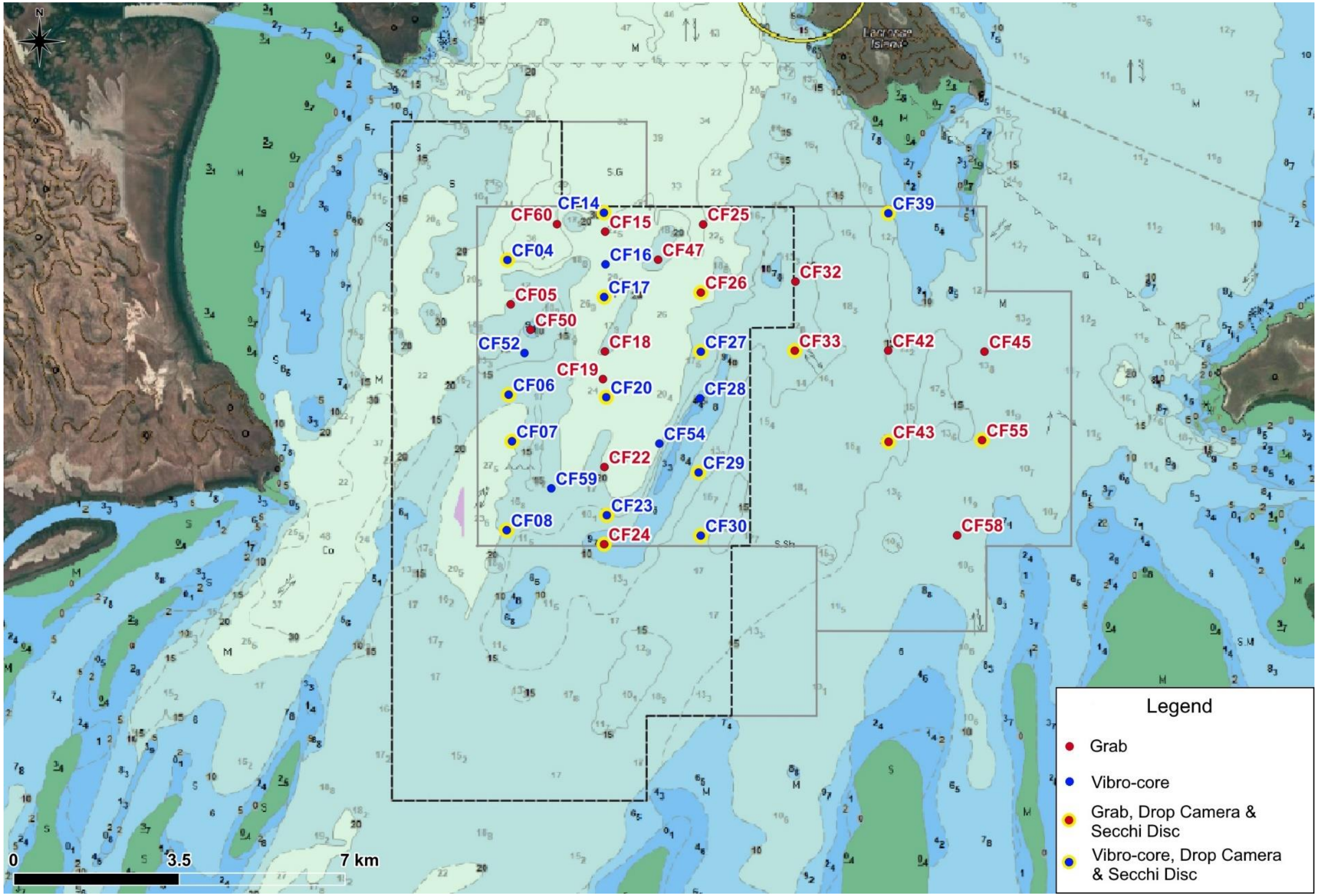


Figure 2. Vibro-core, benthic grab and Secchi disc sample points within Block 4 during the sand exploration survey in March 2023.

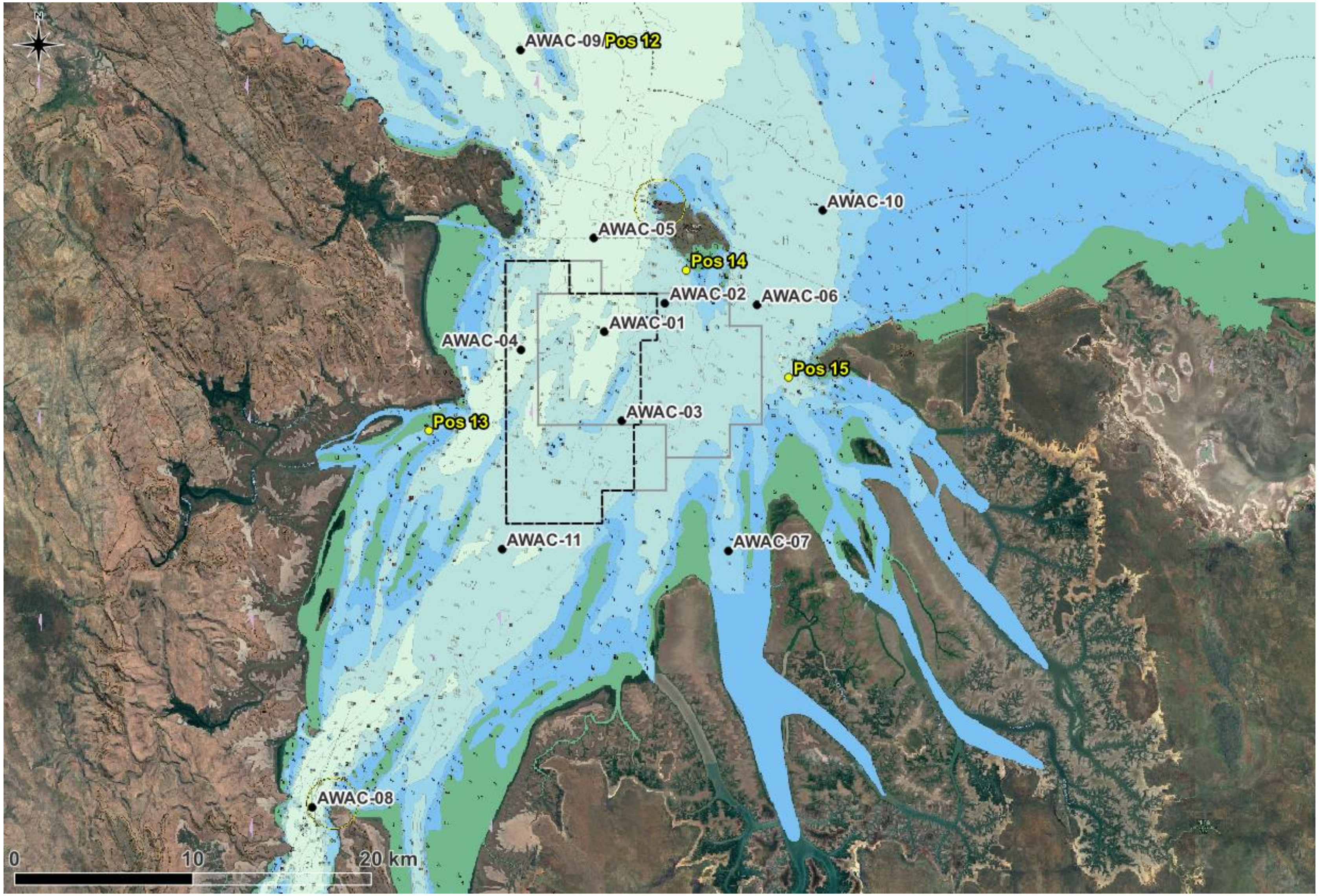


Figure 3. **Eleven sites where AWACs with co-mounted sensors (AWAC-01 to 11) and fours sites with seabed frames with light & multi-sonde sensors (Pos-12 to 15) have been deployed for the project.**

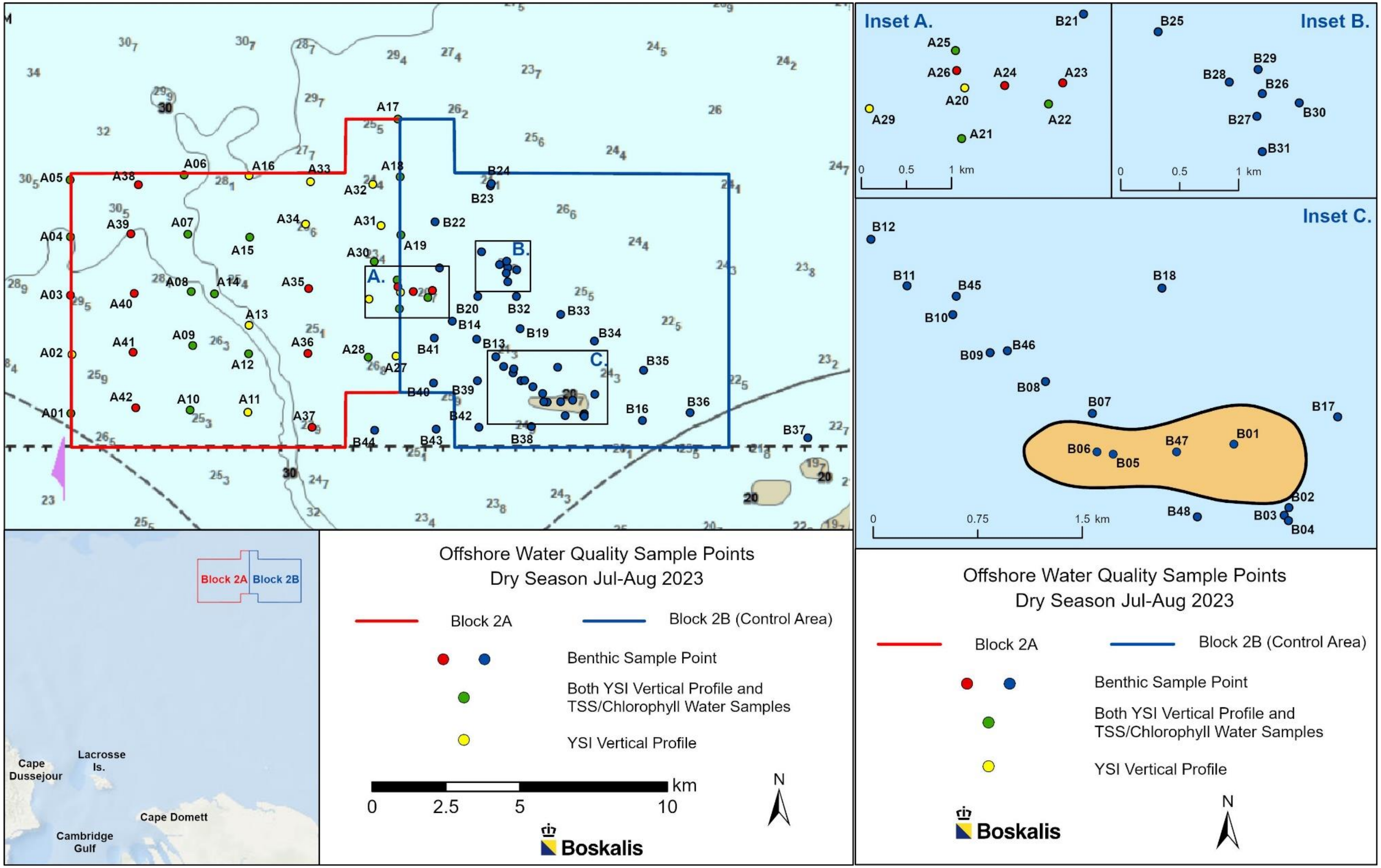


Figure 4. Sample Points (SPs) ~50 km offshore (OS) for the dry season survey Jul-Aug 2023. Benthic grabs were collected at all SPs (red, green & yellow). For water quality - both YSI vertical profiles and TSS/Chlorophyll samples were collected at the green SPs and only YSI vertical profiles were taken at the yellow SPs (source: BKA, 2024d).

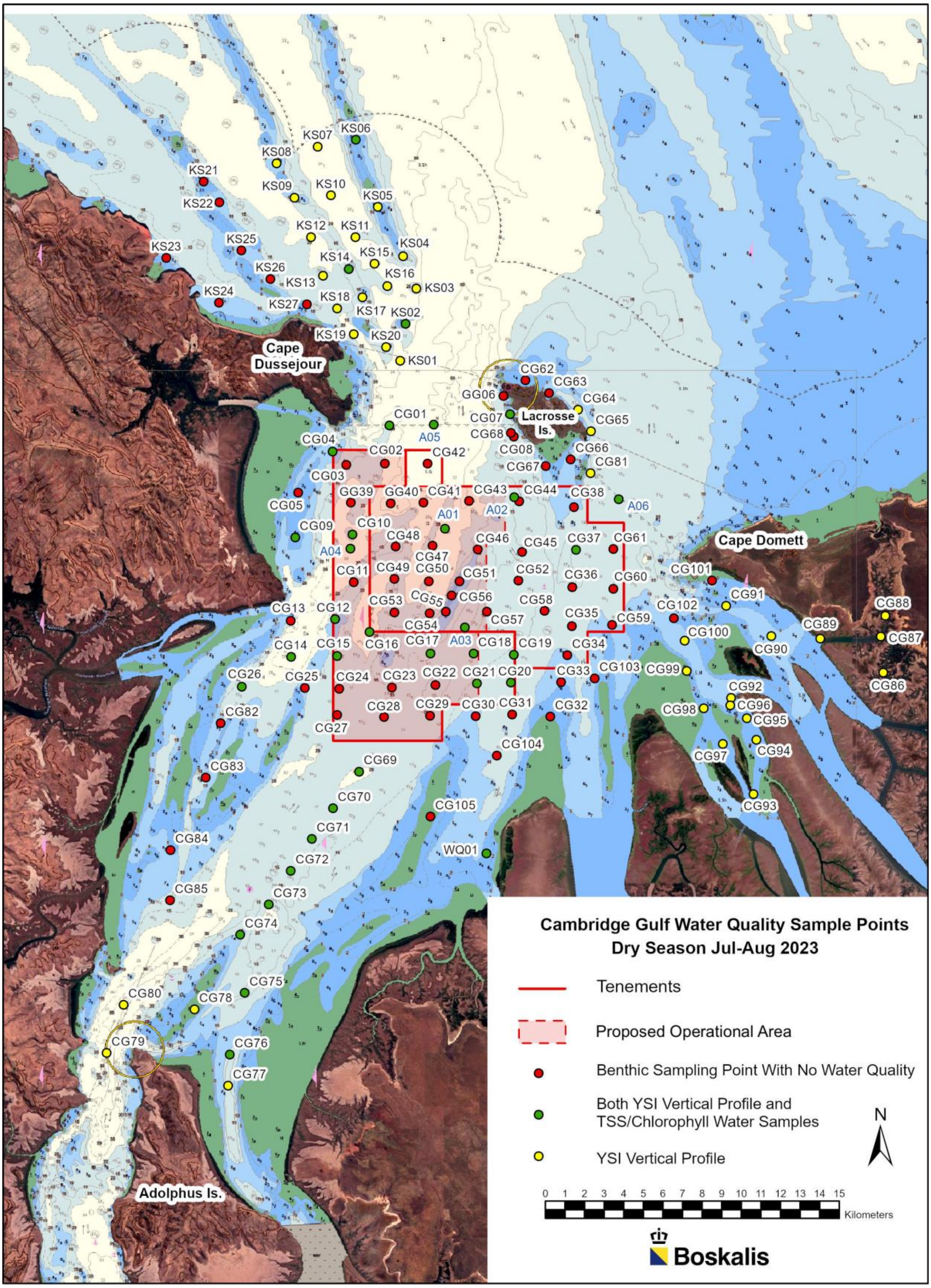


Figure 5. Water Quality Sample Points (SPs) at Cambridge Gulf (CG) and King Shoals (KS) for the dry season survey Jul-Aug 2023. Benthic grabs were collected and drop camera deployed at all SPs (red, green & yellow). For water quality - both YSI vertical profiles and TSS/Chlorophyll samples were collected at the green SPs and only YSI vertical profiles were taken at the yellow SPs (source: BKA, 2024d).

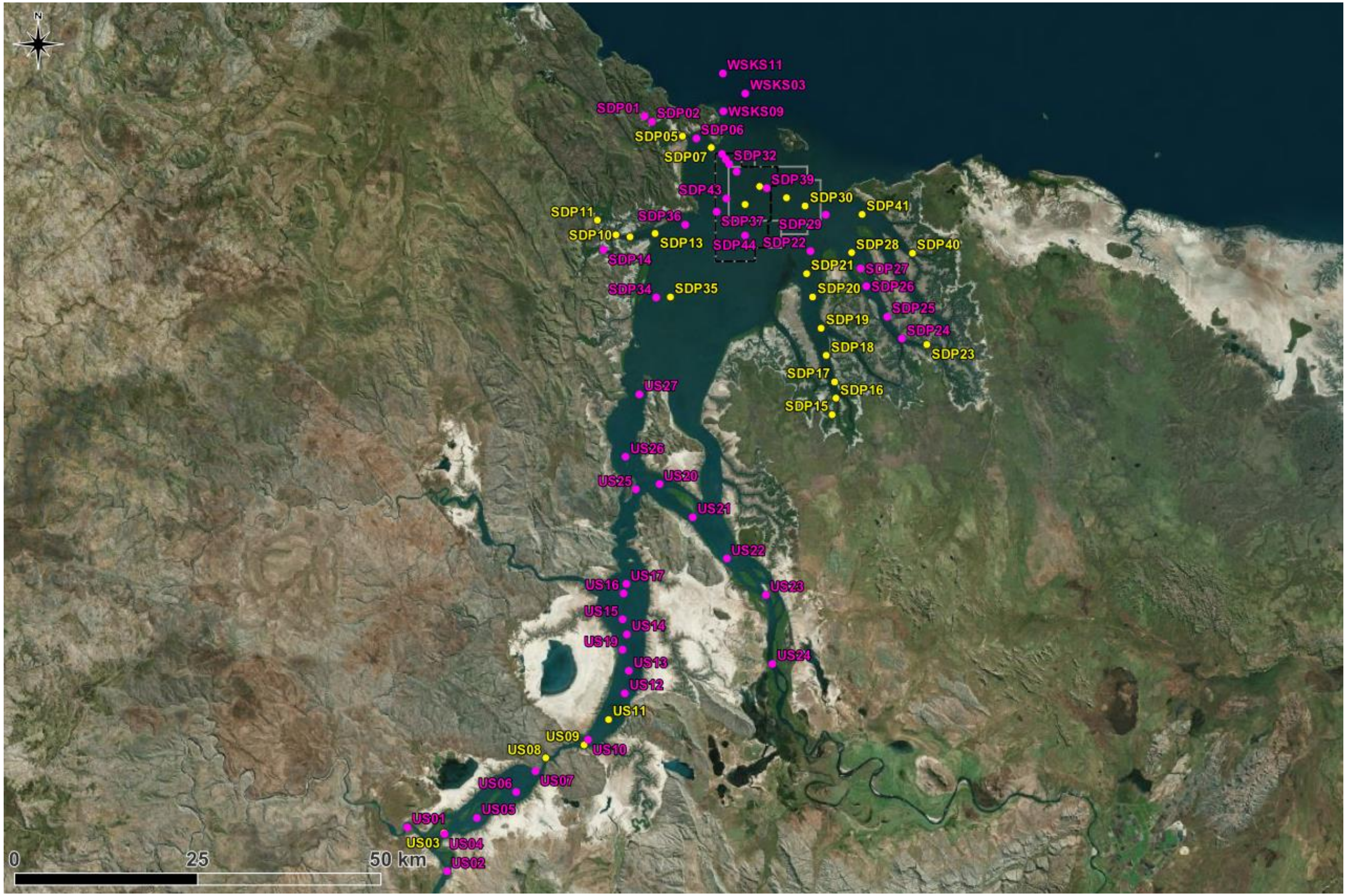


Figure 6. 74 seabed surface sediment samples collected during the 2024 wet season campaign (February 2024) analysed for just PSD (yellow dots) and analysed for PSD and elemental features (pink dots).

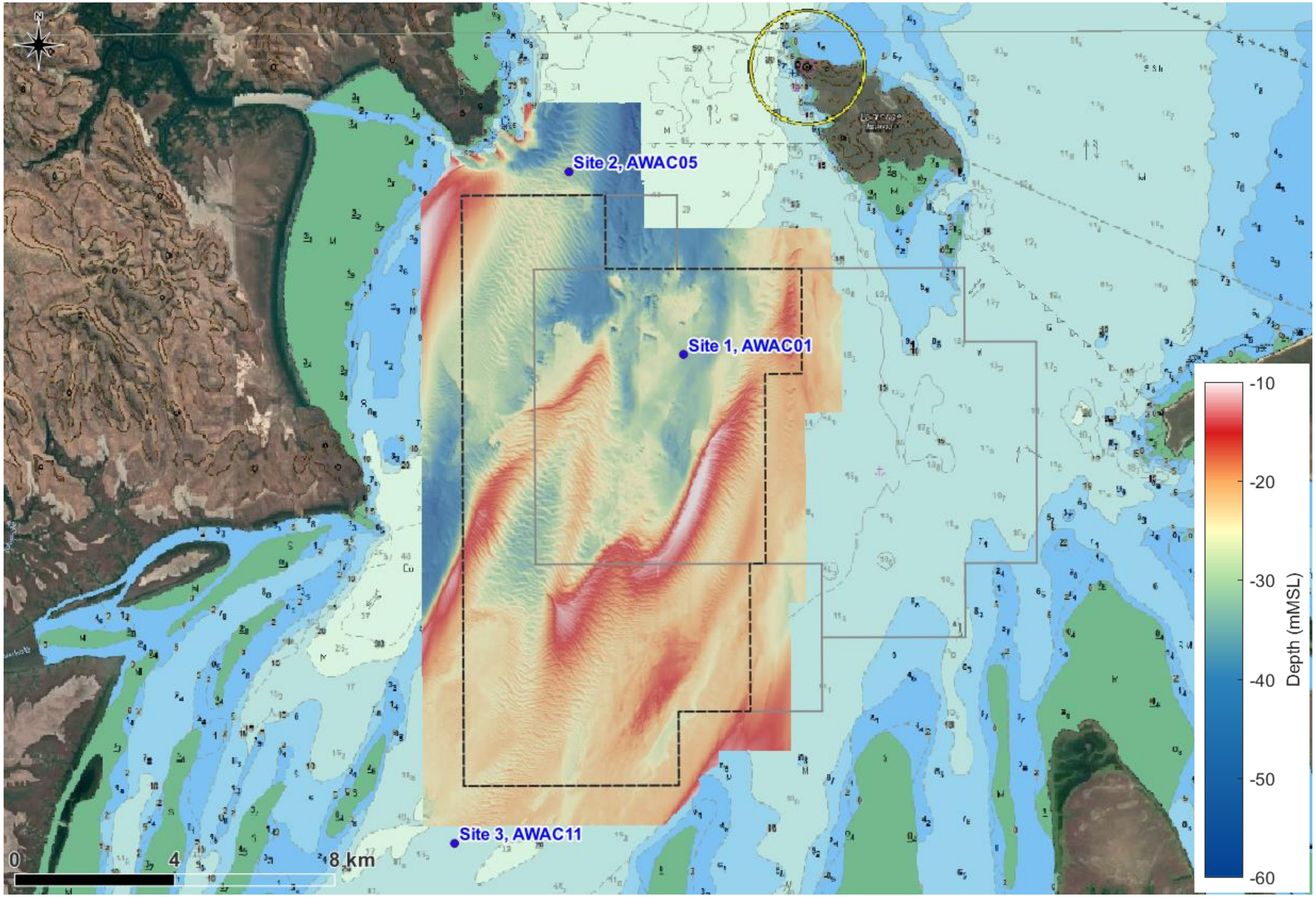


Figure 7. Locations of the three water column profiling sites in February 2024. *Note: the black dashed line shows the POA.*

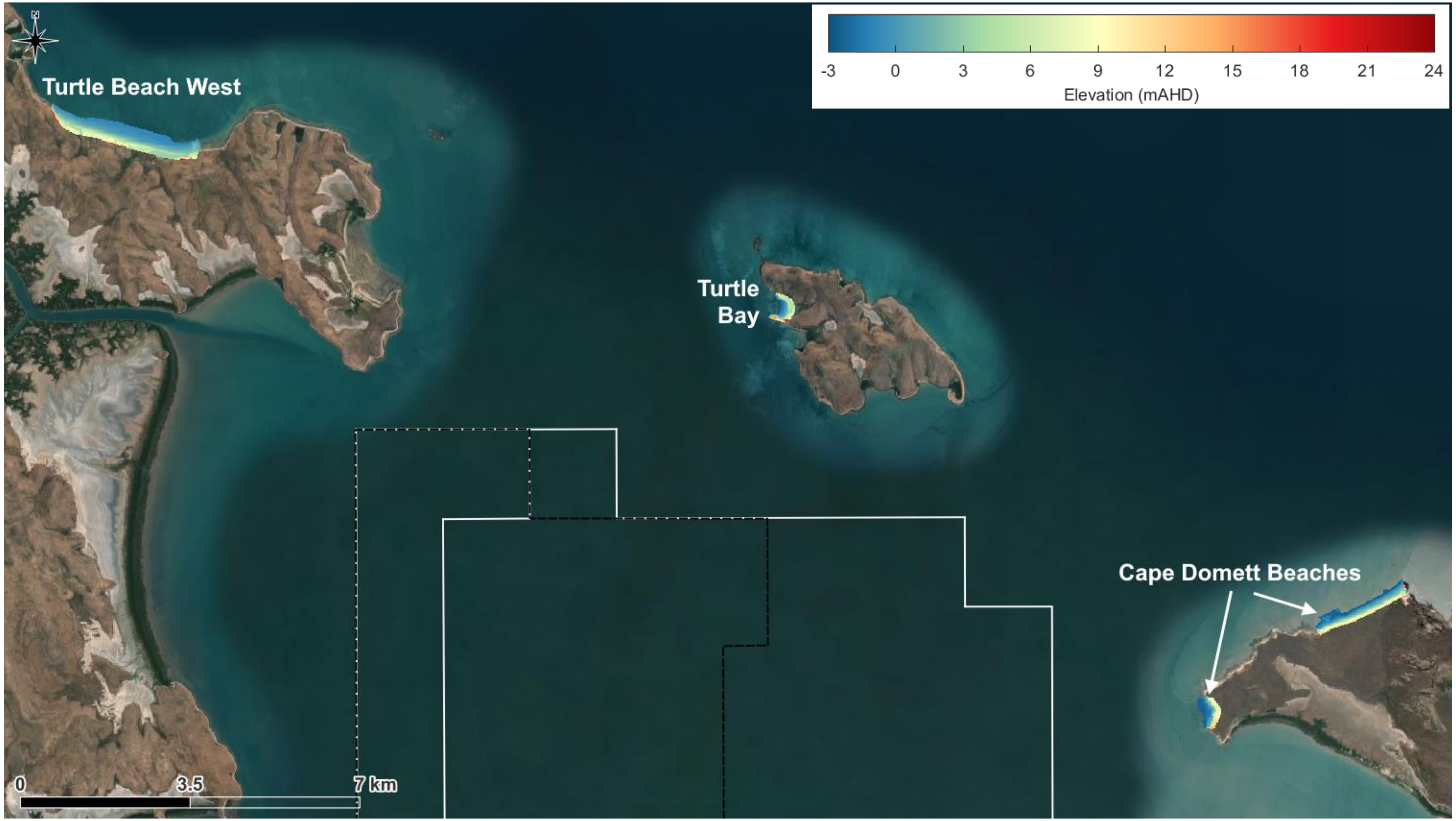


Figure 8. Beaches where the LiDAR and Photogrammetry drone surveys were undertaken. *Note: the black dashed line shows the POA.*

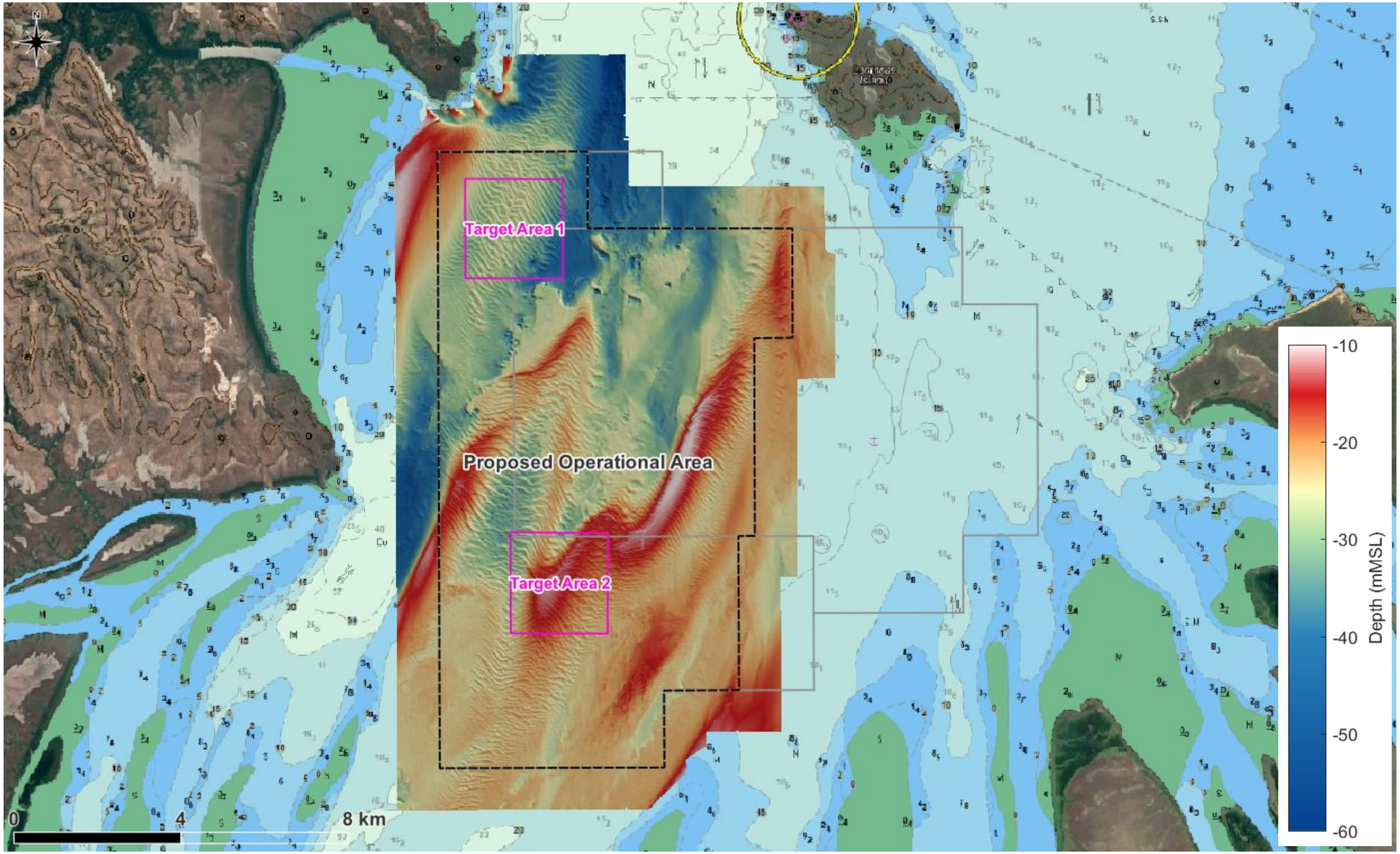


Figure 9. Multibeam bathymetric survey extent along with Areas 1 and 2. *Note: the black dashed line shows the POA.*

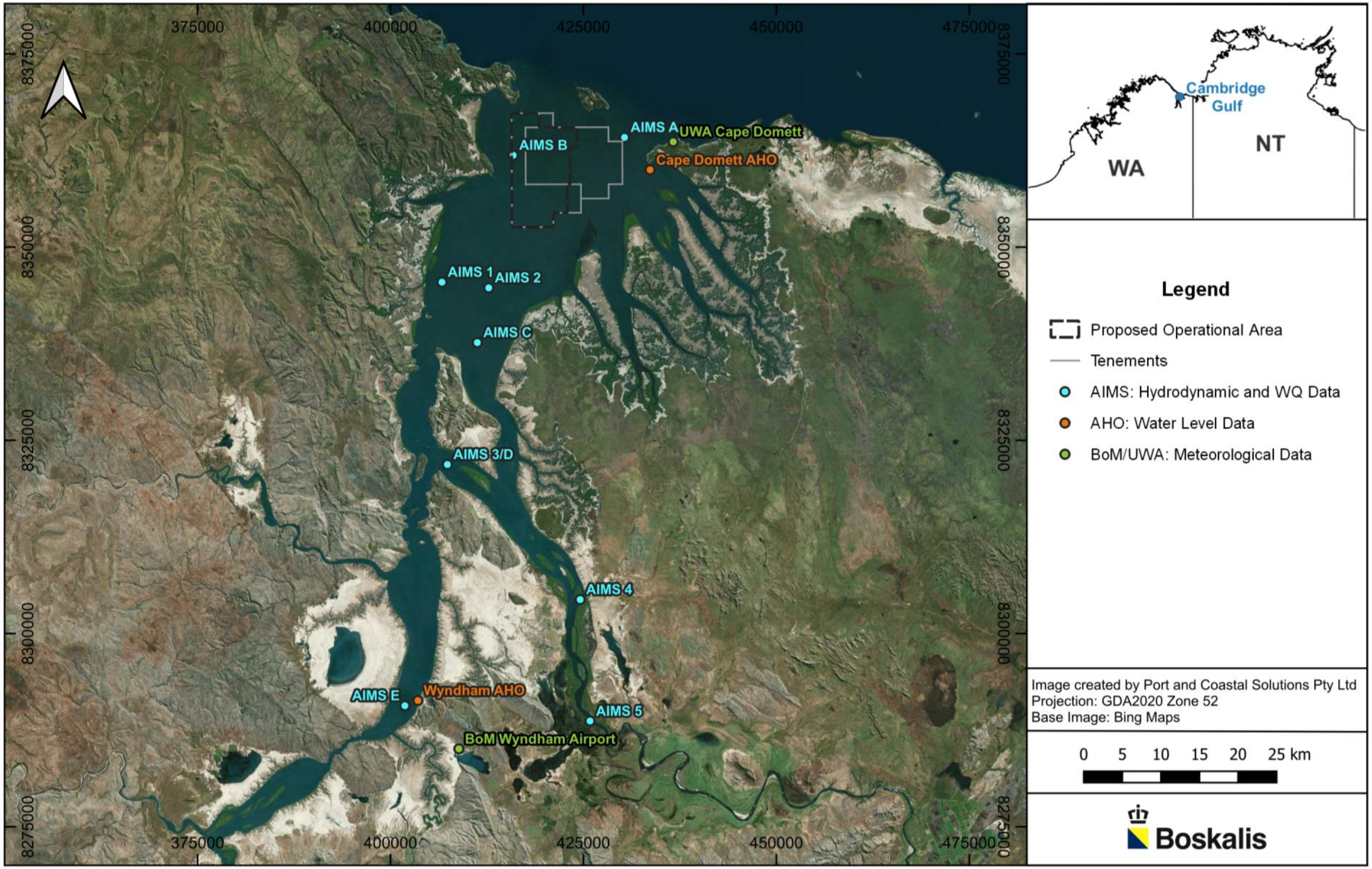


Figure 10. Map showing the locations of pre-existing (external) sources of hydrodynamic and meteorological data in the CG region.

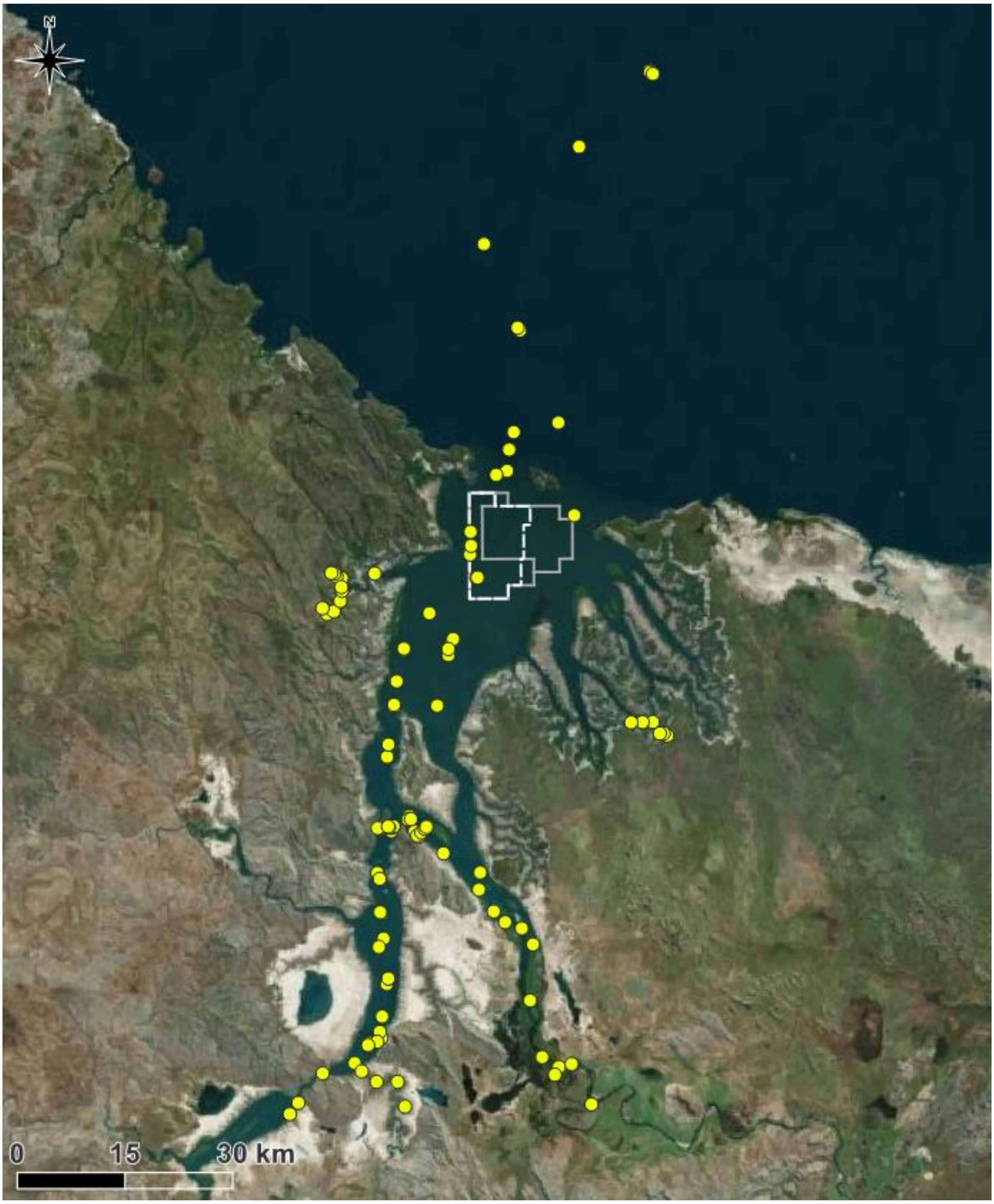


Figure 11. Map showing locations of WQ profile data collected by AIMS between 1999 and 2004.

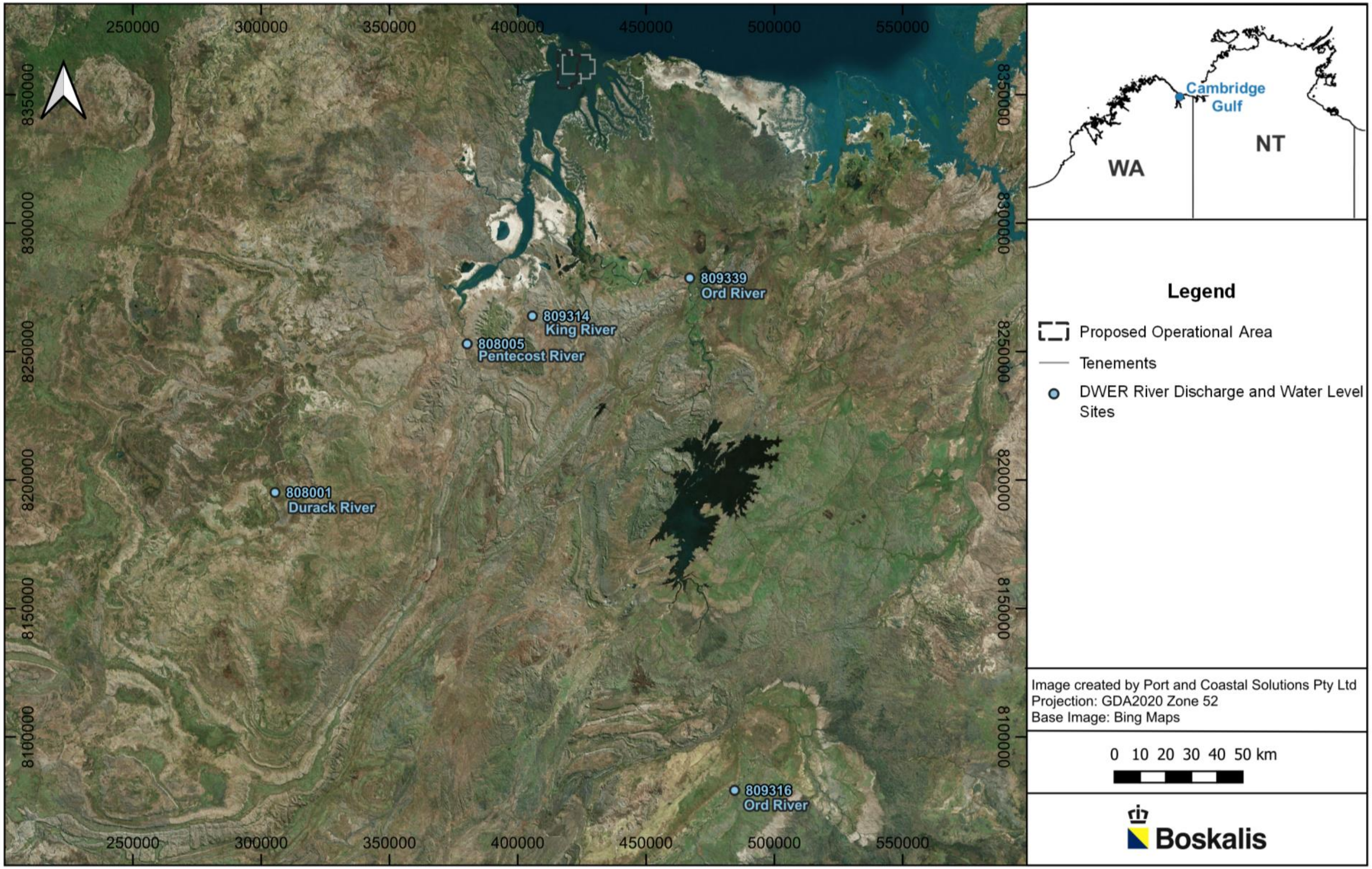


Figure 12. Map showing the locations of river discharge and water level data upstream of CG available from WA-DWER.

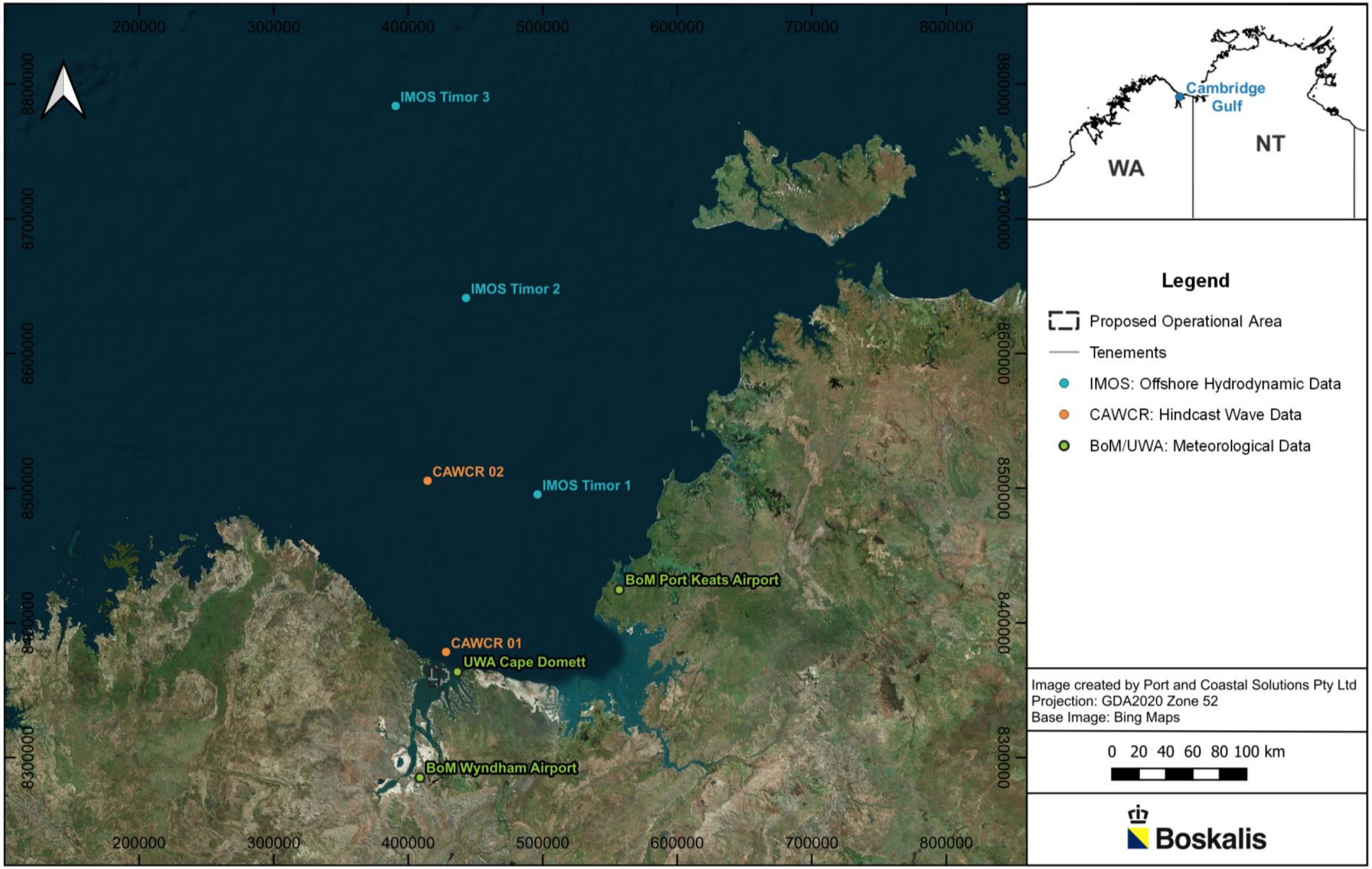


Figure 13. **Map showing the locations of pre-existing (external) sources of regional hydrodynamic, wave and meteorological data.**

3. Field Survey Details for BKA-collected Data

As outlined in Section 2 and Table 1 a range of metocean and sediment dynamics data have been collected in and near CG as part of this project. The field surveys have included the deployment and retrieval of in-situ self-logging oceanographic and water quality instruments from June 2023 to August 2024 as well as targeted field campaigns collecting a range of data during the sand exploration survey in February and March 2023, the dry season environmental survey in July and August 2023 and the wet season environmental survey in February and March 2024.

3.1. In-situ Oceanographic & Water Quality Data Collection

3.1.1. Instruments

The following self-logging instruments have been used as part of the project:

- Nortek Acoustic Wave and Current (AWAC) 600kHz: From June 2023 to August 2024 two AWACs have been deployed on frames on the seabed at three different sites and used to measure water depth, currents through the water column and waves. Current measurements were undertaken every 10 minutes with each measurement representing the average over a 120 second burst. Wave measurements were undertaken every hour and were based on 4096 samples collected at a sampling rate of 2 Hertz (Hz). The AWAC acoustic sensors were facing upward and located approximately 1.2 m above the seabed.
- Nortek Signature 500/1000 Acoustic Doppler Current Profiler (ADCP): From September 2023 to August 2024 four Signature 500/1000 ADCPs have been deployed on frames on the seabed at nine different sites and used to measured water depth, currents through the water column and waves. Current measurements were undertaken every 10 minutes with each measurement representing the average over a 120 second burst. Wave measurements were undertaken every hour and were based on 4096 samples collected at a sampling rate of 2 Hertz (Hz). The ADCP acoustic sensors were facing upward and located approximately 1.2 m above the seabed.
- LI-COR LI-1500 light sensor: From September 2023 to August 2024 LI-CORs have been attached to the AWAC or Signature 500/1000 ADCP frames and the four seabed frame locations (Pos-12 to Pos-15) and used to measure the available benthic light at the seabed at seven different sites. The instruments had an upward and a downward facing light sensor. The frequency that the instruments have been setup to record the benthic light has been variable between the deployments, typically for all of the shorter duration deployments (1-2 days) the instruments have been setup to measure the benthic light every 10 seconds, while for the longer duration deployments (more than 2 days) the instruments have been setup to measure every 30 minutes, with each measurement representing the average over a 60 second burst, to preserve battery life. The LI-COR sensors were located approximately 0.6 m (downward) and 0.7 m (upward) above the seabed. Due to an issue with the instruments they only measured data for a duration of up to eight days.
- Dataflow Odyssey Xtreem Submersible Photosynthetic Active Radiation (PAR) logger (Odyssey loggers): Due to the LI-COR instruments only being able to measure benthic light for a duration of up to eight days, between March and August 2024 up to eight Odyssey loggers were deployed in addition to/in place of the LI-COR sensors. The Odyssey loggers were included at the four seabed frame locations from March to August 2024 (Pos-12 to Pos-15 shown in Figure 3) and at the four AWAC frame locations from June to August 2024. The instruments were used to measure the available benthic light at the seabed over the entire deployment durations. The instruments were configured to record the benthic light every 15 minutes. The Odyssey sensor was located approximately 1.1 m above the seabed.
- Manta/WiMo multi-sonde probes: From September 2023 to August 2024 Manta or WiMo multi-sonde probes were attached to the AWAC and Signature 500/1000 ADCP frames on the seabed and the four seabed frame locations (Pos-12 to Pos-15) and used to measure the near-bed temperature, salinity, depth/pressure and turbidity. The instruments were configured to record every 10 minutes, with each measurement representing the average over a 16 second burst, except for site AWAC-07 from October 2023 to March 2024 which recorded at 1-hour intervals due to the longer duration of the deployment. The Manta/WiMo sensors were located approximately 1.0 m above the seabed.

3.1.2. Deployment Details

An overview of all instrument deployments is provided in Table 3. The table details each site location, the time coverage of the data collection period and the instruments used for taking measurements at each site. Figure 14 shows the location of sites where instruments have been deployed for the project, including AWACs with co-mounted sensors (site names starting AWAC) and seabed frames with light &

turbidity sensors (site names starting Pos). Annotated photographs showing the instruments attached to the frames for a frame with an AWAC/ADCP (e.g. sites AWAC-01 to AWAC-11) and for a water quality frame without an AWAC/ADCP (e.g. sites Pos-12 to Pos-15) are shown in Figure 15 and Figure 16.

All of the AWACs/ADCPs were setup to measure the currents at 1 m bins through the water column, except for the deployment at AWAC-05 from June to August 2024 which was configured with 2 m bins. The blanking distance between the instrument and the first bin varied between the instruments, with a blanking distance of 0.5 m for the AWACs and the Signature 500 ADCPs and 0.2 m for the Signature 1000 ADCPs.

Table 3. Summary of instrument deployment and data collection.

Site		Location		Time Coverage					Data Collection		
Position	Depth (m MSL)	Longitude [deg]	Latitude [deg]	Start	End	Measurement Frequency	Time period [days]	Time reference	Instruments	Waves?	Currents?
AWAC-01 (1st)	21.9	128.268	-14.807	09/06/2023	21/07/2023	10 minutes	41.7	UTC +1hr	Nortek AWAC	No[1]	Yes
AWAC-01 (2nd)	30.1	128.268	-14.803	03/03/2024	08/05/2024	10 minutes	66.2	UTC +8hr	Nortek Signature 500 LI-COR LI-1500 light sensor WiMo multi-sonde probe	Yes	Yes
AWAC-01 (3rd)	25.9	128.262	-14.807	29/06/2024	09/08/2024	10 minutes	41.1	UTC +8hr	Nortek Signature 500 Odyssey Logger WiMo multi-sonde probe	Yes	Yes
AWAC-02	18.0	128.300	-14.788	07/09/2023	08/09/2023	10 minutes	1.2	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor Manta multi-sonde probe	Yes	Yes
AWAC-03	19.2	128.277	-14.848	13/10/2023	15/10/2023	10 minutes	1.9	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor Manta multi-sonde probe	Yes	Yes
AWAC-04	27.6	128.225	-14.812	07/09/2023	08/09/2023	10 minutes	0.8	UTC +8hr	Nortek AWAC LI-COR LI-1500 light sensor	No[1]	Yes
AWAC-05	9.8	128.224	-14.756	20/06/2024	12/08/2024	10 minutes	53.0	UTC +8hr	Nortek Signature 500 Odyssey Logger WiMo multi-sonde probe	Yes	Yes
AWAC-06 (1st)	20.5	128.348	-14.789	08/09/2023	13/10/2023	10 minutes	35.1	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor Manta multi-sonde probe	Yes	Yes
AWAC-06 (2nd)	17.9	128.348	-14.789	06/03/2024	10/05/2024	10 minutes	64.6	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor WiMo multi-sonde probe	Yes	Yes
AWAC-07 (1st)	11.1	128.332	-14.914	15/10/2023	05/03/2024	1 hour	142.0	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor Manta multi-sonde probe	Yes	Yes
AWAC-07 (2nd)	11.3	128.334	-14.919	10/05/2024	25/06/2024[2]	10 minutes	45.9[2]	UTC +8hr	Nortek Signature 1000 LI-COR LI-1500 light sensor Manta multi-sonde probe	Yes	Yes
AWAC-08	26.2	128.109	-15.044	02/03/2024	18/06/2024	10 minutes	108.3	UTC +8hr	Nortek AWAC LI-COR LI-1500 light sensor WiMo multi-sonde probe	Yes	Yes
AWAC-09	28.2	128.176	-14.853	04/03/2024	21/06/2024	10 minutes	109.2	UTC+8hr	Nortek Signature 500 Odyssey Logger WiMo multi-sonde probe	Yes	Yes
AWAC-10	18.1	128.363	-14.734	26/06/2024	13/08/2024	10 minutes	48.3	UTC +8hr	Nortek Signature 1000 Odyssey Logger Manta multi-sonde probe	Yes	Yes
AWAC-11 (1st)	22.2	128.214	-14.914	02/03/2024	08/05/2024	10 minutes	66.8	UTC +8hr	Nortek Signature 500 LI-COR LI-1500 light sensor WiMo multi-sonde probe	Yes	Yes
AWAC-11 (2nd)	22.1	128.218	-14.910	10/05/2024	23/06/2024	10 minutes	43.9	UTC +8hr	Nortek Signature 500 WiMo multi-sonde probe	Yes	Yes

Site		Location		Time Coverage					Data Collection		
Position	Depth (m MSL)	Longitude [deg]	Latitude [deg]	Start	End	Measurement Frequency	Time period [days]	Time reference	Instruments	Waves?	Currents?
AWAC-11 (3rd)	20.0	128.197	-14.902	24/06/2024	11/08/2024	10 minutes	48.0	UTC +8hr	Nortek Signature 500 Odyssey Logger WiMo multi-sonde probe	Yes	Yes
Pos-12 (AWAC-09) (1st)	28.2	128.224	-14.662	04/03/2024	21/06/2024	10 minutes	109.3	UTC +8hr	LI-COR LI-1500 light sensor Odyssey Logger WiMo multi-sonde probe	No	No
Pos-12 (AWAC-09) (2nd)	20.1	128.204	-14.652	28/06/2024	14/08/2024	10 minutes	47.1	UTC +8hr	Odyssey Logger WiMo multi-sonde probe	No	No
Pos-13 (1st)	13.5	128.176	-14.853	03/03/2024	12/05/2024	10 minutes	69.9	UTC +8hr	LI-COR LI-1500 light sensor Odyssey Logger WiMo multi-sonde probe	No	No
Pos-13 (2nd)	12.2	128.183	14.851	23/06/2024	12/08/2024	10 minutes	49.9	UTC +8hr	Odyssey Logger WiMo multi-sonde probe	No	No
Pos-14 (1st)	13.7	128.311	-14.772	03/03/2024	20/06/2024	10 minutes	109.4	UTC +8hr	LI-COR LI-1500 light sensor Odyssey Logger WiMo multi-sonde probe	No	No
Pos-14 (2nd)	13.2	128.312	-14.772	21/06/2024	10/08/2024	10 minutes	50.0	UTC +8hr	Odyssey Logger[3] WiMo multi-sonde probe	No	No
Pos-15 (1st)	22.4	128.364	-14.826	04/03/2024	26/06/2024	10 minutes	114.0	UTC +8hr	LI-COR LI-1500 light sensor Odyssey Logger WiMo multi-sonde probe	No	No
Pos-15 (2nd)	14.4	128.364	-14.826	27/06/2024	11/08/2024	10 minutes	44.7	UTC +8hr	Odyssey Logger WiMo multi-sonde probe	No	No

Numbered comments:

1. Wave measurements not available due to issues with the data files.
2. There was an issue with the ADCP and so data were only captured until 24/05/2024 (14.0 days of data capture).
3. There was an issue with the logger and no reliable data were captured over this period.

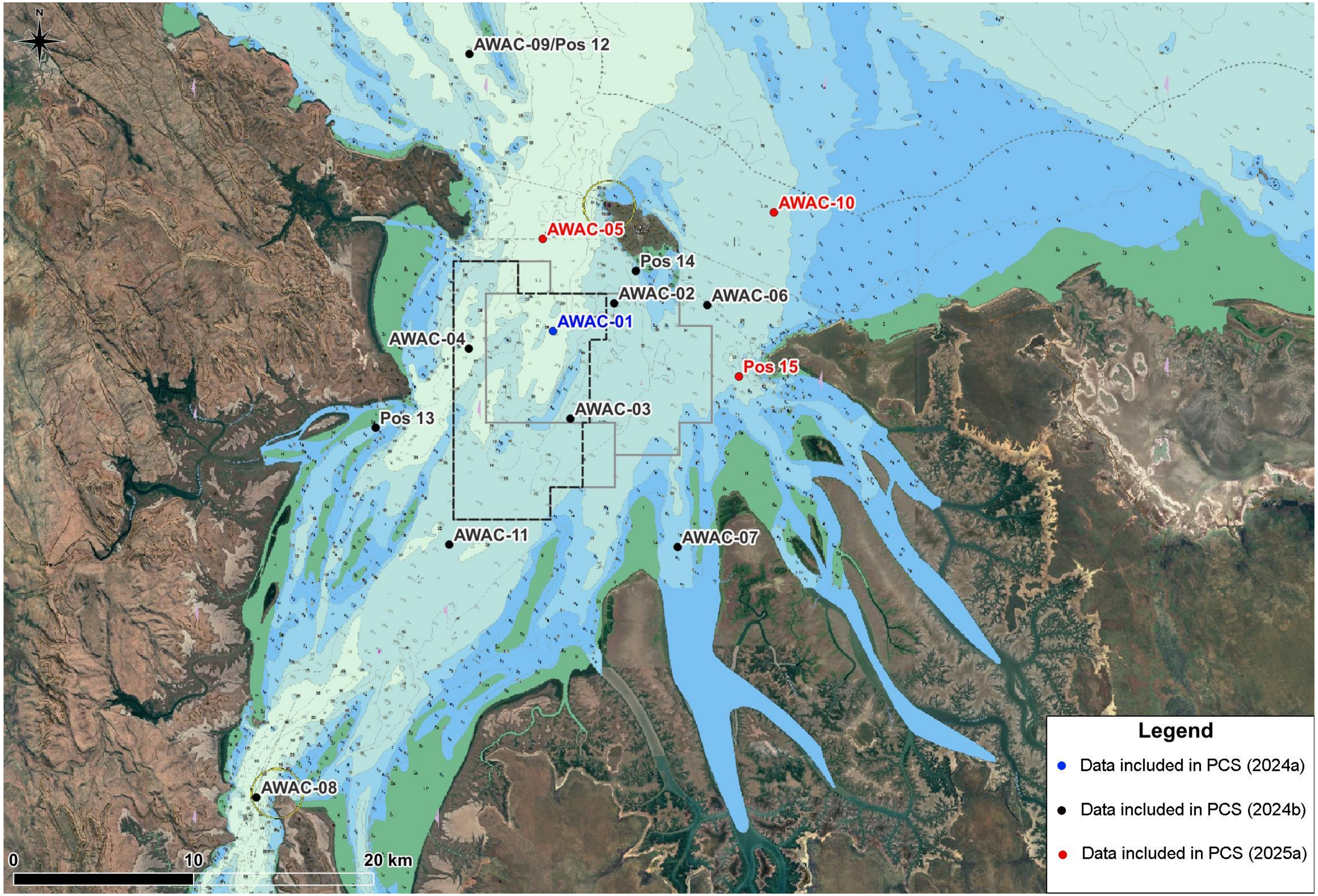


Figure 14. Sites where AWACs with co-mounted sensors (AWAC-01 to 11) and seabed frames with light & turbidity sensors (Pos-12 to 15) have been deployed for the proposal.

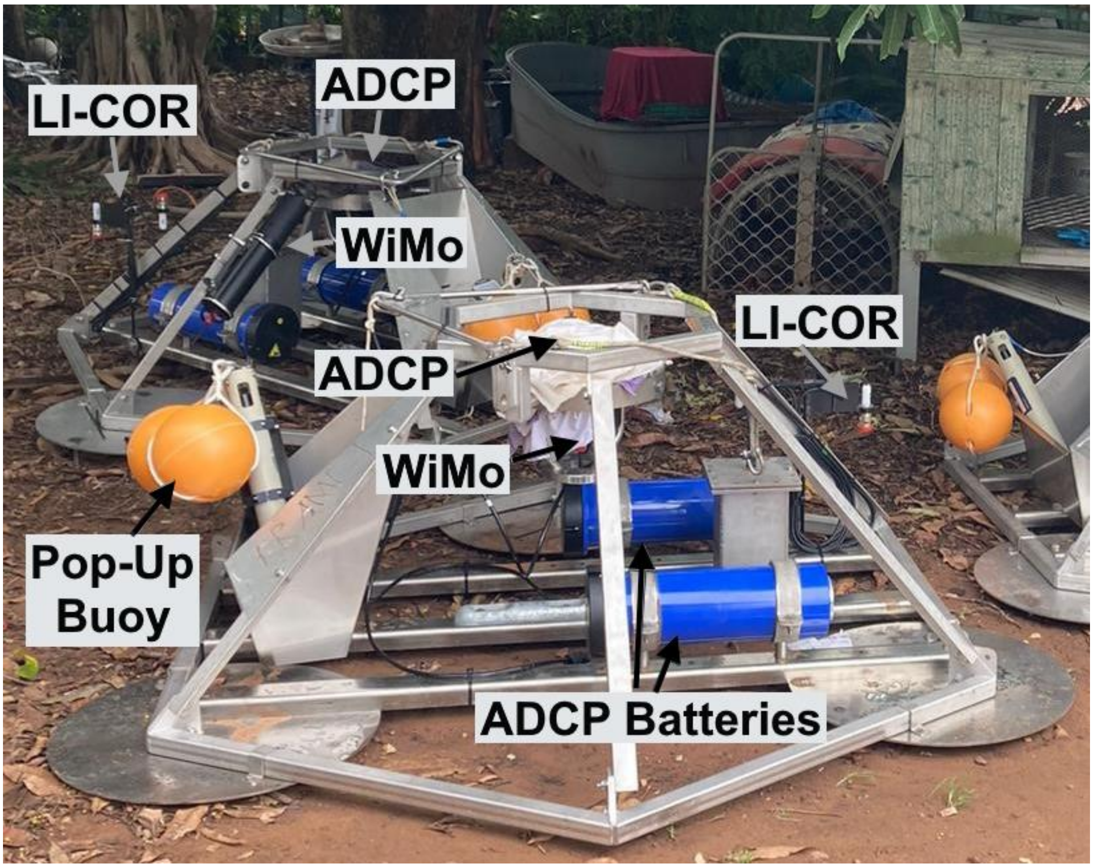


Figure 15. Annotated photograph of the instruments attached to a frame with an ADCP.

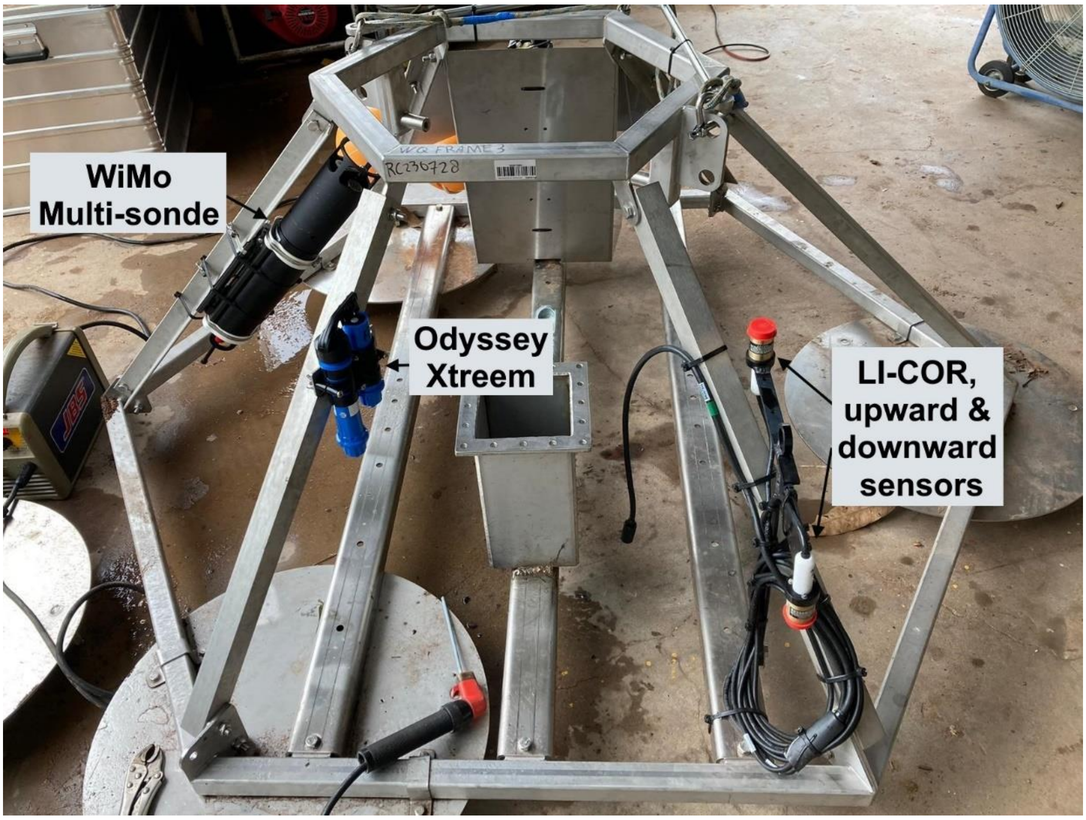


Figure 16. Annotated photograph of the instruments attached to a water quality frame with no ADCP.

3.2. Sand Exploration Survey Feb-Mar 2023

3.2.1. Sidescan Sonar and Sub-Bottom Profiling

The equipment used to conduct the survey was the X-Star Chirp profiler, the Side Scan Sonar and the Emlid Reach RS2+ navigation system. The survey was undertaken between the 22nd February and 6th March 2023. A signal increasing in frequency from 0.5 to 7.2 kHz was used. Several signals with different frequencies were tested, but the used frequency provided the best penetration.

3.2.2. Vibrocore Sediment Sampling

Sediment cores were collected at 35 sites within Block 4 (BKA's Exploration Tenement E80/5655) between the 6th and the 14th March 2023. Sediment samples were collected at varying depths through the core samples where sand was identified so they could be analysed for Particle-Size Distribution (PSD). The samples were analysed by GBAD Services Pte Ltd in Singapore in accordance with BS EN 93301: 2012. The samples were analysed by sieving a 200 g dry sample of the sediment. In total 21 samples were analysed.

3.2.3. Van Veen Grab Sediment Sampling

Surface sediment grab samples were collected using a Van Veen Grab at the same 35 sites within Block 4 (BKA's Exploration Tenement E80/5655) as the vibrocore samples. The samples were collected between the 6th and the 14th March 2023. Duplicate grab samples were collected at each site, these were then sieved on-board to 6 mm and assessed for sediment type and benthic biota. Photographs were taken of all the grab samples and the type of sediment based on a visual assessment was recorded.

3.2.4. Water Clarity Sampling

Secchi Disc readings were taken at 17 of the 35 vibro-core sites within Block 4. The Secchi Disc was lowered through the water column up to the point where it was no longer visible and this depth was then logged.

A drop camera with video turned on was lowered to the seabed at the same 17 sites. The primary purpose was for benthic biota assessment but the video also provides very valuable data on water clarity (or lack there-of).

3.3. Dry Season Environmental Survey Jul-Aug 2023

3.3.1. Vertical Profiling and Water Sampling

Water quality sampling was conducted in July-August 2023, covering large parts of Cambridge Gulf and the offshore waters of King Shoals and further offshore in the Joseph Bonaparte Gulf (JBG) as shown in Figure 4 and Figure 5. The water quality survey investigated a range of physical/chemical properties with sampling up to a maximum depth of around 53 m, using a YSI EXO-1 multiparameter probe and Niskin bottle (operated using a winch).

The YSI probe and Niskin bottle were attached together and lowered to required depths, where a water sample was taken and simultaneously the YSI data reading of turbidity (NTU) was recorded. These data were later used to determine a site-specific (dry season) relationship between NTU and total suspended solids (TSS).

Niskin water samples for TSS analysis were taken at 67 sites as shown in Figure 4 and Figure 5. For each site, a known volume of water (sub-sample) from the Niskin sample was filtered on deck (using a vacuum pump dual-filtration set-up) over a pre-dried and pre-weighed 0.4 µm Wattman glass fibre filter paper, and stored in labelled envelopes in a freezer for later analysis of TSS at the lab. A second sub-sample (of known volume) was also filtered over a 0.4 µm Wattman glass fibre filter paper (not pre-weighed) and stored in labelled envelopes in a freezer for later analysis of Chlorophyll-a (Chl-a) at the lab. The Marine & Freshwater Research Laboratory (MARFL) at Murdoch University in Perth was used for the lab analysis.

The YSI multi-probe was used to measure turbidity (NTU), chlorophyll-a (µg/L), temperature (°C), salinity and pH through the water column at each sampling site. The YSI measurement frequency was set at once every second, corresponding to data from approximately every 1 to 2 m along the depth profile. Data were collected at four sites further upstream within the estuary (near Adolphus Island), fifteen sites within the Ord River mouth (upstream from Cape Domett), three sites east of Lacrosse Island, twenty offshore sites over King Shoals and twenty-eight offshore sites in open waters over Block 2/2A in the Joseph Bonaparte Gulf, as shown on Figure 4 and Figure 5.

3.3.2. Water Clarity

A drop camera was deployed to the seabed at all 105 benthic grab sites throughout CG, at all 27 benthic grab sites across King Shoals and at 81 benthic grab sites offshore as shown in Figure 4 and Figure 5. The primary purpose was for benthic biota assessment but the videos also provide very valuable data on water clarity (or lack there-of).

3.3.3. Sediment Sampling

Benthic grabs (5 litre volume) were sampled at 105 sites throughout CG, 27 sites across King Shoals and 90 sites offshore as shown in Figure 4 and Figure 5. The sediment present at each location was photographed, visually assessed and the sediment type logged.

3.4. Wet Season Environmental Survey Feb-Mar 2024

3.4.1. Sediment Sampling

A total of 74 seabed surface sediment grab samples were collected in February-March 2024 during the 2024 Wet Season survey using a Van Veen Grab, as shown in Figure 6. The samples extended offshore from King Shoals, within and around CG including the inlets, creeks and small rivers on both sides of the gulf, and upstream (south) to where the Durack and Pentecost Rivers join the West Arm. The following laboratory analysis was undertaken on the sediment samples by NATA accredited Microanalysis laboratories in Perth (www.microanalysis.com.au):

- PSD analysis: All 74 samples were wet sieved to separate particles larger than 500 µm. Any particles larger than 500 µm were subsequently analysed through wet sieving, while the particles finer than 500 µm were analysed through laser diffraction using a Mastersizer. For the laser diffraction analysis a dispersing agent (sodium hexametaphosphate) was applied along with sonication to disperse any existing flocs or agglomerates. Following the analysis, the results from the coarser and finer fractions were combined to provide a complete PSD for all particle sizes in each sample.
- Feature analysis: Out of the 74 sample sites a total of 45 sites were analysed using the Scanning Electron Microscope (SEM), with the sites with a higher percentage of clay sized particles present not being analysed as the clay particles can prevent individual particles from being identified. A representative sub-sample was sieved at 500 µm, sonicated, dried and applied evenly to a double-sided carbon tab and then carbon coated. The sample was then analysed using a Carl Zeiss EVO 50 SEM fitted with an Oxford INCA X-Max energy dispersive spectrometer (EDS). Image acquisition, image processing and a compositional analysis was undertaken using the Oxford Instruments Feature software.

3.4.2. Vertical Profiling

Hourly water column profiling was undertaken at the three sites shown in Figure 7 over a 13-hour spring tidal cycle:

- Site 1, AWAC01: This site is located in the northern half of the POA in a water depth of around -30 m MSL. The site is in an area with a relatively flat seabed which is likely to be predominantly rock or consolidated clay, although sediment sampling has shown that some surface sediment can be present. The profiling was undertaken on the 24th February 2024, with the 1st drop at low tide at 11:53 and the 13th drop at the following low tide at 23:30. The predicted tidal range at Cape Domett for the profiling was 5.24 m. At Cape Domett a mean spring tidal range is 5.4 m and mean neap tidal range is 2.0 m, meaning that the tide when the profiling was undertaken was just below a mean spring tide.
- Site 2, AWAC05: This site is located at the western entrance to CG, just north of the POA, in a water depth of around -30 m MSL. The site is in an area where sand waves are present, meaning that the bed sediment is predominantly sand. The profiling was undertaken on the 25th February 2024, with the 1st drop at low tide at 12:30 and the 13th drop at the following low tide at 00:00. The predicted tidal range at Cape Domett for the profiling was 5.45 m, meaning that the tide was just above a mean spring tide.
- Site 3, AWAC11: This site is located to the south of the POA in a water depth of around -21 m MSL. The site is in an area where sand waves are likely to be present, meaning that the bed sediment is expected to be predominantly sand. The profiling was undertaken on the 27th February 2024, with the 1st drop at low tide at 13:37 and the 13th drop at the following low tide

at 01:00 (on 28th February). The predicted tidal range at Cape Domett for the profiling was 5.42 m, meaning that the tide was just above a mean spring tide.

The following instruments were attached to a frame and used to collect data during the water quality profiling:

- YSI Multi-Sonde Probe: The multi-sonde collected measurements of depth, temperature, salinity, pH, chlorophyll and turbidity every second.
- Nortek Aquadopp Deepwater: The Aquadopp collected current speed, current direction and pressure data every 5 seconds.
- Niskin Water Sampler: Water samples were collected during each vertical profile using Niskin water samplers at mid depth and near the seabed. The water samples were then chilled and freighted to the laboratory to be analysed for TSS and PSD. An elemental feature analysis of the samples collected at low water and high water was also undertaken using a SEM.

For each vertical profile the frame was slowly lowered through the water column until it reached the middle of the water column and the frame was left at this depth for at least 60 seconds while a water sample was collected and while the Aquadopp measured the currents without any vertical change. The frame was then slowly lowered to the seabed and it was left at this depth for a further 60 to 120 seconds while a second water sample was collected and while the Aquadopp measured the near bed currents. The frame was then lifted back through the water column and retrieved on the vessel. The data from the downward drop of the frame has been analysed.

Water samples were collected during each vertical profile using Niskin water samplers at mid depth and near the seabed. The water samples were then chilled and freighted to the laboratory to be analysed for TSS and PSD. An elemental feature analysis of the samples collected at low water and high water was also undertaken using a SEM (same approach as detailed in Section 3.4.1).

3.4.3. Aerial Drone LiDAR & Photogrammetry Data

BKA commissioned drone survey and remote sensing company Sensorem to undertake LiDAR and photogrammetry drone surveys of the four beaches where turtle nesting occurs in the seaward parts of CG (Figure 8). These are two beaches (one small and one large) at Cape Domett, Turtle Bay at Lacrosse Island and Turtle Beach West, west of Cape Dussejour. It was not possible to survey the beach at East Bank Point (Barnett Point) within CG where turtle nesting is also known to occur due to safety concerns regarding crocodiles in the area (video footage of this area was captured instead).

The drone surveys were undertaken between 22nd and 25th February 2024. The data were captured using a DJI Matrice 300 RTK with a Zenmuse L2 payload installed. At each beach two known points were surveyed using a Trimble R12 GNSS Receiver and one point was used to set up a D-RTK 2 base station to allow corrections to be sent to the DJI M300 which ensured that the data were captured to a high level of accuracy (root mean squared (RMS) horizontal and vertical errors of 0.02 and 0.05 m). The vertical datum from the surveys was relative to AHD, the difference between AHD and MSL in CG is unknown but AHD could be up to 0.2 m lower than MSL[1]. The average ground sampling resolution was just under 0.02 m and the survey areas ranged from 0.16 km^2 at Turtle Bay to 1.14 km^2 at Turtle Beach West.

3.4.4. Hydrographic (Multibeam) Survey

The bathymetric survey covered the entire POA and typically extended at least 1 km beyond its boundary (except where proximity of the coast on the northwestern side was closer than 1 km and the southeastern corner where bathymetry was too shallow for the survey vessel). The total area surveyed was 155.3 km^2 and is shown in Figure 9. The survey was undertaken using a Norbit Multibeam echosounder with a frequency of 400 kHz and an average opening angle of 130°. The average horizontal and vertical errors were calculated as 0.69 and 0.11 m, respectively, which are within the requirements for the International Hydrographic Organisation (IHO) Special Order.

The multibeam survey was undertaken over two periods as follows:

- Period 1 - 7th February to 14th February 2024: 60% of the total area was surveyed over this period including Target Areas 1 and 2 which were surveyed on the 8th February 2024.
- Period 2 - 3rd March to 6th March 2024: The remaining area was surveyed over this period and Target Areas 1 and 2 were surveyed for a second time on the 6th March 2024.

There were 27 days between the two surveys of Target Areas 1 and 2, with the first survey undertaken midway between neap and spring tides and the second survey undertaken during neap tides. Two

[1] The difference between MSL and AHD has been estimated based on the data collected as part of this project (PCS, 2024e).

spring tides occurred between the surveys around the 11th and 25th February, with maximum tidal ranges of 7.09 and 5.52 m respectively, when seabed currents are strongest. The changes in the bathymetry between the surveys can therefore be considered to be due to changes over a tidal lunar cycle (29 days).

3.5. Pre-existing (External) Data

Further to the information provided on the pre-existing data in Table 2 (Section 2), additional details on the data from the AIMS data collection campaigns in CG in 2000 and 2002 and the fluvial data sourced from DWER for the rivers which drain into the CG, are provided in this section. This is to provide further clarification, in addition to the information provided in Table 2, of what data have been used in the study as there are extensive datasets available from both data sources.

AIMS provided BKA with a range of hydrodynamic and water quality data from previous studies undertaken by AIMS researchers in CG (see https://apps.aims.gov.au/metadata/view/54e833b0-60f5-11dc-9ca3-00008a07204e).

They collected various data over seven separate field campaigns between 1999 and 2004, with the main datasets of most relevance to this project being the hydrodynamic and turbidity data collected over 1 month periods in 2000 and 2002. A summary of the data collected at each site is provided below and further details are provided in Appendix A:

- AIMS 1 (14.964S, 128.132E): 27/09/2000 to 29/10/2000. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS 2 (14.971S, 128.189E): 27/09/2000 to 29/10/2000. Mooring included InterOcean S4, Dataflow, Aanderaa, Nephelometers at near-bed, mid depth and near-surface.
- AIMS 3 (15.177S, 128.138E): 27/09/2000 to 31/10/2000. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS 4 (15.336S, 128.297E): 26/10/2000 to 31/10/2000. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS 5 (15.478S, 128.309E): 26/10/2000 to 31/10/2000. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed and near-surface.
- AIMS A (14.795S, 128.353E): 12/01/2002 to 09/02/2002. Mooring included ADCP, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS B (14.816S, 128.218E): 12/01/2002 to 09/02/2002. Mooring included ADCP, Nephelometers at near-bed, mid depth and near-surface.
- AIMS C (15.035S, 128.174E): 12/01/2002 to 13/02/2002. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS D (15.177S, 128.138E): 13/01/2002 to 13/02/2002. Mooring included InterOcean S4, Dataflow, Nephelometers at near-bed, mid depth and near-surface.
- AIMS E (15.459S, 128.085E): 13/01/2002 to 14/02/2002. Mooring included ADCP, Dataflow, Nephelometers at near-bed, mid depth and near-surface.

River discharge and water levels have been measured for the main rivers that drain into CG by the DWER. Details of the data analysed as part of this project are provided below:

- Ord River: The following long-term datasets are the most relevant for the project:
  - Tarrara Bar, Station 809339 (15.570S, 128.693E): River discharge and water level data are available from 1998 and the data are ongoing. The site is located approximately 70 km downstream of the main Ord River dam.
  - Old Ord Homestead, Station 809316 (17.373S, 128.855E): River discharge and water level data are available from 1970 to 2023. The site is located approximately 110 km upstream of Lake Argyle (i.e. the site is upstream of the Ord River dams).

- Pentecost River, Station 808005 (15.799S, 127.883E): River level data have been measured at this site from February to December 2000.

- Durack River, Station 808001 (16.316S, 127.179E): River discharge and water level data were measured at this location from 1967 to 2000. The site was located approximately 150 km upstream of where both the Durack River and Pentecost River join the West Arm of CG.

- King River, Station 809314 (15.702S, 128.120E): River discharge and water level data are available from 1985 and the data are ongoing. The site is located approximately 35 km upstream of where the King River joins the West Arm of CG.

4. Data QA/QC

This section provides details of the data processing and QA-QC activities undertaken for the data collected as part of the project.

4.1. In-situ oceanographic & water quality instruments

4.1.1. AWAC/Nortek Signature 500/1000

The raw data from the Nortek AWACs and Signature 500/1000 ADCP were post-processed by BKA using the following instrument specific software developed by Nortek:

- For the Nortek AWAC measurements post-processing the “AWAC AST” software was used. This software package provides basic post-processing tools to retrieve current data. The software translates the acoustic signal directly into current speed/direction without any filtering.
- For the Nortek Signature 500/1000 ADCP measurements post-processing the “Ocean Contour” software was used. This software package provides a more advanced toolset which can produce both current and wave data.

As ADCP data are processed at discrete bins for a changing water level (tide), during low water no data are available in certain bins (dry cells). In addition, reflection of ADCP beam side lobes from the water surface can result in an interference region near the surface which can result in unreliable readings. These erroneous data were removed from the dataset by BKA for the data processed using the “Ocean Contour” software (i.e. the Nortek Signature 500/1000 ADCP data). For these data the software quantifies the reliability of the data in each bin throughout the deployment and based on this the uppermost layer which has consistently reliable data throughout the deployments was adopted as the surface layer for plotting purposes. For the AWAC data the unreliable layers were assessed based on the water depth, tidal range and through visual inspection of the bins (as detailed in Point 3 below).

The QA-QC steps undertaken by PCS following receipt of the data from BKA were as follows:

1. Removal of the data during the deployment and retrieval periods.
2. Visual review of time series data to remove error values or ‘spikes’ in the data record.
3. Visual review of binned data (e.g. flow speed & direction) to ensure consistency of data through the water column, and identify depth bin representative of surface conditions.
4. Conversion of water depth time series to MSL (these have not had any seasonal signals removed).

4.1.2. LI-COR LI-1500 and Odyssey Loggers

The raw data from the LI-COR LI-1500 sensors and the Odyssey Loggers were downloaded and initial QA-QC check was undertaken by BKA. The check involved a visual assessment of the data to identify when the instrument was on the seabed, whether the data reacted to day/night as expected and that the values were within expected ranges. The data provided to PCS was in a spreadsheet format which included both the raw data and the preliminary QA-QC data by BKA.

The QA-QC steps undertaken by PCS following receipt of the raw data from BKA were as follows:

1. Removal of the data during the deployment and retrieval periods.
2. Visual check of the data relative to other measured data at the site (e.g. depth and turbidity).
3. Check whether values vary between day and night.
4. Check between concurrent data recorded by the LI-COR and Odyssey Loggers to ensure correlation.

4.1.3. Manta/WiMo Multi-sonde probes

The raw data from the Manta/WiMo multi-sonde probes were downloaded and initial QA-QC checks were undertaken by BKA. This involved removing the data during the deployment and retrieval periods, undertaking a visual check of the different datasets and identifying any potentially unreliable data. The BKA QA-QC typically indicated that the majority of the data were reliable except that the turbidity data at some sites was very noisy. The data provided to PCS was in a spreadsheet format which included both the raw data and the preliminary QA-QC data by BKA.

The QA-QC steps undertaken by PCS following receipt of the raw data from BKA were as follows:

1. Visual check of all variables to identify any unreliable data or erroneous points to be flagged and removed from the QAed dataset.
2. Flagging system developed to identify spikes in turbidity. Data flagged if the difference between data points is over 50 NTU (100 NTU at the sites with higher turbidity values). All flagged data points removed to reduce the number of spikes in the dataset.
3. 30 minute moving average calculated for QAed turbidity data to smooth the time series (only for the 10 minute interval sites).
4. Second visual check conducted on the smoothed QAed turbidity data and any outstanding erroneous spikes identified and removed.
5. Conversion of water depth time series to MSL.

4.2. Sand Exploration Survey Feb-Mar 2023

4.2.1. Sidescan Sonar and Sub-Bottom Profiling

All acoustic data, both the seismic and side scan sonar data were processed and corrected for antenna offset, tow depth and tide. Maximum penetration depth of the seismic system was 15 m, mainly in the channel infill areas. Maximum penetration depth of the 28 vibrocores was 6.1 m.

The vibrocore data and the information of the 20 grab samples provided enough data to ground truth the seismic data. Despite the noise from the survey vessel showing up on the seismic data and the side scan sonar data, data quality of the recordings was good.

No QA-QC of the data was undertaken by PCS.

4.2.2. Sediment Sampling and Water Clarity

No QA-QC of the data was undertaken by PCS.

4.3. Dry Season Environmental Survey Jul-Aug 2023

4.3.1. Vertical Profiling and Water Sampling

The vertical profile datasets were trimmed by removing data from near the surface and at the bed that appeared scientifically compromised (due to surface effects, such as time for sensors to equilibrate, and bottom effects, such as sensor hitting the bed, etc).

Laboratory analysis of TSS and Chl-a was conducted by MAFRL at Murdoch University in Perth (NATA accredited under ISO/IEC 17025). All laboratory analyses followed international best practice (standard) analytical methodology for the respective variables as recommended under the NATA accreditation.

4.3.2. Water Clarity

No QA-QC of the data was undertaken by PCS.

4.3.3. Sediment Sampling

The sediment samples were visually assessed and photographed by BKA to determine the sediment type. No QA-QC of the data was undertaken by PCS.

4.4. Wet Season Environmental Survey Feb-Mar 2024

4.4.1. Sediment Sampling & Analysis

The relevant QA-QC procedures as required as part of PSD and SEM analysis were undertaken by NATA-accredited Microanalysis laboratories in Perth.

PCS undertook a subsequent check of the processed PSD and SEM data which included the following:

- Comparative assessment of the PSD results from the PSD and SEM analysis; and
- Comparison of results at nearby sites and from previous sampling.

4.4.2. Vertical Profiles

Data from the YSI Multi-Sonde Probe and the Aquadopp Deepwater were downloaded from the instruments and provided to PCS by BKA. No additional post-processing of the data was undertaken by BKA.

An initial visual assessment of the data was undertaken by PCS and based on this any unreliable data were removed (e.g. data collected before the instruments were in the water and after they were removed from the water). The vertical profile data were processed by PCS to show how the measured parameters varied through the water column during each vertical profile. The times when the instruments remained at the same depth were removed from the dataset, so the data represents a continuous vertical profile. In addition, results from the mid water column and near-bed were extracted from each vertical profile to show how the measured parameters varied over time at each site. The Aquadopp current data were averaged for the periods the instruments remained stationary at the mid water column and near-bed to also provide time series of current speed and direction over the duration of the profiling at each site.

4.4.3. Aerial Drone LiDAR & Photogrammetry Surveys

The captured drone data were processed by Sensorem to develop digital elevation models (DEMs) for each beach, and these were provided to PCS with a 0.05 m horizontal resolution. In addition, orthomosaic imagery for each beach was also provided at the resolution the imagery was captured.

Further details of the coastal LiDAR survey, data processing and QA-QC undertaken by Sensorem as well as preliminary results are provided in Appendix B.

4.4.4. Hydrographic (Multibeam) Survey

The bathymetric data were post-processed by BKA so that the vertical data were relative to mean sea level (MSL). Point data were provided to PCS at horizontal resolutions of 1 m for the two Target Areas and 5 m for the whole area. These were used by PCS to generate DEMs of the surveyed areas with the same resolution as the point data. These DEMs were then further analysed, including overlaying the repeat DEMs for the two Target Areas to assess changes in bathymetry and sediment movement over the 27-day intervening period.

Further details of the multibeam survey, data processing and QA-QC undertaken by BKA as well as preliminary results are provided in Appendix C.

4.5. Pre-existing (External) Data

This section provides details of the post-processing undertaken by PCS for the external data detailed in Table 2 (Section 2).

Sentinel 2 senor imagery available since 2015 was sourced from Copernicus (Copernicus, 2023) and post processed to calculate the satellite-derived Total Suspended Matter (TSM) based on the approach of Brockmann et al. (2016). This approach has been validated in various studies (Kyryliuk & Kratzer, 2019). An assessment of the accuracy of the satellite derived total suspended matter (TSM) against the in-situ measured data has also been previously undertaken by PCS (2021) in Albatross Bay in the Gulf of Carpentaria and the results showed that the satellite derived TSM was able to provide a good representation of the in-situ measured TSS data near the seabed (this was possible due to shallow depths combined with relatively low TSS (typically 10 to 20 mg/L) and limited variation in TSS through the water column). It is important to note that in high TSS environments such as CG the satellite-derived TSS will typically provide an indication of the TSS in the upper water column and the approach can only determine the TSS up to a certain concentration threshold (as values above that result in the same blocking of the water column). For CG that value is around 50 mg/L. This value was calculated as part of the processing of the satellite imagery. Therefore, although the satellite-derived TSM is not able to differentiate areas of higher TSM within CG, it is able to show the spatial variability in higher and lower values of TSS in the surface layers of the water column. The images selected for the satellite derived TSM analysis were manually identified, this ensured that the images were suitable and did not have high cloud cover or sun glare.

The open-source Python-based tool CoastSat was applied to extract the shoreline position from satellite imagery (Vos et al., 2019a, 2019b). The tool was iteratively applied to multiple images from different satellite platforms including the Landsat 5 (30 m resolution, 1988 to 2013), Landsat 7 (30 m resolution, since 1999), Landsat 8 (15 m resolution, since 2013) and Sentinel 2 (10 m resolution, since 2015). The shoreline positions were corrected to 0 m AHD using predicted water levels from Cape Domett. A manual check of the selected imagery was undertaken to identify which images were suitable for the analysis.

5. Data Files

This section provides tables of the BKA-collected data for some of the sampling undertaken (when data are of a suitable size for presenting in tables) and filenames of the data files for the remaining data which are too large to include in tables in this report.

5.1. In-situ oceanographic & water quality instruments

The filenames of the data files for the in-situ oceanographic and water quality instruments for each dataset are provided in Table 4.

5.2. Sand Exploration Survey Feb-Mar 2023

Details of the vibro-core, sediment grab and Drop Camera/Secchi Disc site locations and sediment types are provided in Table 5. The results from the Secchi Disc are included in Section 6.2.2.

5.3. Dry Season Environmental Survey Jul-Aug 2023

Details of the water quality, sediment sampling and benthic biota sampling undertaken as part of the Dry Season Environmental Survey along with the sediment description results are shown in Table 6 to Table 8. Results from the YSI vertical profiling are available in: CG_YSI_Data_DrySeasonEnviroSurvey.xlsx.

5.4. Wet Season Environmental Survey Feb-Mar 2024

Results from the elemental feature analysis for the grab samples and water samples collected during the Wet Season Environmental Survey are provided in Table 9 and Table 10 and PSD results are provided in Table 11 and Table 12.

The water quality data from the vertical profiling undertaken during the Wet Season Environmental Survey are available in: Site1_AllProfiles_Processed.csv, Site2_AllProfiles_Processed.csv, Site3_AllProfiles_Processed.csv. The current data from the vertical profiling are available in: AllSites_MidandBed_TimeSeries_Currents.csv.

Details of the data files for the Multibeam and LiDAR surveys undertaken during the Wet Season Environmental Survey are provided in Appendices B and C, respectively.

PORT & COASTAL SOLUTIONS

Table 4. Summary of data filenames for processed AWAC/ADCP, LI-COR and Manta data collected from July 2023 to August 2024.

Position	Start	End	Current Data	Wave Data	LI-COR/Odyssey Data	Manta Data
AWAC-01	09/06/2023 10:09	21/07/2023 02:39	QAQC_AWAC01_1st_Pos1.mat	-	-	-
AWAC-04	07/09/2023 08:03	08/09/2023 04:18	QAQC_AWAC01_2nd_Pos4.mat	-	QAQC_AWAC-01 2nd Pos-04 PAR-DLI.xlsx	-
AWAC-02	07/09/2023 06:40	08/09/2023 10:57	QAQC_AWAC02_1st_Pos2.mat	QAQC_WAVES_AWAC02_1st_Pos2.mat	QAQC_AWAC-02 1st Pos-02 PAR-DLI.xlsx	QAQC_AWAC-02_1st_Pos-02_Probe.xlsx
AWAC-06	08/09/2023 11:34	13/10/2023 13:26	QAQC_AWAC02_2nd_Pos06.mat	QAQC_WAVES_AWAC02_2nd_Pos06.mat	QAQC_AWAC-02 2nd Pos-06 PAR-DLI.xlsx	QAQC_AWAC-02_2nd_Pos-06_Probe.xlsx
AWAC-03	13/10/2023 14:09	15/10/2023 12:26	QAQC_AWAC02_3rd_Pos03.mat	QAQC_WAVES_AWAC02_3rd_Pos03.mat	-	QAQC_AWAC-02_3rd_Pos-03_Probe.xlsx
AWAC-07	15/10/2023 14:05	05/03/2024 13:56	QAQC_AWAC02_4th_Pos07.mat	QAQC_WAVES_AWAC02_4th_Pos07.mat	QAQC_AWAC-02 4th Pos-07 PAR-DLI.xlsx	QAQC_AWAC-02_4th_Pos-07_Probe.xlsx
AWAC-08	02/03/2024 09:50	18/06/2024 16:30	QAQC_AWAC01A_1st_Pos08.mat	QAQC_WAVES_AWAC01A_1st_Pos08.mat	QAQC_AWAC-01A 1st Pos-08-PAR-DLI.xlsx	QAQC_Awac-01A_1st_Pos-08_Probe.xlsx
AWAC-11	02/03/2024 15:08	08/05/2024 09:10	QAQC_AWAC05_1st_Pos11.mat	QAQC_WAVES_AWAC05_1st_Pos11.mat	QAQC_AWAC-05 1st Pos-11 PAR-DLI.xlsx	QAQC_AWAC-05_1st_Pos-11_Probe.xlsx
AWAC-01	03/03/2024 09:10	08/05/2024 12:42	QAQC_AWAC03_1st_Pos01.mat	QAQC_WAVES_AWAC03_1st_Pos01.mat	-	QAQC_AWAC-03_1st_Pos-01_Probe.xlsx
AWAC-06	06/03/2024 17:36	10/05/2024 06:48	QAQC_AWAC05_1st_Pos11.mat	QAQC_WAVES_AWAC05_1st_Pos11.mat	QAQC_AWAC-02-5th-Pos-06 PAR-DLI.xlsx	QAQC_AWAC-02_5th_Pos-06 Probe.xlsx
AWAC-09/ Pos-12	04/03/2024 11:00	21/06/2024 17:30	QAQC_Frame01_1st_Pos09.mat	QAQC_WAVES_Frame01_1st_Pos09.mat	QAQC_Frame-01 1st Pos-09-PAR-DLI.xlsx QAQC_Frame-01 1st Pos-09 Odyssey.xlsx	QAQC_Frame-01_1st_Pos-09_Probe.xlsx
Pos-13	03/03/2024 09:00	22/06/2024 10:20	-	-	QAQC_Frame-02 1st Pos-13-PAR-DLI.xlsx QAQC_Frame-02 1st and 2nd Pos-13 Odyssey.xlsx	QAQC_Frame-02_1st_Pos-13_Probe.xlsx QAQC_Frame-02_2nd_Pos-13_Probe.xlsx
Pos-14	03/03/2024 10:20	20/06/2024 17:50	-	-	QAQC_Frame-03 1st Pos-14-PAR-DLI.xlsx QAQC_Frame-03 1st Pos-14 Odyssey.xlsx	QAQC_Frame-03_1st Pos-14_Probe.xlsx
Pos-15	04/03/2024 17:30	26/06/2024 15:30	-	-	QAQC_Frame-04 1st Pos-15-PAR-DLI.xlsx QAQC_Frame-04 1st Pos-15 Odyssey.xlsx	QAQC_Frame-04_1st_Pos-15_Probe.xlsx
AWAC-07	10/05/2024 13:20	25/06/2024 09:20	QAQC_AWAC02_6th_Pos07.mat	QAQC_WAVES_AWAC02_6th_Pos07.mat	QAQC_AWAC-02 6th Pos-07-PAR-DLI.xlsx	QAQC_AWAC-02_6th_Pos-07_Probe.xlsx
AWAC-11	10/05/2024 15:30	23/06/2024 13:40	QAQC_AWAC05_2nd_Pos11.mat	QAQC_WAVES_AWAC05_2nd_Pos11.mat	-	QAQC_AWAC-05_2nd_Pos-11_Probe.xlsx
AWAC-01	29/06/2024 11:34	09/08/2024 14:34	QAQC_AWAC03_3rd_Pos01.mat	QAQC_WAVES_AWAC03_3rd_Pos01.mat	QAQC_AWAC-03 3rd Pos-01 Odyssey.xlsx	QAQC_AWAC-03_3rd_Pos-01_Probe.xlsx

Position	Start	End	Current Data	Wave Data	LI-COR/Odyssey Data	Manta Data
AWAC-05	20/06/2024 15:14	12/08/2024 15:14	QAQC_AWAC01A_2nd_Pos05.mat	QAQC_WAVES_AWAC01A_2nd_Pos05.mat	QAQC_AWAC-01A 2nd Pos-05 Odyssey.xlsx	QAQC_AWAC-01A_2nd_Pos-05_Probe.xlsx
AWAC-10	26/06/2024 10:17	13/08/2024 16:17	QAQC_AWAC02_7th_Pos10.mat	QAQC_WAVES_AWAC02_7th_Pos10.mat	QAQC_AWAC-02 7th Pos-10 Odyssey.xlsx	QAQC_AWAC-02_7th_Pos-10_Probe.xlsx
AWAC-11	24/06/2024 14:51	11/08/2024 15:41	QAQC_AWAC05_3rd_Pos11.mat	QAQC_WAVES_AWAC05_3rd_Pos11.mat	QAQC_AWAC-05 3rd Pos-11 Odyssey.xlsx	QAQC_AWAC-05_3rd_Pos-11_Probe.xlsx
Pos-12	28/06/2024 10:50	14/08/2024 11:30	-	-	QAQC_Frame-01 2nd Pos-09 Odyssey.xlsx	QAQC_Frame-01_2nd_Pos-09_Probe.xlsx
Pos-13	23/06/2024 06:00	12/08/2024 03:20	-	-	QAQC_Frame-02 3rd Pos-13 Odyssey.xlsx	QAQC_Frame-02_3rd_Pos-13_Probe.xlsx
Pos-14	21/06/2024 14:40	10/08/2024 14:00	-	-	QAQC_Frame-03 2nd Pos-14 Odyssey.xlsx	QAQC_Frame-03_2nd_Pos-14_Probe.xlsx
Pos-15	27/06/2024 15:40	11/08/2024 08:50	-	-	QAQC_Frame-04 2nd Pos-15 Odyssey.xlsx	QAQC_Frame-04_2nd_Pos-15_Probe.xlsx

Table 5. Details of the Vibro-core and grab sampling undertaken during the Sand Exploration Survey, Feb-Mar 2023.

Location	Latitude	Longitude	Depth (m)	Recovery (m)	Penetration (m)	Date	Drop Camera & Secchi Disc	Sediment Description
CF04	-14.7939	128.2393	36.3	full	4.34	10/03/2023	Y	0-1.73 m: reddish brown sand; 1.73-1.78 m: clayey sandy gravel; 1.78-4.0 m: f-m sand; 4.0-4.34 m: soft clay
CF05	-14.8026	128.2400	26.7	Grab	0.5	8/03/2023	N	rock/calcarenite
CF06	-14.8203	128.2396	24.2	full	4.35	12/03/2023	Y	0-2.35 m f-m sand; 2.35-3.78 m gravelly sandy clay/silt; 3.78-4.0 m f silty sand/silt; 4.0-4.35 m clayey silt
CF07	-14.8294	128.2402	27.1	1.4	1.23	8/03/2023	Y	0.5 m of gravely silty sand over stiff-hard gravelly clay
CF08	-14.8469	128.2392	25.7	full	5.24	9/03/2023	Y	5.24 m of same reddish brown sand
CF14	-14.7846	128.2583	34.7	?	0.45	10/03/2023	Y	0.45m clayey sandy gravel over very hard gravelly clay
CF15	-14.7883	128.2585	33.6	Grab (silt)		14/03/2023	N	orange clayey silt, trace sand
CF16	-14.7947	128.2586	29.4	full	4.7	8/03/2023	N	2m clayey sandy gravel. 2m to 4.7m sand
CF17	-14.8011	128.2583	29.3	1.5	1.3	10/03/2023	Y	0.56 m of clayey gravel over very stiff/hard clay
CF18	-14.8118	128.2585	26.5	Grab (clayey gravel+rock)		13/03/2023	N	clayey gravel and some cobble sized pieced of sandstone with shells encrusted.
CF19	-14.8172	128.2581	28	Grab (clayey gravel)		14/03/2023	N	gravelly sandy clay/clayey gravel
CF20	-14.8208	128.2587	24.7	3.4	3.38	9/03/2023	Y	0.24 m clayey gravelly sand with many shell fragments over clay
CF22	-14.8345	128.2584	25.5	Grab (rock)		13/03/2023	N	little gravelly clay
CF23	-14.8440	128.2588	20.5	3.2	3	9/03/2023	Y	3.0 m of the same reddish brown sand
CF24	-14.8497	128.2583	13.2	Grab (too shallow) sand		11/03/2023	Y	
CF25	-14.7869	128.2777	36.5	Grab (gravelly clay)		11/03/2023	N	
CF26	-14.8003	128.2773	32.3	Grab (gravelly clay)		11/03/2023	Y	
CF27	-14.8119	128.2773	24.9	full	6.1**	11/03/2023	Y	0-1.12m reddish brown sand; 1.12-2.3 m clayey gravel/gravelly clay; 2.3-4.0 m sandy gravel; 4.0-6.1 m: stiff clay with sandy layer
CF28	-14.8210	128.2771	9.9	full	4.46	9/03/2023	N	5 m of sand
CF29	-14.8356	128.2769	20.9	3	2.76	12/03/2023	Y	2.76 m of sand. VC went down straight, came up straight but with bent barrel.
CF30	-14.8480	128.2773	20.4	4.5	4.36	12/03/2023	Y	0-3.47 m sand; 3.47-4.36 m clay
CF32	-14.7981	128.2958	21.2	Grab - VC possibly later		12/03/2023	N	Very fine sand and clay
CF33	-14.8117	128.2957	17.5	Grab (gravelly clay)		12/03/2023	Y	gravelly sandy clay
CF39	-14.7847	128.3141	17.4	4.15	4.15	6/03/2023	Y	4.15m clay on rock
CF42	-14.8116	128.3141	22.7	Grab (silt)		12/03/2023	N	Silt with some gravel

CF43	-14.8296	128.3141	20.7	Grab (gravelly clay)		12/03/2023	Y	gravelly sandy clay
CF45	-14.8118	128.3330	18.7	Grab (gravelly clay)		12/03/2023	N	Gravelly sandy clay
CF47	-14.7938	128.2689	22.9	Grab (shelly sandy gravel)		13/03/2023	N	shelly sandy gravel
CF50	-14.8076	128.2439	17.2	Grab (sand)		14/03/2023	N	sand
CF52	-14.8121	128.2427	21.8	full	5.45	13/03/2023	N	5.35 m of sand over gravelly clay/clayey gravel.
CF54	-14.8299	128.2692	26.7	full	5.23	14/03/2023	N	5.23 m of sand
CF55	-14.8292	128.3325	21	Grab (gravelly clay)		13/03/2023	Y	gravelly clay
CF58	-14.8479	128.3276	14.7	Grab (silt)		12/03/2023	N	Silt with some gravel
CF59	-14.8387	128.2479	28.4	0.1	0.1	13/03/2023	N	10 cm of gravelly sand with many shell fragments and some clay

Table 6. Details of the CG samples from the water quality and geophysical sampling undertaken during the Dry Season Environmental Survey, Jul-Aug 2023.

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
CG01	-14.7554	128.2424	30	17/07/2023	9:24	Y	Y	Y	Y	No biota	Sand
CG02	-14.7729	128.2404	24	17/07/2023	13:30	Y	N	N	N	No biota	Sand
CG03	-14.7735	128.2227	20	17/07/2023	14:00	Y	N	N	N	Juv spanner crab - see pic	Sand
CG04	-14.7675	128.2165	13	17/07/2023	15:05	Y	Y	Y	N	Juv spanner crab	Sand
CG05	-14.7861	128.2006	8	17/07/2023	15:47	Y	N	N	N	See biota sample	Clay
GG06	-14.7419	128.2947	17	18/07/2023	9:30	Y	N	N	N	Urchin (photo, not sampled)	Clay & small % sand
CG07	-14.7503	128.2979	20	18/07/2023	11:30	Y	N	N	N	Tubeworms	Clay & small % gravel
CG08	-14.7605	128.2996		18/07/2023	12:10	Y	N	N	N	Soft coral	Clay / gravel
CG09	-14.8067	128.1992		18/07/2023	13:50	Y	Y	Y	N	Polychaete	Clay
CG10	-14.8054	128.2256	20	18/07/2023	14:35	Y	Y	Y	N	No biota	Sand & small % shell grit
CG11	-14.8273	128.2261	17	18/07/2023	15:01	N	N	N	Y	See biota sample	Sand
CG12	-14.8441	128.2176	13	18/07/2023	15:40	Y	Y	Y	N	No biota	Sand
CG13	-14.8449	128.1973	16	18/07/2023	16:35	Y	N	N	N	No biota	Sand
CG14	-14.8615	128.1974	40	19/07/2023	10:55	Y	Y	Y	N	See biota sample	Clay & small % gravel
CG15	-14.8611	128.2185	19	19/07/2023	11:30	Y	Y	Y	Y	No biota	Fine sand / gravel
CG16	-14.8502	128.2335	8	19/07/2023	12:00	Y	Y	Y	N	No biota	Sand
CG17	-14.8600	128.2613	17	19/07/2023	12:35	Y	Y	Y	Y	No biota	Sand
CG18	-14.8601	128.2810	18	19/07/2023	13:15	Y	Y	Y	N	Small yellow tunicates	Sand & small % shell grit
CG19	-14.8605	128.2995	15	19/07/2023	13:46	Y	Y	Y	N	No biota	Clay & small % gravel
CG20	-14.8732	128.2982	18	19/07/2023	14:15	N	Y	Y	Y	No biota	Clay / shell grit
CG21	-14.8737	128.2826	18	19/07/2023	14:47	Y	Y	Y	N	No biota	Clay / shell grit / gravel
CG22	-14.8744	128.2636	13	19/07/2023	15:55	Y	N	N	Y	Hydroids	Clay / gravel
CG23	-14.8756	128.2436	20	19/07/2023	16:15	Y	N	N	N	No biota	Sand
CG24	-14.8762	128.2194	24	20/07/2023	8:25	Y	N	N	N	See biota sample	Clay / gravel
CG25	-14.8758	128.2037	5	20/07/2023		Y	N	N	N	No biota	Sand
CG26	-14.8751	128.1749	21-28	20/07/2023	9:25	Y	Y	Y	Y	No biota	Sand & small % shell grit
CG27	-14.8882	128.2185	20	20/07/2023	10:00	Y	N	N	Y	See biota sample	Clay / gravel
CG28	-14.8891	128.2400	21	20/07/2023	10:45	Y	N	N	N	No biota	Sand
CG29	-14.8885	128.2611	20	20/07/2023	11:15	Y	N	N	Y	See biota sample	Clay / gravel
CG30	-14.8887	128.2819	12	20/07/2023	11:41	Y	N	N	Y	No biota	Clay
CG31	-14.8879	128.2988	11	20/07/2023	12:02	Y	N	N	N	No biota	Clay
CG32	-14.8890	128.3162	3	20/07/2023	13:40	Y	N	N	N	No biota	Sand
CG33	-14.8732	128.3212	3	20/07/2023	14:06	Y	N	N	N	No biota	Sand

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
CG34	-14.8608	128.3241	10	20/07/2023	14:25	Y	N	N	Y	No biota	Clay / shell grit
CG35	-14.8475	128.3261	10	20/07/2023	14:48	N	N	N	N	No biota	Sand & small % clay
CG36	-14.8296	128.3263	15	20/07/2023	15:10	N	N	N	N	See biota sample	Clay / shell grit / gravel
CG37	-14.8124	128.3281	17	20/07/2023	15:40	N	Y	Y	Y	No biota	Clay / shell grit / gravel
CG38	-14.7929	128.3271	15	20/07/2023	16:02	N	N	N	N	No biota	Sand & small % shell grit
GG39	-14.7908	128.2248	27	21/07/2023	8:58	Y	N	N	Y	No biota	Sand
GG40	-14.7911	128.2431	43	21/07/2023	9:30	Y	N	N	N	No biota	Sand & small % shell grit
CG41	-14.7909	128.2580	33	21/07/2023	10:00	Y	N	N	Y	See biota sample	Clay / shell grit / gravel
CG42	-14.7729	128.2600	45	21/07/2023	10:33	Y	N	N	N	See biota sample	Clay / gravel
CG43	-14.7901	128.2791	30	21/07/2023	11:05	Y	N	N	N	No biota	Clay / gravel
CG44	-14.7902	128.3020	20	21/07/2023	11:30	Y	N	N	N	No biota	Clay / gravel
CG45	-14.8135	128.3034	20	21/07/2023	12:00	Y	N	N	N	No biota	Clay / gravel
CG46	-14.8123	128.2829	10	21/07/2023	13:47	Y	N	N	Y	See biota sample	Sand
CG47	-14.8107	128.2623	25	21/07/2023	14:05	Y	N	N	N	See biota sample	Clay / shell grit / gravel
CG48	-14.8109	128.2453	15	21/07/2023	14:34	Y	N	N	Y	No biota	Sand
CG49	-14.8258	128.2447	16	21/07/2023	14:55	Y	N	N	N	No biota	Sand
CG50	-14.8269	128.2605	22	21/07/2023	15:10	Y	N	N	Y	Rock with crabs & colonising organisms.	Clay / gravel
CG51	-14.8269	128.2747	6	21/07/2023	15:35	Y	N	N	N	No biota	Sand
CG52	-14.8265	128.3016	37	22/07/2023	8:30	Y	N	N	Y	See biota sample	Clay / gravel
CG53	-14.8412	128.2447	25	22/07/2023	9:05	Y	N	N	Y	No biota	Sand
CG54	-14.8415	128.2609	25	22/07/2023	9:33	Y	N	N	N	No biota	Sand & small % shell grit
CG55	-14.8408	128.2683	10	22/07/2023	9:55	Y	N	N	Y	No biota	Sand
CG56	-14.8335	128.2710	11	22/07/2023	10:15	Y	N	N	N	No biota	Sand
CG57	-14.8408	128.2872	20	22/07/2023	10:42	Y	N	N	N	No biota	Sand & small % shell grit
CG58	-14.8404	128.3136	18	22/07/2023	11:10	Y	N	N	N	See picture	Clay / gravel
CG59	-14.8469	128.3446	12	22/07/2023	11:45	Y	N	N	N	No biota	Clay & small % sand
CG60	-14.8302	128.3452		22/07/2023	12:00	Y	N	N	N	3x hydroids (See picture)	Clay / shell grit / gravel
CG61	-14.8120	128.3452		22/07/2023	12:28	Y	N	N	N	See biota sample	Gravel / clay
CG62	-14.7348	128.3049	8	23/07/2023	9:01	Y	N	N	N	No biota	Clay
CG63	-14.7405	128.3157	8	23/07/2023	9:29	Y	N	N	N	See biota sample	Clay
CG64	-14.7483	128.3291	17	1/08/2023	8:00	Y	Y	N	N	See biota sample	Clay / shell grit
CG65	-14.7581	128.3349		1/08/2023	8:35	Y	Y	N	N	No biota	Shell grit.
CG66	-14.7710	128.3257	15	23/07/2023	10:09	Y	N	N	N	See biota sample	Clay / shell grit
CG67	-14.7741	128.3141	10	23/07/2023	10:29	Y	N	N	N	No biota	Clay

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
CG68	-14.7588	128.2982	24	23/07/2023	11:03	Y	N	N	N	See biota sample	Clay / shell grit
CG69	-14.9141	128.2285	24	25/07/2023	13:09	Y	Y	Y	N	No biota	Small rocks
CG70	-14.9310	128.2166	24	25/07/2023	13:29	Y	Y	Y	N	No biota	Sand
CG71	-14.9450	128.2069	21	25/07/2023	13:55	Y	Y	Y	N	No biota	Clay / gravel
CG72	-14.9596	128.1973	21	25/07/2023	14:37	Y	Y	Y	N	No biota	Small rocks
CG73	-14.9751	128.1871	26	25/07/2023	14:52	Y	Y	Y	N	See photos & biota sample	Clay / gravel
CG74	-14.9890	128.1740	11	25/07/2023	15:18	Y	Y	Y	N	No biota	Sand & small % clay
CG75	-15.0156	128.1761	16	25/07/2023	15:50	N	Y	Y	N	No biota	Sand & small % clay
CG76	-15.0439	128.1693	20m	26/07/2023	9:08	Y	Y	Y	N	No biota	Small rocks
CG77	-15.0581	128.1686	25	26/07/2023	9:30	Y	Y	N	N	No biota	Small rocks
CG78	-15.0231	128.1531	3	26/07/2023	10:20	Y	Y	N	N	No biota	Sand
CG79	-15.0431	128.1129	40	26/07/2023	10:52	Y	Y	N	N	No biota	Rock
CG80	-15.0210	128.1206	18	26/07/2023	11:24	Y	Y	N	N	No biota	Rock
CG81	-14.7773	128.3347		1/08/2023	9:00	Y	Y	N	N	See biota sample	Clay / shell grit
CG82	-14.8920	128.1651	11	1/08/2023	14:45	Y	N	N	N	No biota	Sand
CG83	-14.9169	128.1582	20	1/08/2023	15:05	Y	N	N	N	No biota	Sand
CG84	-14.9501	128.1421	10	1/08/2023	15:39	Y	N	N	N	No biota	Sand
CG85	-14.9731	128.1419	20	1/08/2023	13:55	Y	N	N	N	No biota	Sand
CG86	-14.8688	128.4689	7	2/08/2023	7:54	N	Y	N	N	No biota	Clay & gravel
CG87	-14.8522	128.4679	5	2/08/2023	7:56	N	Y	N	N	See pic - small Caulerpa	Minimal return - rock seabed.
CG88	-14.8426	128.4698	6	2/08/2023	8:03	N	Y	N	N	No biota	Minimal return - rock seabed.
CG89	-14.8532	128.4400	8.7	2/08/2023	8:13	N	Y	N	N	No biota	Clay & gravel
CG90	-14.8520	128.4176	12.5	2/08/2023	8:26	N	Y	N	N	No biota	2 small rocks
CG91	-14.8381	128.3970	9.5	2/08/2023	8:37	N	Y	N	N	No biota	Sand & small % clay
CG92	-14.8803	128.3991	7.5-9	2/08/2023	8:55	N	Y	N	N	No biota	Sand
CG93	-14.9244	128.4094	4	2/08/2023	9:27	N	Y	N	N	No biota	Sand & small % clay
CG94	-14.8995	128.4108	6.6	2/08/2023	9:37	N	Y	N	N	No biota	Clay & gravel
CG95	-14.8896	128.4063	7.2	2/08/2023	9:43	N	Y	N	N	No biota	Sand & small % clay
CG96	-14.8838	128.3987	6.4	2/08/2023	9:52	N	Y	N	N	No biota	Fine sand
CG97	-14.9015	128.3954	2.1	2/08/2023	10:07	N	Y	N	N	No biota	Fine sand
CG98	-14.8851	128.3865	4.8	2/08/2023	10:16	N	Y	N	N	No biota	Clay
CG99	-14.8680	128.3788	11.7	2/08/2023	10:26	N	Y	N	N	No biota	Clay & gravel
CG100	-14.8540	128.3778	9.8	2/08/2023	10:35	N	Y	N	N	No biota	Fine sand
CG101	-14.8266	128.3905	5	2/08/2023	11:56	Y	N	N	N	See biota sample	Clay & gravel
CG102	-14.8439	128.3729	10	2/08/2023	13:00	Y	N	N	N	No biota	Sand & small % shell grit

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
CG103	-14.8714	128.3366	2	2/08/2023	13:43	Y	N	N	N	No biota	Fine sand
CG104	-14.9068	128.2918	12	2/08/2023	14:28	Y	N	N	N	No biota	Clay
CG105	-14.9348	128.2613	2	2/08/2023	14:59	Y	N	N	N	No biota	Clay / shell grit

Table 7. Details of the KS samples from the water quality and geophysical sampling undertaken during the Dry Season Environmental Survey, Jul-Aug 2023.

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
KS01	-14.7257	128.2475	32	27/07/2023	8:04	Y	Y	N	N	No biota	Sand
KS02	-14.7089	128.2499	22	27/07/2023	8:46	Y	Y	Y	N	See biota sample & pic	Sand
KS03	-14.6927	128.2548	30	27/07/2023	9:15	Y	Y	N	N	No biota	Sand & small % shell grit
KS04	-14.6778	128.2487	12	27/07/2023	9:35	Y	Y	N	N	No biota	Sand
KS05	-14.6553	128.2372	10	27/07/2023	10:05	Y	Y	N	N	No biota	Sand
KS06	-14.6245	128.2271	6	27/07/2023	10:29	Y	Y	Y	N	No biota	Shell grit
KS07	-14.6276	128.2097	27	27/07/2023	10:50	Y	Y	N	N	No biota	Clay / gravel
KS08	-14.6352	128.1908	9	27/07/2023	11:12	Y	Y	N	N	No biota	Sand
KS09	-14.6510	128.1990	11	27/07/2023	11:34	Y	Y	N	N	No biota	Sand & small % shell grit
KS10	-14.6500	128.2156	27	27/07/2023	11:55	Y	Y	N	N	No biota	Sand
KS11	-14.6691	128.2268	27	27/07/2023	13:18	Y	Y	N	N	See biota sample	Rock bottom
KS12	-14.6690	128.2066	17	27/07/2023	13:45	Y	Y	N	N	No biota	Rock bottom
KS13	-14.6868	128.2121		27/07/2023	14:00	Y	Y	N	N	Sponge on small rock	Rock bottom
KS14	-14.6837	128.2239	12	27/07/2023	14:20	Y	Y	Y	N	No biota	Sand
KS15	-14.6812	128.2357	26	27/07/2023	14:43	Y	Y	N	N	See sample - various biota	Clay / gravel
KS16	-14.6915	128.2415	25	27/07/2023	15:00	Y	Y	N	N	See sample - various biota	Stones / gravel
KS17	-14.6966	128.2300	10	27/07/2023	15:18	Y	Y	N	N	No biota	Sand
KS18	-14.7018	128.2185	20	27/07/2023	15:31	Y	Y	N	N	See biota sample	Fine sand
KS19	-14.7136	128.2261	26	27/07/2023	15:54	Y	Y	N	N	See sample - various biota	Stones / gravel
KS20	-14.7195	128.2409	15	27/07/2023	16:13	Y	Y	N	N	No biota	Sand
KS21	-14.6437	128.1573	32	27/07/2023	8:04	Y	Y	N	N	No biota	Sand
KS22	-14.6531	128.1645	15	1/08/2023	11:05	Y	N	N	N	No biota	Sand
KS23	-14.6786	128.1402	7	1/08/2023	11:31	Y	N	N	N	No biota	Clay
KS24	-14.6991	128.1643	10	1/08/2023	11:58	Y	N	N	N	No biota	Clay / gravel
KS25	-14.6752	128.1746	1	1/08/2023	12:23	Y	N	N	N	See biota sample	Fine sand
KS26	-14.6882	128.1879	4	1/08/2023	12:39	Y	N	N	N	No biota	Fine sand
KS27	-14.6999	128.2046	20	1/08/2023	12:56	Y	N	N	N	No biota	No return - likely rock

Table 8. Details of the Offshore samples from the water quality and geophysical sampling undertaken during the Dry Season Environmental Survey, Jul-Aug 2023.

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
OSA01	-14.3901	128.5000	30	28/07/2023	10:57	Y	Y	Y	Y	See biota sample	Clay / shell grit
OSA02	-14.3722	128.5004	30	28/07/2023	11:28	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA03	-14.3541	128.5000	30	28/07/2023	12:05	Y	N	N	Y	See biota sample	Clay / shell grit
OSA04	-14.3363	128.4999	30m	28/07/2023	12:32	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA05	-14.3190	128.4998	30m	28/07/2023	13:09	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA06	-14.3176	128.5345	31	28/07/2023	15:05	Y	Y	Y	N	No biota	Clay / shell grit
OSA07	-14.3356	128.5356	30	28/07/2023	15:30	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA08	-14.3531	128.5366	30	28/07/2023	15:50	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA09	-14.3695	128.5371	30	28/07/2023	16:20	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA10	-14.3890	128.5363	28	28/07/2023	16:50	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA11	-14.3897	128.5539	30	29/07/2023	7:30	Y	Y	N	N	See biota sample	Clay / shell grit
OSA12	-14.3719	128.5541	28	29/07/2023	7:58	Y	Y	Y	N	See biota sample	Clay / shell grit
OSA13	-14.3633	128.5542	36	29/07/2023	8:30	Y	Y	N	N	No biota	Shell grit/clay
OSA14	-14.3537	128.5437	35	29/07/2023	9:01	Y	Y	Y	N	See biota sample	Clay / gravel
OSA15	-14.3365	128.5544	30	29/07/2023	9:25	Y	Y	Y	N	See biota sample	Clay / shell grit / gravel
OSA16	-14.3178	128.5542	30	29/07/2023	9:54	Y	Y	N	N	See biota sample	Clay / shell grit
OSA17	-14.3005	128.5995	30	29/07/2023	11:20	Y	Y	Y	N	See biota sample	Clay / shell grit / gravel
OSA18	-14.3181	128.6001	30	29/07/2023	11:45	Y	Y	Y	N	See biota sample	Clay / shell grit / gravel
OSA19	-14.3358	128.6005	28	29/07/2023	12:21	Y	Y	Y	N	See biota sample	Clay / shell grit / gravel
OSA20	-14.3532	128.6003	25	29/07/2023	12:40	Y	Y	N	Y	No biota	Shell grit with sand
OSA21	-14.3583	128.5999	27	29/07/2023	12:58	Y	Y	Y	N	See biota sample	Shell grit with small % clay
OSA22	-14.3548	128.6086	25	29/07/2023	13:17	Y	Y	Y	Y	See biota sample	Sand / shell grit
OSA23	-14.3527	128.6100	25	29/07/2023	15:50	Y	N	N	N	See biota sample	Gravel / shell grit / clay
OSA24	-14.3530	128.6042	25	29/07/2023	16:05	Y	N	N	N	No biota	Clay / shell grit / gravel
OSA25	-14.3495	128.5993	25	29/07/2023	16:24	Y	Y	Y	N	No biota	Small rocks
OSA26	-14.3515	128.5995	27	29/07/2023	16:41	Y	N	N	N	See biota sample	Small rocks / gravel / clay
OSA27	-14.3621	128.6161	28	30/07/2023	13:30	Y	Y	N	N	No biota in pre-sieve	Grab pics missing - refer dropcam video - gravel / shell grit / silt with sparse benthic biota.
OSA28	-14.3730	128.5905	29	30/07/2023	13:43	Y	Y	Y	N	"	"
OSA29	-14.3553	128.5908	30	30/07/2023	14:05	Y	Y	N	N	"	"
OSA30	-14.3439	128.5923	26	30/07/2023	14:25	Y	Y	Y	Y	"	Grab pics missing - refer dropcam video - shell grit with distinct sand waves

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
OSA31	-14.3330	128.5944	30	30/07/2023	14:40	Y	Y	N	N	"	Grab pics missing - refer dropcam video - gravel / shell grit / silt with sparse benthic biota.
OSA32	-14.3204	128.5919	30	30/07/2023	15:00	Y	Y	N	N	"	"
OSA33	-14.3196	128.5729	30	30/07/2023	15:18	Y	Y	N	N	"	"
OSA34	-14.3325	128.5715	30	30/07/2023	15:35	Y	Y	N	N	"	"
OSA35	-14.3521	128.5723	30	30/07/2023	15:50	Y	N	N	N	"	"
OSA36	-14.3718	128.5722	30	30/07/2023	16:05	Y	N	N	N	"	"
OSA37	-14.3943	128.5734	30	30/07/2023	16:18	Y	N	N	N	"	"
OSA38	-14.3206	128.5206	35	5/08/2023	7:13	N	N	N	N	See biota sample	Fine gravel / clay
OSA39	-14.3354	128.5183	33	5/08/2023	7:35	N	N	N	N	See biota sample	Small rocks
OSA40	-14.3536	128.5193	32	5/08/2023	7:50	N	N	N	N	See biota sample	Shell grit / clay
OSA41	-14.3715	128.5190	32	5/08/2023	8:05	N	N	N	N	See biota sample	Rocks / gravel / clay
OSA42	-14.3884	128.5198		5/08/2023	8:17	N	N	N	N	See biota sample	Shell grit / clay
OSB01	-14.3861	128.6527	25	30/07/2023	7:50	Y	N	N	N	No biota in pre-sieve	Gravel / silt
OSB02	-14.3902	128.6562	26	30/07/2023	8:08	Y	N	N	N	"	Shell grit / fine sand
OSB03	-14.3907	128.6560	37	30/07/2023	8:30	Y	N	N	N	"	Shell grit / fine sand
OSB04	-14.3910	128.6562	37	30/07/2023	8:45	Y	N	N	N	"	Shell grit / fine sand
OSB05	-14.3867	128.6449	25	30/07/2023	8:57	Y	N	N	N	"	Shell grit / clay
OSB06	-14.3866	128.6439	25	30/07/2023	9:10	Y	N	N	N	"	Fine sand
OSB07	-14.3841	128.6436	25	30/07/2023	9:22	Y	N	N	N	"	Sand
OSB08	-14.3820	128.6406	37	30/07/2023	9:37	Y	N	N	N	"	Sand
OSB09	-14.3802	128.6370	37	30/07/2023	9:51	Y	N	N	N	"	Sand
OSB10	-14.3777	128.6346	37	30/07/2023	10:08	Y	N	N	N	"	Sand
OSB11	-14.3759	128.6316	26	30/07/2023	10:18	Y	N	N	N	"	Sand
OSB12	-14.3729	128.6293	26	30/07/2023	10:46	Y	N	N	N	"	Sand with clay clumps
OSB13	-14.3675	128.6235	26	30/07/2023	11:05	Y	N	N	N	"	Sand
OSB14	-14.3621	128.6161	25	30/07/2023	11:22	Y	N	N	N	"	Sand with small % shell grit
OSB15	*Not Recorded*		32	30/07/2023	11:41	Y	N	N	N	"	Sand
OSB16	-14.3922	128.6739	30	4/08/2023	6:00	Y	N	N	N		Clay/gravel
OSB17	-14.3843	128.6594	30	4/08/2023	6:20	Y	N	N	N		Clay/gravel
OSB18	-14.3760	128.6481	30	4/08/2023	6:38	Y	N	N	N		Clay/gravel
OSB19	-14.3644	128.6367	30	4/08/2023	6:55	Y	N	N	N		Gravel
OSB20	-14.3546	128.6238	30	4/08/2023	7:20	Y	N	N	N		Clay/gravel

Location	Latitude	Longitude	Depth (m)	Date	Sample Start Time	Drop Camera	WQ YSI	WQ Filtered Chl a/TSS	NADG Sample	Biota Notes	Sediment Description
OSB21	-14.3459	128.6121	30	4/08/2023	7:32	Y	N	N	N		Clay/gravel
OSB22	-14.3319	128.6108	30	4/08/2023	7:46	Y	N	N	N		Clay/gravel
OSB23	-14.3208	128.6277	30	4/08/2023	8:05	Y	N	N	N		Course sand with shell grit
OSB24	-14.3201	128.6279	30	4/08/2023	8:12	Y	N	N	N		Shell grit
OSB25	-14.3410	128.6250	28.5	4/08/2023	8:34	Y	N	N	N		Clay/shell grit
OSB26	-14.3457	128.6329	28	4/08/2023	8:48	Y	N	N	N		Sand/shell grit
OSB27	-14.3474	128.6325	28	4/08/2023	8:57	Y	N	N	N		Sand/shell grit
OSB28	-14.3448	128.6304	27.5	4/08/2023	9:15	Y	N	N	N		Gravel/shell grit/little sand
OSB29	-14.3438	128.6326	27.5	4/08/2023	9:25	Y	N	N	N		Shell grit
OSB30	-14.3464	128.6357	28	4/08/2023	9:35	Y	N	N	N		Clay/shell grit
OSB31	-14.3501	128.6329	27	4/08/2023	9:49	Y	N	N	N		Shell grit/gravel
OSB32	-14.3545	128.6356	26	4/08/2023	11:10	Y	N	N	N		Shell grit/clay
OSB33	-14.3600	128.6490	27.5	4/08/2023	11:25	Y	N	N	N		Small rocks / clay
OSB34	-14.3681	128.6593	26	4/08/2023	11:40	Y	N	N	N		Gravel/clay
OSB35	-14.3770	128.6743	25	4/08/2023	11:10	Y	N	N	N		Gravel/clay
OSB36	-14.3899	128.6883	24	4/08/2023	12:20	Y	N	N	N		Fine gravel
OSB37	-14.3975	128.7242	22	4/08/2023	12:48	Y	N	N	N		Fine gravel & silt
OSB38	-14.3941	128.6401	25	4/08/2023	2:15	Y	N	N	N		Shell grit/clay
OSB39	-14.3802	128.6237	28	4/08/2023	2.3	Y	N	N	N		Shell grit/clay
OSB40	-14.3808	128.6103	26	4/08/2023	2:45	Y	N	N	N		Shell grit/clay
OSB41	-14.3672	128.6106	26	4/08/2023	3	Y	N	N	N		Shell grit/clay
OSB42	-14.3943	128.6241	27	4/08/2023	3.2	Y	N	N	N		Shell grit/clay
OSB43	-14.3949	128.6112	27	4/08/2023	3:30	Y	N	N	N		Fine gravel/clay
OSB44	-14.3952	128.5924	27	4/08/2023	3:50	Y	N	N	N		Shell grit/clay
OSB45	-14.3765	128.6348	26	4/08/2023	6:25	N	N	N	N		Clay / some sand
OSB46	-14.3801	128.6381	26	4/08/2023	6:58	N	N	N	N		Sand
OSB47	-14.3866	128.6490	26	4/08/2023	6:38	N	N	N	N		Sand
OSB48	-14.3908	128.6504	26	4/08/2023		N	N	N	N		Sand

Table 9. Elemental feature results for the grab samples collected during the Wet Season Environmental Survey, Feb-Mar 2024.

Location	Latitude	Longitude	Quartz (%)	Feldspar (%)	Agglomerate (Silicate, Halite) (%)	Agglomerate (Calcite, Halite, Silicate) (%)	Magnesium Aluminosilicate (%)	Titanium Phase (%)	Calcite (%)	Calcium Silicate (%)
SDP01	-14.7203	128.1272	34.27	23.99	10.09	0.01	29.26	0.06	0.06	0.00
SDP02	-14.7274	128.1365	58.32	16.23	13.17	0.01	10.14	0.04	0.08	0.00
SDP06	-14.7482	128.1928	11.48	13.78	17.61	1.21	52.93	0.15	0.22	0.00
SDP08	-14.7675	128.2253	42.02	2.52	11.25	40.47	1.22	2.39	0.00	0.00
SDP09	-14.7742	128.2299	45.85	1.71	6.99	37.30	1.32	4.10	0.25	0.00
SDP14	-14.8850	128.0745	9.14	28.57	10.62	0.64	31.67	0.15	0.07	0.00
SDP22	-14.8877	128.3370	57.85	11.02	9.08	11.16	5.47	0.94	3.77	0.00
SDP24	-14.9959	128.4528	92.14	0.51	2.60	3.29	0.13	0.00	1.20	0.00
SDP25	-14.9691	128.4341	84.21	0.00	10.60	3.06	0.63	0.00	0.00	0.00
SDP26	-14.9312	128.4077	83.48	0.20	7.38	1.32	1.69	0.00	3.41	0.00
SDP27	-14.9094	128.4005	84.51	0.32	12.96	0.38	0.11	0.00	1.15	0.00
SDP29	-14.8429	128.3565	73.34	1.06	2.28	7.58	0.72	0.04	12.25	2.53
SDP32	-14.7799	128.2344	42.60	2.79	16.22	27.87	2.34	5.16	0.54	0.00
SDP33	-14.7894	128.2436	43.26	10.57	4.51	26.97	4.59	0.60	5.06	0.06
SDP34	-14.9443	128.1410	58.68	5.51	10.29	15.75	3.10	3.79	0.63	0.00
SDP36	-14.8547	128.1782	71.66	3.55	8.25	11.97	3.32	0.60	0.07	0.00
SDP37	-14.8388	128.2182	62.26	5.57	13.74	14.42	2.73	0.68	0.02	0.00
SDP39	-14.8098	128.2819	63.77	1.87	6.87	19.57	5.55	0.72	0.25	0.00
SDP43	-14.8224	128.2305	61.16	16.71	9.15	2.67	7.91	0.00	0.94	0.00
SDP44	-14.8683	128.2540	56.69	7.67	20.28	11.28	2.55	0.41	0.01	0.00
US01	-15.5970	127.8217	71.29	16.76	0.00	3.56	6.03	1.56	0.02	0.00
US02	-15.6513	127.8719	60.16	25.57	0.01	0.18	9.56	1.71	0.15	0.01
US04	-15.6055	127.8688	88.00	7.53	0.19	1.17	1.14	1.27	0.00	0.00
US05	-15.5859	127.9102	78.74	14.17	0.49	2.02	3.02	0.91	0.19	0.00
US06	-15.5541	127.9603	98.44	0.00	0.08	0.00	0.04	1.42	0.00	0.00
US07	-15.5285	127.9851	92.73	0.04	4.55	2.24	0.00	0.00	0.01	0.00
US10	-15.4899	128.0520	90.49	1.92	5.78	0.34	0.31	0.86	0.03	0.00
US12	-15.4329	128.0990	77.02	9.81	2.55	4.09	3.00	1.75	0.18	0.00
US13	-15.4050	128.1043	79.83	3.64	15.02	0.00	0.77	0.03	0.02	0.00
US14	-15.3601	128.1020	52.91	20.14	12.84	0.03	10.63	0.82	0.29	0.00
US15	-15.3414	128.0968	57.76	6.40	26.69	1.25	4.15	1.10	0.06	0.00
US16	-15.3096	128.0981	50.16	3.09	41.46	0.00	0.14	0.00	4.99	0.00
US17	-15.2978	128.1017	57.65	7.85	26.91	0.22	5.31	0.59	0.15	0.00

Location	Latitude	Longitude	Quartz (%)	Feldspar (%)	Agglomerate (Silicate, Halite) (%)	Agglomerate (Calcite, Halite, Silicate) (%)	Magnesium Aluminosilicate (%)	Titanium Phase (%)	Calcite (%)	Calcium Silicate (%)
US19	-15.3790	128.0965	55.10	18.70	9.68	0.23	12.21	1.53	0.62	0.00
US20	-15.1746	128.1445	48.11	18.87	15.34	0.00	13.41	1.21	0.84	0.00
US21	-15.2159	128.1865	26.75	34.90	5.67	0.02	29.92	0.71	0.18	0.00
US22	-15.2668	128.2297	35.13	25.28	2.80	0.07	29.87	2.87	0.69	0.00
US23	-15.3121	128.2790	57.67	29.48	0.01	0.01	8.28	0.01	0.01	0.00
US24	-15.3972	128.2870	48.23	25.97	0.00	0.00	18.98	2.63	0.25	0.00
US25	-15.1810	128.1142	2.22	0.56	10.26	4.65	79.68	0.15	0.64	0.00
US26	-15.1407	128.1013	65.35	19.28	13.55	0.07	0.51	0.42	0.06	0.00
US27	-15.0639	128.1193	62.10	14.43	17.45	3.16	2.03	0.00	0.14	0.00
WSKS03	-14.6929	128.2550	51.91	10.36	19.22	2.94	6.62	1.60	0.96	5.19
WSKS09	-14.7147	128.2272	15.75	0.00	4.08	57.77	0.01	0.00	0.05	22.23
WSKS11	-14.6680	128.2267	22.90	1.28	11.20	46.40	0.01	4.30	4.49	9.31

Table 10. Elemental feature results for the water samples collected as part of the vertical profiling during the Wet Season Environmental Survey, Feb-Mar 2024.

Location	Latitude	Longitude	Magnesium Aluminosilicate (%)	Clay/Mica (%)	Magnesium Silicate (%)	Feldspar (%)	Iron Silicate (%)	Quartz (%)	Calcite (%)	Agglomerate (Silicate, Halite) (%)	Halite (%)
BC-1A	-14.8027	128.2681	0.55	0.05	0.00	0.33	0.02	61.37	2.08	21.22	11.06
BC-1B	-14.8027	128.2681	11.49	0.49	0.71	8.02	0.00	4.89	3.41	56.03	10.01
BC-8A	-14.8027	128.2681	17.60	1.81	0.07	16.52	0.00	13.07	9.52	37.30	0.61
BC-8B	-14.8027	128.2681	20.68	1.06	0.04	18.41	0.03	10.23	5.13	38.47	0.36
WE-1A	-14.7614	128.2416	1.51	1.05	0.00	3.89	0.00	74.56	6.70	2.89	3.58
WE-1B	-14.7614	128.2416	53.56	1.14	17.86	11.45	0.00	0.45	0.00	7.92	3.43
WE-8A	-14.7614	128.2416	38.71	3.30	1.66	4.66	36.48	0.00	0.78	8.30	0.30
WE-8B	-14.7614	128.2416	51.72	1.53	0.05	9.11	21.05	0.00	0.73	8.24	1.14
SB-1A	-14.9129	128.2145	42.84	4.07	1.13	1.30	32.08	0.00	8.18	3.05	0.01
SB-1B	-14.9129	128.2145	50.81	2.94	0.49	0.00	31.32	0.00	6.42	2.11	0.02
SB-8A	-14.9129	128.2145	50.11	4.56	4.73	0.00	24.62	0.00	7.02	4.52	0.18
SB-8B	-14.9129	128.2145	32.13	7.95	8.53	0.00	28.90	0.00	11.46	4.31	0.19

Note: sample names ending A represent mid-water column and names ending B represent near seabed.

Table 11. PSD results for the grab samples collected during the Wet Season Environmental Survey, Feb-Mar 2024.

Location	Latitude	Longitude	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Sediment Type (Shepard, 1954)
SDP01	-14.7203	128.1272	0.5	30.5	45.3	23.7	SAND SILT CLAY
SDP02	-14.7274	128.1365	3.2	55.0	28.3	13.5	SILTY SAND
SDP04	-14.7444	128.1554	20.6	18.9	36.6	24.0	GRAVELLY SEDIMENT
SDP05	-14.7452	128.1751	21.2	28.6	30.1	20.2	GRAVELLY SEDIMENT
SDP06	-14.7482	128.1928	1.1	66.2	19.6	13.1	SILTY SAND
SDP07	-14.7594	128.2116	0.1	45.3	38.5	16.2	SILTY SAND
SDP08	-14.7675	128.2253	1.2	98.8	0.0	0.0	SAND
SDP09	-14.7742	128.2299	0.7	92.6	3.9	2.8	SAND
SDP10	-14.8668	128.0903	0.1	10.3	52.7	37.0	CLAYEY SILT
SDP11	-14.8485	128.0669	0.0	5.7	69.7	24.5	CLAYEY SILT
SDP12	-14.8693	128.1082	2.3	18.9	51.3	27.5	SAND SILT CLAY
SDP13	-14.8653	128.1400	0.3	19.4	51.9	28.4	CLAYEY SILT
SDP14	-14.8850	128.0745	0.5	40.1	33.6	25.8	SAND SILT CLAY
SDP15	-15.0898	128.3639	14.6	24.8	41.8	18.9	GRAVELLY SEDIMENT
SDP16	-15.0693	128.3688	5.9	34.7	37.8	21.6	SAND SILT CLAY
SDP17	-15.0494	128.3672	3.7	9.1	61.6	25.6	CLAYEY SILT
SDP18	-15.0164	128.3566	0.7	48.4	36.5	14.5	SILTY SAND
SDP19	-14.9830	128.3503	0.8	17.6	53.1	28.5	CLAYEY SILT
SDP20	-14.9444	128.3396	46.6	17.3	23.2	12.9	GRAVELLY SEDIMENT
SDP21	-14.9155	128.3321	40.7	42.6	11.6	5.1	GRAVELLY SEDIMENT
SDP22	-14.8877	128.3370	0.0	98.5	1.5	0.0	SAND
SDP23	-15.0035	128.4843	41.4	35.0	16.5	7.0	GRAVELLY SEDIMENT
SDP23A	-15.0035	128.4843	3.6	7.7	66.6	22.1	CLAYEY SILT
SDP24	-14.9959	128.4528	23.9	76.2	0.0	0.0	GRAVELLY SEDIMENT
SDP25	-14.9691	128.4341	20.2	79.8	0.0	0.0	GRAVELLY SEDIMENT
SDP26	-14.9312	128.4077	19.0	81.1	0.0	0.0	GRAVELLY SEDIMENT
SDP27	-14.9094	128.4005	6.8	93.2	0.0	0.0	SAND
SDP28	-14.8897	128.3893	0.0	75.6	17.7	6.6	SAND
SDP29	-14.8429	128.3565	3.6	96.5	0.0	0.0	SAND
SDP30	-14.8320	128.3303	28.3	36.0	26.9	8.8	GRAVELLY SEDIMENT
SDP31	-14.8218	128.3068	27.8	36.8	26.7	8.7	GRAVELLY SEDIMENT
SDP32	-14.7799	128.2344	0.1	99.9	0.0	0.0	SAND
SDP33	-14.7894	128.2436	8.7	86.4	3.8	1.1	SAND
SDP34	-14.9443	128.1410	0.0	100.0	0.0	0.0	SAND
SDP35	-14.9438	128.1591	0.7	22.2	59.6	17.5	SANDY SILT
SDP36	-14.8547	128.1782	0.2	99.8	0.0	0.0	SAND
SDP37	-14.8388	128.2182	0.1	100.0	0.0	0.0	SAND
SDP38	-14.8298	128.2543	88.5	7.6	2.8	1.1	GRAVEL
SDP39	-14.8098	128.2819	3.6	96.4	0.0	0.0	SAND
SDP40	-14.8907	128.4665	75.5	18.5	3.8	2.2	GRAVEL
SDP41	-14.8426	128.4027	7.1	78.8	10.8	3.4	SAND
SDP42	-14.8077	128.2728	34.4	60.2	3.8	1.7	GRAVELLY SEDIMENT
SDP43	-14.8224	128.2305	0.0	100.0	0.0	0.0	SAND
SDP44	-14.8683	128.2540	0.8	99.2	0.0	0.0	SAND
US01	-15.5970	127.8217	0.0	56.7	41.8	1.5	SILTY SAND
US02	-15.6513	127.8719	0.0	74.6	24.0	1.4	SILTY SAND
US03	-15.6041	127.8681	0.0	19.8	77.1	3.1	SILT
US04	-15.6055	127.8688	0.0	94.8	5.2	0.0	SAND
US05	-15.5859	127.9102	0.0	96.4	3.6	0.0	SAND
US06	-15.5541	127.9603	0.0	100.0	0.0	0.0	SAND
US07	-15.5285	127.9851	0.0	100.0	0.0	0.0	SAND
US08	-15.5121	127.9982	0.0	22.3	60.0	17.7	SANDY SILT
US09	-15.4964	128.0471	0.0	58.3	33.4	8.3	SILTY SAND
US10	-15.4899	128.0520	0.0	100.0	0.0	0.0	SAND
US11	-15.4652	128.0784	0.0	14.0	62.1	23.9	CLAYEY SILT

Location	Latitude	Longitude	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Sediment Type (Shepard, 1954)
US12	-15.4329	128.0990	0.0	90.8	7.1	2.2	SAND
US13	-15.4050	128.1043	0.5	99.5	0.0	0.0	SAND
US14	-15.3601	128.1020	0.0	87.8	9.4	2.8	SAND
US15	-15.3414	128.0968	0.3	99.7	0.0	0.0	SAND
US16	-15.3096	128.0981	22.2	76.3	1.4	0.1	GRAVELLY SEDIMENT
US17	-15.2978	128.1017	1.6	94.2	3.7	0.4	SAND
US19	-15.3790	128.0965	0.0	82.0	16.3	1.6	SAND
US20	-15.1746	128.1445	0.0	88.8	9.2	2.0	SAND
US21	-15.2159	128.1865	0.0	79.9	16.6	3.6	SAND
US22	-15.2668	128.2297	0.0	75.9	20.4	3.7	SAND
US23	-15.3121	128.2790	0.4	94.7	5.0	0.0	SAND
US24	-15.3972	128.2870	0.0	95.8	3.7	0.5	SAND
US25	-15.1810	128.1142	0.1	56.7	28.2	15.0	SILTY SAND
US26	-15.1407	128.1013	0.0	100.0	0.0	0.0	SAND
US27	-15.0639	128.1193	0.2	99.8	0.0	0.0	SAND
WSKS03	-14.6929	128.2550	25.1	74.9	0.0	0.0	GRAVELLY SEDIMENT
WSKS09	-14.7147	128.2272	27.2	72.9	0.0	0.0	GRAVELLY SEDIMENT
WSKS11	-14.6680	128.2267	5.5	94.5	0.0	0.0	SAND

Table 12. PSD results for the water samples collected as part of the vertical profiling during the Wet Season Environmental Survey, Feb-Mar 2024.

Location	Latitude	Longitude	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d_{10} (µm)	d_{50} (µm)	d_{90} (µm)
BC-1A	-14.8027	128.2681	0.0	1.1	78.1	20.8	2.7	8.2	23.4
BC-1B	-14.8027	128.2681	0.0	3.1	72.9	24.0	2.5	7.6	32.1
BC-2A	-14.8027	128.2681	0.0	3.4	72.4	24.1	2.4	7.9	34.2
BC-2B	-14.8027	128.2681	0.0	2.6	67.9	29.5	2.2	6.7	32.2
BC-3A	-14.8027	128.2681	0.0	0.9	73.2	25.8	2.4	7.1	26.3
BC-3B	-14.8027	128.2681	0.0	0.9	70.8	28.2	2.2	7.0	28.9
BC-4A	-14.8027	128.2681	0.0	2.8	71.7	25.5	2.4	7.1	29.0
BC-4B	-14.8027	128.2681	0.0	4.3	65.4	30.3	2.1	6.8	39.4
BC-5A	-14.8027	128.2681	0.0	5.0	61.3	33.7	1.5	6.5	44.3
BC-5B	-14.8027	128.2681	0.0	2.1	71.4	26.4	2.3	7.3	33.0
BC-6A	-14.8027	128.2681	0.0	5.3	67.6	27.1	2.3	7.6	46.2
BC-6B	-14.8027	128.2681	0.0	3.1	69.8	27.1	2.3	7.2	37.5
BC-7A	-14.8027	128.2681	0.0	2.4	70.8	26.8	2.3	7.2	34.6
BC-7B	-14.8027	128.2681	0.0	4.5	66.6	28.8	2.1	7.5	43.8
BC-8A	-14.8027	128.2681	0.0	3.3	67.9	28.8	2.2	6.9	35.1
BC-8B	-14.8027	128.2681	0.0	3.7	64.4	31.9	1.6	7.1	39.3
BC-9A	-14.8027	128.2681	0.0	4.0	70.5	25.5	2.3	8.2	42.0
BC-9B	-14.8027	128.2681	0.0	5.8	67.0	27.2	2.0	8.5	49.1
BC-10A	-14.8027	128.2681	0.0	5.3	64.8	29.9	1.7	7.8	44.9
BC-10B	-14.8027	128.2681	0.0	5.9	75.5	18.6	2.8	10.4	42.1
BC-11A	-14.8027	128.2681	0.0	14.8	62.7	22.5	2.5	9.6	97.5
BC-11B	-14.8027	128.2681	0.0	35.4	46.8	17.8	2.5	25.9	166.8
BC-12A	-14.8027	128.2681	0.0	2.7	78.1	19.2	2.8	9.0	31.2
BC-12B	-14.8027	128.2681	0.0	13.1	63.5	23.4	2.0	12.1	74.3
BC-13A	-14.8027	128.2681	0.0	4.8	70.9	24.3	2.5	7.5	42.4
BC-13B	-14.8027	128.2681	0.0	5.1	63.8	31.0	2.1	6.9	45.0
WE-1A	-14.7614	128.2416	0.0	5.4	66.1	28.5	2.1	7.3	46.2
WE-1B	-14.7614	128.2416	0.0	5.4	61.5	33.0	1.5	7.0	46.6
WE-2A	-14.7614	128.2416	0.0	5.8	68.3	25.9	2.3	7.7	46.4
WE-2B	-14.7614	128.2416	0.0	5.8	67.2	27.1	2.3	7.3	47.0
WE-3A	-14.7614	128.2416	0.0	5.6	67.8	26.6	2.3	7.8	48.4
WE-3B	-14.7614	128.2416	0.0	7.0	68.6	24.4	2.4	8.1	50.1
WE-4A	-14.7614	128.2416	0.0	4.9	70.5	24.6	2.5	7.5	41.1
WE-4B	-14.7614	128.2416	0.0	12.1	60.7	27.2	1.6	10.7	71.8
WE-5A	-14.7614	128.2416	0.0	5.8	66.8	27.3	2.2	7.7	49.0
WE-5B	-14.7614	128.2416	0.0	9.7	69.5	20.8	2.4	13.8	62.4
WE-6A	-14.7614	128.2416	0.0	7.4	67.9	24.7	2.4	8.0	53.3
WE-6B	-14.7614	128.2416	0.0	16.1	65.0	18.9	2.6	14.0	87.2
WE-7A	-14.7614	128.2416	0.0	4.0	62.9	33.1	1.1	7.4	42.7
WE-7B	-14.7614	128.2416	0.0	5.0	60.7	34.3	1.3	6.6	42.6
WE-8A	-14.7614	128.2416	0.0	5.5	70.0	24.5	2.4	8.3	45.2
WE-8B	-14.7614	128.2416	0.0	2.9	67.6	29.5	2.1	6.8	33.4
WE-9A	-14.7614	128.2416	0.0	4.8	74.8	20.4	2.7	8.6	40.2
WE-9B	-14.7614	128.2416	0.0	8.9	54.8	36.3	1.1	6.2	55.9
WE-10A	-14.7614	128.2416	0.0	13.8	70.3	15.9	3.1	11.8	91.6
WE-10B	-14.7614	128.2416	0.0	6.4	68.1	25.5	2.4	7.7	49.5
WE-11A	-14.7614	128.2416	0.0	6.6	64.9	28.5	2.2	7.4	48.4
WE-11B	-14.7614	128.2416	0.0	6.9	65.9	27.2	1.7	10.3	54.4
WE-12A	-14.7614	128.2416	0.0	8.8	64.5	26.7	2.2	8.3	58.8
WE-12B	-14.7614	128.2416	0.0	9.0	64.4	26.6	1.8	10.3	60.3
WE-13A	-14.7614	128.2416	0.0	6.9	66.7	26.4	2.2	8.3	52.8
WE-13B	-14.7614	128.2416	0.0	7.3	63.8	29.0	2.2	7.3	53.9
SB-1A	-14.9129	128.2145	0.0	2.0	53.3	44.7	0.2	4.8	26.6
SB-1B	-14.9129	128.2145	0.0	5.0	60.4	34.6	0.4	7.4	45.5
SB-2A	-14.9129	128.2145	0.0	3.2	61.3	35.4	0.4	6.9	37.1

Location	Latitude	Longitude	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d_{10} (µm)	d_{50} (µm)	d_{90} (µm)
SB-2B	-14.9129	128.2145	0.0	3.3	53.8	42.8	0.2	5.1	33.8
SB-3A	-14.9129	128.2145	0.0	1.3	47.2	51.5	0.2	3.8	22.1
SB-3B	-14.9129	128.2145	0.0	1.6	54.0	44.4	0.2	4.8	25.8
SB-4A	-14.9129	128.2145	0.0	2.1	62.4	35.4	0.3	6.5	33.5
SB-4B	-14.9129	128.2145	0.0	2.2	53.7	44.1	0.2	4.9	32.8
SB-5A	-14.9129	128.2145	0.0	1.4	72.6	26.0	1.9	7.5	24.0
SB-5B	-14.9129	128.2145	0.0	3.0	49.0	48.0	0.2	4.3	33.6
SB-6A	-14.9129	128.2145	0.0	3.3	56.4	40.3	0.5	5.5	36.5
SB-6B	-14.9129	128.2145	0.0	7.8	50.9	41.3	0.3	5.6	56.2
SB-7A	-14.9129	128.2145	0.0	8.1	65.6	26.3	2.3	7.8	56.6
SB-7B	-14.9129	128.2145	0.0	10.3	65.8	23.9	2.4	8.7	64.6
SB-8A	-14.9129	128.2145	0.0	4.1	69.3	26.6	2.4	7.1	35.6
SB-8B	-14.9129	128.2145	0.0	16.9	54.1	29.0	1.6	9.5	94.1
SB-9A	-14.9129	128.2145	0.0	9.3	50.5	40.2	0.3	5.9	59.8
SB-9B	-14.9129	128.2145	0.0	5.1	59.6	35.3	0.9	6.8	45.6
SB-10A	-14.9129	128.2145	0.0	7.1	59.3	33.6	1.6	6.7	48.8
SB-10B	-14.9129	128.2145	0.0	5.3	54.0	40.7	0.4	5.5	42.9
SB-11A	-14.9129	128.2145	0.0	3.3	55.0	41.7	0.4	5.2	33.3
SB-11B	-14.9129	128.2145	0.0	4.7	53.0	42.3	0.3	5.2	38.9

Note: sample names ending A represent mid-water column and names ending B represent near seabed.

6. Results

The following section shows the plotted results of the hydrodynamic, waves, benthic light and water quality data collected from self-logging devices during field surveys. The measurements extend from September 2023 to June 2024 and cover 12 different measurement sites from the confluence between CG and the West Arm out to King Shoals.

6.1. In-situ Oceanographic & Water Quality Data Collection

To provide measured timeseries data of water levels, waves and currents through the water column, Nortek AWACs and Nortek Signature 500/1000 ADCPs were deployed. The hydrodynamic data gathered from these devices are plotted in Section 6.1.1 showing water levels (m MSL), Flow Speed (m/s) and flow direction (°), and the wave data are plotted in Section 6.1.2 showing wave height (H_{m0}, m), peak waver period (T_p, seconds) and mean wave direction (degrees N).

Section 6.1.3 contains plots of instantaneous benthic light data collected using a LI-COR LI-1500 light sensor, co-mounted to the AWAC / Nortek Signature 500/1000 ADCP.

A Manta Multiprobe was also co-mounted to the frame and collected water quality data which are plotted in Section 6.1.4. The water quality time series plots show water levels (m MSL), Temperature (°C), Salinity (PSU), Turbidity (NTU) and Dissolved Oxygen (mg/L) where available.

6.1.1. Hydrodynamics

This section details the hydrodynamic data from each of the survey deployments. Results are shown in Figure 17 to Figure 33 and are presented in chronological order. Details of the layers adopted to represent the bed, mid and surface layers of the water column are provided in Table 13.

A statistical summary of the measured current speed data for the near-bed, mid-depth and surface layers of the water column at each site over each deployment period is provided in Table 14. The table shows that the lowest current speed was at AWAC-02 (maximum surface current speed = 0.85 m/s), which is located to the south of Lacrosse Island while the highest current speed was at AWAC-08 (maximum surface current speed = 2.96 m/s) which is located at the northern entrance to the West Arm. Peak surface current speeds of more than 2.0 m/s were measured at four sites (AWAC-01, AWAC-05, AWAC-11 and AWAC-08), with three of these within or close to the POA (all except AWAC-08).

Table 13. Details of the bins adopted in the AWAC/ADCP data to represent bed, mid and surface layers.

Position	Start Date	Depth (m MSL)	Bed Bin	Mid Bin	Surface Bin
AWAC-01	09/06/2023	21.9	1	9	18
AWAC-04	07/09/2023	27.6	1	12	22
AWAC-02	07/09/2023	18.0	1	6	12
AWAC-06	08/09/2023	20.5	1	6	14
AWAC-03	13/10/2023	19.2	1	7	13
AWAC-07	15/10/2023	11.1	1	3	5
AWAC-08	02/03/2024	26.2	1	9	18
AWAC-11	02/03/2024	22.2	1	7	14
AWAC-01	03/03/2024	30.1	1	11	22
AWAC-06	06/03/2024	17.9	1	6	11
AWAC-09	04/03/2024	28.2	1	8	17
AWAC-07	10/05/2024	11.3	1	3	5
AWAC-11	10/05/2024	22.1	1	7	14
AWAC-05	20/06/2024	9.8	1	2	3
AWAC-11	24/06/2024	20.0	1	6	12
AWAC-10	26/06/2024	18.1	1	5	11
AWAC-01	29/06/2024	25.9	1	4	8

Table 14. Statistical summary of the measured current speed data collected at the AWAC sites from June 2023 to August 2024.

Position	Start Date	Near-Bed		Mid-Depth		Surface	
		Avg (m/s)	Max (m/s)	Avg (m/s)	Max (m/s)	Avg (m/s)	Max (m/s)
AWAC-01	09/06/2023	0.34	1.02	0.47	1.24	0.52	1.46
AWAC-04	07/09/2023	0.31	0.70	0.43	0.96	0.50	1.20
AWAC-02	07/09/2023	0.19	0.48	0.28	0.59	0.36	0.85
AWAC-06	08/09/2023	0.34	0.89	0.46	1.14	0.53	1.33
AWAC-03	13/10/2023	0.42	0.75	0.56	0.99	0.62	1.13
AWAC-07	15/10/2023	0.27	1.22	0.38	1.52	0.42	1.67
AWAC-08	02/03/2024	0.68	1.86	0.99	2.62	1.15	2.96
AWAC-11	02/03/2024	0.32	1.08	0.51	1.54	0.66	2.34
AWAC-01	03/03/2024	0.40	1.29	0.56	1.55	0.64	2.02
AWAC-06	06/03/2024	0.42	1.18	0.57	1.53	0.63	1.79
AWAC-09	04/03/2024	0.43	1.26	0.56	1.50	0.65	1.79
AWAC-07	10/05/2024	0.32	1.00	0.38	1.19	0.43	1.27
AWAC-11	10/05/2024	0.31	0.99	0.46	1.22	0.59	1.69
AWAC-05	20/06/2024	0.54	1.78	0.59	1.97	0.68	2.03
AWAC-11	24/06/2024	0.43	1.08	0.56	1.51	0.65	1.72
AWAC-10	26/06/2024	0.32	0.80	0.42	0.98	0.49	1.07
AWAC-01	29/06/2024	0.42	1.17	0.54	1.41	0.61	1.47

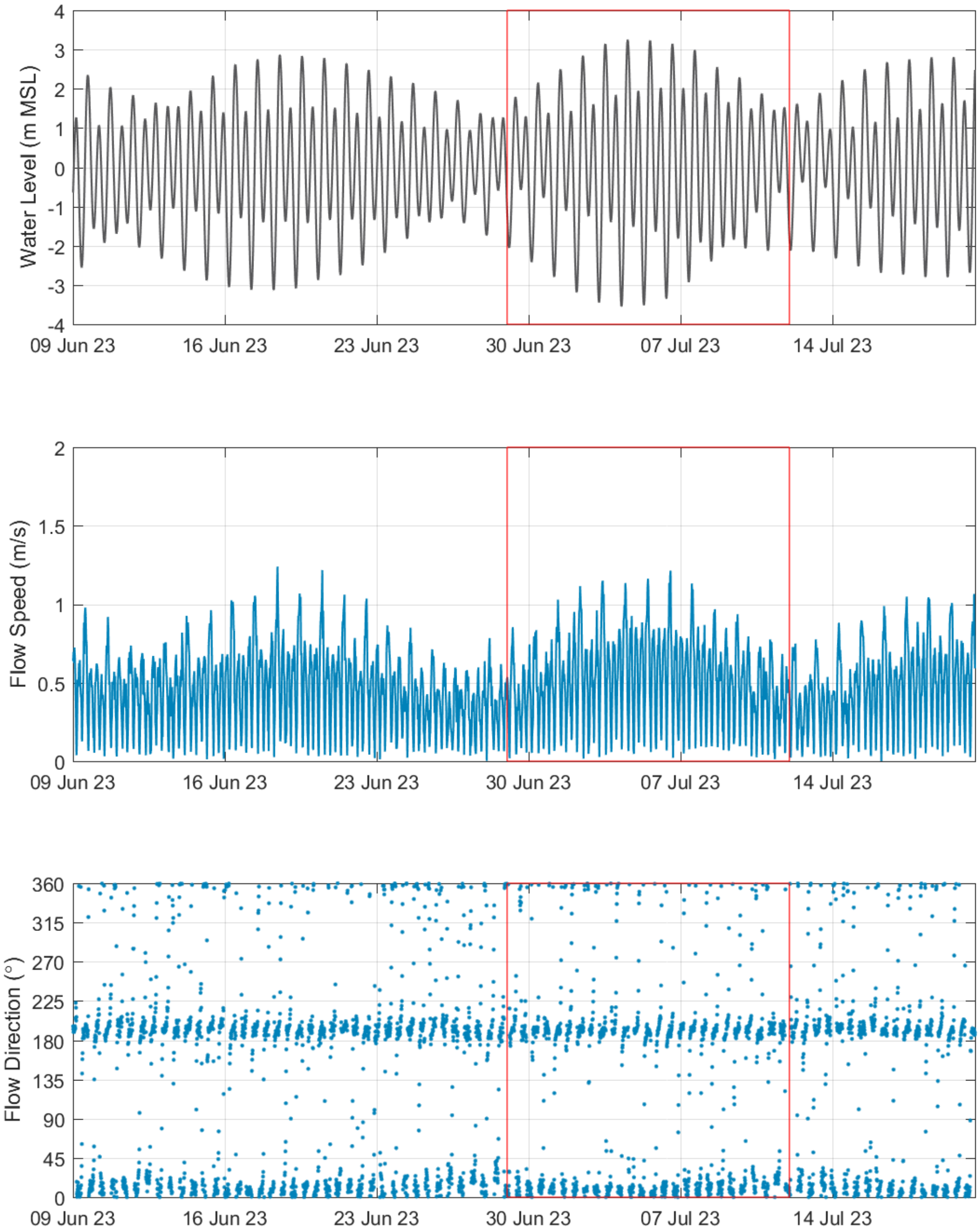


Figure 17. Hydrodynamic survey results for the mid-water column layer at site AWAC-01, 9th June to 21st July 2023.

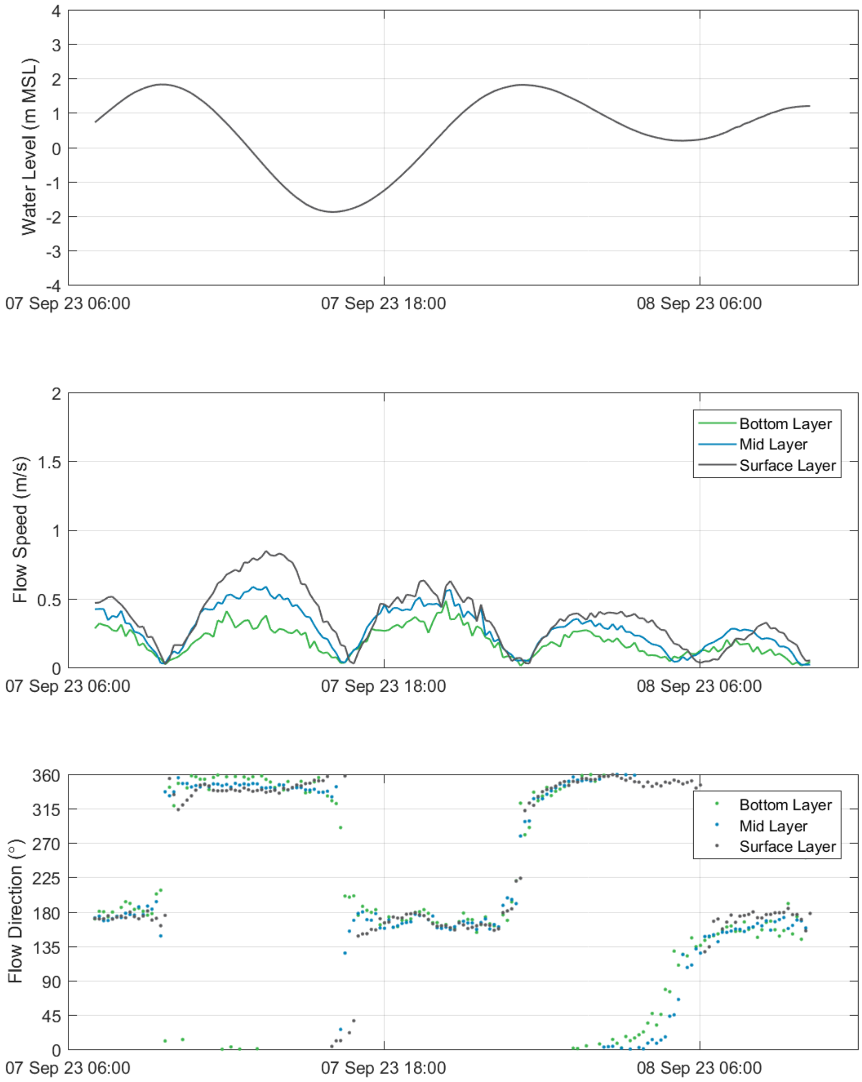


Figure 18. Hydrodynamic survey results for site AWAC-02, 7th to 8th September 2023.

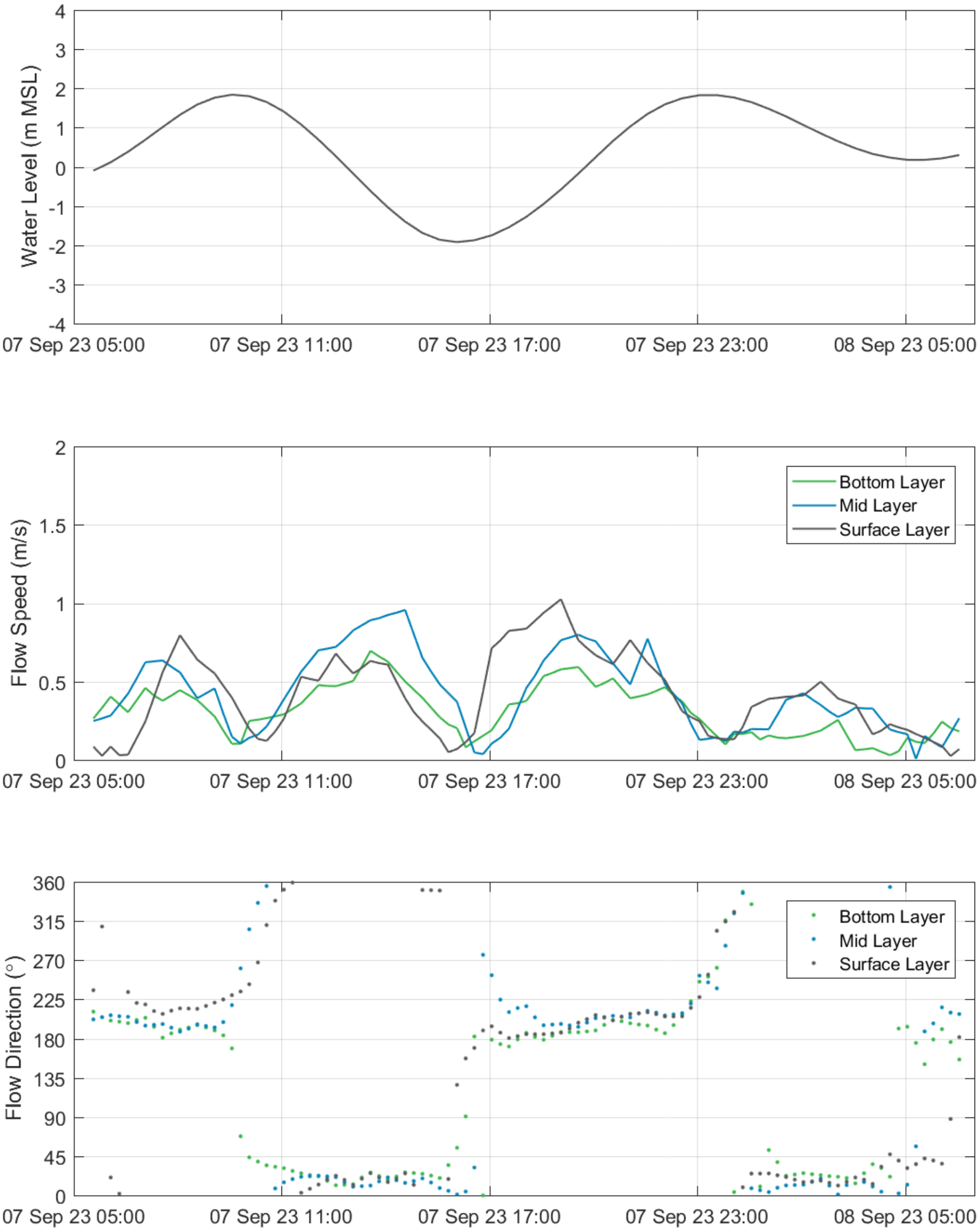


Figure 19. Hydrodynamic survey results for site AWAC-04, 7th to 8th September 2023.

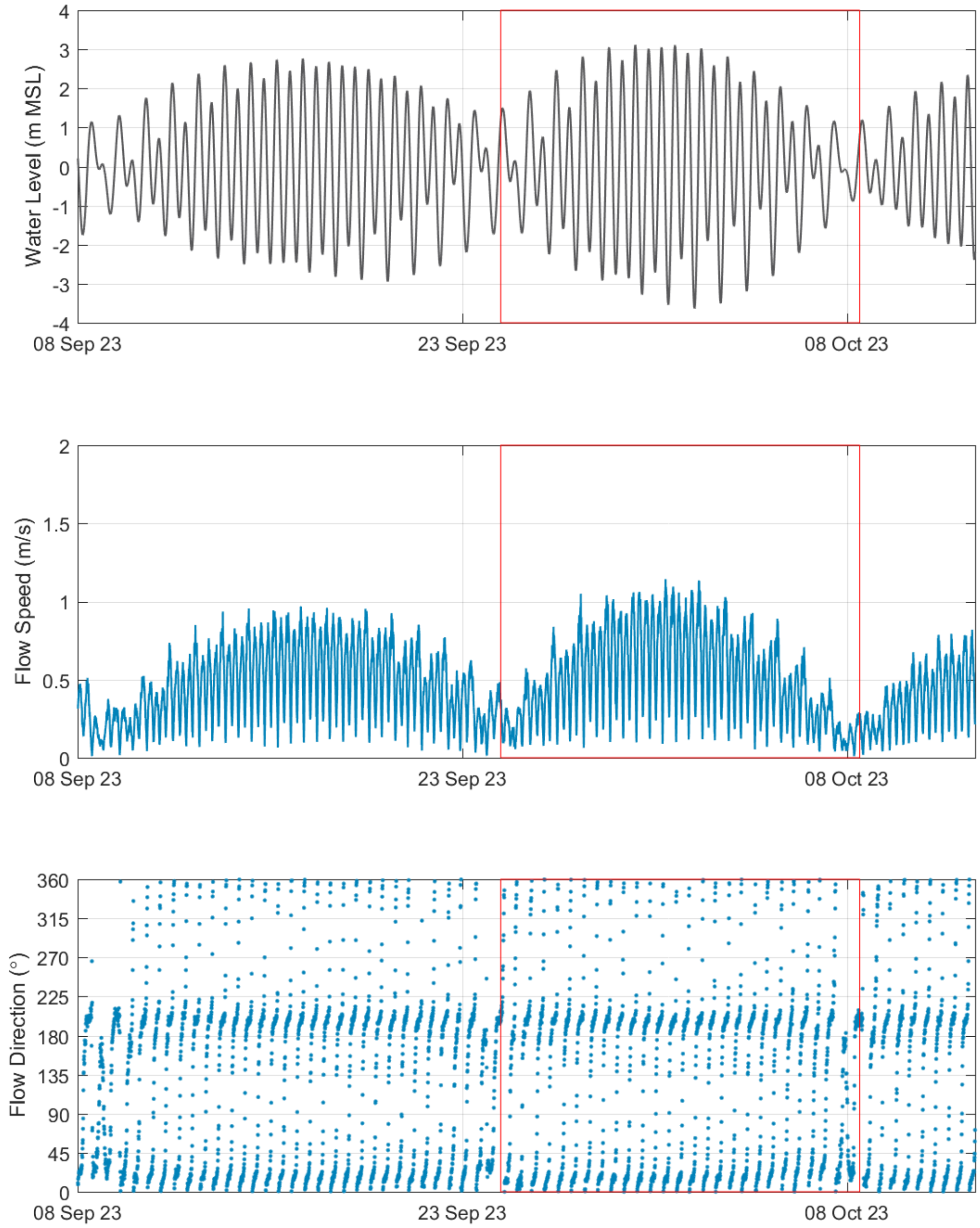


Figure 20. **Hydrodynamic survey results for the mid-water column layer at site AWAC-06, 8th September to 13th October 2023.**

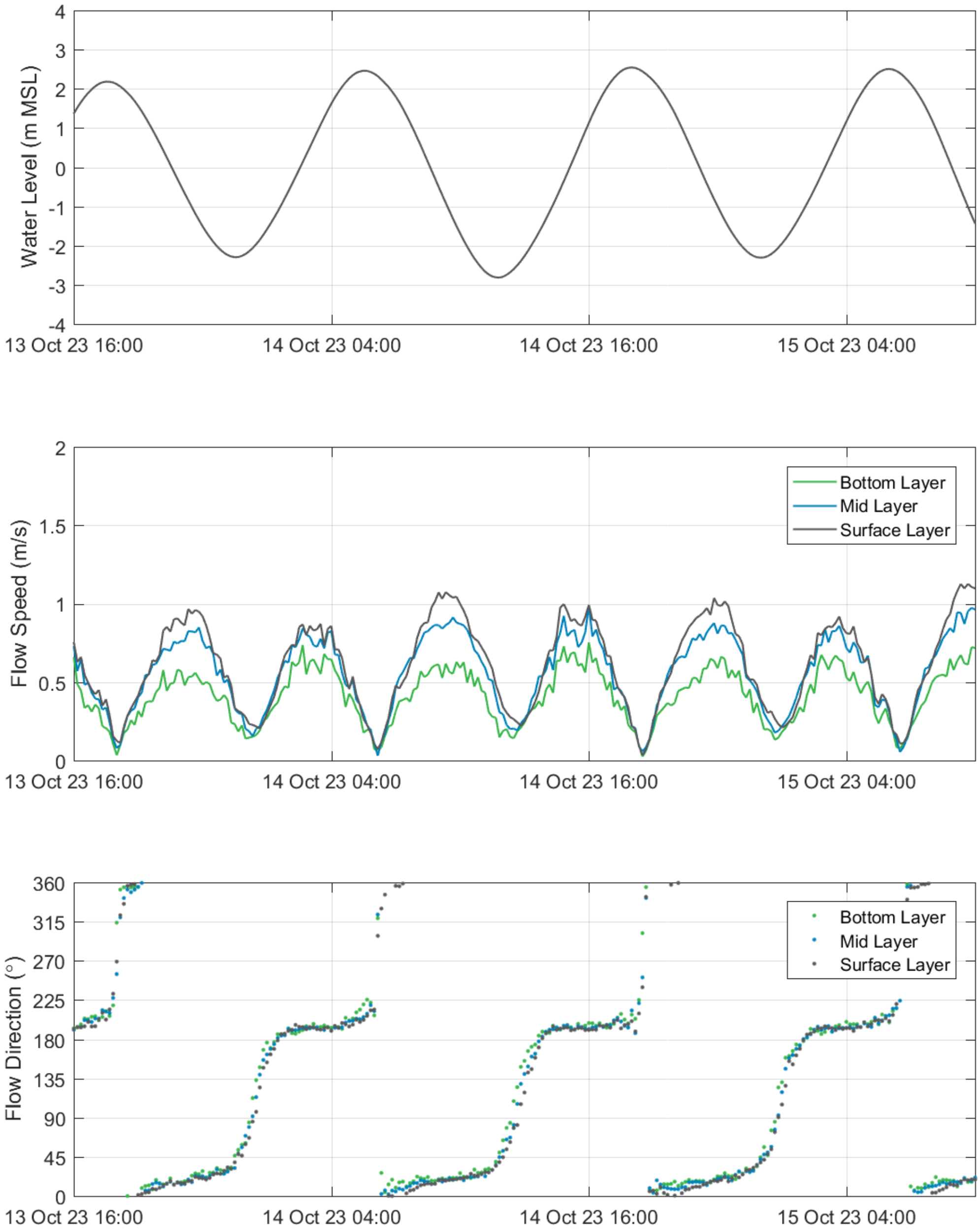


Figure 21. Hydrodynamic survey results for site AWAC-03, 13th to 15th October 2023.

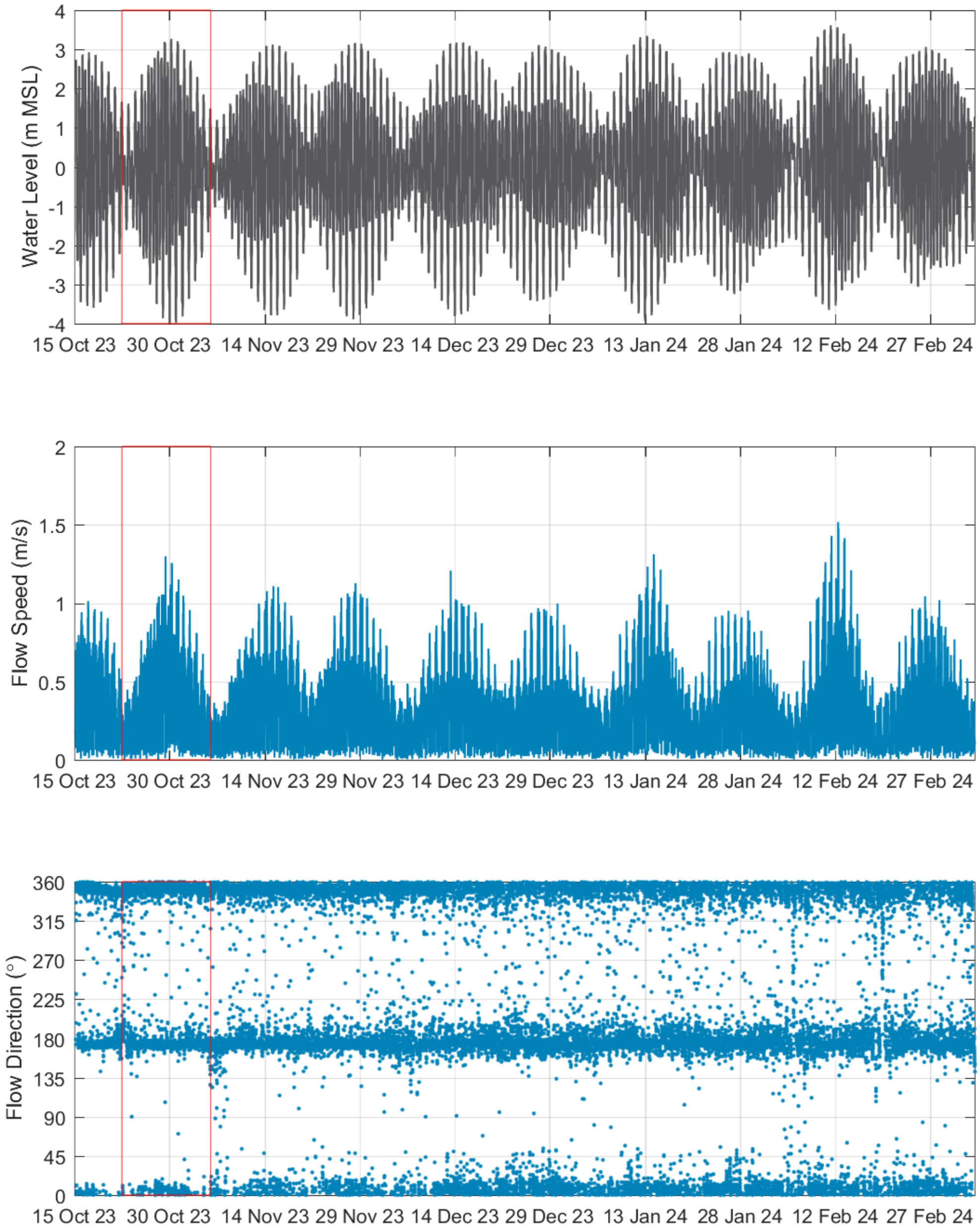


Figure 22. Hydrodynamic survey results for the mid-water column layer at site AWAC-07, 15th October 2023 to 5th March 2024.

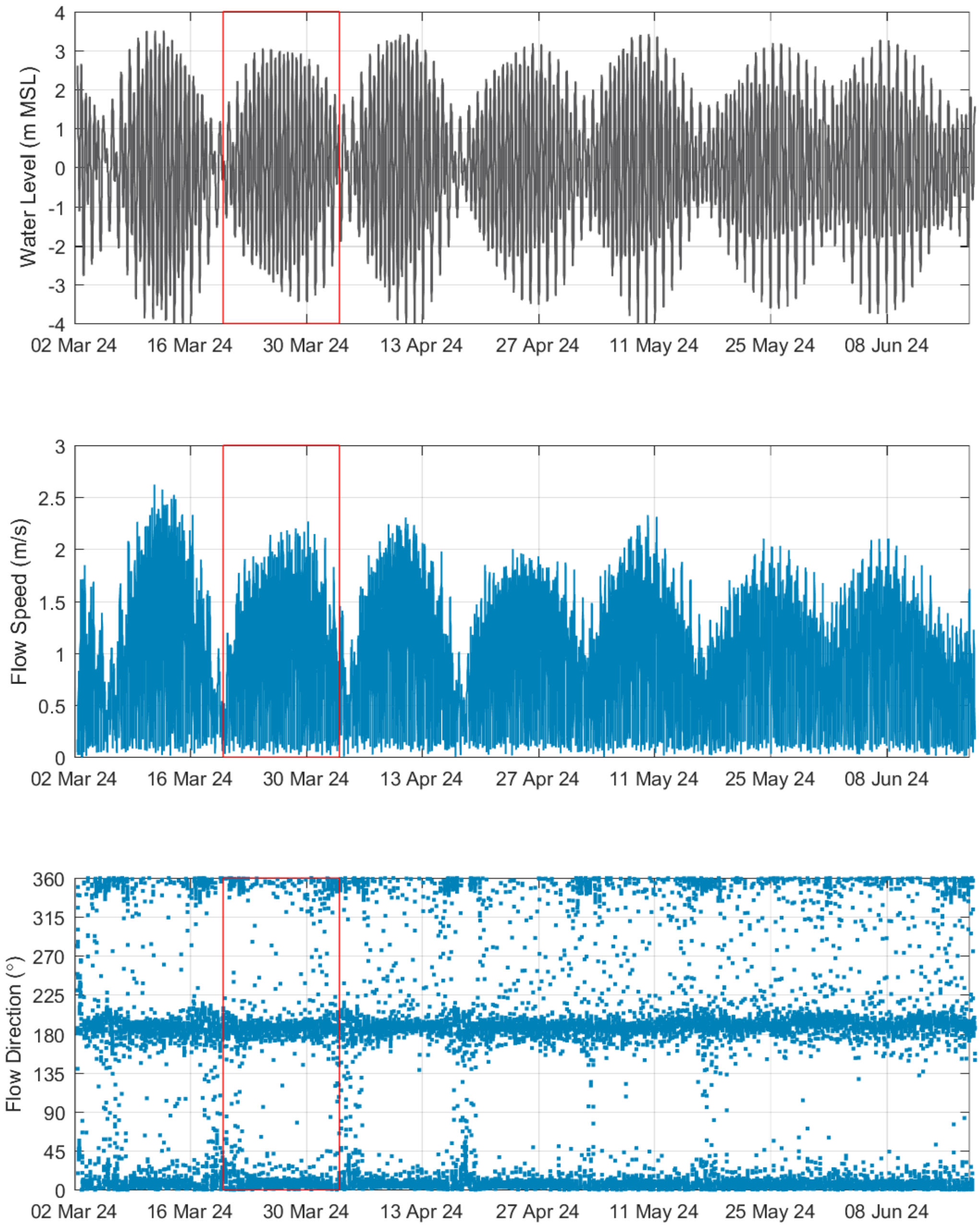


Figure 23. Hydrodynamic survey results for the mid-water column layer at site AWAC-08, 2nd March 2024 to 18th June 2024.

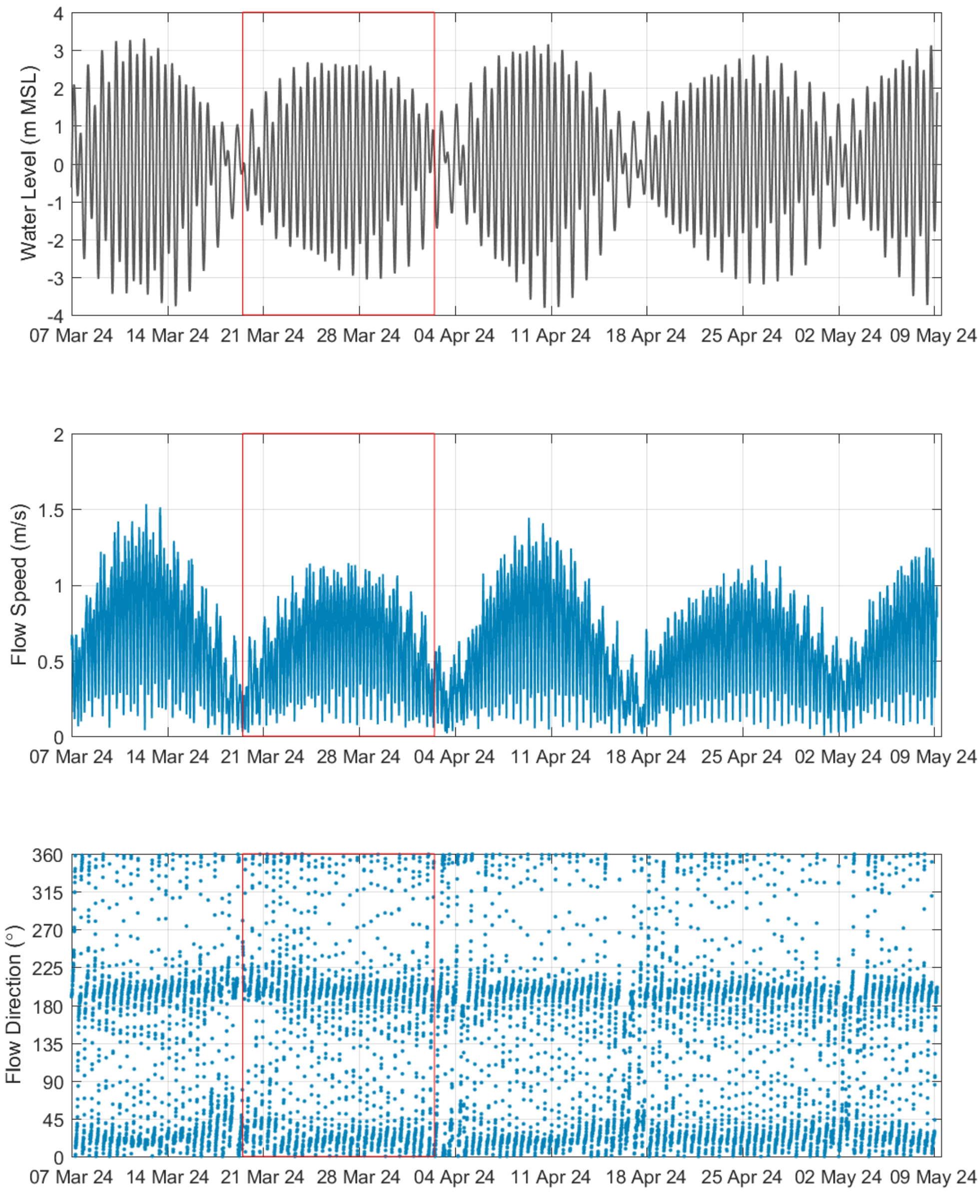


Figure 24. Hydrodynamic survey results for the mid-water column layer at site AWAC-06, 6th March to 10th May 2024.

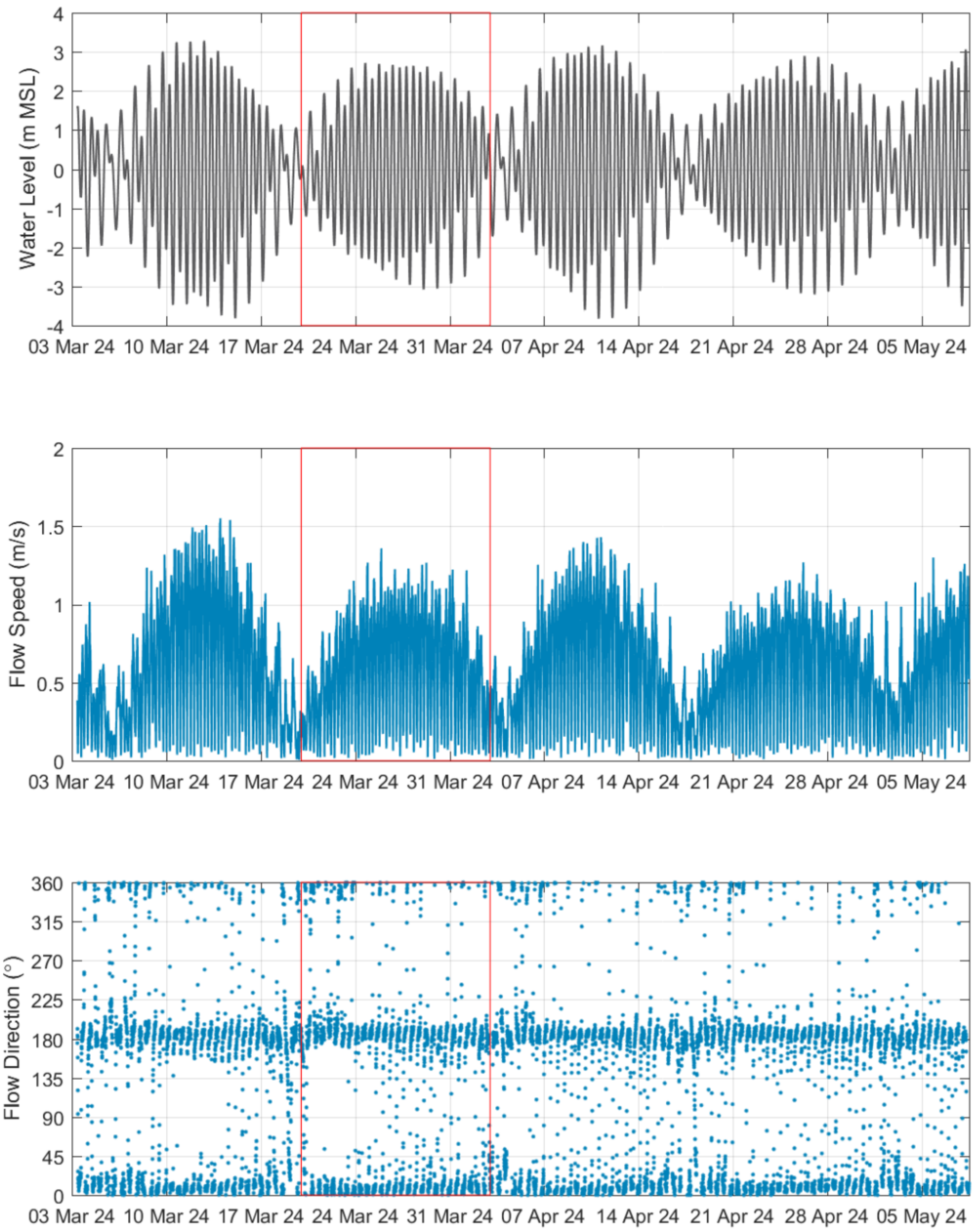


Figure 25. Hydrodynamic survey results for the mid-water column layer at site AWAC-01, 3rd March to 8th May 2024.

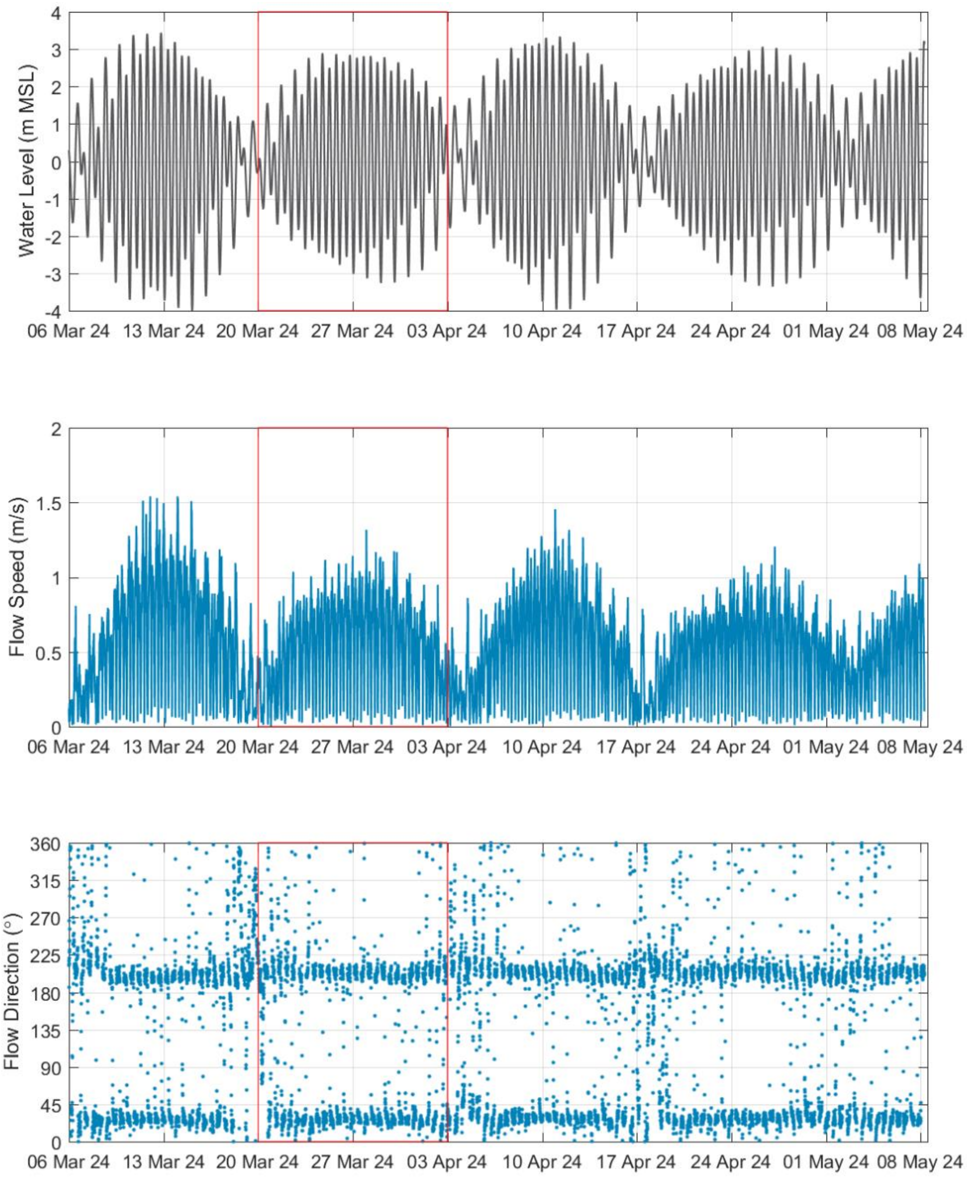


Figure 26. **Hydrodynamic survey results for the mid-water column layer at site AWAC-11, 2nd March to 8th May 2024.**

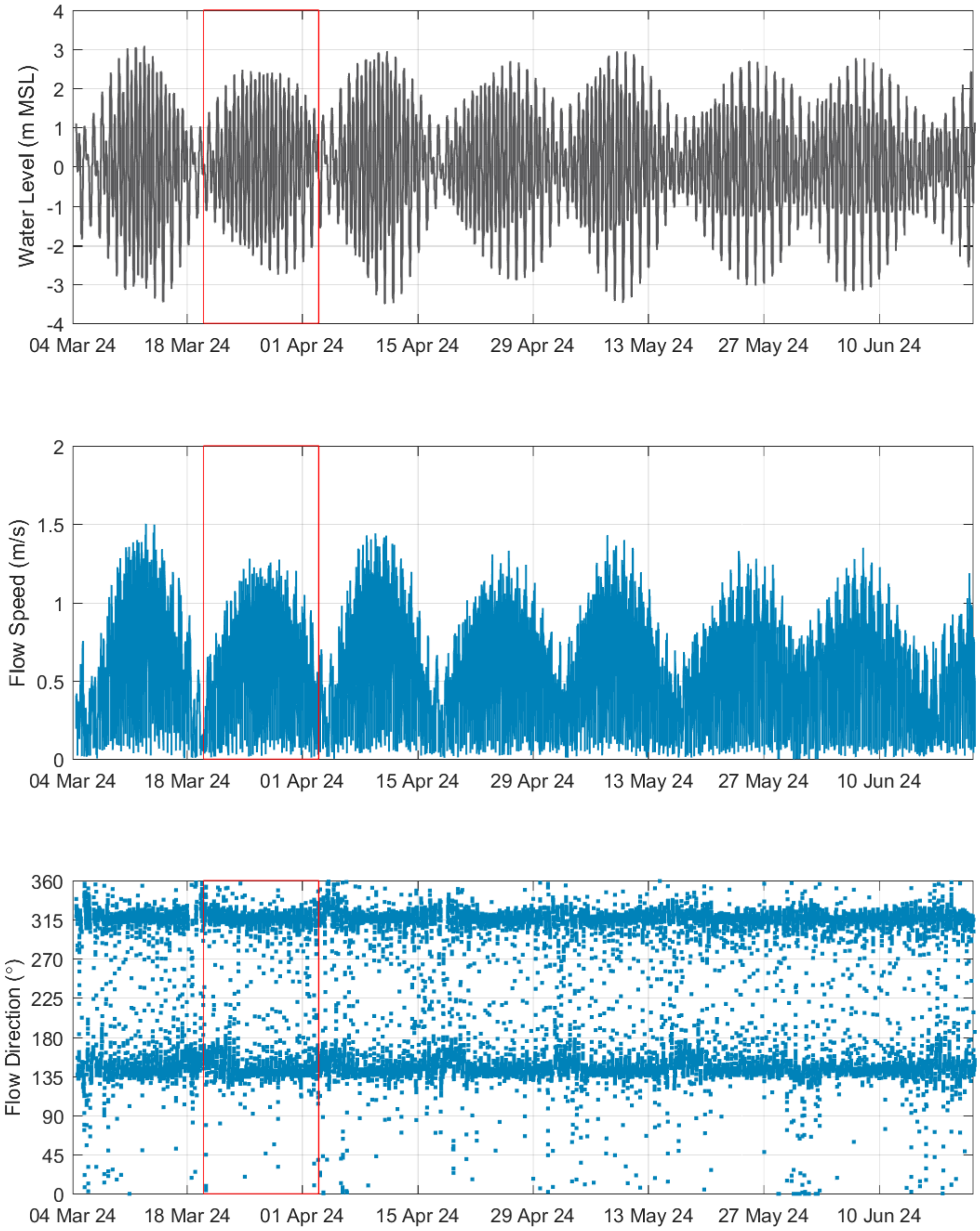


Figure 27. Hydrodynamic survey results for the mid-water column layer at site AWAC-09, 4th March to 21st June 2024.

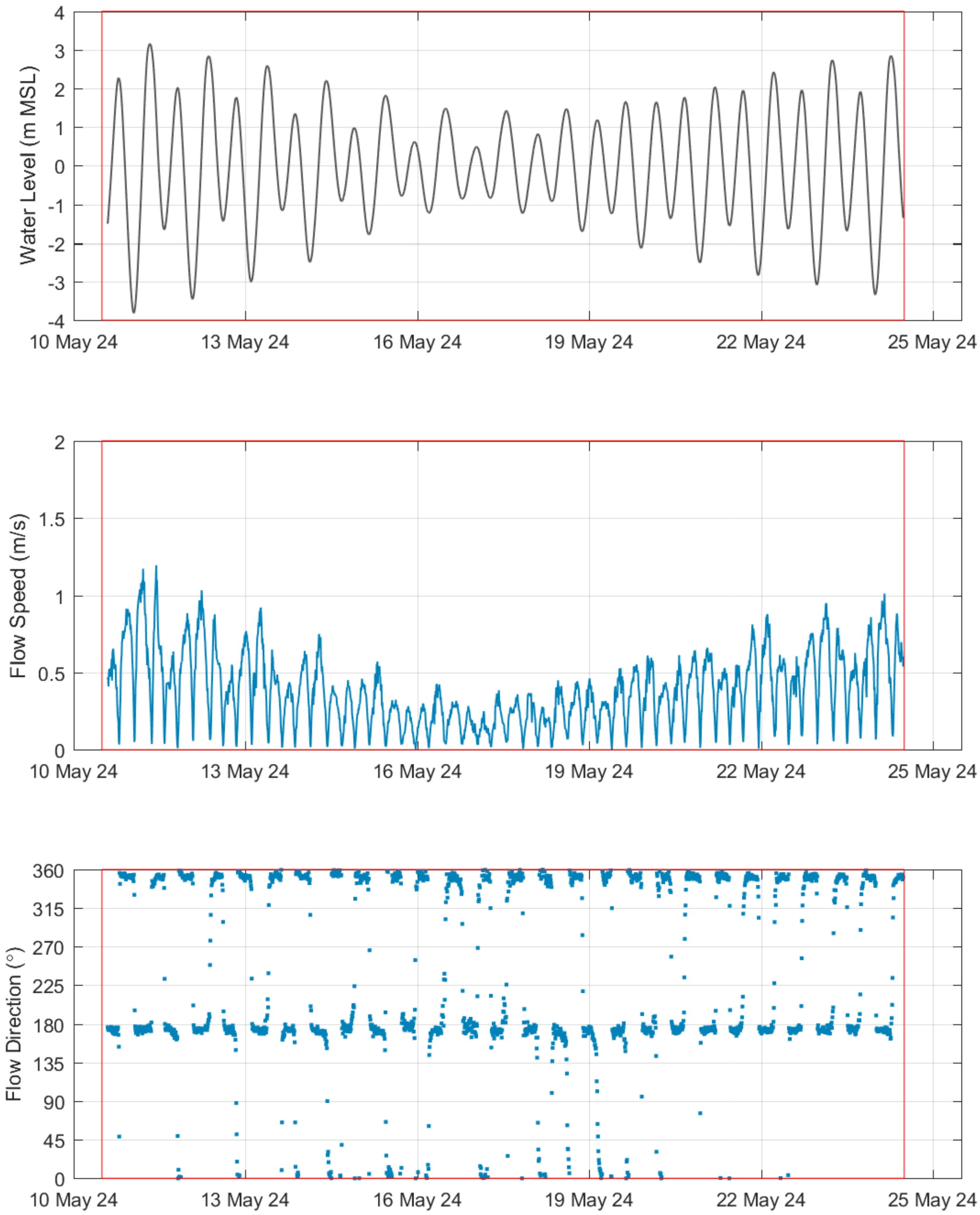


Figure 28. Hydrodynamic survey results through the water column at site AWAC-07, 10th May to 25th May 2024.

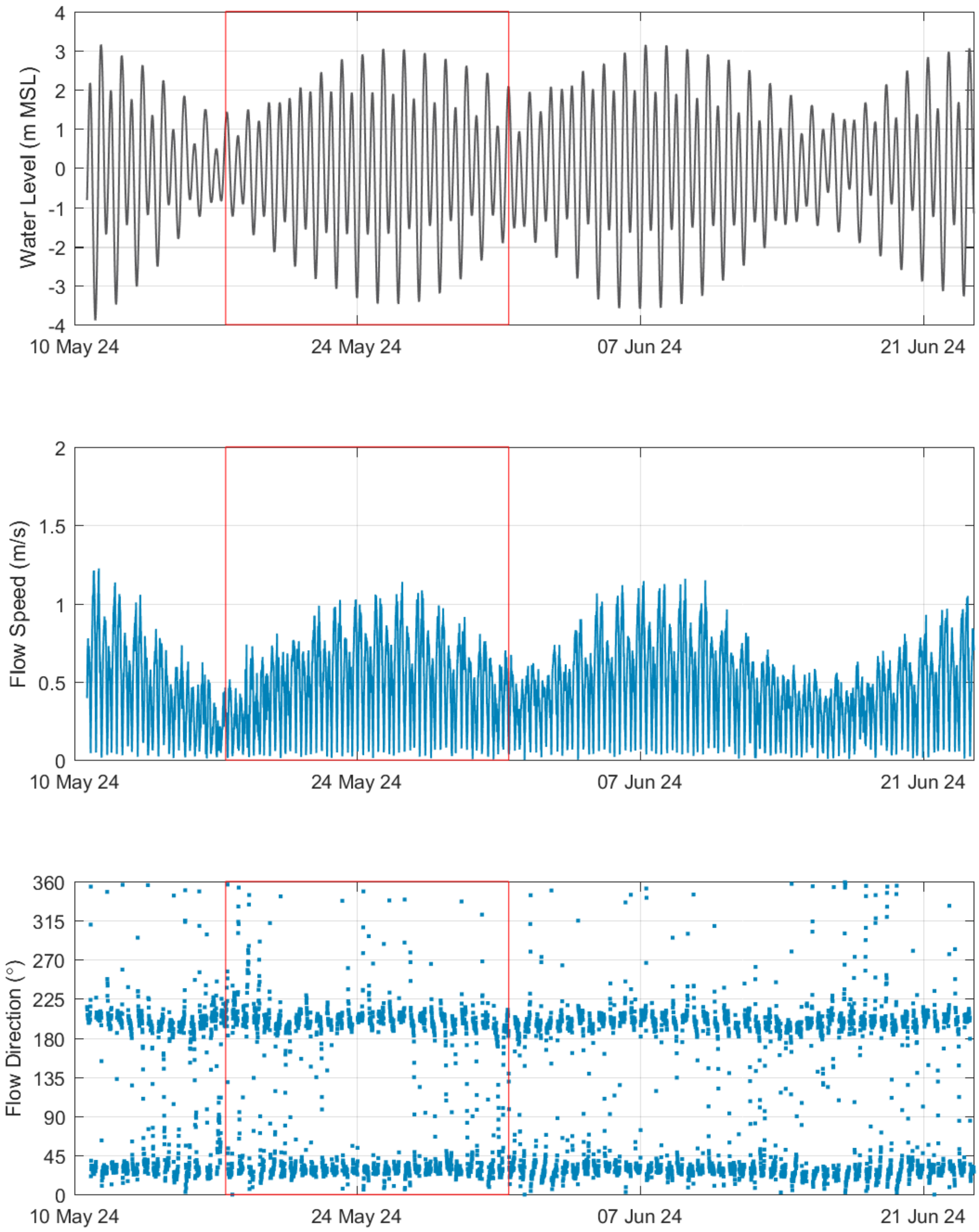


Figure 29. **Hydrodynamic survey results through the water column at site AWAC-11, 10th May to 23rd June 2024.**

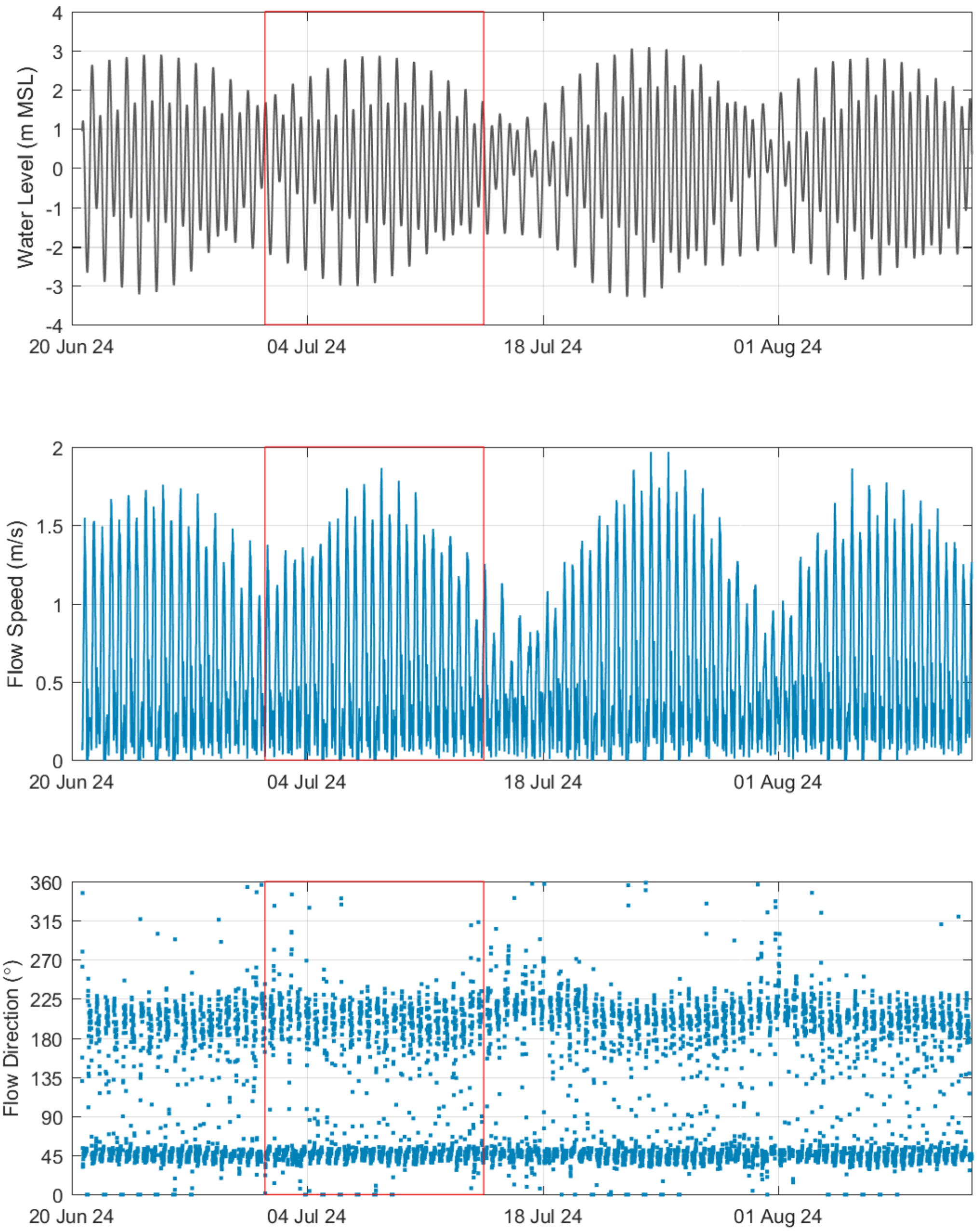


Figure 30. Hydrodynamic survey results through the water column at site AWAC-05, 20th June to 12th August 2024.

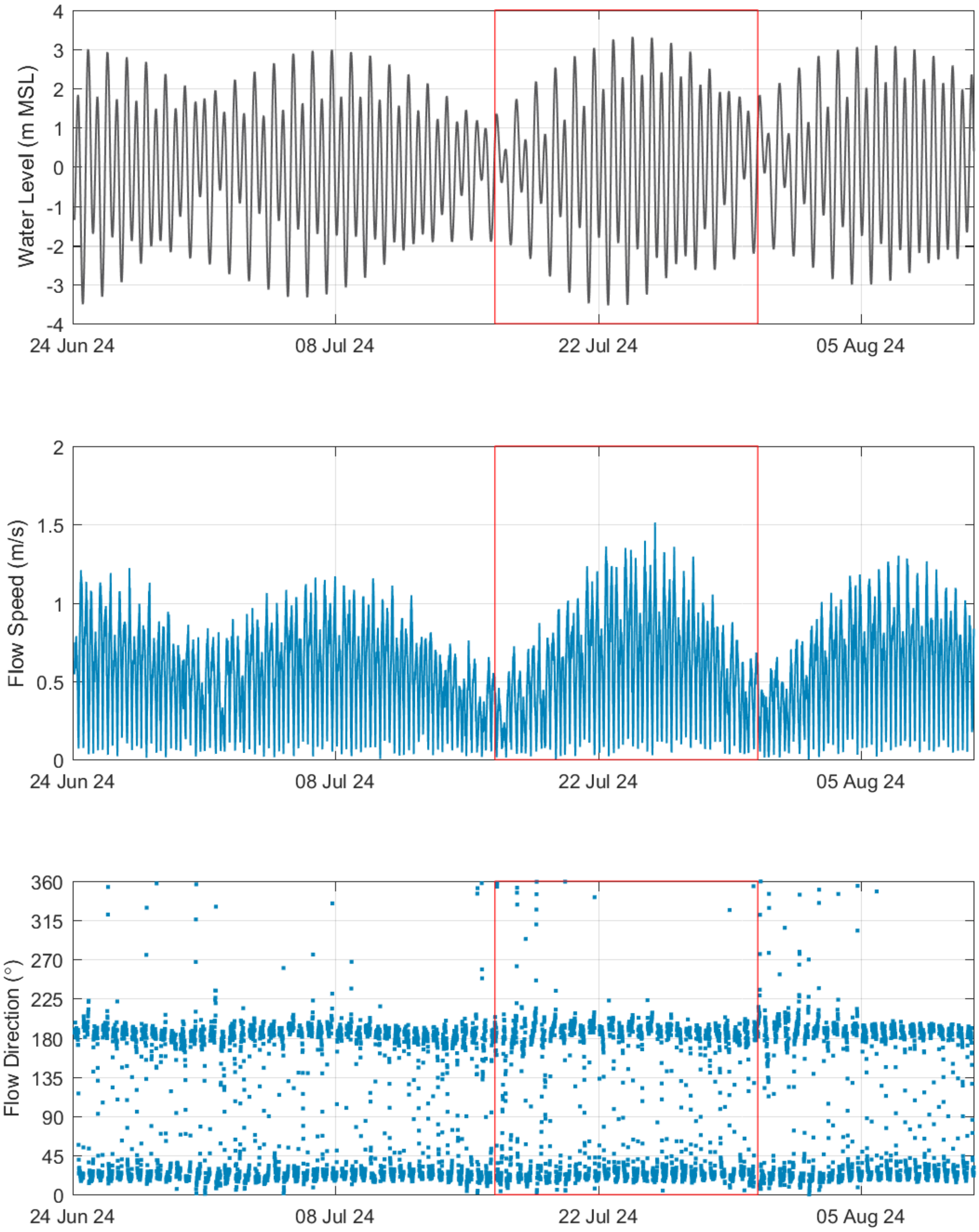


Figure 31. Hydrodynamic survey results through the water column at site AWAC-11, 24th June to 11th August 2024.

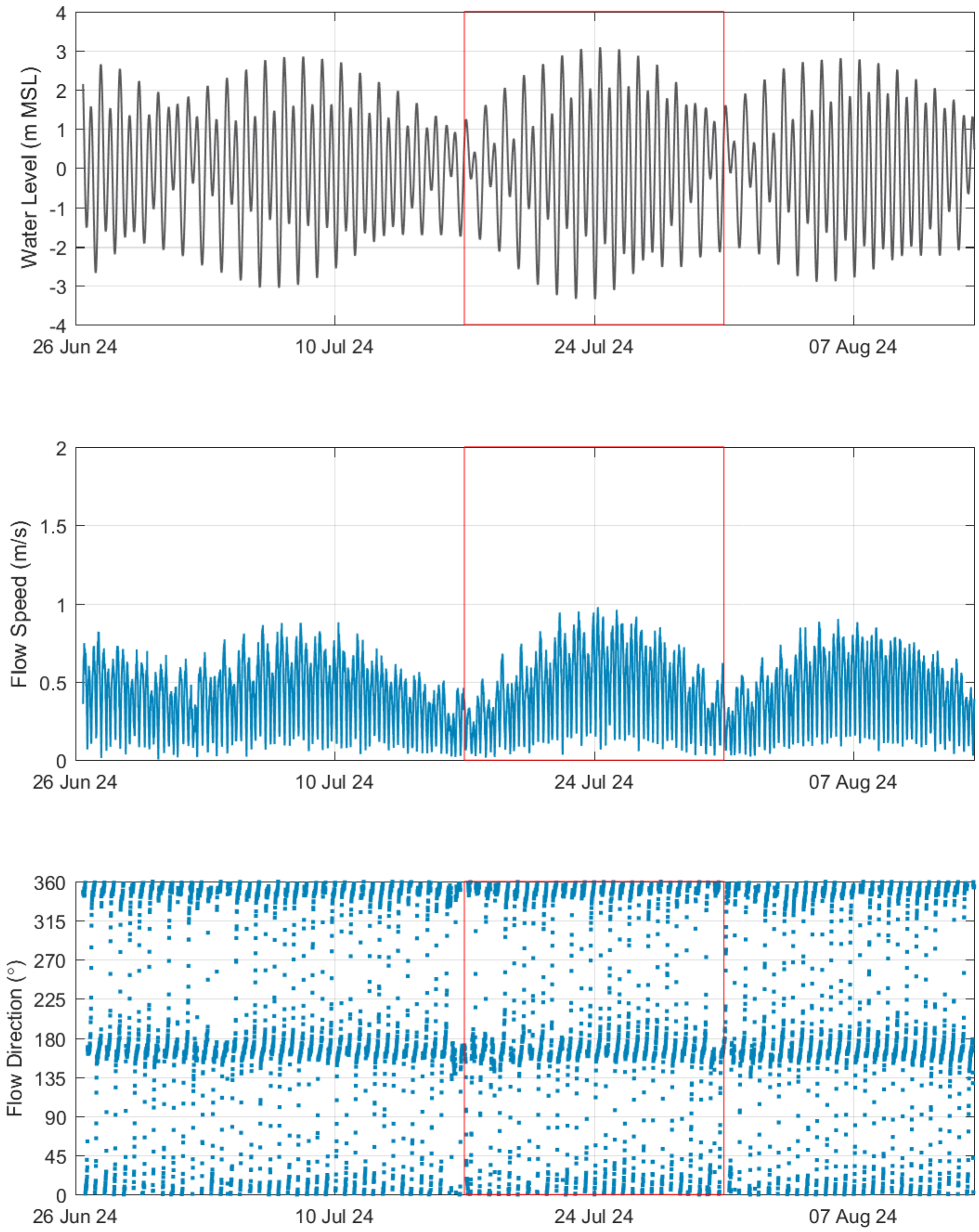


Figure 32. Hydrodynamic survey results through the water column at site AWAC-10, 26th June to 13th August 2024.

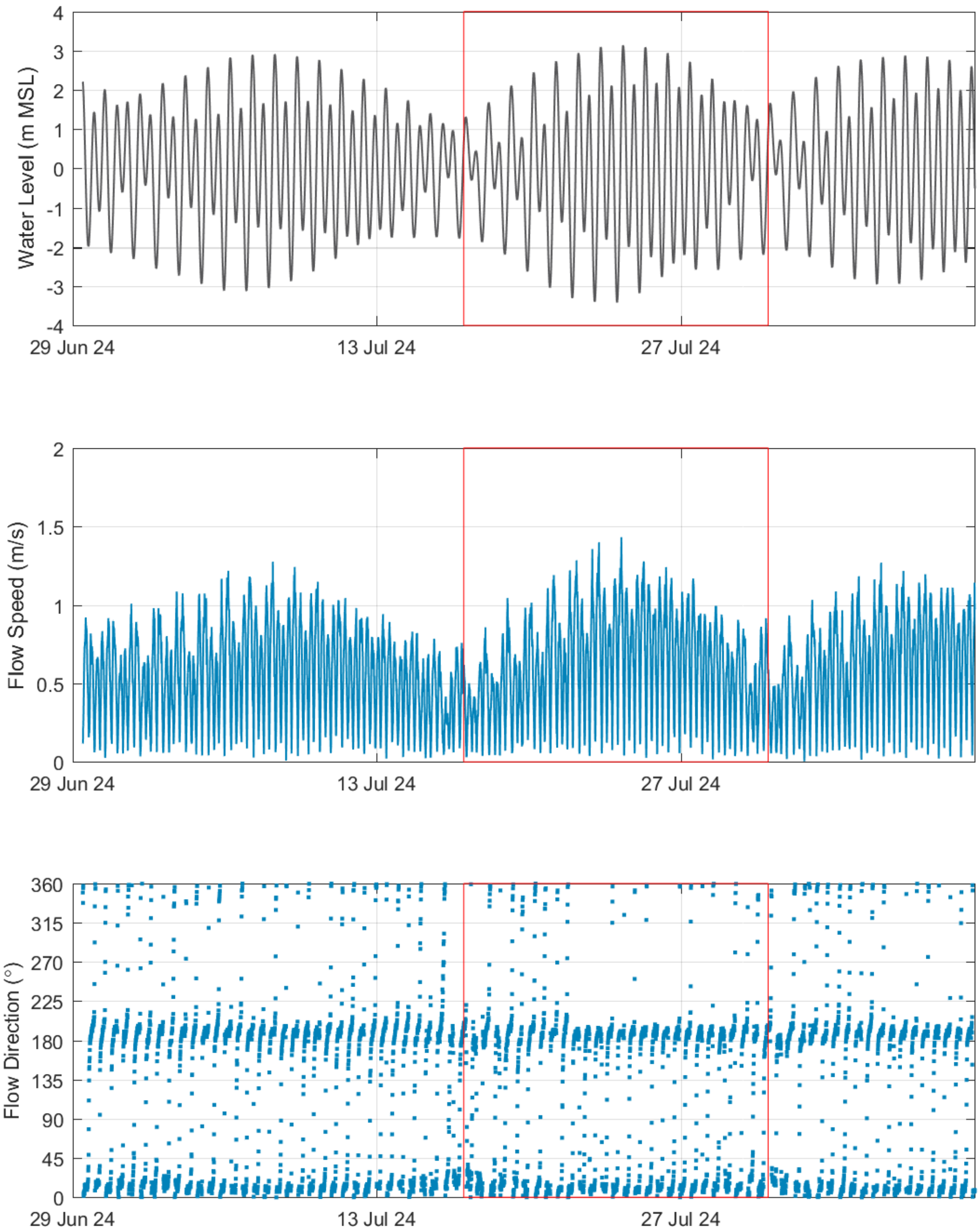


Figure 33. Hydrodynamic survey results through the water column at site AWAC-01, 29th June to 9th August 2024.

6.1.2. Waves

This section details the wave data from each of the survey deployments. Results are shown in Figure 34 to Figure 48 and are presented in chronological order.

A statistical summary of the measured wave conditions at each site over each deployment period is provided in Table 15. To provide a meaningful wave direction statistic the wave directions were rounded to the nearest 5 degrees and then the modal value over the deployment was calculated. The statistics show that the largest H_s was measured at the end of the wet season at a site offshore of CG in King Shoals (AWAC-09). During the dry season the peak H_s measured within CG was larger than offshore of CG (AWAC-10), although the average H_s at the offshore site was larger. The average T_p was typically between 3 and 5 seconds (except offshore of CG at AWAC-10 where it was 5.2 seconds), while the modal wave direction was predominantly between the northwest and northeast (the only exception was at AWAC-05 where it was from the east-northeast, this was likely due to the complex bathymetry in this area), showing that waves from a northerly direction are typically dominant.

Table 15. Statistical summary of the measured wave data collected at the AWAC sites from June 2023 to August 2024.

Position	Start Date	H_s		T_p	Direction
		Avg (m)	Max (m)	Avg (s)	Mode (º)
AWAC-01	09/06/2023	-	-	-	-
AWAC-04	07/09/2023	-	-	-	-
AWAC-02	07/09/2023	0.27	0.35	3.1	350
AWAC-06	08/09/2023	0.34	0.99	3.6	5
AWAC-03	13/10/2023	0.24	0.38	3.1	20
AWAC-07	15/10/2023	0.30	1.10	3.4	350
AWAC-08	02/03/2024	0.19	1.04	3.9	15
AWAC-11	02/03/2024	0.32	1.08	3.6	20
AWAC-01	03/03/2024	0.38	1.01	3.8	15
AWAC-06	06/03/2024	0.42	1.14	3.9	5
AWAC-09	04/03/2024	0.54	1.61	4.3	355
AWAC-07	10/05/2024	0.19	0.47	3.1	345
AWAC-11	10/05/2024	0.28	0.67	4.1	15
AWAC-05	20/06/2024	0.31	1.27	3.9	55
AWAC-11	24/06/2024	0.27	1.27	3.8	40
AWAC-10	26/06/2024	0.36	1.09	5.2	345
AWAC-01	29/06/2024	0.32	1.03	4.8	5

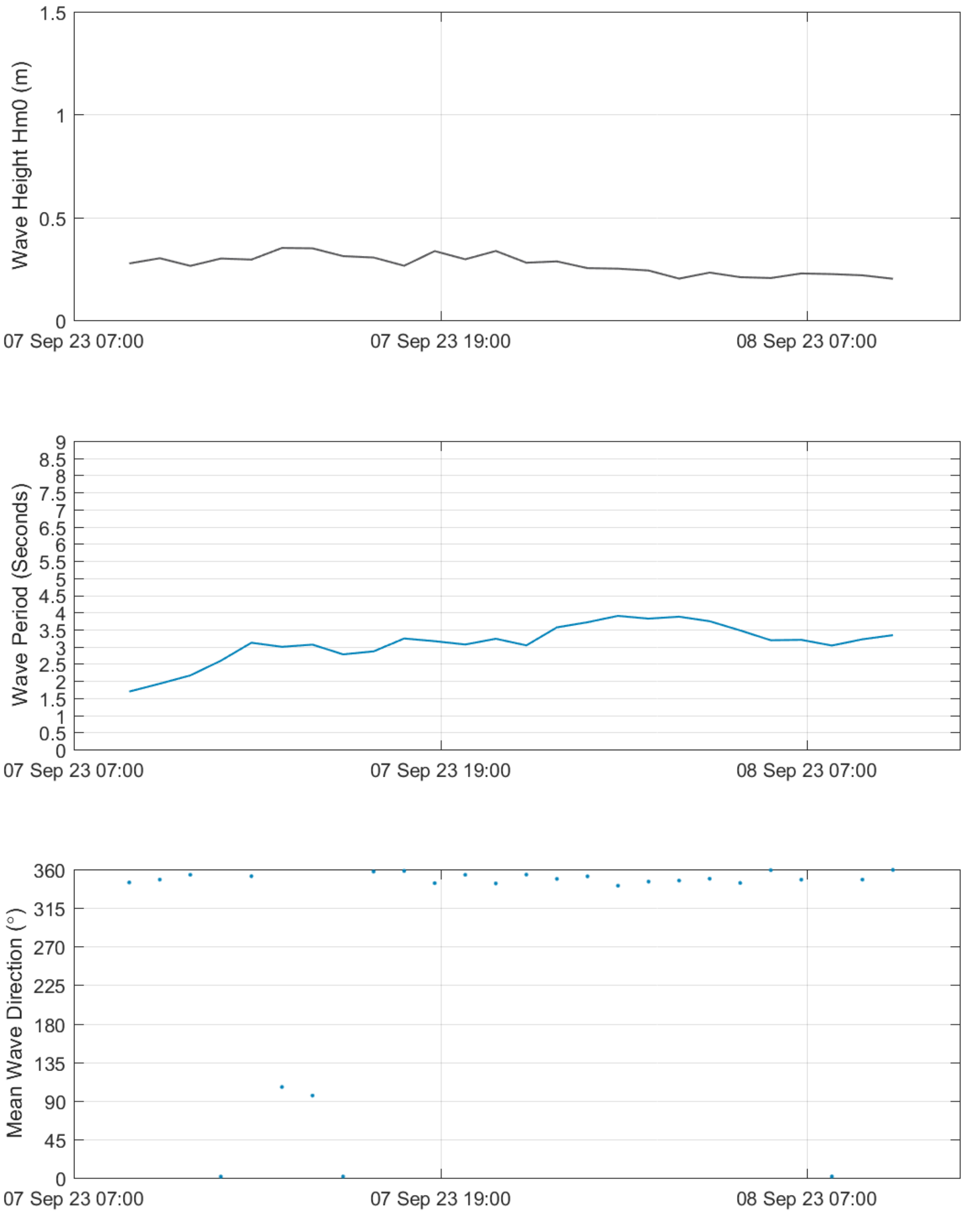


Figure 34. Wave survey results for site AWAC-02, 7th to 8th September 2023.

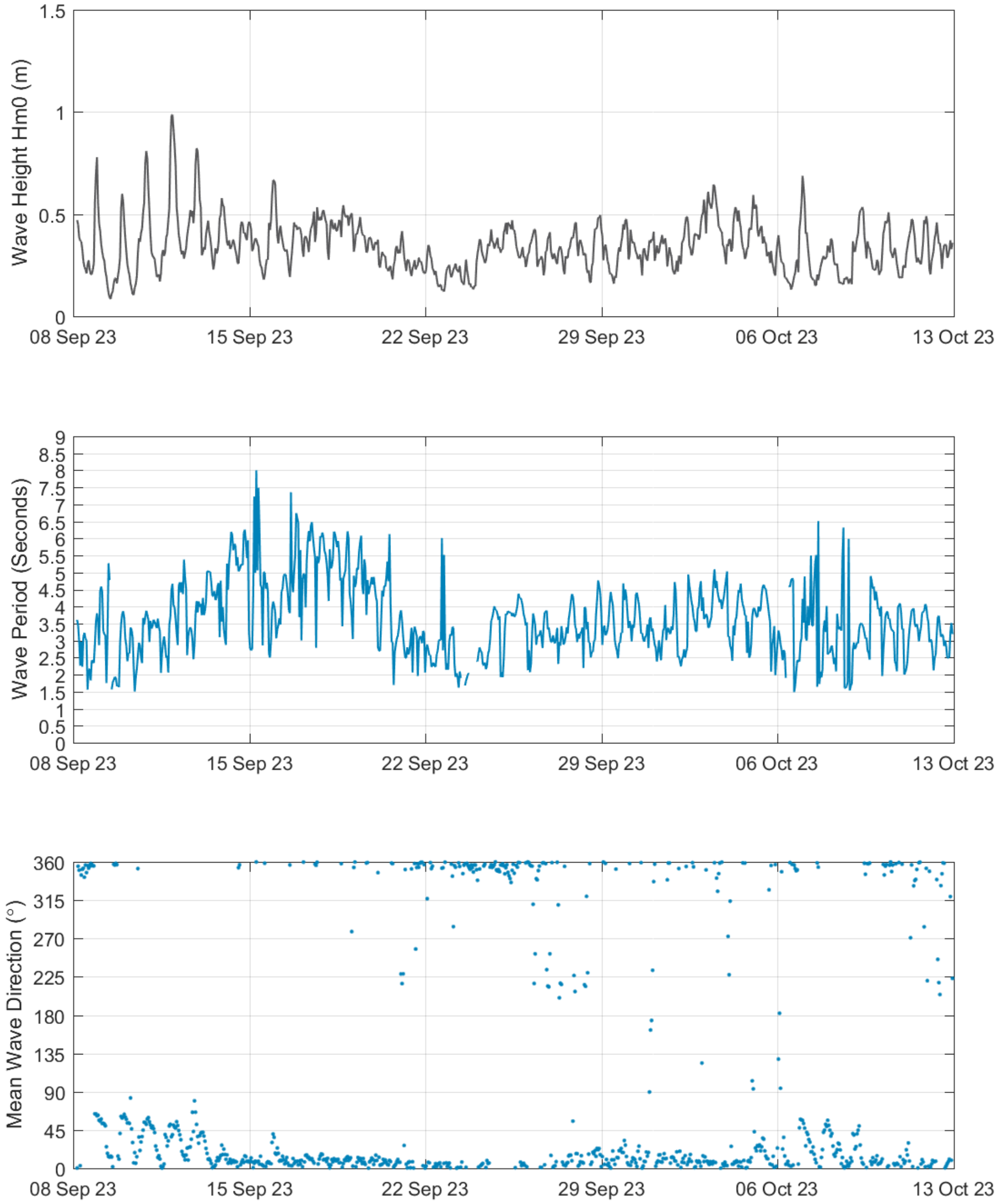


Figure 35. Wave survey results for site AWAC-06, 8th September to 13th October 2023.

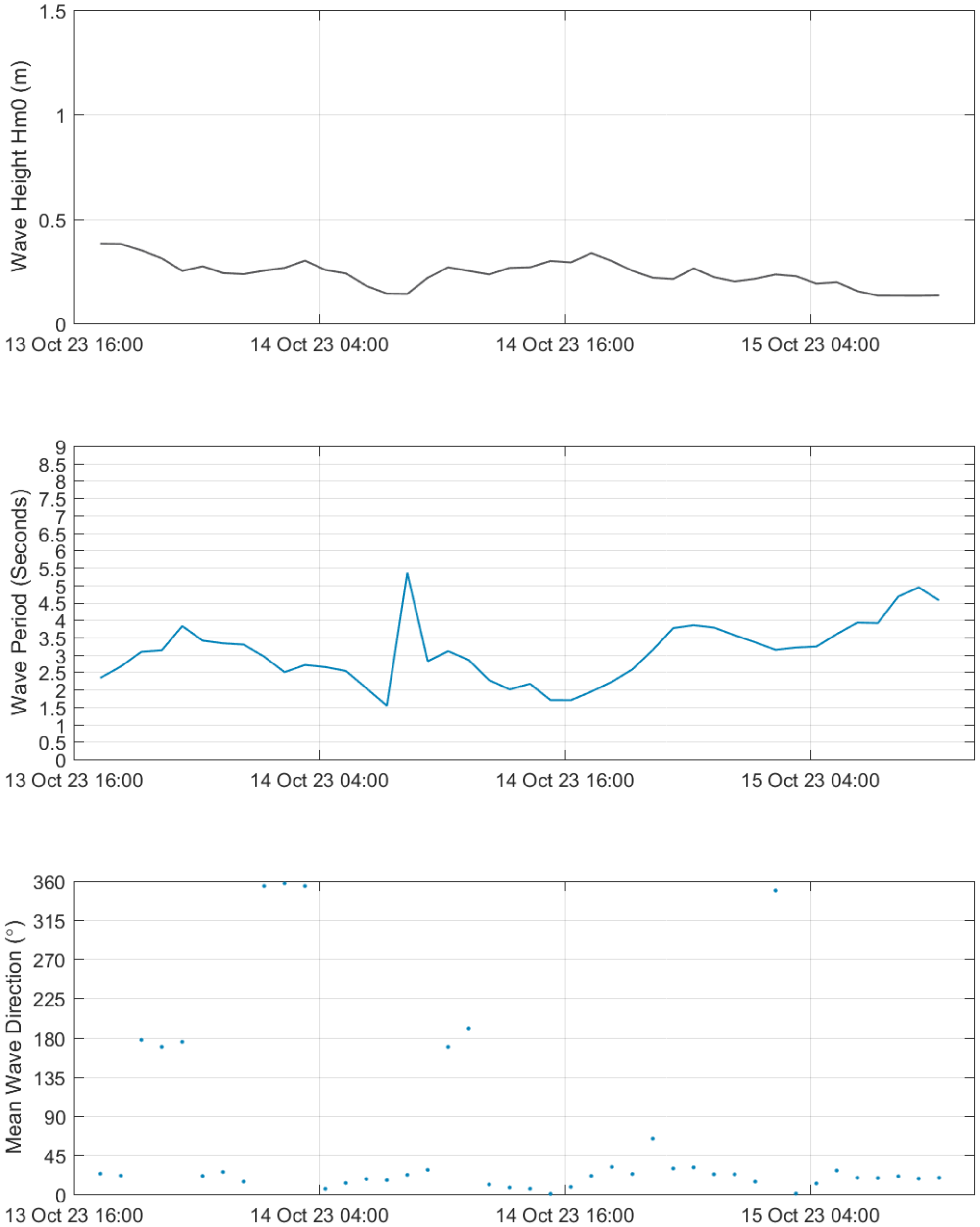


Figure 36. Wave survey results for site AWAC-03, 13th to 15th October 2023.

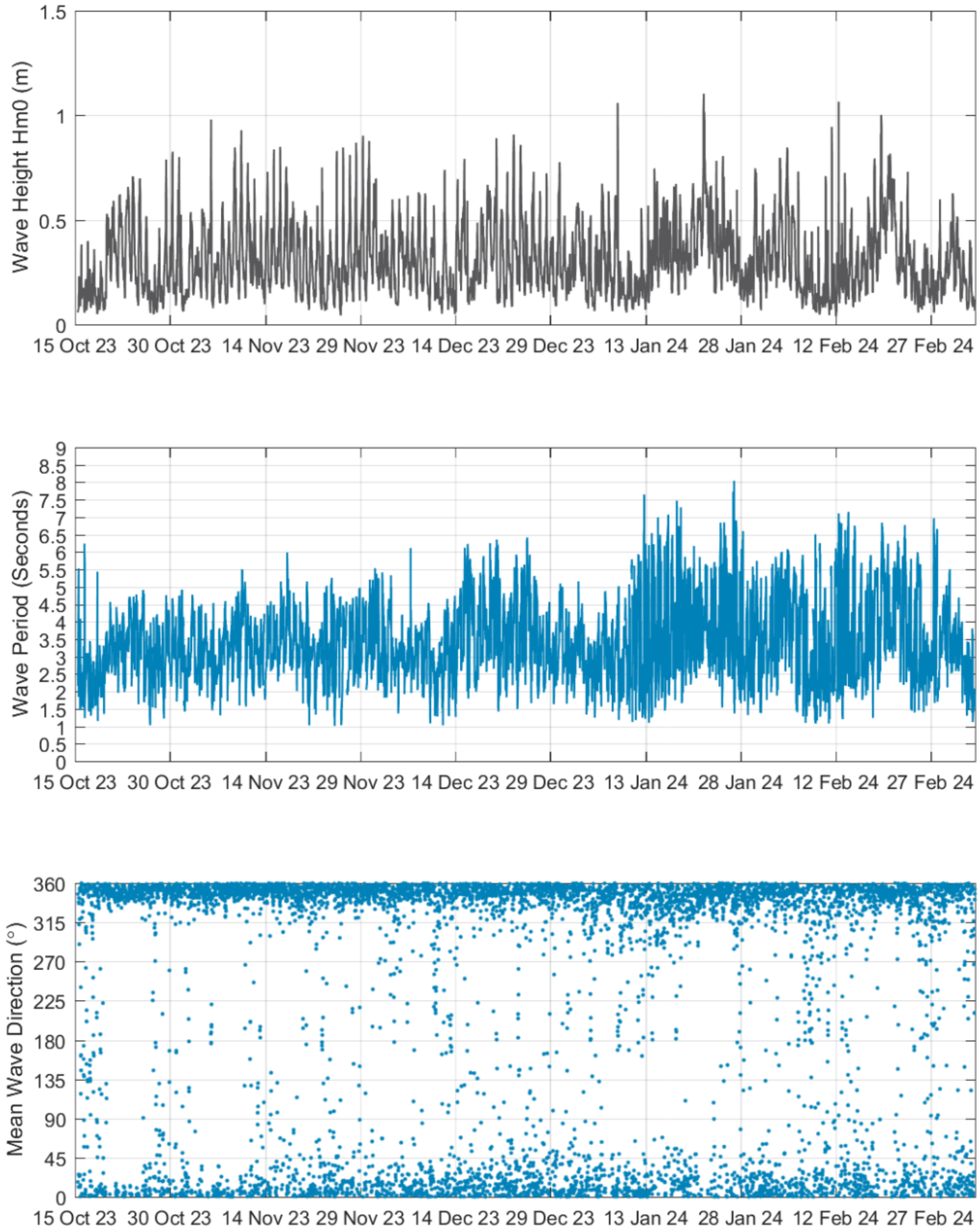


Figure 37. Wave survey results for site AWAC-07, 15th October 2023 to 5th March 2024.

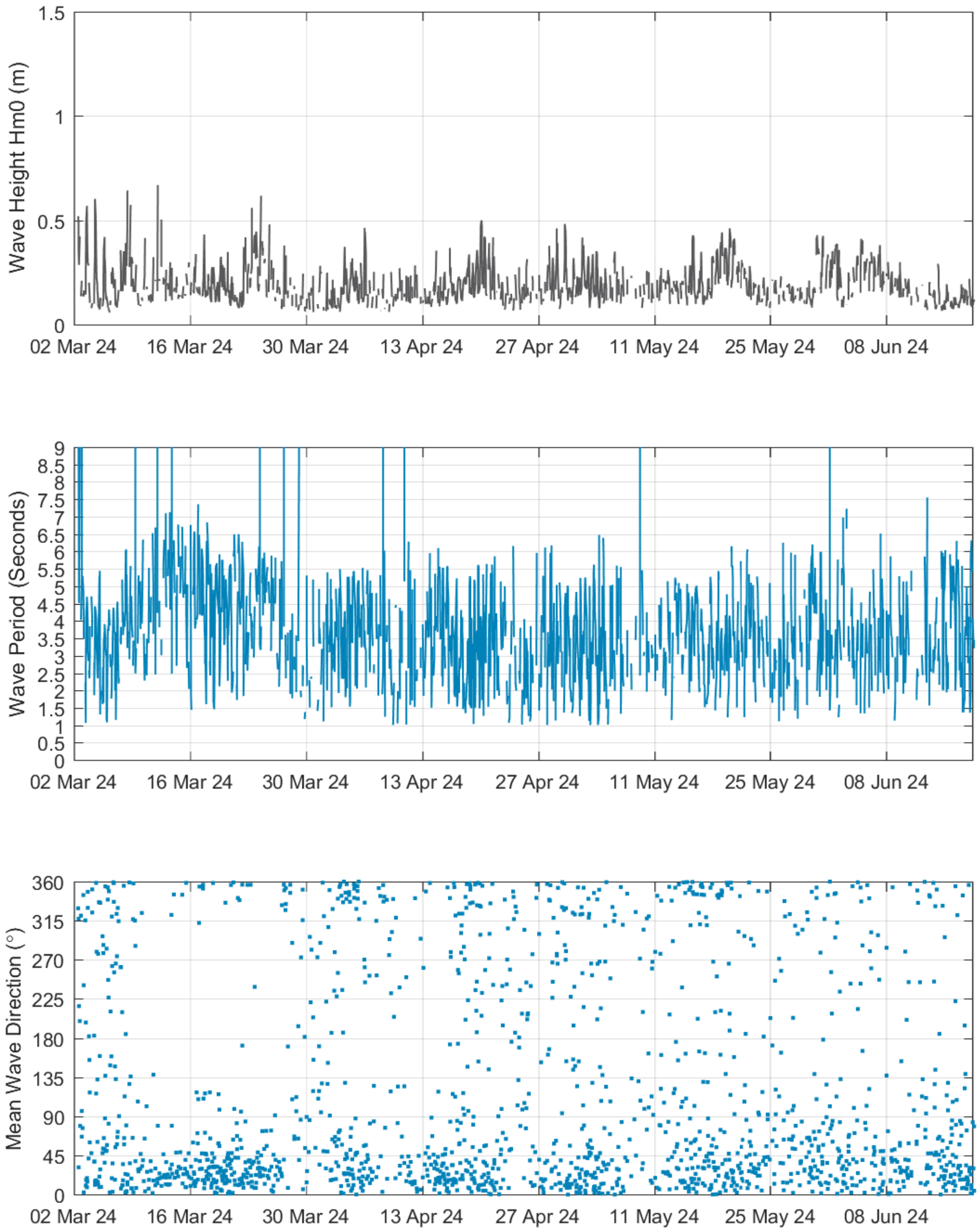


Figure 38. Wave survey results for site AWAC-08, 2nd March to 18th June 2024.

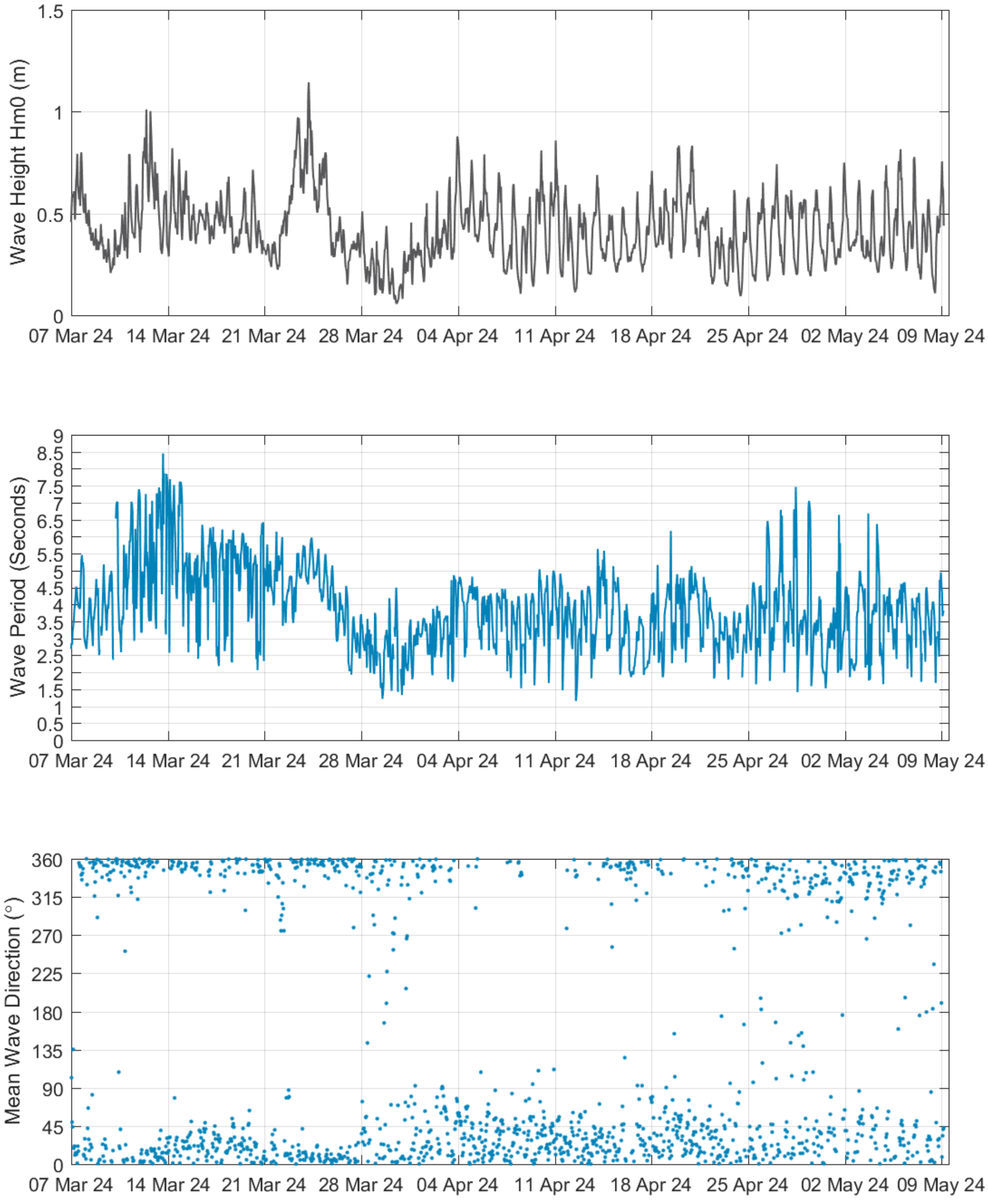


Figure 39. Wave survey results for site AWAC-06 (Second deployment), 6th March to 10th May 2024.

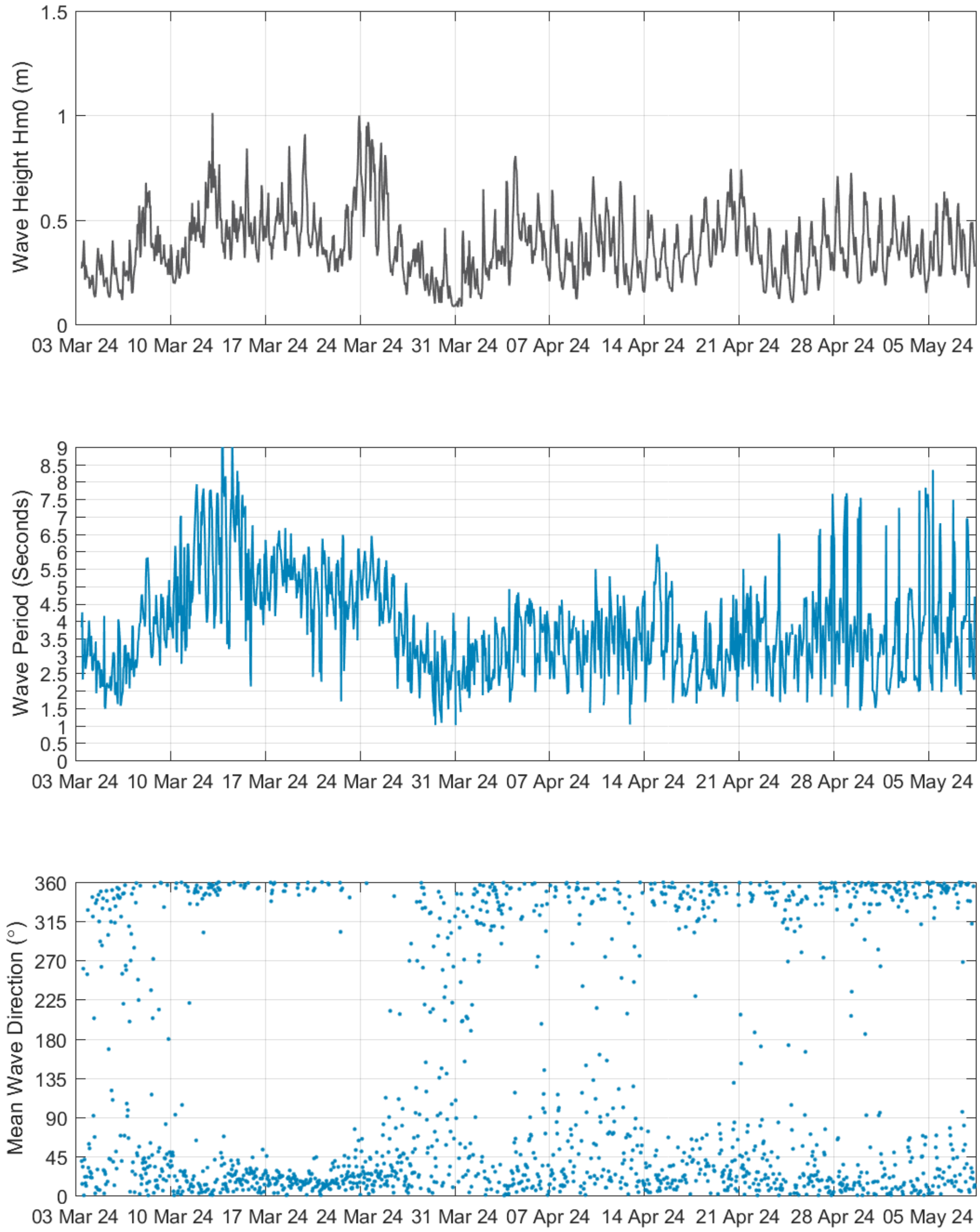


Figure 40. Wave survey results for site AWAC-01, 3rd March to 8th May 2024.

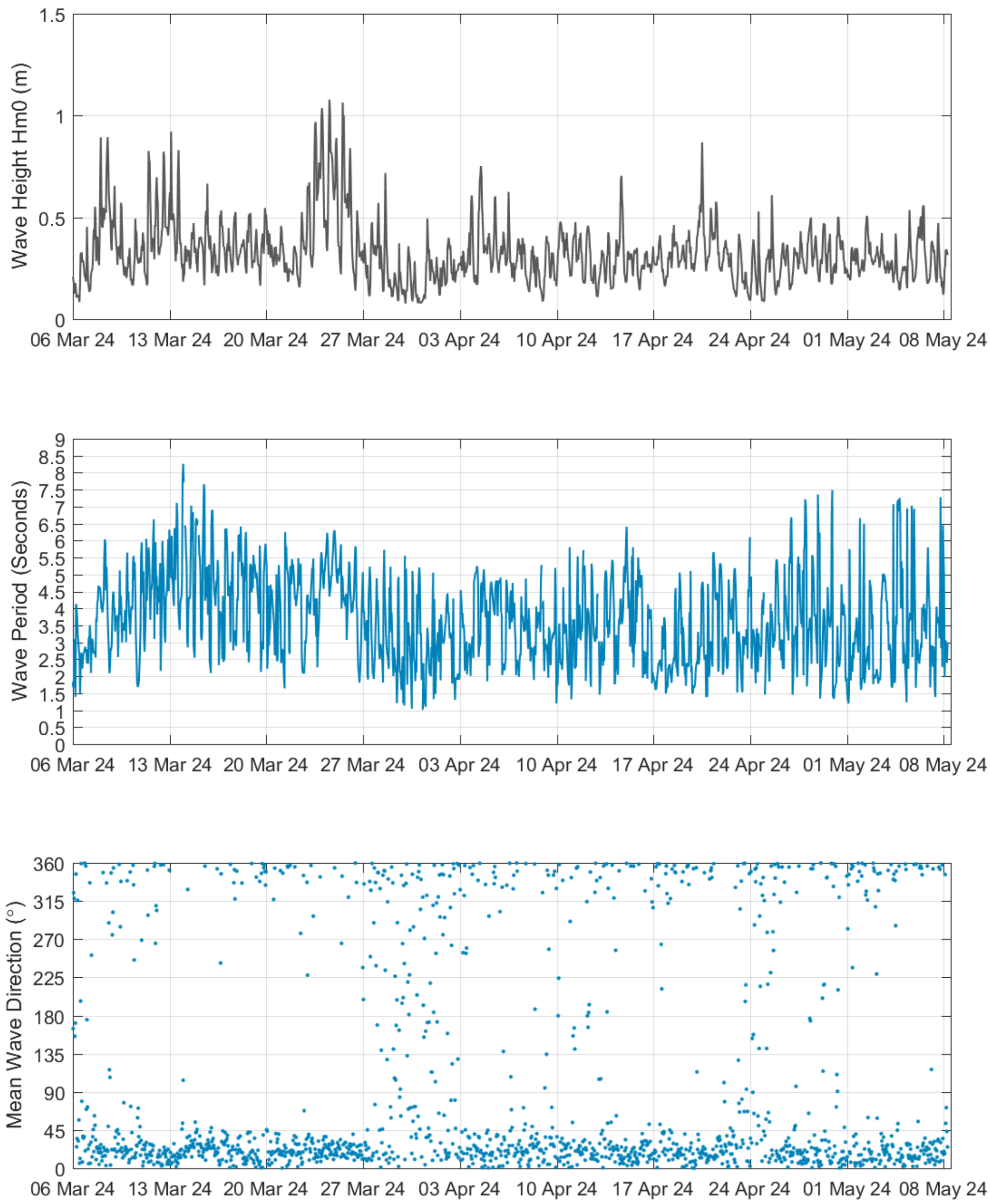


Figure 41. Wave survey results for site AWAC-11, 2nd March to 8th May 2024.

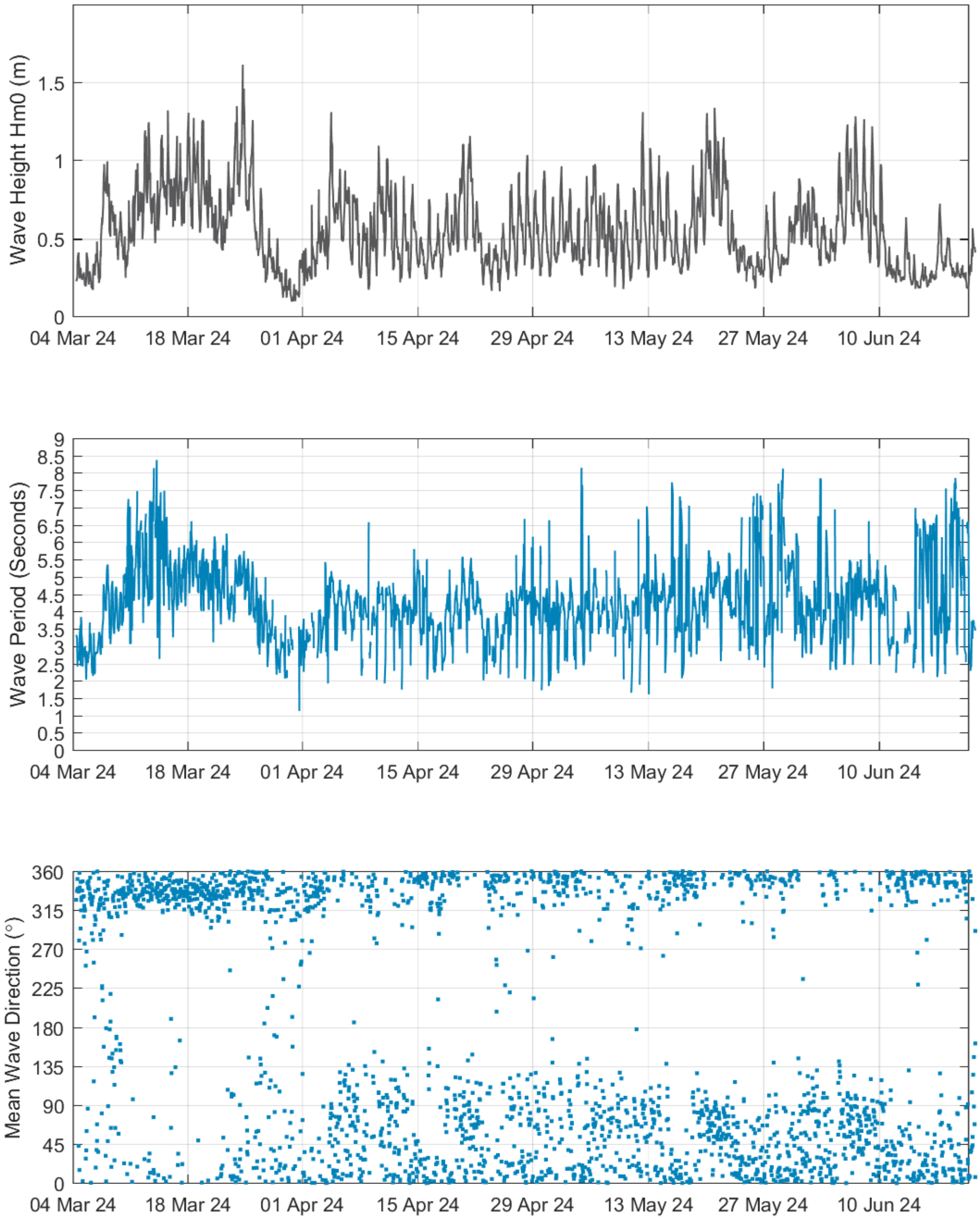


Figure 42. Wave survey results for site AWAC-09, 4th March to 21st June 2024.

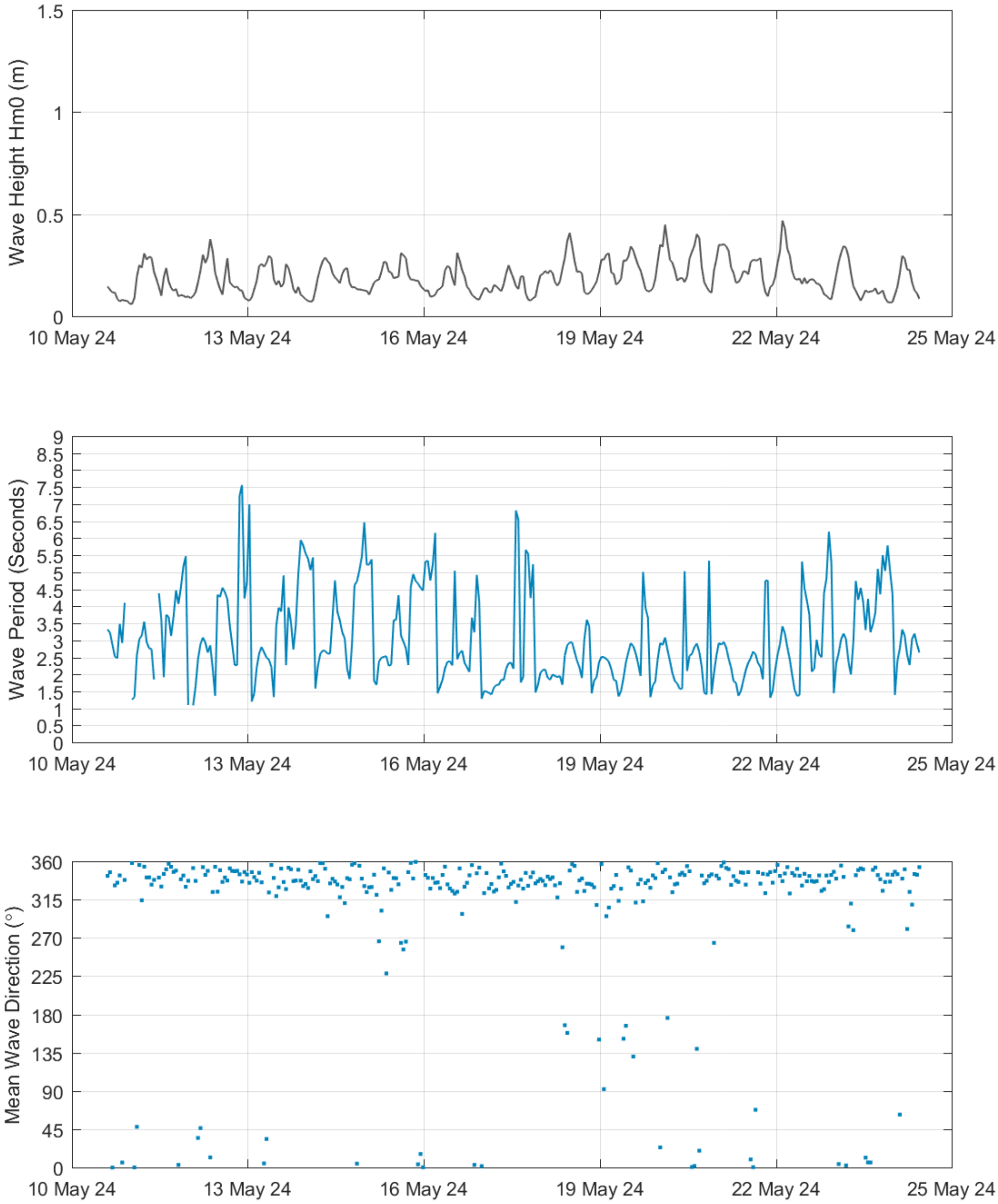


Figure 43. Wave survey results for site AWAC-07, 10th May to 25th June 2024.

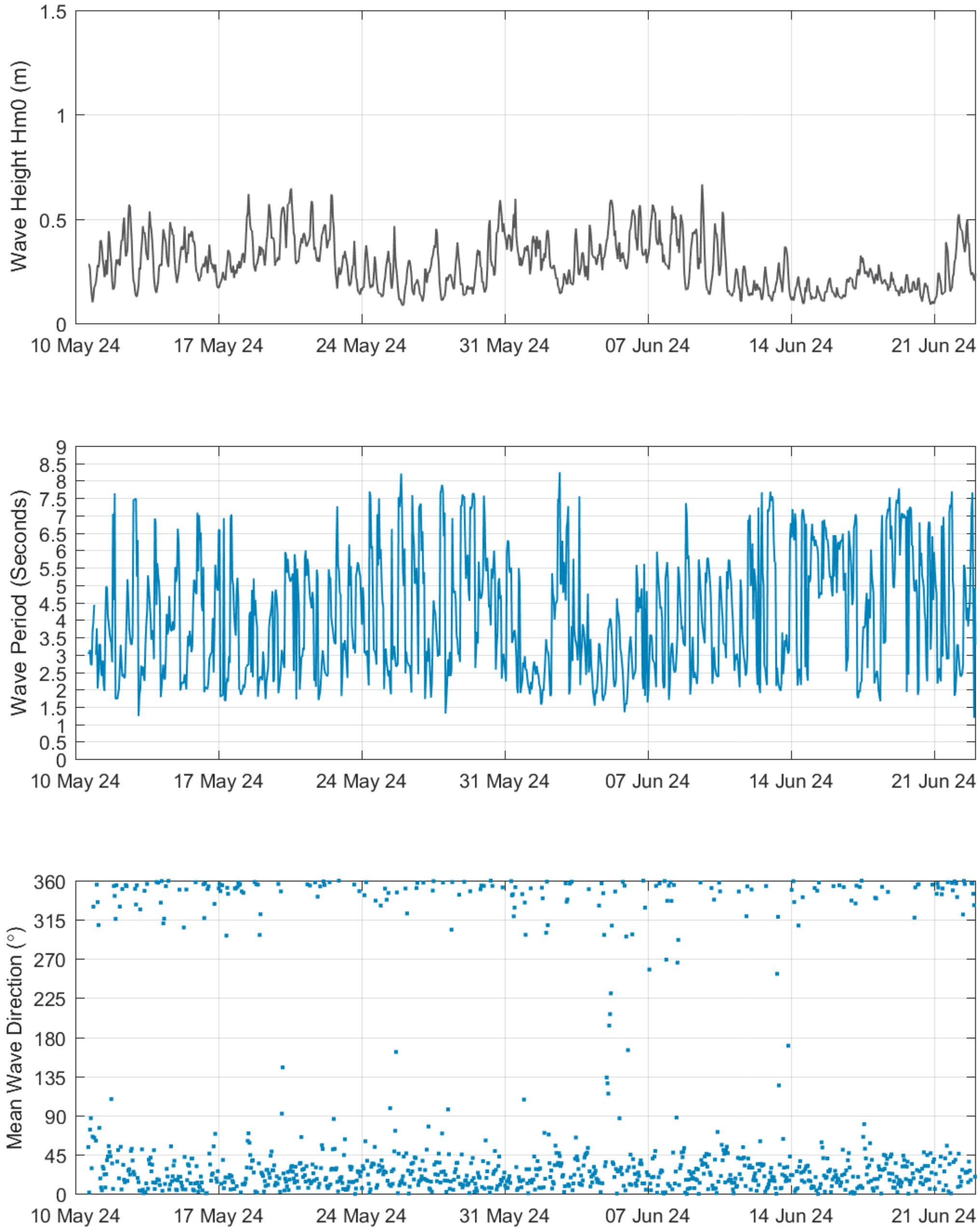


Figure 44. Wave survey results for site AWAC-11, 10th May to 23rd June 2024.

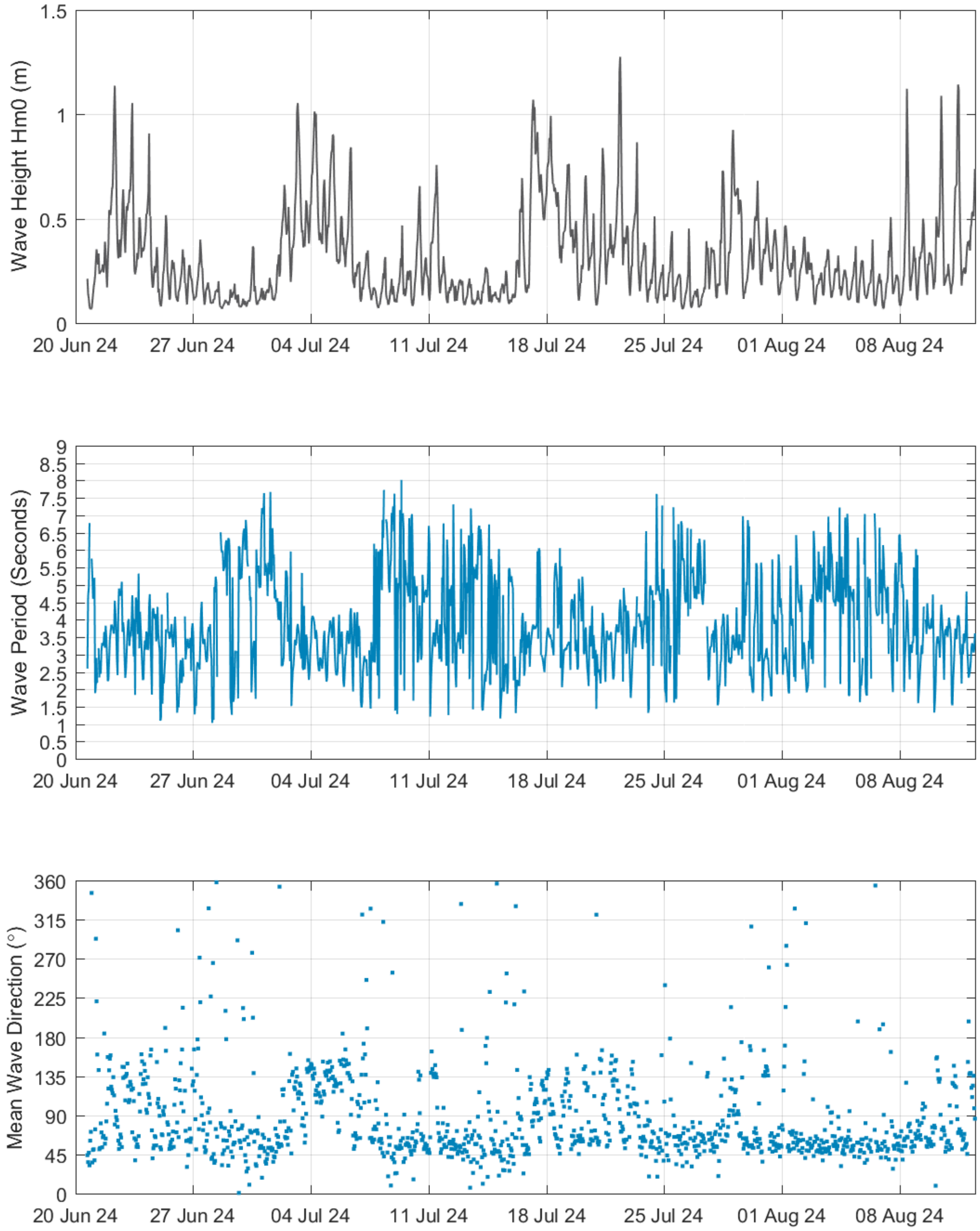


Figure 45. Wave survey results for site AWAC-05, 20th June to 12th August 2024.

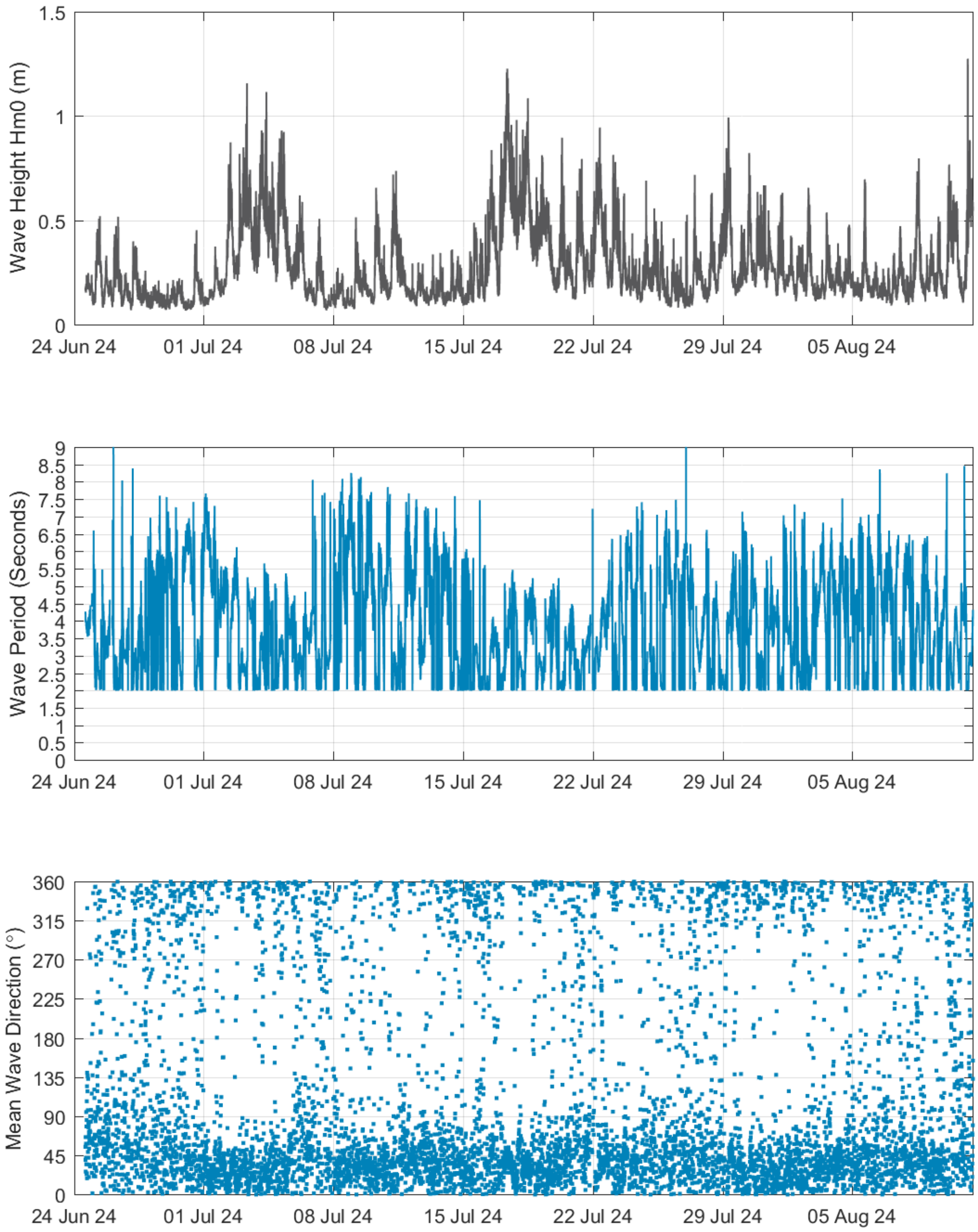


Figure 46. Wave survey results for site AWAC-11, 24th June to 11th August 2024.

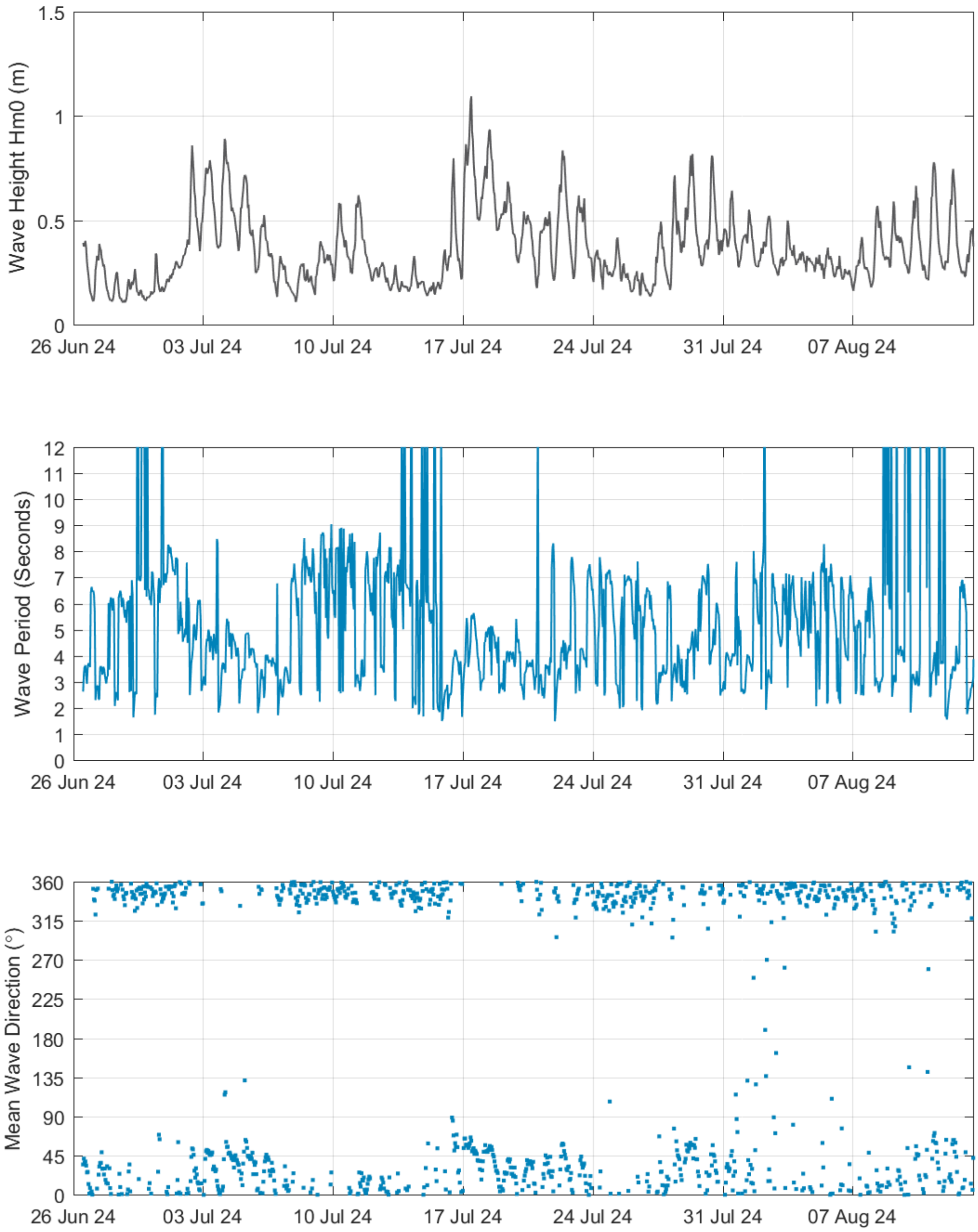


Figure 47. Wave survey results for site AWAC-10, 26th June to 13th August 2024.

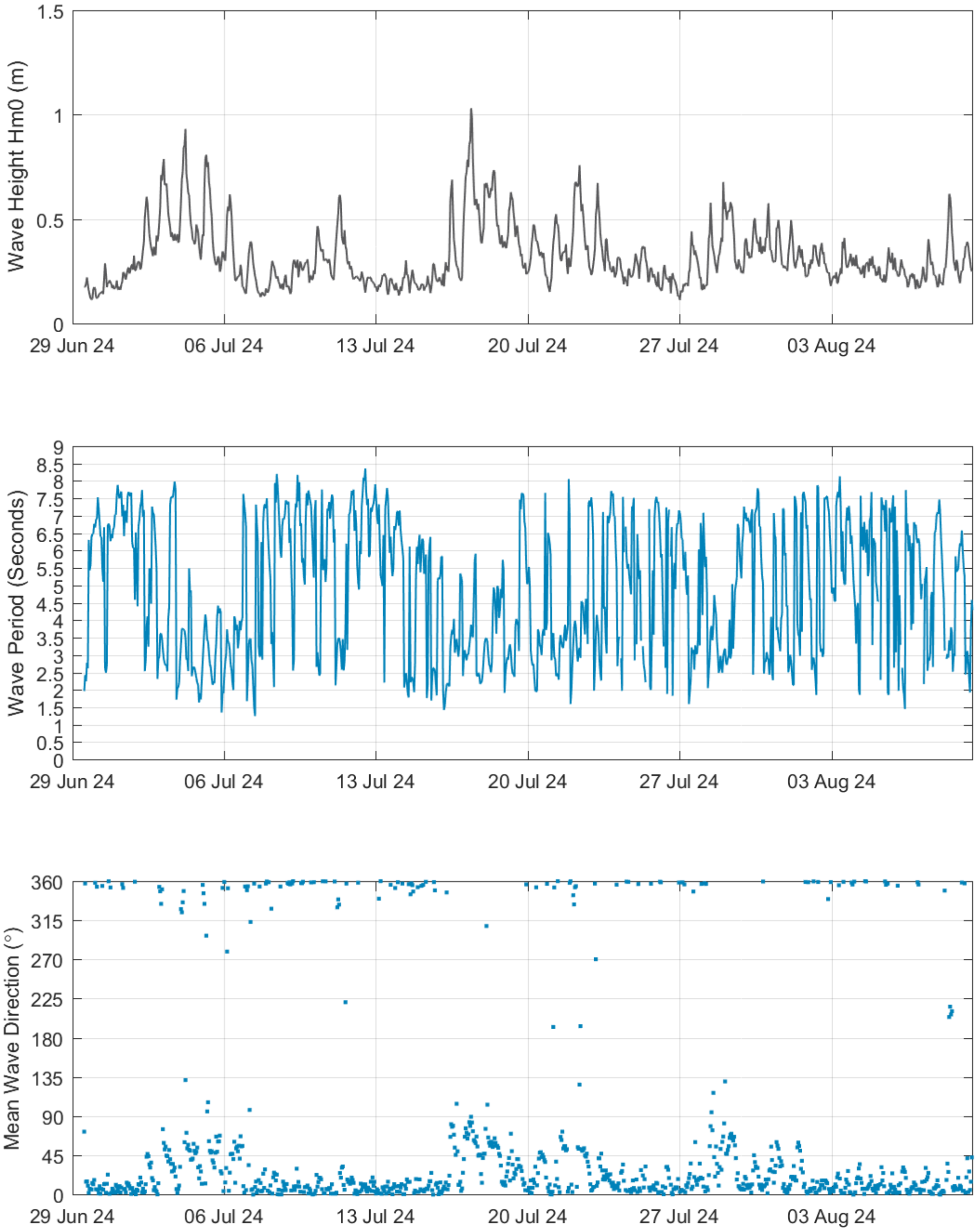


Figure 48. Wave survey results for site AWAC-01, 29th June to 9th August 2024.

6.1.3. Benthic Light

This section details the available benthic light data from each of the survey deployments. The results are plotted in Figure 49 to Figure 67. As noted in Section 3.1.1, due to the LI-COR instruments only being able to measure for a maximum duration of eight days, Odyssey loggers were deployed from March 2024 and they consistently measured benthic light over the entire deployment durations. A statistical summary of the benthic light data measured by the Odyssey loggers, as this provides an understanding of the longer term variability in benthic light over multiple spring neap cycles, is provided in Table 16.

The results show that benthic light was close to zero at most sites throughout the majority of the deployment durations. The only sites which had a mean benthic irradiance of 0.1 µmol/m^2/s and above (AWAC-05, Pos-13 and Pos-14) were in water depths of less than 15 m MSL. The timeseries plots show that at the sites where benthic light was present, it was not consistently present every day. Analysis of the data by PCS (2025a) showed that the periods with higher benthic light correlated with neap tides when the turbidity was at its lowest, with a turbidity of less than approximately 10 NTU required for benthic light to be measured.

Table 16. Summary of the benthic light measurements by the Odyssey loggers from March to August 2024.

Position	Start Date	Depth (m MSL)	Min (µmol/m^2/s)	Max (µmol/m^2/s)	Avg (µmol/m^2/s)
Pos-12	04/03/2024	28.2	0.0	2.0	0.0
Pos-13	03/03/2024	13.5	0.0	36.0	0.1
Pos-14	03/03/2024	13.7	0.0	474.0	2.5
Pos-15	04/03/2024	22.4	0.0	0.0	0.0
AWAC-05	20/06/2024	9.8	0.0	6.0	0.1
AWAC-11	24/06/2024	20	0.0	0.0	0.0
AWAC-10	26/06/2024	18.1	0.0	0.0	0.0
AWAC-01	29/06/2024	25.9	0.0	0.0	0.0
Pos-12	28/06/2024	20.1	0.0	0.4	0.0
Pos-13	23/06/2024	12.2	0.0	0.4	0.0
Pos-14	21/06/2024	13.2	-	-	-
Pos-15	27/06/2024	14.4	0.0	0.1	0.0

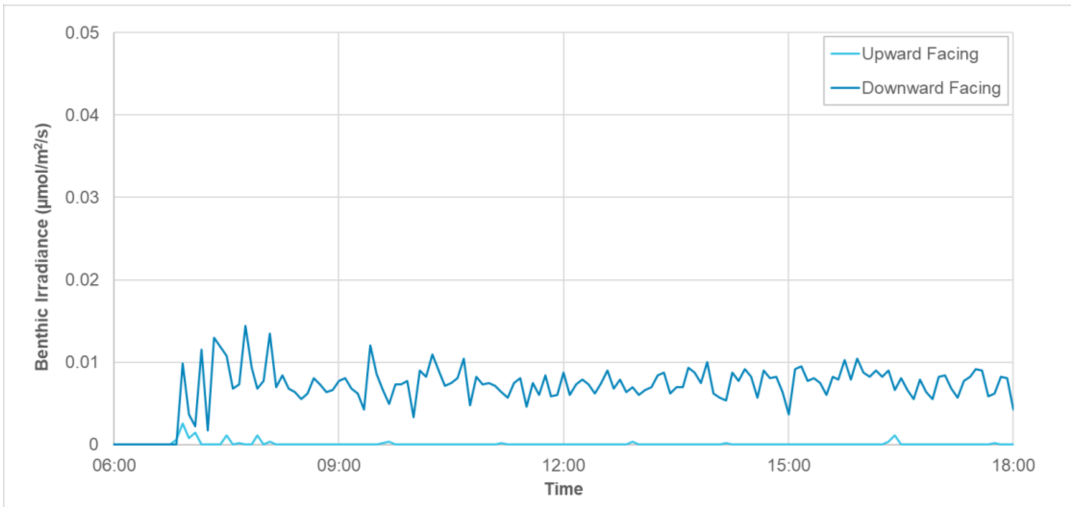


Figure 49. Time series of instantaneous benthic light at AWAC-02 on 07/09/2023.

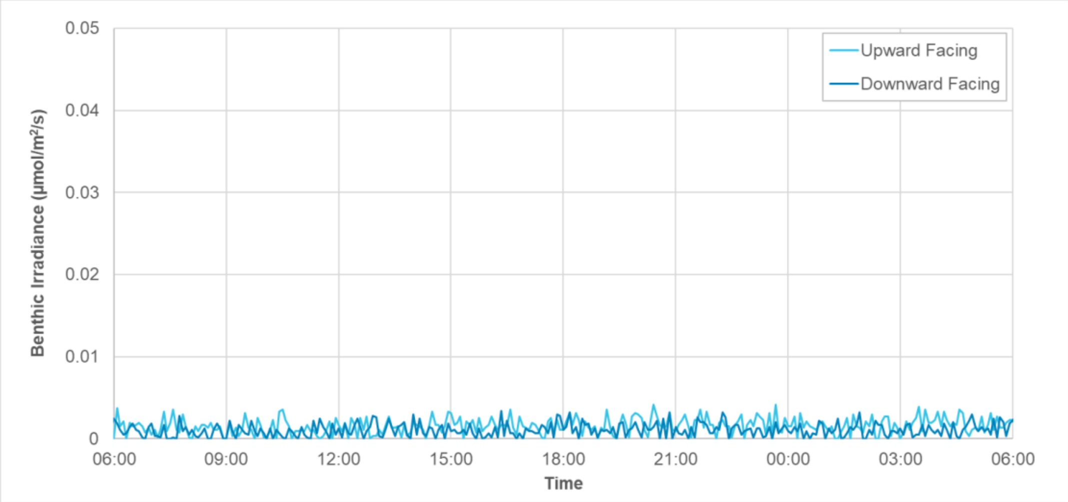


Figure 50. Time series of instantaneous benthic light at AWAC-04 from 07/09/2023 to 08/09/2023.

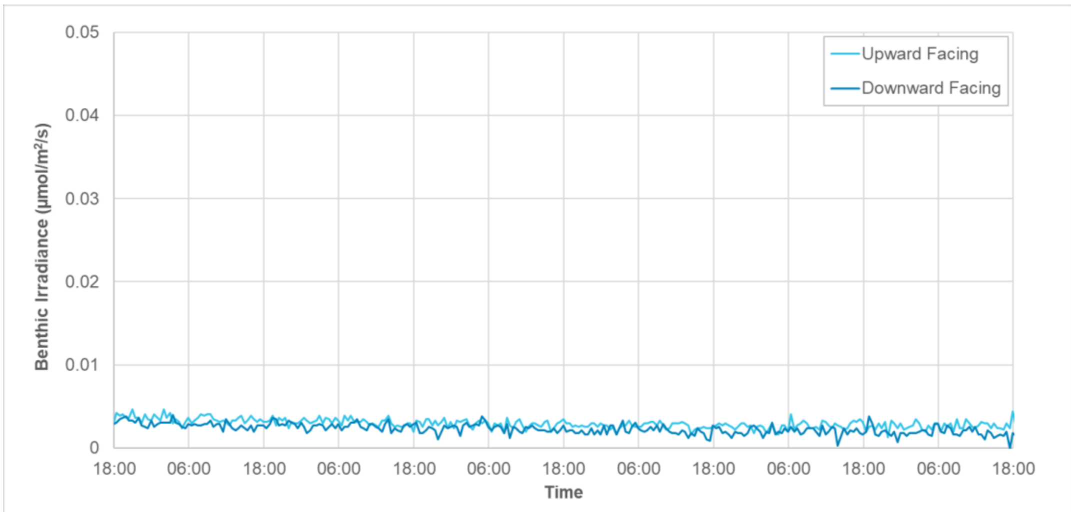


Figure 51. Time series of instantaneous benthic light at AWAC-11 from 02/03/2024 to 09/03/2024.

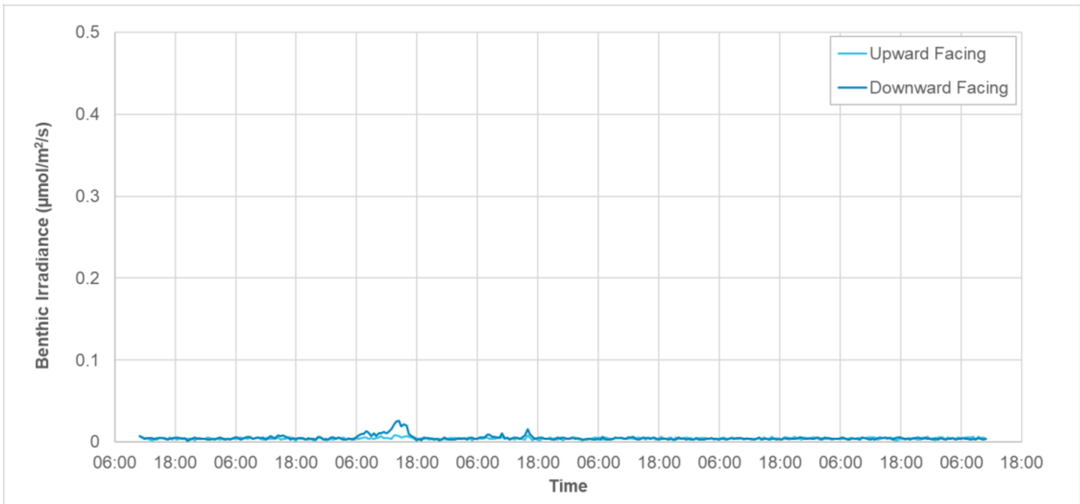


Figure 52. Time series of instantaneous benthic light at Pos-12 from 04/03/2024 to 11/03/2024.

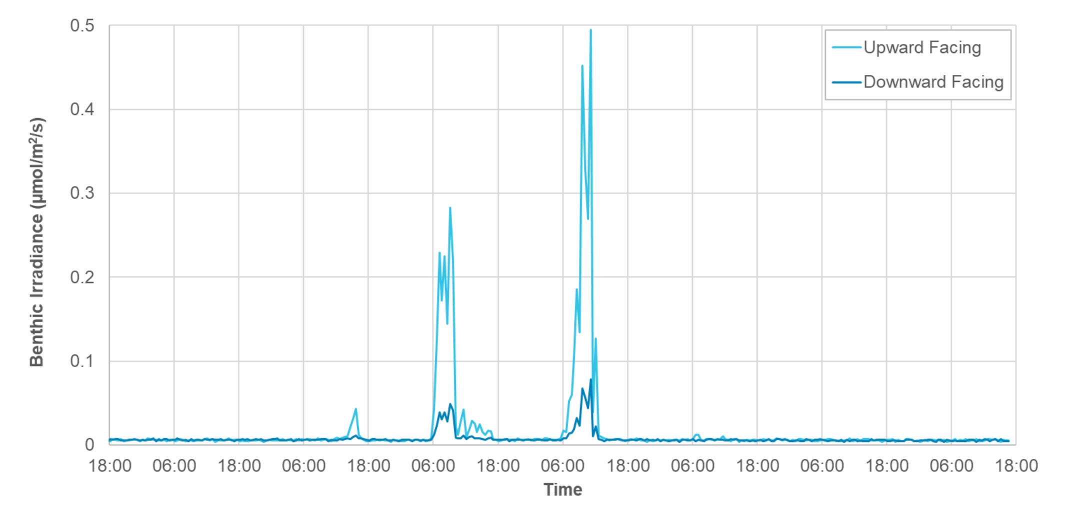


Figure 53. Time series of instantaneous benthic light at Pos-13 from 03/03/2024 to 10/03/2024.

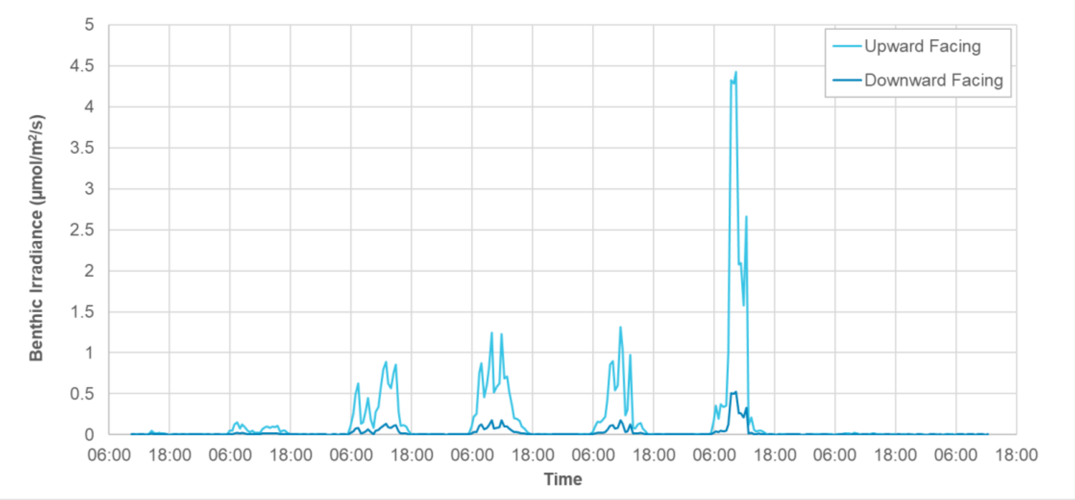


Figure 54. Time series of instantaneous benthic light at Pos-14 from 03/03/2024 to 10/03/2024.

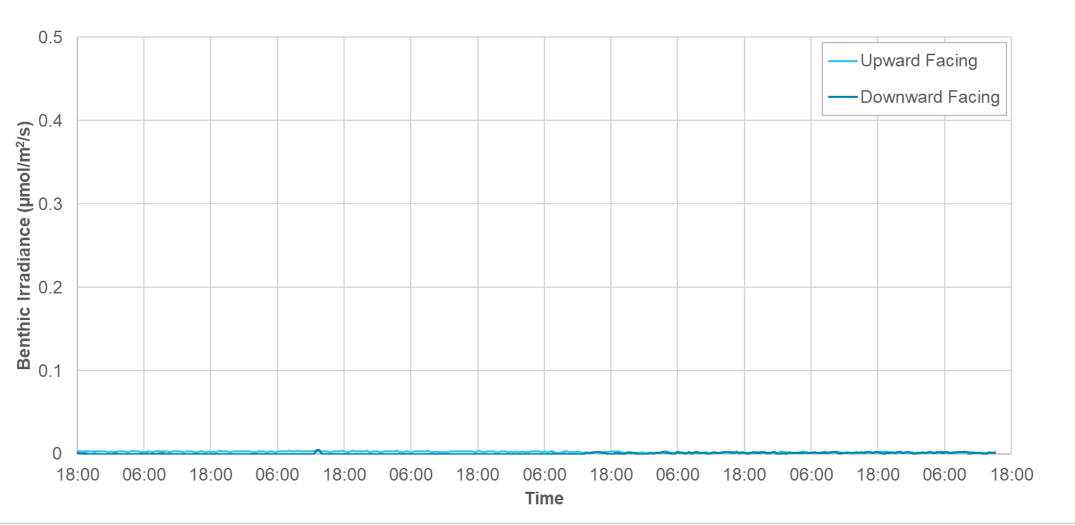


Figure 55. Time series of instantaneous benthic light at Pos-15 from 04/03/2024 to 11/03/2024.

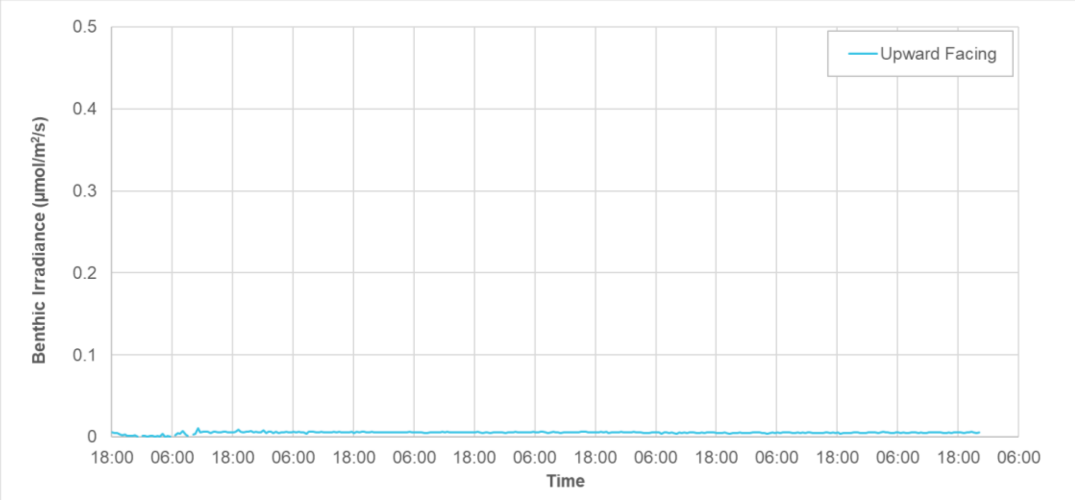


Figure 56. **Time series of instantaneous benthic light at AWAC-06 from 06/03/2024 to 13/03/2024.**

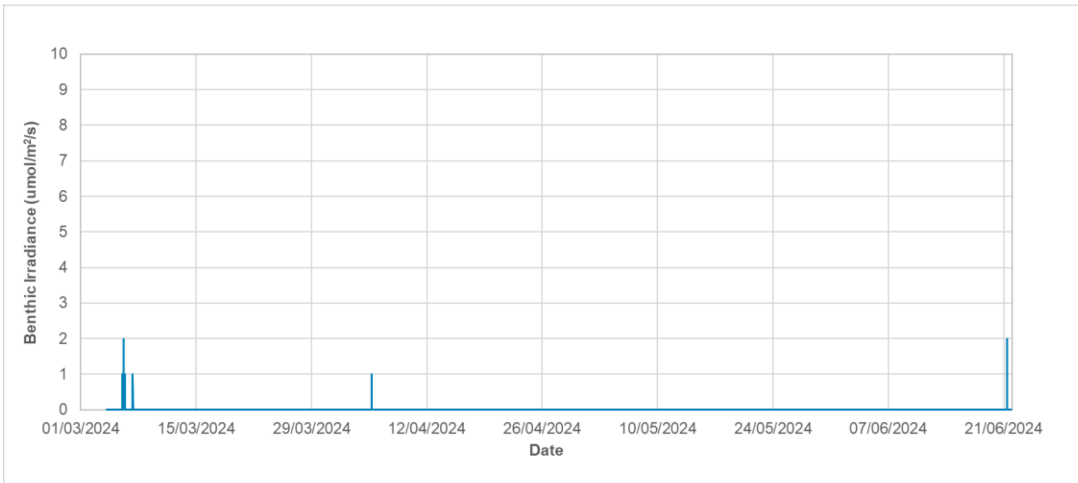


Figure 57. **Time series of instantaneous benthic light at AWAC-09/Pos-12 from 04/03/2024 to 21/06/2024.**

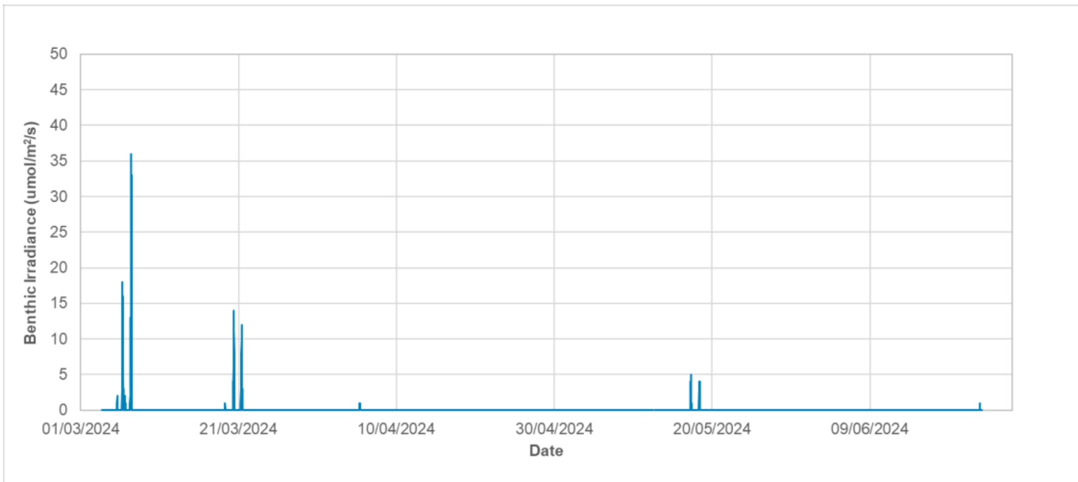


Figure 58. **Time series of instantaneous benthic light at Pos-13 from 03/03/2024 to 23/06/2024.**

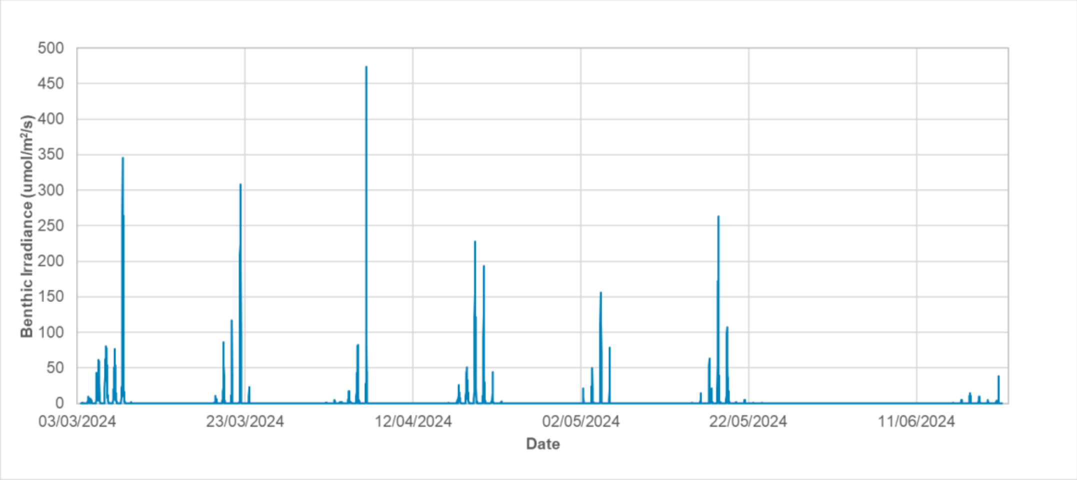


Figure 59. Time series of instantaneous benthic light at Pos-14 from 03/03/2024 to 21/06/2024.

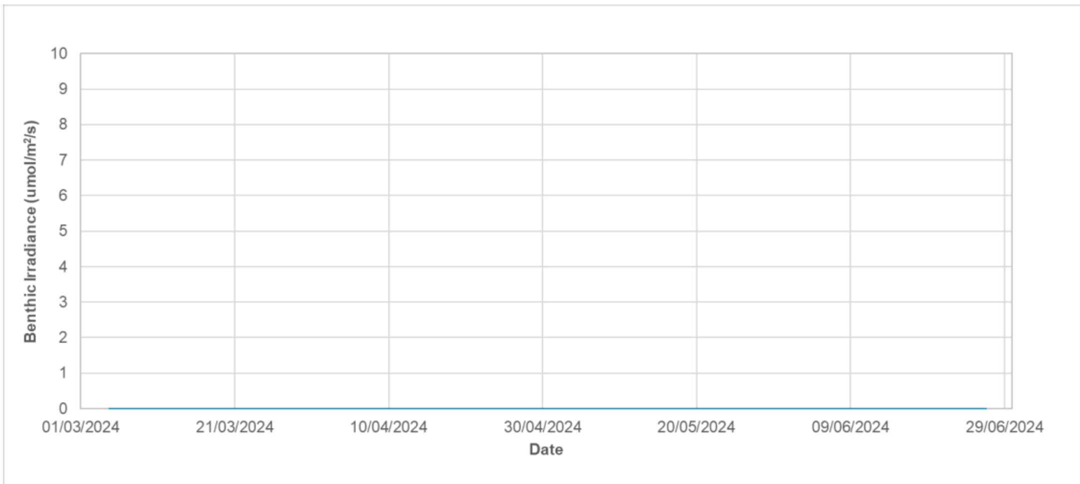


Figure 60. Time series of instantaneous benthic light at Pos-15 from 04/03/2024 to 26/06/2024.

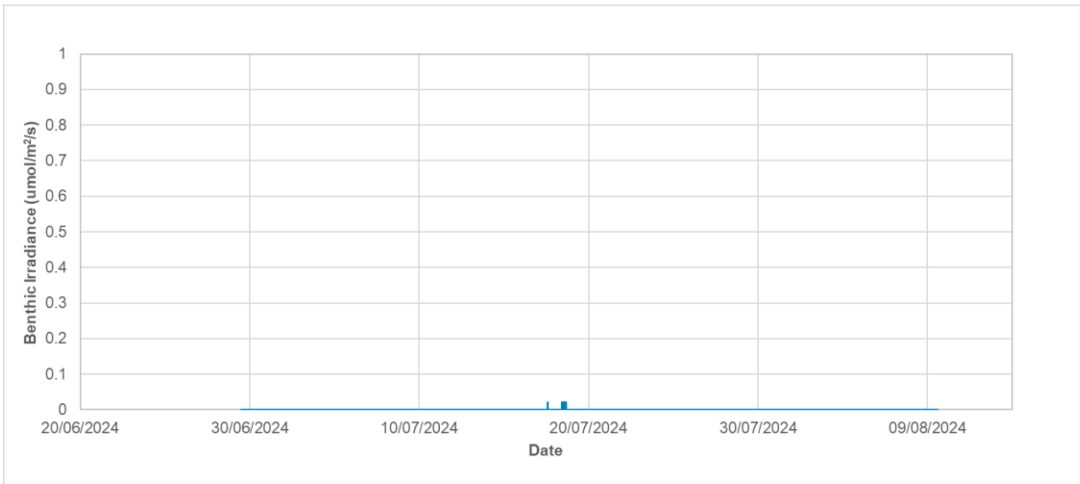


Figure 61. Time series of instantaneous benthic light at AWAC-01 from 29/06/2024 to 09/08/2024.

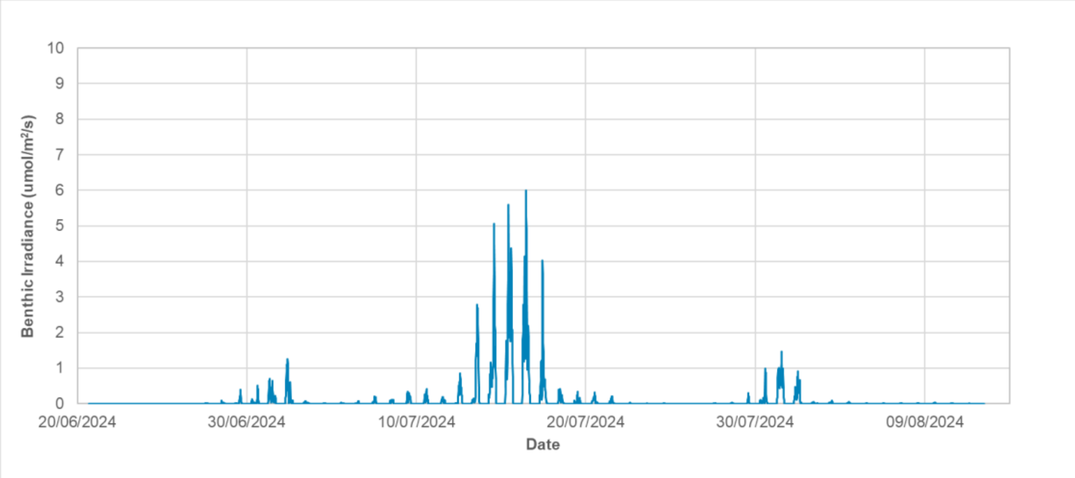


Figure 62. Time series of instantaneous benthic light at AWAC-05 from 20/06/2024 to 12/08/2024.

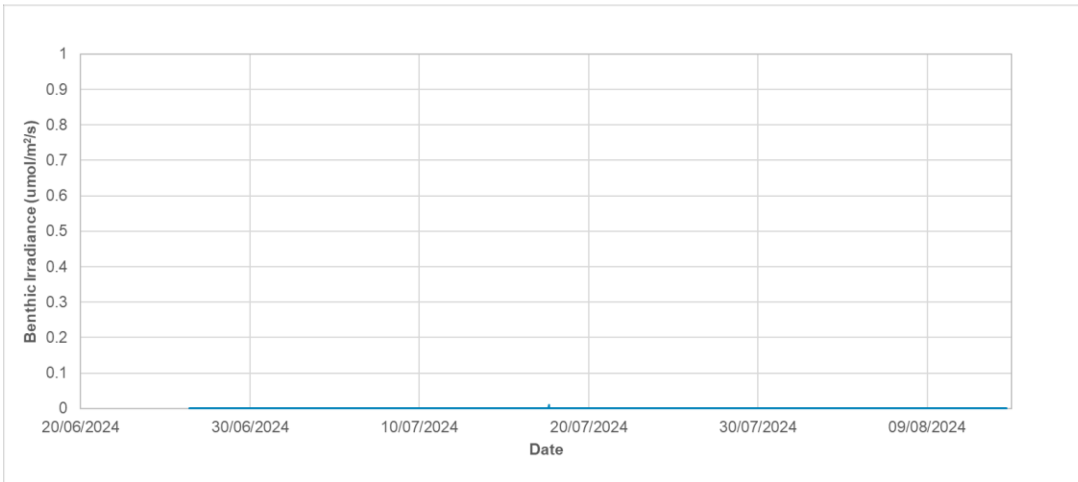


Figure 63. Time series of instantaneous benthic light at AWAC-10 from 26/06/2024 to 13/08/2024.

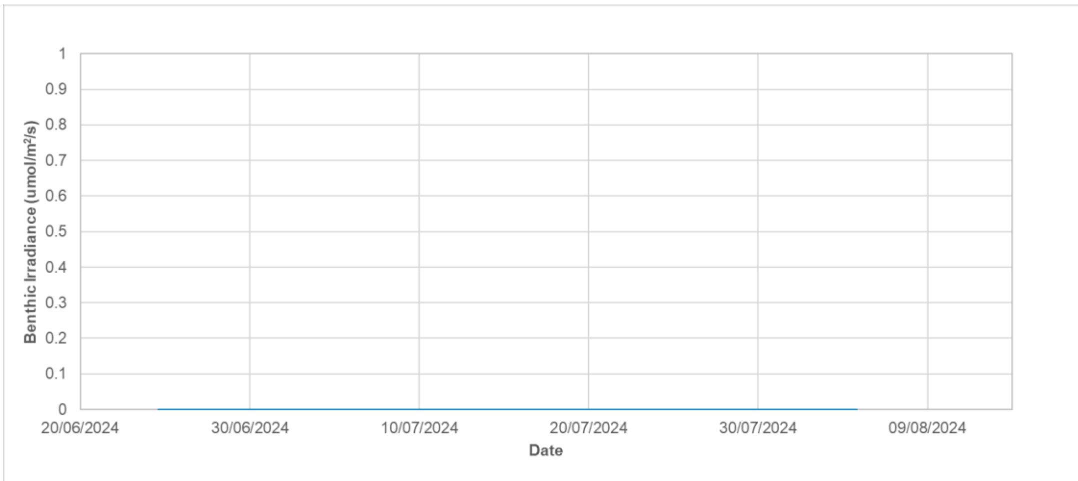


Figure 64. Time series of instantaneous benthic light at AWAC-11 from 24/06/2024 to 04/08/2024.

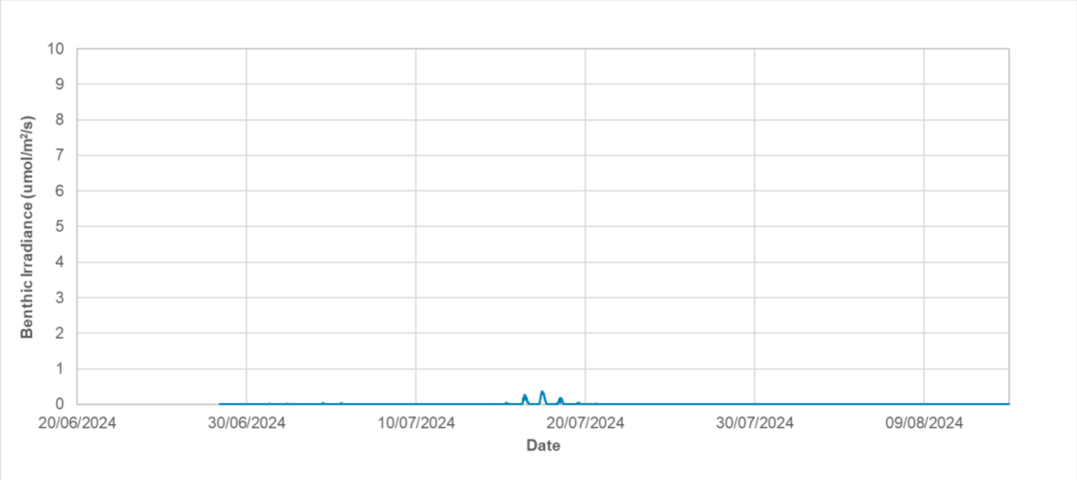


Figure 65. Time series of instantaneous benthic light at Pos-12 from 28/06/2024 to 14/08/2024.

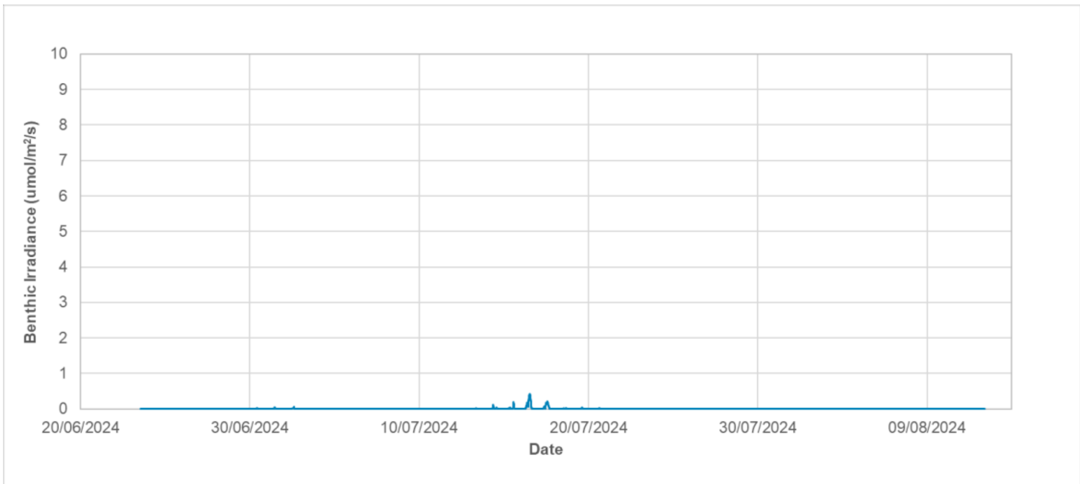


Figure 66. Time series of instantaneous benthic light at Pos-13 from 23/06/2024 to 12/08/2024.

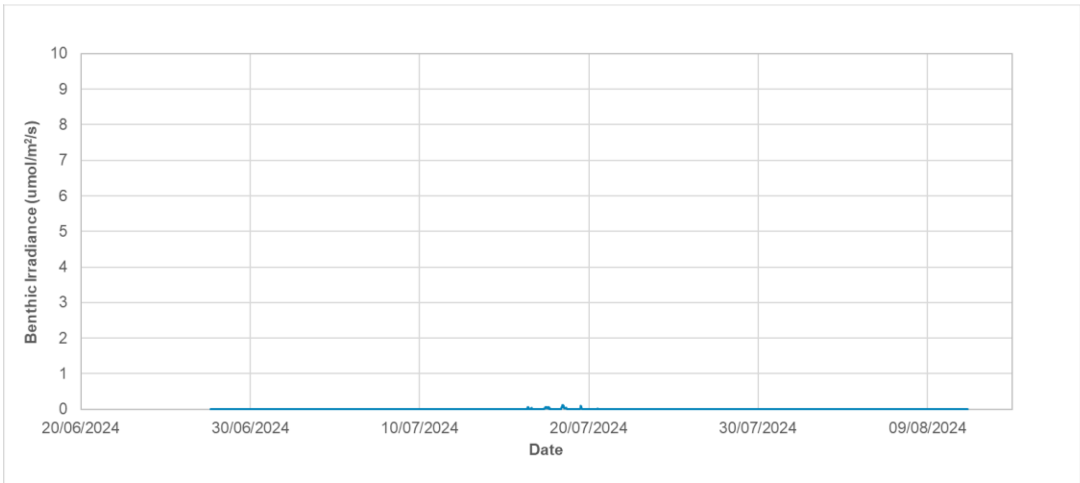


Figure 67. Time series of instantaneous benthic light at Pos-15 from 27/06/2024 to 11/08/2024.

6.1.4. Water Quality

This section details the available benthic water quality data from all of the deployments. The results are plotted in Figure 68 to Figure 90. It should be noted that:

- dissolved oxygen data were only collected up to March 2024;
- at two sites turbidity was negative and therefore removed (AWAC-03 and AWAC-07) and at other sites the turbidity logger became fouled during the deployment (Pos-13 and Pos-15); and
- due to equipment fouling or instrument drop out, there were some sites for which all or periods of salinity data were removed (AWAC-01, AWAC-07, AWAC-10, AWAC-11, Pos-12, Pos-13 and Pos-15).

A statical summary of the measured temperature, salinity and turbidity data at each site over each deployment period is provided in Table 17 and a summary of the measured dissolved oxygen data is provided in Table 18. The data show relatively consistent average temperature values between the sites with average water temperatures ranging from 28 to 30ºC at the end of the wet season (March to May) and remaining just above 24ºC during the dry season (June to August). A minimum salinity of 7.5 psu was measured at the northern entrance to the West Arm (AWAC-08) at the end of the wet season (due to a high river discharge event), while the minimum salinity at King Shoals only dropped down to 23.9 psu over this period. The turbidity varied between the sites, with peak values of around 600 NTU measured at the northern entrance to the West Arm (AWAC-08) and at nearshore sites close to the western and eastern shorelines in CG (Pos-13 and Pos-15). The dissolved oxygen data show that average values remained between 5.3 and 6.6 mg/L, with maximum values ranging from 6.2 and 6.9 mg/L and minimum values ranging from 1.8 to 6.5 mg/L (the lowest value was in the wet season).

Table 17. Statistical summary of the measured water quality data collected at the AWAC and Pos sites from June 2023 to August 2024.

Position	Start Date	Temperature (ºC)			Salinity (PSU)			Turbidity (NTU)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
AWAC-01	09/06/2023	-	-	-	-	-	-	-	-	-
AWAC-04	07/09/2023	-	-	-	-	-	-	-	-	-
AWAC-02	07/09/2023	25.5	25.7	25.6	33.1	33.7	33.5	5	68	31
AWAC-06	08/09/2023	25.7	28.6	27.2	30.9	33.5	32.8	0	84	16
AWAC-03	13/10/2023	28.5	28.9	28.6	30.9	32.8	31.4	-	-	-
AWAC-07	15/10/2023	28.9	32.9	31.0	31.1	34.1	32.7	-	-	-
AWAC-08	02/03/2024	24.6	31.4	28.6	7.5	30.7	23.8	31	597	162
AWAC-11	02/03/2024	28.0	31.3	29.9	15.8	32.7	27.3	10	443	82
AWAC-01	03/03/2024	28.0	31.2	29.8	7.9	33.5	27.3	5	301	40
AWAC-06	06/03/2024	27.8	31.4	29.6	23.0	33.6	28.9	2	417	49
AWAC-09/ Pos-12	04/03/2024	24.7	31.1	28.3	23.9	34.5	30.0	2	249	30
Pos-13	03/03/2024	27.8	31.6	29.7	17.8	32.6	27.0	5	363	62
Pos-14	03/03/2024	24.5	31.5	28.4	19.0	33.7	29.0	1	203	34
Pos-15	04/03/2024	23.6	31.5	28.0	23.6	32.9	28.2	6	628	96
AWAC-07	10/05/2024	23.8	28.0	25.8	23.5	29.4	28.2	6	315	66
AWAC-11	10/05/2024	24.6	28.1	26.2	25.0	30.8	28.6	11	315	79
Pos-13	12/05/2024	23.9	28.2	26.1	-	-	-	11	606	54
AWAC-05	20/06/2024	23.2	25.8	24.3	23.5	30.5	29.3	3	71	17
AWAC-11	24/06/2024	23.6	25.0	24.3	27.6	31.1	29.9	6	207	37
AWAC-10	26/06/2024	23.3	25.0	24.2	30.8	32.2	31.8	5	163	36
AWAC-01	29/06/2024	23.5	24.8	24.2	30.1	32.4	31.4	3	100	24
Pos-12	28/06/2024	23.5	25.0	24.2	32.5	33.7	33.2	4	64	17
Pos-13	23/06/2024	23.3	25.4	24.3	28.2	31.3	30.0	5	164	27
Pos-14	21/06/2024	23.6	25.4	24.3	26.9	32.0	30.2	3	95	22
Pos-15	27/06/2024	22.9	25.2	24.2	25.8	30.9	30.0	10	235	48

Table 18. Statistical summary of the measured dissolved oxygen data collected at the AWAC sites from June 2023 to March 2024.

Position	Start Date	Dissolved Oxygen (mg/L)		
		Min	Max	Mean
AWAC-01	09/06/2023			
AWAC-04	07/09/2023			
AWAC-02	07/09/2023	6.52	6.58	6.55
AWAC-06	08/09/2023	5.57	6.89	6.44
AWAC-03	13/10/2023	6.15	6.38	6.29
AWAC-07	15/10/2023	1.75	6.22	5.27

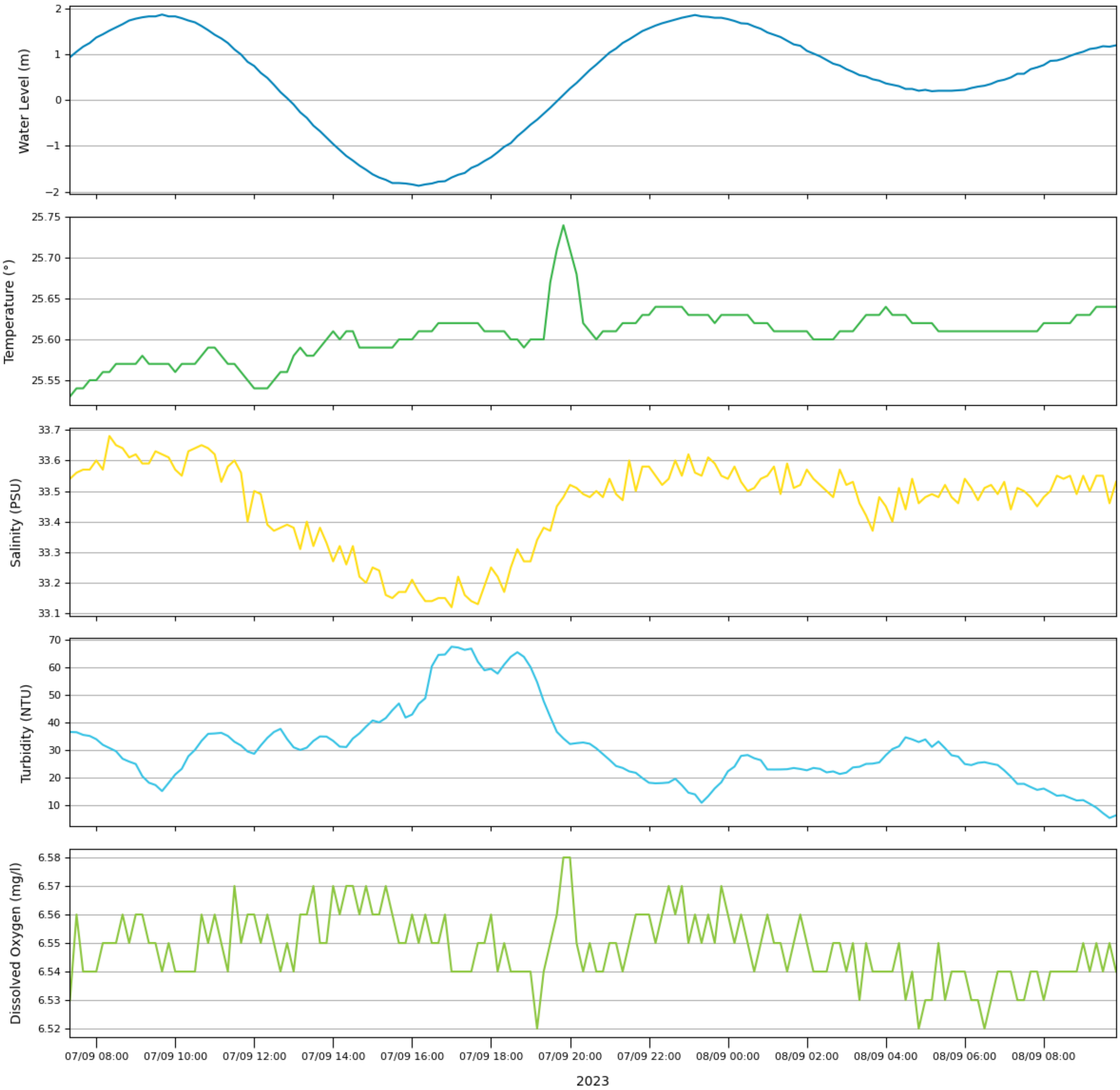


Figure 68. Time series of water level, temperature, salinity and turbidity measured at AWAC-02 in September 2023.

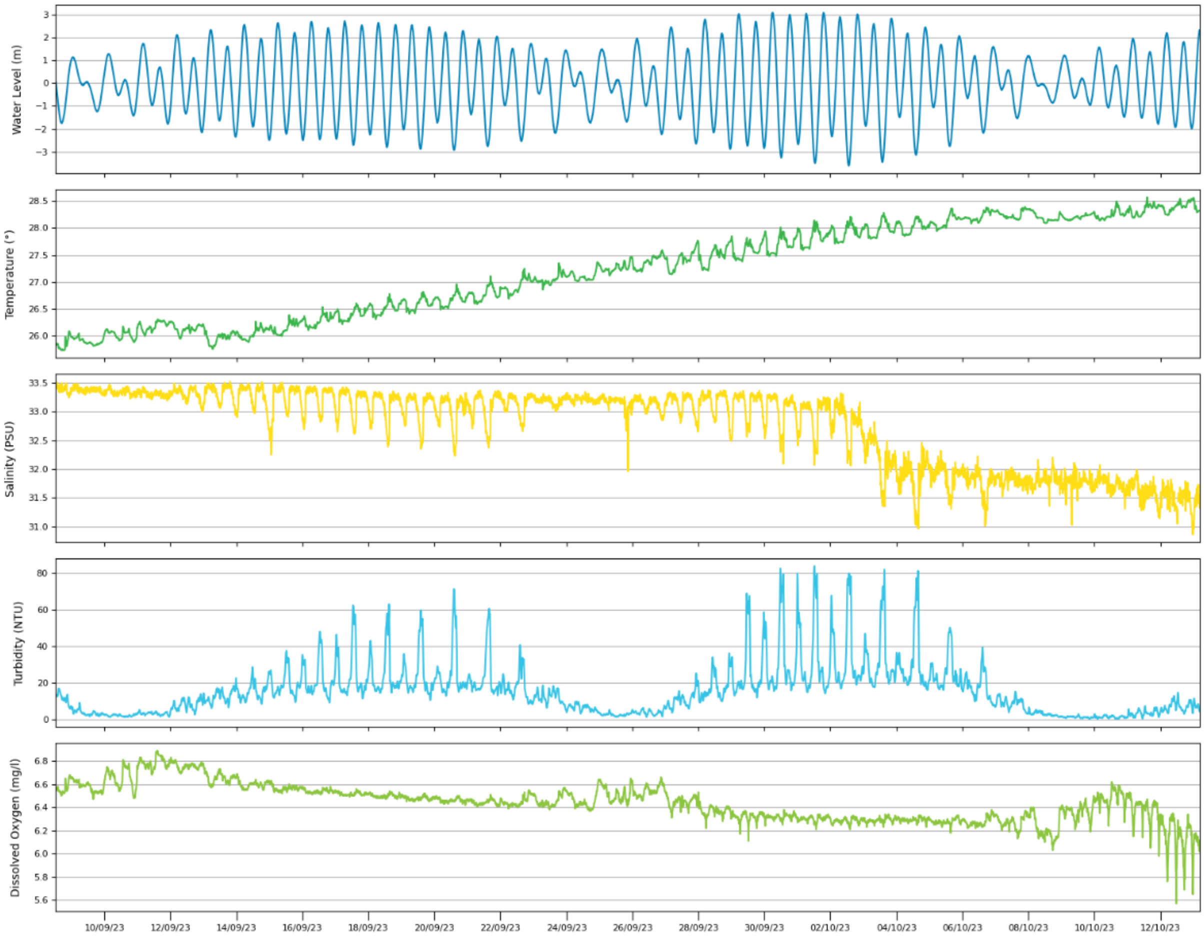


Figure 69. Time series of water level, temperature, salinity, turbidity and dissolved oxygen measured at AWAC-06 from September to October 2023.

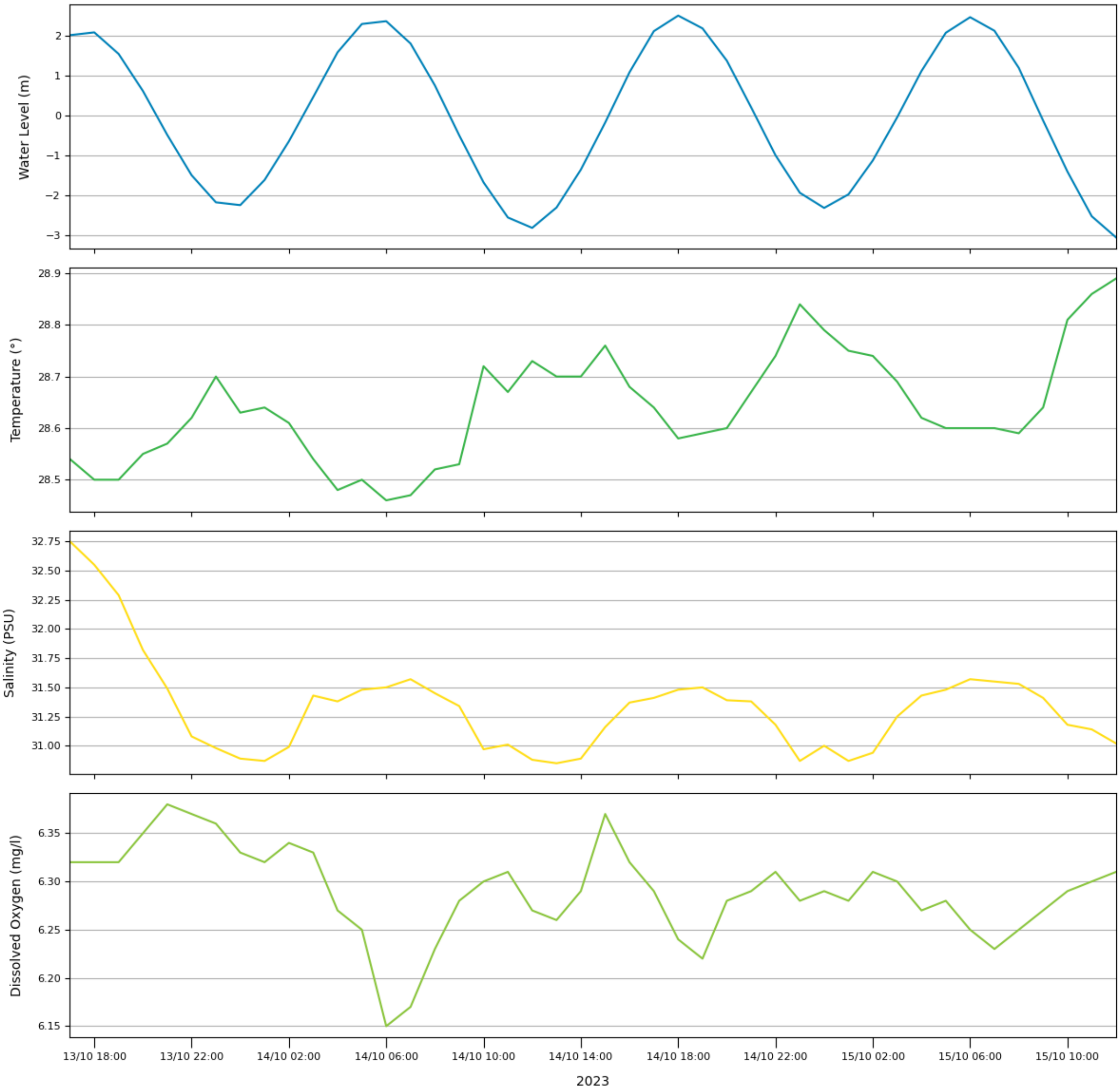


Figure 70. Time series of water level, temperature, salinity and dissolved oxygen measured at AWAC-03 in October 2023.

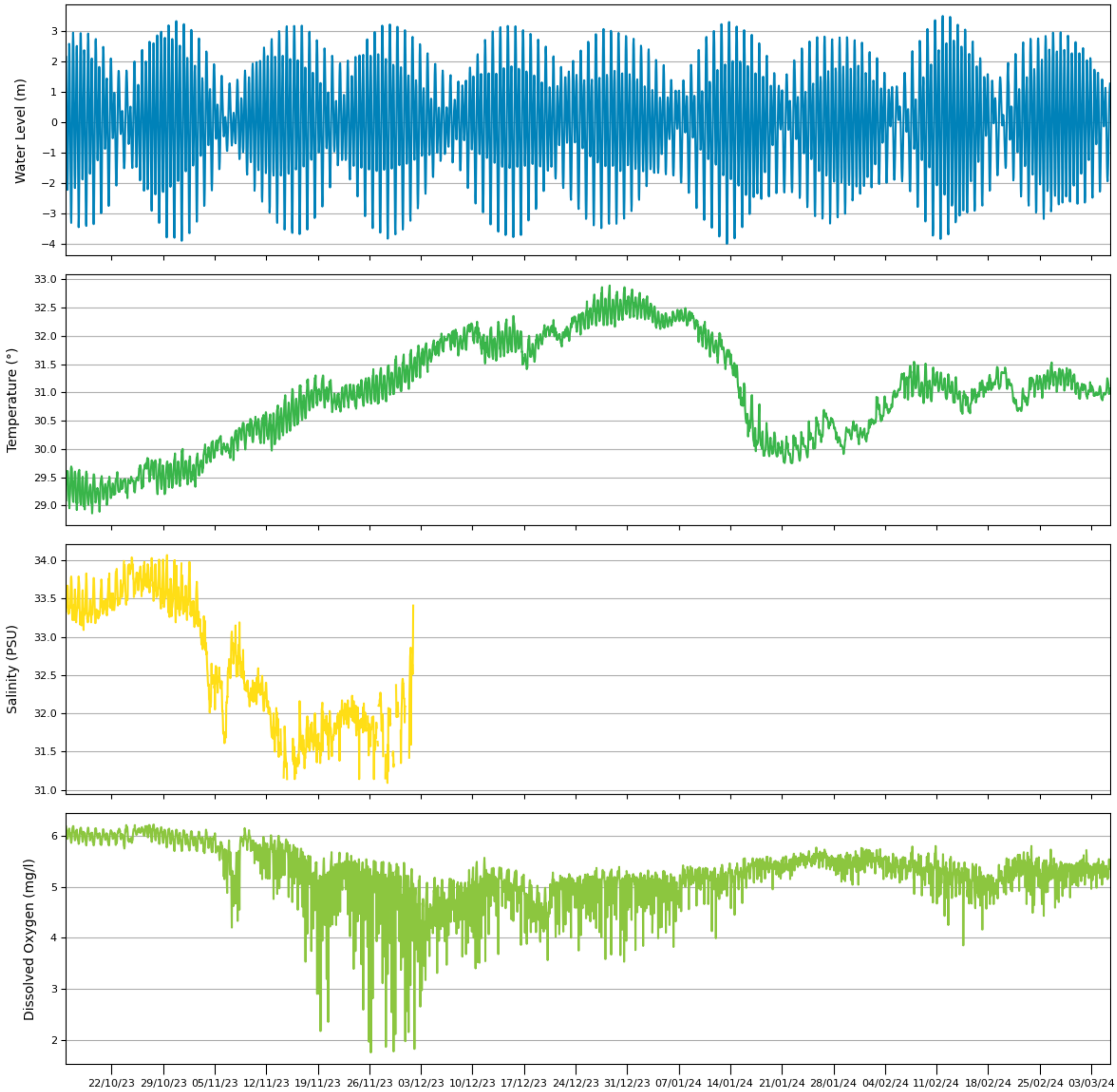


Figure 71. Time series of water level, temperature, salinity and dissolved oxygen measured at AWAC-07 over the whole deployment period from October 2023 to March 2024.

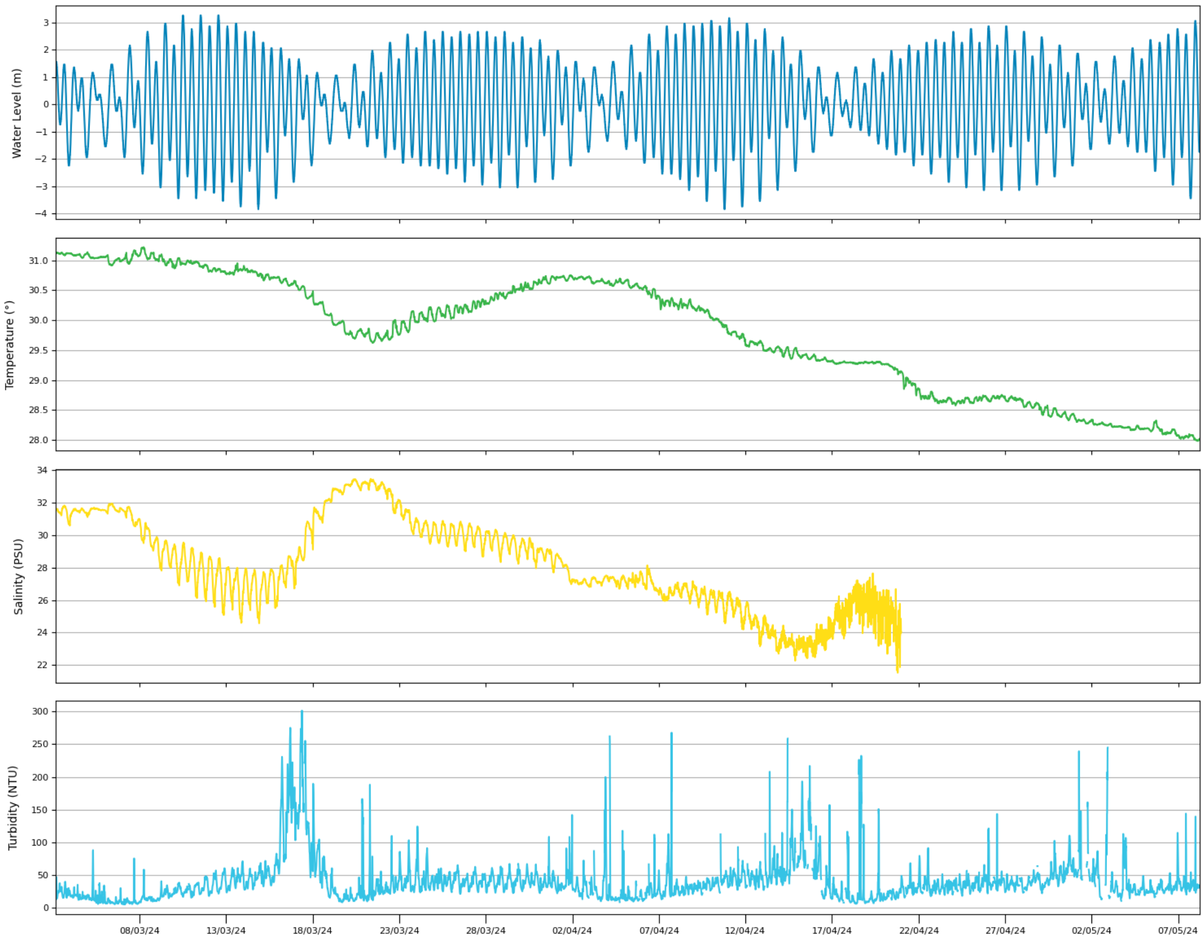


Figure 72. Time series of water level, temperature, salinity and turbidity measured at AWAC-01 over the whole deployment period from March to May 2024.

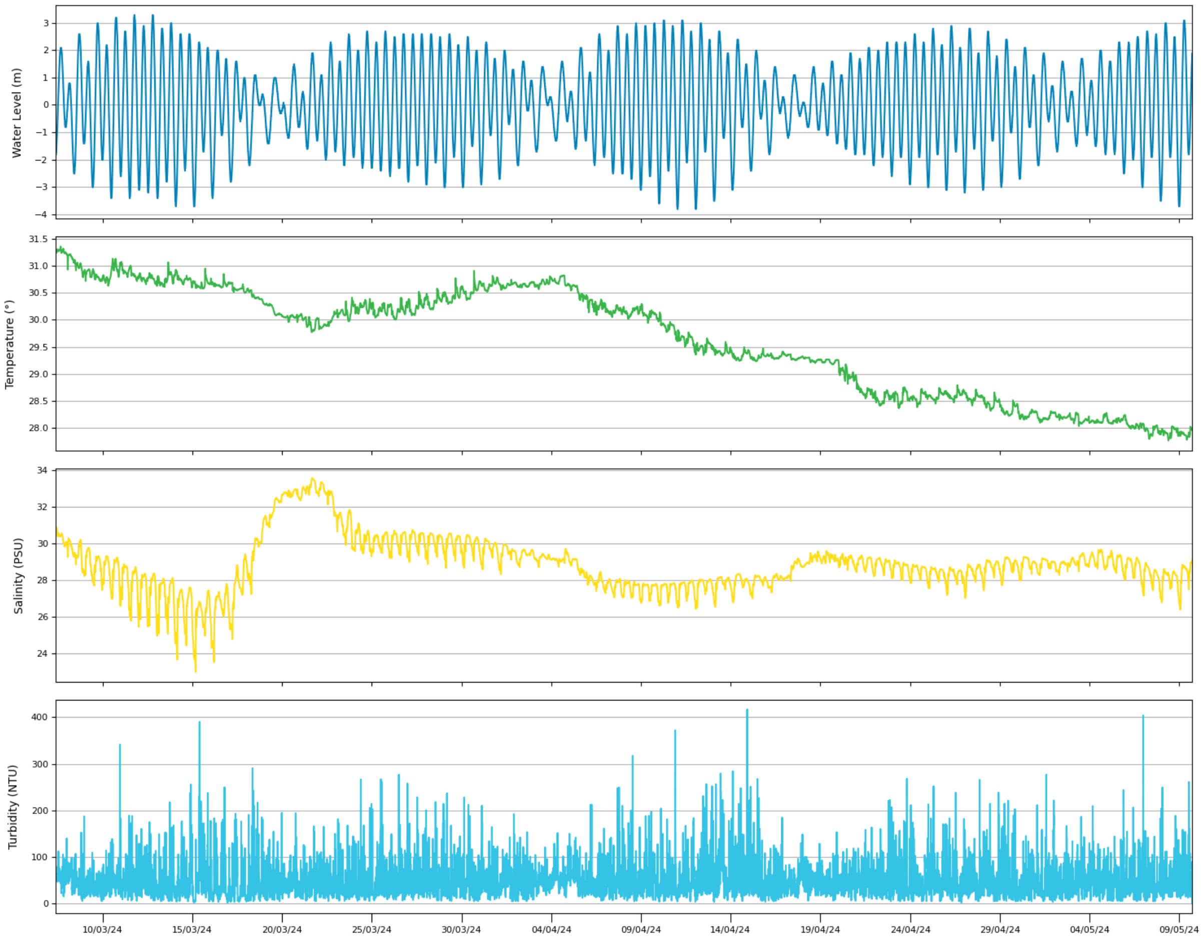


Figure 73. Time series of water level, temperature, salinity and turbidity measured at AWAC-06 over the whole deployment period from March to May 2024.

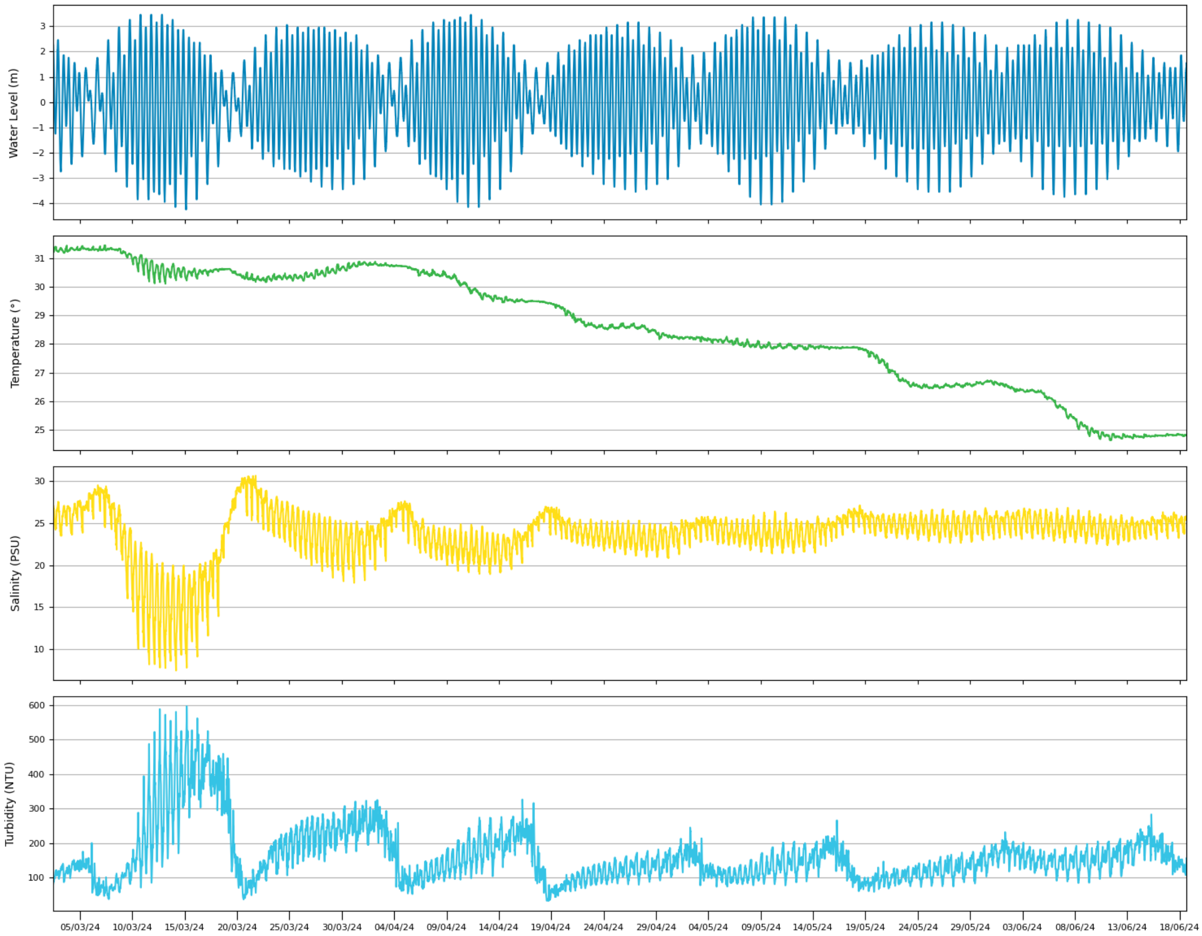


Figure 74. Time series of water level, temperature, salinity and turbidity measured at AWAC-08 over the whole deployment period from March to June 2024.

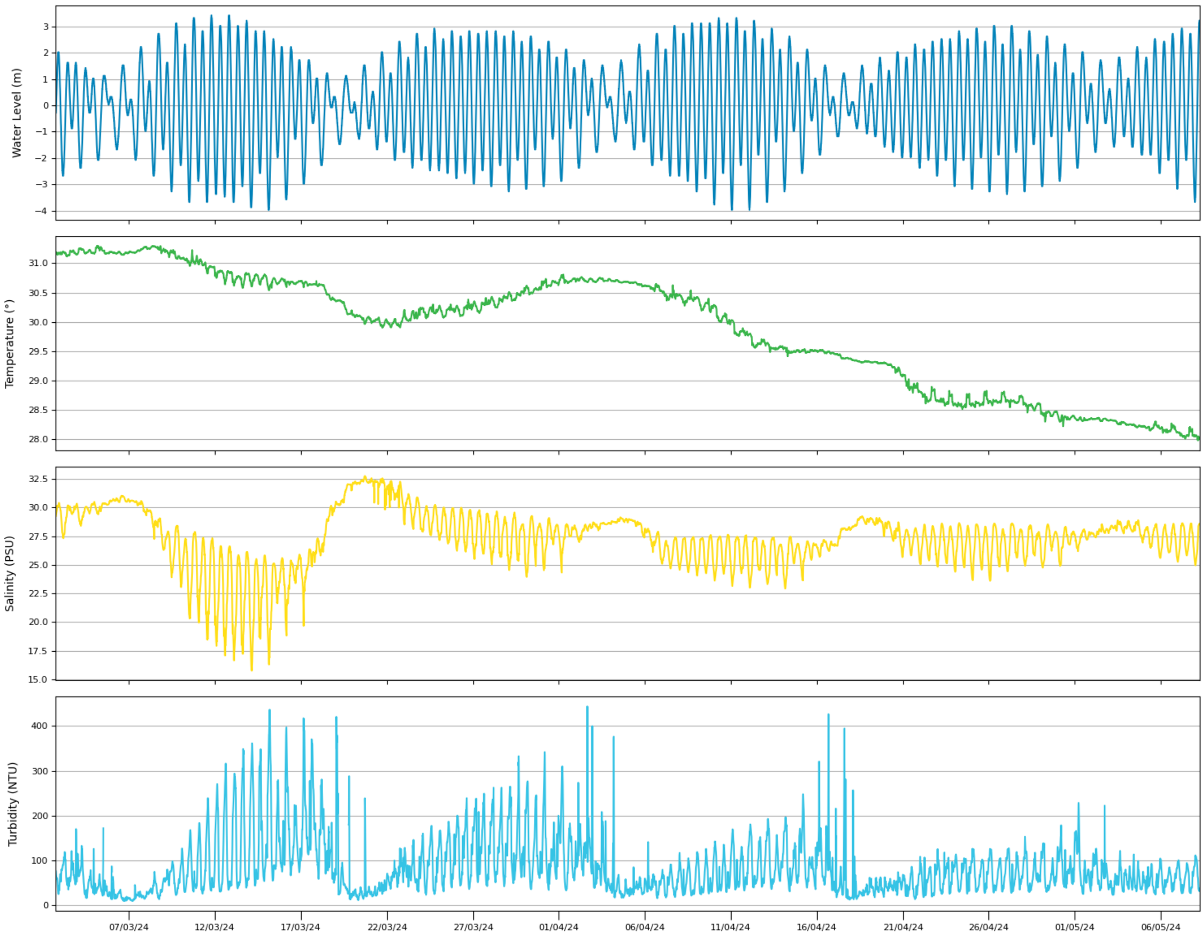


Figure 75. **Time series of water level, temperature, salinity and turbidity measured at AWAC-11 over the whole deployment period from March to May 2024.**

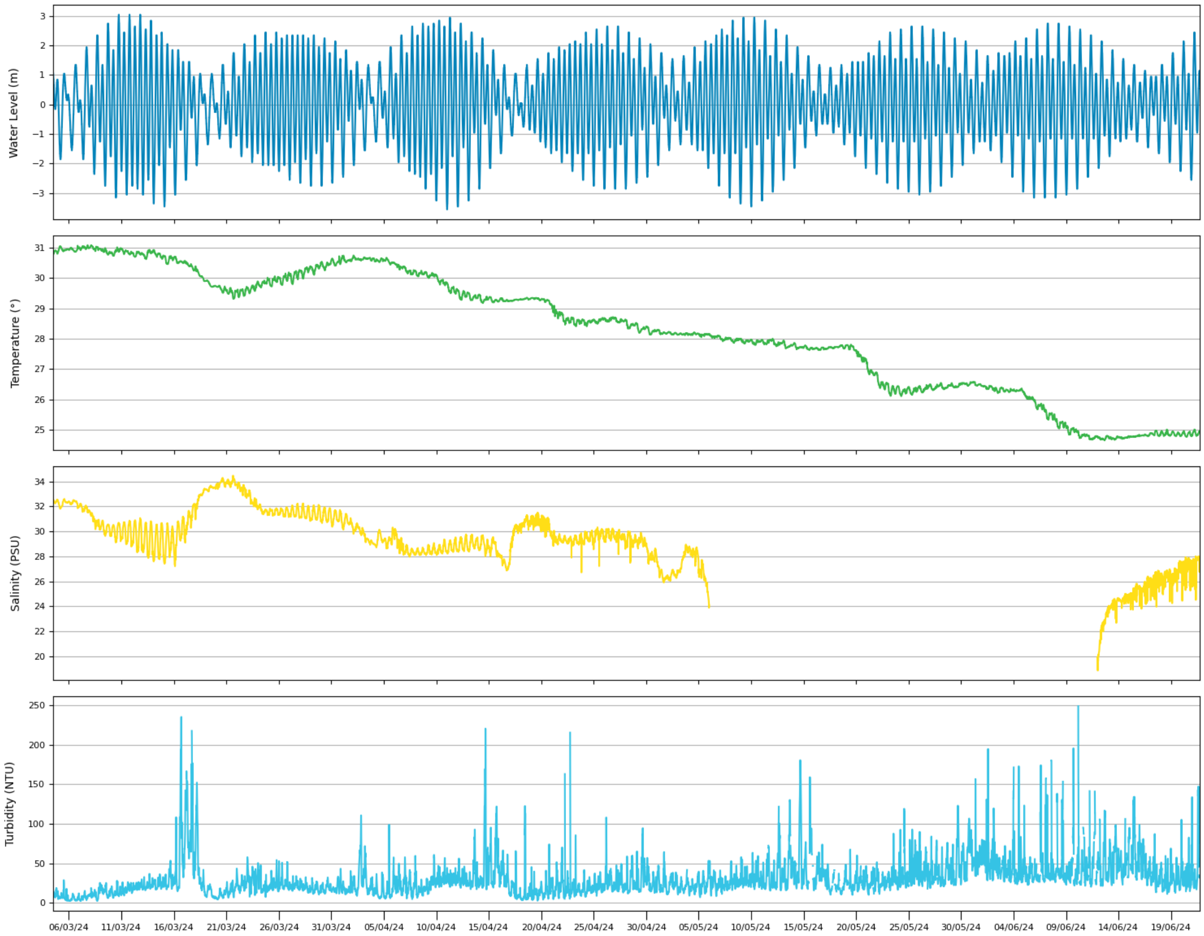


Figure 76. Time series of water level, temperature, salinity and turbidity measured at AWAC-09 / Pos-12 over the whole deployment period from March to June 2024.

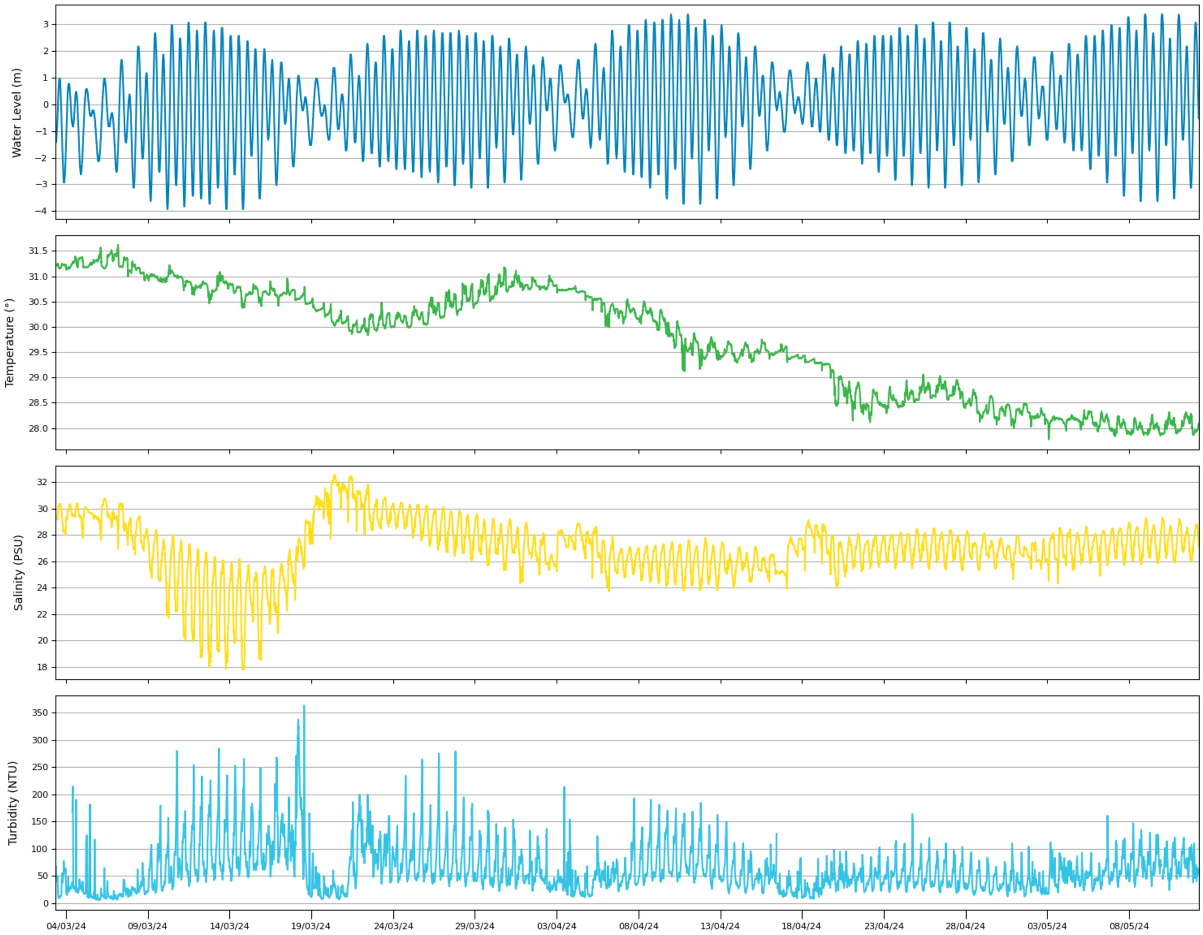


Figure 77. **Time series of water level, temperature, salinity and turbidity measured at Pos-13 over the whole deployment period from March to May 2024.**

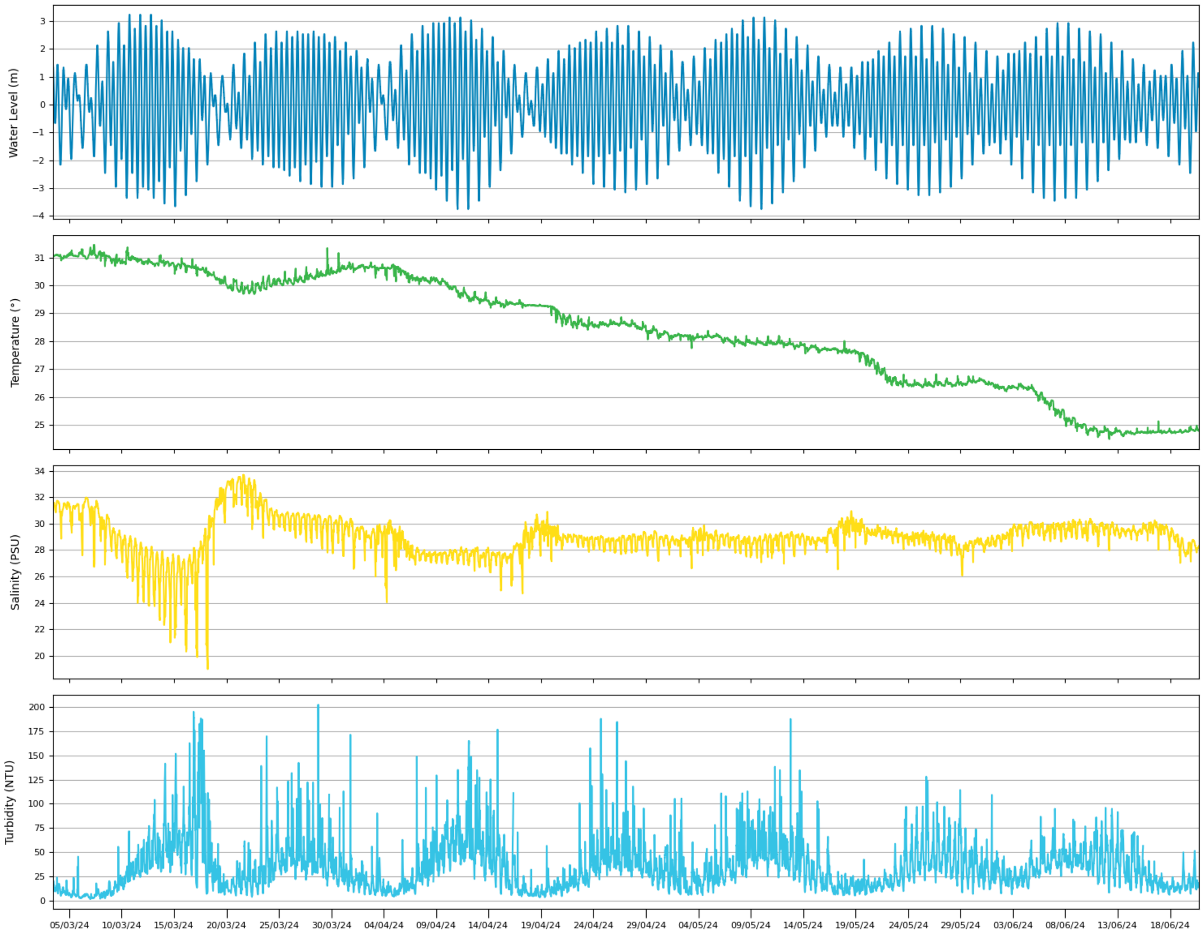


Figure 78. Time series of water level, temperature, salinity and turbidity measured at Pos-14 over the whole deployment period from March to June 2024.

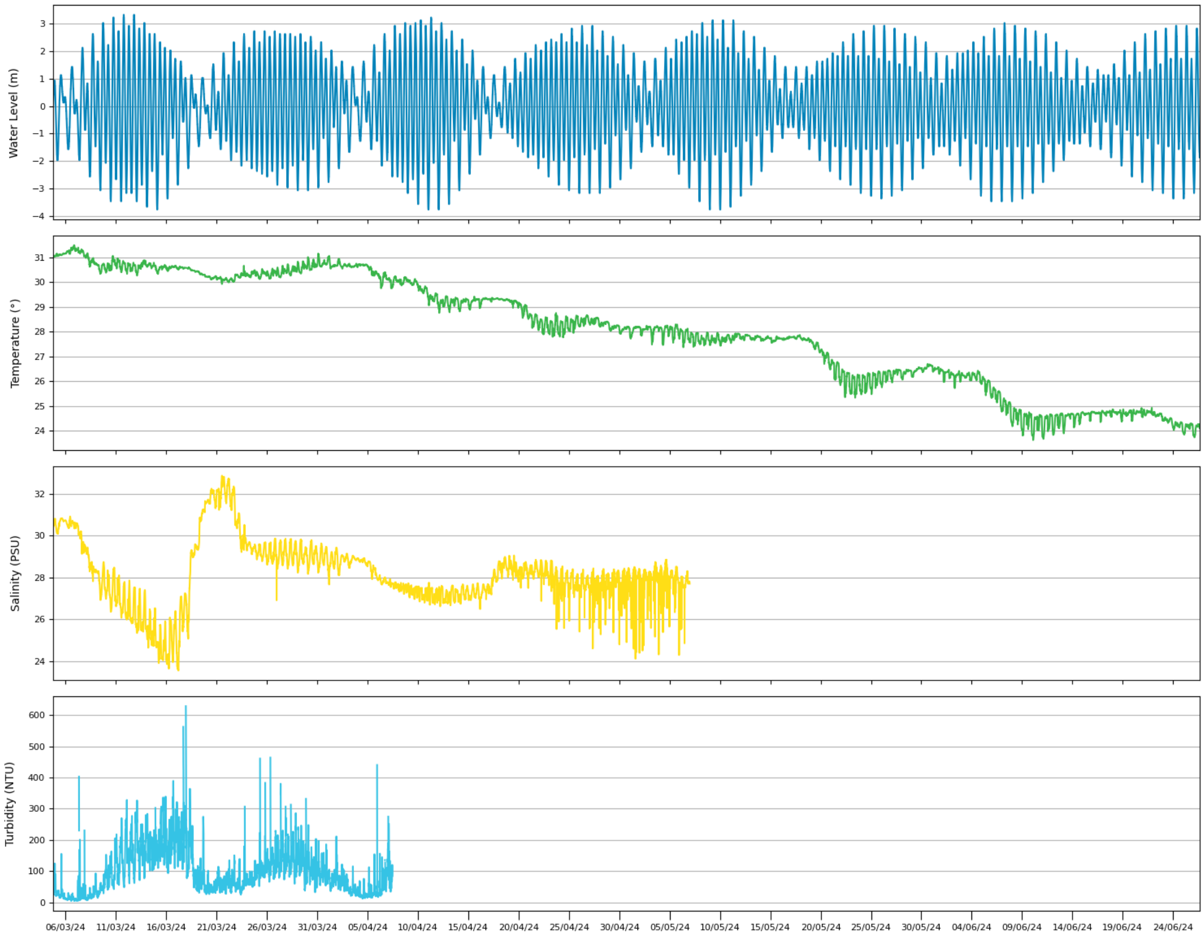


Figure 79. **Time series of water level, temperature, salinity and turbidity measured at Pos-15 over the whole deployment period from March to June 2024.**

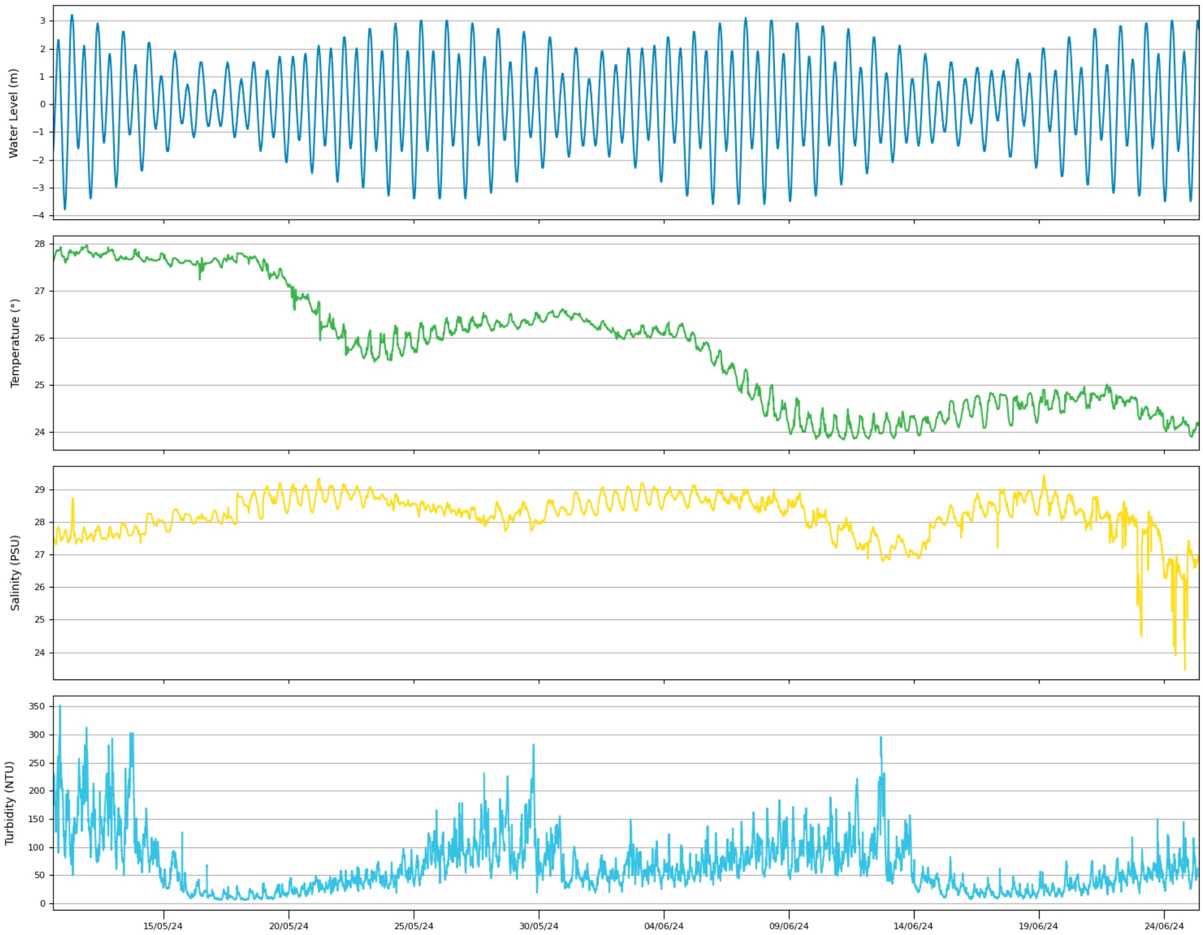


Figure 80. Time series of water level, temperature, salinity and turbidity measured at AWAC-07 over the whole deployment period from May to June 2024.

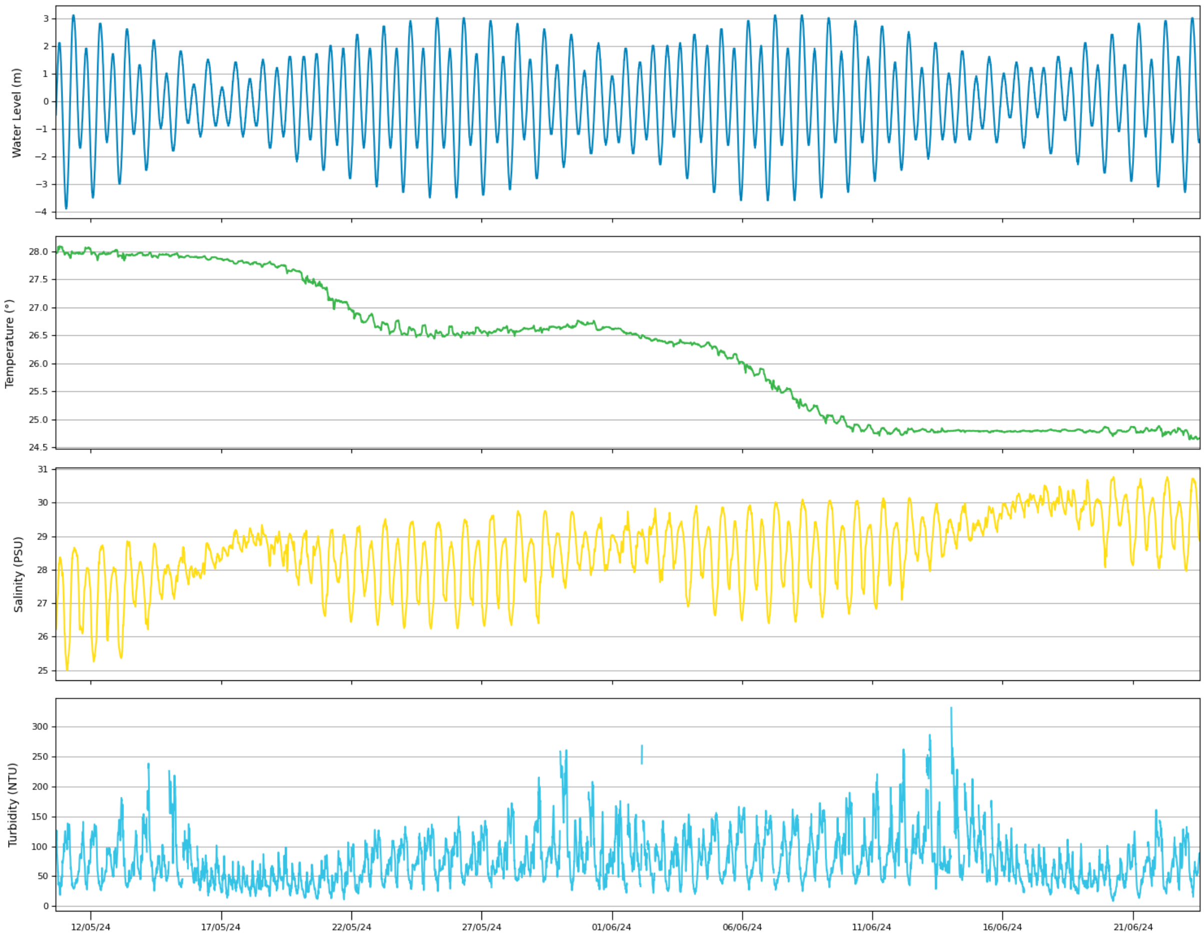


Figure 81. **Time series of water level, temperature, salinity and turbidity measured at AWAC-11 over the whole deployment period from May to June 2024.**

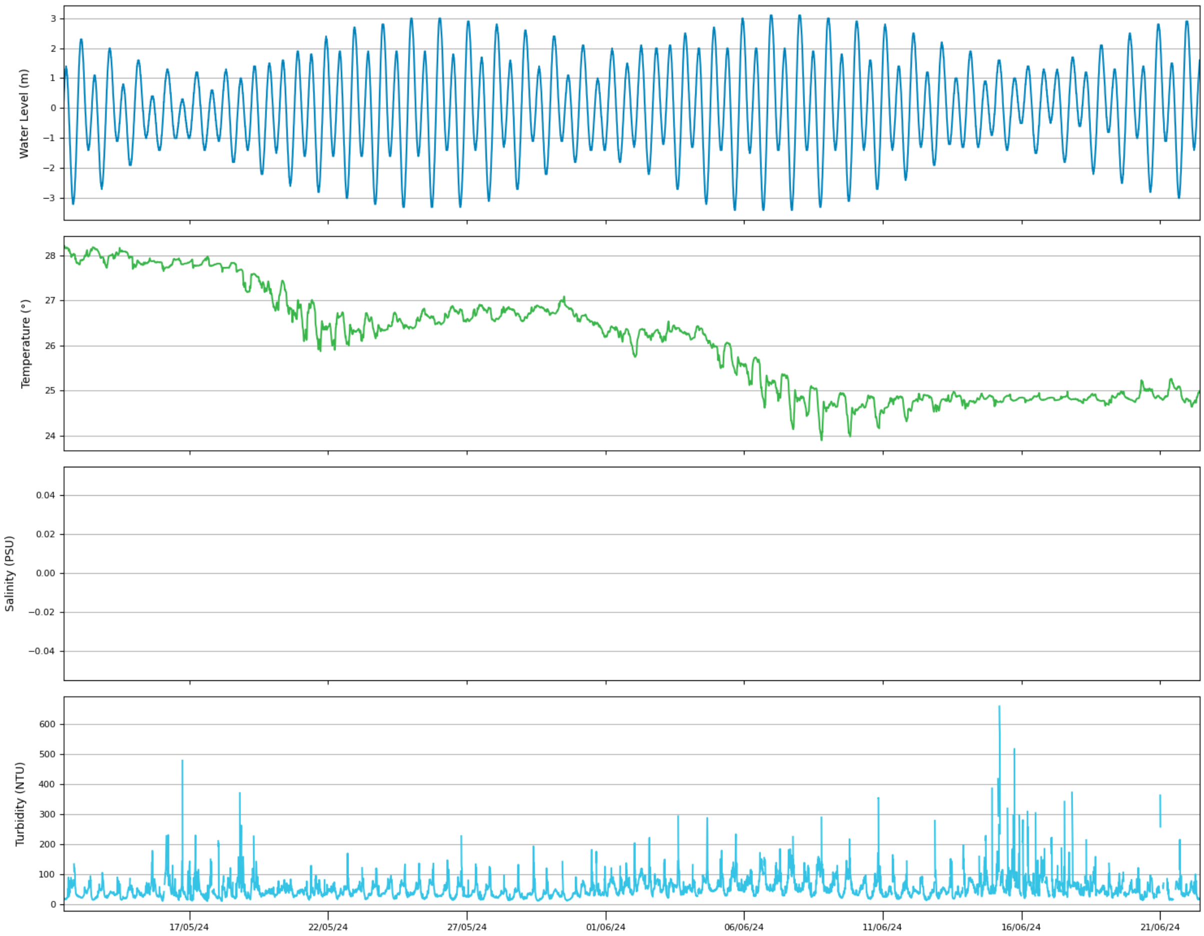


Figure 82. Time series of water level, temperature, salinity and turbidity measured at Pos-13 over the whole deployment period from May to June 2024.

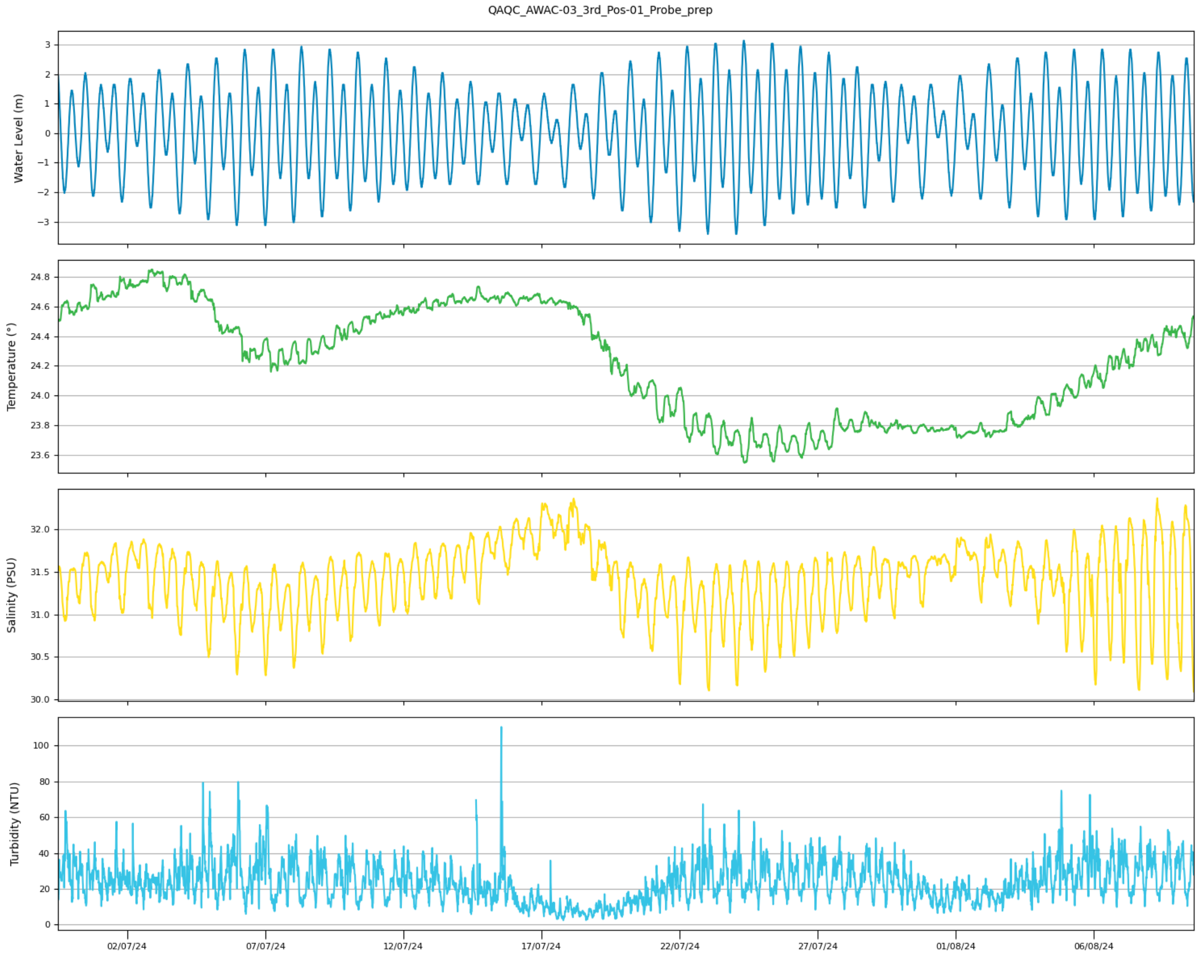


Figure 83. **Time series of water level, temperature, salinity and turbidity measured at AWAC-01 over the whole deployment period from June to August 2024.**

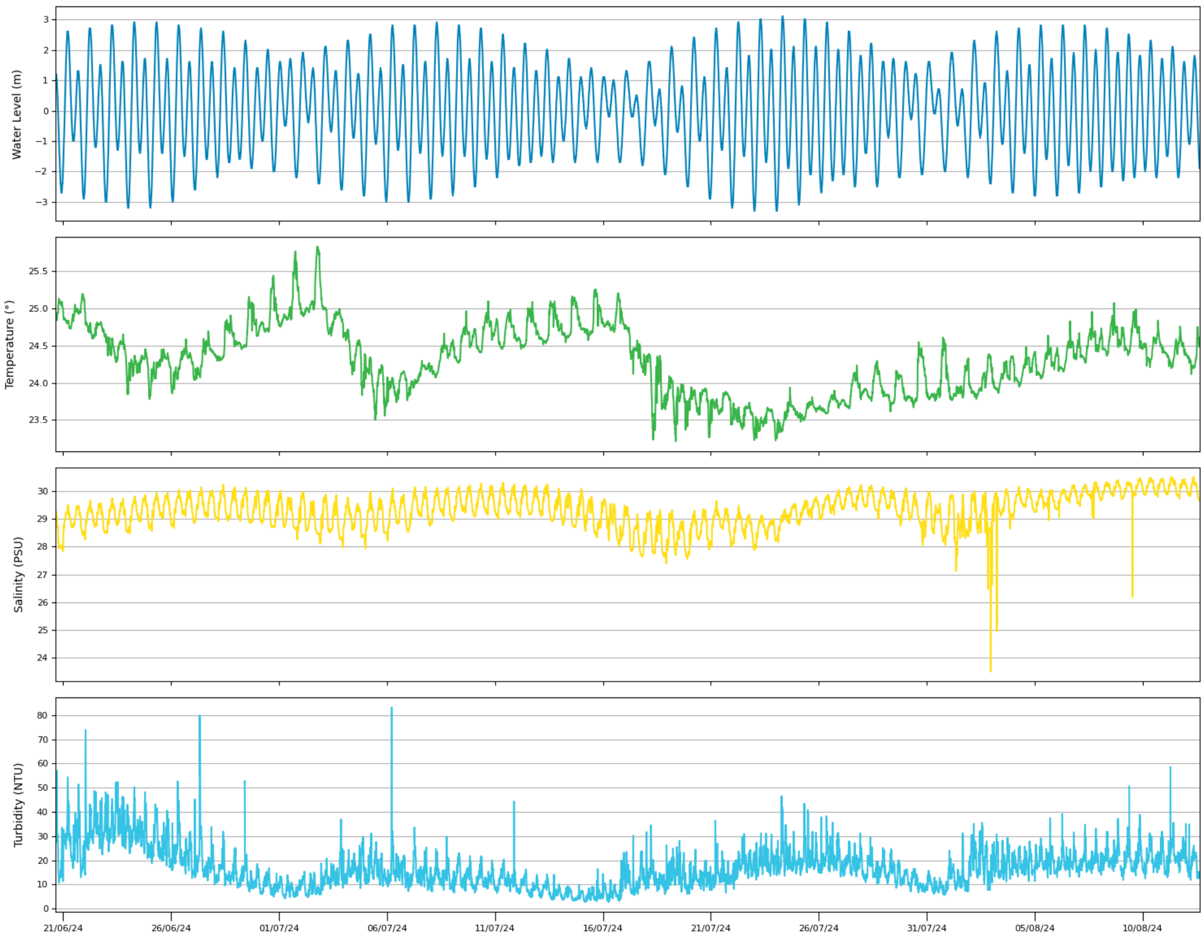


Figure 84. Time series of water level, temperature, salinity and turbidity measured at AWAC-05 over the whole deployment period from June to August 2024.

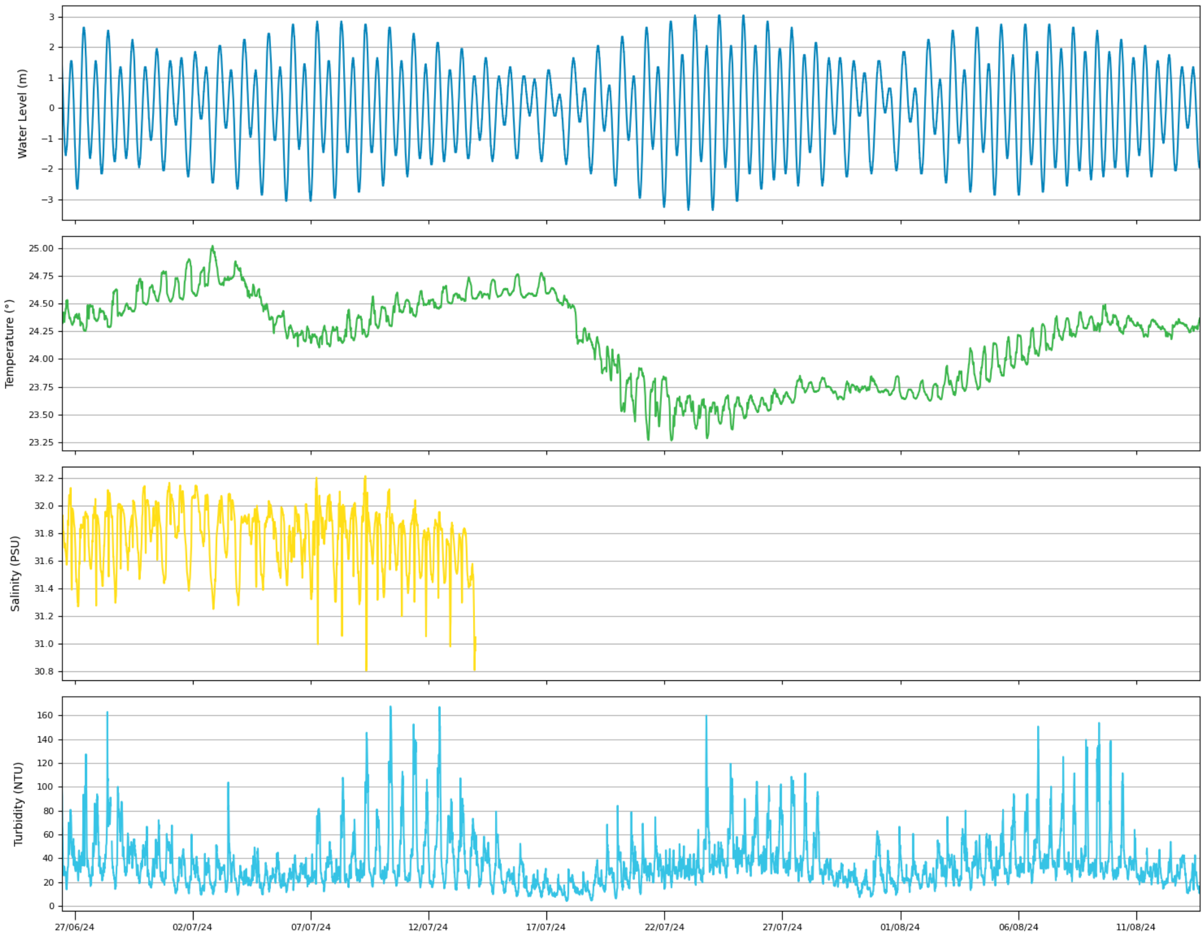


Figure 85. Time series of water level, temperature, salinity and turbidity measured at AWAC-10 over the whole deployment period from June to August 2024.

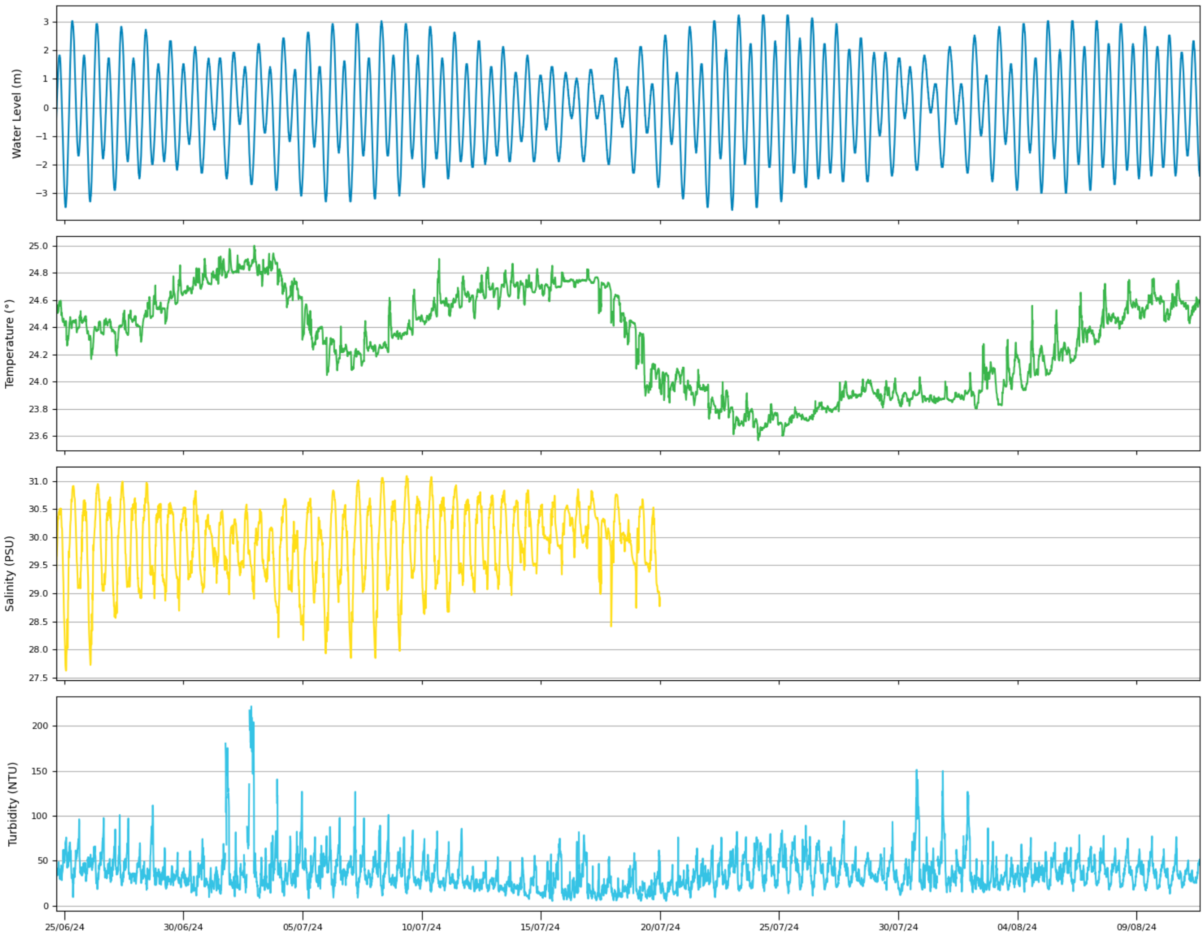


Figure 86. Time series of water level, temperature, salinity and turbidity measured at AWAC-11 over the whole deployment period from June to August 2024.

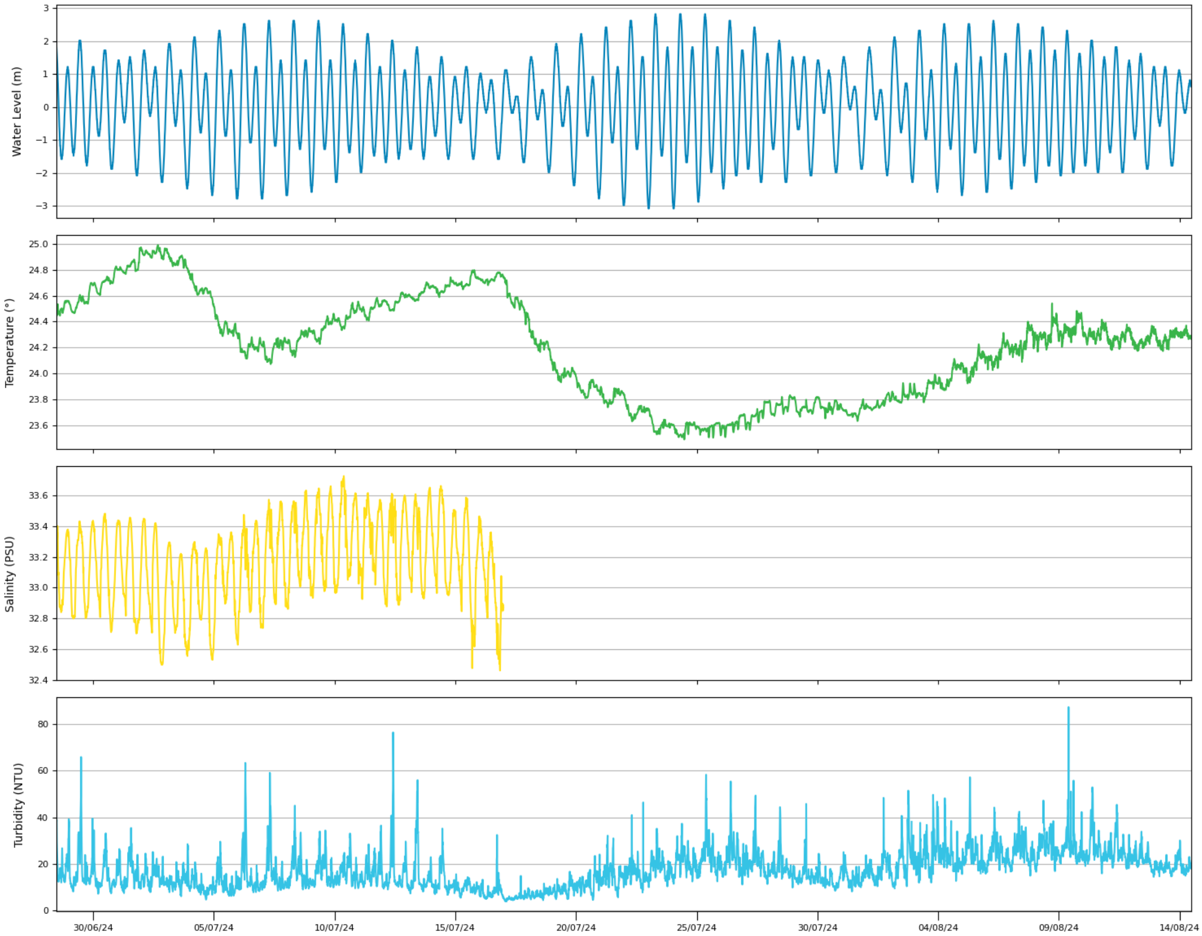


Figure 87. Time series of water level, temperature, salinity and turbidity measured at Pos-12 over the whole deployment period from June to August 2024.

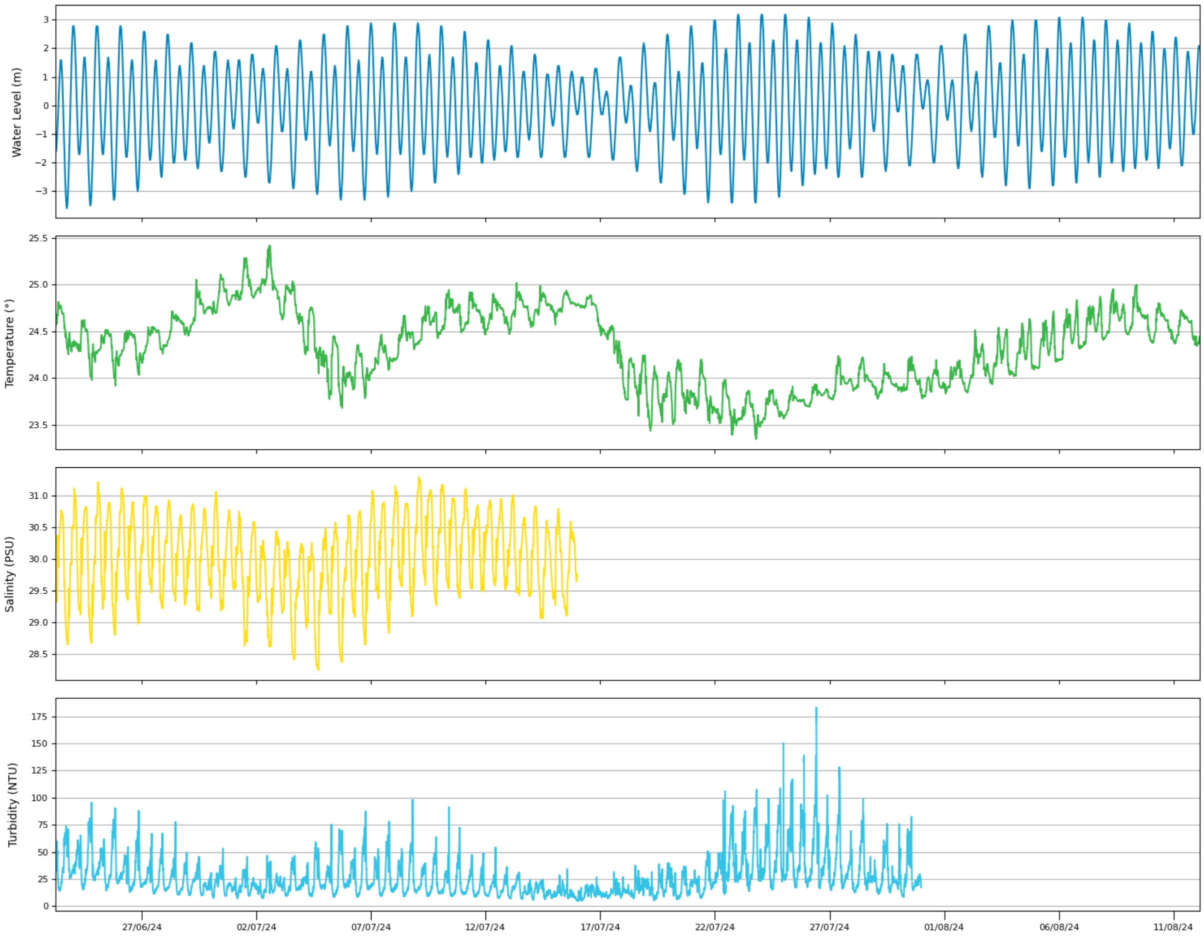


Figure 88. **Time series of water level, temperature, salinity and turbidity measured at Pos-13 over the whole deployment period from June to August 2024.**

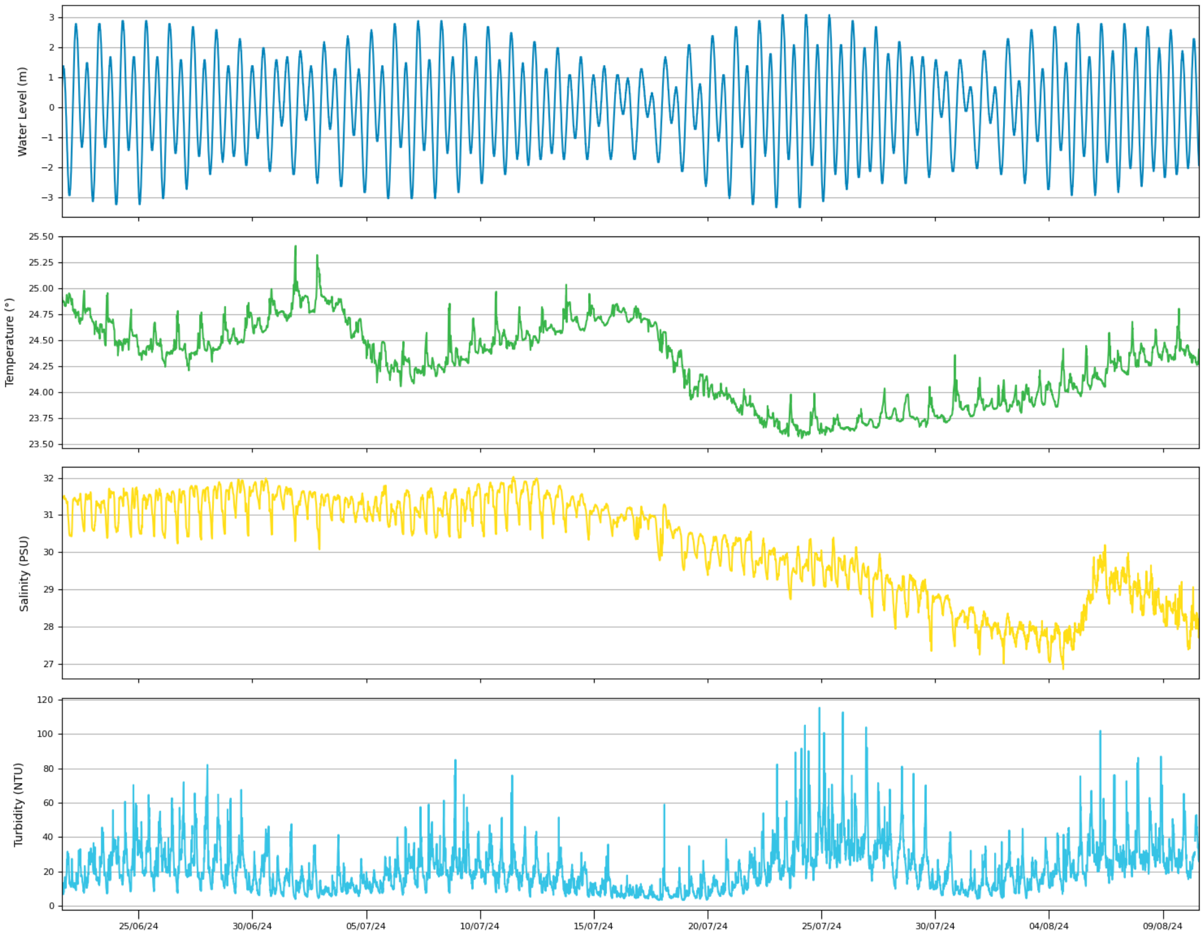


Figure 89. **Time series of water level, temperature, salinity and turbidity measured at Pos-14 over the whole deployment period from June to August 2024.**

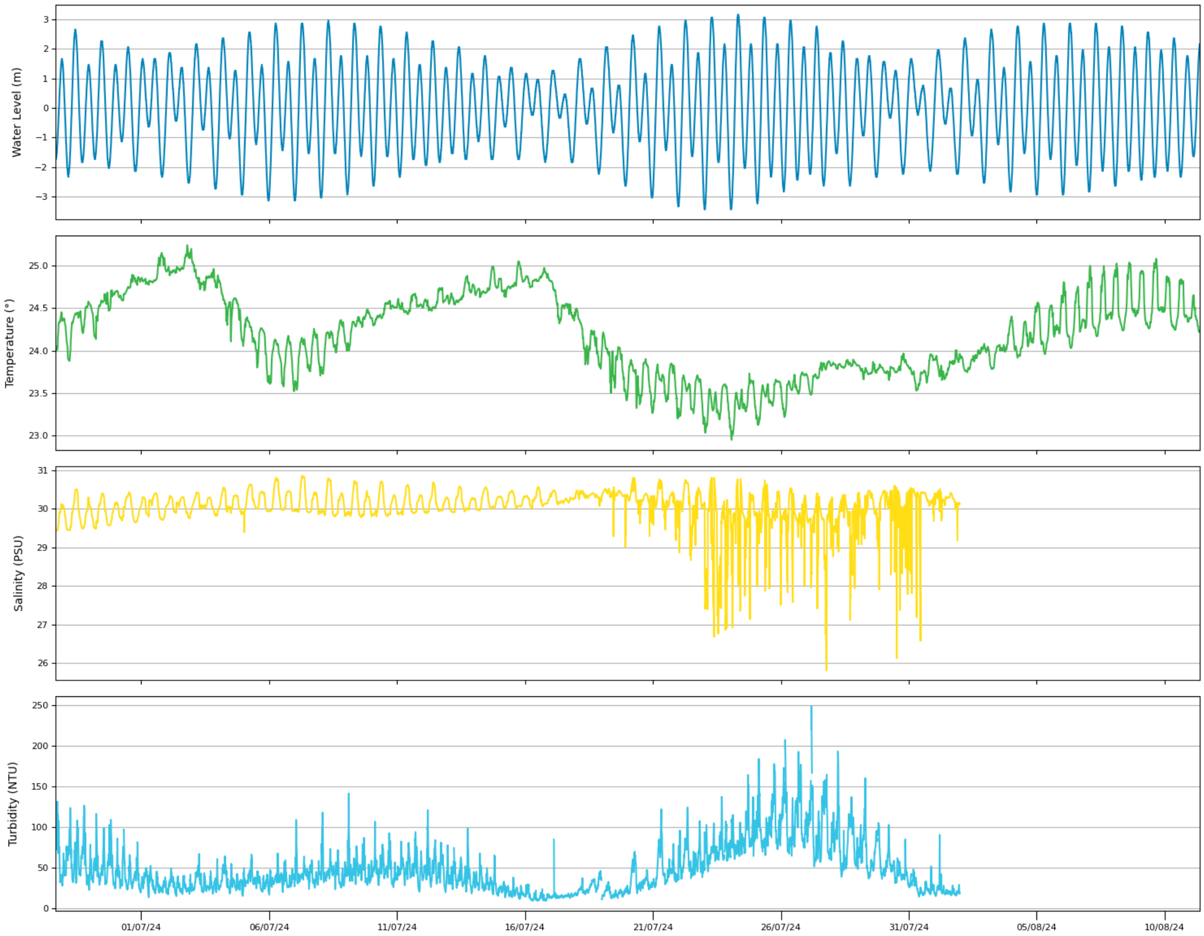


Figure 90. Time series of water level, temperature, salinity and turbidity measured at Pos-15 over the whole deployment period from June to August 2024.

6.2. Sand Exploration Survey Feb-Mar 2023

6.2.1. Sidescan Sonar and Sub-Bottom Profiling

Results from the sidescan sonar and sub-bottom profiling undertaken as part of the 2023 exploratory campaign were used to provide a better understanding of the surface sediment properties within Block 4. Results from these activities are shown in Figure 91.

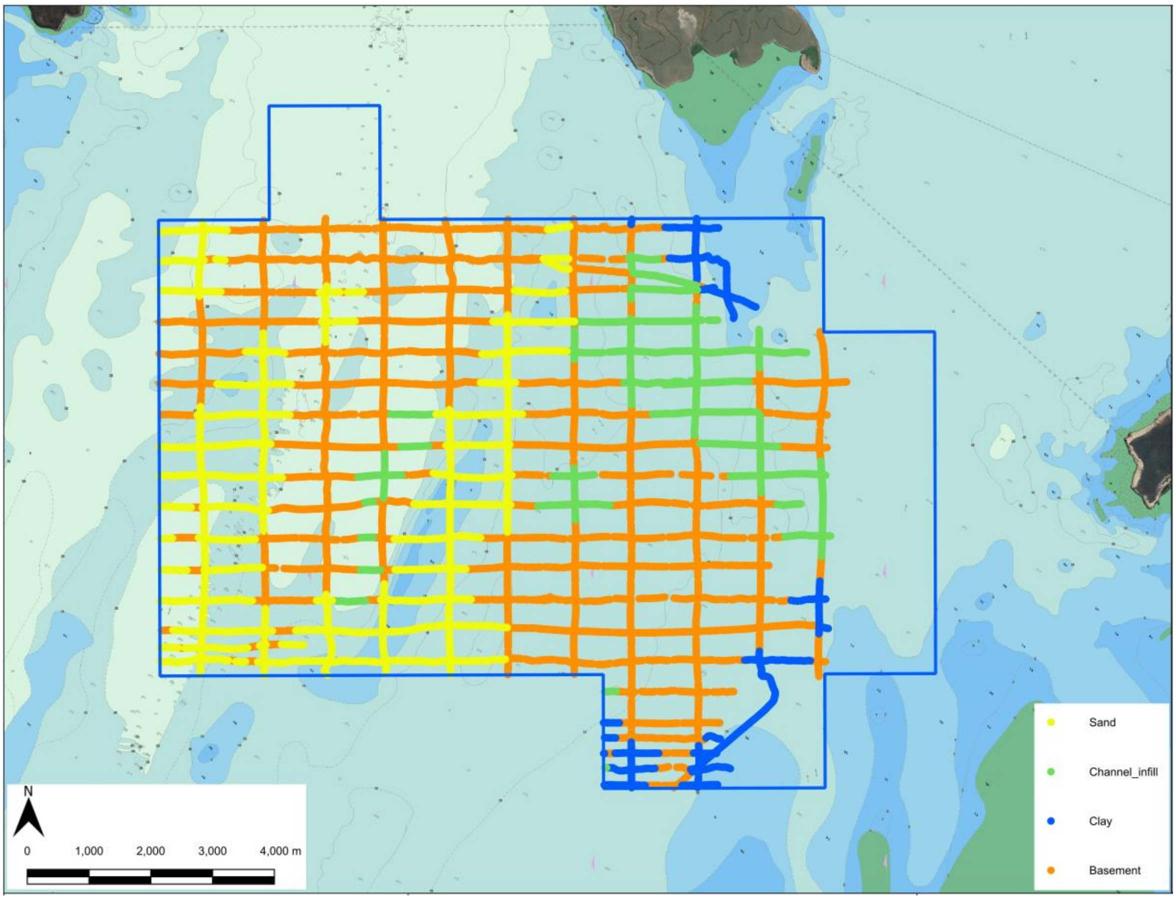


Figure 91. Sediment types within Block 4 based on the sub-bottom profiling and sidescan sonar data.

6.2.2. Sediment Sampling and Water Clarity

Results from the vibro-coring undertaken as part of the exploratory campaign were processed to show how the sediment within Block 4 varied with depth and the PSD of the sandy sediment identified within Block 4. Results from the vibro-coring are summarised in Figure 92 and PSD results from some of the sandy sediment is shown in Figure 93.

Results from the Secchi disc survey undertaken as part of the exploratory campaign are shown in Table 19.

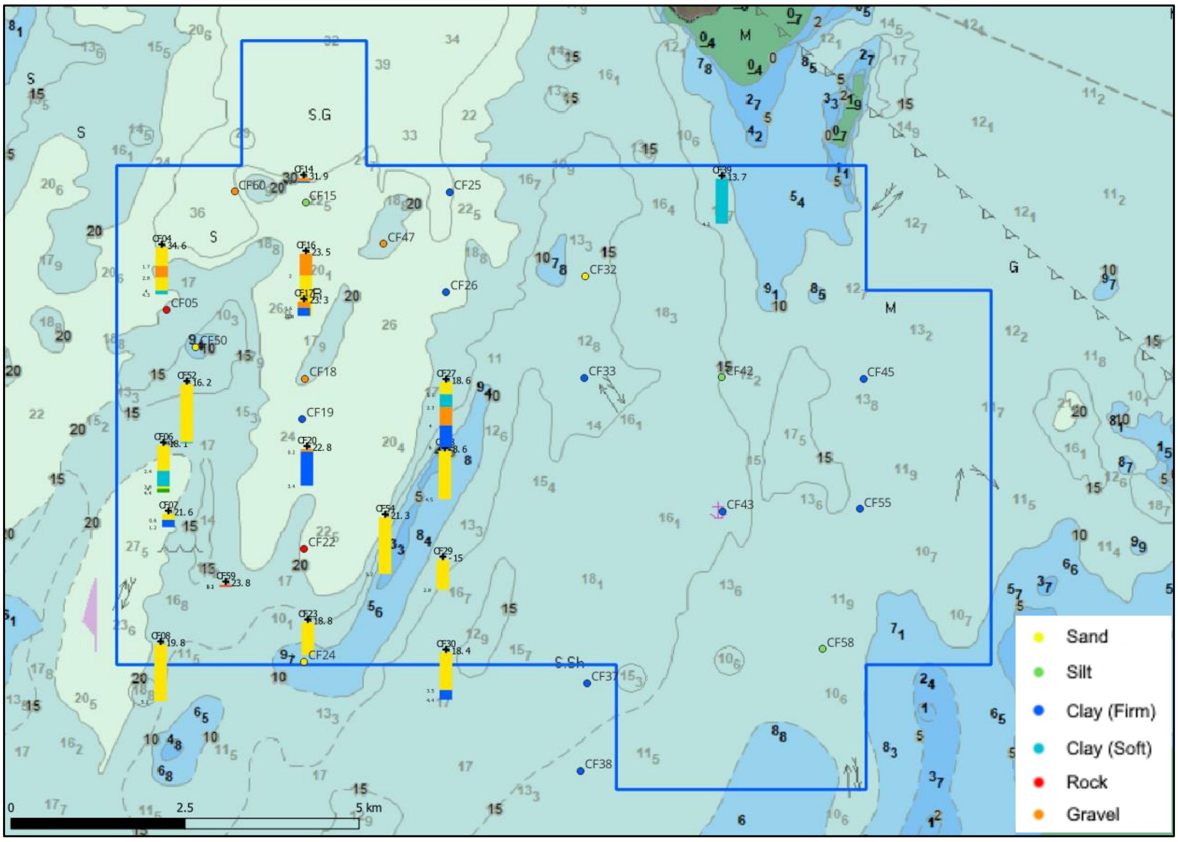


Figure 92. Sediment core data within Block 4 based on the vibro-coring results. *Note: circles represent position of grab samples with same colour coding as the cores.*

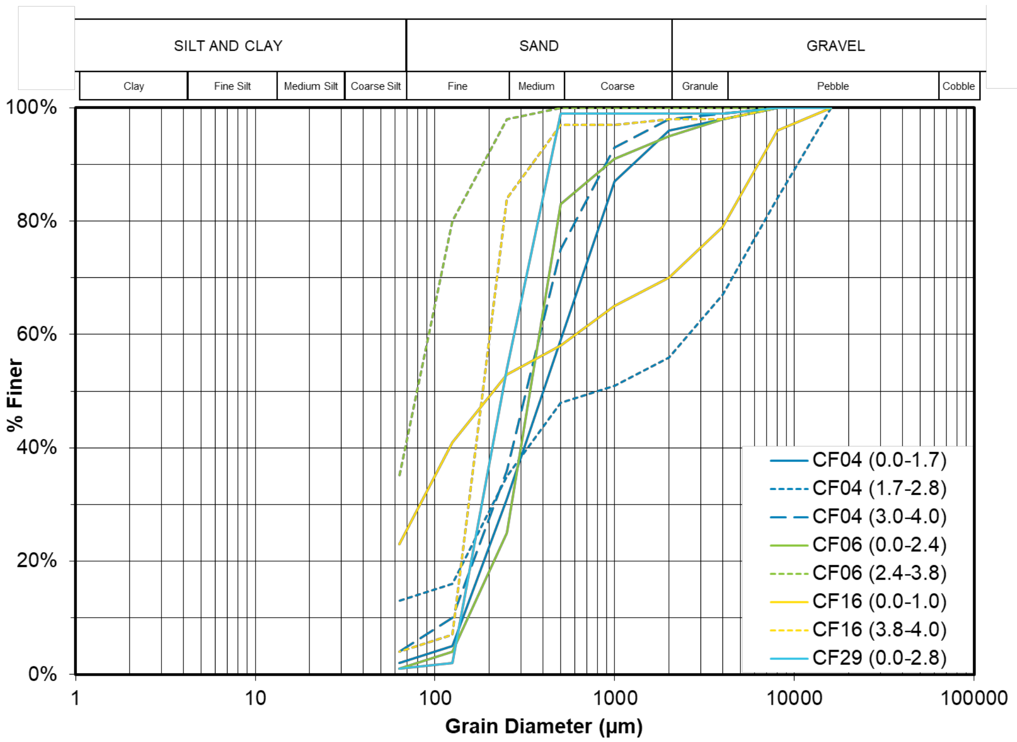


Figure 93. Example plot of PSD from samples within Block 4 of the exploratory campaign.

Table 19. Secchi disc raw data (listed in chronological order by date sampled 6th to 13th March 2023).

Sequential No.	Date Sampled (March 2023)	Site No. (CF)	Secchi Depth (m)
01	06	39	0.82
02	08	07	0.45
03	09	08	0.35
04	09	23	0.35
05	10	20	0.30
06	10	27	0.35
07	10	17	0.40
08	10	14	0.30
09	10	04	0.15
10	11	06	0.40
11	11	24	0.15
12	11	26	0.29
13	11	29	0.35
14	12	30	0.35
15	12	43	0.50
16	12	33	0.55
17	13	55	0.72
		Mean	0.40
		Median	0.35
		Mode	0.35
		Maximum	0.82
		Minimum	0.15

6.3. Dry Season Environmental Survey Jul-Aug 2023

The dry season in Northern Australia is from May to October (inclusive) and is characterised by minimal rainfall, clear skies, and cooler temperatures. During the 2023 dry season, based on data from the BoM Wyndham Aero weather station, the air temperatures in CG ranged from 8-40°C and the region had approximately 5 mm of rainfall per month (although most of this rainfall fell over 2 days).

6.3.1. Vertical Profiling and Water Sampling

Plots of the water quality profiles at sites in CG, KS and offshore are shown for water temperature, salinity, chlorophyll-a and TSS in Figure 94 to Figure 97. Table 20 summarises the salinity, temperature, turbidity and chlorophyll-a vertical profiling results measured by the YSI Multiparameter probe.

Results from the laboratory analysis of the water samples collected during the vertical profiling are presented in Table 21, providing details of Chlorophyll-a (µg/L) and TSS (mg/L) in CG, KS and offshore for the period of July-August 2023. A relationship between the TSS data and concurrent turbidity data was developed to provide a CG specific dry season correlation.

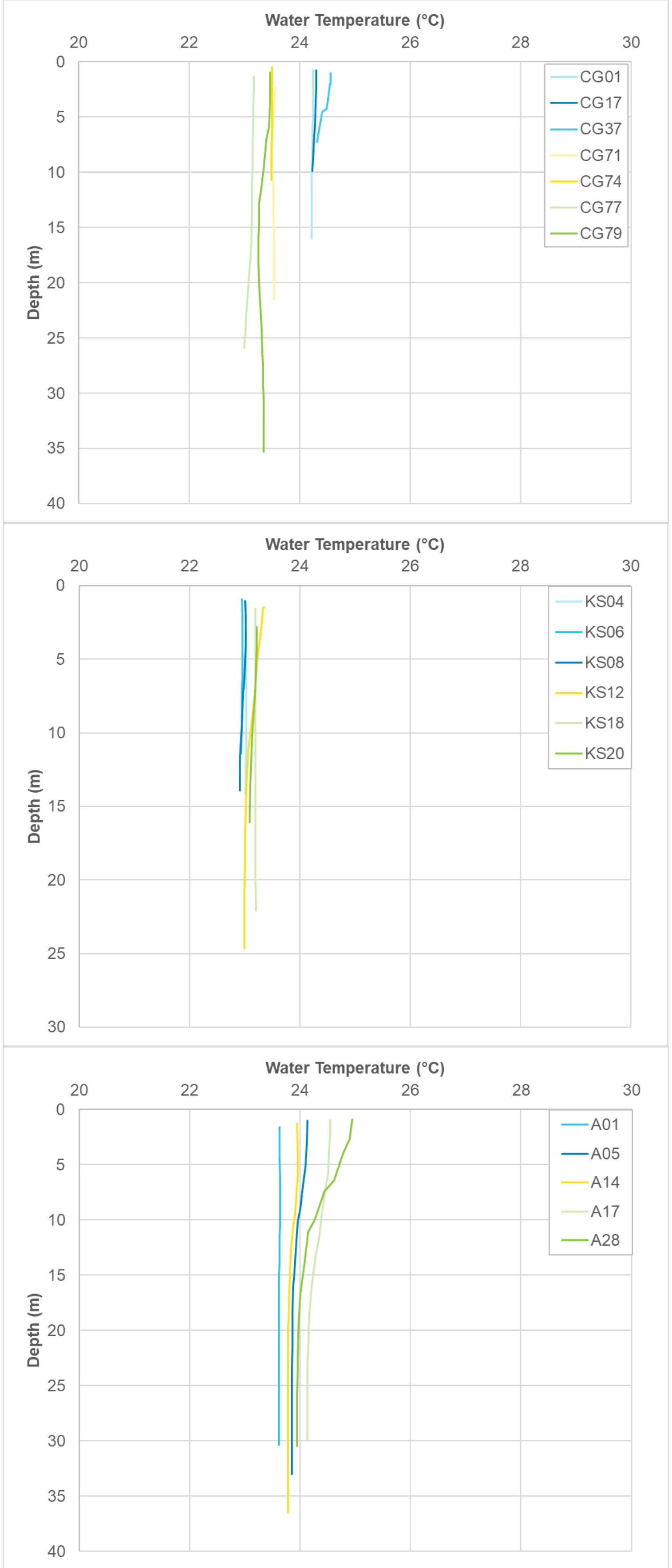


Figure 94. Vertical depth profiles of water temperature at sites in CG (top), King Shoals (middle) and offshore (bottom) measured in July-August 2023.

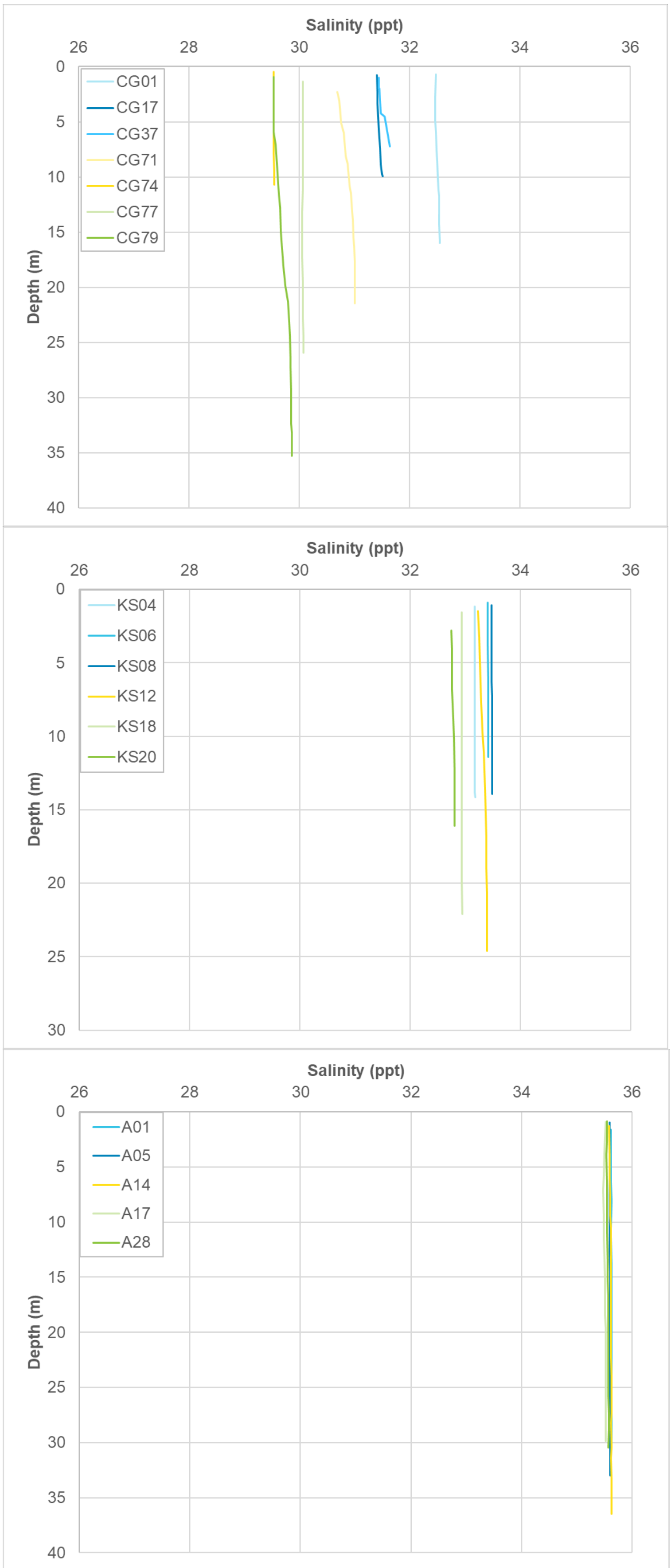


Figure 95. Vertical depth profiles of salinity at sites in CG (top), King Shoals (middle) and offshore (bottom) measured in July-August 2023.

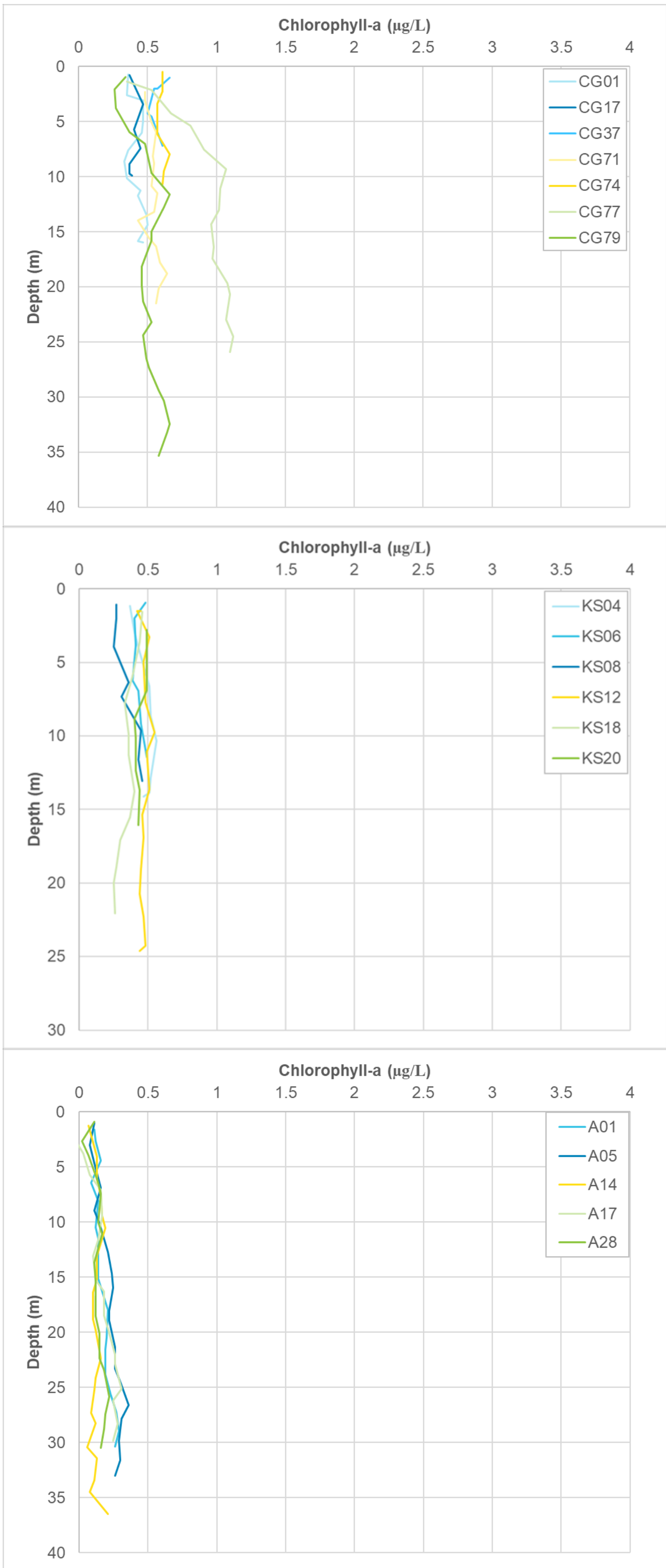


Figure 96. Vertical depth profiles of chlorophyll-a at sites in CG (top), King Shoals (middle) and offshore (bottom) measured in July-August 2023.

PORT & COASTAL
SOLUTIONS

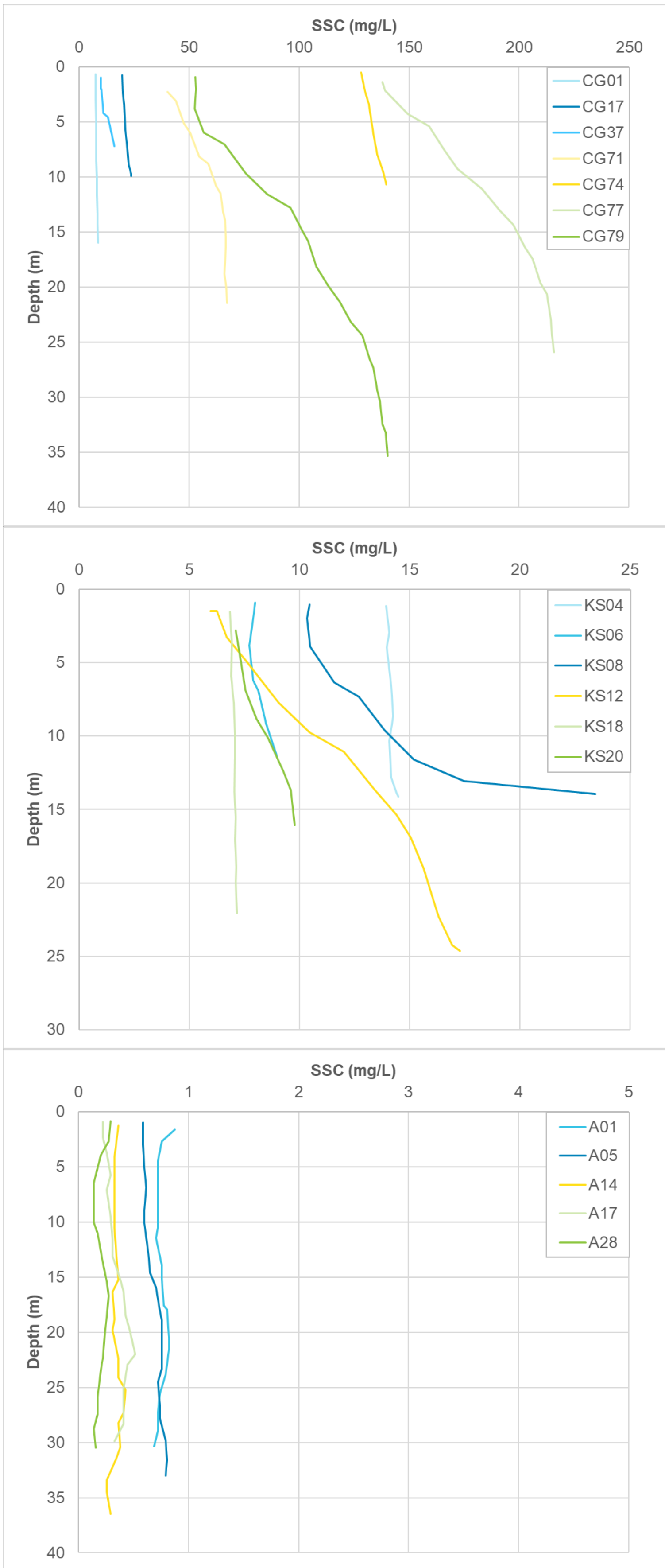


Figure 97. Vertical depth profiles of TSS at sites in the CG (top), King Shoals (middle) and offshore (bottom) measured in July-August 2023.

Table 20. Results of the dry season (July-August 2023) YSI water quality measurements in Cambridge Gulf, King Shoals and Offshore waters (these statistics are based on mid-water-depth measurements only).

		Cambridge Gulf	King Shoals	Offshore Waters
Salinity (ppt)	**Mean**	**31.73**	**33.18**	**35.58**
	Min	29.45	32.78	35.50
	Max	32.91	33.49	35.65
	Mode	31.18	33.10	35.63
	Median	32.04	33.18	35.57
	Standard Deviation	0.91	0.20	0.05
	Standard Error	0.13	0.04	0.01
	Number of Samples	52	20	27
Temperature (°C)	**Mean**	**23.87**	**23.05**	**23.91**
	Min	23.01	22.88	23.46
	Max	24.42	23.22	24.34
	Mode	24.27	22.96	23.62
	Median	23.82	23.04	23.90
	Standard Deviation	0.40	0.10	0.24
	Standard Error	0.06	0.02	0.05
	Number of Samples	52	20	28
Turbidity (NTU)	**Mean**	**29.48**	**6.67**	**0.20**
	Min	2.84	4.04	0
	Max	114.92	12.96	0.49
	Mode	#N/A	7.52	0.15
	Median	21.64	6.26	0.15
	Standard Deviation	27.08	2.23	0.14
	Standard Error	3.75	0.50	0.03
	Number of Samples	52	20	28
Chl-a (µg/L)	**Mean**	**0.60**	**0.41**	**0.18**
	Min	0.29	0.29	0
	Max	1.17	0.52	0.30
	Mode	0.56	0.32	0.21
	Median	0.52	0.40	0.18
	Standard Deviation	0.17	0.07	0.07
	Standard Error	0.02	0.02	0.01
	Number of Samples	52	20	28

Table 21. Results of the dry season (July-August 2023) water sampling for Chlorophyll-a (in µg/L) and Total Suspended Solids (TSS, in mg/L) in Cambridge Gulf, King Shoals and Offshore waters (these statistics are based on the results of laboratory analysis of residue on filters from in situ filtration of known volumes of water samples)

		Cambridge Gulf	King Shoals	Offshore Waters
Total Suspended Solids (mg/L)	**Mean**	**52.67**	**18.67**	**1.67**
	Min	6	11	1
	Max	220	34	3
	Mode	13	11	1
	Median	25	11	2
	Standard Deviation	58.29	13.28	0.69
	Standard Error	11.22	7.67	0.16
	Number of Samples	27	3	18
Chlorophyll-a (µg/L)	**Mean**	**1.26**	**1.00**	**0.37**
	Min	0.90	0.90	0.20
	Max	2.20	1.10	1.20
	Mode	1.1	#N/A	0.3
	Median	1.1	1	0.3
	Standard Deviation	0.33	0.10	0.25
	Standard Error	0.06	0.06	0.05
	Number of Samples	27	3	21

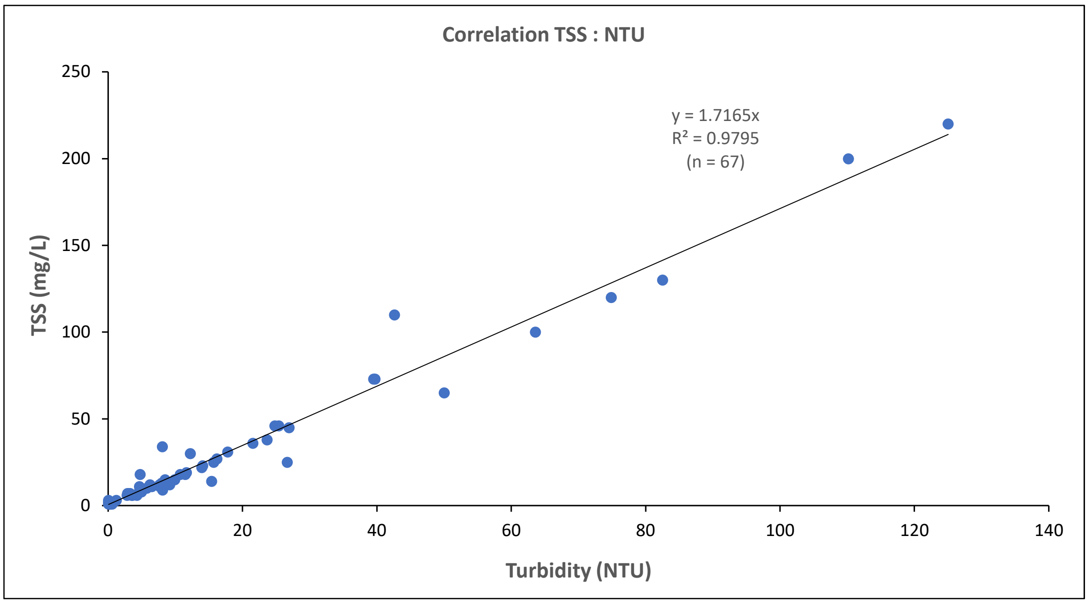


Figure 98. **Site-specific relationship between measured Turbidity (NTU) values and analysed Total Suspended Solids (TSS) concentrations (in mg/L) for Cambridge Gulf (dry season).**

6.3.2. Water Clarity

Drop camera footage was undertaken at 167 sites across CG and King Shoals in March 2023 and July-August 2023. All of the drop camera videos showed a completely blacked-out aphotic zone, with no benthic light at the seabed. Figure 99 shows screenshots from three examples of the drop camera videos.

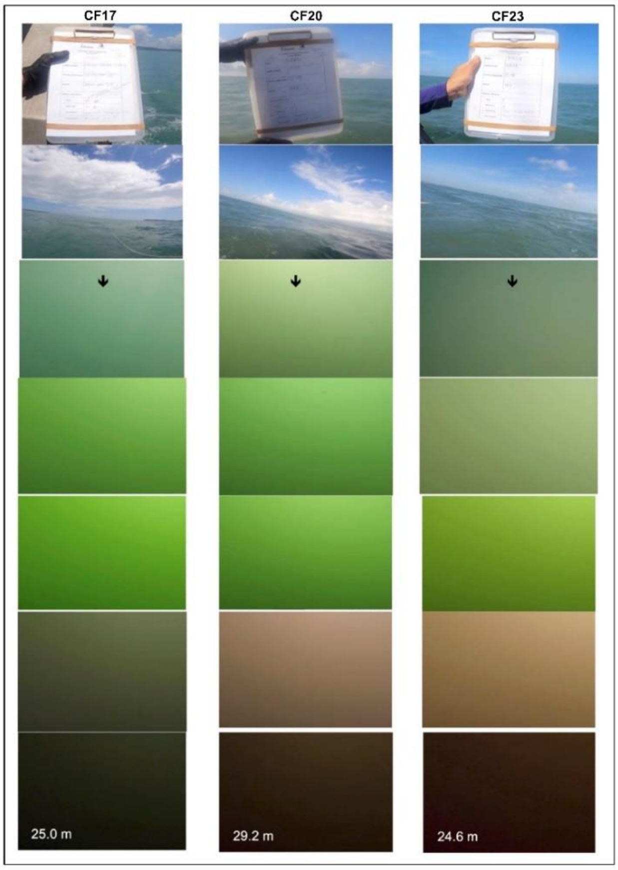


Figure 99 **Screen shots from three examples of the drop camera videos undertaken at 167 sites across CG and King Shoals in March 2023 and July-August 2023, all of the videos show similar results (source: BKA, 2024d).**

6.3.3. Sediment Sampling

Results of the sediment description from the sediment sampling undertaken during the 2023 dry season are summarised below:

- CG: variable sediment types present, with clay, sand, gravel and rock all present. Sand was the most common sediment type with almost half of the samples being predominantly sand;
- KS: the sediment was predominantly sand (60% of samples) with some rock and clay/gravel also present; and
- Offshore: the sediment was variable with the dominant sediment types being sand, shell grit, clay and gravel. Sand was the most common sediment type with approximately 40% of the samples being predominantly sand.

6.4. Wet Season Environmental Survey Feb-Mar 2024

The wet season in Northern Australia is from November to April (inclusive) and is characterised by heavy rainfall, high humidity, and the possibility of tropical cyclones. During the 2024 wet season, temperatures in CG ranged from 22-44 °C and the region had an average of 47 mm of rainfall per month, with March having 114 mm.

6.4.1. Sediment Sampling

A spatial map of the sediment type based on the PSD results from the sediment sampling undertaken as part of the 2024 wet season data collection campaign is shown in Figure 100. Results from the elemental analysis of the spatial variability in the percentage of quartz/feldspar and calcite/calcium silicate present in the bed sediment is shown in Figure 101 and Figure 102.

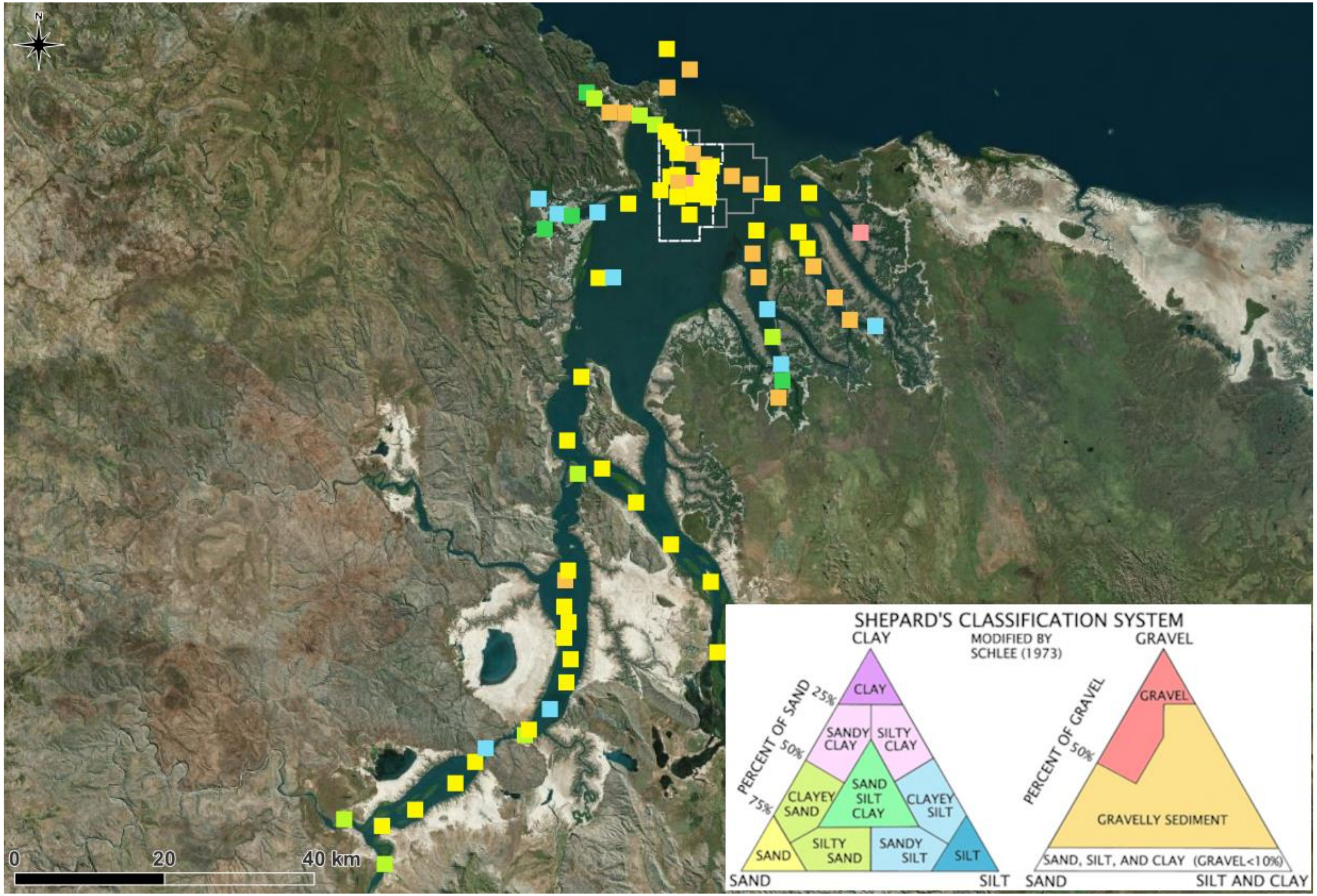


Figure 100. Map showing sediment type for all samples based on Shepard's classification system using the percentage of clay, silt, sand and gravel in the sample.

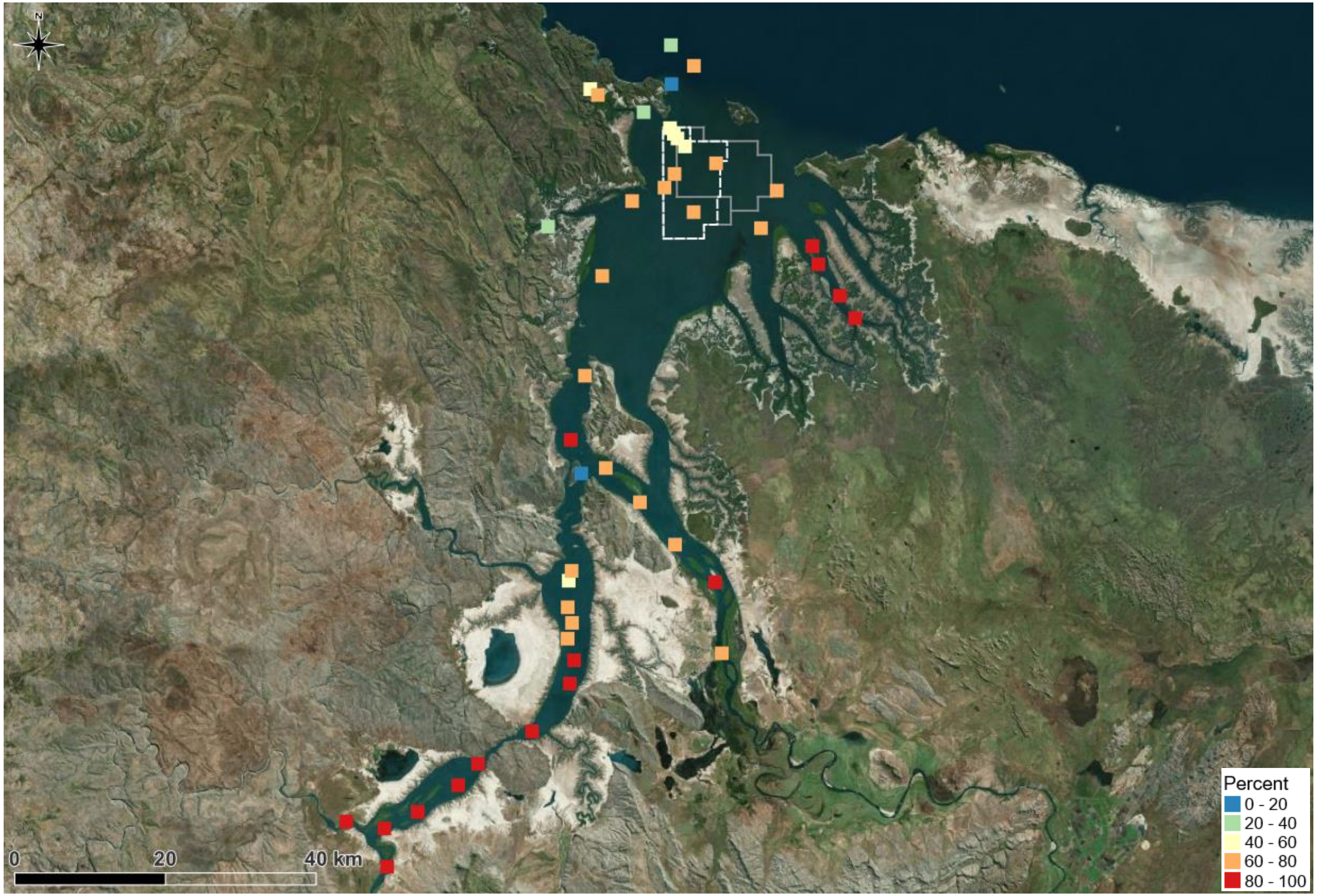


Figure 101. Map showing combined percentage of quartz and feldspar present in the sediment samples.

Figure 102. Map showing combined percentage of calcite and calcium silicate present in the sediment samples.

6.4.2. Vertical Profiles

Hourly water column profiling over a 13-hour spring tidal cycle was undertaken at 3 sites, as detailed in Section 3.4.2. The vertical profile data were processed to show how the measured parameters varied through the water column through a 13 hour spring tide. Vertical profiles for each site at specific points in the tide are shown in Figure 103 to Figure 108. Time series results of the processed currents at the mid-depth and near-bed locations are shown in Figure 109 to Figure 111.

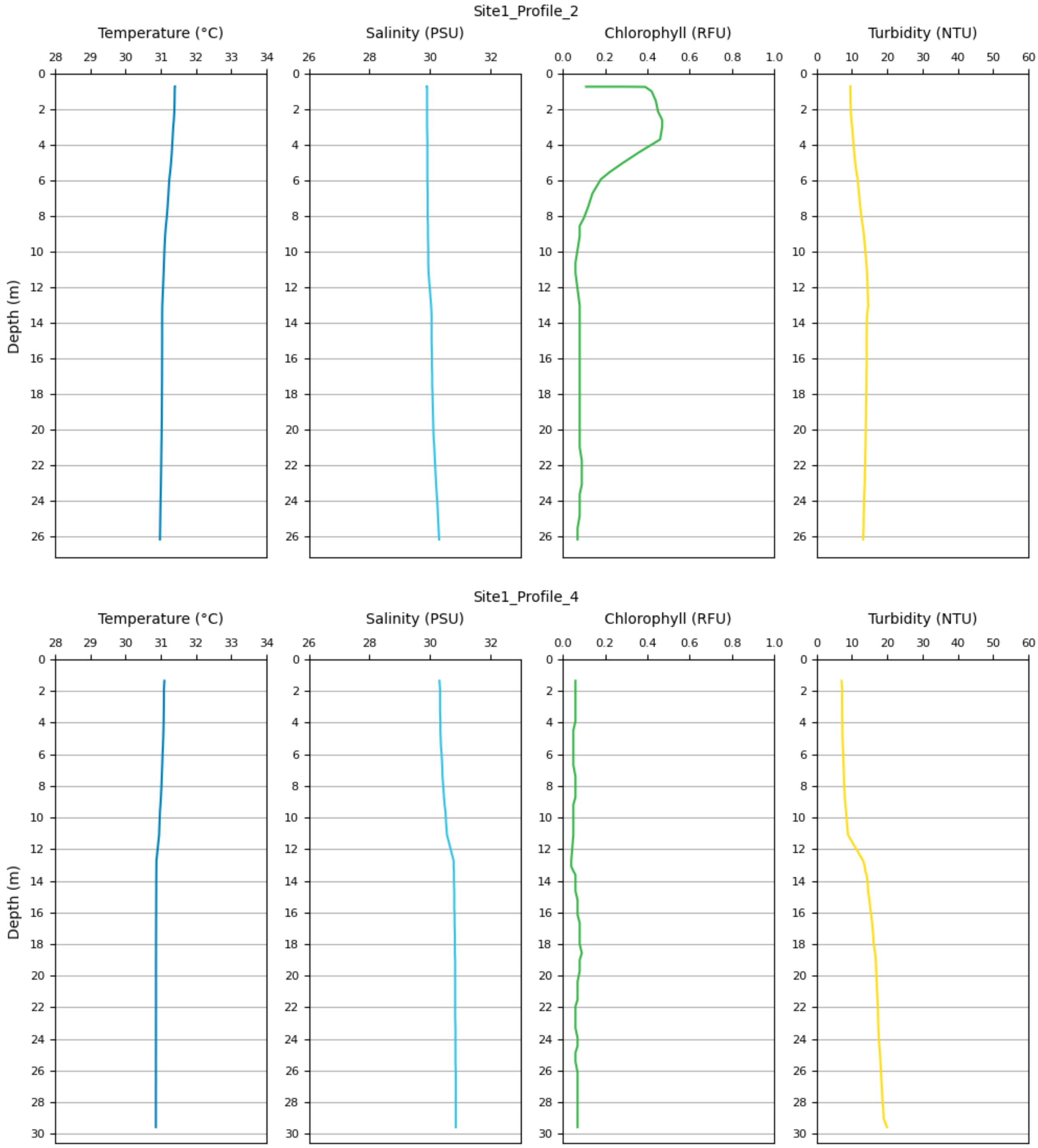


Figure 103. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 1 close to low water (top) and during the flood stage of the tide (bottom).

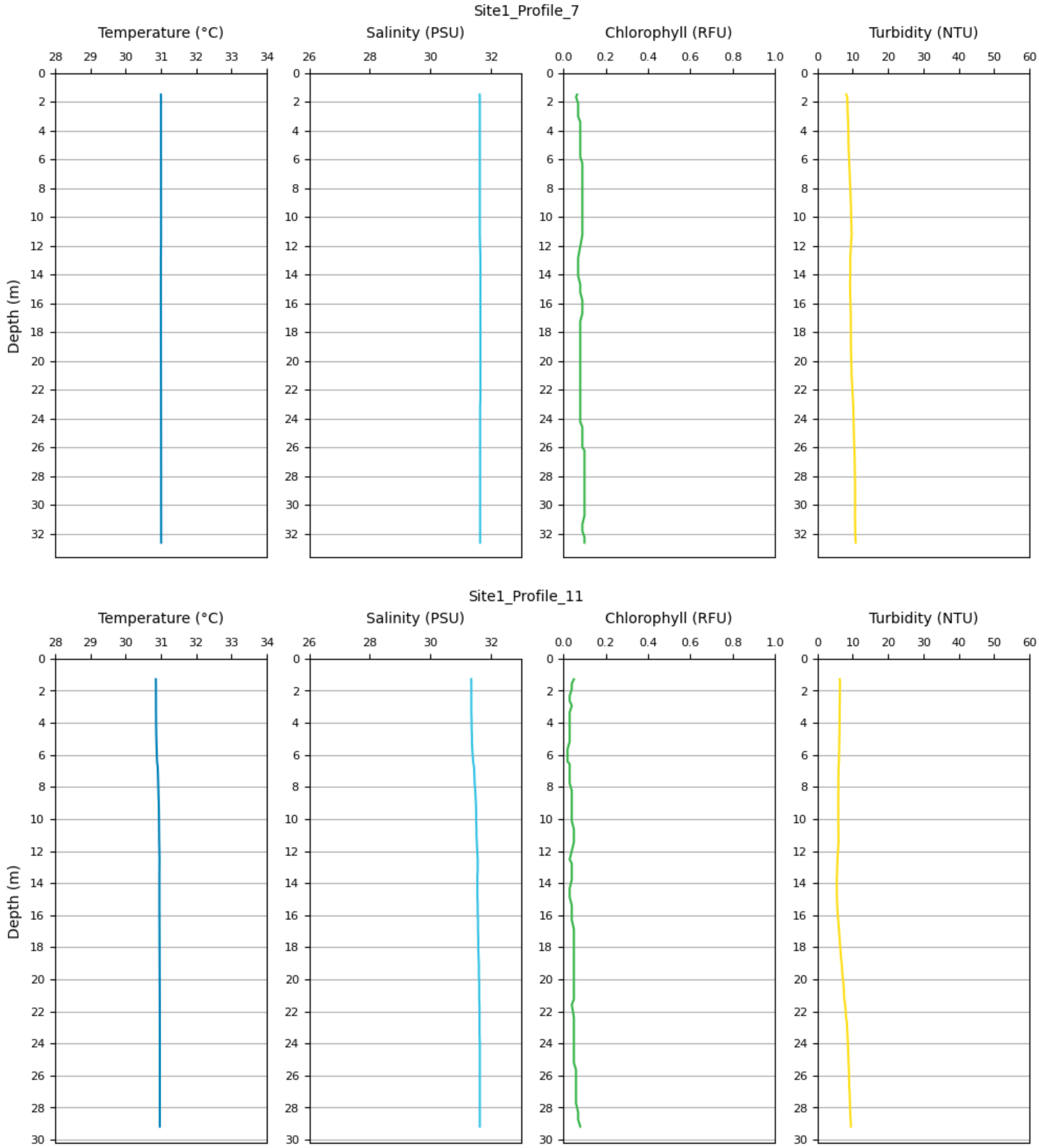


Figure 104. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 1 at high water (top) and during the ebb stage of the tide (bottom).

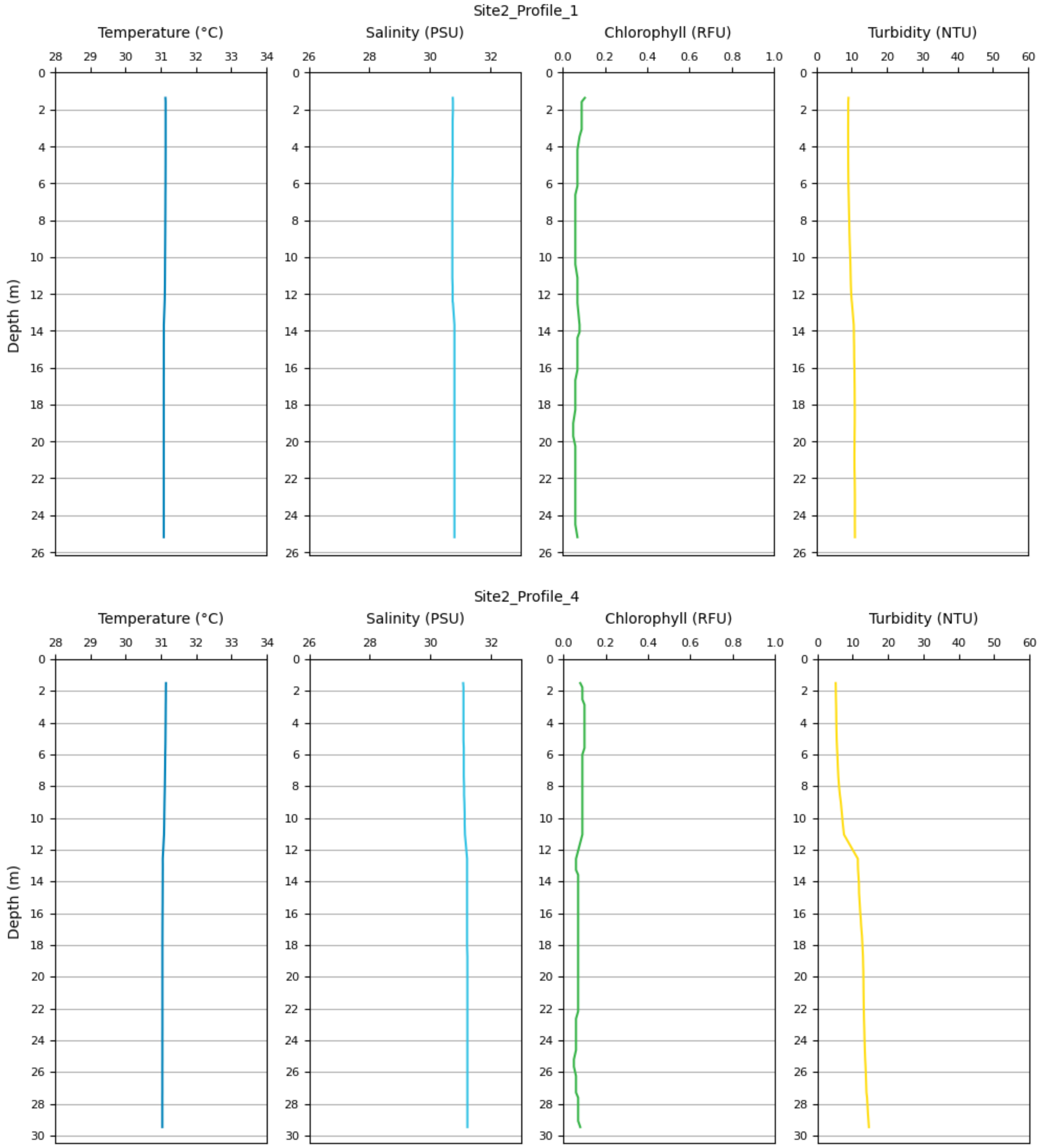


Figure 105. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 2 at low water (top) and during the flood stage of the tide (bottom).

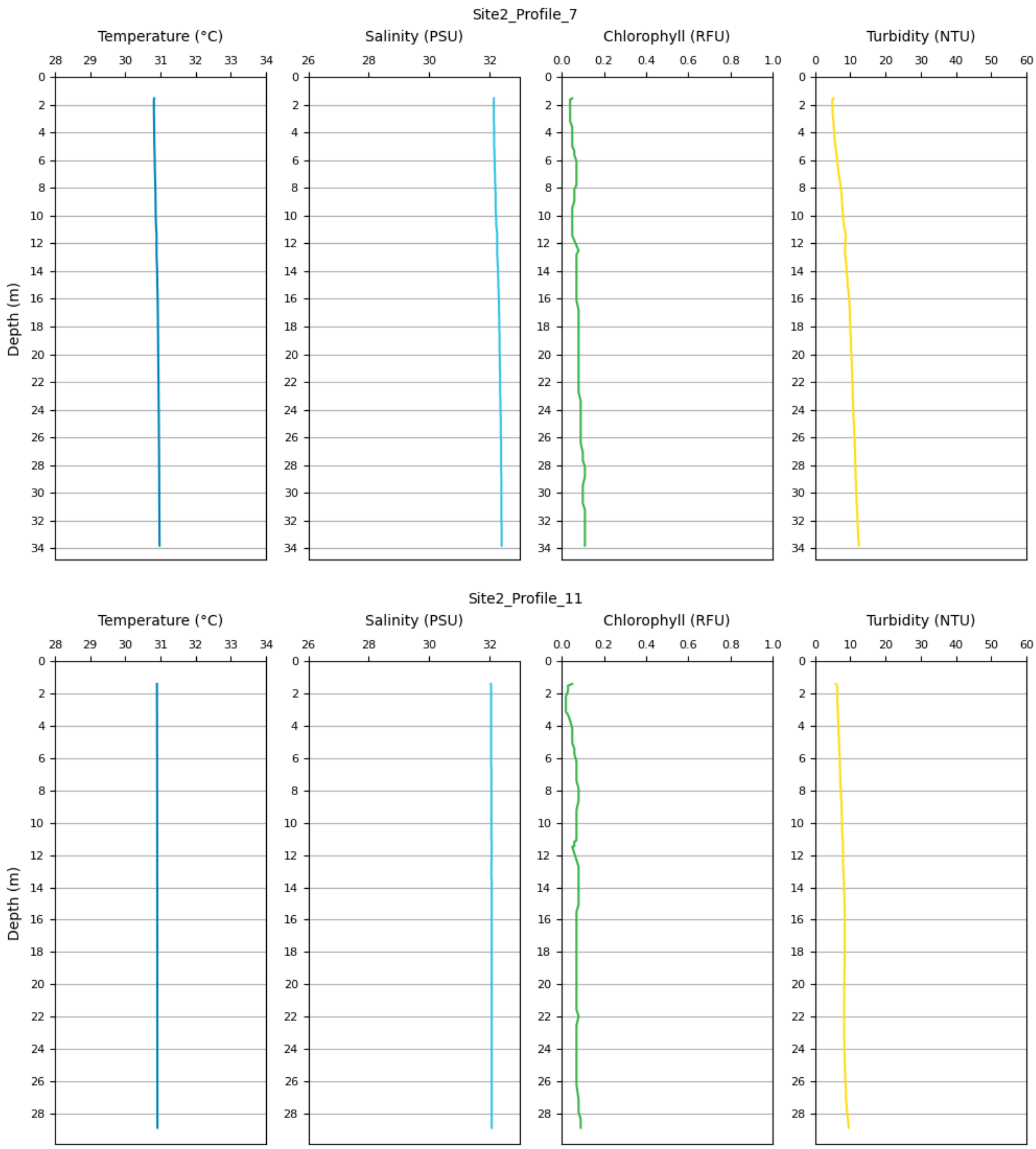


Figure 106. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 2 at high water (top) and during the ebb stage of the tide (bottom).

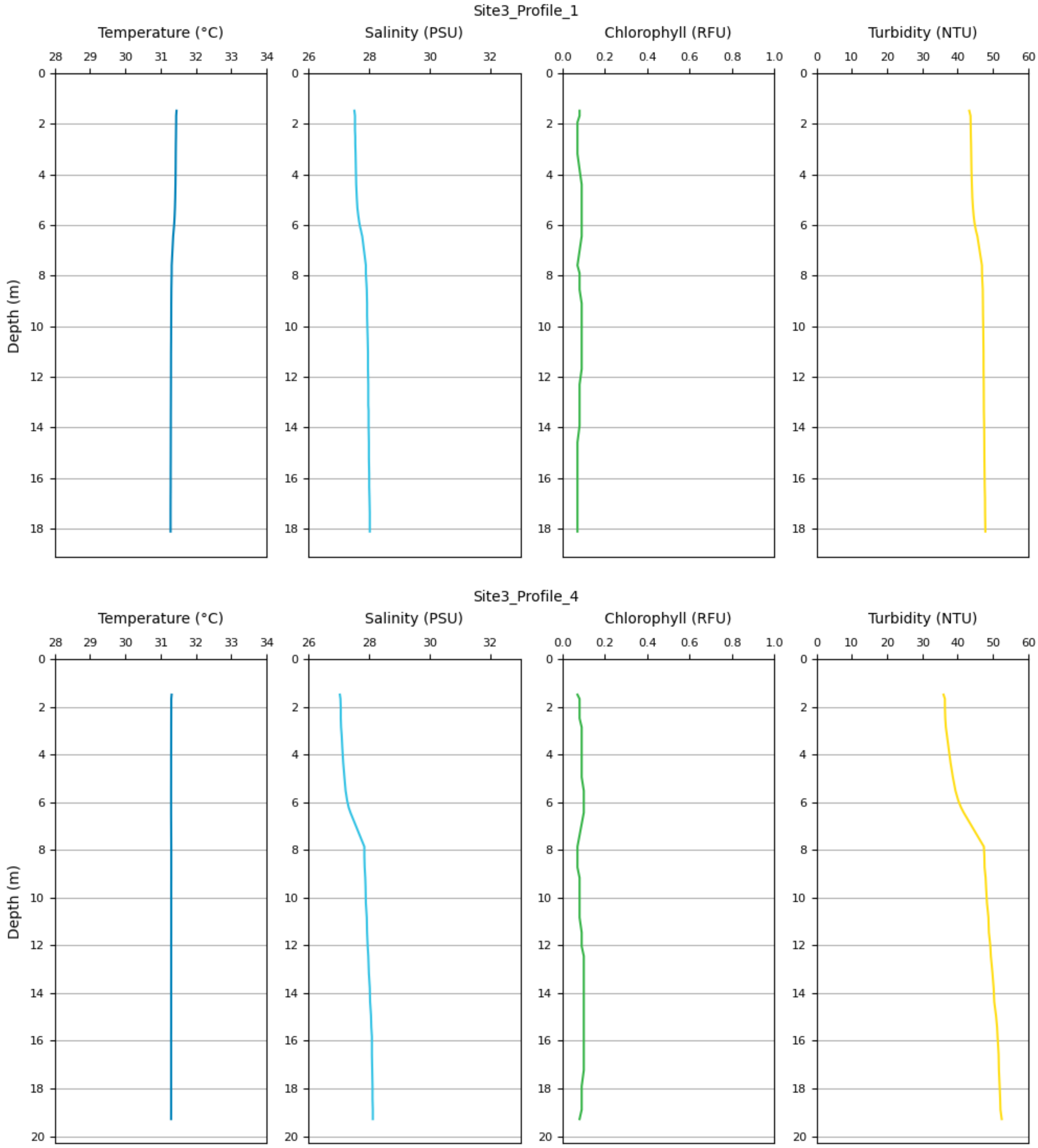


Figure 107. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 3 at low water (top) and during the flood stage of the tide (bottom).

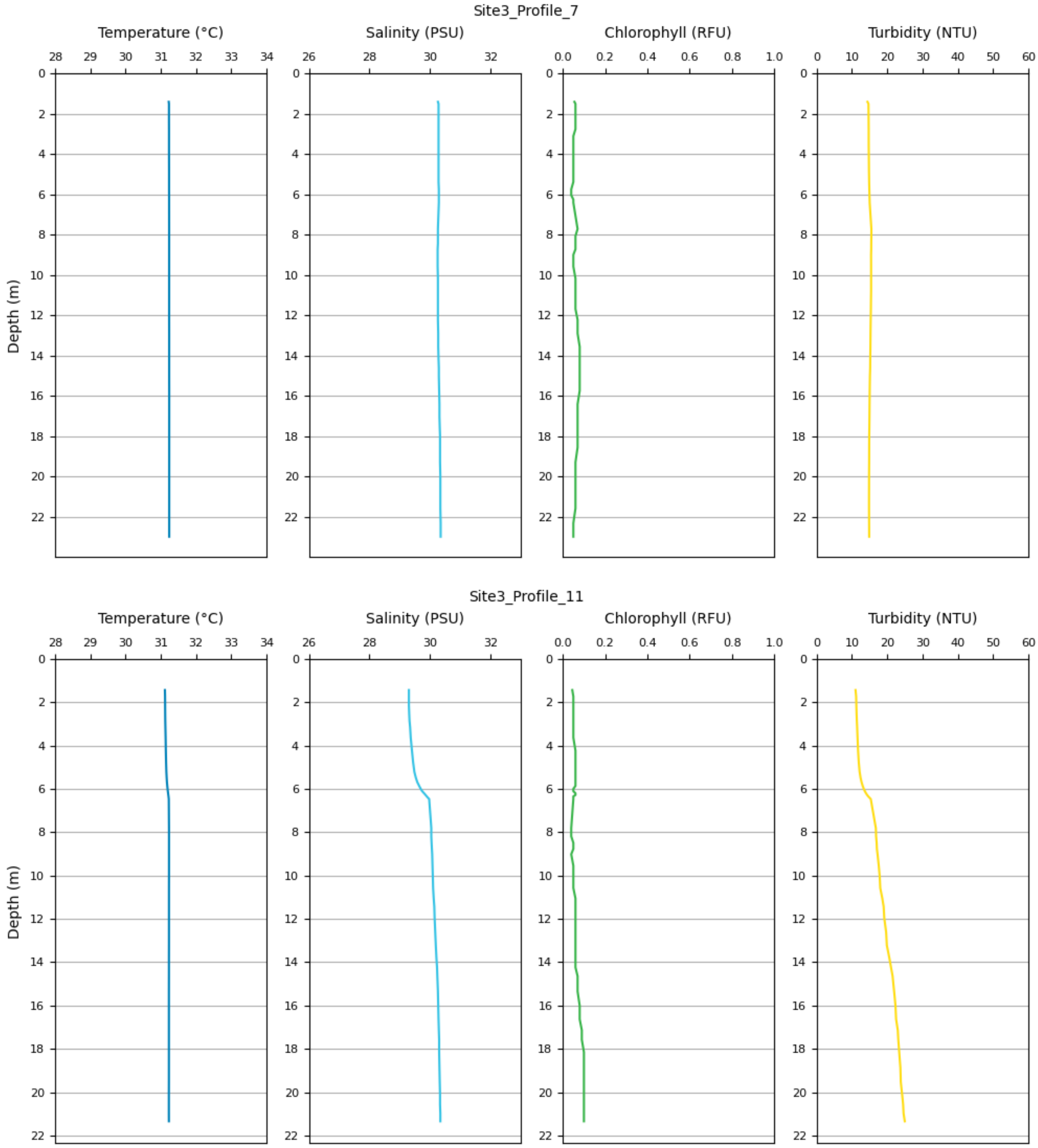


Figure 108. Measured temperature, salinity, chlorophyll and turbidity through the water column at Site 3 at high water (top) and during the ebb stage of the tide (bottom).

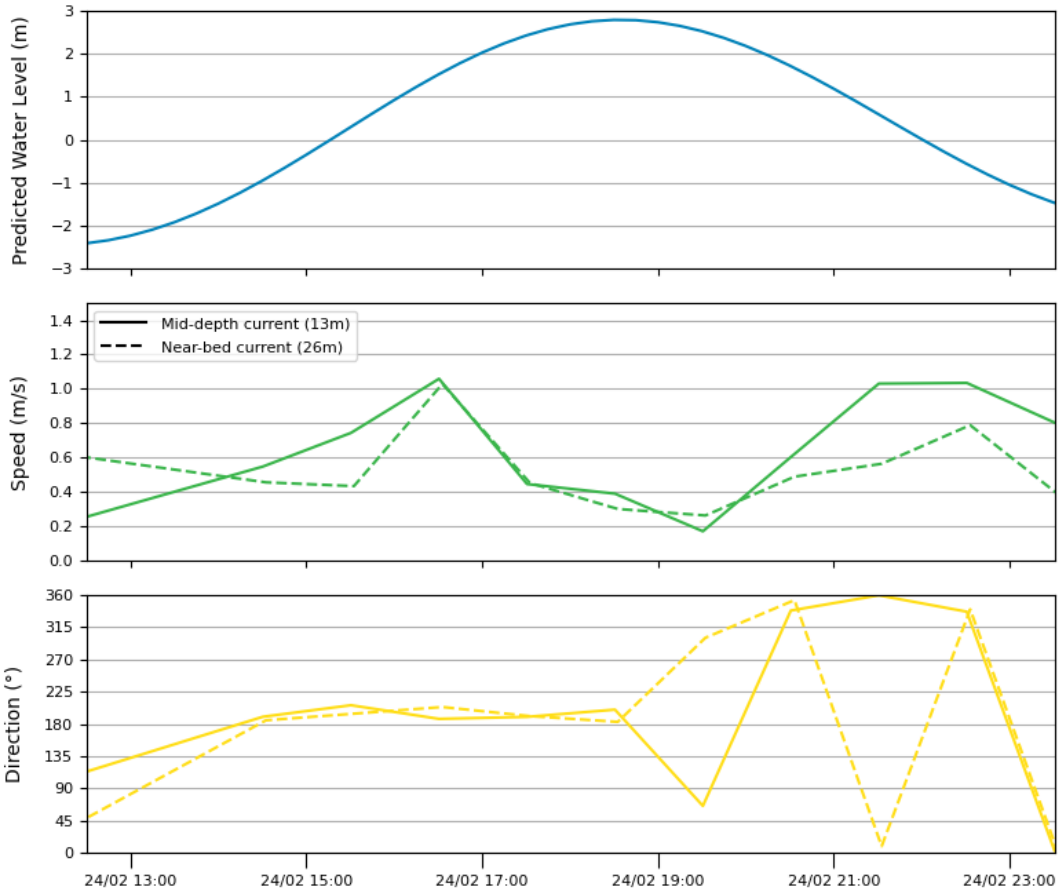


Figure 109. Time series of predicted water level and measured mid depth and near-bed current speed and direction over a spring tide at Site 1.

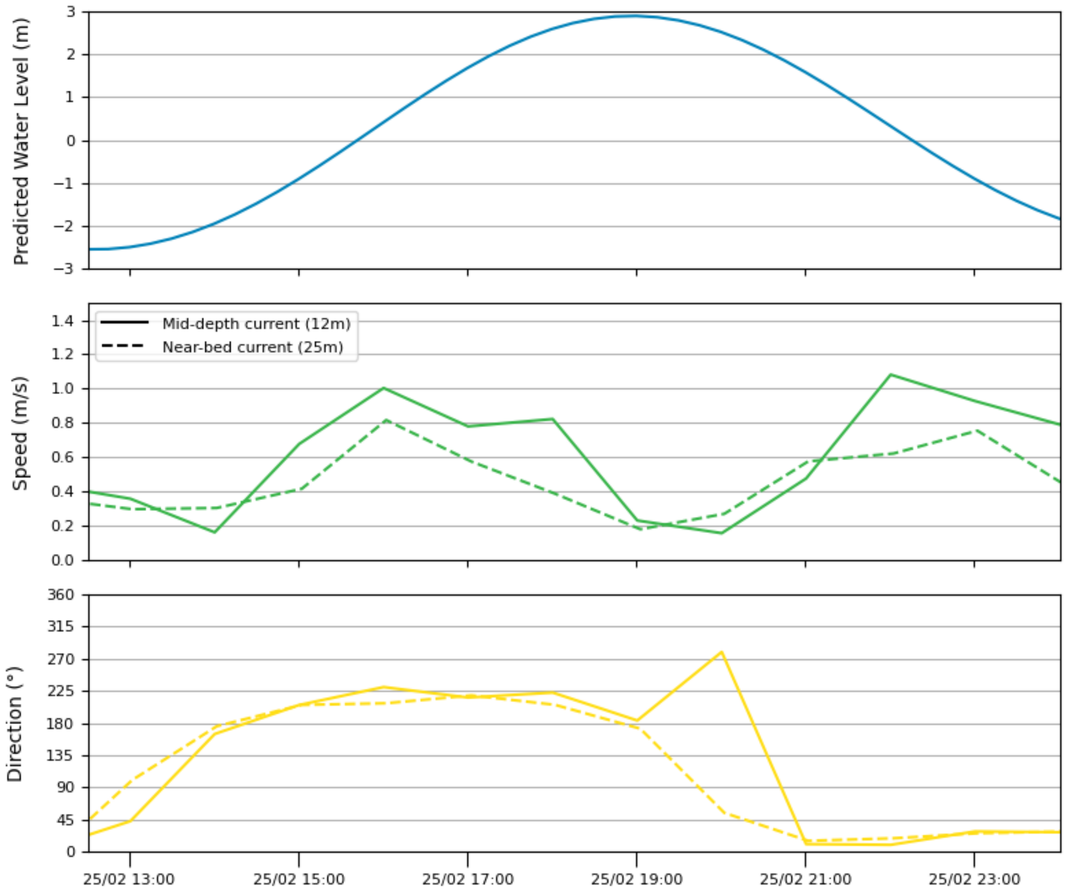


Figure 110. Time series of predicted water level and measured mid depth and near-bed current speed and direction over a spring tide at Site 2.

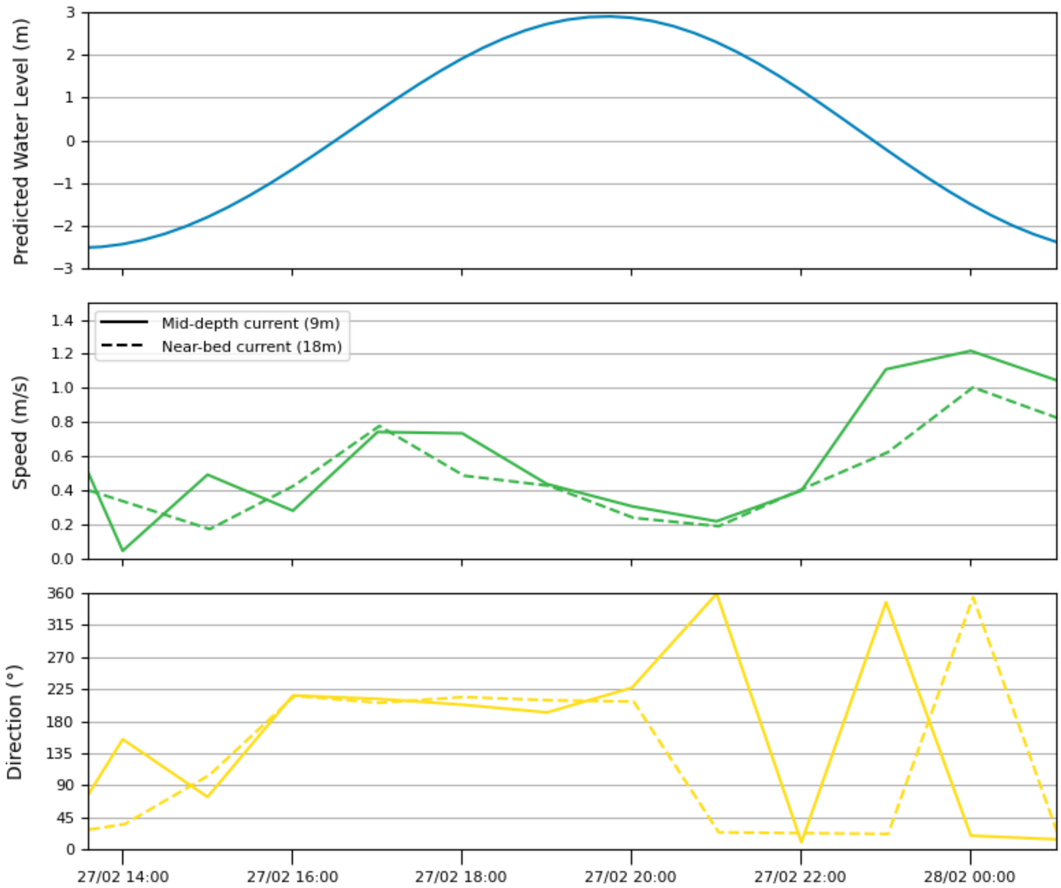


Figure 111. Time series of predicted water level and measured mid depth and near-bed current speed and direction over a spring tide at Site 3.

TSS results from the laboratory analysis of water samples collected at mid-depth and near-bed during each vertical profile were compared with concurrent turbidity measurements to develop a correlation between the two (Figure 112). Results from the PSD analysis are shown for each profile at the three sites in Figure 113 to Figure 115. Results from the elemental analysis of the suspended sediment in the mid-depth and near-bed water samples collected at low water and high water at each site are shown in Figure 116 to Figure 118.

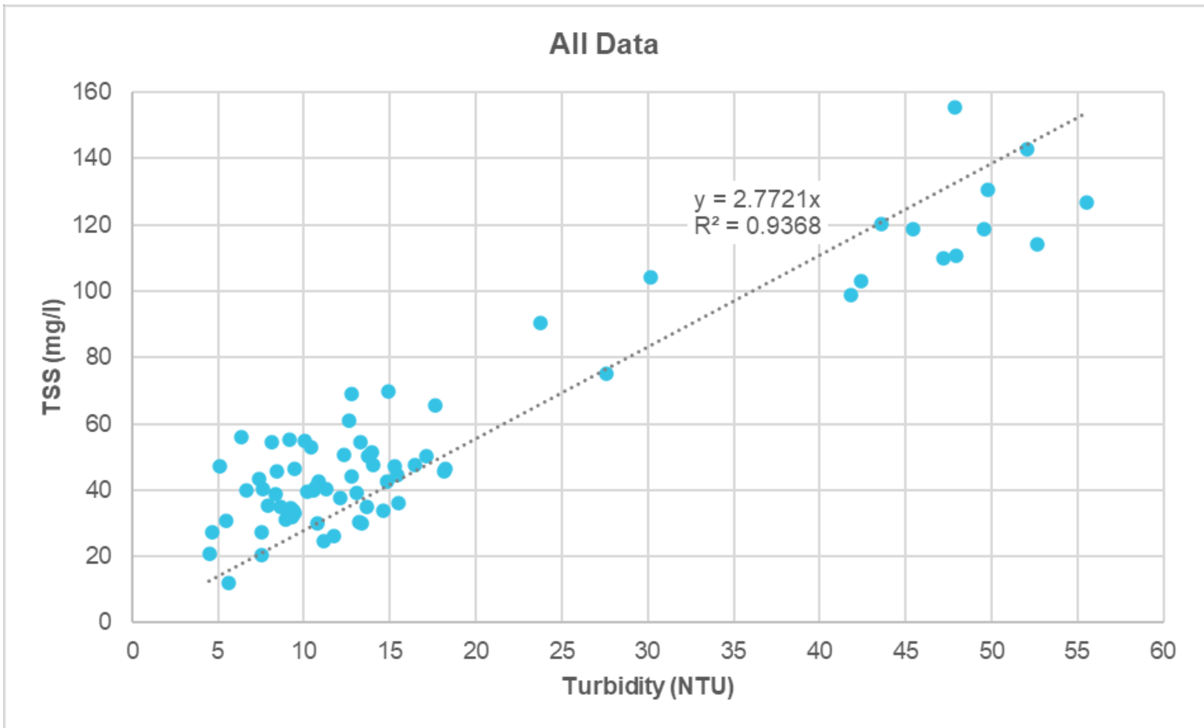


Figure 112. Correlation between measured in-situ turbidity and laboratory calculated TSS for all samples.

Figure 113. Measured near-bed turbidity (top) and composition of the suspended sediment at mid depth (middle) and near-bed (bottom) over a spring tidal cycle at Site 1. *Note: the high percentage of sand sized particles in samples BC-11A, BC-11B and BC-12B are due to sand sized organic matter being present, the actual percentage of sand will have been in line with the other samples (i.e. around 5%).*

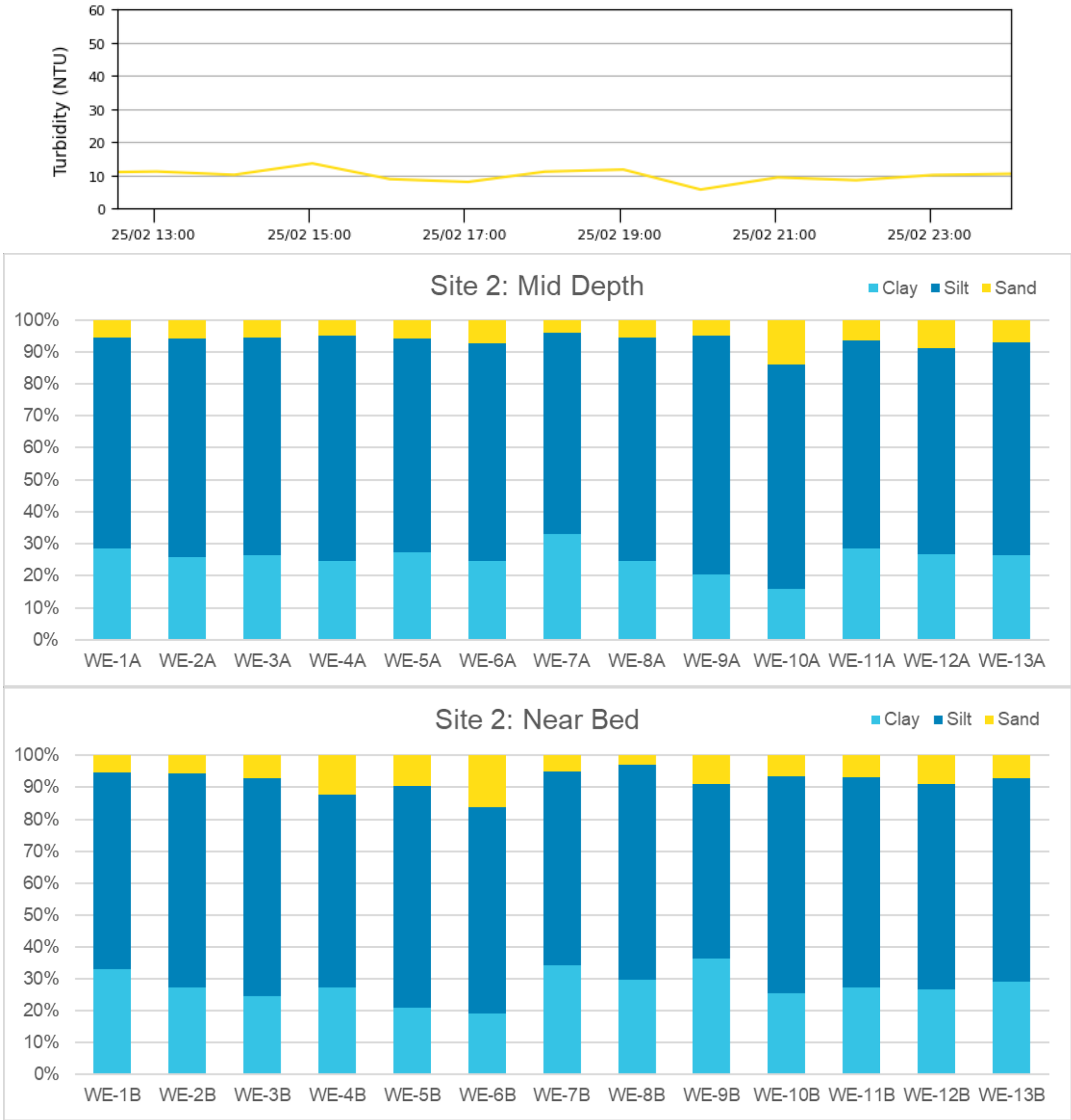


Figure 114. Measured near-bed turbidity (top) and composition of the suspended sediment at mid depth (middle) and near-bed (bottom) over a spring tidal cycle at Site 2. *Note: the higher percentage of sand sized particles in samples WE-4B, WE-6B, WE-9B and WE-10A are due to sand sized organic matter being present, the actual percentage of sand will have been in line with the other samples (i.e. 5 to 10%).*

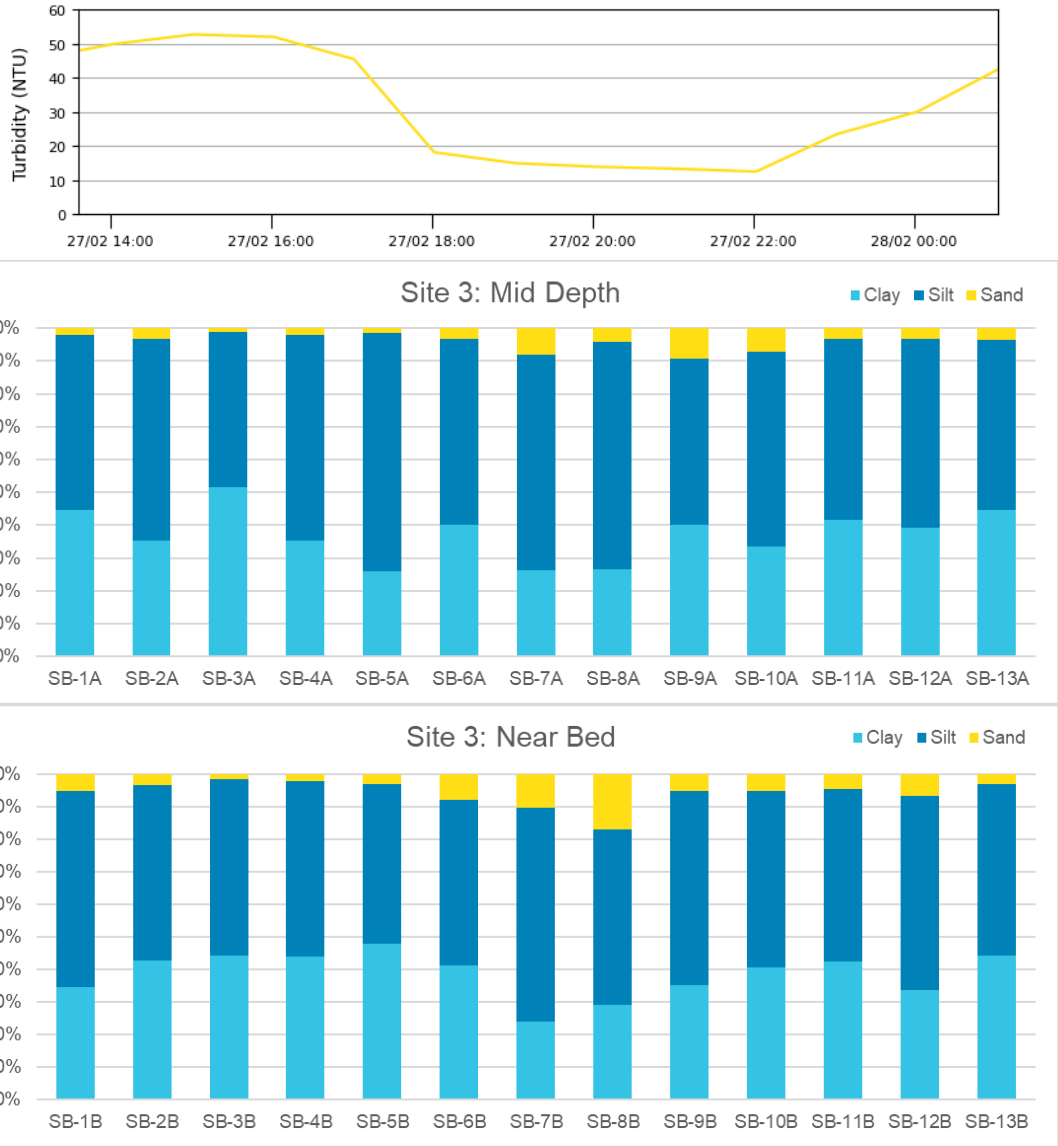


Figure 115. Measured near-bed turbidity (top) and composition of the suspended sediment at mid depth (middle) and near-bed (bottom) over a spring tidal cycle at Site 3. *Note: the higher percentage of sand sized particles in samples SB-7A, SB-7B, SB-8B and SB-9A are due to sand sized organic matter being present, the actual percentage of sand will have been in line with the other samples (i.e. around 5%).*

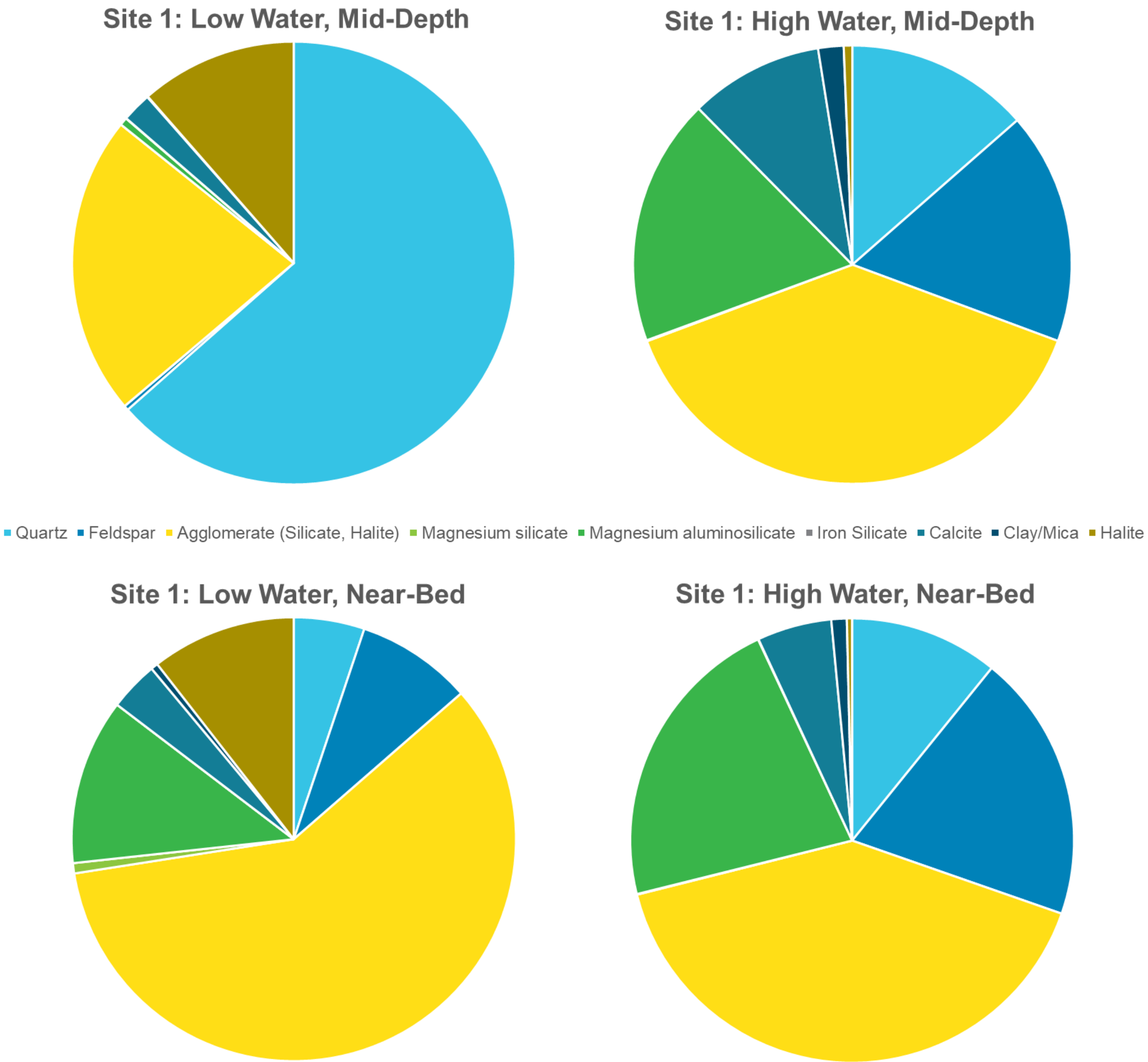


Figure 116. Elemental feature analysis results for the bed sediment close to Site 1 (top) and for the suspended sediment collected from Site 1 at low water and high water.

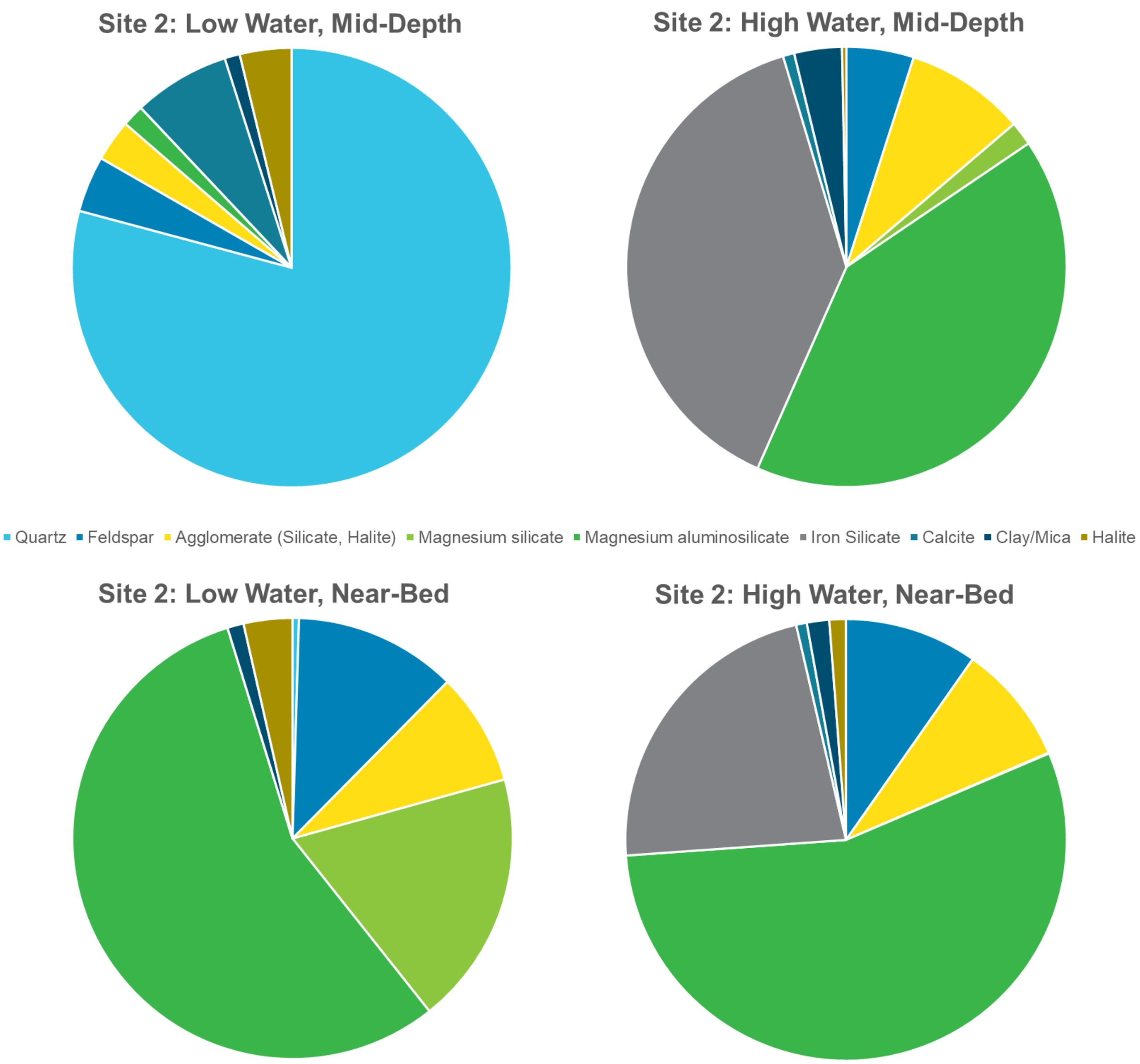


Figure 117. Elemental feature analysis results for the bed sediment close to Site 2 (top) and for the suspended sediment collected from Site 1 at low water and high water.

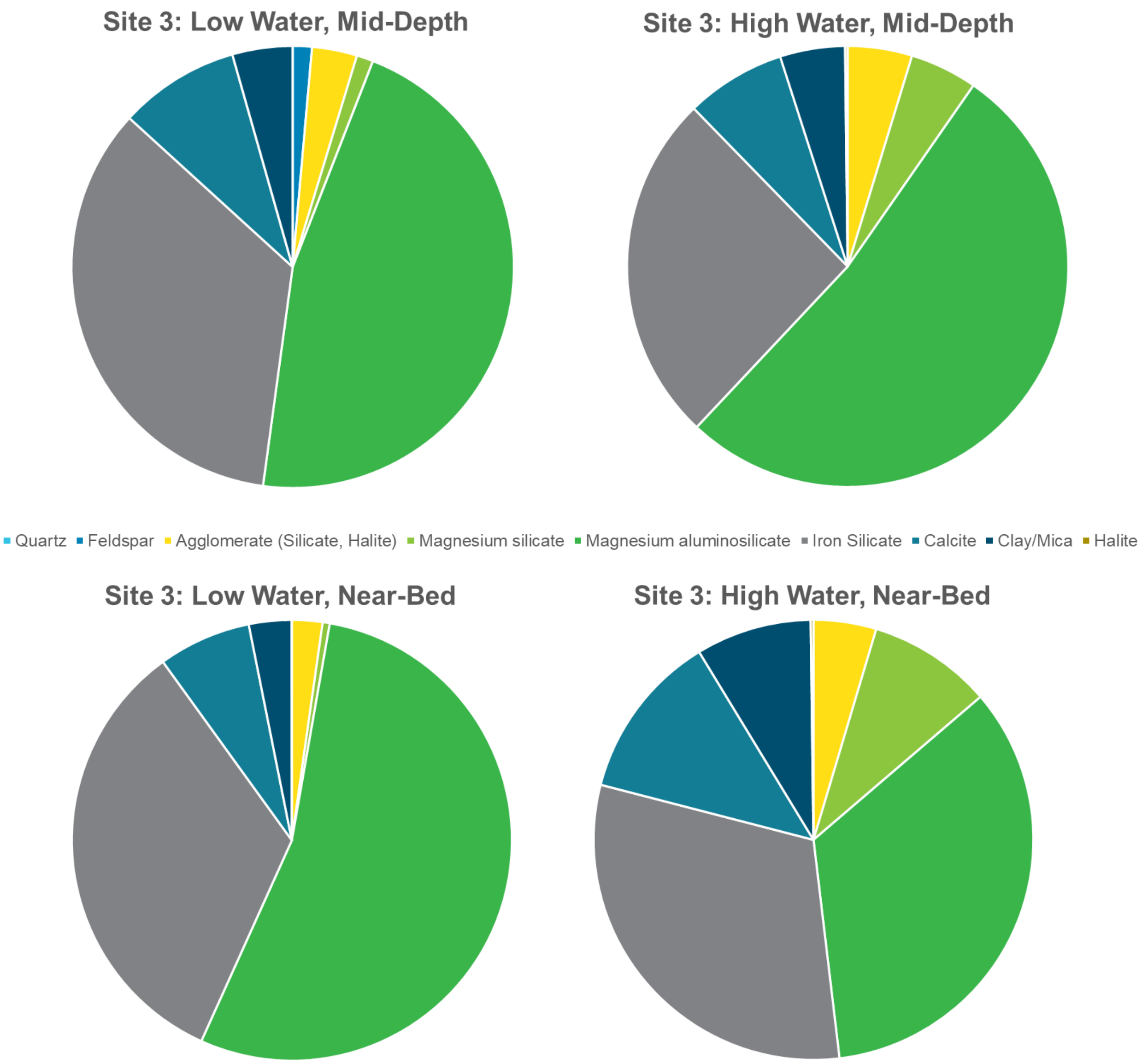


Figure 118. Elemental feature analysis results for the bed sediment close to Site 3 (top) and for the suspended sediment collected from Site 1 at low water and high water.

6.4.3. Coastal LiDAR Survey

Results from the coastal LiDAR survey are provided in Appendix B.

6.4.4. Multibeam Survey

Results from the multibeam survey are provided in Appendix C.

7. Summary

This report presents a factual record of the data which have been analysed as part of the CG Marine Sand Proposal project and subsequently used by PCS to inform the metocean and sediment dynamics assessment. The report provides a summary of the data, the quality control and data processing undertaken and details of the processed data files.

For data collected specifically as part of this project, this report also presents factual results from the data analysis. The report includes data from a range of external sources along with data collected specifically as part of the project during the Exploratory, Wet Season and Dry Season campaigns and data collected by self-logging instruments which have been deployed at a total of 14 sites in the CG region between June 2023 and August 2024.

8. References

BKA, 2024b. Cambridge Gulf Marine Sand Proposal – WA EP Act s38 Referral Report No. 2: *Proposal Setting & Existing Environment Descriptions.*

BKA, 2024d. Cambridge Gulf Marine Sand Proposal – WA EP Act s38 Referral Report No. 4: *Impact Assessments of Relevant Environmental Factors.*

Brockmann, C., Doerffer, R., Peters, M., Stelzer, K., Embacher, S., and Ruescas, A., 2016. Evolution of the C2RCC neural network for Sentinel 2 and 3 for the retrieval of ocean colour products in normal and extreme optically complex waters. Proceedings of Living Planet Symposium, Prague.

Copernicus, 2023. Copernicus Data Space Ecosystem. <https://dataspace.copernicus.eu>, viewed on 2 November 2023.

Kyryliuk, D. and Kratzer, S., 2019. Evaluation of Sentinel-3A OLCI Products Derived Using the Case-2 Regional CoastColour Processor over the Baltic Sea. Special Issue, Remote Sensing of Ocean Colour: Theory and Applications.

PCS, 2024a. Cambridge Gulf Marine Sand Proposal – WA EP Act s38 Referral Report No. 5: *Metocean & Sediment Dynamics – System Understanding, Conceptual Model and Initial Modelling*.

PCS, 2024b. Cambridge Gulf Marine Sand Proposal – WA EP Act s38 Referral Report No. 5: *Metocean & Sediment Dynamics – System Understanding, Conceptual Model and Initial Modelling*. Annex 1: Supplementary Technical Note.

PCS, 2025a. Cambridge Gulf Marine Sand Proposal – WA EP Act s38 Referral Report No. 8: *Metocean & Sediment Dynamics – Data Analysis and Numerical Modelling Report*.

Shepard, F.P., 1954. Nomenclature based on sand-silt-clay ratios. Journal of Sedimentary Research 24.

Vos, K., Harley, M.D., Splinter, K.D., Simmons, J.A., Turner, I.L., 2019a. Sub-annual to multi-decadal shoreline variability from publicly available satellite imagery. Coastal Engineering 150, 160–174.

Vos, K., Splinter, K.D., Harley, M.D., Simmons, J.A., Turner, I.L., 2019b. CoastSat: A Google Earth Engine-enabled Python toolkit to extract shorelines from publicly available satellite imagery. Environmental Modelling & Software 122, 104528.

Appendices

Appendix A – AIMS Data Report

Australian Institute of Marine Science
Cape Ferguson
P.M.B. No 3
Townsville M.C.
Queensland 4810 Australia

ORD RIVER STUDY
Western Australia

Data Report
25th September – 2nd October 2000
24th October – 6th November 2000

1. Introduction

During 25th September to 2nd October 2000, a field study was undertaken at the Ord River, near Wyndham (AIMS trip number 2721). Work was carried out in the West Arm and the freshwater section of the East arm.

The barge *Pillow Talk* was hired from Looksea Tours and was operated by Mark Douglas and Mandy Smith. Aluminium dinghy was hired from Mike Osborn who also acted as skipper for the day trip to the East Arm.

During 24th October to 6th November 2000, a second field study was undertaken at the Ord River, near Wyndham (AIMS trip number 2723). Work was carried out in the West Arm and the freshwater section of the East arm.

The barge *Pillow Talk* and fast boat *Joe's Delight* were hired from Looksea Tours and were operated by Mark Douglas and Mandy Smith.

NOTES

1. DeciDay 0.0 == 0000h 01/01/2000
2. Times, unless otherwise stated are given in Western Standard Time (UTC+0800h i.e. 2 hours behind Eastern Standard Time). Times in CTD files are in Eastern Standard Time during trip 2721 and Western Standard Time during trip 2723.
3. Magnetic variance = 3°20' E = +3.333333

Mooring Details

Mooring 1

Position	S 14° 57.838 E128° 07.929	S 14.964 E 128.132
Water depth at deployment	13.5 m	
In/Out water	10:16 27/09/2000 270.42777778	08:25 29/10/2000 302.35069444
Data start/stop	10:20 27/09/2000 270.43055556	07:00 29/10/2000 302.29166667

	Serial no.	Height (m)	Start	Stop	Filename
Neph	335	9.0	02:00 27/09/2000 270.08333333	13:58 29/10/2000 302.58194444	4680samples n335m1.raw
Neph	321	5.0	02:00 27/09/2000 270.08333333	13:25 29/10/2000 302.55902778	N321m1.raw 4677 samples
Neph	337	1.5	02:00 27/09/2000 270.08333333	13:43 29/10/2000 302.57152778	4679 samples n337m1.raw
InterOcean S4	632	7.75	17:30 26/09/2000 269.72916667	13:32 29/10/2000 302.56388889	1 Block 42783 bytes 6321000.s4b
Dataflow	40177	9.0	02:00 27/09/2000 270.08333333	13:28 29/10/2000 302.56111111	18851 bytes d40177m1.dat
ACR	332				6A/B = 14A/B

Instrument Notes:

Nephelometer setup:

Stabilize period	5 s
Sample rate	0.5 s
On period	10 s
Off period	585 s
Range	high range, low sensitivity

Dataflow setup:

Scan time	00:01:00
Average	00:10:00

S4 setup:

On	1 min
Cycle	10 min
True averaging	enabled
Average count	120
Channels at avg	456
Log mode	north and east

Mooring 2

Position	S 14° 58.249 E128° 11.310	S 14.971 E 128.189
Water depth at deployment	26.0 m	
In/Out water	08:55 27/09/2000 270.37152778	09:32 29/10/2000 302.39722222
Data start/stop	09:00 27/09/2000 270.375	09:30 29/10/2000 302.39583333

	Serial no.	Height (m)	Start	Stop	Filename
Neph	323	9.0	02:00 27/09/2000 270.08333333	13:35 26/10/2000 302.56597222	4678 samples n323m2.raw
Neph	333	5.0	02:00 27/09/2000 270.08333333	14:06 29/10/2000 302.5875	4681 samples n333m2.raw
Neph	320	1.5	02:00 27/09/2000 270.08333333	13:51 29/10/2000 302.57708333	4679 samples n320m2.raw
InterOcean S4	564	7.75	17:40 26/09/2000 269.73611111	13:39 29/10/2000 302.56875	1 block 42620 bytes 5641000.s4b
Dataflow	41053	9.0	02:00 27/09/2000 270.08333333	13:24 29/10/2000 302.55833333	17367 bytes D41053m2.dat
Aanderaa	WLR5 880	2.5	20:30 26/09/2000 269.85416667	16:52 30/10/2000 303.7027778	A880m2.raw
ACR	048				5C/A

NOTES:

- when downloading dataflow, error message received ‘Battery is flat on logger 41055. The log was terminated prematurely.’ Correct serial no. was entered in setup – not sure how incorrect serial no. occurred in error message.

Mooring 3

Position	S 15° 11.279 E128° 06.634	S 15.188 E 128.111
Water depth at deployment	14.5 m	
In/Out water	12:54 27/09/2000 270.5375	11:00 29/10/2000 302.45833333
Data start/stop	13:00 27/09/2000 270.54166667	10:50 29/10/2000 302.45138889

	Serial no.	Height (m)	Start	Stop	Filename
Neph	313	9.0	02:00 27/09/2000 270.08333333	13:45 29/10/2000 302.57291667	4679 samples n313m3.raw
Neph	302	5.0	02:00 27/09/2000 270.08333333	13:41 29/10/2000 302.57013889	4679 samples n302m3.raw
Neph	312	1.5	06:00 27/09/2000 270.25	13:37 29/10/2000 302.56736111	4654 samples n312m3.raw
InterOcean S4	615	7.75	17:20 26/09/2000 269.72222222	13:23 29/10/2000 302.55763889	1 block 42629 bytes 6151000.s4b
Dataflow	39997	9.0	02:00 27/09/2000 270.08333333	13:30 29/10/2000 302.5625	18727 bytes d39997m3.dat
ACR	195				2C/D

Mooring 4

Position	S 15° 10.639 E128° 08.268	S 15.177 E 128.138
Water depth at deployment	10.3 m	
In/Out water	11:39 27/09/2000 270.48541667	06:44 31/10/2000 304.28055556
Data start/stop	11:50 27/09/2000 270.49305556	06:40 31/10/2000 304.27777778

	Serial no.	Height (m)	Start	Stop	Filename
Neph	307	10.0	02:00 27/09/2000 270.08333333	15:27 31/10/2000 304.64375	4977 samples n307m4.raw
Neph	303	5.0	02:00 27/09/2000 270.08333333	15:33 31/10/2000 304.64791667	4978 samples n303m4.raw
Neph	308	1.5	02:00 27/09/2000 270.08333333		N/a
InterOcean S4	630	7.75	17:00 26/092000 269.70833333	15:24 31/10/2000 304.64166667	1 block 45511 bytes 6301000.s4b
Dataflow	41075	10.0	02:00 27/09/2000 270.08333333	15:44 31/10/2000 304.65555556	16207 bytes d41075m4.dat
ACR	017				1D/A

Temporary dataflow mooring (d41075 was possibly damaged on deployment):

Position	S 15° 10.646 E128° 08.380	
Water depth at deployment	9.5 m	
In/Out water	11:53 28/09/2000 271.49513889	09:25 01/10/2000 274.39236111
Data start/stop	12:00 28/09/2000 271.5	09:20 01/10/2000 274.38888889

	Serial no.	Height (m)	Start	Stop	Filename
Dataflow	40673	5.0	06:00 28/09/2000 271.25	17:47 01/10/2000 274.74097222	D4067309.dat 2039 bytes

NOTES:
- when downloading d41075, error message received 'battery is flat on logger 41075. The log was terminated prematurely'
- could not reset n308. Opened up housing – battery voltage = 1.46V

Frame 1

Position	S 15° 20.154 E 128° 17.844	
Water depth at deployment	5.2 m	
In/Out water	07:25 26/10/2000 299.30902778	10:20 31/10/2000 304.43055556
Data start/stop	07:30 26/10/2000 299.3125	10:10 31/10/2000 304.42361111

	Serial no.	Height (m)	Start	Stop	Filename
Neph	324	1.34	20:00 25/10/2000 298.83333333	15:39 31/10/2000 304.65208333	1676 samples n324f1.raw
Neph	336	0.90	20:00 25/10/2000 298.83333333	15:29 31/10/2000 304.64513889	1674 samples n336f1.raw
Neph	338	0.38	20:00 25/10/2000 298.83333333	15:35 31/10/2000 304.64960556	1675 samples n338f1.raw
InterOcean S4	058	0.79 0.72	18:15 25/10/2000 298.76041667	15:21 31/10/2000 304.63958333	1 block 8533 bytes 0581000.s4b
Dataflow	40673	0.71	20:00 25/10/2000 298.83333333	15:55 31/10/2000 304.66319444	6759 bytes d40673f1.dat
Rigo	1138	0.34	06:01:00 26/10/2000 299.25069444	16:08:15 31/10/2000 304.67222222	7806 samples r1138f1.txt

NOTE:

- Rigo flattened out at peak tide – range not big enough.

Instrument Notes:

Nephelometer setup:

Stabilize period	5 s
Sample rate	0.5 s
On period	10 s
Off period	285 s
Range	high range, low sensitivity

Dataflow setup:

Scan time	00:01:00
Average	00:05:00

S4 setup:

On	1 min
Cycle	5 min
True averaging	enabled
Average count	120
Channels at avg	6
Log mode	north and east

Rigo setup:

Interval	60 s

Frame 2

Position	S 15° 28.678 E 128° 18.531	
Water depth at deployment	8.0 m	
In/Out water	06:50 27/10/2000 300.28472222	09:55 30/10/2000 303.41319444
Data start/stop	07:00 27/10/2000 300.29166667	09:45 30/10/2000 303.40625

	Serial no.	Height (m)	Start	Stop	Filename
Neph	334	1.32	20:00 25/10/2000 298.83333333	10:48 30/10/2000 303.45	1331 samples n334f2.raw
Neph	322	0.34	20:00 25/10/2000 298.83333333	10:47 30/10/2000 303.44930556	1330 samples n322f2.raw
InterOcean S4	012	.88 .81	03:50 27/10/2000 300.15972222	15:35 30/10/2000 303.64930556	N/a
Dataflow	39995	0.70	20:00 25/10/2000 298.83333333	15:29 30/10/2000 303.64513889	2847 bytes d39995f2.dat
Rigo	1137	0.83	09:14:00 26/10/2000 299.38472222	15:35:40 30/10/2000 303.64930556	6141 samples r1137f2.txt

NOTES:

- S4 012 did not work well – no current data, depth shows shape of tide but values are incorrect.
- Rigo flattened out at peak tide – range not big enough.

CTD Casts

Date	Time	Deciday	Filename	Location (S14° - 15° E128°) & comments
27/09/2000	08:30	270.35416667	O270908a	Mooring 2; slack current, flat calm
	10:05	270.42013889	O270910a	Mooring 1
	11:25	270.47569444	O270911a	Mooring 4
	12:49	270.53402778	O270912a	Mooring 3
28/09/2000	07:25	271.30902778	O280907a	A 50.655 13.061
	08:00	271.33333333	O280908a	B 50.000 13.134 in plume near A
	08:28	271.35277778	O280908b	C 55.083 09.874
	09:12	271.38333333	O280909a	D 57.799 11.341 mooring 2
	09:37	271.40069444	O280909b	E 57.751 07.882 mooring 1
	09:54	271.4125	O280909d	F 00.229 07.313
	10:36	271.44166667	O280910a	G 05.000 06.657
	11:27	271.47708333	O280911a	H 10.679 08.155 mooring 4
	11:54	271.49583333	O280911b	10.646 08.380 temp. mooring
	12:43	271.52986111	O280912a	I 11.200 06.604 mooring 3
	13:05	271.54513889	O280913a	J 15.157 05.926
	13:26	271.55972222	O280913b	K 20.306 05.849
	13:46	271.57361111	O280913c	L 25.563 06.074
30/09/2000	09:10	273.38194444	O300909a	54.675 01.573; Lynne River near waterfall
01/10/2000	07:32	274.31388889	East100	1 11.966 08.986; ~15m from West Bank; tide flooding
	07:36	274.31666667	East101	2 11.889 08.875
	07:45	274.32291667	East102	3 11.660 09.192
	07:51	274.32708333	East103	4 11.397 09.458
	07:58	274.33194444	East104	5 11.243 09.579; ~20m from mangroves on Barnes Is.
	08:29	274.35347222	East200	1 flat high tide
	08:33	274.35625	East201	2
	08:40	274.36111111	East202	3
	08:45	274.36458333	East203	4
	08:50	274.36805556	East204	5
	09:34	274.39861111	M3400	mooring 4
	09:49	274.40902778	M3401	mooring 3
	11:45	274.48958333	East300	1 peak ebb tide
	11:54	274.49583333	East301	2
	12:00	274.5	East302	3
	12:07	274.50486111	East303	4
	12:13	274.50902778	East304	5
26/10/2000	07:56	299.33055556	O2607a	Frame1
	09:50	299.40972222	O2609a	Frame 1 – ebb current strong

	11:00	299.45833333	O2611a	M4
	11:08	299.46388889	O2611b	M3
27/10/2000	07:47	300.32430556	O2707a	Frame 2
	08:32	300.35555556	O2708a	Location 3: Echo rock S15° 29.209 E128° 20.826
	08:53	300.37013889	O2708b	Location 4: near Green Is. S15° 30.016 E128° 19.514
	09:08	300.38055556	O2709a	Frame 2
	09:37	300.40069444	O2709b	Location 5: upstream Fossil I S15° 24.390 E128° 17.603
	09:55	300.41319444	O2709c	Frame 1
	10:59	300.45763889	O2710a	Location 6: S15° 14.708 E128° 13.756
	11:37	300.48402778	O2711a	M4
	12:30	300.52083333	O2712a	M3
28/10/2000	05:16	301.21944444	O2805a	Rising tide: M4
	05:57	301.24791667	O2805b	frame 1
	06:26	301.26805556	O2806a	frame 2
	06:42	301.27916667	O2806b	Echo Rock
	08:45	301.36458333	O2808a	Slack HT: Echo Rock
	09:06	301.37916667	O2809a	frame 2
	09:52	301.41111111	O2809b	frame 1
	10:31	301.43819444	O2810a	M4
	14:11	301.59097222	O2814a	Low tide: frame 1
29/10/2000	08:36	302.35833333	O2907a	M1
	09:33	302.39791667	O2909a	M2
	10:49	302.45069444	O2910a	M3
30/10/2000	07:59	303.33263889	O3007a	M4
	08:50	303.36805556	O3008a	Frame 1
	09:23	303.39097222	O3009a	Frame 2
31/10/2000	06:37	304.27569444	O3106a	M4
	07:36	304.31666667	O3107a	Frame 1

ustralian Institute of Marine Science
Cape Ferguson
P.M.B. No 3
Townsville M.C.
Queensland 4810 Australia

ORD RIVER STUDY
Western Australia

Data Report
10th – 19th January 2002
8th – 19th February 2002

Introduction

During 10th – 19th January 2002, a field study was undertaken at the Ord River, near Wyndham and in Cambridge Gulf (AIMS trip number 2975) on the R.V. Cape Ferguson.

During 8th – 19th February 2002, a second trip was conducted in the Ord River/Cambridge Gulf (AIMS trip number 2977) on the R.V. Cape Ferguson.

NOTES

1. DeciDay 0.0 == 0000h 01/01/2002
2. Times, unless otherwise stated are given in Western Standard Time (UTC+0800h i.e. 2 hours behind Eastern Standard Time).
3. Magnetic variance = 3°20' E = +3.333333

Mooring Details

Mooring A

Position	14° 47.72' S 128° 21.15' E	14.7953 128.3525
Water depth at deployment	16.3 m	
In/Out water	11:12 12/01/2002 11.46666667	9:09 09/02/2002 39.38125
Data start/stop	11:30 12/01/2002 11.47916667	9:00 09/02/2002 39.375

	Serial no.	Height (m)	Start	Stop	Filename
Neph	312	2.9	9:30 11/01/2002 10.39583333	9:44 09/02/2002 39.40555556	C3120202.raw 4178 samples
Neph	303	8.4	9:30 11/01/2002 10.39583333	9:51 09/02/2002 39.41041667	C3030202.raw 4179 samples
Neph	320	14.3	10:30 11/01/2002 10.4375	9:58 09/02/2002 39.41527778	c3200202.raw 4173 samples
ADCP	61	2.9	17:30 11/01/2002 10.72916667	9:37 09/02/2002 39.40069444	Cary1000.000 1163573 bytes
Dataflow	39993	14.3	11:00 11/01/2002 10.45833333	9:34 09/02/2002 39.39861111	C399302.dat 34183 bytes
ACR	332				6A/B (14A/B)

Instrument Notes – Moorings A and B:

Nephelometer setup:

Stabilize period	5 s
Sample rate	0.5 s
On period	10 s
Off period	585 s
Range	low range, high sensitivity

Dataflow setup:

Scan time	00:01:00
Average	00:05:00

ADCP setup:

Time/ensemble	5 min	
Time/burst	30 min	
Ensembles/burst	1	
Bin size	1.0 m	
No. bins	35	
Setup file	cg2.whp	cg1.whp
Deployment file	cary1	eric1

Mooring B

Position	14° 48.94' S 128° 13.10' E	14.8157 128.2183
Water depth at deployment	31.3 m	
In/Out water	13:37 12/01/2002 11.56736111	10:41 9/02/2002 39.44513889
Data start/stop	14:00 12/01/2002 11.58333333	10:30 9/02/2002 39.4375

	Serial no.	Height (m)	Start	Stop	Filename
Neph	302	3.2	9:30 11/01/2002 10.39583333	11:10 9/02/2002 39.46527778	E3020202.raw 4187 samples
Neph	307	12.8	10:00 11/01/2002 10.41666667	11:14 9/02/2002 39.46805556	E3070202.raw 4184 samples
Neph	313	18.8	10:30 11/01/2002 10.4375	11:18 9/02/2002 39.47083333	E3130202.raw 4181 samples
ADCP	412	3.2	17:30 11/01/2002 10.72916667	11:13 9/02/2002 39.46736111	Eric1000.000
ACR	012				2 B/D (10.5 B/D)

NOTES:

- Instrument setup as per Mooring A
- n313 download – Warning - Battery voltage is TOO LOW! Replace Batteries! Data looks okay though.

Mooring C

Position	15° 02.08'S 128° 10.46'E	15.0347 128.1743
Water depth at deployment	17.9 m	
In/Out water	17:17 12/01/2002 11.72013889	8:50 13/02/2002 43.36805556
Data start/stop	17:30 12/01/2002 11.72916667	8:40 13/02/2002 43.36111111

	Serial no.	Height (m)	Start	Stop	Filename
Neph	324	1.0	15:10 12/01/2002 11.63194444	9:24 13/02/2002 43.39166667	S3240202.raw 4544 samples
Neph	333	4.0	15:00 12/01/2002 11.625	9:18 13/02/2002 43.3875	S3330202.raw 4575 samples
Neph	321	6.5	15:00 12/01/2002 11.625	9:14 13/02/2002 43.38472222	S3210202.raw 4574 samples
InterOcean S4	630	2.6	16:10 12/01/2002 11.67361111	9:20 13/02/2002 43.38888889	6300202.s4b 1 block 22984 bytes
InterOcean S4	564	5.4	17:05 12/01/2002 11.71180556	9:10 13/02/2002 43.38194444	5640202.s4b 1 block 22873 bytes
Dataflow	39994	6.5	15:30 12/01/2002 11.64583333	9:06 13/02/2002 43.37916667	S3999402.dat 37507 bytes
ACR	048				5C/A

NOTES:

- n333 after download – A/D not increasing when sensor covered

Instrument Notes – Moorings C, D & E:

Nephelometer setup:

Stabilize period	5 s
Sample rate	0.5 s
On period	10 s
Off period	585 s
Range	high range, low sensitivity

Dataflow setup:

Scan time	00:01:00
Average	00:05:00

ADCP setup:

Time/ensemble	5 min
Time/burst	30 min
Ensembles/burst	1
Bin size	1.0 m
No. bins	35
Setup file	cg3.whp
Deployment file	timmy

S4 setup:

On	1 min
Cycle	10 min
True averaging	enabled
Average count	120
Channels at avg	6
Log mode	north and east

Mooring D

Position	15° 10.41'S 128° 08.27'E	15.1735 128.1378
Water depth at deployment	9.9 m	
In/Out water	10:57 13/01/2002 12.45625	11:11 13/02/2002 43.46597222
Data start/stop	11:00 13/01/2002 12.45833333	11:00 13/02/2002 43.45833333

	Serial no.	Height (m)	Start	Stop	Filename
Neph	323	0.5	4:00 13/01/2002 12.16666667	11:39 13/02/2002 43.48541667	K3230202.raw 4510 samples
Neph	335	2.7	4:00 13/01/2002 12.16666667	11:36 13/02/2002 43.48333333	K3350202.raw 4510 samples
Neph	334	5.1	4:00 13/01/2002 12.16666667	11:32 13/02/2002 43.48055556	K3340202.raw 4510 samples
InterOcean S4	058	1.9	8:20 13/01/2002 12.34722222	11:33 13/02/2002 43.48125	0580202.s4b 1 block 22488 bytes
InterOcean S4	615	3.5	8:35 13/01/2002 12.35763889	11:30 13/02/2002 43.47916667	6150202.s4b 1 block 22478 bytes
Dataflow	39995	5.1	4:00 13/01/2002 12.16666667	11:23 13/02/2002 43.47430556	K3999502.dat 37003 bytes
ACR	017				1 D/A (10 D/A)

NOTES:
- Approximately same position as M4 during Oct/Nov 2000 trip
- Instrument setup as per Mooring C

Mooring E

Position	15° 27.55' S 128° 05.11' E	15.4592 128.0852
Water depth at deployment	8.0 m	
In/Out water	14:20 13/01/2002 12.59722222	16:58 14/02/2002 44.70694444
Data start/stop	14:30 13/01/2002 12.60416667	16:30 14/02/2002 44.6875

	Serial no.	Height (m)	Start	Stop	Filename
Neph	337	0.5	4:00 13/01/2002 12.16666667	17:25 14/02/2002 44.72569444	T3370202.raw 4689 samples
Neph	336	3.3	4:00 13/01/2002 12.16666667	17:22 14/02/2002 44.72361111	T3360202.raw 4689 samples
Neph	322	6.4	4:00 13/01/2002 12.16666667	17:29 14/02/2002 44.72847222	T3220202.raw 4690 samples
ADCP	974	1.9	13:00 13/01/2002 12.54166667	17:30 14/02/2002 44.72916667	Timmy000.000
Dataflow	41053	6.4	4:00 13/01/2002 12.16666667	17:10 14/02/2002 44.71527778	T4105302.dat 24099 bytes
ACR	195				2 C/D (10.5 C/D)

NOTES:

- Instrument setup as per Mooring C
- d41053 download – Battery is flat on logger 41055. The log was terminated prematurely.
- n336 after download – A/D changes when sensor is covered, BUT reads 0 in air. Significant amount of downloaded data has 0 value.

CTD Casts

Date	Time	Deciday	Filename	Location (S14° - 15° E128°) & comments
				Transect DRW – Cambridge Gulf (in J Bonaparte Gulf)
10/01/2002	6:50	9.28472222	Gc1006a	1. 12° 30.60 130° 00.05
	9:54	9.4125	Gc1009a	2. 12° 49.47 129° 44.05 OBS didn't work
	12:40	9.52777778	Gc1012a	3. 13° 07.17 129° 27.26
	16:30	9.6875	Gc1016a	4. 13° 25.00 129° 10.83
	19:15	9.80208333	Gc1019a	5. 13° 43.60 128° 54.50
	21:45	9.90625	Gc1021a	6. 13° 59.81 128° 40.42
11/01/2002	1:05	10.04513889	Gc1101a	7. 14° 19.85 128° 21.61
	8:00	10.33333333	Gc1108a	8. 14° 42.74 128° 16.11 near Lacrosse Island
12/01/2002	11:22	11.47361111	Gc1211a	A
	14:25	11.60069444	Gc1214a	B
	17:37	11.73402778	Gc1217a	C
13/01/2002	11:15	12.46875	Gc1311a	D – unusual obs profile
	11:24	12.475	Gc1311b	D – same obs profile
	14:27	12.60208333	Gc1314a	Tim
14/01/2002				Tidal station near Wyndham 15° 27.47 128° 05.68
	7:32	13.31388889	Gc1407a	High tide
	8:01	13.33402778	Gc1408a	
	8:30	13.35416667	Gc1408b	
	9:00	13.375	Gc1409a	
	9:30	13.39583333	Gc1409b	
	10:03	13.41875	Gc1410a	
	10:31	13.43819444	Gc1410b	
	11:00	13.45833333	Gc1411a	
	11:30	13.47916667	Gc1411b	
	12:00	13.5	Gc1412a	
	12:29	13.52013889	Gc1412b	
	13:00	13.54166667	Gc1413a	
	13:32	13.56388889	Gc1413b	
	13:37	13.56736111	Gc1413c	
	14:00	13.58333333	Gc1414a	
	14:30	13.60416667	Gc1414b	
	15:01	13.62569444	Gc1415a	
	15:29	13.64513889	Gc1415b	
	15:35	13.64930556	Gc1415c	
	16:01	13.66736111	Gc1416a	
	16:30	13.6875	Gc1416b	
	17:00	13.70833333	Gc1417a	

	17:37	13.73402778	Gc1417b	
	18:01	13.75069444	Gc1418a	
	18:30	13.77083333	Gc1418b	
	19:01	13.79236111	Gc1419a	
	19:31	13.81319444	Gc1419b	
	20:01	13.83402778	Gc1420a	
	20:30	13.85416667	Gc1420b	
	21:00	13.875	Gc1421a	High tide
15/01/2002				Transect from Wyndham to mouth of Lyne River
	8:44	14.36388889	Gc1508a	Tim
	9:23	14.39097222	Gc1509a	15° 22.69 128° 06.64
	9:55	14.41319444	Gc1509n	15° 17.76 128° 06.04
	13:25	14.55902778	Gc1513a	15° 11.28 128° 06.96 mouth west arm
	13:46	14.57361111	Gc1513b	KT
	14:23	14.59930556	Gc1514a	15° 05.97 128° 06.54
	14:54	14.62083333	Gc1514b	15° 02.11 128° 07.11
	15:32	14.64722222	Gc1515a	C
	16:20	14.68055556	Gc1516a	14° 57.15 128° 11.63
	17:15	14.71875	Gc1517a	14° 52.42 128° 13.54
16/01/2002	13:38	15.56805556	Gc1613a	B
	14:44	15.61388889	Gc1613b	A
17/01/2002	7:47	16.32430556	Gc1707a	A
	8:47	16.36597222	Gc1708a	14° 40.71 128° 19.94
	9:40	16.40277778	Gc1709a	14° 33.73 128° 16.98
	10:34	16.4402778	Gc1710a	14° 27.19 128° 14.21
	11:43	16.48819444	Gc1711a	14° 33.52 128° 16.80
	13:52	16.57777778	Gc1713a	14° 44.34 128° 15.94
18/01/2002	09:16	17.38611111	Gc1809a	14° 14.11 128° 27.10
	11:06	17.4625	Gc1811a	14° 04.73 128° 35.41
9/02/2002	1:45	39.07291667	Cg0901a	14° 04.7670 128° 35.3503
	3:15	39.13541667	Cg0903a	14° 14.22 128° 27.13
	7:00	39.29166667	Cg0907a	14° 41.419 128° 16.4719
	8:35	39.35763889	Cg0908a	A – not to bottom; pressure offset of ~6.5m
	8:53	39.37013889	Cg0908b	A
	10:25	39.43402778	Cg0910a	B
10/02/2002				13h tidal station in a channel of false mouth of the Ord
	11:15	40.46875	Cg1011a	Pump didn't turn on
	11:29	40.47847222	Cg1011b	Slack low tide
	12:35	40.52430556	Cg1012a	
	13:30	40.5625	Cg1013a	
	14:30	40.60416667	Cg1014a	
	15:30	40.64583333	Cg1015a	8.70m
	16:31	40.68819444	Cg1016a	10.10m

	17:29	40.72487222	Cg1017a	
	18:28	40.76944444	Cg1018a	10.4m
	19:29	40.81180556	Cg1019a	9.90m
	20:30	40.85416667	Cg1020a	8.50m
	21:30	40.89583333	Cg1021a	7.9m
	22:30	40.9375	Cg1022a	7.1m Pressure sensor didn't work
	23:00	40.95833333	Cg1022b	6.7m Pressure sensor didn't work
	23:26	40.97638889	Cg1023a	6.50m
11/02/2002	00:31	41.02152778	Cg1100a	6.4m
	8:00	41.33333333	Cg1108a	'David' – false mouth of Ord – cast to check press. sensor
				Travel down false mouth – 2nd channel from North
	9:35	41.39930556	Cg110200	0 - 15° 04.400 128° 28.332 farthest point up creek
	9:53	41.41180556	Cg110201	1 - 15° 04.232 128° 28.044
	10:06	41.42083333	Cg110202	2 - 15° 04.232 128° 27.749
	10:35	41.44097222	Cg110203	3 - 15° 03.362 128° 27.214
	11:24	41.475	Cg110204	4 - 15° 03.374 128° 26.414
	11:35	41.48263889	Cg110205	5 - 15° 03.389 128° 25.524
12/02/2002				Transects up 2 forks of Lyne River – ebb tide
	8:19	42.34652778	Lynea00	Tx A - Creek – fork 14° 52.794 128° 03.030
	8:29	42.35347222	Lynea01	14° 52.415 128° 03.081
	8:35	42.35763889	Lynea02	14° 52.293 128° 02.660
	8:39	42.36041667	Lynea03	14° 52.061 128° 02.502
	8:53	42.37013889	Lynea04	Rocks 14° 52.011 128° 02.274
	10:05	42.42013889	Lynea05	Tx B – Lyne River - Rockbar at gorge 14° 55.116 128° 01.931
	10:11	42.42430556	Lynea06	14° 54.917 128° 02.454
	10:18	42.42916667	Lynea07	14° 54.141 128° 02.960
	10:26	42.43472222	Lynea08	14° 53.366 128° 03.087
	10:35	42.44097222	Lynea09	Fork 14° 53.081 128° 03.045
	13:36	42.56666667	Cg1213a	Lyne River anchorage 26.9m 1° 52.064 128° 05.634
				Transects up 2 forks of Lyne River – flood tide
	14:31	42.604860111	Lyneb00	Tx A - Creek – fork 14° 52.794 128° 03.030
	14:37	42.60902778	Lyneb01	14° 52.415 128° 03.081
	14:47	42.61597222	Lyneb03	14° 52.293 128° 02.660

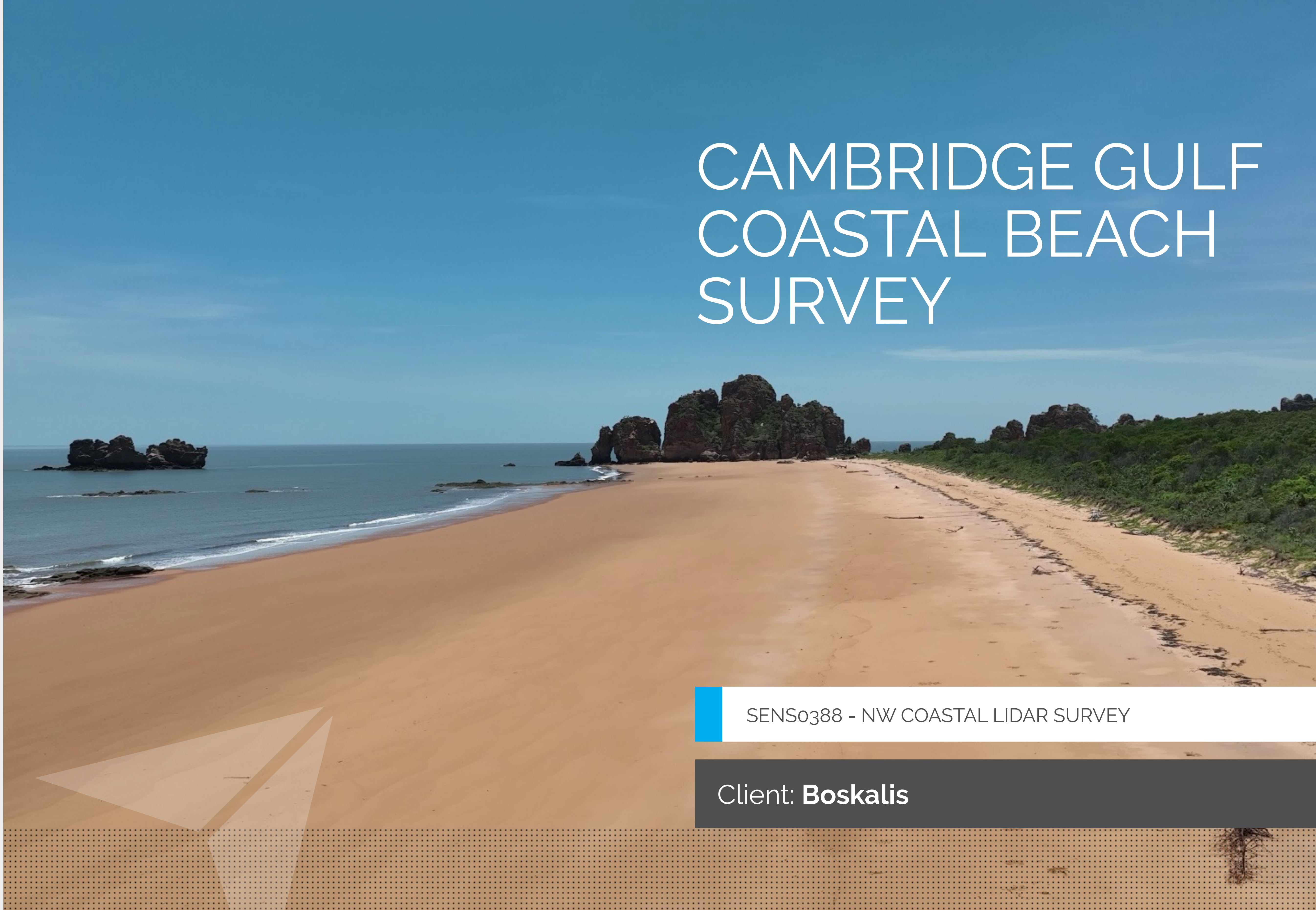
	14:50	42.61805556	Lyneb04	14° 52.061 128° 02.502
	14:55	42.62152778	Lyneb05	Rocks 14° 52.011 128° 02.274
	15:28	42.64444444	Lyneb06	Tx B – Lyne River - Rockbar at gorge 14° 55.116 128° 01.931
	15:34	42.64861111	Lyneb07	14° 54.917 128° 02.454
	15:40	42.65277778	Lyneb08	14° 54.141 128° 02.960
	15:46	42.65694444	Lyneb09	14° 53.366 128° 03.087
	15:51	42.66041667	Lyneb10	Fork 14° 53.081 128° 03.045
13/02/2002	8:35	43.35763889	Cg1308a	C 15.1m
	11:05	43.46180556	Cg1311a	D
				24 hour tidal station
	15:01	43.62569444	Cg1315a	7.8m
	16:01	43.66736111	Cg1316a	9.0m
	17:02	43.70972222	Cg1317a	11m
	18:03	43.75208333	Cg1318a	12m
	19:01	43.79236111	Cg1319a	13m
	20:02	43.83472222	Cg1320a	14m
	21:02	43.87638889	Cg1321a	14.6m
	22:03	43.91875	Cg1322a	14.4m
	23:04	43.96111111	Cg1323a	12.8m
14/02/2002	00:02	44.00138889	Cg1400a	11.7m
	01:02	44.04305556	Cg1401a	10.4m
	02:03	44.08541667	Cg1402a	9.5m
	03:17	44.13680556	Cg1403a	8.0m
	04:03	44.16875	Cg1404a	9.0m
	05:03	44.21041667	Cg1405a	10.7m
	06:02	44.25138889	Cg1406a	12m
	07:02	44.29305556	Cg1407a	12.6m
	08:02	44.33472222	Cg1408a	13.8m
	09:02	44.37638889	Cg1409a	15.1m
	10:02	44.41805556	Cg1410a	12.4m
	11:02	44.45972222	Cg1411a	11.7m
	12:01	44.50069444	Cg1412a	10.7m
	13:00	44.54166667	Cg1413a	9.2m
	14:02	44.58472222	Cg1414a	8.10m
	15:02	44.62638889	Cg1415a	7.90m
	16:00	44.66666667	Cg1416a	8.90m
	16:53	44.70347222	Cg1416b	Tim
15/02/2002				Transect from Wyndham to Lacrosse Island
	6:32	45.27222222	Cg1506a	Wyndham 12.3 m 15° 27.7250 128° 04.9669
	7:25	45.30902778	Cg1507a	15° 22.694 128° 06.5659 18.4m
	8:12	45.34166667	Cg1508a	15° 17.68 128° 5.96 43m

	9:09	45.38125	Cg1509a	15° 11.194 128° 07.0315 63m
	9:50	45.40972222	Cg1509b	15° 05.925 128° 06.5479 15.9m
	10:22	45.43194444	Cg1510a	15° 01.9941 128° 07.0962 58m
	11:07	45.46319444	Cg1511a	14° 57.0420 128° 11.7123 23.6m
	11:42	45.4875	Cg1511b	14° 52.4010 128° 13.6270 21.7m
	12:35	45.52430556	Cg1512a	14° 44.642 128° 15.1015 40m
16/02/2002	20:00	46.83333333	Cg1620a	14° 14.3580 128° 27.3401 38m (of 41m total depth)

Appendix B – Sensorem Technical Note

SENSOREM.

An AERODYNE Company



CAMBRIDGE GULF COASTAL BEACH SURVEY

SENS0388 - NW COASTAL LIDAR SURVEY

Client: **Boskalis**

SENSOREM.
An AERODYNE Company

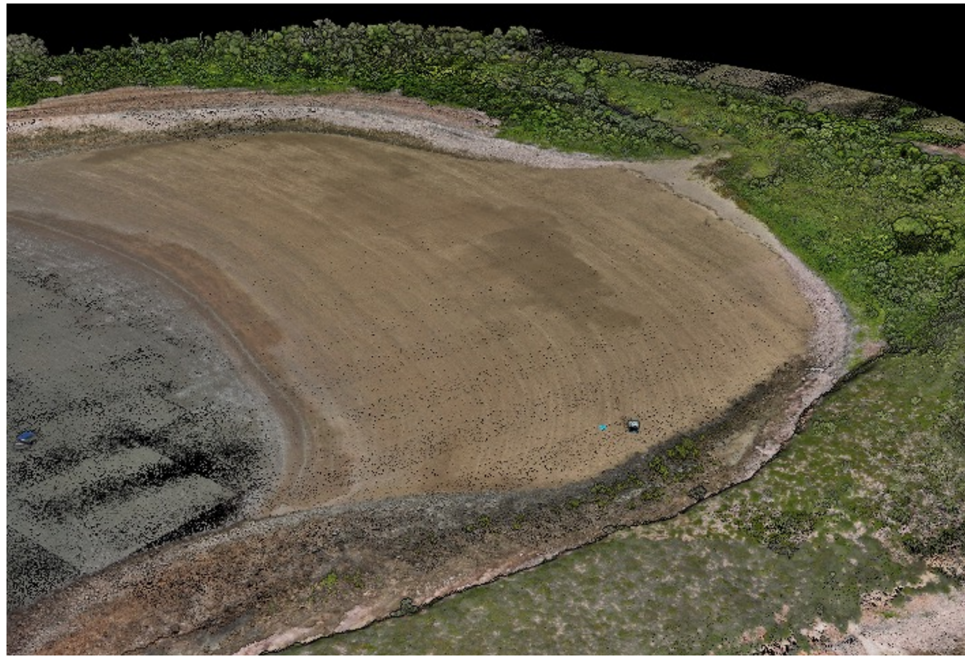
GENERAL PROJECT INFORMATION

Between 22/02/24 – 25/02/24, Sensorem conducted two types of survey, in the form of LiDAR and Photogrammetry, on renowned turtle nesting beaches around the Cambridge Gulf. Data was captured using the DJI Matrice 300 RTK with the Zenmuse L2 payload installed, and flown with RTK corrections for high accuracy.

Between 27/02/24 – 29-02-24, photography and videography was completed on intertidal areas around the Cambridge Gulf.

Orthomosaic of Turtle Bay

Image of Turtle Bay



LiDAR Point Cloud of Turtle Bay

SENSOREM.
An AERODYNE Company

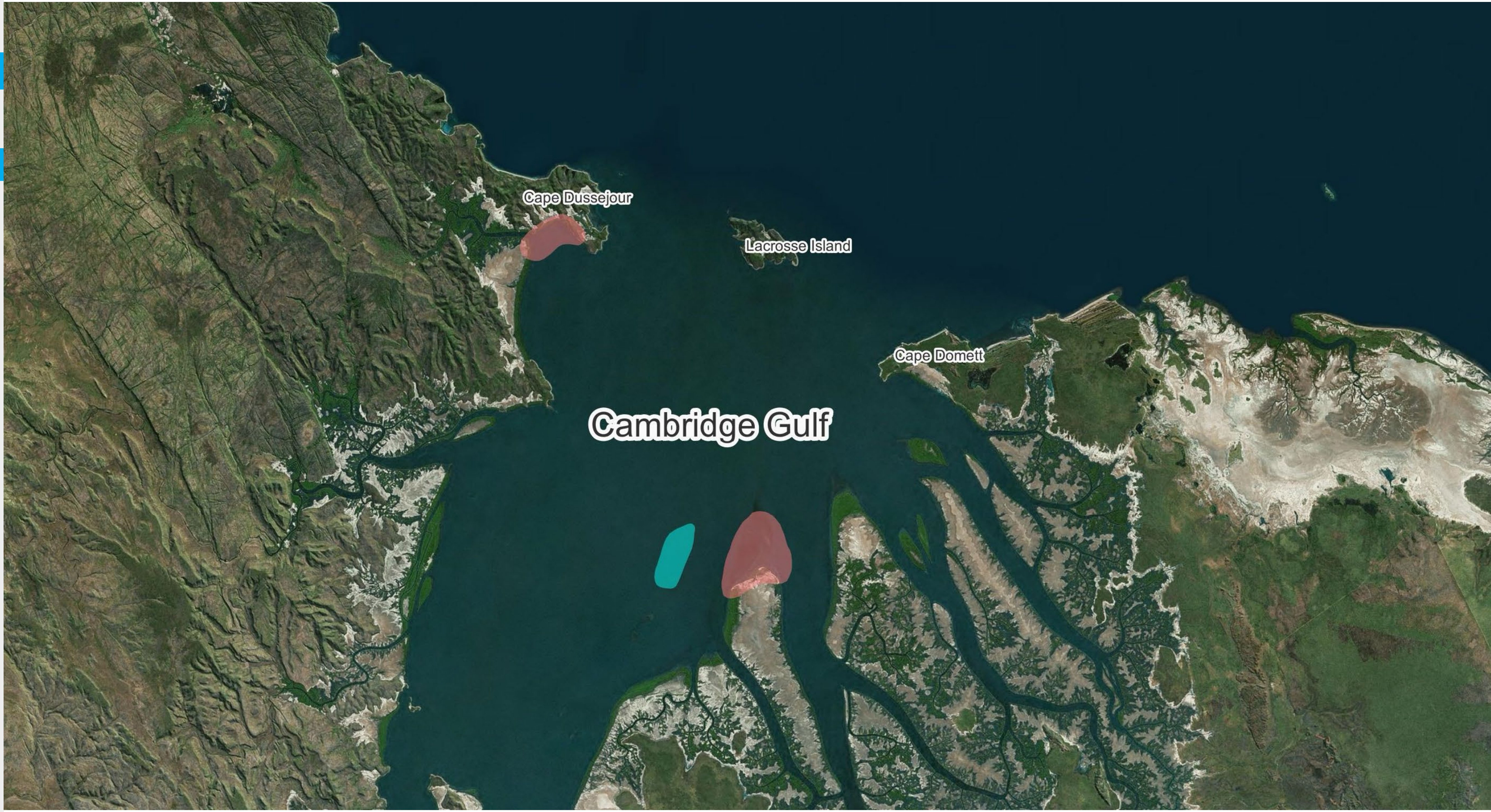
SURVEY LOCATIONS

The surveys were conducted on 4 beaches around the Cambridge Gulf, renowned for turtle nesting. These beaches were located on Cape Domett, Lacrosse Island and Cape Dussejour.

MEDIA CAPTURE LOCATIONS

Media was captured over intertidal areas around the Cambridge Gulf.

Videography Photography



SENSOREM.
An AERODYNE Company

MEDIA CAPTURE LOCATIONS

Panorama

SURVEY EQUIPMENT

UNMANNED AERIAL SYSTEM (UAS)

The unmanned aerial system (UAS) used to conduct this survey was the DJI Matrice 300 RTK Drone. The DJI Zenmuse L2 was used for the photogrammetry and LiDAR survey.

DJI Matrice 300 RTK UAS

- Dimensions: Unfolded, propellers excluded, 810×670×430 mm (L×W×H). Folded, propellers included, 430×420×430 mm (L×W×H)
- Diagonal Wheelbase: 895 mm
- Weight (with single downward gimbal): Approx. 3.6 kg (without batteries). Approx. 6.3 kg (with two TB60 batteries)
- Max Payload: 2.7 kg
- Max Take-off Weight: 9 kg
- Operating Frequency: 2.4000-2.4835 GHz. 5.725-5.850 GHz
- GNSS: GPS, GLONASS, BeiDou, Galileo

DJI Zenmuse L2

Photogrammetry

- Sensor: 4/3 CMOS
- Effective Pixels: 20MP
- Pixel size: 3.3 x 3.3 μm

LiDAR

- Laser class: 1
- Laser Wavelength: 905 nm
- Ranging Accuracy (RMS 1): 2cm @ 150m
- Scan Rate: Single return max 240,000 pts/s, multiple returns max 1,200,000 pts/s
- Field of view: Repetitive scanning pattern 70° horizontal, 3° vertical

SURVEY EQUIPMENT

GNSS RECEIVERS

The DJI Matrice 300 RTK Drone was supported by the DJI D-RTK 2 base station system. Ground control was established using the Emlid Reach RS2+ GNSS Receiver

DJI D-RTK 2
- GNSS: GPS+GLONASS+BeiDou+Galileo
- Horizontal RTK positioning accuracy: 1 cm+ 1 ppm (RMS)
- Vertical RTK positioning accuracy: 2 cm+ 1 ppm (RMS)
- Positioning Update Rate: 1 Hz, 2 Hz, 5 Hz, 10 Hz and 20 Hz

Trimble R12 GNSS System
- Positioning performance: Horizontal 2cm RMS. Vertical 5 cm RMS
- GNSS constellations: GPS, GLONASS, BeiDou, Galileo, SBAS, QZSS, NavIC, L-band
- Survey Network: Trimble RTX

PERSONNEL

OPERATORS TEAM

Cooper Smart Project Manager
Anthony Wu Data Analyst / Report Writer

FIELD OPERATORS

Fred Turley Remote Drone Pilot / Surveyor
Anthony Wu Remote Drone Pilot / Surveyor

SURVEY METHODS

SURVEY SETUP

At each beach, two known points were surveyed with the Trimble R12 GNSS Receiver. One point was used to set up the D-RTK 2 base station, where RTK corrections would be sent to the DJI M300, so that data was captured to high accuracy. The other point was used as a checkpoint to verify the accuracy of the captured data during processing.

The co-ordinate projection used was GDA2020 MGA Zone 52 and vertical datum AHD71 height.

Area	ID	Type	Easting	Northing	Elevation
			GDA2020 MGA Zone 52		AHD71
Area 1A	SENS-1A	Base Station	433351.260	8361312.314	2.983
	GCP-1A	Checkpoint	433342.645	8361298.064	2.988
Area 1	SENS-1	Base Station	436545.307	8363620.091	2.731
	GCP-1	Checkpoint	436528.294	8363609.877	2.847
Area 2	SENS-2	Base Station	424475.384	8369680.210	0.032
	GCP-2	Checkpoint	424486.519	8369685.056	0.149
Area 3	SENS-3	Base Station	412159.326	8373081.953	0.941
	GCP-3	Checkpoint	412141.084	8373083.371	0.878

SURVEY METHODS

LIDAR & PHOTOGRAMMETRY SURVEY

The DJI Matrice 300 RTK UAS with the DJI Zenmuse L2 were used to carry out both the LiDAR and photogrammetry survey. Data was captured during low tide to maximise the survey of the beach's surface.

The surveys were conducted with the following specifications:

Location	Area 1A	Area 1	Area 2	Area 3
GSD	1.88 cm/pixel	1.88 cm/pixel	1.88 cm/pixel	1.88 cm/pixel
Point Cloud Density	887 point / m^2	301 point / m^2	887 point / m^2	301 point / m^2
Route Alt	70m	70m	70m	70m
Speed	7 m/s	7 m/s	7 m/s	7 m/s
Side Overlap (LiDAR)	70%	50%	70%	50%
Side Overlap (Visible)	76%	61%	76%	61%
Forward Overlap (Visible)	75%	75%	75%	75%
Margin	30 m	30 m	30 m	30 m
Area	0.19 km^2	0.65 km^2	0.16 km^2	1.14 km^2

Site team at Cape Domett Small Beach

SENSOREM.
An AERODYNE Company

DATA PROCESSING

AERIAL PHOTOGRAMMETRY

All geo-referenced aerial images were imported to **Pix4Dmapper**. This software identifies common details between the images, to produce an orthomosaic

Location	Area 1A	Area 1	Area 2	Area 3
Images	Median of 56140 keypoints per image	Median of 104954 keypoints per image	Median of 71523 keypoints per image	Median of 61214 keypoints per image
Dataset	1027 out of 1111 images calibrated (92%).	1658 out of 1672 images calibrated (99%).	608 out of 686 images calibrated (88%).	2475 out of 2774 images calibrated (89%).
Camera Optimisation	2.86% relative difference between initial and optimised internal camera parameters.	8.02% relative difference between initial and optimised internal camera parameters.	3.23% relative difference between initial and optimised internal camera parameters.	2.51% relative difference between initial and optimised internal camera parameters.
Matching	Median of 2805.22 matches per calibrated image	Median of 2663.75 matches per calibrated image	Median of 8954.97 matches per calibrated image	Median of 10545.6 matches per calibrated image
Average Ground Sampling Distance (GSD)	1.99 cm	1.93 cm	1.91 cm	1.95 cm
Area Covered	0.22 km^2	0.56 km^2	0.18 km^2	1.21 km^2

1 of 2475 images used to create the orthomosaic at Cape Dussejour beach

DATA PROCESSING

LIDAR MODELLING

The raw data from the LiDAR unit was processed in DJI Terra software. This software takes satellite observations from our survey base station to georeference, adjust and refine the LiDAR measurements to produce a complete point cloud of the survey area. The exported LAS files from Terra are then brought into Blue Marble Geographics' Global Mapper for further refinement. The steps take in Global Mapper include constraining the model to our surveyed ground control points and point cloud classification where the software can automatically extract feature such as ground, vegetation, and water. These classifications can be selected to generate models such as digital terrain models (DTM) and digital surface models (DSM).

Location	Area 1A	Area 1	Area 2	Area 3
Initial number of LiDAR points	607,058,046	774,618,740	345,446,924	1,354,216,200
Ground LiDAR points after spatial thinning	1,142,905	2,815,230	926,532	13,469,237
Point cloud density (samples/m²)	54	34	27	18
Georeferencing	RTK with surveyed checkpoint	RTK with surveyed checkpoint	RTK with surveyed checkpoint	RTK with surveyed checkpoint
Minimum/ Maximum elevation	-2.91m/24.69m	-3.26m/48.75m	-3.30m/27.93m	-4.69m/41.32
Area Covered	0.22 km²	0.56 km²	0.18 km²	1.21 km²
Projected Description	MGA/GDA2020/ meters. AHD	MGA/GDA2020/ meters. AHD	MGA/GDA2020/ meters. AHD	MGA/GDA2020/ meters. AHD

Point Cloud model of Cape Dussejour beach

SENSOREM.

An AERODYNE Company

DELIVERABLES

DTM AND DSM

The geotiff models have been generated at a spatial resolution of 0.05m with a Bit Depth of 32.

LIDAR POINT CLOUD

The point cloud has been exported as a XYZ ascii file with a 0.5m horizontal and 0.25m vertical spatial resolution.

ORTHOMOSAIC IMAGERY

The aerial imagery is exported as full resolution (approximately 2cm). The compete image for each site is available in a TIFF and a tiled JPG has been provided for quick access.

INTERTIDAL MEDIA

Video footage has been filmed with a 5.1K: 5120×2700@50fps camera and still images with a 20MP 4/3 CMOS sensor. All media includes relevant metadata and GPX positioning data.

Through our partnership with Skand, Sensorem also provides a cloud-based software platform for data hosting and viewing of a range of data formats. For this project we have provided an example dataset of our deliverables of Turtle Bay on Lacrosse Island. Please note the data on SKAND will be available for 3 months from 04/04/2024. To organise an extension, contact info@sensorem.com.au.

Models can be viewed on the platform

Turtle tracks at Cape Domett Seaward Beach

Appendix C – Boskalis Technical Note

Boskalis
Dredging & Marine Experts

Survey report

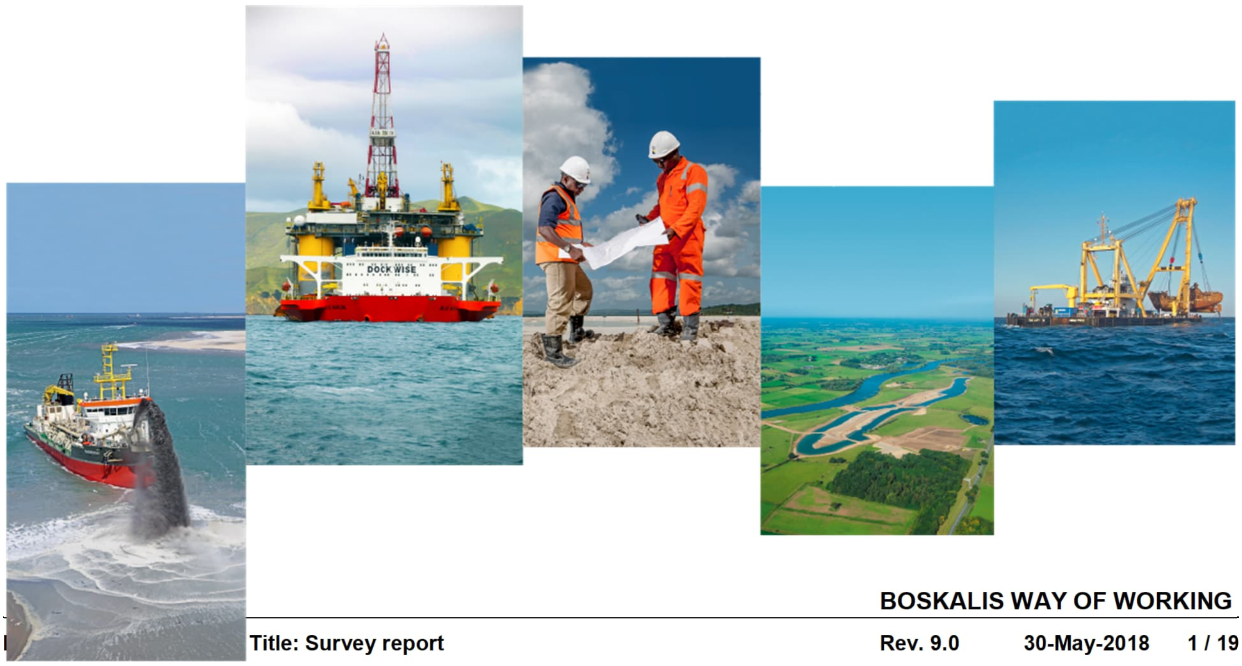
DOCUMENT NUMBER: SURV-130a-1

PROJECT NAME: Australian Sand Source
PROJECT NUMBER: PT056289

CLIENT NAME:

PORT & COASTAL
SOLUTIONS

CLIENT REFERENCE: ANDY SYMONDS | DIRECTOR



DOCUMENT CONTROL

General document data	
Document Title:	Survey report
Document Number:	SURV-130a-1
Project Name:	Australian Sand Source
Project Number:	PT056289
Client Name:	Boskalis
Client Reference:	
Client Revision Number:	001
Boskalis Entity:	…..

Revision status		
Revision Number:	rev. 1.0	
Revision Date:	26/03/2024	
Approval Status:	…..	
Prepared By:	DDBO	Role:Senior Surveyor
Reviewed By:	FAT…..	Role:Senior Surveyor
Interdisciplinary Check:	…..	Role:
Approved By:	…..	Role:

Change log		
Revision	**Section**	**Change**
Rev.	All	New issue
…	…	…

Boskalis
Dredging & Marine Experts

TABLE OF CONTENTS

1. **INTRODUCTION**

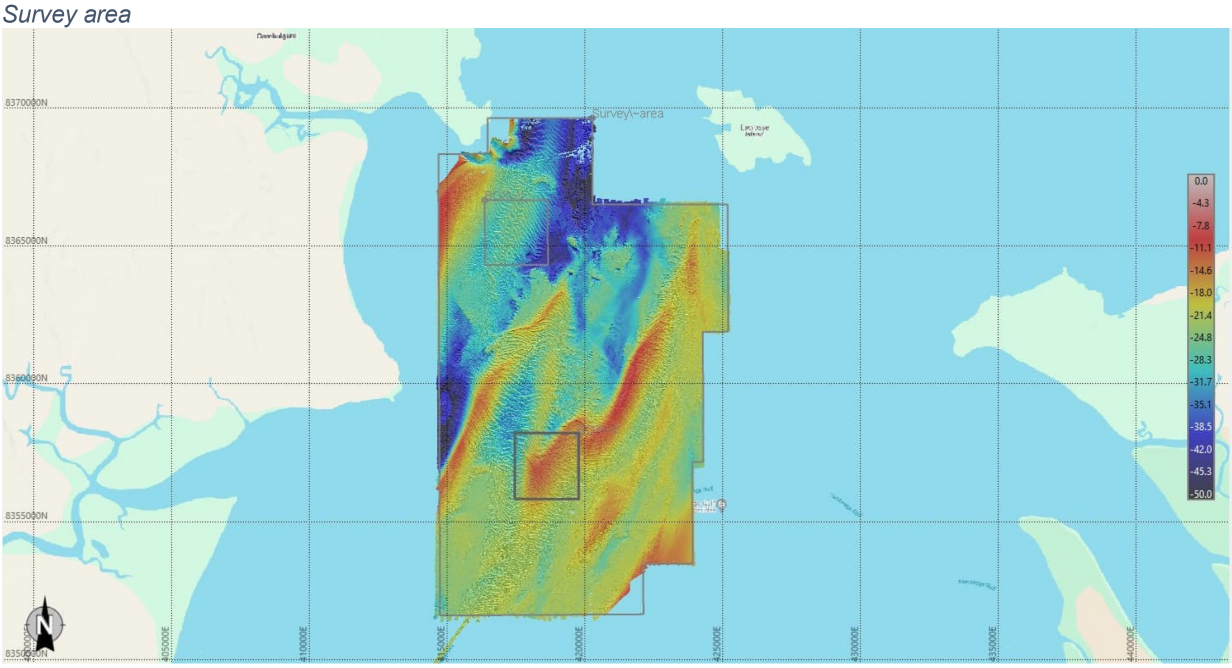
A survey was conducted to assess the surrounding area and monitor sand movement within two designated boxes. The entire area was surveyed to identify objects and types of materials, utilizing a survey vessel equipped with Multibeam technology.

The survey was conducted in two distinct phases.

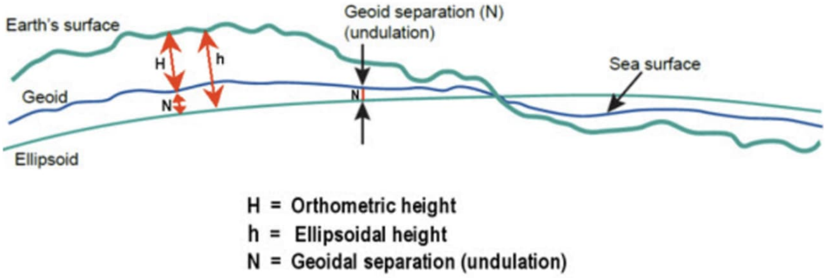
During the first phase, which took place from February 7th, 2024, to February 14th, 2024, measurements were taken for BOX 1 and BOX 2, covering 60% of the total survey area. Specifically, BOX 1 and BOX 2 were surveyed on February 8th, 2024.

The second phase occurred from March 3rd, 2024, to March 6th, 2024, during which measurements were taken for both BOX 1 and BOX 2, along with the remaining area of the survey. Specifically, BOX 1 and BOX 2 were surveyed on March 6th, 2024.

Survey area

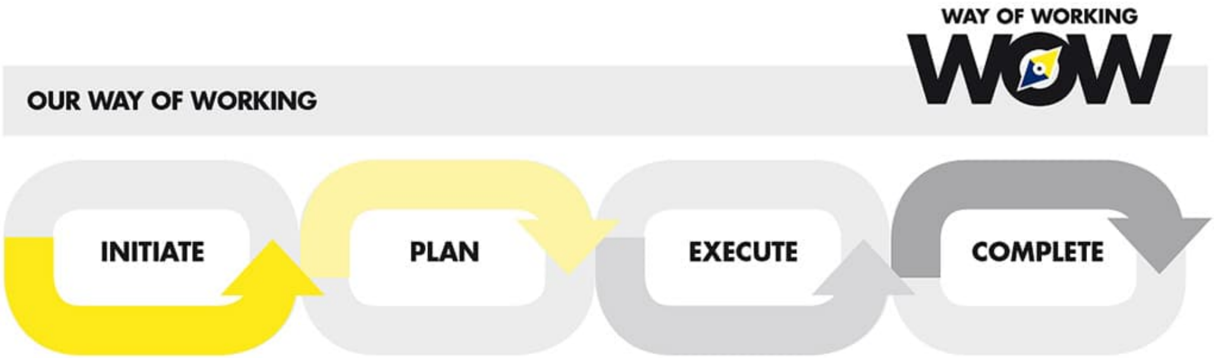


All vertical values reduced to MSL (Ausgoid2020)



2. WOW

This document forms part of the Boskalis Way of Working, the integrated quality management system applicable to all operations in Boskalis. The Boskalis Way of Working is structured around four Phases as pictured below. This final survey report is typically prepared in the Execute Phase, where the main implementation is taking place in the Completion Phase.



More detailed information about the Boskalis Way of Working can be found in the Group Manual and the User Guide. A dedicated website with all supporting materials is available at wow.boskalis.com.

2.1. Scope of Document

The purpose of this document is to describe survey results, how the survey(s) have been performed and to describe how the Project has been carried out related to dimensional control and positioning of floating equipment.

2.2. Safety

The Survey team as part of the Boskalis Project team will work according to the Boskalis Safety standards as stated in the NINA Safety Program (www.boskalis-nina.com) and to the Project client safety program.

3. HORIZONTAL AND VERTICAL DATUM

3.1. Horizontal Datum

The survey was carried out utilizing the Universal Transverse Mercator (UTM) coordinate system, specifically within zone 52S. (129E).

Elevations are computed relative to the ellipsoid.

All positioning has been expressed in local grid coordinates as specified by CONTRACTOR.

Horizontal Datum WGS84-UTM zone 52S			
Local projection parameters			
Projection	Transverse Mercator		
Zone	52S		
Central Meridian	129°		
Latitude of Origin	0°		
False Easting	500000.0		
False Northing	10000000.0		
Scale factor (CM)	0.9996		

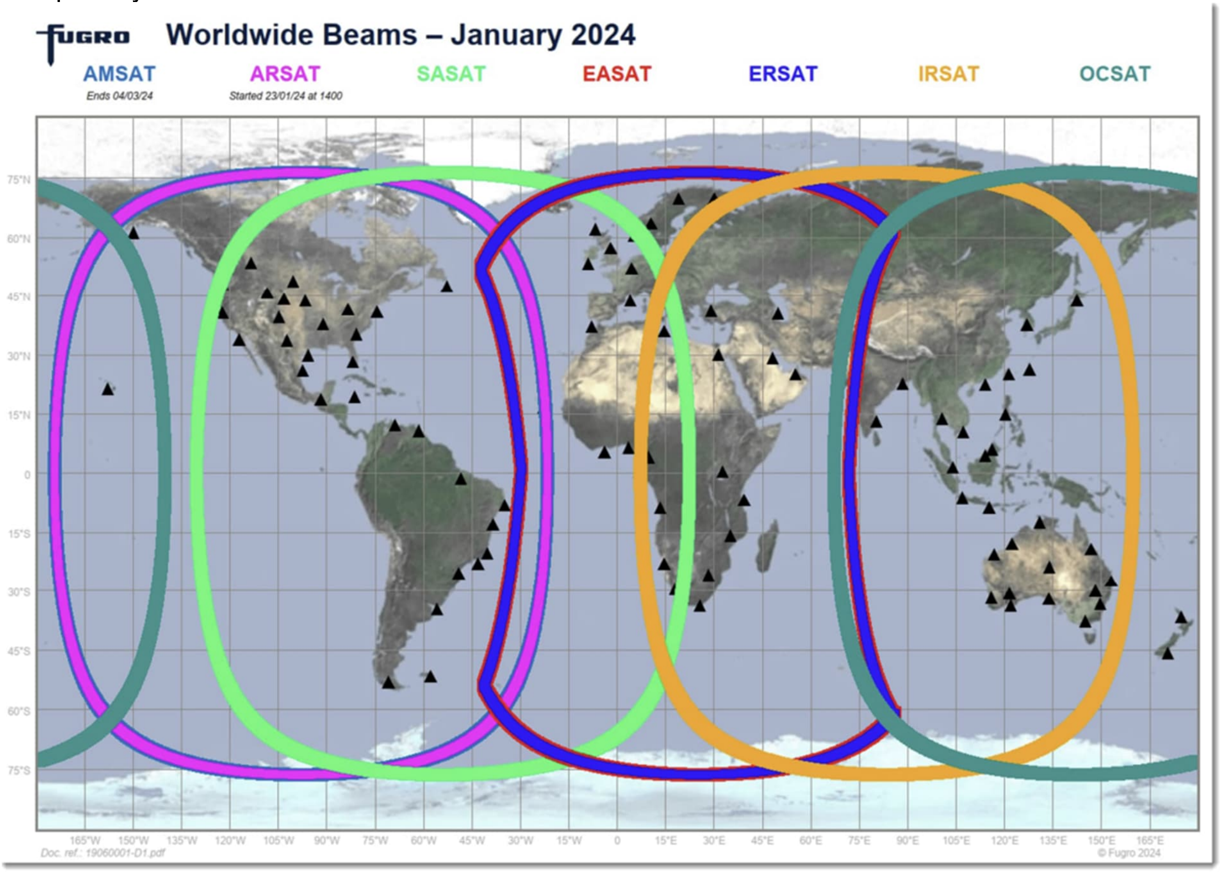
3.2. Vertical Datum

All elevation reduced to MSL (AUS Geoid2020).

4. HORIZONTAL AND VERTICAL CONTROL

4.1. GNSS Fugro marinestar corrections

For this project, we are using the PPP solution provided by FUGRO.
The primary satellite we used was the OCSAT.



The correction type employed was the G2+/G4+ signal.

G4+ signifies the utilization of all four satellite constellations for computations, namely:

- Glonass
- GPS
- Beidou
- Galileo

G2+ signifies the utilization of two satellite constellations for computations, namely:

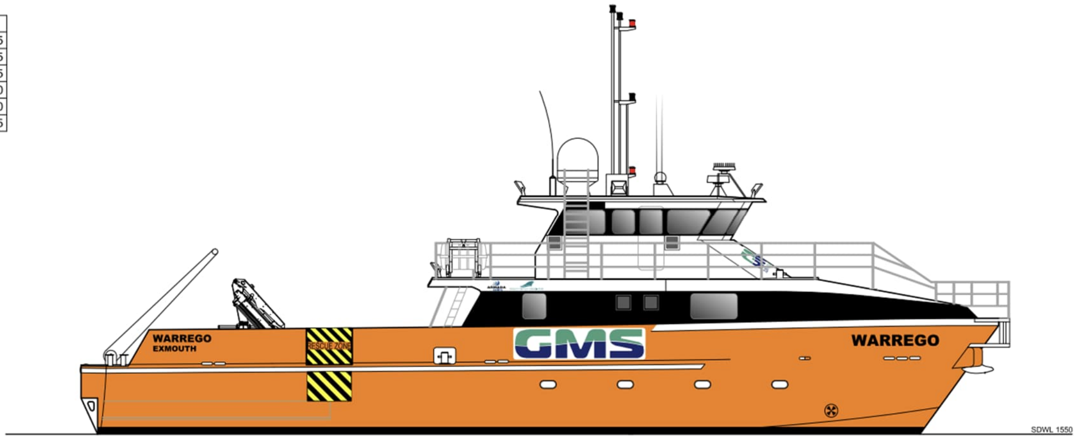
- Glonass
- GPS

Marinestar G2+/G4+ service accuracy

Horizontal 0.02 m (0.06 ft), Vertical 0.06 m (0.20 ft), 95%

5. SURVEY VESSEL

PRINCIPAL PARTICULARS		
LENGTH MEAS.	m	23.95
LENGTH O.A.	m	24.95
BEAM MAX.	m	7.5
F.O. CAPACITY	L	16,400
F.W. CAPACITY	L	3,000
SPEED	kts	15



VESSEL INFORMATION & SPECIFICATIONS

WARREGO UVI 44186

Warrego is a 23.95m utility vessel designed by GMS to support a diverse range of Offshore Oil and Gas operations in challenging sea states.

She can be used as a short range vessel, but can equally support up to 18 personnel on extended offshore programs. She is a new built vessel constructed by Australian labor in Henderson, Western Australia. She has been designed by Southerly Designs, who have a long history of providing vessels suited to the extreme conditions prevalent in Western Australian offshore waters.

Their pedigree in designing such vessels is evident in a long history of orders from the WA Fisheries Department for patrol boats and from the Australian Department of Defense. Warrego has a top speed of 18 knots and is designed to operate in marginal sea states. Her deck is heavily reinforced and designed for a maximum payload of 30T. She has three steering stations, allowing for operation from either side of the bridge or, from an aft-facing console on the rear of the bridge deck. She has twin 911hp engines (Tier 2 emissions certified) mated to purpose-built gearboxes fitted with troll valves, and 75hp hydraulic bow thrusters.

The combination of twin keels, large rudders and large bow thrusters ensure maneuverability, particularly at slow speeds. Warrego currently has a hydraulic A-frame, Hiab and twin winches, but these are all removable and other hydraulic machinery can be accommodated. She has three generators, comprising two 50Kva and one 100Kva generator.

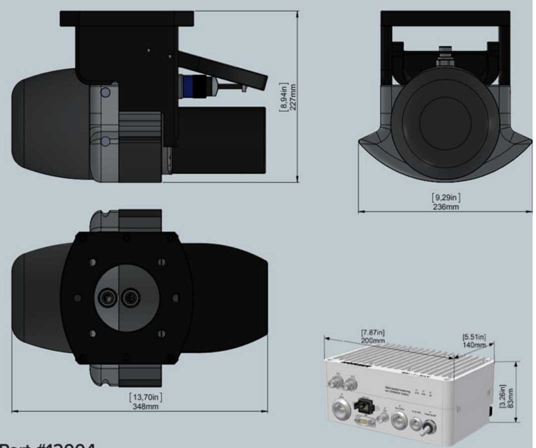
These can run high-demand ancillary equipment, including refrigerated containers. The design of Warrego includes an allowance for over-the-bow passenger transit, with a heavily reinforced and fendered platform with full safety/handrails. The back deck has bulwark doors on both sides and an open transom.

She also has a 850mm square moon-pool designed to facilitate hydrographic survey equipment

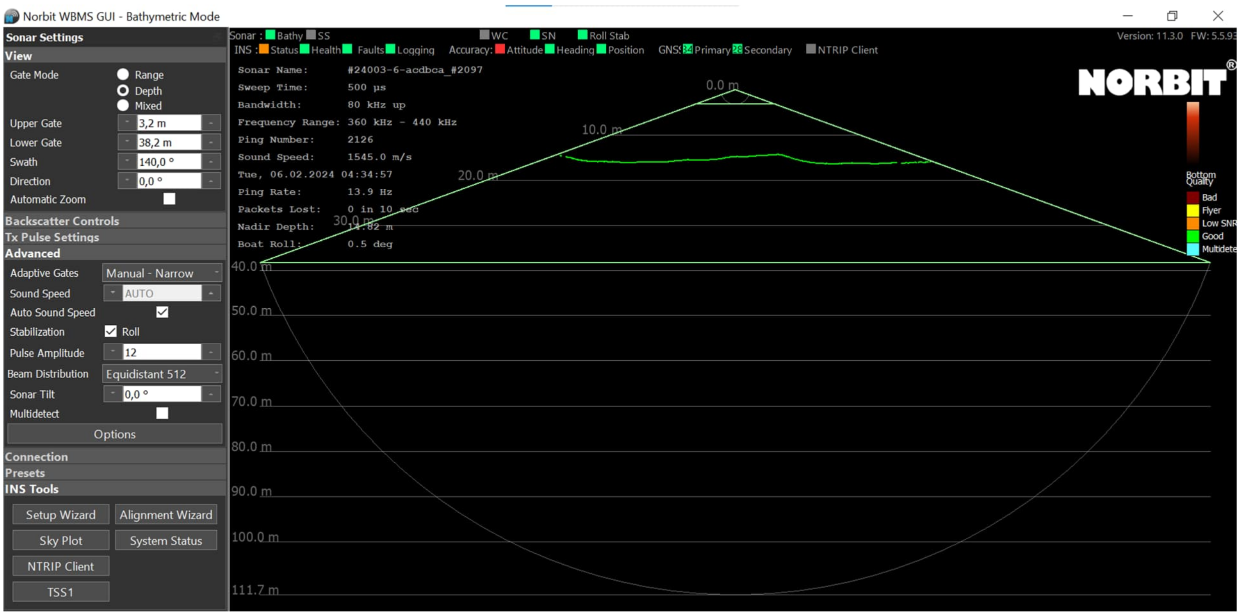
5.1. Installed survey equipment

- Norbit Multibeam echosounder

TECHNICAL SPECIFICATION	
SWATH COVERAGE	5-210° FLEXIBLE SECTOR (SHALLOW WATER IHO SPECIAL ORDER >155°)
RANGE RESOLUTION	<10mm ACOUSTIC w. 80kHz BANDWIDTH
NUMBER OF BEAMS	256-512 EA & ED
OPERATING FREQUENCY	NOMINAL FREQUENCY 400kHz (FREQUENCY AGILITY 200-700kHz)
DEPTH RANGE	0.2-275m (>300m WITH 0.9° X 0.9° OPTION)
PING RATE	UP TO 60Hz, ADAPTIVE
RESOLUTION (ACROSS X ALONG)	STANDARD: 0.9° X 1.9° @400kHz AND 0.5° X 1.0° @700kHz. NARROW OPTION: 0.9° X 0.9° @400kHz AND 0.5° X 0.5° @700kHz
POSITION	HOR: ±(8mm +1ppm X DISTANCE FROM RTK STATION) VER: ±(15mm +1ppm X DISTANCE FROM RTK STATION) (ASSUMES 1m GNSS SEPARATION)
HEADING ACCURACY	0.03° (RTK) WITH 2m ANTENNA SEPARATION
PITCH/ROLL ACCURACY	0.02° INDEPENDENT OF ANTENNA SEPARATION
HEAVE ACCURACY	2 CM OR 2% (TRUEHEAVETM), 5 CM OR 5% (REAL TIME)
WEIGHT	APPROX. 9.5kg (AIR) LESS THAN 6kg (WATER)
INTERFACE	ETHERNET
CABLE LENGTH	STD8M, OPT: 2m, 25m AND 50m
POWER CONSUMPTION	60W (75W MAX) (10-28VDC, 110-240VAC)
OPERATING TEMP.	-4°C to +40°C (TOPSIDE -20°C to +55°C)
STORGAGE TEMP.	-20°C to +60°C
ENVIRONMENTAL	TOPSIDE: IP67: DUST TIGHT, PROTECTED AGAINST THE EFFECT OF IMMERSION UP TO 1m/WET-END: 100m

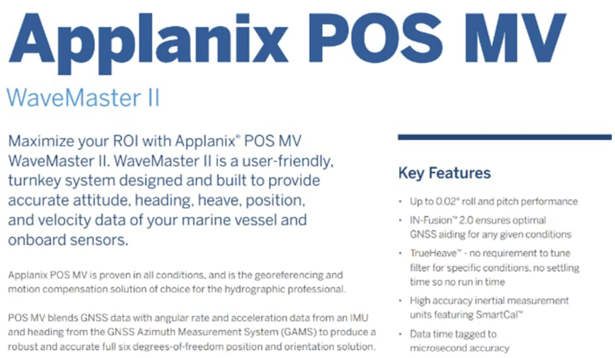


Part #12004



We used a frequency of 400Khz with an average opening angle of 130°

- Applanix GNSS/INS



Applanix POS MV

WaveMaster II

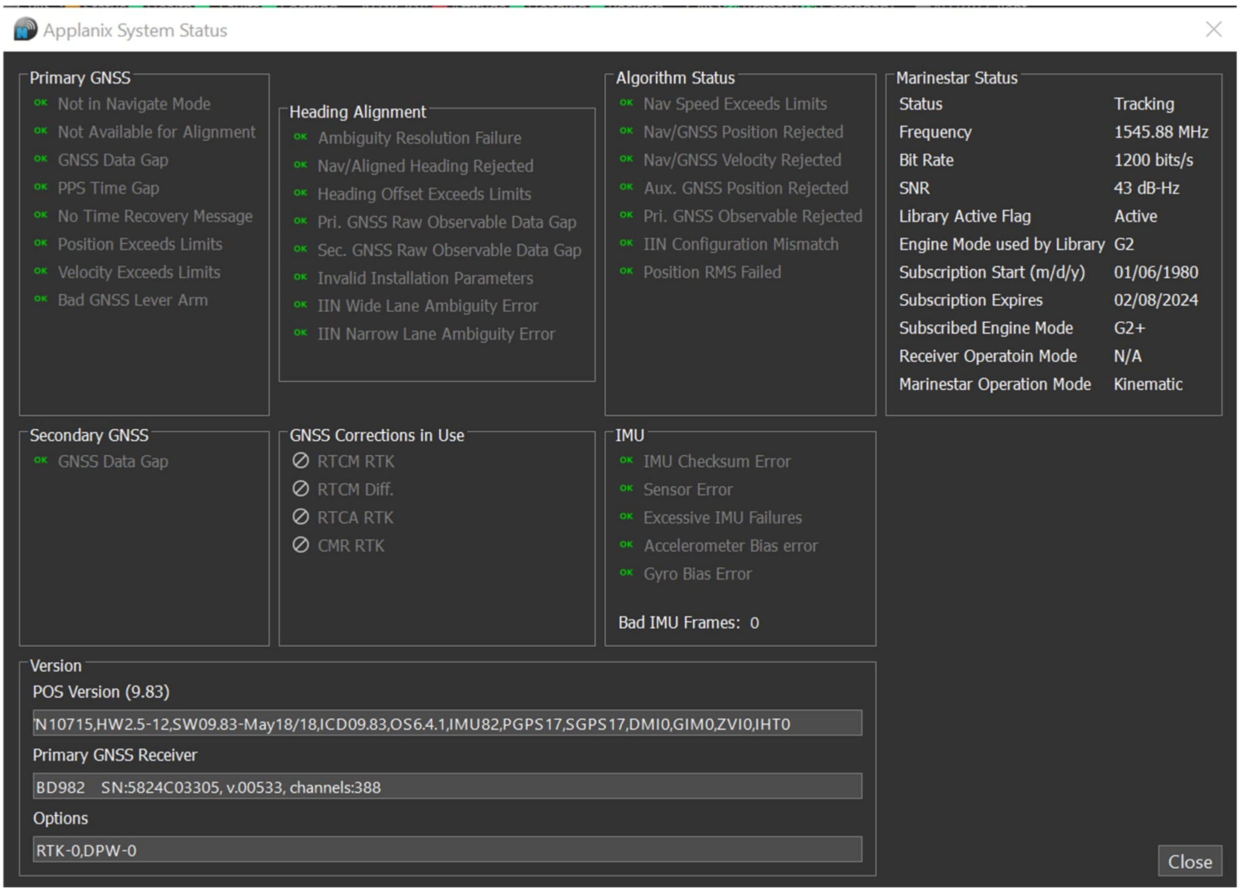
Maximize your ROI with Applanix® POS MV WaveMaster II. WaveMaster II is a user-friendly, turnkey system designed and built to provide accurate attitude, heading, heave, position, and velocity data of your marine vessel and onboard sensors.

Applanix POS MV is proven in all conditions, and is the georeferencing and motion compensation solution of choice for the hydrographic professional.

POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from the GNSS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees-of-freedom position and orientation solution.

Key Features

- Up to 0.02° roll and pitch performance
- IN-Fusion™ 2.0 ensures optimal GNSS aiding for any given conditions
- TrueHeave™ - no requirement to tune filter for specific conditions, no settling time so no run in time
- High accuracy inertial measurement units featuring SmartCal™
- Data time tagged to microsecond accuracy



- Swift SVP

Sensor Specifications
The SWiFT SVP is fitted with Valeport's digital time of flight sound velocity sensor, temperature compensated piezo-resistive pressure transducer and a PRT temperature sensor.

Sound Velocity	
Range	1,375-1,900 m/s
Resolution	0.001 m/s
Accuracy	±0.02 m/s

Pressure	
Range	50 Bar
Resolution	0.001% FS
Accuracy	±0.01% FS

Temperature	
Range	-5°C – +35°C
Resolution	0.001°C
Accuracy	±0.01°C

Calculated Parameters and Accuracy	
Calculations based on Valeport's proprietary DASH formula	
Conductivity	±0.05 mS/cm
Salinity	±0.05 PSU
Density	±0.05 kg/m³

Physical	
Materials	Titanium | Stainless Steel deployment weight
Depth Rating	500m
Dimensions	ø78mm x Length 264mm
Weight	2.0kg (in air) / 0.9kg (in water) | 3.0kg (in air) / 1.8kg (in water) with deployment weight

Communications (set up and data offload)
USB Serial
Bluetooth v4 - low energy

Electrical	
Battery	Internal rechargeable Li-ion battery pack
Battery life	Up to 5 days operations
Charging	USB Typically, 1 hour fast charge will give 12 hours operation

Software
iOS and Android Valeport Connect Pathway Edition for Bluetooth compatible mobile devices – instrument set up, data offload, display and translation to common data formats. Valeport's Ocean PC software, with both USB cable and Bluetooth connectivity, for instrument setup, data extraction, display and translation to common data formats.
Instrument and data time is synchronised to GNSS, UTC.

Ordering	
0660047-50	SWiFT SVP Profiler Titanium housing rated to 500m
Supplied with	Deployment weight PC Bluetooth adapter USB interface and charging cable 1.5 A charger Valeport Connect software Operating manual System transit case

5.2. Offsets

All offsets are measured with leica Disto D5

- +/- 1.0 mm accuracy, 0.1 mm resolution

Vessel Offsets			
Location	**X (m)**	**Y (m)**	**Z (m)**
Center of Gravity	0.000	0.000	0.000
Primary DGNSS Antenna	2.440	2.605	8.070
Secondary DGNSS Antenna	2.440	4.681	8.071
Motion Sensor	0.000	0.064	-0.148
Transducer	0.000	-0.120	-0.070

5.3. Position

No bench marks delivered by client.

5.4. Heading

Upon comparing our heading sensors against the vessel, a discrepancy of 1.2 degrees was observed. Notably, our equipment exhibited superior accuracy in this evaluation.
Regrettably, the unavailability of a total station precluded the possibility of conducting a heading check utilizing this method.

5.5. MBES

MBES Calibration 03-02-2024				
Description	**Pitch correction**	**Roll correction**	**Heading corr.**	**Time delay**
MBES	-0.820º	0.023º	0.450º	0.00 ms

6. PERSONNEL

Survey personnel involved with Pre works survey		
ID	**Qualification**	**Quantity**
1	Senior surveyor / survey engineer **Dennis de Boer**	1
2	Senior surveyor **Claire Thomas**	1

On request curriculum vitae of survey personnel will be made available to the COMPANY.

7. VARIOUS ITEMS

In addition to the previous chapters, the following items shall be described and/or included in the report.

7.1. Project Data

- A digital copy of this report and of above information will be send for filing to the Boskalis survey desk.
- All raw data is stored on a hard drive and will be send to Boskalis and the project manager.
- PCS will receive several electronic files / PDF's as per indicated below

Name	Status	Date modified	Type	Size
01-ASS-PRE-ALL-PT056289.dwg		13/4/2024 2:11 pm	DWG File	49,725 KB
01-ASS-PRE-ALL-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	23,383 KB
02-ASS-PRE-BOX1-PH1-PT056289.dwg		13/4/2024 2:11 pm	DWG File	15,333 KB
02-ASS-PRE-BOX1-PH1-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	6,661 KB
03-ASS-PRE-BOX1-PH2-PT056289.dwg		13/4/2024 2:11 pm	DWG File	13,775 KB
03-ASS-PRE-BOX1-PH2-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	6,611 KB
04-ASS-PRE-BOX2-PH1-PT056289.dwg		13/4/2024 2:11 pm	DWG File	13,058 KB
04-ASS-PRE-BOX2-PH1-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	5,325 KB
05-ASS-PRE-BOX2-PH2-PT056289.dwg		13/4/2024 2:11 pm	DWG File	13,052 KB
05-ASS-PRE-BOX2-PH2-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	5,277 KB
06-ASS-PRE-BOX1-DIFF-PH1-PH2-PT056289.dwg		13/4/2024 2:11 pm	DWG File	59,271 KB
06-ASS-PRE-BOX1-DIFF-PH1-PH2-PT056289.pdf		13/4/2024 2:07 pm	PDF Document	31,199 KB
07-ASS-PRE-BOX2-DIFF-PH1-PH2-PT056289.dwg		13/4/2024 2:11 pm	DWG File	54,460 KB
07-ASS-PRE-BOX2-DIFF-PH1-PH2-PT056289.pdf		13/4/2024 2:08 pm	PDF Document	28,580 KB
08-ASS-PRE-BOX1-PH1-2-LINE1-1.dwg		16/4/2024 3:28 pm	DWG File	20,472 KB
08-ASS-PRE-BOX1-PH1-2-LINE1-1.pdf		16/4/2024 3:26 pm	PDF Document	14,026 KB
09-ASS-PRE-BOX1-PH1-2-LINE1-2.dwg		16/4/2024 3:28 pm	DWG File	20,996 KB
09-ASS-PRE-BOX1-PH1-2-LINE1-2.pdf		16/4/2024 3:26 pm	PDF Document	14,492 KB
10-ASS-PRE-BOX2-PH1-2-LINE2-1.dwg		16/4/2024 3:28 pm	DWG File	15,747 KB
10-ASS-PRE-BOX2-PH1-2-LINE2-1.pdf		16/4/2024 3:26 pm	PDF Document	10,262 KB
11-ASS-PRE-BOX2-PH1-2-LINE2-2.dwg		16/4/2024 3:28 pm	DWG File	16,366 KB
11-ASS-PRE-BOX2-PH1-2-LINE2-2.pdf		16/4/2024 3:26 pm	PDF Document	10,725 KB
12-ASS-PRE-OVERVIEW-PT056289.dwg		16/4/2024 3:28 pm	DWG File	130 KB
12-ASS-PRE-OVERVIEW-PT056289.pdf		16/4/2024 3:26 pm	PDF Document	54 KB
All-area-1x1m.tif		13/4/2024 2:52 pm	TIF File	638,757 KB
Australian sand Source survey-FAT.docx		16/4/2024 3:37 pm	Microsoft Word Docum...	12,670 KB
Box1-Phase1Box1-Phase1-1x1m.tif		13/4/2024 2:52 pm	TIF File	21,504 KB
Box1-Phase2Box1-Phase1-1x1m.tif		13/4/2024 2:51 pm	TIF File	21,323 KB
Box2-Phase1Box1-Phase1-1x1m.tif		13/4/2024 2:51 pm	TIF File	21,749 KB
Box2-Phase2Box1-Phase1-1x1m.tif		13/4/2024 2:51 pm	TIF File	21,946 KB

8. REFERENCES, ABBREVIATIONS, DEFINITIONS

8.1. References

1	SURV-130a-1	Final Survey Reporting

Standards		
No.	**Document No.**	**Document Title**
1	ISO 9001:2015	Quality management system
2	IHO-S44	IHO Standards for hydrographic surveys

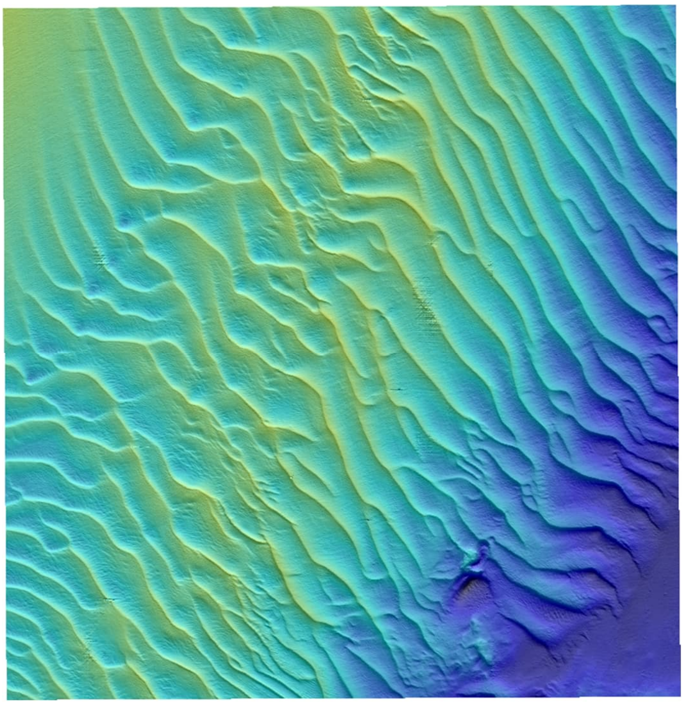
8.2. Abbreviations

Abbreviation	Full meaning
CD	Chart Datum
CM	Central Meridian
CMS	Crane Monitoring System
COG	Center of Gravity
DGNSS	Differential Global Navigation Satellite System
DTM	Digital Terrain Model
DV	DredgeView, Boskalis in-house software
kHz	kiloHertz
KP	Kilometre Point
IHO	International Hydrographic Organization
ISO	International Organization for Standardization
MBES	Multi Beam Echo Sounder
MRU	Motion Reference Unit
NINA	No Incidents No Accidents, Boskalis Safety Program
PPP	Precise Point Positioning
RTK	Real-Time Kinematic
SBES	Single Beam Echo Sounder
TM	Transverse Mercator
TU	Technical University
UPS	Uninterruptable Power Supply
WGS84	World Geodetic System 1984
WoW	Way of Working, Boskalis Quality Program

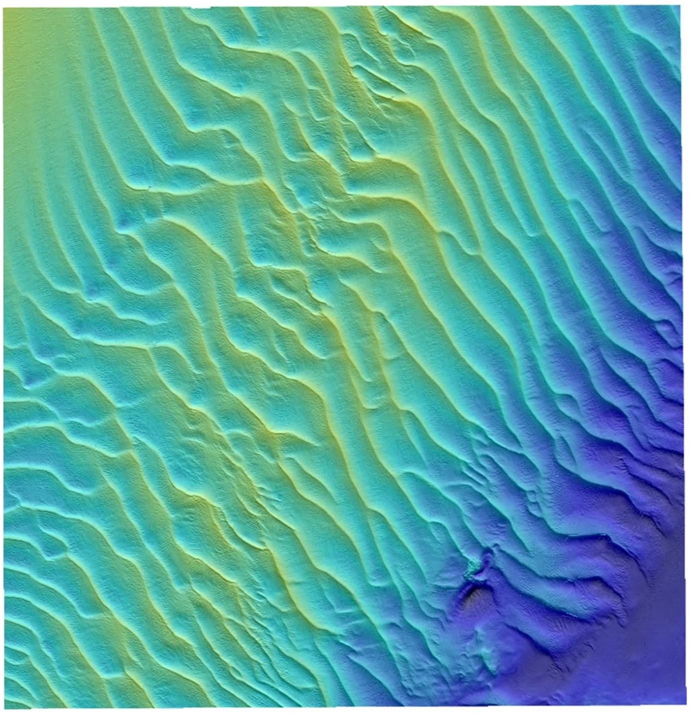
8.3. Definitions

Definition	Full meaning
COMPANY	Company name
CONTRACTOR	Boskalis

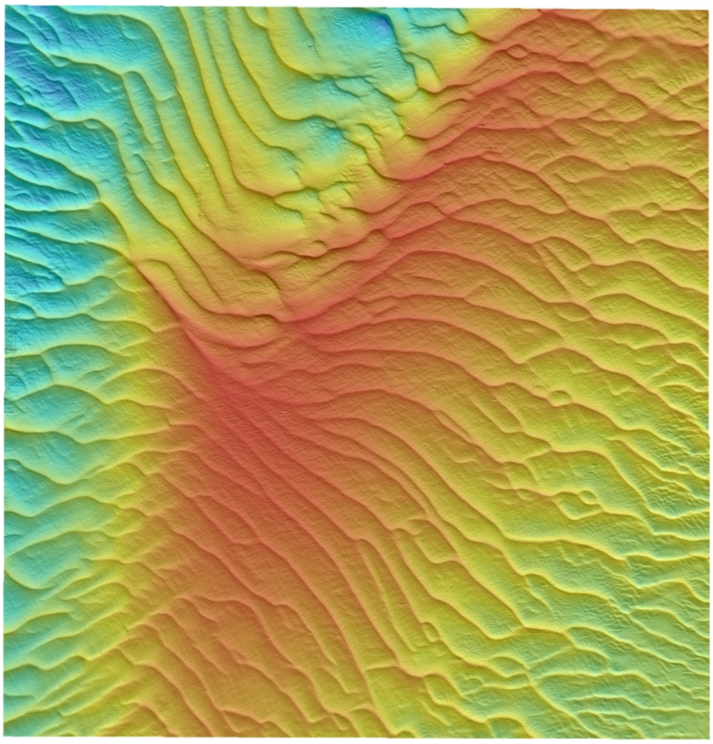
9. ATTACHMENTS



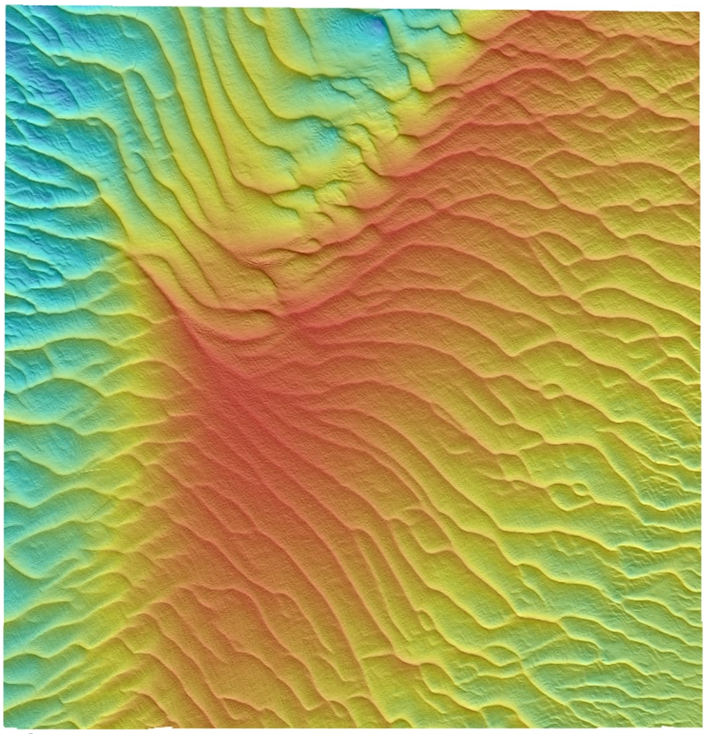
BOX 1 Phase 1



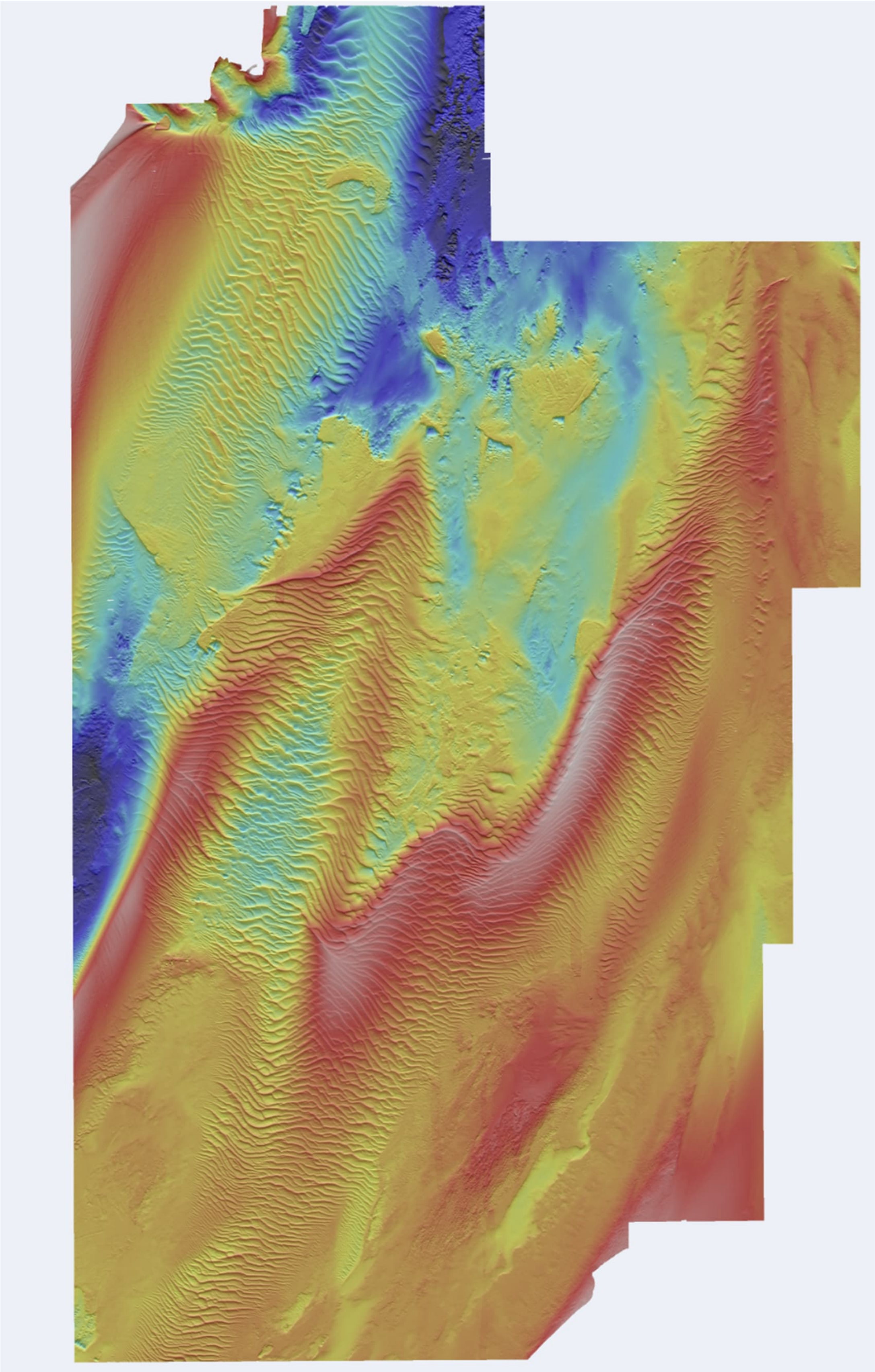
BOX 1 Phase 2



BOX 2 Phase 1



BOX 2 Phase 2



Complete survey area