Baseline Survey of the Blue Economy Zone (Phase II)

Project ID CRC.21.002

Project Report

The Blue Economy CRC is funded in part under the Australian Government's CRC Program, administered by the Department of Industry, Science, Energy and Resources.

The CRC Program supports industry-led collaborations between industry, researchers and the community.

Report Citation: Author Cossu, R. and many more (2021). Baseline Survey of the Blue Economy Zone CRC.21.002– *Interim Project Report.* Place of publication: Blue Economy Cooperative Research Centre.

Version Control

Template Name:	*BE CRC Research Project Report Template – v1*	Last Updated:	20/12/2022 11:42:59 AM

Table of Contents

List of Figures

List of Tables

Executive Summary

This the final report presenting data collected between March 2021 and December 2022 in Bass Strait within the Blue Economy Zone (BEZ) after multiple voyages have been completed and data analysed.

The fieldwork has been a collaboration between–UTas, UQ , Griffith University and industry partners Tassal and Xylem. The major activities included mapping of the seafloor, sediment and benthic habitat, monitoring the local wave and ocean current climate as well as getting an understanding of fish species that live in the BEZ in Bass Strait.

The area of the BEZ has a mild sloping bathymetry with water depths ranging between 35-45 m at the southern (shoreward) edge and depths exceeding > 60 m at its offshore boundary. The depth at the mooring site was roughly 50 m. Sediment grabs and Sub-bottom profiling revealed rocky reef and rubble with limited quantities of sand in the shallower regions (35 m to 45m depth). In localized depressions there are also confined deposits of mud. In the deeper regions and further offshore a layer of mud is present that gradually increases in thickness with increasing water depths. The sub-tidal microbenthic assemblage was dominated by annelid worms (46% of total recorded taxa), arthropods (23% of total recorded taxa), molluscs (19% of total recorded taxa) and the remaining 12% of taxa consisted of diverse taxonomic groups. There were no significant differences in taxonomic composition between the stations along the presumed gradients (off shore to inshore or east to west).

The currents in the BEZ were minimal during the ADCP deployment periods, with mean current speeds of 0.09 m/s and average maximum current speeds of 0.41 m/s at the bottom and middle water column to 0.48 m/s at top water column respectively were found. The overall highest velocity was 0.67 m/s in the top water column on one occasion. C This increase was due to the wind-driven current increasing the tidal velocities on the surface layers more than at depth.

During the measuring period the average wave heights were between 0.91 m and 1.02 m for the Sofar Wave Spotter buoy and the ADCP respectively. The maximum significant wave height recorded was H_s = 4.43 m which occurred in July 2022. Mean wave periods ranged between T_m = 2.96 s and T_m = 4.26 s (depending on measuring device and period of measurement). The wave direction remained strongly focused between North-Westerly directions in winter to North-Easterly directions in summer throughout the deployment period. Using harmonic analysis, the largest constituent found over the ADCP deployment period was the M2 principal lunar semi-diurnal, with a value of 1.14 determined.

Salinity and other parameter measurements were trialled with a vertical profiling winch system housed in a surface buoy (Nautilus system paired with an Exo water quality profiler) but due to heavy weather the profiling mechanism broke down after short period of use. Nonetheless, the collected data suggest that the water column is well mixed within the top 40 meters but was periodically stratified in the bottom 5 meters Between March and May the DO levels remained relatively constant throughout the time at ~ 8mg/L. Salinity varied only little and was found to be between 35.5 PSU 35.7PSU. Chlorophyll levels were around 3mg/L in March and reduced to under 1,5 mg/L in May.

The water temperature was also monitored with a separate thermistor string which was operating between November 2021 and December 2022 Supporting the data from the profiling system, the water is stratified during the summer months. More interestingly, the water temperature exceeded >19C throughout the water column in the later period of the summer, with surface values above 21C. In late February 2022 the water cooled down and becomes well mixed again, with A constant decrease from 19C to < 13C recorded until the end of August 2022, where it again warmed up and began to stratify in October 2022.

For the fish trawls the overall catch composition consisted of sessile (58.7%) and mobile (41.3%) epifauna by weight. The proportion of sessile epifauna varied between trawls from 82.2% (trawl 6) to 41.4 (trawl 4). Fifty-one different species were identified in the mobile epifauna and most (75.5%) of the mobile epifauna by numbers consisted of fish, and the common gurnard (Neosebastes scorpaenoides) was the most abundant species.

1. Introduction

As part of its commitment to the strategic development of activities in the Blue Economy sector located in Australia's offshore waters the BE CRC is developing a demonstration project 'Blue Economy Zone' (BEZ). This project will initiate the characterization of the environmental conditions in the Blue Economy Zone off the coast of northern Tasmania. The analysis of this baseline survey data will provide critical information to plan for a more detailed site characterisation (general project) survey commencing most likely in early 2023 and provide industry partners will initial data that can be fed into their project planning processes.

This project lays the groundwork to linking all physical, environmental, cultural and heritage, resource potential, operational logistics and risks into a comprehensive decision support tool (or suite of tools). There is a paucity of information on the environmental conditions in the BEZ. This information is needed urgently to underpin planning of industry trials and other BE CRC projects that will utilise the BEZ and to inform regulatory submissions and subsequent reporting.

The BEZ constitutes a unique example on a global scale to understanding of the footprint of aquaculture and energy production. Phase 1 was already work in progress in late 2020,when Phase 2 constituted the baseline study for further development in the BEZ and a crucial part to assess the impact on the ecosystems.

1.1. Previous Research & Literature

The area of the Blue Economy Zone is well known to local fishermen but there is no wave gauge, water velocity measurements or wind data in close proximity that could be used as a reliable data source. Likewise, there is no detailed data about the seafloor characteristics (including ground penetrating radar data) and no known published data of the species composition and catch rates from other fishing activities within the BE Zone. This report therefore constitutes a first scientific approach to report about the site conditions and potential use of sea space for BE CRC R&D activities.

1.2. Gaps in Current Knowledge

There is a lack of data for comprehensively assessing offshore site suitability, particularly in respect of benthic environments. Hydrodynamics, benthic habitat and mobile fauna in the designated area to plan a broader general project that will develop MSP strategies, site selection and cumulative effects assessments and supporting tools for Blue Economy industries. This Baseline Study aims to identify what has to be monitored, generation of model-based data layers, collation of existing data layers for "resource and habitat characterisation" in the Blue Economy Zone.

2. Methodology

2.1. BlueFin Voyages

Table 1 Voyage data and activities

Voyage 1: servicing mooring, seabed samples, sub-bottom profiling, deployment vertical profiler.	March 10th-17th 2021
Voyage 2 Seabed samples, single beam profiling service mooring	May 11th-13th, 2021
Voyage 3: Service mooring, maintenance vertical profiler, deployment wave rider buoy	August 26th, 2021
Voyage 4: Service mooring, service wave rider buoy, Sediment grabs 2nd	November 23rd-25th, 2021
Voyage 5: Trawls	November 29th-30th, 2021
Voyage 6: Service temperature mooring, service wave rider buoy	26th April, 2022
Voyage 7: Service temperature mooring, service wave rider buoy	December 6th, 2022

2.2. Single beam

The single beam data was taken from 3 voyages (the first one was done outside of this project) of the MV Bluefin to produce an interpolated bathymetry of the Bass Strait survey area for the Blue Economy CRC.

For the duration of the 3 voyages (Dec 14th-15 2020, March 10th-17th 2021, May 11th-13th) an external USB drive was connected to the onboard SIMRAD echosounder. Of the two transponders, only the 38KHz was operational. This was recorded from the start of the trip till back in safe harbor. The transponder is offset to read actual depth and not depth below the transducer.

In order to read the proprietary .raw files, Sonar5 (Balk, H., Lindem, T., University of Oslo, Norway) was used. Sonar5 was able to read the proprietary files and one of its most basic functions was used to determine the seabed return. This in turn was exported as a .txt file in WGS84. In order to reduce processing, every 50th ping was exported along with time stamps. Using the time stamps the tide from Burnie, Tasmania (Lat 41° 3' S, Long 145° 55' E)(CSIRO, Bureau of Meteorology, Commonwealth of Australia) was used to offset the depth to LAT. After the tidal correction, the files were imported into Golden Surfer (Golden Software LLC, Golden Colorado, USA) for interpolation.

A kriging interpolation was used to grid the bathymetry data. For the Variogram and subsequent Kriging result, the software autofit was used. After gridding, the area was reduced to discount the areas east of Devonport. This still expanded on the survey region yet allows for a greater understanding of the offshore area. The grid was initially done in WGS84 coordinate system before being projected to GDA2020 MGA55. The grid has a bin size of 88m with 381,810 nodes covering an area of 829 km^2. The resulting bathymetry map was exported as an .xyz file in both WGS84 and GDA2020 MGA55.

2.3. Sub-bottom

2.3.1. Import into Sonarwiz 7: V7.04.02 64-bit

Depth below the water (sensor depth): The depth was compared to the offset Bluefin single beam depth on six occasions. The variation was from 4.2 m to 4.7 m with the average being 4.48 m. During acquisition the first 10 m was removed. This needed to be factored into the sensor depth offset. So, 14.48 m were offset from the imported files. The Bluefin maintained a constant speed of 5 kt throughout the entire survey to ensure the towfish's consistent depth in the water column.

Layback from the cable was 27.4 m from a 35 m umbilical. When adding the height of the anchor point and depth below water the horizontal layback was 25.4 m.

The bottom tracking with a threshold detection algorithm was used, and a swell filter of 3 seconds was enabled. The swell filter was used to offset the towfish's slight roll/wobble that would make the seabed appear lumpy. The towfish was below the influence of waves and the anchor point close to the vessels center of gravity (fore and aft, visual observation). The vessels roll could have a minor influence.

Gain settings were applied to transect 4 as it had good representation of seabed: rocky outcrops, mud, large sediment depths, visible bedrock. This was then applied to the remainder of the transects prior to analysis of reflectors.

2.3.2. Processing:

Speed of sound (SOS) through water was taken from the deployed profiler buoy (waiting on Eagle IO access) and using the simplified calculation from Medwin (1975). This uses a realistic combination of temperature ($0 \leq T \leq 35°$ C), salinity ($0 \leq s \leq 45$ ppt), and density/depth ($0 \leq d \leq 1000$ m). Speed of sound through the first sediment layer used measurements from Yang and Tang (2017) (Figure 1). Their site VLA1 was found to have mud over sand, a similar situation theorized in our survey region. Our Edgetech 216S utilized the devices CHIRP spectrum during the acoustic acquisition, 2 kHz-12 kHz (capable of up to 15 kHz). For the SOS in our sediment, the average was taken from Yang and Tang for the 2-10 kHz VLA1 sand (1607.8 m/s) and VLA1 mud (1592.2 m/s) (avg 1600 m/s). The lack of an SOS for the higher frequency is not considered, as these frequencies (11 & 12 kHz) will likely attenuate the quickest and the stronger reflection seen of the bedrock will be due to the lower frequencies. The bedrock was then drawn on the 2d sub-bottom profiles. Where visible, a strong intermediate reflector (RF1) was also drawn, noting a change in acoustic impedance of the sediment type.

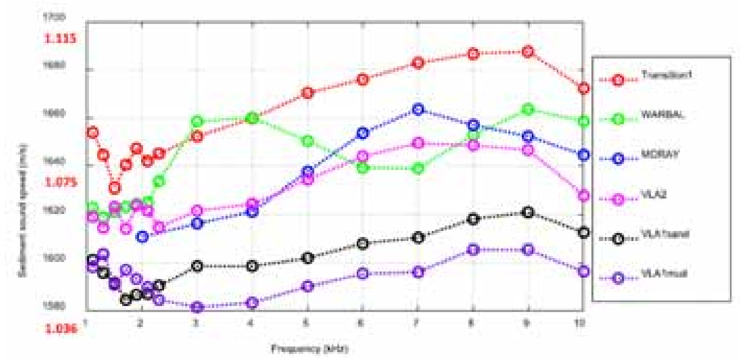

Figure 1 Reprinted from Yang and Tang (2017). Test of sound velocity in different seabed sediment types at various low frequencies. We used a combination of VLA1sand (black) and VLA1mud (purple).

For Kriging interpolation of the seabed, a point Kriging was used with a search ellipse radius of 10,000 m. This ensures that each N-S transect could reach the next transect to the east and west (see Figure 2). For the sediment depth interpolation, 8 types of interpolation were compared, and minimum curvature chosen for its simplified output.

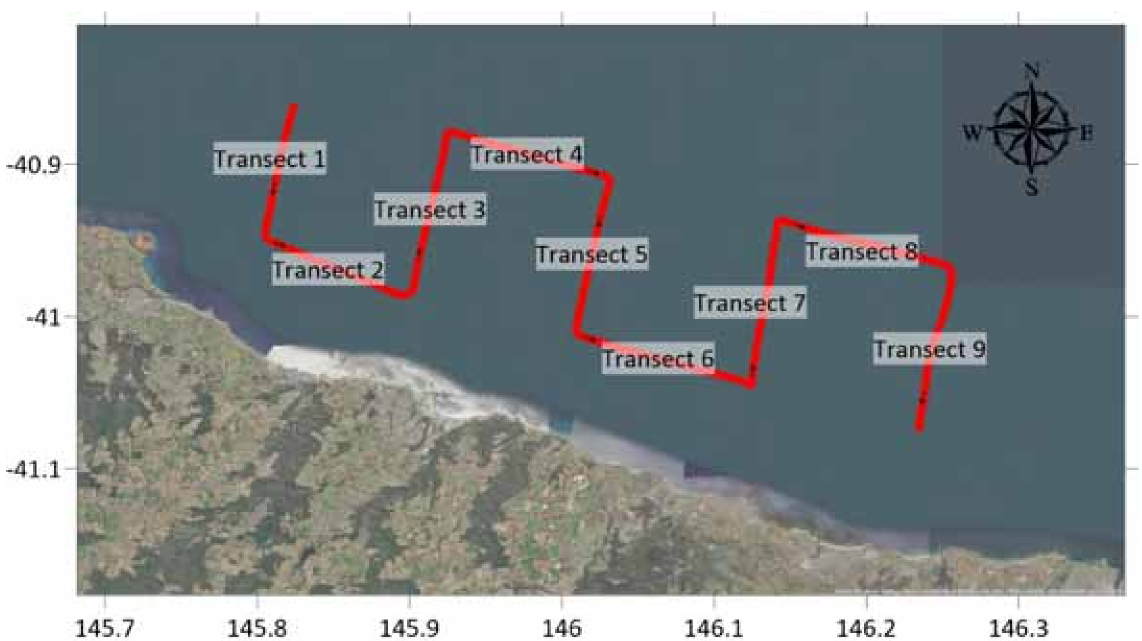

Figure 2: Edgetech 216 towfish sub-bottom transects, a constant speed of 5 kt was maintained throughout the survey region.

2.4. Particle size distribution

The particle size distribution followed a recognizable pattern from nearshore to offshore. As the sediment heads to deeper depths, an increase in fine particulate takes over from larger fluvial deposition in the nearshore environment.

Sediment grabs were taken with a spring loaded Van Veen grab from offshore to nearshore Bass Strait north-east of Burnie in the middle of the designated survey area (Figure 3). A cross-section from offshore to nearshore was sampled to examine the change in sediment type over depth. For laboratory analysis and particles size distribution using laser diffraction (Mastersizer 2000, Malvern Instruments Ltd., UK). Samples were first homogenized before wet sieving through a 1 mm mesh. The Mastersizer has a 1 mm particle size limit which is discussed in more detail later. Sieved particles larger than 1 mm were first dried then weighed and photographed. The slurry of particles smaller than 1 mm was homogenized again before adding to the Mastersizer 2000. The sample was sonicated for 30 seconds before analysis was conducted 5 times with the average result being used.

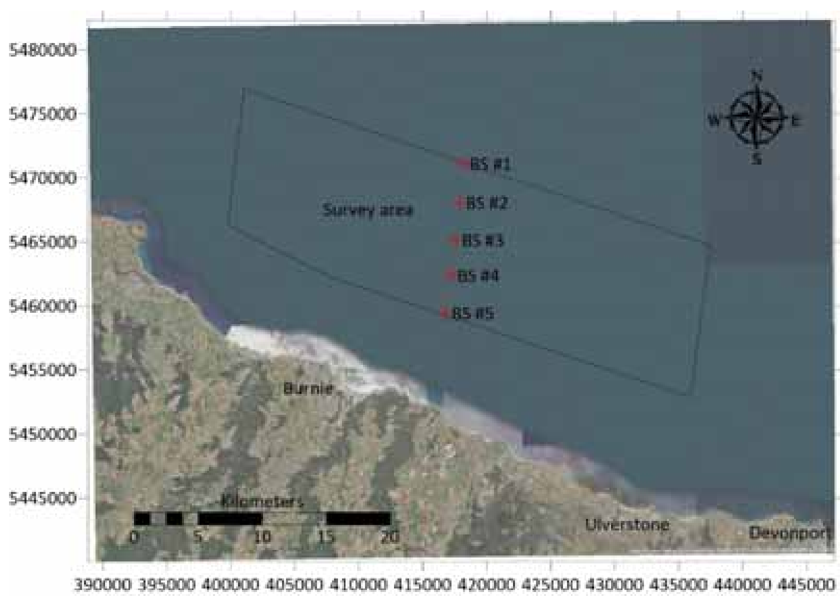

Figure 3 Bass Strait survey area in MGA2020 UTM55 showing the sediment sampling transect from offshore to nearshore.

2.5. Subtidal macrofaunal assemblages in the Bass Strait Blue Economy Zone (Tasmania): Preliminary environmental characterization.

2.5.1. Field methodology

A total survey area of 490 km2 was covered by the 25 stations sampled across the Blue Economy Zone (BEZ). Five replicate 0.07m2 van Veen grab samples were taken for macrofaunal analysis at each station. Grabs less than 50% full were rejected, where repeated attempts failed to obtain adequate samples, grabs were combined and this was noted in the field log.

Grabs samples were gently sieved, over 0.5mm mesh, to remove fine sediment and the residue was transferred to sample jars and preserved in 70% alcohol containing the vital stain Rose Bengal. Samples were kept under cool conditions and transferred to the laboratory for taxonomic analysis.

2.5.2. Laboratory analyses of macrofaunal community composition

The preserved sieved residues from each grab sample (n=25) were carefully examined under a stereoscopic microscope and the macrofauna were enumerated and identified to species level (as far as practicable) using standard Australian taxonomic works (Beesley et al. 1998; Beesley et al. 2000; Glasby and Fauchald 2003; ABRS 2019; Atlas of Living Australia, see www.ala.org.au, accessed 22 March 2019). Dissections were made to aid taxonomic identification where necessary (i.e., molluscs were dissected from their shells, polychaete chaetae were removed). Scientific names were verified using, and follow, the World Register of Marine Species (WoRMS Editorial Board 2019).

2.5.3. Data analysis

The benthic macrofaunal assemblages from the five S-N (inshore-offshore) gradient and across (W-E) the BEZ area were compared using; univariate biotic indices such as macrofaunal density (the total number of individuals per grab), species richness, Shannon Wiener diversity, Pielou's evenness, and the density weighted taxonomic/community composition was compared using non-metric multidimensional scaling (nMDS) on square root transformed Bray Curtis similarity followed by analysis of similarity (ANOSIM). Multivariate analyses were completed using PRIMER v. 6 Beta (Plymouth Marine Laboratory, UK), and univariate statistics were carried out in SPSS Statistics v. 27 (IBM Corp.).

2.6. ADCP Currents

The Acoustic Doppler Current Profilers (ADCP) were deployed on tripods mooring frames on the seabed. Figure 4 presents the map with the location (146° 5'21.41"E, 40°59'53.16"S) of the Current Stations deployed in the BEZ.

Figure 4 Location of the ADCP mooring in BEZ

2.6.1. Configuration

The Nortek Signature 500 kHz ADCP was configured to measure current velocities as follows for each of the five deployments.

Table 2 Instrument's location and configurations to measure current velocities.

Station	Depth [m]	Averaging interval [s]	Measurement interval [s]	Cell size [m]	Blanking distance [m]	Range to last cell [m]	Number of pings	Horizontal precision [cm/s]	Beam precision [cm/s]	Number of beams
Signature 500	52.5	150	600	1	0.5	60.5	360	0.93	0.31	4

2.6.2. Data processing and quality control

The data processing was split into two main parts: the first one conducted in the manufacturer's software Ocean Contour and the second in Matlab.

Ocean Contour

- Export raw data as .mat and NetCDF
- Magnetic declination correction: dependent on deployment date
- Bin mapping, to reduce effects of tilt and roll
- Surface pressure offset correction: 0
- Removal of datapoints with beam correlation below 50 % as per manufacturer's recommendations, minimum amplitude of 20 dB to remove weak signals, amplitude spikes of 35 dB or more and of the top 13 % of the water column, to avoid side lobe interference. Analysis of removal of top of water column revealed that removal of 10 % and 7% resulted in unrealistic current measurements
- Removal of datapoints in which more than 50 % of pings presented bad quality
- Averaging over 10-minute interval

Matlab

- Structuring data in .mat file
- Data analysis
- Export processed data as NetCDF

While performing the processing and analysis of the dataset collected it was found that the burst measurements (wave measurements), which were taken simultaneously with the current speed sampling, interfered with the current speed signal. This phenomenon introduced artificial velocity fluctuations into the signal that could not be removed. The side lobe signal introduced speed and direction variations mostly at mid-water column. This interference occurred for all deployments and influenced current speed measurements particularly in the mid and upper water columns as shown in Figure 5, with velocities typically higher than the surrounding measurements recorded.

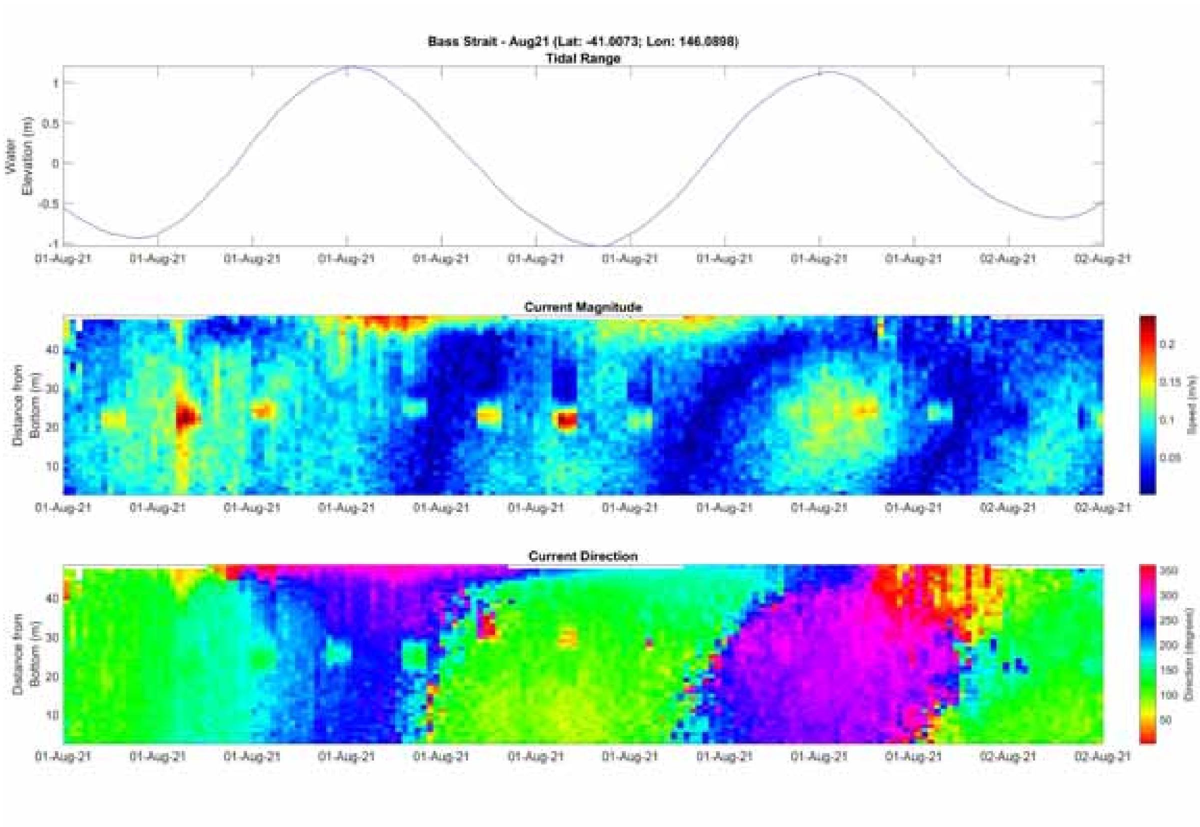

Figure 5: Mid-water column measurement error showing peaks in current speed during wave measurement periods that repeat for 40 minutes every two hours

To evaluate the influence of the artificial mid-water measurements, the ADCP data was processed to remove the time periods when the measurements overlapped. Comparisons of the differences in statistic parameters are shown in Table 3, where it can be seen that the interference did not change the statical values significantly, probably due to the long deployment times and the data averaging process. As a result, the interference removed dataset was used in the determination of all statistics. Note however that the ADCP figures use the full data set as recorded.

Table 3: Comparison of statical parameters for datasets with and without mid-water column beam interference for Deployment Three

	Mean (m/s)	Maximum (m/s)	90^{th} Percentile (m/s)	Direction
Full Data Set	0.08	0.29	0.13	78 / 297

Interference Removed Data Set	0.08	0.26	0.13	73 / 301

2.7. ADPC Waves

2.7.1. Configuration

The Nortek Signature 500 kHz ADCP was configured to measure waves as outlined in Table 4 for each of the five deployments. The units were configured to measure waves in Beam coordinates, as well as current data as shown in Section 2.6.

Table 4 Instrument's location and configurations to measure Waves

Station	**Depth [m]**	**Burst duration (min)**	Measurement interval [s]	**Number of pings**	**Sampling frequency [Hz]**	**Alti start [m]**	**Alti end [m]**	Horizontal precision [cm/s]	Vertical precision [cm/s]
Bass Strait	54.9	34:08:00	7200	2048	1	29.4	77.8	1.99	0.66

2.7.2. Data processing and quality control

The data processing was split into two main parts: the first one conducted in the manufacturer's software Ocean Contour and the second in Matlab.

Ocean Contour

- Export raw data as .mat and NetCDF
- Magnetic declination correction: 13.586°
- Processing method: MLMST and SUV
- Spectrum: Optimized – this technique uses the AST spectrum as default. In case of a bad AST detection, it uses the velocity spectrum.
- Frequency band to be evaluated: 0.02 Hz – 0.99 Hz

Matlab

- Structuring data in .mat file
- Data analysis.

While performing the processing and analysis of the current dataset collected it was found that the burst measurements (wave measurements), which were taken simultaneously with the current speed sampling, interfered with the current speed signal, introducing artificial velocity fluctuations into the signal. The influence of this result on wave measurements is unknown.

Comparisons of SUV and MLMST methods were performed to ensure the accuracy of the wave processing methodology. Results are shown in Table 5 indicate minimal difference between the two methodologies, with only slight differences found for the minimum values of each wave parameter. Given this, the SUV method was used.

Table 5: Wave processing comparison for SUV and MLMST methods showing minimal differences in wave parameters expect for minimal values

Statistics		SUV			MLMST		
		Significant Wave Height	Mean Period	Peak Period	Significant Wave Height	Mean Period	Peak Period
Dec-20	Min	0.02	1.13	1.02	0.28	1.63	2.10
	Mean	0.90	2.85	5.65	0.91	2.87	5.75
	Max	1.84	4.81	12.77	1.84	4.81	12.77
	STD	0.33	0.68	2.31	0.32	0.66	2.36

2.8. Sofar Ocean Spotter

2.8.1. Configuration

A Sofar Ocean Spotter buoy was deployed at -41.0225, 146.08475 from 25-8-2021 onwards to measure wave and wind metocean conditions. This moored spotter collected 3D displacement time series at a sampling rate 2.5 Hz of the following:

- Position/time
- Significant wave height
- Wave mean/peak period
- Wave mean/peak direction
- Wave mean direction spread
- Wave mean/peak directional spread
- Wind speed/direction.

The Sofar Ocean Spotter calculates the local wind from the equilibrium range of the wave spectrum. The Ocean Spotter estimates wind speed and direction from the intensity and direction of the higher-frequency wave field ('sea') which represent a measure of sea surface roughness and is forced by the local wind field. This is a highly effective proxy measurement for open water (effective unobstructed fetch >5 miles), but should not be relied on in confined waters or behind obstacles (e.g. headlands).

2.8.2. Data processing methodology

Due to the lack of input parser for the wave spotter .csv file the wind data was processed with a custom-made MATLAB code. The raw csv files were imported and converted in .mat files for faster access. Erroneous data during deployment and retrieval was deleted. Plots and tables were then created in MATLAB® and exported for use.

2.9. Additional Wind Speed Data

To enable comparison of the wind data collected using the Sofar Wave Spotter buoy, wind data was obtained from both field measurements and model datasets. Wind speed data was collated from the Australian Baseline Sea Level Monitoring Project Burnie Station (IDO71005) for periods covering the ADCP deployment from 2020, 2021 and 2022. These wind measurements included time (UTC) hourly wind direction (Degrees True), gust (m/s) and wind speed (m/s average of last six one-minute measurements taken in the previous hour). Wind model data was also collated from the CAWCR wave model, which uses the Climate Forecast System Reanalysis v.2 (CFSv2) surface winds at 0.2° spatial and hourly temporal resolution (Durant et al., 2019)

2.10. Water Quality

Water column property were obtained with the large Sealite Nautilus buoy system. The details for this using a mooring and its components are:

- -2.2m Rotor moulded PE, closed-cell foam filled buoy designed for coastal and ocean applications
- -Total reserve buoyancy of 3.67T
- -Custom fabricated 10mm marine grade aluminium equipment housing
- -SL15 1-2nm Solar powered beacon
- -2 x 80W Solar Panels
- -20W Wind Generator
- -2 x 12v 120AH AGM Batteries
- -Campbell Scientific CR1000x and CR310 Data Loggers control all onboard measurement, automation, and communications
- -Maxon Unimax 4G+ Router enables real time communications to the web
- -Valeport VA500 500khz Altimeter (Depth sounder) is used to adjust the profiling depth over the tidal cycle

Winch – YSI Vertical Profiler

- -50m Cable length
- -1m to 49m profiling depth
- -Able to cast continually or profile at set depths
- -Capable of 50% profiling duty cycle
- -Constructed of Delrin, PVC, and 316 SS to minimise wear
- -Cable is Kevlar reinforced with a hardwearing insulation

Sensors – YSI Exo2 and Aanderaa DCPS

- -Exo 2 is constructed from Titanium and Xenoy
- -Able to hold up to six water quality sensors + wiper
- -Currently fitted with Wiper, Conductivity, Dissolved Oxygen, Total Algae (PE + Chl) and Depth
- -Reports 2hZ data while casting, in standby mode records at park depth hourly
- -Fitted with anti-fouling measures – brass sonde guard, copper sensor wrap, and central wiper for optics
- -DCPS (Doppler Current Profiling Sensor) is a 600 KhZ, 4 beam profiler fitted underneath the buoy
- -Capable of profiling to 80m, with several configurable measurement columns, cell sizes, and overlaps the data is extremely configurable
- -Ping rate is 1hz for continuous measurement, recorded every 15 minutes.

Figure 6: Picture of the Sealite Nautilus System

2.11. Water Temperature

Water column property measurements of water column temperature were obtained using a mooring with a surface buoy and 8 temperature loggers to measure the variation of temperature along the water column.

2.11.1. Configuration

The temperature mooring as shown in Figure 7 composed of a surface marker fitted with a light; a line with 8 RBR Solo Ts (temperature loggers) equally spaced; and a train wheel weight. The distribution of the loggers is shown on Figure 7. The mooring was initially deployed on the 24/11/2021 at S 41.02263°, E 146.08429°. The depth at this site was approximately 47 m. All 8 loggers were configured to measure continuously at a sample rate of 2 Hz and were set in a mix of local and UTC time, with their location on the mooring line shown in Figure 7. The station was retrieved on 26/4/2022, and the data downloaded for processing. The mooring was redeployed on the 26/4/2022 using the sensor layout shown on Figure 7, and retrieved on the 5/12/22.

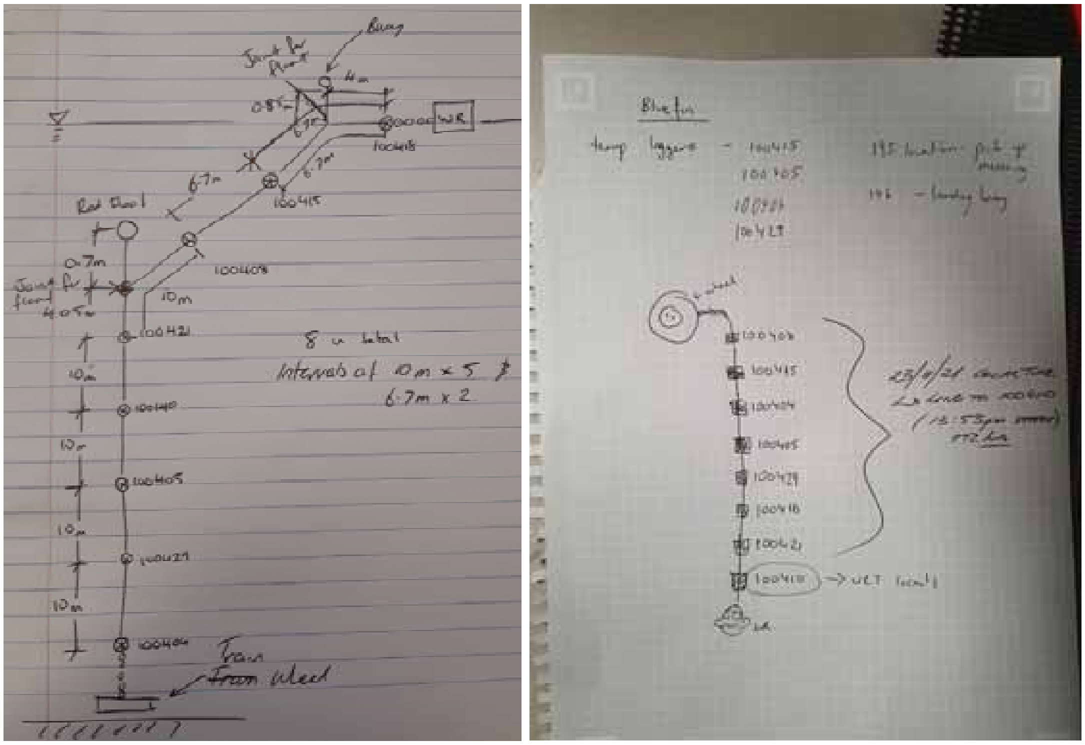

Figure 7: Diagram of the temperature Station deployed in the BEZ for (left) first and (right) second deployments

2.11.2. Data processing methodology

Due to the lack of input parser for RBR .rsk file in the IMOS Toolbox, the data was processed with a custom-made MATLAB code. The raw RSK files were imported and converted in .mat files for faster access. First data before deployment and after retrieval was deleted; then raw (5-minute), daily and monthly averages and raw (5-minute), 10-minute and daily plots and were made for each of the datasets. Outliers of more than 3 standard deviations from the mean were removed and filled with linear interpolation. Plots and tables were then created in MATLAB® and exported for use in the report.

2.12. Fish Trawls

A permit was required for the Trawl Survey using the AMC vessel Bluefin. Australian Fisheries Management Authority (AFMA) Scientific Permit Number 1005009. Animal Ethics approval was granted by the UTAS Animal Ethics Committee on 15/09/2021, application number 23830, project title: Characterisation of the Blue Economy Zone - benthic fish species.

Methods

The vessel used for the survey was the FTV Bluefin, a 34.5-m stern ramp trawler with 850 continuous horsepower. Stations were sampled using a 14 fathom Florida Flyer demersal otter trawl (Figure 1). Mesh size of the net bottom trawl net made of polyethylene (PE 36D) with 44m headline and 34m fishing line. Mesh size of the codend was 90 mm, (NB the design of the trawl means that the sampling gear is species and size selective, so different species in the benthic community would not be sampled equally). The trawl was deployed from the stern of the FTV Bluefin (Figures 2 and 3).

A total of six stations of clear trawl tracks were selected based on the previous habitat survey conducted in the BE Zone and an assessment of seabed by the skipper using a SIMRAD ER60 scientific echosounder and Olex seabed mapping and navigation system. Trawls of 30 minutes duration were conducted at the six different locations.

Sampling was conducted by depth/sediment type (sandy areas, sandy areas with patches of rocky reef and muddy sediments). Muddy sediments occur in deeper waters and sandy and mixed habitats in the shallower, inshore part of the BE Zone. Two trawls within each substrate type were conducted which covered varying depths.

Calculation of swept area of each trawl

The swept area of each trawl was calculated by multiplying the distance across the seabed that the FTV Bluefin travelled during each trawl and the otter board wing-end spread. The Haversine formula, which determines the great-circle distance between two points on the earth given their latitudes and longitudes, was used to calculate the distance between the starting and finishing positions of each trawl recorded from the GPS plotter, and the otter board wing-end spread was measured using a SCANMAR hydroacoustic trawl measuring system. The wind-end spread was calculated from the estimated otter board wing-end spread and the measurements of the sweeps and bridles used (Figure 8).

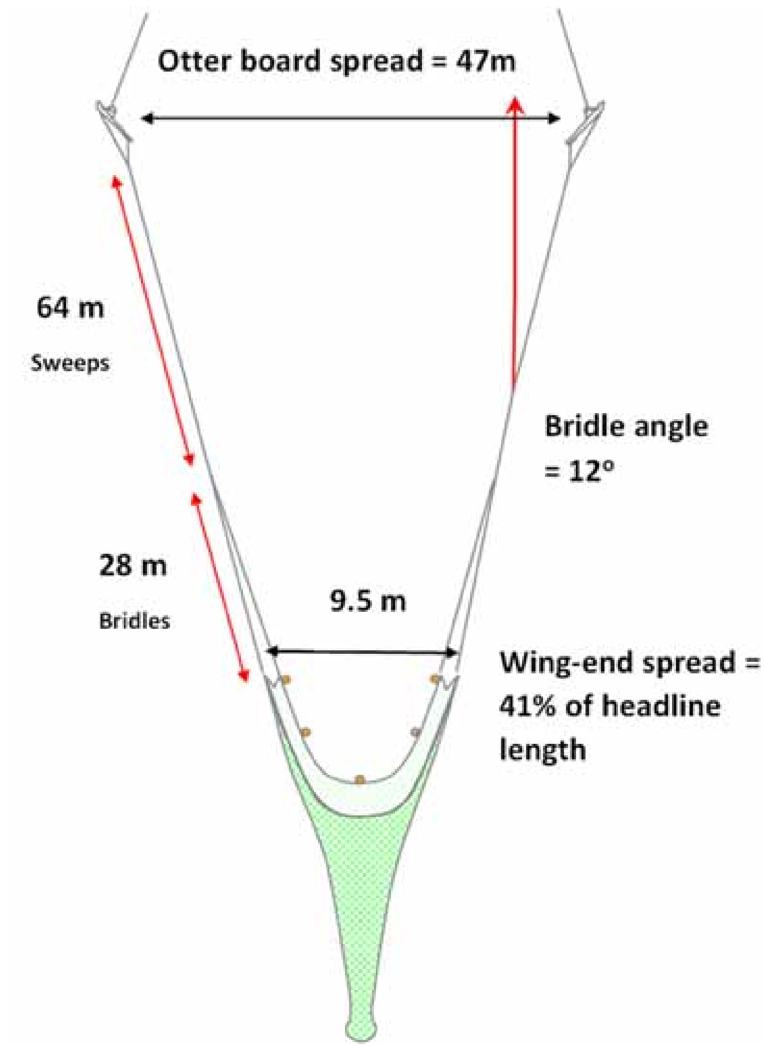

Figure 8 Trawl configuration showing estimated wing-end spread which is based on the measured otter board spread (using Scanmar trawl system) and the length of the sweeps and bridles used

Sorting fish

After each trawl, the codend of the net was hauled on to the back deck of the FTV Bluefin (Figure 4) and the contents of the net were emptied on the back deck (Figure 5). Any animals that were alive (primarily large rays and octopus) were recorded and then released back into the sea.

All of the remaining catch was sorted on the back deck of the FTV Bluefin (Figure 9) into either mobile epifauna including echinoderms (starfishes, brittlestars, sea urchins, sea cucumbers), crustaceans (crabs), cephalopods (squid, octopus) and fishes, and sessile animals such as sponges and bryozoans (see Figure 10).

The sessile animals from each trawl were grouped together and weighed before being returned to the sea. The mobile epifauna were sorted into approximate species groups, counted and weighed. The catch of all the mobile epifauna were placed into either boxes or bags and labelled to identify the trawl that the contents came from. All samples were then frozen onboard the FTV Bluefin.

Frozen samples were returned to the seafood laboratory at Beauty Point for processing. All samples were defrosted and then every individual was identified to species, weighed to the nearest gram, and measured (total length [TL] or fork length [FL] for fish, total length [TL] for elasmobranchs and carapace length [CL] for crustaceans, mantle length [ML] for cephalopods) to the nearest millimetre.

The total numbers and total weight of each species in each trawl and the length-frequencies for each species across all trawls were summarised using Microsoft Excel.

Calculation of diversity

Species Richness

Species Richness for each trawl was measured by the total number of species identified in each trawl.

Simpsons Diversity Index

Simpson’s Diversity Index (D) was used to calculate species diversity indices for each trawl using,

$$D = 1 - \frac{N(N-1)}{\sum n(n-1)}$$

where, N = Total number of organisms of all species found and n = number of individuals of a particular species.

The Simpson’s Diversity Index includes the number of species present (richness), as well as the relative abundance of each species (evenness). The diversity in a trawl (location) increases as species richness and evenness increase, where 0 = no diversity and 1 = total diversity.

Community similarity

Sorenson's Community Similarity Index (SC) was used to measure community similarities between trawl sites using,

$$SC = \frac{2C}{(S_1 + S_2)}$$

where C is the number of species that the two trawls have in common, S1 is the total number of species found in trawl 1, and S2 is the total number of species found in trawl 2. The closer the value is to 1, the more the communities have in common (complete community overlap is equal to 1; complete community dissimilarity is equal to 0).

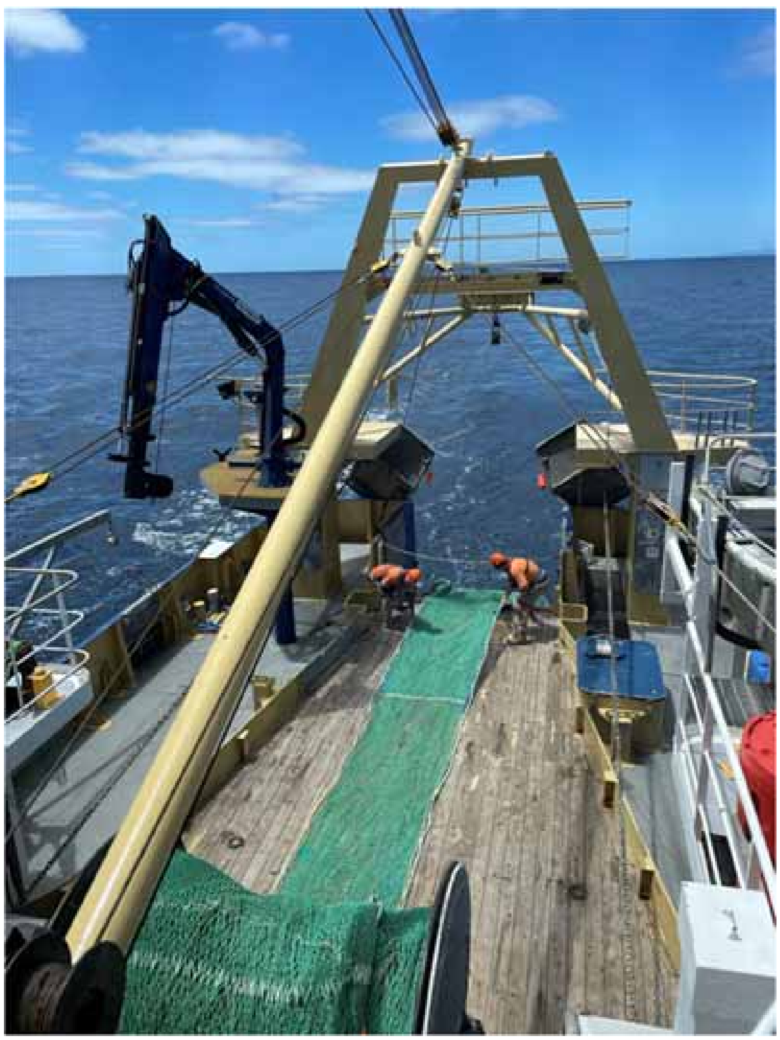

Figure 9 Preparing to deploy trawl from the back deck of FTV Bluefin

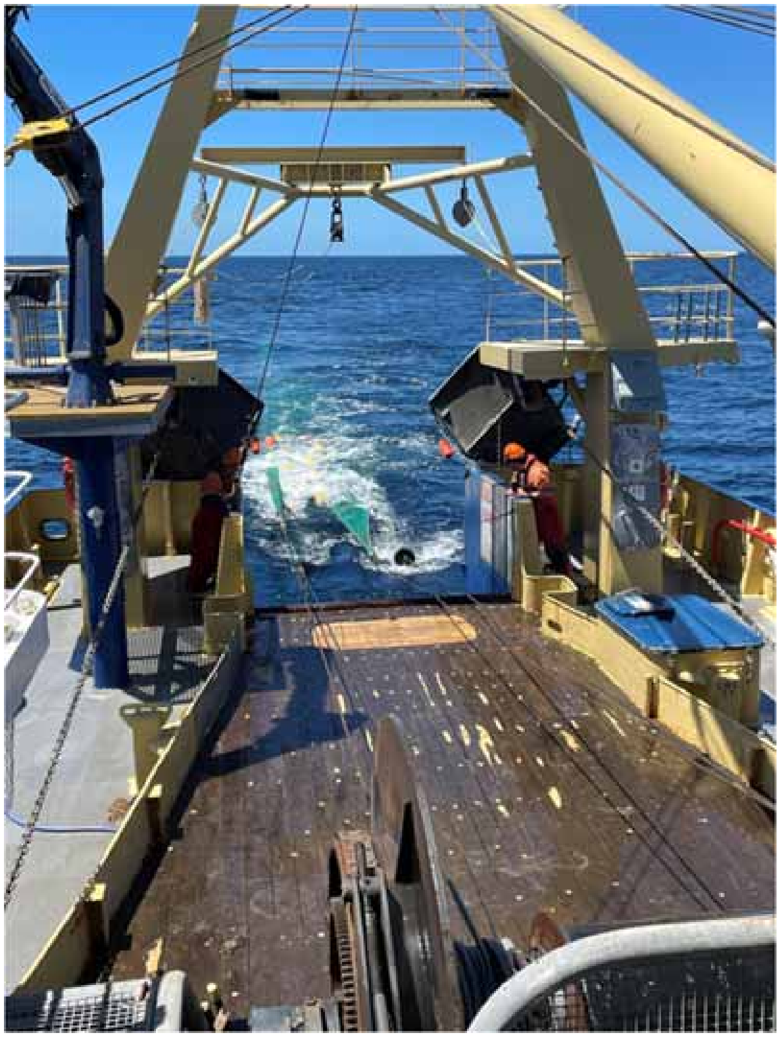

Figure 10 Deploying trawl from the FTV Bluefin

Figure 11 Trawl hauled on to back deck of the FTV Bluefin with catch in codend

Figure 12 Unsorted catch on back deck of the FTV Bluefin

Figure 13 Sorting catch on back deck of the FTV Bluefin

Figure 14 Sorted catch with trays of fish and piles of sessile epibenthos

3. Results

3.1. Bathymetry

The area of the BEZ has a mild sloping bathymetry with water depths ranging between 35-45 m at the southern (shoreward) edge and depths exceeding > 60 m at its offshore boundary. Figure 15gives insight into the depth range within the BEZ. The contour lines and colour scheme (red shallow, blue deep) indicate that the shallowest spots are found in the southeast and depths exceeding 60 m, are found along the northern edge of the BEZ boundary.

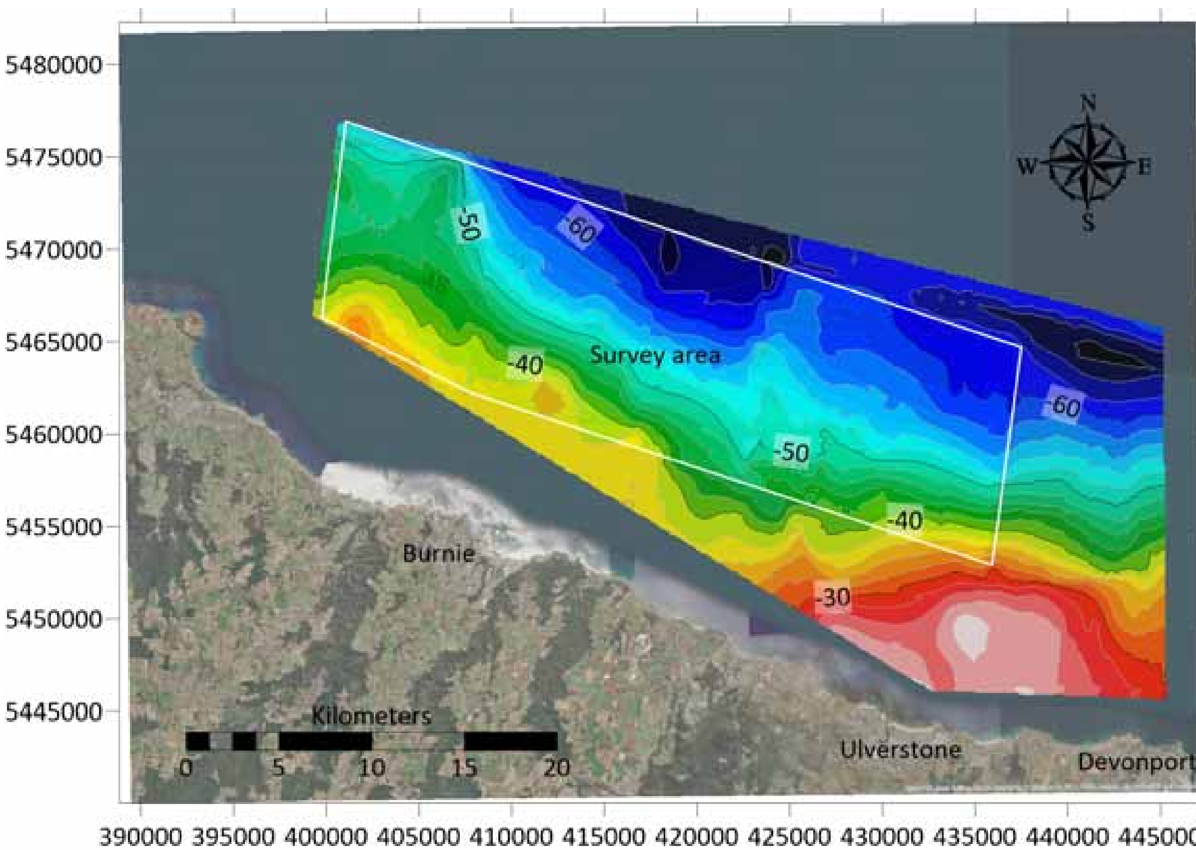

Figure 15 Bathymetry interpolation based on single beam survey

3.2. Sub-bottom

The bathymetry presently uses only the limited transects of the sub-bottom profiler, this will incorporate the Bluefin single beam bathymetry data when available. A gradual deepening towards the north east is evident (Figure 16). There is also a shallowing of the depth as we approach the coastline off the township of Wynyard and Table Cape, the latter of which is a significant geological feature (volcanic plug). Influence from the Table Cape is likely also seen in the peaks and troughs in transect 2 that are more prominent in the western region of the survey area. In most of the peaks and troughs located on the seabed we also see trapped sediment in nearly all of these features (transects 2 & 7, see Figure 2 for location of transects.).

As per the sediment grabs, there is rocky reef and rubble with limited quantities of sand in the shallower regions (-35 m to -45). In localized depressions we also see confined deposits of mud. In the deeper regions a layer of mud gradually increasing in thickness with larger depths. This is particularly well shown in transects 3 and 7 and in each transect parallel to the shore with more sediment present in the deeper regions (transects 4 & 8). Also present in deeper regions is a significant reflector (RF1), representing a significant change in acoustic impedance. This is seen below the mud layer that shows layering or stratification over the layer that is acoustically homogenous. This could suggest mud over sand, yet this would need to be confirmed with physical samples.

Figure 16 Minimum curvature interpolation from sediment depth

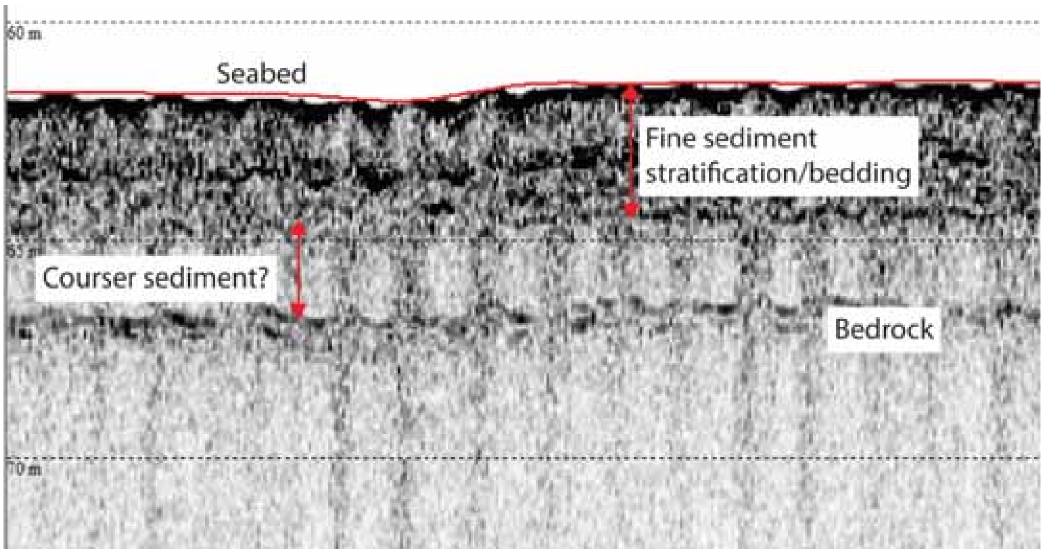

Figure 17 Closeup of the top bedded layer of fine sediment over a homogenous lower sediment layer

3.3. Sediment Particle Size Distribution

The results of the particle size analysis can be seen collated in the Table 6and Figure 18. Table 6 also shows the percentage of particle size that was excluded from the laser diffraction. The main analysis of the particle size distribution was on the fraction smaller than 1 mm due to the limitations of the Mastersizer 2000. This makes comparison with sieved results that contain an abundance of large sand and gravel difficult. This is minimized with examination of the larger sized particles in this project being mostly calcium carbonate shell that is largely removed from most PSD. Most oversized particles were shell content with some gravel sized sediment seen in BS#4 and BS#5.

The general trend is observed of larger particle size distribution closer to shore and only fine silt in the offshore samples. While nearshore sample (BS#5) was taken from 36.5 m depth, it would appear it is still affected by wind and wave action due to the larger particle sizes present and fluvial influence. Whereas the samples further offshore (BS#1-4) are largely silt and no longer subjected to most sediment transport processes.

Table 6 Particle size analysis of Bass Strait samples. Showing percentage of particles above and below 1 mm in size as well as the 10%, 50%, and 90% percentile distribution of the below 1mm particle size using laser diffraction.

	Depth	% > 1MM	% < 1MM	D(0.1)	D(0.5)	D(0.9)
BS #1 offshore	64 m	8%	92%	3.264	12.53	69.966
BS #2	62 m	12%	88%	2.865	6.656	35.252
BS #3	55 m	12%	88%	3.092	12.053	141.949
BS #4	48.5 m	10%	90%	3.142	12.609	266.605
BS #5 nearshore	36.5 m	14%	86%	10.749	251.581	609.094

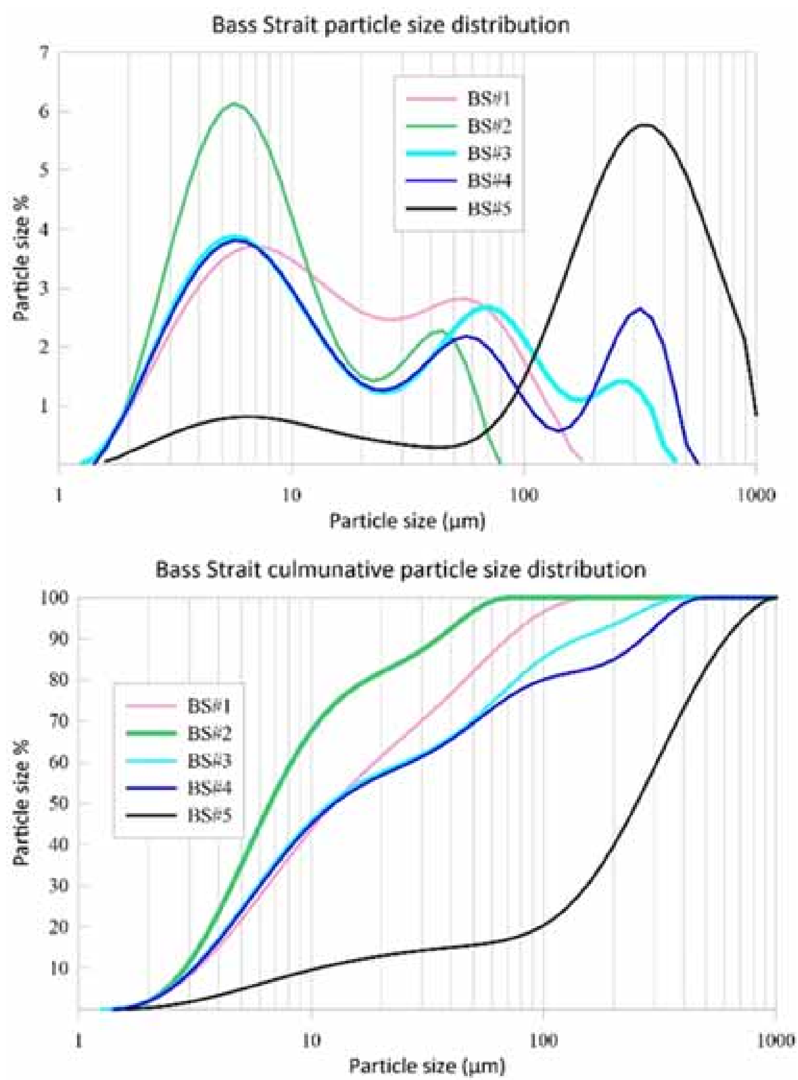

Figure 18 Particle size distribution of sieved particles less than 1 mm in size from Bass Strait survey

3.4. Subtidal macrofaunal assemblages

3.4.1. The macrofaunal assemblage in Bass strait soft sediment

A total of 1001 individuals belonging to 124 macrofaunal taxa were recorded from the initial 1 sample from each of the 25 stations with the depth varying from 34-65m. Of the total 124 taxa, one asteroid (starfish) species *Parvulastra vivipara* (echinoderm; <0.5% of the total individuals) was a new recorded occurrence in Bass Strait but had previously been recorded on Tasmania's east coast. One introduced (non-native) sabellid polychaete (tube worm) *Euchone limnicola* (1% of the total individuals) was also recorded. The remaining 123 taxa have previously been recorded from the Bass strait BEZ according to species occurrence databases such as Australian Faunal Directory, Atlas of living Australia (ALA) and Ocean Biogeographic Information System (OBIS).

Table 7 taxa (ranked by density - number of individuals per grab) as a percentage of the total number of individuals and the cumulative proportion of the density retrieved in each station.

Taxa	Higher taxon group	Proportion of density (%)	Cumulative proportion (%)
Dipolydora giardi	Annelida	14	13.59
Nectonema sp.	Nematomorpha	8	21.98
Apseudes abditospina	Arthropoda	4	26.17
Lumbrineris coccinea	Annelida	4	29.97
Nephtys inornata	Annelida	3	33.17
Melita sp.	Arthropoda	3	36.36
Onuphis holobranchiata	Annelida	3	39.26
Anapella cycladea	Mollusca	3	42.16
Paradoxostoma sp.	Arthropoda	2	44.56
Notomastus torquatus	Annelida	2	46.75
Mediomastus sp.	Annelida	2	48.65
Owenia sp.	Annelida	2	50.45

The Bass Strait BEZ sub-tidal microbenthic assemblage was dominated by annelid worms (46% of total recorded taxa), arthropods (23% of total recorded taxa), molluscs (19% of total recorded taxa) and the remaining 12% of taxa conisted of the following taxonomic groups; echinoderms, oligochaetes, foraminiferans, cnidarians, hirudinids, sipuncula, and nematomorphs. The system was highly dominated, with over 50% of the individuals observed accounted for by twelve taxa (Table 1): the most numereous was a spionid polychaete *Dipolydora giardi* (14% of all the individuals) followed by 6 other polychaetes (Table 1). A tanaid crustacean *Apseudes abditospina*, an amphipod *Melita* sp., ostracod *Paradoxostoma* sp. and bivalve *Anapella cycladea* all also contributed ≥2% of all the individuals (Table 1).

3.4.2. The biodiversity of the macrofaunal assemblages in Bass strait soft sediment

The observed total number of individuals and species richness varied across the 25 stations (Fig. 1A-B). The highest number of individuals (Figure 19A) and species richness (Figure 19B) were found in station 2A and the lowest in station 5A. Twenty-two stations out of the 25 had more than 20 individuals per grab.

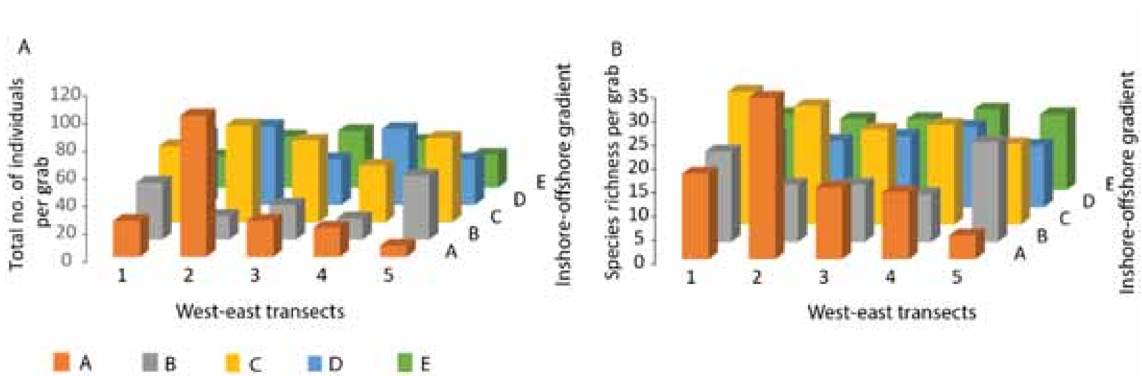

Figure 19 The distribution of (A) the total number of individuals and (B) species richness recorded across 25 stations (one replicate grab per station) at Bass Strait soft sediments.

3.4.3. The biodiversity and taxonomic composition of the macrofaunal assemblages along north-south gradient in Bass strait soft sediment

Considering the five stations in each location on a transects as replicates (i.e. the five station As, etc), the most northernly offshore stations (e.g. Es) were at depths of 56-65m while the most inshore stations (e.g. As) were at depths ranging from 34-39m. Only the median of the total number of individuals differed significantly across north-south gradient (Kruskal-Wallis test, $H = 9.824$, $p < 0.05$, Fig. 2) with the species richness, Shannon Weiner diversity index and Pielou's evenness not differing significantly (Kruskal-Wallis test, $p > 0.05$). The median number of individuals recorded was significantly higher at the middle stations (Cs) compared to the median of number of macrofaunal individuals to the immediate south (Bs) (Mann-Whitney U test, Mann-Whitney $U = 1.500$, $p < 0.05$), other pairwise comparisons were not significant (Figure 20).

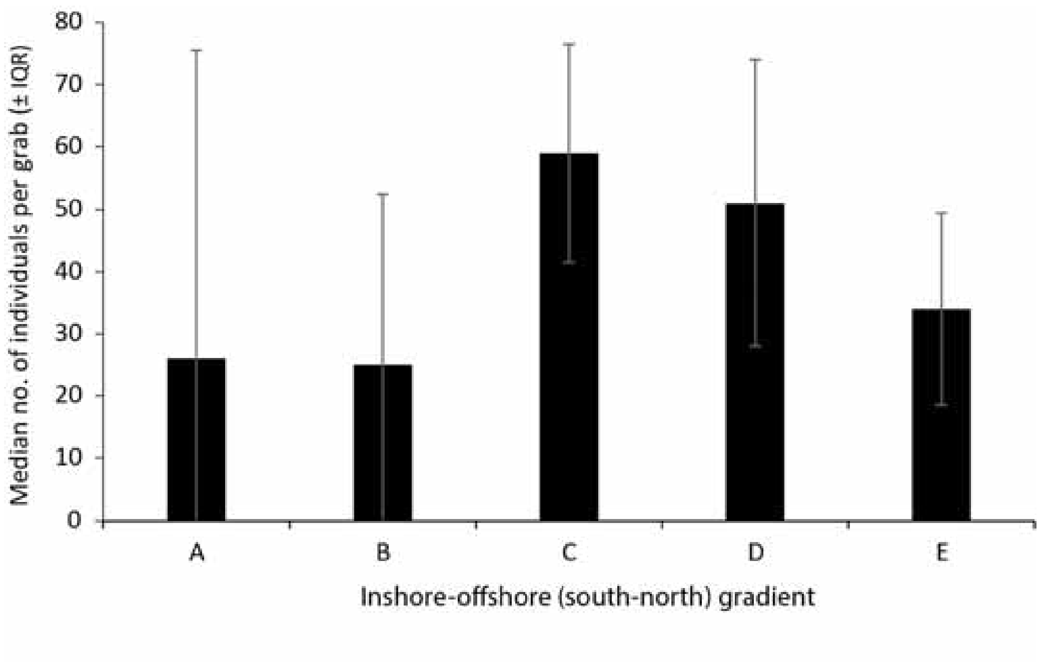

Figure 20 Median (± interquartile range; IQR) number of individuals per grab of the macrofaunal assemblages retrieved from single sediment grabs taken at each of five stations across the Bass Strait BEZ, Tasmania in March 2021.

There was a high degree of variability in the species composition of the macrofauna across the stations. The two most similar stations (2D and 5C) only had a Bray-Curtis similarity of 58%. The cluster analysis of the macrofaunal taxonomic composition of the 25 stations identified 4 groups (separated at around 20% similarity) and a singleton (outlier), station 5A (Figure 21).

There were no significant differences in taxonomic composition between the stations along the presumed gradients (off shore to inshore or east to west) (two-way AMOSIM no replicates; inshore - offshore: $R = 0.048$, $p = 0.317$; east to west: $R = -0.05$, $p = 0.666$, Figure 22).

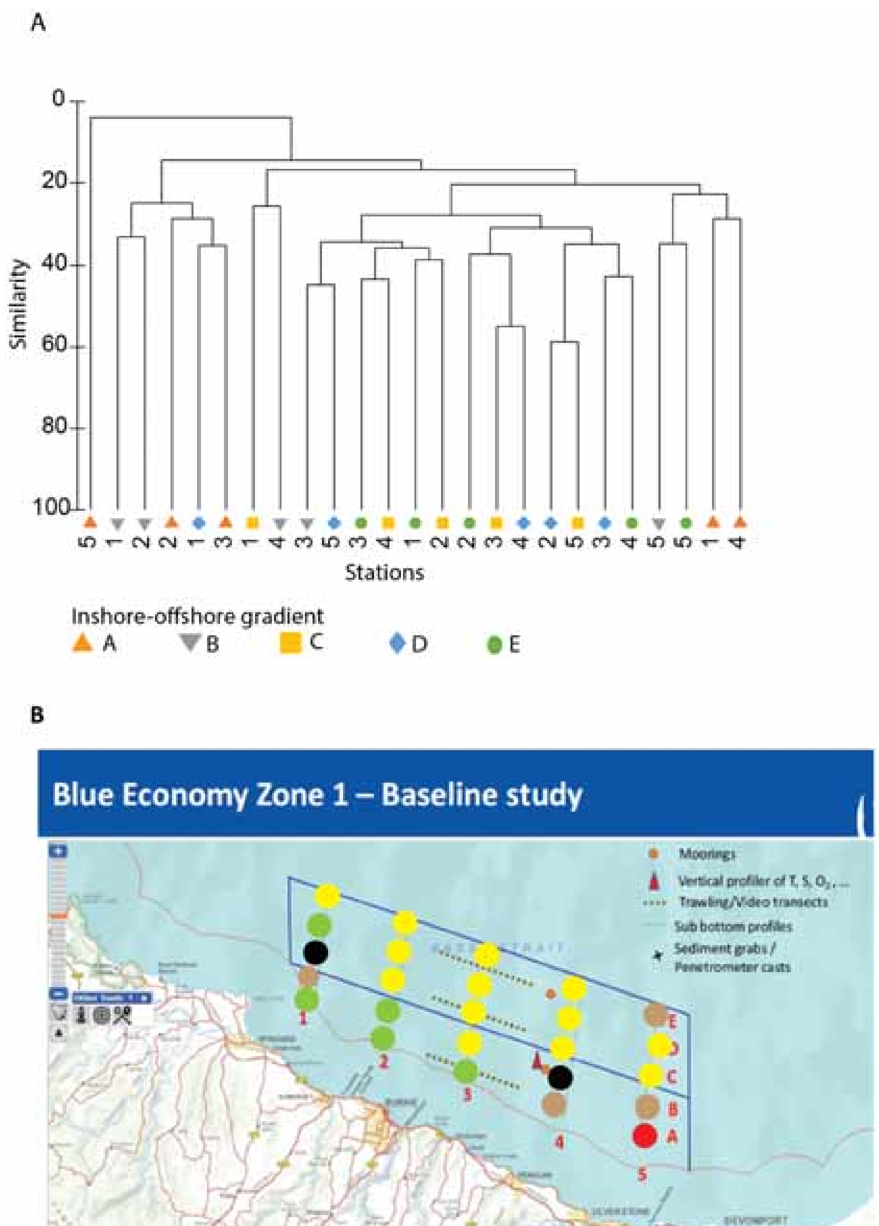

Figure 21 (A) Dendrogram depicting the results of cluster analysis, assigning inshore-offshore gradient to clusters based on the taxonomic composition of macrofaunal assemblages recorded in Bass Strait, Tasmania. Sampled March 2021. (B) Visual illustration of the stations grouped together based on the Bray-Curtis similarity of the cluster analysis.

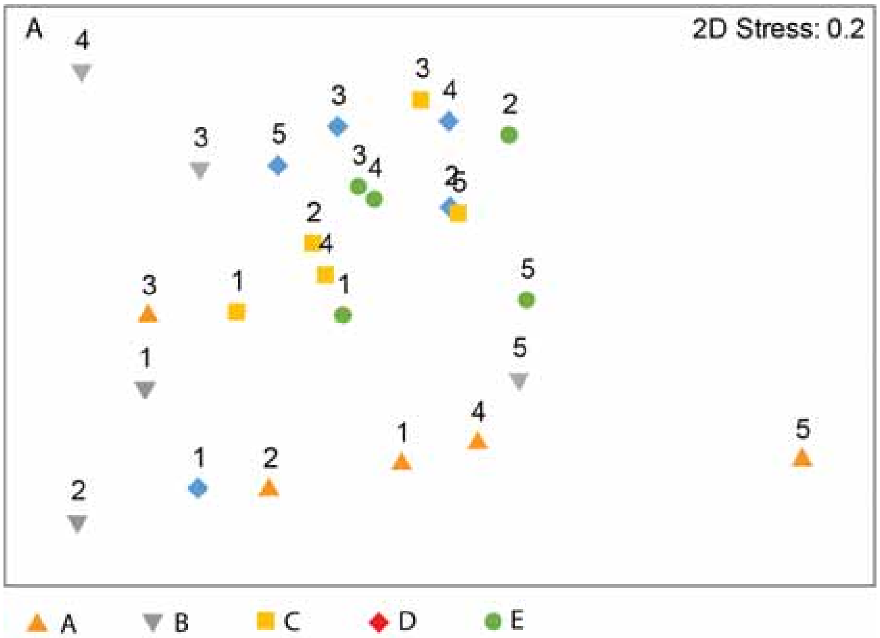

Figure 22 nMDS ordination of the Bray-Curtis similarity (square root transformed) of the density weighted macrofaunal taxonomic composition between the inshore (A) to offshore (E) gradient sampled from Bass Strait, Tasmania. The vertical transects (east to west) are indicated as labels (1 - far west; 2 – west; 3 – central; 4 – east; 5 – far east).

3.5. Currents using ADPC Measurements

3.5.1. Deployment One: November 2020 to March 2021

Tidal range, current magnitude and current direction

Tidal height, current speed, direction statistics and figures are shown in Table 8 and depicted in Figure 23 to Figure 27 for the entire deployment and for each month respectively.

Table 8: Statistical parameters from ADCP results for Deployment One (* denoted not complete month dataset)

Location	Statistics	All	*Dec-20	Jan-21	Feb-21	*March-21
Depth Averaged	Mean	0.11	0.10	0.10	0.10	0.10
	Max	0.32	0.25	0.29	0.32	0.27
	90th Percentile	0.17	0.17	0.17	0.16	0.18
	Direction Ebb / Flood	113 / 304	121 / 298	115 / 305	110 / 297	117 / 308
Bottom Water Column 10.5 m	Mean	0.10	0.10	0.11	0.10	0.10
	Max	0.35	0.28	0.29	0.35	0.30
	90th Percentile	0.18	0.18	0.19	0.17	0.19
Middle Water Column 25.5 m	Mean	0.10	0.10	0.11	0.10	0.10
	Max	0.35	0.28	0.29	0.35	0.30
	90th Percentile	0.18	0.18	0.19	0.17	0.19
Top Water Column 45.5 m	Mean	0.12	0.12	0.12	0.13	0.11
	Max	0.67	0.33	0.67	0.38	0.30
	90th Percentile	0.21	0.20	0.21	0.23	0.20

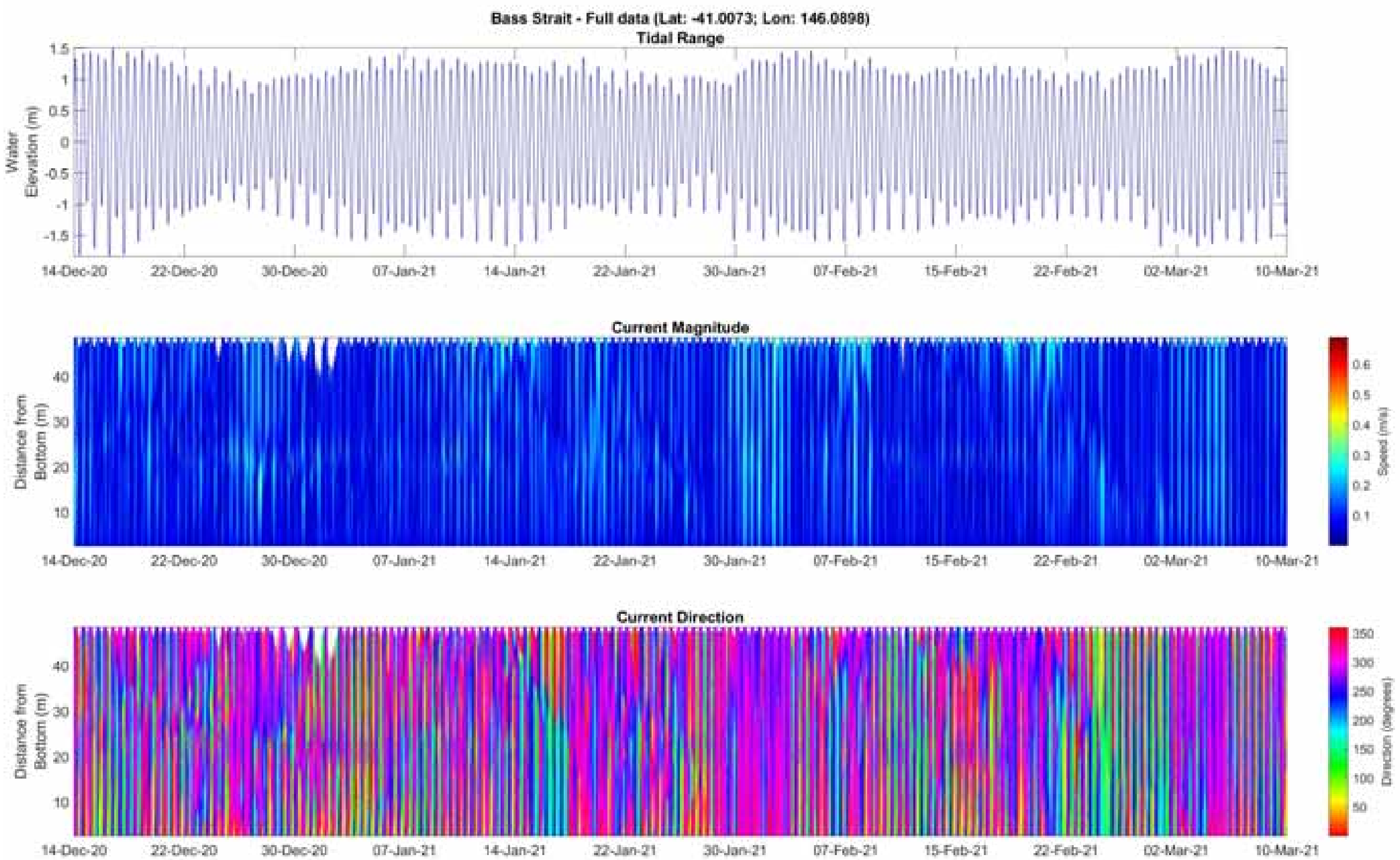

Figure 23: Water elevation, current speed and current direction measurements from 14 December 2020 to 10 March 2021

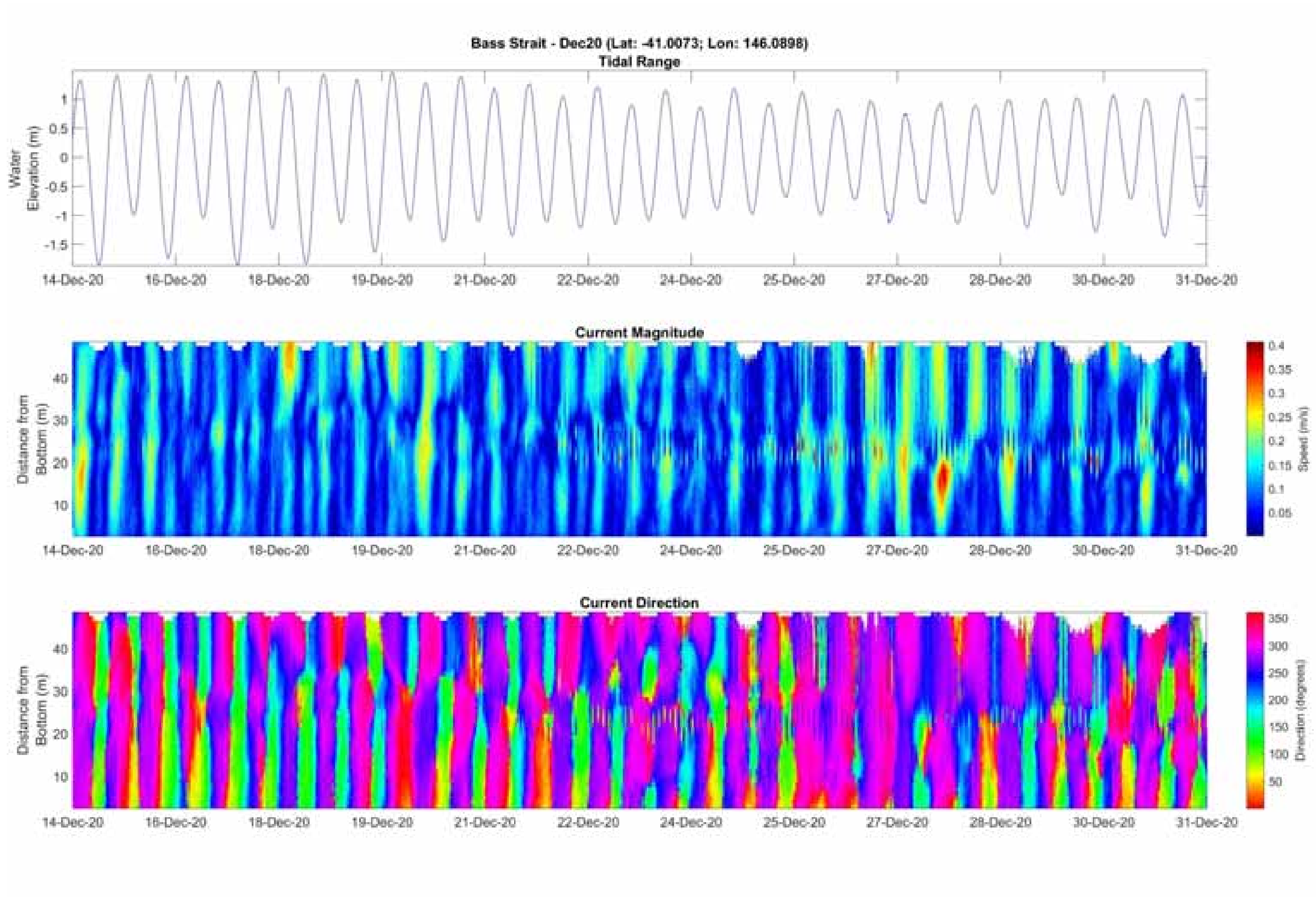

Figure 24: Water elevation, current speed and current direction measurements taken in December 2020

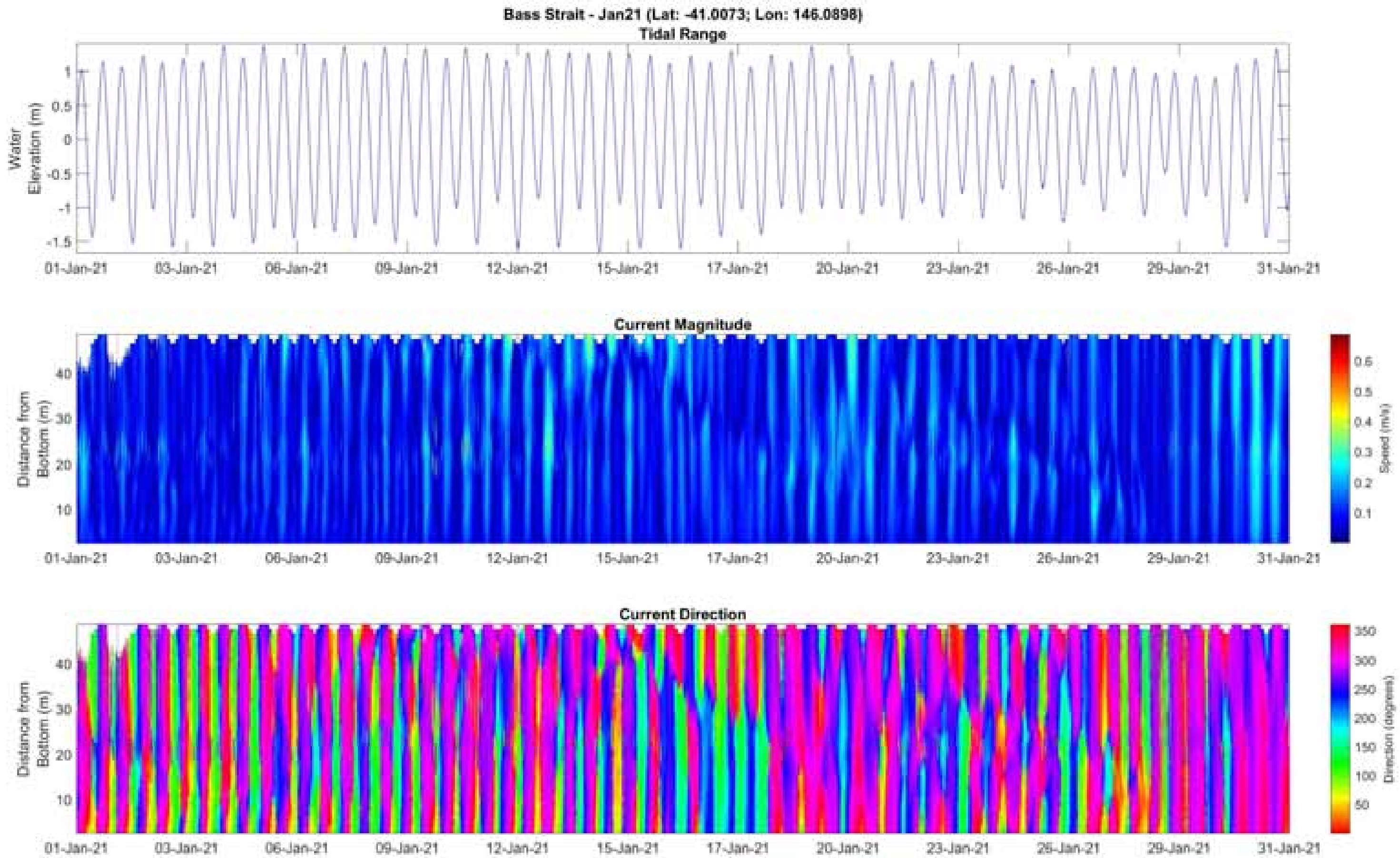

Figure 25: Water elevation, current speed and current direction measurements in January 2021

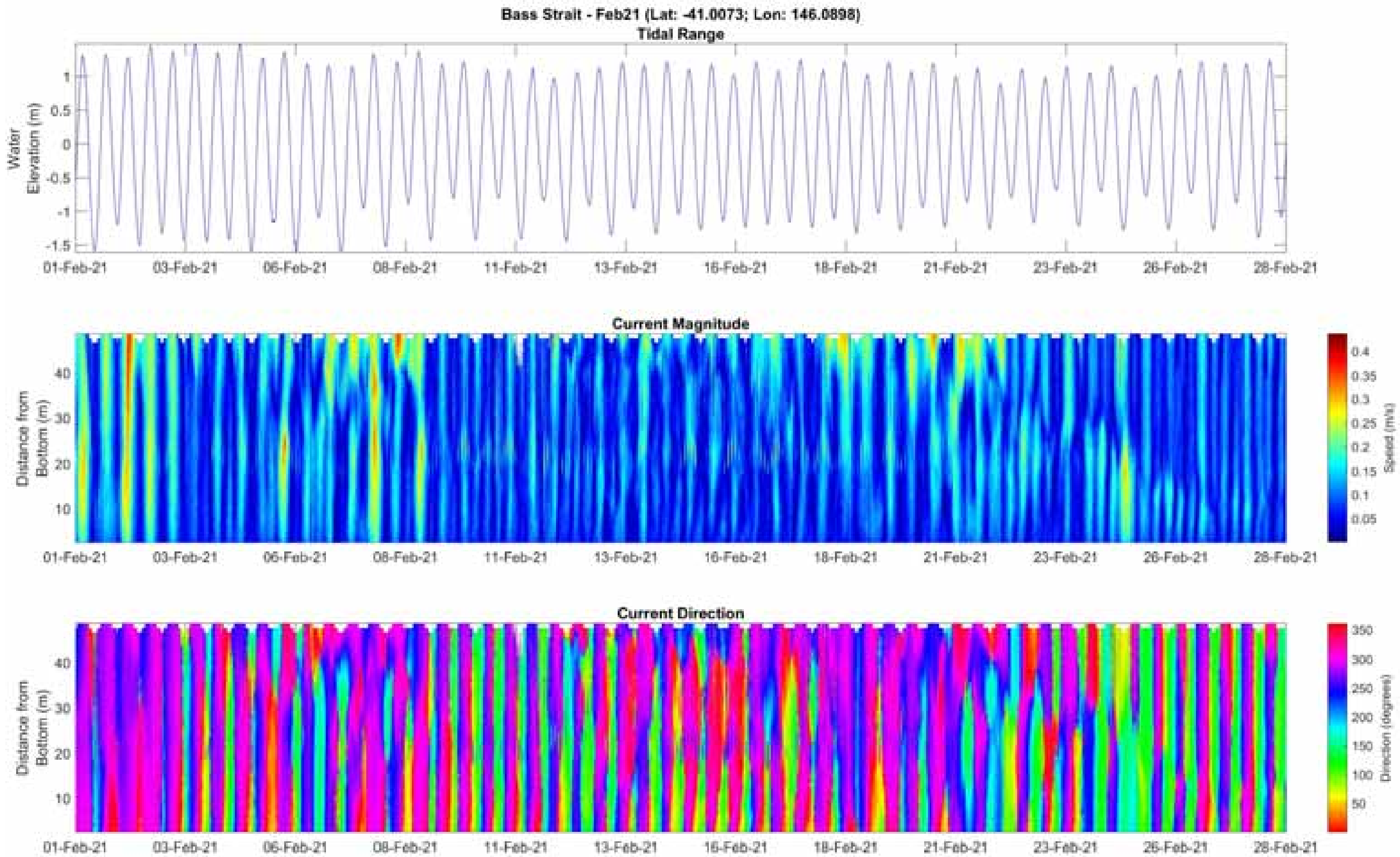

Figure 26: Water elevation, current speed and current direction measurements in February 2021

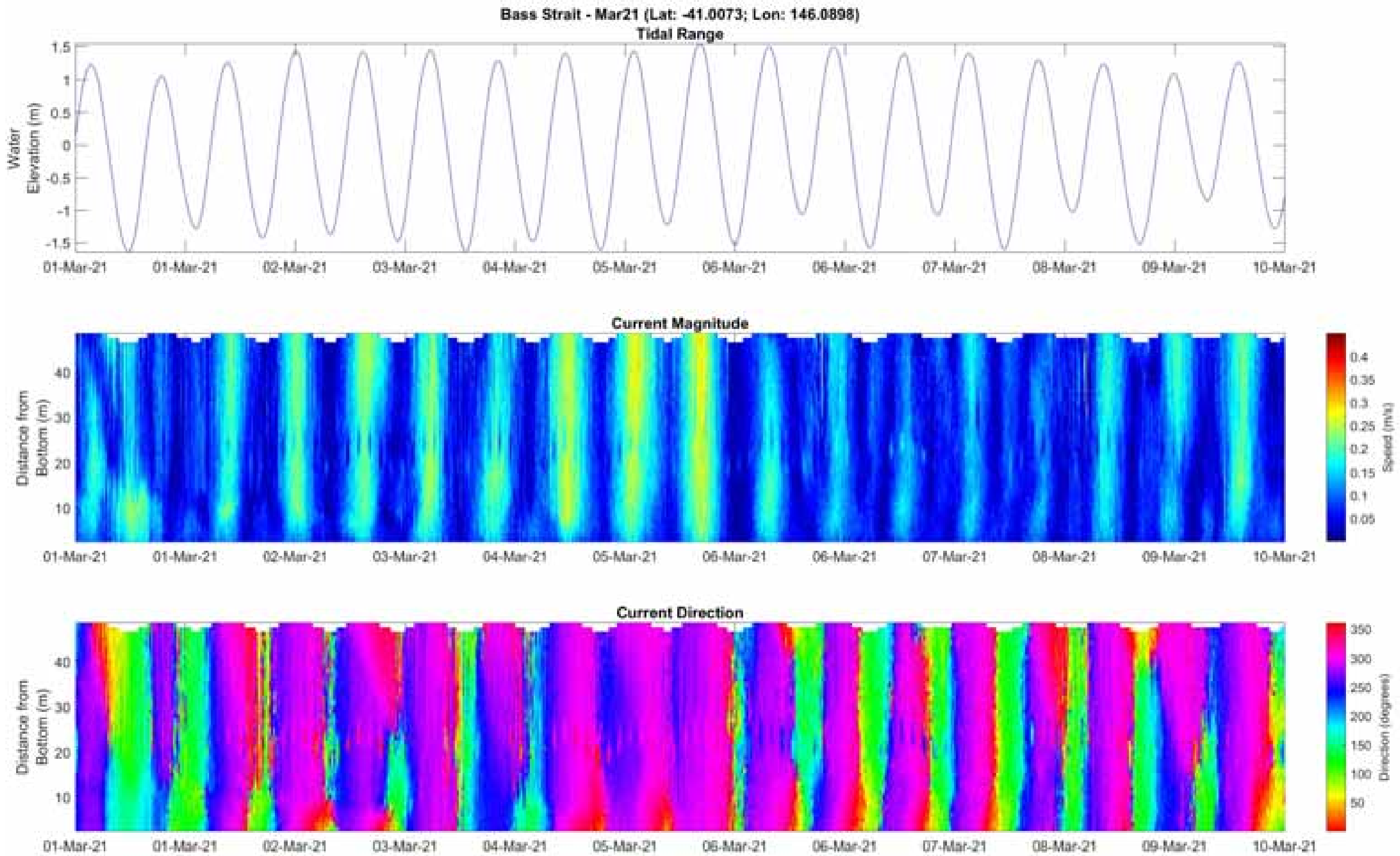

Figure 27: Water elevation, current speed and current direction measurements in March 2021

3.5.2. Deployment Two: March 2021 to May 2021

Tidal range, current magnitude and current direction

Tidal height, current speed, direction statistics and figures are shown in Table 9 and depicted in Figure 28 to Figure 31 for the entire deployment and for each month respectively.

Table 9: Statistical parameters from ADCP results for Deployment Two (* denoted not complete month dataset)

Location	Statistics	All	*Mar-20	April-21	*May-21
Depth Averaged	Mean	0.09	0.09	0.10	0.08
	Max	0.31	0.31	0.31	0.24
	90th Percentile	0.15	0.15	0.16	0.13
	Direction Ebb / Flood	83 / 290	92 // 308	84 / 274	63 / 300
Bottom Water Column 10.5 m	Mean	0.09	0.09	0.10	0.09
	Max	0.54	0.54	0.32	0.27
	90th Percentile	0.17	0.15	0.18	0.17
Middle Water Column 25.5 m	Mean	0.09	0.09	0.10	0.09
	Max	0.54	0.54	0.32	0.27
	90th Percentile	0.17	0.15	0.18	0.17
Top Water Column 45.5 m	Mean	0.10	0.11	0.10	0.08
	Max	0.41	0.41	0.34	0.25
	90th Percentile	0.18	0.19	0.19	0.14

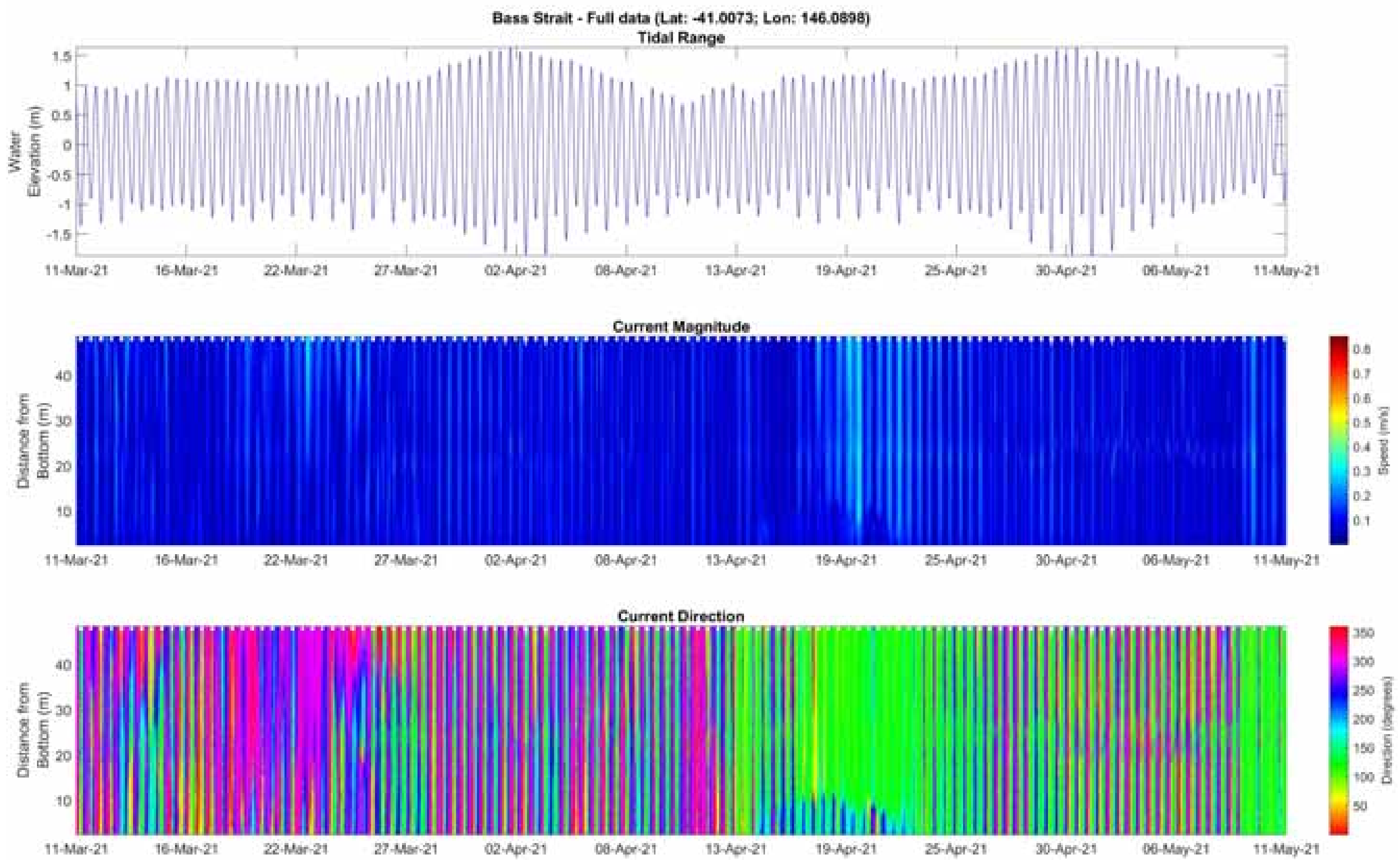

Figure 28: Water elevation, current speed and current direction measurements taken from 11 March 2021 to 11 May 2021

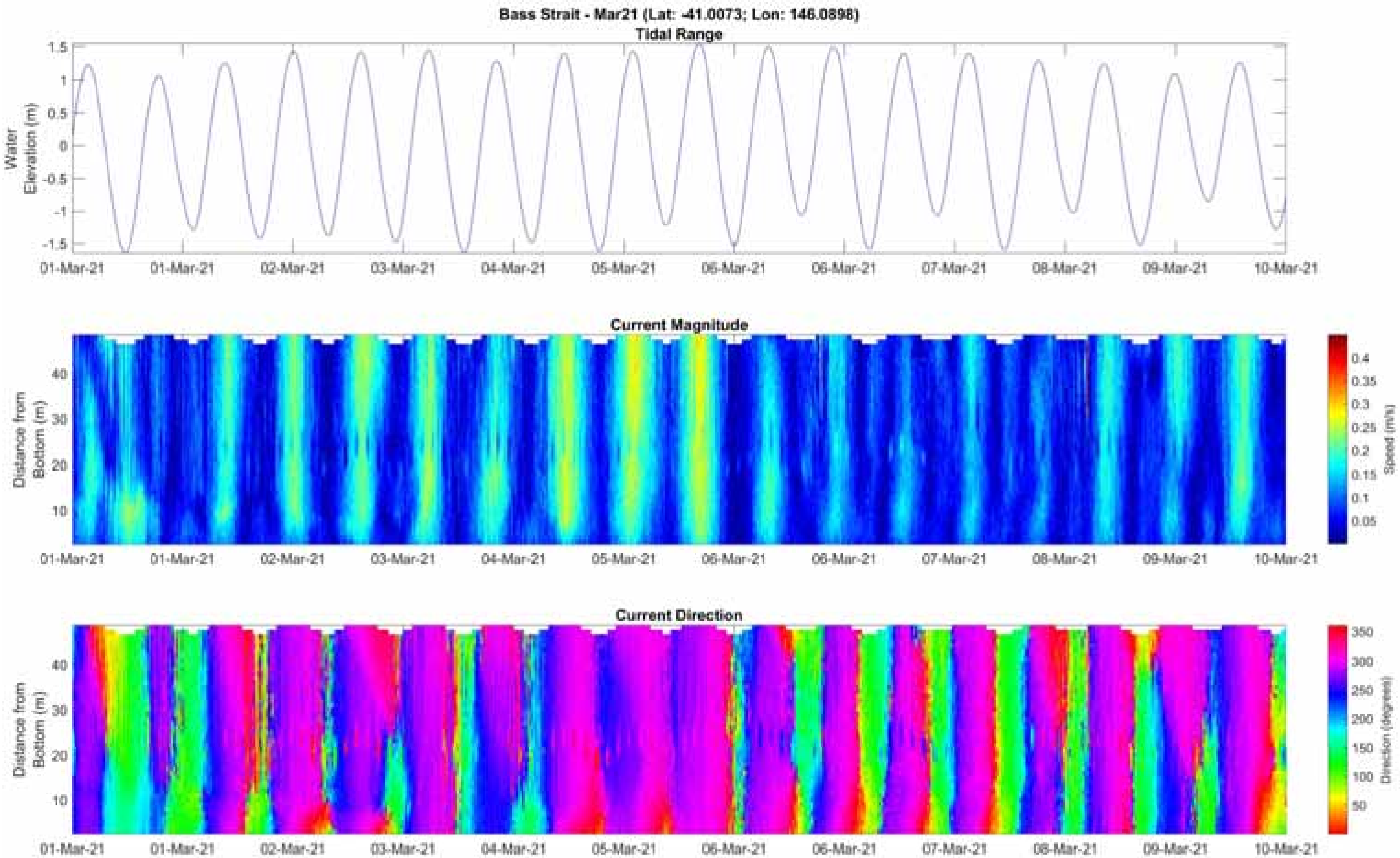

Figure 29: Water elevation, current speed and current direction measurements in March 2021

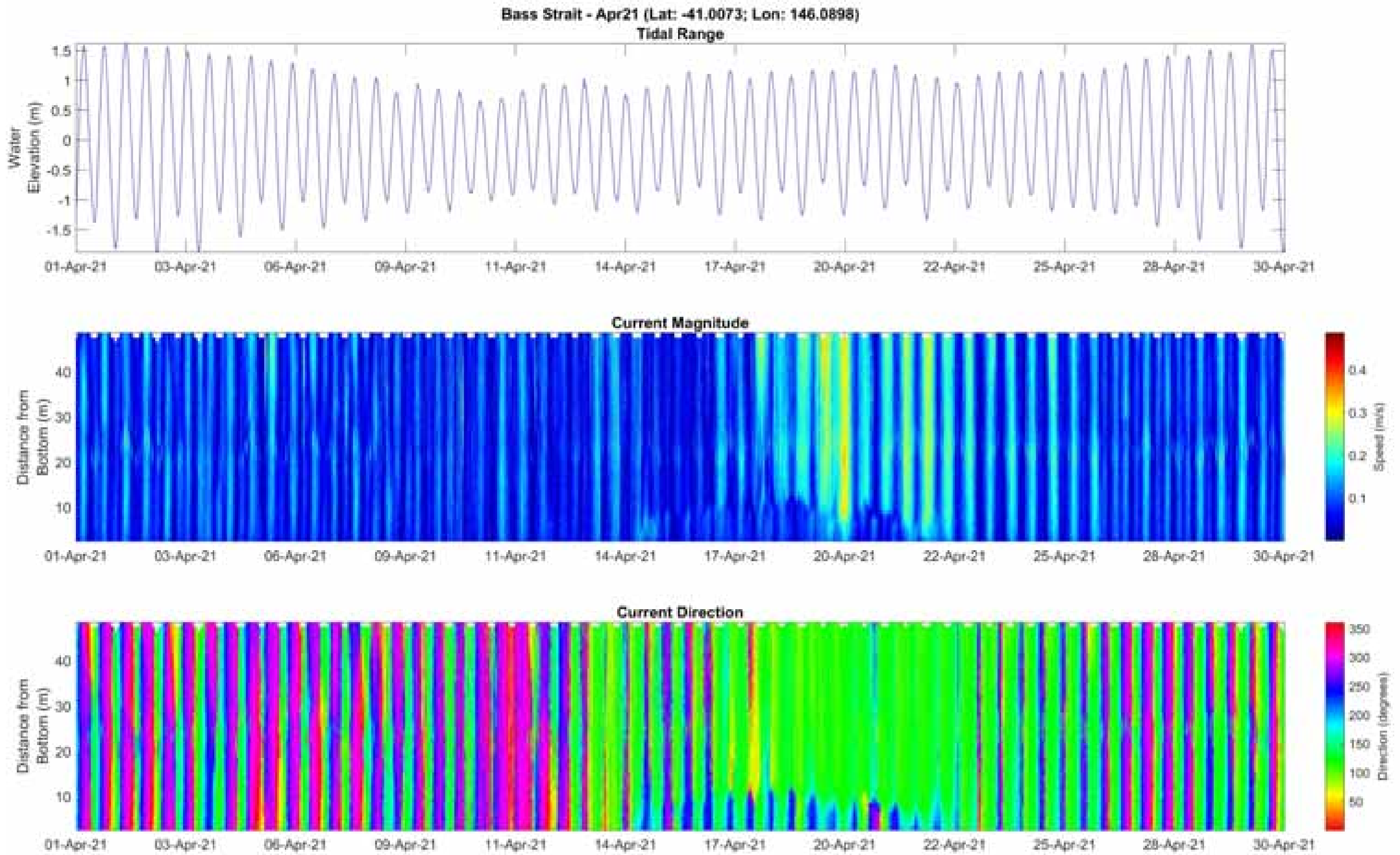

Figure 30" Water elevation, current speed and current direction measurements in April 2021

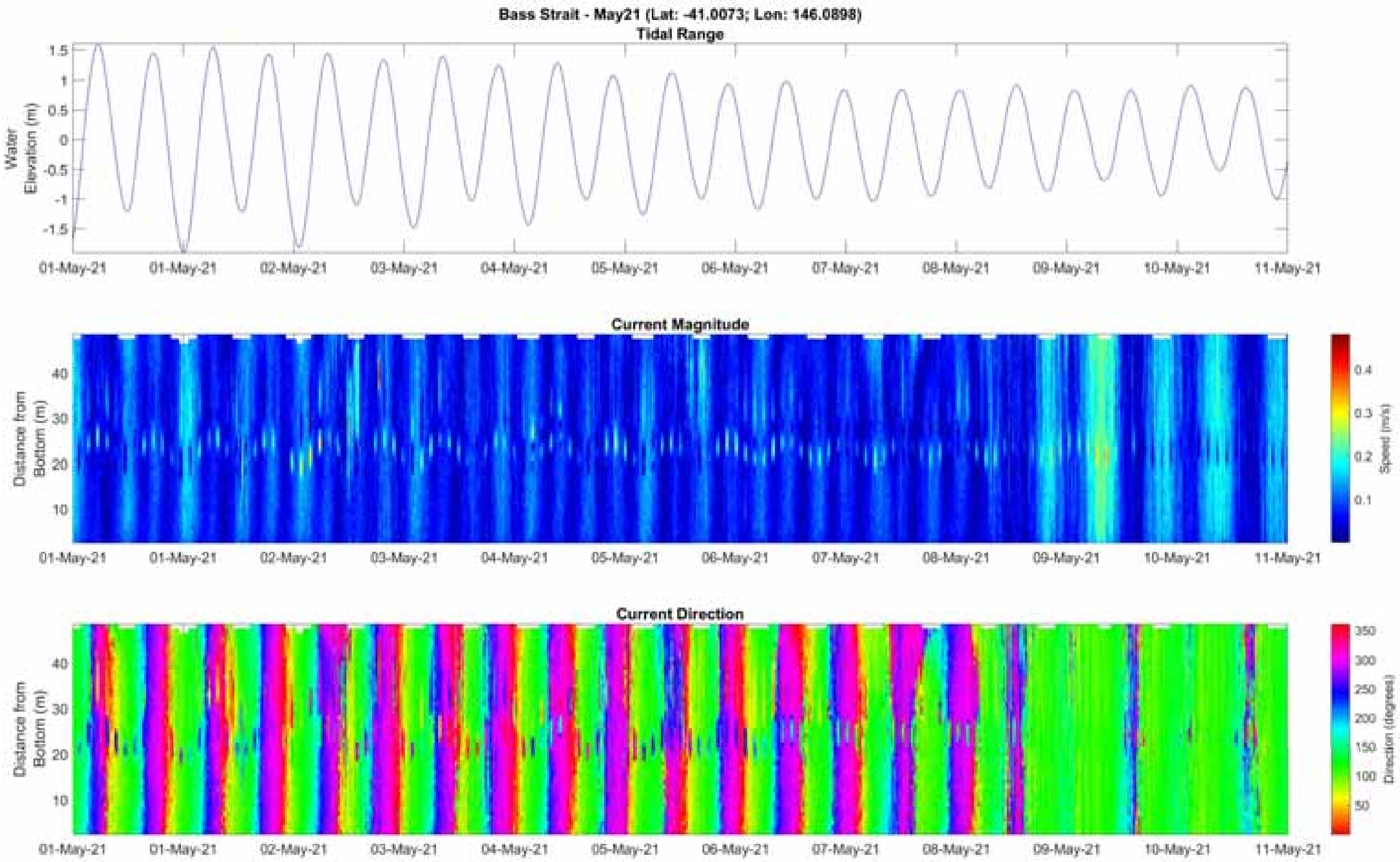

Figure 31: Water elevation, current speed and current direction measurements in May 2021

3.5.3. Deployment Three: May 2021 to August 2021

Tidal range, current magnitude and current direction

Tidal height, current speed, direction statistics and figures are shown in Table 10 and depicted in Figure 32 to Figure 36 for the entire deployment and for each month respectively.

Table 10: Statistical parameters from ADCP results for Deployment Three (* denotes incomplete month)

Location	Statistics	All	*May-21	Jun-21	July-21	*Aug-21
Depth Averaged	Mean	0.08	0.09	0.08	0.08	0.07
	Max	0.26	0.26	0.23	0.23	0.11
	90th Percentile	0.13	0.16	0.13	0.13	0.10
	Direction Ebb / Flood	73 / 301	59 / 288	74 / 307	79 / 298	111 / 273
Bottom Water Column 10.5 m	Mean	0.08	0.09	0.08	0.09	0.07
	Max	0.43	0.26	0.29	0.43	0.14
	90th Percentile	0.14	0.16	0.14	0.14	0.12
Middle Water Column 25.5 m	Mean	0.08	0.09	0.08	0.08	0.07
	Max	0.43	0.26	0.29	0.43	0.14
	90th Percentile	0.14	0.16	0.14	0.14	0.12
Top Water Column 45.5 m	Mean	0.09	0.10	0.08	0.10	0.08
	Max	0.38	0.34	0.33	0.38	0.19
	90th Percentile	0.16	0.18	0.15	0.16	0.13

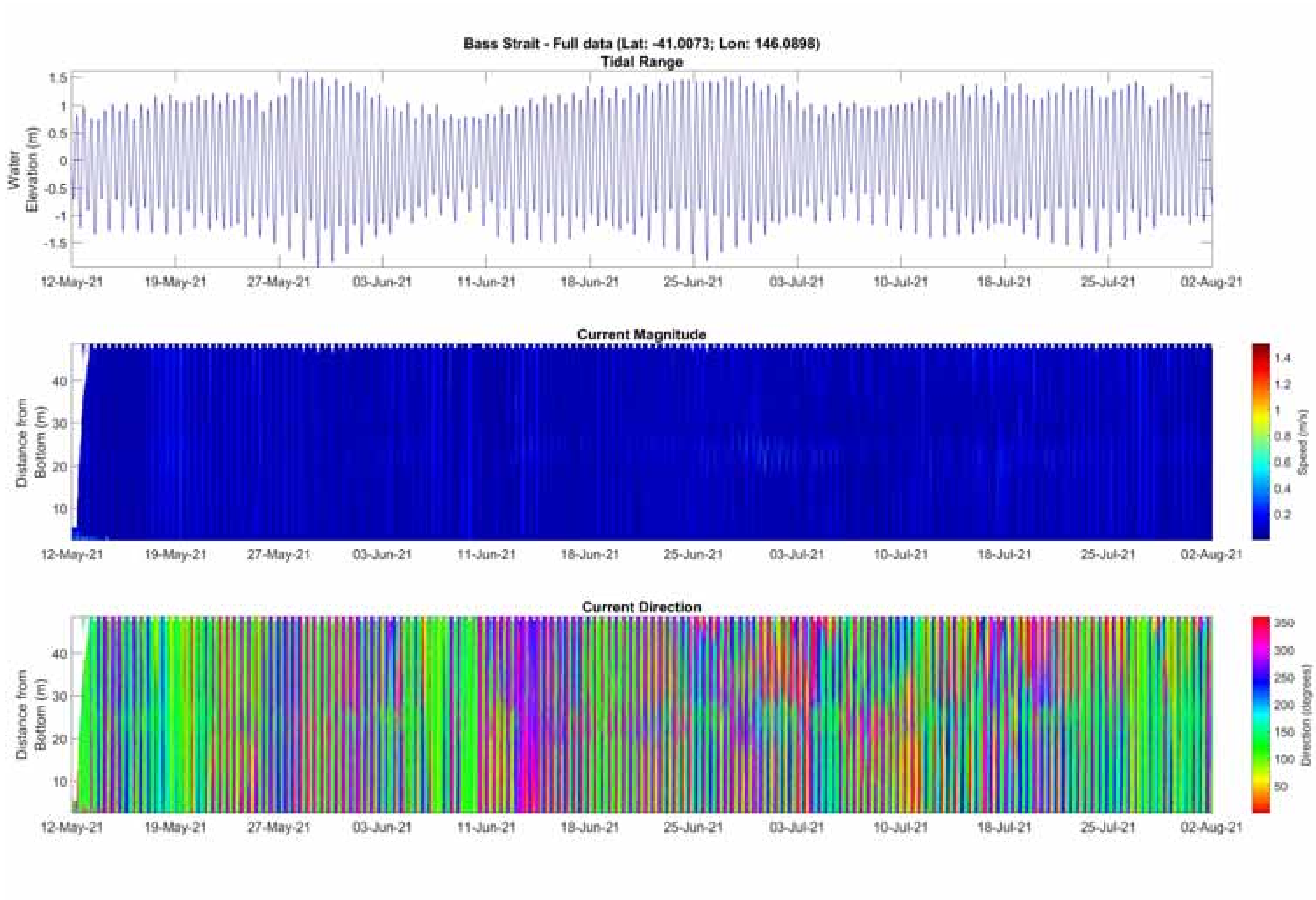

Figure 32: Water elevation, current speed and current direction measurements taken from 12 May 2021 to 02 August 2021

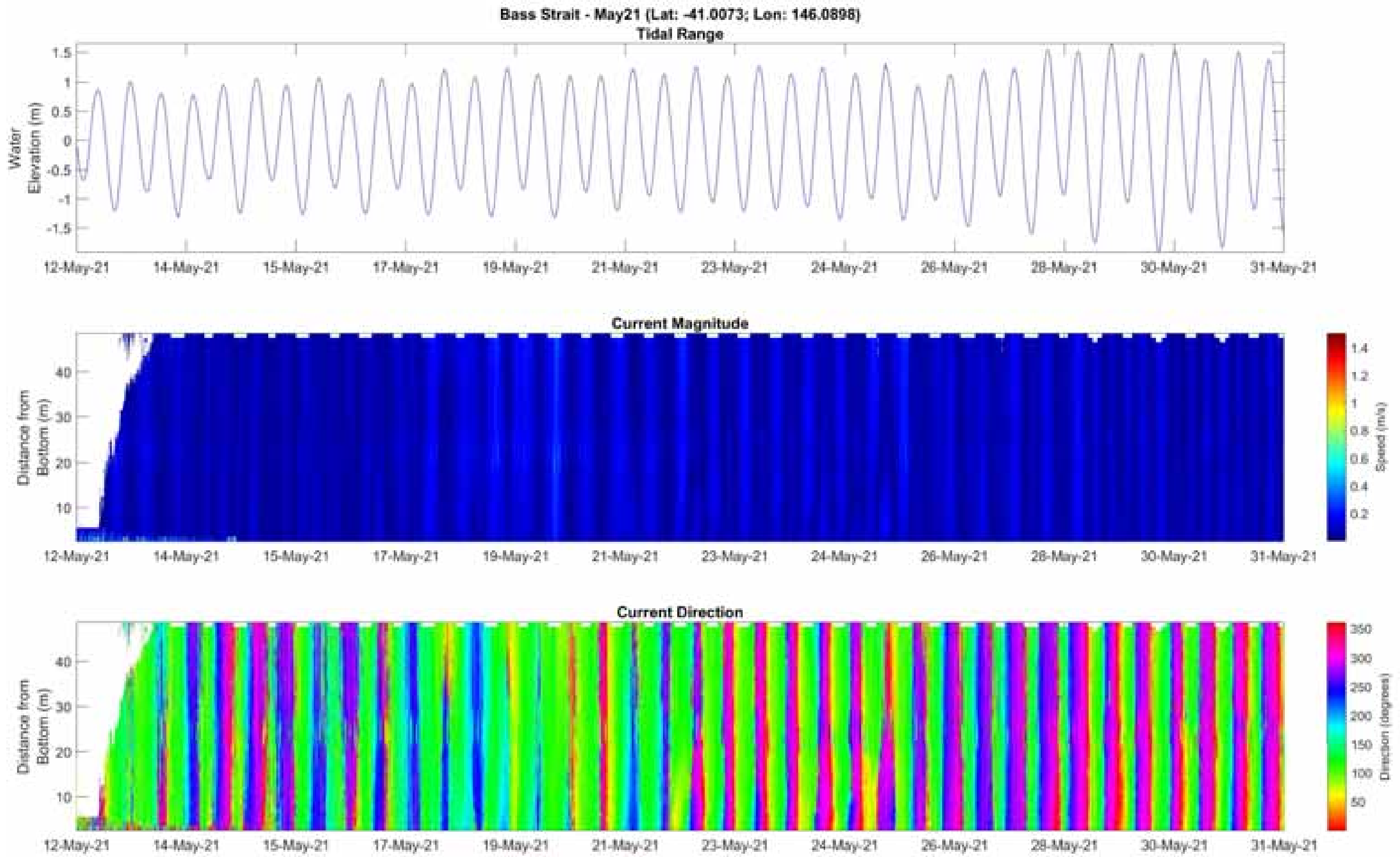

Figure 33: Water elevation, current speed and current direction measurements in May 2021

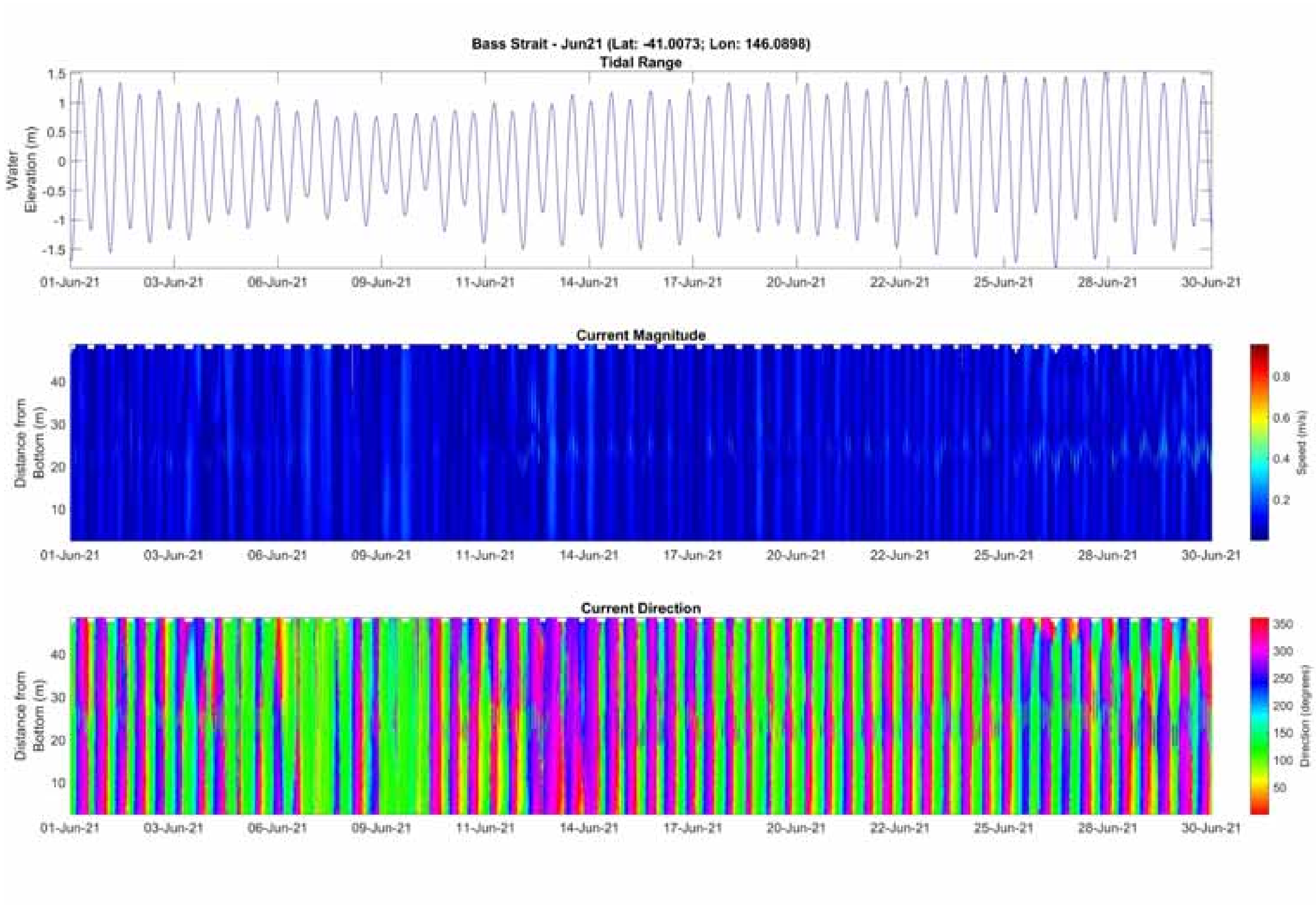

Figure 34: Water elevation, current speed and current direction measurements in June 2021

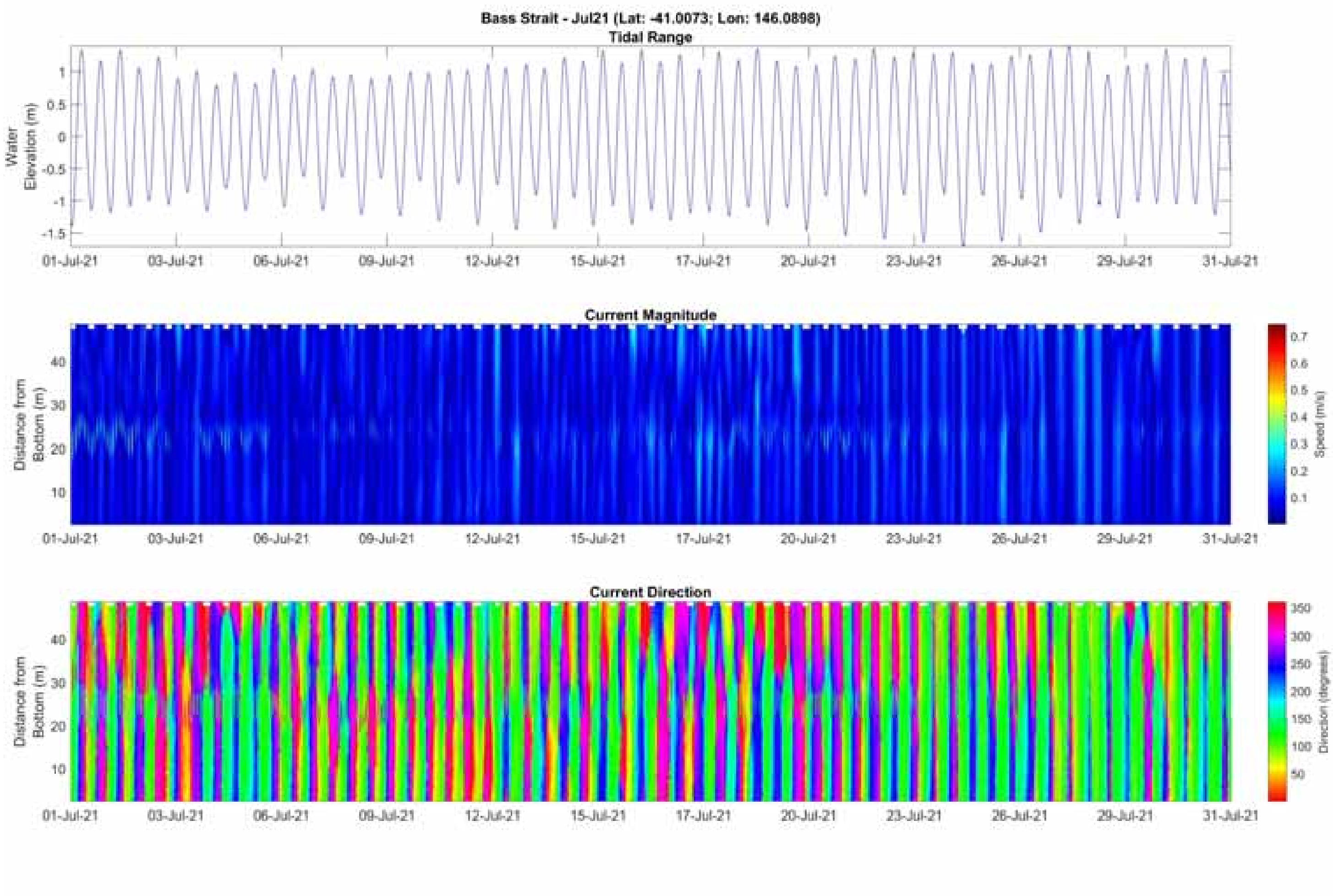

Figure 35: Water elevation, current speed and current direction measurements in July 2021

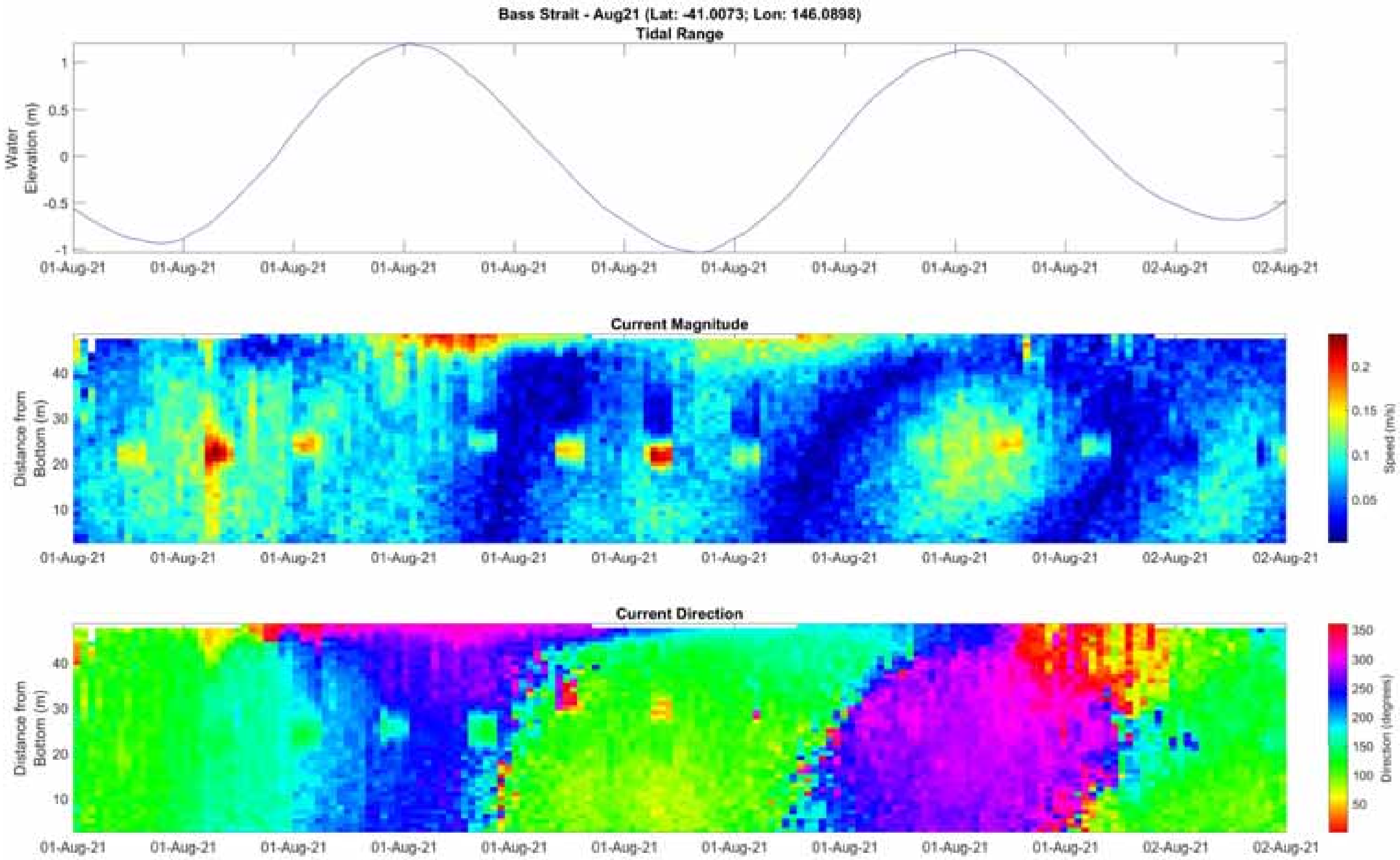

Figure 36: Water elevation, current speed and current direction measurements in August 2021

3.5.4. Deployment Four: August 2021 to November 2021

Tidal range, current magnitude and current direction

Tidal height, current speed, direction statistics and figures are shown in Table 11 and depicted in Figure 37 to Figure 41 for the entire deployment and for each month respectively.

Table 11: Statistical parameters from ADCP results for Deployment Four (* denotes incomplete month)

Location	Statistics	All	*Aug-21	Sep-21	Oct-21	*Nov-21
Depth Averaged	Mean	0.09	0.08	0.09	0.10	0.11
	Max	0.28	0.21	0.27	0.28	0.23
	90th Percentile	0.15	0.14	0.13	0.15	0.16
	Direction Ebb / Flood	95 / 294	76 / 271	75 / 296	106 / 295	110 / 287
Bottom Water Column 10.5 m	Mean	0.09	0.08	0.08	0.09	0.11
	Max	0.35	0.23	0.26	0.35	0.31
	90th Percentile	0.16	0.15	0.14	0.16	0.19
Middle Water Column 25.5 m	Mean	0.09	0.09	0.08	0.09	0.11
	Max	0.35	0.23	0.26	0.35	0.31
	90th Percentile	0.16	0.15	0.14	0.16	0.19
Top Water Column 45.5 m	Mean	0.11	0.09	0.10	0.12	0.13
	Max	0.54	0.36	0.54	0.52	0.49
	90th Percentile	0.20	0.19	0.17	0.21	0.22

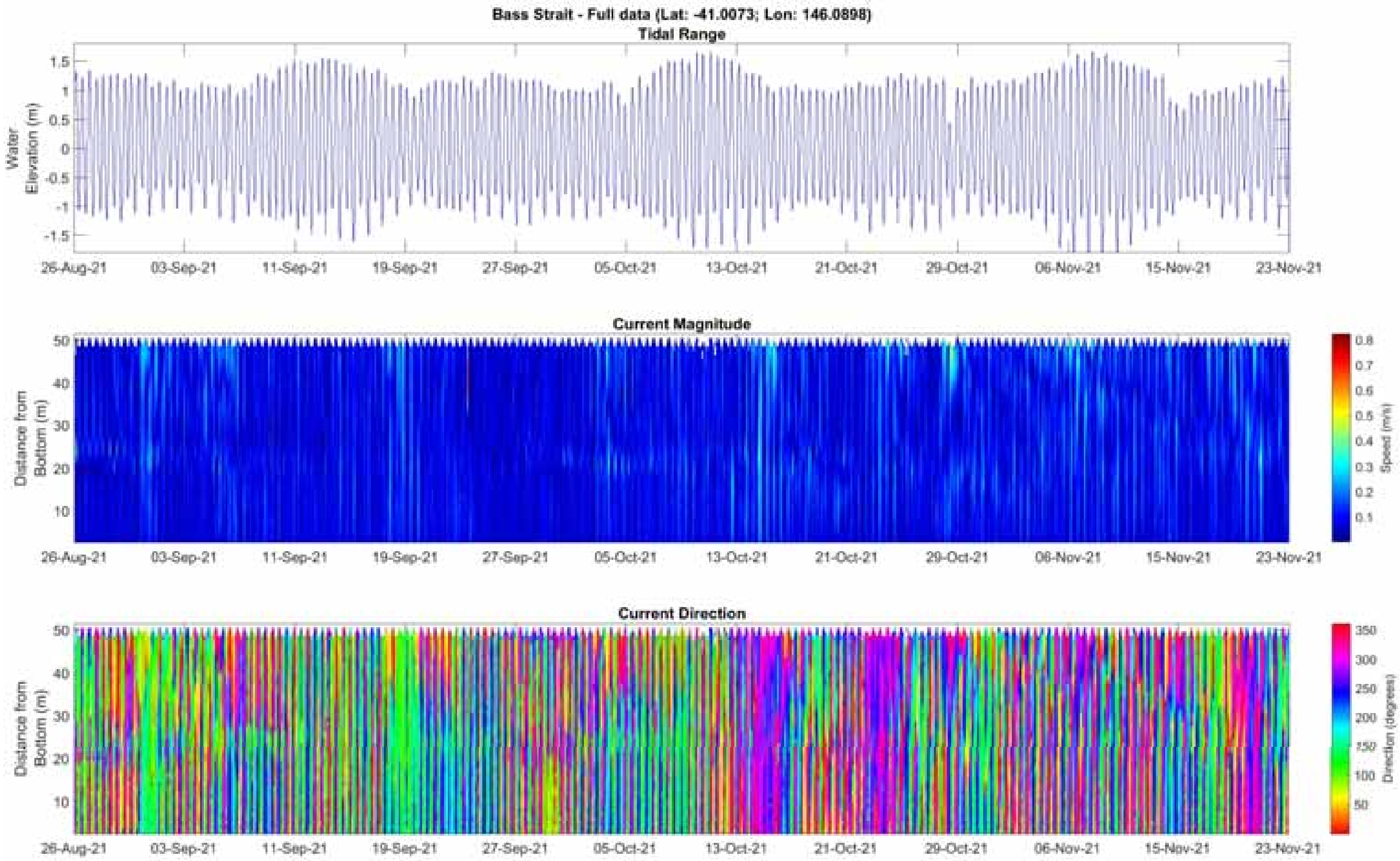

Figure 37: Water elevation, current speed and current direction measurements taken from 26 August 2021 to 23 November 2021

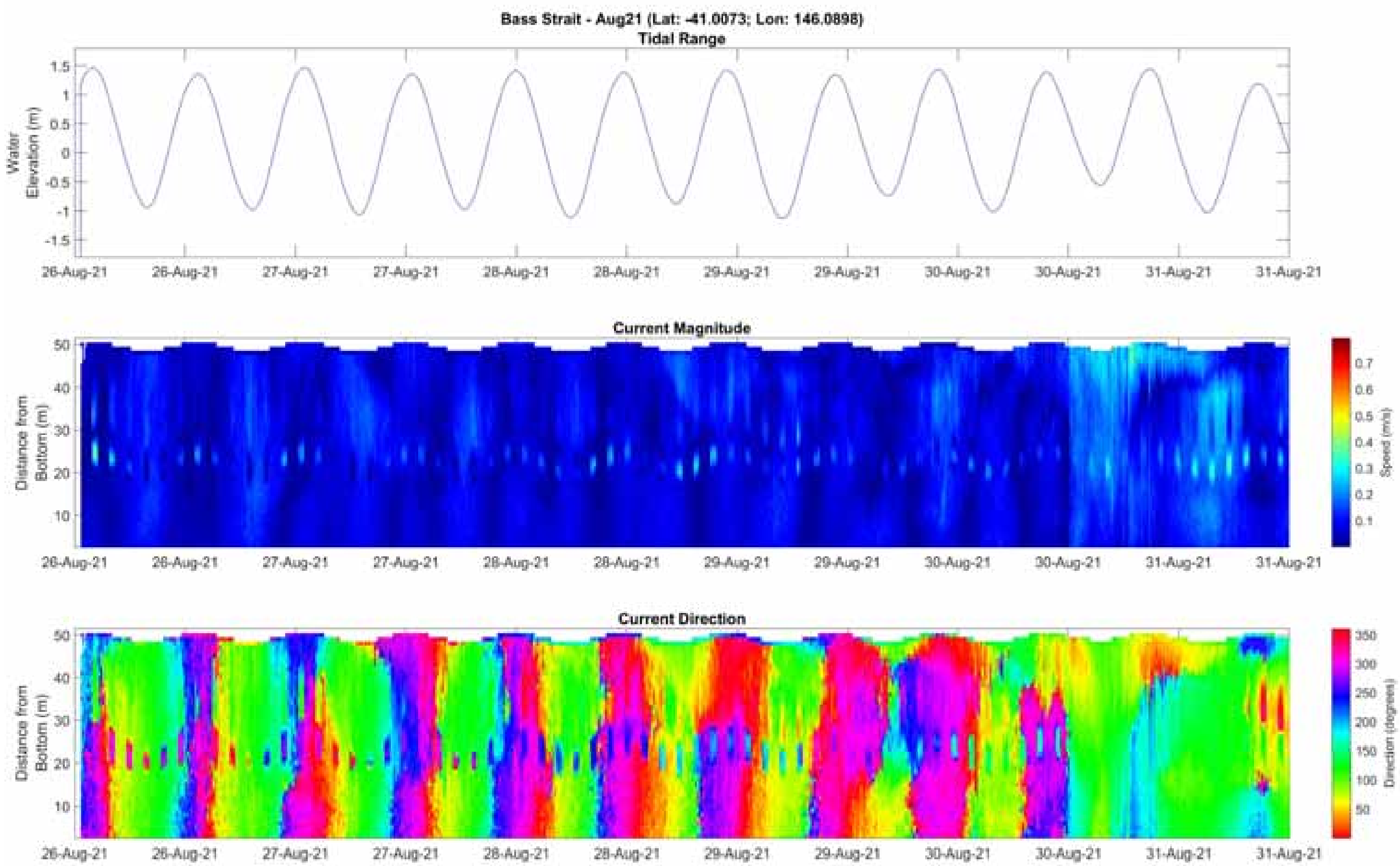

Figure 38: Water elevation, current speed and current direction measurements in August 2021

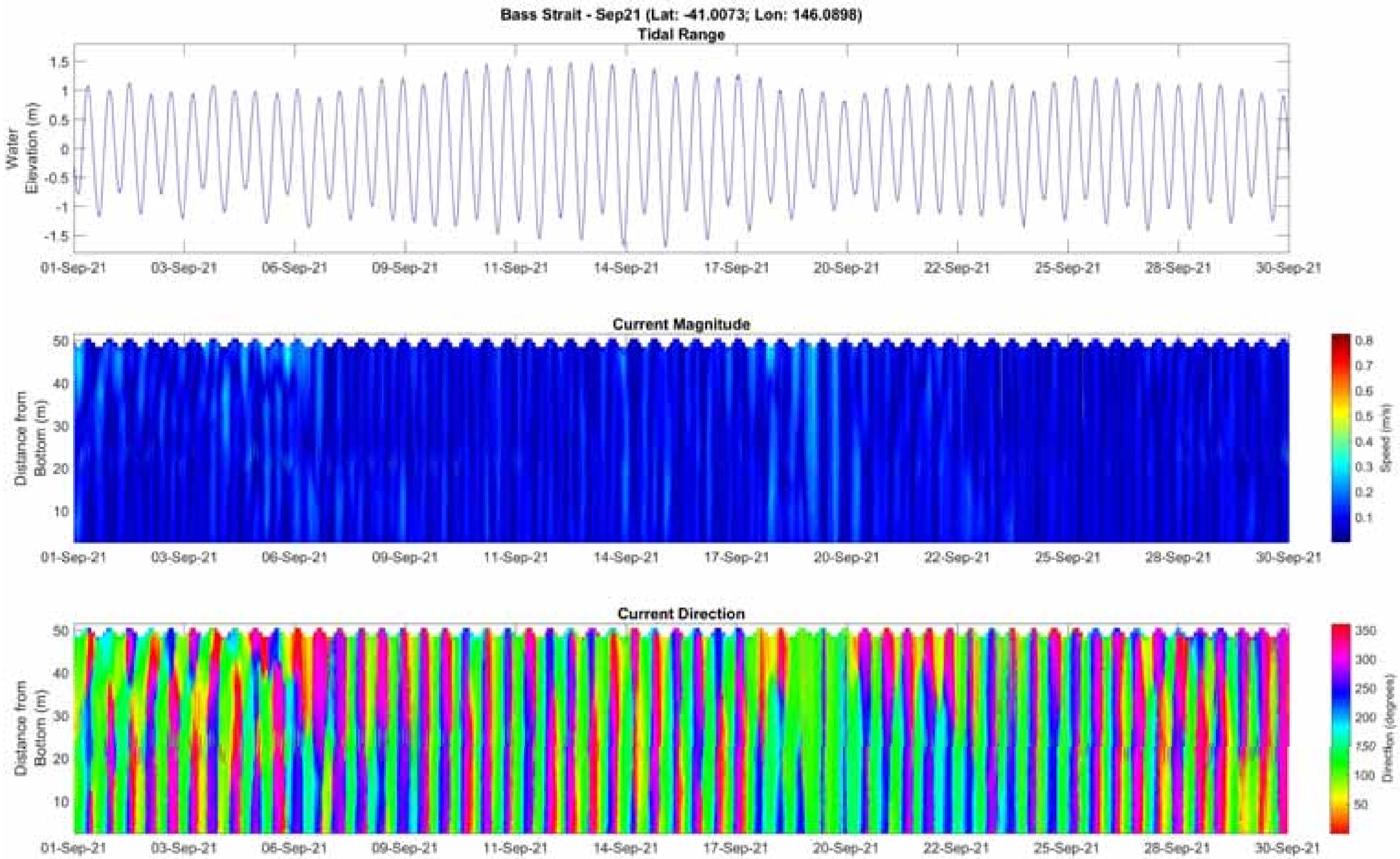

Figure 39: Water elevation, current speed and current direction measurements in September 2021

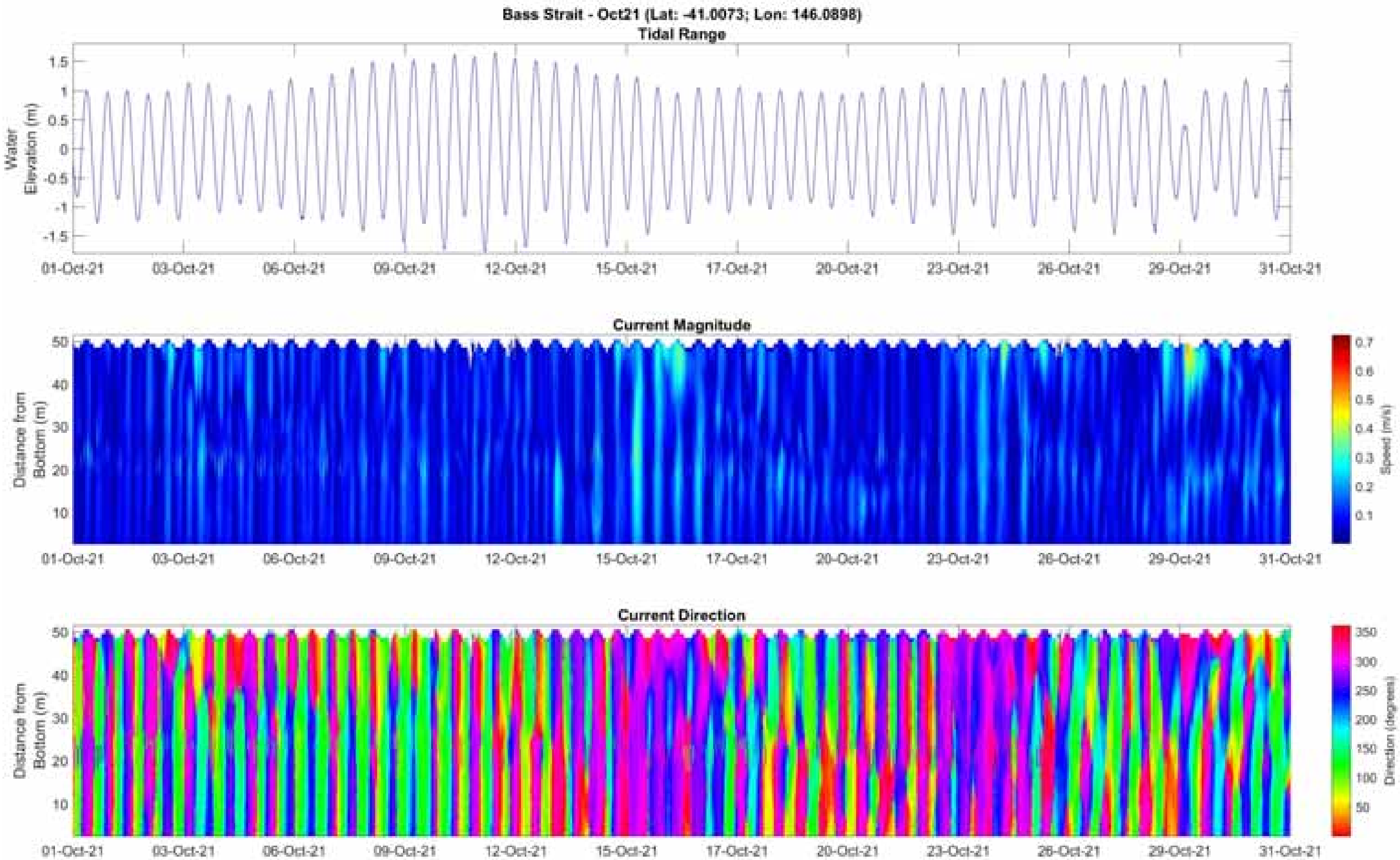

Figure 40: Water elevation, current speed and current direction measurements in October 2021

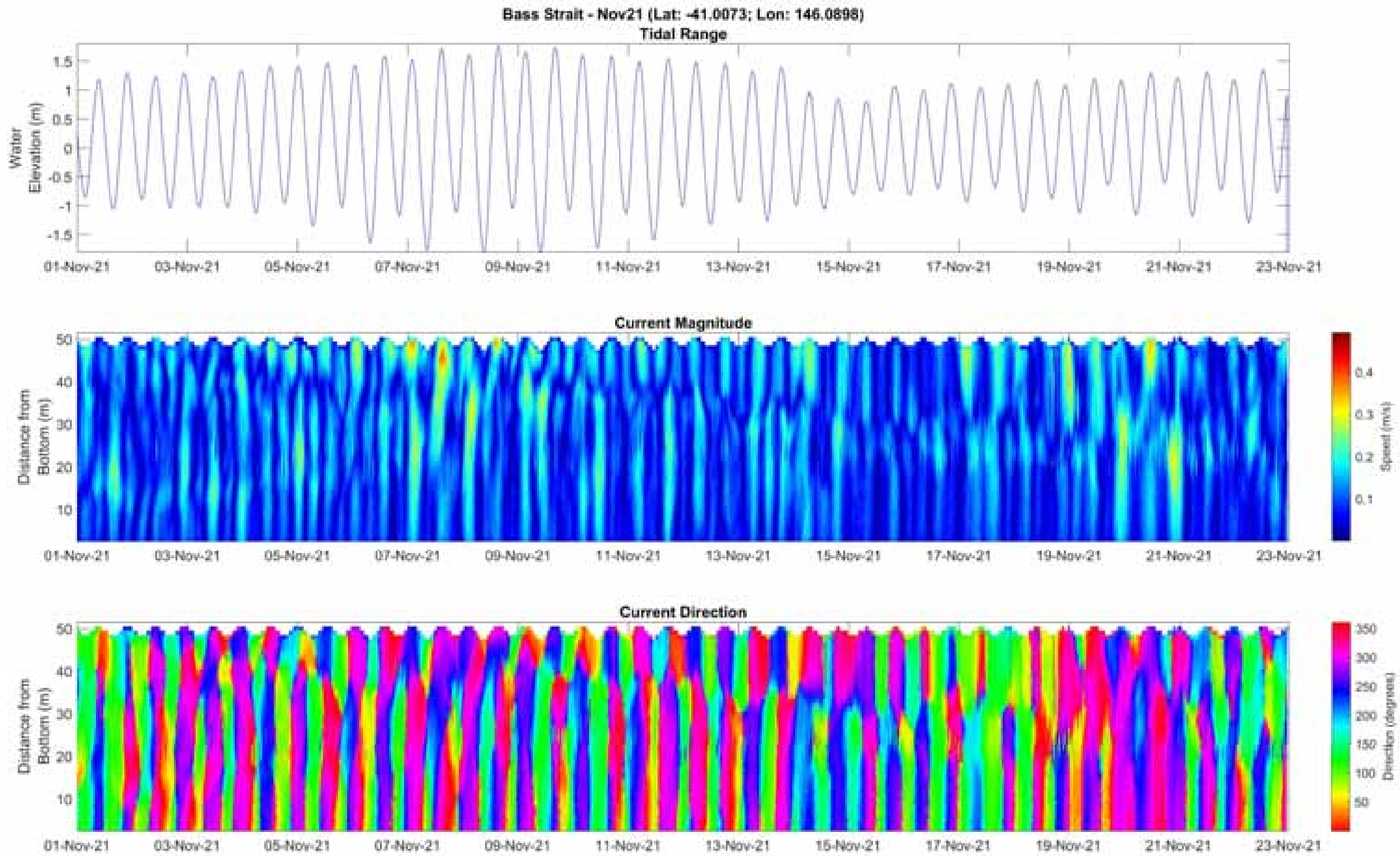

Figure 41: Water elevation, current speed and current direction measurements in November 2021

3.5.5. Deployment Five: November 2021 to April 2022

Tidal range, current magnitude and current direction

Tidal height, current speed, direction statistics and figures are shown in Table 12 and depicted in Figure 42 to Figure 46 for the entire deployment and for each month respectively.

Table 12: Statistical parameters from ADCP results for Deployment Five (* denotes incomplete month)

Location	Statistics	All	*Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	*Apr-22
Depth Averaged	**Mean**	0.09	0.09	0.11	0.11	0.09	0.08	0.08
	Max	0.31	0.15	0.30	0.31	0.26	0.23	0.24
	90th Percentile	0.16	0.13	0.18	0.18	0.15	0.13	0.14
	Direction Ebb / Flood	91 / 306	86 / 295	107 / 297	117 / 307	84 / 304	74 / 311	68 / 308
Bottom Water Column 10.5 m	**Mean**	0.09	0.08	0.12	0.11	0.09	0.08	0.08
	Max	0.39	0.20	0.38	0.39	0.29	0.32	0.25
	90th Percentile	0.17	0.14	0.20	0.19	0.15	0.14	0.15
Middle Water Column 25.5 m	**Mean**	0.09	0.08	0.12	0.11	0.09	0.08	0.08
	Max	0.39	0.20	0.38	0.39	0.29	0.32	0.25
	90th Percentile	0.17	0.14	0.20	0.19	0.15	0.14	0.15
Top Water Column 45.5 m	**Mean**	0.11	0.10	0.14	0.13	0.10	0.09	0.08
	Max	0.40	0.22	0.40	0.35	0.35	0.27	0.33
	90th Percentile	0.20	0.17	0.25	0.23	0.18	0.16	0.15

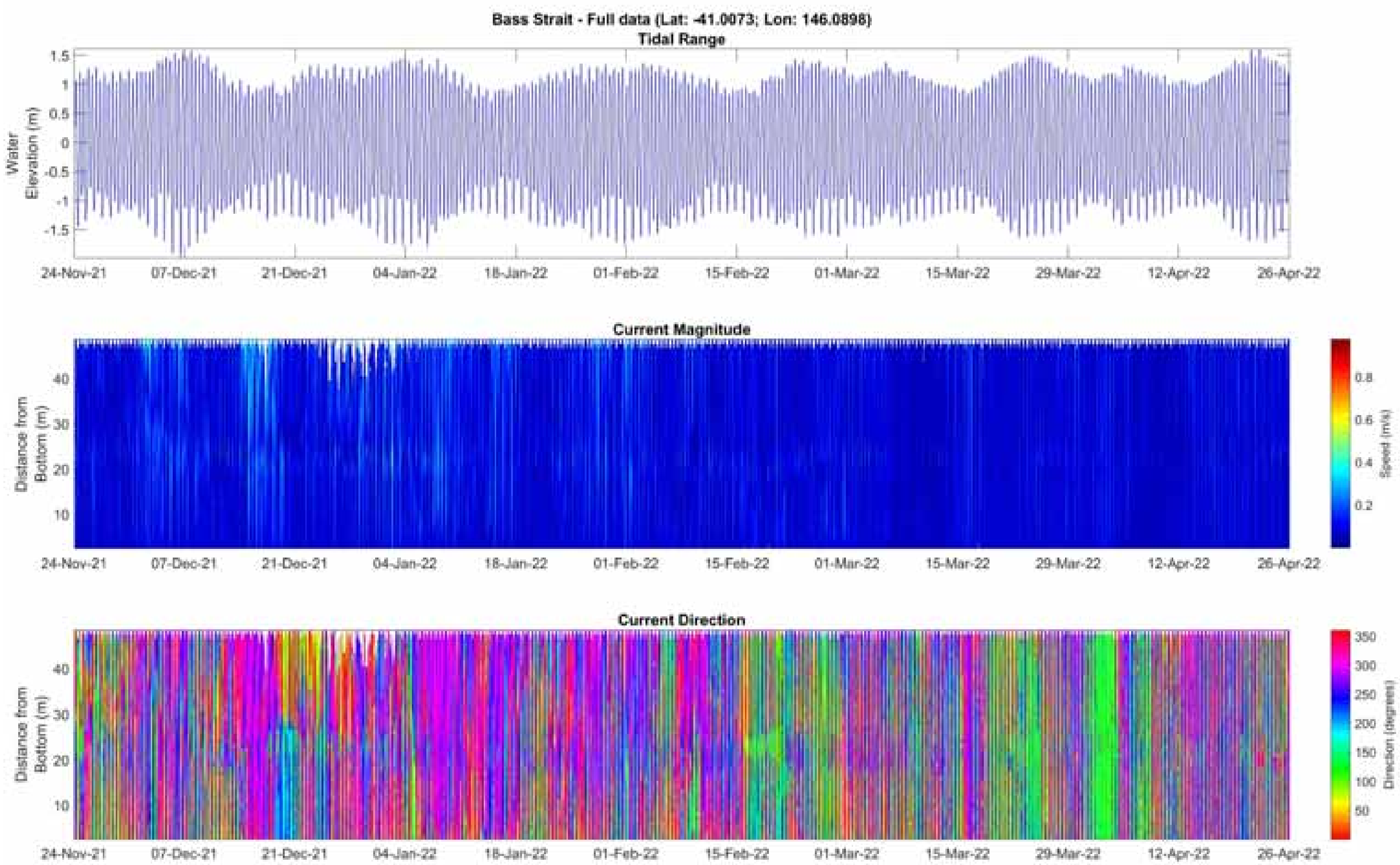

Figure 42: Water elevation, current speed and current direction measurements taken from 24 November 2021 to 26 April 2022

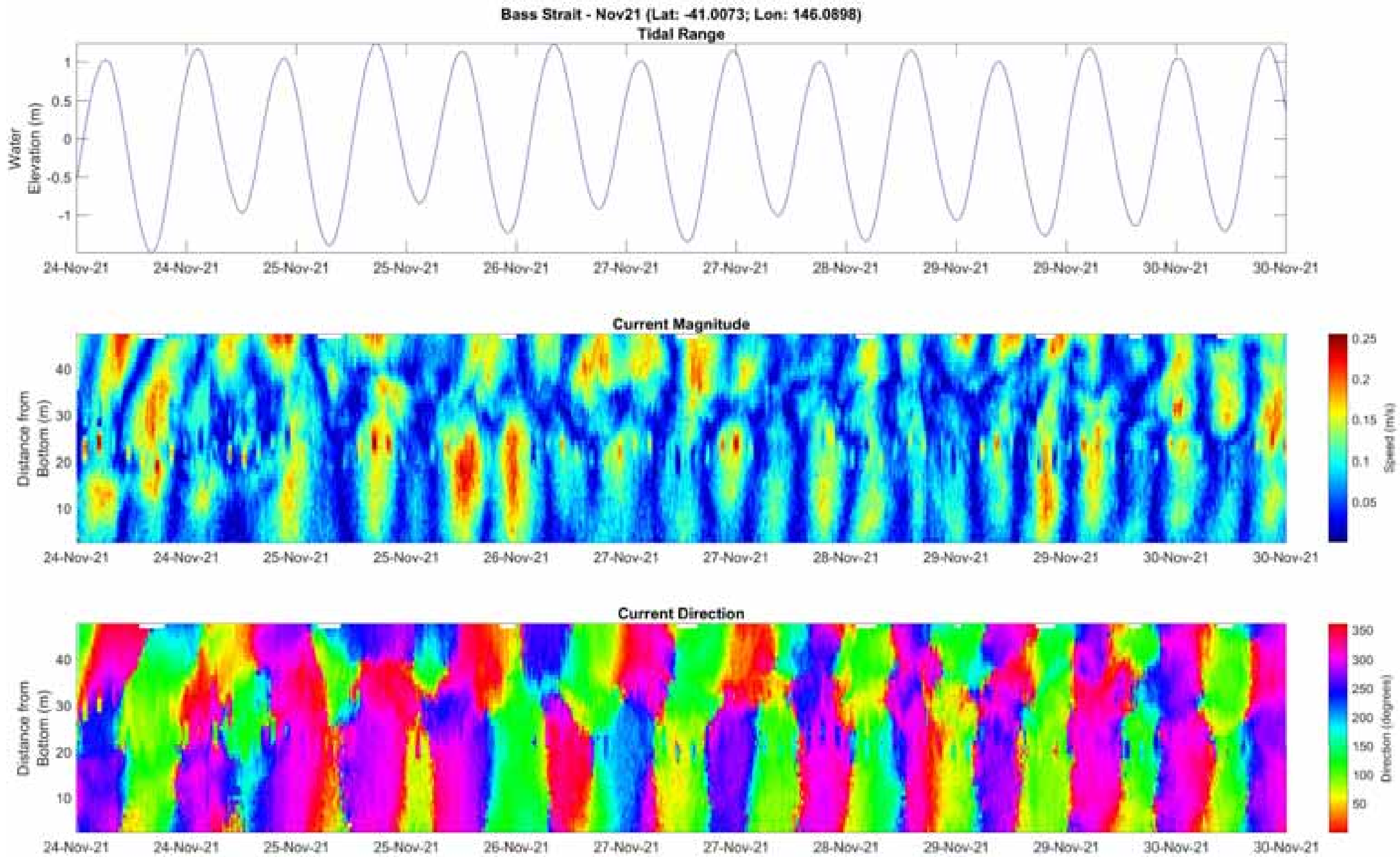

Figure 43: Water elevation, current speed and current direction measurements in November 2021

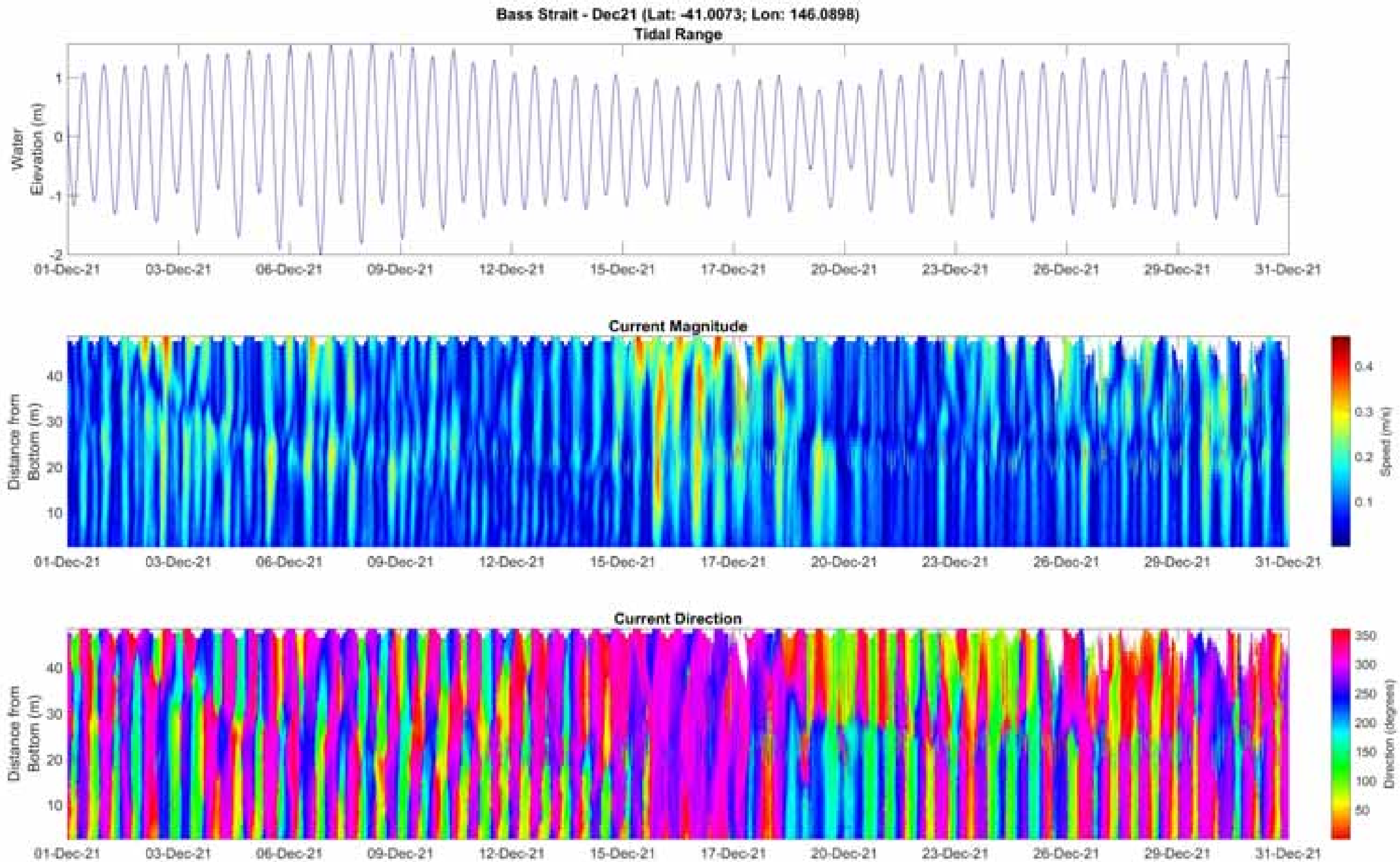

Figure 44: Water elevation, current speed and current direction measurements in December 2021

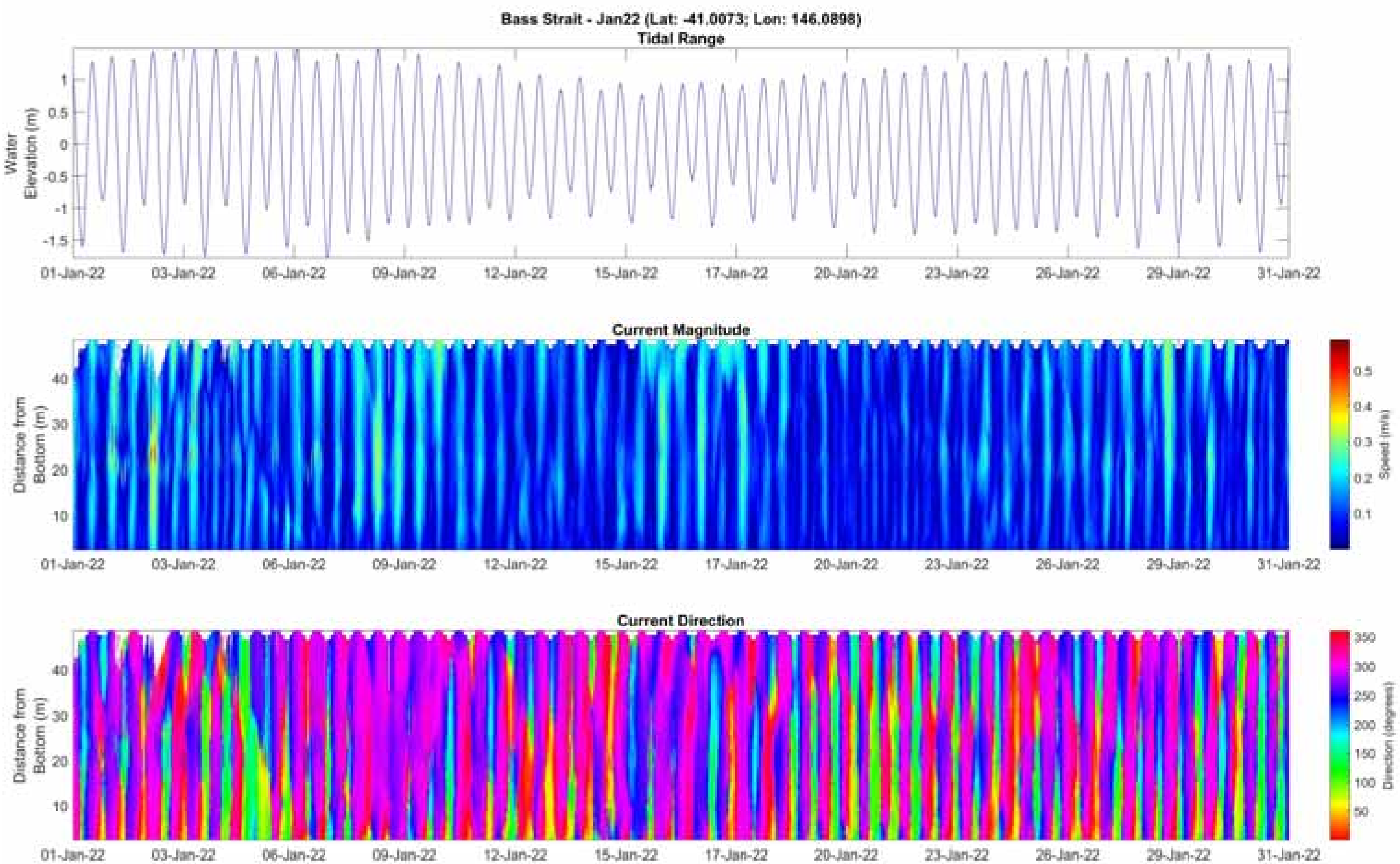

Figure 45: Water elevation, current speed and current direction measurements in January 2022

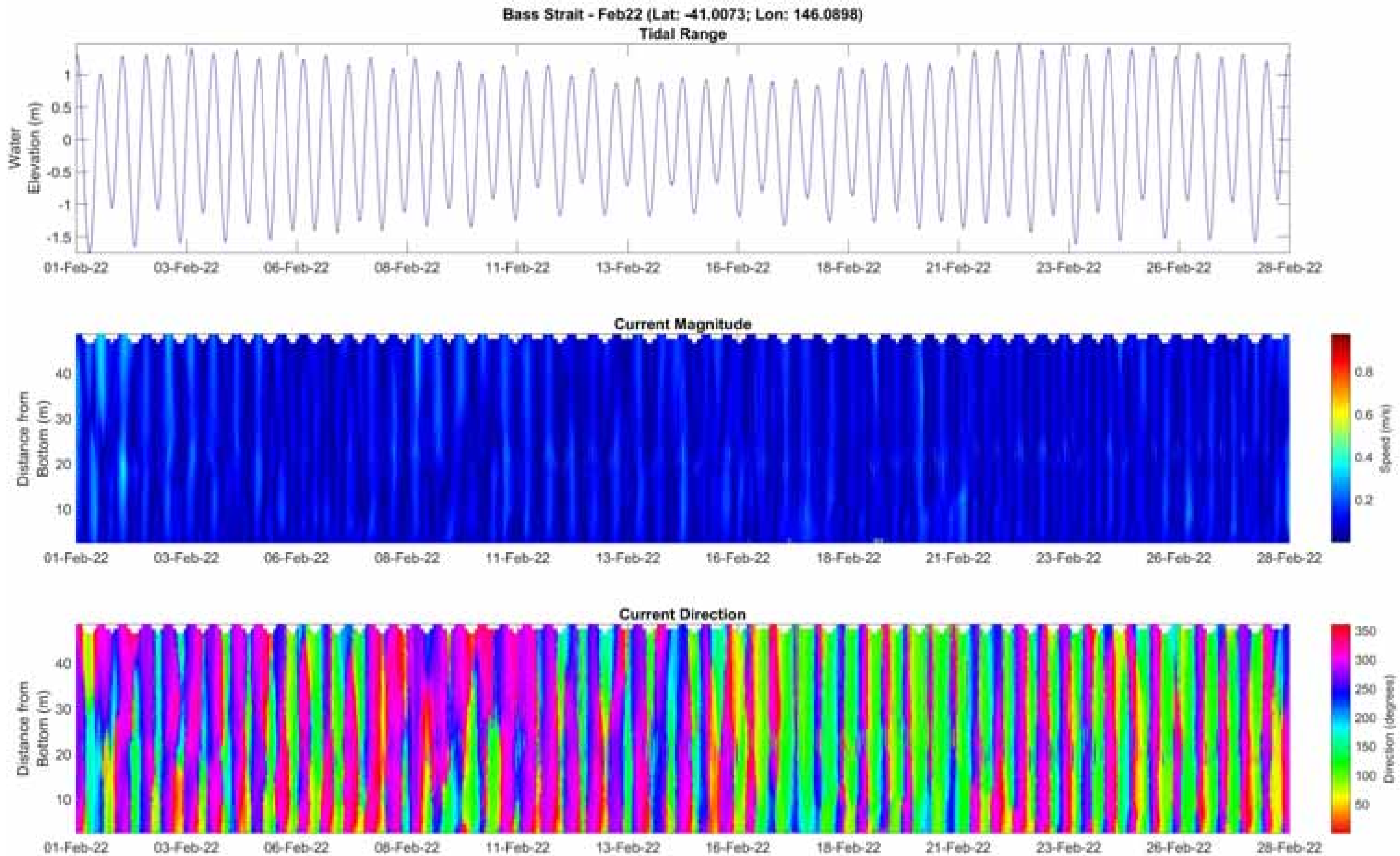

Figure 46: Water elevation, current speed and current direction measurements in February 2022

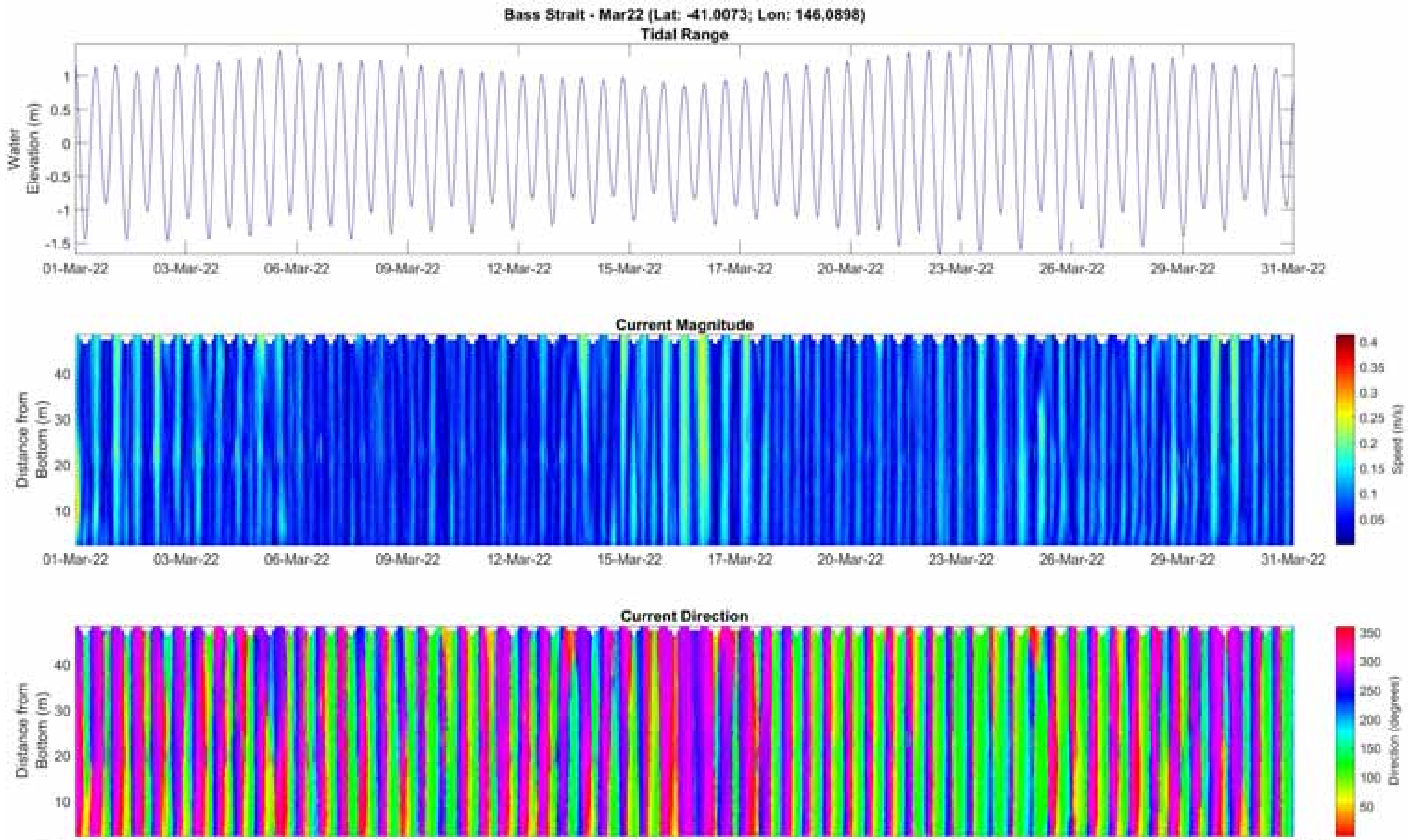

Figure 47: Water elevation, current speed and current direction measurements in March 2022

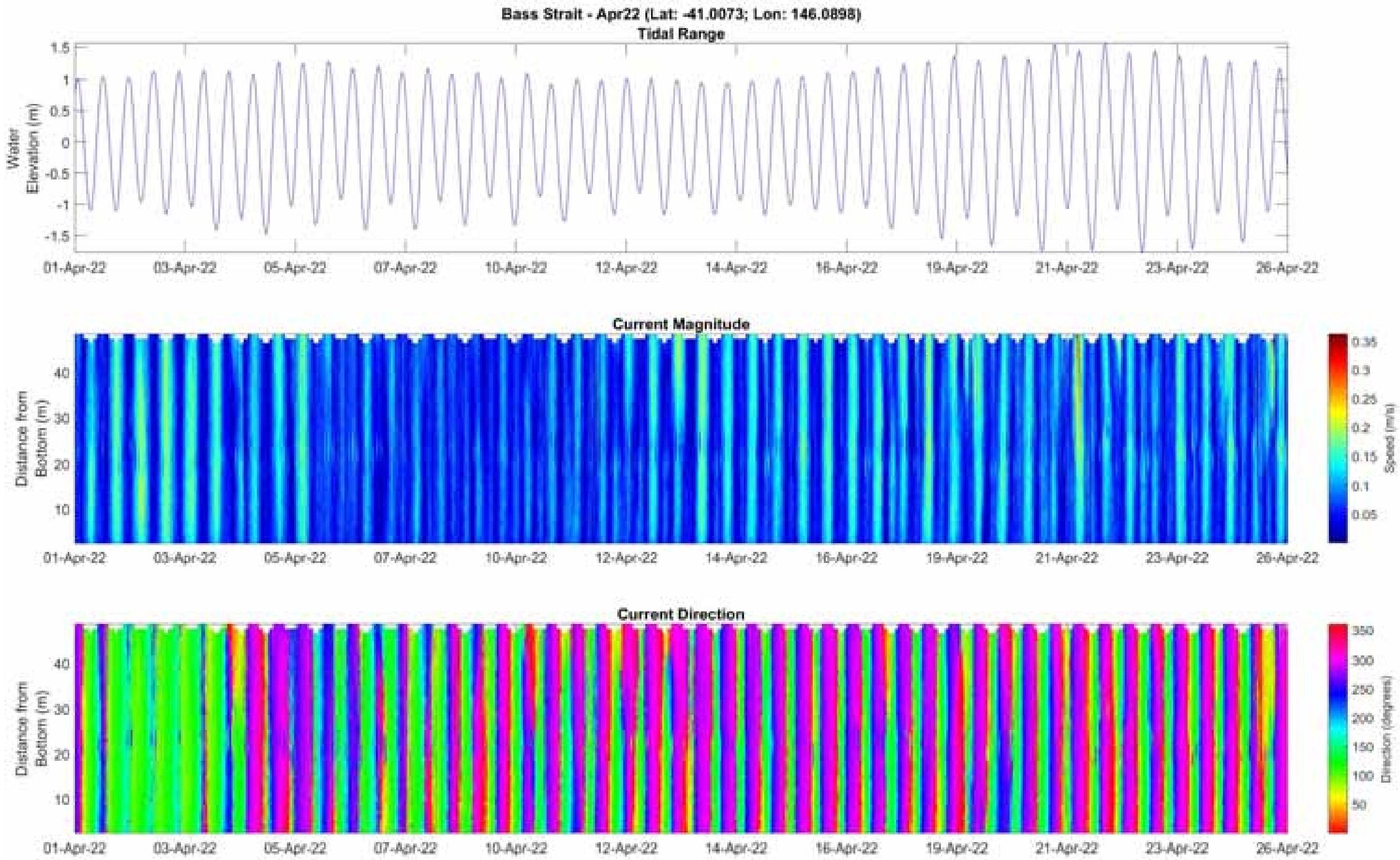

Figure 48: Water elevation, current speed and current direction measurements in April 2022

3.6. Waves using ADPC Measurements

3.6.1. Deployment One: December 2020 to March 2021

Descriptive Statistics

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Table 13.

Table 13: Monthly and total wave statistics for Deployment One (* denotes incomplete month)

Statistics		Significant Wave	Mean Period	Peak Period
Dec-20*	Min	0.02	1.13	1.02
	Mean	0.90	2.85	5.65
	Max	1.84	4.81	12.77
	STD	0.33	0.68	2.31
Jan-21	Min	0.31	1.46	1.99
	Mean	1.00	2.88	5.19
	Max	3.23	5.52	16.60
	STD	0.53	0.79	2.00
Feb-21	Min	0.34	1.52	1.99
	Mean	0.98	2.80	6.46
	Max	2.50	4.93	17.88
	STD	0.41	0.74	3.28
Mar-21*	Min	0.36	1.51	1.99
	Mean	0.76	2.57	4.98
	Max	1.86	4.29	14.17
	STD	0.35	0.62	2.91
All	Min	0.02	1.13	1.02
	Mean	0.95	2.81	5.67
	Max	3.23	5.52	17.88
	STD	0.44	0.74	2.69

Wave height, period and direction

The time-series of significant wave height, mean and peak wave period and mean and peak wave direction is depicted in Figure 49

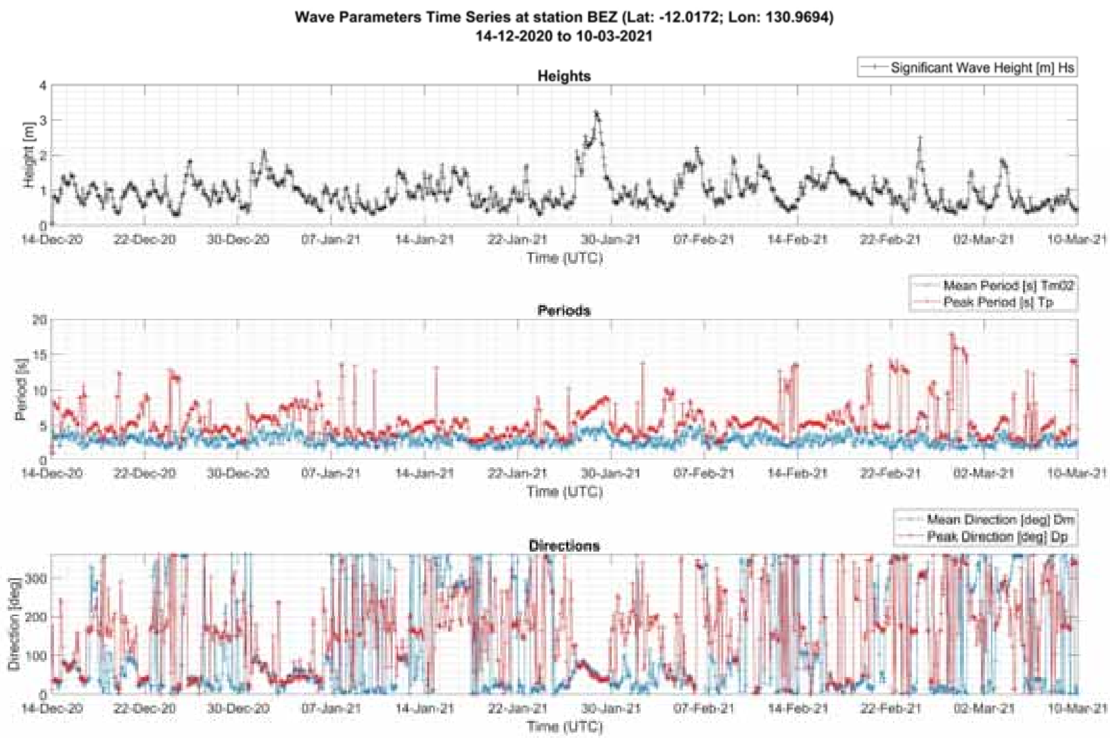

Figure 49: Significant wave height, mean and peak period and mean and peak direction from 14 December 2020 to 10 March 2021

Wave Rose

The average wave spectrum obtained in the measurement period is shown in Figure 50.

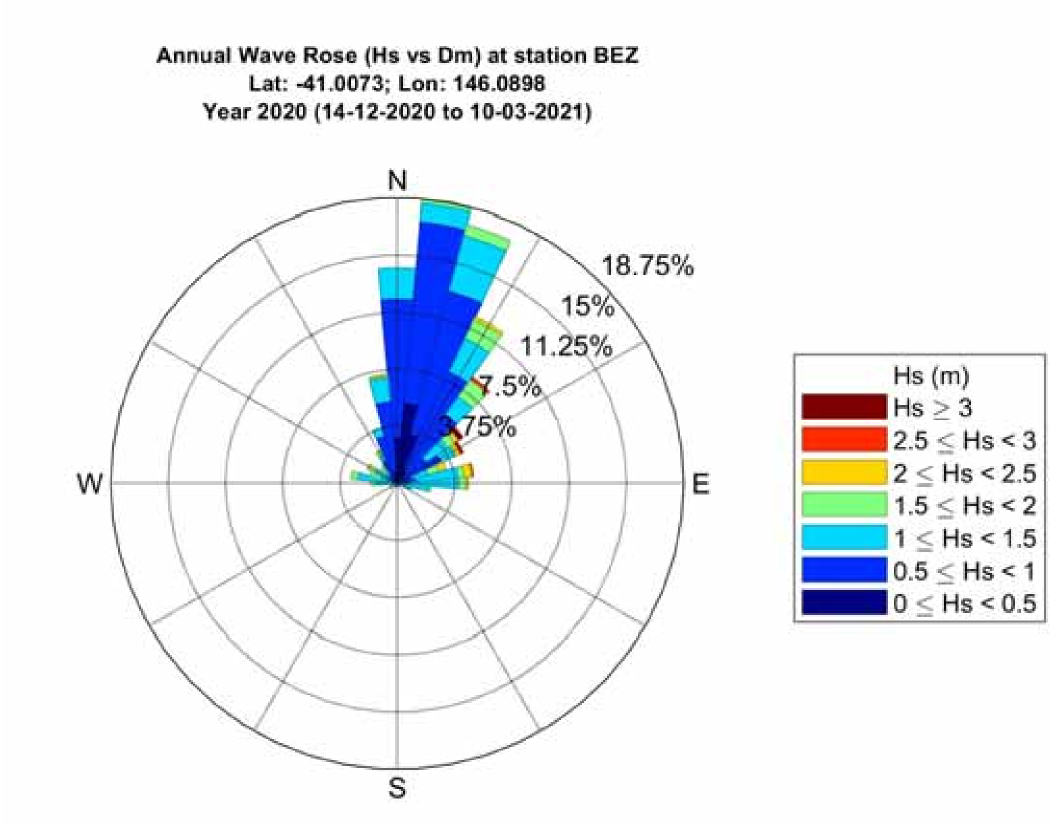

Figure 50: Wave rose for Deployment One showing distribution of significant wave height for Deployment One

Daily Variability

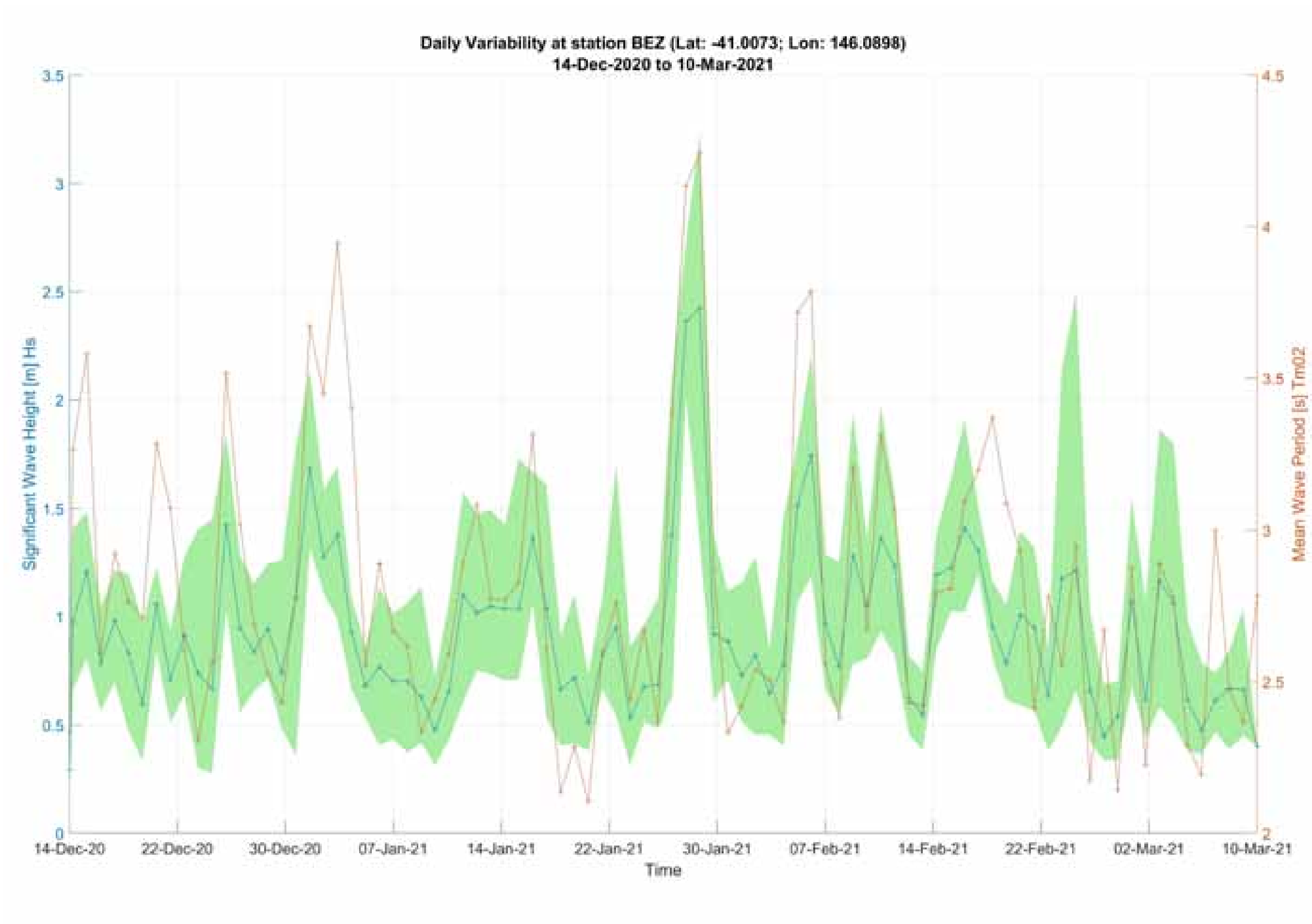

Figure 51: Daily variability of significant wave height and mean wave period for Deployment One

Annual Power Distribution

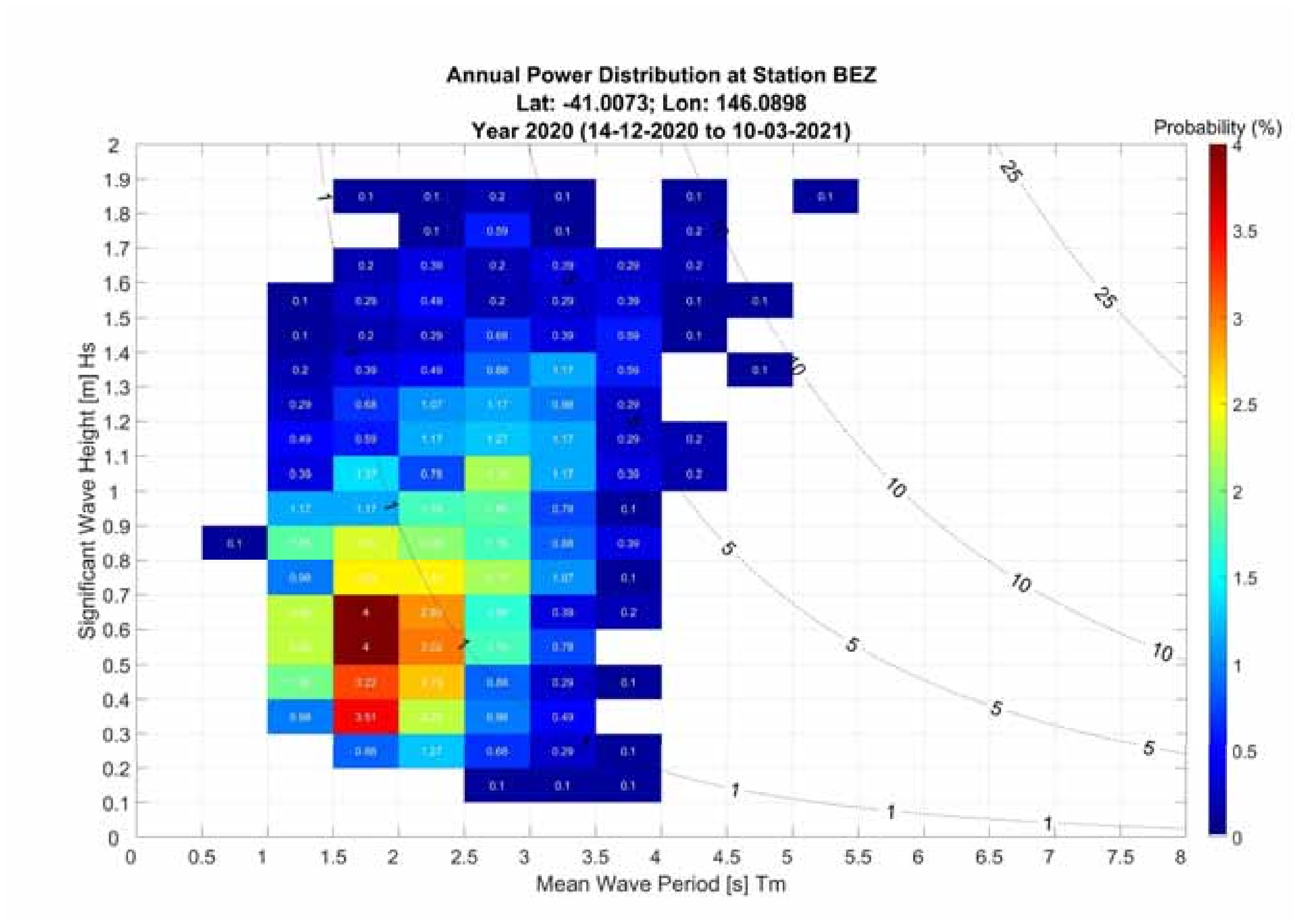

Figure 52: Annual wave power distribution for Deployment One

3.6.2. *Deployment Two: March 2021 to May 2021*

Descriptive Statistics

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Table 14.

Table 14: Monthly and Total Wave Statistics for Deployment Two(* denotes incomplete month)

Statistics		Significant Wave	Mean Period	Peak Period
Mar-21*	Min	0.12	1.11	1.03
	Mean	1.19	3.20	5.60
	Max	2.59	5.55	13.30
	STD	0.50	0.86	1.77
Apr-21	Min	0.23	1.51	2.01
	Mean	0.92	2.88	6.78
	Max	2.91	5.67	17.30
	STD	0.53	0.80	3.65
May-21*	Min	0.03	1.68	2.78
	Mean	0.95	3.10	7.35
	Max	2.96	5.88	15.10
	STD	0.54	0.93	3.88
All	Min	0.12	1.11	1.03
	Mean	1.02	3.03	6.48
	Max	2.96	5.88	17.30
	STD	0.54	0.86	3.25

Wave height, period and direction

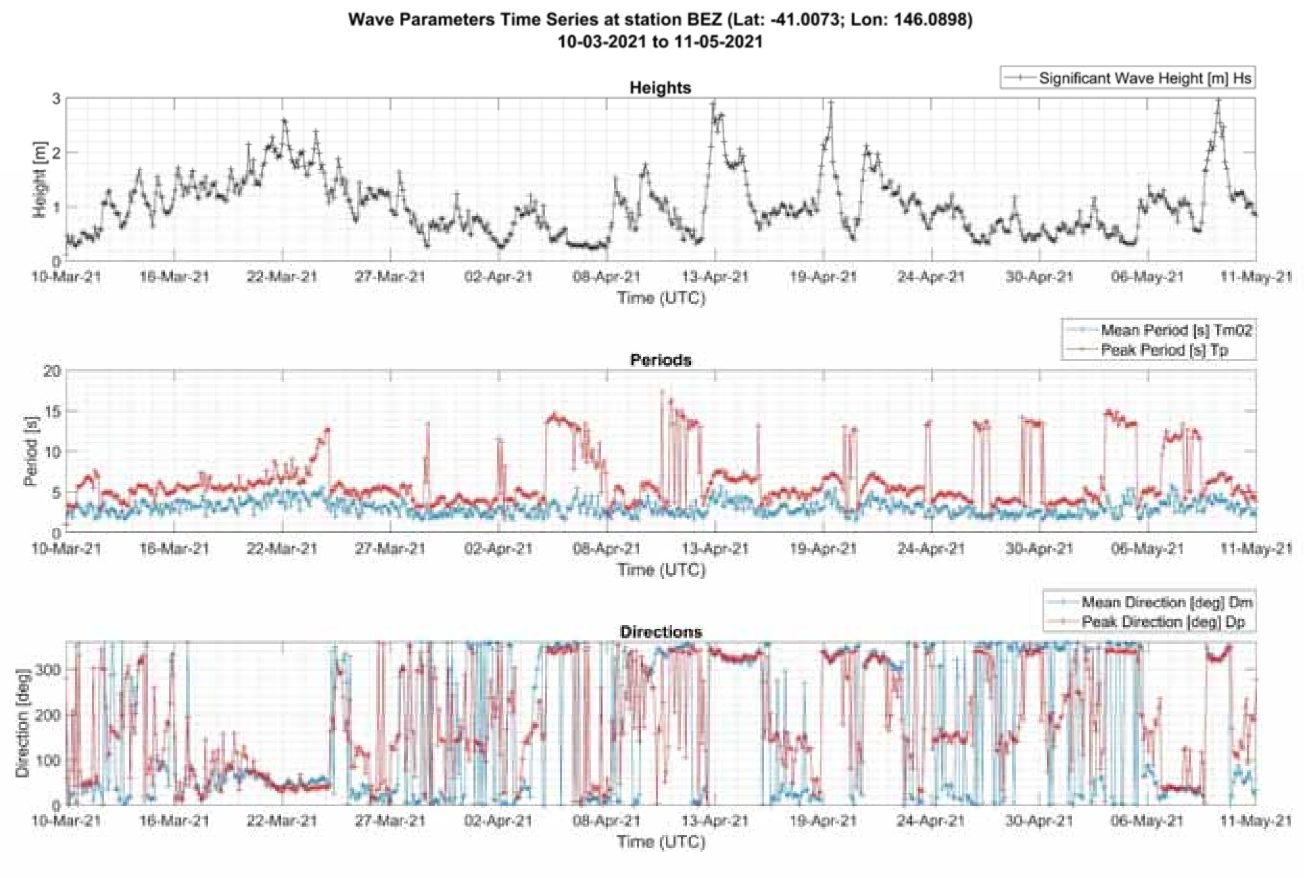

Figure 53: Significant wave height, mean and peak period and mean and peak direction from 10 March 2021 to 11 May 2021

Wave Rose

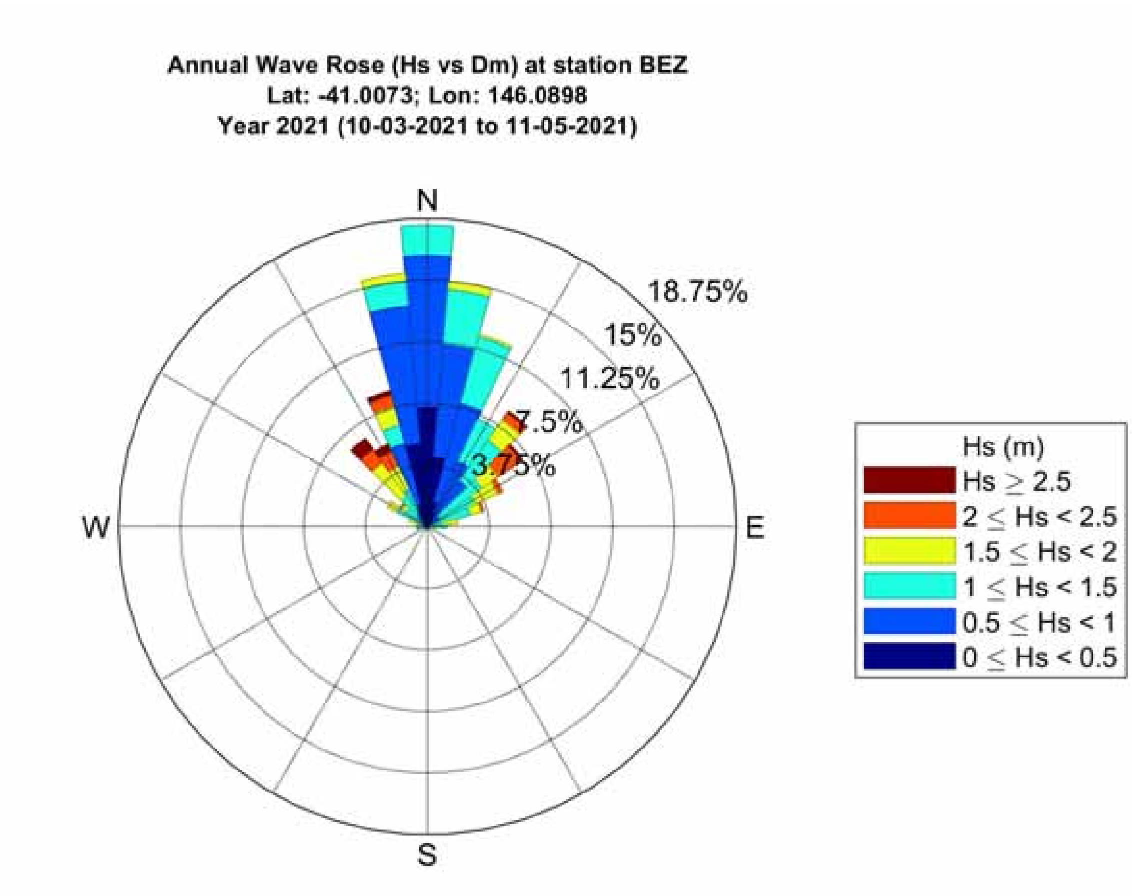

Figure 54: Wave rose for Deployment Two showing distribution of significant wave height for Deployment Two

Daily Variability

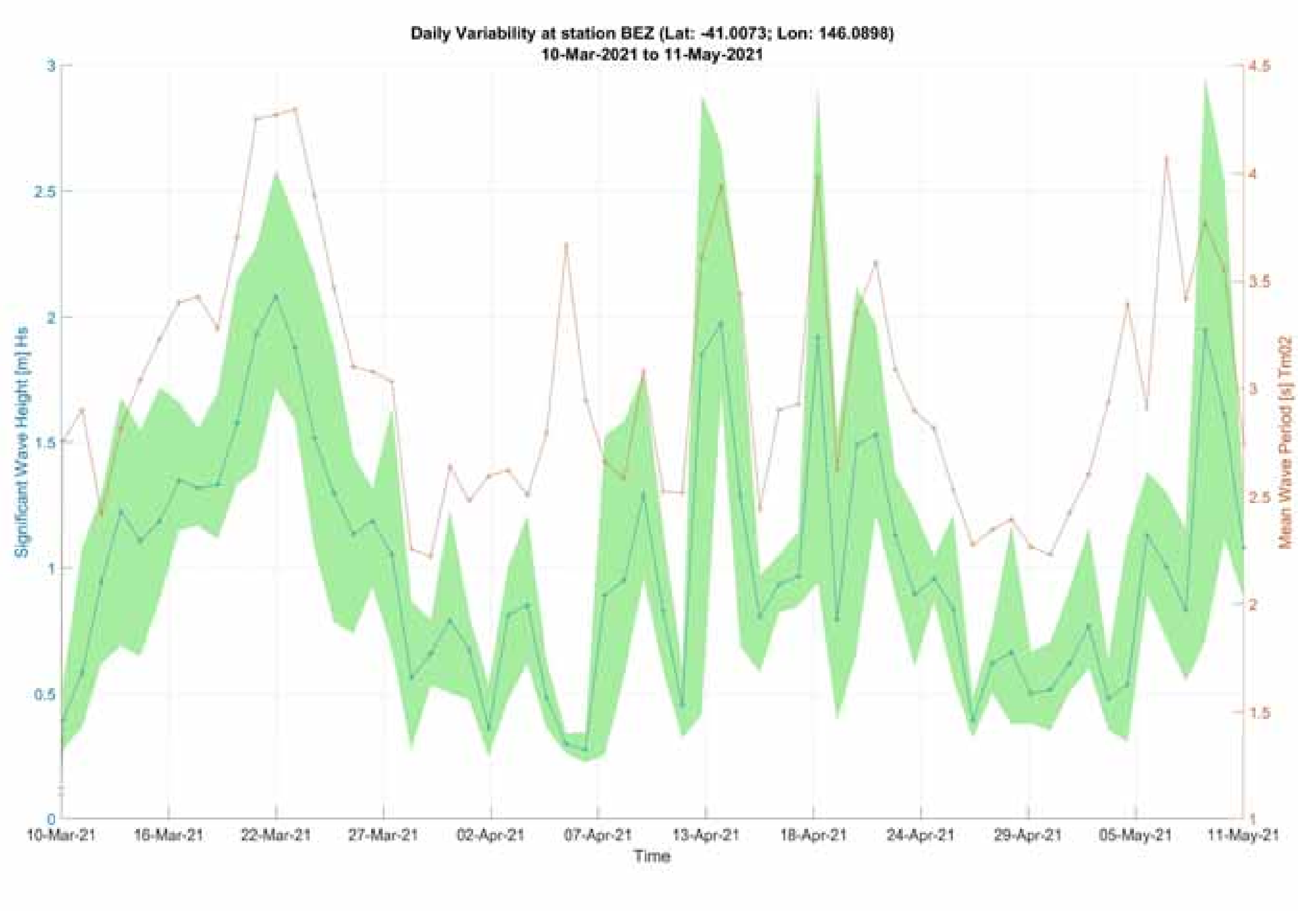

Figure 55: Daily variability of significant wave height and mean wave period for Deployment Two

Annual Power Distribution

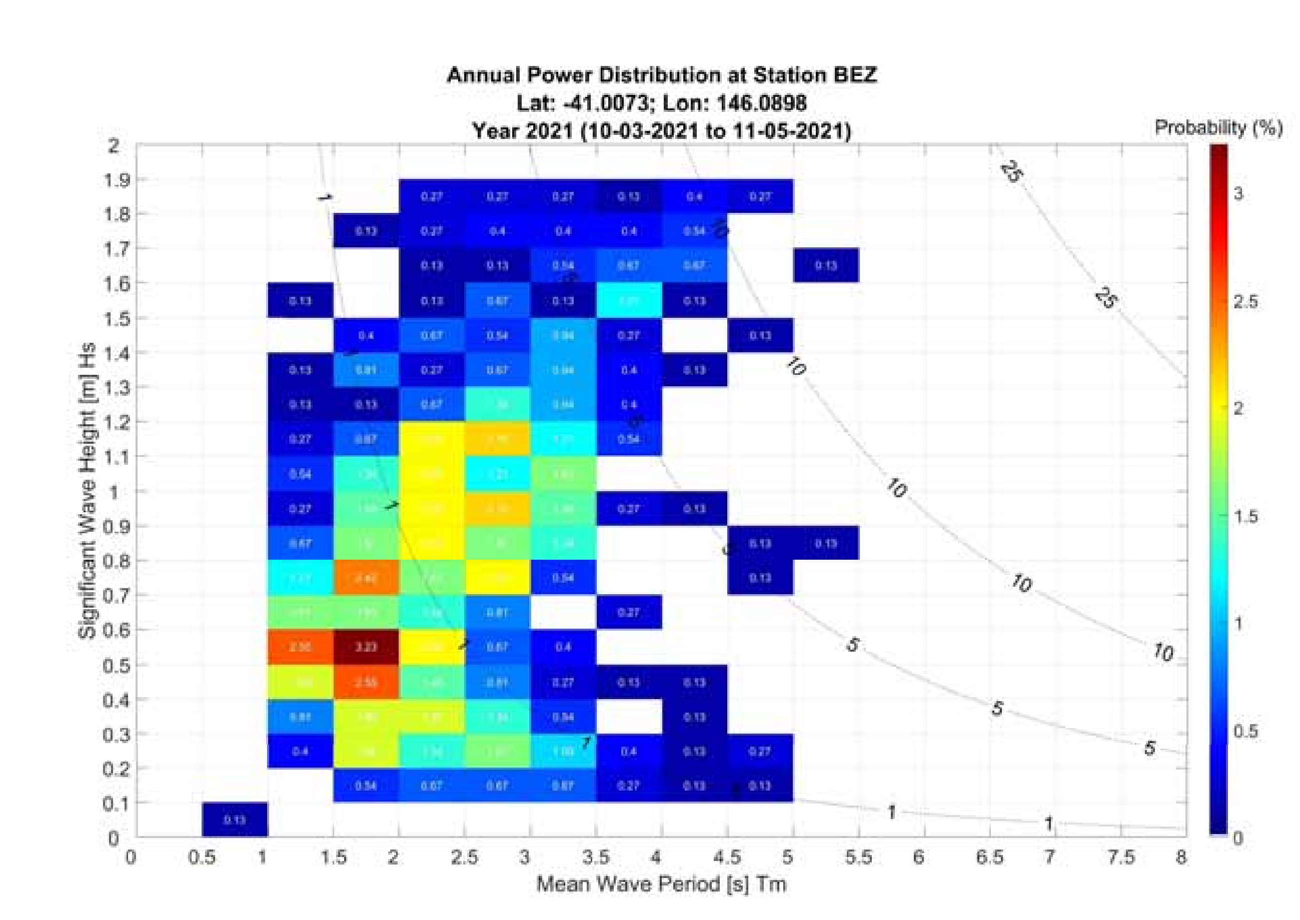

Figure 56: Annual wave power distribution for Deployment Two

3.6.3. Deployment Three: May 2021 to August 2021

Descriptive Statistics

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Table 15.

Table 15: Monthly and total wave statistics for Deployment Three (* denotes incomplete month)

Statistics		Significant Wave Height	Mean Period	Peak Period
May-21*	Min	0.03	1.17	1.02
	Mean	1.01	2.82	7.29
	Max	3.52	5.84	14.94
	STD	0.58	0.83	3.78
Jun-21	Min	0.32	1.55	2.00
	Mean	0.97	3.00	7.04
	Max	3.61	6.03	17.42
	STD	0.65	0.87	3.46
Jul-21	Min	0.32	1.47	1.98
	Mean	1.42	3.39	7.12
	Max	3.80	6.36	13.96
	STD	0.69	0.97	2.47
Aug-21*	Min	0.69	2.22	4.81
	Mean	1.04	3.50	8.49
	Max	1.44	4.73	14.08
	STD	0.27	0.95	4.13
All	Min	0.03	1.17	1.02
	Mean	1.15	3.11	7.15
	Max	3.80	6.36	17.42
	STD	0.68	0.93	3.22

Wave height, period and direction

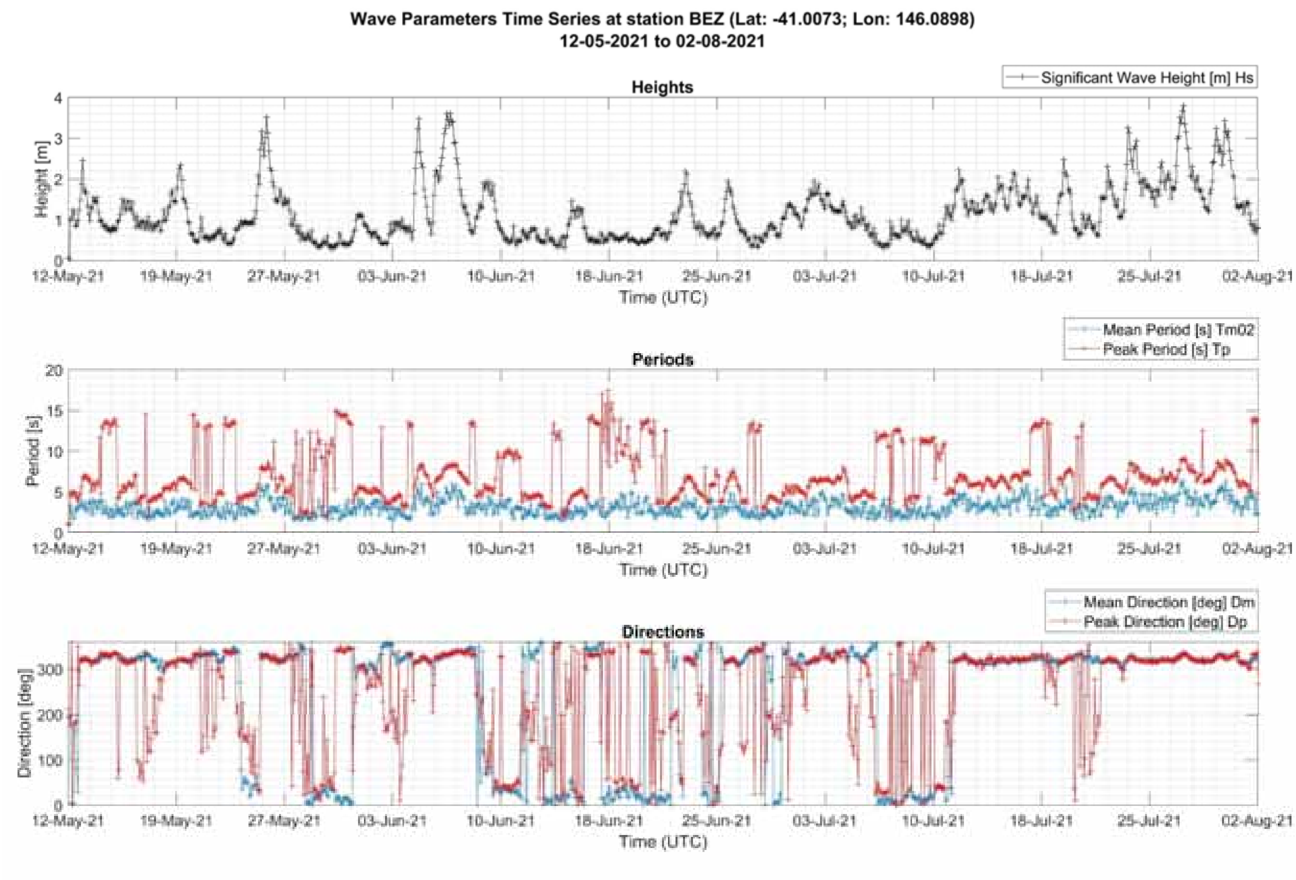

Figure 57: Significant wave height, mean and peak period and mean and peak direction from 12 May 2021 to 02 August 2021

Wave Rose

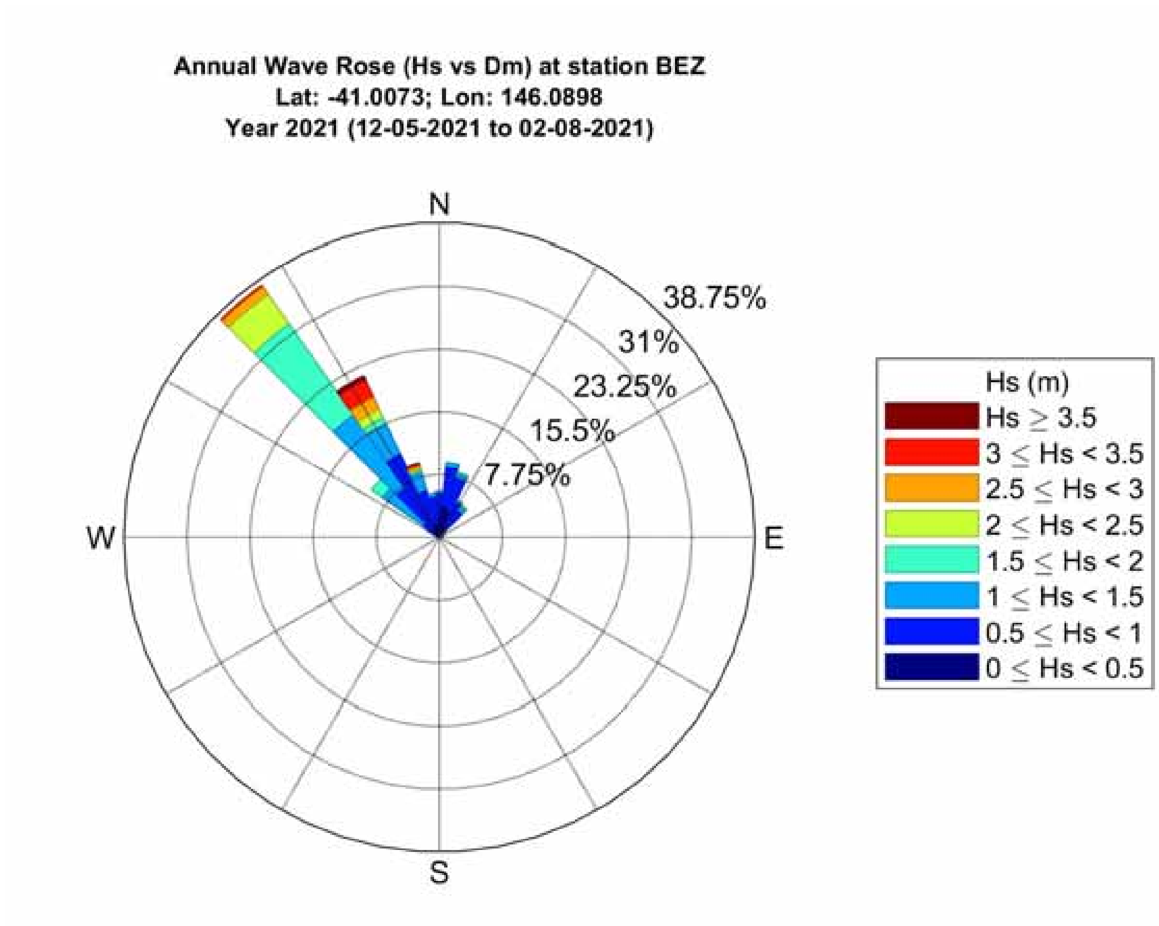

Figure 58: Wave rose for Deployment Three showing distribution of significant wave height for Deployment Three

Daily Variability

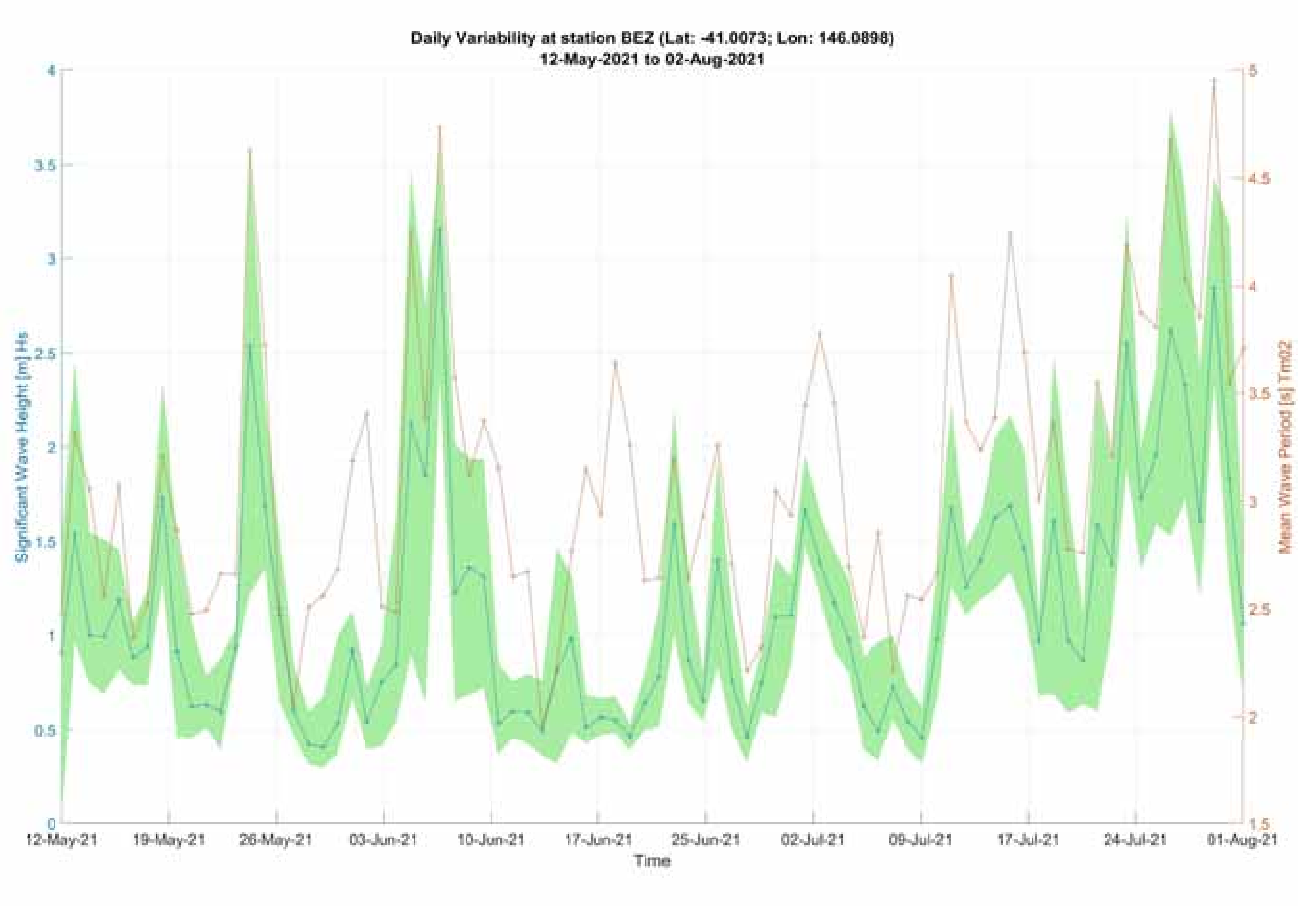

Figure 59: Daily variability of significant wave height and mean wave period for Deployment Three

Annual Power Distribution

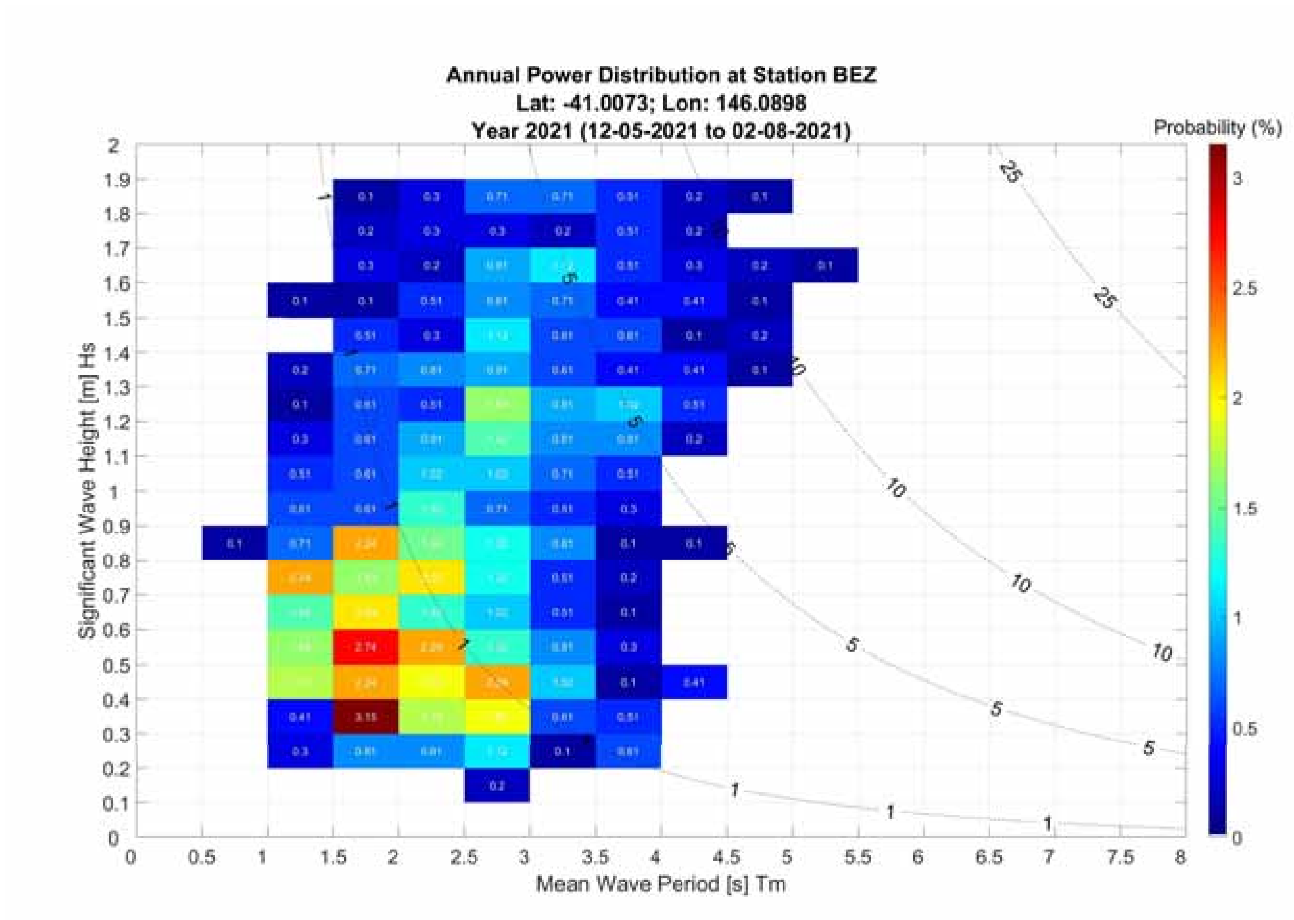

Figure 60: Annual wave power distribution for Deployment Three

3.6.4. Deployment Four: August 2021 to November 2021

Descriptive Statistics

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Table 16.

Table 16: Monthly and total wave statistics for Deployment Four (* denotes incomplete month)

Statistics		Significant Wave Height	Mean Period	Peak Period
Aug-21*	Min	0.10	1.15	1.12
	Mean	1.19	3.05	6.87
	Max	3.48	6.08	11.93
	STD	0.77	0.85	2.81
Sep-21	Min	0.30	1.53	2.00
	Mean	1.25	3.22	8.30
	Max	4.10	6.51	16.51
	STD	0.73	0.96	3.49
Oct-21	Min	0.32	1.54	2.00
	Mean	1.07	2.93	6.43
	Max	2.65	5.33	14.37
	STD	0.47	0.78	2.76
November-21*	Min	0.26	1.48	1.99
	Mean	0.84	2.68	5.18
	Max	2.23	8.61	13.98
	STD	0.32	0.78	2.39
All	Min	0.10	1.15	1.12
	Mean	1.08	2.9	6.78
	Max	4.10	8.61	16.51
	STD	0.59	0.87	3.18

Wave height, period and direction

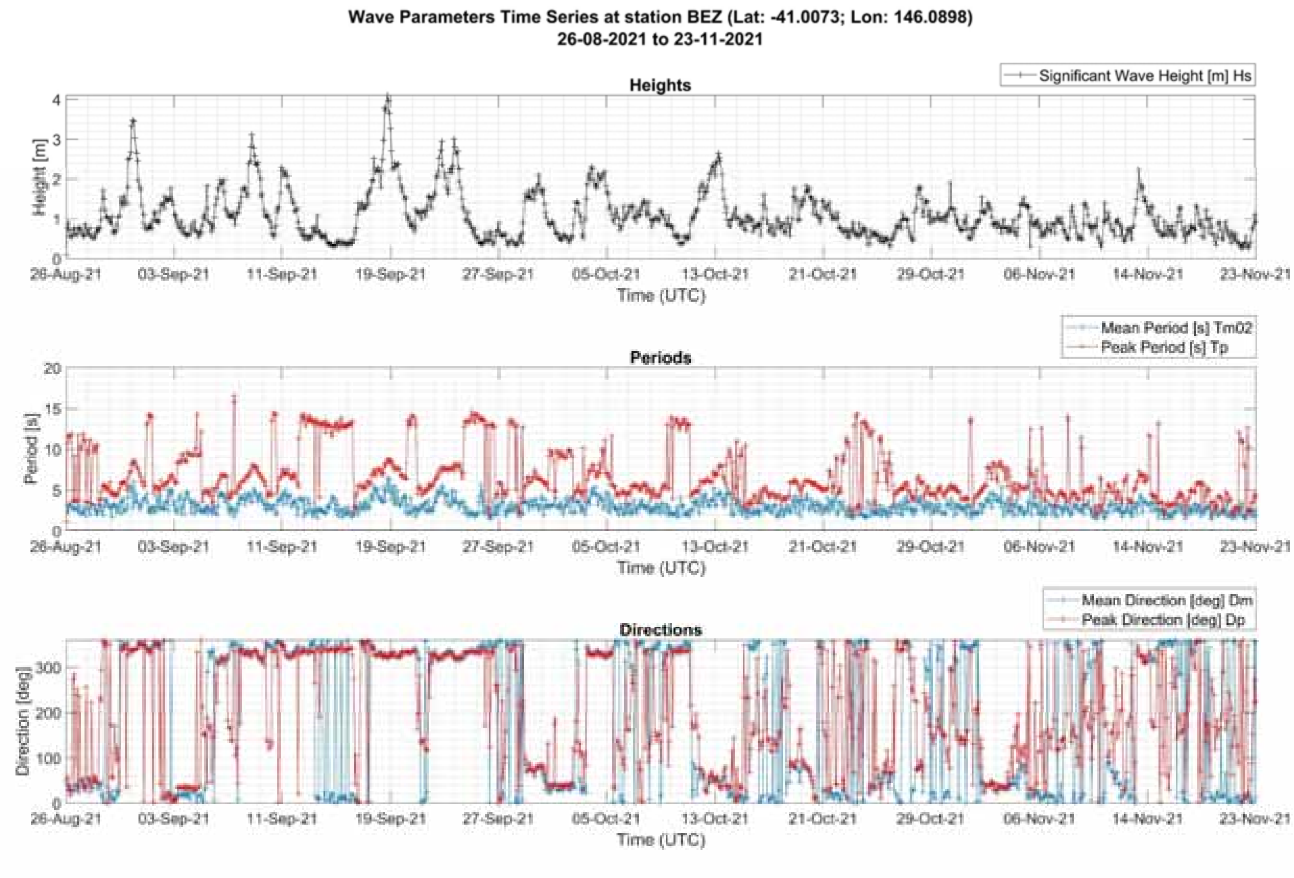

Figure 61: Significant wave height, mean and peak period and mean and peak direction from 25 August 2021 to 23 November 2021

Wave Rose

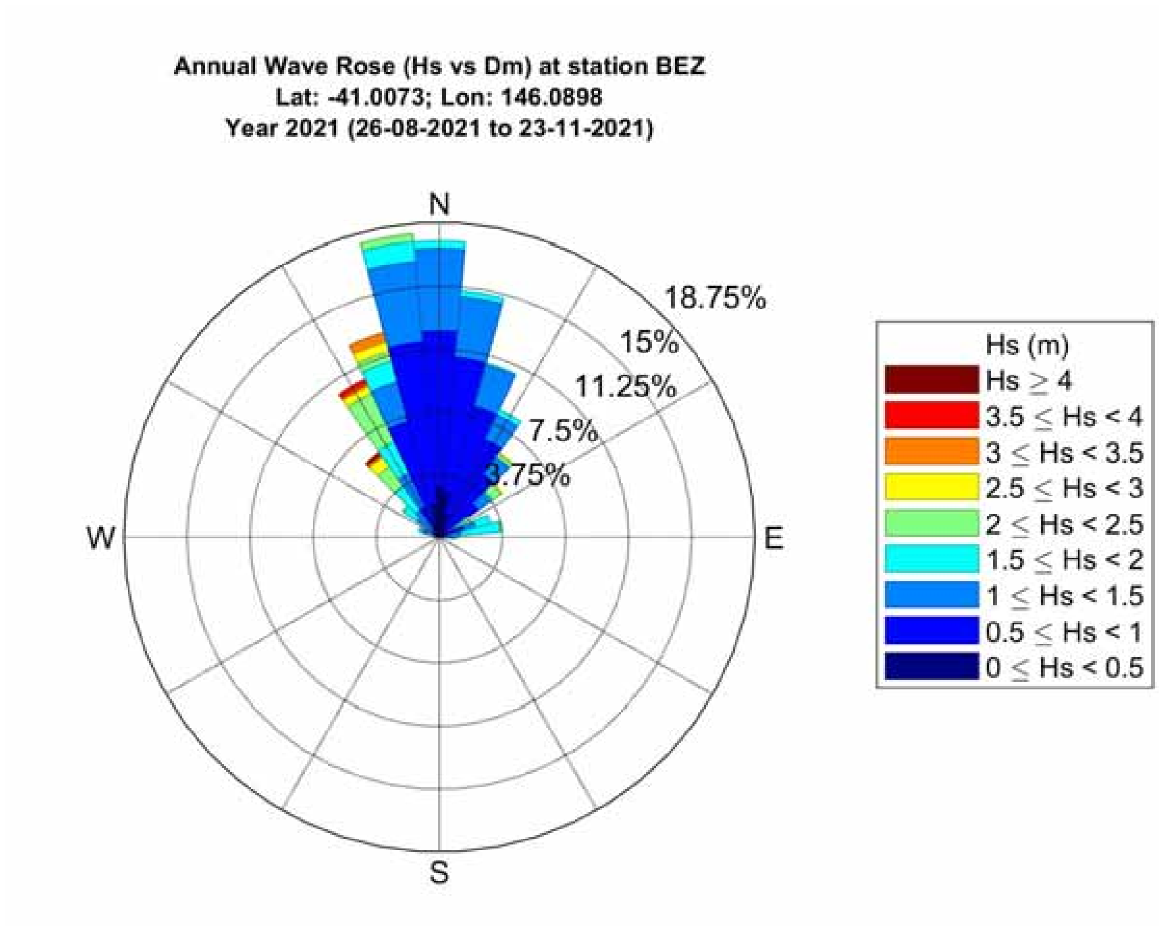

Figure 62: Wave rose for Deployment Four showing distribution of significant wave height for Deployment Four

Daily Variability

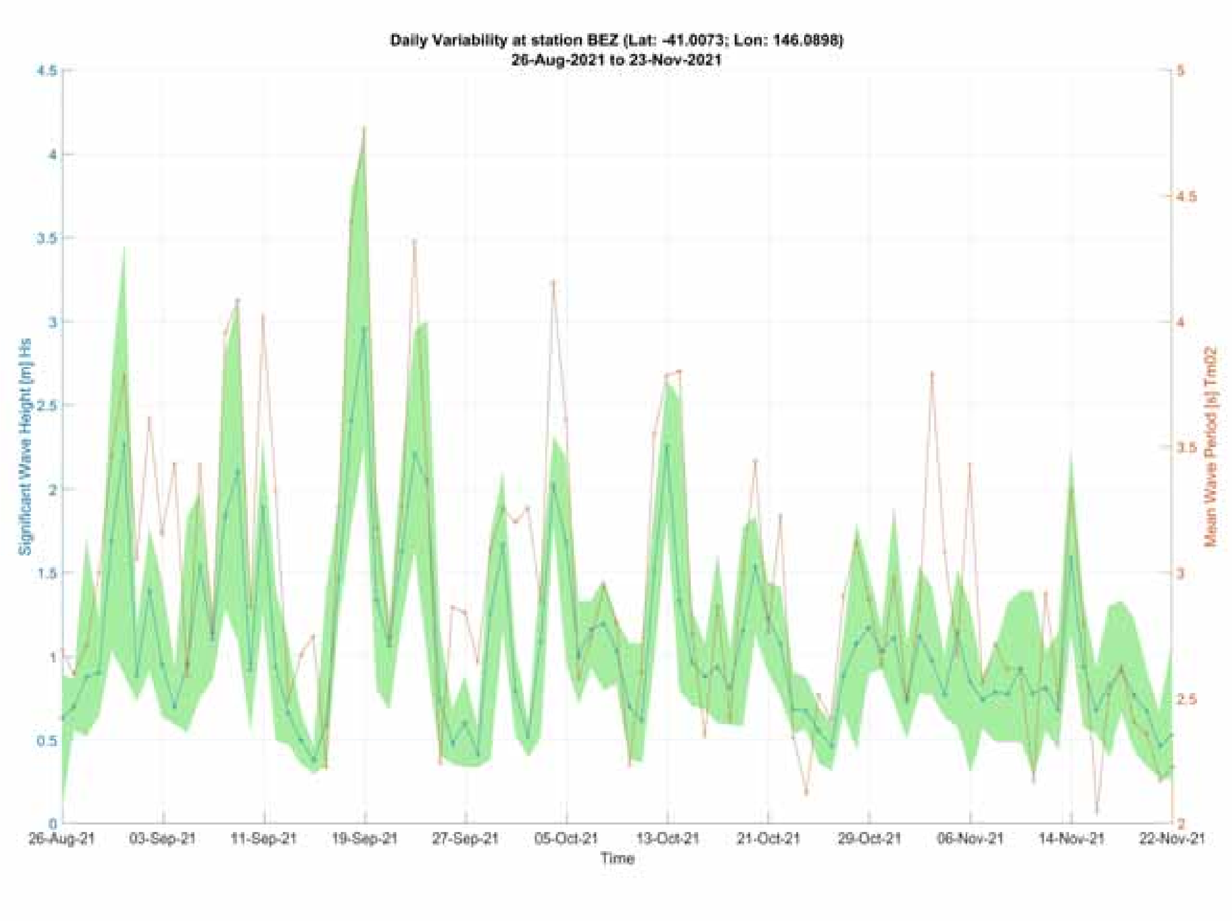

Figure 63: Daily variability of significant wave height and mean wave period for Deployment Four

Annual Power Distribution

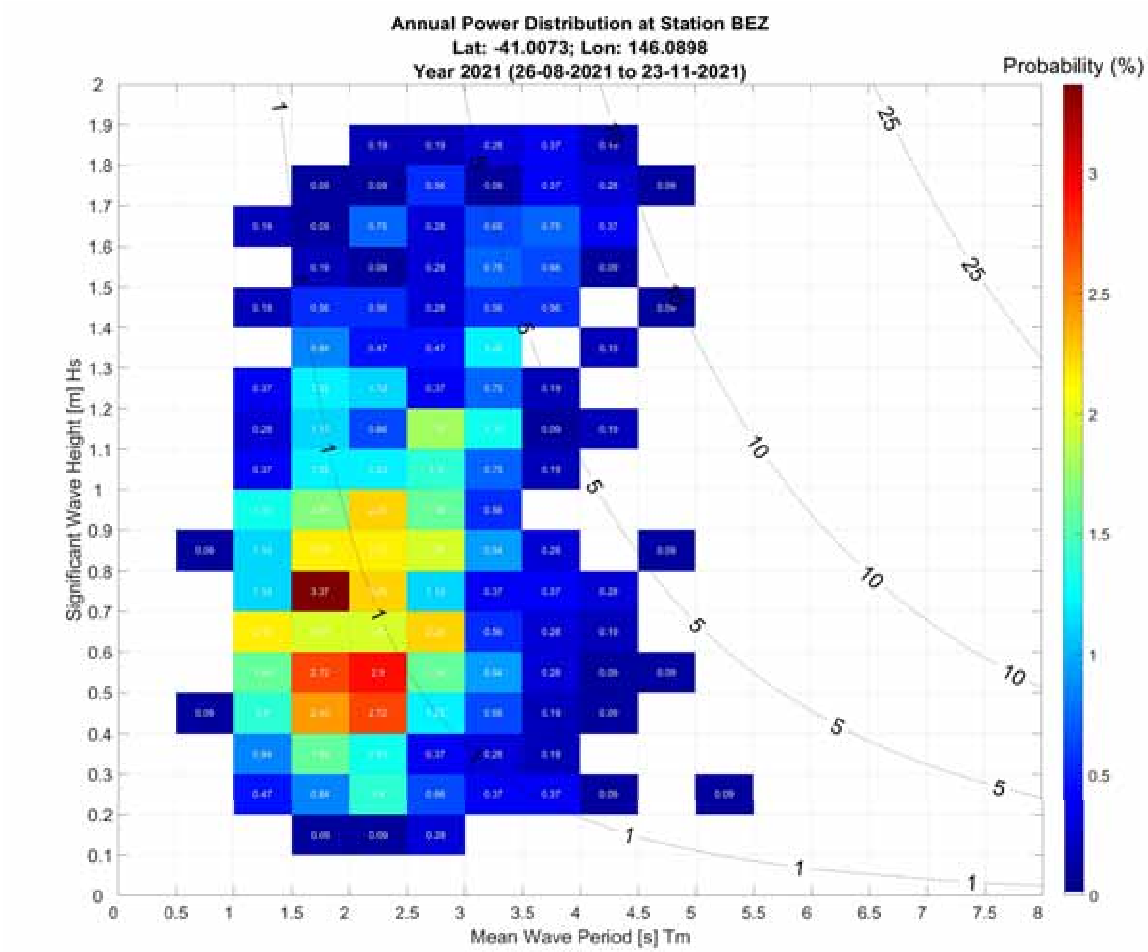

Figure 64: Annual wave power distribution for Deployment Four

3.6.5. *Deployment Five: November 2021 to April 2021*

Descriptive Statistics

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Table 17.

Table 17: Monthly and total wave statistics for Deployment Five (* denotes incomplete month)

Statistics		Significant Wave Height	Mean Period	Peak Period
Nov-21*	Min	0.09	1.12	1.02
	Mean	0.71	3.43	6.16
	Max	1.56	7.70	10.53
	STD	0.32	1.54	2.18
Dec-21	Min	0.30	1.47	1.98
	Mean	0.94	2.79	5.13
	Max	3.16	5.41	15.14
	STD	0.49	0.71	2.20
Jan-22	Min	0.30	1.77	2.62
	Mean	1.02	3.16	6.01
	Max	2.76	5.43	14.55
	STD	0.46	0.72	1.79
Feb-22	Min	0.28	1.54	1.99
	Mean	0.96	2.98	6.15
	Max	2.14	4.86	14.88
	STD	0.36	0.67	2.66
Mar-22	Min	0.27	1.50	1.99
	Mean	0.93	2.89	6.59
	Max	2.28	5.07	13.77
	STD	0.41	0.73	3.05
	Min	0.22	1.50	1.99

Apr-22*	**Mean**	0.79	2.77	7.22
	Max	1.72	4.42	15.44
	STD	0.33	0.69	3.61
Total	**Min**	0.09	1.12	1.02
	Mean	0.92	2.95	6.18
	Max	3.16	7.70	15.44
	STD	0.42	0.78	2.75

Wave height, period and direction

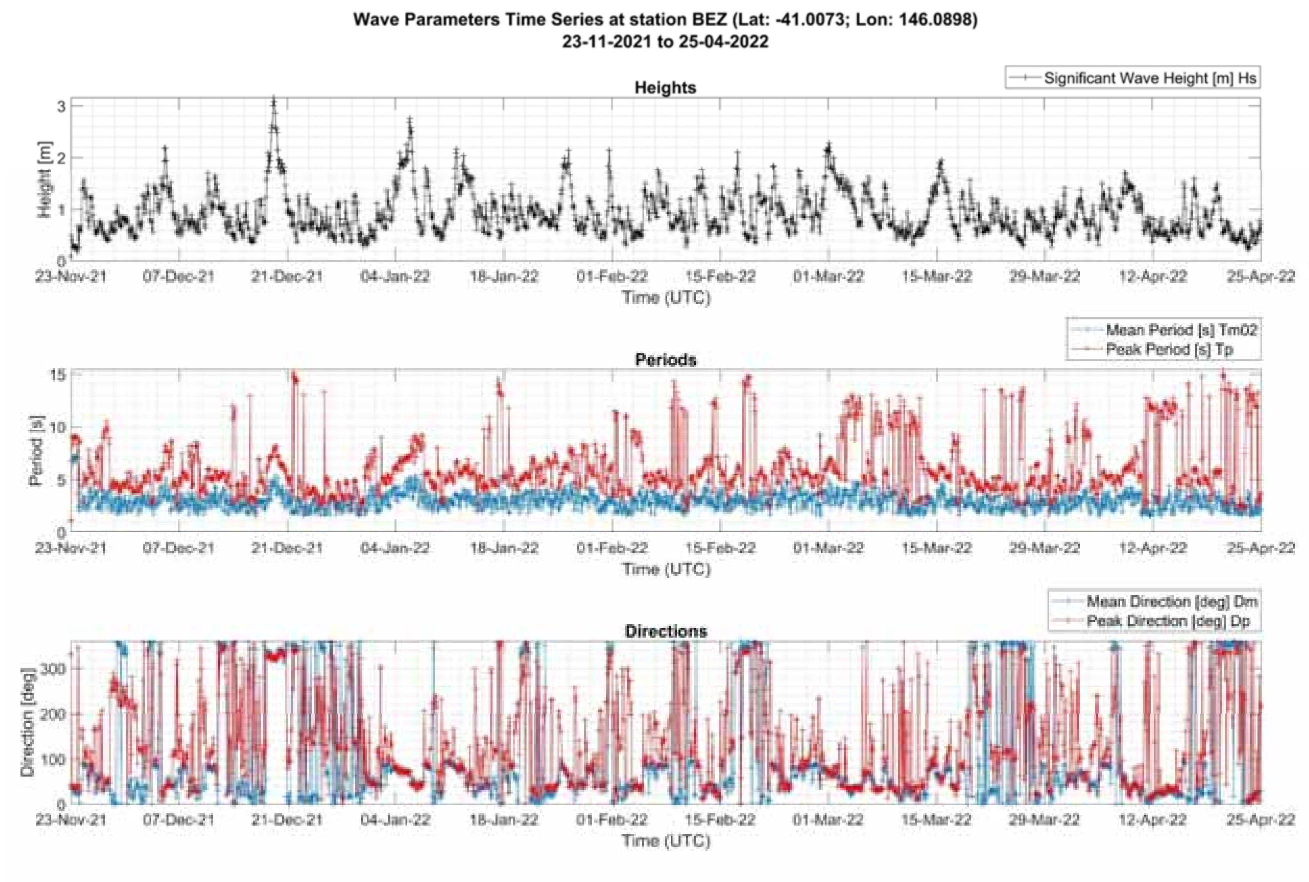

Figure 65: Significant wave height, mean and peak period and mean and peak direction from 23 November 2021 to 25 April 2022

Wave Rose

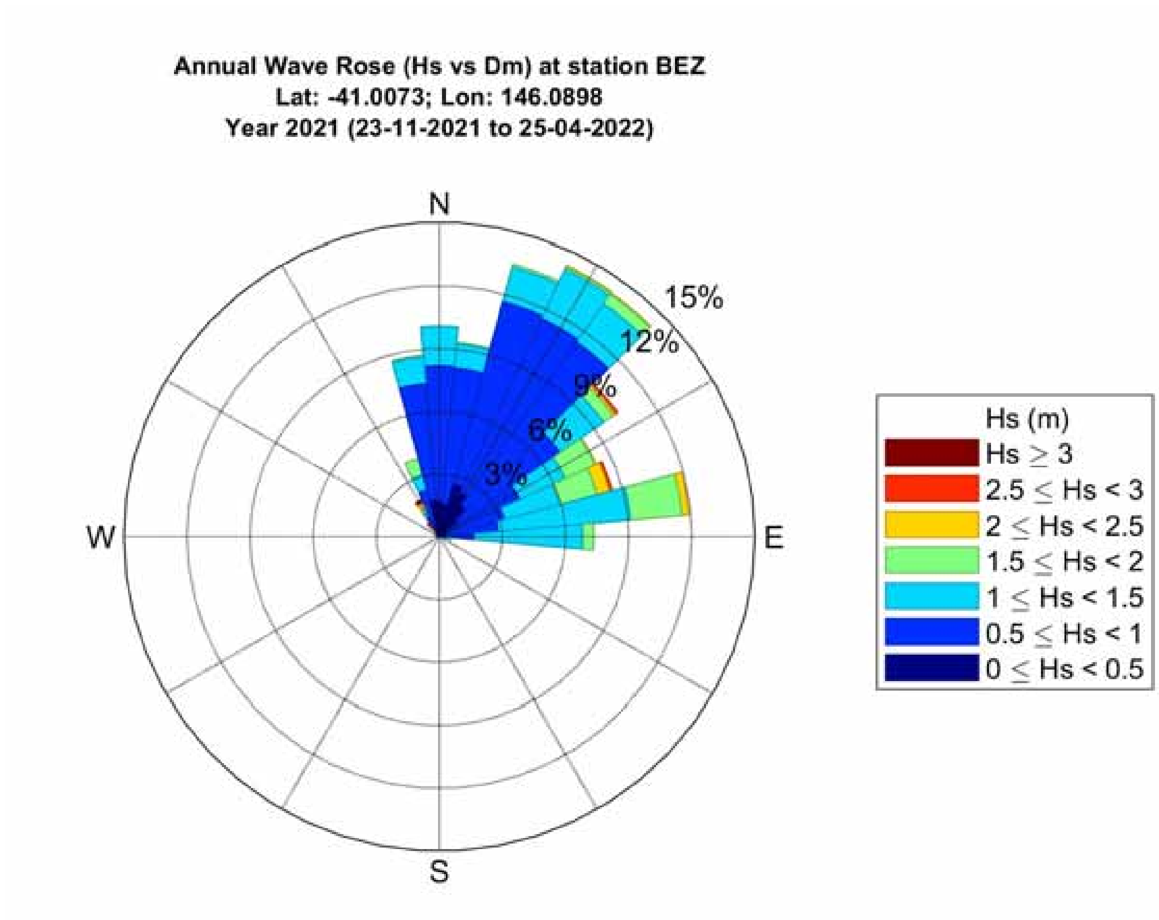

Figure 66: Wave rose for Deployment Five showing distribution of significant wave height for Deployment Five

Daily Variability

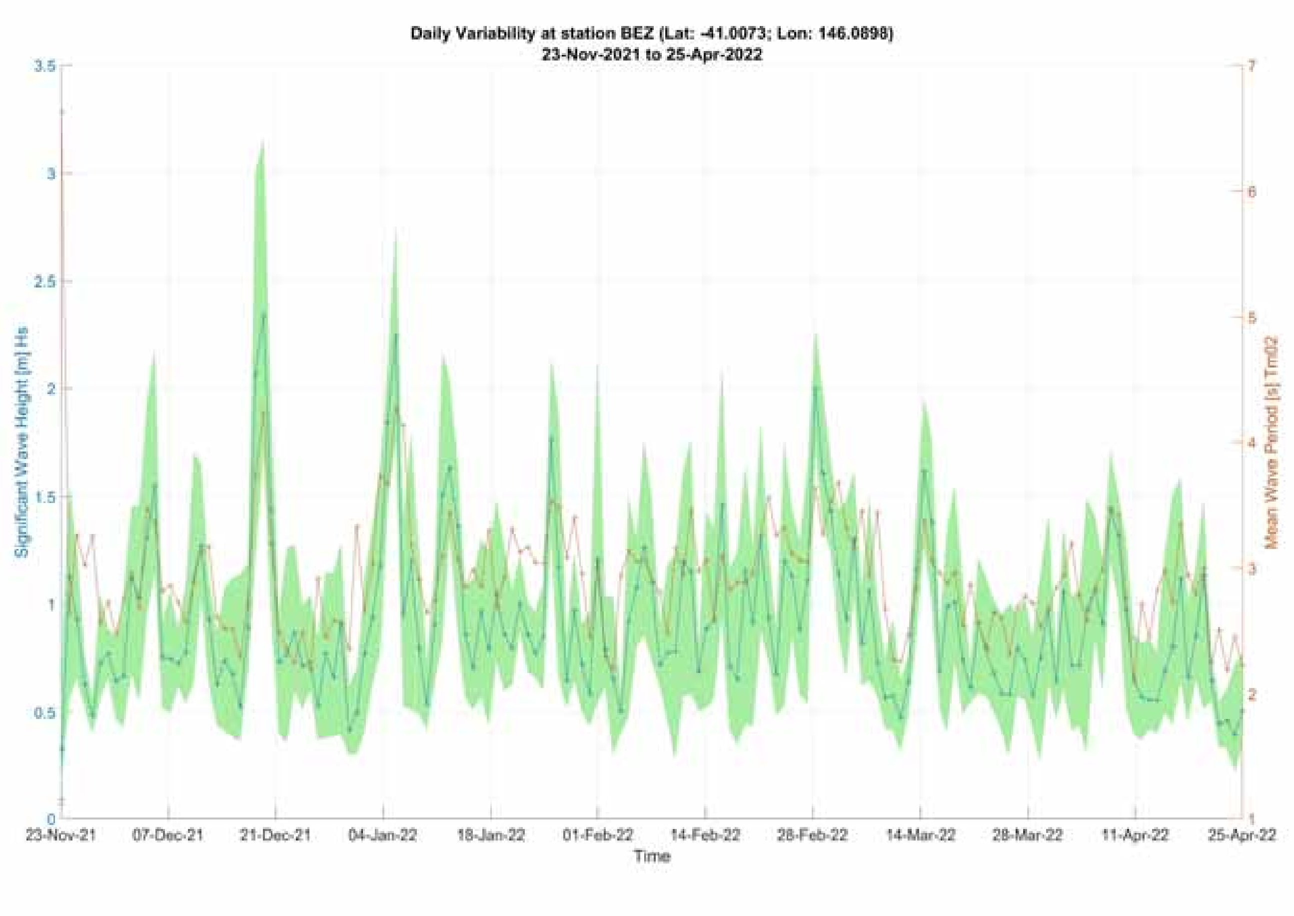

Figure 67: Daily variability of significant wave height and mean wave period for Deployment Five

Annual Power Distribution

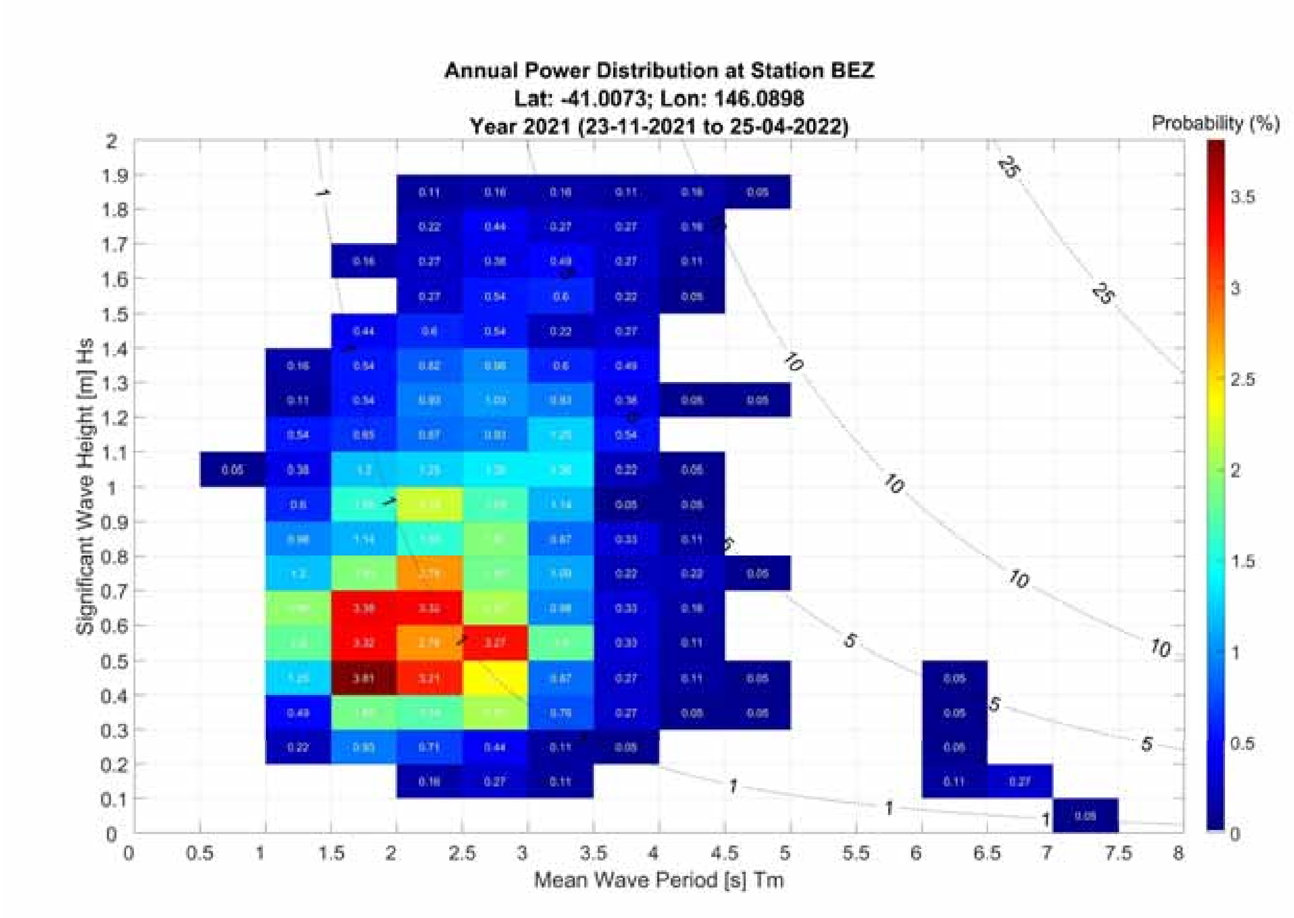

Figure 68: Annual wave power distribution for Deployment Five

3.7. Sofar Ocean Spotter Data

3.7.1. Length of Time Deployed

The Sofar Ocean Spotter was deployed on the 25-8-21. The date of first and last good data (in UTC) as well as total length of deployments in the BEZ are shown in Table 18. Due to unknown causes the mooring line broke on the 11-11-21, with the Ocean Spotter successfully retrieved on the nearby coast shortly afterwards. The Ocean Spotter was redeployed on the 26-11-21 and retrieved on the 21-2-22. The wave spotter wave again deployed on the 25-4-22 till the 25-5-22. A period of data loss occurred between 25-5-22 and 13-7-22 caused by unknown factors, however measurements continued from 13-7-22 onwards.

Table 18: Deployment date and times for Sofar Ocean Spotter

Deployment	Date & Time First Good Data (UTC)	Date & Time Last Good Data (UTC)	Number of days
One	25-8-21 20:34:49	11-11-21 16:57:28	78
Two	26-11-21 03:05:17	21-2-22 12:34:02	87
Three	25-4-22 23:21:55	25-5-22 23:04:45	30
Four	13-7-22 02:53:05	13-12-22 00:35:01	153

3.7.2. Wave measurements for Deployment One: August 2021 to November 2021

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Figure 69 and Table 19

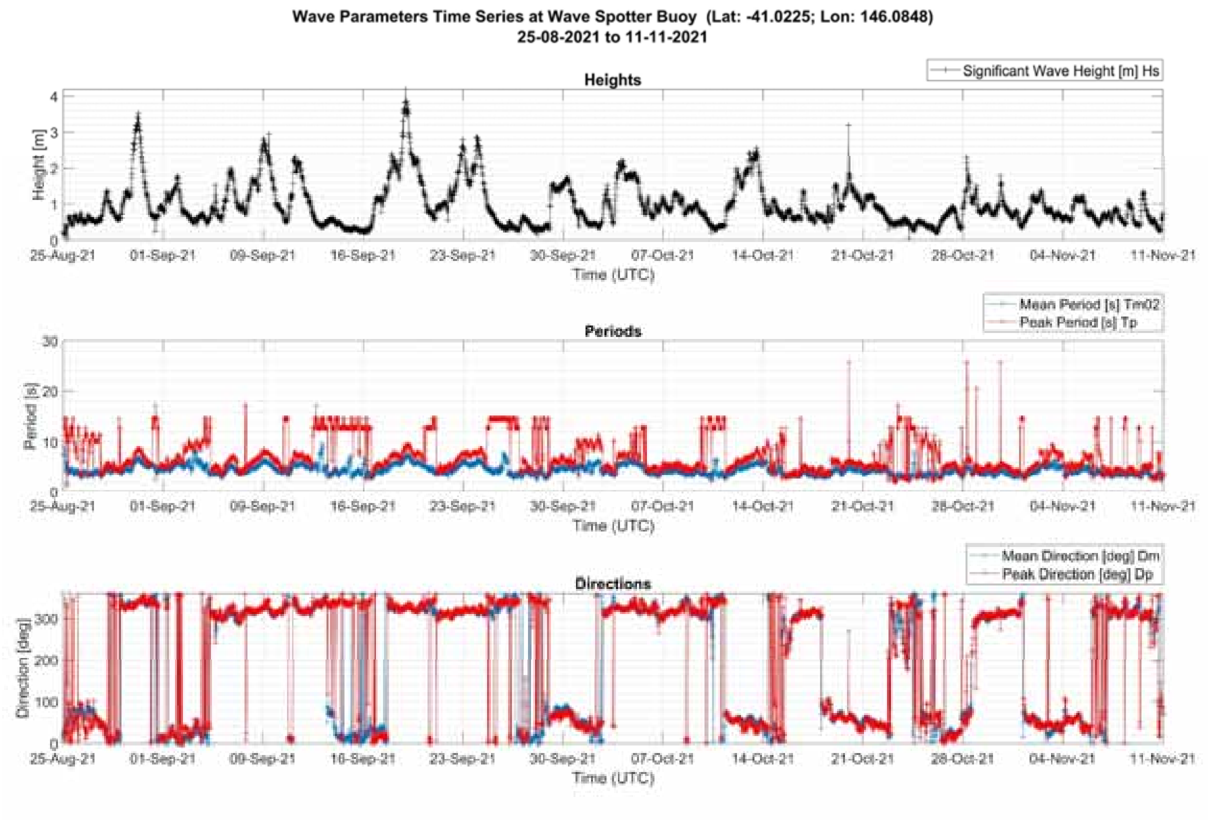

Figure 69: Wave time series of significant wave height, mean and peak period and mean and peak direction measured by the Sofar Ocean Spotter in Deployment One

Table 19: Significant wave height, mean and peak periods for Deployment One measured using the Sofar Ocean Spotter (* denotes incomplete month)

Statistics		Significant Wave Height Hs	Mean Period	Peak Period
Aug-21*	Min	0.04	1.78	1.26
	Mean	1.02	4.46	7.79
	Max	3.53	9.22	14.62
	STD	0.78	1.03	3.12
Sep-21	Min	0.15	2.52	2.68
	Mean	1.11	4.77	8.57
	Max	4.19	9.66	17.06
	STD	0.72	1.00	3.60
Oct-21	Min	0.06	2.34	2.16
	Mean	0.93	4.18	6.73
	Max	3.19	10.26	25.60
	STD	0.47	0.86	3.24
Nov-21*	Min	0.25	2.64	2.32
	Mean	0.74	3.96	6.05
	Max	1.39	6.54	14.62
	STD	0.25	0.69	2.86
All	Min	0.04	1.78	1.26
	Mean	0.98	4.42	7.46
	Max	4.19	10.26	25.60
	STD	0.60	1.18	3.60

3.7.3. Wind measurements for Deployment One: August 2021 to November 2021

The descriptive statistics of the wind parameters measured over the entire deployment period and month-by-month is presented in Figure 70 and Table 20.

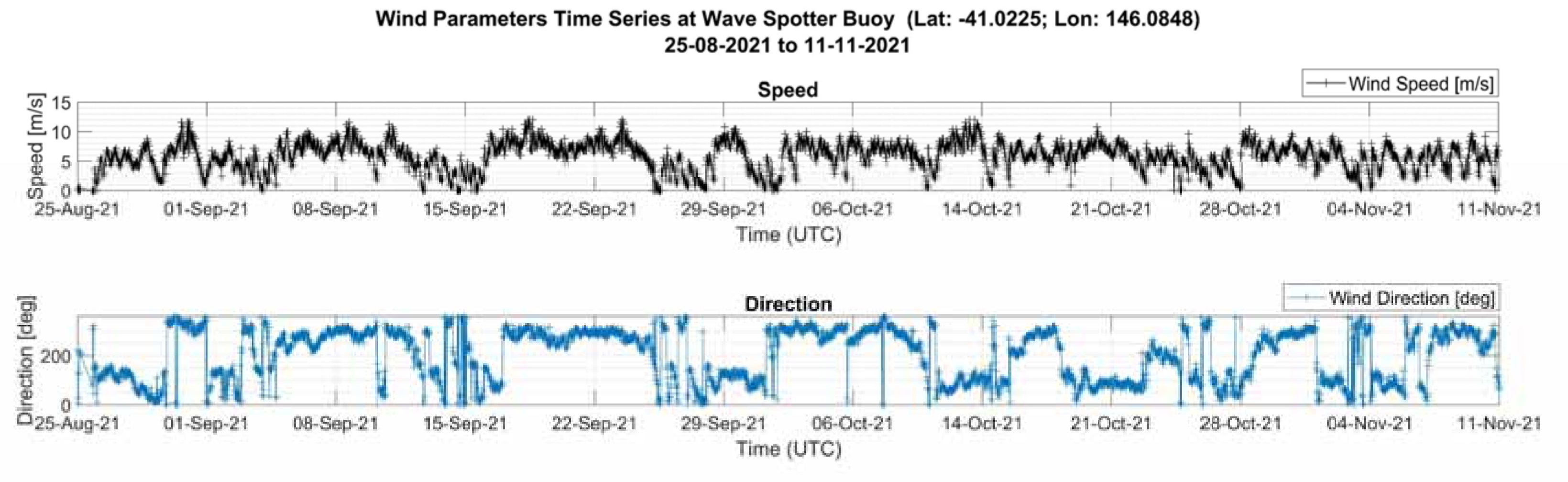

Figure 70: Wind speed and direction estimates from the Sofar Ocean Spotter during Deployment One

Table 20: Wind speed statistics for Deployment One (* denotes incomplete month)

Statistic	Aug-21*	Sept-21	Oct-21	Nov-21*
Mean	5.64	5.89	6.06	5.28
Max	11.60	12.00	12.00	9.60
STD	2.33	2.65	2.25	2.01

3.7.4. Wave measurements for Deployment Two: November 2021 to February 2022

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Figure 71 and Table 21.

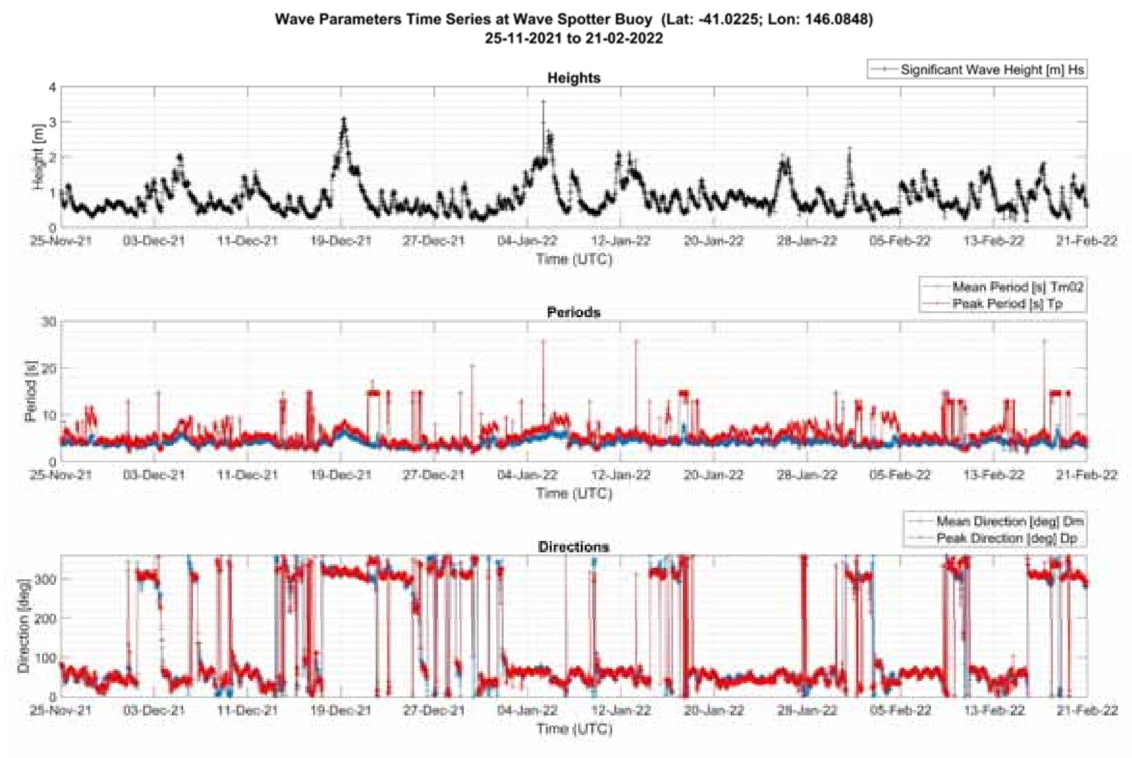

Figure 71: Wave time series of significant wave height, mean and peak period and mean and peak direction measured by the Sofar Ocean Spotter for Deployment Two

Table 21: Significant wave height, mean and peak periods for Deployment Two measured using the Sofar Ocean Spotter (* denotes incomplete month)

Statistics		Significant Wave Height Hs	Mean Period	Peak Period
Nov-21*	Min	0.31	3.16	3.64
	Mean	0.60	4.06	5.89
	Max	1.20	5.82	11.36
	STD	0.19	0.45	2.18
Dec-21	Min	0.27	2.54	1.92
	Mean	0.81	3.86	5.57
	Max	3.09	6.60	20.48
	STD	0.46	0.75	2.84
Jan-21	Min	0.19	2.76	2.42
	Mean	0.90	4.38	6.28
	Max	3.56	11.96	25.60
	STD	0.46	0.72	2.27
Feb-22*	Min	0.18	1.82	2.12
	Mean	0.81	3.98	6.73
	Max	2.24	7.72	25.60
	STD	0.36	0.62	3.33
All	Min	0.18	1.82	1.92
	Mean	0.83	4.08	6.12
	Max	3.56	11.96	25.60
	STD	0.43	0.73	2.79

3.7.5. *Wind measurements for Deployment Two: November 2021 to February 2022*

The descriptive statistics of the wind parameters measured over the entire deployment period and month-by-month is presented in Figure 72 and Table 22

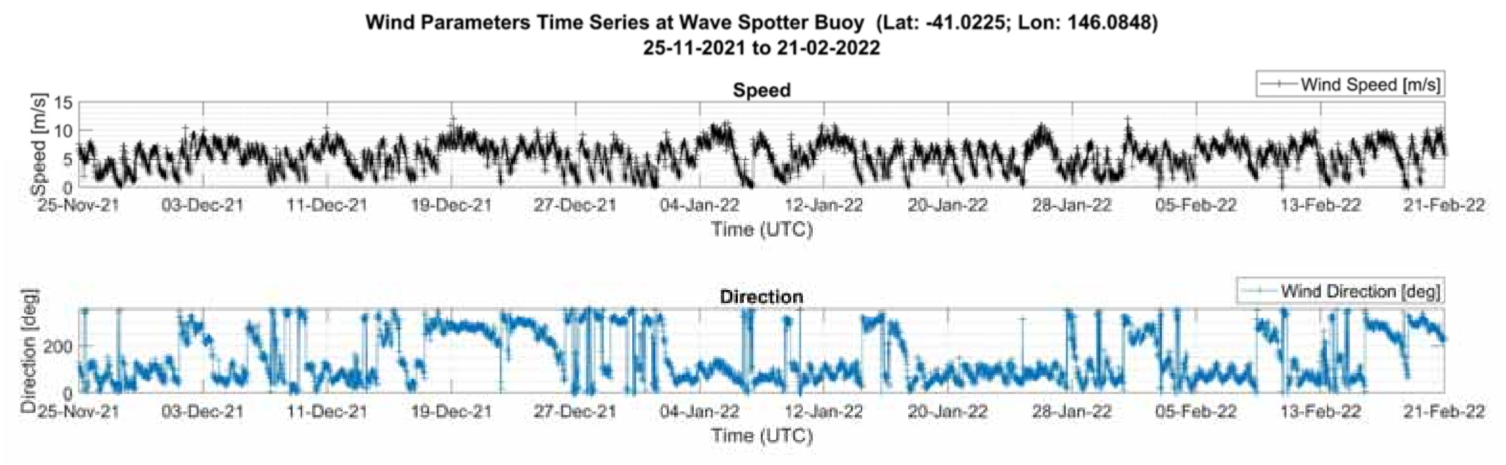

Figure 72: Wind speed and direction estimates from the Sofar Ocean Spotter during Deployment Two

Table 22: Wind speed statistics for Deployment Two (* denotes incomplete month)

Statistic	Nov-21*	Dec-21	Jan-22	Feb-22*
Min	0.40	0.8	0.40	0
Mean	3.95	5.63	5.23	5.84
Max	8.00	12.00	11.12	12.00
STD	2.04	2.12	2.49	2.21

3.7.6. Wave measurements for Deployment Three: April 2022 to May 2022

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Figure 73 and Table 23.

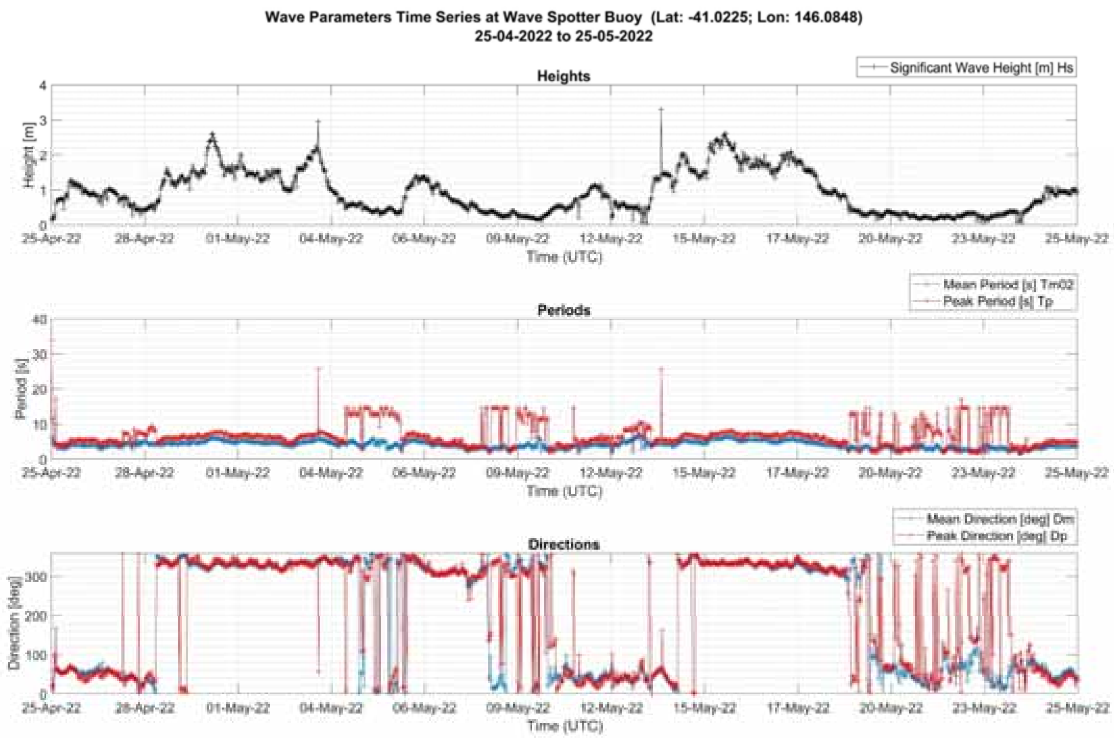

Figure 73: Wave time series of significant wave height, mean and peak period and mean and peak direction measured by the Sofar Ocean Spotter for Deployment Three

Table 23: Significant wave height, mean and peak periods for Deployment Three measured using the Sofar Ocean Spotter (* denotes incomplete month)

Statistics		Significant Wave Height Hs	Mean Period	Peak Period
April-22*	Min	0.14	2.72	3.30
	Mean	0.95	4.26	6.02
	Max	2.22	6.22	34.12
	STD	0.39	0.56	2.44
May-22*	Min	0.05	1.58	1.54
	Mean	0.92	4.15	7.00
	Max	3.30	12.72	25.60
	STD	0.63	1.06	3.54
All	Min	0.05	1.58	1.54
	Mean	0.93	4.16	6.85
	Max	3.30	12.72	34.12
	STD	0.60	1.00	3.41

3.7.7. Wind measurements for Deployment Three: April 2022 to May 2022

The descriptive statistics of the wind parameters measured over the entire deployment period and month-by-month is presented in Figure 72 and Table 22

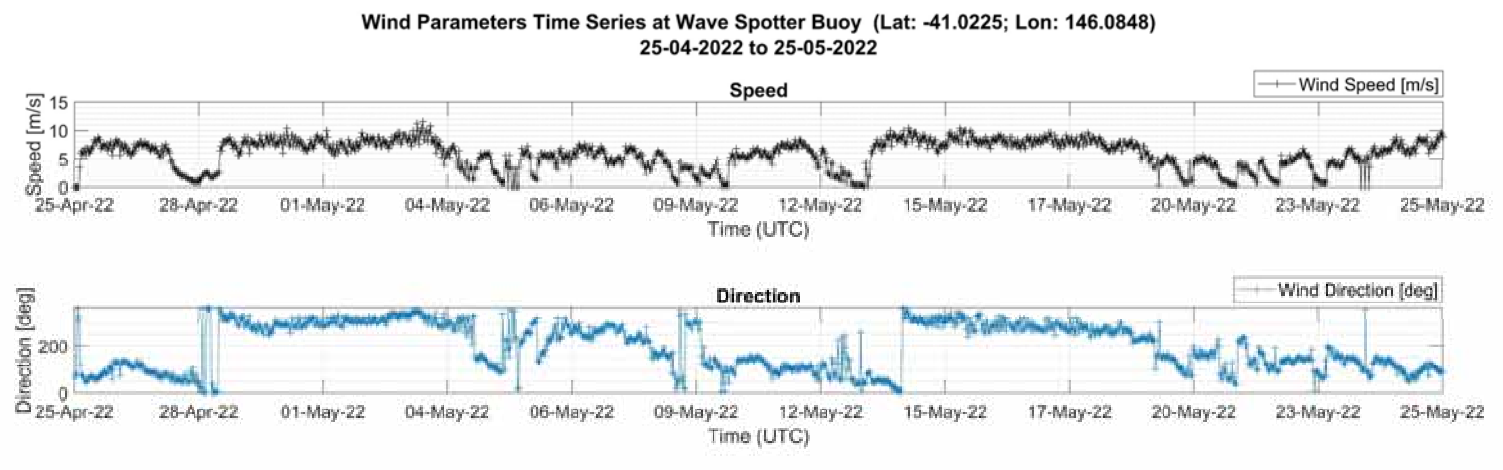

Figure 74: Wind speed and direction estimates from the Sofar Ocean Spotter during Deployment Three

Table 24: Wind speed statistics for Deployment Three (* denotes incomplete month)

Statistic	April-22*	May-22*
Min	0	0
Mean	5.86	5.77
Max	9.20	11.60
STD	2.56	2.52

3.7.8. Wave measurements for Deployment Four: July 2022 to December 2022

The descriptive statistics of the most relevant wave parameters measured over the entire deployment period and month-by-month is presented in Figure 75 and Table 25.

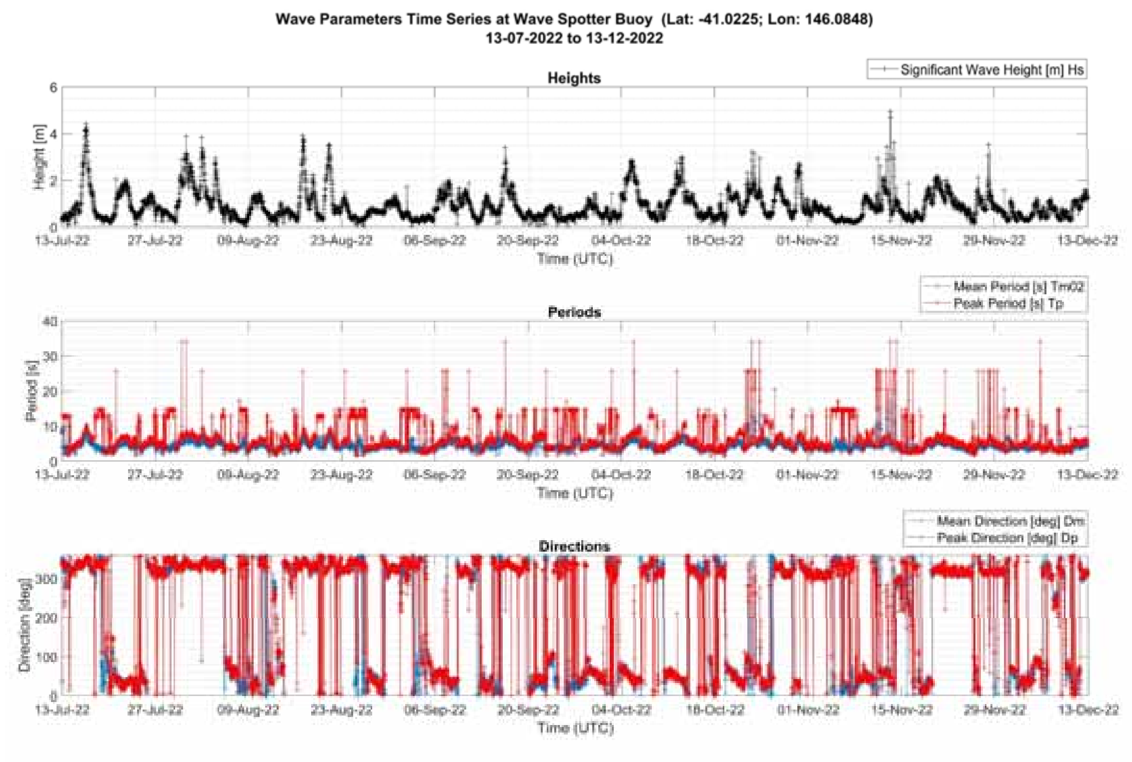

Figure 75: Wave time series of significant wave height, mean and peak period and mean and peak direction measured by the Sofar Ocean Spotter for Deployment Four

Table 25: Significant wave height, mean and peak periods for Deployment Four measured using the Sofar Ocean Spotter (* denotes incomplete month)

Statistics		Significant Wave Height Hs	Mean Period	Peak Period
Jul-22*	Min	0.10	1.66	1.60
	Mean	1.00	4.31	7.83
	Max	4.43	9.80	34.12
	STD	0.76	1.14	3.92
Aug-22	Min	0.04	1.62	1.50
	Mean	0.99	4.45	7.34
	Max	3.93	9.18	34.12
	STD	0.72	1.09	3.65
Sep-22	Min	0.03	1.60	1.54
	Mean	0.76	4.28	7.93
	Max	3.41	12.64	34.12
	STD	0.46	1.15	4.41
Oct-22	Min	0.09	1.66	1.36
	Mean	1.07	4.57	7.47
	Max	3.21	14.52	34.12
	STD	0.62	1.38	4.18
Nov-22	Min	0.15	1.70	1.70
	Mean	0.86	4.27	7.36
	Max	4.95	20.50	34.12
	STD	0.52	1.55	5.01
Dec-22*	Min	0.23	2.12	2.16
	Mean	0.67	3.80	6.00

Dec-22*	**Max**	1.59	12.00	34.12
	STD	0.31	0.72	3.64
All	**Min**	0.03	1.60	1.36
	Mean	0.91	4.34	7.44
	Max	4.95	20.50	34.12
	STD	0.61	1.26	4.26

3.7.9. Wind measurements for Deployment Four: July 2022 to December 2022

The descriptive statistics of the wind parameters measured over the entire deployment period and month-by-month is presented in Figure 75 and Table 26.

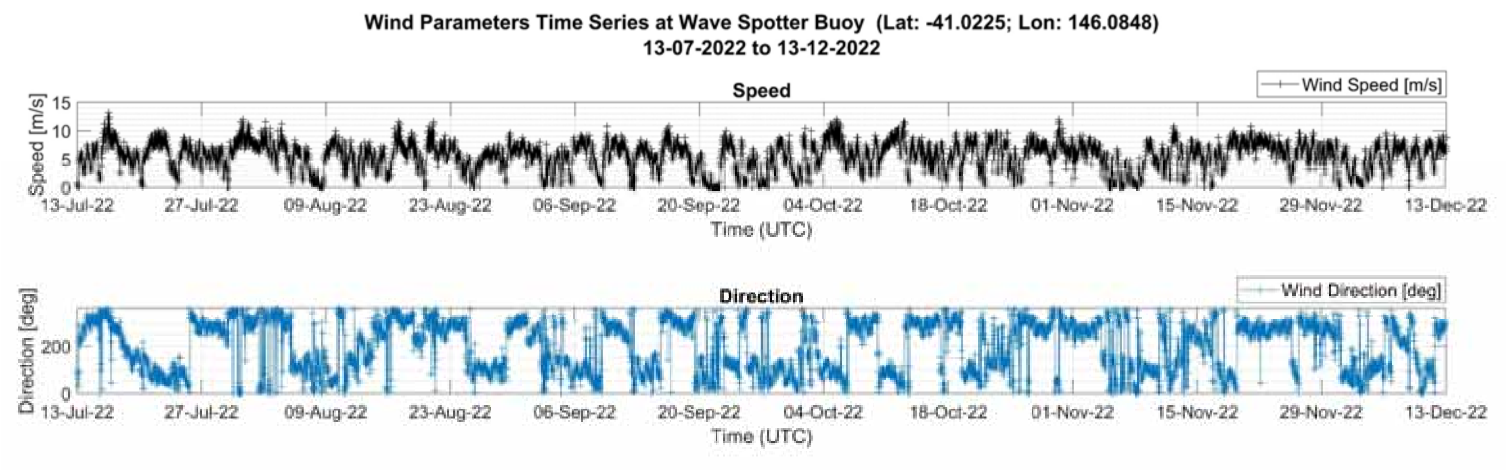

Figure 76: Wind speed and direction estimates from the Sofar Ocean Spotter during Deployment Four

Table 26: Wind speed statistics for Deployment Four (* denotes incomplete month)

Statistic	Jul-22*	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22*
Min	0	0	0	0	0	0
Mean	5.91	5.60	4.92	6.05	5.62	5.01
Max	13.12	12.00	10.80	12.00	10.80	9.60
STD	2.30	2.38	2.65	2.46	2.45	2.39

3.8. Water Quality

Salinity and other parameters measurements were trialled with a vertical profiling winch system housed in a surface buoy (Nautilus system paired with an Exo2 YSI water profiler, see section 2.10). However, due to heavy weather the profiling mechanism broke down after only short period of use. A few times the profiling mechanism could be rebooted remotely but during periods when the system was not in operation, no data could be collected (hence the data gaps in the plots).

The collected Temperature, DO and Salinity profiles taken between end of March to Mid-May 2022 suggest that the water column is well mixed within the top 40 meters but was periodically stratified in the bottom 5 meters (**Error! Reference source not found.** to **Error! Reference source not found.**).

Between March and May the DO levels remained relatively constant throughout the time at ~ 8mg/L (Figure 78). Salinity varied only little and was found to be between 35.5 PSU 35.7PSU. Chlorophyll levels were around 3mg/L in March and reduced to under 1,5 mg/L in May (Figure 79).

In general, the data collection with the profiling system is too short for a more robust analysis. The temperature data was also collected with a thermistor chain which proved the more reliable method in harsh environments and this data is discussed further in section 4.8

Figure 80 gives a hint of how important and significant profiling systems can be if data density across the water column is required.

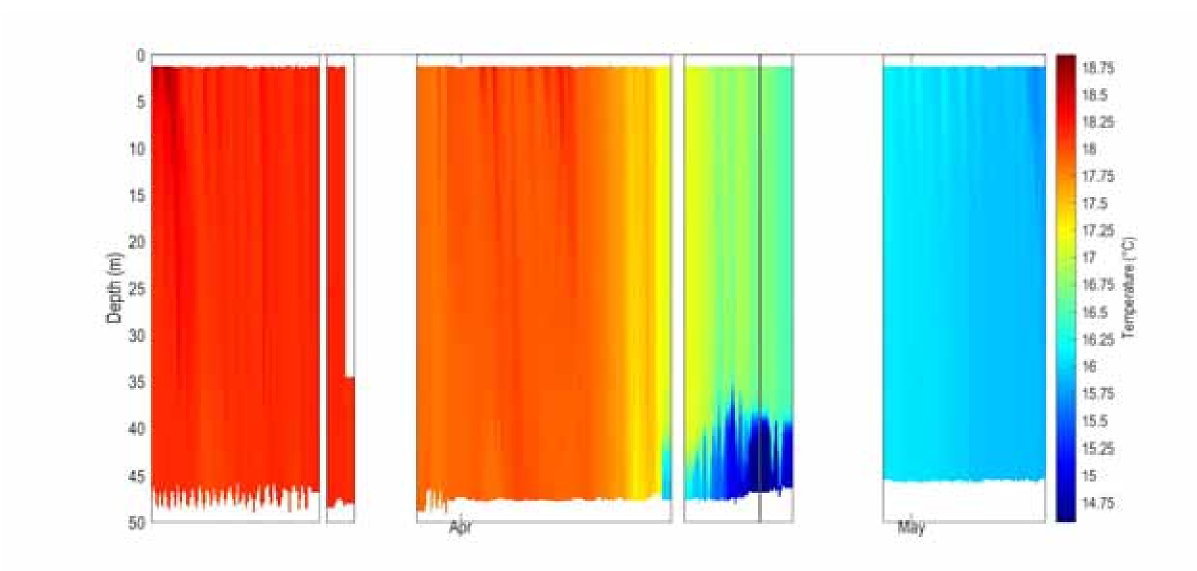

Figure 77 Time series of temperature profiles between March and May 2021

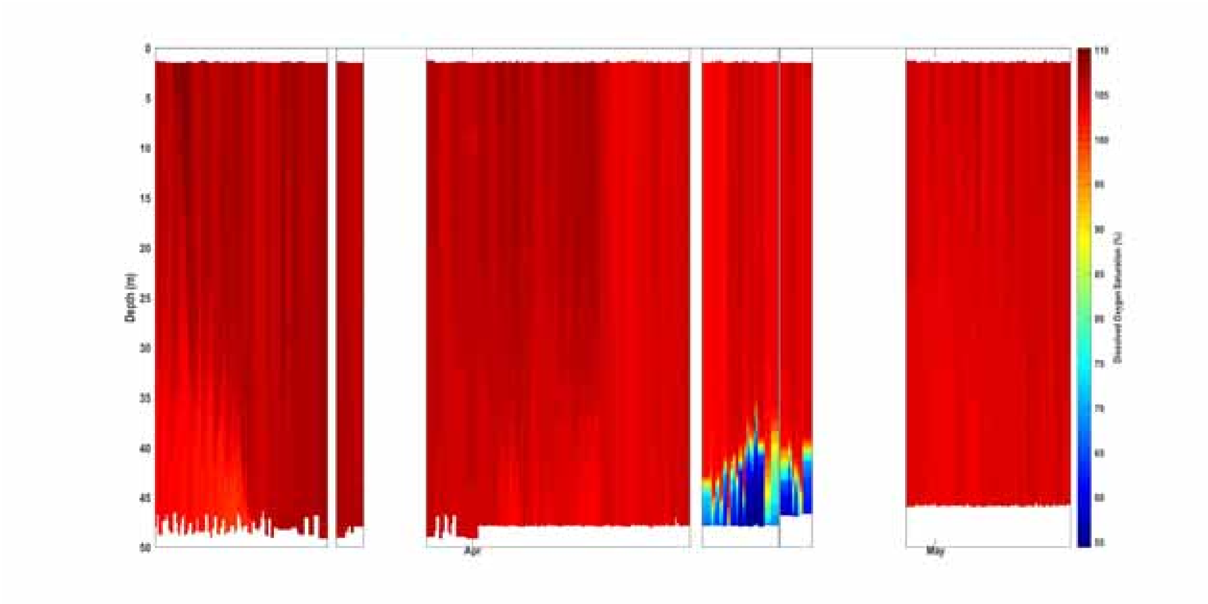

Figure 78 Time series of DO profiles between March and May 2021

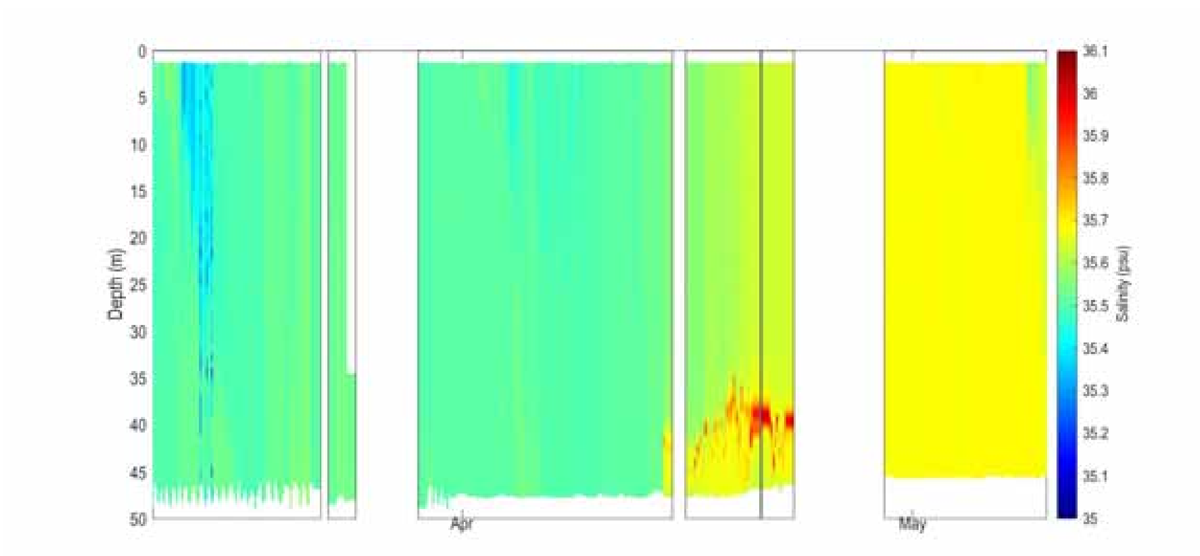

Figure 79 Time series of Salinity profiles between March and May 2021

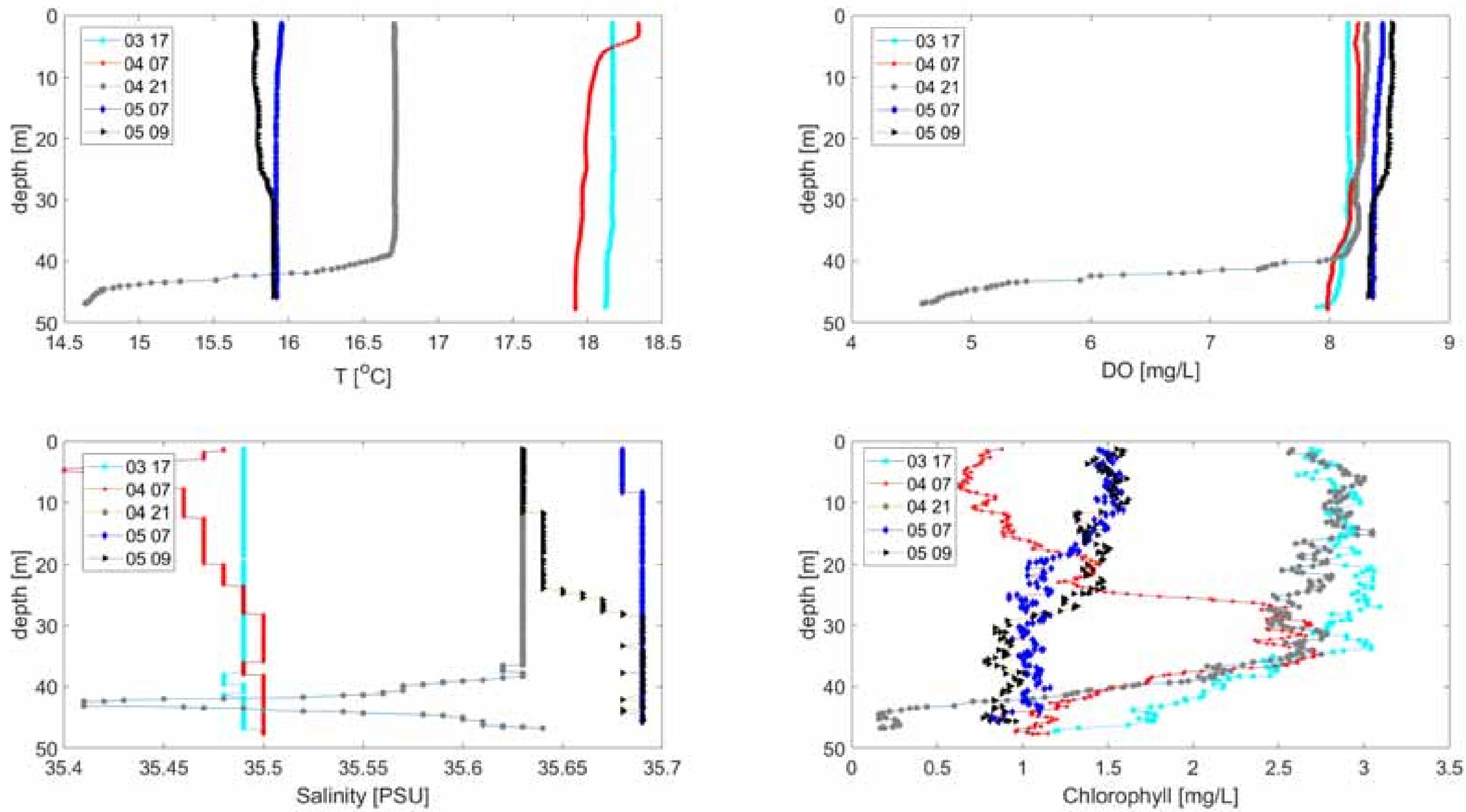

Figure 80 Profiles of water quality parameters between March and May 2021. Top left: temperature. Top right: DO. Bottom left: Salinity. Bottom right: Chlorphyll-

3.9. Water Temperature

3.9.1. Deployment One: Length of data recorded / battery life

The date of first and last good data (in UTC) as well as total length of deployments in the BEZ are shown in Table 27. All loggers returned good data except for Logger 100421, which gave erroneous temperature readings throughout its deployment as shown in Figure 81.

Table 27. Distribution of SoloT loggers along the water column and deployment time frames

RBR Solo T Serial Number	Depth from Bottom of Rope	Date & Time First Good Data (UTC)	Date & Time Last Good Data (UTC)
100404	0	24-11-2021 23:06:29	26-4-2022 00:36:29
100429	10	24-11-2021 23:007:33	26-4-2022 00:37:33
100405	20	24-11-2021 23:04:46	26-4-2022 00:34:46
100410	30	24-11-2021 23:07:55	26-4-2022 00:32:55
100421	40	-	-
100408	50	24-11-2021 23:04:11	26-4-2022 00:29:11
100415	56.7	24-11-2021 23:06:01	26-4-2022 00:31:01
100418	63.4	24-11-2021 23:06:02	26-4-2022 00:31:02

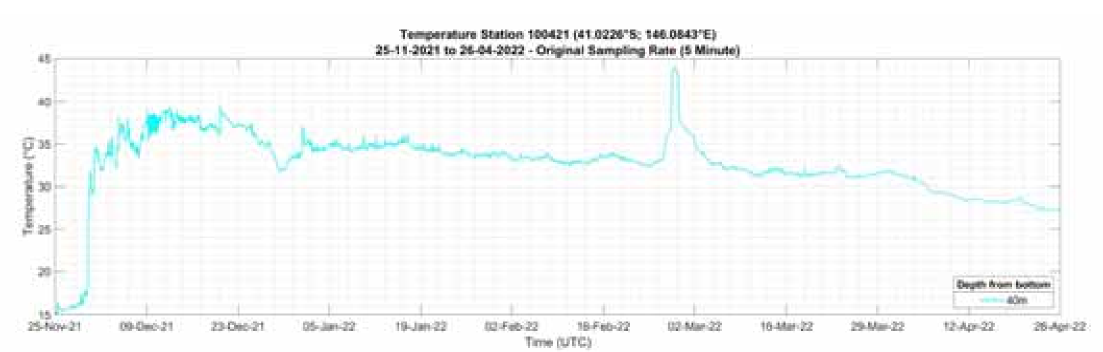

Figure 81: Measurement error on Logger 421 showing initial spike on deployment and slow reduction in temperature readings

3.9.2. Plots and statistics for Deployment One: November 2021 to April 2022

Figure 82 to Figure 88 below presents the raw 5-minute average temperature time series from the 7 temperature loggers deployed on the temperature station from 25-11-2021 to 26-4-2022; Table 28 presents the statistics of the temperature loggers.

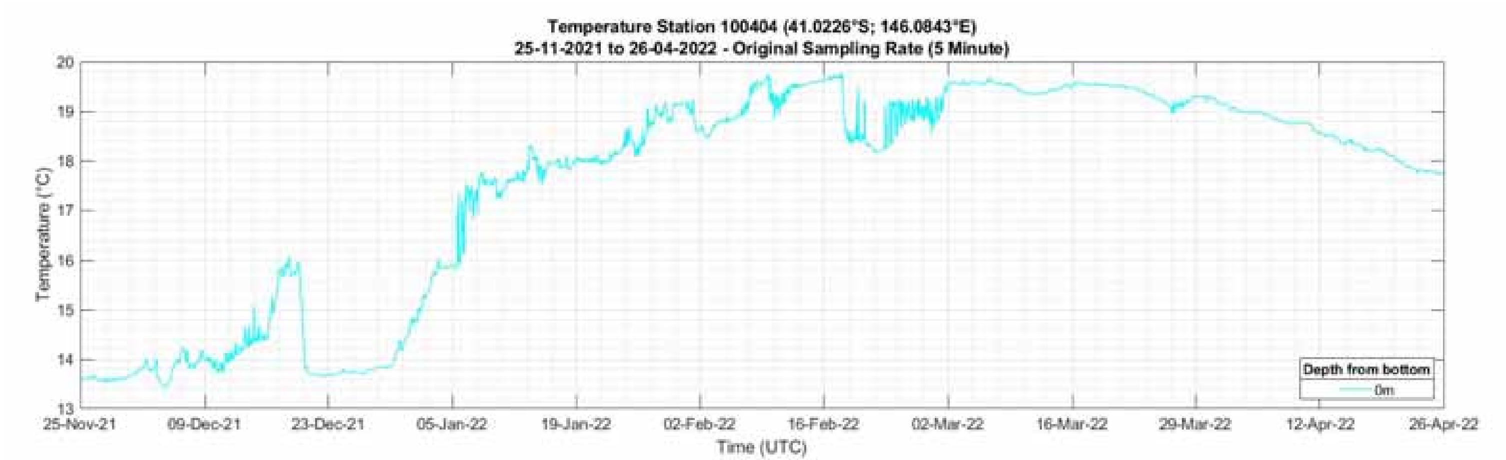

Figure 82: Water temperature at Station 10404 0 m from bottom of mooring from 25-11-2021 to 26-4-2022

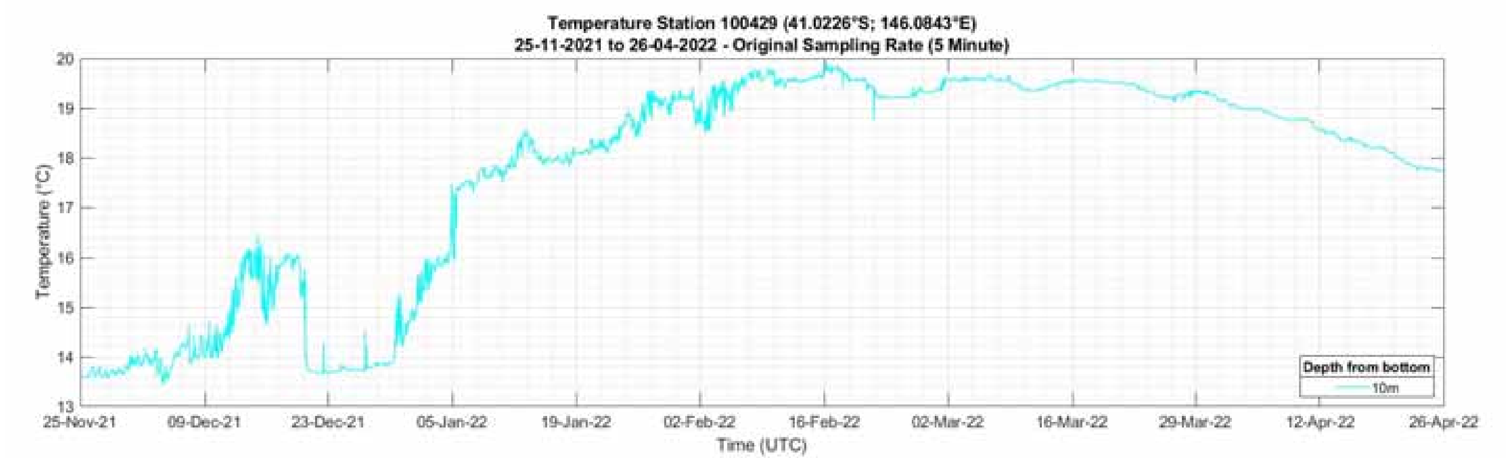

Figure 83: Water temperature at Station 10429 10 m from bottom of mooring from 25-11-2021 to 26-4-2022

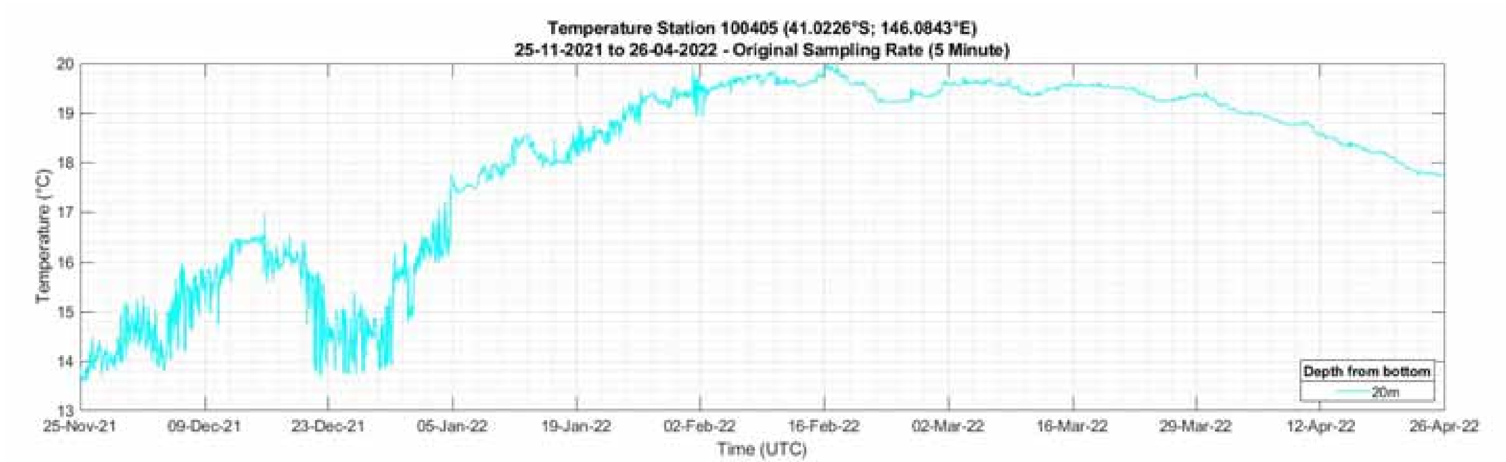

Figure 84: Water temperature at Station 10405 20 m from bottom of mooring from 25-11-2021 to 26-4-2022

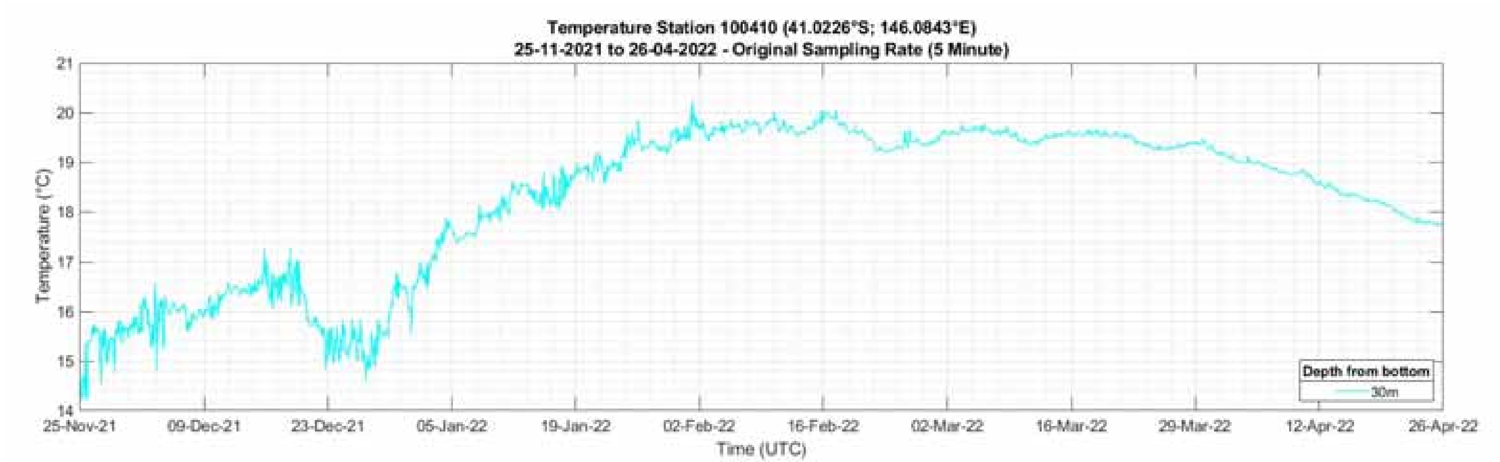

Figure 85: Water temperature at Station 10410 30 m from bottom of mooring from 25-11-2021 to 26-4-2022

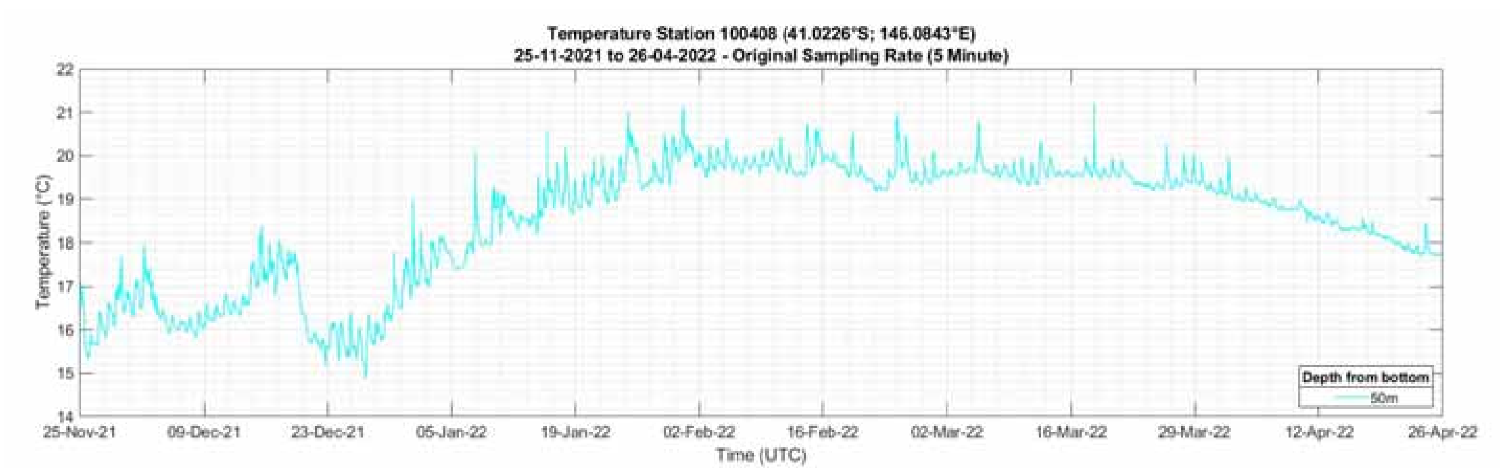

Figure 86: Water temperature at Station 10408 50 m from bottom of mooring from 25-11-2021 to 26-4-2022

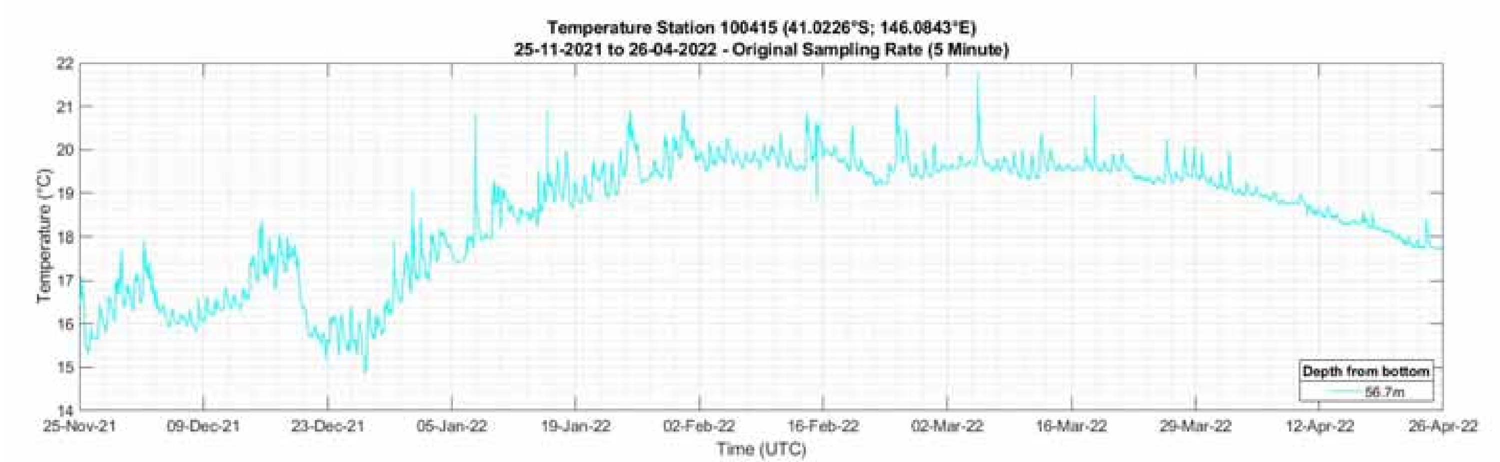

Figure 87: Water temperature at Station 10415 56.7 m from bottom of mooring from 25-11-2021 to 26-4-2022

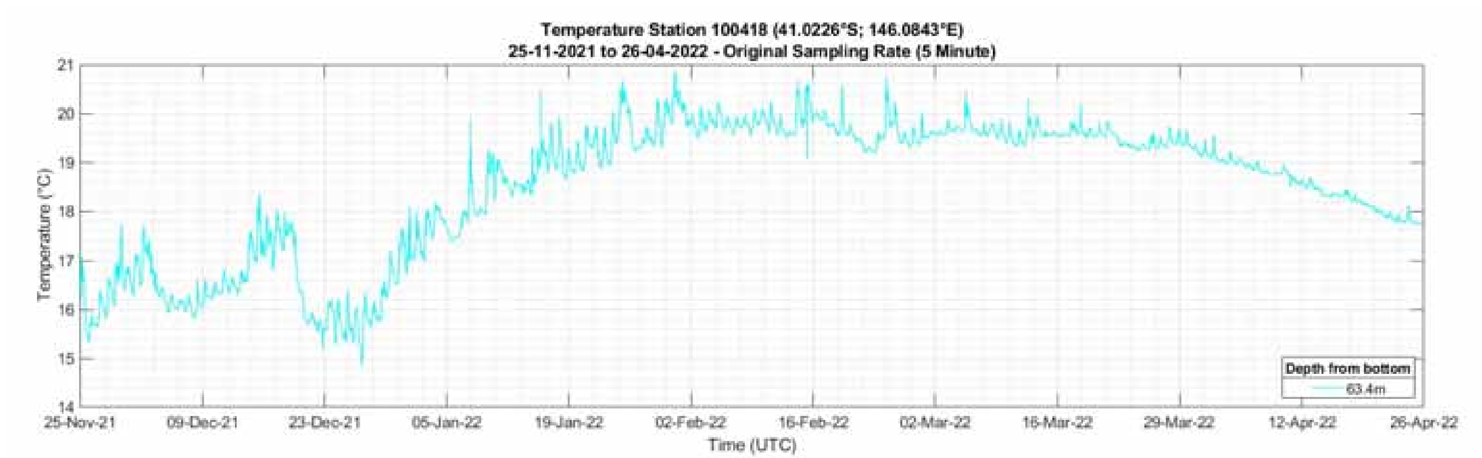

Figure 88: Water temperature at Station 104018 63.4 m from bottom of mooring from 25-11-2021 to 26-4-2022

Table 28: Deployment One water temperature statistics from November 2021 to April 2022 (* denotes incomplete month)

		Temperature (°C) for each Depth (m from bottom of mooring)						
		0	10	20	30	50	56.7	63.4
RBR Solo T Serial Number		100404	100429	100405	100410	100408	100415	100418
Nov-21*	Min	13.54	13.58	13.59	14.22	15.34	15.32	15.34
	Mean	13.60	13.68	14.11	15.34	16.27	16.27	16.26
	Max	13.68	13.95	15.20	15.84	17.71	21.05	17.73
Dec-21	Min	13.43	13.46	13.70	14.58	14.86	14.86	14.85
	Mean	14.12	14.40	15.29	15.99	16.45	16.45	16.45
	Max	16.07	16.41	16.96	17.31	18.39	18.36	18.34
Jan-22	Min	14.51	14.65	14.83	15.56	16.73	16.72	16.73
	Mean	17.56	17.80	18.07	18.35	18.89	18.78	18.76
	Max	19.19	19.38	19.52	19.85	21.13	20.94	20.56
Feb-22	Min	18.17	18.50	18.93	19.21	19.18	18.89	19.08
	Mean	19.03	19.43	19.54	19.61	19.78	19.77	19.76
	Max	19.77	19.93	19.99	20.23	20.98	21.02	20.73
Mar-22	Min	18.78	19.13	19.23	19.23	19.19	19.18	19.21
	Mean	19.42	19.45	19.47	19.49	19.56	19.57	19.55
	Max	19.68	19.68	19.74	19.79	21.22	21.81	20.46
Apr-22*	Min	17.69	17.69	17.69	17.69	17.68	17.68	15.72
	Mean	18.48	18.48	18.48	18.48	18.50	18.50	18.50
	Max	19.24	19.24	19.24	19.23	20.00	19.97	19.54

3.9.3. *Deployment Two: Length of data recorded / battery life*

The date of first and last good data (in UTC) as well as total length of Deployment Two in the BEZ are shown in Table 29. All loggers returned good data except for Logger 100421, which again gave erroneous temperature readings throughout its deployment as shown in Figure 89Figure 81.

Table 29. Deployment Two distribution of SoloT loggers along the water column and deployment time frames

RBR Solo T Serial Number	Depth from Bottom of Rope	Date & Time First Good Data (UTC)	Date & Time Last Good Data (UTC)
100408	0	26-4-2022 02:19:00	5-12-2022 23:14:00
100415	10	26-4-2022 02:11:00	5-12-2022 23:06:00
100404	20	26-4-2022 02:16:00	5-12-2022 23:11:00
100405	30	26-4-2022 02:14:00	5-12-2022 23:09:00
100429	40	26-4-2022 02:17:00	5-12-2022 23:12:00
100418	50	26-4-2022 02:21:00	5-12-2022 23:16:00
100421	56.7	-	-
100410	63.4	26-4-2022 02:29:24	5-12-2022 23:24:24

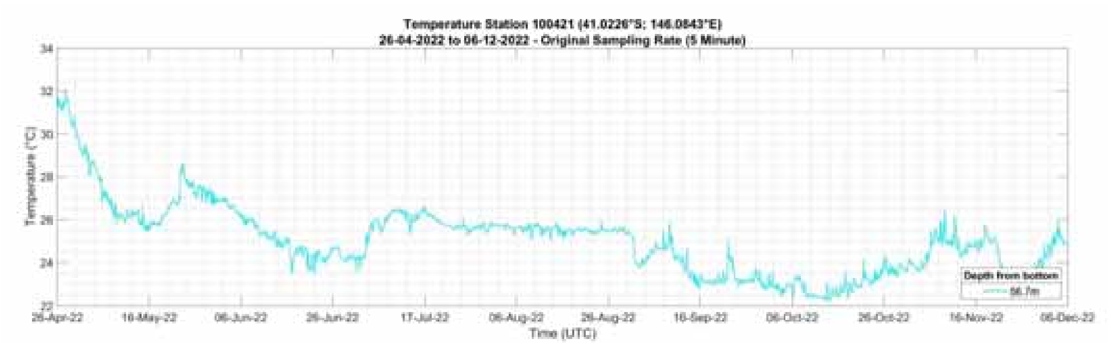

Figure 89: Deployment Two measurement error on Logger 421 showing initial spike on deployment and slow reduction in temperature readings

3.9.4. Plots and statistics for Deployment Two: April 2022 to December 2022

Figure 90 to Figure 96 below presents the raw 5-minute average temperature time series from the 8 temperature loggers deployed on the temperature station from 26-4-2022 to 6-12-2022; Table 30 presents the statistics of the temperature loggers.

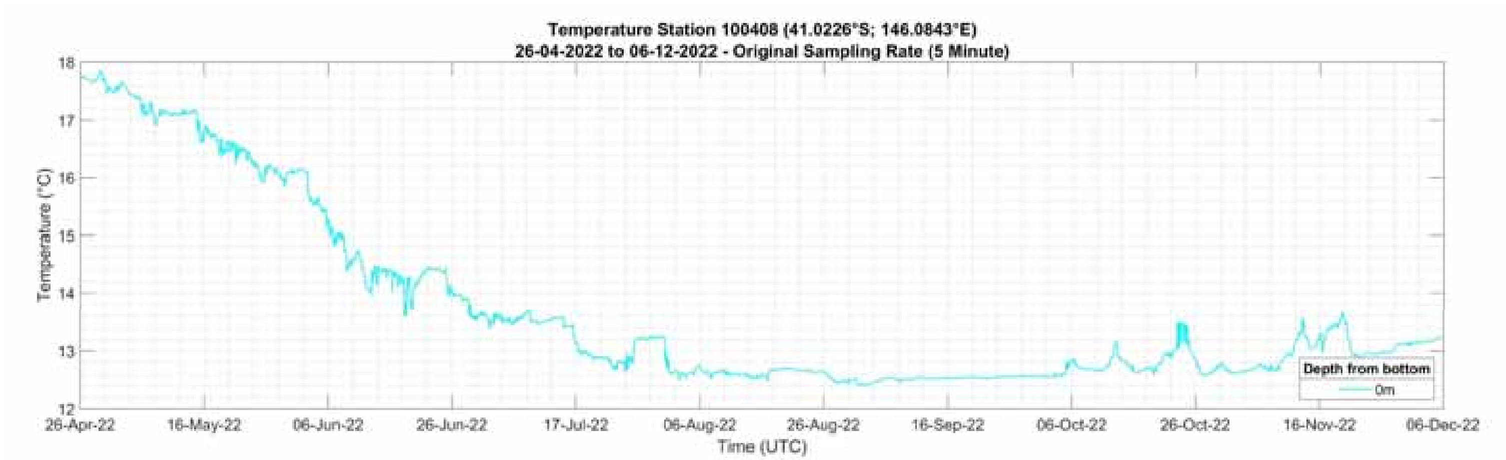

Figure 90: Water temperature at Station 10408 0 m from bottom of mooring from 26-4-2022 to 6-12-2022

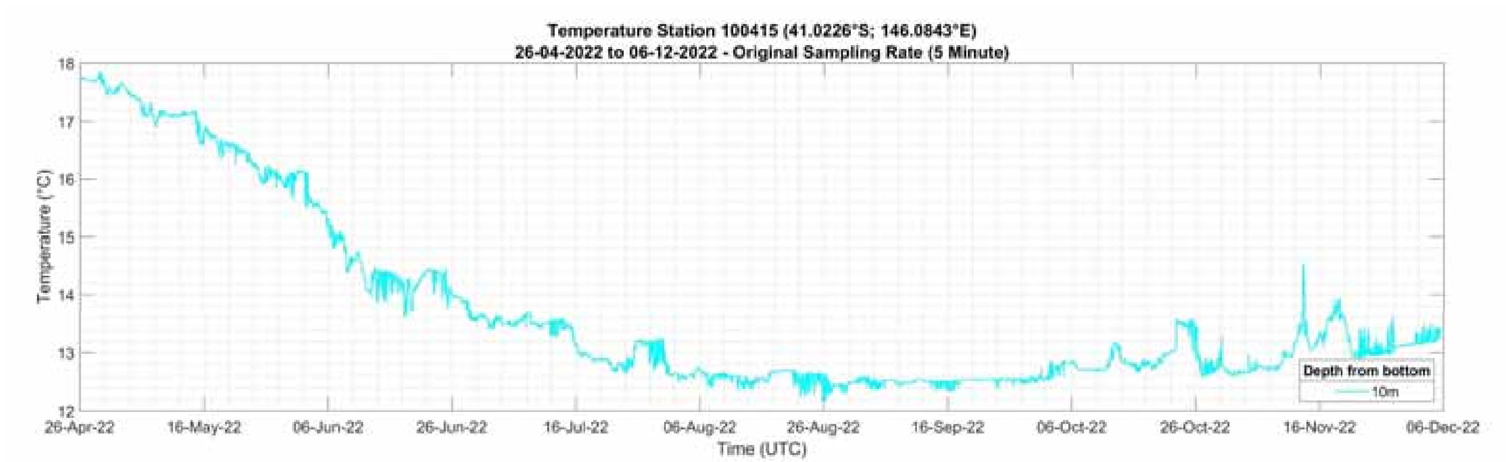

Figure 91: Water temperature at Station 10415 10 m from bottom of mooring from 26-4-2022 to 6-12-2022

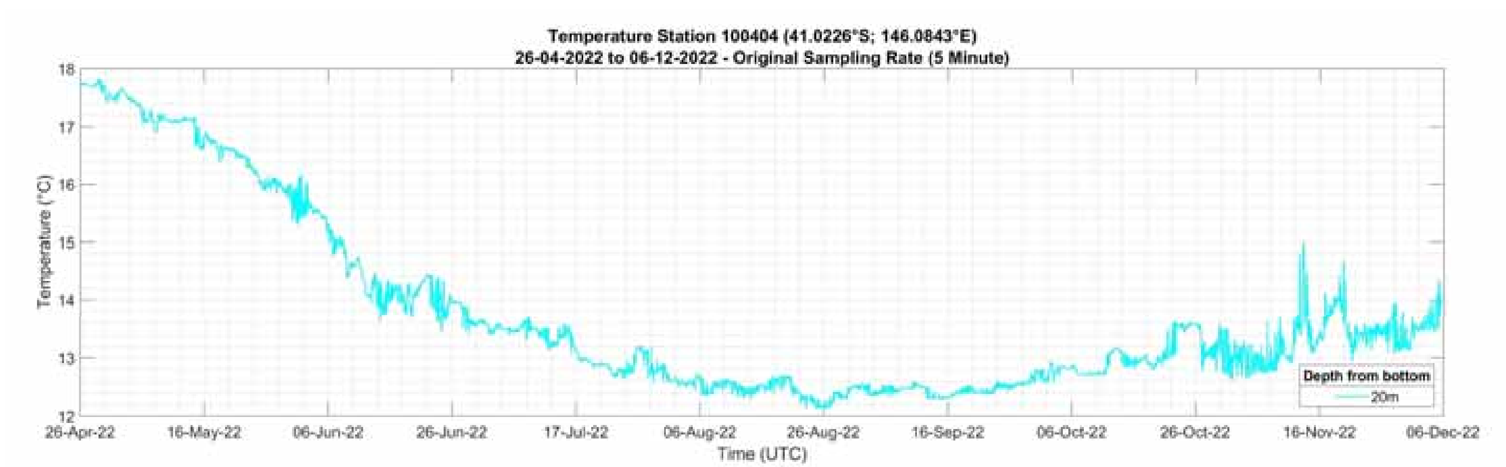

Figure 92: Water temperature at Station 10404 20 m from bottom of mooring from 26-4-2022 to 6-12-2022

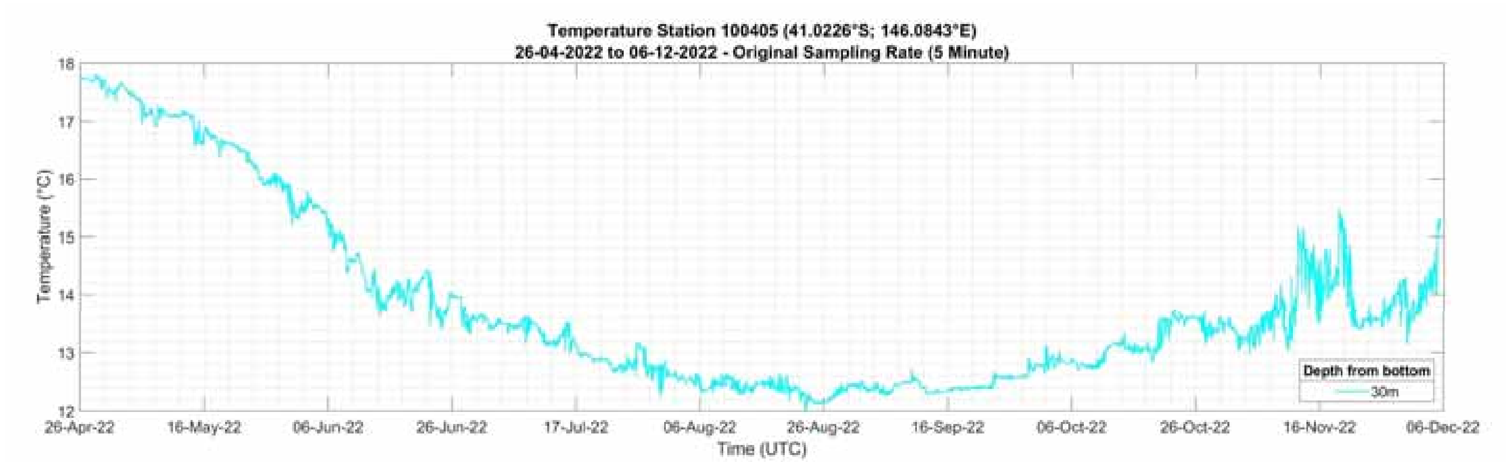

Figure 93: Water temperature at Station 10405 30 m from bottom of mooring from 26-4-2022 to 6-12-2022

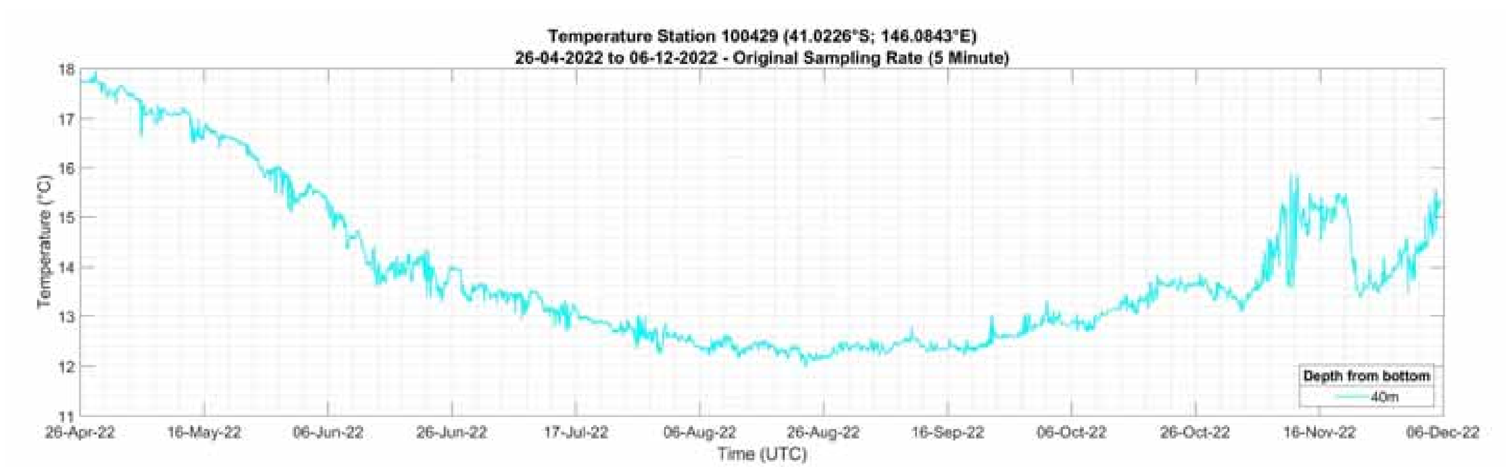

Figure 94: Water temperature at Station 10429 40 m from bottom of mooring from 26-4-2022 to 6-12-2022

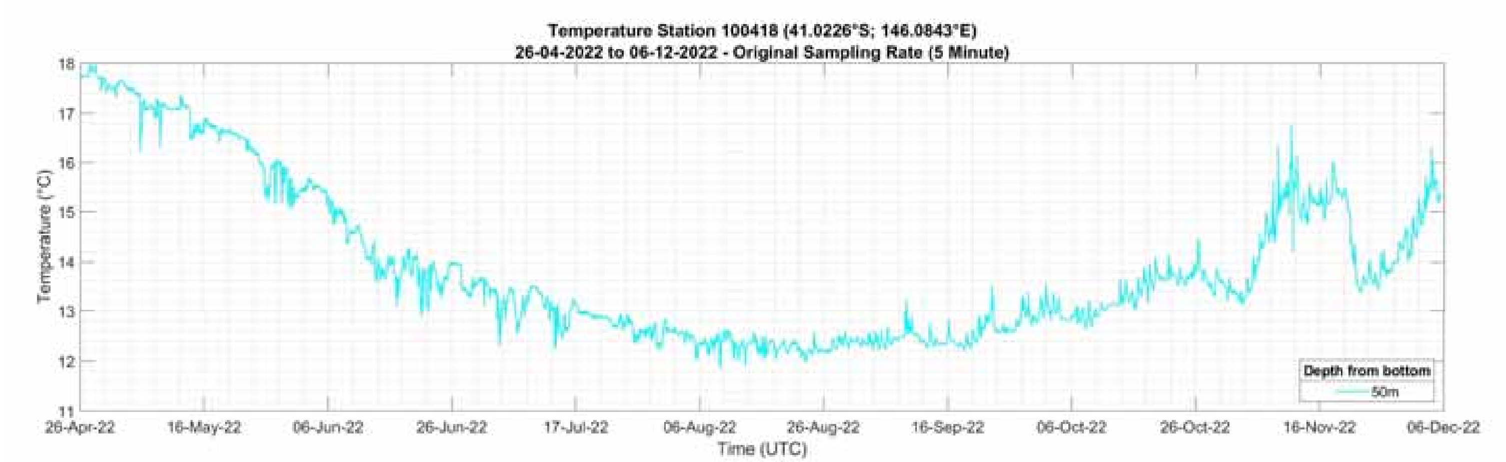

Figure 95: Water temperature at Station 10418 50 m from bottom of mooring from 26-4-2022 to 6-12-2022

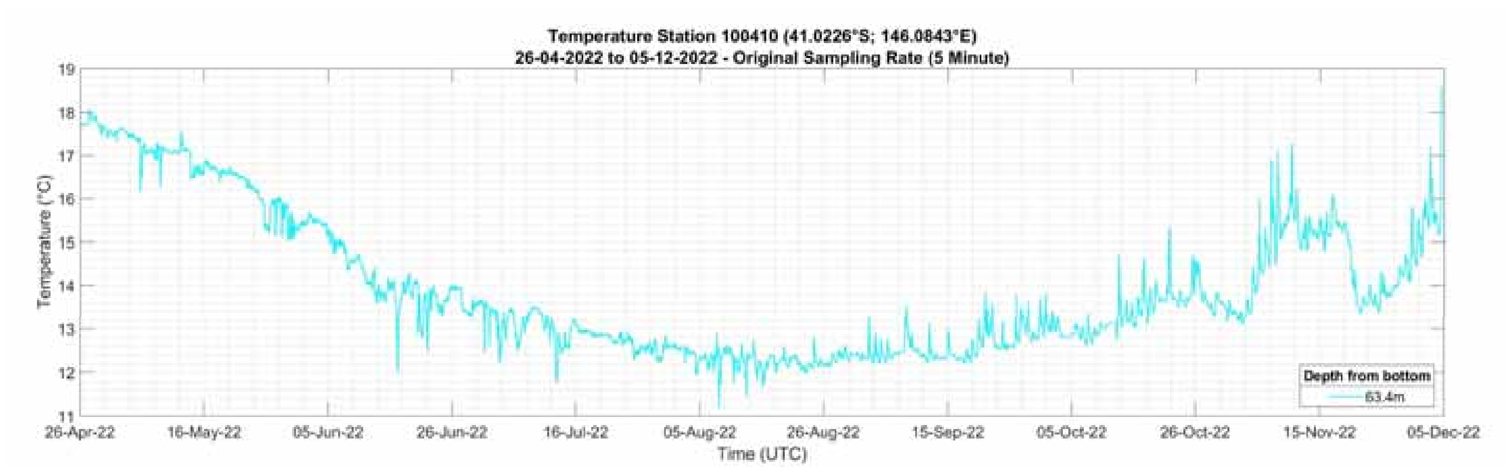

Figure 96: Water temperature at Station 10410 64.3 m from bottom of mooring from 26-4-2022 to 6-12-2022

Table 30: Water temperature statistics from April 2022 to December 2022 (* denotes incomplete month)

		Temperature (°C) for each Depth (m from bottom of mooring)						
		0	10	20	30	40	50	63.4
RBR Solo T Serial Number		100408	100415	100404	100405	100429	100418	100410
Apr-22*	Min	17.65	15.59	17.57	17.56	17.52	17.45	17.42
	Mean	17.72	17.71	17.71	17.72	17.73	17.76	17.74
	Max	17.85	17.85	17.82	17.81	17.94	17.98	18.08
May-22	Min	15.85	15.69	15.39	15.21	15.08	15.06	15.03
	Mean	16.83	16.82	16.81	16.80	16.77	16.73	16.68
	Max	17.72	17.72	17.71	17.71	17.71	17.71	17.66
Jun-22	Min	13.54	13.53	13.41	13.32	13.28	12.89	11.98
	Mean	14.60	14.58	14.47	14.40	14.36	14.29	14.23
	Max	16.15	16.15	16.14	15.78	15.70	15.70	15.69
Jul-22	Min	12.63	12.63	12.56	12.25	12.24	12.23	11.75
	Mean	13.28	13.25	13.19	13.14	13.06	12.96	12.91
	Max	13.70	13.70	13.70	13.68	13.67	13.69	13.70
Aug-22	Min	12.43	12.16	12.13	12.01	11.99	11.85	11.21
	Mean	12.62	12.57	12.47	12.41	12.67	12.34	12.31
	Max	13.23	13.10	12.89	12.86	12.86	12.86	12.93
Sep-22	Min	12.39	12.32	12.29	12.24	12.23	12.22	12.19
	Mean	12.52	12.51	12.46	12.44	12.46	12.53	12.58
	Max	12.56	12.61	12.75	12.91	13.06	13.53	13.84
Oct-22	Min	12.54	12.48	12.56	12.65	12.59	12.64	12.61
	Mean	12.76	12.86	13.00	13.13	13.25	13.33	13.38

	Max	13.51	13.58	13.63	13.75	13.86	14.46	15.33
Nov-22	**Min**	12.62	12.62	12.62	12.97	13.09	13.12	13.09
	Mean	12.98	13.05	13.33	13.84	14.26	14.45	14.55
	Max	13.67	14.53	15.00	15.47	15.9	16.77	17.29
Dec-22*	**Min**	13.08	13.1	13.13	13.15	13.46	13.99	14.46
	Mean	13.16	13.21	13.54	14.11	14.56	15.05	15.38
	Max	13.25	13.51	14.35	15.31	15.58	16.31	18.58

4. Discussion

4.1. Wind Measurements Comparisons between Burnie Station and the Sofar Wave Spotter

Comparisons of wind speed between the Australian Baseline Sea Level Monitoring Project Burnie station and the Sofar Ocean Spotter results are shown in Figure 97. Little correlation can be seen between the wind speed and direction measurements between the two measurement stations, with the offshore wind speed significantly higher than that found at Burnie. This result is expected as higher and more consistent wind speeds are often found offshore. These results indicates that measurements offshore are needed to fully understand the local wind conditions in the BEZ offshore region.

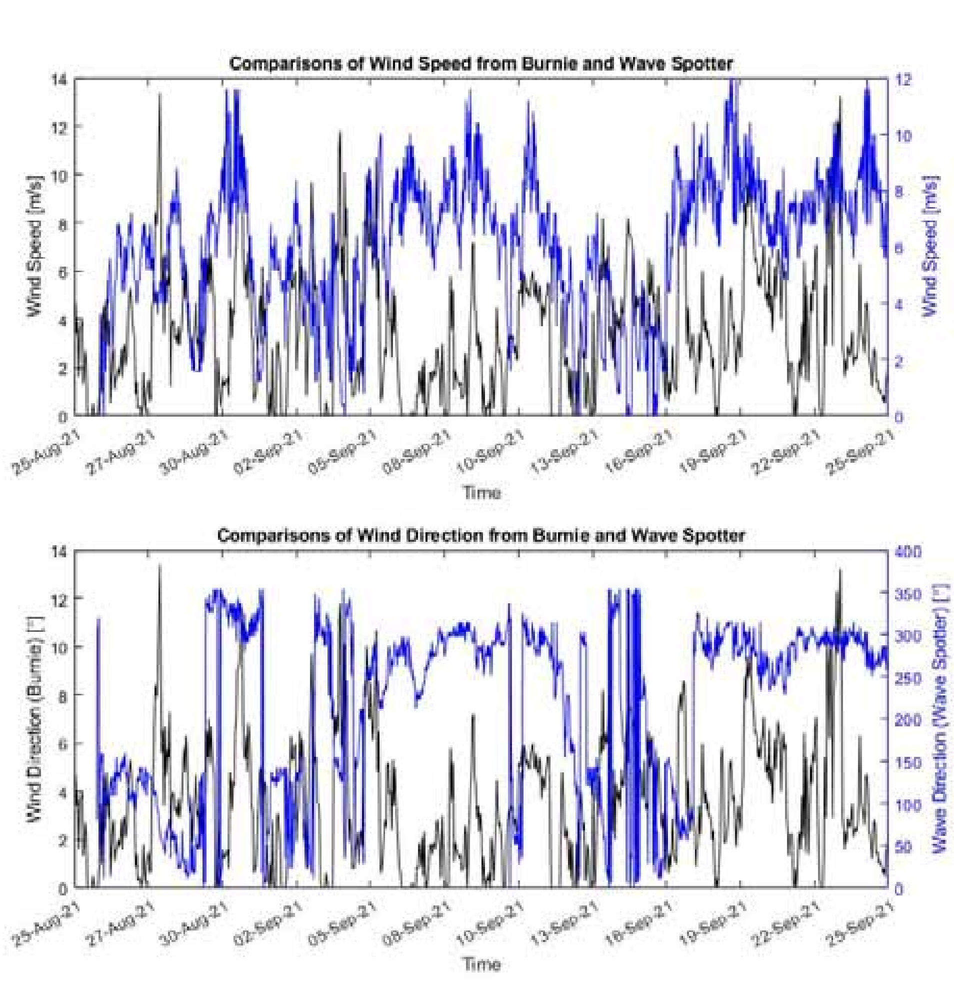

Figure 97: Comparison of wind speed for Australian Baseline Sea Level Monitoring Project Burnie station with Ocean Spotter buoy wind data

4.2. Wind Measurements Comparisons between the CAWCR Model and the Sofar Wave Spotter

Comparison of the CAWCR model wind speed and direction estimates with the Sofar Ocean Spotter buoy wind dataset are shown in Figure 98. As shown, close correlation between both the wind speed and direction were found between the model and buoy measurements. During processing of the Sofar Wave

Buoy dataset a maximum wind speed of 12 m/s was found during deployment, which may be an artificial limit as the wind speed is not directly measured but rather determined from the measured wave conditions.

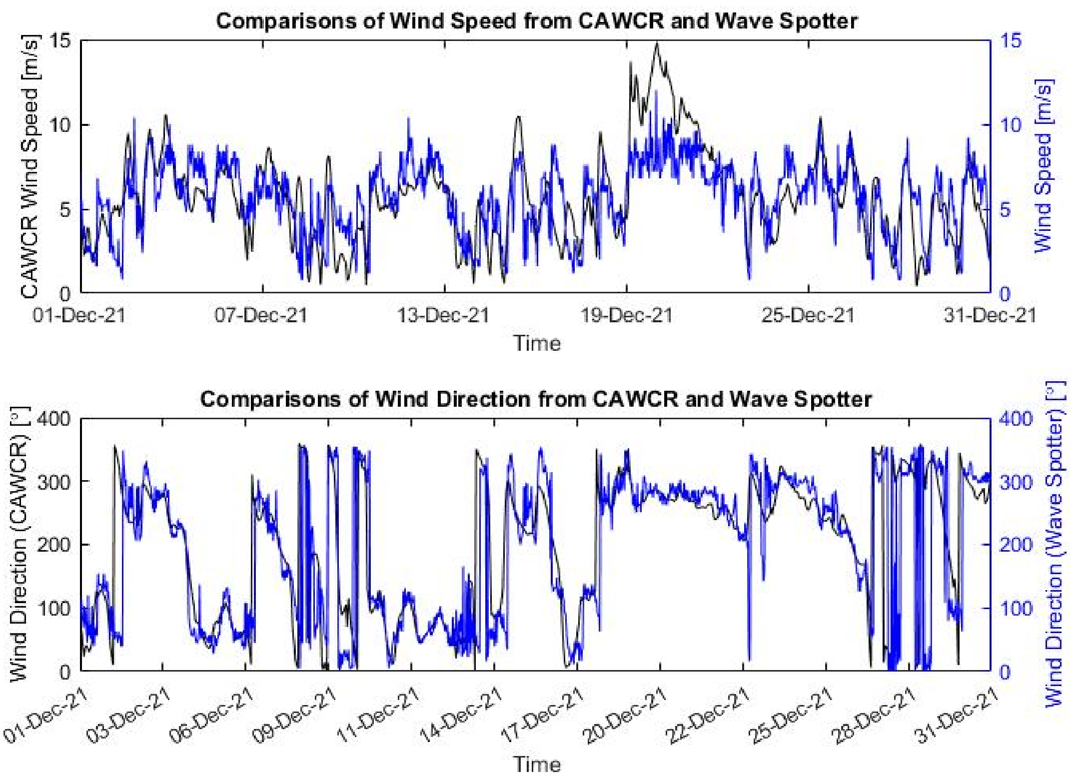

Figure 98: Comparison of CACWR model wind speed and direction with Ocean Spotter buoy measurements for December 2021

4.3. Comparison of Sofar Wave Spotter and ADCP Wave Measurements

Comparison of wave measurements between the ADCP wave and Sofar Wave Spotter buoy are shown in Table 31. Reasonable agreement between the mean Significant Height (Hs) was found between the measurement devices, however large differences in mean wave period between the ADCP and Sofar Wave Spotter were found. Reasons for this discrepancy are unknown.

Table 31: Comparisons of wave Significant Height (Hs) and Mean Period for the ADCP and Sofar Wave Spotter Buoy over the total deployment periods for each device

	ADCP	Sofar Wave Spotter Buoy
Mean Hs (m)	1.02	0.91
Mean Period (s)	2.96	4.25

4.4. Harmonic Tidal Constituents

Using the UTide tidal analysis and prediction software (Codiga, 2011), the first five harmonic tidal constituents were extracted from the ADCP tidal height results as shown in Table 32. These constituents compare favourably with those measured at the Burnie tidal gauge (Wijeratne et al, 2012) and give confidence in the ADCP results obtained during the field campaigns. The largest constituent found was the M2 tidal constituent as commonly found in tidal-driven ocean regions.

Table 32: Harmonic tidal constituents calculated from the ADPC data for each Deployment and from the Burnie tidal gauge from literature (Wijeratne et al., 2012)

Tidal Constituent	ADCP Deployment						Wijeratne (2012)
	One	Two	Three	Four	Five	Average	
M2	1.15	1.12	1.12	1.16	1.16	1.14	1.14
N2	0.21	0.29	0.27	0.24	0.26	0.26	-
K1	0.19	0.13	0.20	0.14	0.17	0.17	0.16
S2	0.14	0.16	0.12	0.17	0.15	0.15	0.14
O1	0.11	0.11	0.12	0.12	0.11	0.11	0.12

4.5. Current Speed Analysis

Comparisons of the depth-averaged current speed with wind speed and direction are shown in Figure 99 for ADCP measurements from December 2021. The tidal currents were influenced by significant wave height, as shown around 20th December 2021 where heights of above 3 m result in an increase in the depth-averaged tidal current magnitudes. The depth-averaged current speed was also influenced by wind speed and direction, where combinations of high wind speed and wind directions from the North-West (approximately 300°) resulted in higher depth-averaged currents as shown around the 16th December 2021. This compares with results from around the 12th December 2021, where although the wind speed is high, the Easterly wind direction (approximately 90°) results in minimal increases in depth-averaged current speed above the tidally-forced current. This influence of wind on current speed is thought to occur due to local wind effects along the Northern Tasmanian coastline.

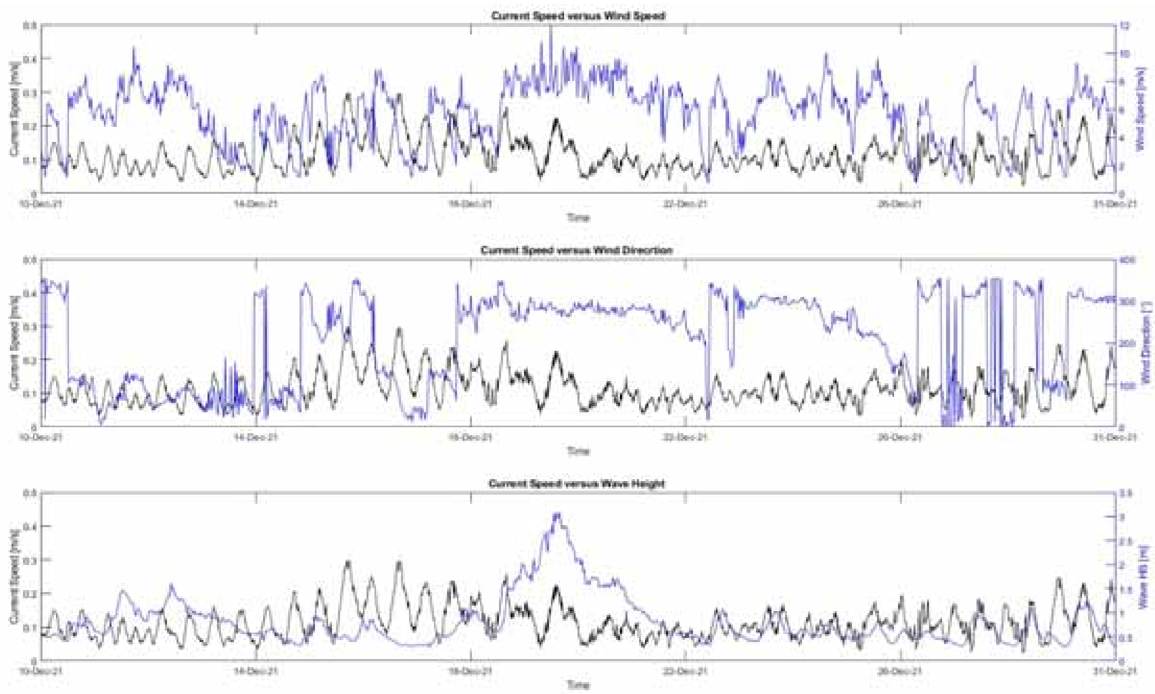

Figure 99: Comparison of ADCP results for depth-averaged current speed with Sofar Wave Buoy wind speed and direction measurements

The mean values of tidal current are evenly spread across the bottom, middle and upper water column, with no significant increase in mean current speed at the top of the water column, with averages of 0.09 m/s, 0.09 m/s and 0.10 m/s found from the ADCP results. However, results for maximum current speed indicate an increase in maximum current speed at the top of the water column, with maximum values increasing from 0.41 m/s at the bottom and middle water column to 0.48 m/s at the top of the water column. This is suggested to occur as a result of the wind-driven nature of the tidal current in the BEZ region.

4.6. Wave Analysis

For all ADPC results, the wave directions were strongly focused in the North-West to North-East quadrants. This occurred due to the considerable wave fetch in Northerly directions as the ADPC and Sofar Wave Spotter measurement locations were close to the Tasmanian mainland. During May to August the wave directions, as shown in Figure 58, shifted strongly to the North-Western quadrant as a result of winter storms that pass through Bass Strait in the West-East direction. In summer months this shifted along with the wind direction to a more North-Easterly direction as shown in the wave rose ADCP results in Figure 50, Figure 54, Figure 58, Figure 62, and Figure 66.

4.7. Water quality

The water quality measurements were only available for a short period of time. Figures **Error! Reference source not found.** to **Error! Reference source not found.** demonstrate the usefulness of continuous vertical profiling for baseline studies. However, due to the failure of the mechanism after 6 weeks of measurements and complex logistics to maintain the profiler it became evident that more work needs to be done to design a more robust system suitable for the offshore environment.

4.8. Water Temperature

Considerable seasonal water temperature fluctuations were found over the period November 2021 to December 2022, with Figure 100 and Figure 101 showing that temperature varies considerably with both depth and time-period. Initially from November 2021 to January 2022 the water column is well stratified, with a gradual increase in temperature rising through the water column. This lack of mixing during the late summer months is likely caused both by the lack of strong tidal currents in the central Bass Strait region where the temperature station was located combined with summer warming of the water. However, a distinct increase in mixing occurred after February 2022, where the water column becomes fully mixed. Interestingly, an inversion of temperature occurs where the surface water is colder than that at depth, the reasons for which are unknown. The water column again stratifies from October 2022 onwards, indicating a highly seasonal water column behaviour. Longer term temperature sensor deployments will indicate whether this occurs annually. Additional deployment of current measuring devices and salinity measurements may also clarify reasons for the water column temperature inversion in the winter months.

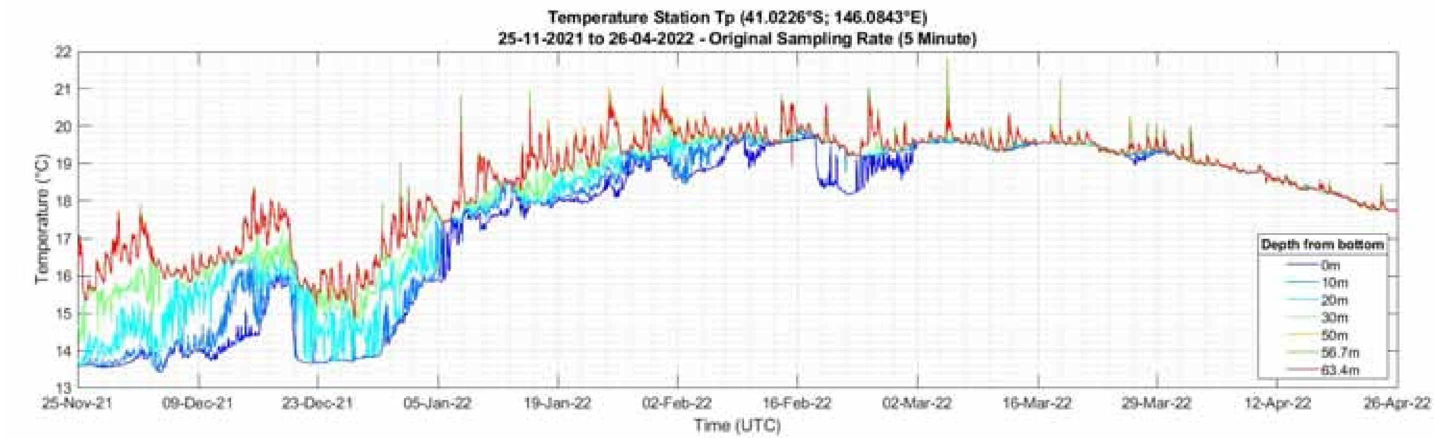

Figure 100: Deployment One water temperature profiles showing a distinct change in water mixing occurring over the late summer months

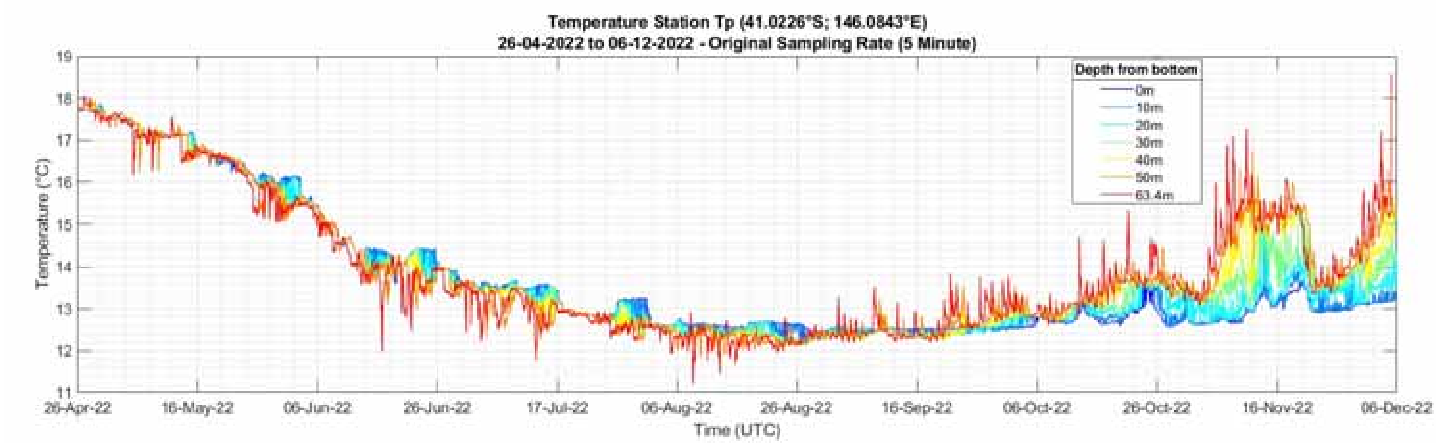

Figure 101: Deployment Two water temperature profiles showing a distinct change in water mixing occurring in early Summer as well as temperature inversion in winter months

5. Trawl Data

5.1. Trawl results

Data collected on the BE Zone Trawl Survey included:

- Station information (date, time, tow coordinates, depth, and trawl spread)
- Environmental data (water temperature)
- Total weights of mobile and sessile epifauna in each trawl
- Total weight and quantity for all mobile epifauna species encountered
- Length frequency data for most species

Results

The FTV Bluefin departed from Beauty Point on 29th November and returned to Beauty Point on 30th November 2021. The survey was conducted at six locations in the BE Zone on 29th and 30th November 2021. A complete list of trawl locations, coordinates, dates, times, and depths are detailed in Table 33.

Table 33 Details of the time, location, depth, water temperature, trawl direction and trawl speed for the six trawls

Date	No.	Trawl Start	Trawl End	Start Position	End Position	Depth (m)	Temp (°C)	Trawl Direct.	Trawl (Knts)
29 Nov	1	1318	1338	41°00.68’ S 146°12.29’E	41°00.59’S 146°10.19’E	56 55.6	15.7 15.7	WNW	3.4
29 Nov	2	1501	1531	40°56.41’S 146°04.70’E	40°55.59’S 146°03.06’E	64.9 65.0	15.7 15.8	WNW	3.2
29 Nov	3	1744	1814	41°01.93’S 146°02.62’E	41°01.93’S 146°04.64’E	47 49.6	16.4 16.7	ESE	3.2
30 Nov	4	0650	0720	40°55.75’S 145°51.96’E	40°54.79’S 145°50.29’E	46.1 48.1	15.2 15.1	NNW	3.2
30 Nov	5	0836	0906	40°51.47’S 145°49.92’E	40°52.09’S 145°51.93’E	55.2 55.3	14.9 14.9	SE	3.2
30 Nov	6	1009	1039	40°55.053’S 145°55.45’E	40°55.9365’S 145°57.013’E	55.9 58.4	15.2 15.2	ESE	3.1

The approximate positions of each trawl are shown in Figure 102.

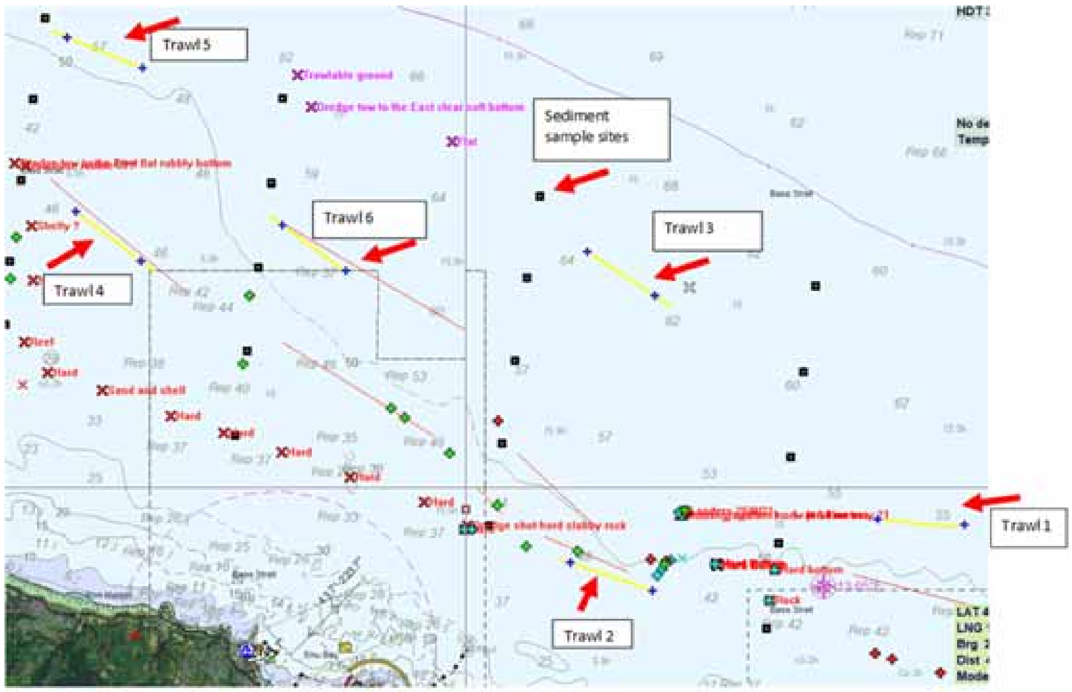

Figure 102 Map showing the approximate positions of each trawl (yellow lines) during the BE Zone trawl survey

The approximate positions of each trawl in relation to depth are shown in Figure 103.

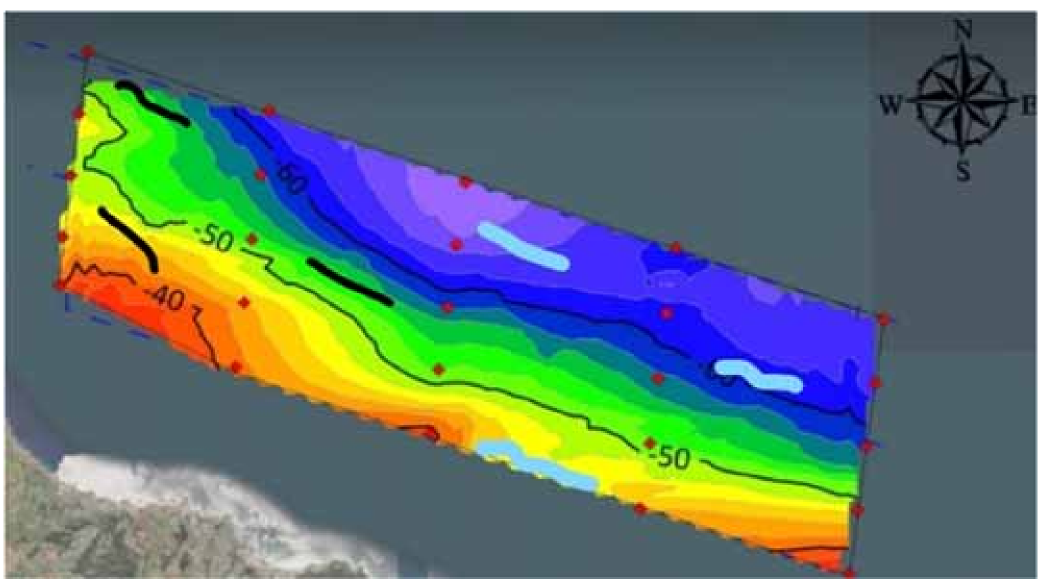

Figure 103 Approximate positions of trawls overlayed on the depth (in metre) contours within the BE Zone

The distance across the seabed (based on the starting and finishing positions), the estimated trawl speed and swept area of each trawl are detailed in Table 34.

Table 34 Trawl distance based on Haversine formula and trawl duration of 30 minutes

Trawl No.	Trawl Distance (nm)	Estimated Trawl Speed (knots)	Swept area (km^2)
1	1.587	3.17	0.138
2	1.486	2.97	0.129
3	1.524	3.05	0.133
4	1.586	3.17	0.138
5	1.624	3.28	0.143
6	1.475	2.95	0.128

Based on the otter board spread of 47 m for each trawl, the total estimated total swept area of the 6 trawls was 0.81 km2.

The total estimated catch in the trawls was 2.024 tonnes with 1.188 tonnes of sessile epifauna (58.7%) and 836 kg of mobile epifauna (41.3%). The total catches within each trawl are shown in Table 35. The weight of the total mixed catch varied from a minimum of 192.74 kg to a maximum of 484.40 kg, with a mean of 337.41 kg (SD = 95.25). The proportion of mobile epifauna in each trawl ranged from 17.8% (trawl 6) to 58.6% (trawl 4).

Table 35 Estimated weight of mobile, sessile, and total catch, and proportion of mobile to total catch in each trawl

Trawl	1	2	3	4	5	6	Total
Mobile benthos (kg)	96.87	77.34	133.83	283.90	178.00	66.03	836.00
Sessile benthos (kg)	221.75	115.40	219.00	200.50	126.50	305.40	1 188.550
Total weights (kg)	318.61	192.74	352.82	484.40	304.47	371.43	2 024.475
Mobile to total	30.4%	40.1%	37.9%	58.6%	58.5%	17.8%	41.3%

The total numbers of mobile epifauna caught was 3 844 of 51 different species. A low of 25 (trawl 1) and a high of 36 (trawl 5) species were identified in an individual tow. The overall breakdown of the mobile epifauna trawl catch was fish (32 species from 26 families), elasmobranchs (sharks and stingarees, 7 species from 5 families), cephalopods (cuttlefish and calamary, 6 species from 4 families), echinoderms (sea cucumbers and seastars, 3 species from 3 families) and crustaceans (bugs and crabs, 2 species from 2 families). Fish (75.5% by numbers and 46.8% by weight) and elasmobranchs (19.7% by numbers and 48.2% by weight) made up most of the mobile epifauna (Table 36). The total catches of each species of the mobile epifauna during the survey are summarised in Table 37. The numbers and weights of each species in each trawl are summarised in Appendix 1 and 2 respectively.

Table 36 Total numbers (Nos) and weights (Wt) and proportion of numbers (% Nos) and weight (%Wt) by family

	Nos	% Nos	Wt (kg)	% Wt
Fish	2 903	75.5%	390.90	46.8%
Elasmobranchs	756	19.7%	403.37	48.2%
Cephalopods	136	3.5%	34.00	4.2%
Crustaceans	15	0.4%	2.80	0.3%
Echinoderms	32	0.8%	3.76	0.4%
Other	2	0.1%	0.18	0.0%
TOTAL	3 844		836.00	

Summary information and images of most of the species caught during the survey are provided in Appendix 3. The length frequency distributions of each species from each trawl are summarised in Appendix 4.

Table 37 Catch numbers and weights by species and the percentage of trawls that each species was caught (Occurrence)

Common name	Scientific name	Family	Numbers	% Numbers	Weights (kg)	% Weight	Occurrence
Common gurnard	*Neosebastes scorpaenoides*	Neosebastidae	731	19.02%	126.026	15.07%	100%
Cocky gurnard	*Lepidotrigla modesta*	Triglidae	724	18.83%	29.022	3.47%	100%
Butterfly gurnard	*Lepidotrigla vanessa*	Triglidae	447	11.63%	40.286	4.82%	100%
Sparsely spotted stingaree	*Urolophus paucimaculatus*	Urolophidae	324	8.43%	97.588	11.67%	67%
Degens leatherjacket	*Thamnaconus degeni*	Monocanthidae	262	6.82%	21.086	2.52%	100%
Banded stingaree	*Urolophus cruciatus*	Urolophidae	202	5.25%	97.658	11.68%	100%
Common stinkfish	*Foetorepus calauropomus*	Callionymidae	127	3.30%	17.253	2.06%	67%
Draughtboard shark	*Cephaloscyllium laticeps*	Scyliorhinidae	126	3.28%	136.458	16.32%	83%
Barracouta	*Thyrsites atun*	Gempylidae	100	2.60%	10.051	1.20%	83%
Toothbrush leatherjacket	*Acanthaluteres vittiger*	Monocanthidae	69	1.80%	7.767	0.93%	83%
Jackass morwong	*Nemadactylus macropterus*	Latridae	57	1.48%	10.766	1.29%	33%
New Holland cuttlefish	*Sepia novaehollandiae*	Sepidae	57	1.48%	12.205	1.46%	83%
Silver biddy	*Parequula melbournensis*	Gerreidae	55	1.43%	4.218	0.50%	100%
Thornback skate	*Dentiraja lemprieri*	Rajidae	55	1.43%	35.34	4.23%	83%
Porcupinefish	*Diodon nicthemerus*	Diodontidae	39	1.01%	13.407	1.60%	67%
Sand flathead	*Platycephalus bassensis*	Platycephalidae	39	1.01%	16.961	2.03%	83%
Barber perch	*Caesioperca rasor*	Serranidae	37	0.96%	3.49	0.42%	17%
Bluestriped goatfish	*Upeneichthys lineatus*	Mullidae	37	0.96%	8.693	1.04%	83%
Southern calamary	*Sepioteuthis australis*	Loliginidae	31	0.81%	4.048	0.48%	100%
Sea cucumber	*Holothurians*	Holothuroidea	29	0.75%	3.626	0.43%	67%
Shaw's cowfish	*Aracana aurita*	Aracanidae	28	0.73%	8.345	1.00%	100%
Elephantfish	*Callorhinchus milii*	Callorhinchidae	27	0.70%	44.728	5.35%	50%
Bearded cod	*Pseudophycis barbata*	Moridae	26	0.68%	6.126	0.73%	33%
John dory	*Zeus faber*	Zeidae	23	0.60%	5.9	0.71%	83%
Silver dory	*Cyttus australis*	Cyttidae	21	0.55%	1.117	0.13%	67%
Arrow squid	*Nototodarus gouldi*	Ommastrephidae	19	0.49%	4.573	0.55%	83%
Giant Australian cuttlefish	*Sepia apama*	Sepidae	19	0.49%	13.902	1.66%	83%

Ocean perch	*Helicolenus percoides*	Sebastidae	17	0.44%	2.857	0.34%	50%
Sixspine leatherjacket	*Meuschenia freycineti*	Monocanthidae	14	0.36%	2.957	0.35%	17%
Snotty trevally	*Seriolella brama*	Centrolophidae	13	0.34%	2.166	0.26%	50%
Piked dogfish	*Squalus megalops*	Squalidae	12	0.31%	2.389	0.29%	17%
Balmain bug	*Ibacus peronii*	Scyllaridae	11	0.29%	1.019	0.12%	83%
Australian burrfish	*Allomycterus pilatus*	Diodontidae	9	0.23%	4.384	0.52%	50%
Sandyback stingaree	*Urolophus bucculentus*	Urolophidae	9	0.23%	18.527	2.22%	33%
Toothy flathead	*Platycephalus aurimaculatus*	Platycephalidae	8	0.21%	5.462	0.65%	50%
Octopus		Octopodidae	7	0.18%	0	0.00%	67%
Sergeant baker	*Latropiscis purpurissatus*	Aulopidae	6	0.16%	3.839	0.46%	33%
Tiger flathead	*Platycephalus richardsoni*	Platycephalidae	5	0.13%	1.555	0.19%	50%
Giant spider crab	*Leptomithrax gaimardii*	Majidae	4	0.10%	1.78	0.21%	33%
Hedley's cuttlefish	*Sepia hedleyi*	Sepidae	3	0.08%	0.269	0.03%	17%
Long snout boarfish	*Pentaceropsis recurvirostris*	Pentacerotidae	2	0.05%	0.772	0.09%	17%
Magnificent biscuit seastar	*Tosia magnifica*	Goniasteridae	2	0.05%	0.057	0.01%	33%
Old wife	*Enoplosus armatus*	Enoplosidae	2	0.05%	0.438	0.05%	17%
Sea squirt	*Ascidians*	Ascidiacea	2	0.05%	0.183	0.02%	17%
Bluespot flathead	*Platycephalus speculator*	Platycephalidae	1	0.03%	3.581	0.43%	17%
Bluethroat wrasse	*Notolabrus tetricus*	Labridae	1	0.03%	0.676	0.08%	17%
Common sawshark	*Pristiophorus cirratus*	Pristiophoridae	1	0.03%	1.8	0.22%	17%
Gunns leatherjacket	*Eubalichthys gunnii*	Monocanthidae	1	0.03%	0.164	0.02%	17%
Hardyhead	*Kestratherina esox*	Atherindae	1	0.03%	0.0046	0.00%	17%
Magpie perch	*Pseudogoniistius nigripes*	Latridae	1	0.03%	0.405	0.05%	17%
Velvet seastar	*Petricio vernicina*	Asteropseidae	1	0.03%	0.078	0.01%	17%
Totals			3844		836.00		

The species richness and the Simpson's Diversity Index (DI) within each trawl are shown in Table 38.

Table 38 Species richness and Simpson's Diversity Index within each trawl

Trawl	1	2	3	4	5	6	Total
Species Richness	25	26	29	29	36	26	51
Simpson's DI	0.818	0.805	0.853	0.807	0.890	0.884	

The Sorenson's Community Similarity Indices between each trawl site are shown in Table 39.

Table 39 Sorenson's Community similarity indices between trawls (the closer the value is to 1, the more the communities have in common).

Trawl	1	2	3	4	5	6
1	X	0.627	0.667	0.704	0.656	0.745
2		X	0.618	0.582	0.677	0.731
3			X	0.724	0.646	0.691
4				X	0.708	0.691
5					X	0.710
6						X

5.2. SUMMARY

The total catch weight from six, 30-minute trawls was 2.024 tonnes.

- The overall catch composition consisted of sessile (58.7%) and mobile (41.3%) epifauna by weight.
- The proportion of sessile epifauna varied between trawls from 82.2% (trawl 6) to 41.4 (trawl 4).
- Fifty-one different species were identified in the mobile epifauna.
- Most (75.5%) of the mobile epifauna by numbers consisted of fish, and the common gurnard (Neosebastes scorpaenoides) was the most abundant species (n = 731).

There is no known published data to make comparisons of the species composition and catch rates recorded in this survey and from other fishing activities within the BE Zone. In the animal ethics application, an estimated catch rate was 1 000 fish per hour based on data from previous trawling activity by the FTV Bluefin around different locations in Tasmania. In this survey, the total numbers of individuals caught was 3 844 during 3 hours of trawling representing a higher catch rate of 1 281 individuals per hour.

All trawl locations have diverse mobile epifauna based on the Simpson's Diversity Index values of greater than 0.8, with trawl 5 being the most diverse (SC = 0.89).

Based on the Sorenson's Community Similarity Index, the most similar trawls (sites) were 1 and 6 (SC=0.745), which were both of a similar depth (approximately 56 m) and the most dissimilar trawls (sites) were 2 and 4 (SC=0.582), which were the deepest (approximately 65m) and shallowest (approximately 47 m) sites respectively.

6. Conclusions & Recommendations

The area of the Bass Strait BEZ has been monitored in a baseline study to gain first insights into the site characteristics to support demonstration projects (offshore) in the Blue Economy CRC. Among other parameters, the Wave climate, water depths, the benthic habitat as well as seafloor conditions suggest suitability for offshore projects. Based on the findings, the Blue Economy CRC and its industry partners have to decide what projects and milestones can be realised in the BEZ Tasmania.

Following the observations reported here some recommendations can be made that should be discussed further and considered in future projects in this BEZ Tasmania. These include:

- The Temperatures exceeded 19C throughout the water column in the late summer months, with values above 21C at the surface. Such temperatures can be considered a significant stressor for fish farming in temperate waters. It is recommended to keep monitoring the temperature at this site over the next summer (until late summer in 2023) to see if these high temperatures are considered an outlier or if this temperature range is indeed more common in Bass Strait. It is also recommended to implement such temperature spikes in any long term prediction models.
- The vertical profiling mechanism usually used in calm nearshore environments is insufficient for an energetic offshore environment. Monitoring with vertical profiling set ups needs to rely on more robust systems (such as strings of loggers sampling at certain depths) to overcome issues associated with strong and dynamic wave climates that occur (occasionally) at this site. This also calls for a need to design and implement new monitoring techniques for offshore applications.
- Parameters such as salinity and DO have not been monitored to the degree as anticipated. Future projects should aim to collect this information to complement the baseline description and gain a better understanding of physical and biological processes in the BEZ.
- Due to the budget the baseline study did only focus on temperature, wave and current data collected in one location. While these parameters can be assumed to have little variation over a larger spatial content, it is recommended to monitor the parameters in other locations in the BEZ, either for validation purposes or if a planned project is to take place in a different area of the BEZ where the singe point measurements of this report do not provide sufficient background
- The nature of the wave climate and local conditions in the BEZ clearly suggest that any offshore platform should be designed and built to withstand heavy storms. The observations of this report are a good basis for basic or even advances design options for offshore platforms.
- Trawling only took place at the beginning of summer (Dec 21). We recommend to repeat fish trawls to better capture the seasonal cycle. This could be combined with a more extensive monitoring effort required for detailed planning of offshore structure deployments in the future.
- Any future study should also look at existing data about offshore bird and mammal surveys. If this information is hard to access, a survey that targets arial habitat mapping should be carried out to complement the baseline study.

7. Acknowledgements

The authors acknowledge the financial support of the Blue Economy Cooperative Research Centre, established and supported under the Australian Government's Cooperative Research Centres Program, grant number CRC-20180101. Moreover, the project ands especially the fieldwork would not have been possible with the contribution of several people, and other special thanks go out to Jean-Roch Nader (UTas), Irene Penesis (BE CRC), Craig Heatherington (UQ), Prof Chris Frid (Griffith University), Nick Rawlinson (IMAS) Thomas King (Xylem), Dr Navodha Dissanayake (Griffith University, "The Bluefin Crew(s)", Several PhD students (Utas), Several PhD students (UQ), Several PhD students (Griffith U) , Sean Riley (Tassal), Brad Evans (Tassal), Xylem Water Solutions

8. References

ABRS 2019. '*Australian Faunal Directory.'* Australian Biological Resources Study, Canberra. Available at https://biodiversity.org.au/afd/home [accessed 4 June 2021].

Beesley, P.L., Ross, G.J.B., and Glasby, C.J. (2000). 'Polychaetes and allies: the southern synthesis. Fauna of Australia. Vol. 4A Polychaeta, Myzostomida, Pogonophora, Echiura, Sipuncula.' (CSIRO Publishing: Melbourne, Vic., Australia.)

Beesley, P.L., Ross, G.J.B., Wells, A., CSIRO., Study, A.B.R., and Environment, E.A.D. (1998). 'Mollusca: The Southern Synthesis.' (Australian Government Publishing Service: Victoria, Australia.)

Codiga, D.L., 2011. Unified Tidal Analysis and Prediction Using the UTide Matlab Functions. Technical Report 2011-01. Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. 59pp. ftp://www.po.gso.uri.edu/pub/downloads/codiga/pubs/2011Codiga-UTide-Report.pdf

Durrant, Thomas; Hemer, Mark; Smith, Grant; Trenham, Claire; Greenslade, Diana (2019): CAWCR Wave Hindcast - Aggregated Collection. v5. CSIRO. Service Collection. http://hdl.handle.net/102.100.100/137152?index=1http://data-cbr.csiro.au/thredds/catalog/catch_all/CMAR_CAWCR-Wave_archive/CAWCR_Wave_Hindcast_aggregate/gridded/catalog.html

Glasby, G., and Fauchald, K. (2003). POLiKEY: polychaete identification and information retrieval system, ver. 2. (Department of the Environment and Energy: Canberra, ACT, Australia.) Available at https://www.environment.gov.au/science/abrs/online-resources/polikey [Verified 31 October 2018].

E.M.S. Wijeratne, C.B. Pattiaratchi, Matt Eliot, Ivan D. Haigh. Tidal characteristics in Bass Strait, south-east Australia. Estuarine, Coastal and Shelf Science. Volume 114,2012,Pages 156-165,ISSN 0272-7714, https://doi.org/10.1016/j.ecss.2012.08.027.

WoRMS Editorial Board (2019). World Register of Marine Species. Flanders Marine Institute Belgium.

Medwin, H. (1975). Speed of sound in water: A simple equation for realistic parameters. The Journal of the Acoustical Society of America, 58(6), 1318-1319. doi:10.1121/1.380790

Yang, J., & Tang, D. (2017). Direct Measurements of Sediment Sound Speed and Attenuation in the Frequency Band of 2–8 kHz at the Target and Reverberation Experiment Site. IEEE Journal of Oceanic Engineering, 42(4), 1102-1109. doi:10.1109/JOE.2017.2714722

Appendix A – Project Synopsis

<table>
<tr><th>Project Leader</th><th>Project Team</th></tr>
<tr><td>R. Cossu, University of Queensland
C. Frid, Griffith University</td><td rowspan="7">• The University of Queensland
• Griffith University
• Blue Economy CRC
• Tassal Group Limited
• University of Tasmania
• Commonwealth Scientific and Industrial Research Organisation (CSIRO)
• Xylem Water Solutions Australia Limited</td></tr>
<tr><th>Report Author(s)</th></tr>
<tr><td>Remo Cossu (University of Queensland)
Philip Marsh (University of Tasmania)
Chris Frid (Griffiths University)
Jean-Roch Nader (university of Tasmania)</td></tr>
<tr><th>Date Reported to the BE CRC</th></tr>
<tr><td>12/2022</td></tr>
<tr><th>Approved by the BE CRC</th></tr>
<tr><td>John’s signature will be added when approved.

Dr John Whittington, BE CRC CEO</td></tr>
<tr><th>Project Objective(s)</th><th>BE CRC Milestones</th></tr>
<tr><td>This project aims to characterize a proposed Blue Economy Zone (BEZ) in Northern Tasmania by the:
(i) Collection of data for comprehensively assessing offshore site suitability, particularly for the benthic environments.
(ii) Data will be collected in a geo-referenced systematic framework to allow integration with other existing data sets, their use as baseline data for future monitoring work and as a resource for trialling site selection and marine spatial planning tools.
(iii) Generation of model-based data layers for resource and habitat characterisation.</td><td>Insert the number and name of the relevant output milestone activity from the Commonwealth and/or Project Agreement.
1.1;1.3
2.1
3.2;3.4
4.1;4.2;4.3
5.1</td></tr>
<tr><th colspan="2">Utilisation/Commercialisation Opportunities</th></tr>
<tr><td colspan="2">This research project establishes a baseline that will enable industry and regulators to plan and develop the Blue Economy Zone through the greater understanding of its characterisation. This will reduce both regulatory and business risk whilst lowering barriers of entry to new industries in the region.</td></tr>
<tr><th colspan="2">Intellectual Property</th></tr>
<tr><td colspan="2">n/a</td></tr>
<tr><th colspan="2">Confidentiality</th></tr>
<tr><td colspan="2">Does this report include confidential information? Yes ☐ or No ☒</td></tr>
</table>

Appendix B – Short Science Summary

A short science summary for this project is provided on the following page(s).

Please fill out the following page(s) to provide a short science summary that can replace the current PDF document on your Project Page on the BE CRC's website.

Note that no confidential information should be included in the Short Summary, as this document will be made publicly available on the BE CRC's website.

The Short Summary should be 2-3 pages long, and include content as per the Headings provided.

Note captions and cross-referencing should not be used within the Short Summary, as this should be a stand-alone document; any figures or tables you may choose to include within the Short Summary should therefore not be included in the Contents List of this report.

BLUE ECONOMY COOPERATIVE RESEARCH CENTRE

Australian Government Department of Industry, Science, Energy and Resources | AusIndustry Cooperative Research Centres Program

21.002 Baseline Survey of the Blue Economy Zone (Phase II)

Research Program

RP4 Environmental and Ecosystems (EE)

Key Points

- This report details the characterization of environmental conditions in the Blue Economy Zone (BEZ) off the coast of Northern Tasmania through field work survey, with results indicating:
  - Mild sloping bathymetry with water depths ranging between 35-45 m at the southern (shoreward) edge and exceeding > 60 m at its offshore boundary, consisting of rocky reef and rubble with limited quantities of sand in the shallower regions (35 m to 45 m depth) and further offshore increasing layers of mud.
  - Mean tidal currents of 0.09 m/s with maximum of 0.48 m/s measured, with wind-driven current speed increase towards surface layers.
  - Average wave heights of approximately 1 m with maximum significant height of 4.95 m. Wave direct was found to be strongly focused between North-Westerly directions in winter to North-Easterly directions in summer.
  - Water column was stratified during the summer months, with temperatures > 19° C found, reducing to a well-mixed column at 14° C during winter. Dissolved Oxygen at ~ 8mg/L, salinity from 35.5 PSU and 35.7 PSU, and Chlorophyll levels from 1.5 to 3mg/L 1,5 mg/L were measured.
  - During Fish trawls the overall catch composition consisted of sessile (58.7%) and mobile (41.3%) epifauna by weight. Fifty-one different species were identified in the mobile epifauna with the common gurnard the most abundant species.

The Challenges

Moving new Blue Economy industries offshore is a significant challenge that requires new approaches to the development and application of traditional site selection criteria and new approaches to accommodating multiple sea users in areas that have traditionally been the ‘high seas’. The requirements for monitoring systems also becomes more complex with respect to reducing risks to staff and infrastructure through the operation of automated systems, data collection and environmental impact assessments.

Specifically, the area of the BEZ in Northern Tasmania is well known to local fishermen but there is no wave gauge, water velocity measurements or wind data in close proximity that could be used as a reliable data source. Likewise, there is no detailed data about the seafloor characteristics (including ground penetrating radar data) and no known published data of the species composition and catch rates from other fishing activities within the BEZ. This report therefore constitutes a first scientific approach to characterise the site conditions and potential use of sea space for BE CRC R&D activities.

The Opportunity

This project lays the groundwork to linking all physical, environmental, cultural and heritage, resource potential, operational logistics and risks into a comprehensive decision support tool (or suite of tools). There is a paucity of information on the environmental conditions in the BEZ, which is needed urgently to underpin planning of industry trials and other BE CRC projects that will utilise the BEZ as well as inform regulatory submissions and subsequent reporting.

The Blue Economy CRC is funded in part under the Australian Government's CRC program administered by the Department of Industry, Science, Energy and Resources.

21.002 Baseline Survey of the Blue Economy Zone (Phase II)

Research

Objective

To characterize a proposed BEZ – a designated marine area for emerging Blue Economy R&D activities – in Northern Tasmania. The approaches developed in this project will be transferrable to other potential and appropriate BEZ's around Australia.

Methodology

Field data was collected between March 2021 and December 2022 within the BEZ. This fieldwork was a collaboration between the University of Tasmania, University of Queensland, Griffith University and industry partners Tassal and Xylem. The major activities performed included mapping of the seafloor, sediment and benthic habitat, monitoring the local wave, wind and ocean current climates as well as getting an understanding of fish species in the BEZ.

Outcomes

Sub-bottom Habitat and Mapping

The area of the BEZ has a mild sloping bathymetry with water depths ranging between 35-45 m at the southern (shoreward) edge and depths exceeding > 60 m at its offshore boundary (Figure 1). Sediment grabs and Sub-bottom profiling revealed rocky reef and rubble with limited quantities of sand in the shallower regions (35 m to 45 m depth). In the deeper regions and further offshore a layer of mud is present that gradually increases in thickness with increasing water depths. The sub-tidal microbenthic assemblage was dominated by annelid worms (46% of total recorded taxa), arthropods (23% of total recorded taxa), molluscs (19% of total recorded taxa) and the remaining 12% of taxa consisted of diverse taxonomic groups. There were no significant differences in taxonomic composition between the stations along the presumed gradients (offshore to inshore or east to west).

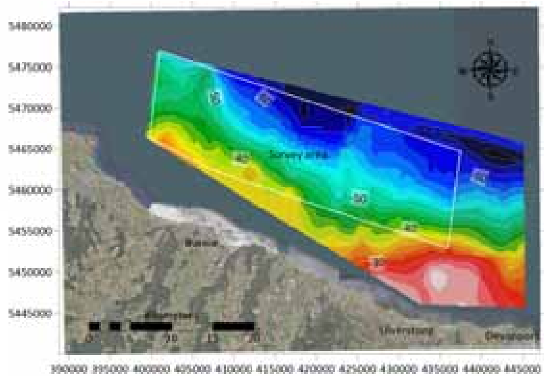

Figure 1104: Single Beam Bathymetry in BEZ

Currents and Wave Characterisation

The currents in the BEZ were minimal during the ADCP deployment period, with mean current speeds of 0.09 m/s found. Maximum current speeds of 0.41 m/s at the bottom and middle water column to 0.48 m/s at top water column were found, with this increase due to the wind-driven current increasing the tidal velocities on the surface layers.

Average wave heights during the deployment were between 0.91 m and 1.02 m for the Sofar Wave Spotter buoy and the ADCP respectively. The maximum significant wave height recorded was Hs = 4.95 m which occurred in November 2022. Mean wave periods ranged between Tm = 2.96 s and Tm = 4.26 s (depending on measuring device and period of measurement). The wave direction remained strongly focused between North-Westerly directions in winter to North-Easterly directions in summer throughout the deployment period.

The Blue Economy CRC is funded in part under the Australian Government's CRC program administered by the Department of Industry, Science, Energy and Resources.

21.002 Baseline Survey of the Blue Economy Zone (Phase II)

Water Column Parameters

Preliminary water column profiling suggests that the water column is well mixed within the top 40 meters but was periodically stratified in the bottom 5 meters. Between March and May the DO levels remained relatively constant throughout the time at ~ 8mg/L. Salinity varied only little and was found to be between 35.5 PSU 35.7PSU.

The water temperature was also monitored with a separate thermistor string which was operating between July 2021 and December 2022. Supporting the data from the profiling system the water was stratified during the summer months, with water temperatures exceeded >19° C throughout the water column in the later period of the summer of 2021. In late February the water starts to cool down and becomes well mixed again. A constant decrease from 19° C to < 14° C was recorded until the end of April, where the temperature again rose to >15° C (at the surface) by the onset of summer of 2022.

Figure 2: Catch sorting on FTV Bluefin

Fish Species

For the fish trawls (Figure 2) the overall catch composition consisted of sessile (58.7%) and mobile (41.3%) epifauna by weight. The proportion of sessile epifauna varied between trawls from 82.2% (trawl 6) to 41.4 (trawl 4). Fifty-one different species were identified in the mobile epifauna and most (75.5%) of the mobile epifauna by numbers consisted of fish, and the common gurnard (Neosebastes scorpaenoides) was the most abundant species.

Next Steps

Among other parameters, the wave climate, water depths, the benthic habitat as well as seafloor conditions suggest suitability for offshore projects. The next steps are to continue monitoring the BEZ to generate longer-term data sets for use in other BE CRC research programs including MSP data inputs. In particular, more data on water temperature, salinity and dissolved Oxygen would be beneficial especially for initiatives to advance the aquaculture industry in Northern Tasmania. Longer-term deployments over larger spatial areas will also capture any temporal and spatial variations. The required monitoring could be achieved with a "Site/Resource Characterization" project" within the BE-CRC in 2023.

Project Team

Remo Cossu (University of Queensland)
Chris Frid, Griffith University
Jean Roch Nader (UTas)
Philip Marsh (UTas/ University of Queensland)
Irene Penesis (BE-CRC)
Sean Riley (Tassal)
Thomas King (Xylem)

Short Summary Author

Philip Marsh (University of Tasmania)
Remo Cossu (University of Queensland)

The Blue Economy CRC is funded in part under the Australian Government's CRC program administered by the Department of Industry, Science, Energy and Resources.

21.002 Baseline Survey of the Blue Economy Zone (Phase II)
SHORT SUMMARY

Appendix C – Supporting Material(s)

Please include any baseline data, tables and graphs in this section of the report (with the main body to be used for summarised data only).

Any additional references not cited in this report could also be provided here.

All other documentation relating to your project (that does not need to be included within the Final Report), should be provided in a separate folder(s) for archiving by the Blue Economy CRC.

The Blue Economy CRC is funded in part under the Australian Government's CRC program administered by the Department of Industry, Science, Energy and Resources.