Current and wave measurements in the Te Tapuwae O Rongokako Marine Reserve during September-October 2003

NIWA Client Report: HAM2003-138
October 2003

NIWA Project: DOC04266

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Prepared for

The Department of Conservation

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Contents

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Executive Summary

NIWA was commissioned by the Department of Conservation (Te Papa Atawhai) to undertake numerical simulations of larvae dispersal in the Te Tapuwae O Rongokako Marine Reserve. The study included the deployment of current, wave and temperature measurement devices in the marine reserve for a one-month period, during September-October 2003: firstly to provide stand-alone information about the hydrodynamics of the marine reserve area, and secondly to provide calibration data for the larvae dispersal modelling. Selected data are presented as a series of plots, and the data are included in ASCII format on a CD inside the back cover of this report.

Currents were recorded using Acoustic Doppler Current Profilers at an offshore site in 24 m depth and an inshore site in 10 m depth. Temperature was recorded at the offshore site at depths of 0.5, 2.5, 6, 12, 16 and 23 m below the water surface, and waves were recorded at the inshore site.

Temperature stratification was not strong during the deployment, as expected during spring, and hence currents were quite uniform throughout the water column. The mean significant wave height over the 1-month period was 0.94 m and the maximum recorded was 3.1 m on 5th October during a southerly wind. Waves generally approached the coast from the east through southeast quadrant.

At the offshore site mean current speeds ranged from 8 cm s^{-1} near the seabed to 11 cm s^{-1} at 20.5 m above the bed. At the inshore site, mean current speeds were slower, ranging from 4 cm s^{-1} near the seabed to 10 cm s^{-1} 8.5 m above the bed. Currents at the offshore site showed a strong alignment in the alongshore direction, whereas the inshore site showed a subtle cross-shore alignment. This was caused by stronger alongshore tidal currents at the offshore site, which averaged 5.6 cm s^{-1}, compared with 2.8 cm s^{-1} inshore. Tidal currents accounted for 36% of the current variance at the offshore site and only 16% at the inshore site.

The currents are mainly generated by two diurnal (once-daily) tides (K_1 and O_1) and the more well-known semi-diurnal (twice-daily) M_2 lunar tides. The presence of diurnal tidal currents off the East Cape - Gisborne is a feature of the oceanography of the region that is not found elsewhere in New Zealand.

Wavelet analysis demonstrated identifiable links between the wind and current time-series, displaying coherent fluctuations between both the wind and current time-series throughout the deployment, particularly at periods of 24-hrs. The energy at 24-hr period is most likely related to prevailing diurnal wind fluctuations - offshore in the morning and onshore in the afternoon sea-breeze.

A consistent net flow through the marine reserve alongshore to the northeast was measured. Similar northeast currents have been measured on two previous current-meter deployments further to the south

off the entrance to Poverty Bay. This fits with an Ekman-induced geostrophic flow, driven by the prevailing regional westerly wind, and may also be enhanced by the Wairarapa Coastal Current.

Work is now in progress to calibrate and run the model to simulate larval dispersal from the marine reserve.

1. Introduction

NIWA was commissioned by the Department of Conservation (Te Papa Atawhai) to undertake numerical simulations of larvae dispersal in the Te Tapuwae O Rongokako Marine Reserve. The study included the deployment of current, wave and temperature measurement devices in the marine reserve for a one-month period, from 3 September to 7 October 2003. The purpose of the deployments was twofold: firstly to provide stand-alone information about the hydrodynamics of the marine reserve area, and secondly to help calibrate a hydrodynamic model of the marine reserve. The deployments were successful with 100% data retrieval from all instruments.

This report presents selected data as a series of plots, and explains some of the probable forcings, including the results of tidal harmonic and wavelet analyses.

In addition the data is included in ASCII format on a CD attached inside the back cover of this report.

2. Methods

2.1 Deployments

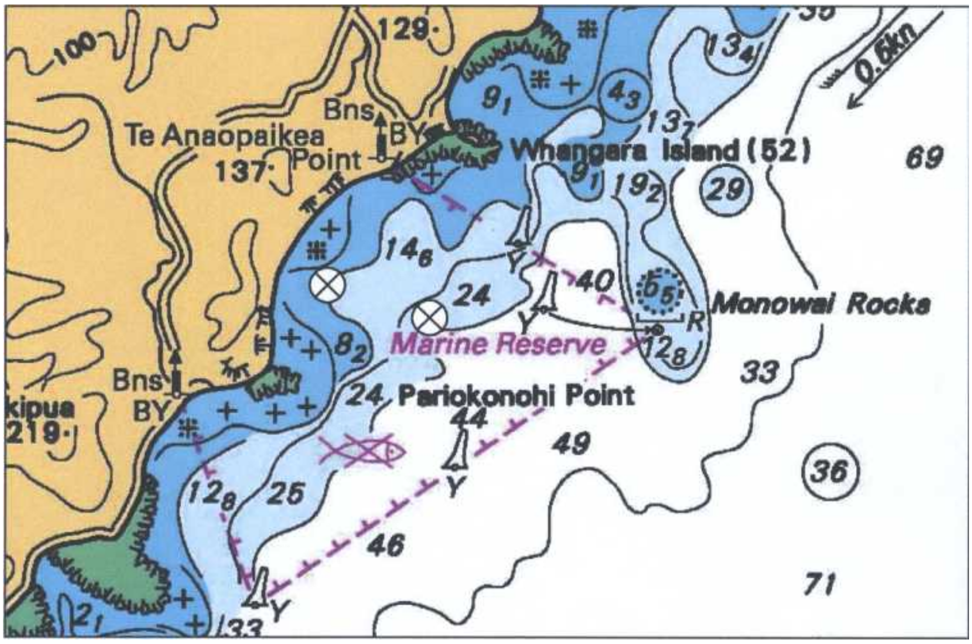

Figure 1: Map of the marine reserve taken from hydrographic chart NZ55 (LINZ, 1998). Deployment sites marked ⊗.

Table 1: Site location and instrument description.

Site	Longitude (WGS-84)	Latitude (WGS-84)	Depth (m)	Measured	Instrument
1	178° 13.576'	38° 35.871'	24	Currents	ADCP
(Outer)					(600 kHz)
			Several	Temperature	Tidbit
2	178° 12.553'	38° 35.610'	10	Currents	ADCP
(Inner)					(1200 kHz)
				Waves	

2.2 Instrumentation

Currents and waves were measured using RD Instruments Sentinel acoustic Doppler current profilers (ADCPs), see http://www.rdinstruments.com. The ADCPs have four transducers that emit acoustic pulses, which reflect off particles in the water column and return to the transducers. The instrument calculates the velocity of the particles by measuring the Doppler shift along each sound beam, then interpolates between beams to calculate the three-dimensional current. The ADCPs can measure different depths (called bins) simultaneously. Wave spectra were measured from high-frequency current and pressure measurements, from which wave statistics were subsequently calculated.

The ADCPs were deployed on the seabed, sampling upward through the water column. The outer ADCP sampled vertically in 1 m bins, beginning 2 m above the seabed with an expected standard deviation (accuracy) of 0.6 cm s^{-1}, and the inner ADCP sampled vertically in 0.5 m bins starting 1 m above the seabed, with an expected standard deviation (accuracy) of 1.0 cm s^{-1}. Acoustic reflection off the water surface corrupts the measurements in the two to three bins closest to the water surface, therefore currents are available to 20 m above the seabed at the outer site and 8.5 m above the bed at the inner site.

Water temperature was measured to an accuracy of $\pm 0.1°C$ at the outer site using Tidbit loggers placed on the mooring rope at approximately 0.5, 2.5, 7, 12.5 and 16.5 m below the water surface.

3. Results

3.1 Wind

The wind blew predominantly from the northwest with occasional southerlies during the deployment (Figure 2). This is typical of this coast where almost 55% of all winds blow from the west through to north sectors, with a high proportion from north-northwest (Figure 3). Fewer northwest winds and more southeast winds are observed in the afternoons, demonstrating the importance of afternoon sea-breeze effects in Poverty Bay, which occur on sunny winter days as well in summer. These results are similar to the long-term observations at Gisborne Airport between 1962-1972 (Hessell 1980). Along with the common regional westerly or north westerly wind situation, katabatic drainage of cold air off the nearby Raukumara ranges at night helps to produce the observed predominance of north-westerly air flows in the morning, while the south-easterly sea breeze is often strong over the Gisborne region in the afternoon and evening (Hessell 1980). Occasional southerly fronts give rise to strong onshore winds at times, but these are typically short-lived, with durations of around 12-hours or less. It should be cautioned that land-based wind measurements are notoriously unreliable for estimating wind-over-water, even for relatively close sites (e.g., Hsu, 1986, Laing and Brenstrum, 1996). The Gisborne airport weather station is located several kilometres inshore and appears to experience sheltering from northeast winds (Figure 3); it will not be entirely representative of winds in the marine reserve.

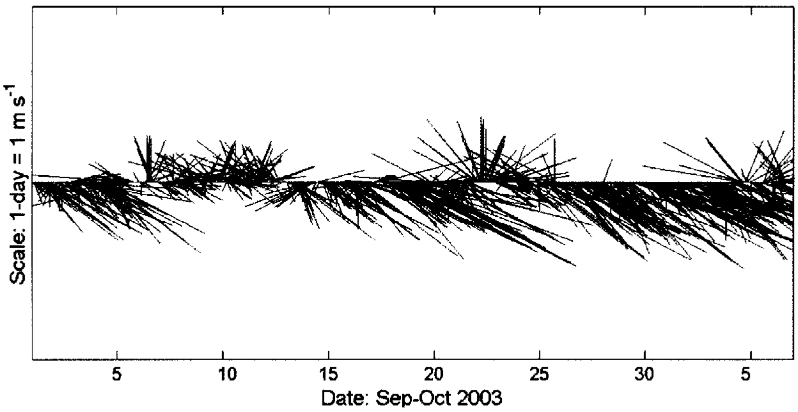

Figure 2: Feather plot of wind time-series measured at Gisborne Airport during the current-meter deployment from 3 Sep to 7 Oct 2003. Wind is plotted in true-vectors ("going to") convention with scale 1-day on the x-axis = 1 m s^{-1} along feather length.

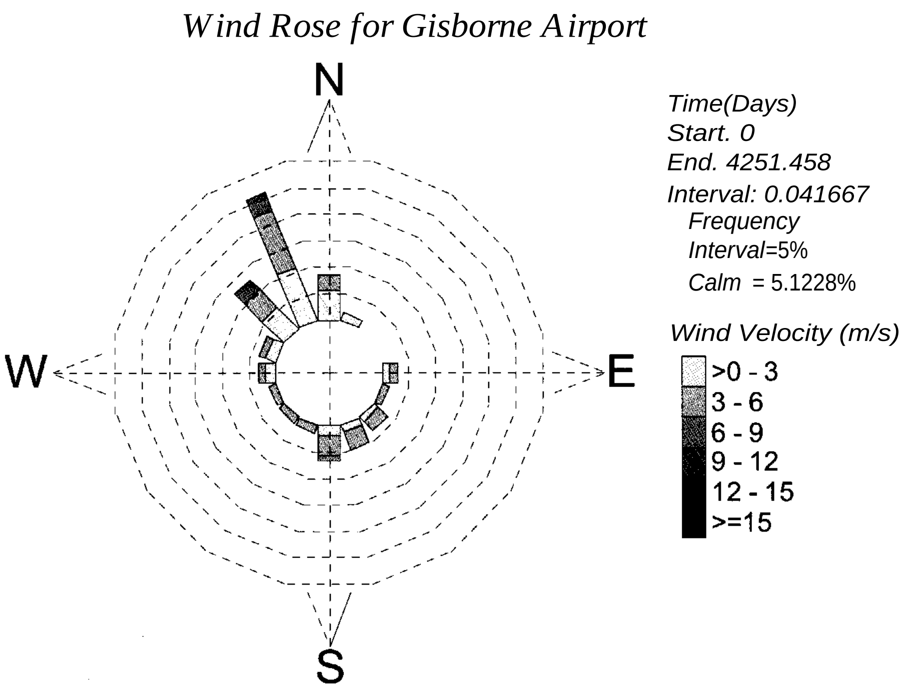

Figure 3: Long-term Gisborne airport wind rose from 86,046 hourly recordings, beginning 01:00, 1 January 1988 until 11:00, 8 August 1999. Directions are meteorological convention ("coming from").

3.2 Currents

Time-series of coastal current velocities from the upper and lower water column at both sites are shown in Figure 4-Figure 7. Figure 8 and Figure 9 show scatter plots of currents measured at the outer and inner sites respectively.

At the offshore site (24 m water depth) mean current speeds ranged from 8 cm s^{-1} near the seabed (Figure 4) to 11 cm s^{-1} 20.5 m above the bed (Figure 5). At the inshore site (10 m water depth) mean current speeds ranged from 4 cm s^{-1} near the seabed (Figure 6) to 10 cm s^{-1} 8.5 m above the bed (Figure 7). Comparing figures 8 and 9, currents at the outer site showed an alignment in the alongshore direction (except right next to the seabed), but those at the inner site did not. This was caused by stronger alongshore tidal currents at the offshore site, which averaged 5.6 cm s^{-1}, compared with 2.8 cm s^{-1} inshore. The inner site shows a subtle cross-shore alignment as shown in Figure 9.

A tidal harmonic analysis was performed for the depth-averaged current (1-metre depth bins 1-19) at the offshore site (Table 2 and Tale 3). During this deployment, the tidal currents with largest amplitudes were the K_1 lunar-solar diurnal (once a day), the principal-lunar diurnal O_1 and the more well-known lunar semi-diurnal (twice-daily) M_2 tide. The dominant tidal component around New Zealand is the semidiumal (twice a day) M_2 lunar tide (Heath 1985), but this is smaller on the North Island east coast (Walters et al. 2001).

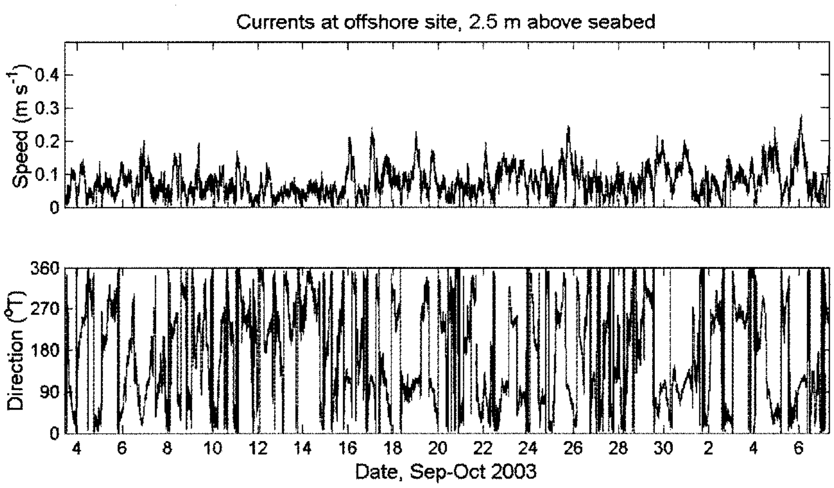

Figure 4: Current speed and direction (°T) measured at the offshore site, 2.5 m above the seabed.

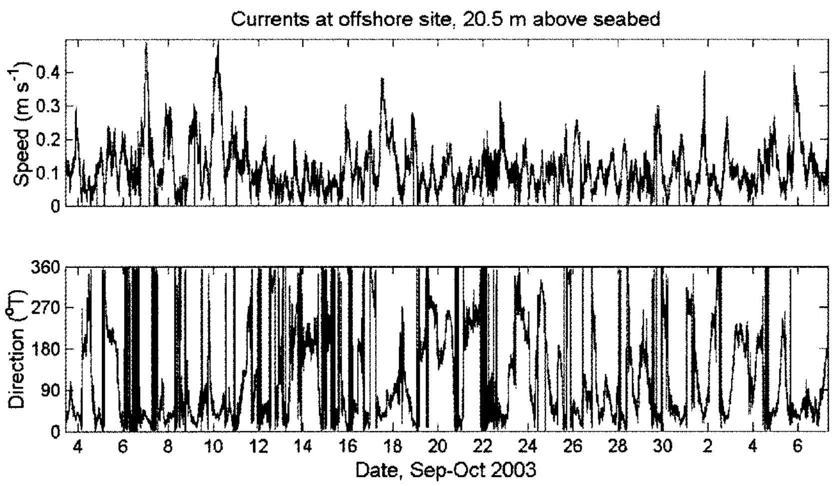

Figure 5: Current speed and direction (°T) measured at the offshore site, 20.5 m above the seabed.

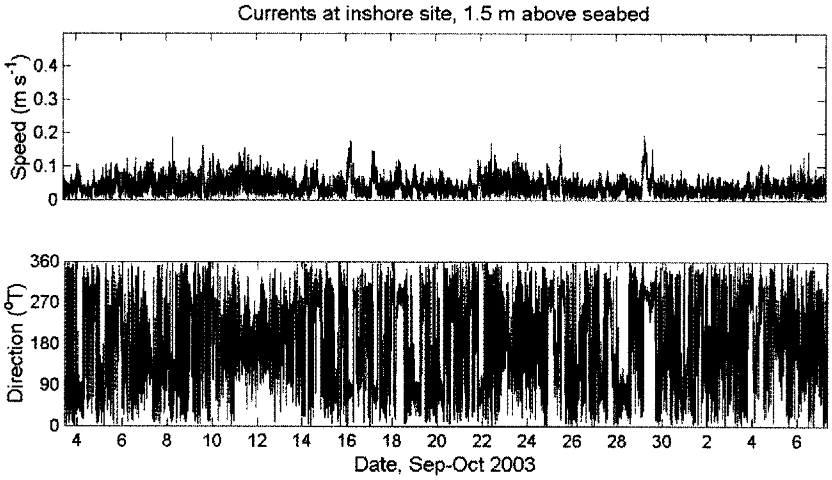

Figure 6: Current speed and direction (°T) measured at the inshore site, 1.5 m above the seabed.

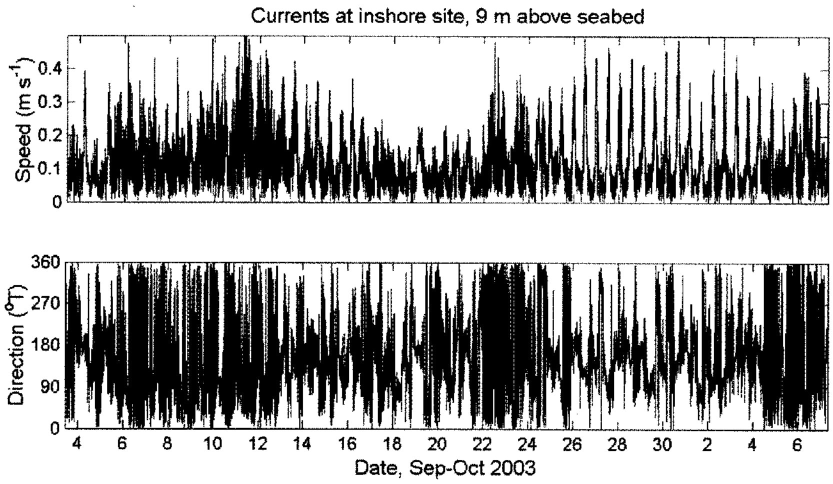

Figure 7: Current speed and direction (°T) measured at the inshore site, 9 m above the seabed.

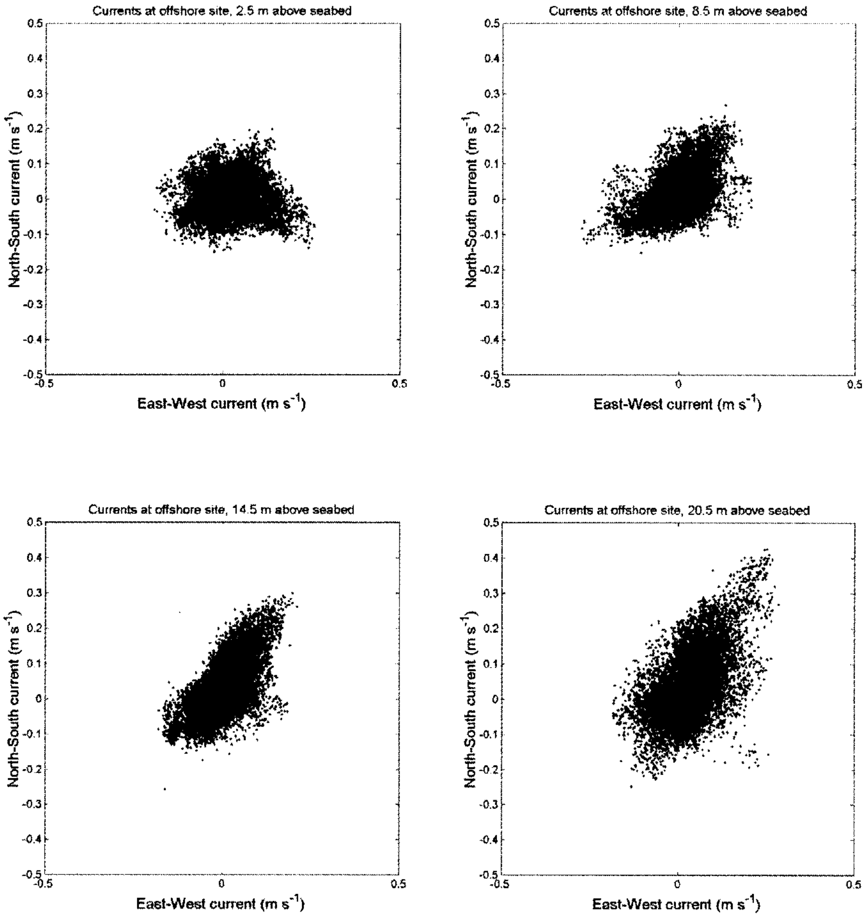

Figure 8: Current scatter plots at 2.5, 8.5, 14.5 and 20.5 m above the seabed at the outer site.

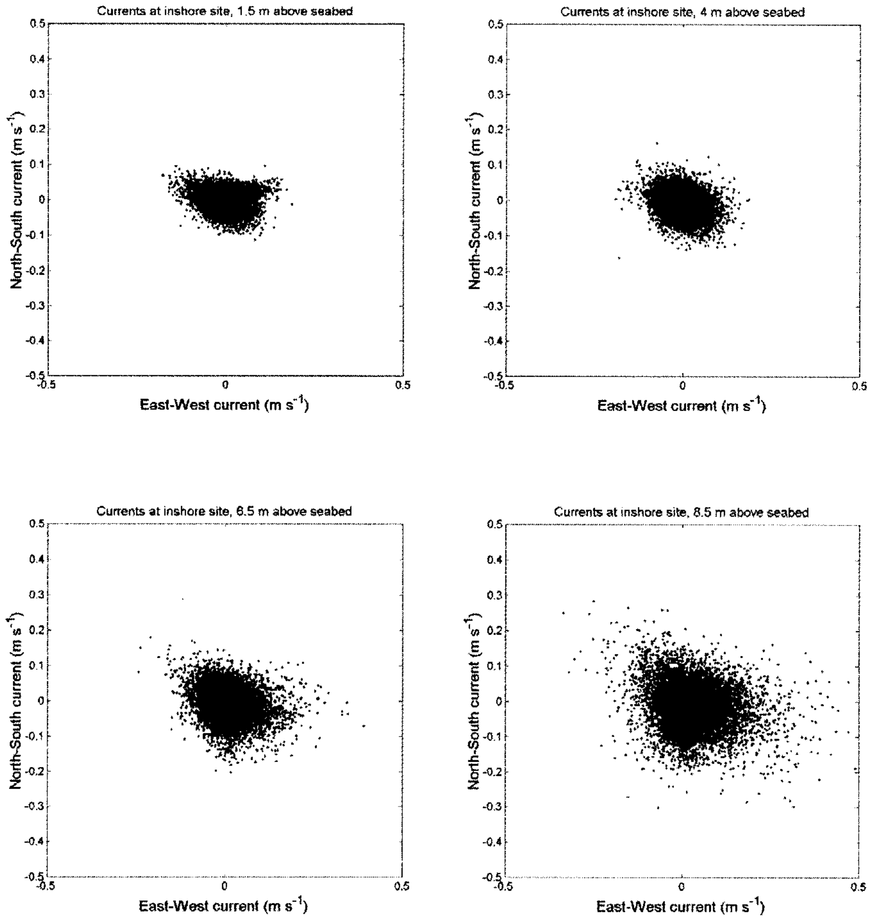

Figure 9: Current scatter plots at 1.5, 4, 6.5 and 9 m above the seabed at the inner site.

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