Poole Bay Nearshore Beach Replenishment Trial

Interim monitoring report

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1 INTRODUCTION

The monitoring programme was designed to assess the evolution of a trial seabed recharge project. The primary purpose of the monitoring is to establish whether material from the seabed recharge moves onshore to the beach, but a key secondary aim is to determine the potential impacts of the deposition upon sensitive/protected marine features, particularly given the proximity of the Poole Rocks MCZ. The monitoring programme comprises the following activities to track the dispersal of the deposited material:

- beach (topographic) surveys
- swath bathymetry (multibeam) surveys
- seabed tracer study
- wave, currents and turbidity monitoring
- tidal monitoring
- silt monitoring

This interim report outlines the preliminary results of the monitoring to date, some 8 weeks after completion of the dredge and deposition.

2 FIELDWORK DIARY

The majority of the planned monitoring activity was compressed into the 6 weeks following completion of dredging activities, in case the material dispersed rapidly. However, some adaption of the initial proposed programmed was necessary to compensate for operational delays such as unsuitable sea conditions, and in response to the results of the surveys. For example, after several days of dredging and deposition, operations were suspended due to worsening weather conditions. In a similar vein, the timing of the tracer insertion was brought forward by a day in order that the effects of the fresh southerly winds which were forecast for the following day might be captured. Furthermore, sticking to the original plan for tracer insertion the following day risked the operation not being completed until 3 or 4 days after the majority of the sediment had been placed, due to the need for calm seas. The full fieldwork diary can be seen in Table 1. Time intervals are expressed as days relative to deposition day, “D”, which is taken as the completion of deposition on 14 February 2015.

Task	Milestone	Completed		Comments
Hydrodynamics	Deploy AWAC	27/11/2014	-	
Survey set 0 (pre-dredge)	Pre-dredge swath	07/02/2015	D-7	
	Pre-dredge topo	08/02/2015	D-6	Scanned additional area at either end of box as trial area moved slightly west of earlier planned position
Tracer	Placement	12/02/2015	D-2	Placed after 2/3 of deposition in order to capture forecast fresh southerly winds
Deposition	**Dredge and Deposition**	**14/02/2015**	**D**	Started 09/02/2015, completion delayed by weather downtime
Tracer search 1	Tracer seabed sweep 1	15/02/2015	D+1	Delayed due to fresh southerly winds
	Tracer beach sweep 1	16/02/2015	D+2	Brought forward and combined with seabed sweep 1 due to southerly winds and indications from seabed sweep that tracer was approaching the shore
Survey set 1 (post-dredge)	Swath 1	17/02/2015	D+3	Delayed due to weather
	Topo 1			
Tracer search 2	Tracer seabed sweep 2	21/02/2015	D+7	
	Tracer beach sweep 2	22/02/2015	D+8	Brought forward and combined with offshore sweep 2 due to indications that offshore tracer was close to the shore
Survey set 2	Swath 2	25/02/2015	D+11	Postponed as surveys did not show much change other than from top of mounds
	Topo 2 (partial)			Brought forward due to appearance of sediment bulge on foreshore
Tracer search 3	Tracer beach sweep 3	19/03/2015	D+33	Additional sweep by Borough of Poole
Survey set 3	Single beam inshore	20/03/2015	D+34	Profiles overlapping topo profiles to tie in beach and nearshore
	Topo 3			
	Single beam nearshore	27/03/2015	D+41	Profiles overlapping swath area; replaced Swath 3 to capture overlap with topo survey
Hydrodynamics	AWAC serviced	27/02/2015	-	
Survey set 4	Swath 4	07/04/2015	D+52	
	Topo 4	16/04/2015	D+61	
Tracer search 4	*Tracer beach sweep 4*	*Jun-15*		*Provisional additional sweep by Borough of Poole*
Hydrodynamics	*Move AWAC*	*Jun-15*		*Provisional*
Survey set 5	*Topo 5 (profiles)*	*Jul-15*		*CCO profiles*
	Swath 5			*Provisional*
Survey set 6	*Topo 6*	*Nov-15*		*Provisional*
	Swath 6			
Hydrodynamics	*Recover AWAC*	*Nov-15*		

Table 1: Monitoring diary

3 DEPOSITION OF MATERIAL

Due to clement sea conditions for the early part of dredging operations, the chosen deposition site was towards the western, shoreward edge of the permitted area, in water depths of approximately 5m CD (Figure 1).

Figure 1: *Magni-R* approaching deposition site (left), deposition (right)

18 dredger loads totalling 30,000 m^3 were deposited, forming 9 discernible mounds within the 0.04 km^2 deposition box. Figure 2 shows an image of the mounds after the first 2 days of dredging operations. After 5 days, dredging activities were suspended by weather (see section 4.1 below) but re-commenced on 14 February and the dredger de-mobilised from site later that day.

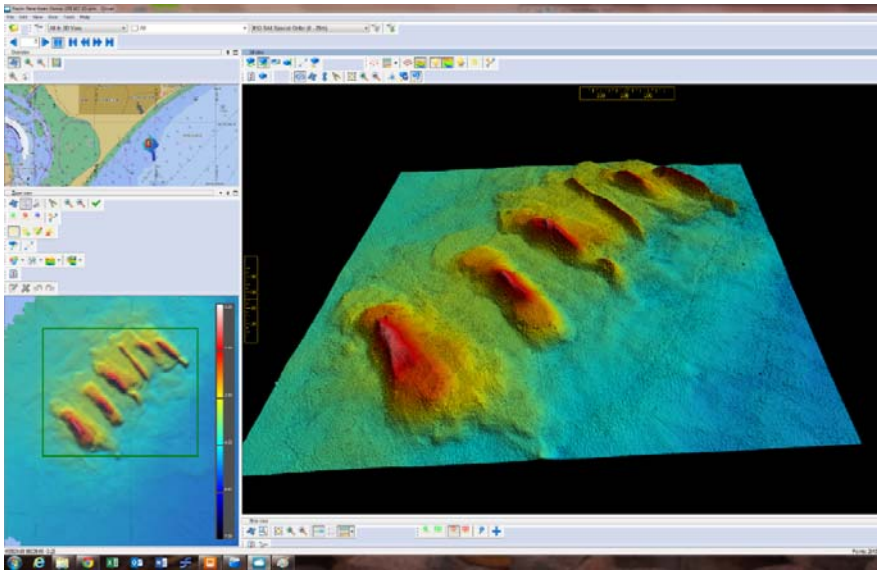

Figure 2: Illustration of sediment mounds (provisional data, S. Pearce, Poole Harbour Commissioners)

4 PRELIMINARY MONITORING RESULTS

4.1 Weather and wave climate

This section describes the ambient weather and sea conditions during the 8 weeks following deposition, to set the survey results into context. Results from the AWAC are given in section 4.5 below. The notable feature of wave conditions at the Boscombe Waverider is the frequent presence of long period swell waves, and intervals of waves from the SE (Figure 3). The wave conditions experienced during the deposition period were the highest during the 6 week survey period, but were followed a week later by the next highest period of waves, but from SbW and with less swell.

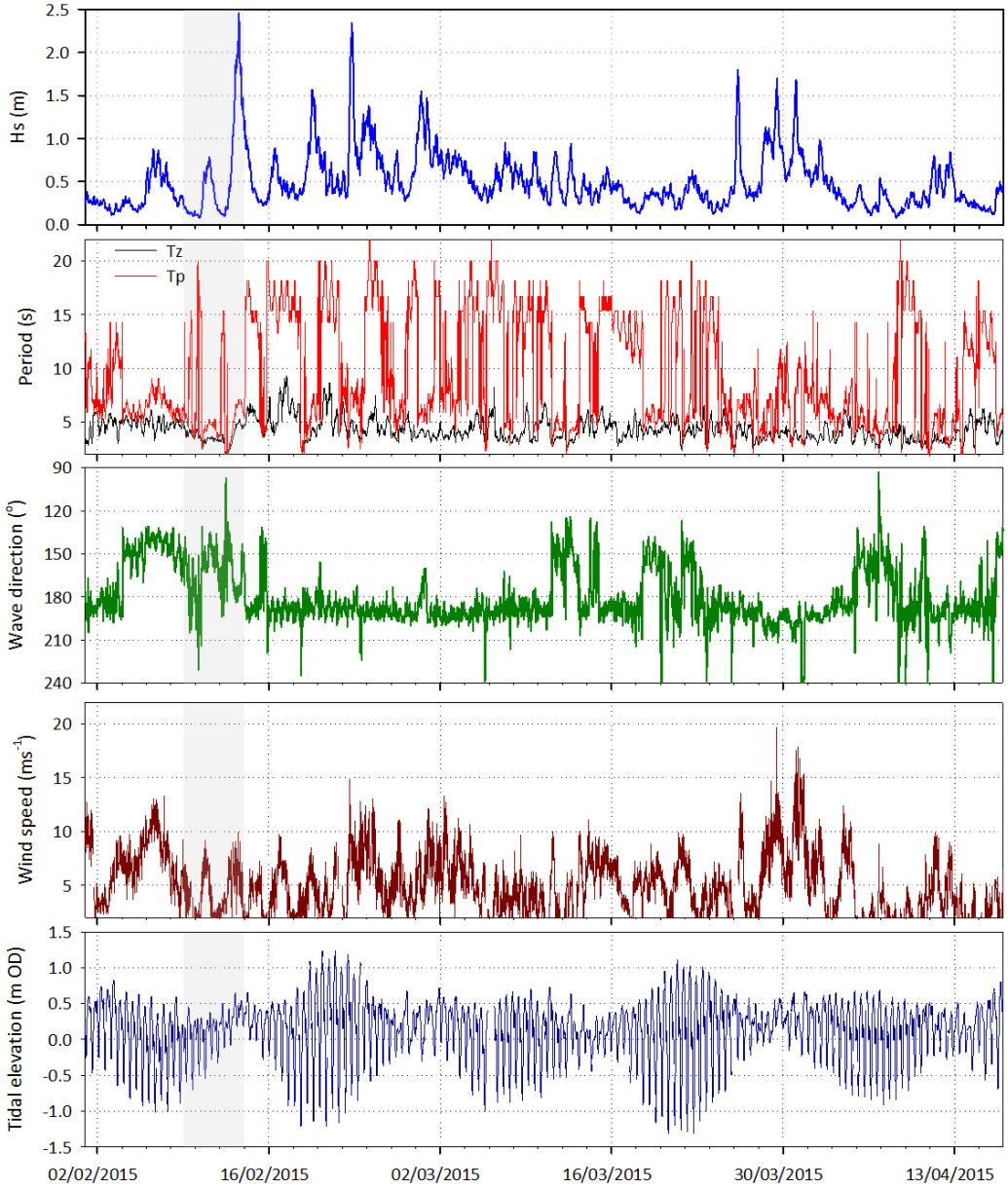

Figure 3: Ambient hydrodynamics during intensive field monitoring phase (from top: wave height, period and direction at Boscombe DWR, wind speed and tidal elevations at Swanage Pier). The grey shaded box represents the deposition phase

4.2 Bathymetry surveys

Swath (multibeam) bathymetry surveys were carried out to IHO Special Order standard for the nearshore trial area consisting of a box approximately 1 km^2 in area, centred around the deposition mounds. The pre-deposition survey took place on 07 February (D-7), but poor weather delayed the post-deposition survey until 17 February (D+3).

The results of the beach tracer sweep indicated that sediment was reaching the inter-tidal area (see section 4.4). Accordingly, survey set 3 comprised a single beam profile survey, with profiles at 20m intervals, extending shoreward to overlap with the topographic survey[1]. The profiles were subsequently extended seawards to cover the offshore trial area, to allow comparison with the preceding and following swath surveys.

Difference models and sediment transport rates were derived separately for the common survey area and the deposition (mounds) area. The plan shape (surface) area of the full swath survey box is 393,752 m^2 (0.39 km^2) and the deposition (mounds) area is 43,543 m^2 (0.04 km^2). Figure 4 shows a time series of difference models for the deposition area. Around 1,800 m^3 of sediment is estimated to have left the deposition box by D+52.

[1] It is not practical to survey this shallow sub-tidal region with swath bathymetry given the small tidal range in Poole Bay

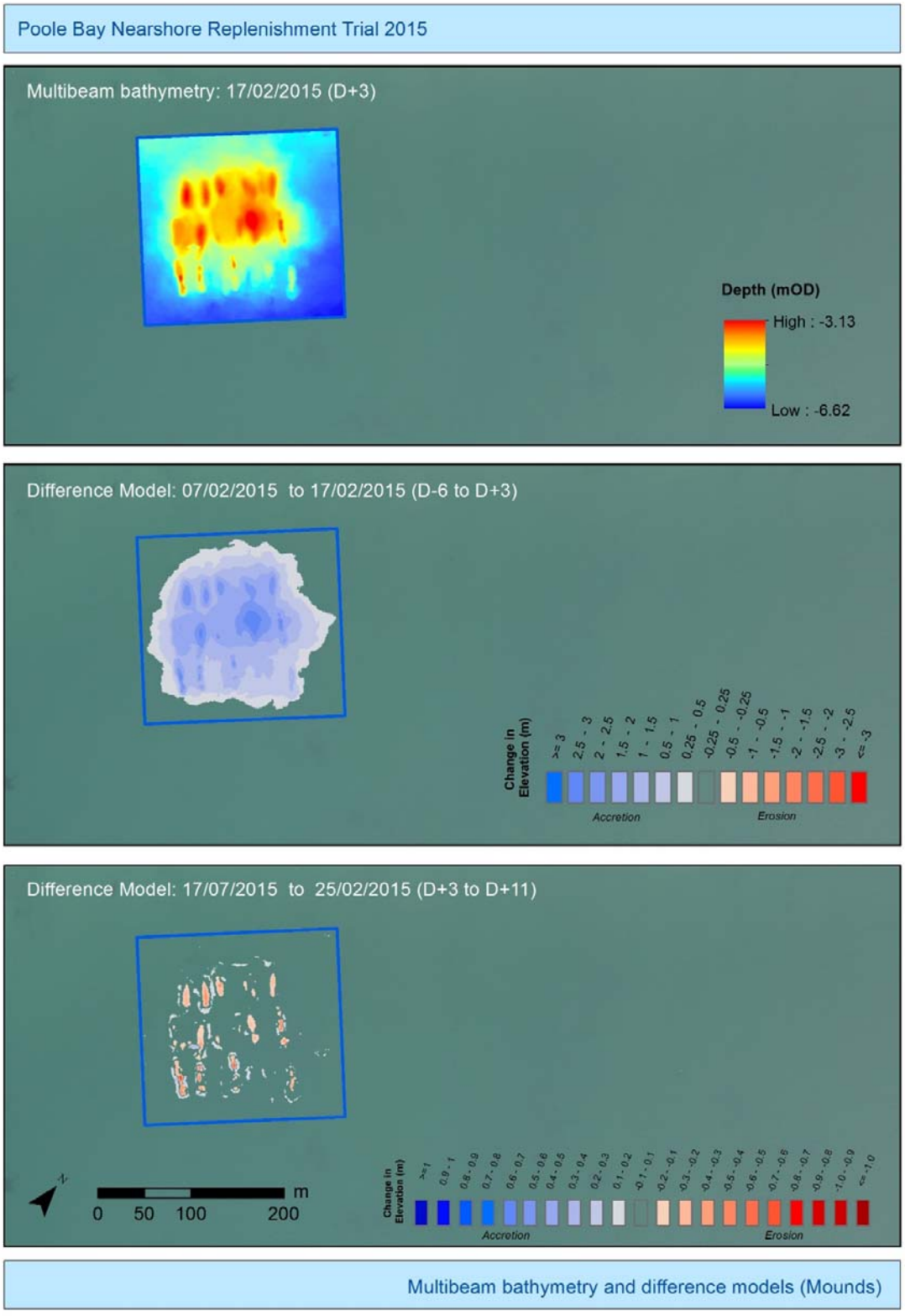

Figure 4: Bathymetric difference models of deposition area (mounds)

4.3 Topographic surveys

Since the deposition site was at the western edge of the permitted area, the planned beach survey area was expanded to extend from the first rock groyne west of Shore Road to Branksome Chine, some 2.5 km of beach length. The beach was surveyed using a Leica C10 laser scanner (Figure 5), with additional RTK GPS over the low tide area since the scanner cannot collect data over wet sand.

Figure 5: Leica C10 laser scanner on site

The pre-works beach survey was carried out 2 days before deposition started (D-6) and the post-works survey 3 days after deposition was completed (D+3) and hence 5 days after tracer insertion. Around 24 February, a noticeable beach bulge was observed near Canford Cliffs (Figure 6), so an additional topographic survey was conducted over approx. 550 m of beach either side of the bulge on 25 February (D+11). The surveys on 20 March (D+34) took place over particularly large equinoctial tides, which allowed beach surveyors to reach levels close to Chart Datum. However, although a nearshore bar has been observed at this location on occasions in the past, no bar was observed during this survey.

Figure 6: Sediment "bulge" at Canford Cliffs, 27 February 2015 [D+13] (photo: D. Robson, Borough of Poole)

Digital Terrain Models (DTM) were produced for each topographic survey and differenced to produce net volumetric changes between surveys. Results are given in Table 3 and their spatial distribution shown in Figure 7 and Figure 8. The plan shape (surface) area of the full beach survey box is 247,509 m^2 (0.247 km^2) and the partial survey area is 61,273 m^2 (0.061 km^2). The net sediment transport rate (within the survey areas) is calculated as the net volume change (m^3) per m^2 of beach per day.

Survey date		Survey Days	No. days	Net volumetric change (m^3)		Sediment transport rate (m^3 m^{-2} day)	
				Nearshore (excl. mounds)	Mounds	Nearshore (excl. mounds)	Mounds
07/02/2015	17/02/2015	D-7 to D+3	10	-1,925	31,086	-	-
17/02/2015	25/02/2015	D+3 to D+11	8	8,043	848	0.0026	0.0024
25/02/2015	07/04/2015	D+11 to D+52	41	-	-1,782	-	-0.0010

Table 2: Net volumetric change - swath bathymetry surveys

Survey date		Survey days	No. days	Net volumetric change (m^3)		Sediment transport rate (m^3 m^{-2} day)	
				Full beach	Partial beach (bulge)	Full beach	Partial beach (bulge)
07/02/2015	17/02/2015	D-6 to D+3	10	1,665	-	0.0007	-
17/02/2015	25/02/2015	D+3 to D+11	8	-	176	-	0.0004
25/02/2015	20/03/2015	D+11 to D+34	23	-	3,575	-	0.0025
17/02/2015	20/03/2015	D+3 to D+34	31	18,265	3,571	0.0025	0.0019
20/03/2015	16/04/2015	D+34 to D+61	27	-917	8	-0.0001	0.0000

Table 3: Net volumetric change - topographic surveys

Figures 7 and 8 and Table 3 indicate that between D+3 and D+34, the beach gained 18,000 m^3, which was still retained on the beach a month later.

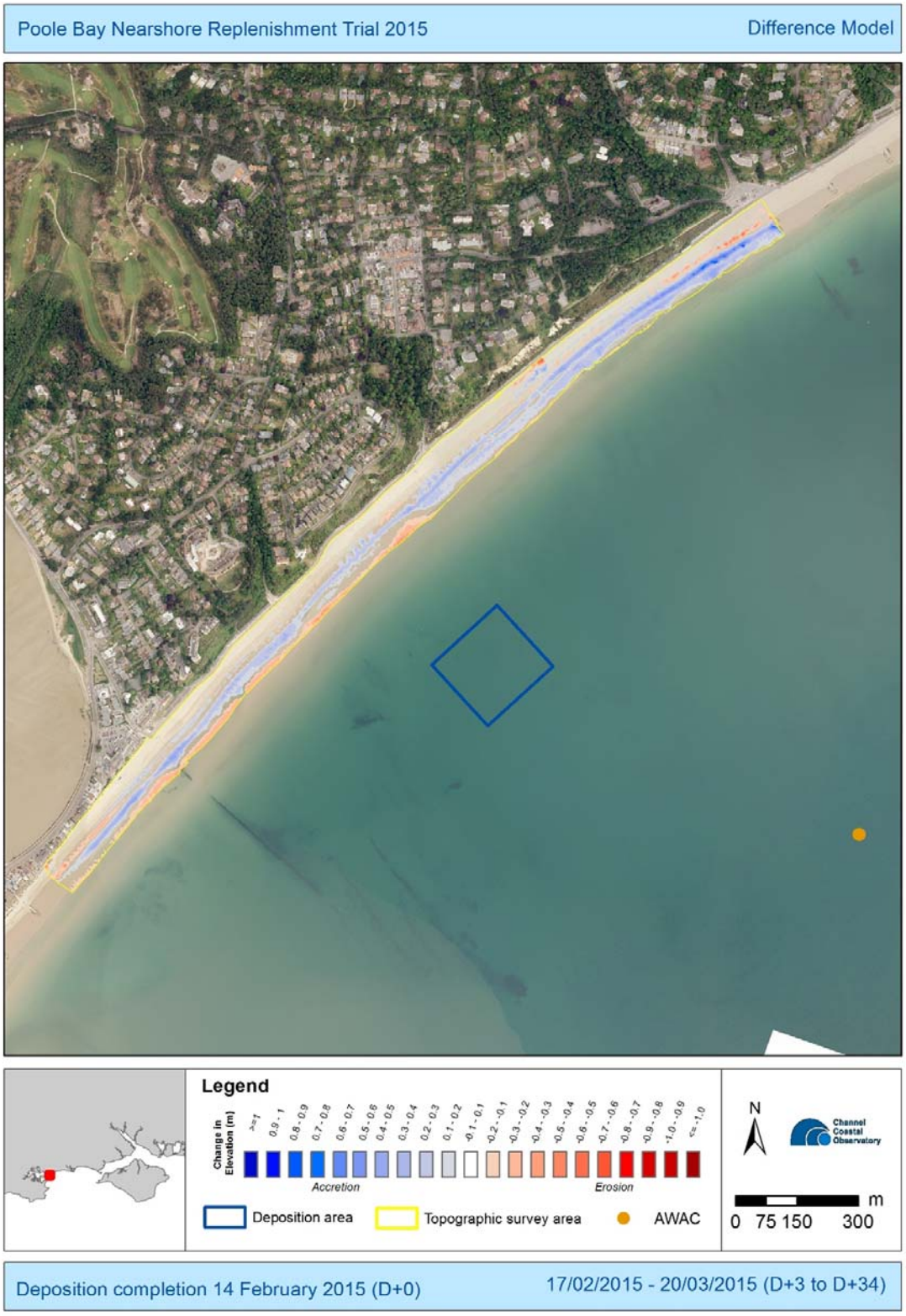

Figure 7: Net beach accretion along whole frontage (D+3 to D+34)

Figure 8: Only minor subsequent net change along entire frontage (D+34 to D+61)

4.4 Tracer surveys

The tracer material was painted marine-grade sand chosen to match the natural sediment size distribution as closely as possible. The tracer fluoresces under UV light, and is treated for hydrophobic properties. A purpose-built release bag was filled with the tracer material and lowered to the seabed before being released using an acoustic signal from the surface, thus reducing mid-water column losses of sediment to a minimum. Approximately 1 tonne of yellow fluorescent tracer material was deposited in the middle of the landward row of mounds on 12 February 2015 (D-2). The position was chosen since the principle aim was to investigate whether material from the deposition site would be transported to the beach, but a practical advantage was to reduce any potential for the tracer to be covered by dredger activity further seaward. Different vessels were used for the tracer insertion (Figure 9) and subsequent searches in order to prevent any potential for cross-contamination.

Figure 9: *CH-Horn* at tracer placement site (photo: S. Terry, Borough of Poole)

Originally, the first seabed tracer sweep was planned for around 3 days after placement, with the first beach sweep several days later, depending on the findings of the seabed sweep. However, the shallow location of the deposition site and several days with south or south-easterly winds resulted in the first tracer sweep 3 days following tracer placement (D+1).

Seabed samples of approx. 20 kg were taken using a day grab and a 5-10 kg sub-sample was then extracted for analysis. Samples were taken broadly along four shore-parallel transects, at a spacing of ~ 50m closer to the insertion position, increasing to 100 m intervals further afield. Samples continued to be taken along the transect until no tracer was present. Grabs were also made at two control sites along a transect between the insertion point and the nearest point of the Poole Rocks MCZ.

During the first seabed sweep, some tracer was found in the most landward of the seabed grab samples and, accordingly, the first beach sweep took place the following day (D+2). Three of the 14 beach samples showed the presence of tracer and, as a result, the timing of the second tracer search was brought forward, taking place on 21 and 22 February (D+7, D+8).

Analysis has concentrated on the second tracer sweep since the longer time interval allowed for wider dispersion. Preliminary analysis was based on field observations of the samples, which were allocated into one of 4 bands:

- 0 particles
- 1 – 25 particles
- 26 – 100 particles
- > 100 particles

These initial results are shown in Figure 10. The highest concentration of particles was found at the site of tracer insertion, confirming that the tracer material had not been covered by dredger deposition further seawards. No fluorescent particles were observed at the two MCZ control sites on either tracer search. 27 of the 50 seabed samples and 6 of the 20 beach samples contained some tracer material.

The initial results were used to sub-select 24 samples for full tracer enumeration by UV analysis at the Contractor's UKAS-accredited sediment laboratory, by counting the number of particles in a 1 kg sub-sample, with results being allocated into one of 7 bands:

- 0 particles
- 1 – 25 particles
- 26 – 100 particles
- 101 - 500 particles
- 501 – 1000 particles
- 1001 – 5000 particles
- 5001 – 10,000 particles (none found)
- 10,001 – 100,000 particles (none found)
- > 100,000 particles

The enumeration results confirmed the pattern observed in the field (see Figure 11). Of the two MCZ control sites, 1 tracer particle was found in G9 (the closest to the MCZ), none in G8.

Particle size distributions at 0.5 ϕ intervals were derived for the samples taken at the MCZ control sites (G8 and G9) by dry sieving (63,000 to 1,000 µm) and laser diffraction (< 1,000 to <0.09 µm). Results are given in Table 4. Total fines content (silt and clay) was 3% at G8 and 0.1% at G9.

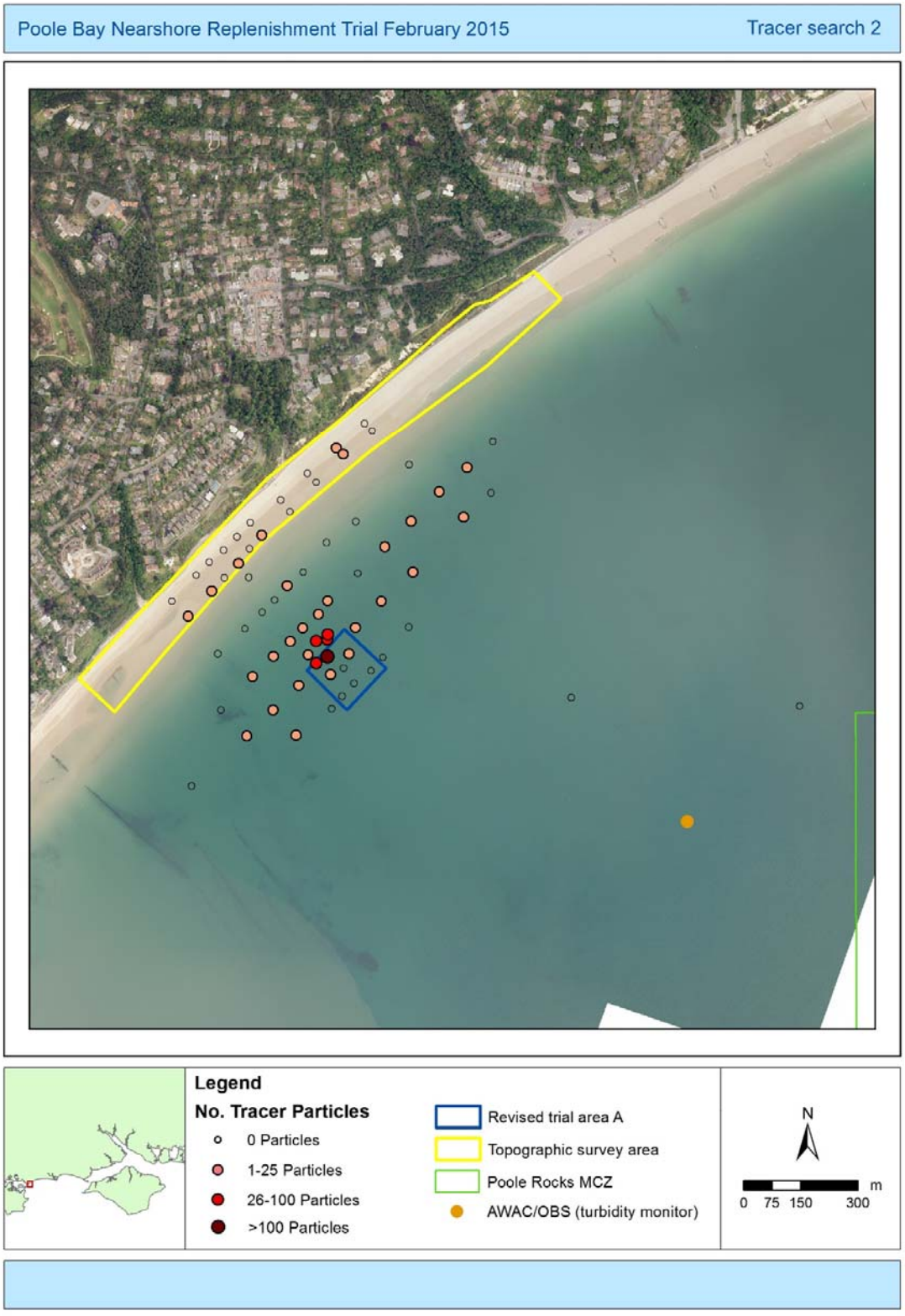

Figure 10: Initial results from tracer search 2 (D+7 [seabed], D+8 [beach])

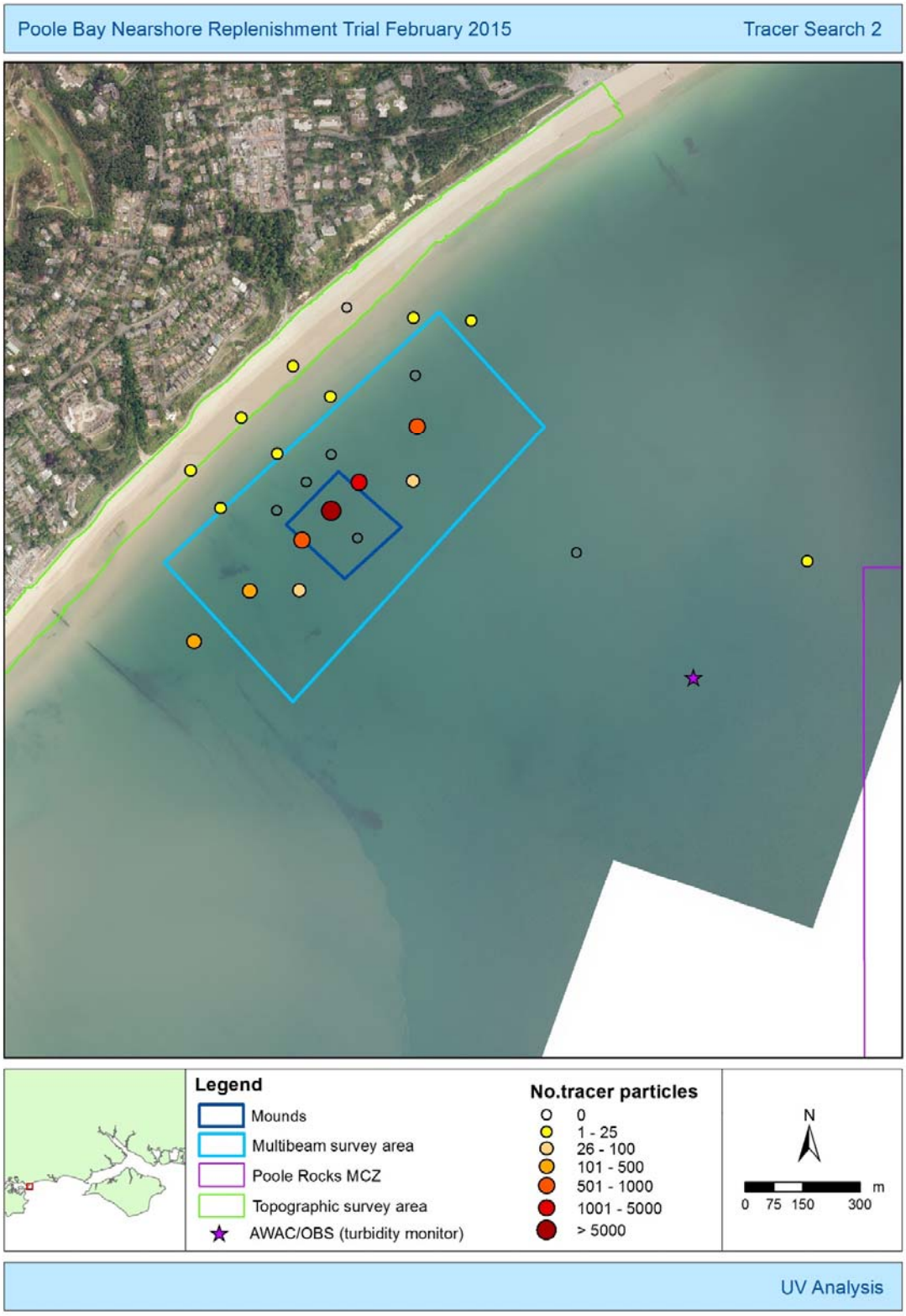

Figure 11: Tracer enumeration results (tracer search 2)

SAMPLE ID	S2_G8	S2_G9
Textural Group		
SAMPLE TYPE	Bimodal, Very Poorly Sorted	Bimodal, Poorly Sorted
FOLK [1954 ORIGINAL]	Gravelly Sand	Gravelly Sand
FOLK [BGS MODIFIED]	Gravelly Sand	Gravelly Sand
SEDIMENT NAME	Very Coarse Gravelly Fine Sand	Coarse Gravelly Fine Sand
Description (Folk & Ward method)		
MEAN	Medium Sand	Fine Sand
SORTING	Very Poorly Sorted	Poorly Sorted
SKEWNESS	Very Coarse Skewed	Very Coarse Skewed
KURTOSIS	Very Leptokurtic	Very Leptokurtic
D10 [µm]	115.03	101.04
D50 [µm]	250.00	192.82
D90 [µm]	7630.69	953.90
(D90/D10) [µm]	66.34	9.44
(D90 - D10) [µm]	7515.66	852.86
(D75/D25) [µm]	3.11	2.23
(D75 - D25) [µm]	343.46	165.99
D10 [Phi]	-2.93	0.07
D50 [Phi]	2.00	2.37
D90 [Phi]	3.12	3.31
(D90/D10) [Phi]	-1.06	48.56
(D90 - D10) [Phi]	6.05	3.24
(D75/D25) [Phi]	2.67	1.67
(D75 - D25) [Phi]	1.64	1.15
% GRAVEL [63000 - 2000 µm]	15.61	8.87
% SAND [< 2000 - 63 µm]	81.27	91.06
% MUD [< 63 µm]	3.12	0.08
% V COARSE GRAVEL	4.97	0.00
% COARSE GRAVEL	3.28	7.74
% MEDIUM GRAVEL	1.55	0.58
% FINE GRAVEL	2.83	0.14
% V FINE GRAVEL	2.98	0.42
% V COARSE SAND	3.08	0.88
% COARSE SAND	6.46	3.85
% MEDIUM SAND	24.85	18.79
% FINE SAND	38.13	48.28
% V FINE SAND	8.75	19.26
% V COARSE SILT	0.09	0.01
% COARSE SILT	1.14	0.00
% MEDIUM SILT	0.41	0.00
% FINE SILT	0.76	0.03
% V FINE SILT	0.60	0.03
% CLAY	0.11	0.00

Table 4: Particle size distribution at MCZ control sites

4.5 Hydrodynamics

Wave height and direction, current profile and turbidity are measured using a Nortek AWAC (Acoustic Wave and Current Profiler) and co-located optical backscatter sensor (OBS). Turbidity is determined from the instrument's backscatter measurements, which together can monitor sediment sizes ranging from silt to coarse sand.

The AWAC/OBS frame was deployed at 50°41.561'N 001° 4.311'W (406793E 88121N) on 27 November 2014. Wave parameters were measured every 20 minutes, and current profiles taken at 1 minute intervals. The AWAC was recovered for servicing on 27 February 2015 and replaced by a similar instrument later that day, with a data gap of only 5 hours. The AWAC and OBS worked well throughout the entire deployment period, with no significant data gaps. The data have been calibrated and quality controlled, and some summary statistics derived, including tidal levels (Table 5) and depth-averaged mean current speeds (Table 6). The maximum Hs measured was 2.48 m on 14/15 January 2015. Work is ongoing to analyse the time series data.

Tidal stage		Elevation	
		Chart Datum	Ordnance Datum
Highest Astronomical Tide	HAT	2.53	1.13
Mean High Water Springs	MHWS	2.19	0.79
Mean High Water Neaps	MHWN	1.80	0.40
Mean Low Water Neaps	MLWN	1.34	-0.06
Mean Low Water Springs	MLWS	0.94	-0.46
Lowest Astronomical Tide	LAT	0	-1.40

Table 5: Summary tidal elevation statistics

Tidal phase	Depth-averaged current speed	
	ms^{-1}	knots
Mean Spring rate	0.235	0.46
Mean Neap rate	0.132	0.26

Table 6: Depth-averaged mean current speeds

5. PRELIMINARY CONCLUSIONS

The tracer study has demonstrated clearly that, given the right hydrodynamic conditions, sediment does move quickly from the sub-tidal nearshore region (~5 m CD) to the inter-tidal beach, along at least 600 m of the shore. The deposited material has remained broadly in situ, with only ~2,000 m^3 loss since deposition. Such small net volumes of sediment change, however, are difficult to identify even from high precision bathymetric and topographic surveys.

Following 6 months of AWAC/OBS data, Natural England has agreed that sufficient data has been collected to set the trial period turbidity results into the context of naturally-derived turbidity. Accordingly, Natural England has agreed to the re-siting of the AWAC/OBS further inshore for the remainder of its year's deployment; this will allow a more detailed understanding of the sediment transport regime in the hydrodynamic conditions experienced at the deposition site.