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Kier Ltd for Environment Agency

Arne Moors Coastal Change Project: Characterisation of Wareham Channel Sediments

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Executive Summary

Kier (acting on the behalf of the Environment Agency) commissioned Enviromud in August 2023 to undertake a sediment characterisation survey in the Wareham Channel, Dorset, UK, to provide a baseline understanding of sediment dynamics at the outer Frome and Piddle estuaries in support of the Arne Moors Coastal Change project.

A two-day survey campaign was carried out on 26 and 27 October 2023, using an Environment Agency fisheries vessel to access mid-channel and bank sites for 7 chosen profiles. Survey positions encompassed the mouths of the Rivers Frome and Piddle, banks and one position on the north adjoining mudflat. A total of 22 sites were surveyed using grabs, and detailed *in-situ* observations, 1cm and 7cm mini-density cores and bed sediment samples for particle size analysis were taken.

The samples were analysed in the laboratory to yield bulk density, particle size distributions (PSD) and further analyses were carried out to investigate sand and silt populations and mineralogy. These results, together with analysis of bathymetric profiles (taken by Atkins Ltd 2019-2022) and field observations were used to build up a picture of the sediment dynamics along the outer Wareham Channel.

For most of the sites, the bed sediments were predominantly around 95% mud content (clay and silt <63µm). Mid-channel sites contained a mixture of mud, sand and gravel. The coarsest sediment was found in the mid channel to the west of Gigger's (P5), that was on a locally-known persistent shoal. The region is likely to be an area of i) Fluvial coarse deposits from the confluence of the rivers Piddle and Frome, carried down the estuary during high energy extreme erosion flooding events and ii) Remains of exposed paleo gravels exposed during erosive events. The region is likely at the lower energy end of fluvial input region (end of an alluvial fan), with coarse sands and gravels persisting in an ebb- dominated tide region with combined ebb tide and fluvial velocities reducing downstream. There were encrustations indicating movement only under high-energy conditions (such as river flood events following storms).

The density results showed lower values in the Piddle estuary, mudflat and bank areas within depositional environments where fine sediment had deposited during periods of low flow, high water periods and was undergoing slow consolidation. The highest densities were found at the confluence of the Rivers Frome and Piddle and shoal region where flows and bed shear stresses are greatest with a higher sand content.

The main channel comprised coarser sediments with medium and medium-fine sand populations transported as bedload, primarily from fluvial input. These mid-channel areas experience regular (low energy) tidal recycling, with sediment moving up and down the estuary, depending on prevailing tidal and river flows.

Finer sands and silts are deposited on the upper banks and mudflats at times of slack currents when these areas are inundated during high water periods. Deposition is greatest when the suspended load is high, such as during river flood events or storm conditions (turbidity during the latter being created by small-amplitude waves).

Further towards Wareham and Turner's Cove to the west, the sediments comprised an increasing biogenic component of leaf, reed and seaweed debris. This is consistent with degradation of upper estuary banks during early autumn storms, particularly the fringing reed (*Phragmites sp.)* beds and drainage from Arne Moors via Furzey Stream from the east into Turner's Cove.

Silt populations were the major constituent on the Frome banks, Poole Harbour and channel eastern banks with slightly finer silt populations at the outer Piddle, and edges of the mudflats and inner banks. These silt fractions are readily recycled in suspension during tidal cycling, normal riverine flows and erosion of wider intertidal Poole Harbour mudflat surfaces by action of small amplitude waves during shallow water periods.

The shelly fragments were typically estuarine species and local oysters likely originating within the intertidal environment of Poole Harbour.

Analysis of the three dominant (coarser) sand size populations (63µm to 2mm) generated by the flow regime within the region indicated;

i) Bedload - Medium Sand
ii) Transition (Bedload and Suspended Load)- Fine Sand
iii) Suspended Load - Very Fine Sand

The mineralogy images showed a significant component of white sands, comprised of mostly shell and quartz being regularly recycled around the upper intertidal Poole Harbour region. The coarser mid-channel sediments were comprised shells, quartz and flint being slightly rounder in appearance, representative of a moderately mobile bedload, derived primarily from terrestrial sources. The slip-off inner bank slopes and mudflat sediments were much finer (~95% mud) and were of mixed sand composition that included a higher component of shell fragments, quartz and darker reed fragments consistent with an upper estuarine depositional environment. The dominant sediments in the region are derived from erosion of chalk river valleys to the west (quartz and flint) of fluvial input, mixed shells and seaweeds from littoral beaches, intertidal mudflats and oyster beds within Poole Harbour and broken reeds and algal/seaweed matter from the upper estuary banks.

Investigation of the bathymetric profile plots broadly showed that the channel, inner and outer banks sedimentary environments showed features that were expected with a typical estuarine setting. The sediment regime is a complex one, having two river mouths and a small stream input at Turner's Cove. The profile plots showed an overall picture of erosion of gradual deepening of the channel beds between October 2019 and November 2023.

The survey area covered the south western region of Poole Harbour. The seabed sediment properties measured during the survey are consistent with an ebb-dominated/river flow regime. Inputs from the Rivers Frome and Piddle occur during high rainfall/high river flow conditions, mostly over late autumn-winter-early spring stormy weather periods giving an intermittent feed of fluvial sediment. Accretion in the study area is a combination of riverine discharge and tidal recycling of Poole Harbour mudflats. These processes are consistent with the Conceptual Model of Poole Harbour Sediment Transport Model proposed by EA/Atkins (2024). Further comment on the conceptual model is not covered by this survey and would require a thorough investigation of additional data within the wider Poole Harbour.

It is recommended that velocity profile monitoring should be undertaken to investigate the applied bed shear stresses during ebb dominated (high river flow and high Spring Tide) conditions is measured via velocity profiles, and the critical erosion shear stress (SedErode) and surface shear strength (high-sensitivity Shear Vane) to enable evaluation of local hydraulic sediment surface conditions. Long-term measurements of turbidity (ideally vertical profiles, calibrated to provide Total Suspended Solids) and flow are recommended at a suitable site (perhaps near Turner's Cove where change might be expected).

It is recommended that the existing (and ongoing) LIDAR bed level data is analysed in GIS to further investigate regions of erosion and deposition, hypsometry and approximate sediment budgets. It is recommended that the conceptual model should additionally include wave-action and associated erosion and movement of sediments by wave-induced bed shear stresses over the shallow Poole mudflat region.

1. Introduction

1.1 Background

The Arne Moors Coastal Change Project is currently underway in the western region of Poole Harbour, to the east of the mouth of the Frome and Piddle (Trent) estuaries (Figure 1). The existing seawall fronting the north of Arne Moors is to be breached in three places to allow tidal exchange, saline inundation, and fine sediment deposition in the region to the south of the old seawall. A new seawall is being constructed to the south of the area. The aim of the project is to create new regions of tidal lagoons, salt marsh and mudflat to replace that lost by coastal squeeze, the latter being important habitats and avian feeding areas. The project is jointly funded by the Environment Agency, Natural England and RSPB.

As part of this project there is a need to characterise the local bed sediments and provide a baseline estuarine condition and sediment dynamics and transport within in the region. Enviromud was instructed in August 2023 to carry out this work. This data set will complement a previous sediment survey in the region by ABPmer in 2016 and bathymetric profiling by Atkins Ltd (2019-2022).

Figure 1. Wareham Channel region to the west of Poole Harbour (Google Maps).

1.2 Objectives

The objective was to characterise the channel and bank sediments of the outer Frome and Piddle and western edge of Poole Harbour, Dorset, UK. Following bathymetric surveys of profiles along the estuary (Atkins 2022), seven chosen cross-channel profile locations were surveyed, prescribed by the Environment Agency. A sediment sampling survey was carried out during Spring tide conditions on Thurs 26 and Fri 27 October 2023. At each profile location, three bed samples were taken using grabs; in mid-channel and on adjacent bank slopes. A full set of grab samples and measurements

were taken, including *in-situ* observations, photos, mini density cores and sediment samples. The samples were analysed in the laboratory for density and particle size distribution (PSD). The resulting data set was analysed to investigate the sediment characteristics and regime within the outer Wareham Channel region.

1.3 Site Characteristics

The Frome and Piddle/Trent estuaries in the survey region are intertidal with a tidal range of typically around 1m. The Frome estuary drains from the west through the town of Wareham into Poole Harbour, west of Gigger's Island. There are two bends in the channel in this region (Figure 2), near the mouths of the Frome and Piddle to the north, and near Turner's Cove to the south. The channel is around 30 to 100m wide and varies with location (Atkins 2022). Mid channel depths are 0.3 to 1.0m CD. There are mudflats surrounding the channel, around Gigger's Island and east of Turner's Cove, typically between 1.0 to 1.5 m CD.

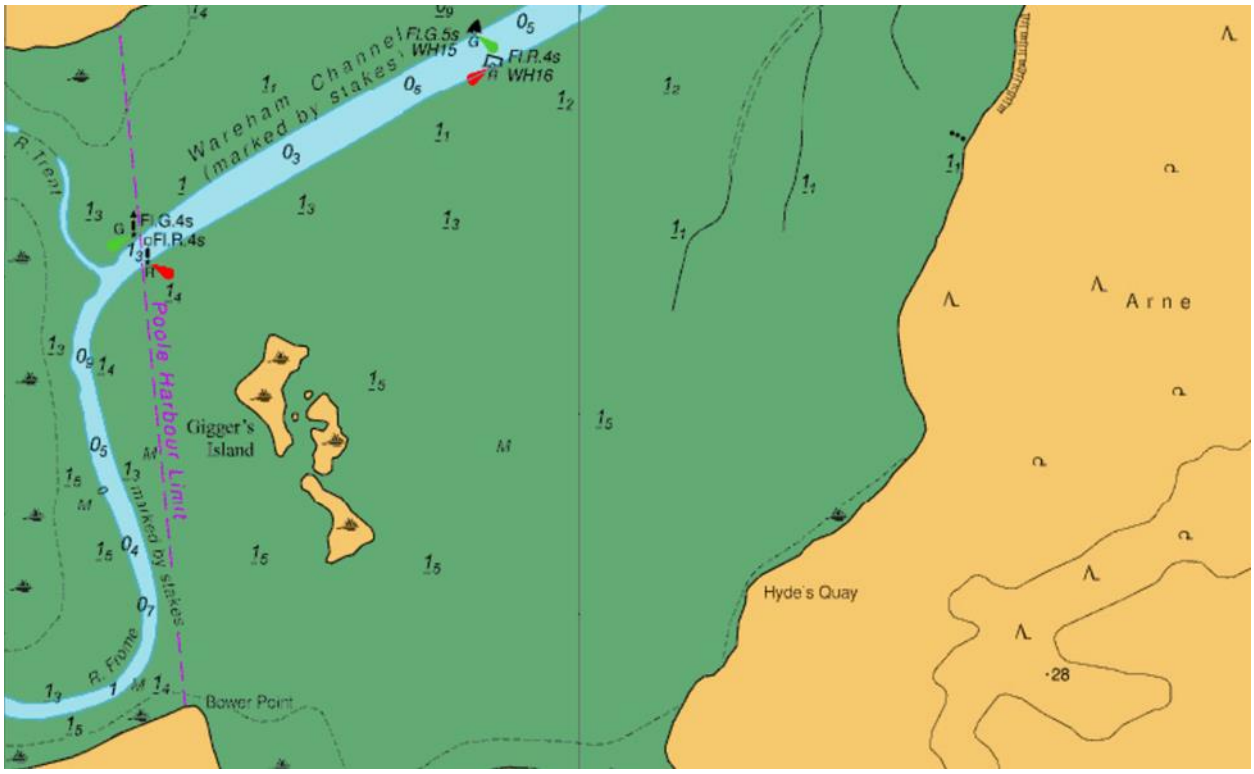


Figure 2. Extract of Admiralty Chart AC 2611 (Poole Harbour and Approaches) showing local levels to m Chart Datum.

2. Sediment Sampling Survey

2.1 Methodology

Bed sediment samples were obtained by grabs during inundated periods during HW Spring tide conditions on 26 and 27 October 2023. It was impractical to access exposed banks during the LW periods due to limited exposure time and insufficient daylight hours. It was decided that sediments would be sampled at both mid-channel and bank sites using either a van Veen grab or Ekman corer. The EA Fisheries vessel, the 'Orion' (out of Wareham) was used to access 22 sample positions.

At each site measurements and sampling comprised the following:

- Site Meta Data (positions and conditions)

- Detailed site observations, manual assessment, and photographs
- 10cm depth Sediment Sample for Particle Size Distribution
- 1cm and 7cm Density cores

The samples were analysed in the Enviromud laboratory to obtain:

- Particle Size Distributions
- Sediment fraction photographs and microscope images
- Bulk Density of mini-cores

2.2 Logistics and Boat Access

The bed surface was inundated throughout the survey days. The Environment Fisheries vessel 'Orion' provided access, leaving Wareham Quay at morning HW and surveying during a dropping tide. The local EA Fisheries Boat Team was the most favourable choice to provide the vessel, and the skipper has good local estuary, navigation knowledge and experience in the local area. Positioning of the mid-channel locations was achieved by use of mobile phone What3Words App to within +/- 3m estimated accuracy, together with local channel knowledge and channel marker sticks. A bow anchor was used to maintain the boat position during flowing tidal currents. A small van Veen day grab was used to sample bed deeper sediments in deeper water and a pole mounted Ekman corer was used to sample in shallower water depths. A total of 22 positions were surveyed.

The tides were as follows (times in GMT):

Thursday 26 October 2023

02:54 LW1 +0.6m CD

08:09 HW1 +2.1m CD

12:05 HW2 +1.9m CD

15:08 LW2 +0.8m CD

Survey period was between 07:30 and 15:00 GMT (08:30 and 16:00 BST)

Figure 3. Poole Harbour Tides during the first survey day 26 October 2023 (from Belfield Tide Plotter Programme, 2018).

Friday 27 October 2023

03:35 LW1 +0.5m CD

08:47 HW1 +2.2m CD

12:52 HW2 +2.0m CD

15:57 LW2 +0.6m CD

Survey period was between 07:30 and 16:30 GMT (08:30 and 17:30 BST)

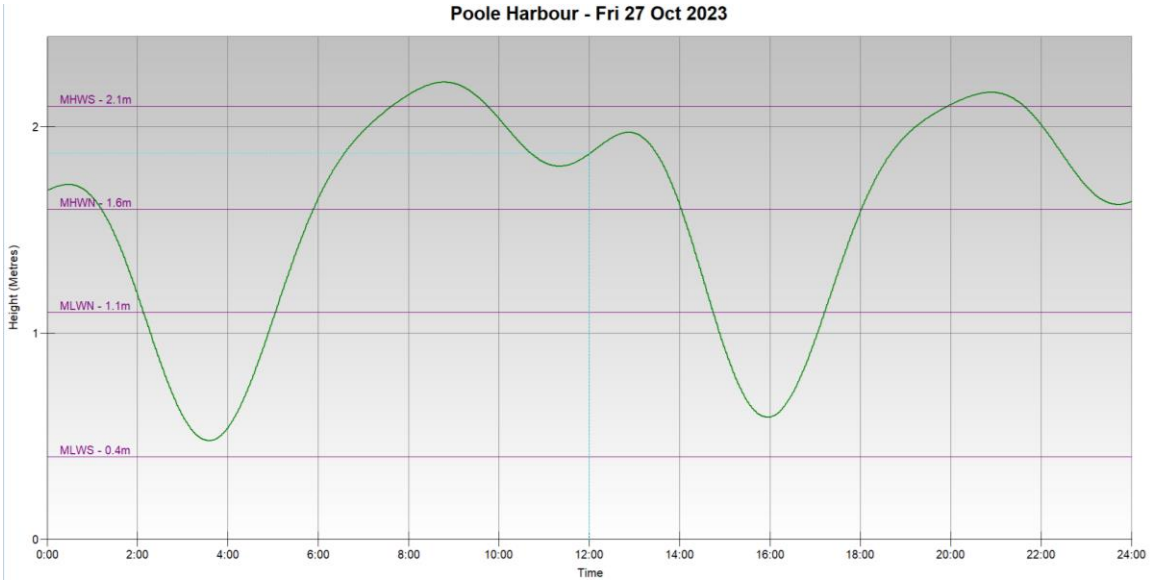


Figure 4. Poole Harbour Tides during the second survey day 27 October 2023 (from Belfield Tide Plotter Programme, 2018).

2.3 Field Equipment

A 2m pole-mounted Ekman corer was used to obtain bed samples at shallower (mostly bank) sites by driving the corer into the bed and obtaining a 20cm x 20cm area sample (depth varying with substrate composition) and is shown in Figure 5. In deeper water (at high tide and mid-channel), a small van Veen grab was deployed (Figure 6).

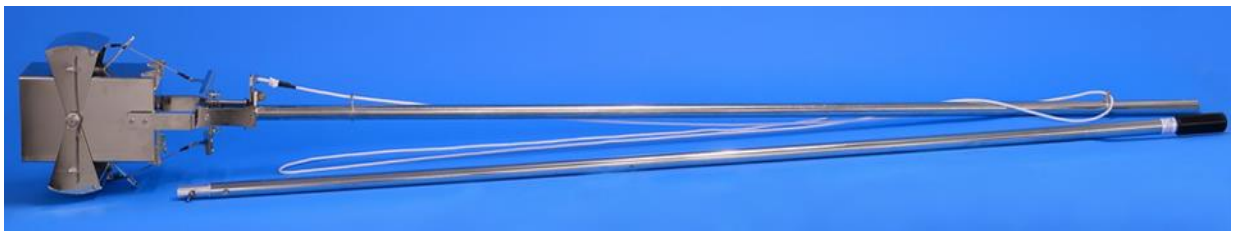


Figure 5. Pole mounted Ekman grab used during the survey (2m length, corer size 20 x 20 x 20cm).

Figure 6. Van Veen grab (0.1m^3) used during the survey in deeper water.

Density core samples were taken from the surface of the grab samples by driving the straight-sided bespoke beakers vertically into the sediment and using a cutting plate at the base to extract a fixed-volume sample. The beakers with samples were placed into pre-weighed bags and stored in a cool box prior to weighing in the laboratory. 1cm and 7cm density beakers are shown in Figure 7.

Figure 7. 1cm and 7cm density beakers and cutting plate.

For each site a ~500g sediment sample was taken from 0-10cm depth for particle size analysis. The samples were double-bagged and stored in a cool box and fridge prior to laboratory analysis.

3. Laboratory Analysis

3.1 Density

The beaker core samples collected from the grabs were extracted into individual beakers that had unique weights and volumes pre calibrated to 2dp. The beakers and contents were weighed to +/- 0.01g. The mass of sediment was divided by the individual beaker volume to calculate bulk density.

3.2 Particle Size Distribution

The sediment samples were analysed in the laboratory for particle size distribution (PSD). Methods (based on BS 1377) are described in AEC 2018.

The samples were initially wet sieved to separate the non-cohesive sand fraction (>63µm) from the cohesive mud fraction (<63µm). The sand fraction PSD was analysed via the dry sieving method and the mud fraction PSD via pipette analysis. Coarse material greater than 2mm (pebbles, shells, seaweed and reeds) were retained on a separate dish so that they were not broken up during the wet sieving and dried before adding to the dried sand fraction (>63µm) for dry sieving.

Wet Sieving

A representative sediment sub-sample of ~300ml was taken and stirred into water in a 1 litre beaker to make an even slurry. The sample was washed and brushed through a 63 µm sieve and repeatedly rinsed with water to ensure all fines were removed. The >63µm fraction retained on the sieve was oven dried at 105°C until a constant weight was obtained and cooled in a desiccator for dry sieve analysis of the sand fraction (described below). The sediment concentration of the slurry passing the sieve (approximately 2 litres) was determined by drying a 100ml sub sample. A further 100ml sub sample was taken for pipette analysis of the fine <63µm silt and clay fraction (see below).

Dry Sieve Analysis of Sand Fraction

The oven-dried sand fraction was dry sieved on a sieve shaker through a set of sieves (63µm to 2mm, -1.0 to 4.0phi at 0.5 phi intervals) for 20 minutes. The sand retained on individual sieves was weighed and the contents of each observed for lithogenic or biogenic origin and colour on 'fraction wheel plates'. In addition, modal sediment fractions were observed under the microscope and images taken to check both sieving effectiveness and grain characteristics.

Pipette Analysis of the Mud Fraction

The <63µm mud (silt and clay) fraction slurry from the sieving (~2litres) was transferred to a stirring receptacle with a baffle and stirred as fast as practical to ensure full dispersion. Two representative subsamples (identical, 100ml each) were taken from the stirred slurry volume with a syringe/tube. The remaining volume of the slurry was measured. One subsample was dried at 105°C until a constant weight was reached and weighed, from which (with the volume data) the percentage of the total sample finer that 63µm was determined. The other sample was not dried but treated with hydrogen peroxide (12%wt/vol) to digest and remove organic material. When effervescence had ceased, the subsamples were boiled to a thick slurry to remove the remaining hydrogen peroxide. Thes samples were then dosed with 50ml of sodium hexametaphosphate (dispersant) and suspended in 1000ml of water. Batches of samples (4 or 5) were placed in a water bath at 20°C, stabilised, then a pipette analysis was undertaken (BS1377) to determine the percentages of the 63-16µm, 16-4µm and <4µm fractions within the <63µm fines fraction.

The data for the sand and mud fraction were combined to yield full particle size distributions for the three grab samples. Sediment type descriptors (e.g., Folk and Ward) were assigned on the basis of statistical analysis ('Gradistat'), and component log-normal populations were identified for the sand and silt fractions (between 2 and 8 phi) using an Excel facility.

4. Results

4.1 Sample Positions

A total of 22 locations were sampled between 26 and 27 October 2023 over 7 cross-channel profiles including mid-channel and banks positions (Table 1 and Figure . An additional location 'PH-FLAT' was sampled, over the northern mudflat within north-west Poole Harbour.

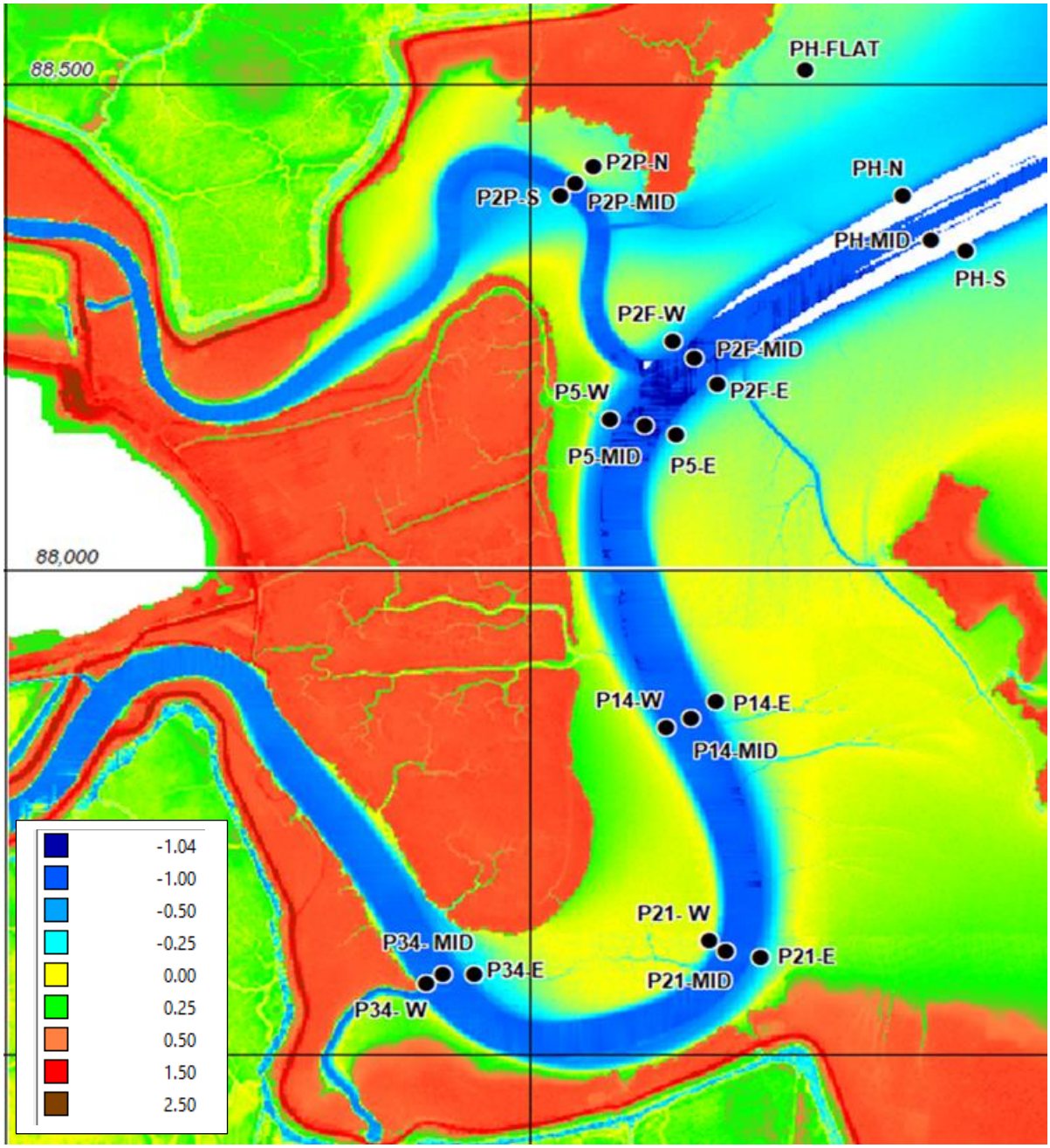


Figure 8. Mid-channel survey sampling positions during the 26-27 October 2023 sediment survey. Lidar base map (Bed level in metres relative to ODN, surveyed 2017, supplied by Channel Coastal Observatory).

Site	Date	Time	W3W	Lat N	Long E	Sampling
		Start	position			Method
PH-N	26.10.23	11:37	editor.ships.forks	50.695033	-2.074204	Grab
PH-FLAT	26.10.23	11:07	nature.down.tape	50.696192	-2.075523	Ekman
PH-S	26.10.23	12:05	over.slug.labels	50.694521	-2.073353	Grab
PH-MID	26.10.23	09:55	boot.hired.joke	50.694629	-2.073821	Grab
P2P-MID	26.10.23	12:20	even.moon.just	50.695141	-2.078630	Grab
P2P-N	26.10.23	12:48	belts.float.sunset	50.695302	-2.078375	Ekman
P2P-S	26.10.23	13:13	brief.poker.strike	50.695033	-2.078843	Ekman
P2F-MID	26.10.23	14:09	swung.heads.universally	50.693524	-2.077013	Grab
P2F-W	26.10.23	14:42	slowly.usage.slap	50.693685	-2.077311	Ekman
P2F-E	26.10.23	15:13	thank.gives.foods	50.693281	-2.076715	Ekman
P5-MID	26.10.23	16:53	waddled.pouch.chops	50.692904	-2.077694	Grab
P5-E	26.10.23	16:27	train.police.crash	50.692823	-2.077268	Ekman
P5-W	26.10.23	15:58	club.spark.remark	50.692958	-2.078162	Ekman
P14-MID	27.10.23	09:40	skin.piano.almost	50.690182	-2.077056	Grab
P14-E	27.10.23	10:08	stump.doctor.placed	50.690343	-2.076715	Grab
P14-W	27.10.23	10:41	chin.tall.moss	50.690101	-2.077396	Ekman
P21-MID	27.10.23	11:25	caked.soda.brass	50.688026	-2.076588	Grab
P21- W	27.10.23	11:51	juror.custom.heats	50.688133	-2.076800	Grab
P21-E	27.10.23	12:40	loser.complains.gangs	50.687972	-2.076119	Grab
P34- MID	27.10.23	13:35	late.wanted.files	50.687810	-2.080418	Grab
P34- W	27.10.23	13:39	rank.sudden.shave	50.687729	-2.080631	Grab
P34-E	27.10.23	14:08	stale.ports.jobs	50.687810	-2.079992	Grab

Table 1. Survey positions, times, and grab sampling methods for the October 2023 sediment survey.

4.2 Results Summary

A summary table of the key numerical results of the sediment survey and sample analysis are shown in Table 2. The PSD data is given as i) overall % of mud, sand and gravel, ii) % clay (<4µm) within the <63µm fines fraction, and iii) three component sand populations analysed within the sand fraction.

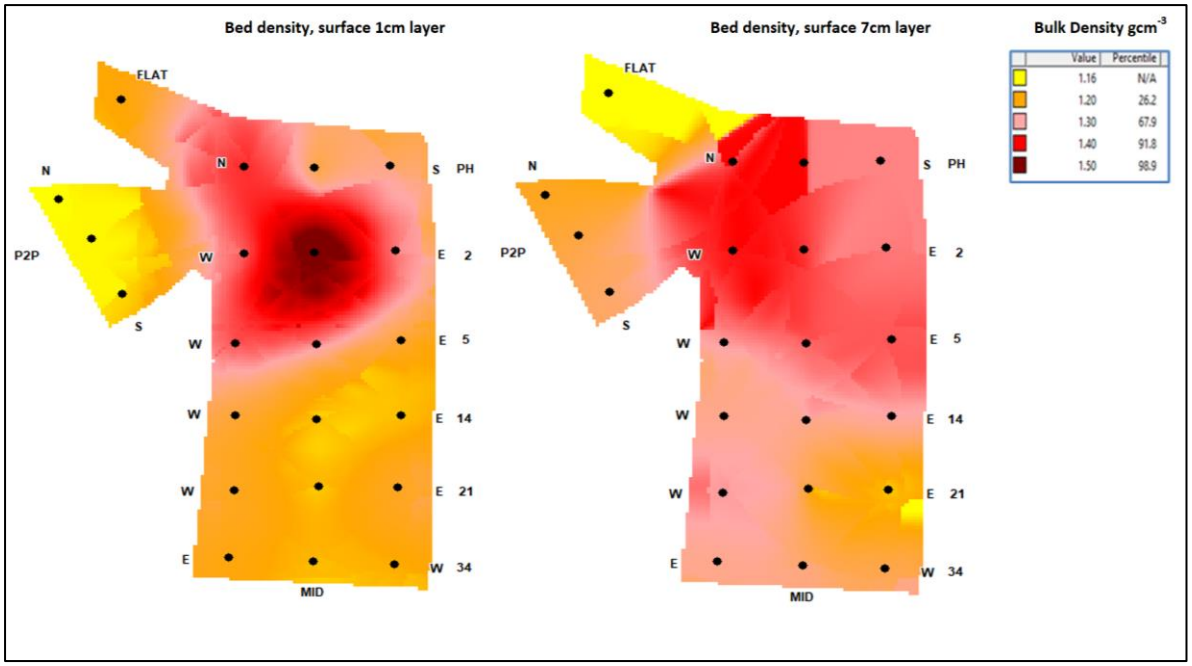
Site	Lat N	Long E	%Gravel	% Sand	%Mud	ClayAs% Mud	Median	Sand Population 1			Sand Population 2			Sand Population 3			Density	Density
			(Actual)	*(Actual)*	*(Actual)*	*%<4µm*	*d50 ϕ*	*mean φ*	*SD*	*%*	*mean φ*	*SD*	*%*	*mean φ*	*SD*	*%*	**1cm**	**7cm**
PH-N	50.695033	-2.074204	0.1	4.6	95.3	25.6	5.7	3.55	0.27	0.68	2.60	0.40	0.24	1.00	0.59	0.08	1.45	-
PH-FLAT	50.696192	-2.075523	0.5	1.4	98.2	42.4	7.2	3.58	0.36	0.41	2.49	0.40	0.33	1.10	0.60	0.27	1.20	1.15
PH-S	50.694521	-2.073353	0.0	5.6	94.3	36.4	6.0	3.56	0.26	0.83	2.55	0.29	0.07	1.20	1.00	0.10	1.27	-
PH-MID	50.694629	-2.073821	0.1	36.7	63.2	43.1	5.3	3.50	0.33	0.37	2.52	0.34	0.36	1.80	0.60	0.27	1.17	-
P2P-MID	50.695141	-2.078630	11.2	4.4	84.5	46.7	6.7	3.50	0.35	0.15	2.50	0.30	0.36	1.00	0.59	0.49	1.17	-
P2P-N	50.695302	-2.078375	0.6	0.7	98.7	48.7	7.7	3.53	0.33	0.39	2.53	0.33	0.32	1.00	0.59	0.29	1.16	1.22
P2P-S	50.695033	-2.078843	0.3	3.5	96.2	43.9	6.9	3.52	0.28	0.58	2.57	0.35	0.23	1.00	0.80	0.20	1.16	1.26
P2F-MID	50.693524	-2.077013	0.4	67.9	31.7	47.1	1.3	3.52	0.28	0.01	2.25	0.44	0.14	1.03	0.42	0.85	1.87	-
P2F-W	50.693685	-2.077311	0.3	3.0	96.7	37.9	6.2	3.55	0.29	0.61	2.51	0.38	0.39	1.03	0.42	0.00	1.16	1.39
P2F-E	50.693281	-2.076715	0.4	3.3	96.3	37.8	6.4	3.55	0.24	0.80	2.51	0.28	0.14	1.03	0.42	0.06	1.22	1.32
P5-MID	50.692904	-2.077694	48.2	29.6	22.2	48.1	-1.0	3.50	0.31	0.04	2.51	0.49	0.21	1.00	0.46	0.75	-	-
P5-E	50.692823	-2.077268	0.6	4.8	94.5	40.4	6.5	3.55	0.30	0.63	2.70	0.47	0.25	1.00	0.90	0.13	1.22	1.35
P5-W	50.692958	-2.078162	7.1	38.5	54.4	41.2	5.0	3.50	0.27	0.05	2.00	0.51	0.60	1.00	0.40	0.35	1.44	-
P14-MID	50.690182	-2.077056	22.1	13.3	64.5	50.6	5.7	3.53	0.30	0.20	2.55	0.54	0.49	1.03	0.56	0.31	1.14	-
P14-E	50.690343	-2.076715	0.0	2.1	97.9	34.0	6.2	3.55	0.26	0.77	2.50	0.32	0.20	1.03	0.56	0.03	1.17	1.34
P14-W	50.690101	-2.077396	1.9	1.2	97.0	41.3	6.6	3.57	0.27	0.45	2.55	0.55	0.40	0.58	0.48	0.15	1.20	1.27
P21-MID	50.688026	-2.076588	0.9	0.4	98.7	52.1	8.2	3.54	0.32	0.39	2.17	0.44	0.36	0.95	0.32	0.25	1.17	-
P21- W	50.688133	-2.076800	0.1	1.8	98.1	41.2	6.0	3.61	0.34	0.50	2.52	0.30	0.25	0.98	0.49	0.25	1.26	1.33
P21-E	50.687972	-2.076119	0.2	1.8	97.9	40.5	6.7	3.52	0.29	0.41	2.64	0.43	0.27	1.05	0.95	0.32	1.28	1.12
P34- MID	50.687810	-2.080418	0.5	64.7	34.8	43.9	1.7	3.50	0.29	0.01	2.10	0.20	0.04	1.58	0.51	0.95	1.18	-
P34- W	50.687729	-2.080631	0.1	37.2	62.8	44.1	5.7	3.46	0.30	0.10	2.45	0.33	0.72	1.58	0.51	0.18	1.18	1.28
P34-E	50.687810	-2.079992	0.1	1.3	98.6	42.6	6.7	3.52	0.29	0.33	2.73	0.50	0.47	1.05	0.40	0.19	1.21	1.27

Table 2. Summary of key results from the October 2023 Wareham Channel Sediment survey.

4.3 Density

A total of 22 x 1cm depth cores and 12 x 7cm depth cores were taken if possible. For coarser sediments and shallower grab samples only 1cm density cores were obtained.

Table 2 shows the density values for each site and Figures 9a and 9b show the density variation plotted schematically in GIS.



Figures 9a and 9b. GIS spatial image of the distribution of sediment density from 1cm and 7cm cores.

The density data show a variation in density of the top 1cm between 1.16 and 1.87gcm^{-3}. The highest values, 1.87gcm^{-3}, were found at site P2F-MID, in the mid channel at the confluence of the Frome and Piddle mouths where the samples contained a lot of sand, that increased the density and compaction. Figure 10 shows the density vs sand content for the top 1cm layer, showing a density variation between 1.15 to 1.30 gcm^{-3} for 0-10% sand, reflecting different degrees of consolidation. The lowest 1cm surface densities (around 1.16gcm^{-3}) were found within the outer Piddle estuary, with high mud content and low sand content and of soft, underconsolidated consistency indicating recent deposition. Generally, the surface 1cm densities were lower at the edges of the channels and mudflat areas, reflecting depositional environments where fine sediments dropout during high tide, low flow periods and slowly consolidate.

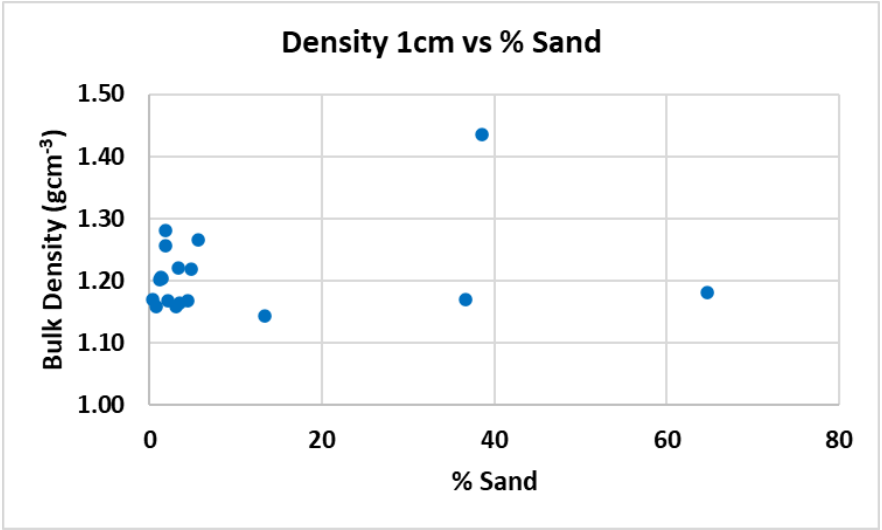


Figure 10. Density of top 1cm vs %Sand content.

Figure 11 shows the density vs sand content for the top 7cm layer, showing a positive relationship, as found in literature (Whitehouse *et al*., 2000). The 7cm densities ranged from 1.15 to 1.39cm^{-3},

with the highest values around the confluence of the Frome and Piddle mouths and Profile 5. The lowest 7cm density layer values were found on the mudflat proper sites to the north of site PH and at the Frome banks at profiles P21 and P34, in regions of quieter flow, depositional environments with high mud contents (fines fall out) and underconsolidated sediments.

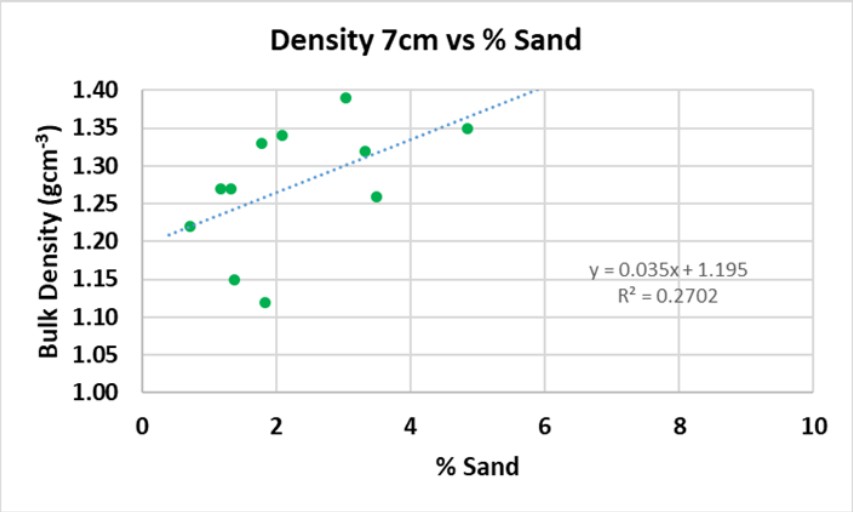


Figure 11. Density of top 7cm vs sand content.

4.4 Particle Size Distribution

4.4.1 Sediment Composition

Table 2 shows the percentages of gravel (>2mm), sand (63µm to 2mm) and mud (<63µm) for the bulk samples taken from the top ~10cm of the bed. Figures 12a, 12b and 12c show the GIS images of the distributions of these fractions.

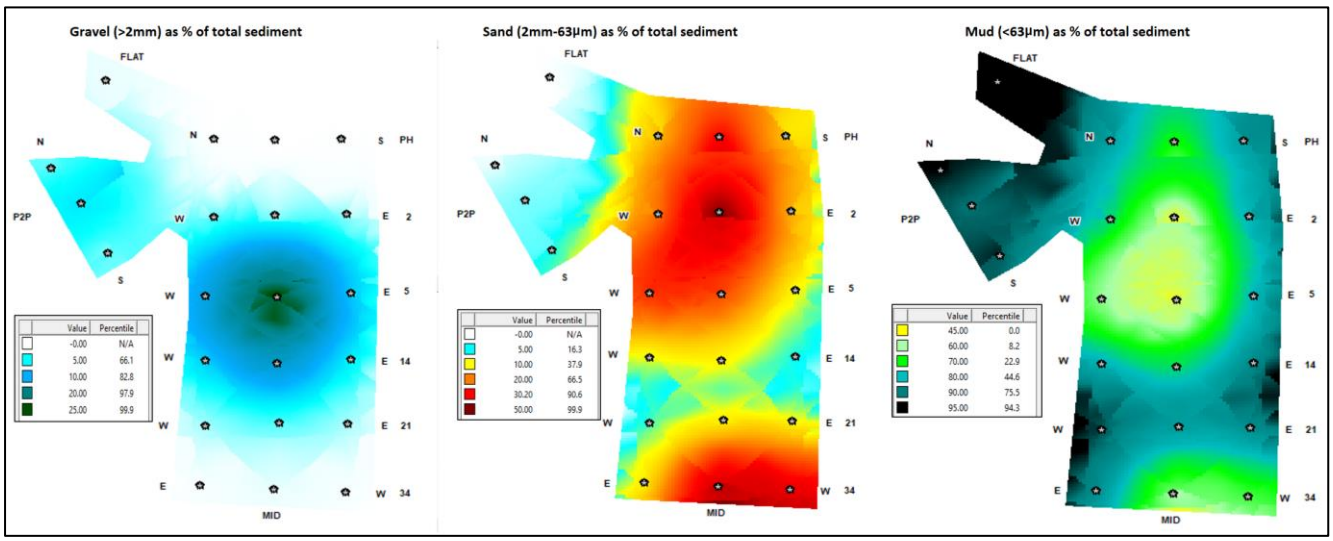


Figure 12a, 12b and 12c. Relative contributions of gravel, sand and mud in the sediment samples.

Gravel amounts varied between near-zero to a maximum of 48% at P5-MID on a known shoal in the mid channel. Highest gravel contents were found in the mid channel towards the north in mid-stream (P5-MID and P14-MID) where flows and bed shear stresses are likely to be the greatest during extreme weather events with high river flows, wave induced currents and high Spring and Autumn Equinox Spring tides. The lowest % gravel was found in the outer region in Poole Harbour

and the adjoining mudflat, banks and to the south near Turner's Cove (profile 34), associated with fine sediment deposition from lower flows.

Sand content varied between 0.4% and 64%. The highest sand content was generally found in mid-channel regions, particularly at the Piddle estuary mouth and the west of Turner's Cove (profile 34), where it is likely to have been deposited load from suspension or as local bedload. The lowest sand contents generally occurred in the lower Piddle estuary (P2P), mudflat site (PH-FLAT) and towards the bank regions.

Site	% Sand	% Gravel	% Combined S+G	Comments
P2F-MID	68	~0	68	Near confluence of R. Piddle and R. Frome
P5-MID	30	48	78	Over mid channel persistent shoal
P14-MID	13	22	35	
P21-MID	1	~0	1	Not in channel, suspect over bank
P34-MID	65	~0	65	Turner's Cove near Furzey Stream outlet and small mudflat

Table 3. Percentage Sand and Gravel Contents for Mid-Channel Sites.

Table 3 shows the % sand and gravel, and %combined (>63µm) for the mid-channel sites. There is an increase in % sand going down-channel from P14-MID (22%) to P2F-MID (68%). There is also an increase in gravel content between P14 and P5 (22% to 48%). There was virtually no gravel at sites P2F-MID and P34-MID, but high sand content at around 68%, both sites representing riverine drop-out of coarse sand at the R. Piddle and R. Frome confluence and near the Furzey Stream outlet.

The mud content was generally very high, over 95% for most of the sites, except for mid-channel sites in the Frome estuary (profiles 2, 5, 14 and 35). For the true mudflat site (PH-FLAT), Piddle estuary mouth and bank areas the mud content was highest, reflecting depositional zones in areas of quieter flows. Mud contents were lowest in the mid-channel bank regions and to the west of Turner's Cove in areas higher flows.

4.4.2 Size Distributions

Figure 13 shows the distribution of all of the size fractions between -5 and 8 phi (4µm to 3cm) for all of the sites, as discrete distributions, thus highlighting the particle populations present. The majority of the sites were predominantly mud (95% or higher) and this is reflected in the generally higher % contributions from the silt and fine sand fractions (0 to 8 phi).

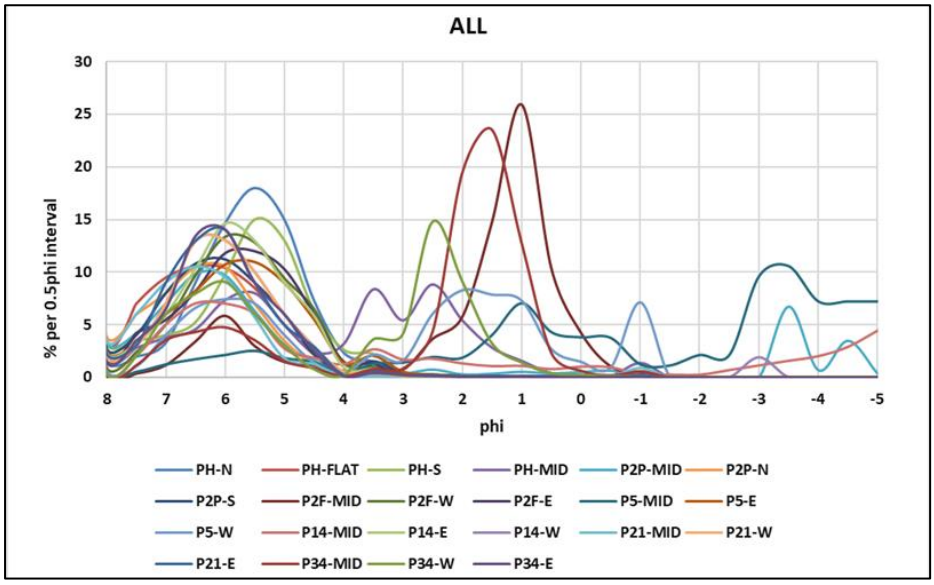


Figure 13. Distribution of all the fractions within the samples from 8 to -5 phi (4µm to 3cm).

For the banks, mudflat and Piddle sites most of the size components have peaks around 5.5 to 6.5 phi (medium and fine silt) with lower peaks around 3.5 and 1-2 phi (very fine and medium sand).

The mid-channel sites contain higher contributions from the sand fraction (0 to 3 phi) and also some gravel (~-3 phi), notably P5-MID and P21-MID near the mid channel shoal.

These results are consistent with fine sediment silts and clays being deposited over the banks, mudflats and quieter outer Piddle and coarser sand fractions being transported as suspended load or bed load within the mid channel regions where flows and bed shear stresses are higher.

Figure 14 shows the three derived sand populations for selected mid-channel sites and at Turner's Cove (P34) where higher sand contents are found. The most dominant peaks are for medium sand (highlighted in yellow) and fine sand (highlighted in blue). There is a lower peak around 6 phi (medium silt). These populations indicate deposition of medium and fine sand and silt fallout. medium sand likely carried as bedload in higher flow zones.

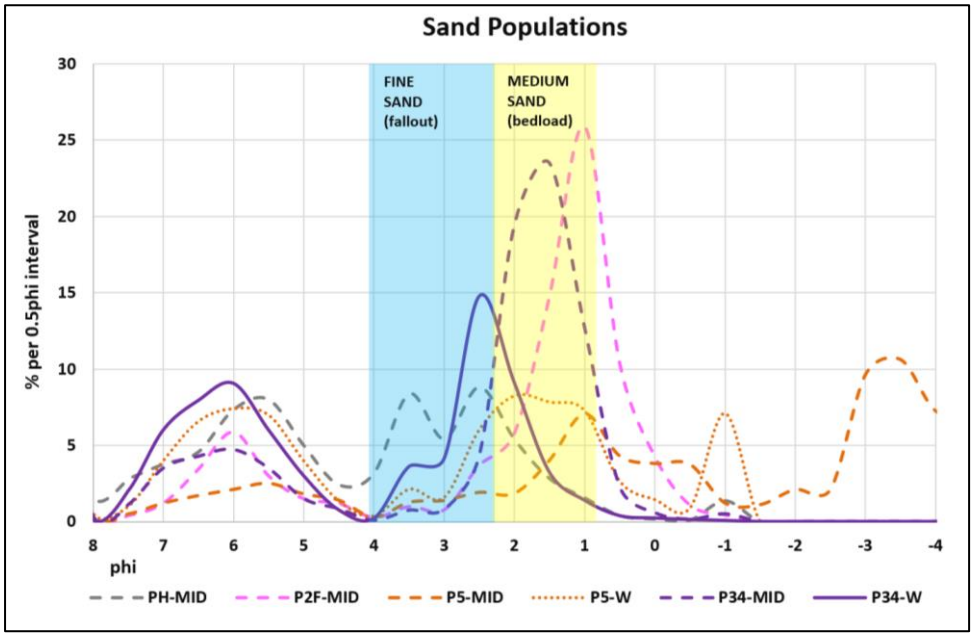


Figure 14. Sand populations for some mid channel sites and Turner's Cove (P34).

The data was further investigated to distinguish between 2 distinct silt populations in the muddy samples (around 95% mud), between 6 and 6.5 phi (fine silt) and 5.5 and 6 phi (medium silt). Figures 15 and 16 show fine sand and medium silt populations for selected muddy sites.

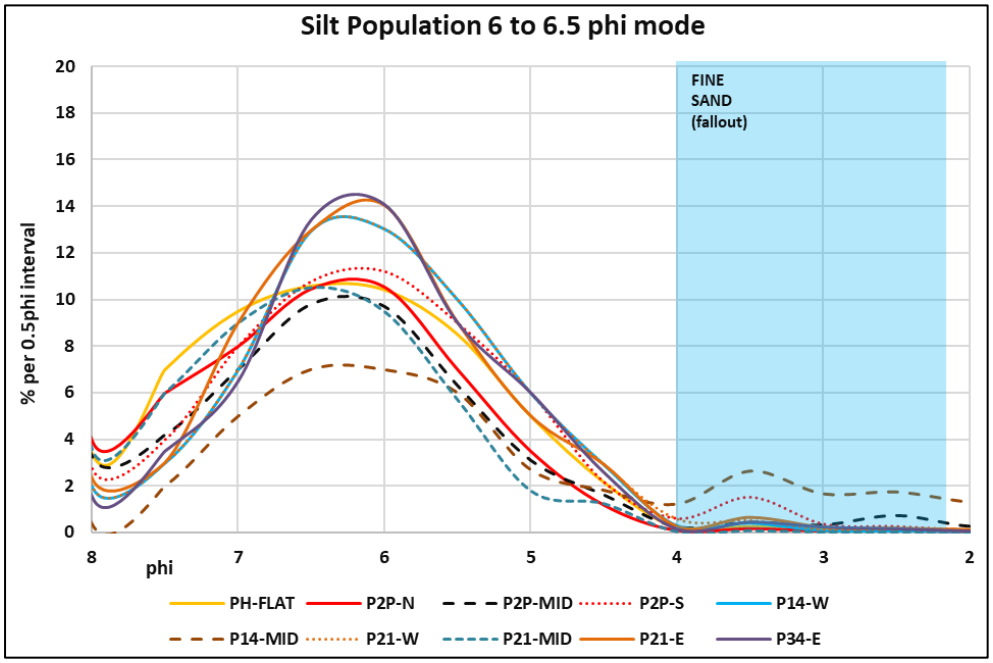


Figure 15. Fine silt populations at 6 to 6.5 phi for selected muddy sites.

Both plots have small peaks around 3.5 phi (very fine sand) representing fine sand fallout deposits. Finer silt populations (5.5 to 6 phi), shown in Figure 15 were found at the Piddle estuary mouth (P2F), mainstream channel regions (P14 and P21), mudflat to the north and mudflat opposite Turner's Cove. Medium silt populations (6 to 6.5 phi) were found at the Frome estuary banks, on the banks of the Poole Harbour channel and mid-channel eastern banks (Figure 16).

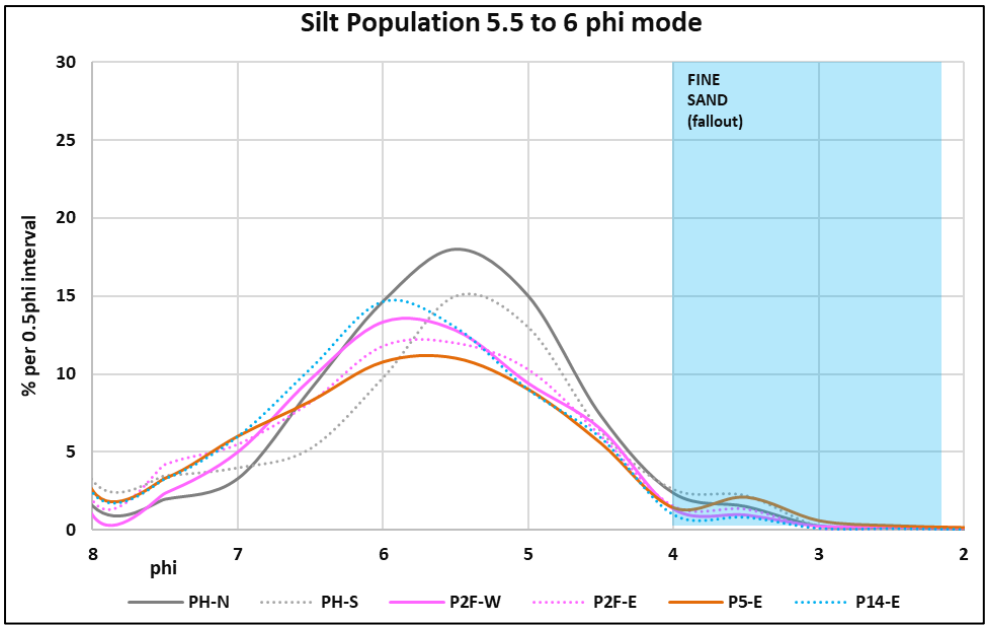


Figure 16. Medium silt populations at 6 to 6.5 phi for selected muddy bank sites.

It is important to recognise that the SILT populations (measured under conditions of deflocculation and with binding organic matter removed) are only indicative of the distributions of natural grain sizes that occur in nature. The latter show naturally highly agglomerated characteristics *in situ* with

particle size and structure relation to salinity effects (flocculation), organic binding (biogenic) and flow energy (that can break up agglomerations).

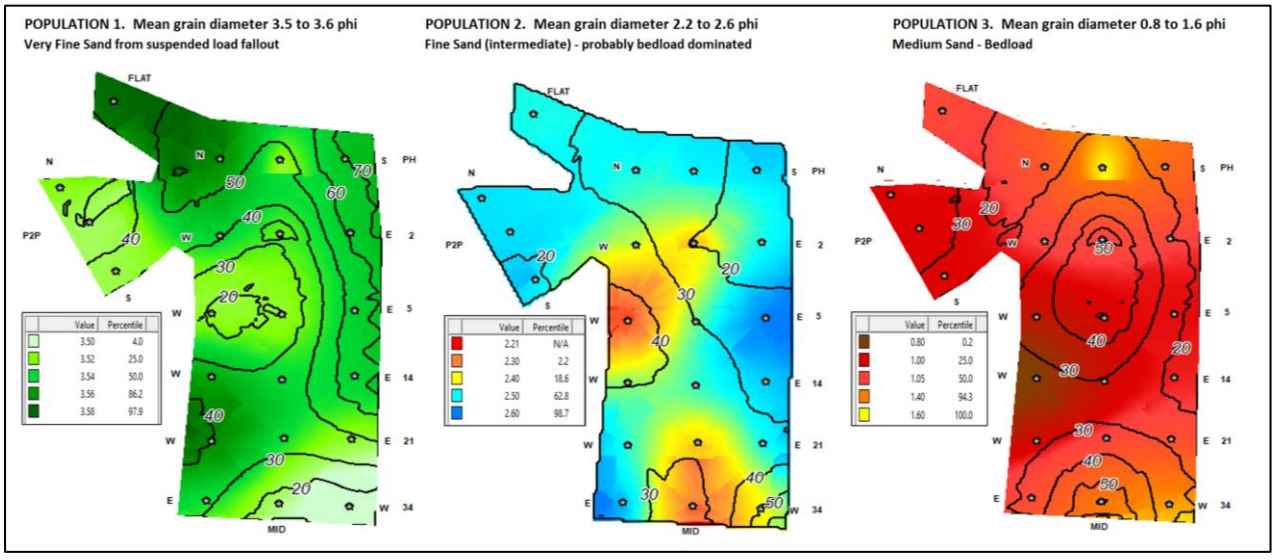
4.4.3 Component Sand Populations

The PSD results were analysed to generate the statistical parameters for 3 component populations within the SAND-ONLY fraction of the samples (0 to 4 phi).

	Population 1			Population 2			Population 3		
	mean	SD	%	mean	SD	%	mean	SD	%
PH-N	3.6	0.3	67.92%	2.6	0.4	24.24%	1.0	0.6	7.85%
PH-FLAT	3.6	0.4	40.68%	2.5	0.4	32.68%	1.1	0.6	26.64%
PH-S	3.6	0.3	82.99%	2.6	0.3	6.84%	1.2	1.0	10.17%
PH-MID	3.5	0.3	37.16%	2.5	0.3	35.51%	1.8	0.6	27.33%
P2P-MID	3.5	0.4	15.00%	2.5	0.3	36.00%	1.0	0.6	49.00%
P2P-N	3.5	0.3	39.06%	2.5	0.3	32.25%	1.0	0.6	28.69%
P2P-S	3.5	0.3	57.78%	2.6	0.4	22.61%	1.0	0.8	19.61%
P2F-MID	3.5	0.3	0.84%	2.3	0.4	14.25%	1.0	0.4	84.91%
P2F-W	3.6	0.3	61.48%	2.5	0.4	38.52%	1.0	0.4	0.00%
P2F-E	3.6	0.2	80.42%	2.5	0.3	13.73%	1.0	0.4	5.85%
P5-MID	3.5	0.31	4.31%	2.51	0.49	21.07%	1.0	0.5	74.62%
P5-E	3.55	0.3	62.57%	2.7	0.47	24.77%	1.0	0.9	12.65%
P5-W	3.5	0.27	4.68%	2	0.51	59.93%	1.0	0.4	35.39%
P14-MID	3.53	0.3	20.03%	2.55	0.54	48.95%	1.0	0.6	31.02%
P14-E	3.55	0.26	77.21%	2.5	0.32	20.01%	1.0	0.6	2.78%
P14-W	3.57	0.27	45.05%	2.55	0.55	39.51%	0.6	0.5	15.44%
P21-MID	3.54	0.32	38.89%	2.17	0.44	36.21%	1.0	0.3	24.90%
P21- W	3.61	0.335	49.87%	2.52	0.3	25.28%	1.0	0.5	24.85%
P21-E	3.5	0.3	41.15%	2.6	0.4	26.51%	1.1	1.0	32.35%
P34- MID	3.5	0.3	0.80%	2.1	0.2	4.06%	1.6	0.5	95.14%
P34- W	3.5	0.3	9.97%	2.5	0.3	71.78%	1.6	0.5	18.24%
P34-E	3.5	0.3	33.28%	2.7	0.5	47.29%	1.1	0.4	19.43%

Table 4. Three component log-normal population parameters within the sand fraction (0 to 4 phi, 63µm to 2mm).

Table 4 and Figures 17a, 17b and 17c show the component log-normal distributions fitted to the SAND-ONLY FRACTION of the sediment.



Figures 17a, 17b and 17c. Individual Sand Population distributions for the sand-only fraction of the sediment.

Note: Colours (shown in keys) show mean grain diameter of the sand population. Contours show the contribution of this population to the total SAND content (2 to 4 phi).

For Population 1 (very fine sand, Figure 17a), the results indicate that the coarser fraction of the suspended fall-out sediments (low phi values, light green) occurred the Piddle mouth region, outer bend at Turner's Cove (P34-W) and the western banks near profile 5. The finest sand, reaching 3.6 phi was found on the mudflat and main channel banks. The highest contribution of very fine sand load fallout was found at the eastern channel banks (up to 70% of the sand fraction) and the west banks at P21, both next to mudflat areas.

Population 2 (fine sand, Figure 17b) represented an intermediate sand grain size that was carried either as suspended load or as bedload. The coarser fraction (around 2.2 phi probably bedload) was found to the west of profile 5 (shoal area) and in the mid-channel off Turner's Cove. The higher phi values (likely suspended load) were found on the inner east slip-off bank at Turners Cove (P34-E) and the east banks of the main channel (mudflat zones).

Population 3 represents the coarsest sand component (medium-coarse sand, Figure 17c) that is likely to be predominantly carried as bedload. The coarsest bedload sediments were found in the central and west channel region near profiles 5, 14 and 21, likely associated with the shoal at P5-MID. The finer bedload components (~1.6 phi, yellow) were found to the west of Turner's Cove (P34-W) and mid channel in the outer Poole Harbour (PH-MID).

4.4.3 Sediment Observations and Minerology

Photographs of the sand fractions and microscope images of the dominant fractions provided further information on the sedimentary environment. Figures 18 and 19 show the sand fraction 'wheel' photos for lower estuary bank sites PH-S and a close-up of the 90µm fraction.

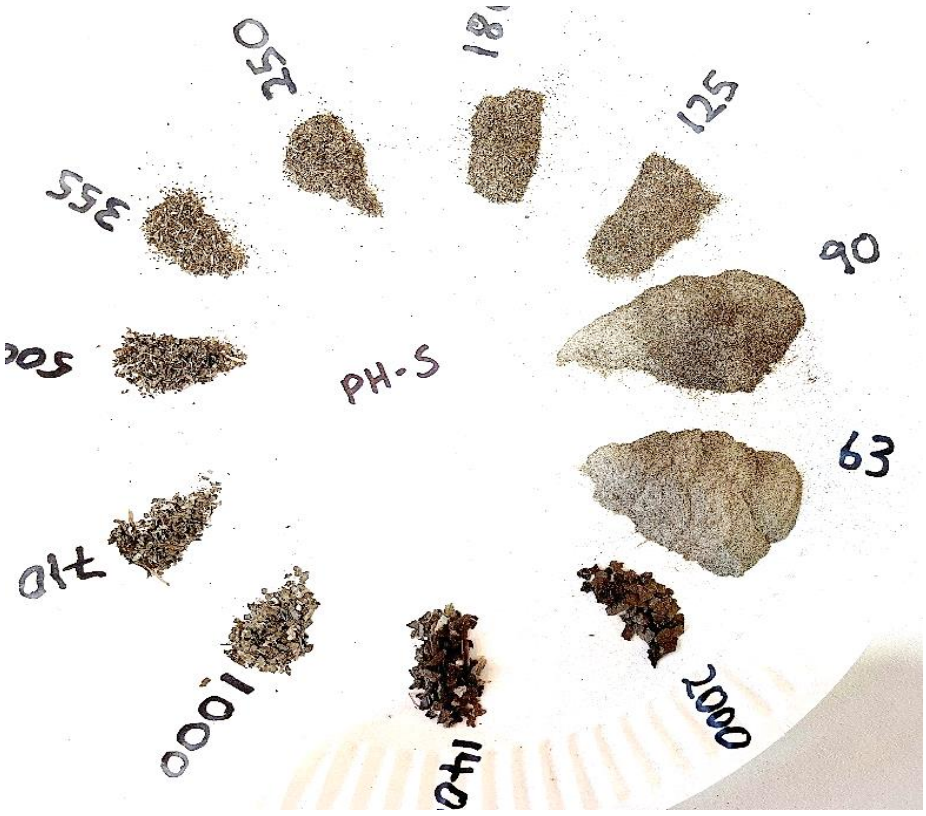


Figure 18. Grain size fractions >63µm for site PH-S, on the mudflat bank near Gigger's Island.

Figure 19. Close up of sediment grains retained on the 90µm sieve at site PH-S.

The sand fractions in at PH-S on a slip-off slope, depositional environment shown in Figure 18 show darker fragments for the coarse fractions composed from reed fragments brought down from the river and estuary banks. Figure 19 (close up of the very fine fraction at 90µm) shows that the finer fractions are lighter, comprising mixed components of largely near-white shell fragments (shell and oyster nacre), quartz grains and small reed fragments. These sediments are typical of the sediment deposited on the outer estuary banks and represent a mixture of riverine and harbour derived sediments.

Figure 20. Grain size fractions >63µm for site P5-MID, on the shoal in the mid-channel central region.

Figures 20 and 21 show the sand fraction 'wheel' photos for the mid channel shoal sites, P5-MID and close up of the 500µm fraction. Figure 22 shows a close-up of the >2mm fraction.

Figure 21. Close up of sediment grains retained on the 500µm sieve at site P5-MID.

The size wheel for the mid-channel shoal at P5-MID (Figures 20) shows generally lighter coloured fine/med/coarse sand grains, predominantly of shell and quartz sand from erosion of Frome and Piddle chalk valleys and Poole Harbour shells. Figure 21 shows a close-up of the 90µm fraction of mixed composition. There are angular broken shell fragments from Poole Harbour, greyer more translucent quartz grains and oyster shell fragments (with shiny nacre). For the 500µm fraction, there is an approximately 1:1 mixture of shell and quartz indicating a mixture of shells derived from Poole Harbour and riverine input quartz material.

The coarse fraction (>2mm), sample shown in Figure 22, is more rounded, and contains fewer shell fragments, the dominant coarse sediment being rounded flints and encrusted pebbles, indicative of fluvial origin. These sediments have been abraded by movement as bedload during tidal recycling and river flood events. These sediments are typical of mobile estuarine channel sediments with significant medium and coarse sand populations and gravel constituents, being carried downstream during high-energy periods of extreme river flow, storm events and high Spring tides.

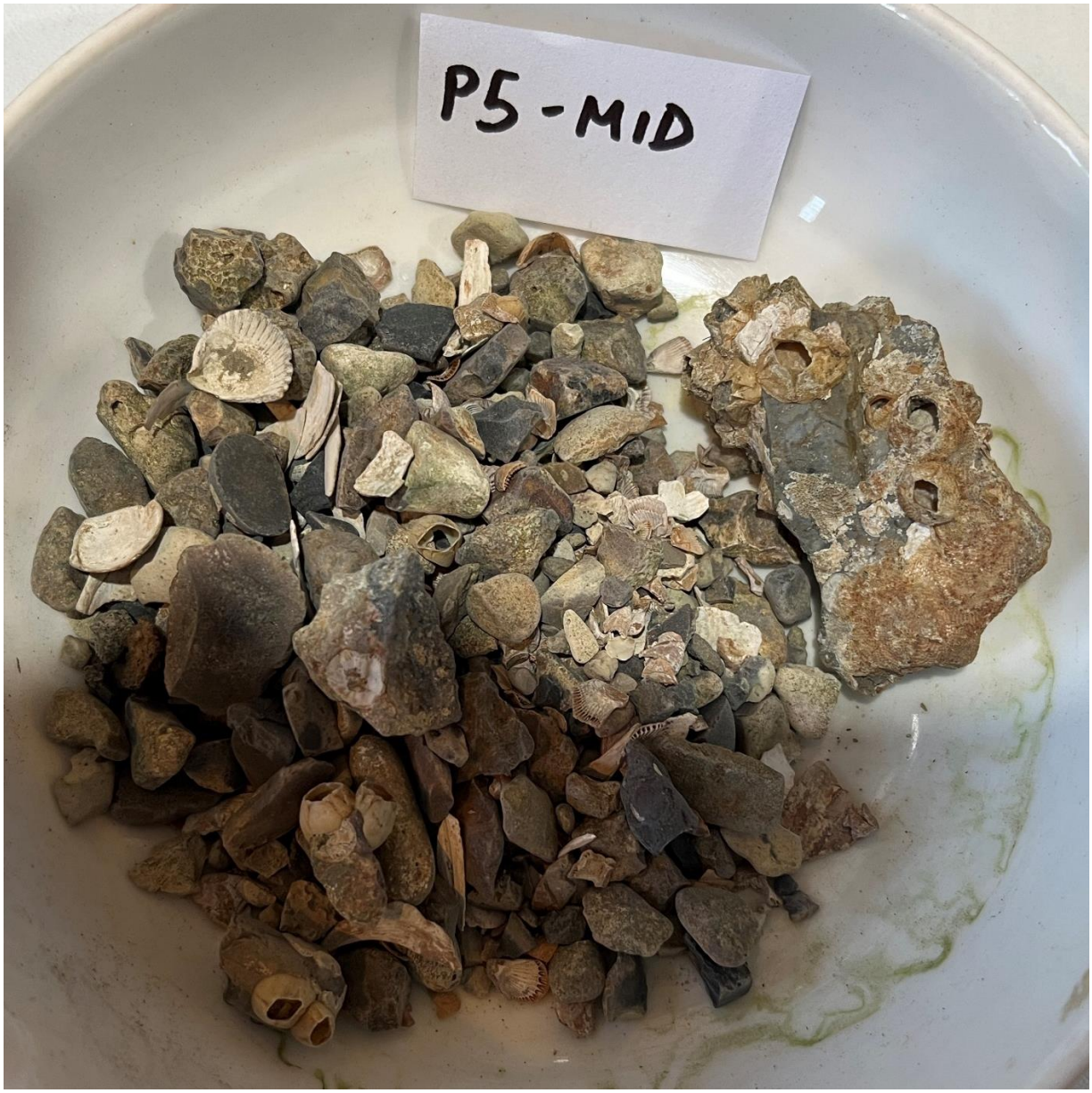


Figure 22. Close up of the >2mm fraction from sample P5-MID.

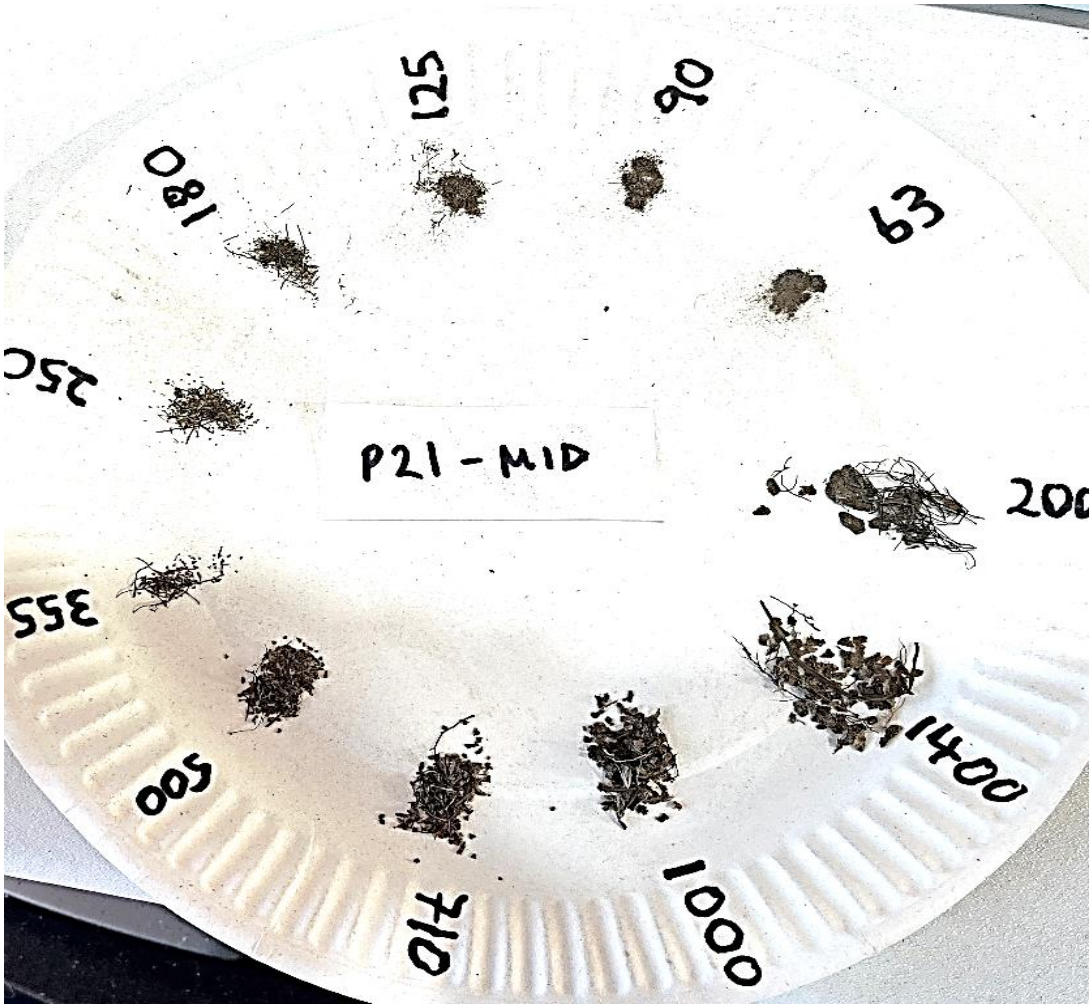


Figure 23. Grain size fractions >63µm for site P21-MID, in the upper Frome region.

Figure 23 shows the grain size fractions for the mid-channel site, P21-MID towards the upper Frome estuary. The sample comprised ~98% mud and there is a large component of vegetated matter, derived from the degradation of reeds (*Phragmites sp.)* from the upper estuary banks and some filamentous seaweed strands.

4.5 In-Situ Observations

Appendix 1 shows a summary of the logs taken at the time of sampling for each site and shows a grab/corer sample photo, 'sand fraction wheel' image and close ups of individual selected sand fractions. The surface photos of the samples show marked differences between the mid-channel sites (such as P5-MID, P2F-MID), with rough and coarse surfaces, with bank sites having softer, smoother surfaces. In general, the observations agree with the findings from density and PSA results indicating mobile coarser (rougher) mid-channel sites and finer, smoother depositional bank environments.

4.6 Channel Profile Changes

Atkins carried out bathymetric profiling along the outer Wareham Channel twice a year between October 2019 and October 2023 (Atkins 2020a and 2020b). The sediment survey profiles are shown in Appendix 2.

The profiles measured at the outer Piddle (the north-west side of Profile 2) showed a variable mid-channel shoal that has varied by +/-10cm between 2019 and 2023. Comparison of the overall bed level envelope to October 2023, indicates erosion and deepening of the banks by ~20cm between 2019 and 2023 and an aggradation of the mid-channel region of around 20cm. The channel profile in the outer Piddle is bifurcated with a deeper channel to the west and a deeper channel to the east. The mid-channel shoal is likely one of deposition in agreement with the PSD results, that showed higher gravel content (~11%). The Piddle mouth is likely area of mobile sediment, characterised by finer sediment populations and high silt contents, in agreement with the PSD results. The overall picture between 2019 and 2023 was erosion of the banks and aggradation of the mid-channel shoal.

The lower section of Profile 2, situated in the Wareham channel just to the east of the mouth of the Piddle, showed a that the mid-channel depth varied considerably between 2019 and 2023, with depths between -3.4mCD to -2.5mCD, almost a 1m variation, with periods of accretion and erosion, depending on inter-annual high energy events associated with extreme weather with high river flows, wave action and high Spring tides. Bank levels remained largely unchanged over the survey period and the overall pattern is one of mid-channel sediment movement of sandy bedload. The current situation at October 2023 shows a bifurcated channel, with a deeper channel to the west, shallower channel to the east and a shoal developing in the mid channel. This is consistent with the stronger flows expected from combined Frome and Piddle River flows and strong tidal currents and mid-channel movement of riverine coarser sediments. The overall picture was of erosion between 2019 and 2023.

Profile 5 was situated over a mid-channel persistent shoal to the south of the Piddle mouth. The bathymetric changes indicated a +/- 10cm variability and gradual erosion of both banks, shoal and channels of around 20cm between October 2019 and October 2023. The eastern bank showed corresponding slightly more erosion up to ~30cm during this time. There overall pattern was that of gradual erosion with a stationary channel location and no meandering with sediment most likely moving during storms, high river flow and peak tidal currents. The overall picture was of erosion between 2019 and 2023.

Profile 14, halfway down the outer Frome estuary, was over a wider channel section than the downstream profiles, around 50m wide, with a shallower channel bed to the west (up to -1.9mCD) and deepening channel towards the east (to ~-2.2mCD). The profile evolution showed overall erosion of the west bank of ~20cm between 2029 and 2023. The eastern bank showed stable upper bank level, and increasing erosion further down the bank, with erosion reaching ~30cm towards the bottom of the bank. The channel had 2 regions – the shallower western side eroding by ~20cm with a variability of ~+/-10cm, and the eastern region showing overall erosion of ~40cm with a higher variability +/- 20cm. his region was comprised of several grain size populations that are consistent with a changeable sedimentary environment in the mid-channel and fluvial bedload transport. The overall picture was of erosion between 2019 and 2023.

Profile 21, situated on the southerly bend of the outer Frome showed a steeper western slope adjoining a small mudflat, with a more gradual bank slope to the east. The channel and east bank however showed an overall pattern of erosion, with these areas deepening by ~30cm between 2019 and 2023, with a variability of ~+/- 15cm. Gradual accretion up to ~50cm, (with variability ~+/- 10 to 20cm) occurred over the upper west bank on the slip-slope region of the mudflat consistent with deposition of fines on a slip-slope during channel meandering. The profile shape remained the same, shifting only towards the east. Overall, the profile 21 indicates a meander of the Frome estuary towards the east, of around 10m between October 2019 and March 2022.

Data is only available u to March 2022 for Profile 34. The profile is near Turner's Cove (P34) situated further round the Frome bend west of P21. The bathymetry shows a steep sided west (outer) bank and more gradual inner east bank. The profiles show that between October 2019 and March 2022, there was gradual erosion of the lower east bank, main channel and outer west bank of around 20-30cm. The upper east bank, on the inside of the bend shows bank accretion of ~20-40cm, consistent with a depositional environment and agreeing with the muddy fine sediment found in this region and a meandering of the channel towards the west.

A summary of the profile changes for bank and channel regions is shown in Table 5.

Site	West Bank	East Bank	Channel Region	Channel Depth Variability (cm)	Bifurcated/ Shoal?	Comments
P2P	Erosion ~20cm	Erosion ~20cm	Deposition ~20cm	+/-10cm	Yes	Slight movement to East ~5m?
P2F	No change	No Change	Variable	+/-50cm	Developing?	Steep channel banks remaining almost constant
P5	Erosion ~20cm	Erosion ~20cm	Erosion ~20cm	+/-10cm	Slight	East bank moving ~5m to East
P14	Erosion ~30cm	Erosion ~30cm	Erosion ~20cm W side, ~40cm E side	+/-10 to 20cm	No	High Variability Deepening East side of channel. Upper E bank same depth, Lower E and W bank regions eroding.
P21	Deposition ~20cm	Erosion ~30cm	Erosion ~30cm	+/-10cm	No	Whole profile meandering ~10m to E
P34	Upper: Deposition ~30cm Lower: Erosion~20cm	Erosion ~10cm	Erosion ~30cm	+/-10cm	No	(* 2019 to Mar 2022). Meander ~5m to E

Table 5. Bathymetric Profile Patterns Oct 2019 to Oct 2023 (*P34 to Mar 2022).

A summary of the bathymetric profiles shows a general erosive picture between October 2019 to October 2023, with typical 20-30cm erosion from the banks and 20-40cm in the channels. Deposition 20-30cm occurred on the upper, inner banks of P21 and P34, coincident with erosion of the outer banks (~30cm) and slight deepening of the mid-channel, indicating gradual channel meandering to the southern bend of the Wareham Channel.

5. Discussion

The estuarine environment of the outer Wareham Channel comprises a winding estuary channel opening to the east into the second largest natural harbour in the world, Poole Harbour. Two rivers drain from the west through chalk and clay valleys, the larger River Frome via Wareham and smaller River Piddle (also known as Trent). There is a large mudflat to the east opposite Gigger's Island and two smaller mudflats near the estuary banks to the south-west near Turner's Cove and the inner bend of the Frome to the west.

For most of the sites, the bed sediments were predominantly around 95% mud content (clay and silt <63µm). Mid-channel sites contained a mixture of mud, sand and gravel, with sand contents between 4 and 68% and gravel 7 to 48%. The coarsest sediment was found in the mid channel to the west of Gigger's (P5), that was on a locally known persistent shoal, likely predominantly comprised of fluvial origin deposits with some remains of exposed paleo gravels.

Highest gravel contents were found in the mid channel towards the north in mid-stream (P5-MID and P14-MID) where flows and bed shear stresses are likely to be the greatest during extreme weather events with high river flows, wave induced currents and high Vernal and Autumn Equinox Spring tides where drop-out has occurred when fluvial and ebb currents reduced. There is an increase in % sand going down-channel from P14-MID (22%) to P2F-MID (68%). There was virtually no gravel at sites P2F-MID and P34-MID, but both sites had high sand contents at around 68%, both sites representing riverine drop-out of coarse sand at the R. Piddle and R. Frome confluence and near the Furzey Stream outlet.

The main channels, that experience higher flows from combined tidal currents and river flows (particularly during flood events) comprised coarser sediments. Medium sand populations are transported as bedload and fine and very fine sand transported in suspension and deposited on the upper banks and mudflats at times of low flows. These regions are areas of regular tidal recycling, with sediment moving up and down the estuary, depending on prevailing tidal and river flows.

The channel banks and mudflat areas are inundated during high water periods and experience lower flows and variable periods of exposure determined by their levels. These are areas of fine sediment deposition (fine sand, silts and clays), that occur mainly over slack water at high tide. Deposition is greatest when the suspended load is high, such as during river flood events or storm conditions (turbidity during the latter being created by small-amplitude waves).

Top 1cm layer density range was 1.16 to 1.87gcm^{-3}, the highest value reflecting the highest sand and gravel content over the shoal region. For the other sites where sand content was between 0 and 10%, the density varied with the degree of consolidation, between 1.15 and 1.30gcm^{-3}. The surface layer densities were lower in the Piddle estuary, mudflat and bank areas within depositional environments where fine sediment had deposited during periods of low flow, high water periods and was undergoing slow consolidation.

The 'bulk' 7cm densities showed a positive relationship with sand content, in agreement with that found in literature (Whitehouse *et al*., 2000), related to greater grain size and compaction. The highest values were found at the confluence of the Rivers Frome and Piddle and shoal region where flows and bed shear stresses are greatest and the bed is undergoing periods of erosion and tidal sediment recycling, either as bedload (medium sand) or suspended load (fine sand). The bank and mudflat sediments had the lowest densities consistent with finer underconsolidated muddy sediments.

Further towards Wareham and Turner's Cove to the west, the sediments comprised an increasing biogenic component of leaf, reed and seaweed debris. This is consistent with degradation of upper estuary banks during early autumn storms, particularly the fringing reed (*Phragmites sp.)* beds and drainage from Arne Moors to the east into Turner's Cove via a culvert.

The mineralogy images showed a significant component of white sands, comprised of mostly shell and quartz being recycled around the upper Poole Harbour region. The mid-channel sediments were coarser and comprised shells, quartz and flint being slightly rounder in appearance, representative of a moderately mobile bedload likely derived from fluvial inputs. The shoal at P5 showed rounded, encrusted gravel, indicative of older less mobile sediment, only moving during extreme storm and high fluvial flow events. The slip-off inner bank slopes and mudflat sediments were much finer (~95% mud) and the sand images indicated a mixed composition that included a higher component of shells, quartz and darker reed fragments consistent with a depositional environment.

The dominant sediments in the region are from erosion of chalk river valleys to the west (quartz and flint), mixed shells from beaches and mudflats and oyster beds within Poole Harbour and broken reeds and seaweed matter from the upper estuary banks.

The sediment particle size populations are generated by the flow regime within the region. Three sand particle populations were found and are transported and moved around as:

- Bedload - Medium Sand (0.8-2.2 phi),
- Transition (Bedload and Suspended Load)- Fine Sand (2.2-2.6 phi)
- Suspended Load - Very Fine Sand (3.5-3.6 phi)

These sediments are most mobile in high flow environments (mid channel regions) during peak tidal flows and high river discharge. Silt populations comprised of a coarser component (medium silt, 5.5-6.0 phi) were found on the Frome banks, Poole Harbour and channel eastern banks. A slightly finer silt component (fine silt 6.0-6.5 phi) was found in the outer Piddle, and edges of mudflat and inner banks. These sediment fractions are readily recycled during tidal cycling, normal riverine flows and erosion of wider Poole Harbour mudflat surfaces by action of small amplitude waves during shallow water periods.

In general, the coarser sediments were found in the channels and contained fewer shell fragments, with the dominant coarse grains being rounded flints and encrusted pebbles, indicative of fluvial origin. The mid-channel sediments are likely to have been abraded by movement as bedload during tidal recycling and river flood events. These coarse sediments are typical of mobile estuarine channel sediments with significant medium and coarse sand populations and gravel constituents, of fluvial origin, being carried downstream during high-energy periods of extreme river flow, storm events and high Spring tides.

A summary of the bathymetric profiles shows a general erosive picture between October 2019 to October 2023, with typical 20-30cm erosion from the banks and 20-40cm in the channels. Deposition 20-30cm occurred on the upper, inner banks of P21 and P34, coincident with erosion of the outer banks (~30cm)and slight deepening of the mid-channel, indicating gradual channel meandering to the southern bend of the Wareham Channel. Overall, there was an erosive picture of deepening banks and outer channel beds between October 2019 and October.

A Conceptual Model of Poole Harbour Sediment Transport was proposed by EA/Atkins (2024). The sediment survey area covered the south western region of Poole Harbour, and the dominant local processes is shown in Appendix 2. The seabed sediment properties measured during the survey are consistent with an ebb-dominated/river flow regime as proposed. Inputs from the Rivers Frome and Piddle occur during high rainfall/high river flow conditions, mostly over late autumn-winter-early spring stormy weather periods giving an intermittent feed of fluvial sediment. Intertidal accretion is likely over time in the mudflat region around Giggers Island as a combination of tidal recycling of Poole Harbour mudflats and riverine fine sediment discharge, deposited over high water periods during high sediment load conditions. These processes are consistent with the overall Conceptual Model.

It is recommended that the conceptual model should additionally include wave-action and associated erosion and movement of sediments by wave-induced bed shear stresses over the shallow Poole mudflat region. Further comment on the conceptual model is not covered by this survey and would require a thorough investigation of all the relevant data within the wider Poole Harbour.

Overall, the characterisation of sediments in the Wareham Channel, Frome and Piddle estuary mouths and western Poole Harbour has allowed for a broad evaluation of the sediment regime showing the underlying upper estuarine sediment transport features. This information can be used as a baseline of current sedimentary conditions within the outer Wareham Channel for the Arne Moors Coastal Change Project.

6. Recommendations

1. Evaluate the monitoring (bathymetry) results within a sediment transport context, noting periods of high fluvial inputs following extreme weather events with high rainfall (flooding events), wave action and high Spring tides.

2. Measurement of Sediment Behavioural (Hydraulic) Properties of the mudflats fronting Arne Moors, around Gigger's Island and banks around Turner's Cove – including Critical Erosion Shear Stress via SedErode (Mitchener *et al* 1996a and Mitchener 1996b, (available from Enviromud)) and shear strength of the top 1cm using a high-sensitivity shear vane- to provide 'real data' input for model calibration and validation.

3. Measurement of Velocity Profiles fronting Arne Moors and the outer channel to obtain knowledge on maximum applied bed shear stress during ideally high fluvial and ebb flows, and typical conditions during low river flow and tidal range.

4. Use existing (and ongoing) LIDAR data to investigate bed level changes between 2019 and 2023 via GIS to analyse erosion and accretion patterns. If possible, use LIDAR data to generate hypsometric curves for the Wareham Channel region that would help understanding the regions and mechanisms of local erosion and deposition.

5. Long-Term monitoring of Total Suspended Solids (via optical turbidity and water samples) at key position(s) within the Wareham Channel around Turner's Cove and fronting Arne Moors (areas of possible sediment regime change).

6. It is recommended that wave action and wave induced shear stresses are included in the conceptual model (particularly when the wind is from the NE directing waves towards the area). This will allow a reflection of erosion and tidal recycling of finer material from the shallower mudflat regions that will have the effect of increasing the overall sediment load in the region.

7. Obtain more data to validate and calibrate the Conceptual Model.

6. References

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UK Hydrographic Office. Admiralty Chart AC 2611. Poole Harbour and Approaches.

Appendix 1 Site Logs and Photographs

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	PH-MID
DATE	26.10.23
TIME START	09:55
POSITION: LAT N	50.694629
POSITION: LONG E	-2.073821
EXPOSED OR GRAB TYPE	GRAB
WATER DEPTH (m)	N/A
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	G
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	4.6
%MUD (Lab):	95.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~1% scant fine sand
%MUD:	~99% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

LAYERED?	YES - TOP 1-2mm LAYER overying coarser firmer substrate below with mud balls (1-2mm). Anoxic more consolidated base

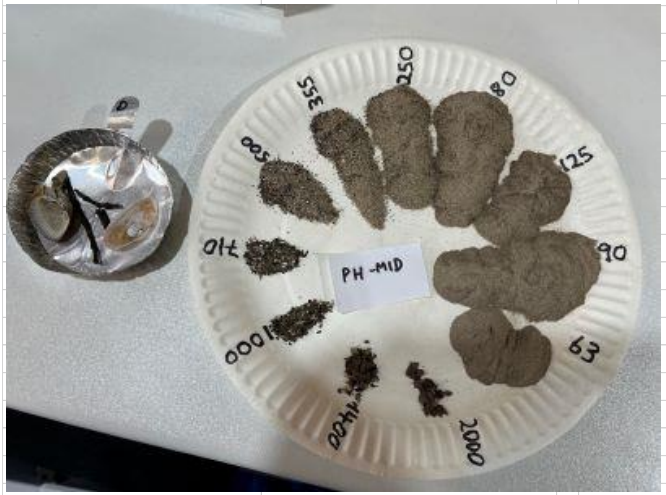
SURFACE DESCRIPTION

Topography	+/-2mm, smooth
Covering	none
Bioactivity	none
Biofilm?	none

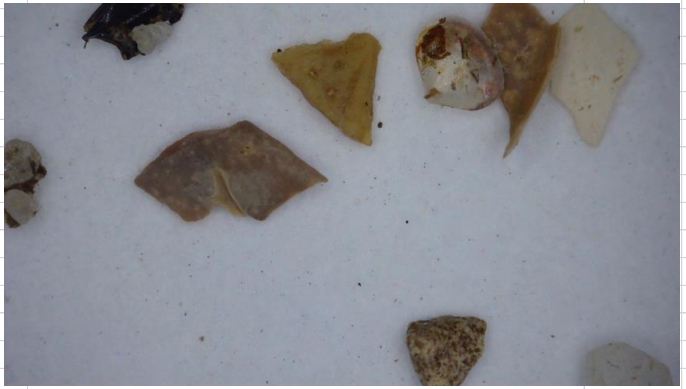
OTHER

none

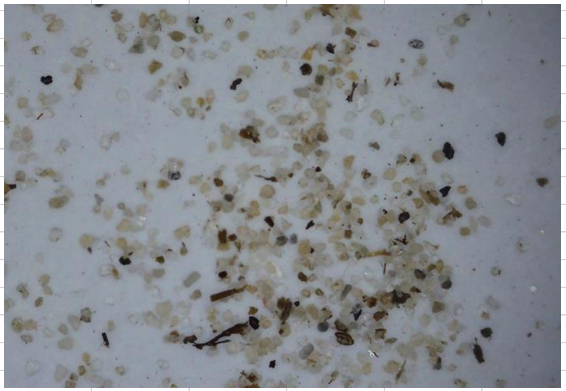
Grab sample



Sand Fraction wheel



710µm fraction



90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	PH-FLAT
DATE	26.10.23
TIME START	11:07
POSITION: LAT N	50.694629
POSITION: LONG E	-2.073821
EXPOSED OR GRAB TYPE	GRAB
WATER DEPTH (m)	N/A
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	G
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	4.6
%MUD (Lab):	95.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~1% scant fine sand
%MUD:	~99% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

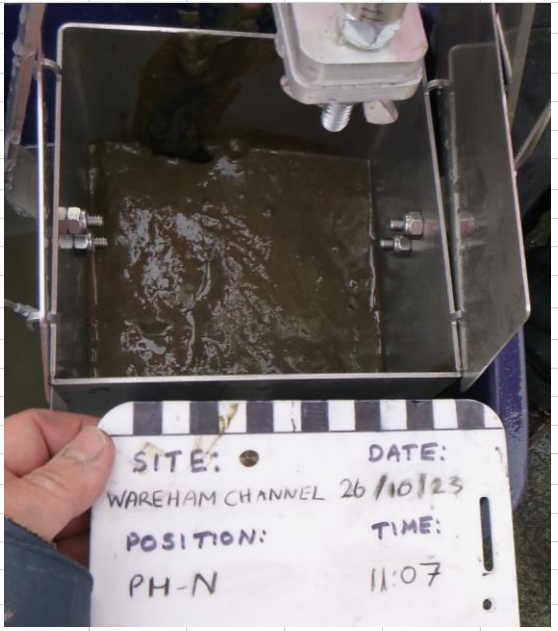
LAYERED?	YES - TOP 1-2mm LAYER overying coarser firmer substrate below with mud balls (1-2mm). Anoxic more consolidated base

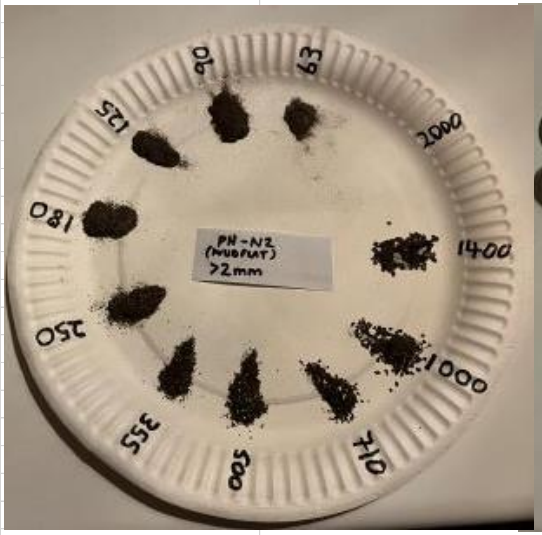
SURFACE DESCRIPTION

Topography	+/-2mm, smooth
Covering	none
Bioactivity	none
Biofilm?	none

OTHER

On true mudflat to north of PH-MID
Bag labelled as PH-N2 (second grab attempt)





Sand Fraction wheel

710µm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	PH-N
DATE	26.10.23
TIME START	11:35
POSITION: LAT N	50.695033
POSITION: LONG E	-2.074024
EXPOSED OR GRAB TYPE	EKMAN
WATER DEPTH (m)	4 ft
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	E
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	4.6
%MUD (Lab):	95.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~2% scant fine sand
%MUD:	~98% mid-brown, underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

LAYERED?	NO but increasing consolidation with depth. Anoxic under surface.

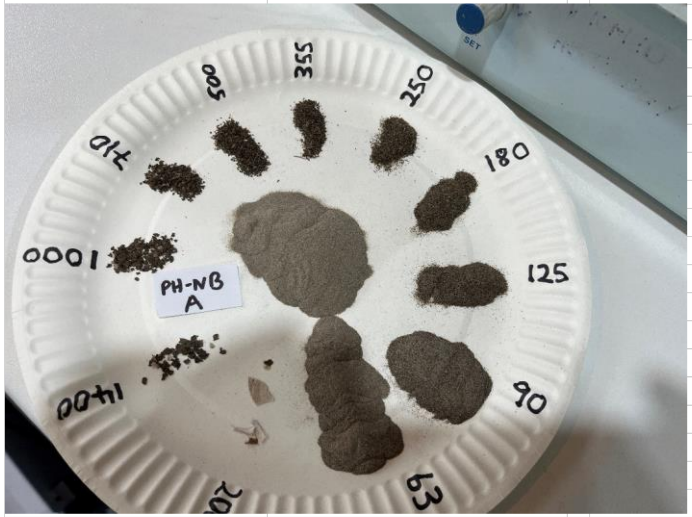
SURFACE DESCRIPTION

Topography	+/-2mm, smooth
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

On channel N bank

Grab sample



Sand Fraction wheel

>1mm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	PH-S
DATE	26.10.23
TIME START	12:05
POSITION: LAT N	50.694521
POSITION: LONG E	-2.073353
EXPOSED OR GRAB TYPE	GRAB
WATER DEPTH (m)	N/A
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	A
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	4.6
%MUD (Lab):	95.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~2% scant fine sand
%MUD:	~98% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

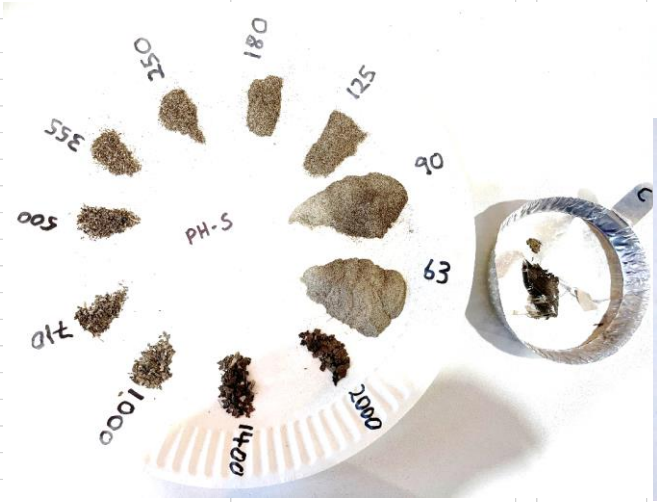
LAYERED?	YES- Mid brown, smooth surface, mud clasts 2-10mm below surface. Anoxic more consolidated base

SURFACE DESCRIPTION

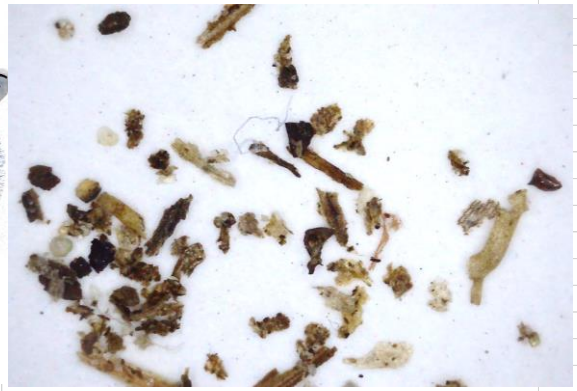
Topography	+/-2mm, smooth
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Grab sample



Sand Fraction wheel



180µm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P2P-MID
DATE	26.10.23
TIME START	12:29
POSITION: LAT N	50.695141
POSITION: LONG E	-2.078630
EXPOSED OR GRAB TYPE	GRAB
WATER DEPTH (m)	4 ft
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	F
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	
%SAND (Lab):	4.6
	95.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 5cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~2% scant sand
%MUD:	~98% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

LAYERED?	YES- Mid brown, soft, coarser with shell fragments 3cm below surface. Anoxic more consolidated base

SURFACE DESCRIPTION

Topography	irregular +/-5mm
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Grab sample

Sand Fraction wheel

500µm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	**Wareham Channel, Dorset, UK**
SITE NAME	**P2P-N**
DATE	26.10.23
TIME START	12:48
POSITION: LAT N	50.695301
POSITION: LONG E	-2.078271
EXPOSED OR GRAB TYPE	GRAB
WATER DEPTH (m)	2ft
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	C
DENSITY CORE 7cm (g/cm^3)	9
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.6
%SAND (Lab):	0.7
%MUD (Lab):	98.7
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 5cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~5% scant fine sand
%MUD:	~95% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1cm mid brown, medium consolidation, small (2mm) mud balls 3cm below surface. Anoxic grey brown more consolidated base.

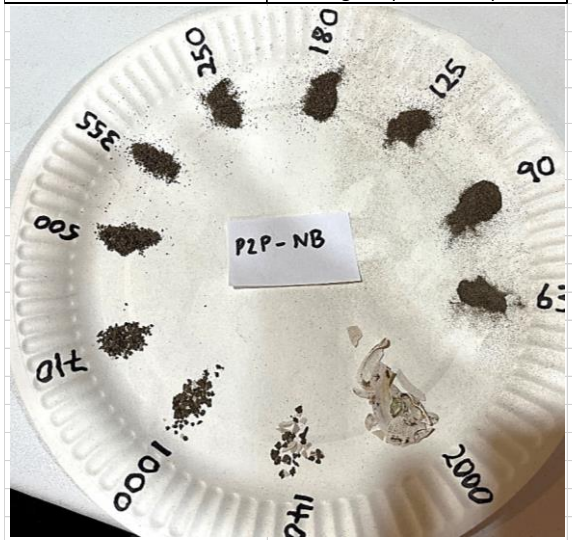
SURFACE DESCRIPTION

Topography	irregular +/-3mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

	Just over mudflat

Ekman sample



SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P2P-S
DATE	26.10.23
TIME START	13:13
POSITION: LAT N	50.695033
POSITION: LONG E	-2.078843
EXPOSED OR GRAB TYPE	Ekman
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud, damp
DENSITY CORE 1cm (g/cm^3)	S
DENSITY CORE 7cm (g/cm^3)	9
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.3
%SAND (Lab):	3.5
%MUD (Lab):	96.2
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~2% scant fine sand
%MUD:	~98% underconsolidated, cohesive, no clasts

SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1cm mid brown, soft consolidation. Anoxic grey brown more consolidated base.

SURFACE DESCRIPTION

Topography	smooth +/-2mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Ekman sample

Sand Fraction wheel

500µm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P2F-MID
DATE	26.10.23
TIME START	14:09
POSITION: LAT N	50.693524
POSITION: LONG E	-2.077013
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	5.5.ft
WEATHER	Overcast, grey cloud, brightening
DENSITY CORE 1cm (g/cm^3)	B
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.4
%SAND (Lab):	67.9
%MUD (Lab):	31.7
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 6cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~50% sand
%MUD:	~50% mud, just cohesive

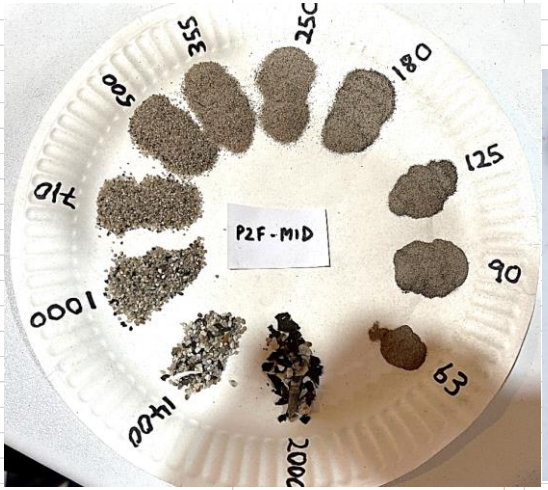
SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1cm mid-brown mottled homogeneous compacted mud/sand mixture. Slightly anoxic grey brown below 1cm surface layer.

SURFACE DESCRIPTION

Topography	+/-2mm, rough texture
Covering	small whitish (shell?) grains
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER



Sand Fraction wheel

500µm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P2F-W
DATE	26.10.23
TIME START	14:42
POSITION: LAT N	50.693739
POSITION: LONG E	-2.077396
EXPOSED OR GRAB TYPE	Ekman
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	P
DENSITY CORE 7cm (g/cm^3)	I
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.3
%SAND (Lab):	3
%MUD (Lab):	96.7
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~2% sand
%MUD:	~98% mud

SEDIMENT OBSERVATIONS

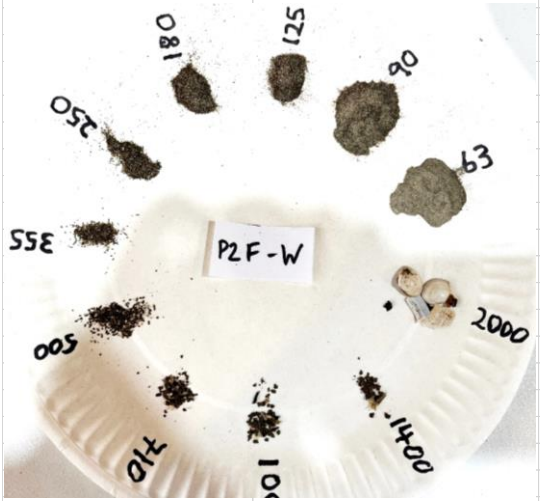
LAYERED?	YES- Surface 1cm mid-brown mottled homogeneous compacted mud/sand mixture. Slightly anoxic grey brown below 1cm surface layer.

SURFACE DESCRIPTION

Topography	+/-2mm, rough texture
Covering	small whitish (shell?) grains
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Ekman sample



Sand Fraction wheel

500µm fraction

90µm fraction

ENVIROMUD

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P2F-E
DATE	26.10.23
TIME START	15:13
POSITION: LAT N	50.693281
POSITION: LONG E	-2.076715
EXPOSED OR GRAB TYPE	Ekman
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	Q
DENSITY CORE 7cm (g/cm^3)	15
SHEAR VANE (kPa)	N/A
MACROBENTHOS OBS.	N/A
%GRAVEL (Lab):	0.4
%SAND (Lab):	3.3
%MUD (Lab):	96.3
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	none
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

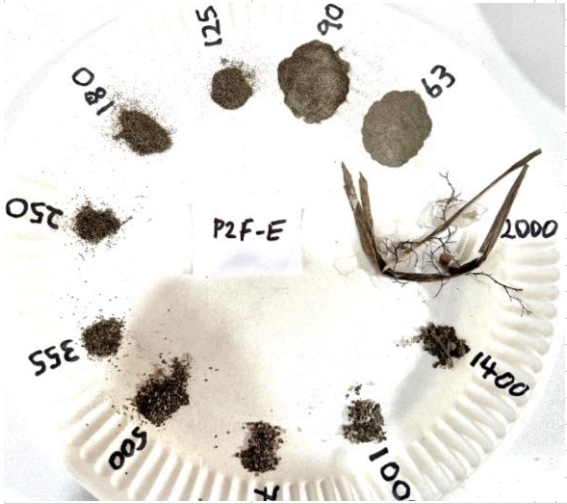
LAYERED?	YES- Surface 1cm mid-brown soft mud. Anoxic dark grey brown below with mud balls (up to 5mm). Very cohesive

SURFACE DESCRIPTION

Topography	+/-3mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Ekman sample



Sand Fraction wheel

2mm fraction

whole 2mm fraction

ENVIROMUD

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P5-MID
DATE	26.10.23
TIME START	16:53
POSITION: LAT N	50.692904
POSITION: LONG E	-2.077694
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	6.5 ft
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	-
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	48.2
%SAND (Lab):	29.6
%MUD (Lab):	22.2
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 5cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~70% gravel
%SAND:	~30% sand
%MUD:	~0% mud

SEDIMENT OBSERVATIONS

LAYERED?	NO- Not cohesive, mid brown with lots of pebbles, shells and shell fragments.

SURFACE DESCRIPTION

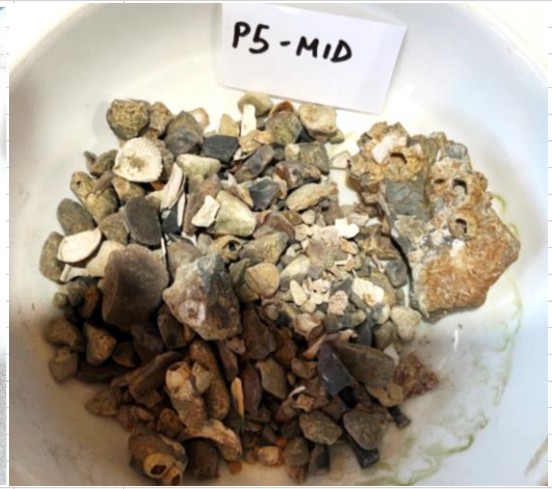
Topography	+/-3mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

	3 attempts to obtain enough sample by grab. One small sample conatined sea lettuce (*Ulva sp.?*)

Grab sample

Sand Fraction wheel



2mm fraction

500µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P5-W
DATE	26.10.23
TIME START	15:58
POSITION: LAT N	50.692958
POSITION: LONG E	-2.078035
EXPOSED OR GRAB TYPE	Ekman
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	J
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	7.1
%SAND (Lab):	38.5
%MUD (Lab):	54.4
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 5cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~20% gravel
%SAND:	~40% sand
%MUD:	~40% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES- Hard, coarse, mid brown, cohesive with lots of pebbles, gravel, shells and shell fragments (3mm-3cm).

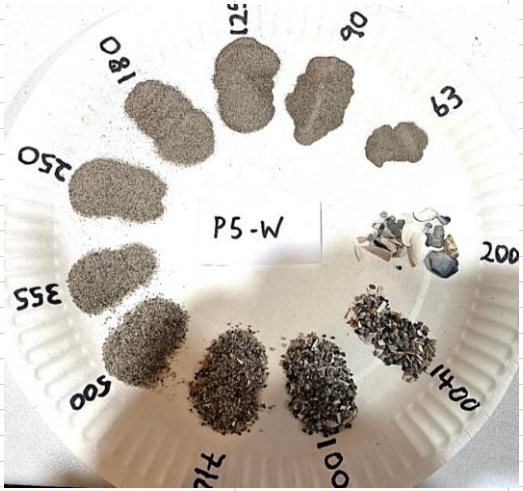
SURFACE DESCRIPTION

Topography	+/-7mm, rough texture with embedded shell fragments
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

	3 attempts to obtain enough sample by grab. One small sample conatined sea lettuce (*Ulva sp.?*)

Ekman sample



Sand Fraction wheel

710µm fraction

250µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P5-E
DATE	26.10.23
TIME START	16:27
POSITION: LAT N	50.692823
POSITION: LONG E	-2.077268
EXPOSED OR GRAB TYPE	Ekman
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	M
DENSITY CORE 7cm (g/cm^3)	16
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.6
%SAND (Lab):	4.8
%MUD (Lab):	94.5
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1cm cohesive, soft underconsolidated, mid brown. Below increasing consolidation, black anoxic dark grey brown.

SURFACE DESCRIPTION

Topography	+/-1mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Ekman sample

Sand Fraction wheel

250µm fraction

500µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P14-MID
DATE	27.10.23
TIME START	09:40
POSITION: LAT N	50.690182
POSITION: LONG E	-2.077056
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	F
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	22.1
%SAND (Lab):	13.3
%MUD (Lab):	64.5
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 5cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

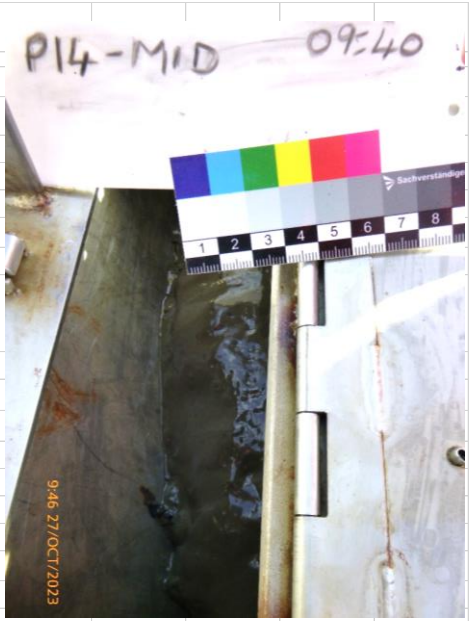
SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1cm cohesive, soft underconsolidated, mid brown. Below increasing consolidation, black anoxic smelly dark grey brown with stalks and shell fragments and mud balls.

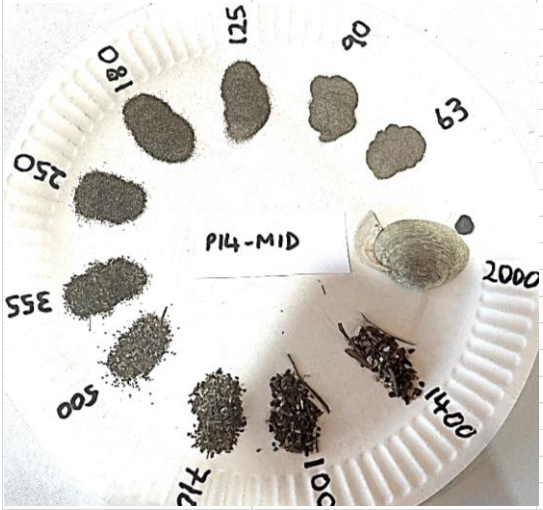
SURFACE DESCRIPTION

Topography	+/-2mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER



Grab sample



Sand Fraction wheel

>2mm fraction

500µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P14-E
DATE	27.10.23
TIME START	10:07
POSITION: LAT N	50.690343
POSITION: LONG E	-2.076715
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	5ft
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	H
DENSITY CORE 7cm (g/cm^3)	12
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0
%SAND (Lab):	2.1
%MUD (Lab):	97.9
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

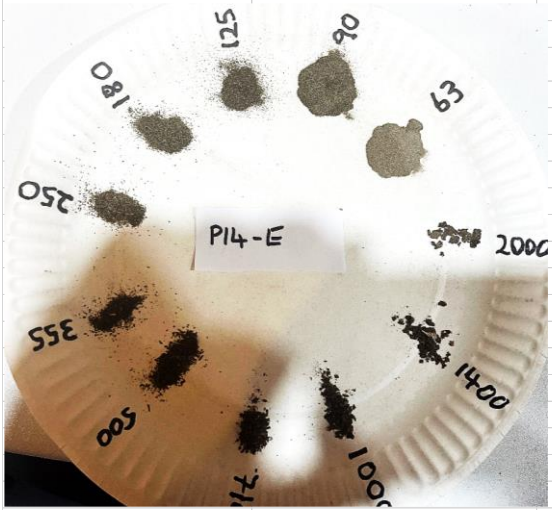
SEDIMENT OBSERVATIONS

LAYERED?	YES- Surface 1-2cm cohesive, v. soft underconsolidated, mid brown. Below 2cm increasing consolidation, black anoxic smelly dark grey, homogeneous..

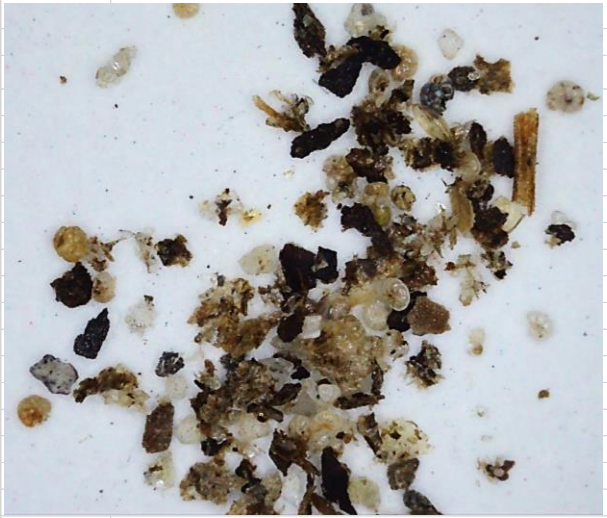
SURFACE DESCRIPTION

Topography	+/-2mm, smooth texture
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

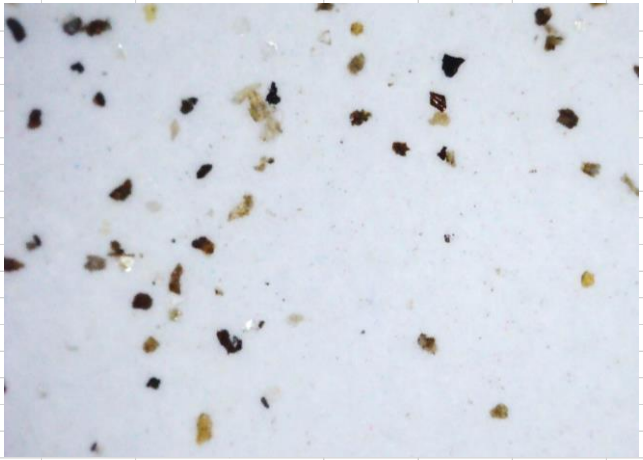
OTHER



Sand Fraction wheel



180µm fraction



90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P14-W
DATE	27.10.23
TIME START	10:41
POSITION: LAT N	50.690101
POSITION: LONG E	-2.077396
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	5ft
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	B
DENSITY CORE 7cm (g/cm^3)	17
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	1.9
%SAND (Lab):	1.2
%MUD (Lab):	97
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~2% sand
%MUD:	~98% mud

SEDIMENT OBSERVATIONS

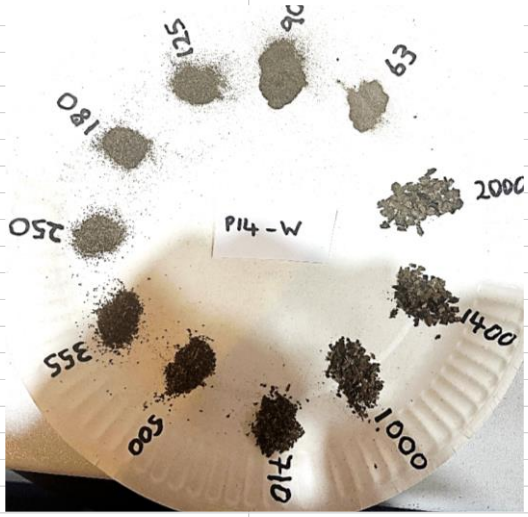
LAYERED?	YES - Surface 1cm cohesive, soft underconsolidated, mid brown. Below 1cm increasing consolidation, black anoxic smelly dark grey. Base hard and lumpy. Plant fragments.

SURFACE DESCRIPTION

Topography	+/-3mm, smooth texture with embedded dark biogenic debris.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Grab sample



Sand Fraction wheel

2mm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P21-MID
DATE	27.10.23
TIME START	11:25
POSITION: LAT N	50.688026
POSITION: LONG E	-2.076588
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	10ft
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	A
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.9
%SAND (Lab):	0.4
%MUD (Lab):	98.7
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES - Surface 1cm cohesive, soft, underconsolidated, mid grey-brown. Below 1cm not anoxic, seaweed and plant fragments within substrate. Few shell fragments 3-5mm.

SURFACE DESCRIPTION

Topography	+/-5mm, lumpy with smooth surface.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

	Seaweed binding substrate.

Grab sample

Sand Fraction wheel

1mm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P21-W
DATE	27.10.23
TIME START	11:51
POSITION: LAT N	50.688133
POSITION: LONG E	-2.076800
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	10ft
WEATHER	Overcast, grey cloud
DENSITY CORE 1cm (g/cm^3)	A
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	1.8
%MUD (Lab):	98.1
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~2% sand
%MUD:	~98% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES - Surface 1cm cohesive, soft, barely consolidated, mid grey-brown. Below 1cm slightly anoxix with small plant fragments within substrate.

SURFACE DESCRIPTION

Topography	+/-2mm smooth surface with small embedded plant fragments.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

Grab sample

Sand Fraction wheel

1mm fraction

90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P21-E
DATE	27.10.23
TIME START	12:40
POSITION: LAT N	50.687972
POSITION: LONG E	-2.076119
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	10ft
WEATHER	Overcast, grey, light rain
DENSITY CORE 1cm (g/cm^3)	L
DENSITY CORE 7cm (g/cm^3)	4
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.2
%SAND (Lab):	1.8
%MUD (Lab):	97.9
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES - Surface 1-2cm cohesive, soft underconsolidated, mid grey-brown. Below 1cm slightly anoxic, lumpy with small plant and shell fragments within substrate.

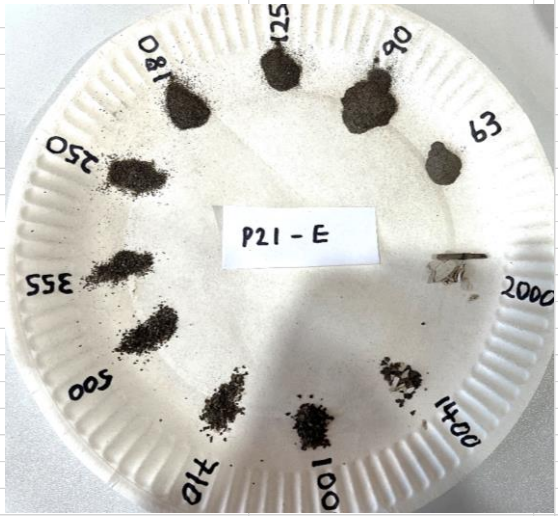
SURFACE DESCRIPTION

Topography	+/-4mm smooth surface with few clasts and fragments.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

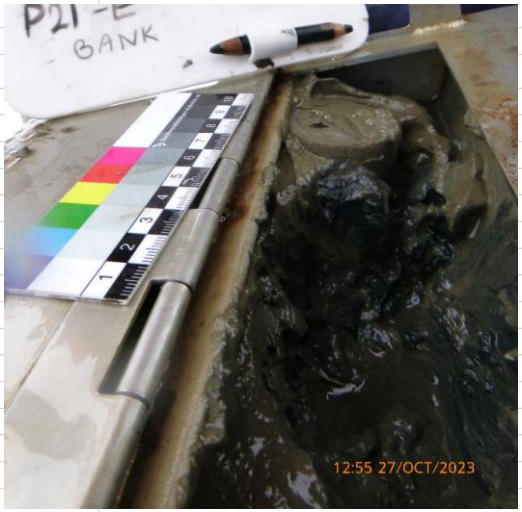
OTHER

	Very consolidated and black at the base.

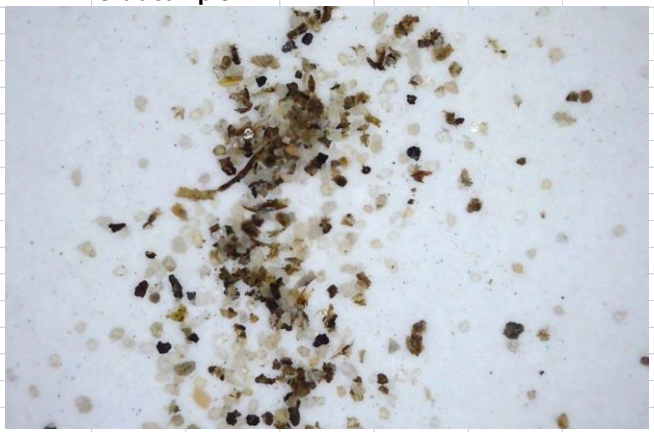
Grab sample



Sand Fraction wheel



Anoxic lower layer



90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P34-MID
DATE	27.10.23
TIME START	13:35
POSITION: LAT N	50.687810
POSITION: LONG E	-2.080418
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	
WEATHER	Overcast, grey.
DENSITY CORE 1cm (g/cm^3)	J
DENSITY CORE 7cm (g/cm^3)	-
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.5
%SAND (Lab):	64.7
%MUD (Lab):	34.8
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION*

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES - Surface 1cm cohesive, very soft underconsolidated, mid grey-brown. Below 1cm slightly anoxic, gritty grey/brown.

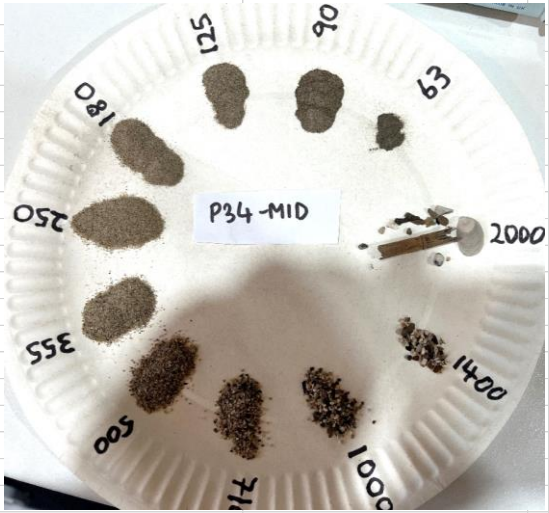
SURFACE DESCRIPTION

Topography	+/-3mm smooth surface.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

	*Under surface 1cm gritty consolidated ~80% sand, ~20% mud. the base.

Grab sample



Sand Fraction wheel

355µm fraction

90µm fraction

ENVIROMUD

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P34-W
DATE	27.10.23
TIME START	14:39
POSITION: LAT N	50.687729
POSITION: LONG E	-2.080631
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	
WEATHER	Overcast, grey.
DENSITY CORE 1cm (g/cm^3)	I
DENSITY CORE 7cm (g/cm^3)	2
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	37.2
%MUD (Lab):	62.8
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION*

%GRAVEL:	~0% gravel
%SAND:	~10% sand
%MUD:	~90% mud

SEDIMENT OBSERVATIONS

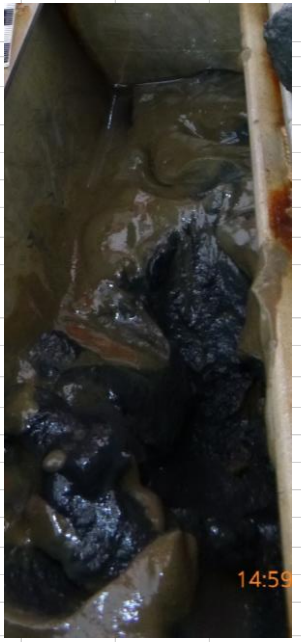
LAYERED?	YES - Surface 5mm cohesive, very soft underconsolidated, mid grey-brown. Below 5mm anoxic, gritty grey/brown.

SURFACE DESCRIPTION

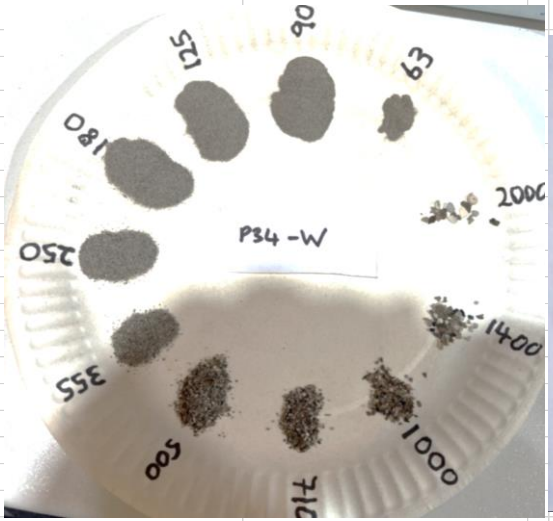
Topography	+/-4mm undulating smooth surface.
Covering	none
Bioactivity	no tracks or fauna
Biofilm?	none

OTHER

*Under surface 5mm gritty consolidated base.

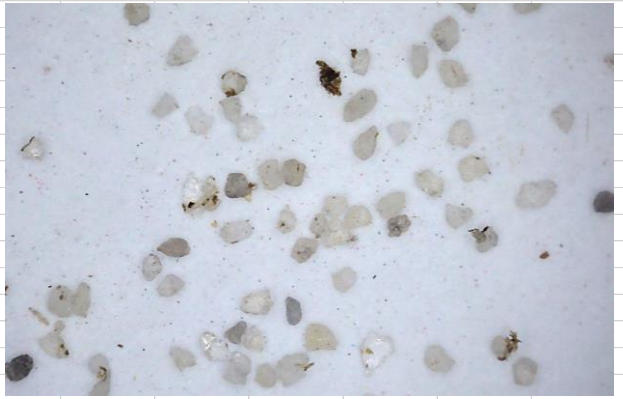


Grab sample



Sand Fraction wheel

355µm fraction



90µm fraction

SEDIMENT SURVEY LOG

AREA	Wareham Channel, Dorset, UK
SITE NAME	P34-E
DATE	27.10.23
TIME START	14:08
POSITION: LAT N	50.687810
POSITION: LONG E	-2.079992
EXPOSED OR GRAB TYPE	Grab
WATER DEPTH (m)	
WEATHER	Overcast, grey.
DENSITY CORE 1cm (g/cm^3)	Q
DENSITY CORE 7cm (g/cm^3)	11
SHEAR VANE (kPa)	N/A
MACROBENTHOS	N/A
%GRAVEL (Lab):	0.1
%SAND (Lab):	1.3
%MUD (Lab):	98.6
LOI (%b.wt)	N/A
SAMPLES	PSA 500g sample from top 10cm

IN-SITU OBSERVATIONS SEDIMENT COMPOSITION AND DESCRIPTION*

%GRAVEL:	~0% gravel
%SAND:	~1% sand
%MUD:	~99% mud

SEDIMENT OBSERVATIONS

LAYERED?	YES - Surface 5mm cohesive, very soft underconsolidated, mid grey-brown. Below 5mm anoxic, dark grey/brown, homogeneus some plant matter.

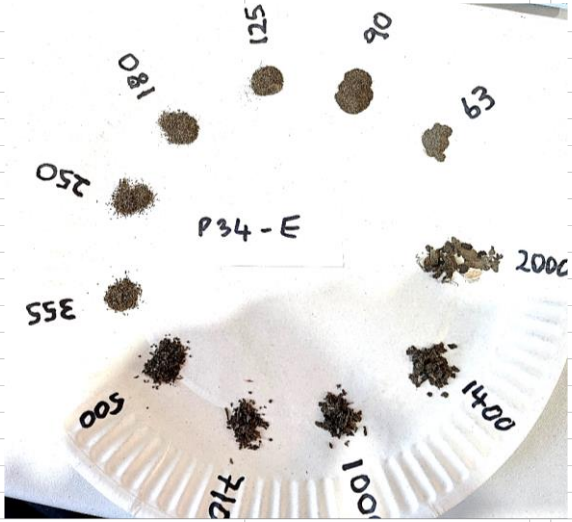
SURFACE DESCRIPTION

Topography	+/-3mm undulating smooth surface.
Covering	none
Bioactivity	slight - few worms 1mm dia. 5-20mm long.
Biofilm?	none

OTHER

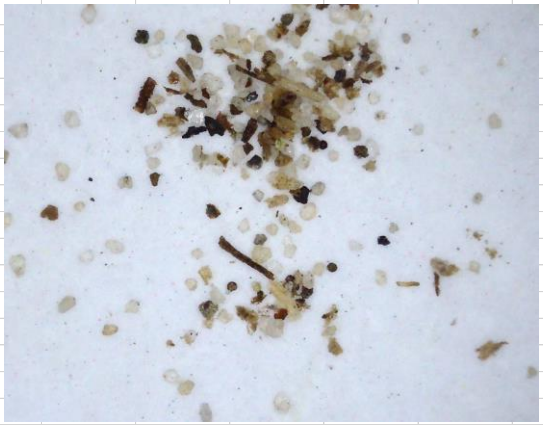
	*Under surface 5mm more consolidated base. Very close to eastern mudflat.

Grab sample



Sand Fraction wheel

Anoxic base.

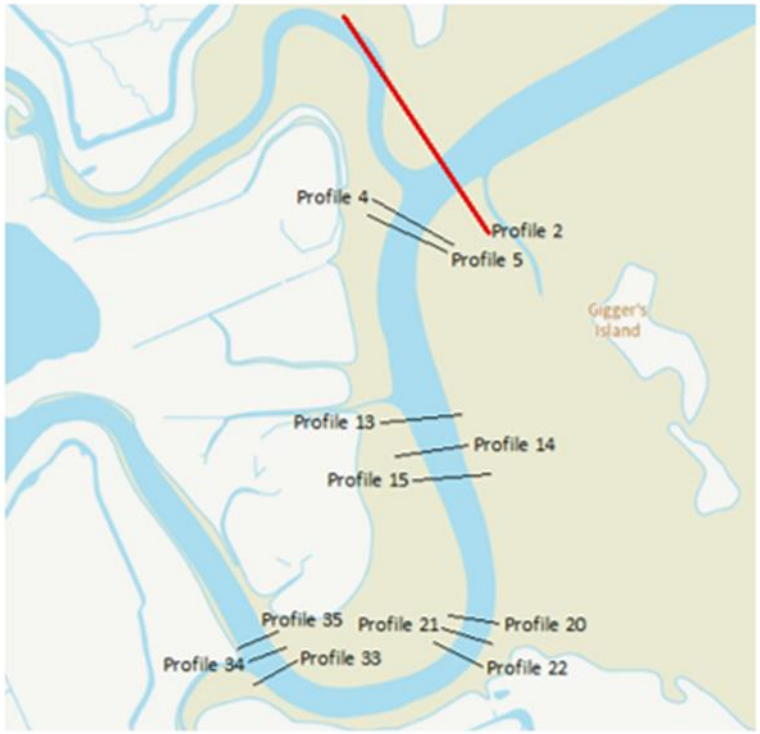


90µm fraction

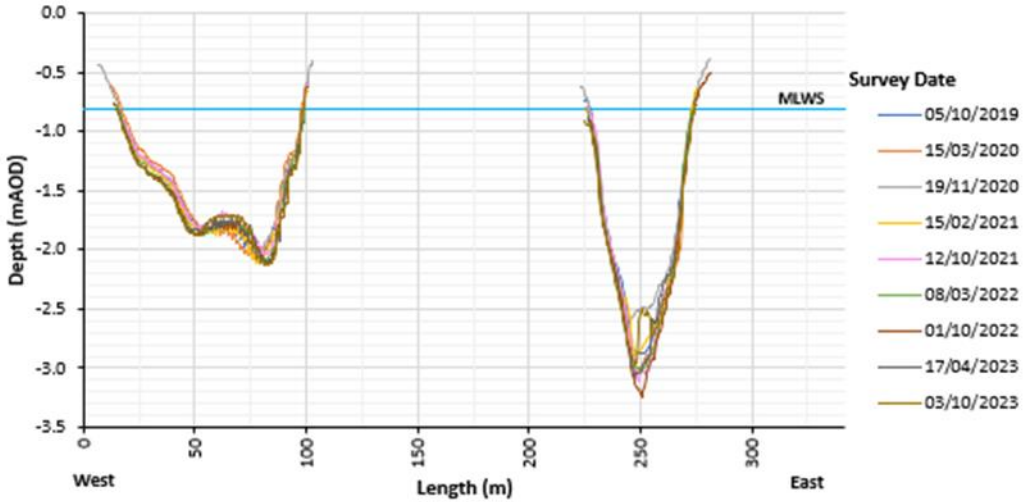
Appendix 2. Bathymetric Profile Changes Oct 2019 to October 2023.

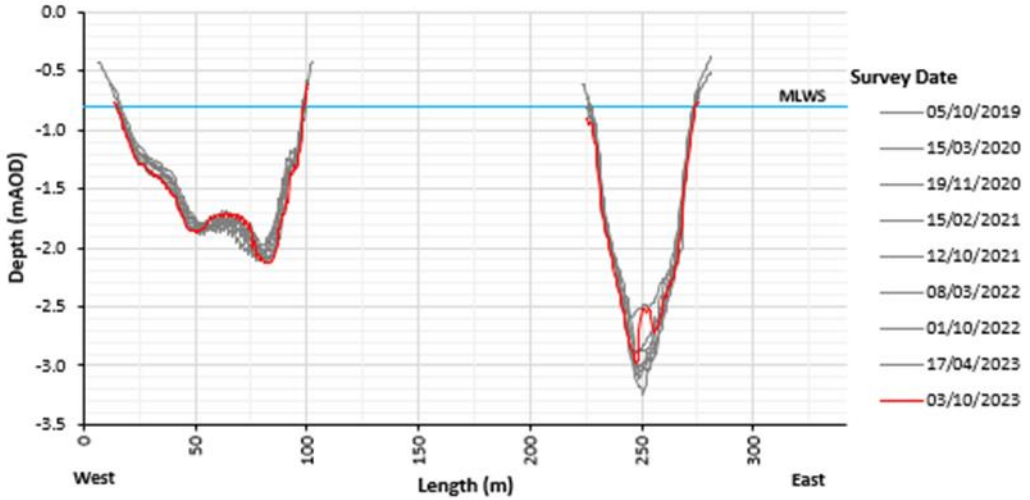
(Taken from PowerPoint by Atkins 2023).

Bathymetry Comparison – Profile 2

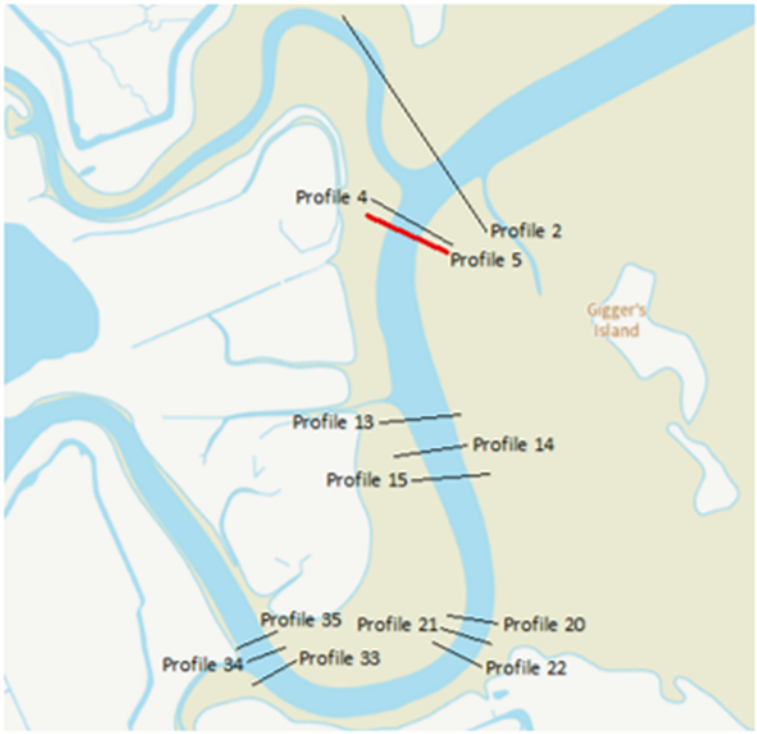


Wareham Channel cross-section locations

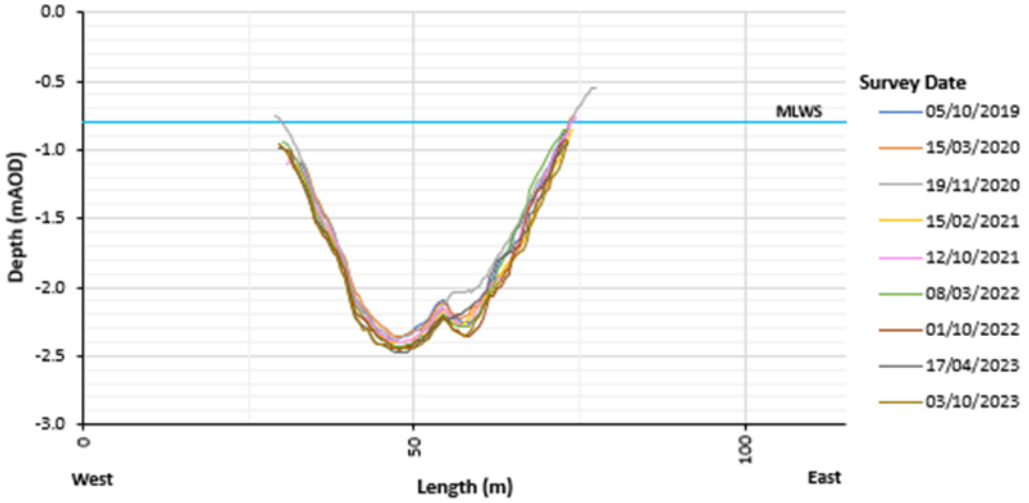


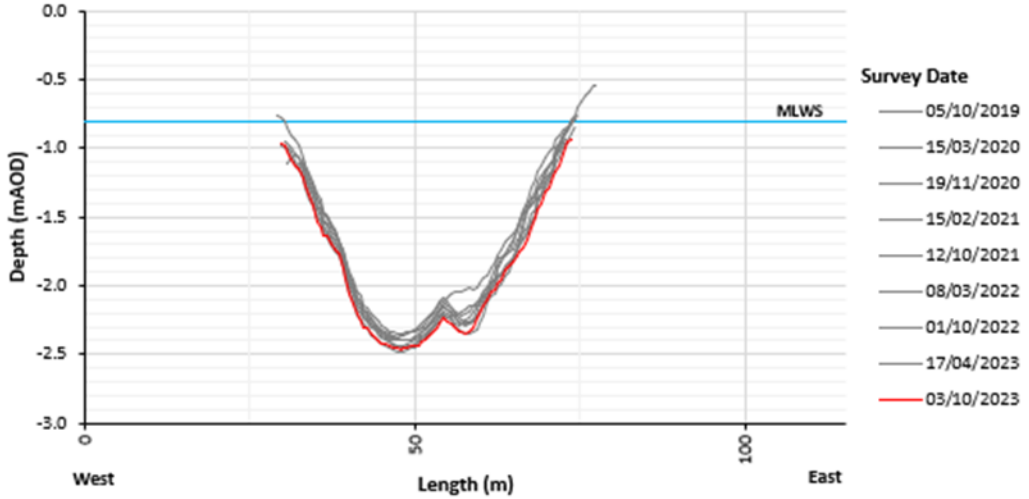


Bathymetry Comparison – Profile 5

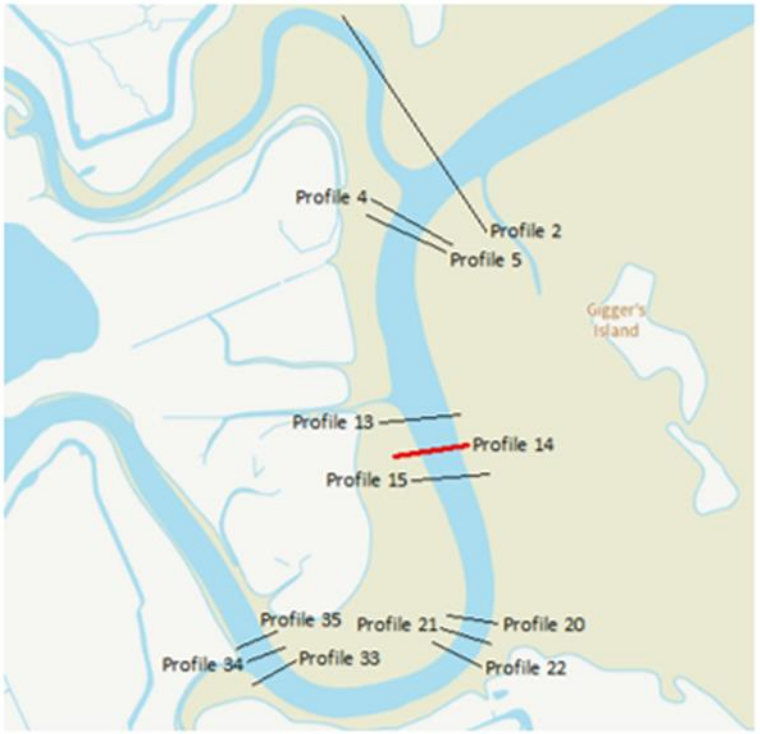


Wareham Channel cross-section locations

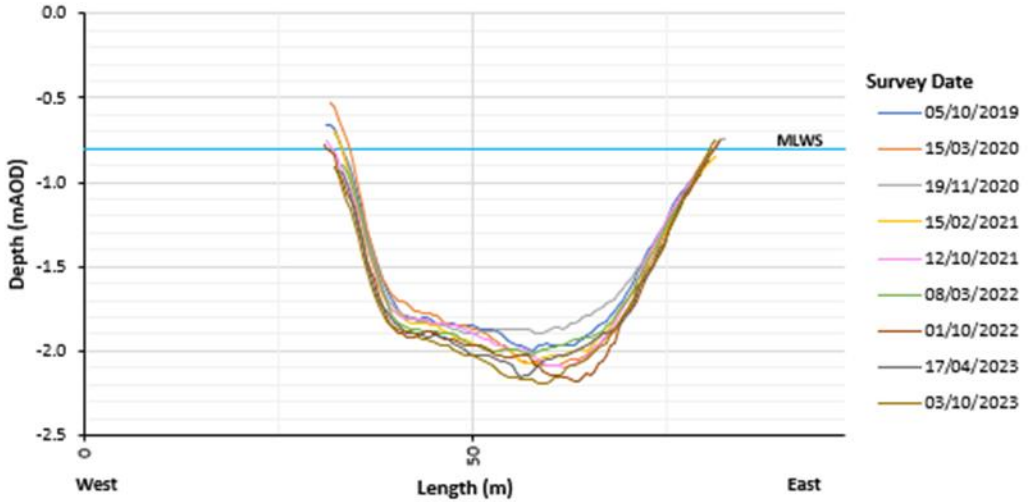


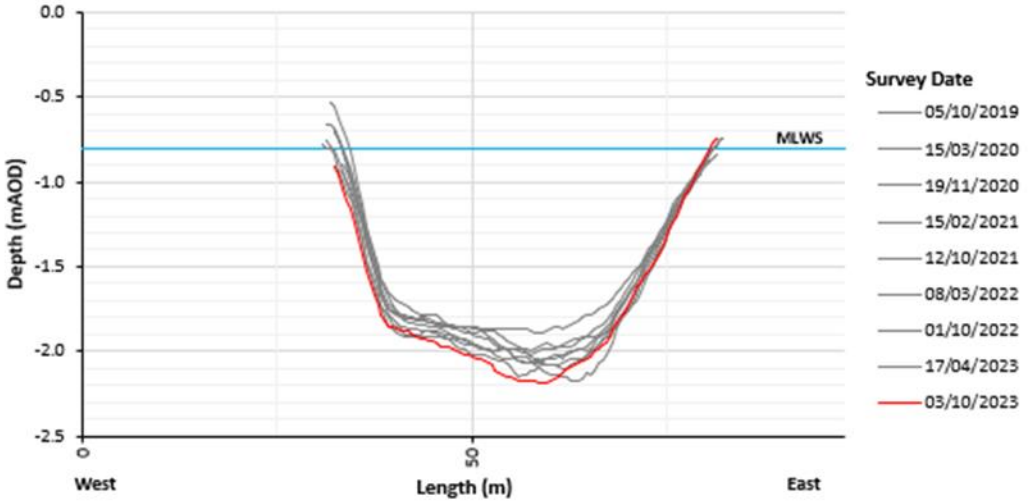


Bathymetry Comparison – Profile 14

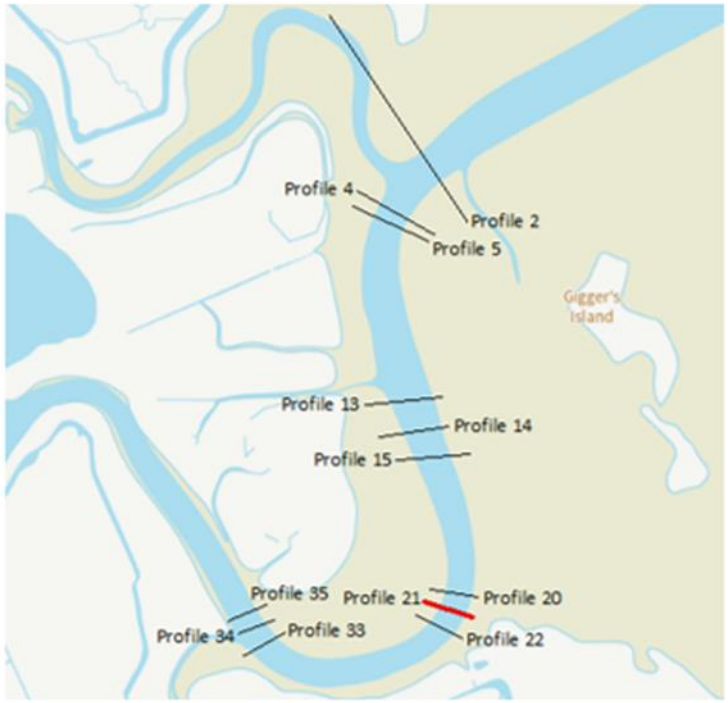


Wareham Channel cross-section locations

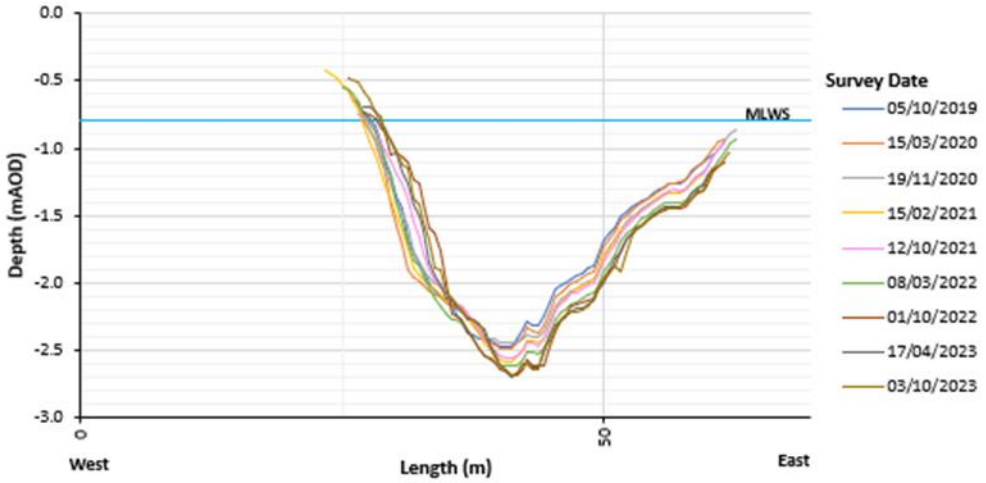


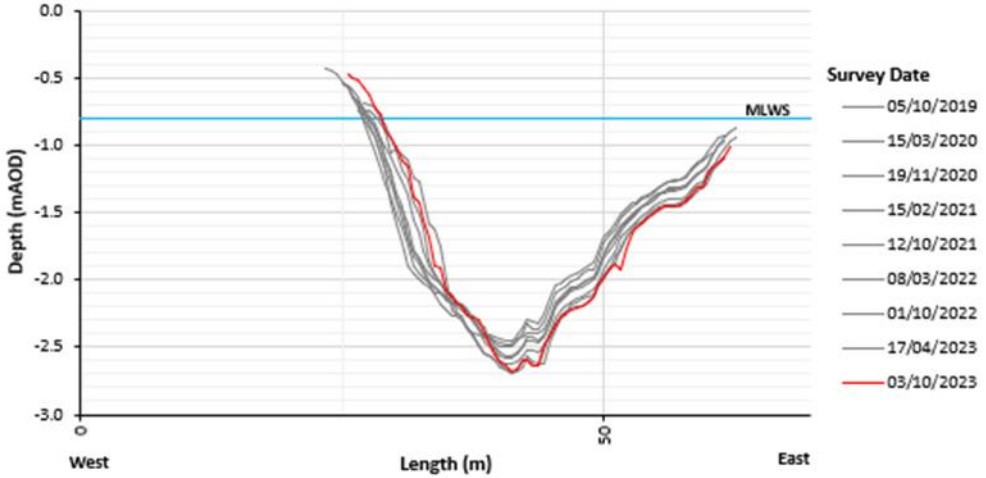


Bathymetry Comparison – Profile 21

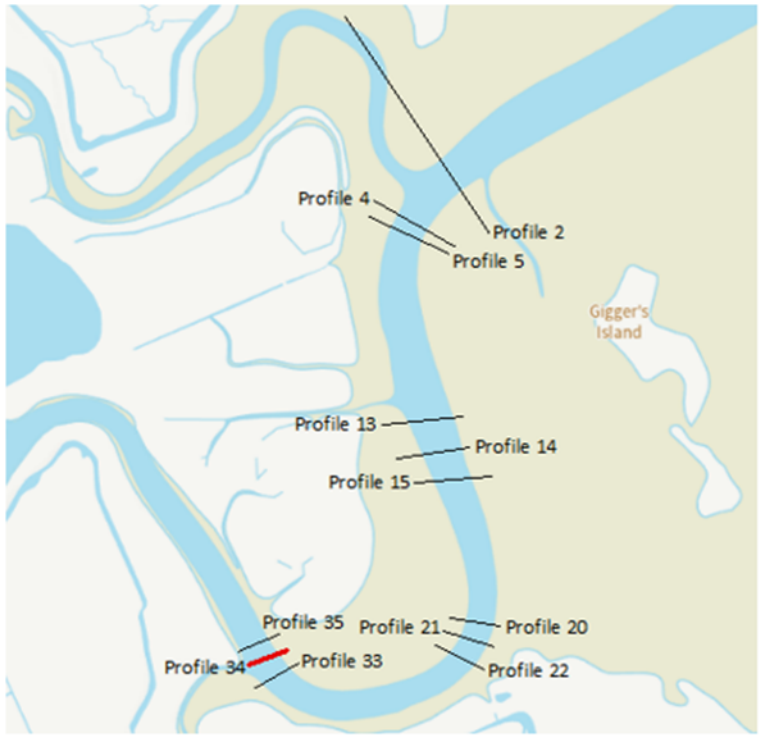


Wareham Channel cross-section locations

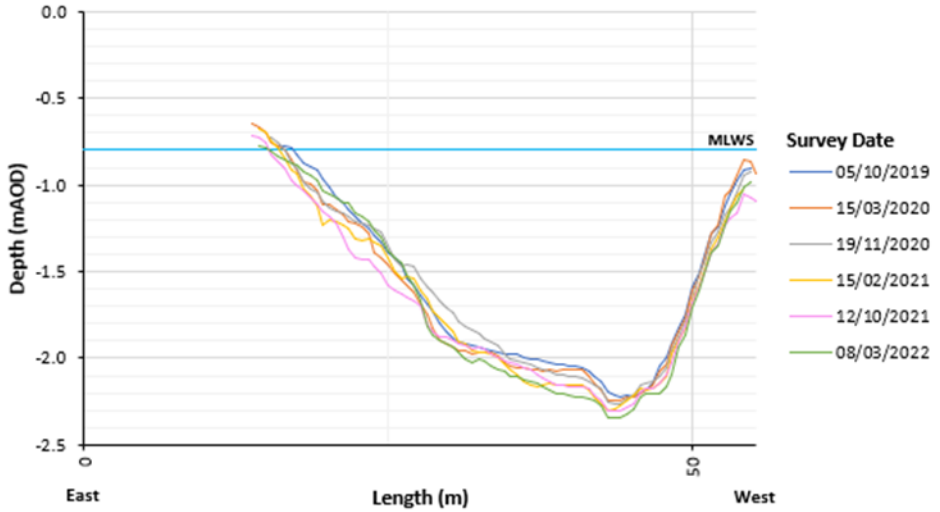


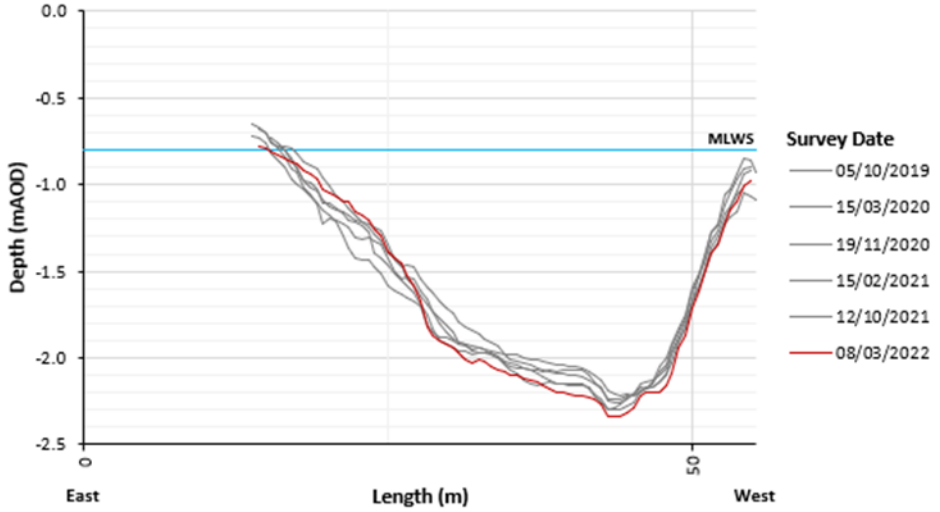


Bathymetry Comparison – Profile 34



Wareham Channel cross-section locations





Appendix 3. Conceptual Model of the Frome and Piddle Mouths Survey Area (at October 2023)