Marine
Management
Organisation

Review of available sediment data to aid understanding of the provenance of the subtidal mud habitat within Whitsand and Looe Bay Marine Conservation Zone (MCZ)

October 2015

Introduction

In early 2015 the Marine Management Organisation (MMO) received advice from Natural England which stated the existence of an area of subtidal mud situated in the Whitsand and Looe Marine Conservation Zone (MCZ) which is in the proximity of the Rame Head disposal site. The origin of this mud habitat was unknown and consideration was required in order to ascertain if its existence could be attributable to anthropogenic factors.

The MMO took a precautionary approach regarding this advice and made the decision to suspend disposal activities at the Rame Head disposal site whilst the nature and origins of this mud habitat were explored.

The MMO commissioned its scientific advisors the Centre for Environment Fisheries and Aquaculture Science (Cefas) to review existing data collected during the annual "Dredged Material Disposal Site Monitoring Around the Coast of England" project (SLAB5) in order to provide advice on the origin of the subtidal mud and whether disposal at Rame Head South was the cause of its existence.

The review is provided below in its entirety:

COMMENCEMENT OF CEFAS REVIEW

1. Background

Cefas has been tasked by the Marine Management Organisation (MMO) to review historical sediment data that have been acquired under the auspices of the dredged material disposal site monitoring project (SLAB5) to help understand whether the existence of the subtidal mud habitat within the Whitsand and Looe Bay MCZ, identified in the Whitsand and Looe Bay MCZ Summary Site Report (Defra, 2015), results from dredged material disposal activity to the Rame Head South disposal site (PL031).

In compiling this minute Cefas have drawn on information provided by the SLAB5 project manager.

2. Approach

Four historical SLAB5 stations fall within the subtidal mud habitat within the MCZ (Figure 1). Data from these stations are reviewed in this minute with the aim of providing any insight as to whether this mud habitat is present as a result of the disposal activity at the nearby Rame Head South disposal site.

The time-series data of the physical (particle size) and chemical (organic carbon and contaminants) characteristics of the sediment from the four stations sampled under the dredged material monitoring project SLAB5 (formerly BA004) are presented. Sampling was conducted using a Shipek grab at each station to obtain an undisturbed sediment sample: the top 2-3 cm of sediment being carefully removed for all subsequent analyses. For details of any sampling or sample processing methods, please contact Cefas.

The four stations were positioned as part of a wider survey to address the aims of SLAB5 and their location within the subtidal mud habitat within the MCZ is purely coincidental, i.e., they were not established to acquire data to characterise or determine the provenance of the material within this habitat. The four stations are G2, G6, G35 and G36 (see Figure 1). G35 lies on the edge of the subtidal mud habitat but data from this station are included in this study. To allow the data from the four stations within the subtidal mud habitat to be put into a wider spatial and temporal context, data from stations located within the disposal site (G18, G19, G20, and G16 lying just outside the licenced boundary) are also provided, together with data from two stations located at the opposite side of the disposal site to the subtidal mud habitat, i.e. to the southeast (G28, G33) (Figure 1). The sample stations are grouped to the three ‘regions’ (the subtidal mud habitat (SM), the disposal site (DS) and, southeast of the disposal site (SE)) in the results tables (Tables 1-5) in Section 3 below.

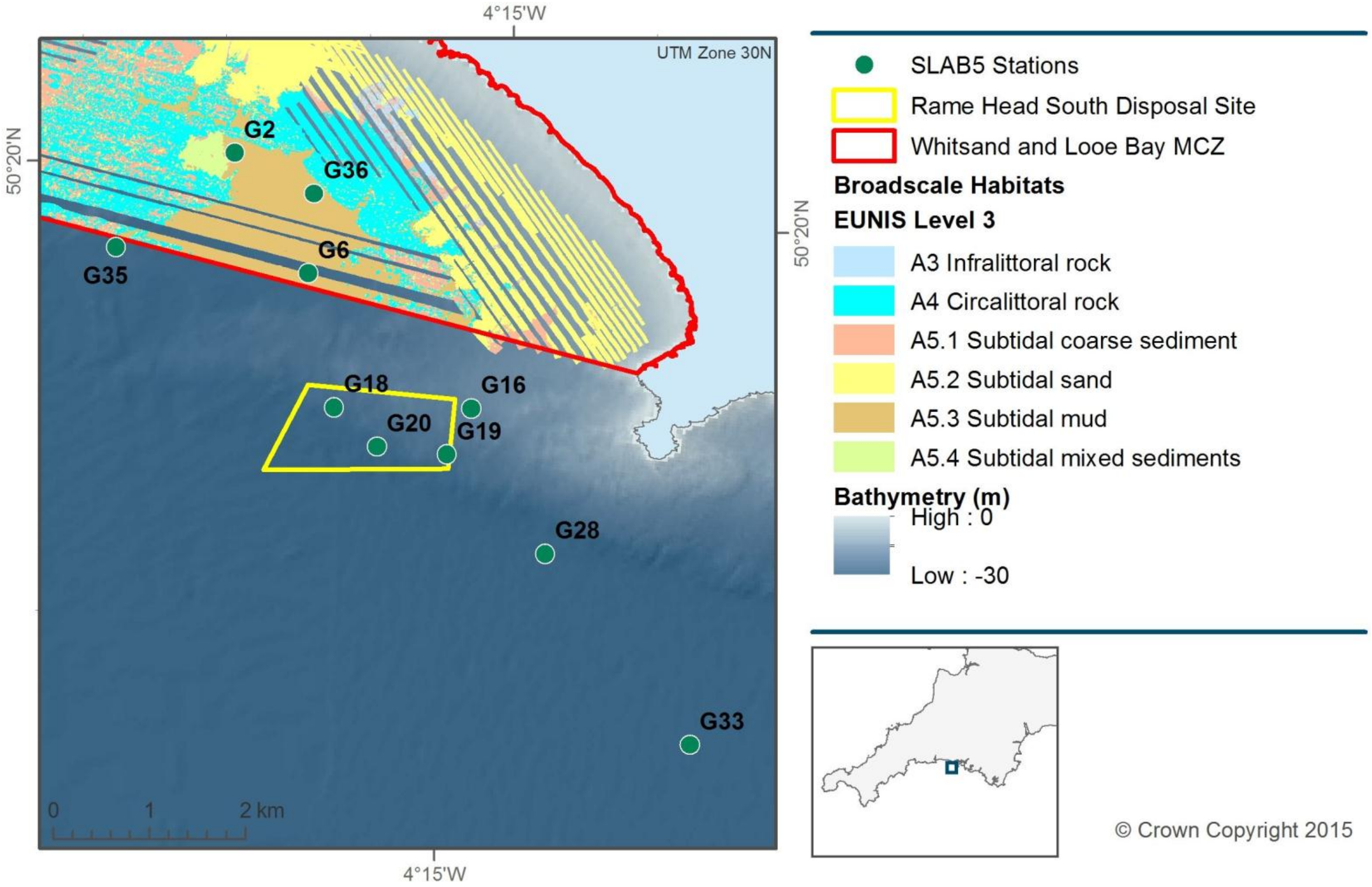

Figure 1. Location of the stations for which sediment data are reviewed under the current review. The four stations located northwest of the disposal site lie within the subtidal mud habitat region as indicated by the Whitsand and Looe Bay MCZ. Bathymetry is from the Defra Digital Elevation Model (Astrium, 2011). The MCZ information is from the Whitsand and Looe Bay MCZ Summary Site Report (Defra, 2015).

3. Results

3.1 Sediment particle size

The sampled sediments were assessed for their granulometric properties through particle size analysis (PSA). Of particular importance is the percentage of the finer mud fraction or the silt/clay content, as it is this component of the sediments with which the majority of the contaminants tend to be associated.

It can be seen (Table 1) that there is a notable spatial variability in the silt/clay component across the stations. While some stations are generally low in silt/clay (e.g. G16, G19) others are relatively silty (e.g. G18, G28). The four stations in the subtidal mud habitat within the MCZ are muddy, except for G35 which lies on the edge of the subtidal mud habitat (Figure 1). There is generally no indication of any temporal change in the mud content of these stations, apart from some increases at G2 and G36 in 2014. G16 was the only station sampled from the disposal site in 2014, as it lies just outside the licenced boundary G16 alone may not be representative of the disposal site.

Table 1. Silt/clay content (%) of the surficial (top 2-3 cm) sediments of the stations reviewed under the current study. Data from 2001 to 2014 are presented. Blank cells indicate either no sample was taken or the sample was not processed.

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	37.6	39.1	34.2				35.2	33.2	30.49	56.32
	G6	5.2					38.7	38.8	33.3	33.82	23.12
	G35			13.9				19.3		12.77	
	G36			29.0				34.4	25.3	28.39	38.65
DS	G16	0.5	1.5	0.9			1.3				23.13
	G18	20.7	85.5	78.7	13.1	58.7	44.8		42.9		
	G19	1.4	3.0	2.9	4.3	2.4	9.0	0.3	1.1		
	G20	40.5						31.0	26.6		
SE	G28	28.2	42.0	30.7	42.0	48.5	47.6	27.5	27.6	23.38	23.34
	G33		15.6	19.7	14.9	15.7	18.0	14.0	16.0	14.87	82.16

3.2 Organic carbon content

The organic carbon contents of the sediments vary between approximately 1% and just over 3% (Table 2). The higher organic carbon content values tend to be found at the stations within the disposal site. These data do not indicate any temporal trend in organic carbon contents of the sediments in the region.

Table 2. Total organic carbon content (%) of the surficial sediments of the stations reviewed under the current study. Data from 2001 to 2014 are presented. Blank cells indicate either no sample was taken or the sample was not processed.

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	1.72	1.91	1.29				1.35	1.03	1.04	1.79
	G6	1.30						1.44	0.96	0.97	1.59
	G35			1.94				1.88		1.34	
	G36			1.04				1.51	1.50	0.81	1.58
DS	G16		1.48	2.06			1.64				1.54
	G18	2.08	3.03	3.06	1.81	2.45	2.23	2.57			
	G19	1.86	1.26	2.28		0.90	1.89				
	G20	2.93						1.20	2.32		
SE	G28	2.09	1.59	1.93	1.65	1.52	1.65	1.84	1.70	1.71	1.82
	G33		1.99	1.82	1.92	2.05	1.82	1.85	1.78	1.93	2.58

3.3 Tri-butyltin (TBT)

The concentrations of the TBT in sediments within the Rame Head region are low (Table 3), predominantly below limit of detection (or LOD). Only one sample in the subtidal mud habitat within the MCZ showed detectable concentrations (0.009 mg/kg at G36, 2003). Concentrations within the disposal site are noticeably higher, with detectable (although still low) concentrations being observed, particularly during 2002. No samples were processed for TBT in 2014 due to the low levels in previous years.

Table 3. TBT concentrations (mg/kg dry weight) of the surficial sediments of the stations reviewed under the current study. Data from 2001 to 2014 are presented. Blank cells indicate either no sample was taken or the sample was not processed. † represents concentrations measured were below limit of analytical detection (0.002 mg/kg).

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	†	†	†				†	†	†	
	G6						†	†	†	†	
	G35			†				†			
	G36			0.009				†	†	†	
DS	G16		0.004	†			†				
	G18		0.153	†	†	0.016	†	†	†		
	G19		0.005	†				†			
	G20			†				†	0.010		
SE	G28	†	0.005	†	†	†	†	†	†	†	
	G33	†	†	†	†	†	†	†	†	†	

3.4 Trace elements

The concentrations of a number of trace elements for the stations sampled under SLAB5 are presented within Table 4. The regional background assessment concentrations for each element are also presented. These assessment concentrations represent the concentrations of each element for the sediments of the western Channel, and are more appropriate for the assessment of disposal activity than the OSPAR background assessment concentration values (Cefas, 2011) as they allow for the natural variations in element concentrations across the coast of England and Wales. Trace elements are a natural feature of marine sediments and their concentrations vary across the UK shelf, partly due to differences in the mineralogical characteristics across the region (see Section 5) and also due to variations in sediment particle size as finer grained sediments usually have higher trace element contents. The data acquired under SLAB5 indicate that for all the eight elements, concentrations are slightly elevated above the regional assessment concentrations within the disposal site, but generally appear similar to these regional values within the subtidal mud habitat and SE stations. No temporal trend can be observed for the three regions.

Table 4. Trace element concentrations (mg/kg dry weight) of the surficial sediments of the stations used for the current review. Data from 2001 to 2014 are presented. Blank cells indicate either no sample was taken or the sample was not processed. The eight elements presented here are those for which regional assessment concentrations exist to allow comparisons with concentrations expected for non-disposal conditions. Trace element concentrations that are at or below the regional assessment concentrations are presented in grey cells. Data result from total digest of the < 63 µm fraction of the sediments (Cefas, 2011).

Arsenic (As) Regional baseline = 34 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	31	26	24				26	25	27	31
	G6	32					24	24	27	27	114
	G35			38				32		35	
	G36			26				31	34	28	37
DS	G16	49	62	33			85				39
	G18	58	82	71	28	57	35		72		
	G19	56	80	26	44	50	32		52		
	G20	93						18	65		
SE	G28	45	27	33	29	33	26	28	33	31	39
	G33			22	411	21	20	27	20	23	27

Cadmium (Cd) Regional baseline = 0.19 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	0.34	0.13	0.15				0.37	<0.15	<0.14	0.25
	G6	0.16					0.29	0.27	<0.16	<0.15	0.7
	G35			0.06				0.29		<0.15	
	G36			0.18				0.37	<0.14	<0.16	0.23
DS	G16	0.44	0.1	0.19			0.4				0.28
	G18	2.5	0.44	0.58	0.09	0.19	0.31		0.47		
	G19	0.13	0.36	0.2	0.3	<0.16	0.34		0.37		
	G20	0.83						0.23	0.36		
SE	G28	0.27	0.15	0.31	0.11	0.14	0.24	0.19	0.2	<0.16	0.27
	G33			0.28	0.1	<0.13	0.18	0.22	<0.15	<0.15	0.2

Chromium (Cr) Regional baseline = 105 mg/kg

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	78	91	94				75	64	108	93
	G6	94					78	60	79	102	106
	G35			102				67		113	
	G36			124				82	93	127	83
DS	G16	88	115	94			105				91
	G18	69	108	96	92	87	83		84		
	G19	104	111	85	97	95	69		76		
	G20	114						77	101		
SE	G28	106	72	101	89	81	73	93	86	113	90
	G33			103	93	75	58	77	74	117	81

Copper (Cu) Regional baseline = 72 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	68	50	53				43	40	46	48
	G6	55					50	44	72	58	94
	G35			69				55		61	
	G36			51				51	56	53	52
DS	G16	144	250	94			68				51
	G18	133	238	242	53	144	129		197		
	G19	123	110	64	114	70	96		178		
	G20	287						22	150		
SE	G28	86	55	81	69	59	67	61	74	66	67
	G33			59	50	49	46	52	45	59	46

Mercury (Hg) Regional baseline = 0.77 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	0.52	0.45	0.45				0.38	0.31	0.34	0.45
	G6	0.33					0.34	0.44	0.5	0.51	1.06
	G35			0.57				0.4		0.4	
	G36			0.35				0.35	0.44	0.38	0.56
DS	G16		0.39	0.67			0.44				0.49
	G18	1.8	0.34	0.72	0.32	0.86	0.61		0.81		
	G19	0.75	0.54	0.64		0.9	0.81		0.41		
	G20	0.92						0.1	0.61		
SE	G28	0.51	0.45	0.59	0.36	0.39	0.49	0.58	0.65	0.63	0.62
	G33			0.64	0.54	0.68	0.97	0.62	0.78	0.52	0.49

Nickel (Ni) Regional baseline = 50 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	47	33	33				36	33	41	41
	G6	34					30	27	36	44	43
	G35			45						45	
	G36			32						48	36
DS	G16	51	56	46			59				39
	G18	32	51	46	38	41	37		43		
	G19	47	37	39	58	48	39		39		
	G20	58						31	49		
SE	G28	37	31	41	36	35	41	36	42	43	37
	G33			36	36	30	28	38	37	49	37

Lead (Pb) Regional baseline = 108 mg/kg											
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014

SM	G2	88	56	63				62	55	70	78
	G6	59					61	55	59	86	169
	G35			91				75		88	
	G36			64				71	74	72	80
DS	G16	247	110	197			129				83
	G18	132	148	176	76	136	124		147		
	G19	141	118	98	152	177	139		144		
	G20	165						29	138		
SE	G28	92	64	213	77	79	80	87	100	92	108
	G33			97	93	100	73	86	70	103	75

Zinc (Zn)		Regional baseline = 153 mg/kg									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	148	127	119				121	92	107	132
	G6	125					113	108	134	120	196
	G35			154				146		134	
	G36			106				135	116	126	118
DS	G16	208	230	249			198				128
	G18	338	316	320	140	234	209		262		
	G19	215	179	160	184	164	192		192		
	G20	425						62	213		
SE	G28	159	152	155	146	117	145	144	152	133	149
	G33			147	146	130	125	116	128	150	126

3.5 *Hydrocarbons*

The spatial and temporal variations in the total hydrocarbon (or THC) concentrations for the SLAB5 stations are presented in Table 5. Cefas use THC concentrations as a screen to identify sediment samples with high hydrocarbon levels. The data from the SLAB5 stations presented here are low compared to those observed at many disposal sites around the coast of the UK, with values of up to ten times higher being found at sites off the north east coast (Rumney et al., 2015). These data, akin to the situation reflected by the trace elements data, indicate that no temporal trend in THC concentrations are evident for the samples taken from within the subtidal mud habitat.

Table 5. Total hydrocarbon concentrations (mg/kg dry weight) of the surficial sediments of the stations reviewed under the current study. Data from 2001 to 2014 are presented. Blank cells indicate either no sample was taken or the sample was not processed.

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2014
SM	G2	103		70				63	88	74	93
	G6						147	187	225	279	188
	G35			40				48			
	G36			64				104	95	120	117
DS	G16	16		24			17				24
	G18	2000		316	198	184	348		267		
	G19			27	210	26	56	3	19		
	G20	187						30	158		
SE	G28			286	179	255	150	131	281	208	168
	G33			48	59	70	38	85	62	23	137

4. Discussion

The purpose of this minute has been to review SLAB5 monitoring data from the Rame Head South disposal site to ascertain if they can provide any insight into the origin of the subtidal mud habitat identified in the Whitsand and Looe Bay MCZ. Recent subtidal sampling conducted by Environmental Agency (EA), to support the Defra MCZ field survey program and verify the presence of the subtidal features proposed for designation (Arnold & Godsell, 2014), used a different grab type (a mini-Hamon grab) which does not allow acquisition of undisturbed sediments nor contaminants to be assessed, therefore SLAB5 data currently represents the only source of contaminants data for the subtidal mud habitat.

The sediment physical (granulometric PSA) and chemical (organic carbon and contaminants) data presented for the four stations within the subtidal mud habitat, together with those within the disposal site and those to the southeast of the site, provide a spatial and temporal assessment of the variability of the sediments in this region. The data have shown that while the three ‘regions’ (i.e. the subtidal mud habitat, the disposal site, southeast of the disposal site) display some spatial variability, both within and between regions, there does not appear to be any obvious trend over time.

Contaminants concentrations within the subtidal mud habitat and SE stations generally appear similar to the regional background assessment concentrations. Contaminant concentrations within the disposal site are slightly elevated above the regional assessment concentrations, but not appreciably higher, which is what we would expect at a dispersive disposal site. A dispersive disposal site is where dredged material may either be dispersed during deposition or eroded from the bottom over time and transported away from the site by currents and/or wave action. The Rame Head South disposal site, like the majority of those across the coast of England and Wales, is a dispersive site being located in a hydrologically dynamic area. Dredged material disposed at the site will, therefore, generally be moved in the direction of the prevailing tidal currents i.e. in a north-west to south-east direction. It has been shown that the predominant residual movement of disposed material is in a south-easterly direction away from the disposal site (Cefas, 2005 & 2007) and the MCZ site. While storm conditions may periodically move the material in different directions the long-term residual sediment transport pathways are not affected. The presence of contaminants at the monitoring stations does not necessarily mean that they are derived from the disposal operations as there are other sources of contaminants, for example natural inputs of metals and other anthropogenic sources of hydrocarbons such as road run-off and the discharge of industrial and sewage effluents (Cefas, 2007).

While prevailing tidal currents will take material in suspension from the disposal site in the general direction of the MCZ, over part of the tidal cycle, the long-term residual sediment transport pathway is away from the MCZ (Cefas, 2005 & 2007). The monitoring data reviewed under this minute spans a relatively short time period (thirteen years) relative to the lifespan of the disposal site (greater than 100 years). No pre-disposal data for the region or, more specifically, for the subtidal mud habitat area, are available. As such, it is impossible to unequivocally state that the subtidal mud habitat within the MCZ was or was not muddy prior to any disposal activity taking place. Material is transported naturally out of the Tamar Estuary, a proportion of which would inevitably end up in the Whitsand Bay area including the MCZ (Siddorn et al. 2003, Elliott & Mazik 2011). The dredged material disposed at the Rame Head South site consists of material from within the Tamar Estuary and therefore it is extremely difficult to distinguish between the natural deposition and that resulting from disposal activity in this region. All of these factors make it impossible to determine the origin of the mud and to determine how long it has existed. Historical evidence may, however, provide a useful source of information, for example Crawford (1937) refers to an area called 'Rame Mud' when reporting on surveys of crustaceans in the area from 1934 and 1935.

Recent sampling of the surface sediment and benthic communities within the MCZ, undertaken by the EA (Arnold & Godsell, 2014, Defra 2015) does, however, suggest that the subtidal mud habitat is a stable habitat supporting a well-established benthic community. Seabed images captured from stations within the subtidal mud habitat clearly show the presence of benthic organisms on the surface and the evidence of burrowing activity (Figure 2).

Figure 2. Seabed images of the subtidal mud habitat captured during the Whitsand and Looe Bay MCZ 2013 habitat verification survey (Arnold & Godsell, 2014).

Based on the data reviewed here it is currently very difficult to address the origin of the subtidal mud identified in the MCZ and determine how long it has been there.

However, it is clear that the area has been muddy for at least 14 years (Table 1) and it may have been muddy for some 78 years or more based on information in Crawford (1937).

5. Potential approaches to provide additional information on the subtidal mud

As indicated earlier, the capacity of the data from the small number of surficial sediments taken under SLAB5 to ascertain the origin of the material occupying the subtidal mud habitat within the MCZ is very limited (Section 3). There are, however, a number of alternative approaches that may offer the potential to provide further information and/or data to help aid our understanding of the subtidal mud habitat located within the MCZ. These could be employed in a step-wise approach to ensure resources are targeted cost effectively. The first two approaches below would be relatively low cost and quick to undertake, and would determine if further work is required, these are:

- Literature search/review of historical evidence relating to the 'Rame Mud' area, and;
- Interviews with fishermen to explore their local knowledge of the subtidal habitats in the area.

The following approaches would provide more information on the extent and volume of the subtidal mud which could potentially provide information of the source of the subtidal mud:

- An acoustic (multibeam bathymetry and backscatter) survey to map out the full spatial extent of the subtidal mud habitat, and;
- A spatial assessment of the sediment depth profiles of the subtidal mud. Employing sub-bottom profiling and a suitable corer (e.g. vibrocorer), it would be possible to determine the depth of the mud throughout the subtidal mud habitat (using spatial extent information from the above-mentioned mapping approach). This would allow an estimation regarding the volume of material that presently lies within the subtidal mud habitat.

The following could also potentially provide information of the source of the subtidal mud:

- Radioisotopes in the sediment could be analysed to provide evidence on the age of the material, and;
- A detailed hydrological and sediment transport pathway survey of the wider coastal region may offer some insight regarding sediment movement (sources and sinks) between the Tamar Estuary and adjacent coastal areas.

While hydrological and/or tracer studies may be of help in predicting the fate of material disposed over relatively short time-scales (tidal, monthly, seasonally), their capacity to determine the long-term fate of material is very limited. Decadal storms, for example, may ultimately be of overriding importance in determining the sedimentary nature and the fate of material disposed. With no pre-disposal data, a long-term study is arguably required to address this long-term issue.

6. Conclusion

Based on historical sediment data from the dredged material disposal site monitoring project (SLAB5) and the further evidence reviewed in this minute it is at present not possible to determine the origin of the subtidal mud habitat within the Whitsand and Looe Bay MCZ, however while it is likely that disposal activity at the Rame Head South disposal site contributes fine material, it is highly unlikely that it is responsible for the presence of the mud habitat located within the MCZ. The alternative approaches suggested above (Section 5) to help aid understanding of the subtidal mud habitat would provide further information on the characteristics of the subtidal mud, however even if undertaken it would still be difficult to confidently ascertain the origin of the subtidal mud habitat.

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END OF REVIEW

MMO post-script

Based on the conclusions of the Cefas review provided above, along with the best available scientific evidence, the MMO has determined that the Rame Head South site is a viable option for disposal of dredged material and therefore it will now consider applications for disposal at the site on a case by case basis.