Appendix 8.1

Benthic Survey Proposal

Titan Environmental Surveys Limited

A GARDLINE COMPANY

Pre-survey Report for

Tidal Lagoon Swansea Bay Ltd

Project:

Benthic Survey Proposal Proposed Tidal Lagoon Development in Swansea Bay

Date:

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1.0 INTRODUCTION

1.1 General

1.1.0.1 This report documents the repositioning of proposed grab sampling sites and the addition of further sites as part of the subtidal benthic characterisation survey for the Swansea Tidal Lagoon Development. This action follows a telephone conference meeting held on the 13th December 2012 between representatives of Tidal Lagoon Swansea Bay Ltd (Gill Lock), Titan Environmental Surveys Ltd (Gwyn Nelson) and Countryside Council for Wales (CCW) (Lucy Skates, Karen Robinson, Kirsten Ramsey, Ben Ray). Additional comments received from CCW on 24th Jan 2013 have also been taken into consideration.

1.1.0.2 At the meeting it was confirmed that the objective of the characterisation survey was to gather information, across the area potentially affected by the proposed tidal lagoon, during all stages of its development. To achieve this CCW requested that single samples be analysed from relevant sites, with a distribution such that there would be multiple samples (approx 4) from the various substrate types in the bay. Where samples could not be collected due to coarse substrate, the site was to be revisited with a drop down camera to try and obtain a towed video sequence of the seabed.

1.1.0.3 It was agreed that the positioning of the samples within the substrates was to be based on site specific bathymetric survey data collected for the project, and existing data such as British Geological Society information and Admiralty charts. Dropdown video data has also been collected by CCW within the Bay and this will be reviewed as part of the wider project.

1.1.0.4 Note, although the objective of this work is to characterise the benthic ecology associated with the different substrates within the bay, it would be proposed that some of these sites would also be used for the baseline line survey, should consent for the development be approved. As such it would be proposed to collect three replicates from all of the sites, with those which are not needed for analysis at this stage being stored for future use. The sites to be used for the baseline survey will be confirmed based on the results of the Environmental Impact Assessment (EIA) and discussion with CCW (Natural Wales). As identified in CCW letter of 24th Jan 2013, it is appreciated that if the findings of the EIA indicate a wider area of potential area of effect or if the project is significantly delayed, then further benthic characterisation may be required.

2.0 SAMPLE SITE SELECTION

2.1 High Level Modelling and Extent of Survey Area

2.1.0.1 To determine the extent of the characterisation survey, the results of the high level coastal processing modelling undertaken by ABPmer were reviewed. The preliminary modelling was undertaken using the existing model of the Bristol Channel and Severn Estuary and is essentially the same modelling tool which was applied to support the Scarweather Sands Offshore Wind Farm EIA (ABPmer, 2002). ABPmer consider that the model is ideally suited to support the feasibility stage of the lagoon project and the work undertaken provides a high-level assessment of the concerns relating to the potential extents of any far-field influence. Further details of the model can be found in Appendix A. At this stage the high-level modelling considers waves and tides only and in due course this modelling will be refined to also include for sediment transport.

2.1.0.2 The preliminary modelling was based on an earlier lagoon design, without representation of the flows from the turbine housing. Again detailed modelling will be undertaken for the EIA which will be based on the final lagoon layout and it will include representation of the flow from the turbine housing.

2.1.0.3 Overall the results of the high-level modelling assessment suggest that there should be no far-field effects in the tidal regime across the wider area (downstream in the Bristol Channel and upstream in the Severn Estuary). In terms of more local effects Figure 2.1 below shows the results of the modelling for an ebb and flood spring tide. The main illustration of the figure shows the current vectors for the baseline (black line) and lagoon scenario (red line). Where there is a difference in speed or direction the two vectors deviate from each other. The net change between the two scenarios is also shown on the main figure by either shades of blue (a decrease) or shades of yellow (an increase) in current speed. Note the “change” in current speed does not necessarily mean that there will be a resultant change in sediment movement as this is dependant on the substrate present. This will be investigated during the main EIA.

2.1.0.4 As can be seen from Figure 2.1, the potential change as a result of the lagoon is mainly focused around the actual lagoon. To the east there is potential for a slight increase in current speed (up to around 0.1m/s) and to the west there appears to be a potential for a small net decrease (approx 0.1m/s). This decrease appears to extend out around the Gower, but with a lesser effect.

2.1.0.5 For the characterisation survey, the study area is therefore identified as the area extending from Pwll Du Head on the southern Gower coastline in the west across to Port Talbot on the east side of the lagoon. The sampling sites have therefore been located within this zone.

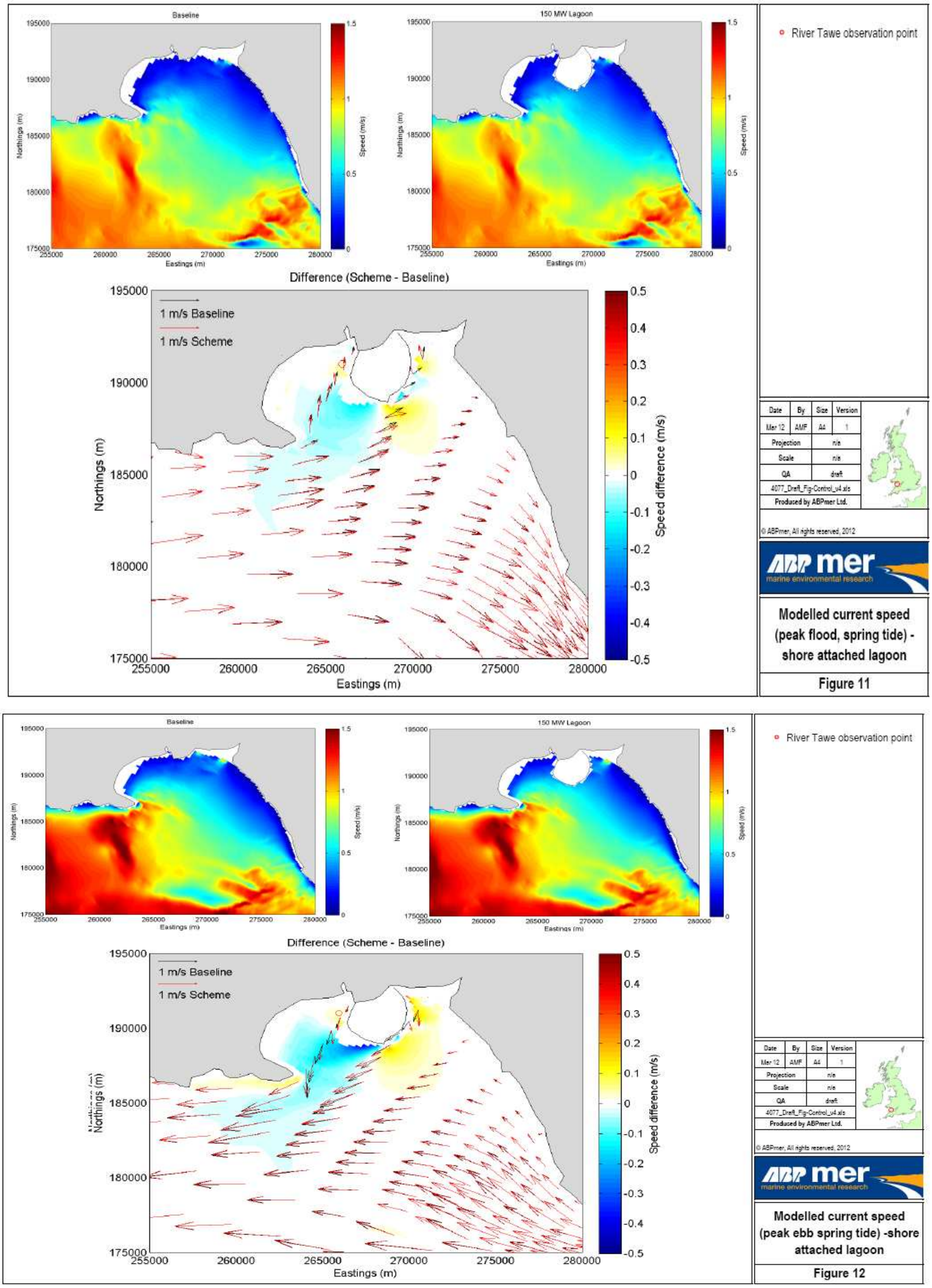

Figure 2.1 ABPMer Coastal Process Modelling Charts (Spring Tide)

2.2 Sediment Distribution and Sample Locations

2.2.0.1 In order to position the sample sites such that information is gathered across the different substrates within the study area, the following information on sediment distribution was used:

i. British Geological Society (BGS) sediment distribution chart of Swansea Bay ((Figure 2.4)

ii. Figure 2.2)

iii. Admiralty Chart 1161 of Swansea Bay (Figure 2.3)

iv. Sidescan Sonar Survey data covering the inner lagoon area collected by Titan in February 2012 (Figure 2.4)

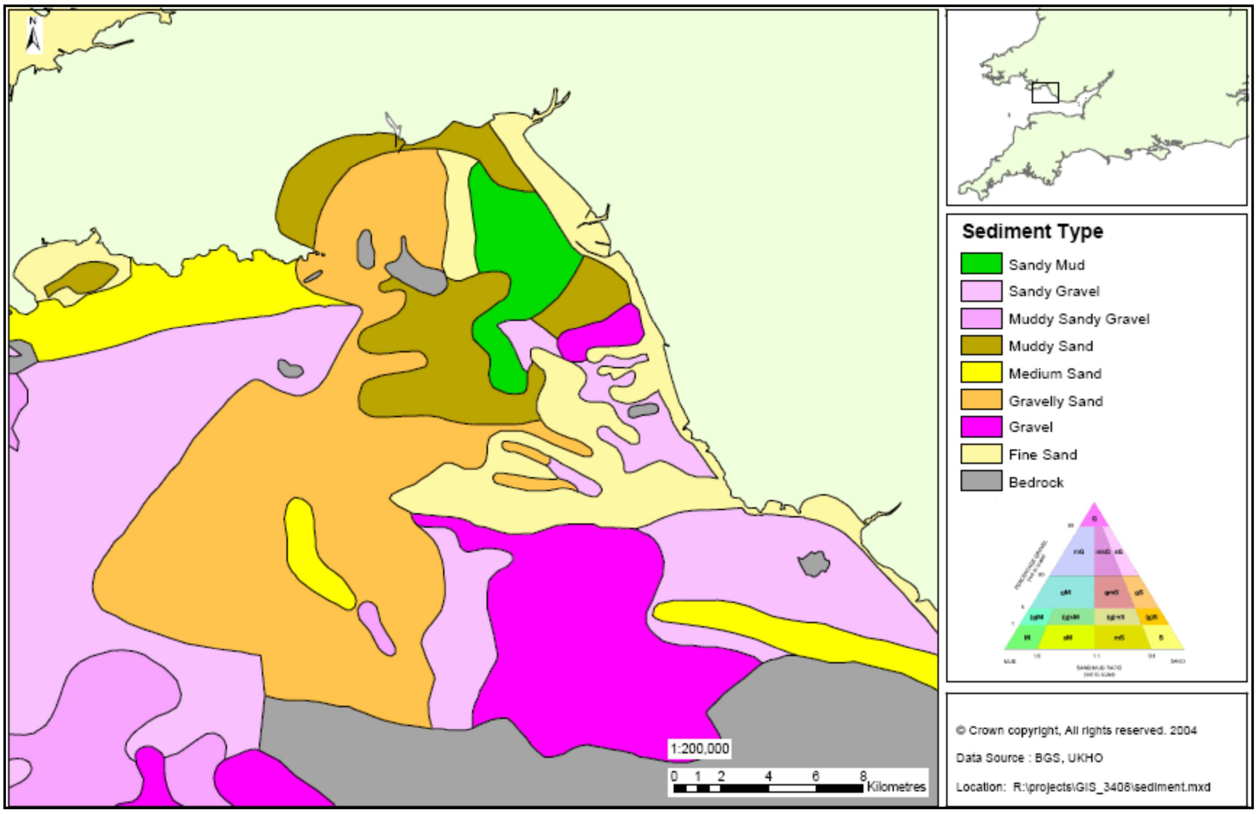

Figure 2.2 British Geological Society Sediment Distribution Chart

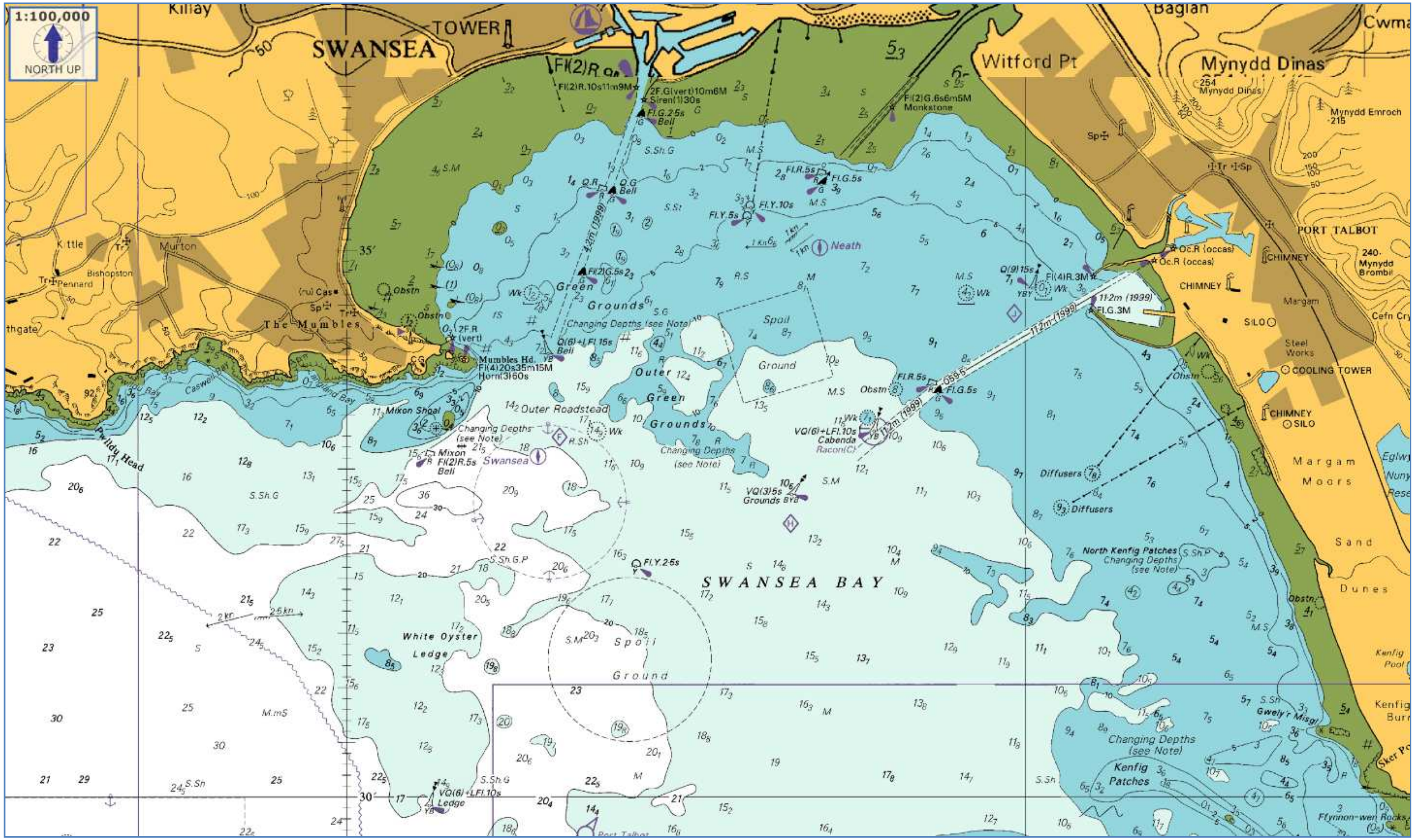

Figure 2.3 Admiralty Chart Image of the Swansea Bay area (© Maptech)

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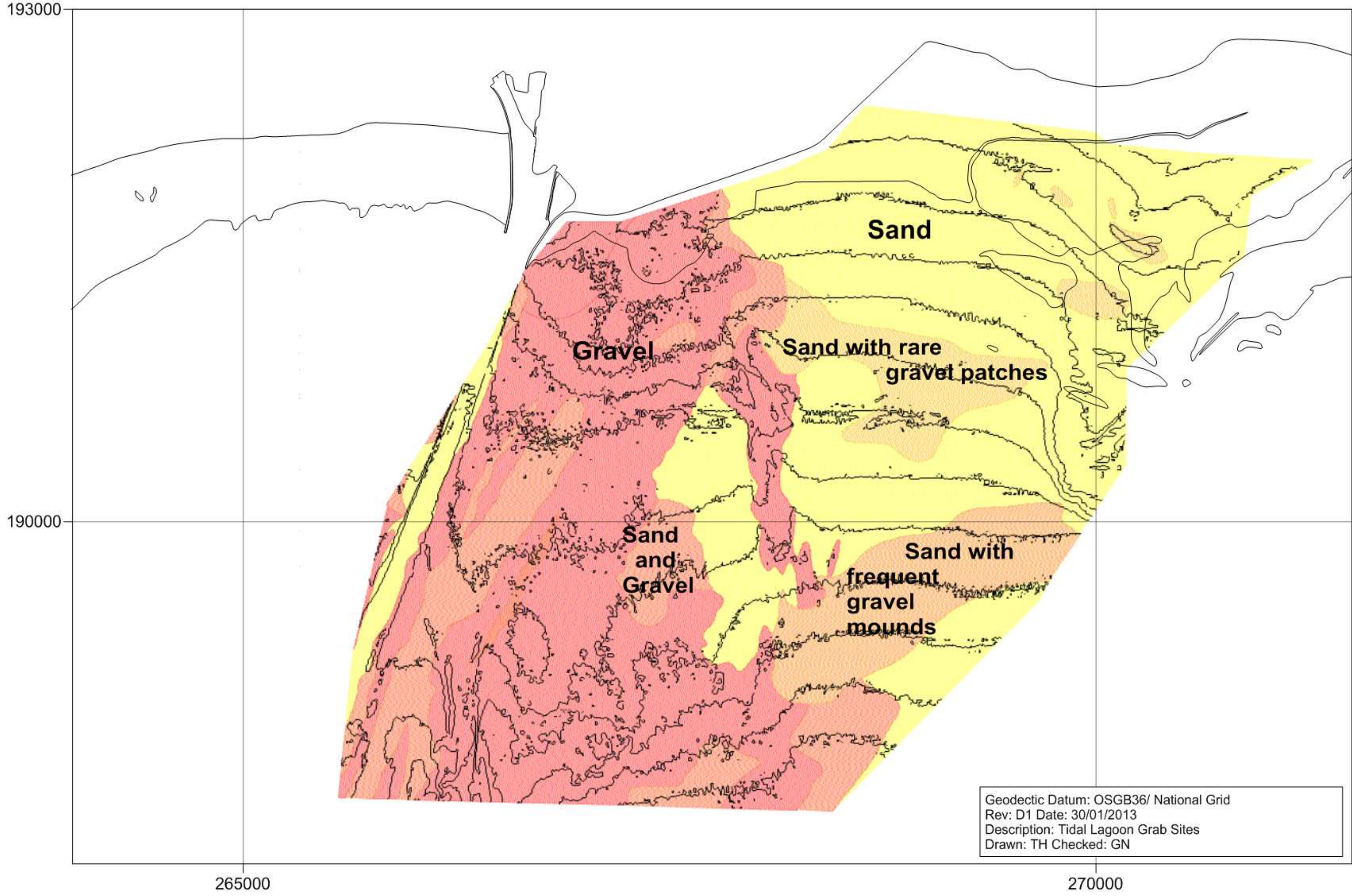


Figure 2.4 Image of the side scan sonar data highlighting the major seabed sediment types identified in the lagoon area

2.2.0.2 Based on the interpretation of the given information, a total of 57 sites have been chosen (Table 2.1) to provide a range of sediment samples for benthic, particle size analysis and metal analysis. This includes an additional 9 sites which have been selected to gain further information on the sediment particle size in the area and the data will be used to inform the coastal process modelling. A detailed account of the proposed sites is given in Table 2.4 accompanied by graphical representations of the area containing the sites in Figure 2.5 and Figure 2.6. Details of the proposed survey protocol, sampling and analysis methodology is given in Section 3.

Table 2.1 Summary of proposed sediment sampling sites and analysis

Proposed Sampling Zone	Number of Samples	Sample Analysis		
		Benthic	PSA	Metal
Lagoon development	26	26	26	10
Upstream and downstream tidal extent Including additional PSA sites	31	22	31	5
Total number for analysis	**57**	**48**	**57**	**15**

2.2.1 Benthic lagoon development

2.2.1.1 A total of 26 sample sites have been selected in the area of the lagoon development based on the five sediment types identified during the Titan Environmental Surveys Ltd side scan sonar survey (Figure 2.4). The five main sediment types are: Sand; Gravel; Sand and gravel; Sand and rare gravel patches; and Sand with frequent gravel. A summary of the number of samples per sediment type is given in Table 2.2 below.

Table 2.2 Number of samples in each sediment facies within the lagoon development

Sediment type based on SSS or BGS Distribution Chart	Number of Benthic/PSA Samples in Lagoon development
Gravel	7
Sand and Gravel	7
Sand with frequent gravel	4
Sand and rare gravel patches	4
Sand	4

2.2.2 Benthic wider Swansea Bay area

I. A total of 22 sample sites were selected within the area surrounding the lagoon within the upstream and downstream tidal extent based model output on the major sediment types identified in the BGS sediment distribution chart (Figure 2.4)

2.2.2.1 Figure 2.2). The five main types within the area are: Sandy Mud; Muddy Sand; Gravelly Sand; Fine Sand; and Medium Sand. A summary of the number of samples per sediment type is given in Table 2.3 below.

Table 2.3 Number of samples in each sediment facies outside the lagoon development

Sediment type based on SSS or BGS Distribution Chart	Number of Benthic/PSA Samples outside Lagoon	Number of PSA only outside lagoon
Gravelly Sand	6	6
Medium sand	4	0
Fine Sand	4	1
Sandy Mud	4	2
Muddy Sand	4	0

2.2.3 Metals Sample Sites

2.2.3.1 In addition to benthic and Particle Size Analysis of each sample discussed above, 15 sites will also be processed for metal analysis. The location of the sample sites have been selected based on areas potentially used for fill of the geotextile tubes, or in areas where sediment mobilisation or deposition is likely to occur following the construction of the lagoon walls. Details of the sites can be found in Table 2.4.

2.2.4 Additional PSA Samples Swansea Bay area

2.2.4.1 Finally 9 additional samples will be collected for PSA analysis from around the bay.

Table 2.4 Sediment Sampling Site Locations

Sample No.	Area	Sampling Type			Sediment type based on SSS or BGS Distribution Chart	OSGB36		WGS84	
		Benthic	PSA	Metal					
1	Up/Down	✓	✓		Medium Sand	260405.30	185178.48	51.5477	-4.0135
2	Up/Down	✓	✓	✓	Medium Sand	260415.21	186159.16	51.5565	-4.0137
3	Up/Down	✓	✓		Medium Sand	262515.25	185178.48	51.5482	-3.9831
4	Up/Down	✓	✓		Gravelly Sand	262469.73	186459.09	51.5597	-3.9842
5	Up/Down	✓	✓		Muddy Sand	263139.32	188249.29	51.5760	-3.9756
6	Up/Down	✓	✓	✓	Gravelly Sand	263514.17	189435.48	51.5867	-3.9703
7	Up/Down	✓	✓		Medium Sand	264427.07	186466.24	51.5603	-3.9560
8	Up/Down		✓		Gravelly Sand	264159.02	188149.52	51.5753	-3.9605
9	Up/Down	✓	✓		Gravelly Sand	265516.71	187605.41	51.5708	-3.9407
10	Up/Down	✓	✓	✓	Gravelly Sand	264808.16	189089.16	51.5839	-3.9515
11	Up/Down		✓		Gravelly Sand	264777.01	190258.44	51.5945	-3.9524
12	Lagoon	✓	✓	✓	Sand and Gravel	265925.64	189000.00	51.5834	-3.9354
13	Lagoon	✓	✓		Sand and Gravel	266873.81	188288.92	51.5772	-3.9214
14	Lagoon	✓	✓	✓	Gravel	267013.74	188730.30	51.5812	-3.9196
15	Lagoon	✓	✓		Gravel	266735.83	189497.08	51.5881	-3.9239
16	Lagoon	✓	✓	✓	Gravel	266381.93	190370.92	51.5958	-3.9292
17	Lagoon	✓	✓	✓	Gravel	266860.07	191000.00	51.6016	-3.9226
18	Lagoon	✓	✓	✓	Sand and Gravel	266818.75	190403.15	51.5962	-3.9230
19	Lagoon	✓	✓		Sand and Gravel	267500.00	189816.81	51.5911	-3.9130
20	Lagoon	✓	✓		Gravel	268893.8	190581.5	51.5987	-3.8944
21	Up/Down	✓	✓		Fine Sand	268151.67	187565.79	51.5717	-3.9027
22	Lagoon	✓	✓		Sand	267954.33	189583.20	51.5891	-3.9063
23	Lagoon	✓	✓	✓	Sand and Gravel	268592.20	188712.91	51.5815	-3.8968
24	Lagoon	✓	✓	✓	Sand with frequent gravel mounds	268317.8	189162.3	51.5858	-3.9021
25	Lagoon	✓	✓		Sand with frequent gravel mounds	268627.7	189435.2	51.5884	-3.8978
26	Lagoon	✓	✓	✓	Sand with frequent gravel mounds	268901.05	189798.37	51.5912	-3.8927
27	Lagoon	✓	✓		Sand	268372.36	190370.09	51.5963	-3.9006
28	Lagoon	✓	✓		Gravel	268046.54	190695.91	51.5992	-3.9054

Sample No.	Area	Sampling Type			Sediment type based on SSS or BGS Distribution Chart	OSGB36		WGS84	
		Benthic	PSA	Metal					
29	Lagoon	✓	✓		Sand and Gravel	268083.43	191415.17	51.6056	-3.9051
30	Lagoon	✓	✓		Sand with rare gravel patches	268456.77	191082.22	51.6027	-3.8996
31	Lagoon	✓	✓		Sand with rare gravel patches	268975.9	190916.5	51.6018	-3.8933
32	Lagoon	✓	✓		Sand with rare gravel patches	269468.8	190875.5	51.5565	-3.9477
33	Lagoon	✓	✓	✓	Sand with frequent gravel mounds	269558.84	189773.78	51.5912	-3.8832
34	Up/Down	✓	✓		Sandy Mud	270221.99	187585.60	51.5717	-3.8729
35	Up/Down	✓	✓		Sandy Mud	270235.78	189614.73	51.5899	-3.8734
36	Lagoon	✓	✓	✓	Sand	269932.48	190221.20	51.5953	-3.8780
37	Lagoon	✓	✓		Sand	269767.35	191587.30	51.6076	-3.8809
38	Lagoon	✓	✓		Sand with rare gravel patches	268907.20	191624.18	51.6052	-3.8776
39	Up/Down	✓	✓	✓	Muddy Sand	270866.40	190653.57	51.5994	-3.8647
40	Up/Down	✓	✓		Sandy Mud	271833.84	188050.03	51.5762	-3.8498
41	Up/Down	✓	✓		Fine Sand	272037.49	189764.06	51.5917	-3.8475
42	Up/Down	✓	✓		Fine Sand	272935.46	188923.08	51.5843	-3.8342
43	Up/Down		✓	✓	Gravelly Sand	264216.83	190772.76	51.5993	-3.9619
44	Up/Down		✓		Gravelly Sand	264996.71	191136.4	51.6028	-3.9508
45	Up/Down		✓		Gravelly Sand	266069.77	191189.19	51.6035	-3.9353
46	Lagoon	✓	✓		Gravel	266280.86	188285.97	51.5775	-3.9312
47	Up/Down	✓	✓		Gravelly Sand	266867.23	188039.63	51.5754	-3.9226
48	Lagoon	✓	✓		Sand and Gravel	267289.42	188280.1	51.5777	-3.9166
49	Up/Down	✓	✓		Fine Sand	272560.7	190267.9	51.5968	-3.8413
50	Up/Down		✓		Fine Sand	273771.8	189334.5	51.5886	-3.8235
51	Up/Down		✓		Sandy Mud	268809.95	186684.03	51.5637	--3.8941
52	Up/Down	✓	✓		Muddy Sand	268820.1	185631.4	51.5542	-3.8936
53	Up/Down	✓	✓		Muddy Sand	270537.1	186105.8	51.5589	-3.8690
54	Up/Down		✓		Sandy Mud	272039.5	186473	51.5625	-3.8475
55	Up/Down		✓		Gravelly Sand	265073	185980.8	51.6015	-3.8862
56	Up/Down	✓	✓		Gravelly Sand	265897.9	185368.5	51.5512	-3.9356
57	Up/Down	✓	✓		Sandy Mud	273741.4	187187.8	51.5693	-3.8232

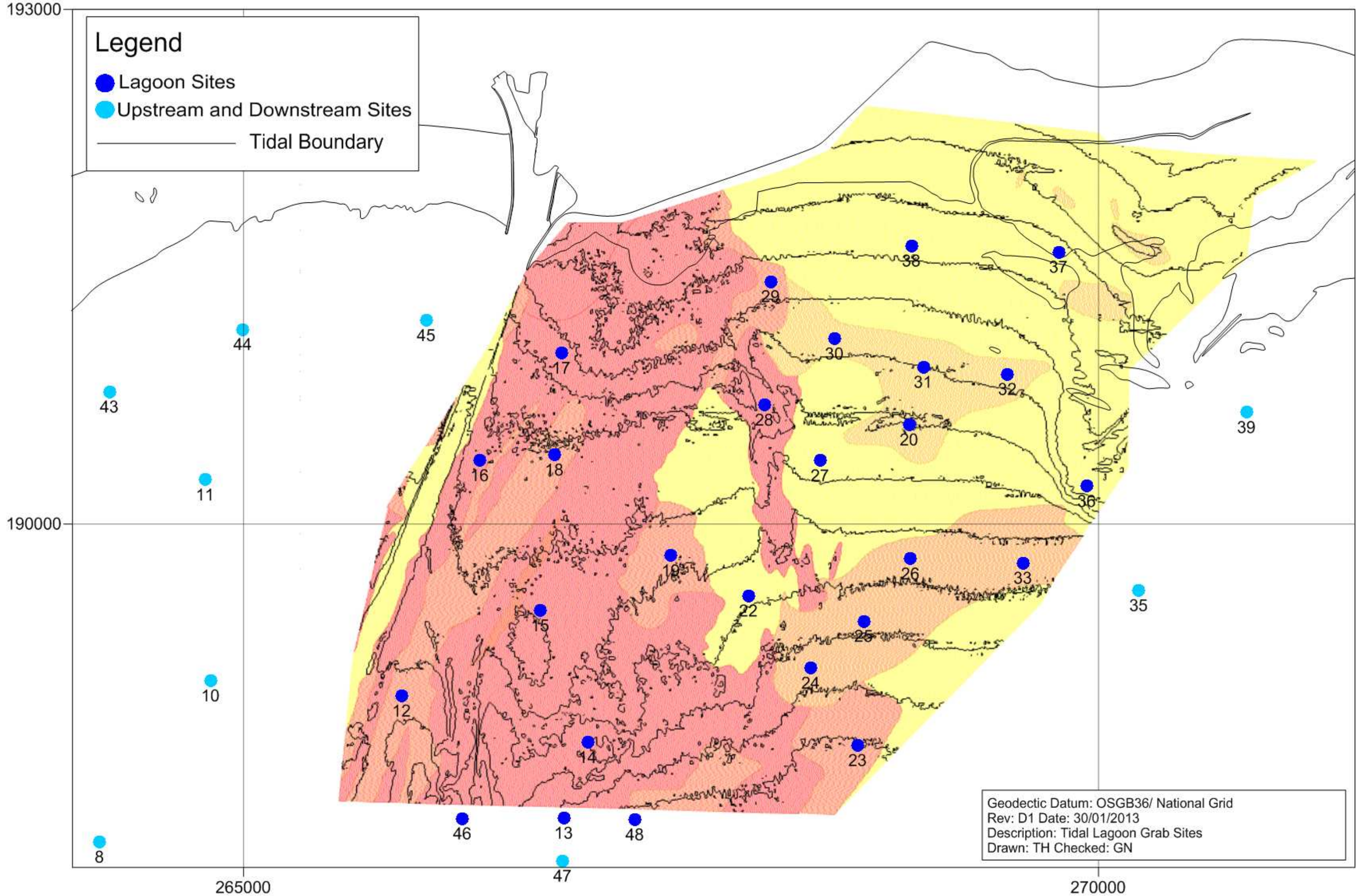


Figure 2.5 Lagoon Sampling Sites together with the Side Scan Sonar data

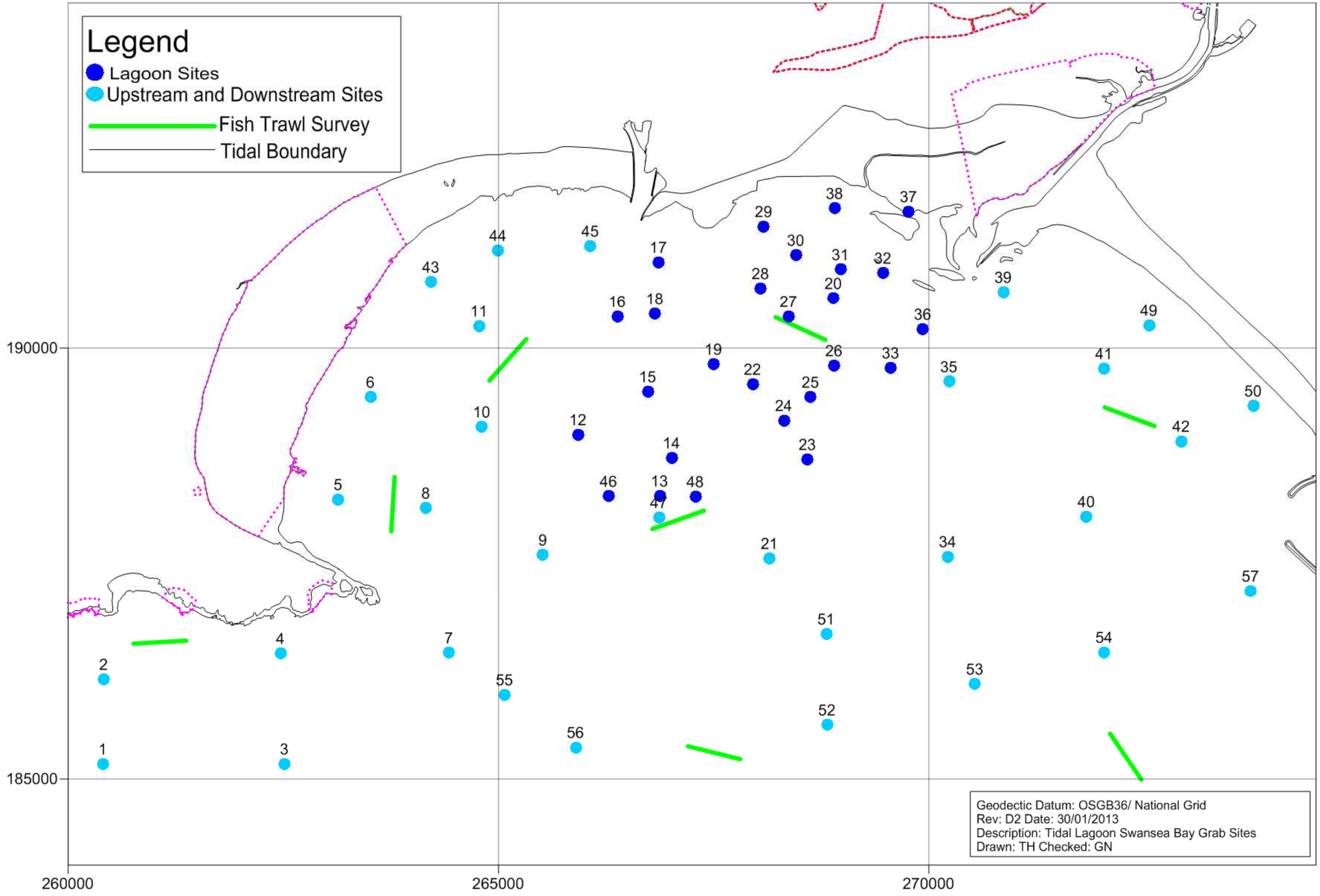


Figure 2.6 Suggested sediment sampling sites within the subtidal area of Swansea Bay

3.0 SURVEY METHODOLOGY

3.1 Survey Vessel

3.1.0.1 All benthic operations will be undertaken on the RV Noctiluca (Figure 3.1). This is a research vessel owned by Swansea University and is used for marine research and training in connection with the university's teaching and research programmes.

3.1.0.2 It is a unique, twin-hulled, shallow-draft, aluminium vessel that combines speed, manoeuvrability and efficiency with a flexible work platform. The Noctiluca is suitable for a wide range of scientific tasks, ranging from hydrographic assessment to trawling and other forms of bottom sampling.

3.1.0.3 The Noctiluca is a 12.5m, diesel-powered catamaran capable of 20 knots. It can cruise at 16 knots with a range of 500 nautical miles. The vessel is also equipped with the latest navigation aids enabling offshore operation for several days.

Figure 3.1 RV Noctiluca

3.2 Instrumentation

3.2.1 Integrated Navigation and Data Acquisition System

3.2.1.1 The navigation and data acquisition system will be based on Trimble's navigational software, HYDROpro, running on a ruggedised field computer. Interfaced to this software will be a positioning system equipped with a heading sensor, CSI Vector. Real time navigation will be outputted to a skipper/helmsman monitor to provide information relating to the site location to ensure the samples are collected within a predetermined radius of the target.

3.2.1.2 A CSI Vector GPS receiver will be utilised as the primary navigation system throughout the survey and will provide position and heading information. The CSI Vector has two GPS antennas that use a moving base station Real Time Kinematic

(RTK) technique to provide heading information to within 0.5 degrees accuracy. The GPS differential antennae is located within a separate housing linked to the receiver and can be configured to receive differential corrections from a specific frequency within the HF band, or, via the satellite transmitted Wide Area Augmentation system (WAAS).

3.2.2 Sediment Sample Procedure

3.2.2.1 It is proposed that three benthic grab samples would be collected from each site using a refined compact $0.1m^2$ Hamon grab with stainless steel head (Figure 3.2). Using a stainless steel head, the grab will be suitable for collecting samples for metal and chemical analysis.

3.2.2.2 In terms of the mini Hamon Titan has refined the standard mini Hamon grab design to provide a compact $0.1m^2$ sampler unit. Its single shovel action makes this unit the ideal sampler for coarse sediments and is routinely used in areas where the standard Day grab is deemed unsuitable. The mini-Hamon grab consists of a rectangular frame forming a stable support for a sampling bucket attached to a pivoted arm. On reaching the seabed, tension in the wire is released which activates the grab; the pivoted arm is rotated through 90°, dr iving the stainless-steel sample bucket through the sediment. At the end of its movement, the sample locates onto an inclined rubber-covered steel plate, sealing it completely and preventing the sample washing out during recovery.

Figure 3.2 Mini Hamon grab

3.2.2.3 Samples for infaunal analysis will be collected from each site listed in Table 2.4. The minimum acceptance volume for hard-packed sand will be 2.5L and for muddy sands /muds 5L. Samples will be rejected where jaws are not completely closed, as this would result in a loss of material when it is brought to site. Once the first sample is brought to the surface, the grab will be opened and the sample photographed.

Comprehensive notes will be taken on the nature of sediment and any obvious larger epifauna recovered within the grab together with detailed logs of sampling coordinates, times and all onboard activities/observations.

3.2.2.4 A 3cm Perspex corer will be used to collect a sub sample from the grab which would be analysed for Particle Size Analysis (PSA). A metal subsample will also be removed from the grab sample where appropriate. The remainder of the sample will be sieved though a 1mm mesh and the residue stored in separate containers in buffer formalin. The residue will be transported to the labs for benthic analysis. Note if it is deemed that there will be insufficient sample for metal analysis an additional grab sample will be collected if necessary. A further two more grab samples will be taken at the site sieved and stored in buffer formalin. These samples once onshore will be archived for future use.

3.2.2.5 Subsequent to the grab sampling survey, information on those sites where samples could not be collected due to the coarse substrate will be summarised on a Figure. These sites will then be revisited with a drop down camera and where possible a towed video of the seabed taken. Where concerned about the visibility we will endeavour to get the best footage/stills possible with the time and resources available.

3.2.2.6 Should a grab sample contain any historic evidence of human activity, including artefacts and environmental material, the find will be reported to the Glamorgan-Gwent Archaeological Trust.

3.3 Analytical Methodology

3.3.1 Macro-invertebrate analysis of benthic samples

3.3.1.1 Samples will be rinsed with freshwater prior to sorting and identification. Sieve residues are initially elutriated with fresh water to extract the majority of "light" organisms, notably amphipods and small polychaetes (care being taken to retain all specimens adhering to the surface film). Subsequent sample examination of the residue is under x10 magnification (binocular microscope) where necessary. Routine procedures require the resorting of at least 10% of samples, with the aim of extraction of ≥95% of individuals and 100% of species in each sample.

3.3.1.2 All animal specimens are identified to species where possible using experience, the latest identification keys (in litt. or otherwise if more recent) and with reference to existing voucher material held at the laboratory, attributing names as in accord with the most recent publications available (e.g. Howson & Picton, 1997 for the British Marine Fauna and Flora) except where such publications have been superseded. Relevant experts in certain taxonomic groups are consulted for any difficult specimens. Specimens are counted as "heads", or as oral disks for ophiuroids/asteroids. Voucher material is retained if required.

3.3.1.3 Animal specimens and sample residues (as required) are retained in formaldehyde or alcohol. Should staining (for example with Rose Bengal to enhance specimen extraction efficiency), or sub-sampling be considered efficacious, such practices would be discussed in the first instance with the client and only undertaken with their agreement.

3.3.2 Sediment Particle Size Analysis

3.3.2.1 A sub-sample would be taken from the mini Hamon sample for particle size and organic content analysis (loss on ignition). In coarse or heterogeneous sediment areas with large pebbles or shell material, where small volumes of material will not adequately reflect the sediment composition, sub-samples for PSA will be taken from the grab sample. Samples for PSA will be stored chilled, but not frozen, as this would break down any clay mineral lattice bonds present altering the natural particle size distribution. Samples will then be delivered to the National Laboratory Service with proven expertise in such analysis on marine sediment samples.

3.3.2.2 Particle size analysis is undertaken using traditional sieve analysis – with laser diffraction of fines where these are present in significant amounts (the <63 micron fraction only analysed if <10% present in the sample). Samples are analysed at ½ phi intervals and results reported together with all traditional statistical parameters (median diameter, sorting coefficient, skewness and kurtosis).

3.3.3 Metals analysis

3.3.3.1 It is proposed to undertake the following analysis at sites listed in Table 2.4.

i. Al – Aluminium
ii. As - Arsenic
iii. B - Barium
iv. Cd - Cadmium
v. Cr – Chromium
vi. Cu - Copper
vii. Fe - Iron
viii. Hg – Mercury
ix. Ni - Nickel
x. Pb - Lead
xi. Sn – Tin
xii. Va - Vanadium
xiii. Zn - Zinc
xiv. TPH - Total Petroleum Hydrocarbons
xv. TBT – Tributyl Tin

3.3.3.2 Note: In order to gain a better understanding of the levels of potential contamination within the sediments at depth that maybe mobilised by the project, it is proposed to collect further information during the Stage 1 Geotechnical Site Investigation. Samples will be collected for metal analysis from a range of depths from each of the proposed borehole samples. The details of the Stage 1 Geotechnical Survey and analysis will be provided to the MCU through the consenting process.

3.4 Epifauna Trawls

3.4.0.1 In addition to the benthic sampling survey, seven epifauna/fish trawls will be used to obtain qualitative samples of the epibenthos from across the area. The epifauna trawls will comprise approximately 200m trawls using a 2m beam trawl with 5mm cod end mesh. The material collected in the trawl to be fixed in a 10% buffered formalin and seawater solution.

3.4.0.2 If possible to minimise disturbance to the Bay, the trawls would be coincided with the seasonal fish trawls which are currently underway. The location of the fish trawls are shown on Figure 2.6. If the two surveys cannot be linked, the locations of the beam trawls will be confirmed after the benthic grab survey has been undertaken. The initial inspection of the benthic samples onboard will be used to confirm that there are no-protected species present at the sites. CCW will be consulted further on this matter.

Appendix A. Description of the High Level Coastal Modelling Tool

A.1 Model Description

1.0.0.1 The model is a 2D application of Delft3D (from Deltares) and based on a curvilinear grid which covers the region from the Outer Bristol Channel into the Severn Estuary, including Swansea Bay. The curvilinear grid has a variable resolution which is approximately 110m x 350m across the area of interest for the lagoon.

1.0.0.2 Figure A.1 shows the local extent of the model in the vicinity of Swansea Bay and including the two lagoon layouts. The same model grid is applied to the solution of waves and tides and the wave model applies the description of the predicted tides. This configuration is an adaptation of the original modelling as since 2002 the wave model supported by Deltares is SWAN and no longer HISWA.

A.1.1 Bathymetry

1.1.0.1 The model bathymetry is derived from a number of sources but is largely based on charted surveys from UKHO and local surveys made available from ports, including; ABP Swansea, ABP Port Talbot and The Bristol Port Company. The accuracy and detail of the present bathymetry is regarded as sufficient for the high-level assessment but in due course more detailed and up-to-date bathymetry can be introduced to support further stages of modelling.

A.1.2 Boundaries

A.1.2.1 Hydrodynamics

1.2.1.1 The model boundary conditions for the hydrodynamic model were derived from water level time-series extracted from a larger scale model. In total, eight stations were chosen to provide a reasonable coverage along the seaward boundary. Harmonic analysis of the time-series water level data was undertaken to provide astronomical tidal constituents at each station. A total of 32 tidal constituents were extracted for each station. These constituents provide an accurate representation of the tidal variations and enable a full 28-day lunar tide sequence, including periods of springs and neaps.

A.1.2.2 Waves

1.2.2.1 Wave boundaries are provided by a combination of local wind information applied across the model grid and wave information at the seaward boundary.

1.2.2.2 The wave model has been applied to examine a set of representative and discrete wave events. These wave events are selected for two primary directions:

(a) Westerlies: Local wind-waves and Atlantic swells (centred on 270°N with values determined between 255 to 285°N); and

(b) South-easterlies: Local wind-waves (centred on 120°N with values determined between 105 to 135°N).

1.2.2.3 For each of these two direction three sets of wave heights and periods have been defined and representing a typical wave (defined as the 50th percentile), a high wave (90th percentile) and a very high (95th percentile). The target percentile values for the model to recreate are based on the 6-years of wave records measured by the Scarweather Buoy.

1.2.2.4 Table A.1 summaries the wave scenarios and their input conditions.

Table A.1 Wave model input conditions

Scenario	Wave Height, Hs (m)	Wave Period, Tp (s)	Wave Direction (°N)	Wind Speed (m/s)	Wind Direction (°N)
Typical wave height, coming from the west	1.39	6.14	270	8.50	270
High wave height, coming from the west	3.03	8.56	270	12.45	270
Very wave height, coming from the west	6.04	12.21	270	12.60	270
Typical wave height, coming from the west	0.51	3.42	120	7.90	120
High wave height, coming from the west	0.83	4.16	120	10.28	120
Very high wave height, coming from the west	1.36	4.90	120	13.50	120

1.2.2.5 Table A.1 also clearly illustrates the difference in wave period between westerly and south-easterly wave scenarios, with longer period waves only associated with the westerly events. These longer period waves have a far greater influence on wave driven transport than shorter period waves.

1.2.2.6 The associated tidal conditions applied to the wave runs represent high water conditions during a spring tide.

A.1.3 Verification

1.3.0.1 To verify that the modelling tool remained fit-for-purpose a series of verification runs were performed against existing observational records, noting that these records remain separate to the ongoing metocean campaign.

1.3.0.2 Figure A.2. provides an indication that the model remains sufficient in predicting local water levels from Mumbles and local currents within Swansea Bay. The currents clearly show the asymmetry between peak flood and peak ebb flows.

1.3.0.3 Small differences remain between predicted depth-average currents and equivalent observations of currents based on a fixed station deployment. These differences are likely to be due to issues such as:

i. Measurements being 'near' mid-depth rather than at depth average height;

ii. Measurements being inclusive of non-tidal effects, such as local winds;

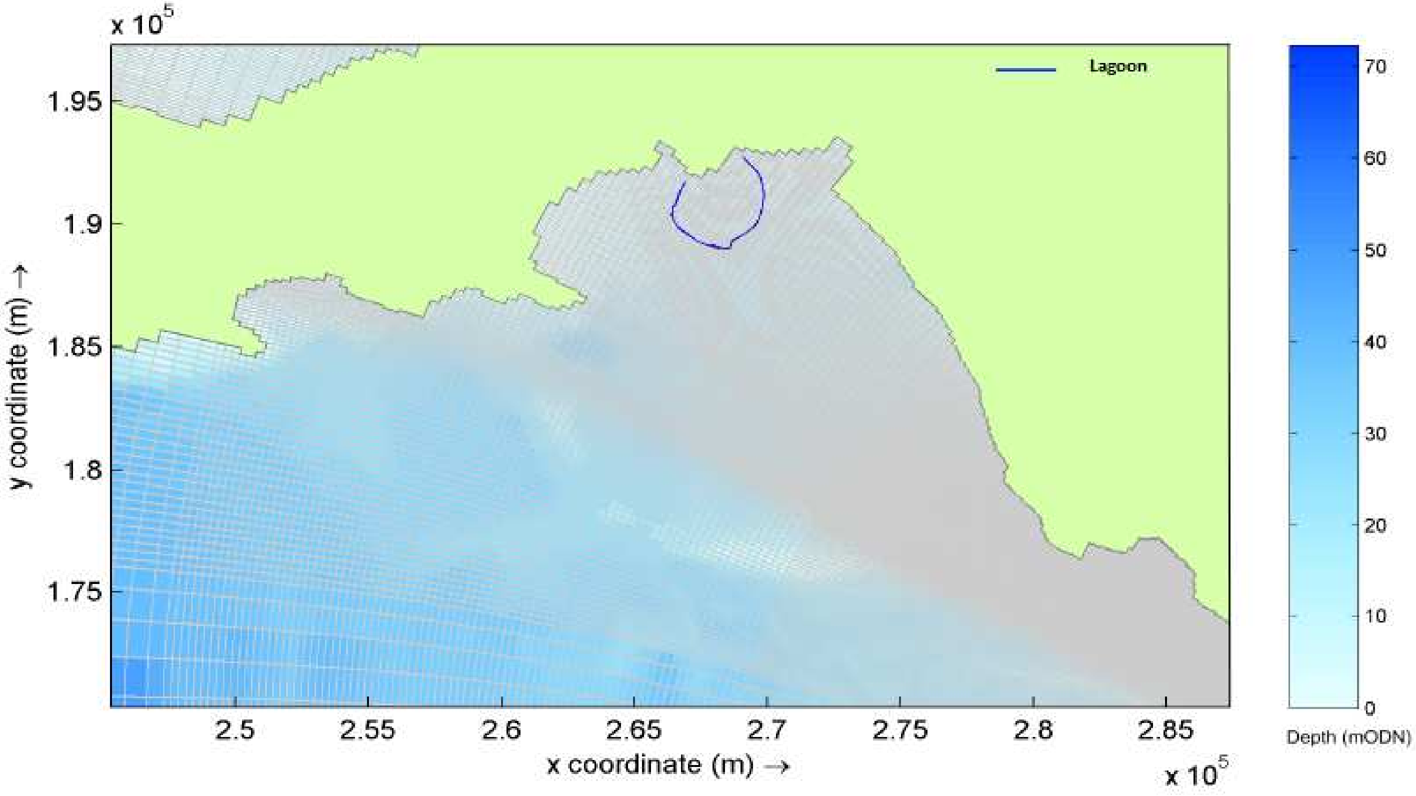
iii. Measurements being representative at a point compared to a model being the average over the dimension of the computational grid point; and

iv. Limitations in measuring equipment and the calibration of the equipment.

A.2 References

ABPmer, 2002. Scarweather Sands Offshore Wind Farm: Coastal Process Investigation. ABP Marine Environmental Research Ltd. Report No. R985a. December 2002.

Titan Environmental Surveys Limited



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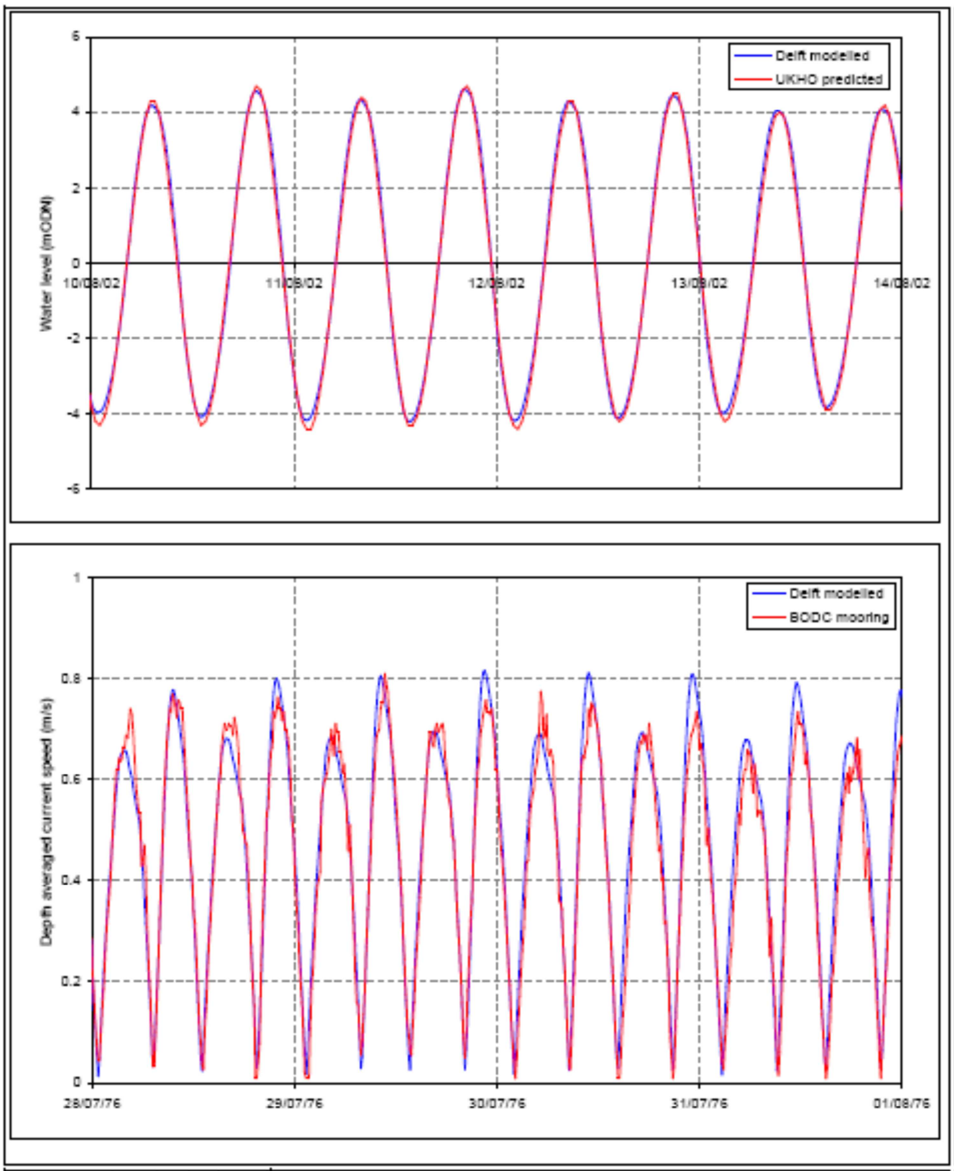
Delft3D model grid with lagoon

Figure A1



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Calibration check for water levels at Mumbles and current flows in Swansea Bay

Figure A2