MONITORING PROPOSAL

Mapping Marine Habitats and Species from above

Ross A. Griffin and Gary J. Robinson[1]

[1] Ocean Ecology Limited, River Office, Severnside Park, Epney, GL2 7LN, United Kingdom

ross.griffin@ocean-ecology.com
gary.robinson@ocean-ecology.com

Abstract

The recent advance in Unmanned Aerial Vehicles (UAVs), otherwise known as drones, has presented a myriad of possibilities for capturing high resolution aerial imagery spanning nearly all sectors of academic and commercial research. This has now been furthered by advances in cloud based post-possessing facilities making creation of high resolution orthomosaics, Digital Elevation Models (DEMs) and 'plant health' maps relatively simple. Despite this, applications of this technology for marine ecological studies appears to be in its infancy likely due to the issues associated with optical scattering caused by the rugosity of the surface of water. A key benefit of new UAV mapping capabilities is the ability to map previously inaccessible areas of intertidal shores. Using a number of examples from one of Europe's largest estuarine environments, the Severn Estuary in the UK, we demonstrate novel applications of UAV methodologies for mapping a number of designated intertidal habitats of the Severn Estuary European Marine Site (EMS) protected by the EU Habitats including honeycomb worm reefs (*Sabellaria alveolata*) and seagrass bed (*Zostera* spp.) and discuss further applications of this promising technology.

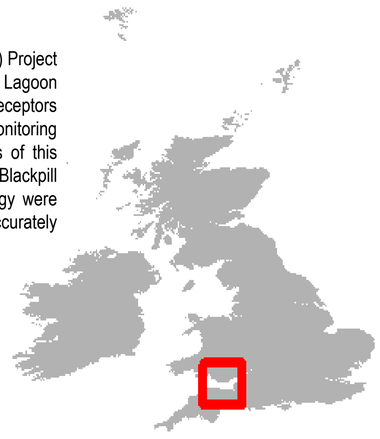
Applications

- Intertidal *Sabellaria alveolata* extent mapping and monitoring
- Zostera spp. bed extent mapping and monitoring
- Saltmarsh accretion / erosion monitoring
- Sand dune accretion / erosion and complexity modelling
- Intertidal Broad Scale Habitat Mapping
- Intertidal foreshore profiling

Case Study 1: Swansea Bay Intertidal Sediment Monitoring

Background

A Development Consent Order (DCO) was granted by the Secretary of State (SoS) for the Tidal Lagoon Swansea Bay (TLSB) Project in June 2014. The Environmental Impact Assessment (EIA) for the Project predicted that construction and operation of the Lagoon may result in some localised changes to coastal processes, leading to associated changes in the intertidal area at identified receptors within Swansea Bay. In order to gather baseline data prior to construction, and to further develop the coastal processes monitoring programme within the AEMP, initial sediment sampling surveys were undertaken. Taking into consideration the findings of this preliminary sediment sampling survey, further discussion with NRW(A) regarding concerns of increased mud on the nearby Blackpill SSSI in Swansea Bay and the preference to understand sediment changes over the wider Swansea Bay, Ocean Ecology were commissioned to undertake a review of the suitability of topographic data collected by Unmanned Aerial Vehicles (UAV) for accurately monitoring accretion of fine sediments (mud) across this area.



Aims and Objectives

The main aims of this pilot study were to:

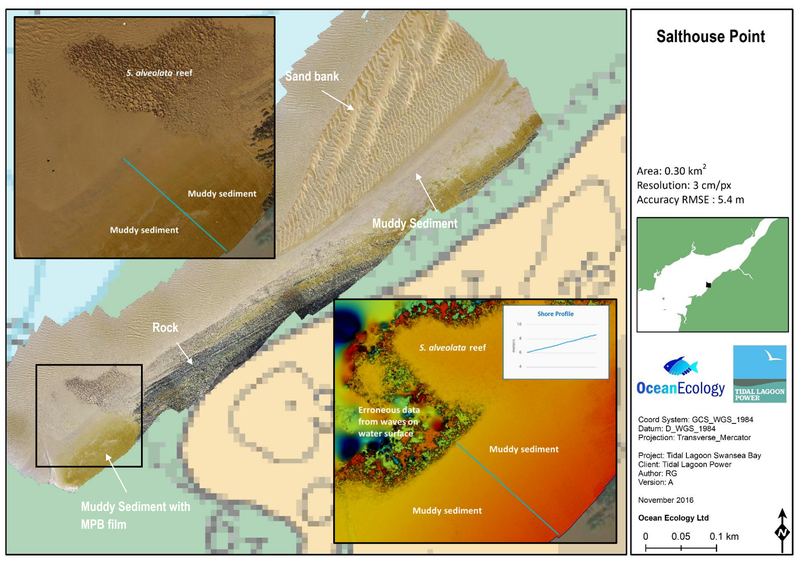
- Determine whether UAV survey methods are suitable for collecting topographic data across muddy sediments on the shore between the lower boundary of the Blackpill SSSI and the Lowest Astronomical Tide (LAT) mark.
- Confirm the presence of muddy sediments between the lower boundary of the Blackpill SSSI and the LAT mark.

Methods

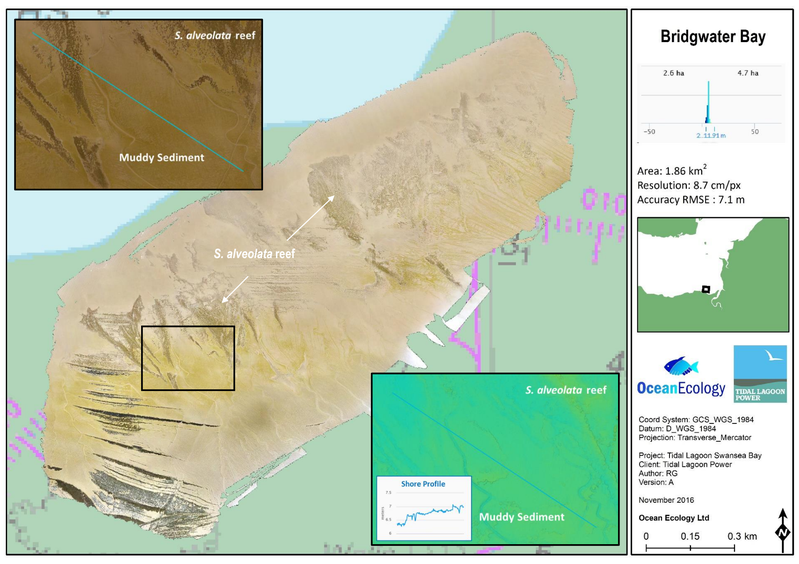
All UAV operations were conducted by Ocean Ecology's Qualified UAV Pilots under its Permission for Aerial Work (PfAW) (CAA ID: 2654) granted by the Civil Aviation Authority (CAA). The UAV used was a DJI Phantom 4 multi-rotor quadcopter flown at an altitude of 60 – 100 m with a minimum of 60 % side lap and 55 % front lap (depending on the area to be covered). Each pre-planned flight was designed in ArcGIS 10.2 based on existing extent data provided by Natural England (NE) and NRW and flown using the DJI Go software for flight safety checks and licenced navigation software. Each flight resulted in the collection of between 400-1000 high resolution images that were initially screened to remove erroneous images and subsequently processed into orthomosaic, Digital Surface Model (DSM) and Vegetation Adjusted Reflectance Index (VARI) (Gitelson et al. 2002) outputs. Output resolution ranged from 2.8 - 8.7 cm/px with accuracy Route Mean Squared Error (RMSE) values ranging from 6.3 m to 10 m.

Results

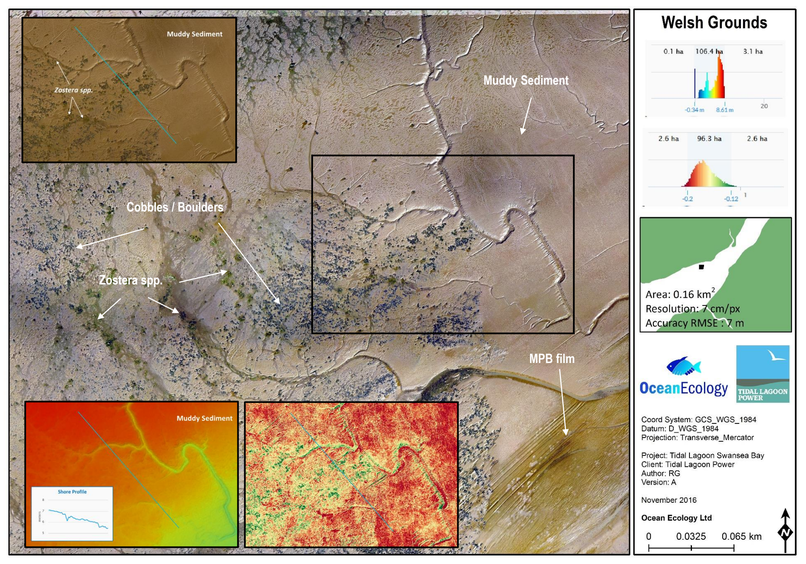
Upon review of the various processed outputs from the subset of UAV surveys undertaken throughout the Severn Estuary, it is clear that monitoring of accretion of fine sediments within Swansea Bay would be possible. This pilot study demonstrated that with some further adaptations, the methodologies employed during UAV surveys undertaken throughout the Severn Estuary SAC during 2016 provide an alternative option for monitoring of accretion of fine sediments on the lower shore within Swansea Bay. Accurate representation of shore profiles was obtained as well as the ability to extent map aggregations of the tow littoral species in focus, *Sabellaria alveolata, Zostera spp.* These surveys were not, however, undertaken using high accuracy positioning (RTK) and therefore the horizontal and vertical accuracy ranged on a scale of metres rather than centimetres as would be required for high accuracy and high confidence monitoring of accretion. An important discovery during the surveys was the ability of the UAV surveys in identifying and mapping biofilms on the mud surface formed by the MPB (principally diatoms). These commonly overlooked assemblages can play important roles in mud and sand flat systems by driving primary production (Underwood & Kromkamp 1999).



Aerial imagery and processed orthomosaic data captured during the *S. alveolata* reef extent mapping survey at Salthouse Point in the Severn Estuary. The area was found to be relatively complex with fucoid dominated rocky substrate on the upper shore transitioning into scoured rock and then areas of *S. alveolata* reef, sand banks and fine muddy sediments. The muddy sediments found in the south west of the survey area exhibit a distinctive surface film formed by MPB. The processed data resulted in a DSM that clearly illustrates the low rugosity and homogenous surface of the sediment in this area also illustrated by the straightness of the shore profile (inset graph).



Aerial imagery and the processed orthomosaic data captured during the *S. alveolata* reef extent mapping survey in Bridgwater Bay. The extensive *S. alveolata* reef found along most of the lower shore in this area was bordered by large areas of mud flat extending to the upper shore. Large expanses of these muddy sediments were covered by MPB. The processed data resulted in a DSM that clearly illustrates the low rugosity and homogenous surface of the muddy sediments. This is also illustrated by the reduced variation of the shore profile when intersecting these sediments in comparison to the marked variation observed when crossing elevated areas of *S. alveolata* reef (inset graph).



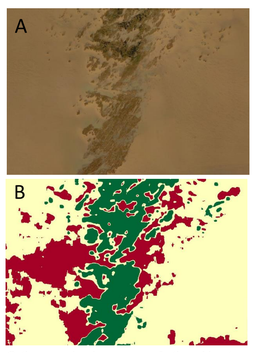
Aerial imagery and the processed orthomosaic data captured during one of the 13 separate UAV flights to map the extent of the three *Zostera* spp. beds found on the Welsh Grounds along the welsh coast. The *Zostera* spp. beds located along this shore were bordered by extensive mud flats extending to the upper shore. The processed data resulted in a DSM that clearly illustrates the low rugosity and homogenous surface of the muddy sediments in this area. Also illustrated by the reduced variation of the shore profile when intersecting these sediments. Greater rugosity is visible in the areas of the fucoid covered cobbles and boulders interspersed between the patches of *Zostera* spp. Inset VARI output highlights the greater reflectance of vegetation (green) (i.e. the patches of *Zostera spp.* and the macrophytes attached to the boulders/cobbles) than the surrounding muddy sediments.

Case Study 2: *Sabellaria alveolata* Reef Extent Mapping

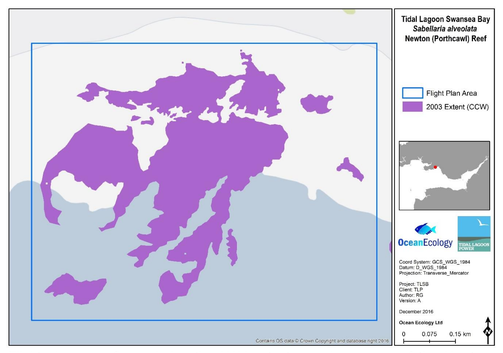
Ocean Ecology were commissioned to map the extent of 15 *S. alveolata* reefs throughout the Severn Estuary, as part of the ongoing Site Characterisation surveys for the Tidal Lagoon Cardiff (TLC) development. This was undertaken by aerial extent mapping using Ocean Ecology's UAV and ground-truthing by foot. The UAV used was a DJI Phantom 4 multi-rotor quadcopter flown at an altitude of 80 m and with 50 % side lap and 50 % front lap. Each pre-planned flight was designed in ArcGIS 10.2 based on existing extent data from previous surveys undertaken at the same reef and flown using licenced software for survey navigation.

The flights resulted in the collection of 777 high resolution images that were initially screened to remove erroneous data and subsequently processed into orthomosaic, DSM and Vegetation Adjusted Reflectance Index (VARI) (Gitelson et al. 2002) outputs. Output resolution was 5.9 cm/px with an accuracy Route Mean Squared Error (RMSE) value of 5.9 m. This information was used to ground-truth the VARI output by refining the thresholds used to 'zone' the reef based on red, green, blue (RGB) values. Colony elevation and percentage coverage data from the 2016 ground-truthing survey was available from 160 quadrats located across the Newton Beach reef. This provided a sufficient number of ground-truthing points for optimising the 'zoning' of reef and non-reef areas in the VARI model. The UAV surveys resulted in the generation of fine scale reef extent maps for the Newton *S. alveolata* reef which indicated that the 2016 reef extent (0.08 km^2) was 72.4 % less than that mapped in 2003 (0.29 km^2).

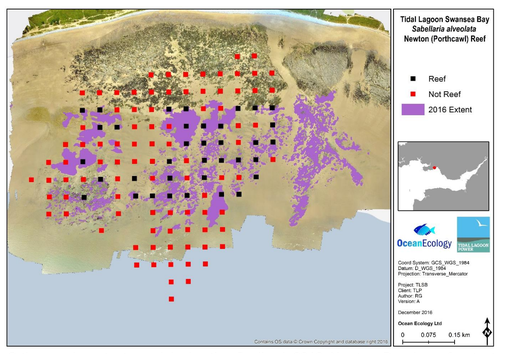
When compared to previous mapping it is clear that extent mapping using UAV methodologies is more accurate, less time consuming and safer than traditional perimeter walking methods. The study also emphasised the importance of setting a series of 'hard and fast' rules for mapping the various *S. alveolata* reefs during the baseline surveys that can be easily repeated e.g. excluding colonies <5 m^2 and areas of standing water within the broad reef area.



Orthomosaic imagery of the Newton Beach reef (A) and 'zoned' VARI output of the same reef area (B). *S. alveolata* reef extent is shown in green.



Flight plan area flown during the UAV extent mapping survey of the Newton Beach *S. aveolata* reef during 2016.



Orthomosaic output overlain by the finalised 2016 Newton Beach reef extent (purple) and the locations of quadrat sampling locations used for ground-truthing of the VARI output.

References

Gitelson, A. A. Kaufman, Y.J., Stark, R., Rundquist, D. (2002). Novel Algorithms for Remote Estimation of Vegetation Fraction" Papers in Natural Resources. Paper 149.
Underwood & Kromkamp 1999 Underwood, G.J.C., Kromkamp, J. (1999). Primary production by phytoplankton and microphytobenthos in estuaries. Ad. Ecol. Res. 29: 93-153.

T: +44 (0) 1452 740697
E: info@ocean-ecology.com
W: www.ocean-ecology.com

OceanEcology
MARINE SURVEYS, ANALYSIS & CONSULTANCY
TIDAL LAGOON POWER

NMBAQC SCHEME
NMBAQC
NE Atlantic Marine Biological Analytical Quality Control Scheme
Achilles®