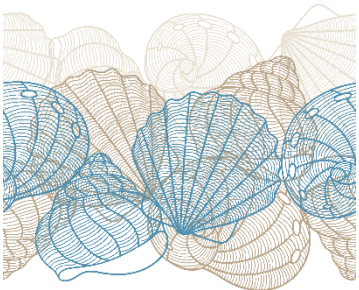


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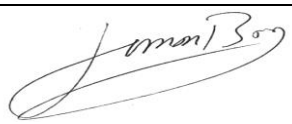
Passive Saltmarsh Restoration Trial, Lands' End, River Hamble

Data and Implication Assessment

18 JULY 2023



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1. Introduction

1.1. Study Background

This report considers the method and outcomes of a small scale saltmarsh restoration trial at Lands' End, Old Bursledon, River Hamble (Figure 2.1). The site is private property, where the landowner has been proactive in investigating opportunities to reduce saltmarsh erosion and to consider habitat restoration trials, studies of ecological habitat and general opportunities to minimise erosion against a background of human mediated impacts.

Accordingly through a request for AQASS Limited to bid into the Solent Forum Natural Environment Group (NEG) Funding Award, AQASS were successful in their bid to trial a small scale passive saltmarsh restoration study (confirmation letter, 19th May 2020); the funding award was matched by the landowner.

The study award was made in 2020, however the impact of Covid19, necessitated the delay of field work until March 2021. The bulk of the work was undertaken between March 2021 and March 2022, however, the ground work for planning and permissions was undertaken during 2020.

1.2. Proposal and AQASS Ltd

With agreement and backing from the landowner and Solent Forum, in 2020 AQASS proposed a small scale placement of passive sediment retention structures within a creek system at Lands' End, Old Bursledon. This was in relation to the numerous studies and proposals that have been made for declining saltmarsh sites in the Solent (e.g. Cope *et al*. 2008; Hudson *et al*., 2009; Williams *et al*., 2010; Foster *et al*., 2014; ABPmer, 2018 and ABPmer, 2020) and the River Hamble (see Bray *et al*., 2016), of which the majority have considered beneficial dredge spoil use for larger scale projects. The proposal was well received, with significant interest in the passive small scale approach potentially leading to (appropriately considered) similar projects and an overall cumulative effect on saltmarsh integrity at *some* Solent sites. After the positive reception to the proposal, the grant was awarded, however as above; the work was delayed until 2021 due to COVID restrictions.

AQASS is a consultancy and research SME with strong academic links to the University of Southampton where staff hold Visiting Researcher status and links to the Marine Biological Association (MBA) of the United Kingdom. AQASS provides management, ecological, pollution guidance relating to aquatic / marine habitats and water resources. Regarding this project, Dr Simon Bray of AQASS is a marine / aquatic ecologist with over 25 years' experience in research and commercial / education projects considering human impacts on marine ecosystems / species ranging from habitat loss / restoration to chronic and acute pollution episodes. Dr Ilse Steyl is a geomorphologist and analyst of aerial and satellite geospatial data with a background in python programming and significant project experience in river restoration schemes and the estuarine / river interface. She is the lead author of a book considering geospatial analysis of polluted harbour sediments to which Simon contributed ecology and pollution analysis aspects.

AQASS team members were involved in the initial University of Southampton 2010 Scoping Study examining the potential for beneficial dredge spoil use within the Solent, as well as a Feasibility Study investigating possible River Hamble saltmarsh and soft sediment habitat retention opportunities in

2016. Of pertinent note, we have also recently assisted with habitat assessment, and saltmarsh creation considerations, for a Chichester Harbour based study regarding coastal squeeze / saltmarsh creation in relation to plans to future proof a residence sea wall against sea level rise.

AQASS partnered SAND Geophysics with whom AQASS shares an office, who provided team members to assist with drone flights, data capture and pre-processing (see methods below). We were also assisted with field work by Mr Rayner Piper of Fathom Ecology who had input to the placement of structures and in-field input to overall design.

2. Short Review

2.1. Solent and River Hamble

The Solent is a body of water broadly in the centre of the English south coast and the River Hamble is an estuary running broadly north off of Southampton Water located at the western end of the Solent (Figure 2.1). The Solent is heavily influenced by one of the highest concentrations of recreational craft (and associated infrastructure) in the UK, major oil terminals and naval / civil ports, general industry, coastal protection (with circa 80% of the coast hard engineered (Cope *et al*., 2008)), housing and social / recreational infrastructure. In contrast, the Solent is recognised for its natural habitats and the River Hamble is subject to national and international conservation designations (Figure 2.2).



Figure 2.1: Location of study area along River Hamble

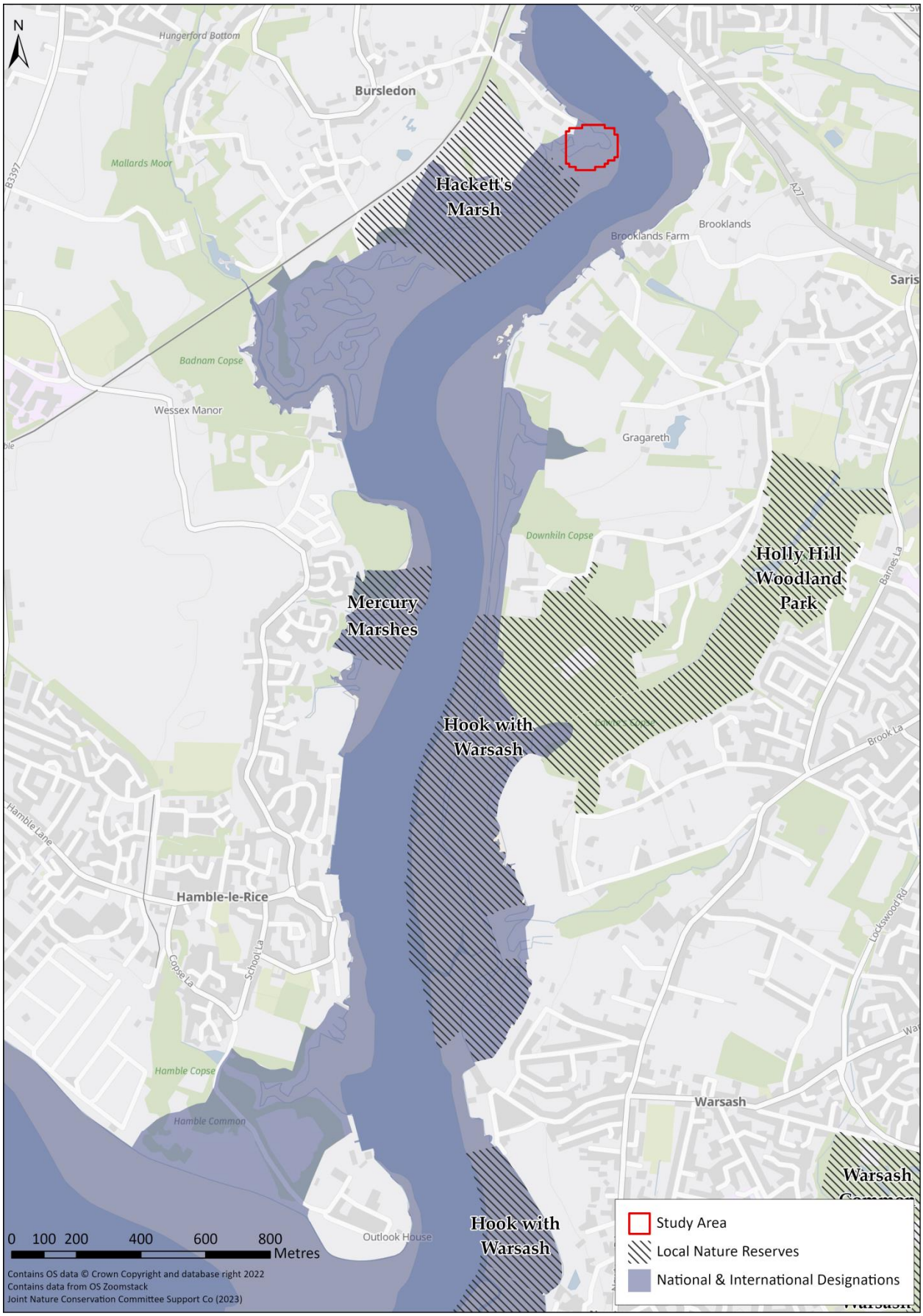


Figure 2.2: Designations along the lower River Hamble Estuary

Numerous previous Solent saltmarsh studies have considered relationships between natural assets and anthropogenic demands. Factors influencing saltmarsh decline have been variously considered as sea level rise, coastal squeeze and algal smothering due to excess nitrate and phosphate nutrient loading in estuarine waterways, amongst others. Several UK based trials and practical projects have been undertaken to restore saltmarsh to meet EU and UK Government goals. However, for the Solent, aspirations have still not yet led to major practical outcomes for significant beneficial use projects (though see Lowe, 2012; 2013), although well intentioned Solent specific research projects (Williams *et al*., 2010; Bray *et al*., 2016) and reviews (e.g. Hudson *et al*., 2009; Foster *et al*.,2013; Foster *et al*., 2014) have taken place and research is ongoing into the issue in a UK context particularly considering physical challenges and stakeholder engagement (e.g. Ladd, 2020) and major grants have recently been awarded to look into saltmarsh restoration amongst other habitats, notably in the Solent region (EA, 2022).

2.2. Site Context

2.2.1 Location and Regulatory Status

The location of the Lands' End site, as an extension of the Hampshire County Council (HCC) managed Lincegrove to Hackett's Marsh complex, is shown in Figure 2.2. The site has suffered from historic loss and erosion which was assessed in Bray *et al*. (2016) (Figure 2.3).

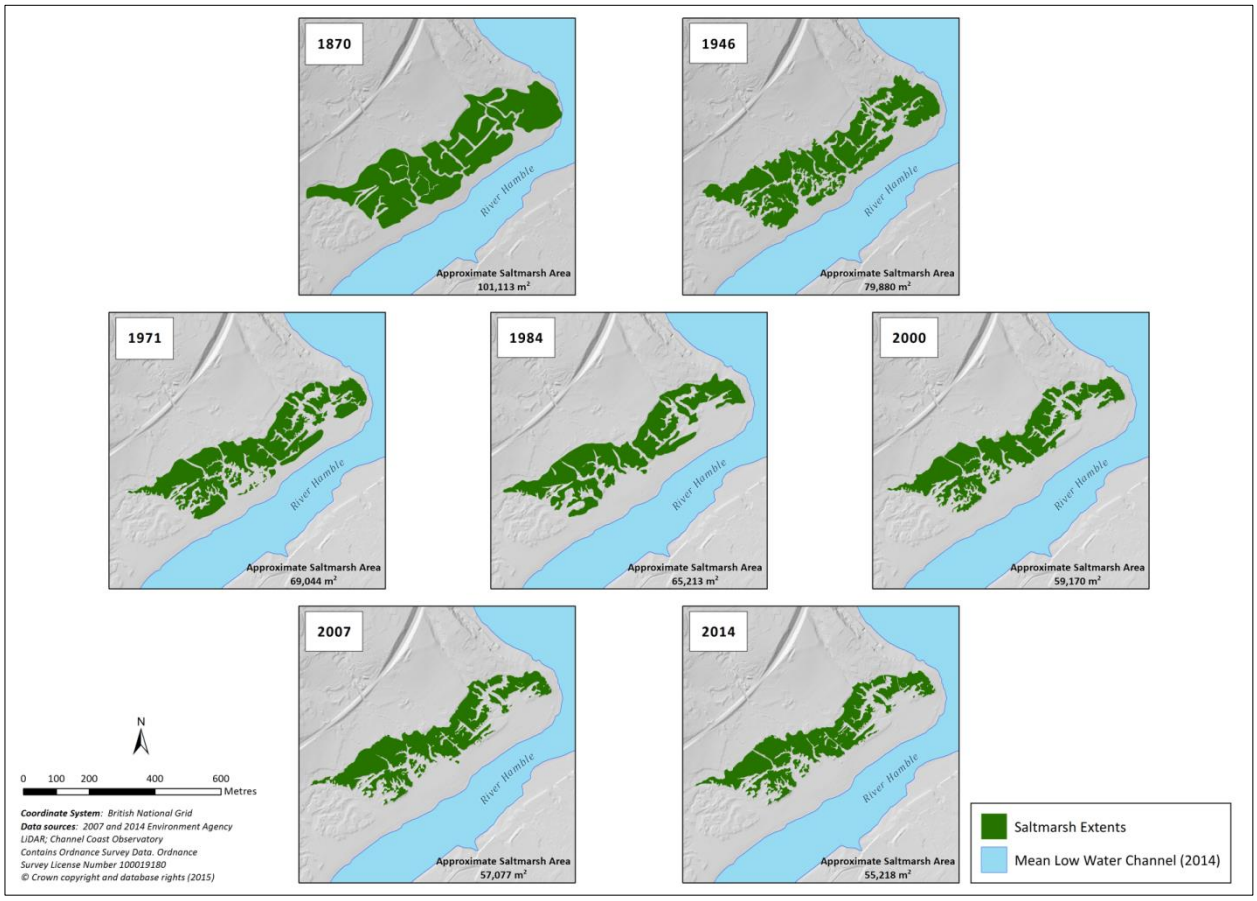


Figure 2.3: Hackett's Marsh, encompassing Lands' end showing historic erosion patterns
(From Bray *et al*., 2016)

Hackett's Marsh in its entirety has a natural transition from saltmarsh to unimproved pasture with no artificial delineation or tidal control and as a result is very species rich. The marsh is closed to the public

with the western section managed by HCC, whilst the eastern section (Lands' End, pertinent to this study) is privately owned.

The marsh system has a number of designations, including European SPA (Special Protection Area) and international Ramsar (Wetland of International Importance) status, whilst the mudflat area falls within the European Solent Maritime SAC (Special Area of Conservation). It is also a Local Nature Reserve (LNR), as well as a SSSI (Site of Special Scientific Interest). The SSSI is divided into two units, both of which are classified as being in *unfavourable no change* condition (the condition assessment was originally undertaken in 2014 and last updated in 2018). In the presentation *"Natural England's work on the Hamble",* Crane (2014), noted that threats from diffuse water pollution and smothering from algal mats were evident. As noted in the 2018 update, and previously recorded for the wider SSSI and for the Lands' End site, the major issues affecting the marsh are those of erosion (possible vessel wash, but certainly tidal / wind driven), and coupled within this, smothering by algal matts causes loss of pioneer and mid marsh species resulting in enhanced erosion through loss of binding root structures.

Against this background of erosion at Lands' End, and wider saltmarsh loss throughout the UK in many locations, some saltmarsh restoration projects have been successful with beneficial re-use of dredge spoil projects, flooding of former agricultural areas and sediment retention structures. In the Solent however, much discourse has currently led to limited progress though signs are improving with significant studies such as BUDS and the grant detailed above for Solent habitat.

3. Methodology

3.1. Proposal and acquiring permissions

AQASS, in conjunction with the landowner at Lands' End, Hacketts Marsh Old Bursledon, put in place a proposal to the Solent Forum Natural Environment Group (NEG) for a grant to undertake a small scale passive saltmarsh restoration trial. The Solent region has seen much discussion on saltmarsh restoration goals, but little practical progress, largely due to consideration and caution of regulatory aspects. Accordingly, little progress has been made (though see work at Lymington), such that it was felt that a small scale passive method may encourage others to trial this based on limited funds and regulatory aspects. The NEG kindly awarded £2,500 in 2020, which was matched by the landowner. Field work was delayed by the COVID-19 pandemic restrictions on movement; accordingly, regulatory matters were dealt with during 2020.

As discussed, the proposal was developed based on small scale passive sediment trapping methodology used in an area of significant erosion. At this area, the marsh is declining significantly (e.g. see Bray *et al*., 2016) and is almost bifurcated through significant tidal and wind driven ingress (Figure 2.3). In addition as mentioned, erosion and loss in the site is also driven by algal smothering and subsequent marsh binding flora loss; this is listed as the major factor in the unfavourable condition assessment by Natural England (NE). Where the erosion is significant, there is little or no pioneer marsh left, with a rapid and truncated transition from mudflat to lower-mid marsh typified by sea purslane (*Atriplex portulacoides*) (Figure 3.1) which grades to mid and upper marsh species. In terms of habitat function, the mud and saltmarsh flats are important grazing habitat for overwintering birds and foraging areas for fish species (notably grey mullet) during the tidal cycle. Furthermore, the marshes provide valuable ecosystem services (e.g. see Clough *et al*., 2009), not least passive coastal protection.



Figure 3.1: Lands' End at intervention site
(Photo: AQASS, 2020)

Following selection of the location within the Lands' End marsh, to undertake the trial and placement of structures, it was proposed to undertake temporally independent drone surveys to map change in vegetation and sediment levels through GIS / photogrammetry analysis. On the latter, the matter of regulatory consultation has been viewed by many as the main barrier to effective saltmarsh / mudflat enhancement in the region; the same has also been commented upon elsewhere in the UK and has also been noted in EU countries (PIANC conference, 2019).

For regulatory permissions, during the 2020 process towards this study, an initial contact to NE resulted in a suggestion that an approach was made to the Marine Management Organisation (MMO) to check the status of a Marine Licence requirement. The online system of the MMO did not fit this case / requirement well, thus a direct email query was sent.

This resulted in approximately two months of queries, after which it was established by a team member from the MMO that a licence was not required as materials were being transferred by road and being placed by hand. Having established this, NE undertook a Habitat Regulations Assessment (HRA) and gave requisite restrictions on activities (e.g. minimising number (five) and duration (max 30 min) of drone flights, minimum altitude of 30 m and avoiding overwintering bird behaviour). The team then received permission to proceed with the study. Finally the River Hamble Harbour Authority (RHHA) undertook a prompt assessment with regard to Harbour regulations and also gave permission to proceed.

3.2. Baseline survey and installation of structures

As overwintering birds were in place by the end of the permissions period, sediment retention structures were put in place in late March 2021 (Figure 3.2 and Figure 3.3); this was following a baseline drone flight and overview habitat assessment in early March, respecting the NE required HRA restrictions on drone activity.



Figure 3.2: Study site before installation of coir rolls
(Photo: AQASS, 2021)



Figure 3.3: Study site after installation of coir rolls
(Photo: AQASS, 2021)

The sediment retention features were minimal in size in an attempt to assess if small scale passive sediment retention was an option. The design was also aimed to optimise what may require more in depth regulatory assessment in the face of limited funding. Structures comprised 2 m long coir fibre rolls, held in place with 2 m length chestnut posts upright into mud, and the resulting assemblage was bound with natural fibre rope thus ensuring all structures will decay over time (Figure 3.4 and Figure

3.5). The rolls were placed angle back slightly toward the head of the creek with varying degrees of distance from the creek bank. Four coffee sacks were filled with brush wood and placed three locations at the head of the creek (Figure 3.3). The design was considered with input from sedimentologist Dr Dafydd Lloyd-Jones of Marine Space (now ERM).



Figure 3.4: Placement of coir rolls
(Photo: AQASS, 2021)



Figure 3.5: Coir roll after installation
(Photo: AQASS, 2021)

After the baseline drone flight, an assessment of flora status, and placement of the sediment retention structures, photographic records were taken.

3.3. Drone surveys

The drone surveys followed the restrictions specified by NE. All flights were undertaken by a qualified and licensed drone operator with appropriate insurances in place. The drone used for all surveys was a multirotor DJI Mavic Pro Platinum (Figure 3.6).



Figure 3.6: Drone during take-off at start of survey
(Photo: AQASS, 2021)

Flight planning was managed through the open source software DroneDeploy and the flight plan generated ensured coverage of both the survey and control sites (Figure 3.7). Six ground control points (GCPs) were distributed across the area covered by the flight, which ensured that each orthomosaic generated from the photos for each flight could be overlaid to assist with monitoring change (Figure 3.8). The geographic position of the GCPs were all referenced using Global Navigation Satellite System Real-Time Kinematic (GNSS RTK) positioning, ensuring a positional accuracy of <1 cm (Figure 3.9).

The flight plan assured that photo overlap was between 70% and 80%. This allows imagery to be processed using photogrammetry software to generate elevation models. This in turn assists with analysing elevation change across the study site and between different time periods.

The six georeferenced orthomosaics had a median absolute horizontal and vertical accuracy of <1.5 cm and <2 cm respectively.



Figure 3.7: Flight plan for surveys
(Image: SAND Geophysics, 2021)

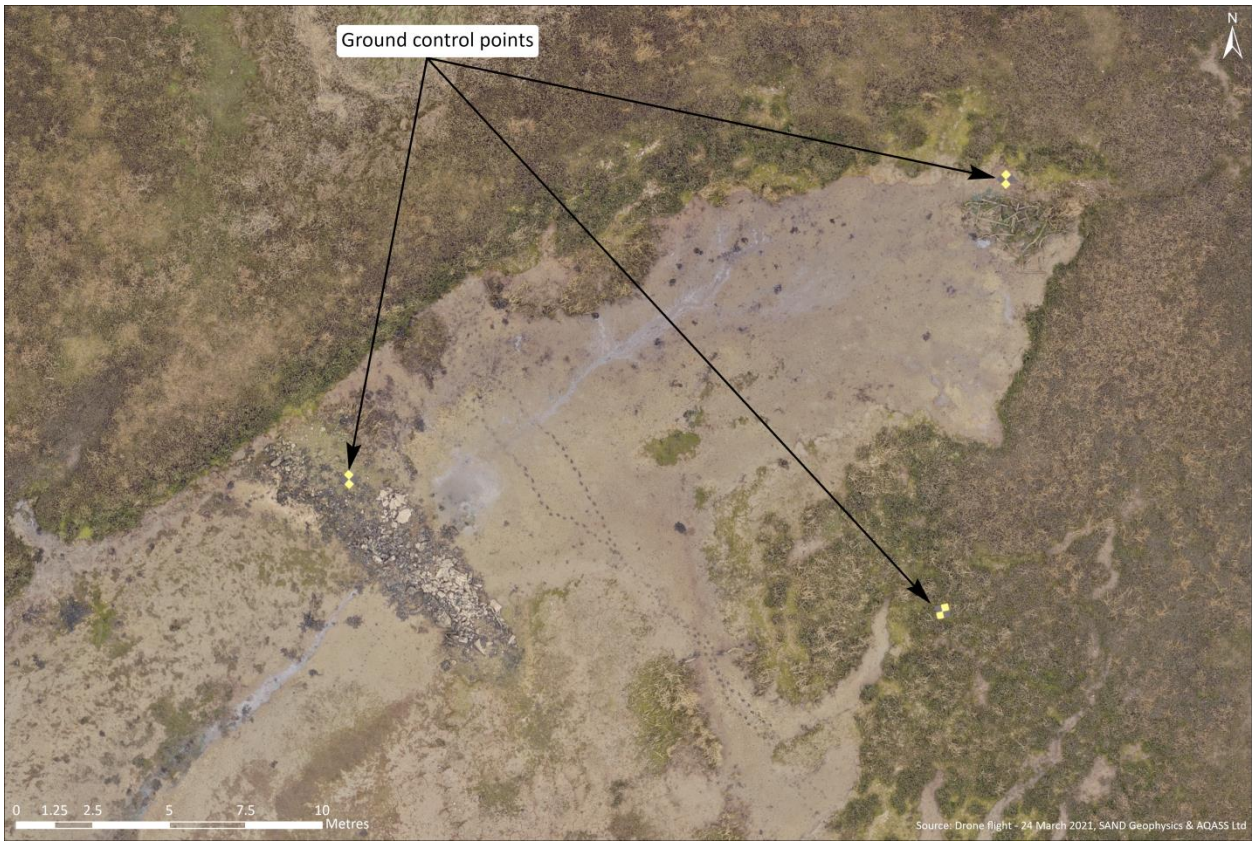


Figure 3.8: Three of the GCPs positioned across the flight area
(Image: AQASS, 2021)



Figure 3.9: GCP positioning
(Photo: AQASS, 2021)

Following the permitted five flights (ending March 2022), permission for a final flight for context was requested from NE and undertaken in December 2022. Due to a change in flight parameters as required by NE, the flight was at 40 m altitude rather than the 30 m of previous flights. This was to ensure that disturbance was minimal for birds in the SPA / Ramsar designated habitat as the survey was in the overwintering period. The data from this flight were further added to the developed GIS analysis dataset and allowed further consideration of temporal change.

Data were analysed and results presented here and in a talk to the NEG group, April 2023.

4. Results

4.1. Baseline survey

The baseline survey identified the marsh loss within the creek system showing former attempts at minimising erosion by previous landowners; these comprised a rubble bund placed at the creek entrance and old iron work at the creek head (Figure 4.1).

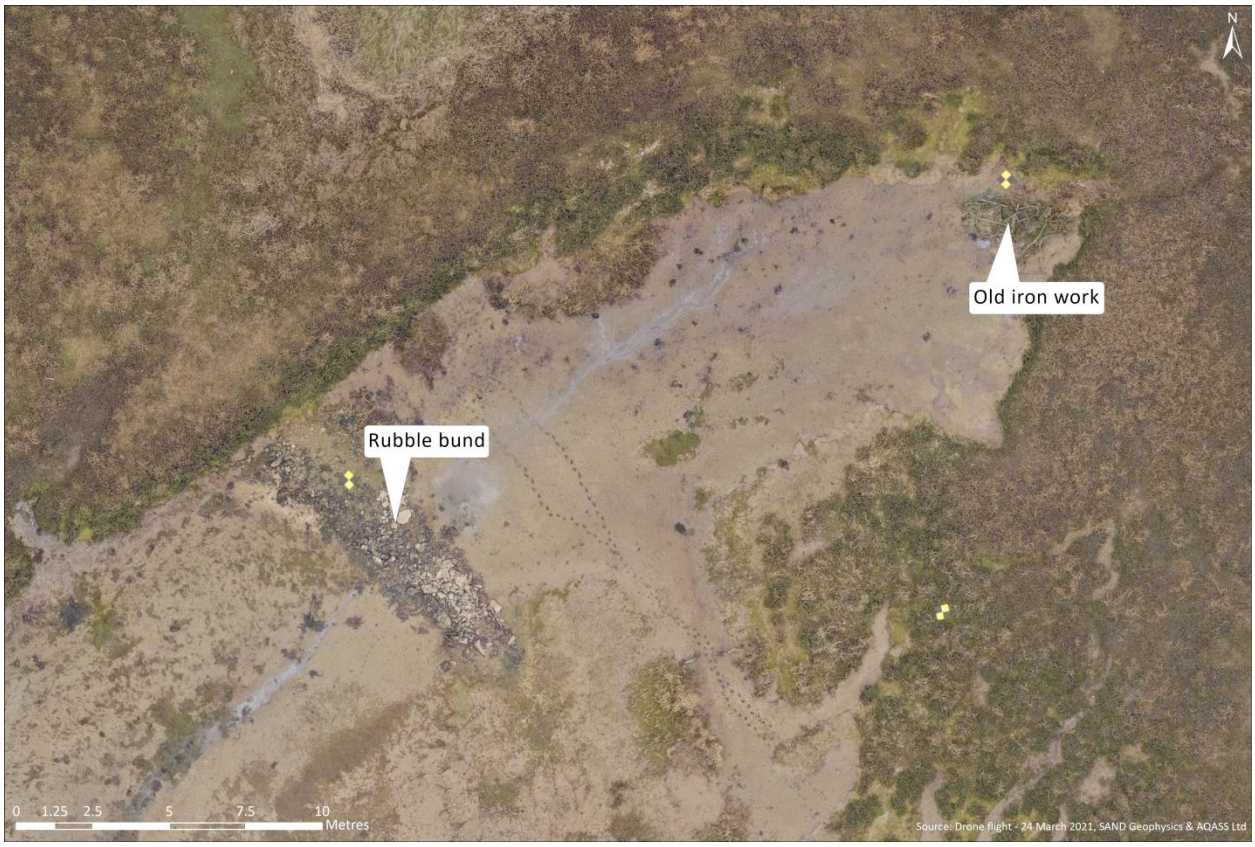
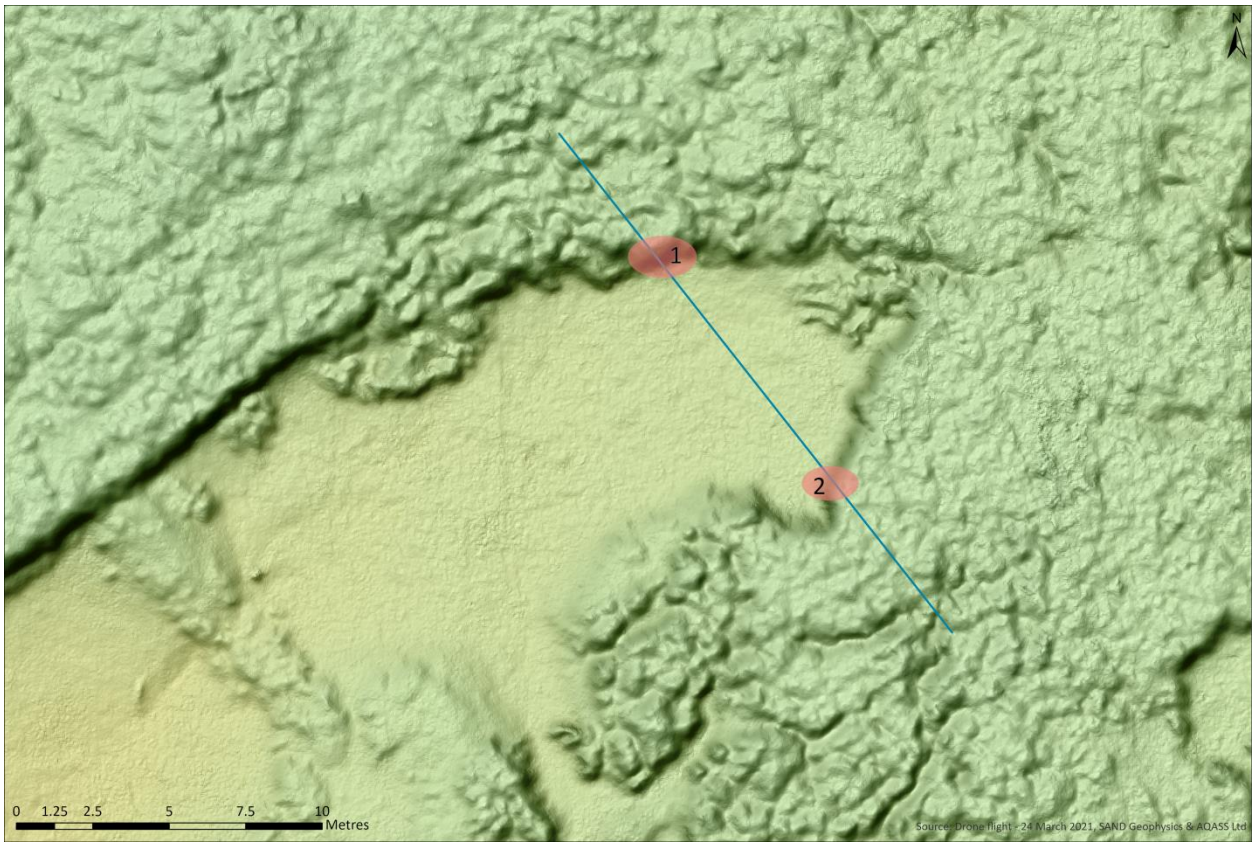


Figure 4.1: Study area on 24 March 2021 – baseline survey

As noted in original site visits, the marsh was found to be cliffed within the creek with limited gradient, more a sudden step change from isolated clumps of pioneer marsh Spartina species or bare mudflat to mid marsh dominated by sea purslane (*Atriplex portulacoides*).

Figure 4.2 demonstrates the steep slopes at the top of the study area as an example of the cliffed edges between the vegetation and the mudflat area.



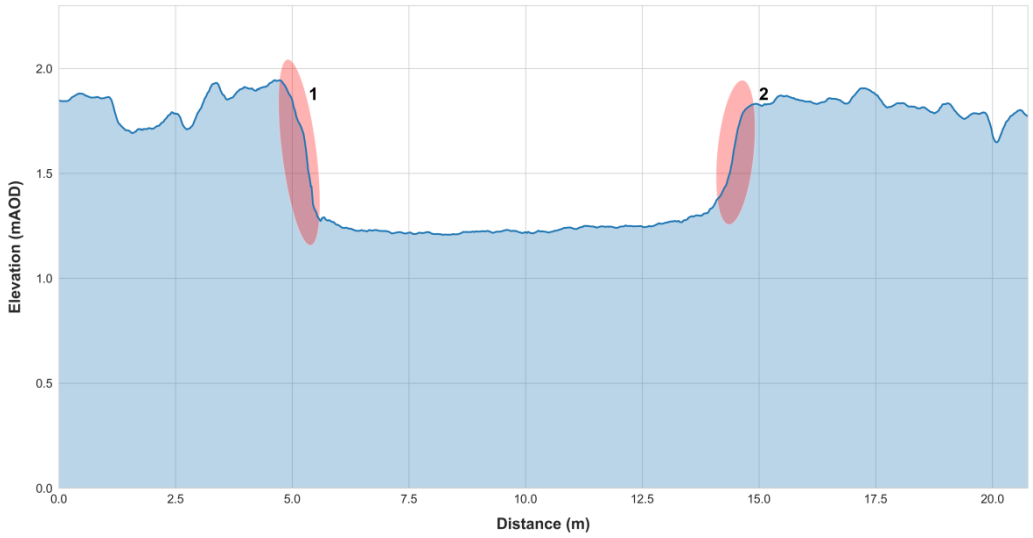
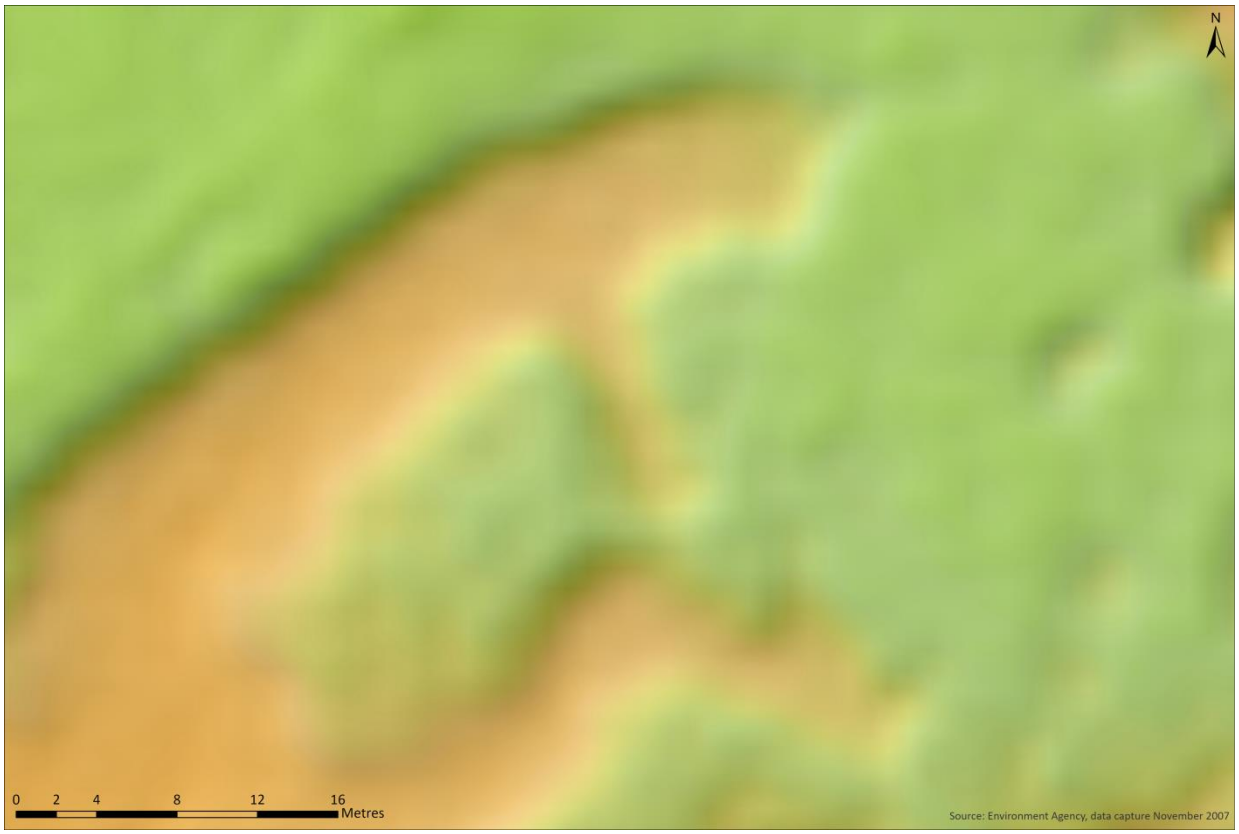


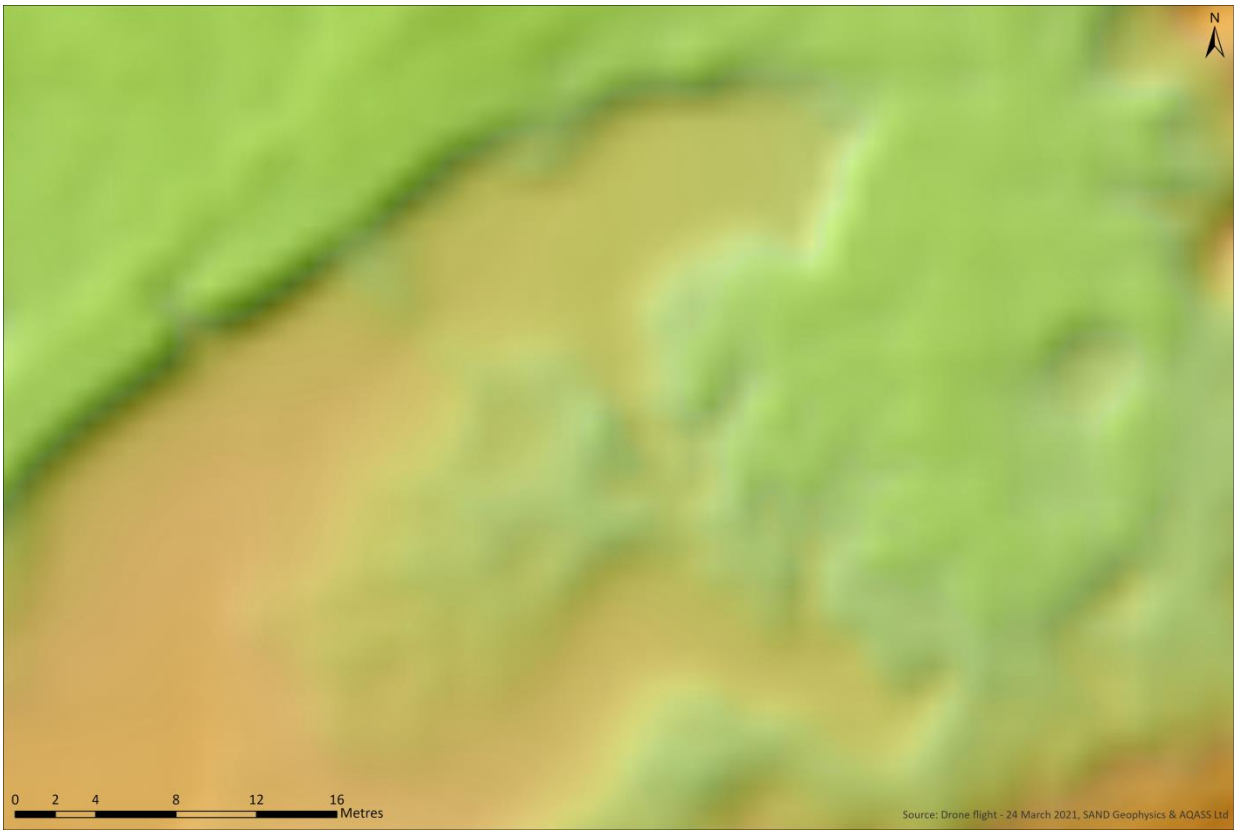
Figure 4.2: Example of vertical cliffs at vegetation edge (March 2021)
The red ellipses depict the equivalent areas on the map and the chart

LiDAR (Light Detection and Ranging) data captured by the Environment Agency in November 2007 was also accessed to demonstrate how erosion of the saltmarsh area compare to the data captured during the baseline survey in 2021. The data captured during the drone survey were resampled to a resolution of 1 m to allow for comparison with the Environment Agency data, which was only available at a resolution of 1 m.

Figure 4.3 demonstrates the erosion along the edges of the vegetated areas over the 14 year period, with increased fragmentation of the saltmarsh area.



November 2007



March 2021

Figure 4.3: Erosion at study area between in 2007 and 2021

4.2. Monitoring surveys

After the baseline flight and subsequent installation of the coir roles in March 2021, monitoring surveys were undertaken at the following intervals:

- June 2021;
- September 2021;
- December 2021;
- March 2022; and
- December 2022.

Figure 4.4 depicts the six orthophotos generated from the drone imagery collected during the flights. Digital surface models (DSMs) were created from the photogrammetry images, which were subsequently used to analyse the change in elevation along the edges of the saltmarsh, as well as directly in front of and behind the locations of the coir roles.

Saltmarsh extent for March 2021 (prior to the installation of the coir rolls) and December 2022 (the last monitoring drone survey undertaken) was also digitised; this can be viewed in Figure 4.5.

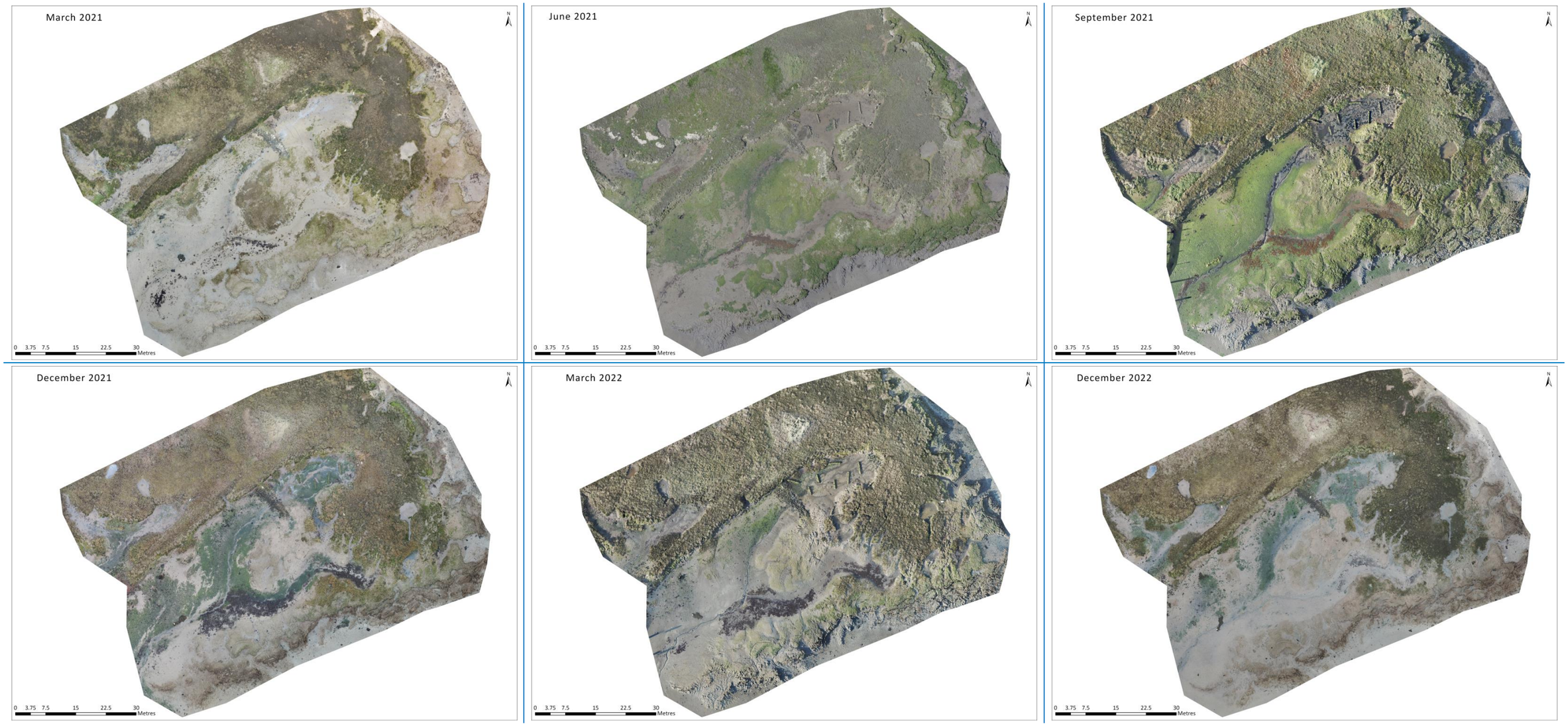


Figure 4.4: Orthophotos of the baseline flight (March 2021) and the five monitoring flights

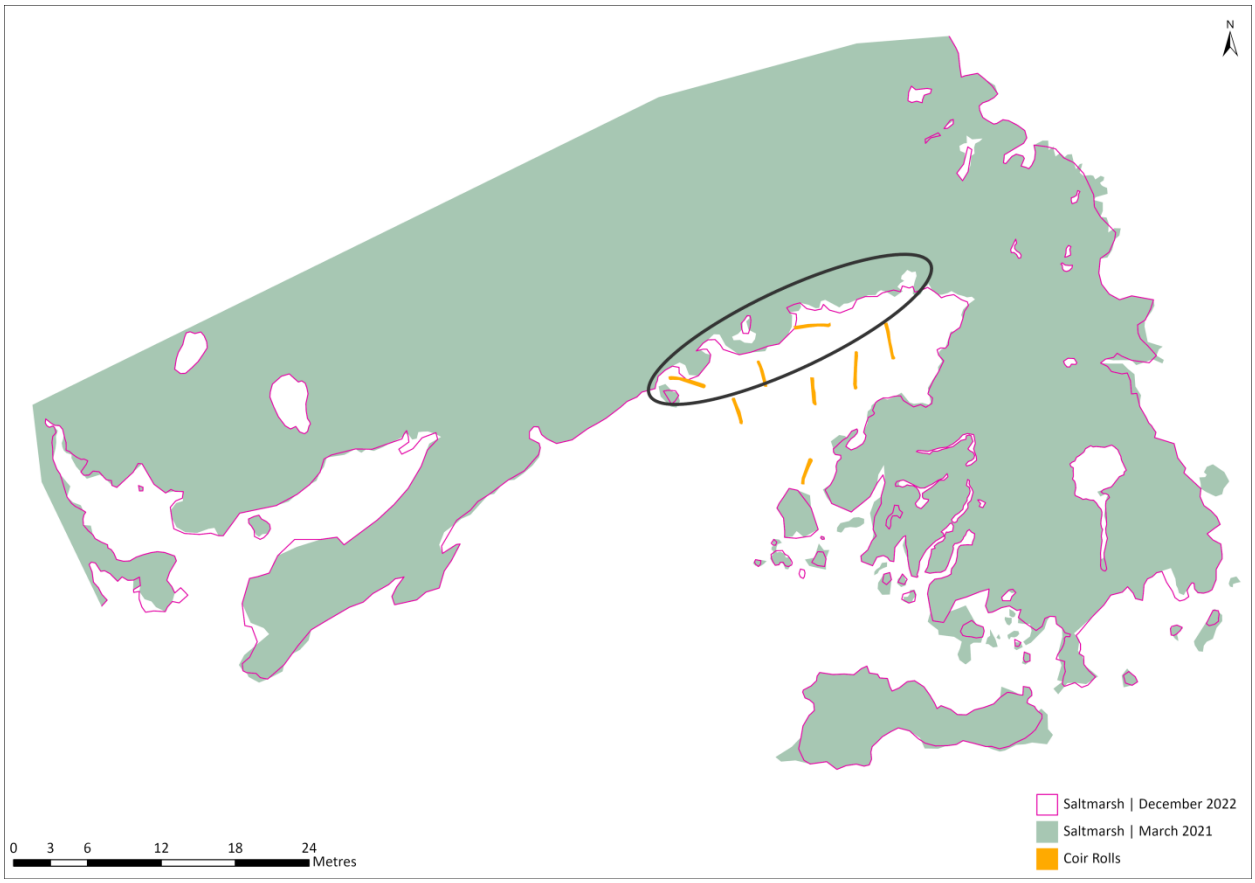


Figure 4.5: Saltmarsh extent change between March 2021 and December 2022

The location of the coir rolls are included in Figure 4.5 (they can be viewed in Figure 4.4, June onwards), with the baseline saltmarsh extent of March 2021 depicted in green and the final survey data of December 2022 depicted as a purple line. The continuing erosion along the southern edges of the saltmarsh is evident, whilst some saltmarsh growth has been observed along the north western edge of the study location (black ellipse).

The data were also used to assess build-up of sediment around the coir rolls. The cross section depicted in Figure 4.6 shows a comparison between December 2021 (blue area in chart) and December 2022 (green area in chart). The position of the cross section is shown as the blue line across the surface image in the top of the figure, going from left to right.

The three spikes in elevation between 18 m and 26 m are the three coir rolls. The elevation of all three has stayed very similar. There is a slight increase in elevation in front of and behind the first coir roll, but after the third coir roll there is a reduction in elevation, which continues along to the end of the profile line.

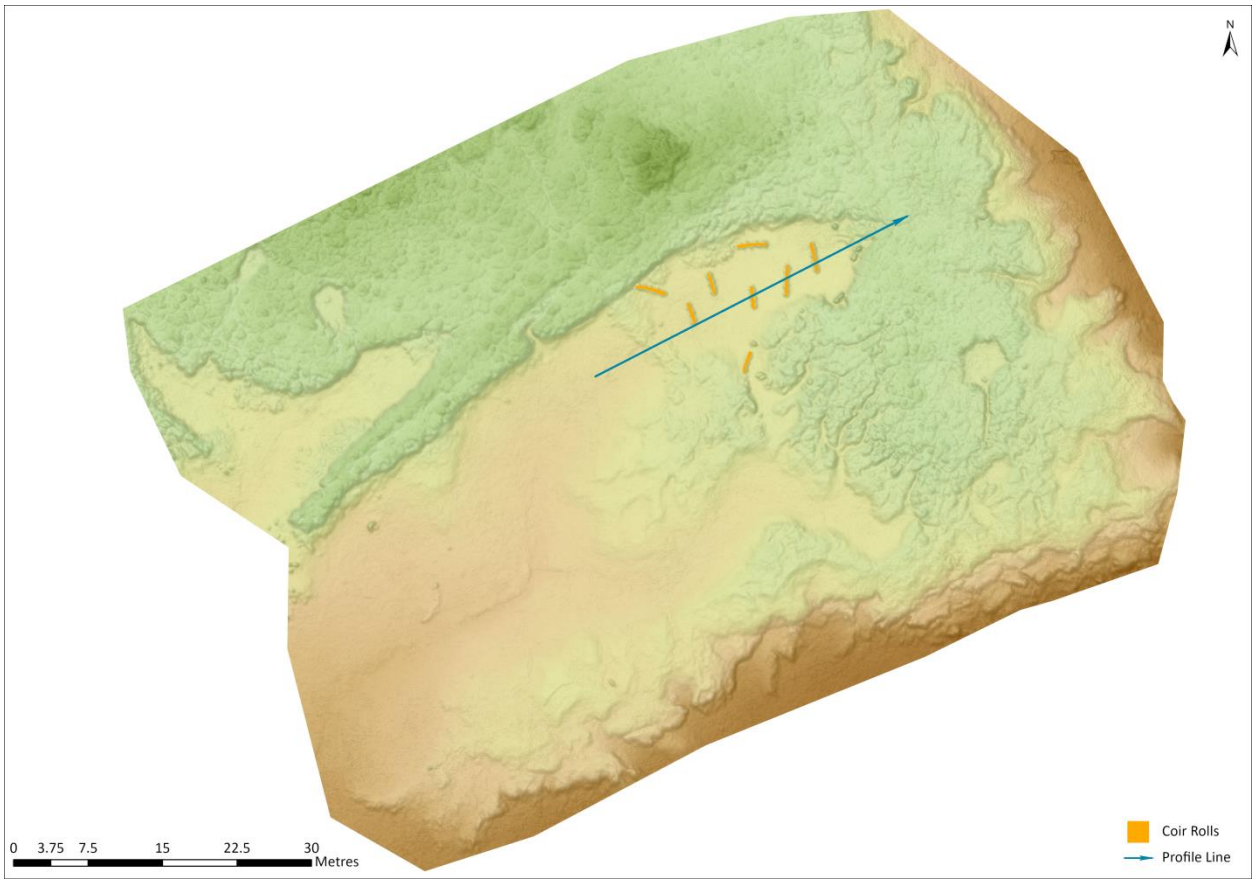


Figure 4.6: Cross section of data showing elevation change between December 2021 and December 2022

A change detection image between the two dates clearly demonstrates the areas of increase and decrease in elevation. Figure 4.7 focusses on the location where the coir rolls were installed, with the profile line included.

Along the southwestern part of the image, elevation increase could be due to the reflection from water, where water in the December 2022 flight did not drain completely. The decrease in elevation along over the vegetation areas to the north of the image will be due to flattened vegetation rather than a true reflection of reduction in surface height. However, the elevation changes along the edges of the

vegetation growth (black ellipses), coincides with the increase in saltmarsh growth depicted in Figure 4.5.

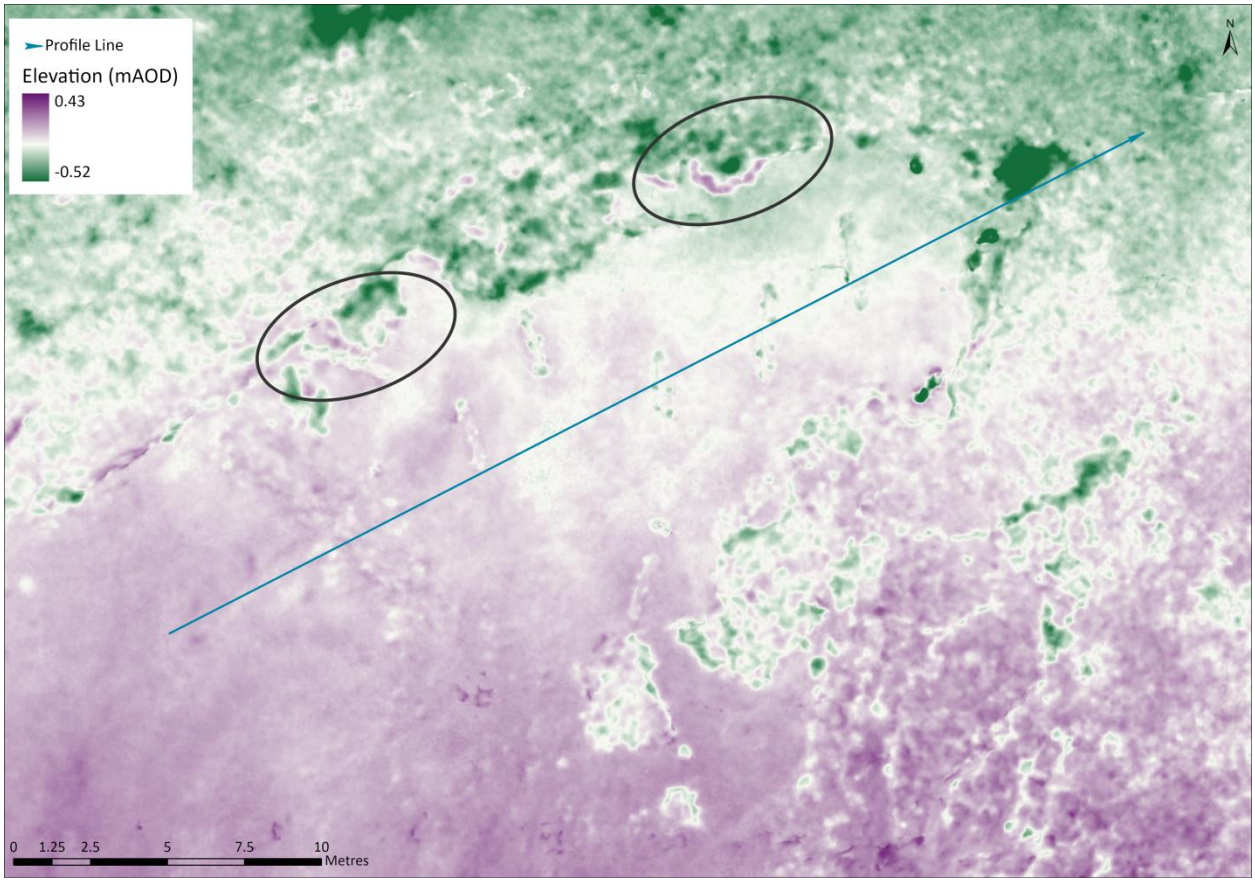


Figure 4.7: Change detection image between December 2021 and December 2022

5. Discussion

The baseline data from March 2021 showed that the saltmarsh along the study area for Land's End (i.e. the area depicted in Figure 4.5) has reduced in size by approximately 1,137 m^2 when compared to the 2014 data. During the period of the study the saltmarsh area has reduced further in coverage by another 35 m^2, i.e. between the baseline flight and the last flight in December 2022. Table 5.1 below shows the area calculations for the Land' End saltmarsh, between the years 2014 and 2022.

Table 5.1: Saltmarsh area reduction for study area

YEAR	SALTMARSH AREA (m^2)
March 2014	3,535
March 2021	2,398
December 2022	2,363

This means that just in the 5,892 m^2 area that represents the study area, there has been a 35% reduction in saltmarsh between 2014 and 2021. During the 22 months that the saltmarsh was monitored, there was a reduction of 1.5% in saltmarsh coverage.

This loss is mostly along the southern edge of the intertidal area where the wind / wave action will be greatest. Additional factors that also have an impact are algal smothering. This reduces the ability of saltmarsh plants to photosynthesise, reducing growth or in the worst case scenario, killing the plants. This increases the vulnerability of intertidal area to erosion. Based on data and observations, it is possible that a more robust approach which minimises the impact of smothering algae will lead to greater effect of such an approach; options are being explored including semi permeable higher organic fencing.

A number of lessons have been learnt during the course of the study. These are summarised below:

- It is a challenging environment to work in both physically and using remote sensing technology, e.g. since the GCPs were temporary, i.e. they were not fixed to the same locations during the course of the study, which is difficult to do in such a dynamic environment. A drone with an in-built RTK sensor, used in conjunction with GCPs, will increase locational accuracy of surveys.
- The surveys only collected data in the RGB spectrum, which means that it can be difficult to visually compare vegetation between repeat surveys. The resolution of the data made it easier (i.e. 1 cm x 1 cm), but due to different light conditions at each survey, the training of data for automation purposes is more difficult. The inclusion of a multispectral sensor to assist with differentiation between saltmarsh and algae will improve mapping of vegetation. This will potentially add an additional benefit of assessing the health of vegetation.
- The use of a LiDAR sensor to add accuracy to elevation data will also assist in monitoring erosion and deposition more accurately, however along the exposed mudflat areas, photogrammetry provides very useful insights.
- The excess algal growth in the River Hamble has hampered growth of saltmarsh vegetation. Including a structure that could reduce the algae entering the study area, might assist the vegetation to grow better. This will trap more sediment, which in turn will assist in further saltmarsh vegetation increase.

6. Summary

- A proposal was submitted to the Solent Forum NEG to trial a small scale saltmarsh sediment retention method. This was successfully funded through the land owner and the NEG;
- The site is at Hackett's Marsh, Lands' End, Old Bursledon;
- Following permissions (established during 2020), coir role structures were put in place in March 2021.
- A limited impact design was chosen to see if small scale structures may have meaningful effect, whilst minimising legislation and permissions need in relation to limited funding and time;
- Following a drone baseline survey in March 2021, further surveys were undertaken to establish sediment retention and pioneer marsh species growth, throughout 2021 to March 2022, and finally a one off flight in December 2022;
- Surveys revealed brief spurts of pioneer species growth, but significant algal smothering (as a sign of excess nutrients) confounded growth and thus enhanced sediment retention;
- Overall, a slight further decline in the marsh was seen, further methods of a more robust approach are being explored.

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