Scientific Final Report
1. Full Title: Stemming the rising tide: The protective role of saltmarshes
a. Acronym: STORM
b. Scientific Panel: ENV
2. Proposal Number: 623720
3. Grant Agreement Number: PIIF-GA-2013-623720
4. Duration of the project: 24 months
5. Scientist in Charge: Prof Tom Spencer
Researcher: Dr Ruth Reef

6. Project Abstract:
Sea level rise and the associated flooding of coastal regions are predicted to lead to severe impacts in many European countries. It is recognised that coastal habitats will play a vital role in mitigating the effects of sea level rise, through increasing sediment accretion rates and thus surface elevation. In Europe, saltmarshes are the primary vegetated coastal habitat and are widely distributed along the European coastline. Both geological evidence from the Holocene, when sea levels rose quickly and significantly and models of contemporary sea level rise suggest that saltmarshes are able to keep pace with sea level rise when sediment supply is sufficient, thus protecting inland habitats from inundation. Saltmarshes have also been shown to be very effective at attenuating wave energy during storm surges. Vertical accretion rates in vegetated coastal habitats are the result of complex interactions between geomorphological (e.g. geological subsidence, sedimentation rates) and biological processes (e.g. root growth and organic matter accumulation and thus require a multidisciplinary research approach. Salt marsh growth and physiology can be an important driver of change in vertical accretion but the lack of data on biological processes, especially belowground, has been identified as a confounding factor for salt marsh models. This project is academically innovative, as it will simultaneously determine the role of biological processes (both above and below ground) and geomorphological processes in the overall changes to vertical accretion under different global change scenarios and incorporate those into existing salt marsh evolution and surface elevation models that predict the vulnerability of coastal areas to sea level rise.

Project Achievements over the 24 months (January 2015-December 2016)

Over the past 24 months we have achieved most of our project goals.

1) We have successfully constructed and executed an elevated CO_2 experiment, which measured how elevated CO_2 and eutrophication would impact vertical accretion rates in saltmarshes. We found a significant, positive, influence of elevated CO_2 on vertical accretion in vegetated coastal habitats and, using boosted regression modelling, identified a number of factors contributing to this, namely decomposition rates, root growth and plant water use (Reef et al. 2016). We have also identified a key role for the grass *Puccinellia maritima* in encouraging vertical accretion. *Puccinelllia maritima* is a climate sensitive and grazing sensitive species and our results can be used to guide management policy regarding the conservation of saltmarshes in the face of sea level rise. The mesocosm study identified a significant change in canopy morphology with eutrophication and elevated CO_2 and the impact of such changes on surface accretion was addressed in experiment 3.

Figure 1) The mesocosm experiment constructed at the Cambridge University Botanic Gardens where saltmarsh blocks were grown under different climate change scenarios to measure the effects of elevated CO_2 and eutrophication on surface elevation change (Reef et al. 2016).

2) Field campaigns planned at both Tillingham (Essex) and Donna Nook (Lincolnshire) saltmarshes have been completed over the two-year period. Our fieldwork allowed us to measure the biological components (root growth and decomposition) of vertical accretion for both the winter and summer season (manuscript #1 in advanced stages of preparation). Our study suggest a significant, previously overlooked gain to marsh elevation by biological contributions. In this component of the study we find that there is a spatio-temporal variation in the contribution of belowground biological processes to surface accretion on saltmarshes, ranging from a vertical gain of 1.6 mm/y in

the upper marsh in the summer to 0.3 mm/y in the lower marsh in the winter. Using a UAV survey, we are able to identify the marsh zones and apply the correct biological contribution to an entire foreshore for the summer and the winter season.

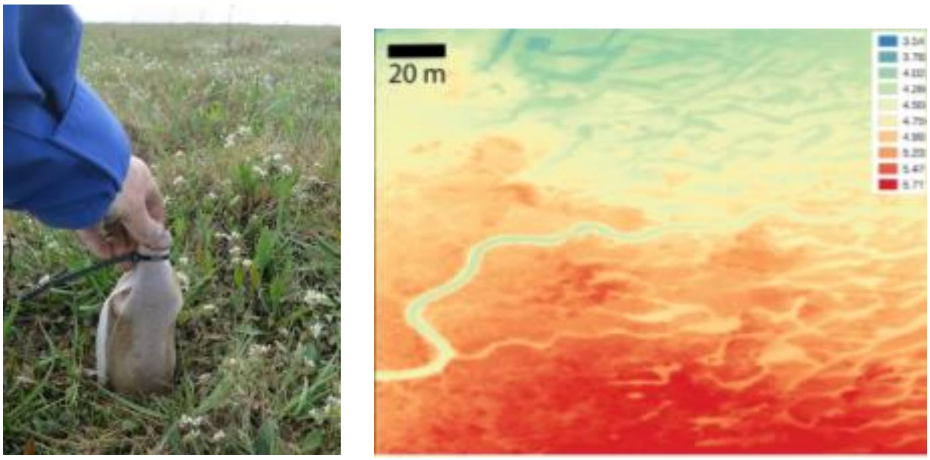

Fig 2 A) Burying a root in-growth bag at the Tilingham saltmarsh to measure below ground biomass accretion over time B) A high resolution digital elevation model of the foreshore generated using airborne (UAV) photogrammetry

3) The final experiment of this fellowship has been completed in December 2016 (Fig. 3). This novel field study, done in collaboration with German colleagues from the University of Kiel, measured how these changes to the canopy could affect sediment deposition and retention. We are currently analysing the data from this experiment and a manuscript (#2) is in advanced stages of preparation.

Fig 3 A) The winter field flume experiment at the Tillingham marsh to measure sediment deposition/canopy morphology interactions. OBS = Suspended sediment profilers (ASM-IV), ADV = Flow velocimeter. B) and C) the plant canopy before and after final manipulation during the summer field flume experiment.

4) The results from experiments 1-3 provides us with a quantification of

1) Biological contribution to surface elevation gain in European saltmarshes
2) The effect of elevated CO_2 and nutrients on #1
3) The spatial distribution of #1
4) The effects of elevated CO_2 and nutrients on canopy morphology
5) The effects of canopy morphology on sediment accretion

Together these processes determine the shallow movement of the marsh surface and these parameters are now being incorpororated in a zero-D model for vertical accretion we are developing (manuscript #3, early stages of preparation) which is based on the Mariotti and Fagherazzi model (2010).

Mariotti G, Fagherazzi S (2010) A numerical model for the coupled long-term evolution of salt marshes and tidal flats. Journal of Geophysical Research, **115**, F01004.