SAMFHIRES

Saltmarsh Function and Human Impacts in Relation to Ecological Status

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BEC CONSULTANTS

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epa Research
Climate • Water • Sustainability
Identifying pressures • Informing policy • Developing solutions

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Introduction

The **Saltmarsh Function and Human Impacts in Relation to Ecological Status (SAMFHIRES)** project is a 36-month multidisciplinary collaboration between Botanical, Environmental and Conservation (BEC) Consultants Ltd. and the Department of Botany, Trinity College Dublin (TCD). Through field survey, collation of existing data, modelling and analysis, the project will link anthropogenic pressures to changes in saltmarsh communities and investigate the ecosystem services and ecological functions of saltmarshes in Ireland. By integrating the outputs of this research, it will refine the tool developed by the recent SMAATIE (Saltmarsh Angiosperm Assessment Tool for Ireland) project for the purposes of the Water Framework Directive. The tool, which assesses ecological status for part of the angiosperm Biological Quality Element in coastal and transitional waters, will be tested in the field and applied to a selection of water bodies.

The project consists of three work packages (WPs). There is synergy between WP1 and WP2, with outputs from both feeding into WP3.

Work Package 1: Anthropogenic pressures on Irish saltmarshes

The objectives of this WP are to:

1. Review the literature pertaining to anthropogenic pressures on saltmarshes
2. Collate existing data on anthropogenic pressures on Irish saltmarshes
3. Investigate impacts of grazing pressure on Irish saltmarsh communities
4. Investigate patterns and impacts of eutrophication on Irish saltmarsh communities
5. Identify potential refinements to SMAATIE related to anthropogenic pressures

Work Package 2: Ecosystem services and ecological function of Irish saltmarshes

The objectives of this WP are to:

1. Review the literature pertaining to ecosystem services and ecological function
2. Investigate the regulating services/functions of saltmarshes
3. Investigate the habitat/supporting services/functions of saltmarshes
4. Identify potential refinements to SMAATIE related to function/services

Work Package 3: Refinement and testing of SMAATIE

The objectives of this WP are to:

1. Finalise list of water bodies for which saltmarsh monitoring is needed
2. Record data on under-recorded saltmarsh communities
3. Refine tool and methodology
4. Field test the tool and methodology at a selection of contrasting sites

Expected Outputs:

The SAMFHIRES project outputs will include a fully detailed final report, a non-technical synthesis report and a revised Practitioner's Manual reflecting the revised assessment tool. Other project outputs will include final metric and Ecological Quality Ratio (EQR) data for all assessed water bodies in Microsoft Excel format, vegetation quadrat data in Turboveg format and GIS data in ESRI format defining Potential Saltmarsh Area. At least two oral conference presentations will be made and three to four papers will be published in peer-reviewed journals. TCD will hold two seminars where progress on the project will be presented and feedback can be received, and more newsletters will be produced and disseminated in PDF format.

Project term: January 2016—January 2019 **Funder:** EPA

Project team: Philip Perrin, BEC; Steve Waldren, TCD; Marcin Penk, TCD; Fiona Devaney, BEC; Fionnuala O'Neill, BEC; Jim Martin, BEC; Simon Barron, BEC.

The project team would like to thank the support and advice received from the steering committee: Karen Roche (EPA), Robert Wilkes (EPA), Deirdre Lynn (NPWS), Kate Harrington (Irish Water), Claire Young (DAERA, NI), Clare Scanlan (Scottish EPA), Cilian Roden (Cilian Roden Associates) & João Neto (Universidade de Coimbra).

Work Package 2: Ecosystem services and ecological function of Irish saltmarshes

Saltmarsh vegetation biomass changes

Vascular plants are the structural and functional pillar of saltmarsh ecosystems, and thus they deliver key ecosystem services, such as energy fixation for consumers, wave attenuation, sediment binding and carbon storage. It is important to understand how these services vary across saltmarshes to inform coastal management and maximise the benefits provided by these services. We surveyed 15 saltmarshes along the south and east coasts of Ireland to investigate how saltmarsh plant biomass (above-ground (AG), below-ground (BG), total and AG:BG ratio) changes with ground elevation and soil conditions (Figure 1). BG biomass exceeded AG in 80% of plots (Figure 2), and thus the former more strongly influenced total biomass. AG biomass ranged from 0.019 to 3.959 kg/m². It generally increased up the shore, but with the highest biomass recorded at intermediate elevations (Figure 3a). It was most strongly driven by *Atriplex portulacoides*, followed by *Juncus maritimus* and *Spartina* spp. BG biomass ranged from 0.007 to 12.31 kg/m² and it increased up the shore (Figure 3b). It was most strongly driven by *Juncus maritimus*, followed by *Triglochin maritimum* (=*maritima*), *Spartina* spp., Juncus *gerardii, Plantago maritima* and *Atriplex portulacoides*. Total biomass ranged from 0.036 to 13.708 kg/m². It generally increased up the shore, but at a decelerating rate (Figure 3c). It was most strongly driven by *Juncus maritimus*, followed by *Triglochin maritimum* (=*maritima*), *Atriplex portulacoides*, *Spartina* spp., *Juncus gerardii* and *Plantago maritima*. AG:BG biomass ratio ranged from 0.05 to 15.90. It did not change significantly along the shore height gradient (Figure 3d). It increased with ground cover of *Atriplex portulacoides* and decreased with *Triglochin maritimum* (=*maritima*), followed by *Spartina* spp., *Limonium humile, Juncus gerardii, Plantago maritima* and *Juncus maritimus*. Changes in vegetation biomass partitioning between AG and BG components can affect important ecosystem services and we have strong evidence linking such changes to soil nutrient gradients.

Figure 1. Sampling above– and below-ground plant biomass in middle marsh

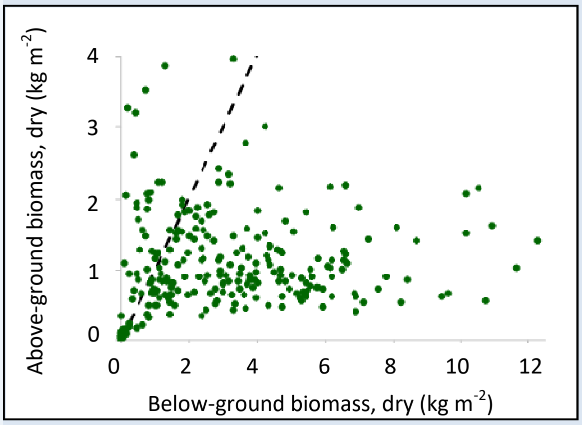

Figure 2. Relationship between dry above– and below-ground vegetation biomass on a natural scale across all plots in 15 saltmarshes. Dashed line indicates 1:1 relationship.

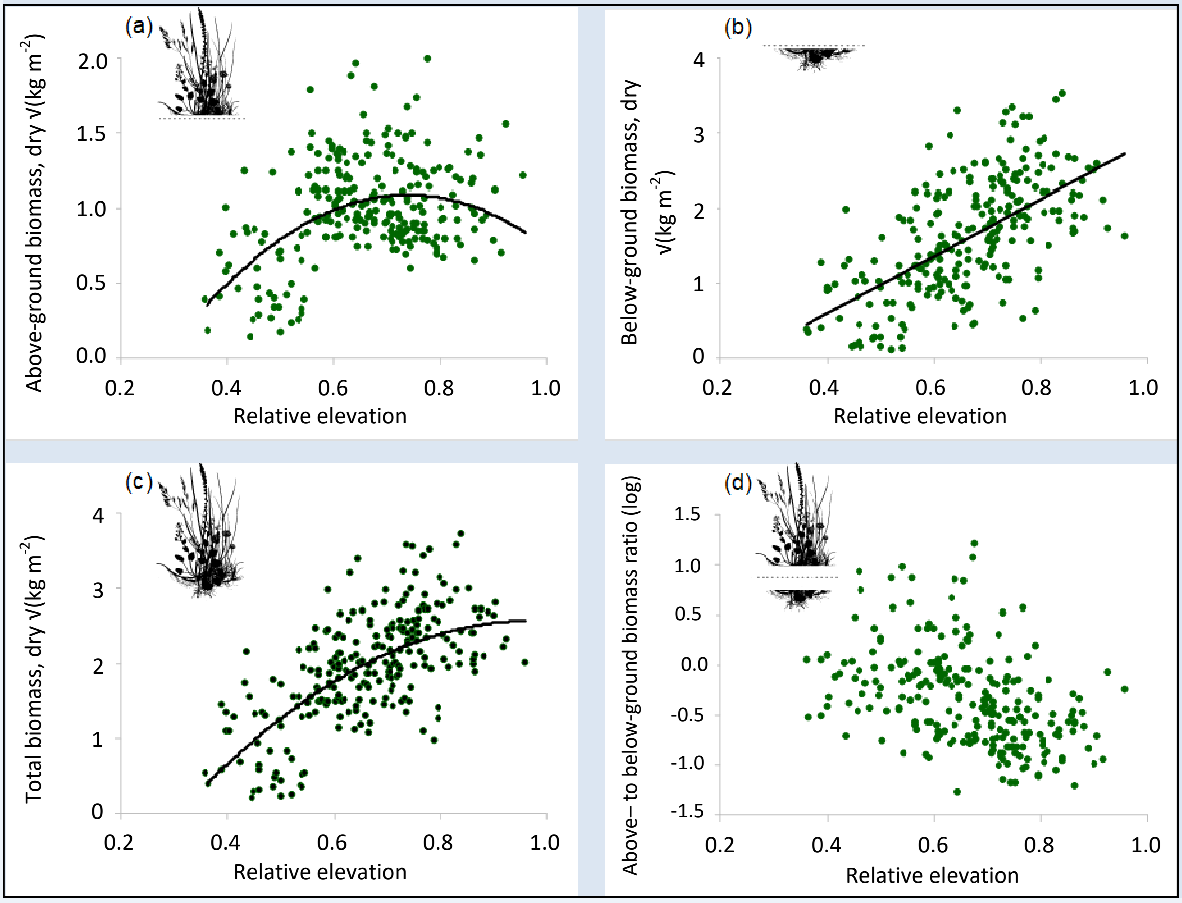

Figure 3. Relationship of different measures of vegetation biomass, on transformed scales, with ground elevation, expressed as a proportion of the highest astronomical tidal amplitude. Trendlines indicate significance ($P \leq 0.05$).

Work Package 2: Ecosystem services and ecological function of Irish saltmarshes

Managed and unmanaged realignment with respect to Irish saltmarshes

Managed realignment (hereafter, MR) may be broadly described as a landscape management strategy whereby previously reclaimed land along coasts, estuaries or rivers is surrendered back to natural tidal processes. The aim of MR projects can be to improve the level of coastal protection that is provided as an ecosystem service by intertidal habitats. Saltmarshes provide this protection service through functions of wave attenuation, shoreline stabilisation and floodwater storage. In light of predicted sea level rise and increased storm frequency resulting from climate change this ecosystem service is becoming increasingly relevant. We reviewed case studies of four Irish MR projects (including one from Northern Ireland) and three examples of unmanaged realignment (hereafter, UR), with the location of the seven case study sites shown in Figure 4. A brief review of one MR case study site and one UR case study site is presented here.

Figure 4. Location of case study sites. Closed circles indicate MR sites, open circles indicate UR sites.

<u>MR case study: Kilmacleague West Wetlands, Co. Waterford</u>

In 2005, the Court of Justice of the European Communities found against Ireland for general and persistent breaches of the Waste Directive (74/442/EEC as amended by 91/156/EEC) in Co. Waterford (Case C 494/01). One of the complaints that the case was based on was the unauthorised operation of the municipal landfill on Tramore Back Strand since 1939, adjoining and encroaching upon now protected areas within the Tramore Dunes and Backstrand SAC. Part of Ireland's response to this judgement was a commitment to create a compensatory wetland to offset this illegal waste deposition. This wetland was to be created through MR on an area of agricultural land at Kilmacleague West adjacent to existing areas of saltmarsh (Figure 5a).

Figure 5. Aerial views of the MR site at Kilmacleague West dated 2004 (left) and *c.* 2013 (right). The newly inundated area, new levee and the breach in the old levee can be seen on the left of the photo taken *c.* 2013.

Field studies indicated that the eastern portion of the proposed site was used for foraging and roosting by wintering waterfowl so the initial plan was modified so that only the western half (22 ha) would be used to create the new wetland. The aim was to create 5.0 ha of mudflat, 1.0 ha of transitional saltmarsh, 0.5 ha of upper salt marsh and 1.0 ha of pioneer marsh (B. Guest, pers. comm.). Works on creating the new levee began in May 2012, with breaching of the old one in April 2013 and works concluding in May 2013 (B. Guest, pers. comm.) (Figure 5b). Rock armour was used to prevent the tidal erosion from broadening the breach point.

As of August 2018, saltmarsh vegetation with distinct zonation has established along the shoreline of the created wetland. The lowest zone is a bed of *Salicornia* agg. with locally abundant *Suaeda maritima*. This is most well-developed on the northern and eastern shorelines where plant growth is dense and the zone is 4-6 m across. This zone corresponds to Annex I habitat **1310 *Salicornia* and other annuals colonising mud and sand**. Isolated clumps of the invasive non-native *Spartina anglica* have established here. Above this area occurs a narrower zone with *Aster tripolium*, *Puccinellia maritima*, *Triglochin maritimum* (=*maritima*) and *Limonium humile*, amongst which *Inula crithmoides* is locally abundant. Along the western shore, this zone has a patchy upper fringe of *Juncus gerardii*. This zone corresponds to habitat **1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)**. On the northern and eastern shores, a third zone occurs on the lower slope of the levee, dominated by *Elytrigia repens* with some *Atriplex prostrata*, *Beta vulgaris* subsp. *maritima* and *Sonchus arvensis*. *Elytrigia atherica* dominates a small area in the northeast corner. These *Elytrigia* swards should also be considered as habitat 1330.

Work Package 2: Ecosystem services and ecological function of Irish saltmarshes

UR case study: Harper's Island, Cork

Harper's Island lies in Cork Harbour between Little Island to the west and Brown Island to the east, with Fota Island to the south. The N25 national road crosses the southern part of the island and the Cork-Cobh railway line runs along the western shore. A short bridge connects the island with the mainland to the north. In recent decades the island had been managed as farmland, with the northern part comprising improved grassland behind a levee. By around 2006, however, the land had become somewhat abandoned. Around this time, a small subsurface breach in the northern levee appears to have occurred allowing saline waters to enter and saltmarsh vegetation rapidly established in an example of UR (T. Gittings, pers. comm., 20th January 2017). Changes in habitat resulting from the breach can be seen in Figure 6. As of August 2018, extensive and dense beds of *Salicornia* agg. dominate the area of saltmarsh that has developed (Figure 7). These correspond to the EU Habitats Directive Annex I habitat **1310 *Salicornia* and other annuals colonising mud and sand**. Within these beds, patches of *Juncus gerardii* and *Bolboschoenus maritimus* have established. To the rear of these beds, there is only a narrow band of saltmarsh vegetation with abundant *Aster tripolium* before the land slopes sharply up to grassland and hence there is little natural zonation. A single clump of *Spartina anglica* was observed.

Figure 6. Aerial images of the site UR at Harper's Island dated 2003 (left) and 2017 (right).

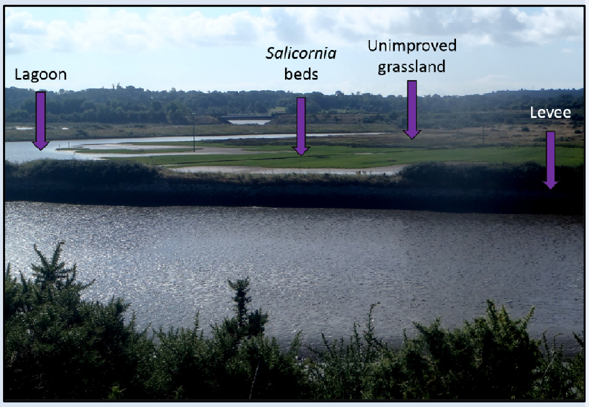

Figure 7. View of recently established saltmarsh at Harper's Island, Cork, 2018.

National strategies

Ireland is behind most other countries from northwest Europe in terms of number of MR projects implemented or under construction and significantly behind all of these countries in terms of area of these projects. Whilst it should be acknowledged that all countries differ in terms of opportunities for MR, this still shows that Ireland has yet to adopt MR as a mainstream coastal engineering option. Ireland lacks a national coastal management strategy meaning that Ireland's approach is reactive rather than proactive like our European neighbours (Murphy 2017).

Ecological considerations

* MR/UR does not solely result in the creation of saltmarsh but also mudflats and lagoons which themselves may constitute Annex I habitats. Re-profiling may be needed to ensure development of saltmarsh and for this to have appropriate zonation.
* Broadly speaking, where MR projects are within or adjacent to designated conservation areas, conflicts may arise as the creation of intertidal habitats might necessitate the destruction of designated freshwater habitats (Esteves and Williams 2017).
* Swift action is recommended at MR/UR sites if *Spartina anglica* plants are found as this will make removal easier and less expensive. Ongoing monitoring will, however, be required.
* Long-term monitoring is needed to assess the success of MR projects relative to project-specific aims. Monitoring needs to cover multiple interconnected disciplines addressing not only the changes in vegetation but also birds, fish, invertebrates including benthic fauna, geochemistry and topography/physical processes.

Conclusions

Ireland currently lacks a coastal management strategy but, in light of projected sea level rise, MR is likely to become an increasingly attractive option, with some small-scale MR projects already having been implemented.

Work Package 3: Refinement and testing of SMAATIE

Preliminary refinement of the SMAATIE tool

A recent project, the Saltmarsh Monitoring Project 2017-2018, commissioned by NPWS, collected saltmarsh data to help inform both the Habitats Directive and the Water Framework Directive (WFD). Part of the remit of that project was to run the data through the SMAATIE tool; this assesses data for the purposes of the WFD. This task was completed by us, and during the process, some changes were made to the tool following a review of the metrics. These changes are outlined below. It is expected that there will be more refinements made to the tool before SAMFHIRES concludes and therefore the changes outlined below may need to be adjusted again.

Metric II: proportion of saltmarsh zones present

The reference condition for this metric is the presence of the expected number of saltmarsh zones that should occur naturally within the water body for a fully functioning saltmarsh. This reference value differs depending on the type of saltmarsh present. When SMAATIE was designed, data on five zones were available and this metric was defined on the basis on these five zones (two zones within the Annex I habitat 1330, and one zone apiece represented by the Annex I habitats 1310 and 1410, and 'other saltmarsh'). Since then, the IVC project has revised the saltmarsh classification and five zones are now defined within 1330 (Table 1). It was decided that although 1330 may in fact have all five zones present within a water body, a maximum number of three would be allowed as the point of this metric is to measure the successfulness of the ecological functioning of the saltmarsh by having a full successional sequence of saltmarsh zones. As the number of zones increased by one for 1330, the overall required number of zones increased by one for each saltmarsh type (Table 2).

Table 1. Comparison of old zones and count based on Devaney & Perrin (2015) and the new zones and count based on SAMFHIRES

Saltmarsh habitat	Old zones	Old zone count	New zones	New zone count
1310	1b	1	SM1a	1
1330	2a-e & 3a-d	2	SM2, 3, 4, 6b-d & *Elytrigia*	5 (with max. of 3 counted)
1410	4a-b	1	SM5	1
Other saltmarsh	6a-d	1	Swamp	1
Total		**5**		**6**

Table 2. Comparison of old expected number of zones based on Devaney & Perrin (2015) and the new expected number of zones based on SAMFHIRES defined by saltmarsh type

Saltmarsh type	Old # Expected Zones	New # Expected Zones
Estuary	5	6
Bay	4	5
Sandflat	4	5
Lagoon	2	3
Fringe	2	3

Metric V: proportion of observed taxa up to 15 taxa

The reference condition for this metric is the presence within saltmarsh habitat of at least 15 predetermined halophytes. Common halophytes are listed in Table 3 and are counted only if they have a frequency of at least 15% in terms of the number of plots in which they are present within their characteristic zones. While the list of species in Table 3 has not changed, the characteristic zones which each is assigned to has changed due to the fact that the saltmarsh vegetation communities and groups were redefined as part of the Irish Vegetation Classification (IVC) project after SMAATIE was completed.

Table 3. List of common halophytes with their characteristic zones

Species	Characteristic zone	Species	Characteristic zone	Species	Characteristic zone
Armeria maritima	SM2, 3, 4, 5	*Glaux maritima*	SM3, 4, 5, 6b-d	*Puccinellia maritima*	SM2, 3
Aster tripolium	SM2, 3, 4, 5, 6b-d	*Juncus gerardii*	SM3, 4, 5, 6b-d	*Salicornia species*	SM1, 2
Atriplex portulacoides	SM2	*Juncus maritimus*	SM5	*Samolus valerandi*	SM6b-d
Atriplex prostrata	SM4, 6b-d	*Limonium binervosum* agg.	SM2	*Schoenoplectus tabernaemontani*	Swamp
Bolboschoenus maritimus	Swamp	*Limonium humile*	SM2, 3	*Spergularia marina*	SM1
Carex extensa	SM3, 4, 5, 6b-d	*Oenanthe lachenalii*	SM5	*Spergularia media*	SM2, 3
Cochlearia spp.	SM2, 3, 4, 5	*Phragmites australis*	Swamp	*Suaeda maritima*	SM1, 2
Eleocharis uniglumis	SM6b-d	*Plantago coronopus*	SM4	*Triglochin maritimum* (=*maritima*)	SM2, 3, 4, 5, 6b-d
Elytrigia repens	*Elytrigia*	*Plantago maritima*	SM2, 3, 4, 5		

Milestones for the next three months

* Submit manuscripts on soil and vegetation composition, and biodiversity indices;
* Complete manuscripts for soil and vegetation biomass, grazing and sea level rise;
* Complete refinement of the SMAATIE tool and write up Work Package 3;
* Submit chapters to the Steering Committee by 4th December and submit Technical Report in January;
* Compile final report and synthesis report.

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