1. Purpose of this paper

This paper provides an update on coastal change at Musselburgh's Fisherrow Links (East Lothian) following a survey on 22nd October 2024. It is intended to complement Dynamic Coast & University of Glasgow's February 2024 assessment (link) and surveys of October 2023, before and after Storm Babet. This report aims to support East Lothian Council's understanding of coastal change, alongside partners and the public.

2. Headlines

1. Much of Musselburgh's Fisherrow Links and beach has largely recovered following losses experienced during Storm Babet (18th Oct 2023), however losses remain towards the east where erosion persists (adjacent to Mountjoy Terrace), and the shoreline is now landward of the pre-Storm Babet position.
2. Across Fisherrow Links as a whole, the upper beach (ie Mean High Water Springs) has advanced (recovered) seawards just over 2m on average in the last year, with maximum gains of 24.6m and maximum losses of -8.62m. However, the edge of the terrestrial vegetation has retreated landwards an average of -0.4m over the period, with maximum gains of 9.8m and maximum losses of -7.17m.
3. Natural coastal processes have built-up sediment (reflected in a seaward advance of MHWS and in places vegetation lines) over the last year since Storm Babet. Although this is perceived as a 'good thing', where the recent erosion continues to dominate, there remain potential implications for East Lothian Council's proposed flood risk management activities.
4. Thus, coastal erosion remains a risk within the links and so should continue to be monitored as part of the Council's proposed Coastal Change Adaptation Plan (CCAP) and proposed flood risk management activities.

3. Context

Dynamic Coast staff were contacted by a Musselburgh resident (August 2024) regarding apparent improvements to beach levels and colonization by plants along parts of the upper beach (Figure 1). Such coastal changes are likely to be considered within the forthcoming CCAP and associated monitoring plan. However, as these are in preparation, Dynamic Coast offered to undertake a survey to support the policy area.

Figure 1:Seaward growth of vegetation on the upper beach, to the east of the harbour. © N. Armstrong (2024).

4. Methods

The survey was in three parts. Firstly, a survey of the terrestrial vegetation edge using a high precision GNSS (GPS) receiver (Emlid Reach RX, with RTK corrections via SmartNet). The surveyor walked along and recorded points along the edge between the terrestrial vegetation and the (unvegetated) sandy beach. There is an interpretive element to these surveys and ground data is enriched with drone imagery, where the vegetation edge line is drawn between points with added detail from imagery. Discretion was used whether to include or exclude small, isolated small patches (ie islands) of vegetation (often incipient new growth). The survey concentrated on the main seaward edge of vegetation and does not include paths and interior bare patches.

Secondly, a survey of Mean High Water Springs (MHWS) using the same equipment as above. Points along a contour at 2.64mOD was surveyed.

Following permissions secured from ELC and NatureScot a drone survey was also undertaken between the River Esk and Brunstane Burn. Using a Mavic Mini Pro4 with a flying height of 80 mAGL, a series of overlapping vertical images were collected of the upper beach and dune areas. These were converted into an orthomosaic to enhance the vegetation edge survey and provide contextual information. Pre-existing surveys were used, alongside the GNSS survey to geo-rectify the imagery.

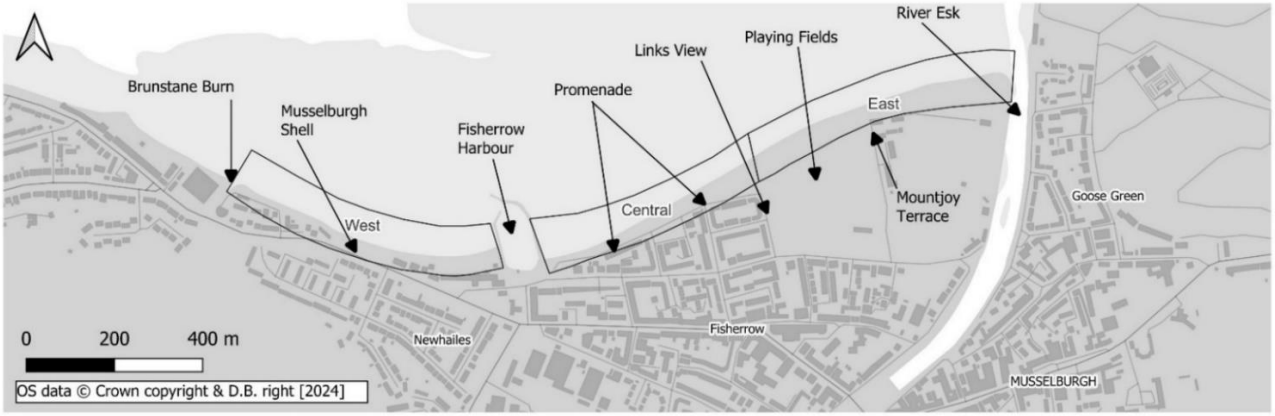

Figure 2: Location map, noting areas and points referred to within the text.

5. Results: Coastal changes between 2023 and 2024

The coast to the west of the harbour has seen modest change, with increased beach levels appearing resulting in a seaward advance of both MHWS and where present the vegetation edge. Table 1 summarizes the average, maximum and minimum changes; with positive values reflecting seaward advance of features (ie accretion) and negative values reflecting landward retreat of features (ie erosion). To the east of the harbour, for the central section, the coast has also shown seen a similar modest seaward movement of both MHWS and vegetation edge, with greatest gains in MHWS and vegetation edge adjacent to the harbour wall (Figure 1). The eastern section (Playing fields to River Esk) has seen more complex changes, generally retreating landwards except for an area localised area adjacent to the prominent beach ridge, where MHWS has moved seawards.

Table 1: Summary of horizontal coastal change amounts between October 2023 and October 2024.

	West	Central	East	All areas
	Brunstane Burn to Harbour	Harbour to Links View (last road before playing fields)	Playing fields to River Esk	West, Central and East
MHWS	Average +2.57m (+4.22 to -1.04m)	Average +2.96m (+7.94 to +0.99m)	Average +1.02m (+24.62 to -8.62m)	Average +2.11m (+24.62 to -8.62 m)
Vegetation Edge	Average +1.11m (+5.6 to +0.04m)	Average +1.18m (+9.76 to -0.22m)	Average -2.64m (+1.16 to -7.17m)	Average -0.39m (+9.76 to -7.17 m)

Figure 3 shows detailed changes to MHWS between October 2023 and October 2024. To the west of the harbour the average change to MHWS is +2.57m over this period. This makes up for much of the losses that occurred during Storm Babet, where an average of -2.89m was lost. The vegetation edge (Figure 4) has also moved seawards with an average change of +1.11m over this period.

In the central section (ie between the east of the harbour and Links View) the MHWS has also advanced seawards, with an average change of +2.96m over this period. This more than makes up for the -0.61m loss that occurred during Storm Babet. At this location the vegetation edge advanced seawards +1.18m, over this period.

Changes along the eastern section of the links (playing field to the Esk mouth) are more variable. Over this period, MHWS has advanced seawards an average of +1.02m, though the greatest gain is 24.6m and the greatest losses of -8.62m (Figure 3). These modest gains sit on top of the small gains observed following Storm Babet where MWHS moved an average of +0.25m seawards, fuelled by losses towards the vegetation edge (See Figures 5 & 9 within earlier report). Where erosion has occurred recently, MHWS now sits landwards of both October 2023 surveys. Within the playing fields the vegetation edge retreated landward an average of -2.64m over the period, masking maximum (seaward) gains of +1.16 and maximum (landward) losses of -7.17m over the period (Figure 4).

Figure 3 Changes to MHWS between October 2023 and October 2024. Points symbolized to reflect coastal change over the preceding year, annotation shown at ca 50m intervals, in metres of change.

Figure 4: Changes to the vegetation edge between October 2023 and October 2024.

6. Discussion

Figure 5 shows more detailed changes, adjacent to the Musselburgh Shell, with the more seaward position of 2024 MHWS (blue line), compared with 2023 MHWS (black line), annotations quantify changes (in metres over this period). The 2024 vegetation edge is also shown (purple dotted line) alongside the 2023 vegetation edge (green dotted line), again with annotations quantifying changes. The location of proposed flood risk management structures is also shown for comparison.

Figure 6 shows more detailed change immediately to the east of the harbour, with the left-hand image showing the post-Storm Babet 2023 air photography, whilst the right-hand image showing the 2024 air photography. The seaward advance of MHWS over the last year is shown (see 7.38m annotation, between the 2024 blue MHWS line and the 2023 black MHWS line). The adjacent vegetation edge changes are of greater magnitude, with ca 10m of advance between the purple dotted 2024 vegetation edge line and the green dotted 2023 vegetation edge line. The bank of seaweed left following Storm Babet in 2023 (see left image), may have provided additional growing medium which has contributed to the isolated patches of vegetation seaward of the 2024 vegetation edge line.

Figure 7 shows more detailed changes, adjacent to Mountjoy Terrace, with the more seaward position of 2024 MHWS (blue line), compared with 2023 MHWS (black line), annotations quantify changes (in metres over this period). The 2024 vegetation edge is also shown (purple dotted line) alongside the 2023 vegetation edge (green dotted line), again with annotations quantifying changes. The proposed location of flood risk management structures is also shown for

comparison. Figure 7 shows the general retreat of the coast along this section, with the localised advance of MHWS associated with the (north-south orientated) beach ridge.

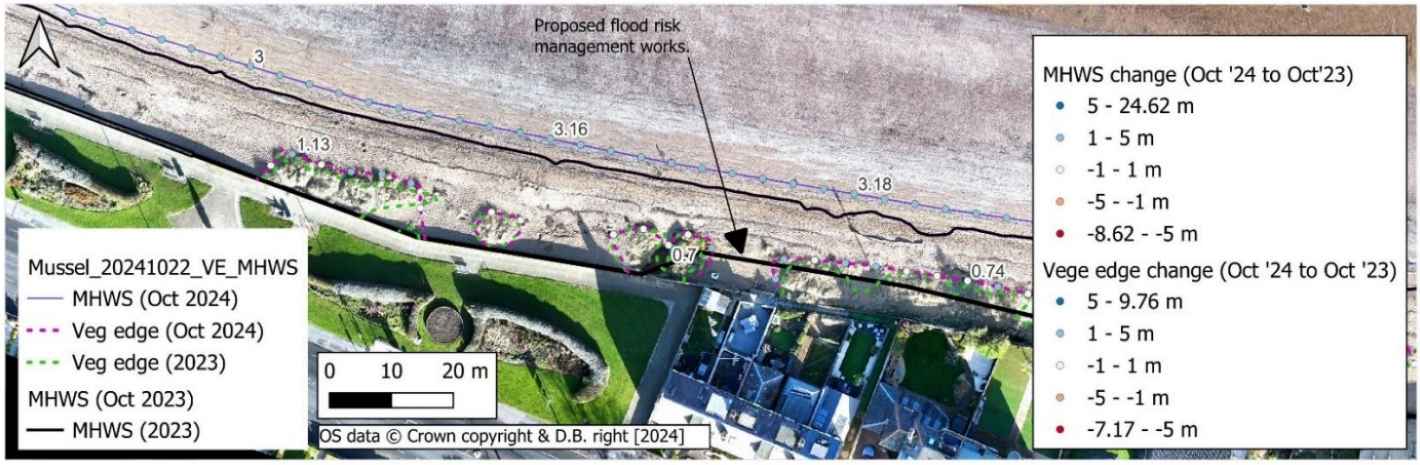

Figure 5: Detailed coastal changes near the Musselburgh Shell, including linework showing proposed flood risk management structures. (Imagery: Dynamic Coast Oct 2024).

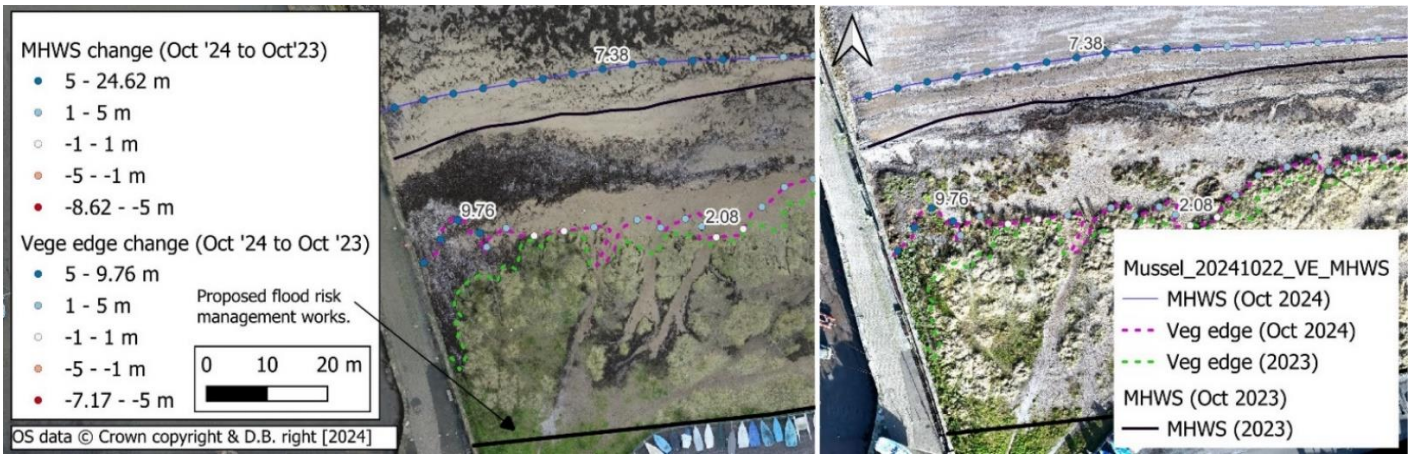

Figure 6: Detailed coastal changes immediately to the east of the harbour, including linework showing proposed flood risk management structures. (Left Image UoG 2023 post Storm Babet. Right image: Dynamic Coast Oct 2024).

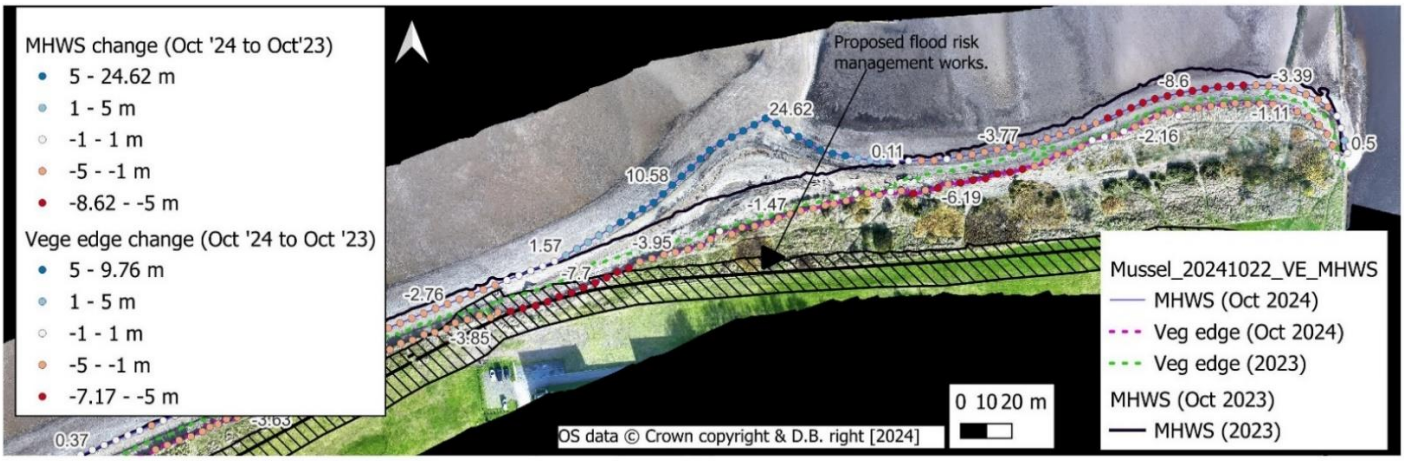

Figure 7: Detailed coastal changes adjacent to Mountjoy Terrace, including linework showing proposed flood risk management structures. (Imagery: Dynamic Coast Oct 2024).

The coastal changes (summarized above) have potential implications for the proposed flood risk management works, being developed by ELC. MHWS is advancing seawards for much of the Musselburgh shore which should be perceived as a 'good thing'. However, the accretion is located on the upper beach (MHWS) and there is little evidence that the crest elevation (further inland that MHWS) is increasing in elevation. It is the crest elevation which ultimately provides greater flood protection. Unfortunately, those areas of earlier erosion, adjacent to Mountjoy Terrace, continue to retreat over the last year.

Nevertheless, these recent changes should be seen in the context of earlier assessments with the current update underlining that coastal erosion remains a key risk to parts of the coast and the proposed flood risk management works. Thus, justification exists for this risk to continue to be considered by the council under its statutory duties. Dynamic Coast's earlier recommendations to address this within ELC's forthcoming Coastal Change Adaptation Plan remain valid.

7. Data

The following data was used in this update.

Date	Name	Original Product Type	Derived products
27th & 31st October 2023 (post Storm Babet)	University of Glasgow	Musselburgh 2 survey Digital Elevation Model (Structure-from Motion)	Digital Elevation Model (Structure-from Motion) Orthomosaic, MHWS contour & Vegetation edge line
22nd October 2024	Dynamic Coast	GNSS points along vegetation edge	Vegetation edge line
22nd October 2024	Dynamic Coast	GNSS points along MHWS	MHWS
22nd October 2024	Dynamic Coast	Drone aerial imagery	Orthomosaic

8. Measurement and other uncertainty

The GNSS receiver collected points with a maximum RMS error of 0.014m; thus, the vegetation edge and MHWS was recorded to centimetre-level accuracy. The orthomosaic was geo-rectified to the University of Glasgow (UoG) LiDAR and aerial survey, the RMS difference between these images was ca 0.08m. The UoG survey was a fully metric survey with extensive ground control points (see earlier Musselburgh report for further details).

ELC staff have confirmed that the Musselburgh beach was subject beach raking by tractor routinely during summer periods at least ten years ago. Whilst staff do not recall a link with erosion, they noted that a minimal amount of sand would have remained stuck to the damp bits of seaweed which was removed from the beach.

The academic literature contains studies that have shown a linkage between beach cleaning and erosion.

There may also be other forms of interventions to the beach and dunes at Musselburgh, which should be noted and considered further (if appropriate) during the CCA Plan.

End