Scotland’s Dynamic Coast: The National Coastal Change Assessment

Jim Hansom (UofG)
James Fitton (UofG)
Alistair Rennie (SNH)

Find out how your coast is changing at www.dynamiccoast.com

[Logos for University of Glasgow, Scottish Natural Heritage, and Scottish Government]
1. Introduction to Scottish Coast
   – Why is understanding coastal change important in Scotland?

2. What is the NCCA

3. Methods

4. Results and Outcomes

5. Conclusions
Scottish coastal assets

Population

• 20% of the Scottish population live within 1 km of the coast (1 million)

• ~12% of European coast (Pranzini and Williams 2013)

• Highly variable: resilience & assets
Most Scottish beach and dune coasts display chronic erosion: East coast .....Montrose
So what drives coastal erosion?

- Sea level rise
- Enhanced storm impact
- Reduced sediment supply
- Increased “management”
### Wave height (Hs) Increase rate Season Period Source

<table>
<thead>
<tr>
<th>Region</th>
<th>Increase Rate</th>
<th>Season</th>
<th>Period</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE Atlantic</td>
<td>0.022 m/yr</td>
<td>Annual</td>
<td>1960-90</td>
<td>Bacon &amp; Carter, 1991</td>
</tr>
<tr>
<td>NE Atlantic</td>
<td>0.027 m/yr</td>
<td>Annual</td>
<td>1960-88</td>
<td>Bouws et al., 1996</td>
</tr>
<tr>
<td>NE Atlantic</td>
<td>0.025 m/yr (min)</td>
<td>Annual</td>
<td>1955-94</td>
<td>Gunther et al., 1998</td>
</tr>
<tr>
<td>NW Atlantic</td>
<td>0.023 m/yr</td>
<td>Annual</td>
<td>1960-88</td>
<td>Bouws et al., 1996</td>
</tr>
<tr>
<td>NW Atlantic</td>
<td>0.024 m/yr</td>
<td>Annual</td>
<td>1976-06</td>
<td>Komar et al., 2010</td>
</tr>
<tr>
<td>NW Atlantic</td>
<td>0.032 m/yr</td>
<td>Winter</td>
<td>1976-06</td>
<td>Komar et al., 2010</td>
</tr>
<tr>
<td>NW Atlantic (Hurricanes)</td>
<td>0.277 m/yr</td>
<td>Summer</td>
<td>1996-05</td>
<td>Allen &amp; Komar, 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>33%inc =7.5-10m</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Table shows trend in Hs (highest 33% of all waves) Maximum wave height (Hmax) is higher than Hs.
GMSL Rates

CU: 3.2 ± 0.4 mm/yr
AVISO: 3.2 ± 0.6 mm/yr
CSIRO: 3.1 ± 0.4 mm/yr
NOAA: 3.2 ± 0.4 mm/yr

1-1.5mm/yr historically 1880-1980
Why is understanding Coastal Processes and Dynamics important?

Is sediment supply an issue?

Kirkibost/Baleshare HWM/LWM migration 1881-1971

Hansom & McGlashan, 2004 Scotland’s coast: understanding past and present processes for sustainable management, SGJ
Hansom, 2010 Coastal Steepening in Scotland, SNH Report
Is management an issue?

Rip rap wall, Nov 2012
Golspie, Sutherland

Rip rap wall, Jan 2013
Golspie, Sutherland

Unsustainable to elevate sea walls \textit{ad infinitum} except for key infrastructure (eg Grangemouth)
Many organisations have an obligation to incorporate coastal erosion within their statutory advice. Yet there is no centralised national dataset on coastal erosion – no single organisation has responsibility.

Part of this is due to the devolved nature of erosion, where it is the responsibility of the landowner. The LA normally intervenes when there is a flooding concern. This means the LA may be aware of issues, but there is no national oversight.

Any organisation will struggle to objectively appraise the risk coastal erosion poses to its own interests, let alone collaborate with others.
UK CCRA (2012) noted this as an evidence gap in Scotland:

‘Maps of past erosion, current state and future erosion conditions are required.’


- Large parts of the Scottish coast have no Shoreline Management Plan
Sea levels are rising across Scotland and this is already leading to increased flood occurrences. e.g. Aberdeen, Millport and Stornoway. Ball T, Werrity A, Duck RW, Edwards A, Booth L & Black AR. (2008)

Coastal flood risk in Scotland is expected to grow most rapidly in the coming decades. Estimated increase in total properties at risk for a 10% AP flood:

<table>
<thead>
<tr>
<th>10% AP (10yr)</th>
<th>Fluvial</th>
<th>Coastal</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current estimates</td>
<td>15,420</td>
<td>4,121</td>
<td>9,672</td>
</tr>
<tr>
<td>2035 estimates</td>
<td>18,456</td>
<td>6,107</td>
<td>12,052</td>
</tr>
<tr>
<td>Increase</td>
<td>3,036</td>
<td>1,986</td>
<td>2,380</td>
</tr>
<tr>
<td>% increase</td>
<td>19.7%</td>
<td>48.2%</td>
<td>24.6%</td>
</tr>
</tbody>
</table>

And this **excludes** erosion exacerbated flooding. SG & JBA (2014)
A major policy-driven pan-government research project collating data and information on historic and future coastal change.

NCCA has/will:

• Undertake a quality assessment on existing data
• Establish the past changes along Scotland's coastline
• Extrapolate the historic change into the future
• Undertake an initial assessment of societies' interests within these areas (road, railways, houses etc.)
• Review national and regional coastal policies

Enable Strategic Planning
50+ organisations are involved in the development of the project, and will also have access to the outputs.
Who is involved?

Aberdeen City Council  
Aberdeenshire Council  
Adaptation Scotland  
Angus Council  
Argyll and Bute Council  
BGS  
Clackmannanshire Council  
Clyde Forum  
CnES  
CREW  
Crown Estates  
Dept of Envi, NI  
Dumfries & Galloway Council  
Dundee City Council  
East Lothian Council  
Edinburgh City Council  
Falkirk Council  
Fife Council  
FCERM.net  
Forth Estuary Forum  
Glasgow City Council  
Herriot Watt University  
Highland Council  
Historic Scotland  
Inverclyde Council  
Keep Scotland Beautiful  
Marine Scotland  
MoD  
Moray Firth Partnership  
Moray Council  
N.Ayrshire Council  
National Library of Scotland  
Orkney Islands Council  
Ordnance Survey  
Perth and Kinross Council  
RCAHMS  
Renfrewshire Council  
RSPB  
S.Ayrshire Council  
Scottish Borders Council  
Scottish Coastal Forum  
Scottish Government  
SEPA  
Scottish Golf Environment Group  
Scottish Golf Union  
Shetland Islands Council  
SNH  
Solway Firth Partnership  
St Andrews University  
Stirling Council  
Transport Scotland  
University of Glasgow  
West Dunbartonshire Council  
West Lothian Council

Funded by
Scotland’s centre of expertise for waters
1890s OS Second Edition Country Series Maps

1970s OS 1:10,000

Current MHWS (derived from LiDAR/Aerial Photography)
NCCA Methods – Historic Change

- **1890s** OS Second Edition Country Series Maps
- **1970s** OS 1:10,000
- **Current MHWS** (derived from LiDAR/Aerial Photography)

- Calculate the change rate between these lines (distance/time)
Use of OS MasterMap data

'current coastline'
National Mapping agency

2009 Aerial Imagery

Scot Gov Lidar (2011-12)

160m accretion
The NCCA has established...

- Scotland’s coastline is **21,234 km** long
- **4,434 km** is soft / erodible
- SG LiDAR covers **1,710 km** of MHWS & will be used to update MHWS
- This leaves **2,724 km** which was checked to ensure it’s accuracy
- Of this **2,297 km (84%)** was found to be representative
- **427 km (16%)** needed revision
- **120 km** updated using OS supplied DSMs
- **307 km** needs to be updated in the future

(all measured on OS MasterMap)
Fife – 1890s to 1970s
### Fife Statistics

**1890s to 1970s**

<table>
<thead>
<tr>
<th>Fife Character</th>
<th>Length (km)</th>
<th>Length (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard &amp; Mixed</td>
<td>74.1</td>
<td>33.9</td>
</tr>
<tr>
<td>Artificial</td>
<td>88.8</td>
<td>40.7</td>
</tr>
<tr>
<td>Soft</td>
<td>55.5</td>
<td>25.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>218.4</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### 1970s to 2010s

<table>
<thead>
<tr>
<th>Fife Character</th>
<th>Length (km)</th>
<th>Length (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard &amp; Mixed</td>
<td>77.2</td>
<td>34.1</td>
</tr>
<tr>
<td>Artificial</td>
<td>87.4</td>
<td>38.6</td>
</tr>
<tr>
<td>Soft</td>
<td>61.8</td>
<td>27.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>226.4</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Max Soft Advance (m)** 537 North Tentsmuir

**Average Soft Change (m)** 25

**Max Soft Retreat (m)** 556 South Tentsmuir

**Max Soft Advance (m)** 386 North Tentsmuir

**Average Soft Change (m)** 21

**Max Soft Retreat (m)** 196 North Tentsmuir
Improving the evidence base (Montrose)

NCCA overlaid with Angus SMP

• Supporting a policy led approach to coastal management (better than reactive approach) thus supporting the LA as Coastal Protection Authorities

• Also informing Scottish Planning Policy, Flood Risk Management Strategies, Local Development Plans, Climate Change Adaptation Programme, National & Regional Marine Plans etc
Change between 1984 and 2011
Change between 1991 and 2011
Interim results available online...

www.dynamiccoast.com
The future coast?

Future coast: 25 years (i.e. 25 x past rate)

Future coast will be amended by CESM.
Coastal Erosion Susceptibility Model (CESM)
Do we have the data to identify assets impacted by coastal erosion and target our responses? Can we model erosion susceptibility and vulnerability?

**Table 8: Potential scores achieved when the four data layers of the UPSM are aggregated.**

<table>
<thead>
<tr>
<th>Weighting</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most susceptible</td>
<td>Least susceptible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevation (mAOD)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Rockhead (mAOD)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Distance to open coast (m)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Wave Exposure</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Aggregate Score</td>
<td>17.5</td>
<td>14</td>
<td>10.5</td>
<td>7</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Hansom, Fitton, & Rennie, 2013. Consideration of the impacts of coastal erosion in flood risk management appraisals. CREW/SEPA Stage 1, 2, GIS. 56 + 63pp.
Adding coastal defences and natural accretion reduces susceptibility and generates a national coastal erosion model that links to flooding.

Model now part of SEPAs national coastal flood and erosion risk online maps.
Hansom, Fitton, & Rennie, 2013. Consideration of the impacts of coastal erosion in flood risk management appraisals. CREW/SEPA Stage 1, 2, GIS. 56 + 63pp.
The NCCA pan-government project has classified Scotland’s erodible coast for the first time. The project is due to finish in September 2016.

It will inform statutory advice across Agencies and Local Authorities alike in support of their strategic planning individually, but also collaboratively, thereby supporting the SG Climate Change Adaptation Programme.

It will inform areas where erosion may influence flood risk – currently not identified within flood mapping.

It has prompted the first checking & update of MHWS since the 1970s, and has ensured that the OS can, and will, maintain this in the future.

The NCCA has prompted the OS into revisions to their coastal mapping methods pan-UK.