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Scotland's National Coastal Change Assessment

Dr Alistair Rennie[1], Prof Jim Hanson[2] & Dr James Fitton[2]
([1] SG / SNH , [2] University of Glasgow)

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Scotland's National Coastal Change Assessment

Workshop for Local Authorities

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Introduction to the workshop

Dr Alistair Rennie
SNH & SG

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Introduction

You’re here because of an interest in coastal erosion, but let me start with two paradoxes:

- Many organizations have an obligation to incorporate coastal erosion into our work, but until now there have been no centralized datasets. How are we to be proactive or collaborate on these shared issues?
- “Coasts are dynamic” yet the datasets we’d use to establish this are not updated as often as we believe…. Or in some cases not updated in my lifetime!

Introduction

Whilst there are similarities with flooding maps, we've developed the NCCA in 21 months with less than three full-time staff.

We're having this workshop, not because it is perfect and finished, but because we hope you'll use the NCCA and we want your thoughts to finish it. **The NCCA is for you after all.**

Also bear in mind that this is the first coastal resilience and vulnerability assessment at a national-level.

We are already planning improvements to further strengthen and refine our understanding of Scotland's coastal resilience and vulnerability.

Introduction – who's involved?

Debi Garft: Flooding & Coastal Erosion Policy Lead for Scottish Government

Alistair Rennie: Project Manager, Scottish Government Placement at SNH

Jim Hansom: Principal Investigator, University of Glasgow

James Fitton: Secondary Investigator, University of Glasgow

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Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

University of Glasgow

Steering Group:

Alan Corbett (Scottish Government), **Kat Ball** (SEPA), **Mairi Davies** (HES), **Joseph Hagg** (Adaptation Scotland), **Tracy McNicol** (Marine Scotland), **Nicholas Williamson** (Fife Council), **Tom Dawson** (University of St Andrews), **Duncan Moss** & **Dominic Cuthbert** (Ordnance Survey)

Funded via: Crew (**Jannette MacDonald** & **Emily Hastings**)

Support from National Library of Scotland & **Chris Fleet**.

crew
Scotland's centre of expertise for waters

Introduction

Who is involved? You!

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 Environment 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
Renfrewshire Council
RSPB
S. Ayrshire Council
Scottish Borders Council
Scottish Coastal Forum
Scottish Government
Scottish Water
SEPA
Scottish Golf Environment Group
Scottish Golf Union
Scottish Coastal Forum
Shetland Islands Council
SNH
Solway Firth Partnership
St Andrews University
Stirling Council
Transport Scotland
University of Glasgow
West Dunbartonshire Council
West Lothian Council

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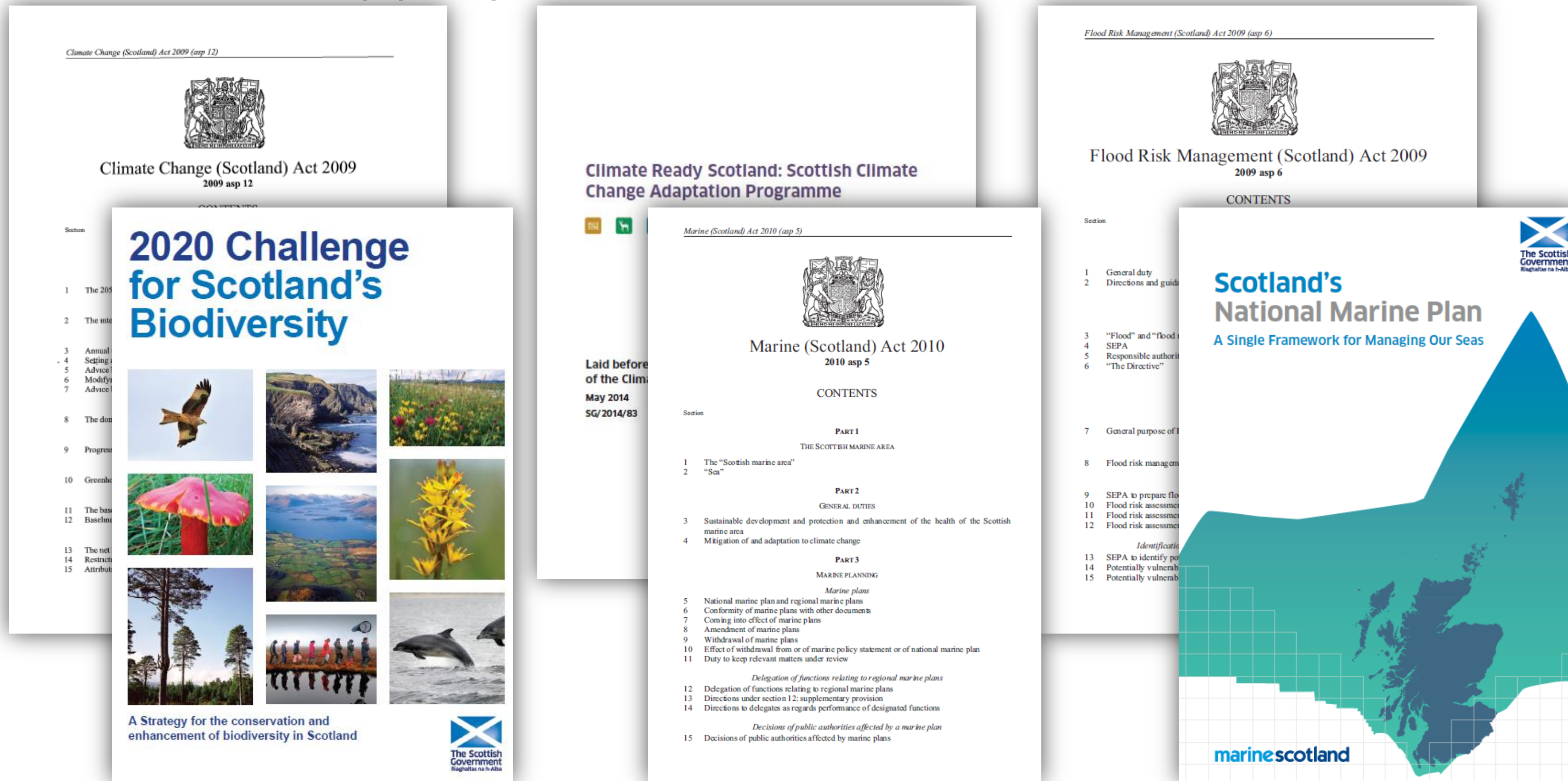
Policy Context

Dr Alistair Rennie
SNH & SG

Montrose

Policy Drivers

What are the key policy drivers for the work?



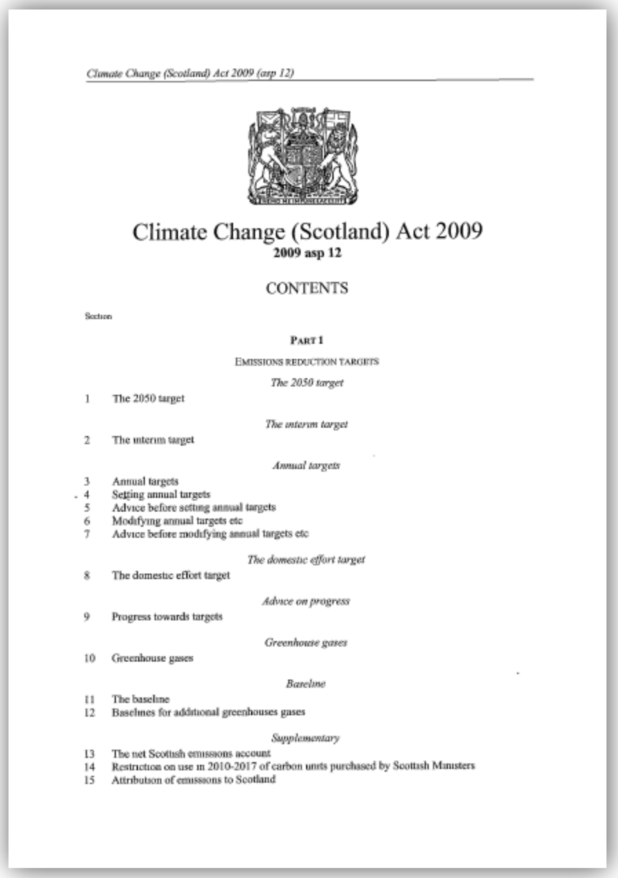
The implementation of coastal erosion policies may have been historically weak and uneven across the country. BUT the policy intent is clear: erosion is important and needs to be planned for across multiple sectors.

Policy: Climate Change Act

The Climate Change (Scotland) Act 2009 requires Scottish Ministers to develop a Scottish Climate Change Adaptation Programme which addresses the risks identified for Scotland in the UK Climate Change Risk Assessment.

It also places a Duty on Ministers to produce a Land Use Strategy, which outline the achievement of the Scottish Ministers' objectives in relation to adaptation to climate change, (by March 2011 +5yr updates)

Sect 44 places a duties of public bodies relating to climate change. A public body must… act in the way … to help deliver … Adaptation Programmes.



Climate Change (Scotland) Act 2009 (asp 12)

Climate Change (Scotland) Act 2009
2009 asp 12

CONTENTS

Section

PART 1

EMISSIONS REDUCTION TARGETS

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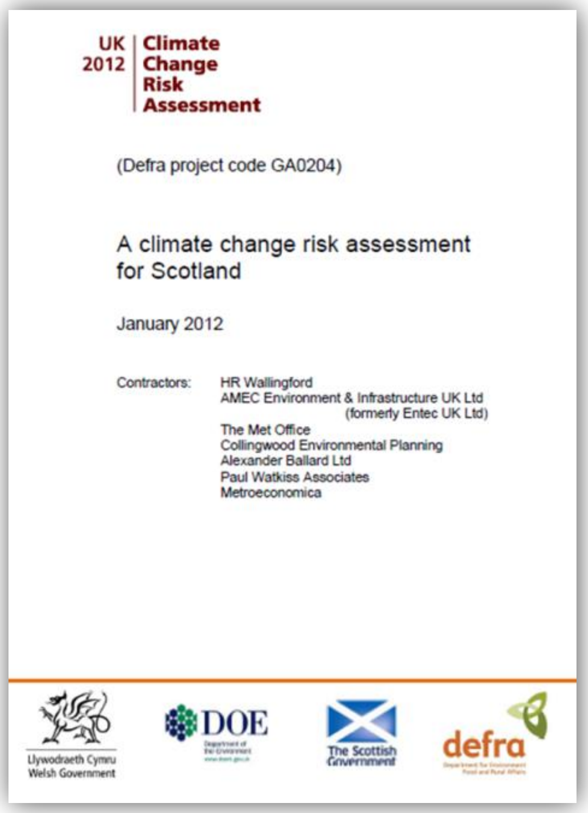
Policy: UK CCRA

UK Climate Change Risk Assessment (Scotland) 2012

anticipates rising sea level, more coastal erosion and associated increases in coastal flooding to increasingly affect Scotland's soft coastlines, its assets and its communities.

It states that maps of past erosion, current state and future erosion conditions are required, along with ecosystem service impacts to be assessed.

'…manage coasts, promoting adaptive coastal management that works with natural processes.'


UK 2012 | Climate Change Risk Assessment

(Defra project code GA0204)

A climate change risk assessment for Scotland

January 2012

Contractors: HR Wallingford
AMEC Environment & Infrastructure UK Ltd (formerly Entec UK Ltd)
The Met Office
Collingwood Environmental Planning
Alexander Ballard Ltd
Paul Watkiss Associates
Metroeconomica

Llywodraeth Cymru Welsh Government
DOE
The Scottish Government
defra

Policy: SCCAP

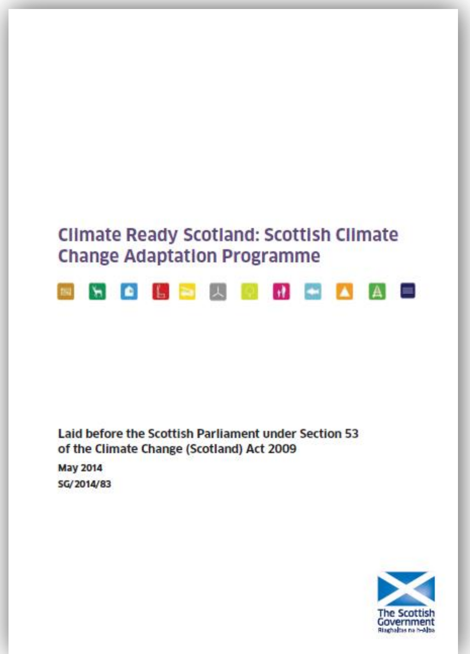
The Scottish Climate Change Adaptation Programme (HES & Partners)

“Map anticipated coastal erosion risk to cultural heritage (B1-2)

Undertake risk assessment to evaluate threat from coastal erosion (B4-2)

Provide advice on sites & property exposed to flooding and coastal erosion…

Reduce flood risk through natural flood risk management (B2-5).”


Climate Ready Scotland: Scottish Climate Change Adaptation Programme

Laid before the Scottish Parliament under Section 53 of the Climate Change (Scotland) Act 2009

May 2014

SG/2014/83

The Scottish Government

Policy: SCCAP

The Scottish Climate Change Adaptation Programme (SNH & Partners)

Identify consequences of CC for protected places and put in place adaptive measures. (N2-4 N2-15)

Marine Plans to ensure development doesn't have an unacceptable effect on coastal processes and flooding. (N2-20)

Assess and manage coasts, promoting adaptive coastal management that works with natural processes: (N2-20)

- *Use the Coastal Erosion Susceptibility Model for Scotland to inform Flood Risk Management Plans and other regional and local plans.**
- *Identify locations where habitats are most vulnerable to coastal erosion and sea level rise.**

** SG, SNH, SEPA, Local Authorities*

Policy: SCCAP

The Scottish Climate Change Adaptation Programme…

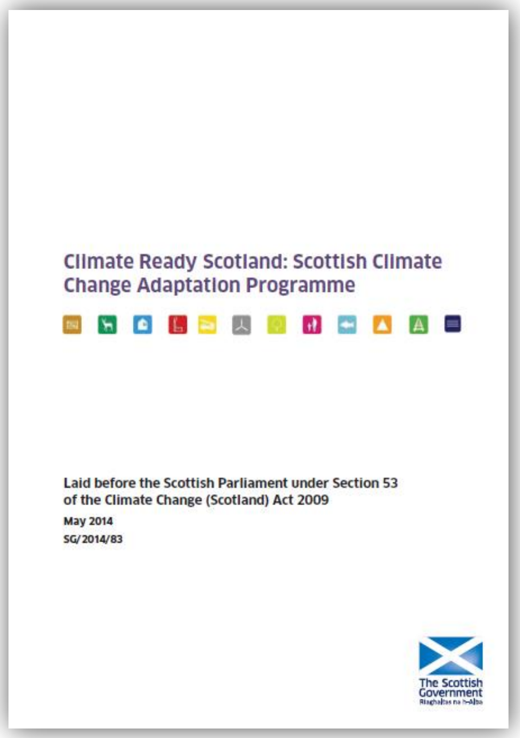
Coastal erosion affects many aspects across the SCCAP:

Communities and supporting infrastructure

Planning.

Consideration of risks within LDPs

NCCA should inform early stages, much like flooding



Policy: UKCCRA2

UK Climate Change Risk Assessment (Scotland) 2017

Ne12: **Risks to habitats and heritage in the coastal zone** from sea-level rise; and **loss of natural flood protection**

Ne5: Risks to natural carbon stores and carbon sequestration

In3: **Risks to infrastructure** services from coastal flooding and **erosion**

PB6**: Risks to the viability of coastal communities from sea level rise**

Bu2: **Risks to business from loss of coastal locations and infrastructure**

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Policy: FRM Act

Flood Risk Management (Scotland) Act

Sect 9: *"SEPA to prepare flood risk assessments …taking into account as far as possible … natural features and characteristics of any … coastal area…"*

Sect 19: "SEPA to prepare maps of artificial structures and natural features … the removal of which … would significantly increase the risk of flooding"

Sect 20: "SEPA to assess possible contribution of alteration etc. of natural features and characteristics of any … coastal area … that could contribute to the management of flood risk …"

…Whilst the Act doesn't use 'erosion' the dynamic characteristic and therefore erosion and accretion is implicit.

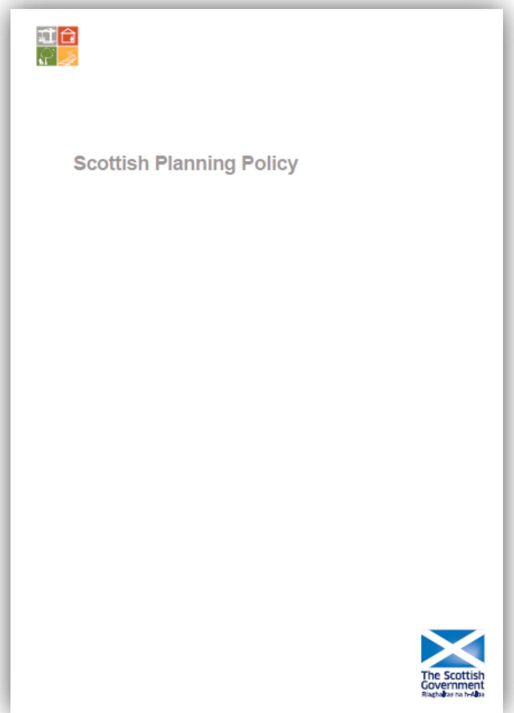
Scottish Planning Policy

"88. Development Plans should recognise rising sea level and extreme weather will potentially have a significant impact and a precautionary approach to flood risk should be taken.

New development should avoid areas of coastal erosion or coastal flooding

Development plans should identify areas at risk and areas where a managed realignment of the coast would be beneficial.

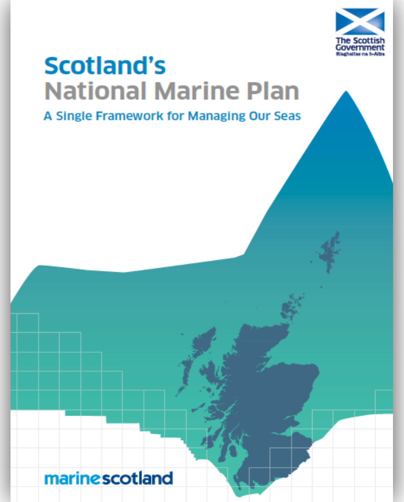
89. Plans should identify .. areas with significant constraints"



Marine (Scotland) Act, National Marine Plan & Regional Plans

GEN 5 Climate change: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.

GEN 8 Coastal process and flooding: Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding.



Regional policy: Regional marine plans should be aligned with terrestrial development plans and reflect coastal areas likely to be suitable for development, taking into account the most recent flood risk and flood hazard maps, and forthcoming coastal erosion vulnerability mapping.

Adaptation: Offshore and coastal developments should be appropriately sited and designed … appropriate now and in the future.

Marine planning authorities…satisfied that adequate risk management and contingency plans are in place, particularly in relation to … changes in sea level rise, storminess and extreme water levels

Reducing human pressure and safeguarding ecosystem services such as natural coastal protection should be considered

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Policy: SBS

Scottish Biodiversity Strategy

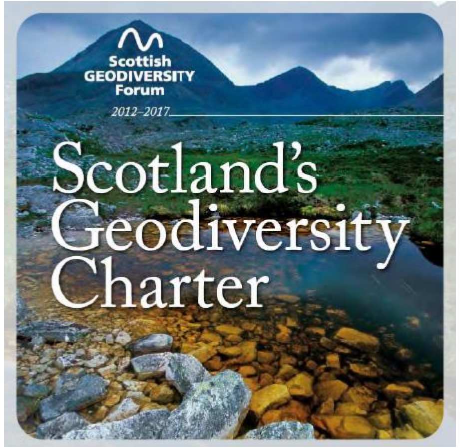
P67. "The Government and its agencies aim to heighten awareness of the role coastal habitats play in providing natural flood protection, erosion control and in supporting distinctive wildlife.

As sea-level rise accelerates, coastal habitats will move inland, except where barriers exist.

We need to plan in advance for coastal adaptation, considering the needs of neighbouring settlements, transport infrastructure and facilities, but also taking account of the valuable protection afforded by coastal habitats and landforms that are allowed to adjust naturally.

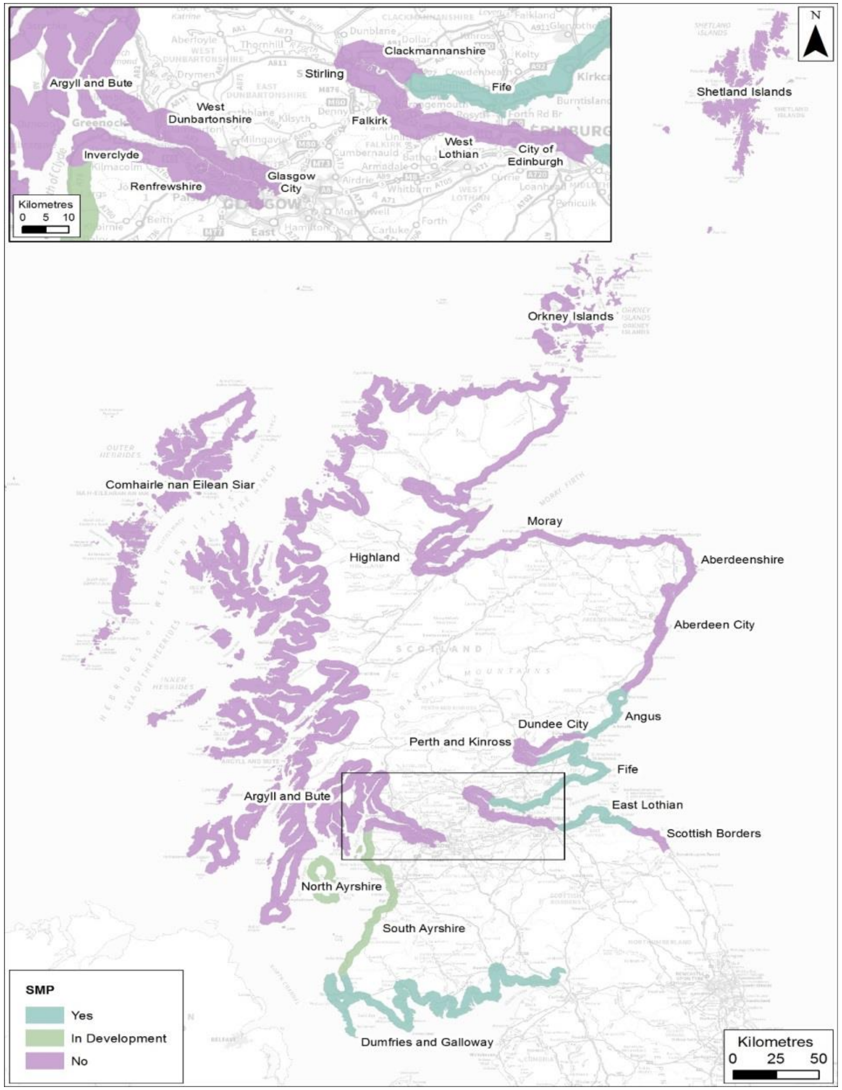
These issues will predominantly be tackled at a local level, through local flood risk management strategies, and will be coordinated at a national level."

This is about valuing our geodiversity (landforms and processes) and thus conforms with 'Scottish Geodiversity Charter'.



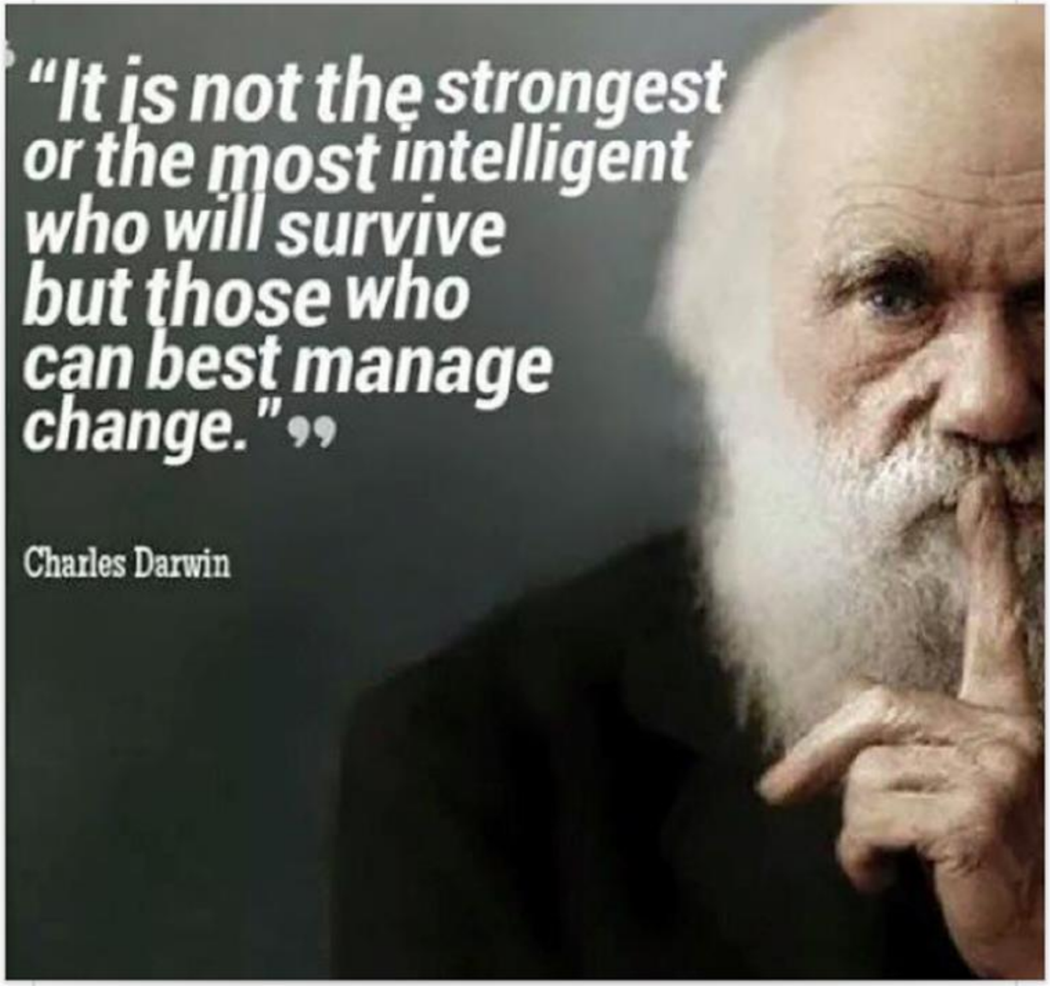
Policy SMPs

Which LA have Shoreline Management Plans?



Policy: Why adaptation?

What lies at the core of these policies?



What is the Aim of the NCCA?

An initial national-level assessment of historical and recent coastal change, to identify society's assets at increased risk from coastal erosion, based on existing nationally available datasets.

This therefore provides strategic overview, NOT a specific prediction at a precise location for a single asset.

Where were we, and where are we now?

- Uncertain how long and dynamic our coast was, what lies behind it, what was safe and what might not be.
- Very varied evidence base largely unavailable from public sector & public… although there are exceptions.
- Little appreciation of practical interaction of erosion and flooding.
- Limited collaboration across public sector in appraising risk, shared adaptation or skill sets.
- No understanding of errors nor agreement on updates for OS products.

Aim

We now know:

- Scotland’s coastline is over 21,000 km long.
- Scotland has 4,000 km of ‘soft’ (ie erodible) coast, about 20% of the total coast.
- 42% of this lies within protected sites for nature conservation
- Of the 4,000 km of soft coast found 17% (463 km) is not shown correctly on OS mapping.
- £1.2bn of residential properties (alone) benefit from the protective function of coastal sediment accretion (8,387 properties)

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East Wemyss

A9 Evanton

Science

Prof. Jim Hansom
University of Glasgow

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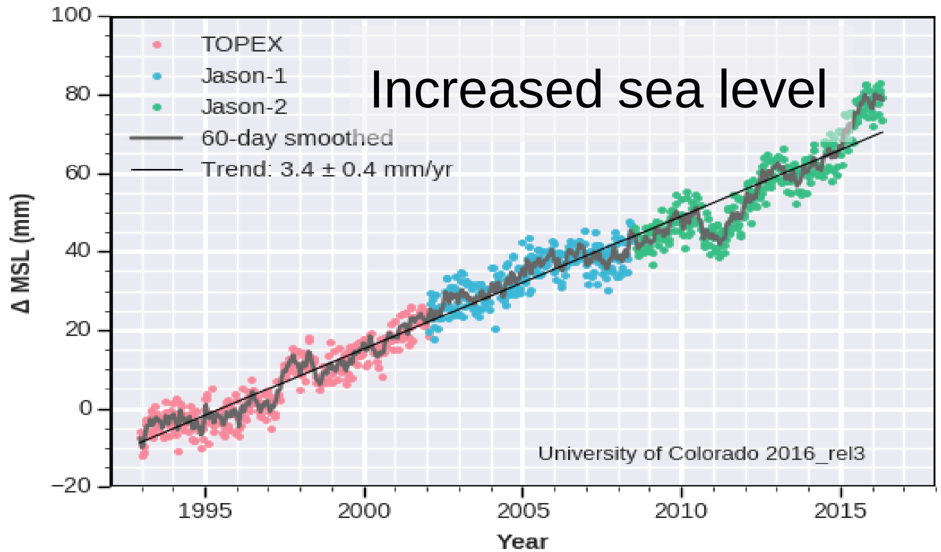
What drives coastal erosion?



Global sea level rise

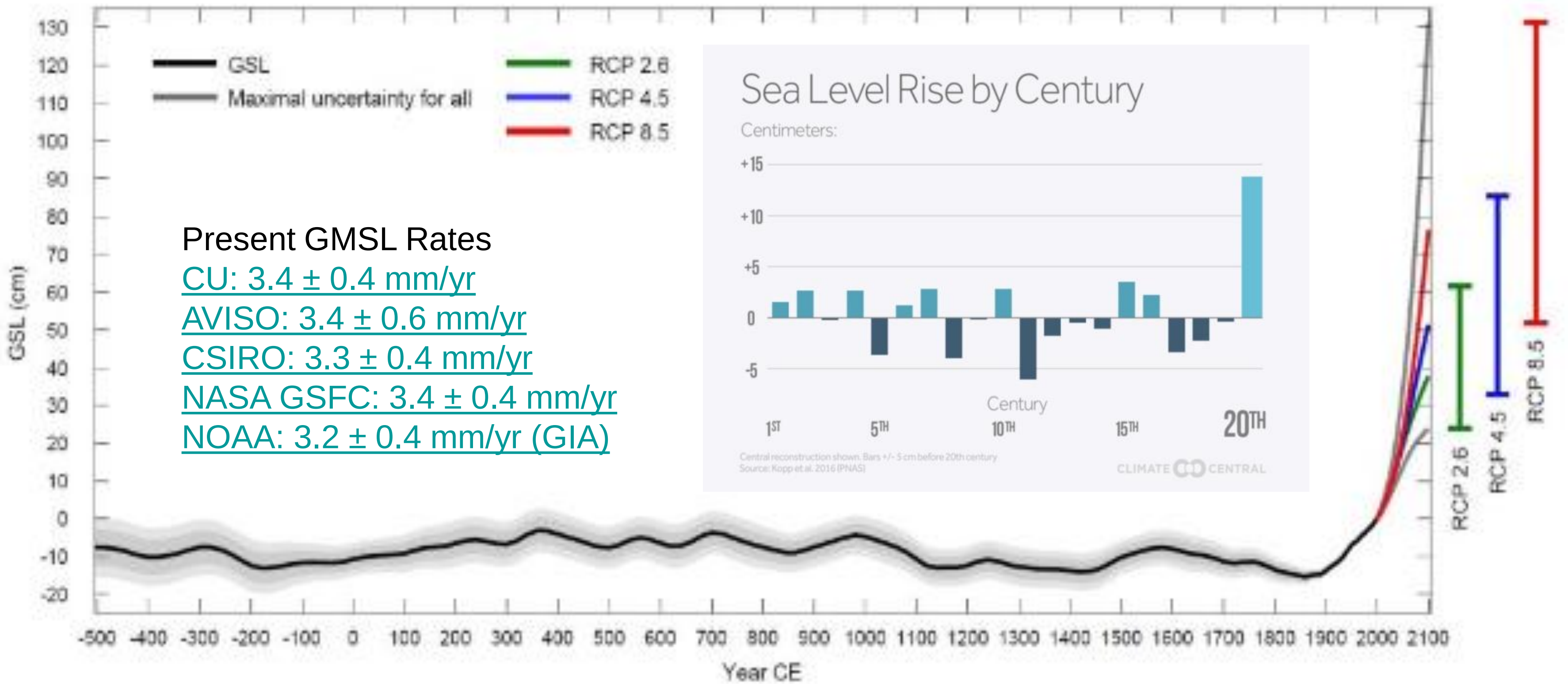
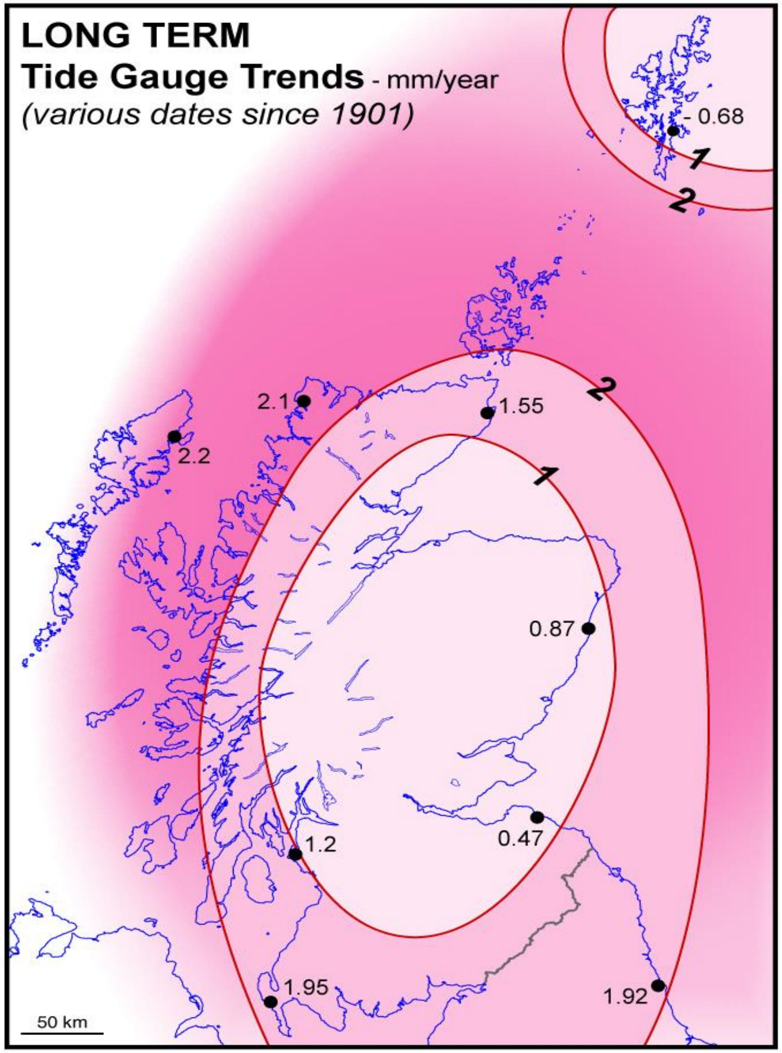


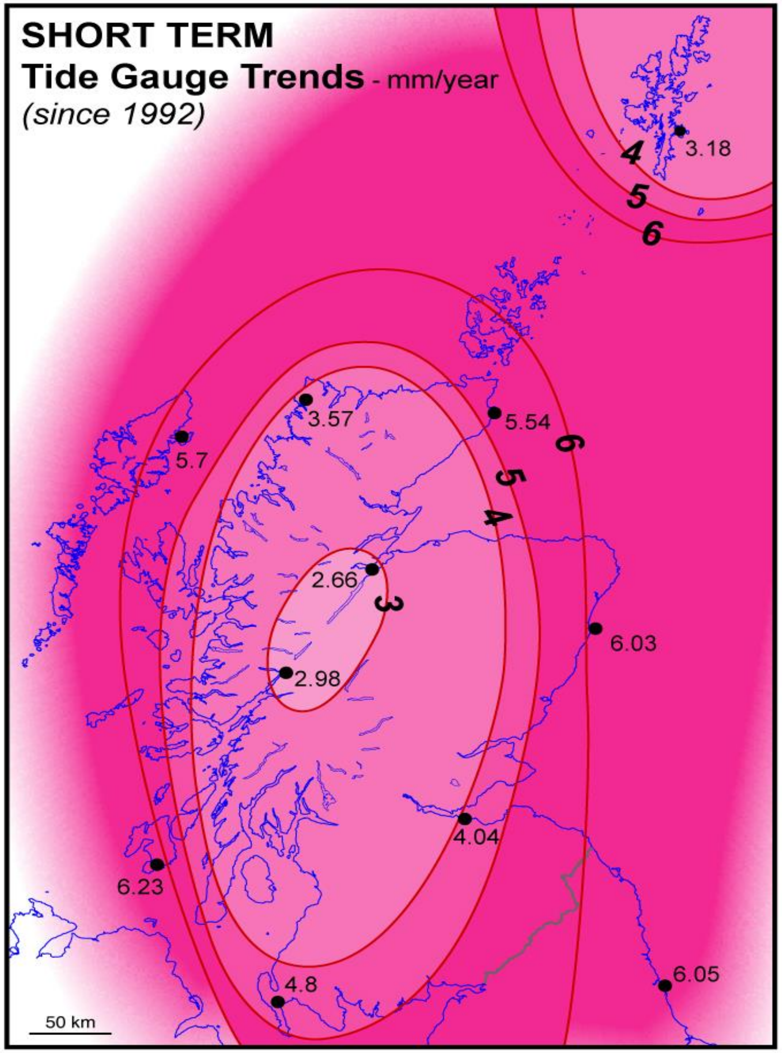
Fig. 3 The last 2500 years of sea level together with the projections of Kopp et al. for the 21st century. Future rise will dwarf natural sea-level variations of previous millennia.

http://www.realclimate.org/index.php/archives/2016/02/millennia-of-sea-level-change/

Sea level rise

Scotland





Rennie & Hansom (2011) *Geomorphology*

Sea level rise

Scotland

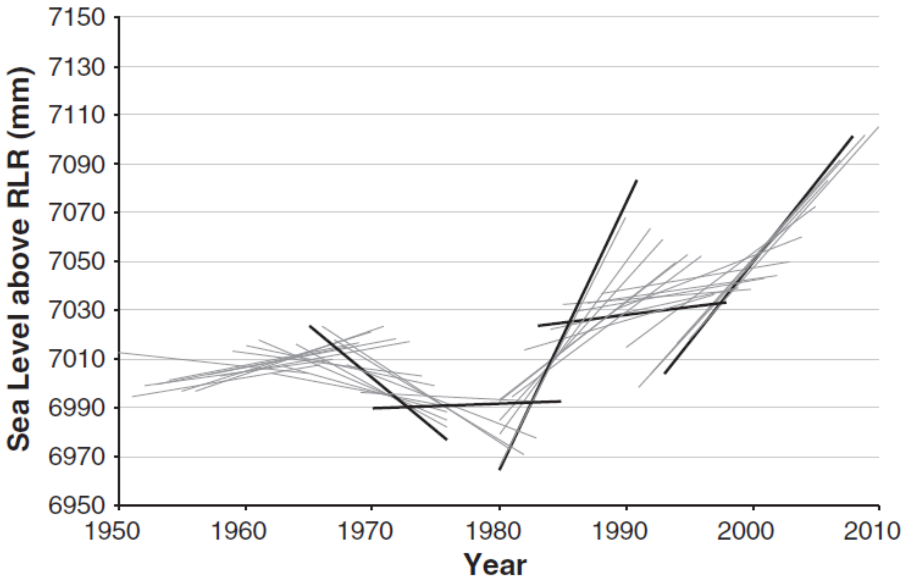
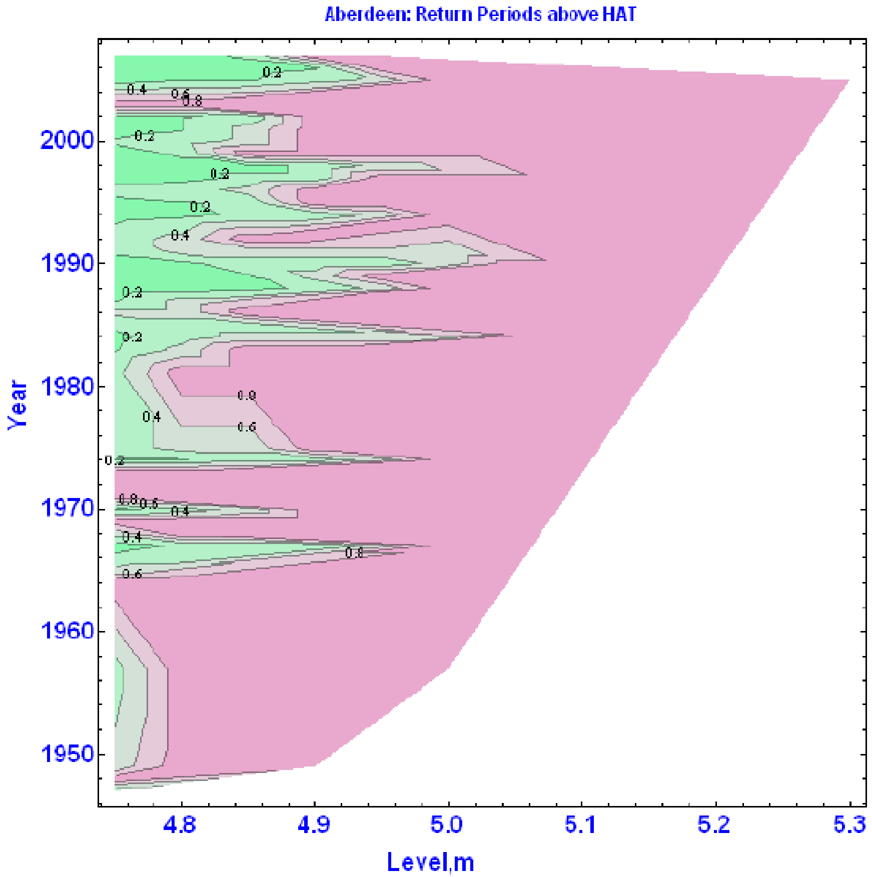


Fig. 1. Observed changes in 15 year sea level trends between 1950 and 2009 from Aberdeen RLR monthly data. All grey lines represent 15 year linear trends with the five black lines highlighting extreme variations in trend. 1966–1969 data are missing and trends beginning or ending in these years have been omitted.



(Ball *et al* 2008)

Sea level change is noisy, but rising across Scotland………

……Leading to increases in coastal flood frequency

Enhanced storm impact

Wave height (Hs)	Increase rate		Season Period	Source
NE Atlantic	2.2 cm/yr		Annual 1960-90	Bacon & Carter, 1991
NE Atlantic	2.7 cm/yr		Annual 1960-88	Bouws et al., 1996
NE Atlantic	2.5 cm/yr (min)		Annual 1955-94	Gunther et al., 1998
NW Atlantic	2.3 cm/yr		Annual 1960-88	Bouws et al., 1996
NW Atlantic	2.4 cm/yr		Annual 1976-06	Komar et al., 2010
NW Atlantic	3.2 cm/yr		Winter 1976-06	Komar et al., 2010
NW Atlantic (Hurricanes)	2.8 cm/yr		Summer 1996-05 33%inc =7.5-10m	Allen & Komar, 2009

Significant wave height increases in N. Atlantic are rising an order of magnitude faster than Mean Sea Level…2-3 cm/yr over last 4 decades….

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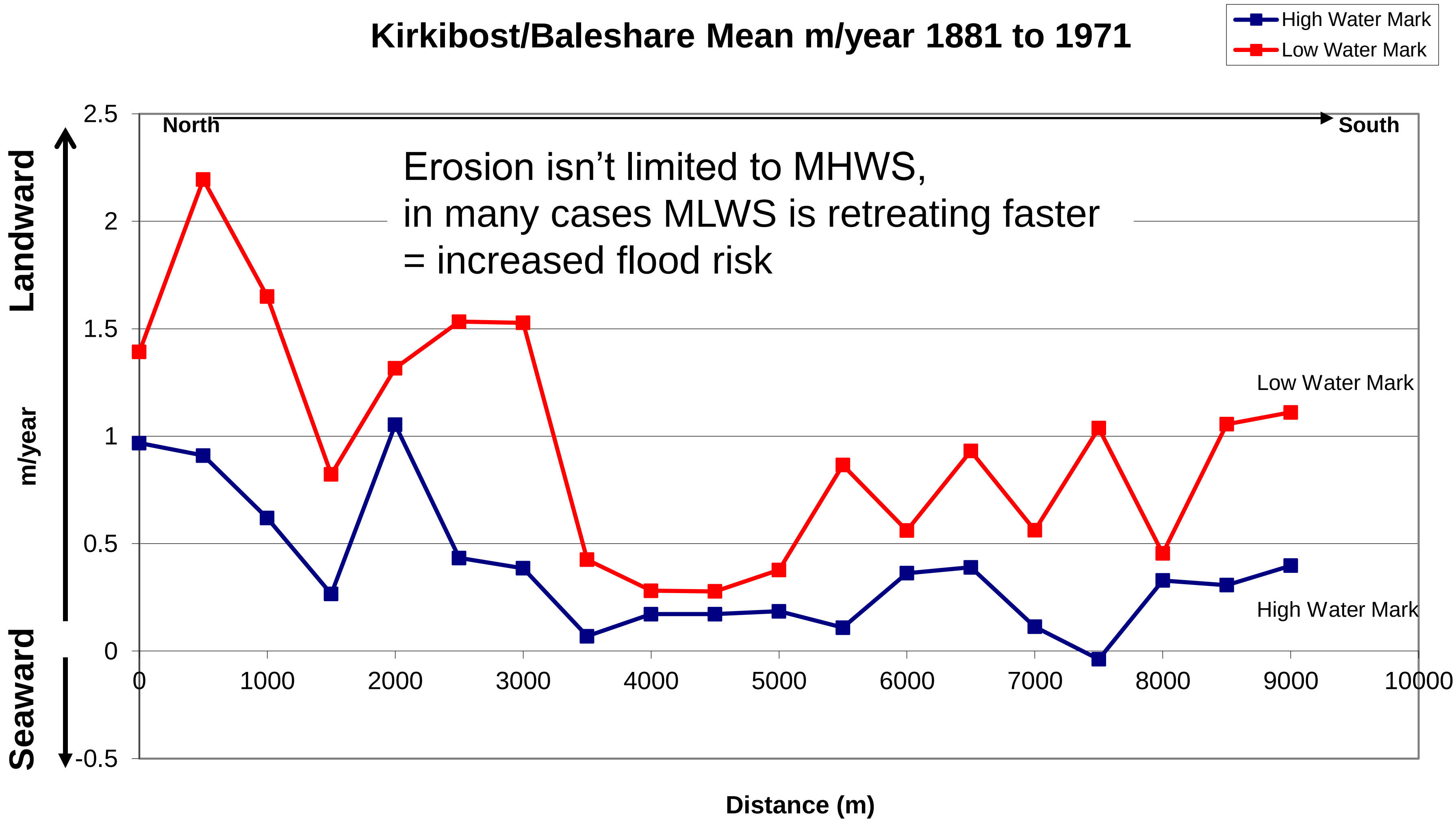
Reduced sediment supply



Reduced sediment supply

Skara Brae, Orkney Isles, 1850: Storm erosion reveals a Late Neolithic village (5,000 BP) originally built well inland behind a dune system and lagoon, both of which have now been lost to frontal erosion.

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More on sediment supply

Sediment supply seen as key to manage shoreline erosion :

1) Coastal sediment cells and Sub-cells identification (HR, 2000).

2) No sediment exchange between major cells.

3) Only limited sediment exchange between sub-cells.

4) So, for example, intervention in cell 1 should not affect sediment supply to cell 2 etc.

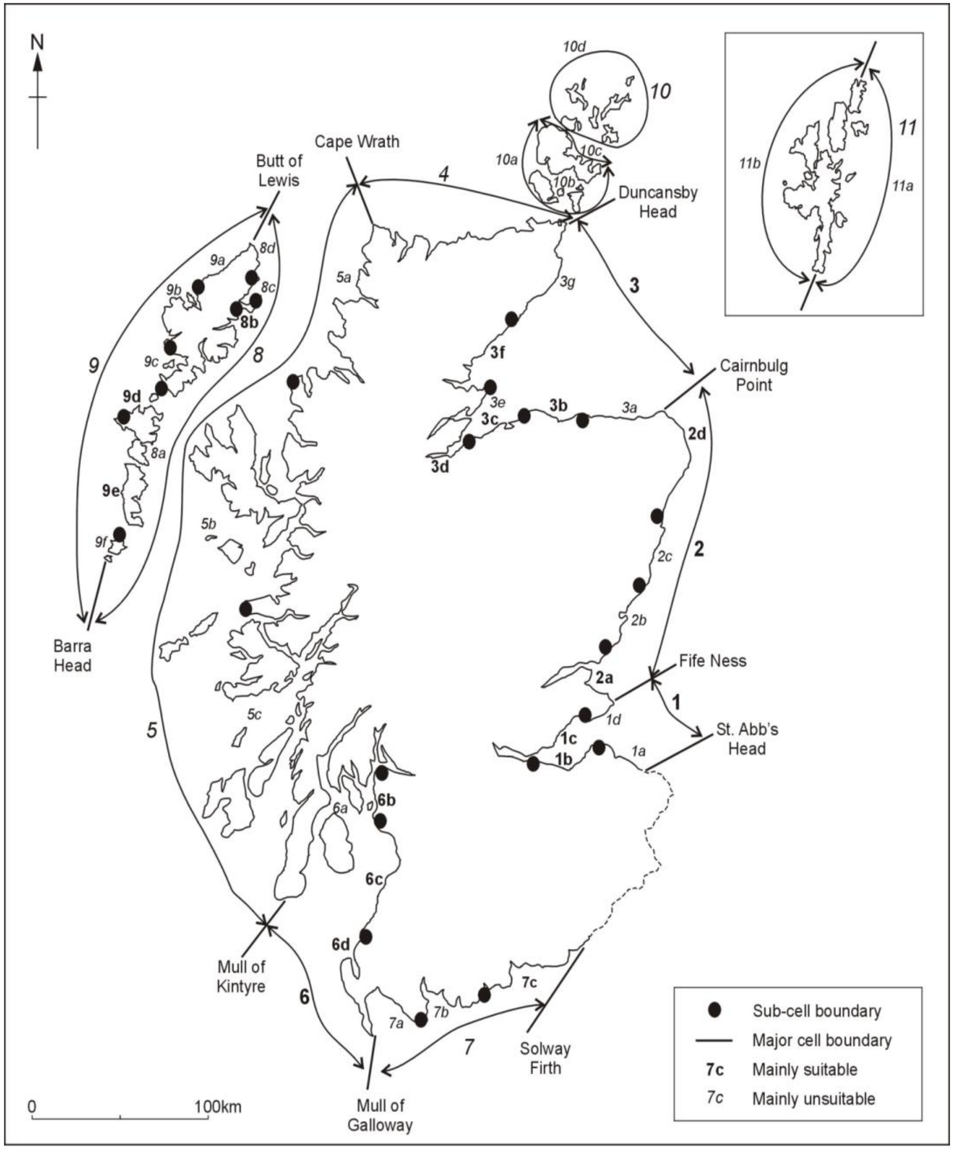

Figure 1. Coastal Cell boundaries of Scotland and their suitability to an SMP-style approach

Increased intervention

Intervention fixes MHWS with 3 effects:

1) Reduces on-site sediment supply and limits beach ability to repair after storms.

2) Causes beach lowering & erosional bights at end of defence.

3) Downdrift beaches progressively starved of sediment and begin to erode.

4) In-combination erosion and flood risk is thus enhanced along coast……………

..And so the process is self-perpetuating

Flooding and erosion

Coastal flooding and erosion are inextricably linked…...

yet our present maps and strategies have neither appreciated nor captured the dynamism of the coast (erosion/accretion) or of the sea (wave overtopping)

NCCA, NCCA2* aims to support this, alongside SEPA's NFRA work.

2012 Golspie Golf Club, c. Unknown

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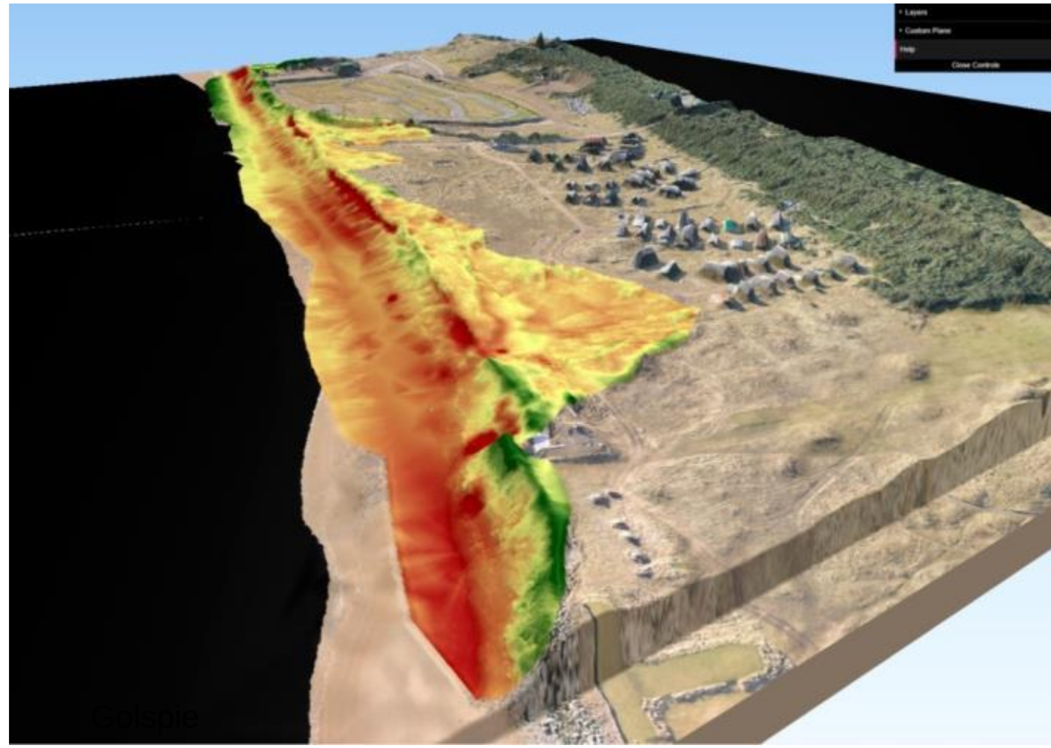
Antecedent conditions

Interdependence between beach health and risk of wave overtopping.

The length of time between storms greatly influences the impact of the subsequent storms.

As sea levels rise, smaller & more frequent storms reach same height as previous larger & less frequent events…..



Golspie Elevation change in metres between Feb 2013 and Oct 2014 (erosion is red, accretion/repairs is green, orange is little change)

So the 1:10 yr storm is expected to become a 1:6 yr storm (at Golspie), due to +5cm MSLR by 2025. So a 10% probability occurrence in any one year becomes a 16% probability.

Antecedent conditions

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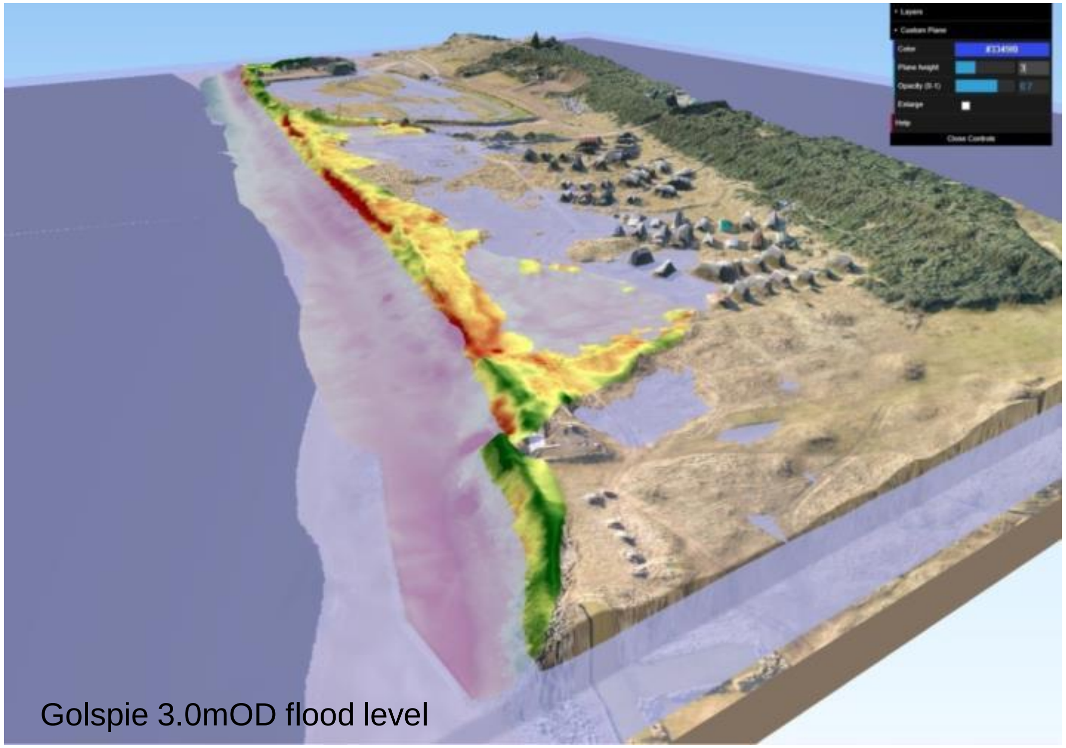
Golspie 3.0mOD flood level

So the 1:10 yr storm is expected to become a 1:6 yr storm (at Golspie), due to +5cm MSLR by 2025. So a 10% probability occurrence in any one year becomes a 16% probability.

Past = Future or ≠ Future?

Past change may not be the same as future change…….

- Accelerating sea level
- Increased frequency of storm erosion and flood events
- Increased intervention, limiting sediment supply
- Negative gradient shores: enhanced impacts

➢ So the past rate is an initial guide, future rates will vary dependent on a range of natural changes and intervention scenarios.

➢ So adopting anything more than known past rates is more open to legal challenge….

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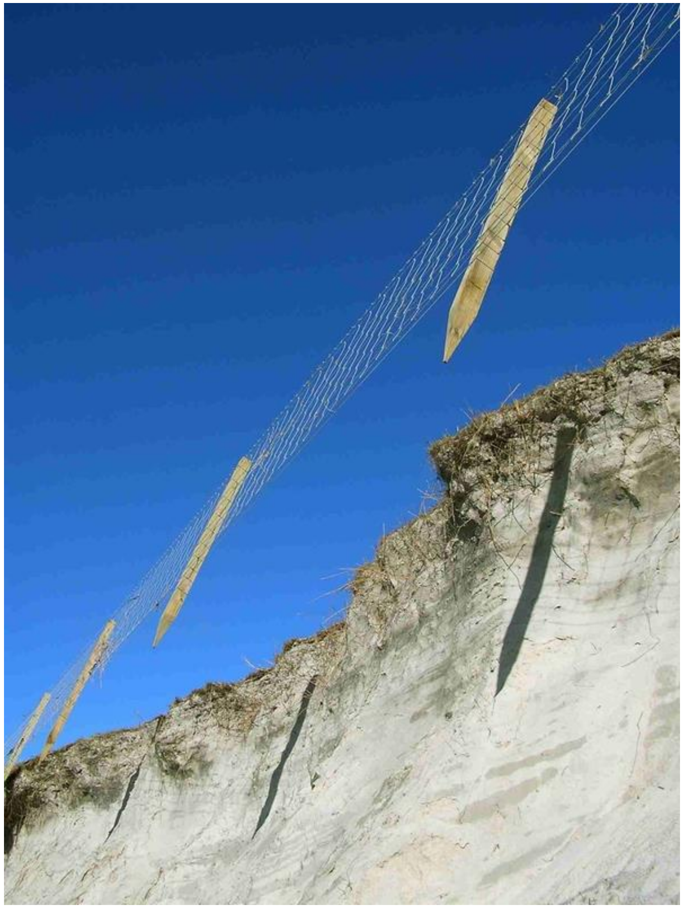


Methods

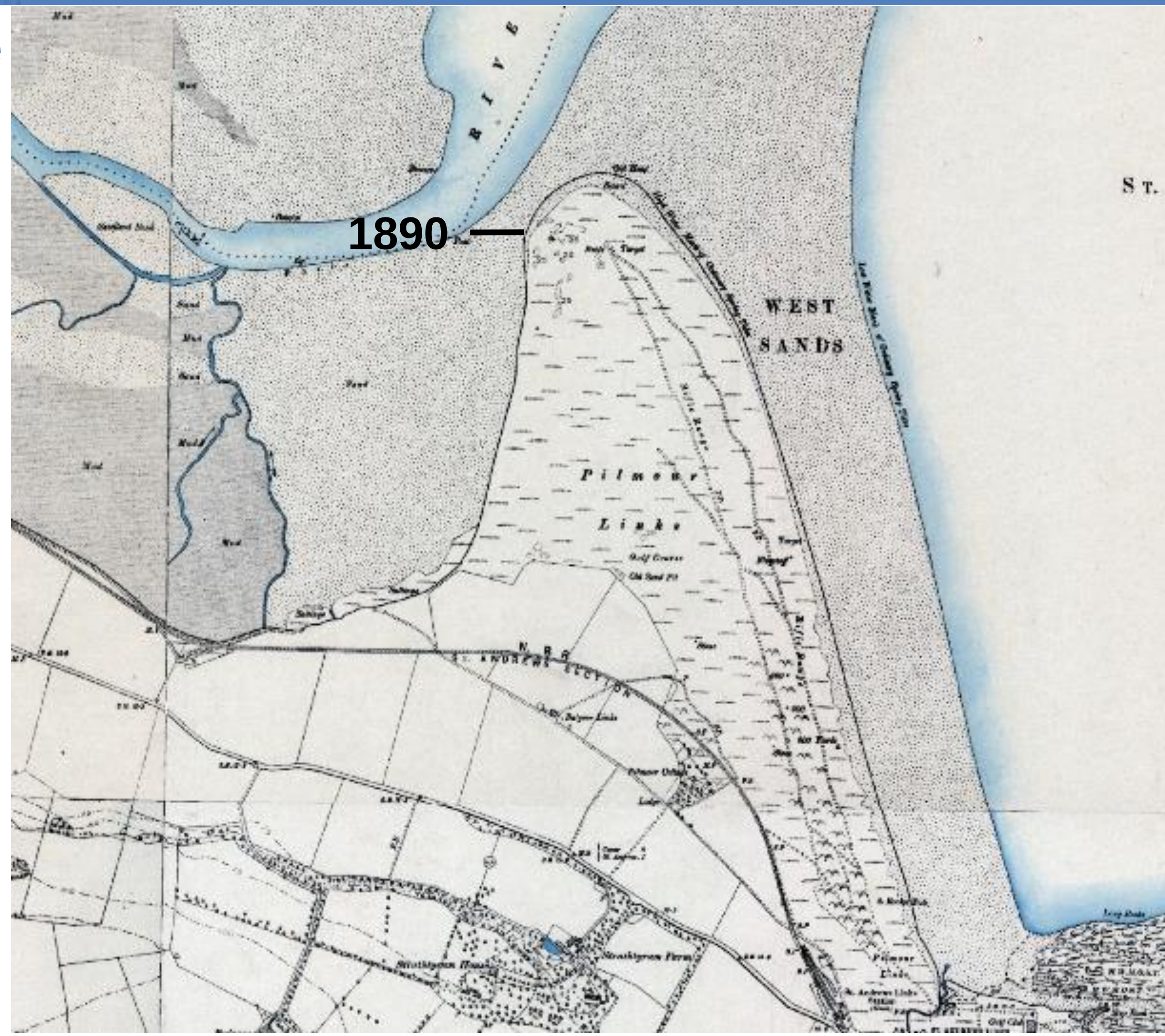
Dr James Fitton
University of Glasgow

South Uist (S.Angus) &
Balivanich, Benbecula

HWMOST & MHWS

Extract tide line & analyze

- 1890s OS 6 Inch Second Edition Country Series Maps (NLS)



HWMOST & MHWS

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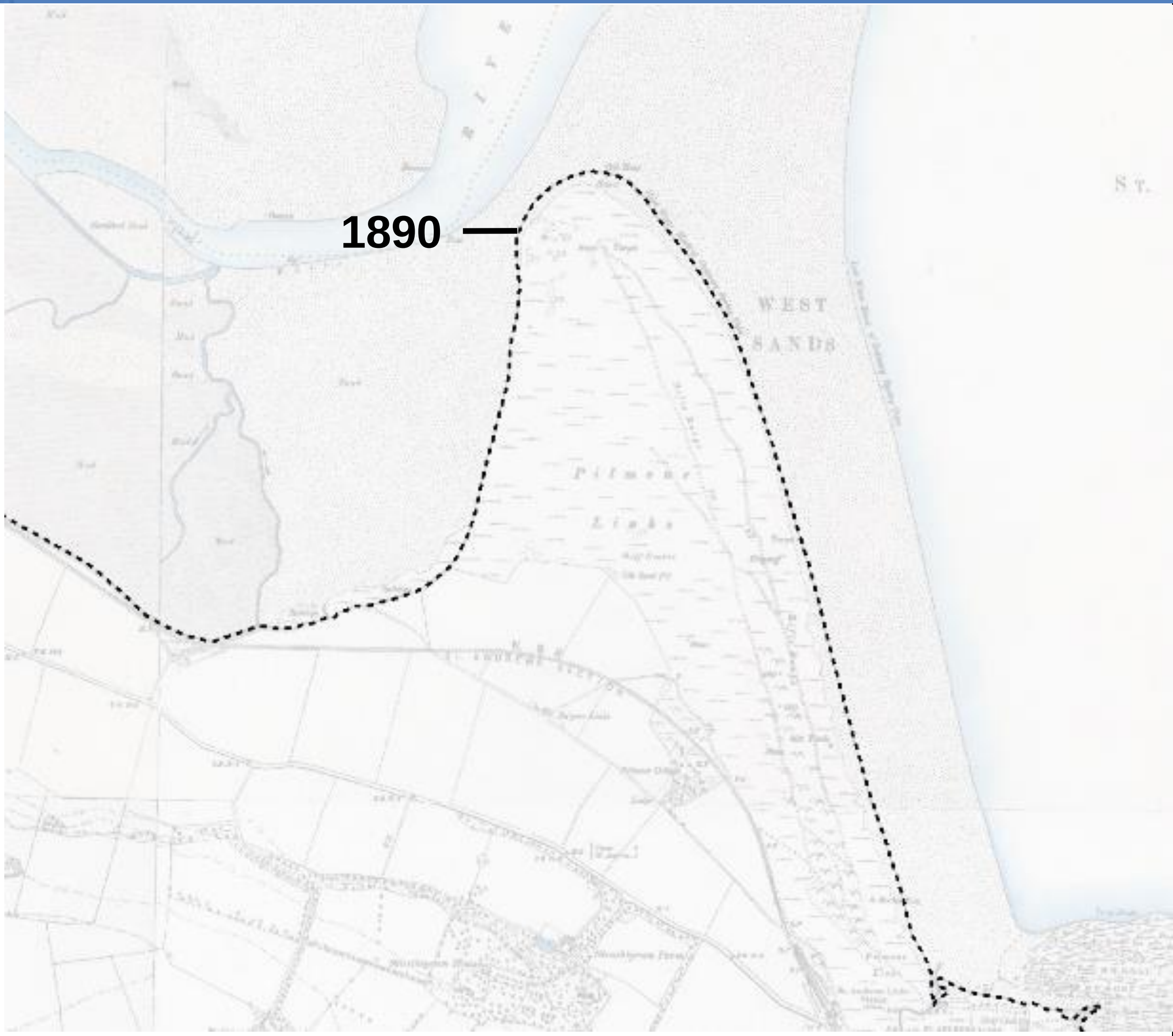

HWMOST & MHWS

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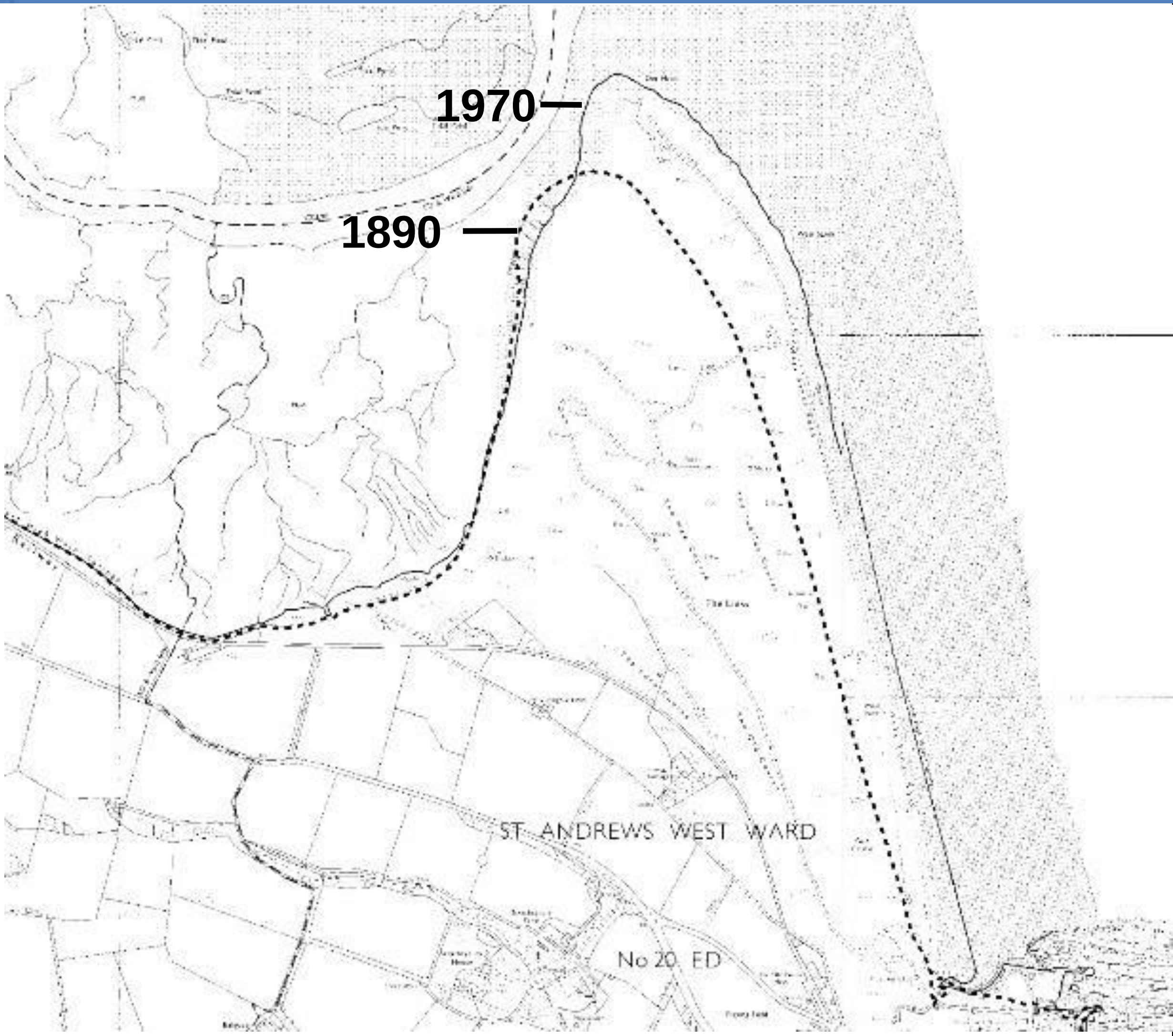
- 1970s OS 1:10,000 (NLS)



HWMOST & MHWS

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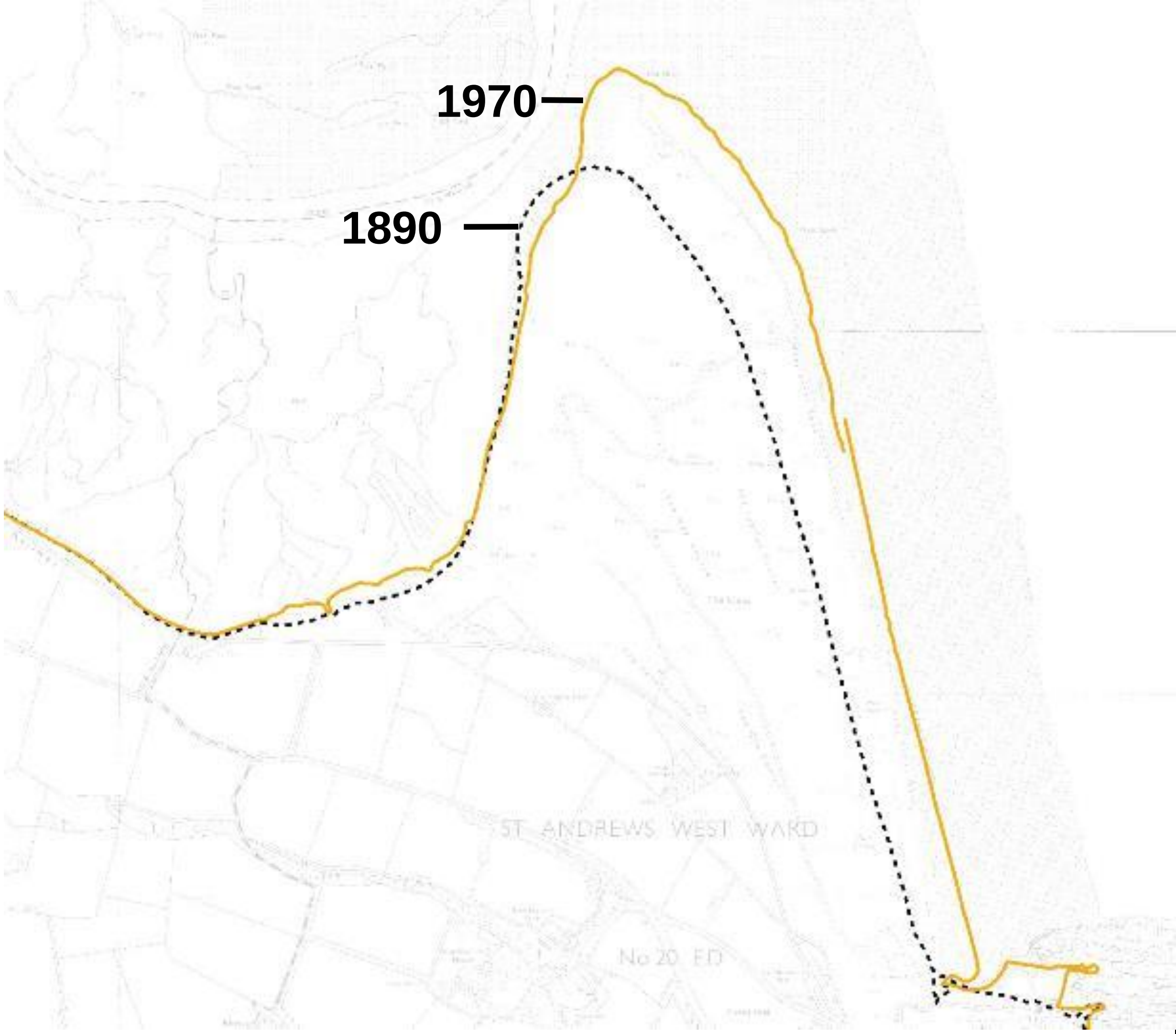
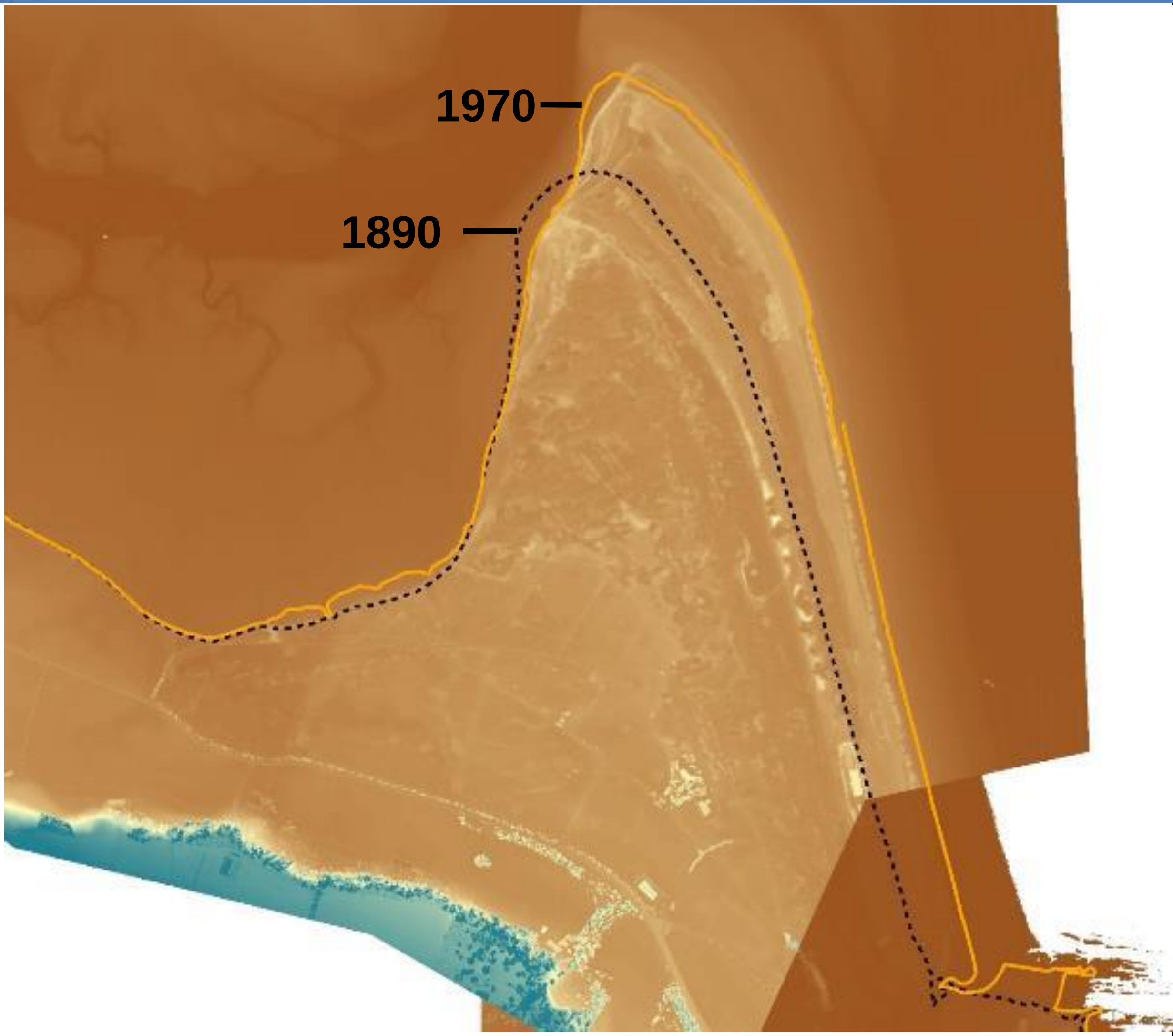


HWMOST & MHWS

Extract tide line & analyze

- 1890s OS 6 Inch Second Edition Country Series Maps (NLS)
- 1970s OS 1:10,000 (NLS)
- Current MHWS derived from:
    - QA'ed OS published data
    - LiDAR
    - Aerial photography
    - Terrestrial Laser Scan



HWMOST & MHWS

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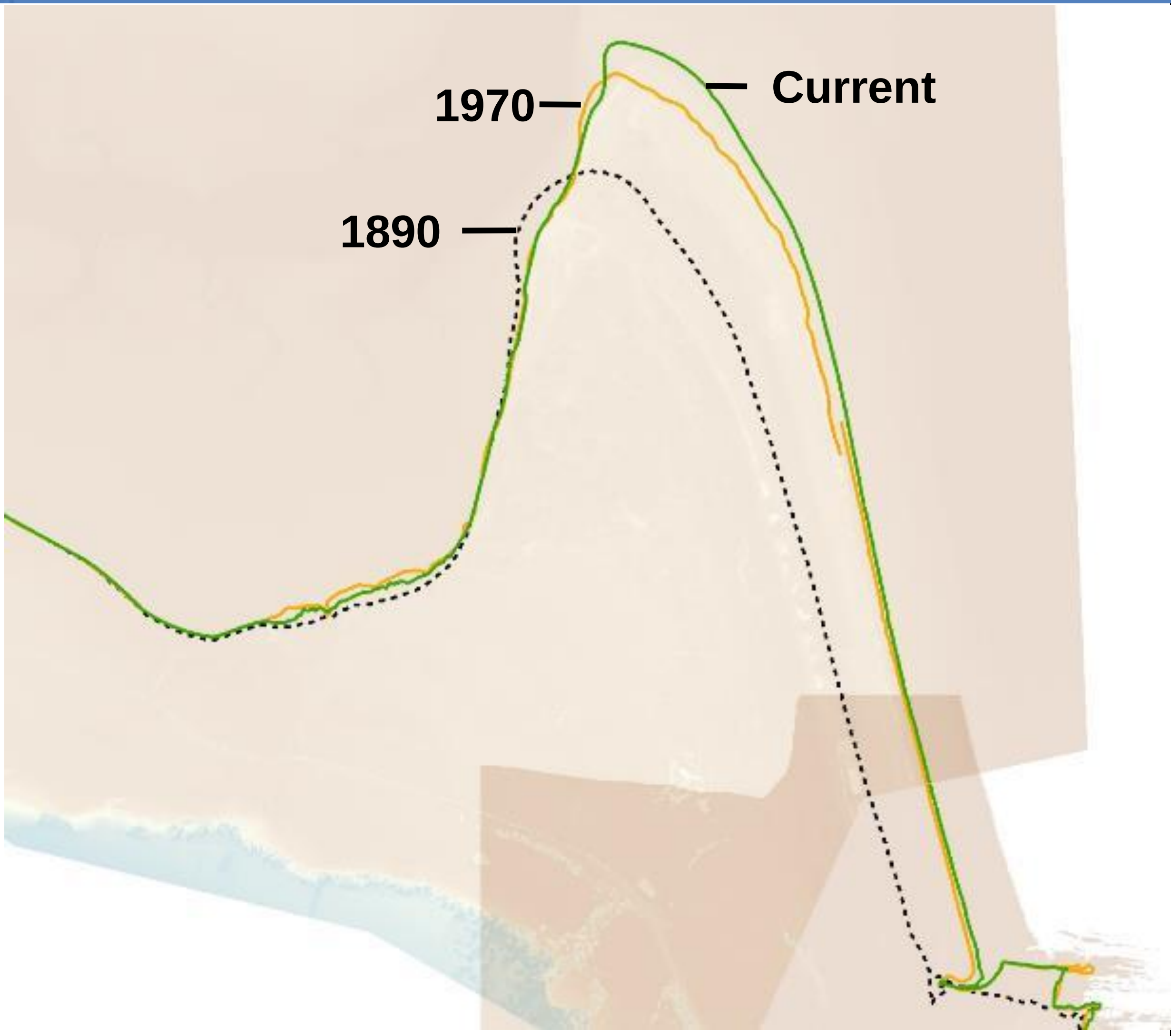

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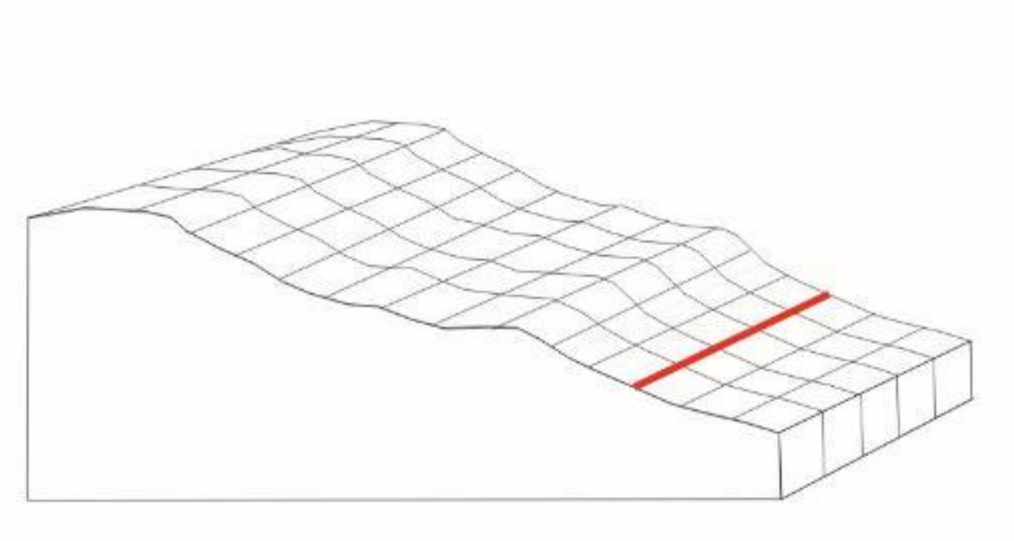
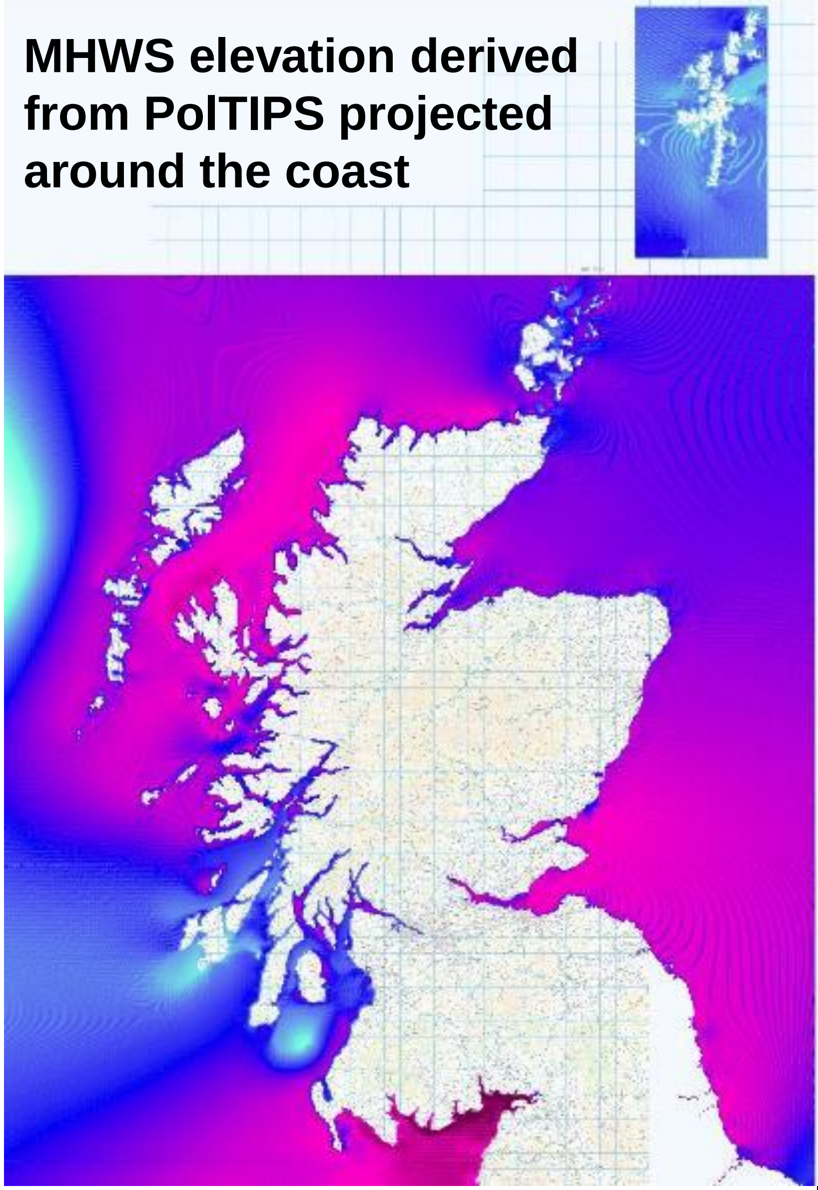
Using DSMs to update MHWS



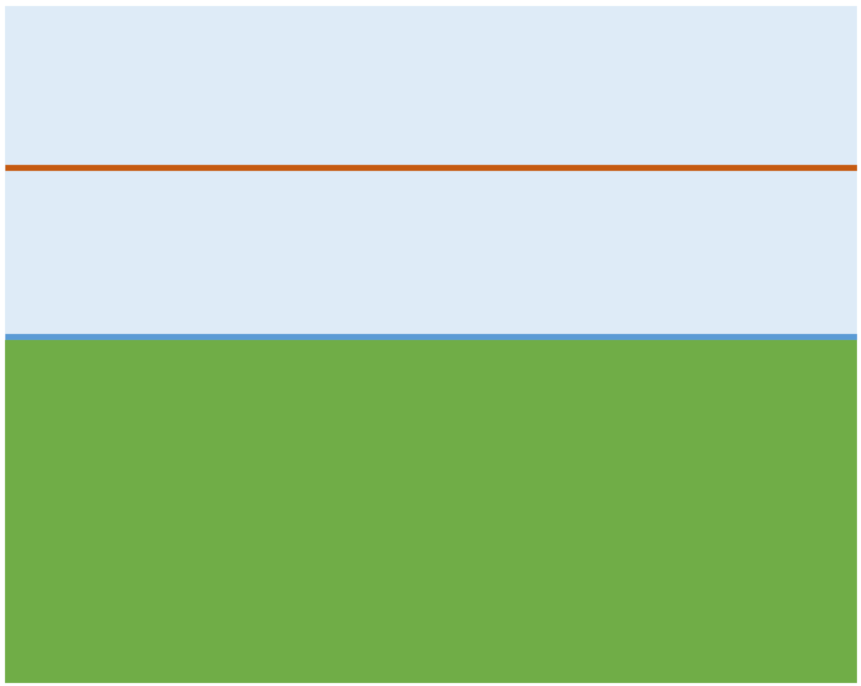
The altitude of Mean High Water Springs (MHWS) varies across Scotland. The local tide level is intersected with the modern digital surface model to extract a new MHWS line.

MHWS elevation derived from PolTIPS projected around the coast



Coastal Change Method

Old shoreline and current soft shoreline are plotted…



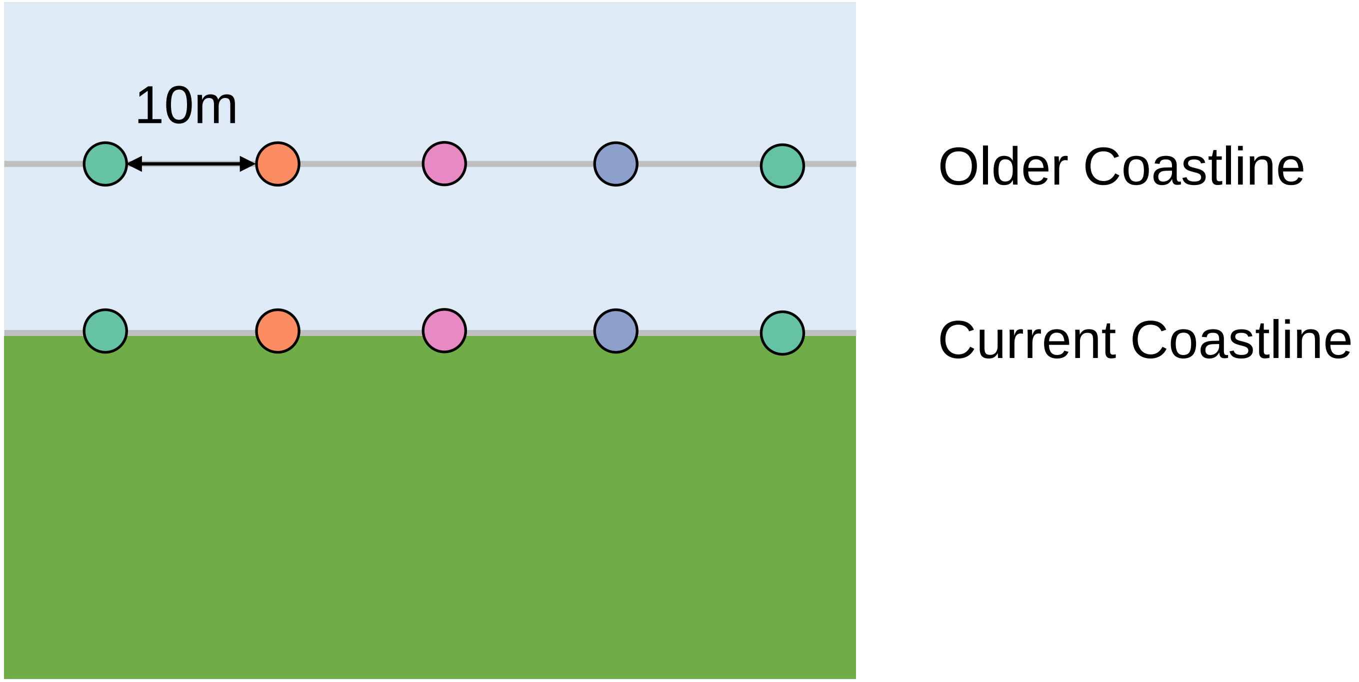
Older Coastline

Current Coastline

Coastal Change Rate = Distance/Time

Coastal Change Method

And points are located at every 10m



Coastal Change Rate = Distance/Time

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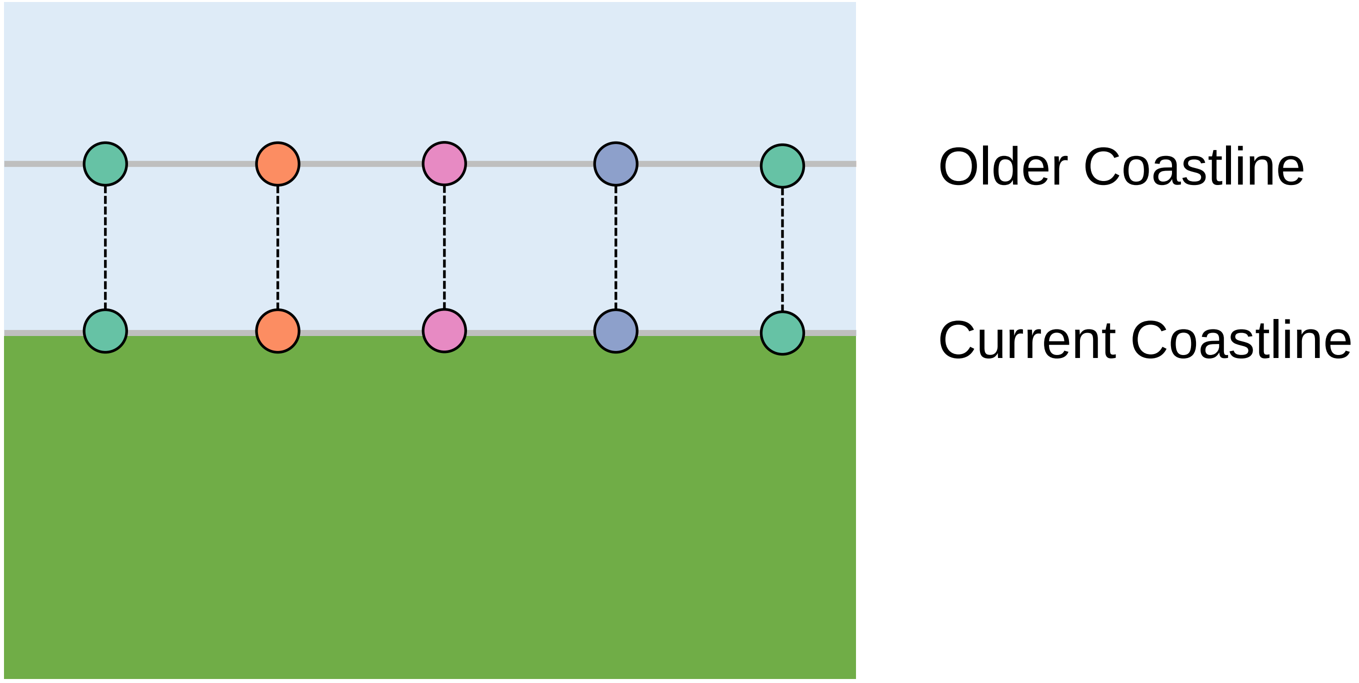
Coastal Change Method

Each point on the old line then measures the distance to the new line



Coastal Change Rate = Distance/Time

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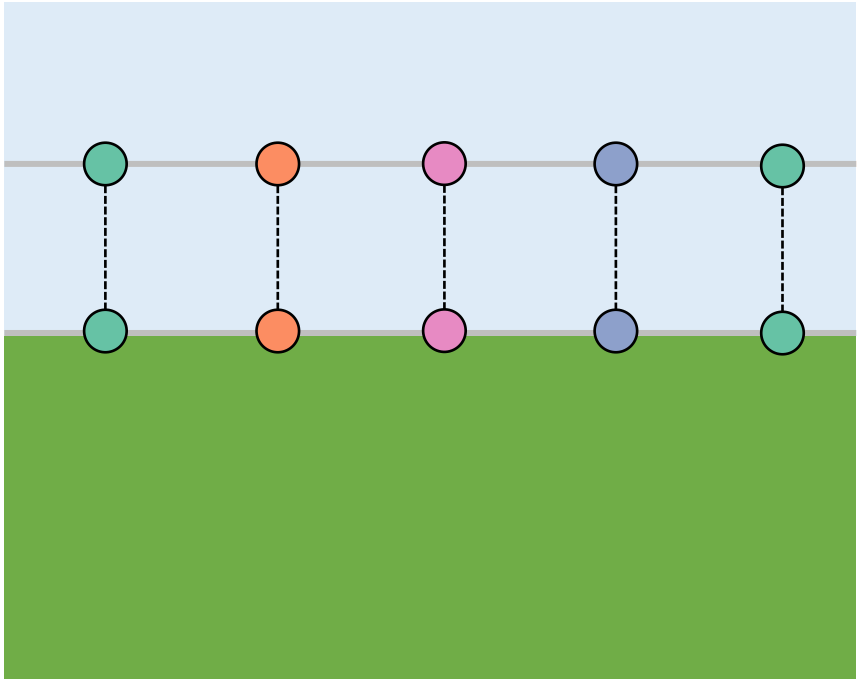
Coastal Change Method

Erosion is shown as a negative value
Accretion is shown as a positive value



Older Coastline

Current Coastline

Coastal Change Rate = Distance/Time

Method

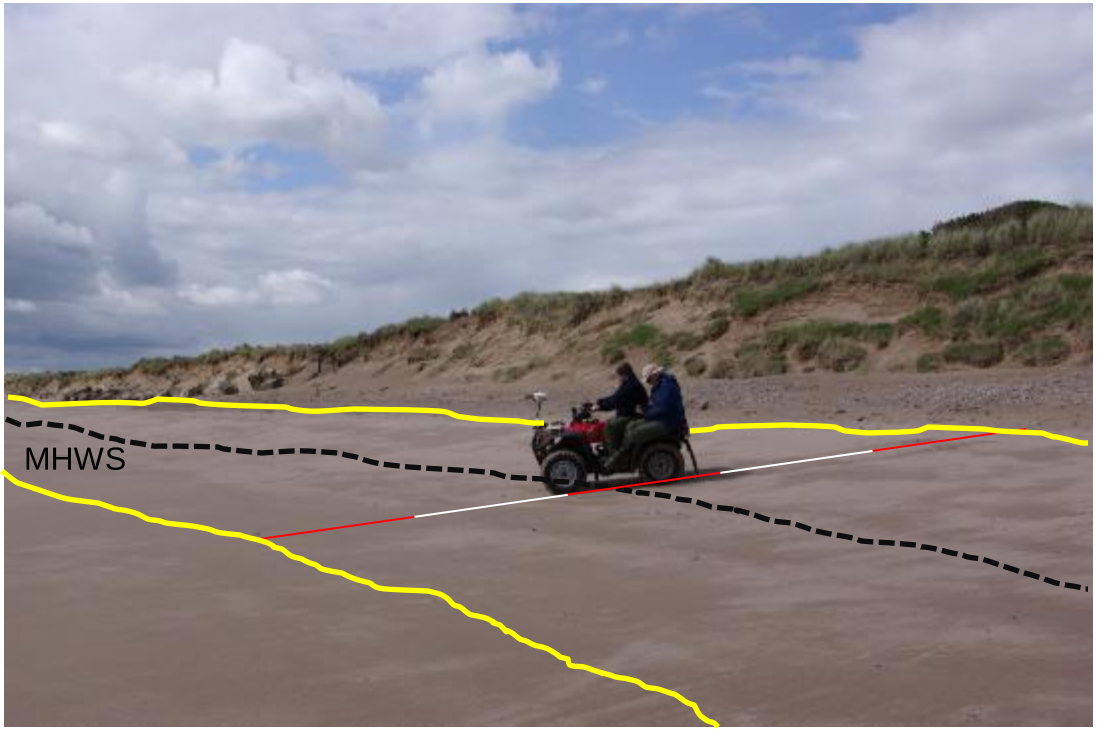
1mm line 1:10k map =
10m on ground

So when are we confident of change?
1890 & 1970 +/- 10m

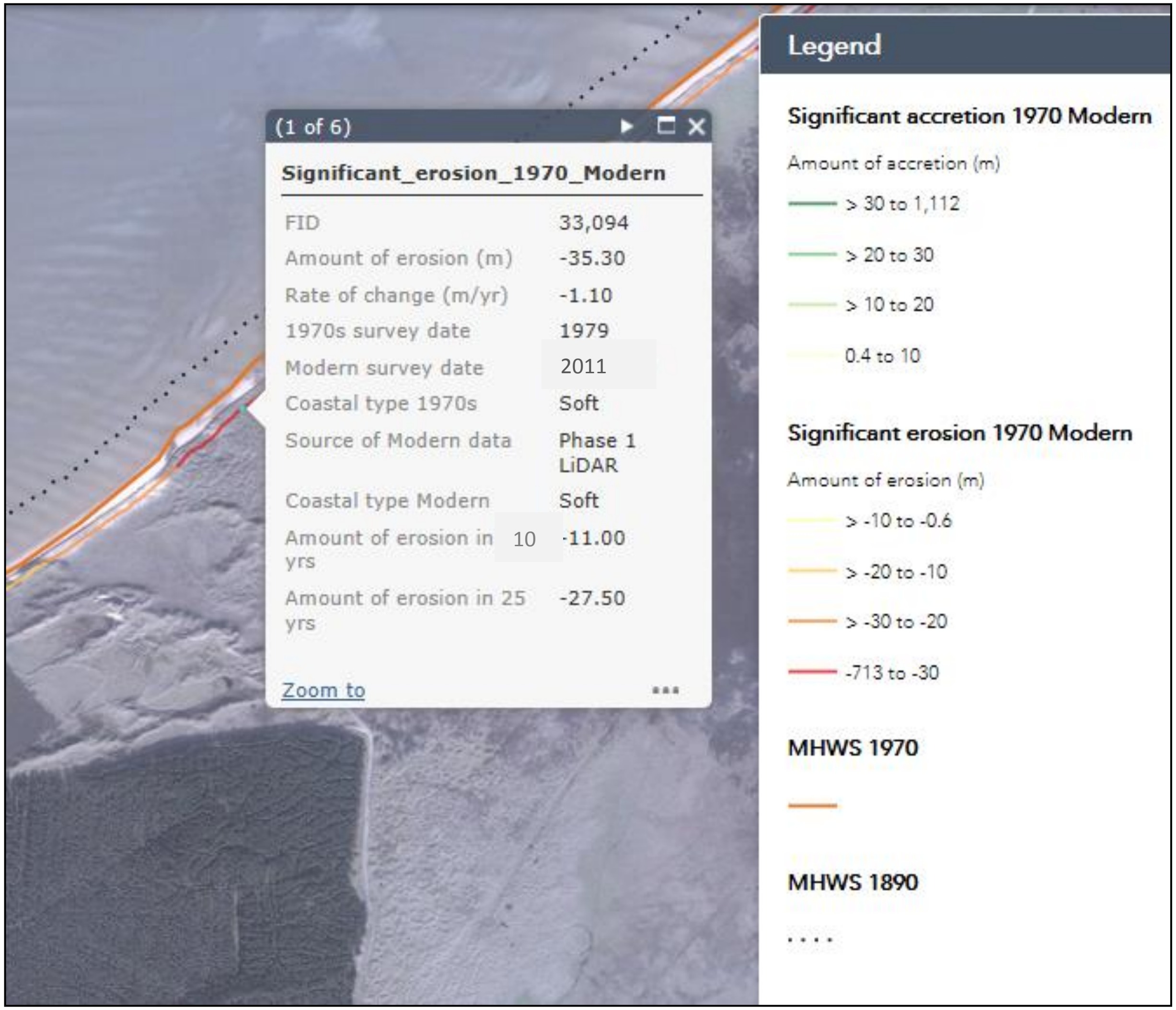
OS MasterMap & LiDAR better

However we've used +/- 10m , or faster than 0.5m/yr (to account for recent map updates).

Future analyses should aim to reflect greater precision. However as a national-level assessment this is satisfactory.



What extra attribute data is available?



Query & Confidence layer (in prep) which will allow more nuanced interpretation

Method

Inherent limitations:

- No inclusion of the impact(s) of climate change
- Therefore, the past may not be indicative of the future
- Different scenarios have not been modelled, i.e. the influence of accelerated erosion, or increased protection.
- 2D lines summarising 3D mobile surfaces

The method we have used is a reliable initial national appraisal, and the most secure position from legal challenge. The logical next step(s) is to have more specific case studies (unique context).

Method

What can we conclude from this assessment?

"stable areas vs. those worthy of more targeted investigation"

What it does say:

✓ *"in the past erosion has affected this shore, and there are adjacent assets that may be affected **if** this erosion continues"*

✓ *in the past accretion has affected this shore, there are adjacent assets that may be affected **if** this accretion continues"*

What it doesn't say:

x *"house will be eroded by 2019"*

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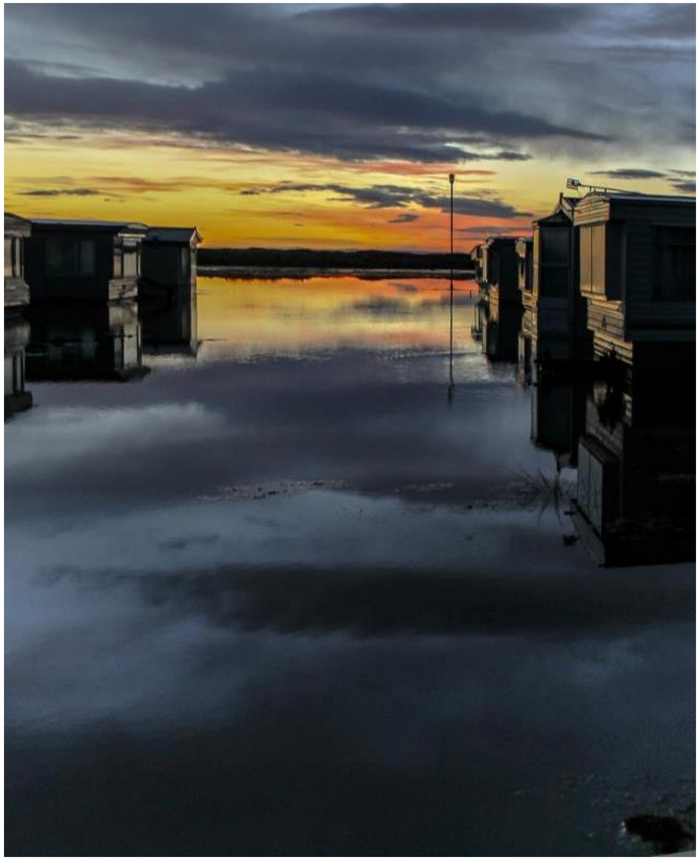


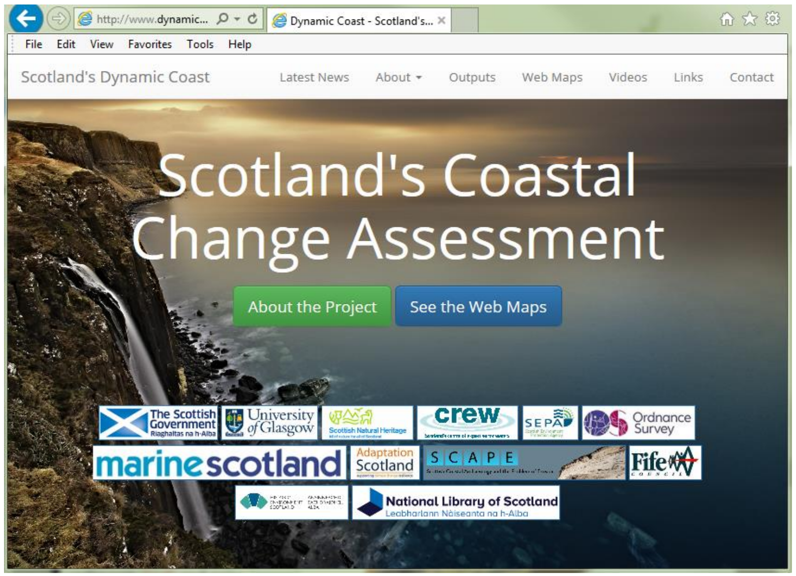
Results

Dr Alistair Rennie
SNH & SG

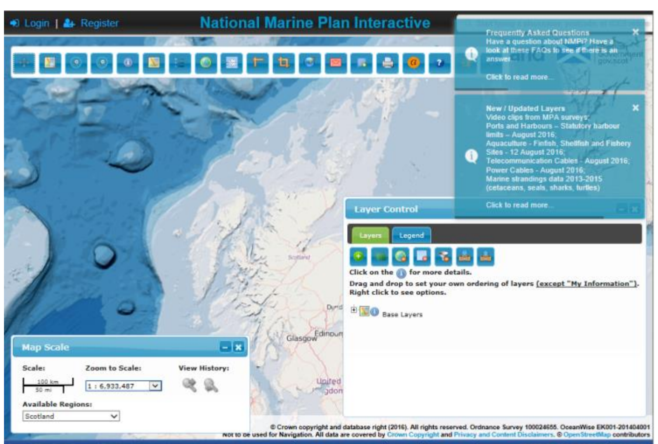
2012 Golspie. c. Unknown

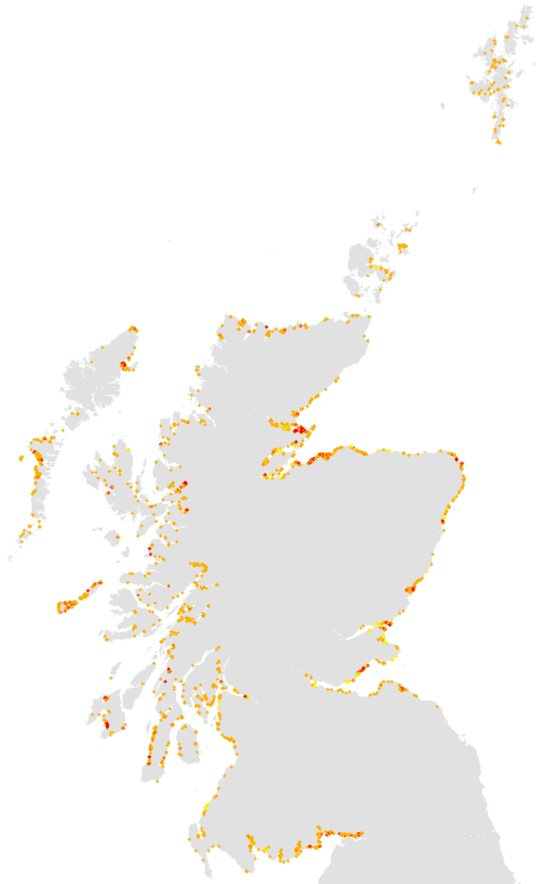
Results

Results are available in several formats:
Lines, Stats, Pies and Reports

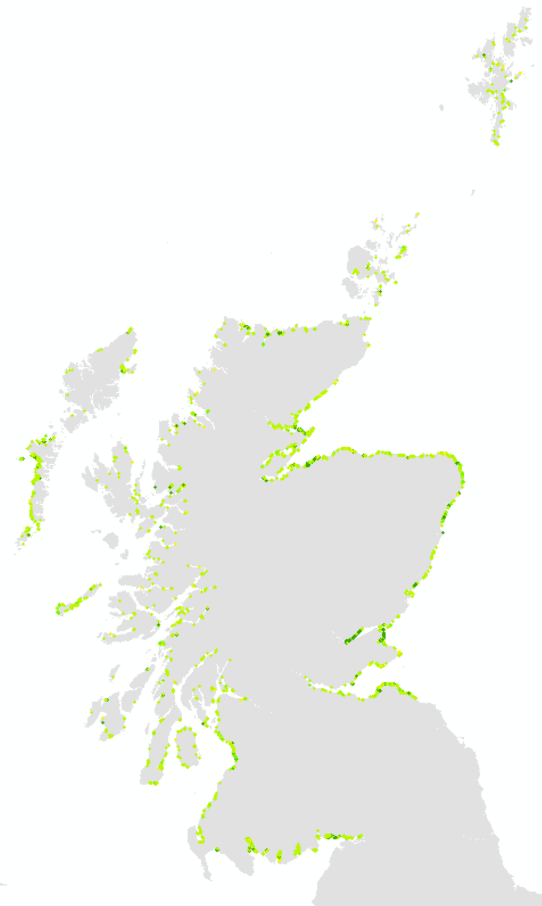


Main trends within NMPI





Significant erosion
More than 10m of erosion
or faster than 0.5m/yr



Significant accretion
More than 10m of accretion
or faster than +0.5m/yr

Stats & Pies (Pie charts)

Statistics for Cell 1

Within the soft sections of Cell 1, 42% has been advancing between 1890 and 1970; compared with 31% between 1970 and modern data.

Within the soft sections of Cell 1, 8% has been retreating between 1890 and 1970; compared with 12% between 1970 and modern data.

Within the soft sections of Cell 1, the average rate of advance is 0.9m/yr between 1890 and 1970, and 2.3 m/yr between 1970 and modern data.

Within the soft sections of Cell 1, the average rate of retreat is -0.2m/yr between 1890 and 1970, and -1.3 m/yr between 1970 and modern data.

Within the soft sections of Cell 1, 49% has not changed significantly between 1890 and 1970; compared with 57% between 1970 and the modern data.

Coastal Cell	Overall change (1)			Advance (2)				Retreat (3)				Insignificant change (4)		
	Average 1890 to 1970 Change on Soft Coast (m)	Average 1890 to 1970 Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1890 to 1970 Soft Coast Advance (m)	Average 1890 to 1970 Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Area of Soft Coast Advance (hectares)	Average 1890 to 1970 Soft Coast Retreat (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Area of Soft Coast Retreat (hectares)	Average 1890 to 1970 Soft Coast Insignificant Change (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 1a	51.2	0.62	49.4	121.4	1.46	21.5	260.7	-18.3	-0.21	4.4	8.0	0.4	0.01	23.6
Cell 1b	11.3	0.12	26.1	30.2	0.31	10.7	32.4	-22.8	-0.24	2.4	5.5	2.0	0.02	13.0
Cell 1c	20.4	0.22	32.9	51.7	0.56	13.8	71.5	-18.0	-0.24	2.5	4.6	0.2	0.00	16.6
Cell 1d	7.5	0.10	3.2	17.9	0.23	1.1	2.0	-10.7	-0.12	0.1	0.1	2.2	0.03	2.0
Cell 1	31.6	0.37	111.7	77.8	0.91	47.1	366.6	-19.4	-0.22	9.4	18.2	0.8	0.01	55.2
	-	-	-	-	-	42.2%	-	-	-	8.4%	-	-	-	49.4%

Coastal Cell	Overall change			Advance				Retreat				Insignificant change (4)		
	Average 1970 to Modern Change on Soft Coast (m)	Average 1970 to Modern Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1970 to Modern Soft Coast Advance (m)	Average 1970 to Modern Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Area of Soft Coast Advance (hectares)	Average 1970 to Modern Soft Coast Retreat (m)	Average 1970 to Modern Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Area of Soft Coast Retreat (hectares)	Average 1890 to 1970 Soft Coast Insignificant Change (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 1a	12.3	0.61	44.1	55.9	2.44	13.9	77.5	-44.9	-1.38	5.9	26.4	1.3	0.05	24.4
Cell 1b	28.6	1.32	27.3	64.4	2.97	12.3	79.6	-19.9	0.90	1.9	3.7	1.8	0.08	13.1
Cell 1c	-1.5	-0.06	31.7	21.9	0.72	6.2	13.5	-40.3	-1.40	5.2	20.8	1.3	0.04	20.4
Cell 1d	2.8	0.07	3.6	16.7	0.53	0.6	0.9	-13.5	-0.58	0.3	0.5	1.9	0.06	2.7
Cell 1	12.1	0.57	106.7	52.1	2.29	32.9	171.5	-38.8	-1.29	13.2	51.4	1.4	0.05	60.6
	-	-	-	-	-	30.9%		-	-	12.4%		-	-	56.7%

1 Overall change shows the mean value for the whole cell / sub-cell, averaging gains and losses.

2 Advance shows the mean value for the shoreline gains, where there has been greater than 10m of change, or change which is faster than 0.5m/y

3 Retreat shows the mean value for the shoreline losses, where there has been greater than 10m of change, or change which is faster than 0.5m/yr

4 Insignificant change shows the lengths of coastline which have changed less than 10m

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Results

Stats & Pies (Pie charts)

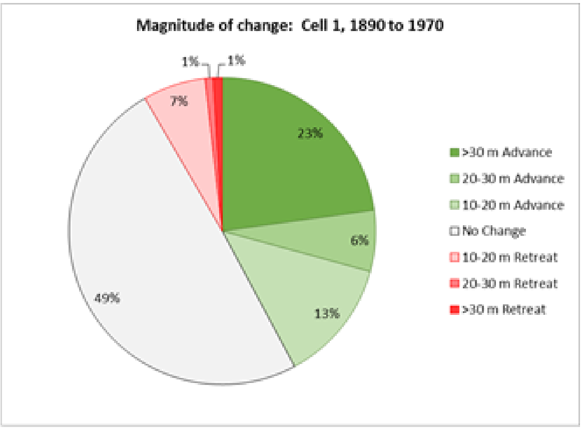
1890-1970	Cell 1 Length (km)	Cell 1 Length (%)	Cell 1a (km)	Cell 1a (%)	Cell 1b (km)	Cell 1b (%)	Cell 1c (km)	Cell 1c (%)	Cell 1d (km)	Cell 1d (%)
>30m Advance	25.5	23%	12.6	11%	3.7	3%	9.1	8%	0.1	0%
20-30m Advance	7.2	6%	2.1	2%	2.6	2%	2.2	2%	0.3	0%
10-20m Advance	14.5	13%	6.7	4%	4.4	4%	2.5	2%	0.8	1%
No Change	55.2	49%	23.6	21%	13.0	12%	16.6	15%	2.0	2%
10-20m Retreat	7.4	7%	3.5	3%	1.8	2%	2.0	2%	0.1	0%
20-30m Retreat	0.9	1%	0.4	0%	0.2	0%	0.4	0%	0.0	0%
>30m Retreat	1.1	1%	0.4	0%	0.5	0%	0.2	0%	0.0	0%
Total length	111.7	100%	49.5	44%	26.1	23%	32.9	29%	3.2	3%

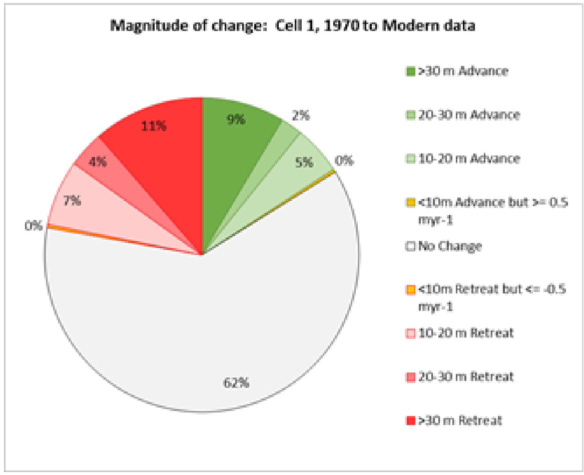
	Cell 1		Cell 1a	Cell 1b	Cell 1c	Cell 1d
Max advance (m)	628	John Muir Country Park	628	257	246	44
Average change (m)	31.6		51.2	11.3	20.4	7.5
Max retreat (m)	95	John Muir Country Park	95	85	79	13

1970-Modern	Cell 1 Length (km)	Cell 1 Length (%)	Cell 1a (km)	Cell 1a (%)	Cell 1b (km)	Cell 1b (%)	Cell 1c (km)	Cell 1c (%)	Cell 1d (km)	Cell 1d (%)
>30m Advance	10.0	9%	4.6	4%	4.5	4%	0.9	1%	0.0	0%
20-30m Advance	6.4	6%	2.4	2%	2.2	2%	1.7	2%	0.2	0%
10-20m Advance	15.8	15%	6.6	6%	5.4	5%	3.5	3%	0.3	0%
<10m Advance but >=0.5 myr^{-1}	0.6	1%	0.3	0%	0.2	0%	0.1	0%	0.1	0%
No Change	60.6	57%	24.4	23%	13.1	12%	20.4	19%	2.7	3%
<10m Retreat but <= -0.5 myr^{-1}	0.2	0%	0.1	0%	0.1	0%	0.1	0%	0.0	0%
10-20m Retreat	4.4	4%	1.8	2%	1.0	1%	1.4	1%	0.3	0%
20-30m Retreat	2.4	2%	1.0	1%	0.6	1%	0.8	1%	0.0	0%
>30m Retreat	6.2	6%	3.0	3%	0.3	0%	2.9	3%	0.0	0%
Total length	106.7	100%	44.1	41%	27.3	26%	31.7	30%	3.6	3%

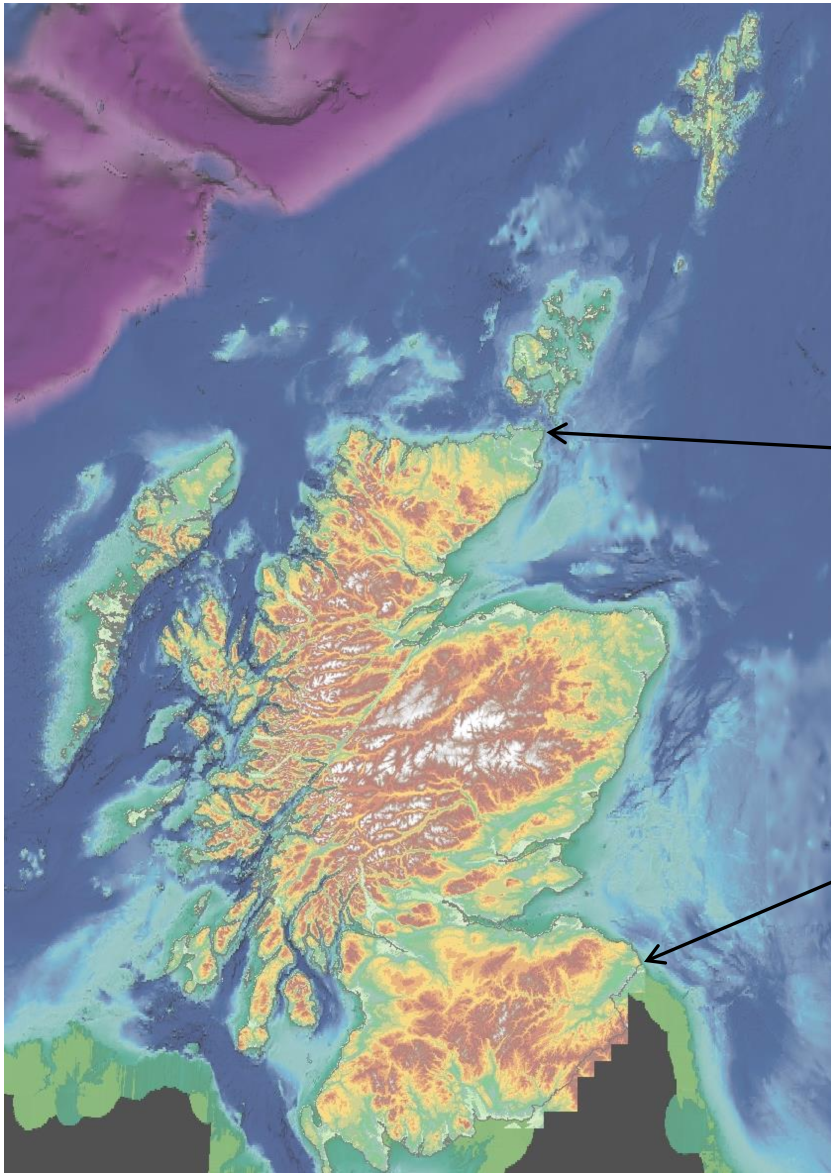
	Cell 1		Cell 1a	Cell 1b	Cell 1c	Cell 1d
Max advance (m)	516	John Muir Country Park	516	347	103	29
Average change (m)	12.1		12.3	28.6	-1.5	2.8
Max retreat (m)	157	John Muir Country Park	157	38	111	23

Modern Coastal Type	Length km	Length %
Soft	106.7	24%
Artificial	161.0	36%
Hard and Mixed	184.5	41%
Total Length (excluding tidally influenced inlets)	452.2	100%





Results: East coast



East Coast		
Modern Coastal Type	Length	
	km	%
Soft	900.8	45%
Artificial	311.3	15%
Hard and Mixed	809.9	40%
Total Length (excluding tidally influenced inlets)	2022.0	100%

Results: East coast

Stats & Pies (Pie charts)

Coastal Cell	Overall change (1)			Advance (2)				Retreat (3)				Insignificant change (4)		
	Average 1890 to 1970 Change on Soft Coast (m)	Average 1890 to 1970 Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1890 to 1970 Soft Coast Advance (m)	Average 1890 to 1970 Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Area of Soft Coast Advance (hectares)	Average 1890 to 1970 Soft Coast Retreat (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Area of Soft Coast Retreat (hectares)	Average 1890 to 1970 Soft Coast Insignificant Change (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 1	31.6	0.37	111.7	77.8	0.91	47.1	366.6	-19.4	-0.22	9.4	18.2	0.8	0.01	55.2
Cell 2	21.2	0.03	184.9	58.9	0.71	90.9	536.0	-60.6	-0.68	25.6	154.9	1.5	0.02	68.4
Cell 3	33.4	0.45	583.6	114.0	1.54	194.4	2,251.0	-32.7	-0.45	97.5	319.4	0.7	0.01	288.5
East Coast	28.7	0.28	880.2	83.5	1.05	332.5	3,153.6	-37.6	-0.45	132.4	492.4	1.0	0.01	412.1
	-	-	-	-	-	37.8%	-	-	-	15.0%	-	-	-	46.8%

Coastal Cell	Overall change			Advance				Retreat				Insignificant change (4)		
	Average 1970 to Modern Change on Soft Coast (m)	Average 1970 to Modern Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1970 to Modern Soft Coast Advance (m)	Average 1970 to Modern Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Area of Soft Coast Advance (hectares)	Average 1970 to Modern Soft Coast Retreat (m)	Average 1970 to Modern Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Area of Soft Coast Retreat (hectares)	Average 1890 to 1970 Soft Coast Insignificant Change (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 1	12.1	0.57	106.7	52.1	2.29	32.9	171.5	-38.8	-1.29	13.2	51.4	1.4	0.05	60.6
Cell 2	23.9	0.88	191.2	76.0	2.78	74.0	562.7	-37.6	-1.34	28.1	105.6	6.4	0.00	89.1
Cell 3	0.0	-0.03	602.9	73.5	2.26	97.3	714.9	-53.7	-1.78	133.8	719.1	0.0	0.00	371.8
East Coast	12.0	0.47	900.8	67.2	2.44	204.2	1,449.0	-43.4	-1.47	175.1	876.0	2.6	0.02	521.4
	-	-	-	-	-	22.7%		-	-	19.4%		-	-	57.9%

Within the soft sections of the East Coast, **38%** has been advancing between 1890 and 1970; compared with **23%** between 1970 and modern data.
Within the soft sections of the East Coast, **15%** has been retreating between 1890 and 1970; compared with **19%** between 1970 and modern data.

Within the soft sections of the East Coast, the average rate of advance is **1.1 m/yr** between 1890 and 1970, and **2.4 m/yr** between 1970 and modern data.
Within the soft sections of the East Coast, the average rate of retreat is **-0.5 m/yr** between 1890 and 1970, and **-1.5 m/yr** between 1970 and modern data.

Within the soft sections of the East Coast, **47%** has not changed significantly between 1890 and 1970; compared with **58%** between 1970 and the modern data.

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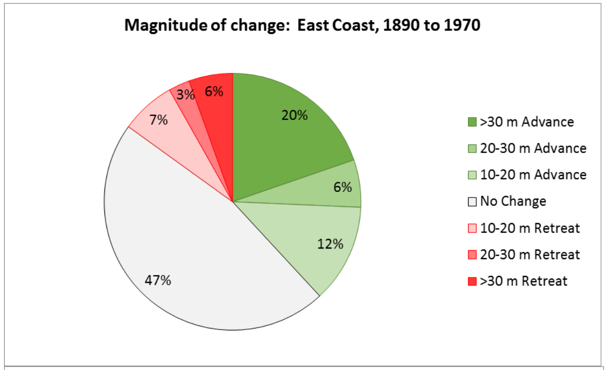
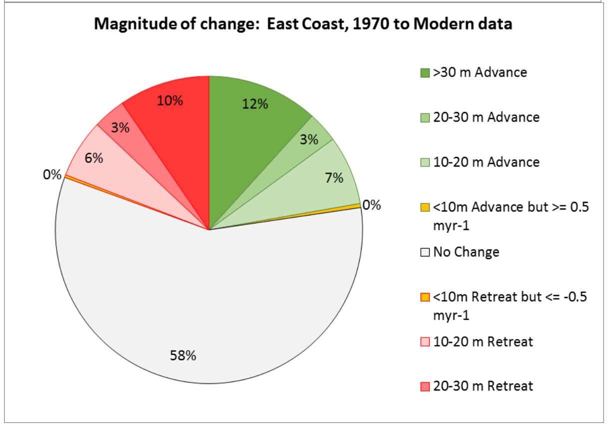
Results: East coast

Stats & Pies (Pie charts)

1890-1970	East Coast		Cell 1		Cell 2		Cell 3	
	Length (km)	Length (%)	(km)	(%)	(km)	(%)	(km)	(%)
>30 m Advance	173.6	20%	25.5	3%	48.6	6%	99.4	11%
20-30 m Advance	52.6	6%	7.2	1%	16.3	2%	29.1	3%
10-20 m Advance	109.4	12%	14.5	2%	26.0	3%	68.9	8%
No Change	412.1	47%	55.2	6%	68.4	8%	288.5	33%
10-20 m Retreat	60.6	7%	7.4	1%	11.8	1%	41.4	5%
20-30 m Retreat	23.5	3%	0.9	0%	4.7	1%	17.9	2%
>30 m Retreat	48.4	6%	1.1	0%	9.1	1%	38.3	4%
Total length	**880.1**	**100%**	**111.7**	**13%**	**184.9**	**21%**	**583.5**	**66%**

1970-Modern	East Coast		Cell 1		Cell 2		Cell 3	
	Length (km)	Length (%)	(km)	(%)	(km)	(%)	(km)	(%)
>30 m Advance	105.5	12%	10.0	1%	43.9	5%	51.6	6%
20-30 m Advance	29.2	3%	6.4	1%	9.3	1%	13.5	1%
10-20 m Advance	65.7	7%	15.8	2%	19.5	2%	30.4	3%
<10m Advance but >= 0.5 myr^{-1}	3.8	0%	0.6	0%	1.4	0%	1.8	0%
No Change	521.4	58%	60.6	7%	89.1	10%	371.8	41%
<10m Retreat but <= -0.5 myr^{-1}	2.5	0%	0.2	0%	0.5	0%	1.8	0%
10-20 m Retreat	55.6	6%	4.4	0%	10.3	1%	40.9	5%
20-30 m Retreat	30.9	3%	2.4	0%	6.0	1%	22.5	2%
>30 m Retreat	86.1	10%	6.2	1%	11.3	1%	68.6	8%
Total length	**900.8**	**100%**	**106.7**	**12%**	**191.2**	**21%**	**602.9**	**67%**





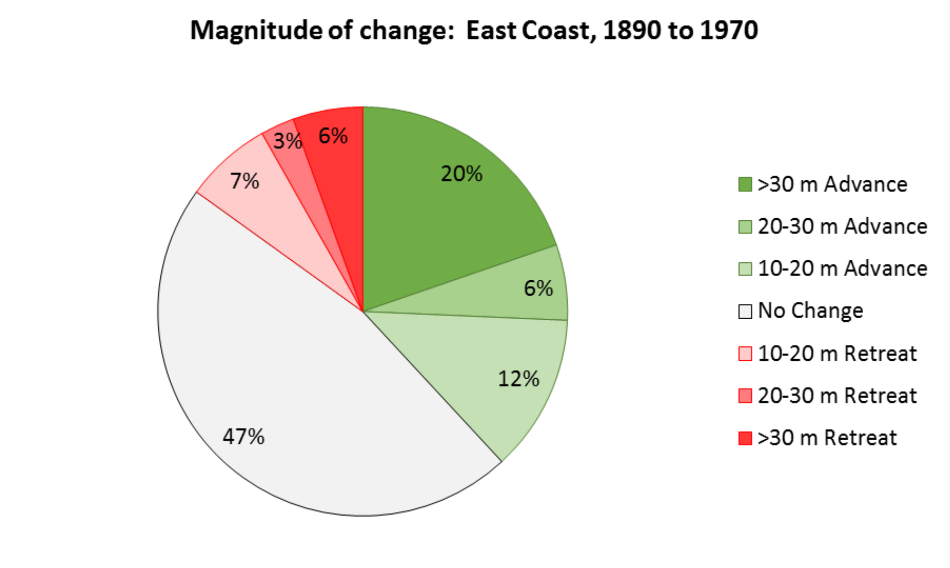
Results: East coast

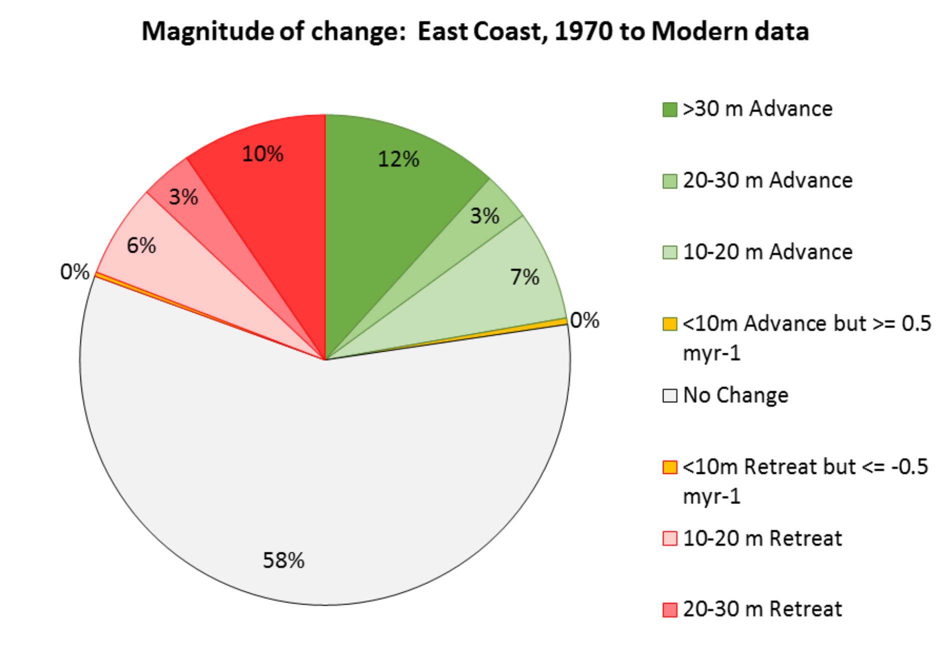
So what's happened between 1980-1970 and 1970 to modern?

Increasing % of coast stable

Erosion increasing in extent
More extreme erosion
Rate of erosion quickening

Accretion reducing in extent
Rate of accretion quickening





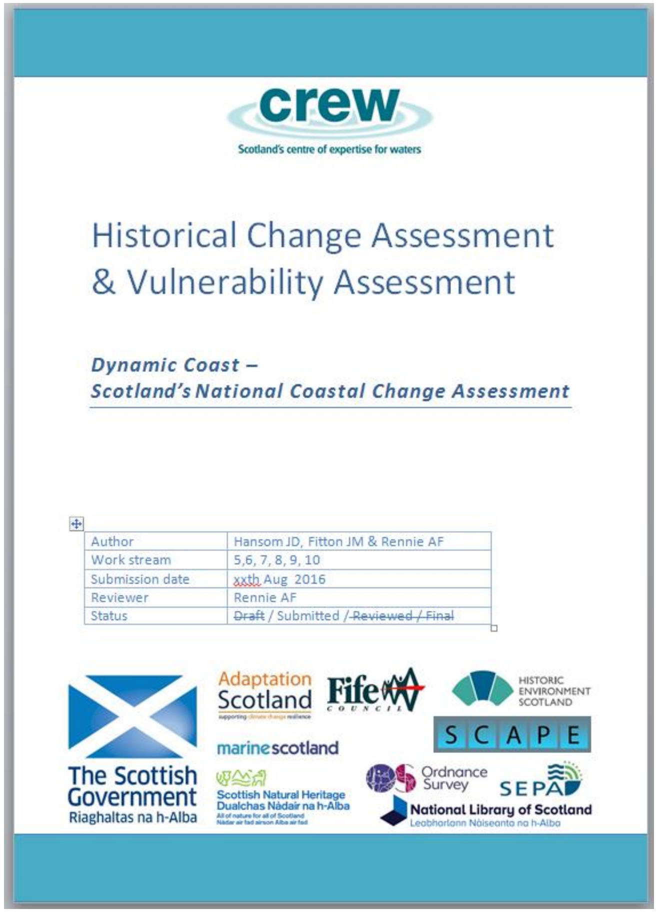
Results

Reports

Provide a narrative of historic and recent change. Alongside the future change and vulnerability assessment.

Stats are available:

- Scotland
- Cell & Sub-Cell
- Local Authority*
- Marine Planning Area



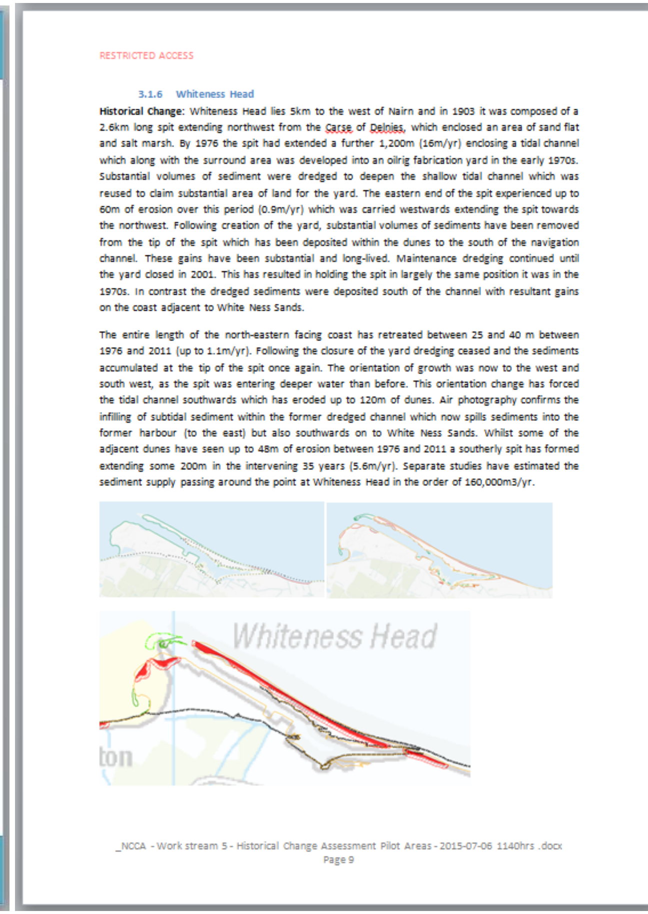
crew
Scotland's centre of expertise for waters

Historical Change Assessment & Vulnerability Assessment

Dynamic Coast – Scotland's National Coastal Change Assessment

Author	Hansom JD, Fitton JM & Rennie AF
Work stream	5,6, 7, 8, 9, 10
Submission date	xxth Aug 2016
Reviewer	Rennie AF
Status	~~Draft~~ / Submitted / ~~Reviewed / Final~~

The Scottish Government Riaghaltas na h-Alba · Adaptation Scotland · Fife Council · Historic Environment Scotland · SCAPE · marinescotland · Scottish Natural Heritage Dualchas Nàdair na h-Alba · Ordnance Survey · SEPA · National Library of Scotland Leabharlann Nàiseanta na h-Alba



RESTRICTED ACCESS

3.1.6 Whiteness Head

Historical Change: Whiteness Head lies 5km to the west of Nairn and in 1903 it was composed of a 2.6km long spit extending northwest from the Carse of Delnies, which enclosed an area of sand flat and salt marsh. By 1976 the spit had extended a further 1,200m (16m/yr) enclosing a tidal channel which along with the surround area was developed into an oilrig fabrication yard in the early 1970s. Substantial volumes of sediment were dredged to deepen the shallow tidal channel which was reused to claim substantial area of land for the yard. The eastern end of the spit experienced up to 60m of erosion over this period (0.9m/yr) which was carried westwards extending the spit towards the northwest. Following creation of the yard, substantial volumes of sediments have been removed from the tip of the spit which has been deposited within the dunes to the south of the navigation channel. These gains have been substantial and long-lived. Maintenance dredging continued until the yard closed in 2001. This has resulted in holding the spit in largely the same position it was in the 1970s. In contrast the dredged sediments were deposited south of the channel with resultant gains on the coast adjacent to White Ness Sands.

The entire length of the north-eastern facing coast has retreated between 25 and 40 m between 1976 and 2011 (up to 1.1m/yr). Following the closure of the yard dredging ceased and the sediments accumulated at the tip of the spit once again. The orientation of growth was now to the west and south west, as the spit was entering deeper water than before. This orientation change has forced the tidal channel southwards which has eroded up to 120m of dunes. Air photography confirms the infilling of subtidal sediment within the former dredged channel which now spills sediments into the former harbour (to the east) but also southwards on to White Ness Sands. Whilst some of the adjacent dunes have seen up to 48m of erosion between 1976 and 2011 a southerly spit has formed extending some 200m in the intervening 35 years (5.6m/yr). Separate studies have estimated the sediment supply passing around the point at Whiteness Head in the order of 160,000m3/yr.

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* Its worth remembering that processes are better considered within sediment cells rather than within LA boundaries

Inherent limitations

- Generally three data capture points in time (1890s / 1970 / Modern)
- Range of survey methods & precision (1890s vs 2016).
- MHWS is 2D time-series rather than 3D time series analysis.
- Binary classification of complex nuanced settings (soft vs defended shores).
- MHWS is located within a highly mobile part of the beach, other features may better complement this assessment to better reflect the risks to terrestrial assets.
- To reduce risk of legal challenge, past rates are projected forward.
- Limited account of climate change, past management approaches or step changes in processes.

Past performance might not be a good indicator of future performance

Nevertheless…

Conclusions

Policy:

1. Scotland's policies w.r.t. coastal erosion and adaptation are clear an unambiguous. There is an expectation to manage our coast better.

2. The NCCA provides the evidence base necessary to implement the:
   - Climate Change (Scotland) Act
   - Scottish Climate Change Adaptation Programme
   - Flood Risk Management (Scotland) Act
   - Marine (Scotland) Act & National Marine Plan
   - Scottish Planning Policy
   - Scottish Biodiversity Strategy

3. It enables the overlapping interests, assets, risks and opportunities to be considered together, thereby increasing the likelihood of use of collaborative approaches to manage them.

4. As an initial appraisal it is open about inherent limitations and precision, but is already acting as a catalyst for further improvements in data acquisition and sharing, methodology and partnership working.

Conclusions

Science:

1. The NCCA has identified and quantified the coastal changes between the1890s and Modern.
2. It has incorporated data from across the public sector to create the most representative series of MHWS lines Scotland has ever had.
3. It presents the evidence base in a clear, objective and informative manner to both public and competent authorities alike.
4. It has acted as a catalyst to further cross-sector research into coastal change to better inform risk assessments and adaptation strategies.

Solas, N Uist

Conclusions

Results:

1. The NCCA has identified the areas experiencing rapid, modest and stability across Scotland's varied soft shore.

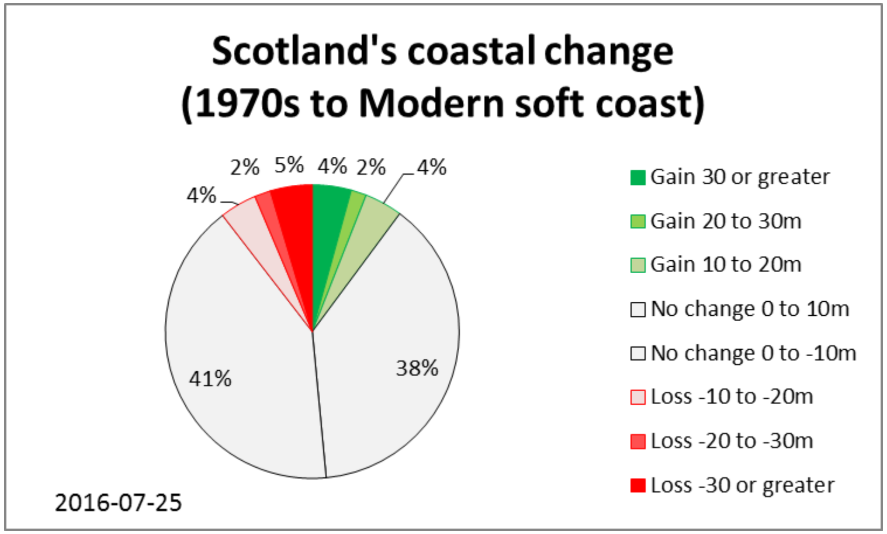
   ~ 79% of our soft coast is stable
   ~ 8% is accreting
   ~ 11% is eroding

2. This highlights the considerable resilience of stable and accretional areas:

   "Sustainable management of our natural capital is vital to protect essential services and economic growth in Scotland"

   "Nature can help us cope with Climate change".

3. It has projected the past rates forward to highlight assets at greater risk, enabling further and more detailed assessments.



Change	Length (km)	% of soft coast
Gain 30 or greater	166	4%
Gain 20 to 30m	66	2%
Gain 10 to 20m	162	4%
No change 0 to 10m	1,488	38%
No change 0 to -10m	1,594	41%
Loss -10 to -20m	158	4%
Loss -20 to -30m	69	2%
Loss -30 or greater	179	5%
sum	3,881	

Please note these figures are subject to change as analysis & QA concludes

Conclusions

Our soft coast defends a huge range of assets (£bn), fundamental to Scotland's people & national wealth.

We must value our natural capital accordingly, and manage it sustainably, adapting to the future risks.

All public bodies have a duty to implement Adaptation Programme

Conclusions

Updates & collaboration

1. The NCCA has highlighted the unresolved issue of the accuracy of MHWS.
2. It has led to improvements within our national mapping and how the OS operates across the UK. Ensuring our MHWS tideline will remain updated.
3. It has fostered efficiency and collaboration across the public sector to share and use our data to appraise risks, opportunities and undertake adaptation planning.
4. Emerging opportunities (NFRA, NCCA2) may provide new appreciation of our natural coastal defences (natural capital) to be put at the core of sustainable development planning along the coast. This provides an exciting alternative to SMPs and is the focus of future SG, SEPA & SNH collaboration.

The Scottish Government
Riaghaltas na h-Alba

15 mins of questions

We would be happy to take your questions

Please can you state your name and organization

For further information please visit www.dynamiccoast.com or

email ncca@snh.gov.uk