Dynamic Coast:
GIS & collaboration for enhanced coastal resilience

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Climate change matters, WHY?

- **Sea levels, storm impact and flood frequencies are now rising.**
- **In most countries modern society is built on the assumption that they wouldn't.**
- **Some of the greatest impacts are anticipated within the coastal zone**.

Scotland

- Before 2015 the Scottish Government and public sector had limited knowledge of the **precision** of coastal mapping, **no national overview of coastal erosion or impacts on society**.
- **With Dynamic Coast we do now**, with a GIS evidence base to inform national, regional, local & sectoral investigations to improve resilience and adaptation along our coast.

What is Dynamic Coast?

- **Dynamic Coast is a Scottish Government project,** funded by Scotland's Centre of Expertise for Waters (CREW), managed by Scottish Natural Heritage (SNH), delivered by University of Glasgow.
- It is a publically available evidence base of **changes to Scotland's erodible coast,** to improve decision making and **resilience of coastal infrastructure, assets, and communities.**

Why is this important nationally and locally?

A successful, resilient and plan-led economy needs a reliable evidence base in a changing world: nowhere is this more crucial than at the coast.

Climate change is occurring, new risks and coastal impacts are being identified and need a response.

Yet this is occurring at a time of public sector cuts and funding uncertainty.

Dynamic Coast had to **collaborate** and **innovate** to **deliver** the improvements required, given Cabinet-level interest in the issue of coastal erosion.

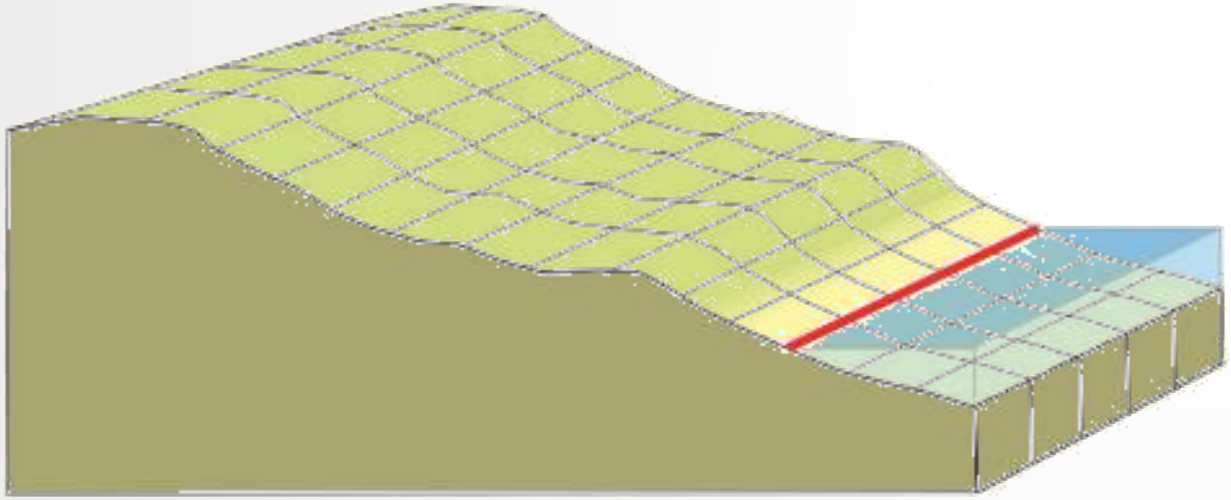
What we did: a summary

We compared the positions of 3 epochs of shorelines across all the Scottish coast, focusing on our soft (erodible) coastline, via 1M data points.

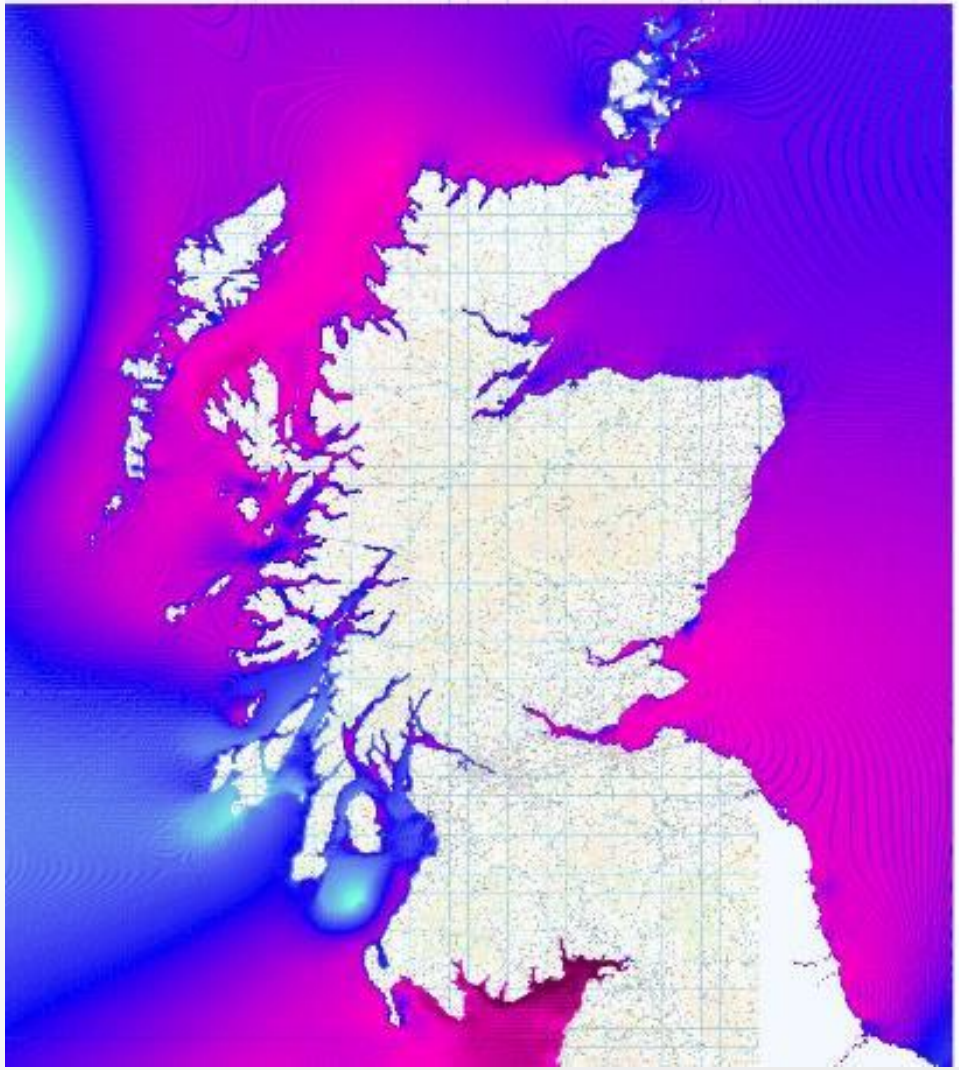
1. This identified significant changes whose extents and rates were projected forward to forecast the locations of **coastal risk**;
2. We then overlaid the locations of society's **coastal assets**;
3. We then **monetized** the analysis to allow a projection of present and future costs from the impact of coastal erosion.

What did we do?

- The key spatial data nationally available in mapped and digital form was Mean High Water Springs (MHWS)
- We used Digital Surface Models to nationally update MHWS



MHWS elevation projected around the coast between ports (source: PolTIPS)



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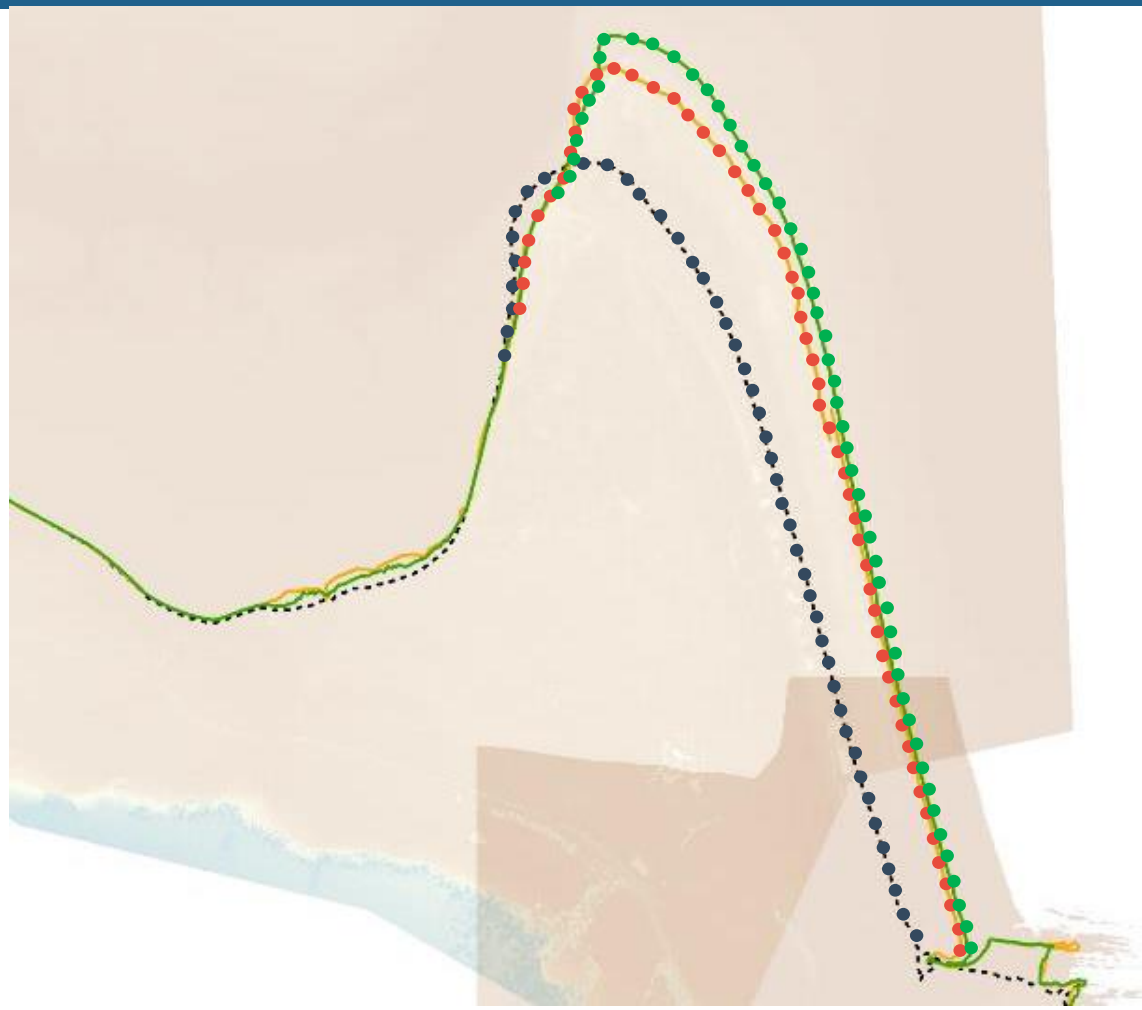
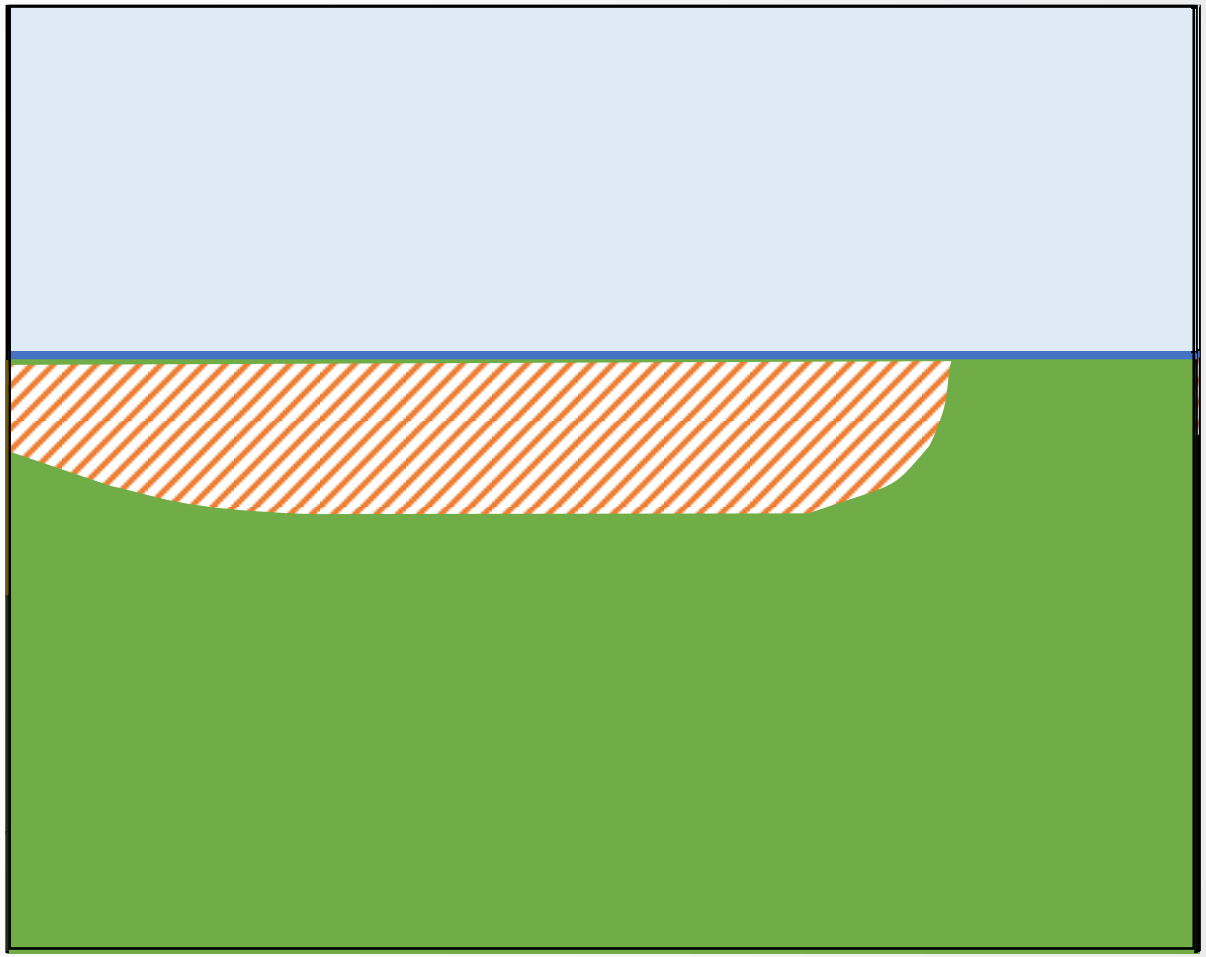


What did we do?

- Coastal retreat rates calculated from the change analysis at 10m intervals along the coast into areas of erosion risk:
  - High (red-orange),
  - Intermediate (blue)
  - low risk (green)
- Rate used to model retreat to 2050.
- Points smoothed, producing an area of erosion.
- Coastal Erosion Susceptibility Model (Fitton et al. 2016) was used to limit erosion into less susceptible areas.
- Final area of erosion established

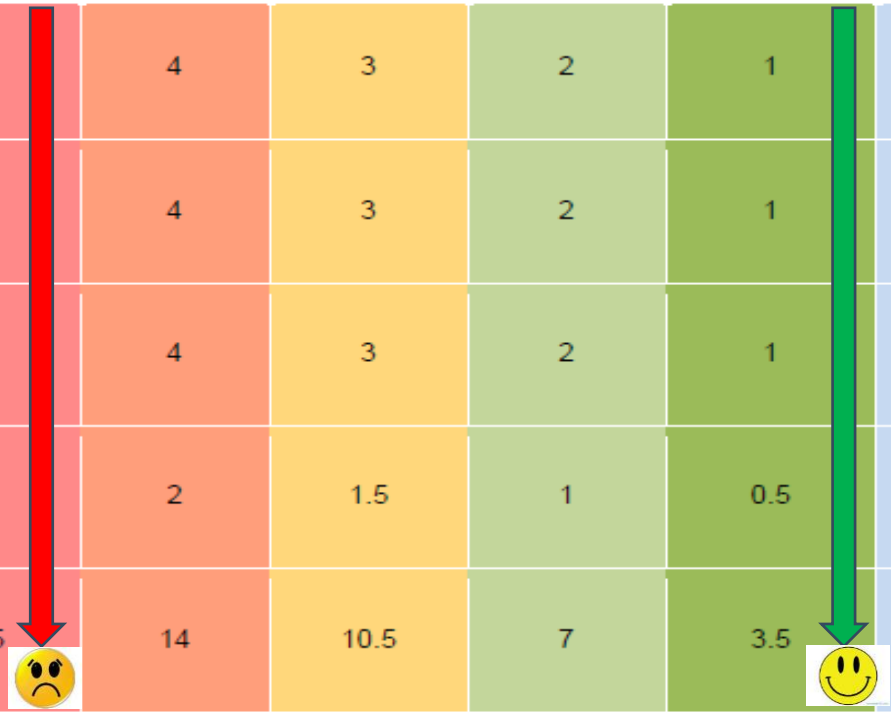


Fitton, J.F., Hansom, J.D., Rennie, A.F. (2016) *A National Coastal Erosion Susceptibility Model for Scotland* Ocean & Coastal Management – link will be on dynamiccoast.com

A National Coastal Erosion Susceptibility Model for Scotland to model erosion susceptibility and vulnerability (50m ground resolution)

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

	5	4	3	2	1	Weighting
	Most susceptible				Least susceptible	
Elevation (mAOD)	5	4	3	2	1	1
Rockhead (mAOD)	5	4	3	2	1	1
Distance to open coast (m)	5	4	3	2	1	1
Wave Exposure	2.5	2	1.5	1	0.5	0.5
Aggregate Score	17.5	14	10.5	7	3.5	



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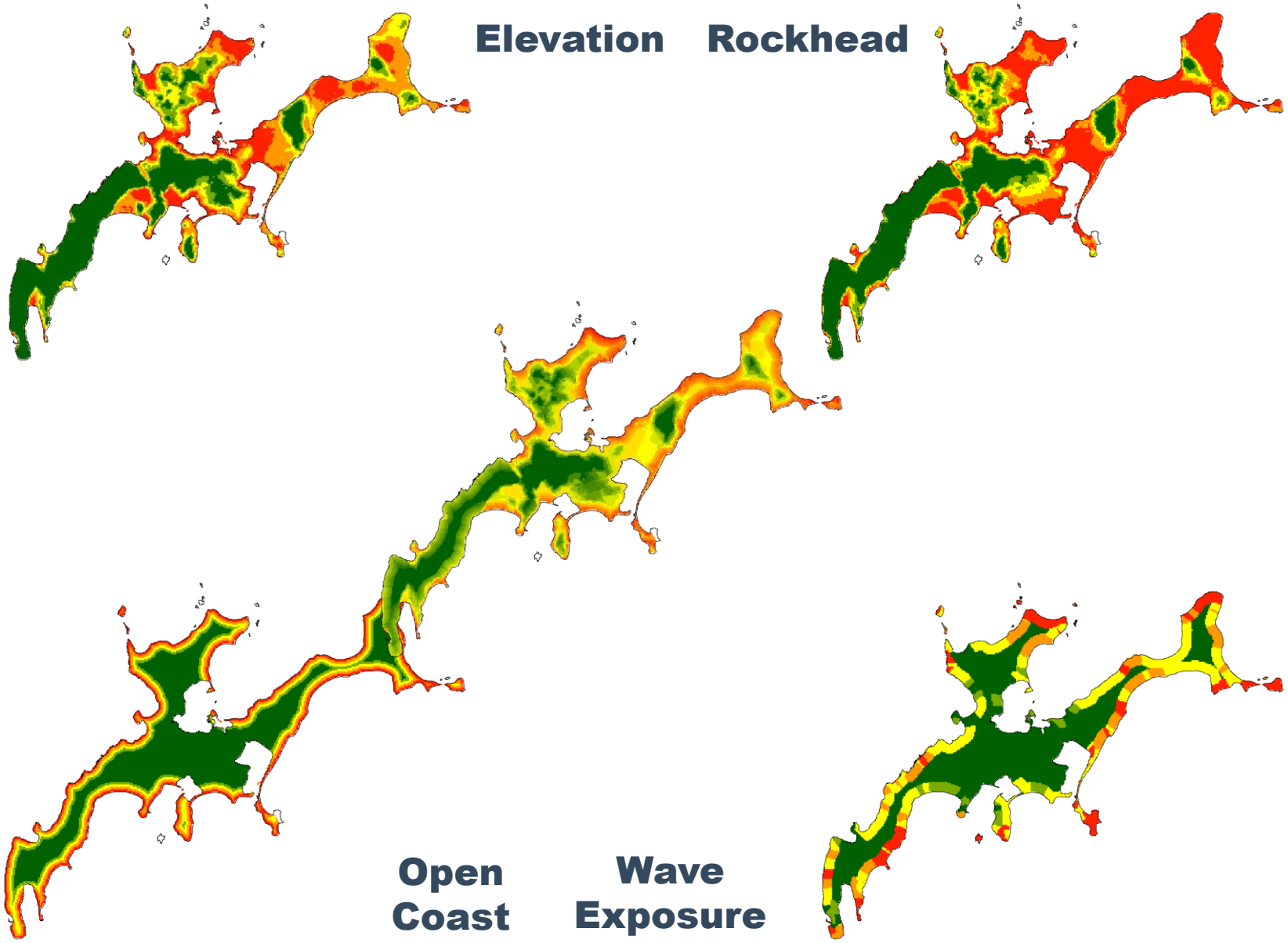
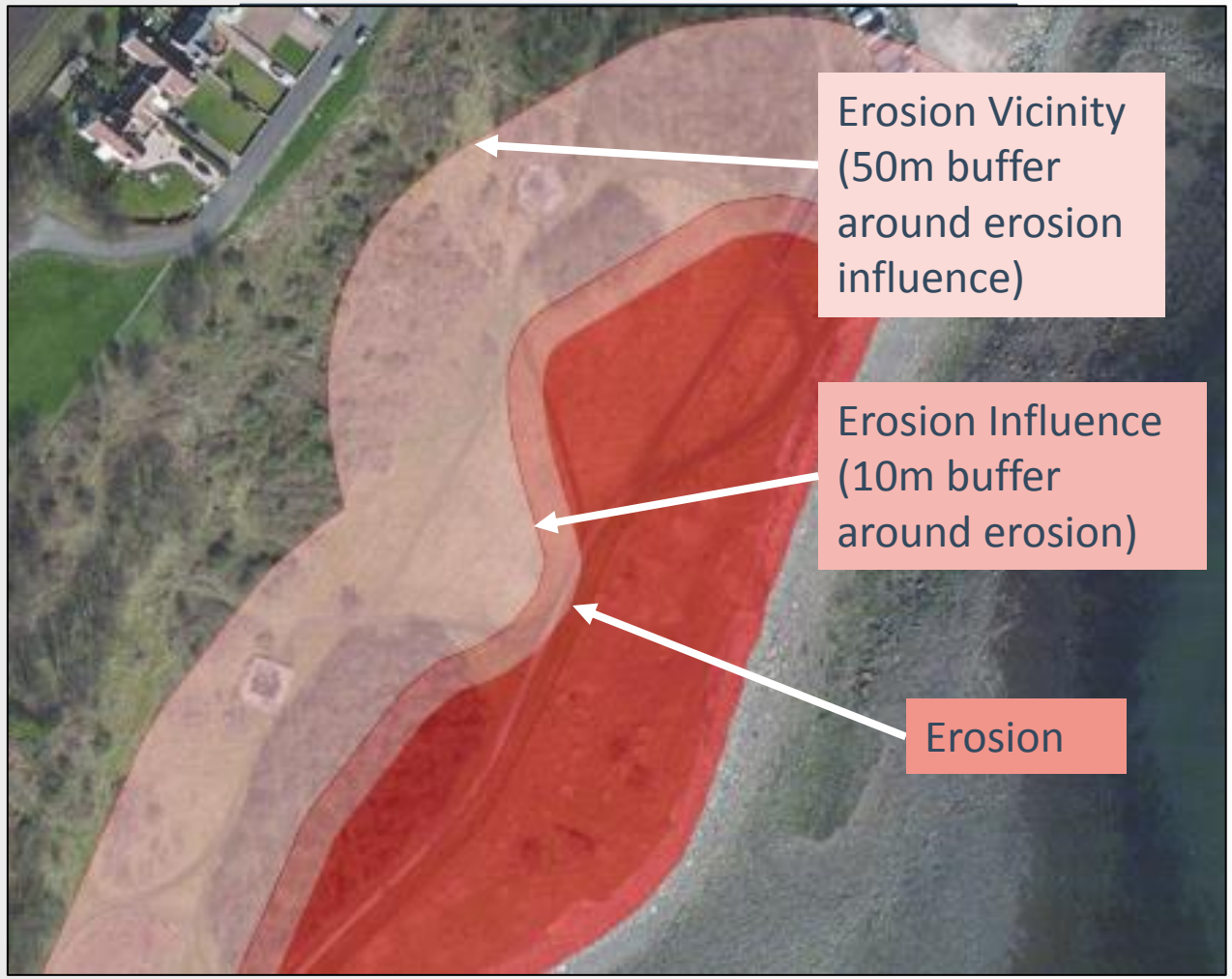
Combined this looks like …
Sanday (Orkney)



What did we do?



Old Balivanich School, Benbecula, Outer Hebrides, closed following storm damage >10m

Future coast identifies the shoreline changes anticipated by 2050

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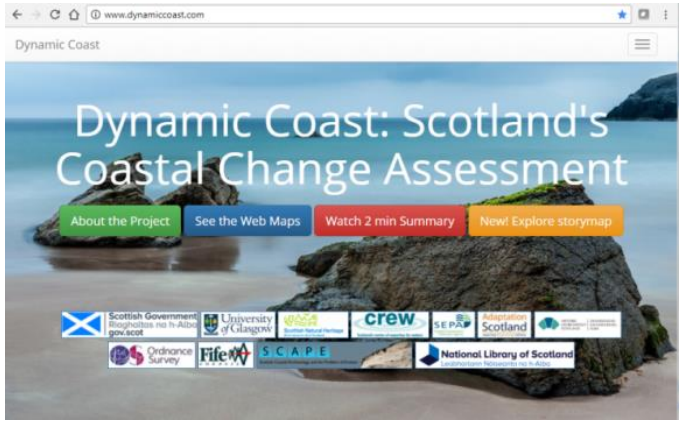
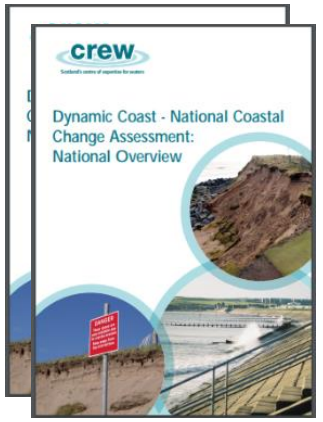
What did we do?

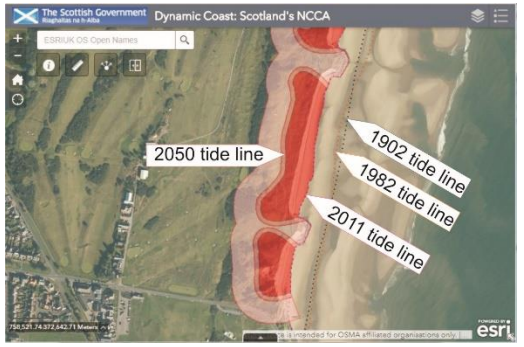
All of the evidence base was then shared publicly via www.DynamicCoast.com with interactive maps, reports and videos.

Data is being made available to inform partner's work (OS updates & LA planning).

- ✓ Saving mapping agency £ by knowing where & how frequently to update
- ✓ Allowing local gov. to spend money on Policy not map analysis
- ✓ Allowing business to forecast risks and build with nature to safeguard assets
- ✓ Allowing flood strategies to be more accurate







What did we establish?

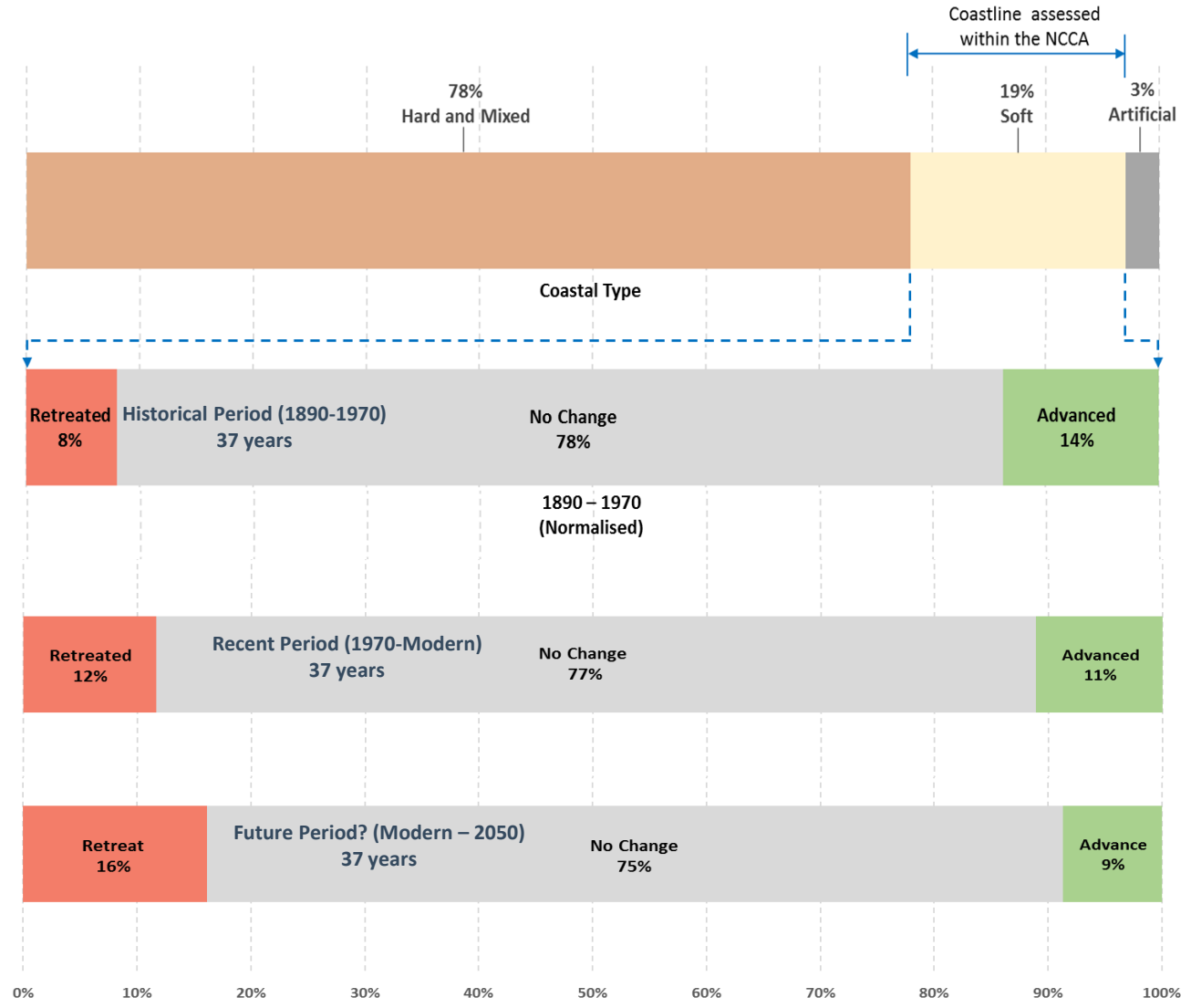
77% soft coast dynamic stability
23% directional changes

Before the 1970s:
(normalised for time period)
8% extent of erosion
14% extent of accretion

Since the 1970s:
39% ↑ in extent of erosion
22% ↓ in extent of accretion

+ Doubling of erosion rates to 1m/yr

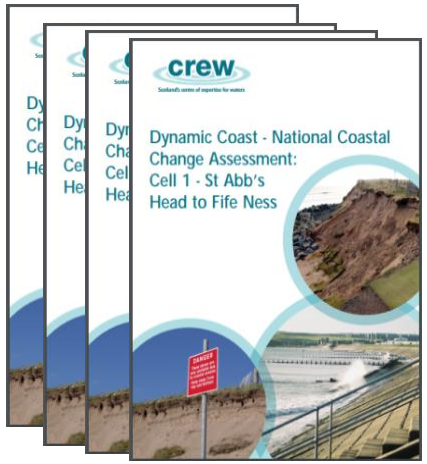
BUT National picture conceals significant regional changes and patterns.

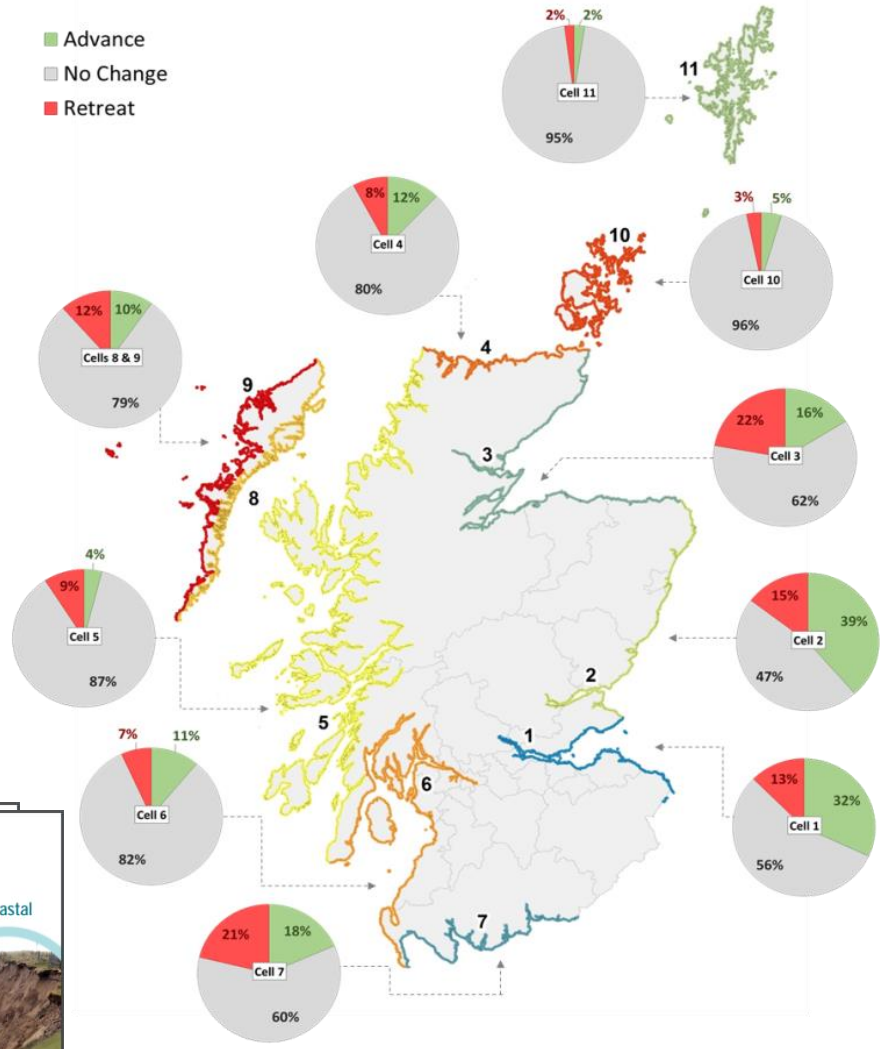


Climate change is a likely driver: (sea level, increasing wave impact & exacerbating storms; added to human factors)

What did we establish?

- Our soft shoreline is more dynamic than it used to be.
  (substantial changes were not routinely updated by OS – they are now)
- 19% (3,802km) of Scotland's 21,305km long shoreline is soft and of that soft coast….
  - 11% has accreted since the 1970s (423km)
  - 12% has eroded since 1970s (442 km)
  - 77% stable
  - Strong regional biases exist with erosion higher on Scotland's open east coast (accretion is also higher in the east but is strongly inlet-concentrated).





% of soft coast change since 1970s

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Since the 1970s ….

- Extent of accretion is reducing (↓ 22%)
- Extent of erosion is increasing (↑ 39%)
- The erosion rate has doubled (now 1m/yr average)
- Consistent with climate change

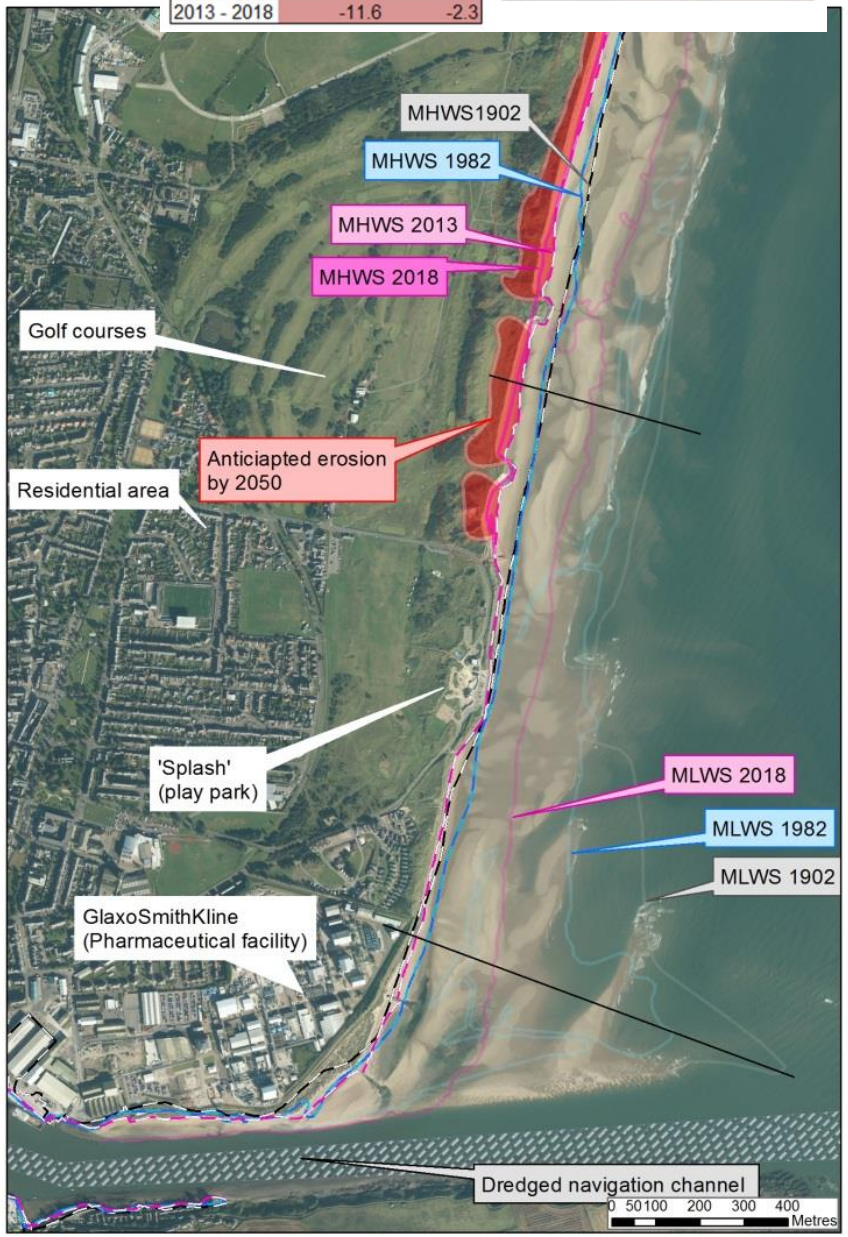
S. golf course

MHWS

Year	change (m)	rate (m/yr)
1902 - 1982	-12.4	-0.2
1982 - 2013	-48.2	-1.6
2013 - 2018	-11.6	-2.3

MLWS

Year	change (m)	rate (m/yr)
1902 - 1982	-103.2	-1.5
1982 - 2018	-57.8	-1.2



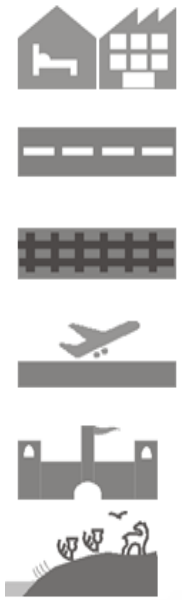
What did we establish?

- For example: 26ha of key heritage sites are anticipated to erode in next 30 years if recent rates continue.
- 43% of heritage sites are on soft shores.
- Natural defences protect 4x the length of road/rail, and almost 4x the area of key heritage sites that are protected by built defences.

Whole Coast Assessment Results

e.g. 156km of roads lie within 10m of MHWS, 53km on soft

Total number of assets within 50m of MHWS



Anticipated (2050) recent rate	Anticipated (2050+) double rate	All	Hard & Mixed	Soft	% in soft coast	Artificial	
52	150	33,494	14,359	9,503	27%	9,632	Buildings
5	10	1,336	733	497	37%	107	Roads (km)
2	2	104	27	58	56%	18	Rail (km)
1	4	3	2	0	11%	1	Runways (ha)
26	27	1,029	471	438	43%	120	Cultural (ha)
447	670	23,430	14,873	8,424	36%	133	Natural (ha)

Results available via webmaps on www.DynamicCoast.com

What did we establish?

- If recent erosion continues, then over £340m of coastal assets will be directly impacted by 2050 –this **underestimates** indirect costs.
  (all sectors in all cells: rail, road, buildings, infrastructure, tourism, cultural & natural heritage)

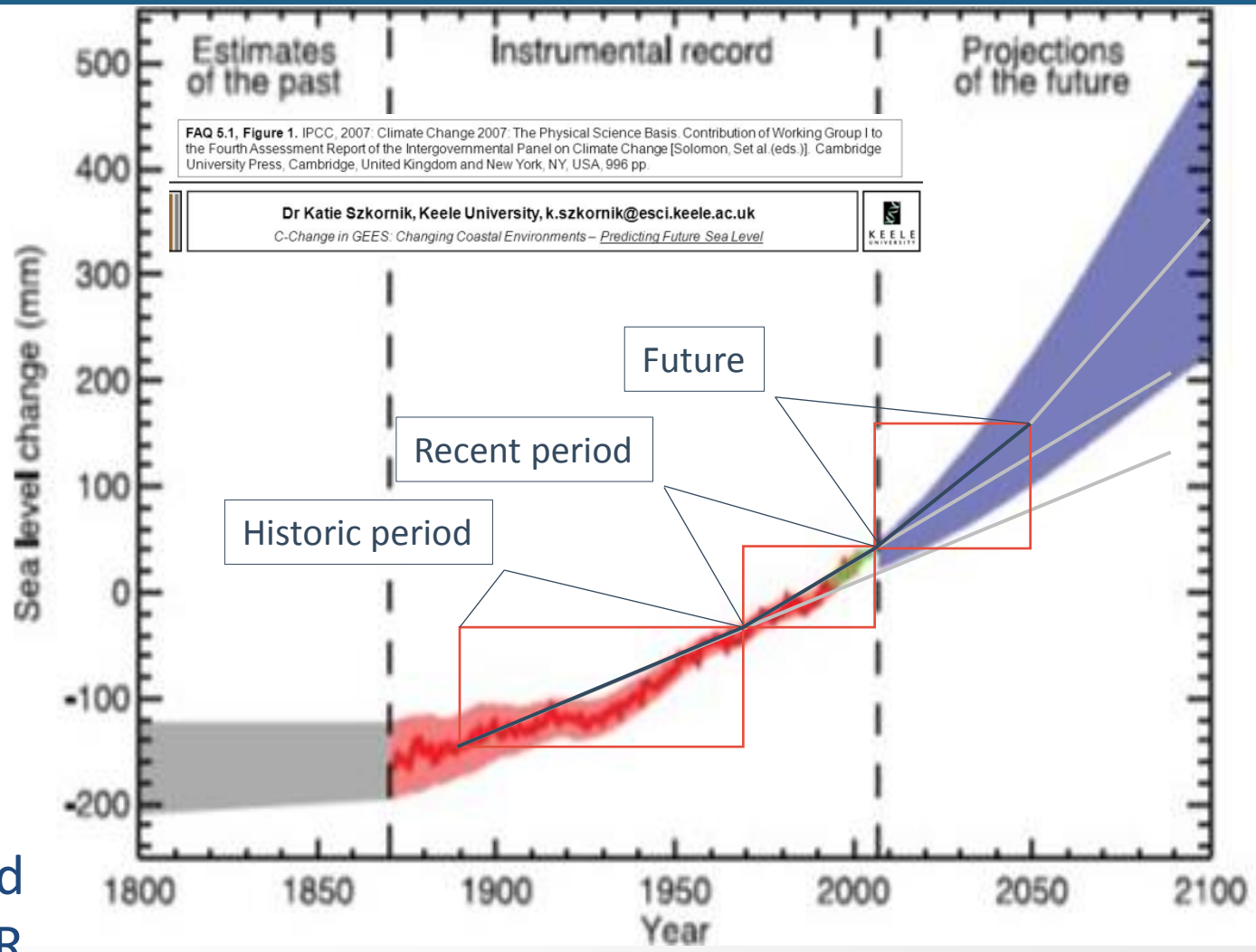
- £13bn of assets and infrastructure protected by natural defences.
- £5bn of assets and infrastructure protected by artificial defences.

- Nature and natural defences are doing a better job than we are!

- *We must value Scotland's natural defences and natural capital.*
  Roseanna Cunningham
  (Scottish Government Cabinet Secretary)

These are likely to be underestimates…

Not just sea level rise: Storm freq.,
Human factors etc are also relevant.



Vulnerability assessment (ie £240m) based on **PAST** rates NOT faster **FUTURE** rates OR erosion expanding into adjacent areas. Flooding & erosion expected to increase significantly. In many areas substantial asset damage is not imminent, but we must start to plan now.

Why is this important?

Erosion enhanced flooding is one of the key ways climate change will be manifested.

SLR will have big impact on

flood frequency.

M.E.S. Leith +0.3 m sea level by 2090 =

1:100 yr event → 1:8 yr

(1% or 12.5% probability)

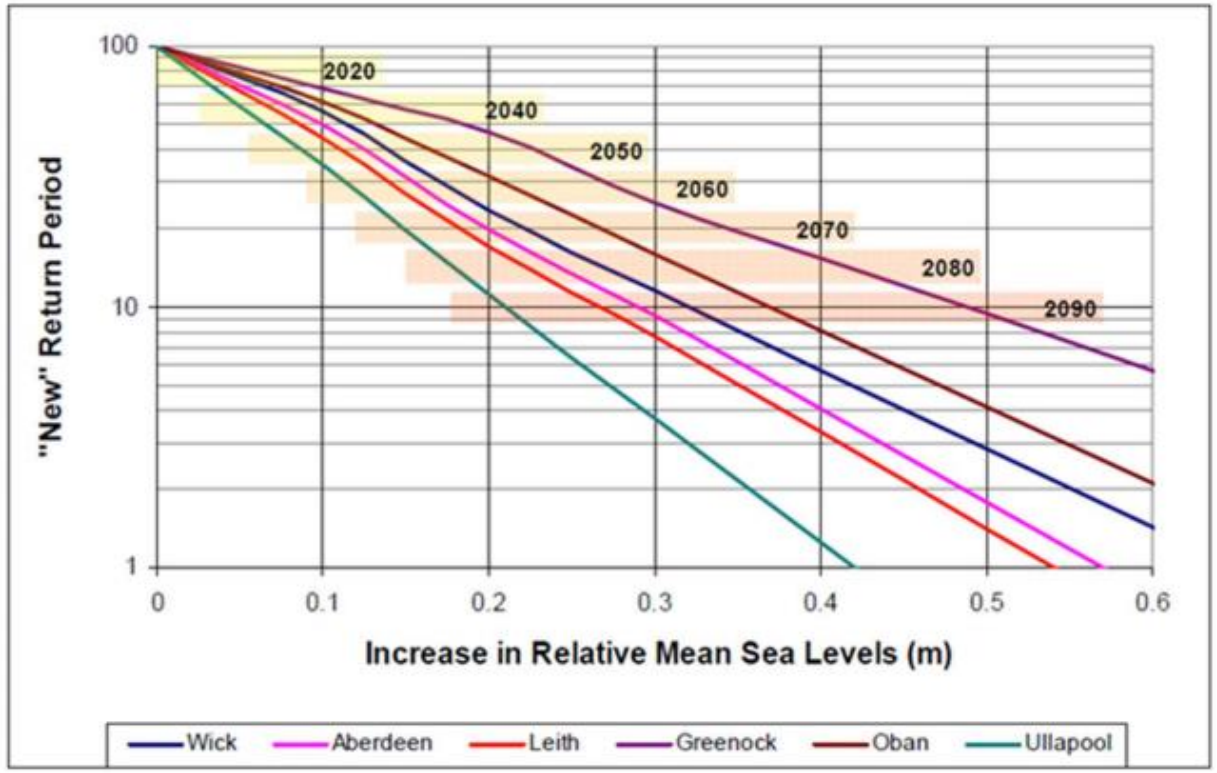


Figure 4.6: Reduction in flood return period given increases in mean sea level (Defra (2012) UKCCRA for Scotland – Technical Report. Fig3.5 p43, based on the central estimate of the Medium Emissions Scenario, locations are approximate)

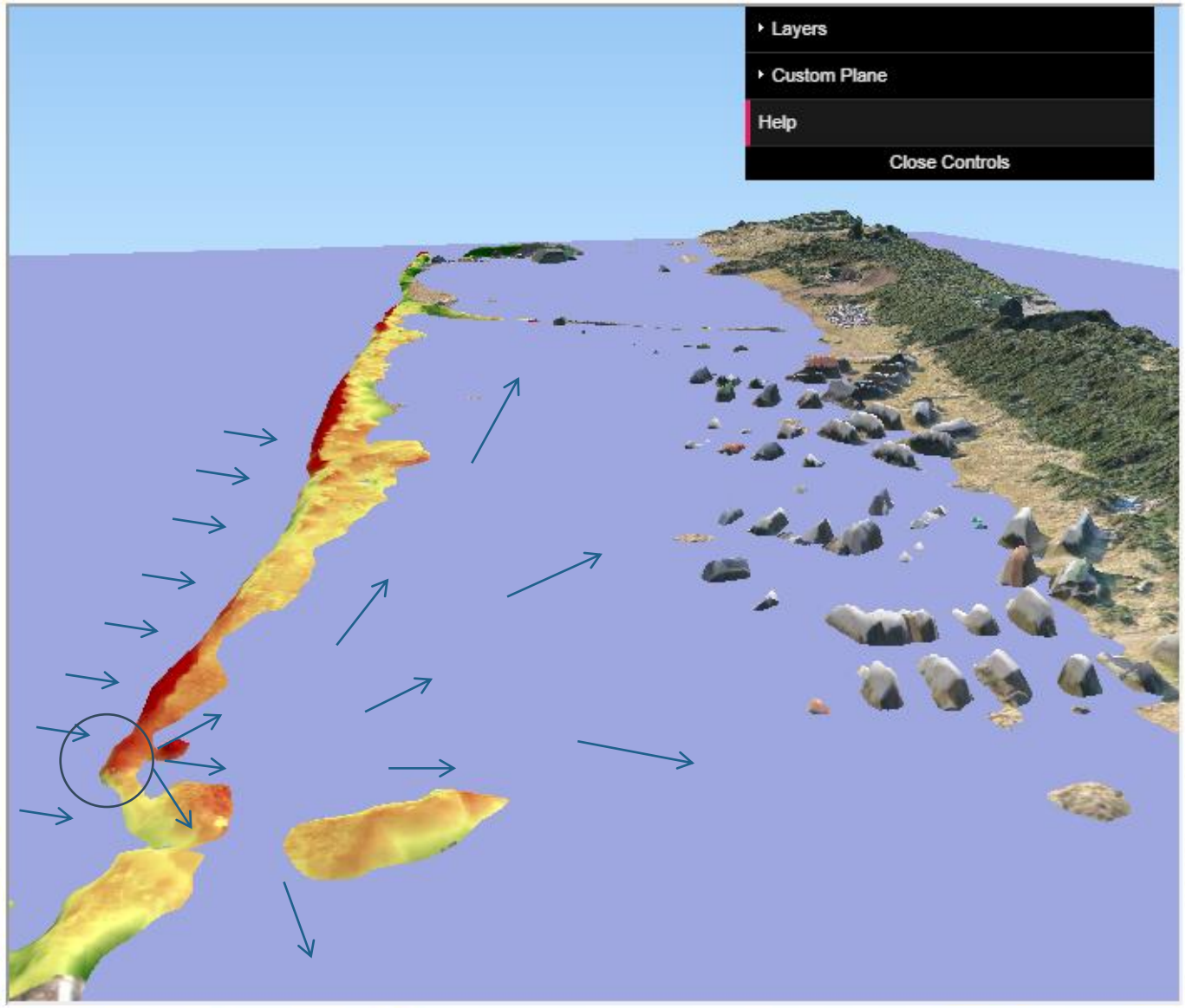
Table 3-2: Estimated increase in total properties at risk for a 10% AP flood

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

What are we doing now?

Dynamic Coast 2 has started, using 3-D modelling to:

- Update coastal topography and position at key sites using UAV drones,
- Appraise resilience of soft natural defences,
- ID breach-points for erosion enhanced flooding…this is how climate change at the coast will impact people,
- Consider impact of future RSL accelerations for future erosion extents, rates and erosion related flooding.
- So we can be better prepared, more resilient and adaptive.

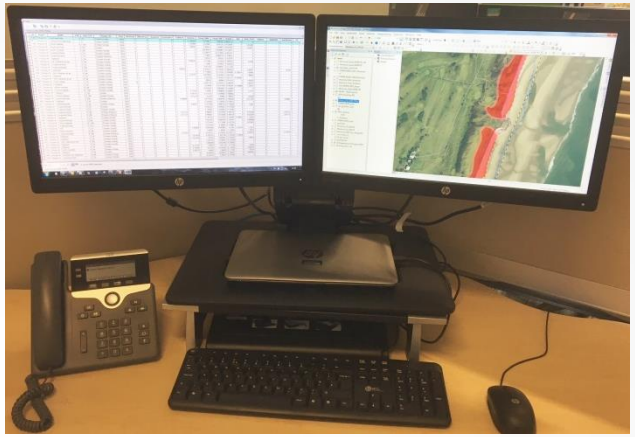


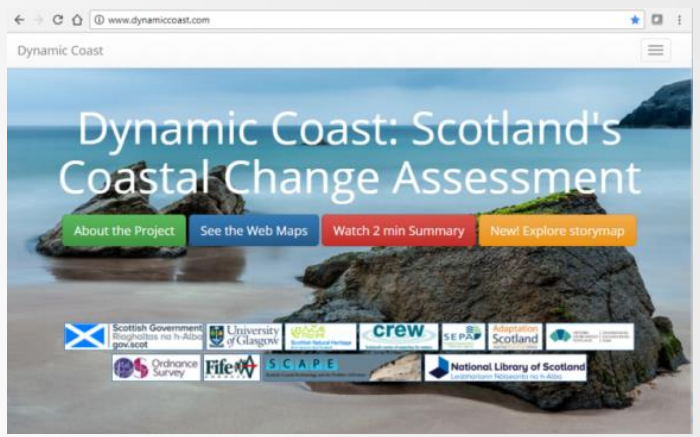
Conclusions

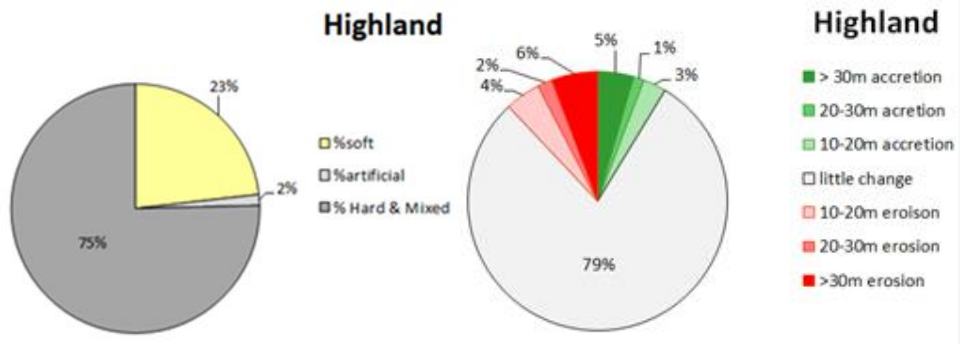
None of this is possible without GIS…

- in every Local Gov office computer,
- The public are able to view data too,
- Other specialists (flood staff, archaeologists) able to collaborate
- iPad or iPhone in the field
- Adjustable to audience (national, regional, local, sector)
- Updateable via multiple tech

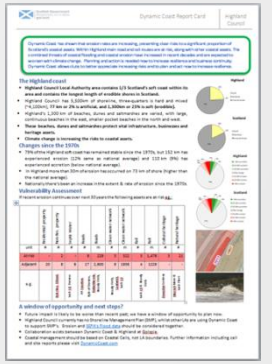
… GIS everywhere!







	Residential property	Non-Res. property	Septic Water	Roads	Roads	Clean water network	Clean water network	Rail	Rail	Cultural heritage	Natural heritage
unit	#	#	#	#	m	#	m	#	m	#	#
At risk	-	1	-	8	229	3	322	3	1,478	3	21
Adjacent	20	8	8	17	2,600	9	1,936	4	1,229	-	-
e.g.		Kylerhea, Kilmuir	Loch Eil, Durness	A9 Evanton, Kyle of Durness, Kinlochbervie, Beauly Firth,		Beauly Firth, Sandwick, Loch Eil		Loch Eil & Beauly Firth		Dunrobin Gardens	Morrich More & Loch Fleet



We have a window of opportunity to prepare mitigation, adaptation and resilience plans

"Dynamic Coast gives Scotland it's most advanced, nationally consistent and locally informed understanding of the causes and consequences of coastal change that it has ever had, so we have to use it and build on it now."

Environment Secretary Roseanna Cunningham

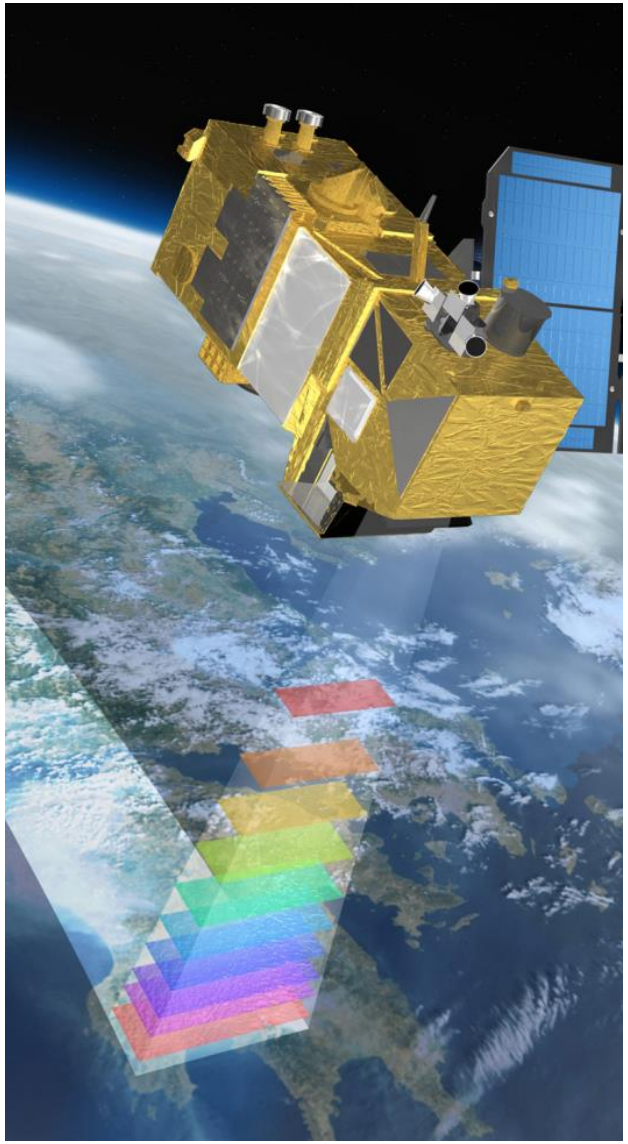
(August 2017)

Greater future need?

- Our world is changing (physically, societally & technologically) and we must act and invest now to understand the implications and, if warranted, deliver early warning.

- **Dynamic Coast has shown that a small team working closely with supportive key partners can deliver a step change in our shared understanding and approach to better manage future risk at the coast.** Ongoing collaboration to explore greater efficiencies and options merging EO, LiDAR, Aerial, Drone & Ground Survey data.

- What MHWS has shown us may be the tip of the ice-berg… **What about MLWS?** Perhaps EO can deliver change intelligence here… but that's another presentation!



Thanks to the Dynamic Coast team

Questions?

www.DynamicCoast.com

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