A FORWARD LOOK AT SEA LEVEL AND CLIMATE CHANGE: IMPLICATIONS FOR THE COAST

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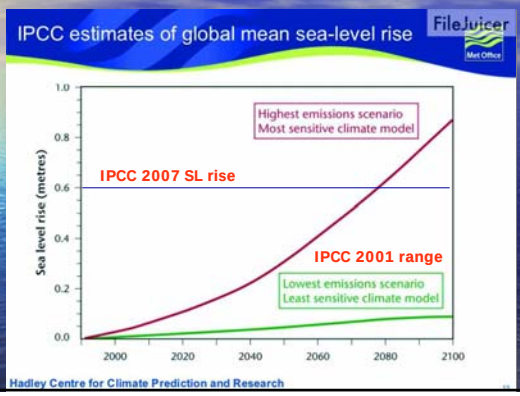
IPCC ESTIMATES OF GLOBAL SL RISE



(UN)CERTAINTIES TO MAKE COASTAL LIVING MORE EXPOSED

Global climate change

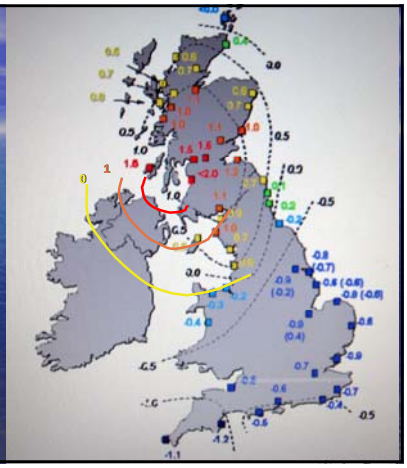
- Mean temperature forecast to increase by 2-4°C over the next century

This is likely to lead to

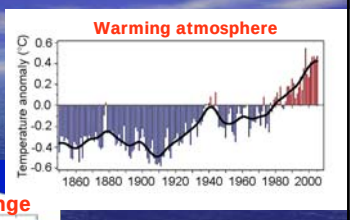
- **Accelerating sea-level rise**
  - UK rates from 1-2mm/yr to forecasts of 12-15mm/yr by end of 21st century. C 0.8m rise
- **Changing storminess**
  - Storm frequency and intensity increasing(?)
  - The role of hurricanes as extra-topical storms

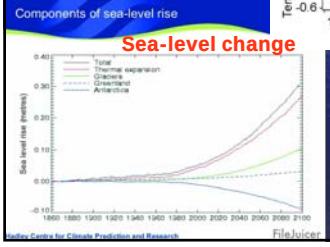
PRESENT UK HOLOCENE RATES OF VERTICAL DISPLACEMENT DUE TO ISOSTATIC FORCING

UKCIP02
+ NI DATA
(Orford et al., 2007)



WHY "THREAT" OF RISING SEA LEVEL?

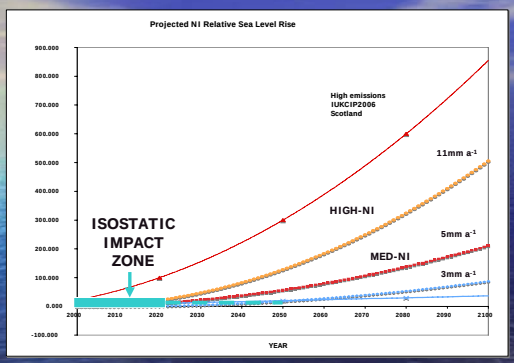




CONTEMPORARY RATES OF RELATIVE MEAN SEA LEVEL CHANGE FOR THE NORTH OF IRELAND (mm a^{-1})

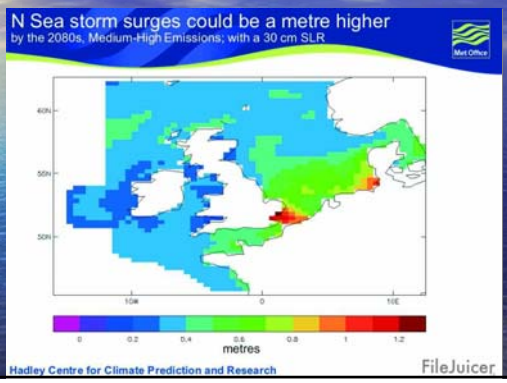
Modelled on 20th century tide gauge trends
(Orford et al 2007a)

FUTURE RSL CHANGE



Future Coastal Scenarios in Northern Ireland (Orford et al, 2007b)

FUTURE SURGE CHANGES



CHANGES IN STORMINESS

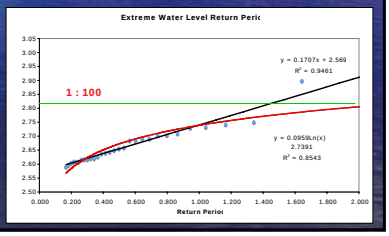
- SST and increasing hurricane number
- Increasing intensity
- More hurricanes moving out of the tropics - degenerate
- H.Donna 1961
- H.Mitch 1998
- H.Gordon 2006

- Intensification of westerly depressions - lower LP
- Blocking continental HP intensify, so that SE storms more likely for Ireland

NORTH COAST: FORECAST EXTREME WATER LEVELS BY 2100AD

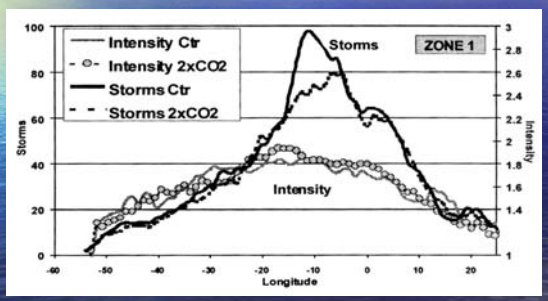
- Assessment may under-estimate event returns due to extreme outlier
- Current 1:100 year event level by 2050AD, could reoccur 1:5 years (HIGH) and 1:20 years (MED).
- By 2100AD, current 1:100 year event might re-occur 1:1 year
- By 2100AD 1:100 year event probable to reach approximately 3.0 - 3.5m OD, possible to reach 3.5-3.9m

Return period (yrs)	Extreme water level (mOD)
2	2.54
5	2.77
10	2.89
20	3.01
50	3.17
100	3.29
200	3.41
500	3.57
1000	3.69



NUMBER AND INTENSITY OF CYCLONES - NOW and FUTURE

(Lozano et al, 2004)



UNCERTAINTIES IN 1:50 yr EXTREME ELEVATION FOR THE NORTH COAST

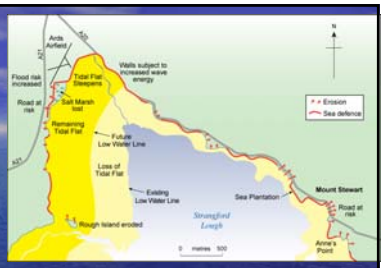
	2020AD	2050AD	2080AD	2100AD	RSL adjusted for regional differences
UKCIP (2006) Scotland	2.89 (+0.1)	3.09 (+0.3)	3.39 (+0.4)	3.64 (+0.85)	3.22 – 4.06
Defra (2006)	2.95 (+0.06)	3.02 (+0.23)	3.29 (+0.5)	3.52 (+0.74)	3.16 – 3.90
IPCC(2007)	n/a	n/a	n/a	3.38 (+0.59)	3.09 – 3.67
Lowe & Gregory (2005)			2.99 – 3.19		

Orford et al., 2007b

SELECTED NATIONAL TRUST (NI) COASTAL SITES FOR CHANGE SCENARIOS

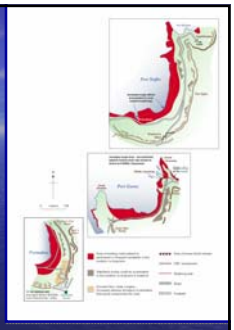
Orford et al., 2007b

STRANGFORD LOUGH OF THE FUTURE?



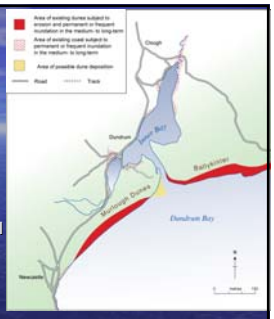
- c.1m rise in sea-level (SL) = significant loss of tidal mudflats
- Steep lough-shore slopes and coastal walls = coastal squeeze
- Seal haul outs and nesting shingle beaches lost under SL rise
- Saltmarsh losses as onshore transition potential lost with rapid SL rise
- Increased winter storms and surges = increased overtopping threatening roads, and undermining defences

THE CAUSEWAY COAST OF THE FUTURE?



- By 2020
  - threat of storms and adverse weather conditions = stronger access control.
- By 2050 - 2080
  - likely slope instability and cliff retreat = realignment of the cliff top path.
  - Past major slips reactivated = road access to the Causeway Stones may be threatened.
- Rising sea level and peak surges = increase the area of Causeway washed by winter waves.
- Changing conditions will impact on significant cliff foot habitats of saltmarsh and vegetated shingle

MURLOUGH OF THE FUTURE?



- Sea-level rise would lead to between 50-400m landward dune erosion. Dune erosion rate depends on rate of sea-level rise
- Longshore storage capacity of sand dependent on rate of sea-level rise
- Inner Bay flooding leading to saltmarsh losses on west side, though possible growth on eastern side
- Changes in 'seasonality' of rainfall will stress dune heath vegetation

THE GIANT'S CAUSEWAY OF THE FUTURE?

- 2100
  - Increase in extreme flood levels = difficult access to the stones
  - The Grand Causeway could experience considerable erosion, while parts of the Middle and Little Causeways could be under water for periods of the winter

UNCERTAINTIES OF COASTAL RECESSION RATES (ma^{-1}) for IRELAND

- Based on the Bruun Rule (Carter 1990)

Location	Low SLR (9cm)			Med SLR (18cm)			High SLR (30cm)		
	1	2	3	1	2	3	1	2	3
West	0.64	0.60	0.47	1.28	1.20	0.14	2.14	2.00	1.58
North	0.96	0.84	0.56	1.92	1.68	1.12	3.21	2.81	1.87
Northeast	3.60	2.57	1.20	7.20	5.14	2.40	12.03	8.59	4.01
East	4.50	3.75	2.25	9.00	7.50	4.50	15.04	12.53	7.52
South	1.63	1.50	1.12	3.26	3.00	2.24	10.90	5.01	5.45
Southwest	0.88	0.75	0.37	0.76	1.50	1.74	2.95	2.50	1.25

1=shoreline, 2=2m high cliff and 3=10m high cliff.

LOSS WITH 1m RSL RISE: IRELAND

IMPACT	NUMBER	PROPORTION	VULNERABILITY
People affected	<250000	4.6%	Med (1-10%)
People at risk (floods)	<100000 1:100 flood	#/1000 people	Low (<10/1000)
Capital value loss (total loss/GNP)	c.US$170M (agric land value)	c. 0.2% GNP	Low (< 1%)
Dry land loss	<230 km^2	<0.3% Total area	Low (< 3%)
Wetland loss	c.800km^2	c. 30% Wetland area	High (10-30%)
Protecton/adapt ation costs (ROI only)	Potential US$420M/yr Likely US$10M/yr	c. 0.6% GNP c.0.02% GNP	High (0.25 – 1%) Low (< 0.05%)

- After Devoy (2008)
- Vulnerability classes: (Watson et al 1996)

IF WE DON'T RETREAT, THEN WE MUST ACCEPT MORE OF THIS!

ESTIMATES OF EXISTING COASTAL PROTECTION COSTS

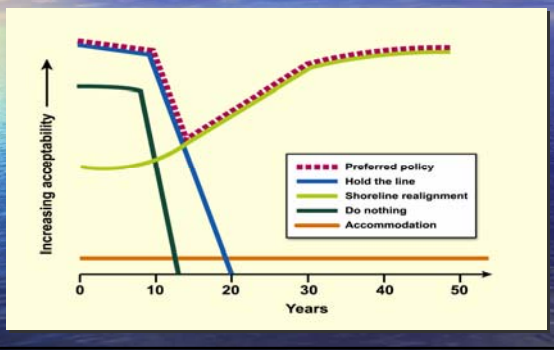
Given 1m RSL RISE in 100 year (Devoy 1992)

	Coast km	Defenc km	COST to bring SoP to meet 1m RSL rise				Total £k
			Low coast	Urban coast	Harbour	Beach	
BRITAIN	15000	5500	£1898M	£2536M	£624M	£1164M	£6222M
IRELAND	6500	200	£62M	£336M	£39M	£0	£437M

MOVING FORWARDS

- Generic need:Marine Spatial Planning
- Specific approach: - Shoreline Management Planning as in GB
  - Natural coastal units - cells
  - Coast and shoreline behaviour - based on both long term and short term time forcing
- Treat the coastal zone as hazardous in planning

WHAT ARE THE OPTIONS FOR COASTAL SOCIETY FACED WITH SUCH PHYSICAL CHANGES



INAPPROPRIATE DEVELOPMENTS: RELATIVE TO FUTURE SEA-LEVEL RISE

- Single dune ridge system
- Dunes as flood defence
- Dune erosion and breaching under sea-level rise

Inishcrone, Mayo

- 2nd / holiday homes
- On flood plain to rear of dunes

THE UNINTENDED THREAT POSED BY COASTAL REGENERATION

Future sea-level rise could turn this
Into a FLOOD hazard development

VARYING INTERVENTION UNDER FUTURE SOCIETY SCENARIOS

NATIONAL ENTERPRISE
- Protect barriers with push for agricultural self-sufficiency as economic benefit (as in 1939-45)
- Regional scale activity
- Barrier protection for common good

LOCAL STEWARDSHIP
- Barriers left untouched under ecological principle and left to retreat
- Local self-motivation might pursue barrier stability
- Local scale will reduce effective need in integrated coast, but might work in segmented coast
- Real estate forcing is minimal

WORLD MARKETS
- Maintain barriers for agriculture
- No subsidies, so marginal land may allow barrier breakdown as no effort made to support barrier
- Real estate values can force barrier protection

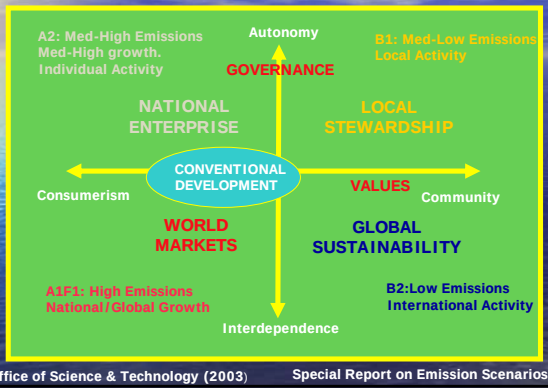
GLOBAL SUSTAINABILITY
- Barriers maintained for habitat protection.
- Variable value on specific habitats relative to international agenda
- Not controlled by agricultural return
- Real estate carries little weight

MORE OF THIS - PIECEMEAL NON-SUSTAINABLE DEFENCES

CONCLUSIONS

- 21st century coastlines are likely to change at unprecedented rates
- Physical responses currently uncertain
- Human responses will be dominated by 'protection issues'
- Protection is generally non-sustainable and needs to be resisted
- Spatial coastal planning for long-term retreat, must be a priority
- Any 'solution' is likely to be tempered by governance issues

FUTURE SOCIETY SCENARIOS



UK Office of Science & Technology (2003) Special Report on Emission Scenarios