A TEMPLATE FOR MODELLING AND MANAGING SEA LEVEL RISE AND CLIMATE CHANGE

James Carley
Water Research Laboratory
University of New South Wales

Matt Blacka, Wendy Timms, Ron Cox: WRL
Phil Watson: Clarence City Council
Clive Attwater: SGS Economics and Planning

Clarence TAS Project Outline
Two main elements:
• Social and economic impact and response
  – SGS Economics & Planning
  – Myriad Research
  – Dr. Melissa Nursey-Bray
• Scientific/technical assessment of impacts
  – Water Research Laboratory, UNSW

Social and economic assessment
• Literature search - experience elsewhere
• Determine baseline attitudes - community focus groups and survey
• Implications – issues, options identified by the technical and scientific assessment
• Education strategy
Community survey - focus groups

- People *like* living on or near the coast

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Key Climate Change Variables

- NCCOE (2004) lists six key environmental variables applicable to coastal engineering, namely:

1. Mean Sea Level.
2. Ocean Currents and Temperature.
3. Wind Climate.
4. Wave Climate.
5. Rainfall/Runoff.
6. Air temperature.

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Secondary Climate Change Variables

- NCCOE (2004) also lists 13 secondary or process variables applicable to coastal engineering, namely:

1. Local Sea Level
2. Local Currents
3. Local Winds
4. Local Waves
5. Effects on Structures
6. Groundwater
7. Coastal Flooding
8. Beach Response
9. Foreshore Stability
10. Sediment Transport
11. Hydraulics of Estuaries
12. Quality of Coastal Waters
13. Ecology

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Matrix of Climate Change

- Table 1.1: Interactions of Climate Change Variables for Potential Impacts

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Matrix of Climate Change

- Table 1.1 continued

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NCCOE Template

- Guidelines for Responding to the Effects of Climate Change in Coastal and Ocean Engineering

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The National Committee on Coastal and Ocean Engineering

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Water Research Laboratory
Technical assessment: Processes
- Tide and tidal anomalies - DATA
- Offshore extreme waves - DATA
- Swell wave penetration - SWAN
- Local wind waves - CEM
- Stormwater - QUALITATIVE
- Sea level rise - IPCC
- Tsunamis – COMMENT
- LIDAR DATA ACQUIRED DURING STUDY

Hazard
Hazards (generally 100 year ARI):
- Present day, 2050, 2100 – IPCC SLR
- Erosion - SBEACH
- Recession – BRUUN RULE
- Entrance stability - QUALITATIVE
- Wind blown sand – CEM, OBSERVATION
- Open coast inundation - MODELLING
- Lagoon/bay inundation - MODELLING
- Cliff/bluff stability - OTHER
Seawater intrusion to groundwater - DESK

“Design Event”
BUILDING CODE OF
AUSTRALIA (2007) For
private house:
Wind load: 500 year ARI
Snow load: 150 year ARI

MOST FLOOD POLICIES
AND COASTAL
STRUCTURES
in Australia and USA
100 year ARI plus freeboard of
0.5 m

NETHERLANDS COASTAL
DEFENCES: 10,000 year ARI

Sea level rise scenarios adopted

<table>
<thead>
<tr>
<th>SLR Scenario</th>
<th>2050</th>
<th>2100</th>
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<tbody>
<tr>
<td>“Mid” range scenario</td>
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<td>0.4</td>
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<tr>
<td>“High” range scenario</td>
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</table>

IPCC (NCCOE, 2004) Sea level rise projections
SEA LEVEL RISE for ~2100
0.9 m from NCCOE (2004) SLR curves based on IPCC (2001)
7 m IPCC (2007) for total melting of the Greenland ice sheet
70 m if all the world’s ice sheets were to melt (GACGC, 2006)

Present day water levels
Wave buoys

Ocean waves – Cape Sorell TAS

Analysis of Cape Sorell (top) and Wedge Island wave buoy data (Data source: BoM and CSIR)

ERA-40 DIRECTIONAL WAVE CLIMATE

SWAN Wave Modelling
Technical assessment:
SWAN wave modelling fine grid

SWAN output

Barometric and Wind Setup
Wind setup and barometric setup

Barometric data
Barometric pressure >100 years of data

WIND SPEED

Wind Setup
Simple 1-D model
WIND SETUP
RALPHS BAY SOUTH ARM NECK

Wind Setup, South Arm Neck, North Wind

Average Recurrence Interval (Years)

<table>
<thead>
<tr>
<th>Recurrence Interval (Years)</th>
<th>Wind Setup (m)</th>
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SWL = 0.0 m AHD
SWL = 0.5 m AHD
SWL = 1.0 m AHD
SWL = 1.5 m AHD
SWL = 2.0 m AHD
SWL = 2.5 m AHD
SWL = 3.0 m AHD

EXTREME WIND WAVES
RALPHS BAY SOUTH ARM NECK

Ralphs Bay, South Arm Neck

Average Recurrence Interval (Years)

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<tr>
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Wind waves

Wind waves

EROSION MODELLING
For locations where there is minimal historic data
Consideration of:
Carley and Cox (2003)
Nielsen and Adamantidis (2007)
WA Government (2005)

BRUUN RULE – CLOSURE DEPTH METHODS
- Hallermeier inner
- Hallermeier outer
- SBEACH 100 year ARI
- Profile evidence

- ADOPTEO BRUUN FACTOR
  - Rule of thumb 50 to 100
  - Range for Clarence (12 locations) 11 to 432

ADOPTED BRUUN FACTOR
- 20, 50
Setback components

Setback components:
- S1: Allowance for storm erosion
- S2: Allowance for long term (underlying) recession
- S3: Allowance for beach rotation
- S4: Allowance for reduced foundation capacity (to Stable Foundation Zone)
- S5: Allowance for future recession (Bruun Rule)

DUNE STABILITY SCHEMA
after Nielsen et al (1992)

HAZARD LINES FOR BUILDINGS
PRELIMINARY

Erosion (Wamberal 1978)

POTENTIAL INUNDATION
using LIDAR data
Retreat options:

- Relocate structures beyond inundation and erosion
- Need to test community attitudes to preserving public foreshore access
- Repurchase of the seaward portion of allotments to maintain access

Responses

Retreat, accommodate, protect

- Planning controls, which must deal with:
  - Building setbacks.
  - Minimum floor levels.
  - Appropriate engineering assessments.
  - Appropriate construction techniques (eg piled buildings).
- Planning controls which may also consider a development freeze in some locations.
- Physical works such as seawalls, groynes, dune management or sand nourishment.
- Ongoing monitoring, analysis and review of findings.
- Additional data collection or studies.
ADAPTATION
Accommodation
– ELEVATED HOUSES

GROYNES AND NOURISHMENT
LADY ROBINSONS BEACH

ADAPTATION – SEAWALLS

ADAPTATION – SEAWALLS

206 x 735

PROTECTION NOT ALWAYS POPULAR
PROPOSED SEAWALL
COLLAROY – NARRABEEN

1.1 km human line
in the sand
17/11/2002
SUMMARY / CONCLUSIONS / DISCUSSION

- 10 separate coastal processes and ~10 separate coastal hazards need consideration in coastal assessments
  - The combination of major storm events with future sea level rise is the dominant factor to consider for planning
  - Modelling of moderate complexity can answer many questions
  - Technical output needs to be integrated into socio-economic framework

The end