Future Coastlines:

Planning, Management and Adaptation Strategies for Climate Variability & Climate Change

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Coastal Settlements Node Convenor – Australian Climate Change Adaptation Research Network for Settlements & infrastructure

NCCARF National Climate Change Adaptation Research Facility Adaptation Research Network SETTLEMENTS AND INFRASTRUCTURE

GCCM Griffith Centre for Coastal Management

Griffith UNIVERSITY

Acknowledgements

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NCCARF
National
Climate Change Adaptation
Research Facility
Adaptation Research Network
SETTLEMENTS AND INFRASTRUCTURE

Department of Climate Change funding of $50 million over 5 years 2008-2012

- **To underpin the development of adaptation strategies based upon sound scientific knowledge**
- **To foster research and synthesize knowledge about climate change adaptation**
- **To stimulate research investment with contributions from research funding bodies, State governments, the private sector and other bodies and programs.**

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National Climate Change Adaptation Research Facility

- **$10 million to establish and manage the new Climate Change Adaptation Research Facility (hosted by Griffith University);**
- **$30 million for specific research projects to support implementation of the National Adaptation Research Plans**
- **$10 million to support the activities of 8 Adaptation Research Networks**

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Network Themes

- **Terrestrial biodiversity:**
- **Primary industries:**
- **Water resources and freshwater biodiversity:**
- **Marine biodiversity and resources:**
- **Human health:**
- **Settlements and infrastructure:**
- **Disaster management and emergency services:**
- **Social, economic and institutional dimensions**:

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Settlements and Infrastructure

Covering climate change impacts and adaptation issues/options across:

- **coastal settlements**
- **urban planning and management**
- **the built environment –design and construction**
- **public and private infrastructure including energy, water security, flooding, transport, communications**
- **the social, economic and institutional implications of these impacts and implications for planning, design, and management of settlements and infrastructure**

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Node 1: Coastal settlements

- To play a major role in
  - leading the exploration of the implications of climate change
  - development of adaptive strategies for the densely populated coastal zone (including open coasts and estuaries),
  - modeling urban adaptation outcomes from climate change projections.
- www.nccarf.edu.au

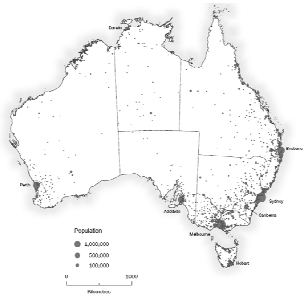
Coastal Settlements – Issues and Needs

1966
(40,000 people)

Now
(500,000 people)

Australia's Population

- 77% within 50km of the coast (ABS, 2006)
- We're seeing rapid non-metro coastal growth
  - 1997 non-metro coastal population: 4.99 million
  - 2007 non-metro coastal population: 6.26 million (Stokes, 2008)
- Since 2001:
  - 9.8% non-metro growth
  - 6.1% national growth



Sea Change

- The 'Sea Change' phenomenon (Burnley and Murphy, 2004; Gurran et al., 2005; Gurran et al. 2006; Harvey et al. 2008)
  - Population shift to the coastal zone
  - Different 'types' of Sea Change communities & settlements
- The social profile of these communities compounds their vulnerability to climate change impacts due to limited adaptive capacity (Gurran et al., 2008)
  - Lower household incomes
  - Significant proportion aged 65+

When Sea-Change meets Climate Change

+

=

Climate change threats to coastal environments

- Increased flooding
- Increased storm surge
- Saline water intrusion upstream
- Modified coastal processes particularly sediment transport
- Accelerated erosion due to higher water levels and increased storm intensity
- Large scale modification to coastal landforms
  - Breaching of barriers
  - River deltas
- Ecological collapse of systems unable to tolerate increased marine environment
- Modification of distribution of fauna and flora

Planning for the Future

- The combination of major storm events with future sea level rise is the dominant factor to consider for adaptive coastal planning and management
- Erosion and inundation combined with climate change are the dominant coastal hazards
- Numerous potentially feasible adaptation options are available at varying costs

People safety – adaptation options include awareness, warning and evacuation

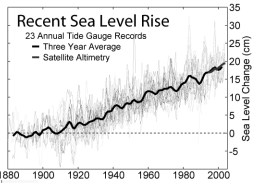
Defining Moments

- UNSW- Masters course, 1977
  - look to the real world for models of impact (Doug Foster)
  - SLR -300mm
- Stern Report, 2006
  - Climate Change is politically real
- Recent GCCM research since 2001
  - The Pacific Wobble
  - Cat. 5 storm?
  - Most of the worst things you can expect from CC can happen tomorrow,
  - Climate variability vs climate change
- Climate Change Adaptation (NCCARF, 2007)
  - finally have a catchy title for years of coastal engineering practice and investigations
- HoR Report (George et al, 2009
  - Framework for action?

Sea Level Rise and Extremes

Sea Level Rise

- GLOBAL SEA LEVEL RISE
  - Last 50 years
    1.8 ± 3 mm pear year
  - last 100years
    1 to 2 cm per decade



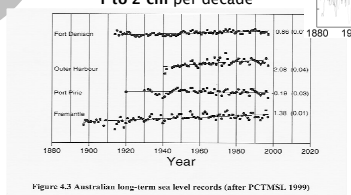
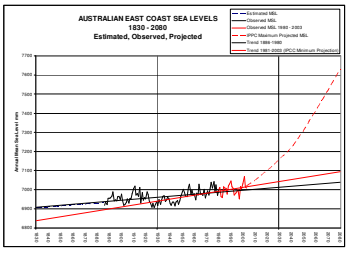


Figure 4.3 Australian long-term sea level records (after PCTMSL 1999)

Sea Level Rise Trends

- GLOBAL SEA LEVEL RISE
  - **future – 3 - 30cm by 2040**
  - **future - 9 – 88 cm by 2100**
  - **Sea level is higher than expected since 1970s**



Sea Level Rise Trends

Period	Annual rise (mm/yr)	Rise over 50yrs (mm)	Reference
1850 - 1900	<1.0	35	Estimated after Pugh and others 2001
1901- 1950	1.1	55	Helman 2007
1951 - 2000	1.8	90	Helman 2007
2001 - 2050	>4	>200	CSIRO (Satellite altimeter 1992-2007) and IPCC projection
2051 - 2100	>8	>400	Estimated from upper limb IPCC projection

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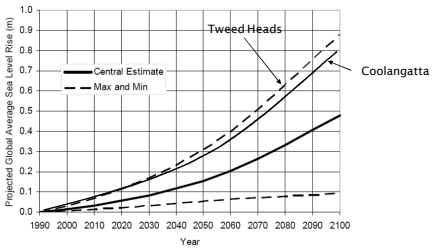
Projected Average MSL



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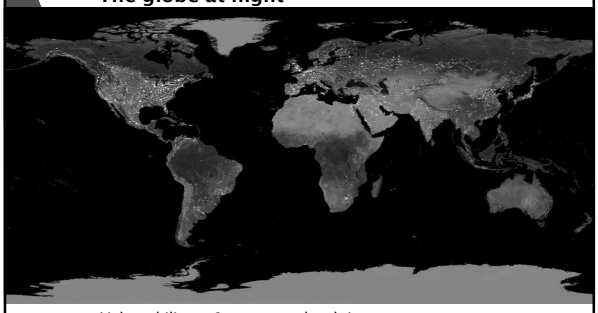
The globe at night



Vulnerability to 1 metre sea-level rise

Source: ONLINE, <http://www.nasa.gov/topics/earth/tipping_points_hiresmulti.html>, accessed 5th May 2009

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Geraldton Reefs

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Extreme Events -
Tropical cyclone data for Queensland

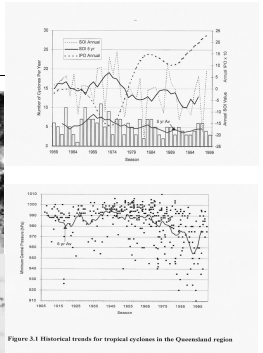

Figure 3.1 Historical trends for tropical cyclones in the Queensland region

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Coastal Inundation
Tropical Cyclone Storm Surge - Cairns

GCCM NCCARF

Storm Surge Inundation – Mackay 1918

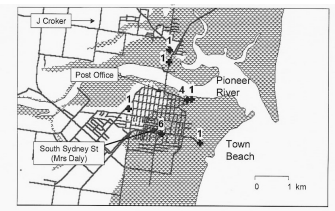


Figure 10.6 Extent of inundation due to the storm tide during *Mackay 1918* (after Parkinson 1950, and AGSO 2000)

Storm Surge Inundation Ballina – 1890s

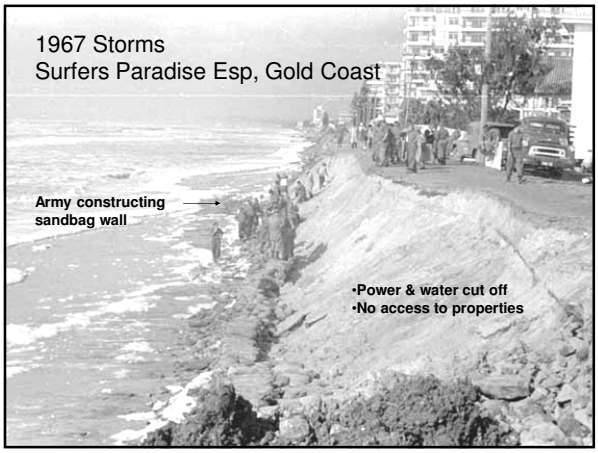
Extreme Events

2002

- Jan – May 1967: Cyclones Dinah, Barbara, Dulcie, Elaine and Glenda
- June 1967: 3 East Coast Lows
- 8 million cubic metres of sand eroded from beaches
- How big an event was it?

1967

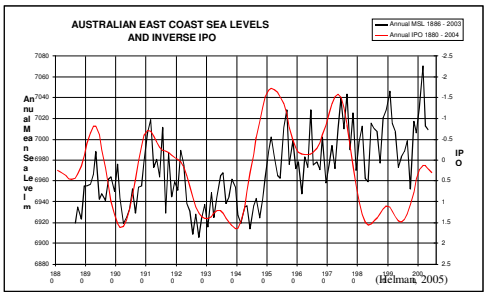
Extreme Events - 1967



1974 Flood

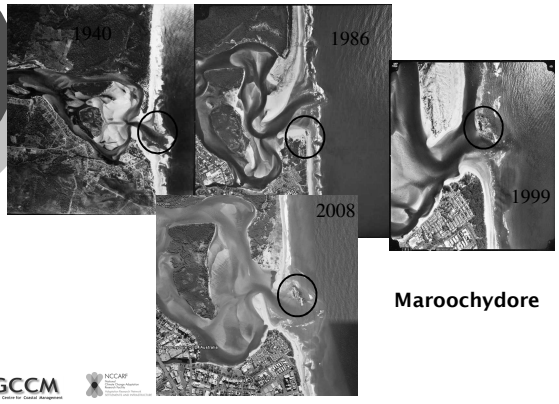
Climate Variability

Annual mean sea level correlates well with inverse IPO from 1890 to the late 1970s



(Helman, 2005)

Decadal Oscillation



Maroochydore

Climate Shift

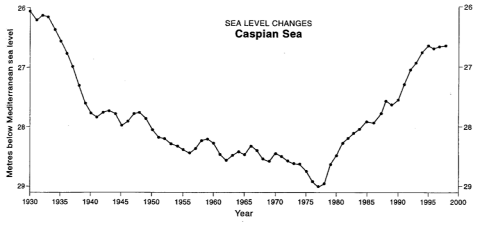


Figure 3.9 Changes in the level of the Caspian Sea since 1930, as indicated on the Baku tide gauge. Until 1977 there was an intermittent lowering of sea level, but subsequently there has been a rise of about two metres, probably because of a trend towards a more humid climate in the region. Information supplied by Dr S. Lukyanova of Moscow State University.

Coastal Settlements – issues and needs

- Controversial coastal development and planning policies in South East Queensland and Northern NSW
- Relative calm since the mid-1970s – leads to complacency
- Rapid coastal development since the mid-1970s (Seachange) – leads to short-term management and policy solutions
- A shift to an emphasis on bio-chemical environmental issues and decline in geo-physical since the mid 1970s
- Until recently the most up to date investigations were from the 1970s – PWD Byron-Hastings Point, Delft Report
- Media response: – minor storms become major erosion events; major storms are "proof" of climate change
- Conflicting "scientific" opinion

How do we plan for the future in the light of climate change predictions and largely ignored climate variability?

Future Coastlines: What is the answer?

- **18th NSW Coastal Conference**
  - **Global and national perspectives – Nick Harvey**
  - **NSW Guidelines**
    - **Doesn't deal with coastal protection works**
    - **Rule of Thumb**
    - **Local Govt. need resources and skills**
    - **Statutory powers to back them up**
    - **Merit-based assessment – resources**
  - **Muddling through, short-termism, need for a synoptic view, adaptive management – Nick Holmes**
  - **Community & media – Anne**
  - **Models for SLR, Wave conditions shifts – Chris, Dean**
  - **Responses for existing urban areas - Ian**

Future Coastlines: What is the answer?

- QLD State Coastal Management Plan?
- NSW State Guidelines?
- 42?
- 47

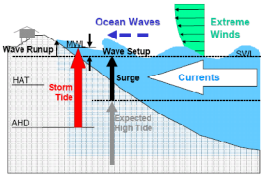
HoR Recommendations

- Increased investment in coastal climate change research (3)
- Wave climate research (5)
- Training of planners and engineers (6)
- Coastal zone research plan – NCCARF (9)
- Coastal database (11)
- Assessment of coastal infrastructure vulnerability (16)
- Nationally consistent sea level rise planning (21)
- Capacity building for local councils (38)
- Funding for infrastructure (39)
- Awareness campaign (40)

Climate Change Predictions

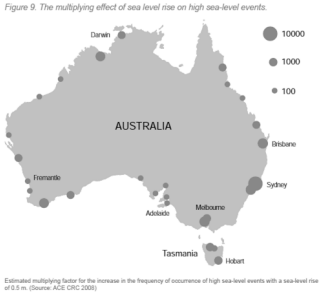
STORMINESS (East Coast)

- entering a new phase of IPO – more storms anyway
- climate change may increase frequency and intensity of storms
- Increase of 15% in maximum intensity – causing a doubling in property damage. Storm surge levels increase by 0.3m for 1 in 100 year event in 2050.



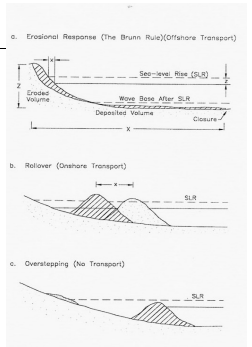
Increased Risk from Extreme Water Levels

Climate Change 2009 – Faster Change & More Serious Risks, Will Steffen



Future Coastlines

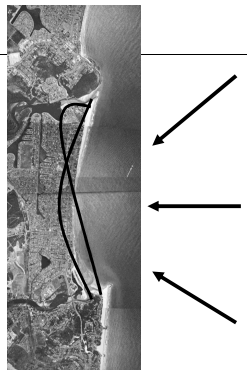
- Receding Shoreline
- Bruun Rule
  - Controversial
  - 50 to 150 m erosion for every 1 m of rise (10 -15m over last 100years on SEQ coast)
  - Not applicable on coasts with tidal inlets
  - Reliability is location dependent



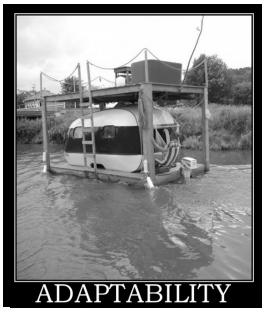
Future Coastlines

Future Coastlines

- A Category 5+ storm?
  - Evidence for 250 – 300 years return period (Central Queensland)
- Wave climate shifts – direction and intensity



Coastal Adaptation – *Staying Afloat*

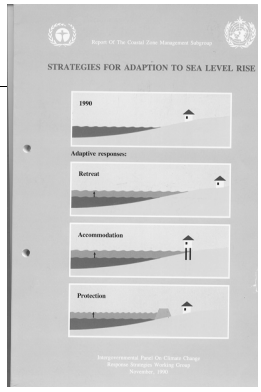


Source: ONLINE, <www.motifake.com>, accessed 5th May 2009

Coastline Adaptation Options

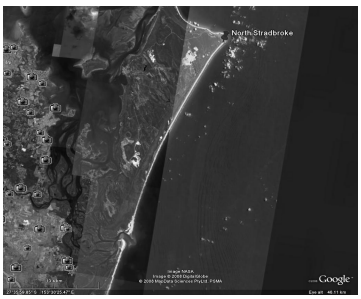
Response will depend on location

- Do Nothing
- Protect
- Accommodate
- Retreat



Do Nothing

Do Nothing – undeveloped areas



Do Nothing

- No beach
- Infrastructure damage
- Loss of ecosystems

Protect

Protection options

- Venice
- Holland
- France

Protect

Accommodate

- **Innovation**
- **Management**
  - **Gold Coast**

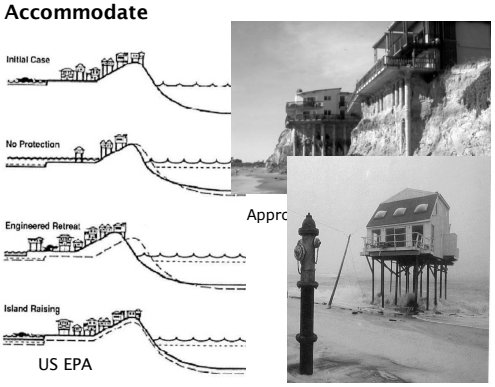
Adaptation - elevated houses

Geoff Mackley

Adaptation – appropriate design

Category 5 Hurricane Texas Gulf coast

Accommodate



US EPA

Appropriate Utilities Design

Accommodate - Short to Medium Term Management – A Local Govt. Problem – Gold Coast

Pressures on Local Government

- Local Government (LG) primarily responsible for coastal development and management (Shepherd, 2005)
  - Demand for infrastructure and service provision
  - Changes in the social 'mix' of communities
  - Rising property values affect housing affordability
  - Waterfront gentrification & marina development
  - Lack financial capabilities
  - Lack specific planning and management expertise
  - Increased future liability due to SLR
- LG will be burdened with much of the 'cost'

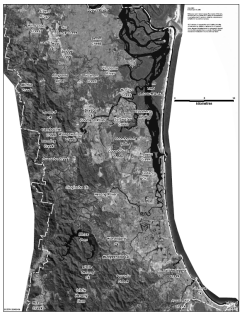
Gold Coast

- The Gold Coast is one of Australia's premier coastal tourist destinations
- Estimated population of 520,000+
- Gold Coast City Council is the second largest municipality in Australia based on population

Burleigh Heads looking North

Gold Coast Beaches

- 36km of developed coastline
- 600km of waterways and canals



Gold Coast Beach Management

Table 2: Gold Coast City Council beach management costs in 2007-08

GCCC Activity	Expenditure
Major Coastal Protection Works	$2.85M
Beach Maintenance	$2.1M
Capital Works (primarily beach access projects)	$1.57M
Lifeguard Service	$7.02M
Total	$13.54M

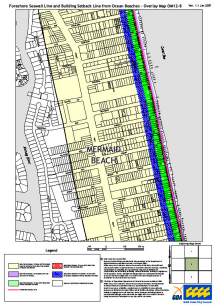
Source: GCCC

Coastal Management Initiatives

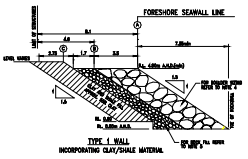
- Planning and Development Conditions
- Ocean Beaches and Foreshore Strategy
- Flood Strategies Planning
- Disaster Coordination Centre
- Shoreline Management Plan

Coastal Planning

- Planning Scheme developed by GCCC in line with Queensland legislation
- Relevant planning codes guide coastal development
  - Ocean Front Land Code
  - Canals and Waterways Code
  - Flood Affected Areas Code



Gold Coast Planning Scheme



Recent Beach Management Initiatives

- Northern Gold Coast Beach Protection Strategy
- Palm Beach Protection Strategy
- Tweed River Entrance By-Passing Program
- Shoreline Management Plan
- GCCM

Narrowneck 1900

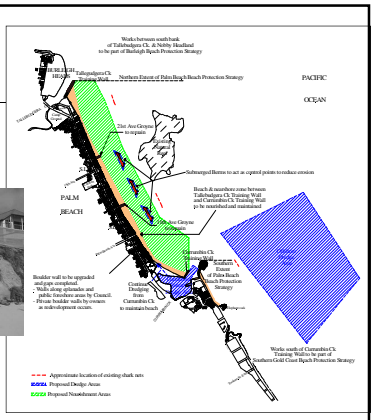
Northern Gold Coast Beach Protection Strategy

- Objectives:
  - widen the beach and dunes along the Surfers Paradise Esplanade to increase the volume of sand within the storm buffer and also provide additional public open space;
  - improve the surfing conditions at Narrowneck.

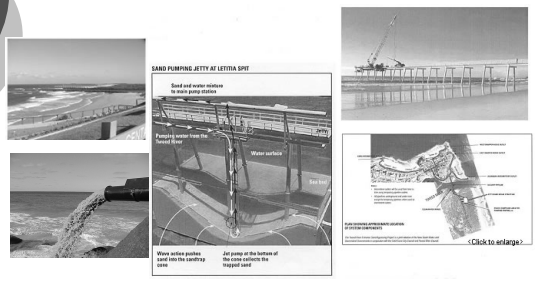
Narrowneck

Palm Beach Protection Strategy

Palm Beach 2000



Tweed River Entrance By-Passing Program



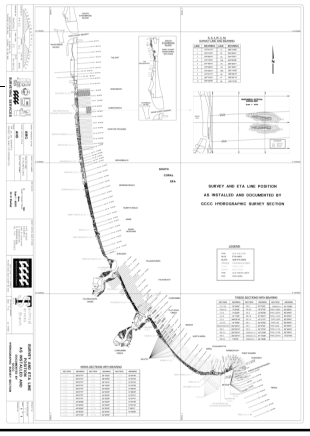
Kirra

Shoreline Management Plan

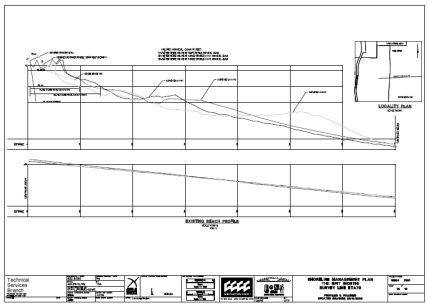
- Based on 5 themes
  - Physical Processes
  - Community value and involvement
  - Ecological beach processes
  - Economic value of beaches
  - Beach management

Beach Profile Surveys

- Commenced in 1966
- Annual surveys
- Specific projects in detail
- Volumetric analysis



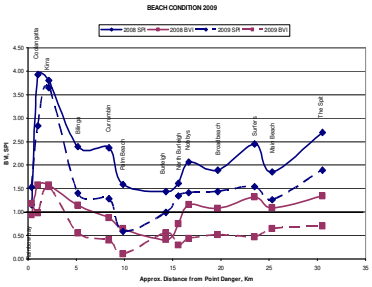
Typical Beach Profile



Beach Design – Gold Coast Style

- **BPA Design Profile**
  - Acceptable post-storm profile
  - 400m³/m
- **GCCC objectives**
  - Maintain beach width with nourishment and control structures

Beach Condition Indices



Retreat

But where to?

Existing or New Development?

Planning for New Development

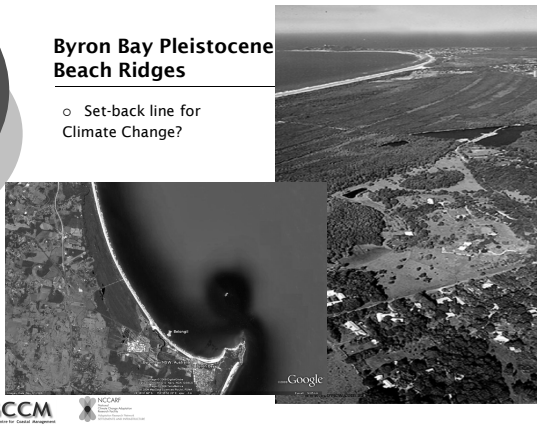
- **Queensland State Coastal Management Plan**
- **NSW Guidelines**
- **HoR report**

New Development

- **Future predicted decadal scale coastline variability and/or projected significant global climate changes will occur within the usual planning and infrastructure design-life time-frame (*The time to act is now*)**
- **Planning and management to accommodate known extremes of variability are needed urgently**
  - **Is ~1m MSL rise too small?**
  - **How about a 20 year moratorium on new development below RL 5 or 10m say?**

Byron Bay Pleistocene Beach Ridges

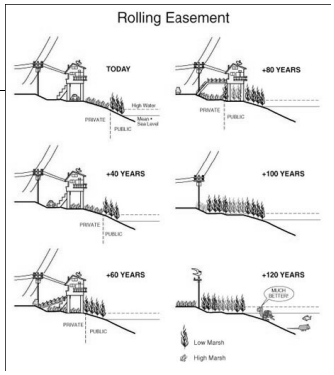
- Set-back line for Climate Change?



Rolling Easement

Suitable for new development

Problematic for existing development



Existing Coastal Settlements - issues & needs

- **Responses need to be introduced now to allow transition to long term solutions**
- **Major social and economic implications for the next generation**
- **If we don't protect – how do we deal with assets seaward of the set-back line?**

Existing Coastal Settlements - issues & needs

- **Paralysis of responsibility and liability across three levels of government –needs resolution (HoR?)**
- **Financial analysis /modelling for longer planning horizons with variable change and uncertainty – standard treasury models are no longer appropriate for climate change**
- **Decision making with limited resources – trade-offs and value sets – levees and/or beach sand replenishment VS parks, bicycle paths, bus shelters, library books**

Narrabeen/Collaroy

- **Management Plan (since 2003):**
  - buy back (of single dwelling properties only, no apartments or high rises)
  - minor sand nourishment (from the lagoon entrance and building sites)
  - major sand nourishment (if ever approved by the State govt)
  - no private seawalls permitted
  - no council funded continuous seawall (Included prior to "Line in the sand protests in 2003)

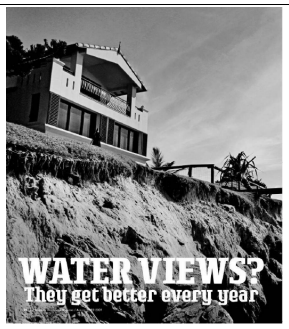
All the apartments & high rises already have make shift seawalls as do many of the houses (made from a range of materials). However many are expected to fail in a major event.

Narrabeen/Collaroy

- **Actions:**
  - 3 yearly dredging of the lagoon entrance with sand placed on the beach
  - a few building sites have dumped their excavated sand
  - 6 properties have been repurchased, the last in 2007 cost $2.7 mill
    - funded from the council development funds (rated on all new developments to enhance public amenity in the area) and some from State govt
  - once purchased the properties are demolished and a small park and possibly parking area developed

A very vulnerable site at Collaroy was redeveloped this year. In the early 1990's the council did place a moratorium on any new & redevelopment but this was lost in the Land and Environment Court

Byron Bay



Byron Bay

- Accurate survey for land, beach mining leases and harbour works commenced in mid 1800s

Byron Bay

·Wreck of the Wollongbar in 1921
·Shoreline recession of 1.8m / year since

Byron Bay

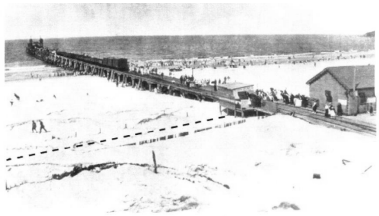


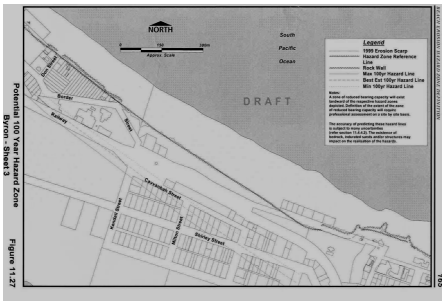
Figure 49a January, 1919 Byron Bay jetty. Note the abundance of sand on the beach and foredunes. A brush fence is buried in the foredunes and sand blowing into town was a reported problem (Ryan and Smith 2001). There is presently no beach seaward of the car park wall (location shown by dashed line) and constructed near the erosion face shown in Figure 28.

Byron Bay - 1954

The 1954 cyclone saw the sea break through and flood parts of the town.

Byron Bay - 1974

Byron Bay – Hazard Lines



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Byron Bay – 2009

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Byron Bay – Set-back policy

- NSW Govt introduced set-back lines in 1988 while Council under administration
- Development constraints within set-back lines
- Council action against construction of coastal protection
- Properties within 20 m of erosion scarp to be removed
- Emergency powers invoked in the past
- Legal challenges
- Doesn't apply to public assets
- Currently 12 houses within 20m – will Council force removal?

- Is this an effective coastal management/climate change adaptation Strategy?
- Policies & guidelines vs statutes vs property law

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Byron Bay

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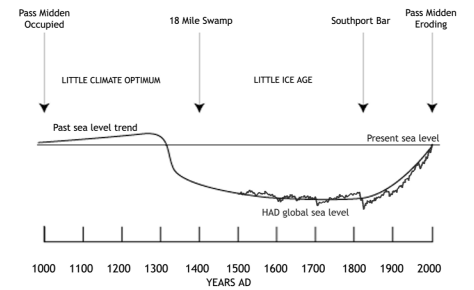
Will retreat work on the Gold Coast?

Sea level and Common Law



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Some Principles of Shoreline Law

- The legal boundary between tidal waters & adjacent land is High-water mark
- The legal boundary of the land changes to reflect changes in the position of the water's edge, but only if certain conditions are met.
- To be recognised in law, changes in a water boundary must be gradual
- Survey measurements do not necessarily define property boundaries
- Land lost below MHW is gained by the Crown and no compensation is payable
- Natural 'ambulatory' boundaries can transcend/rescind surveyed 'right-line' boundaries

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Some Tenets of Shoreline Law

- Let the buyer beware
- Potential climate change impacts are public interest considerations
- Statute law is superior to and may extinguish part of the common law

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"Storm of Litigation"

- Pro-active policy and statute law responses needed
- A pre-occupation with litigation, due to an undue emphasis on issues of liability may:
  - deflect or distract the focus of public authorities from developing appropriate responses to the range of public policy and legal issues, and/or
  - distort the wider discussion / debate about appropriate responses to, and priorities of, the range of public policy and legal issues triggered by rising sea-levels

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Casuarina Beach NSW

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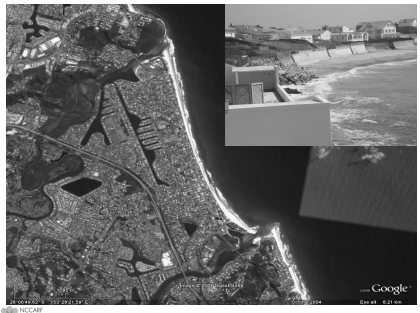
Palm Beach



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Geraldton

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Poona

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NCCARF

Thank you

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