Eurobodalla Sea Level Rise
PUBLIC FORUM

28 April 2014

NSW GOVERNMENT

Public Works
Manly Hydraulics Laboratory

Ocean Water Level Drivers & Local Data Review

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Presentation Outline

- Just who/what is:

  NSW Public Works'
  Manly Hydraulics Laboratory

Refresh Forum Objective: to establish common understanding

- Where & How is Ocean Water Level Data collected in NSW
- Why do we Measure Ocean Water Levels
- Ocean Water Level Forcing Mechanisms
- Sea levels in NSW and Eurobodalla
- Sea Level Trends & Traps for the Unwary

NSW Public Works Overview

- Over 150 years experience in planning, design, delivery and maintenance of building and engineering projects

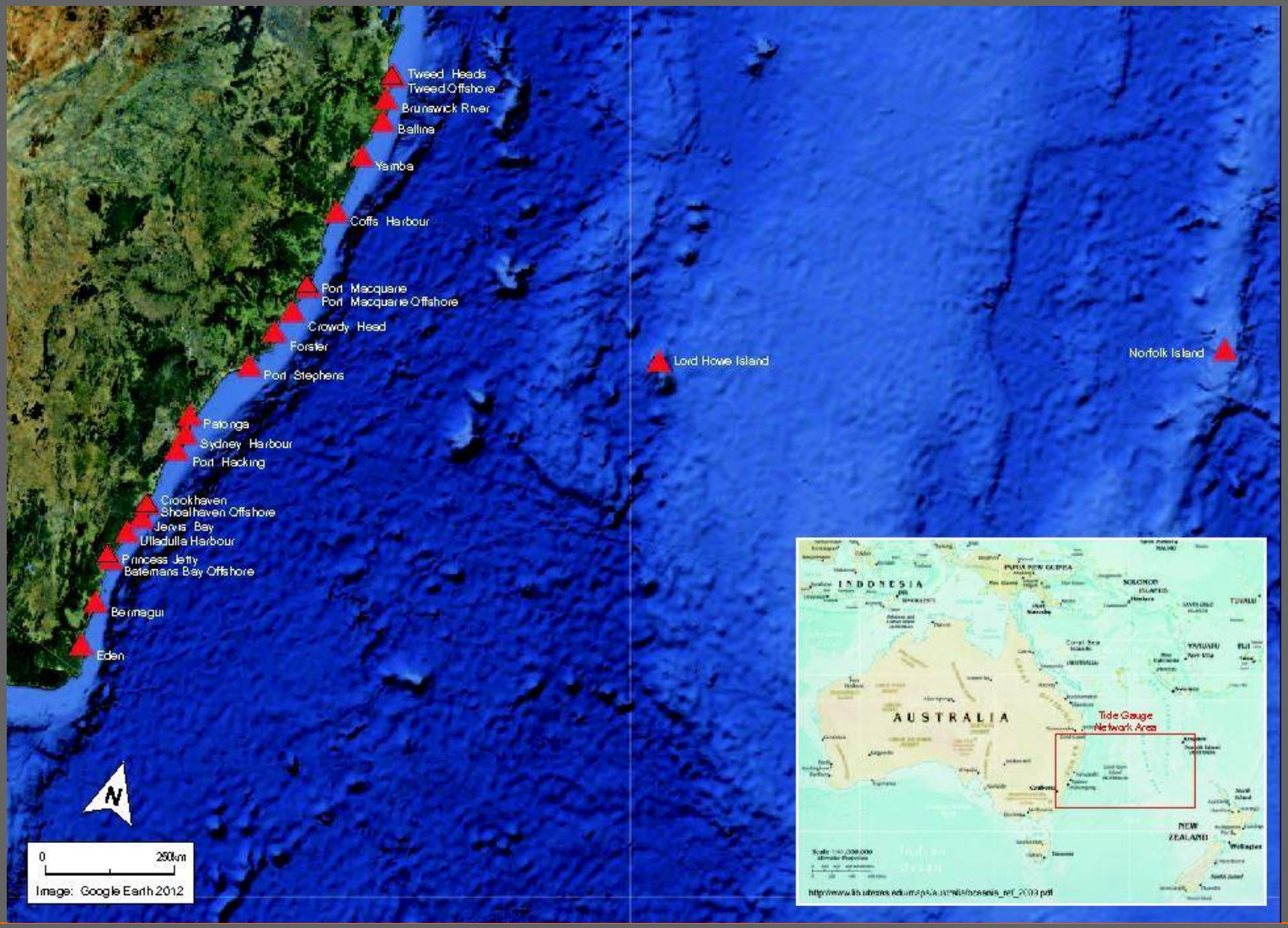
- NSW Public Works now provides expert advice to Govt. in:
  - asset and facilities management;
  - architectural, landscape & urban design;
  - heritage and conservation;
  - all aspects of project management; &
  - coastal engineering & coastal data, water cycle and water services management

- Network of ~ 20 offices throughout NSW

➔ Supports/manages environmental vulnerabilities communities expect

Who is Manly Hydraulics Laboratory (MHL)

Where MHL Measures Ocean Levels (for OEH)



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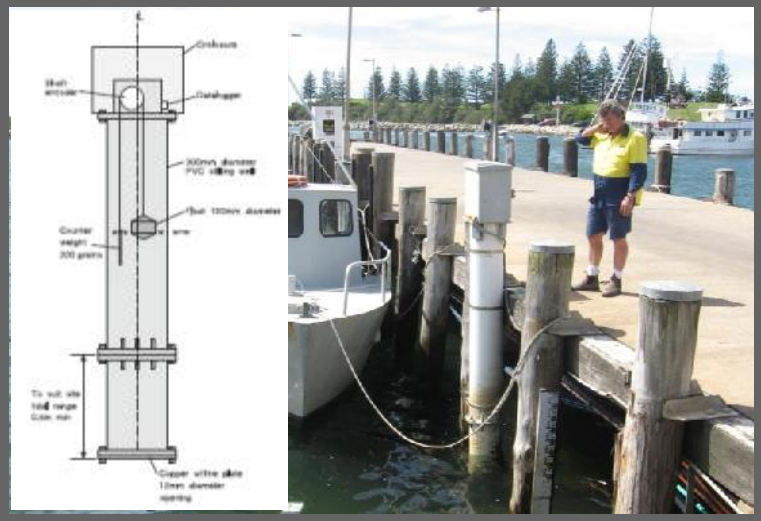
Site Classifications

We classify the gauges according to their location:

- Offshore Open Ocean (O) stations (submersible pressure sensors) that have no fixed datum so are NOT suitable for sea level trend analysis
- Onshore Bay or Port (OB) stations are unaffected by rainfall runoff flows and have a fixed datum, BUT can be affected by seiching
- Onshore River Entrance (OR) stations can be affected by rainfall runoff but are generally representative of the ocean

How we Measure Ocean Levels

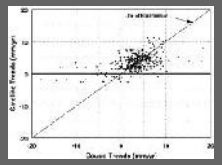


Bermagui
(was Floatwell,now
pressure sensor)

Gauges measure Relative Sea Levels

Satellites:

- Spatially averaged
- Gauge Calibrated



→ Dr Church's talk

Sea Levels and the Coast – Why we Measure WLs

While coastal focus is on Sea Level Rise, Climate Change also involves:

- Waves – Energy and Direction
- Wind - Energy and Direction
- Water levels – Storm Surge & Wave setup

} **Increased storminess**

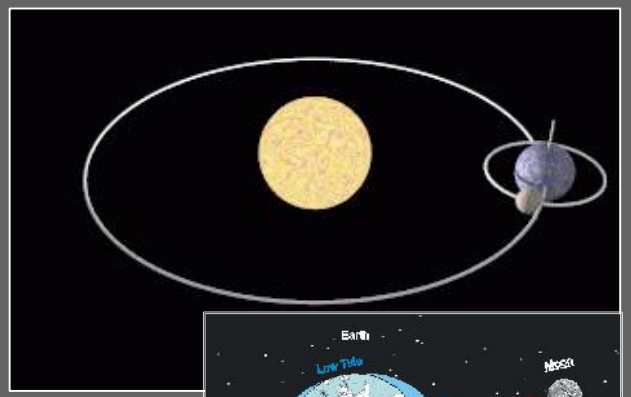
➔ Sea levels & Sea level rise Our Focus

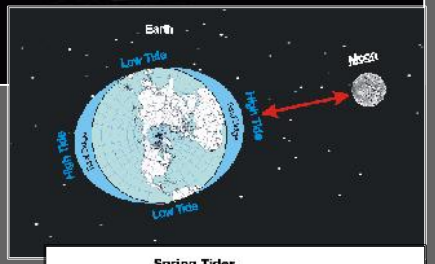
- Coastal flooding, erosion & recession
- Impacts on structures and development
  (armour size, crest height, toe extent)

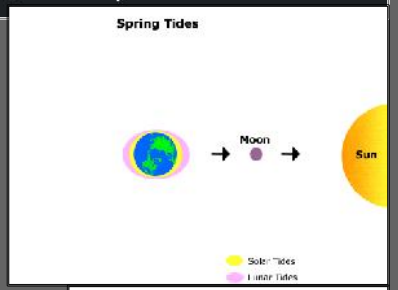
A problem when assets are in harms way !

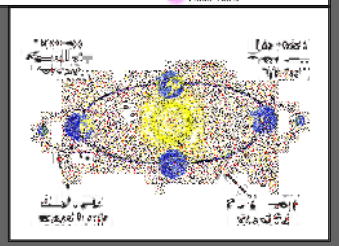
Ocean Water Level Forcing Mechanisms

- World's oceans rise & fall typically twice daily (semi-diurnal) from gravitational pull of the moon (x2) and sun (astronomical tide);
- Relative positions earth, moon & sun affect tides
- Different time scales operate:
  - 24h earth axis rotation (1 day, 2 tides)
  - 28d moon orbits the earth in same direction
    - → 24h 50m moon reaches same location on earth
    - → 14d earth, moon & sun align = SPRING tide
    - → 14d earth, moon & sun 90^0 = NEAP tide
  - 365d earth rotates the sun (summer/winter)
    - → "King" tides (Jan & Jul) when earth closest to sun









BUT not quite that simple…

- Orbits elliptical, eccentric & inclined, + sun NOT still!

→ every 18.6 years (Tidal Epoch) moon/earth orbit planes re-align

→ 41,000y Milankovitch earth wobble, 100,000 years eccentricity

Non-Astronomical Ocean Water Level Forcing

There are other non-astronomical factors affecting the ocean's water levels:

Barometric effect: L/H atmospheric pressure → rise/fall in WL (1cm / hPa)

Wind stress: raised/reduced WL downwind/upwind (shallow water)

} Storm Surge

Steric effects: water density changes from temp & salinity (EAC)

Ocean Currents: transporting large quantities of water in/out (EAC)

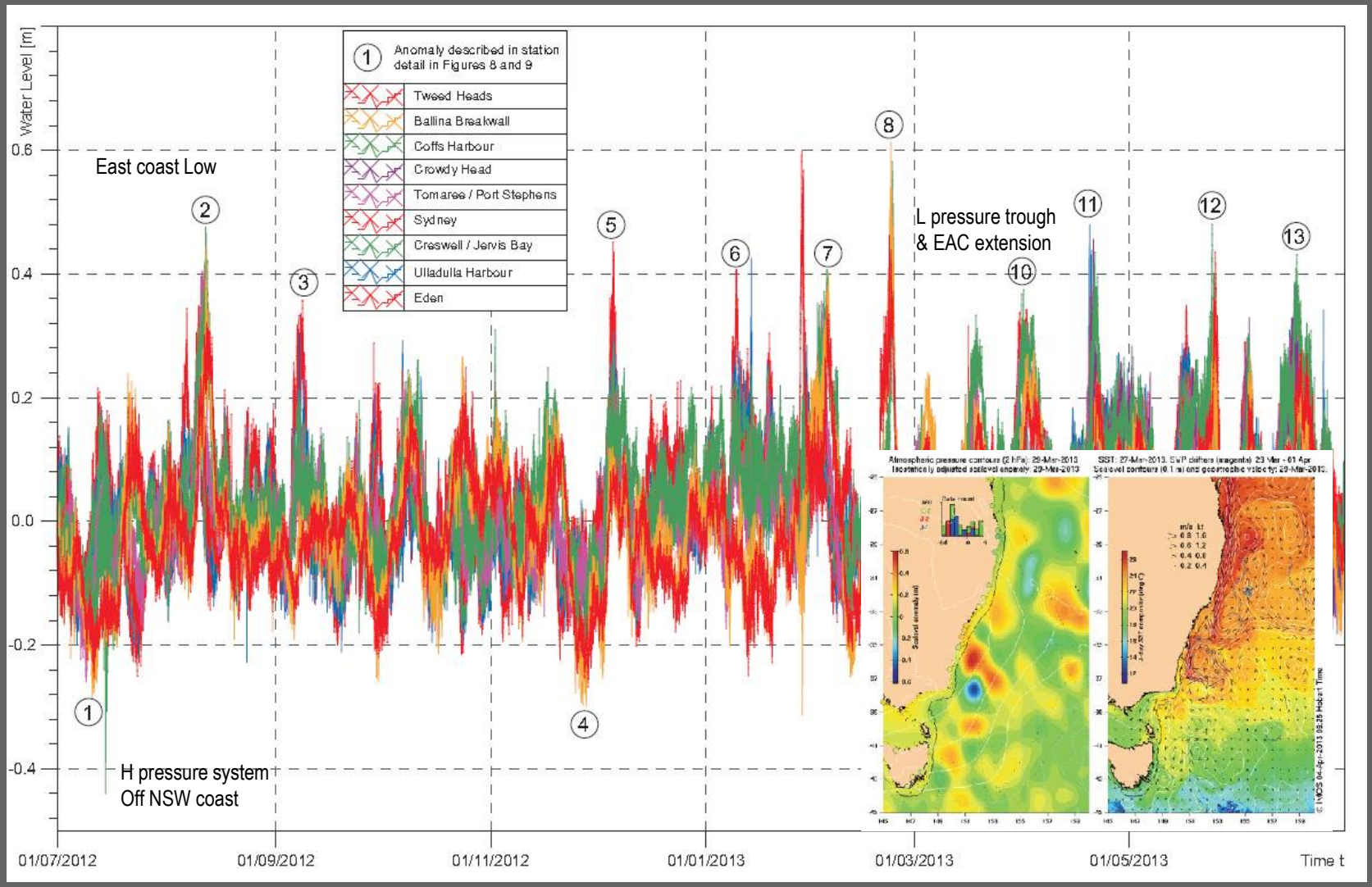
Seiches: standing waves in bays from meteorological events

Coastal trapped waves: travel along continental shelf (±0.2m WL)

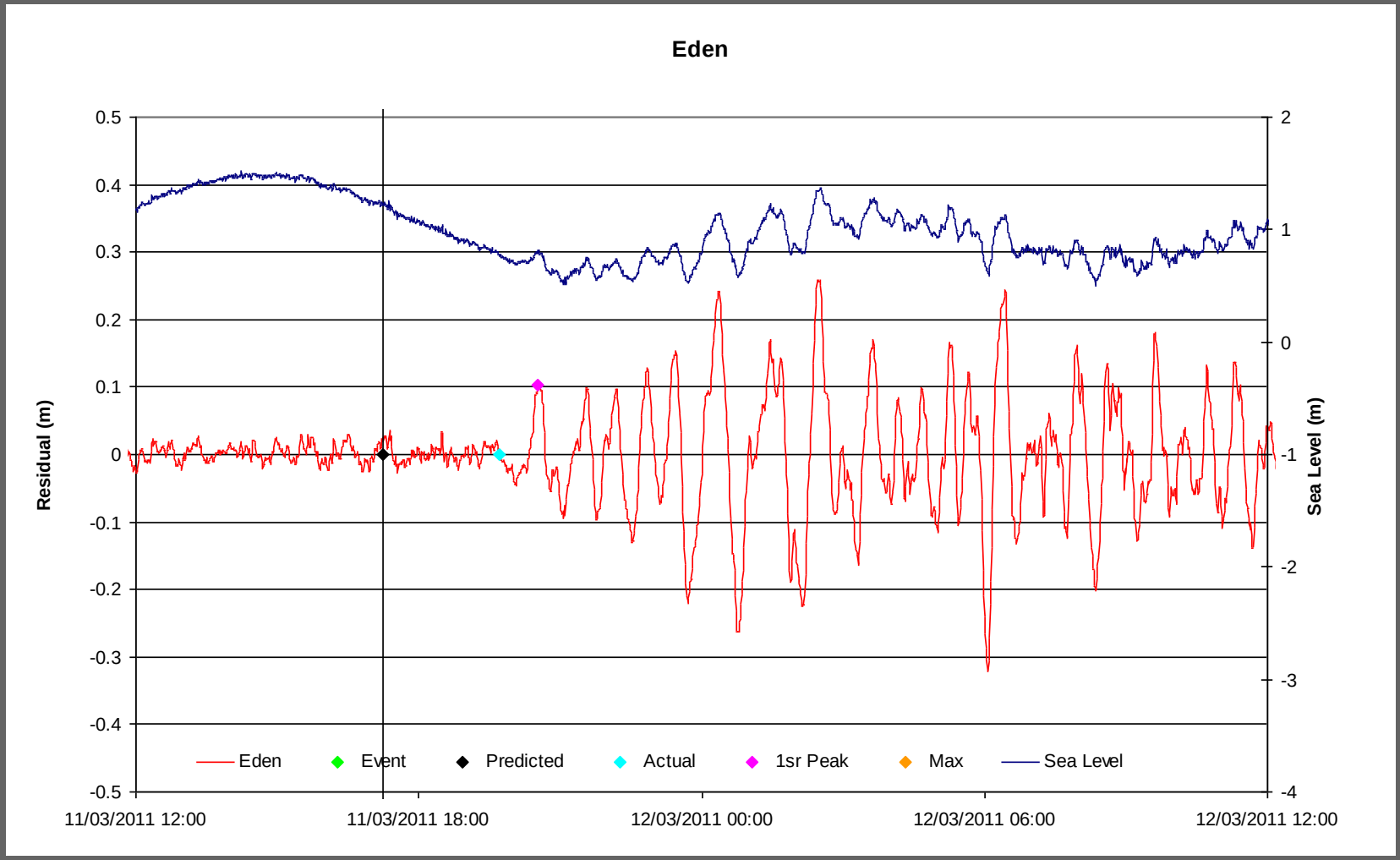
Wave setup: +1.5m on NSW coast

Tsunamis: from seismic activity & can generate seiches

Eg. NSW Tidal Anomalies July 2012 – June 2013



Eg. Japanese Tsunami – Eden Gauge March 2011



Summarising Ocean Water Level Forcing

We can classified ocean & weather variability based on:

Short term:
- Daily (semi-diurnal tides + weather fronts)
- Monthly (Spring/Neap tides + weather patterns)
- Annual ("king" tides + seasonal weather cycles)

El Niño/La Nina: 3 to 5 year episodic variations (ENSO) - known but not well understood

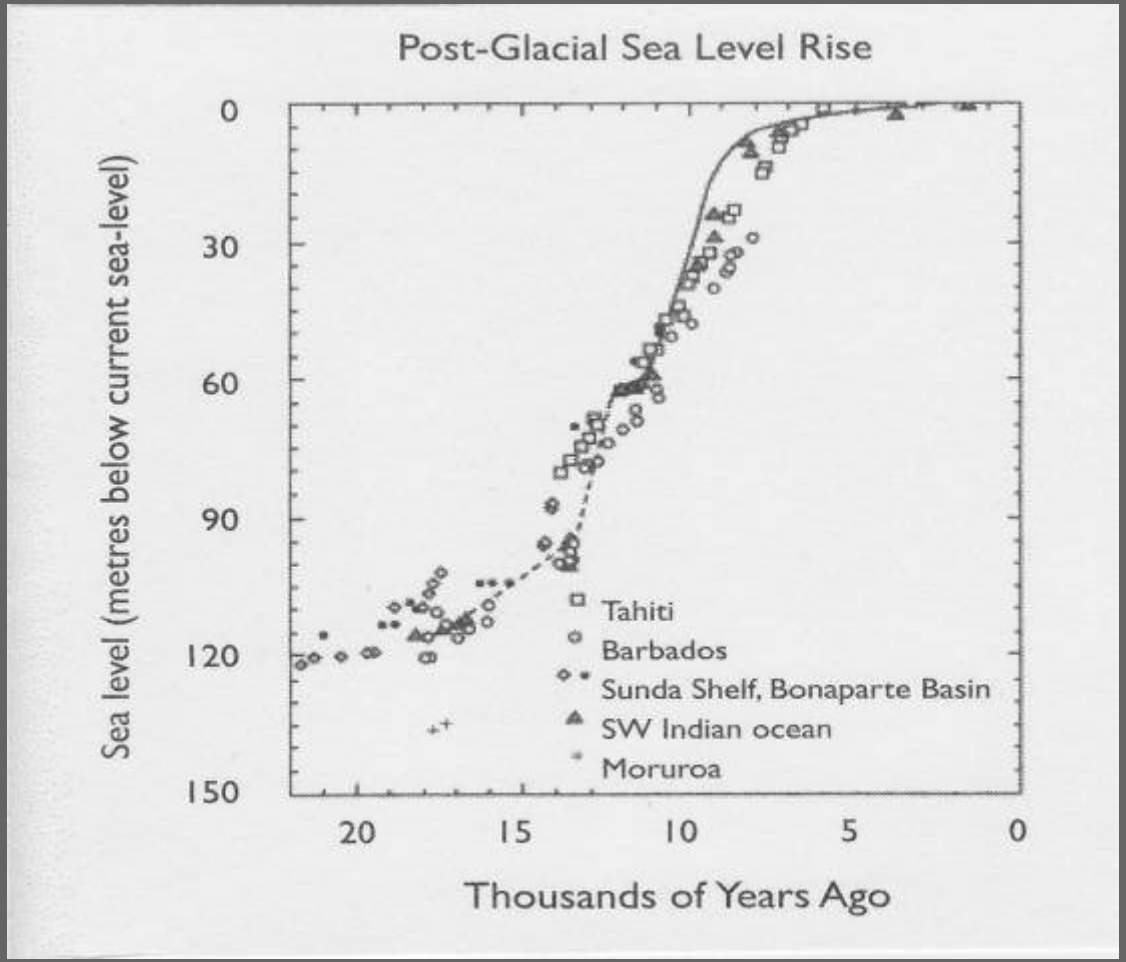
IPO: Inter decadal variations in the Pacific Oscillation
20-30 year phases in 50-60 years cycle – poorly understood

Longer term : thousands of years cycles (solar/astronomical & atmospheric)

Climate Change: Anthropogenic/naturally caused long term change

Undisputed Sea Level Trends during past 20,000 years

mainly due to land ice melt after the last great glaciation



Last ICE AGE → Milankovitch Theory (earth wobbles)

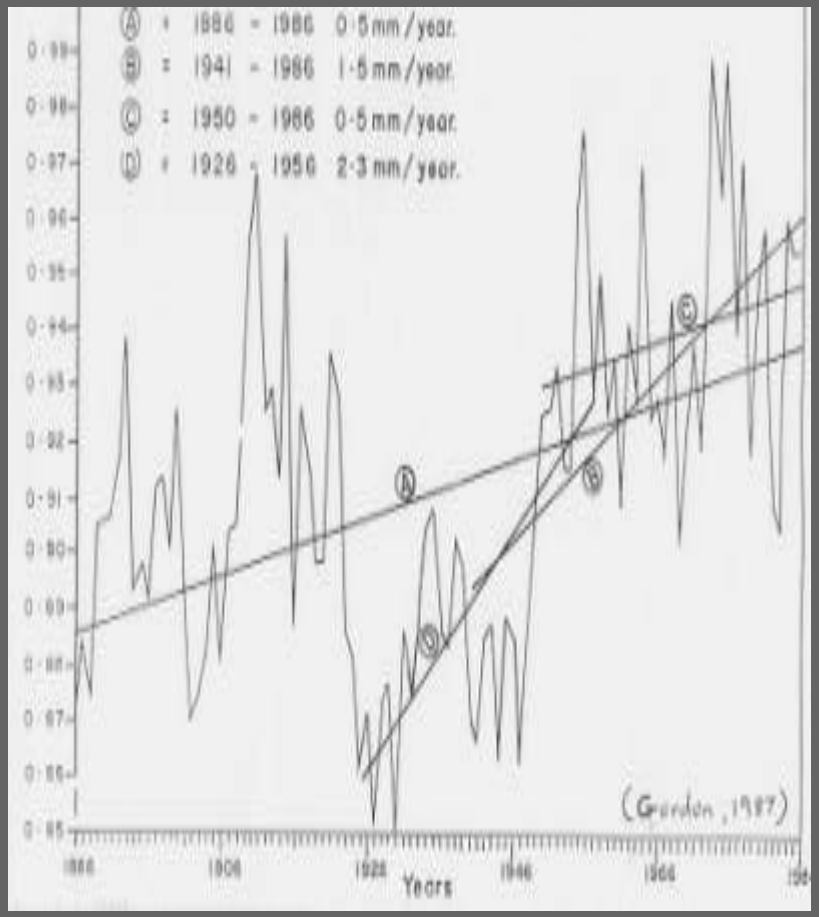
From Carter , "The Counter Consensus" 2010

NSW sea level variability and trend from Fort Denison

Annual sea level variations Fort Denison due to El Nino and IPO. Note various "trends" **depending on record length & start date**

Global Average (IPCC, CSIRO)
1– 3 mm/yr ; implied acceleration?

Recent trends of acceleration could be associated with limited records length although accelerations are supported by climate change modelling (IPCC)



Emphasises importance of long term monitoring

NSW Sea Level Variability and Data "trends"

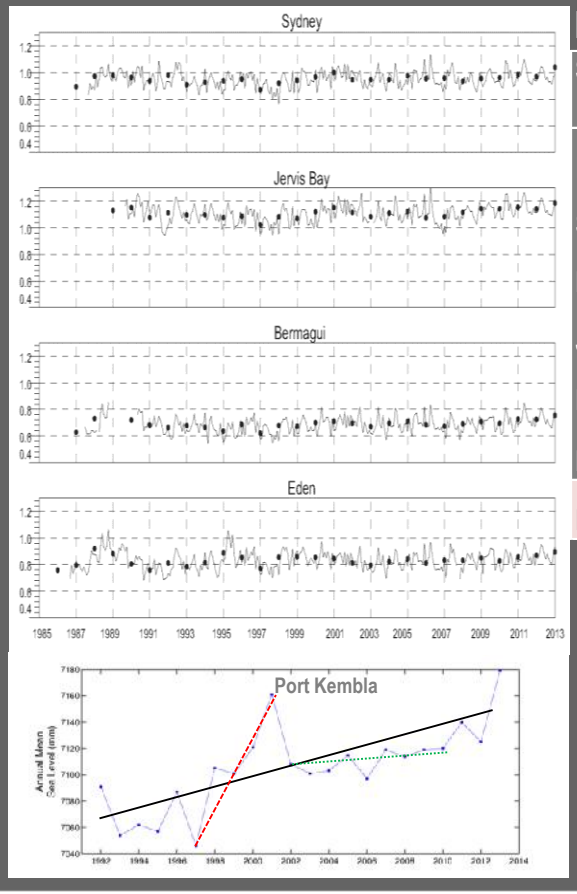
Annual SL variations along NSW coast - influenced by inter-decadal factors (EAC, El Nino/La Nina/IPO).

Note spatial variability

Note limitations of record length and start year

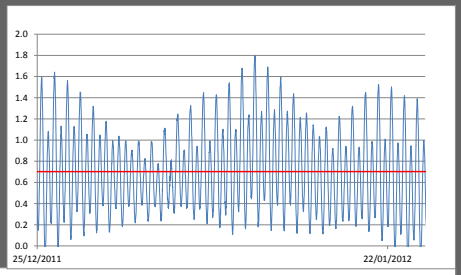
Inter-annual "trends" are **NOT representative of long-term sea level change**

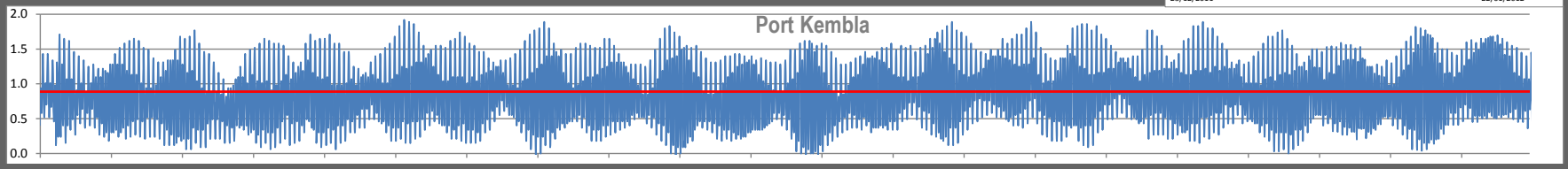
Trends may be important to Relative Sea Level change!



Linear Sea Level Trends to 2013

Station	Starting		Starting 01/1993
Fort Denison	06/1914	0.94 +/- 0.03	2.97 +/- 0.33
Sydney	09/1987	1.11 +/- 0.12	3.16 +/- 0.16
Port Kembla	11/1957	0.88 +/- 0.11	3.46 +/- 0.33
Jervis Bay	09/1989	1.97 +/- 0.13	3.56 +/- 0.16
Princess Jetty	12/1985	2.87 +/- 0.11	4.60 +/- 0.16
Bermagui	07/1987	1.76 +/- 0.11	3.05 +/- 0.15
Eden	09/1986	0.86 +/- 0.11	1.31 +/- 0.16





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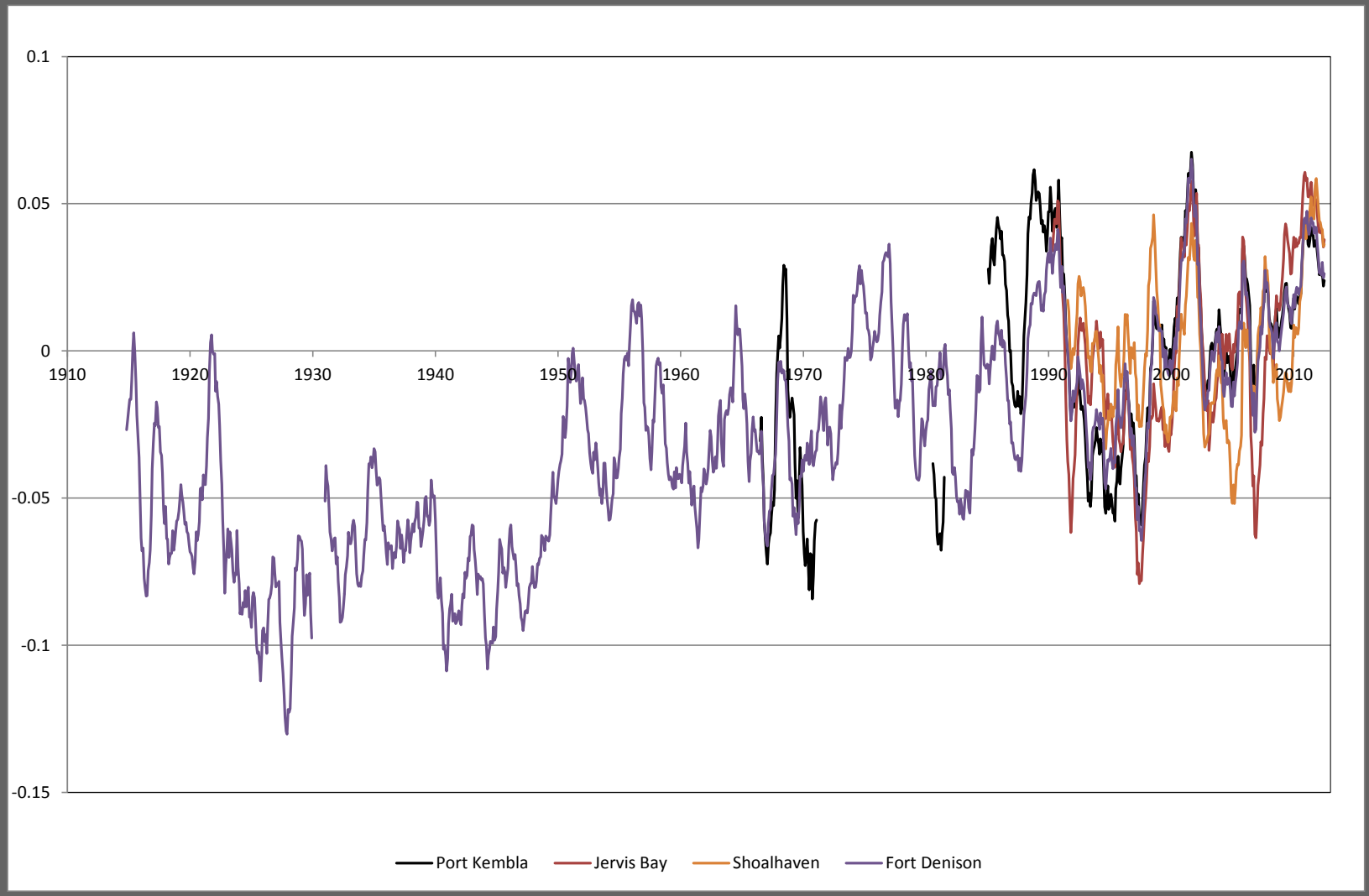
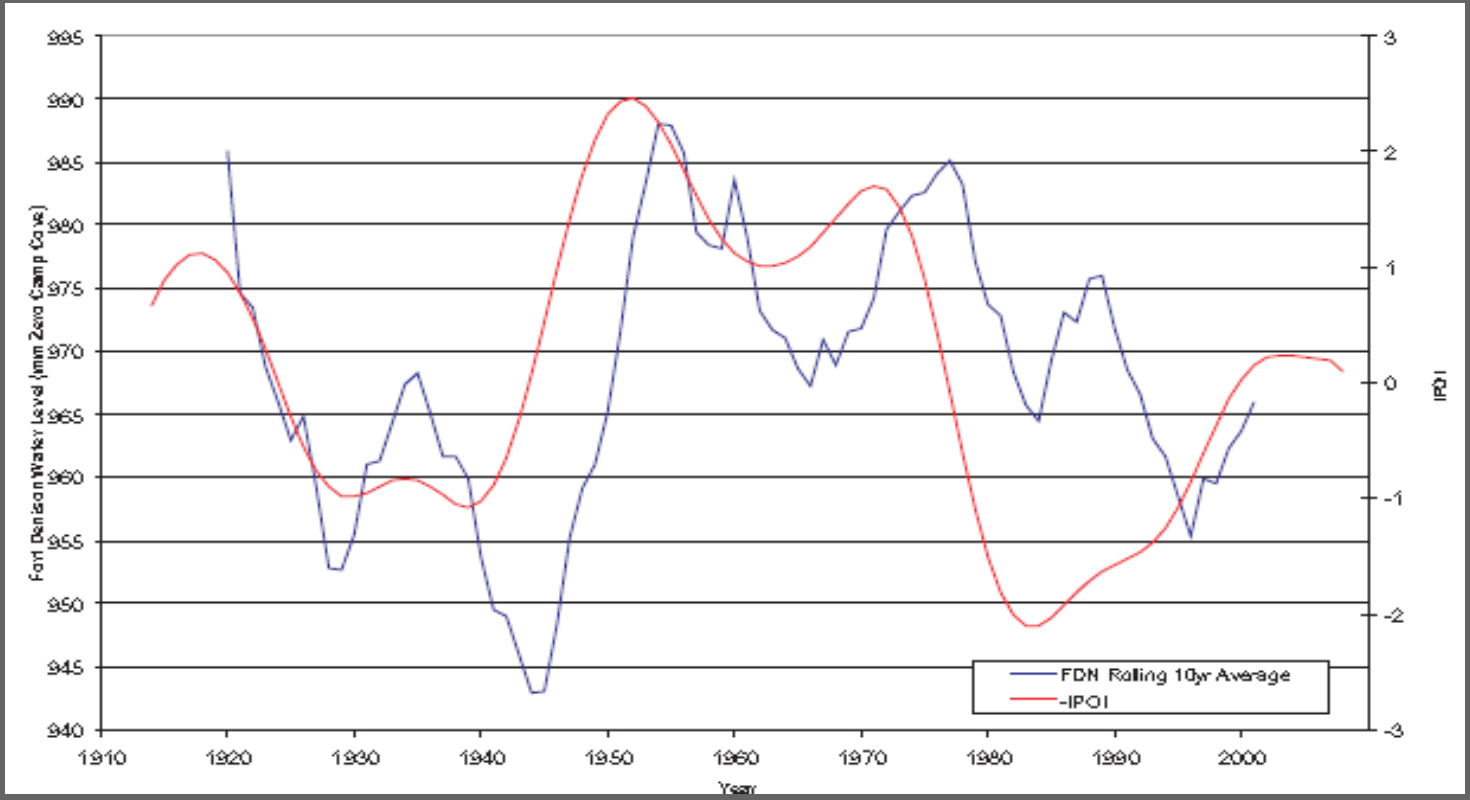
Eurobodalla Regional Data “trends”



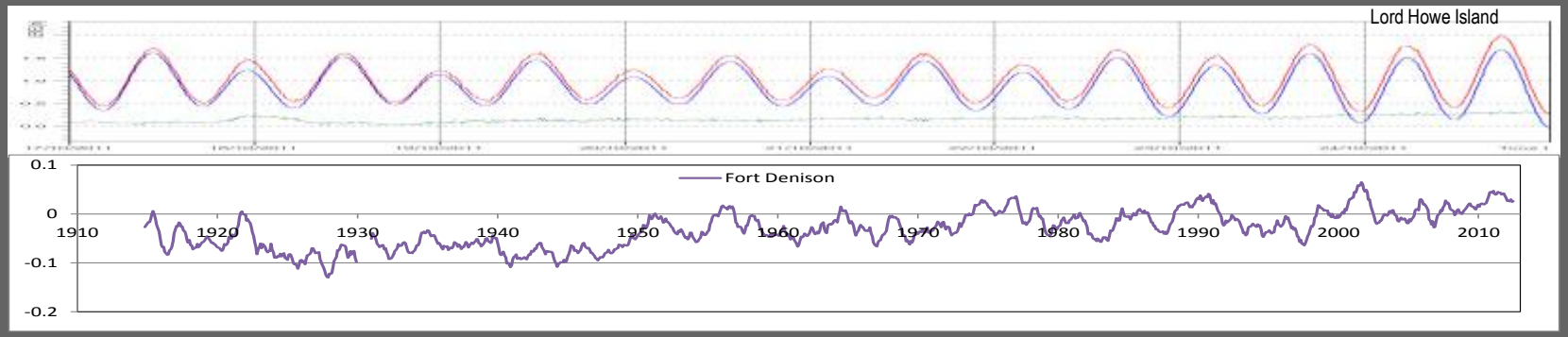
Strong IPO Correlation Evident for NSW

Fort Denison 10-year rolling average level with linear “trend” of 0.9mm/yr removed verses an inverted Inter-decadal Pacific Oscillation (IPO) index

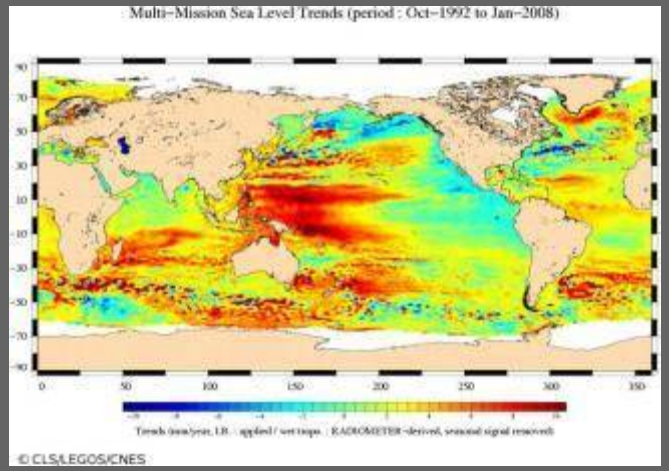


Sea level rise/fall can be a trap for the unwary

- Sea levels ⇧⇩ due to changes in astronomical and meteorological forcing
  - ➔ ± 0.2m – 0.6m can mask long term sea level trends



- As with tidal response, sea level change is NOT uniform around the globe
- Sea level change must be considered as being both Geocentric and Relative. Relative change at a location is of most interest to coastal zone managers
- The GSL change for NSW may not be the GMSL change!

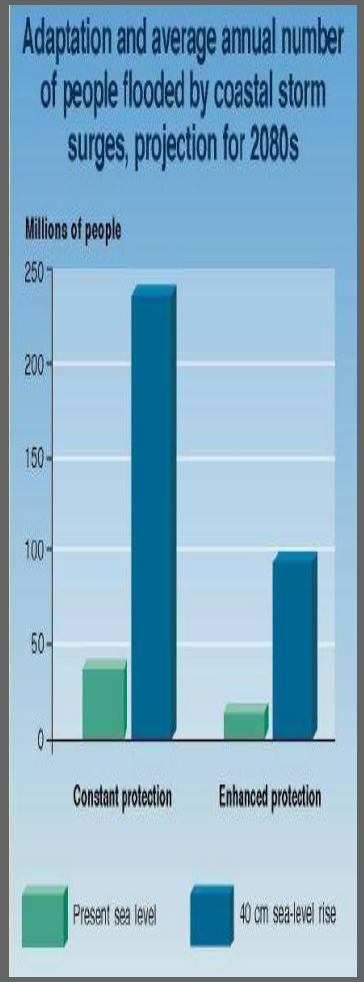


Eurobodalla / NSW Data Summary

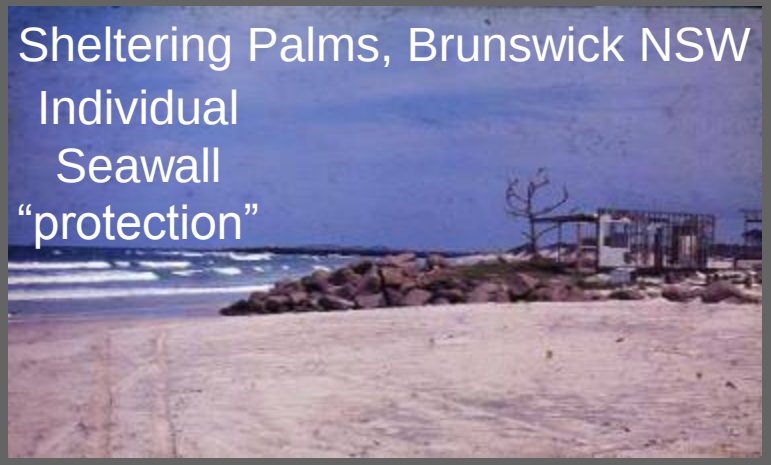
- Linear trends NOT necessarily representative of LOCAL sea level change over periods less than one IPO cycle or 50++ years
- Record length, start date and averaging methods all have marked effect on indicated “trends”
- Implied accelerations from recent records could be part of inter-annual (ENSO) and inter-decadal cycles – LOCAL
- Inter-annual & inter-decadal trends SIMILAR between Eurobodalla region and Fort Denison
- Fort Denison records provide a reasonable surrogate for sea level trends in the Eurobodalla region (long term)
- Our understanding of the processes driving spatial and temporal sea level change are improving
- Ongoing monitoring important to identify local Relative sea level change…

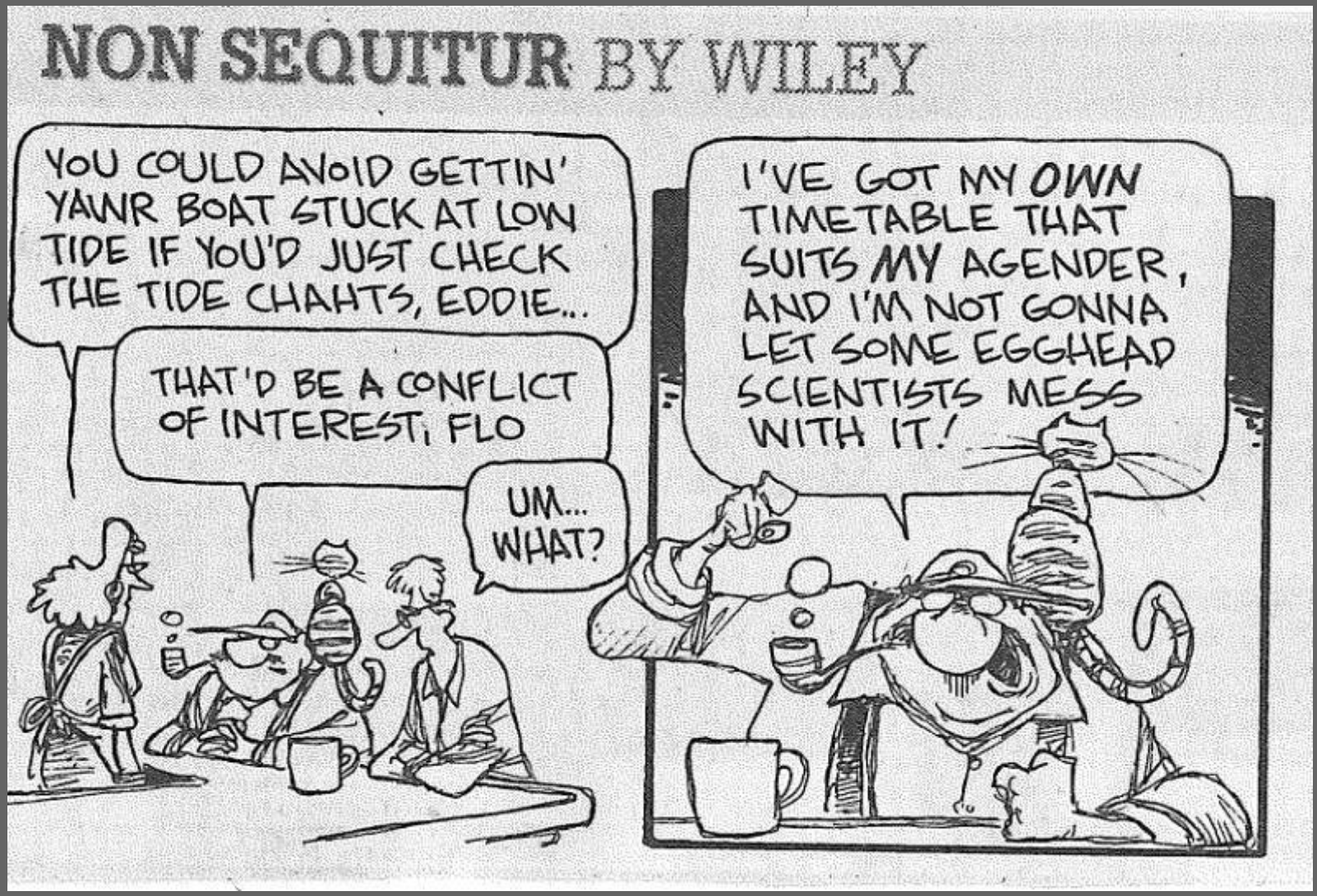
Summing Up

1. Despite complexities & uncertainties, Climate Change & sea level rise is taking place;
2. Whether or not accelerating due to human influence ➔ it must be considered to fulfil the 'good faith' provisions for liability protection;
3. Stern Review (2009) → Cost equiv 5% - 20% global GDP for ever vs cost of Adaptation being only 1% of global GDP pa.
4. **Experienced practitioners** MUST be consulted to understand local processes and RSL changes to develop risk based planning benchmarks and implementation guidelines; and
5. A TOOLBOX of Adaptive Strategies is best suited to deal with the uncertainty, noting Adaptation should happen at a local / regional scale



If not, then is this the future ?




NON SEQUITUR BY WILEY
YOU COULD AVOID GETTIN' YAWR BOAT STUCK AT LOW TIDE IF YOU'D JUST CHECK THE TIDE CHAHTS, EDDIE...
THAT'D BE A CONFLICT OF INTEREST, FLO
UM... WHAT?
I'VE GOT MY OWN TIMETABLE THAT SUITS MY AGENDER, AND I'M NOT GONNA LET SOME EGGHEAD SCIENTISTS MESS WITH IT!