

# Coastal Management in Uncertain Times - Climate Change Or variability? – Fact or Fiction



Angus Gordon

# Yesterday was Armageddon, today we have a serious problem (Stieg Larsson)

- What if climate change is not wholly (or even partially) due to anthropogenic causes?
- If this is the case we really do have a serious problem



# Ambulatory Nature of Coastlines

- Coastlines, both sandy and rocky, and including those of estuaries, are transitory, wave, current and wind action causes them to recede if there is a sand deficit and accrete if there is a surplus.
- Much of the Australian open coast has been experiencing recession for at least the past 2,000 years - so we better start adapting!



## So, always REMEMBER

- Coastal erosion and recession are natural phenomena that will continue due to wind and wave action regardless of whether the climate changes or sea level rises.
- Sea level rise will simply act to accelerate the underlying trend and increase oceanic flooding
- Climate change may increase or even decrease the magnitude of erosion and/or rate of recession
- Erosion and recession are only a problem if non adaptive assets have been placed in harms way

# Science

Science is about developing theories to explain our experiences of the world and hopefully being able to use those theories to predict future outcomes (best approximations, not absolute truth)

Science involves questioning and constantly testing existing theories and modifying them as further information comes to light; ie **being skeptical !**

Science is not a belief or disbelief system.

**It is a journey, not a destination**

**If someone “believes” in a scientific proposition they are not a scientist**

# What do we mean by climate?

- Generally taken as average conditions over a 30 year period (bit of a worry for those who talk about 1 in 100 year events! But that is a whole other talk!) However the general use of 1% events is clearly an unsound approach
- Evidence (including recent studies on coastal storms) suggest 60 and 800/1000 year cycles....bit of a problem if climate is averaged over a subset!
- Reliable “hard” data sets are at best 150 years, that is just over 2 cycles of the smaller cycle!

# What drives the climate?

## Atmosphere or oceans? ...Or the Sun

- Oceans have over 3,000 times the heat capacity of the atmosphere (and far greater CO<sub>2</sub> absorption)
- Climate is to a large part dependent on ocean circulations/water temperatures because of system momentum
- Weather is linked to ocean/atmosphere interaction eg cyclones, storms
- Is the tail wagging the dog? Or in bushranger terms “Who is robbing the coach?” ..or is it the SUN?

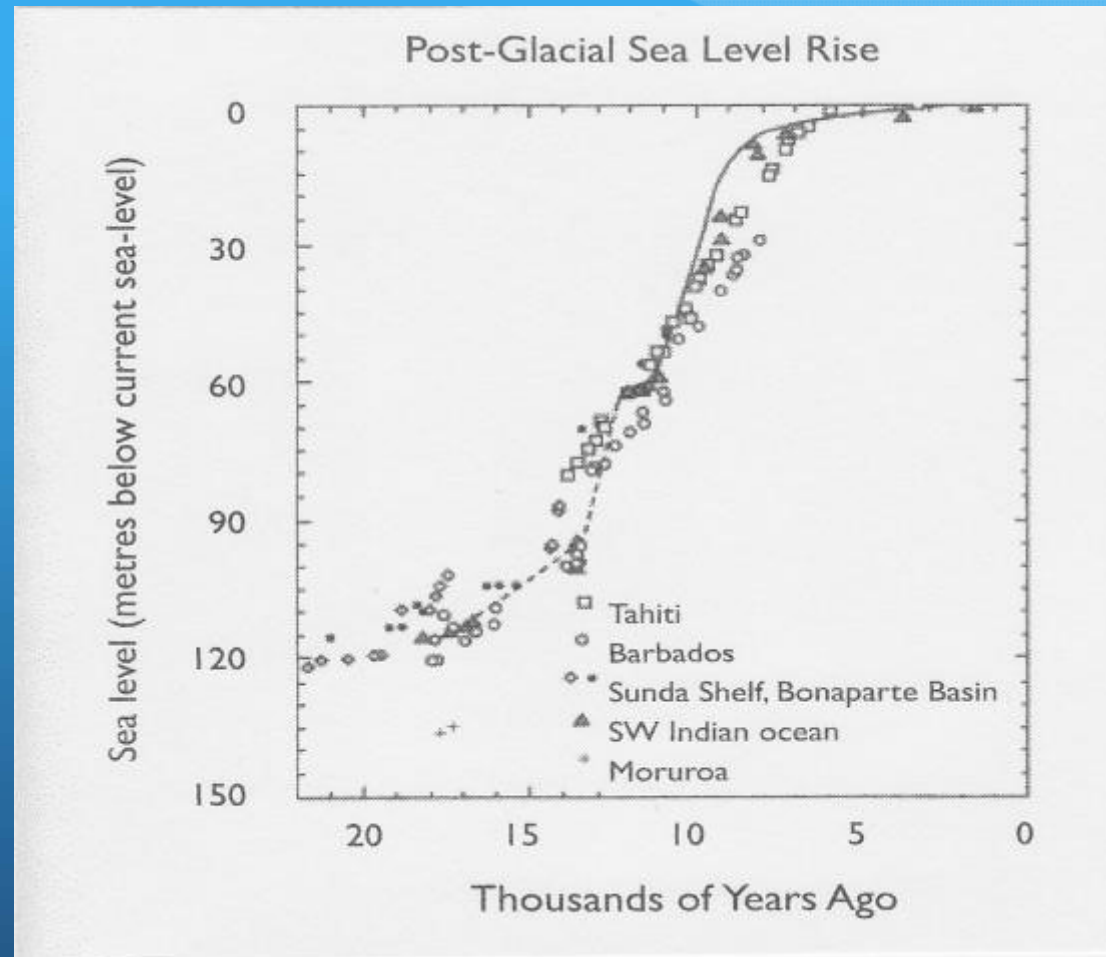
# Oceanography

- Ocean circulations are complex and still poorly understood but broadly linked to heating and salinity increase at the equator, surface flow towards the Poles then diving as water cools and salinity remains high to form deep ocean return currents. But if fresh water is introduced at high latitudes salinity is reduced so current becomes less active - 800 to 1000 year cycle
- The strength of the Gulf Stream is known to be critical for the climate in England, Iceland, Greenland and Europe - Strong - mild climate. Weak - cold climate
- The East Australia Current has been penetrating further South since CSIRO measurements commenced

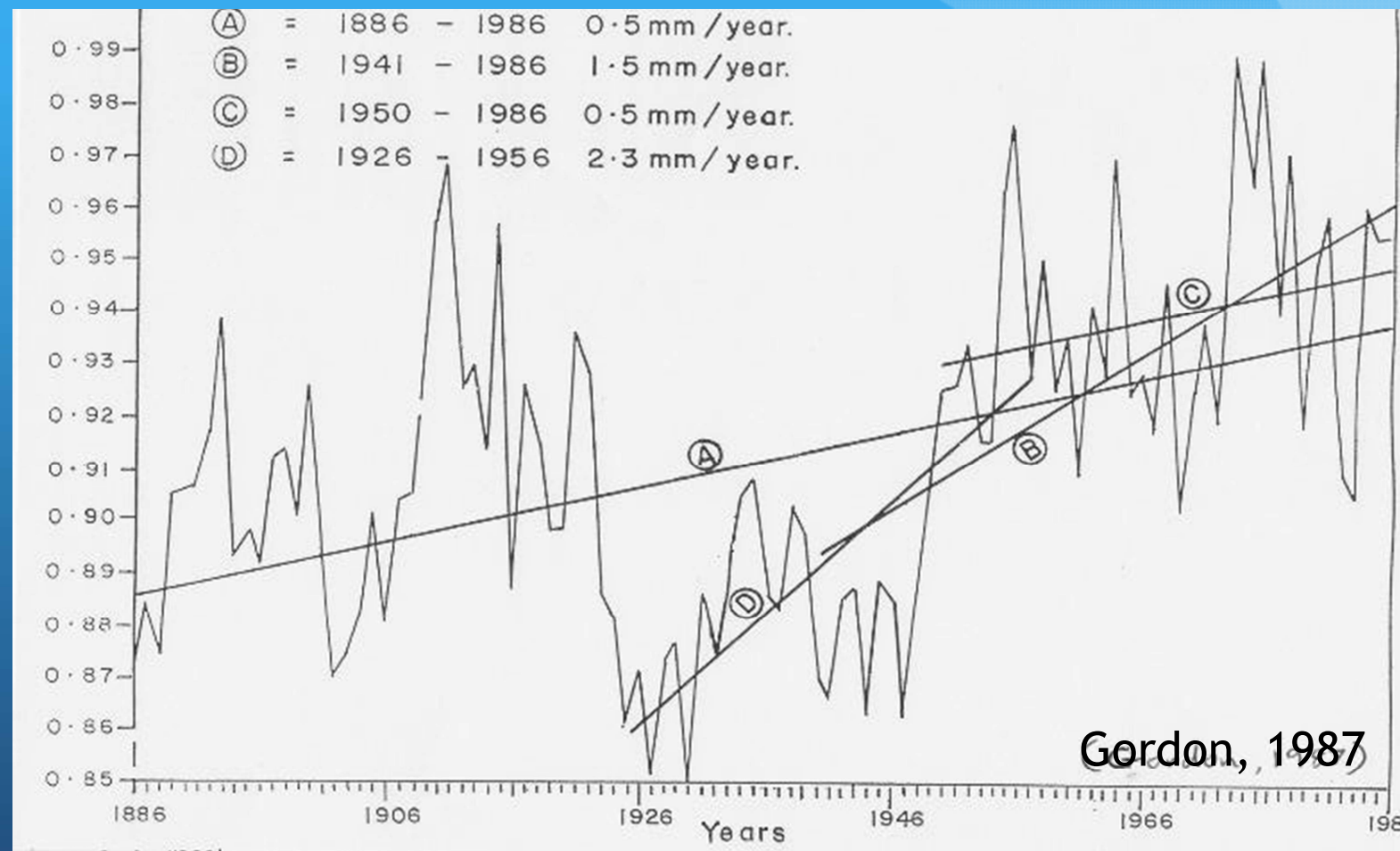


# Geology/Paleontology and Sea level

- Around 140,000 bp sl 140 m below present, coast many km offshore of current position
- 130,000 to 119,000 sl rose rapidly (rise rate 20mm/y) to 2 to 6m above present, with coast initially km massive accretion forming wide coastal plains
- Then oscillated downwards till 22,000 y bp when 120/130 m below present - slow rise till about 17,000 bp then started to accelerate
- 14,000 to 8,000 to 3 m below present (20mm/y)
- Present level 7,700 then oscillated 1 to 2m either side of present during last 6,000 y



From Carter , “The Counter Consensus” 2010



Global average around 1.5 to 2 mm/y but is it accelerating? Evidence???

# Glaciers

- More complex behaviour than currently assumed by many
- Mass balance determines retreat or advance. Global warming causes initial retreat, warmer conditions increases precipitation on higher ice fields which adds pressure to drive the glacier.
- Global warming does not necessarily result in massive release of ice - can in fact build ice fields trapping water
- High variability with both short term (20 to 60 years or less) advances and retreats indicative of a “noisy” climate



## Glaciers (continued)

- NZ glaciers Franz Joseph retreating since 1750 (not 1850), little retreat 1860 to 1927, max retreat 1927 to 1983 then significant advance 1983 to present
- NZ Tasman glacier has mainly thickened in the trunk as a result of high ice field trapping
- Alaskan glaciers - some retreating, some advancing. Vitus Bering 1741 mapped some Alaskan glaciers subsequent mapping suggest retreat prior to 1850
- Ice core evidence present a problem: does CO<sub>2</sub> increase precede global warming or is it a result of global warming?
- Ice cores evidence of water trapping in ice fields during warm periods? No sea level rise component

# Sea Ice

- Melting of sea ice does not raise water levels only land ice does (mainly low level ice sheet melt and low level ice field fed glaciers)
- The “fabled” North West Passage - how did they know it was there? - now passable in summer but when was this last the case in the past - Thule people (whalers) occupation of Davis Strait to Alaska, 1,000 y bp
- When oceans warm sea ice melts however ice shelves are “eaten out” from underneath and suffer “catastrophic” failures releasing ice flows and trapped bergs, water levels should initially drop (due to arching) and then be restored as release occurs. Don’t be fooled by sea ice influences

# Lessons to be learnt from the past

- Major variations in climate have occurred over millennia.
- During 2000 yrs recorded history - Roman Warm period to 400 CE - cold period to 900 CE - Medieval Warm till 1350 then Little Ice Age till 1850 CE.
- Societies prospered and declined depending on climate and adaptability - Attila the Hun, Norse/Inuit, Chaco Canyon, Genghis Kahn, Angkor Wat.
- **sophisticated societies are vulnerable, less complex societies are adaptable so learn and understand adaptability - less sophisticated infrastructure and buildings are required.**

# Climate Change Conclusions

- All evidence suggests the climate is much less certain, and more variable than previously assumed/utilized/relied on
- Statistically stationary series assumptions out the window so no more safety in statistically based design criteria nor assuming time of record (last 100 to 150 years) representative
- Future data collection programs are a priority
- If the anthropogenic driven concept is correct then the future somewhat predictable but if not then all bets are off and we have a real problem



# BEWARE, AND BE AWARE

- Don't "throw the baby out with the bathwater"
- Anthropogenic climate change is a theory, the evidence from science suggests the possibility of other potential causes (in whole or part)
- If anthropogenic change loses credibility so might coastal management/engineering if locked in too tightly to one theory when in fact the evidence of long term climate variability is very strong as is the paucity of our climate/modeling/knowledge
- Negligence is a two edged sword

# Disposable Infrastructure

- Roads, Railways and Bridges
- Water Supply Infrastructure
- Sewerage Infrastructure
- Parks and Public Access
- Power
- Telecommunications
- gas

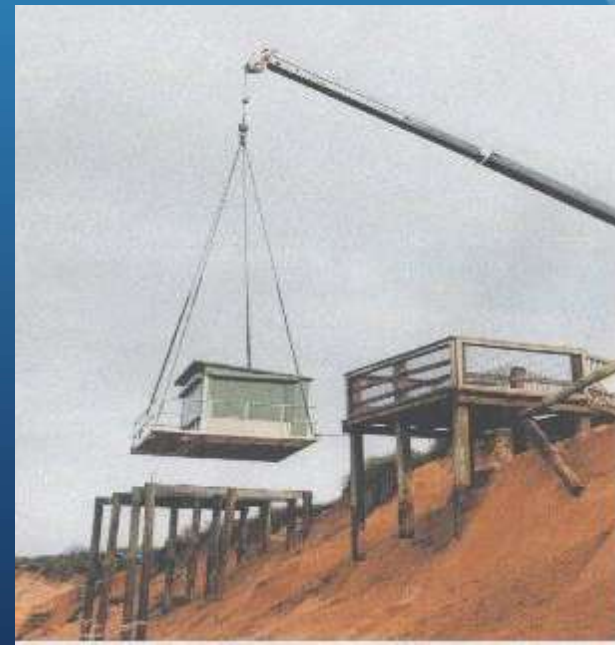














# Progressive withdrawal

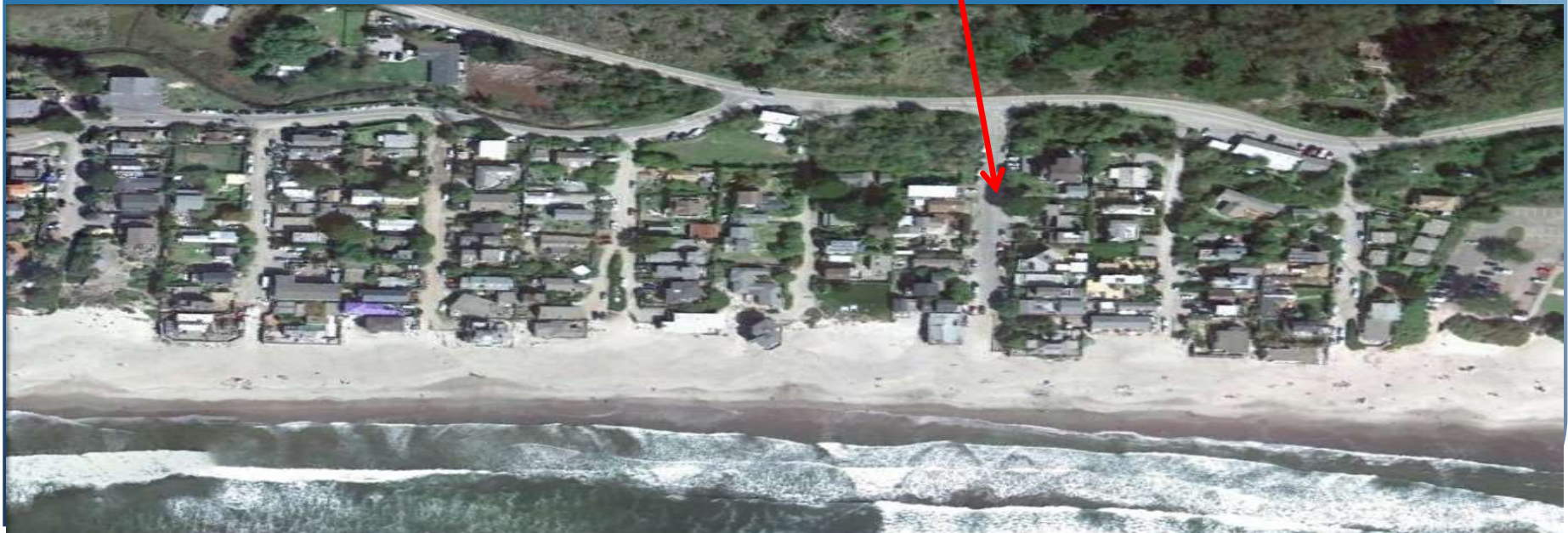






Coast Parallel Residential Roads

Coast Normal Residential Roads







Coast Parallel Residential Roads

Coast Normal Residential Roads





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# Defence - Revetments





# Defence - Artificial Headlands

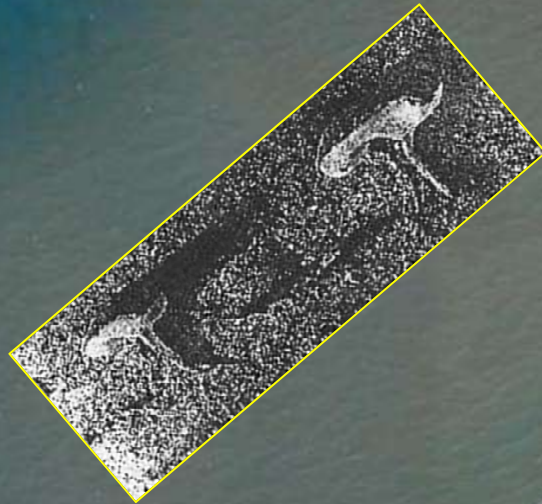


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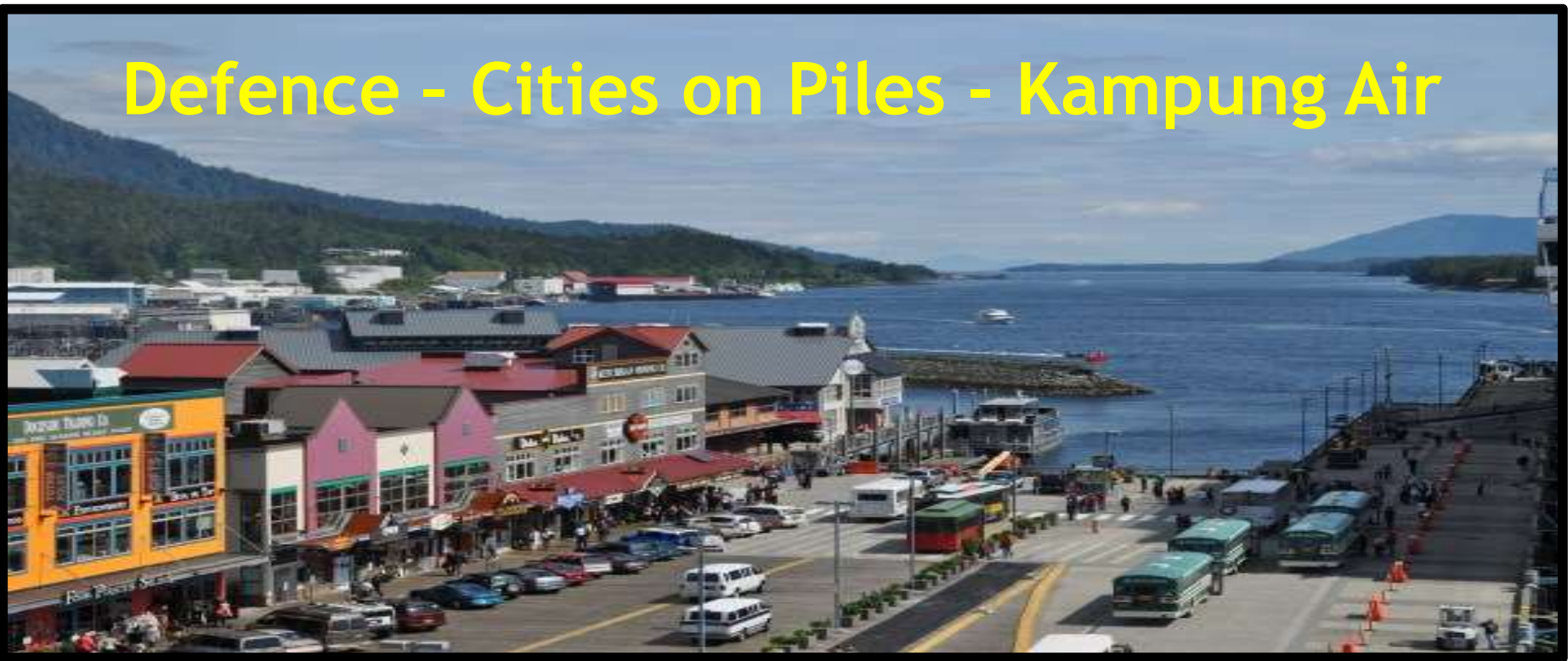


# Defence - Nourishment including dunes





# Defence - Cities on Piles - Kampung Air





# Defence? - Floating Suburbs

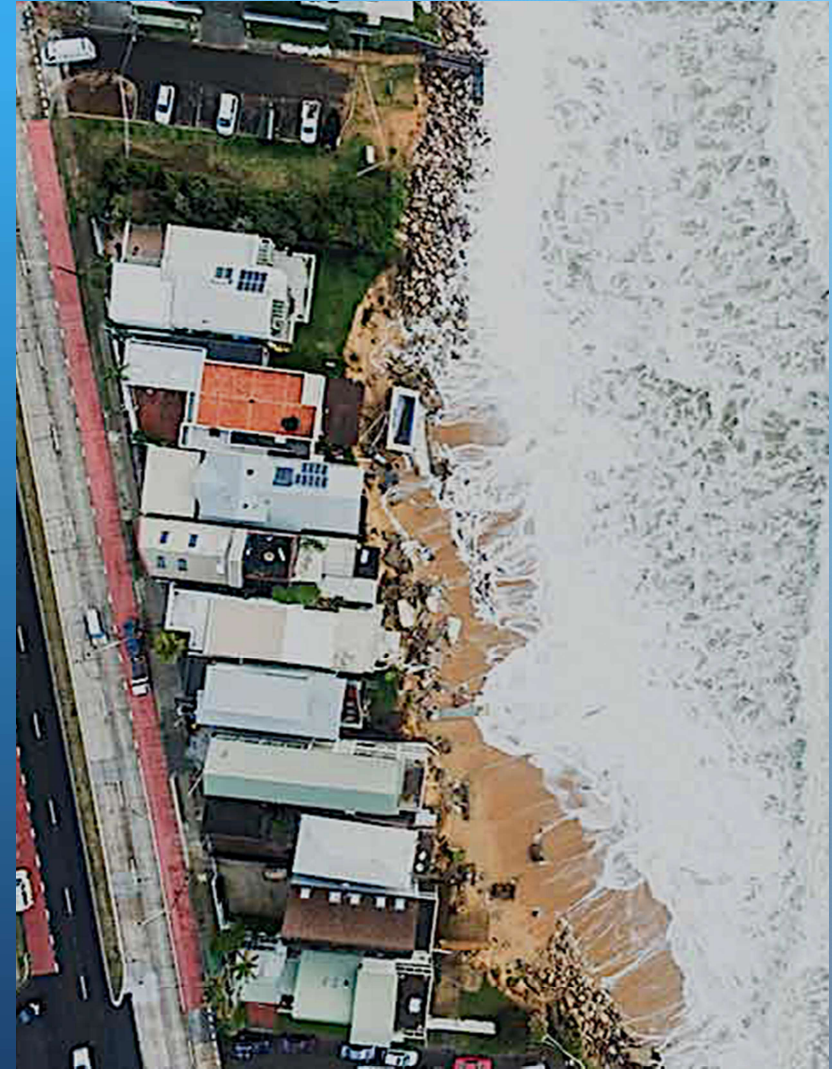


Collaroy, Sydney, June 2016





## 40m “trigger distance?”



12,000 cu m in 3 to 4 hours  $\approx$  1,000 20 T trucks

# New development(un-zoned) areas

- Leasehold not freehold (rezoning condition).
- Land ownership transferred to the State after current owner sells long term lease.
- Individual lessees can “trade” lease (as in ACT).
- Time and Distance limited consents for development.
- Shore -normal, disposable infrastructure and re-locatable buildings.

# Existing development/zoned lands

- Where development is sparse option to repurchase and convert to leasehold, as appropriate.
- Where development intense - protect but offset with on-going nourishment funded by beneficiaries.
- Statutory requirement for Time and/or Distance limited consents and re-locatable structures.
- Progressively replace aging infrastructure with disposable systems - less capitally intense.



# What is required for the Future

- Recognize the coastline is transitory. Coastal zone management must be approached holistically. Piecemeal solutions only further degrade the coast and place development, infrastructure and public amenity at risk.
- Only realistic and equitable solutions with statutory force will succeed. Refusal to accept this is a commitment to forfeiture of both the coastal environment and public amenity.
- DISPOSABLE INFRASTRUCTURE AND RE-LOCATABLE BUILDINGS are important tools in limiting liability.
- Intergenerational legacy - Say NO to 2100 timeframe - need on-going adaption - “Rolling Easements”.



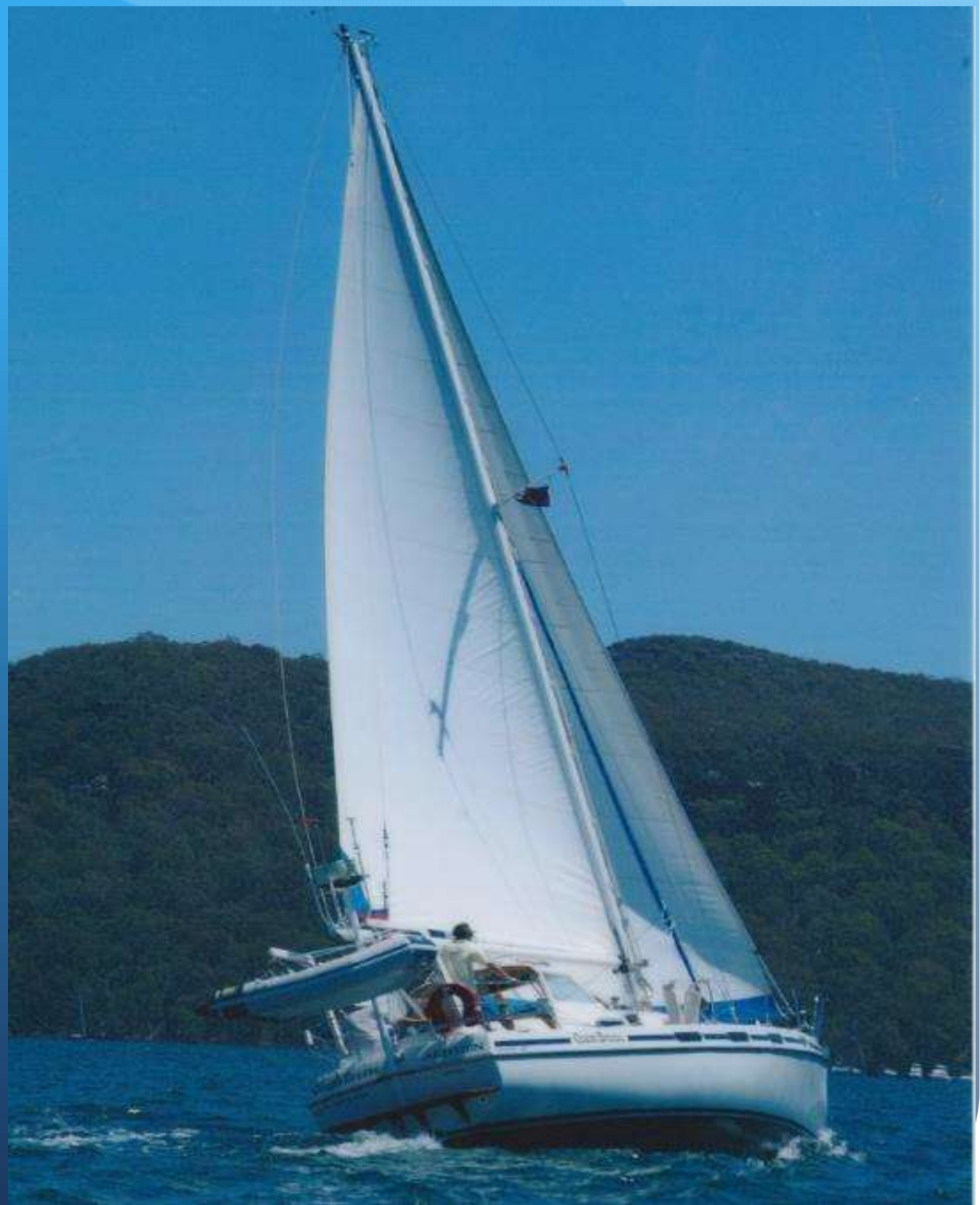


IF NOT, THEN THIS IS THE FUTURE



# The Ultimate Adaptive Coastal Asset

Relocatable  
dwelling with  
self contained,  
disposable  
infrastructure

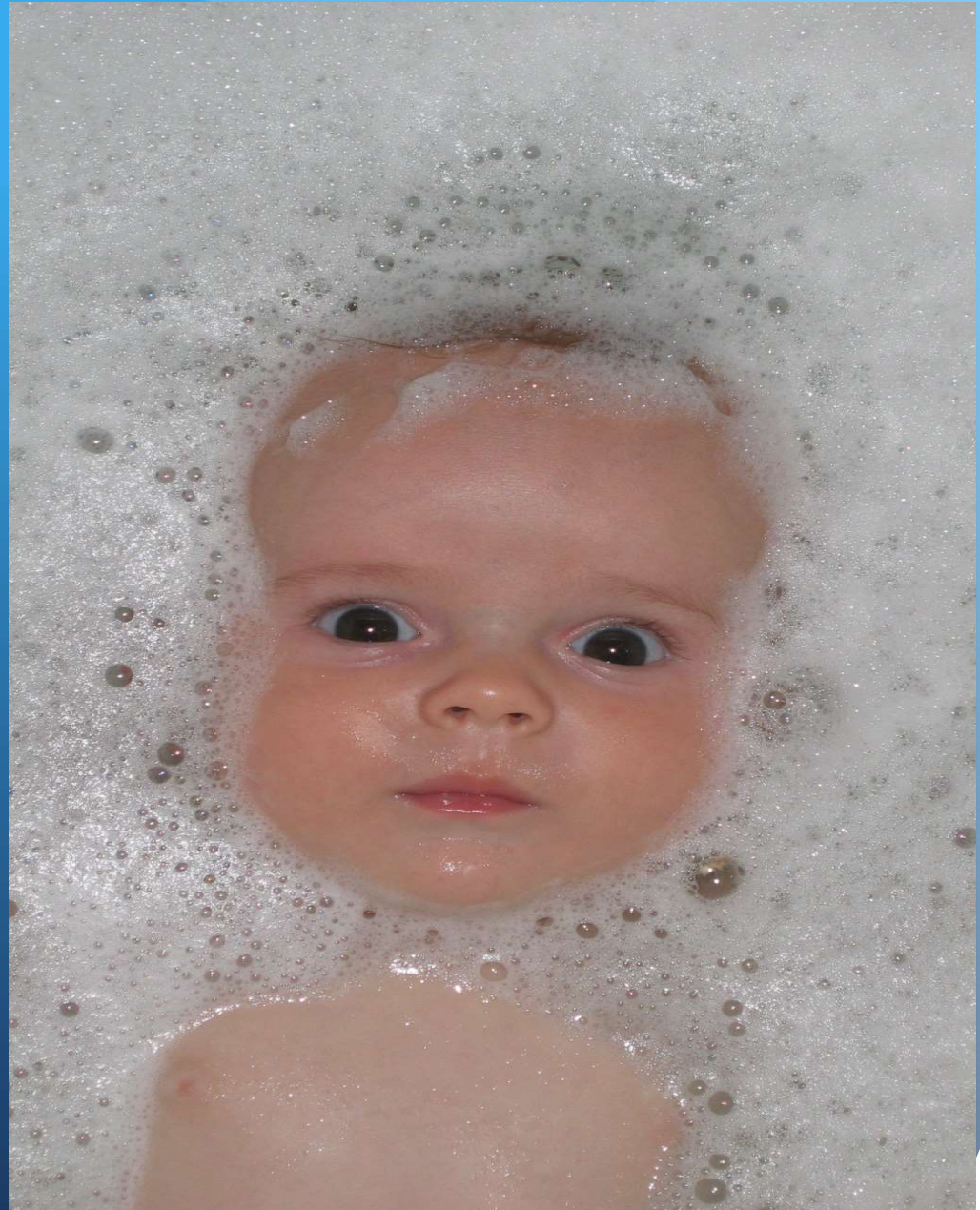




**“SANITY CHECK”:  
WHAT IS THE  
LEGACY WE ARE  
CREATING FOR  
FUTURE  
GENERATIONS ???**

“May you all live in  
interesting times” responding  
to an uncertain and changing  
environment

**THANK YOU**





# The Industrial Age (1850 to present)

- Start of precise (but not necessarily accurate) measurement data (some measurements precede)
- Constantly improving techniques and numbers of locations can give misleading outcomes
- Measured rise in air and water temperature and sea level but not constant with many reversals
- Heat island concerns regarding temperature
- Is sea level rise accelerating or decelerating?
- “Noisy” record (eg 1880/90s storms)

# The Little Ice Age (1300 to 1850)

- Major onset in only about two decades but variable
- Extensive reports of famine and massive loss of life (collapse of sophisticated farming)
- Record cold temperatures 1685, ice sheets expanded covering northern Europe - 5km belt of sea ice in Channel - Ships logbooks - Cook's, Beagle and others
- Initial benefit for Holland (low sea levels)...then,
- French armies used frozen rivers to invade Holland
- Could walk from Manhattan to Staten Island
- Vikings in Greenland wiped out after 400 years
- Genghis Khan's invasion southward 1206 - 1227

# Medieval Warm Period (900 to 1300 AD)

- 900 - 1150 Chaco Canyon increasingly sophisticated Pueblo culture then destroyed by drought
- Egypt- Low flow levels in the Nile 930 - 1070
- Kenya drought from 1000 - 1270
- Angkor Wat (1100 - 1400) increasingly sophisticated irrigation
- Prosperity in Europe - England invaded 1066
- Norse in Greenland and US - emerging evidence



## Norse in Greenland (985 to 1300 AD)

- 985 start of settlement with European livestock
- Two major settlements (East/South and West/North) at heads of Fjords about 250 farms at least 5,000 people (1,000 W and 4,000 E)
- Traded with Scandinavia but used up their timber and turf for buildings and fire (warmth)
- Towns, farms, barns, and churches + 2 Cathedrals
- Norse wiped out because non-adaptive culture, no boats to escape and didn't eat fish, Inuit survived

## Dark Ages (500 to 900 AD)

- Sudden cooling around 535
- Cold - snow in the Mediterranean
- Black Sea froze 800-801 and 829 AD
- Ice reported on the Nile
- Famine with sun being reported as not shining for a year in Constantinople (Procopius 545 AD)
- Wars as people tried to obtain food
- Very narrow growth rings on trees indicating reduced growth

# Roman Warming (250 BC to 450 AD)

- Hannibal crossing Pyrenees + Alps (218 BC)
- Vineyards near Hadrian's wall
- Olive trees in Germany
- Ptolemy reported unusual rain - North Africa a major agricultural region around Carthage (now desert)
- Roman Ports now inland or too shallow
- Ideal conditions for empire expansion with reliable crops reported throughout the empire
- Attila (450 AD) driven south by cooling climate/famine



## Evidence further back

- Greek warm period 500 to 150 BC
- Bronze age cooling around 1200 to 500 BC
- Minoan warm period 1500 to 1200 BC
- Akkadian cooling 3,500 to 1,500 BC
- Holocene Warm period 6,000 to 3,500 BC
- Egyptian Cool period 6,500 to 6,000 BC
- Aboriginal dreamtime stories of sea level