EIANZ

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Unintended Long Term Environmental Disturbances from Estuary Entrance Breakwaters

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Unintended Long Term Environmental Disturbances from Estuary Entrance Breakwaters

- Study background
- Hydrologic/ecological implications
- Case study, Wagonga Inlet
- Where to next

Forster – Tuncurry Bridge Wallis Lake, NSW

Where it all started

Nielsen, A.F[1] Gordon, A.D[2] (1980)

A by-product of a 1970 study found:

- The entrance channel was in an “unstable scour mode”
- Bridge pylons compromised – resulting in major rectification works
- The tidal range had increased markedly
- Scouring commenced shortly after breakwater constructed

[1] Lex Nielsen, Worley Parsons, Sydney Australia
[2] Angus Gordon , Coastal Zone Management & Planning, Sydney Australia

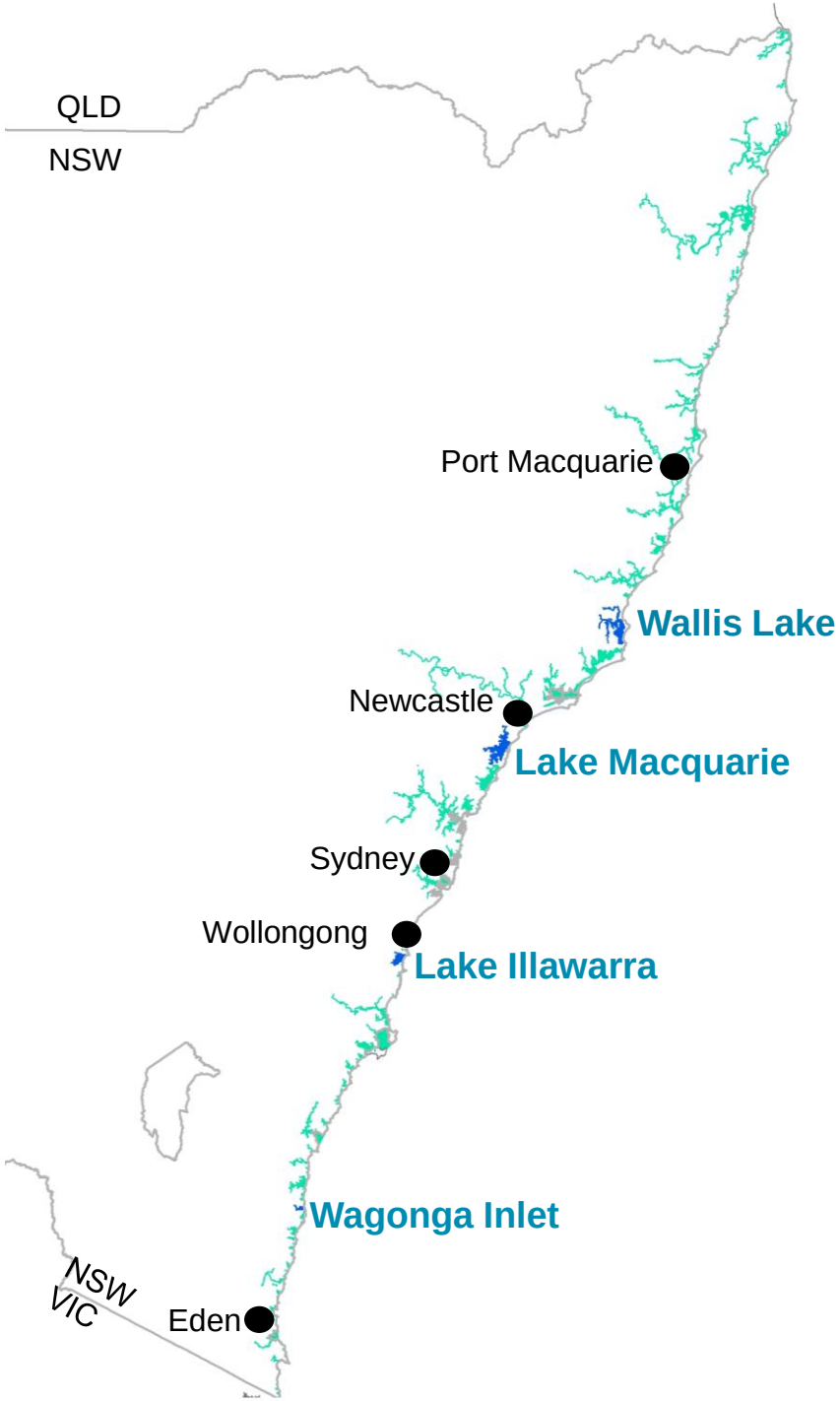

Bridge collapsing
Channels scouring
Beach building
Spring tidal Velocities
screaming @ 3 m/s
Drop-overs aggrading

Subsequent study

Analysis of tidal data (25yrs)

- Wallis Lake
- Lake Macquarie
- Lake Illawarra
- Wagonga Inlet

(Nielsen, Gordon 2008)



Wallis Lake

Breakwaters constructed in 1898, 1966

33% tidal range increase over 25 years

Estimated 450 yrs to maturity

(Nielsen, Gordon 2008)

1951

2010

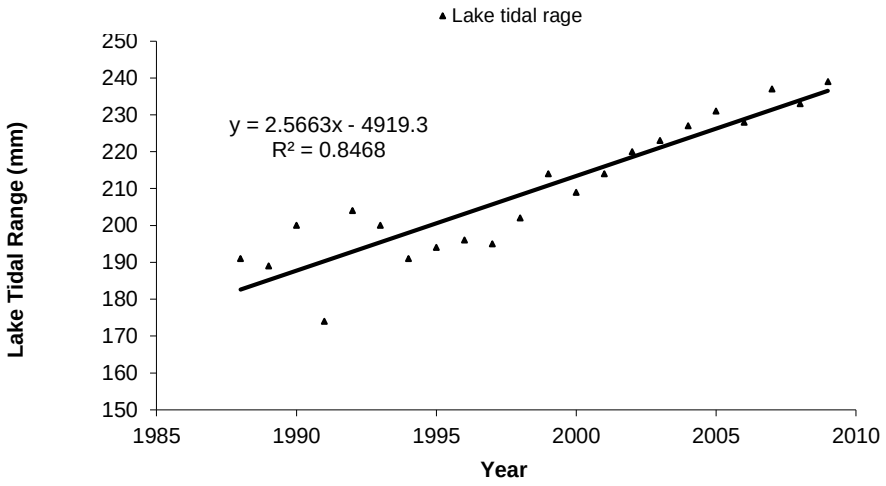
Lake Macquarie

Breakwater constructed in 1887

Tidal range doubled in 25 years

Estimated 480 yrs to maturity

(Nielsen, Gordon 2008)

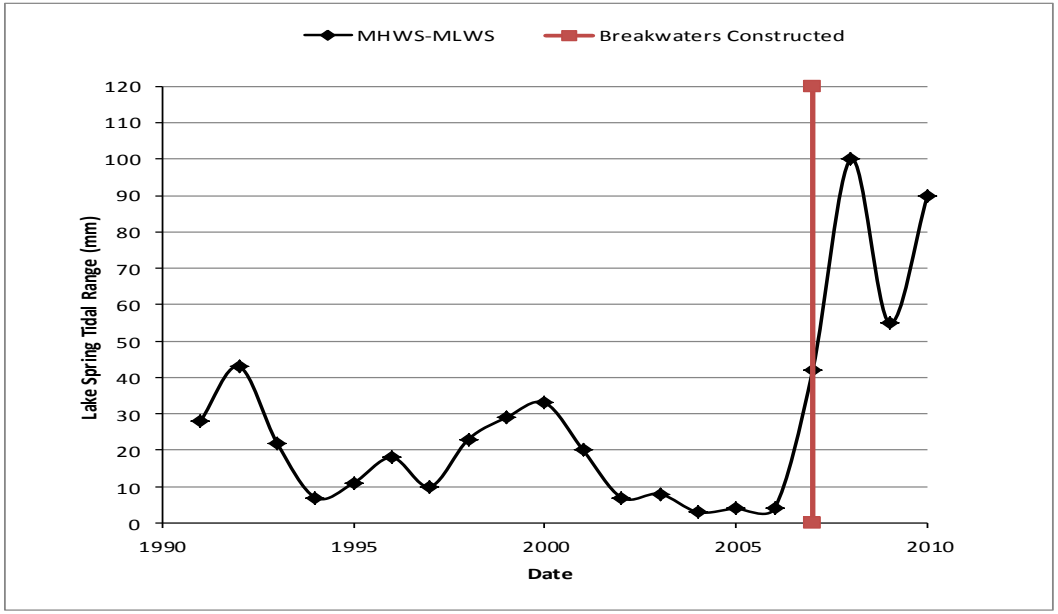


Lake Illawarra

Breakwater constructed in 2007

Tidal range more than doubled since construction

(Nielsen, Gordon 2008)



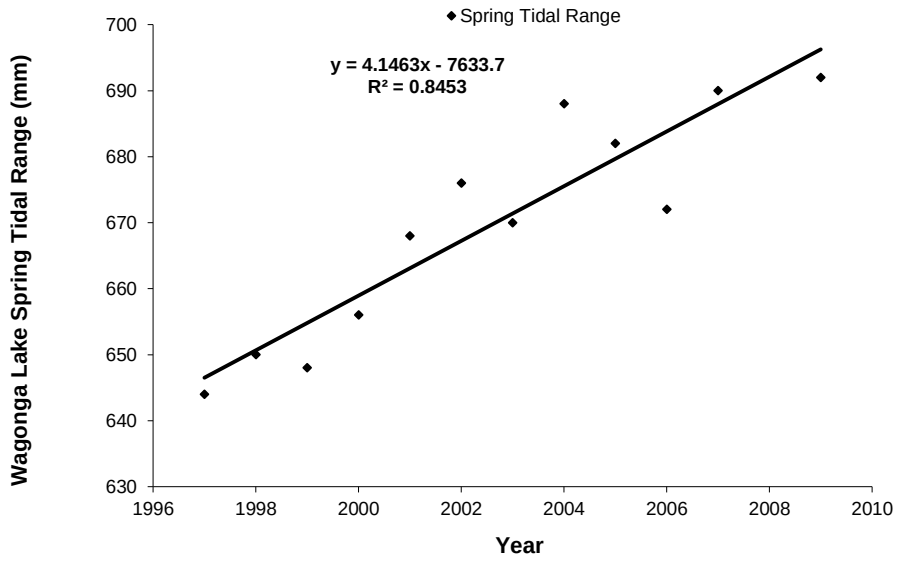
Wagonga Inlet

Breakwater constructed 1978

10% increase in tidal range over 15 years

Estimated 125 yrs to maturity

(Nielsen, Gordon 2008)



Hydrological Implications

Increasing tidal range

- Higher high water levels and therefore inundation of estuary margins

Increased tidal velocity

- Bank and bed scour progress upstream / channels change direction
- Sedimentation-changes in channel patterns and growth of deltas
- Increased hazards at inlet entrances

Increased tidal exchange

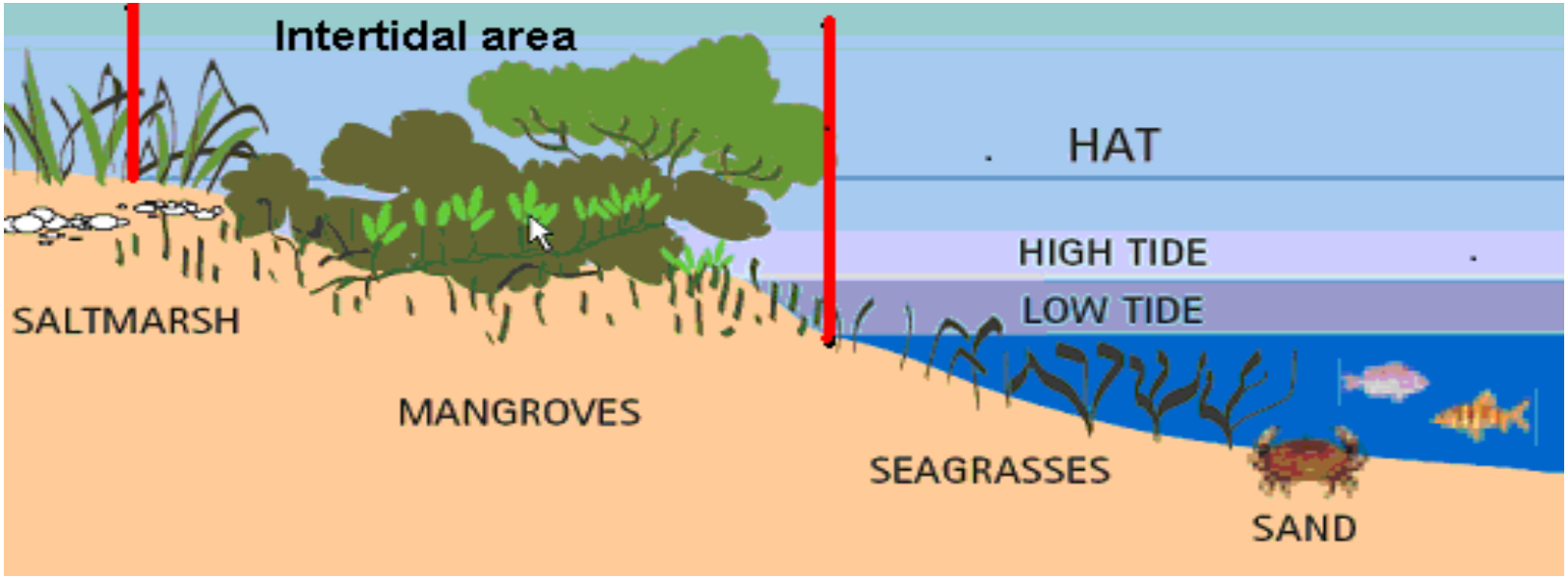
- Altered water chemistry (i.e. marinisation)

Flood waters clearing more quickly

- Decreased fluctuation in water chemistry, marinisation

Ecological implications? Estuarine Macrophytes

- Estuarine macrophytes grow within the subtidal and intertidal zones
- Their presence is affected by physical, chemical and hydrodynamic conditions.



Common habitat zones in an estuary, where HAT = highest astronomical tide (adapted from Kailola et al 1993)

Estuarine Macrophytes

Community or Species	Legislation	Status
Seagrass, mangrove and saltmarsh	FM Act	Protected Marine Vegetation
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	TSC Act	Endangered Ecological Community
Subtropical and Temperate Coastal Saltmarsh	EPBC Act	Vulnerable Ecological Community
Posidonia australis, the largest of eight species of seagrass that occur in NSW	FM Act	Endangered population in Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie
Posidonia Seagrass Meadows	EPBC Act	Item currently under finalised priority assessment

Implications for Estuarine Macrophytes

- **Bank and bed scour progress upstream**
  - Loss of seagrass beds
  - Undermining of mangroves
  - Formation of saltmarsh ‘cliffs’
- **Changes in sedimentation**
  - Smothering of seagrass beds
  - Establishment of new or altered habitat for seagrass, mangroves and saltmarsh

Implications for Estuarine Macrophytes

Increasing tidal range

- increased inundation of estuarine margins
  - Upslope migration of mangrove & saltmarsh
  - Upstream migration of mangrove & saltmarsh
  - Mangrove invasion of saltmarsh

Growth of tidal delta

- changes in patterns and growth of sedimentation
  - Changed distribution of seagrass (contraction & migration)
  - Changed composition of seagrass (faster colonising species -vs- Posidonia)

Confounding factors

- Other non-estuary entrainment but anthropogenic changes (e.g. catchment clearing/altered hydrograph, reclamation, dredging)

- Lack of time series data at a regular frequency from both:
  - Entrained estuaries, and
  - Reference estuaries which have not been entrained

Case Study Wagonga Inlet

West (1985) & NSW MER Program (Fisheries data 2005)

Data used for comparison of macrophyte distribution over 26 years (1979-2005)

Estuary	Year entrained	Yrs post impact to date of aerial photo used by West (1979)	Yrs post impact to 2005
Wagonga Inlet	1978	1 yr	27 yrs
Wallis Lake	1966	13 yrs	39 yrs
Lake Macquarie	1887	92 yrs	118 yrs
Lake Illawarra	2007	Post mapping	

Wagonga Inlet showed a significant decrease in estuarine habitat between mapping campaigns

Wagonga Inlet

Seagrass distribution & composition – over 26 yrs & 1 yr post impact

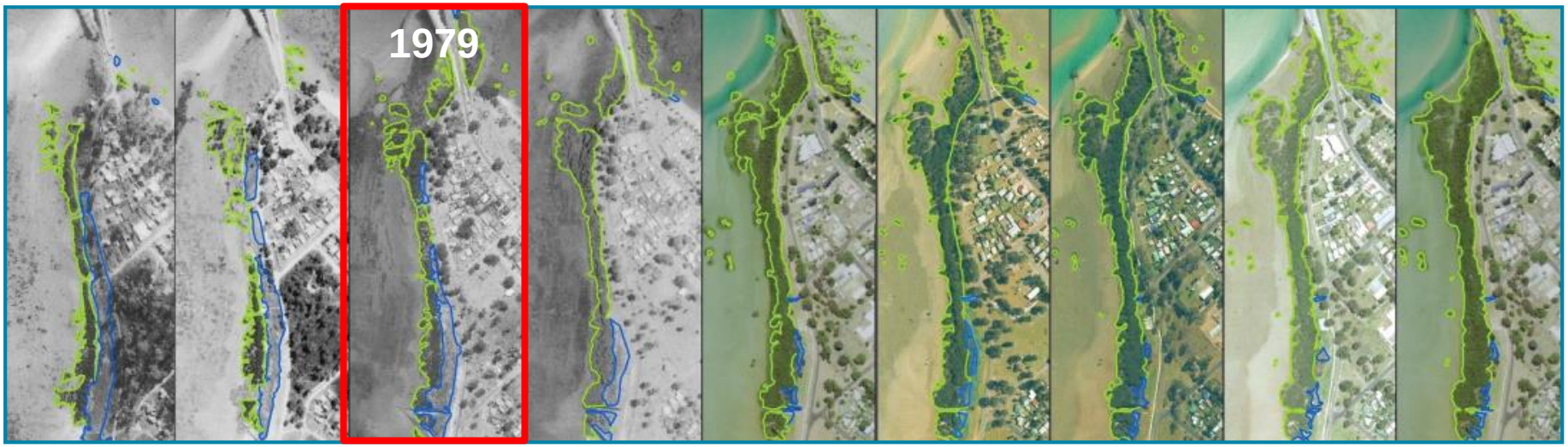
Throughout Estuary			
Dominant Genus	1985	2005	Change
Posidonia	130.2	60.5	69.7
Zostera	59.1	20.4	38.7
Total	**189.3**	**80.9**	**108.4**

Estuary Inlet			
Dominant Genus	1985	2005	Change
Posidonia	24.5	14.4	10.0
Zostera	64.3% seagrass loss		25.7
Total	33.3% seagrass loss		**35.7**

Wagonga Inlet mangrove & saltmarsh

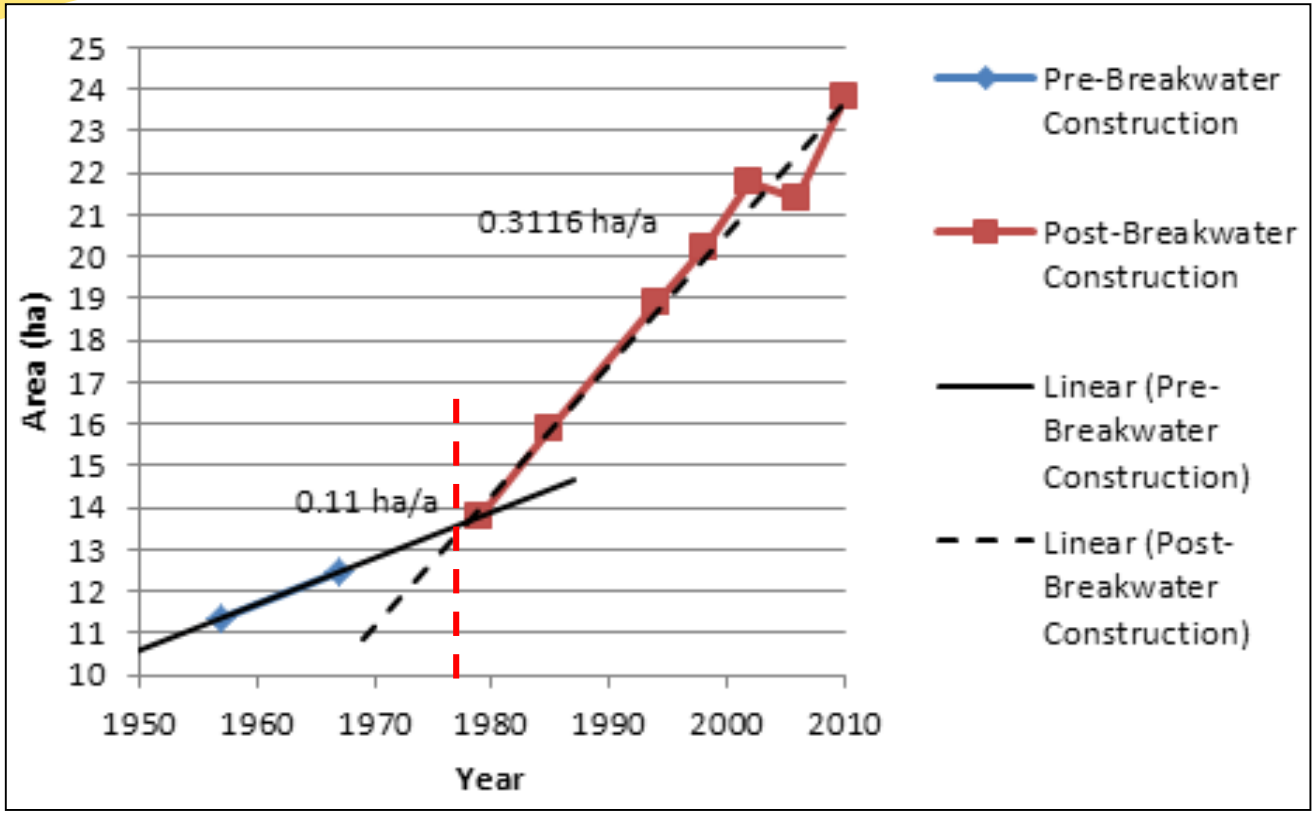
Burrell (2012) mapped changes in the extent of mangrove and saltmarsh between 1957 - 2010

1957 → **2010**



Wagonga Estuary – mangroves (1957-2010)

Long term changes found by Burrell (2012) indicate an increase in rates of change since breakwaters constructed (1976-78)



Stable or expanding mangroves found.

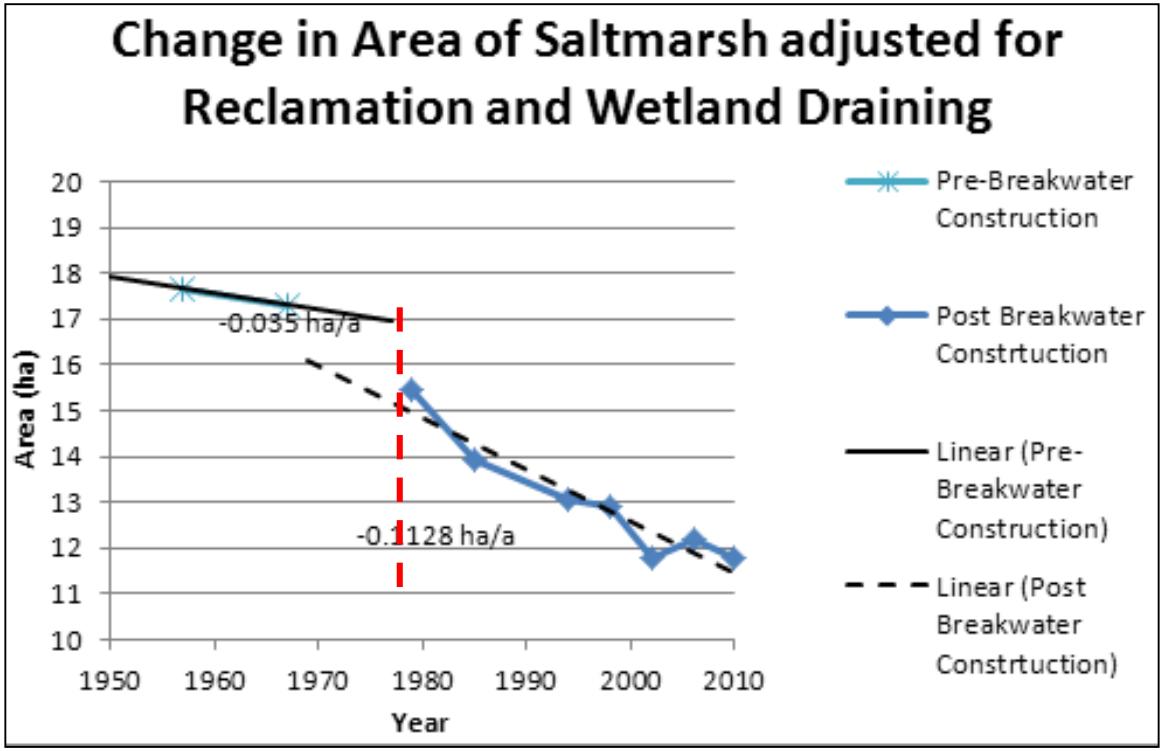
Expansion due to:

- Incursion up-slope into saltmarsh;
- Laterally along the foreshore; and
- Down-slope onto prograding deltas and sandbars

Above: Change in area of mangrove and rates of change prior to and after entrance breakwater construction (data from Burrell 2012).

Wagonga Estuary – saltmarsh (1957-2010)

Burrell (2012) also found that since 1957 saltmarsh had decreased throughout the estuary



Reclamation, draining of wetlands & other urbanisation accounted for the most significant losses within the Inlet.

Removing these factors, the rate of loss is shown to have increased significantly since breakwaters construction

Above: Change in area of saltmarsh and rates of change prior to and after entrance breakwater construction (data from Burrell 2012).

Nominal Dynamics of Estuarine Macrophyte Cover at NSW Estuaries with Modified Entrances

Estuary	Seagrass	Mangrove			Saltmarsh	
	Observation	Migration			Migration	
		Up-slope	Up-stream	Lateral	Up-slope	Up-stream
Wagonga	Δ distribution & losses in inlet[2]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Wallis Lake	Δ composition[2]	Yes [2]	Yes [2]	Yes [2]	Yes [2]	Yes [2]
Lake Macquarie	losses, u/s migration in inlet[2]	Yes [2]	Yes [2]	Yes [2]	Yes [2]	Yes [2]
Lake Illawarra	losses in inlet[2]	?	?	Yes[3]	?	?

[1] data from Burrell 2012 provides evidence of changes in estuarine flora consistent with the physical changes expected as a result of estuary entrainment

[2] preliminary discovery exercise using 1985 (West) and 2005-2008 (NSW MER)

[3] anecdotal observations Wiecek 2013

Conclusion

- Stabilising entrances with breakwaters can cause estuarine instability **that may take centuries to stabilise**!
- Further complicating these processes is sea level rise amplification of high tides and lake levels
- The longer term impacts of modifying entrances requires further understanding – and urgently

Where to next?

- Examine time series data similar to Burrell (2012) in both subject and reference lakes
- Model salinity and water level changes throughout Wallis, Macquarie, Illawarra and Wagonga Inlet
- Consolidate/obtain multidisciplinary study linking hydrological and ecological observations

Questions?

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