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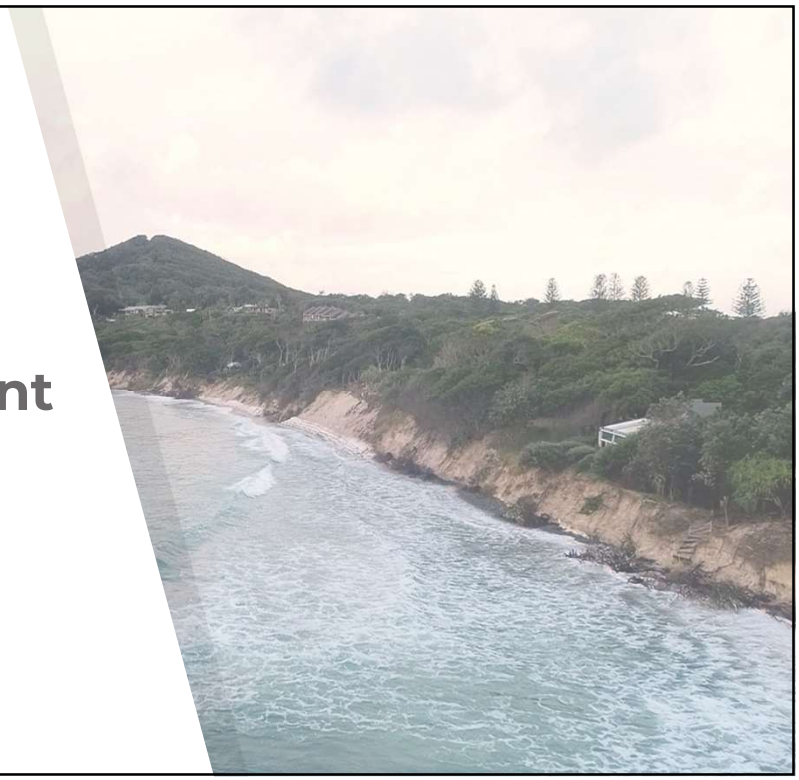
Sand budgets for coastal management in NSW



Heiko Loehr &
Evan Watterson

NSW Coastal Conference 2022

1

What is a sand budget?

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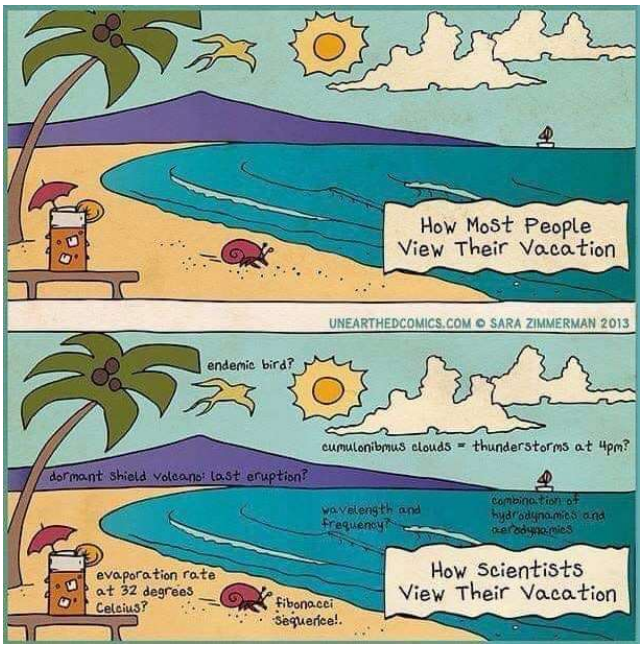
Understand the beach system and the sand movements through this system



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What is a sand budget?

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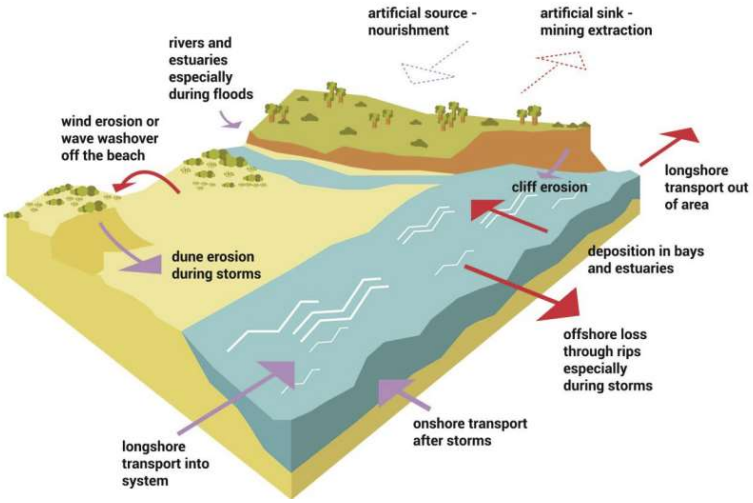
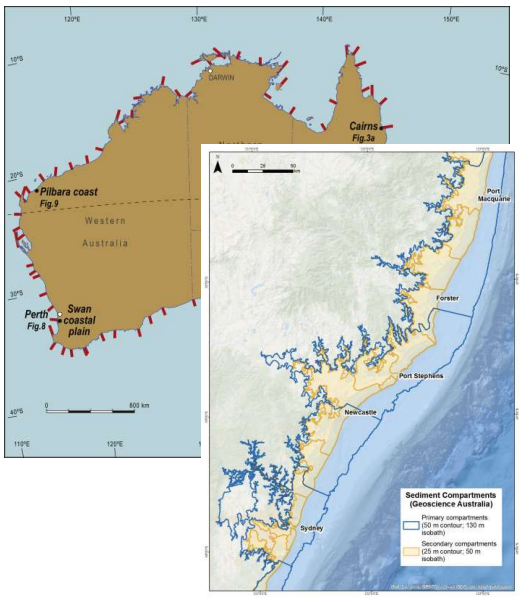
Sand budget





Sediment compartments

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What is a sand budget?

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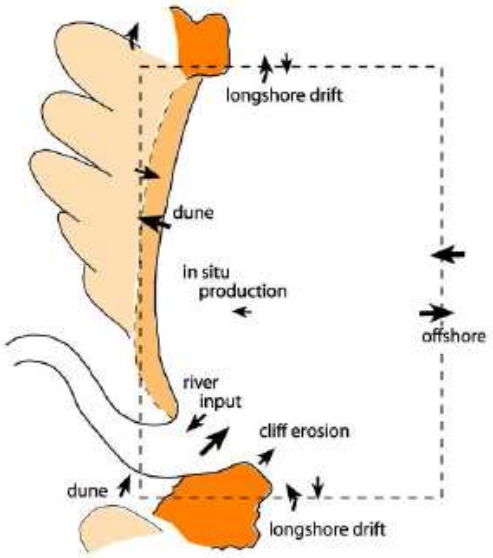
Potential sand budget inputs/outputs

- Longshore sand transport
- Beach/cliff erosion
- Aeolian sand transport/ dunes
- Shoreface sand supply/ offshore losses
- Coastal lakes and estuaries
- Biogenic production
- Erosion limiting factors (bed rock, coffee rock,..)
- Cyclic variability due wave climate
  - Headland bypassing
  - Beach rotation
  - Cross embayment transport
- Climate change impacts on sand movements



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NSW Coastal Management Act 2016

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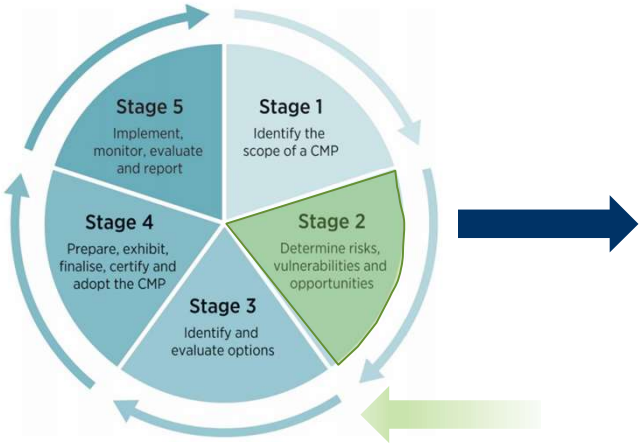

Consider evolutionary history. Including obtaining knowledge about the historical and present sources and sinks, geological/geomorphological evidence and recorded history of impacts of extreme events. From this evidence determine whether an area is experiencing long-term recession or accretion, and if so, why.

Immediate erosion. Estimate the potential present day or immediate erosion hazard related to severe storms, storm clustering, rips and other aspects of variability, usually taken to be the 1% probability of occurrence in any one year.

Sediment budget/shoreline trend. Determine the net long-term shoreline recession/accretion trend, and its variability, due to deficits and/or gains in the onshore, offshore and longshore sediment budget under current conditions.

Response to climate change/variability impacts. Estimate the potential shoreline movements due to future sea level rise or relative sea level rise (land subsidence) or other changes such as beach rotation due to aspects of climate change and/or climate variability.

Combine and evaluate erosion, shoreline recession and shoreline rotation threats/hazards for specified planning and management timeframes.

NSW Coastal Management Manual Part B: Stage 2

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Case study - Stockton Bight

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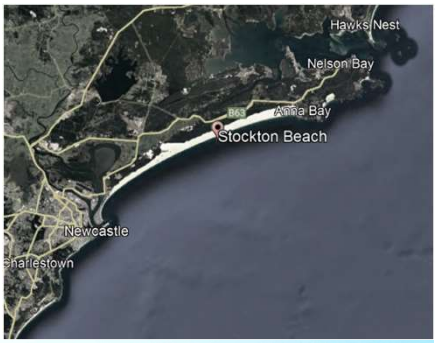
Study area

- 32km long beach (NSW's longest beach)
- Largest active dune system in Australia
- One of the highest wave energy beaches in NSW
- Grades from highly developed in the south to natural along its central and northern sections (mostly)
- Downdrift from Port of Newcastle



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Sand budget - Stockton Bight

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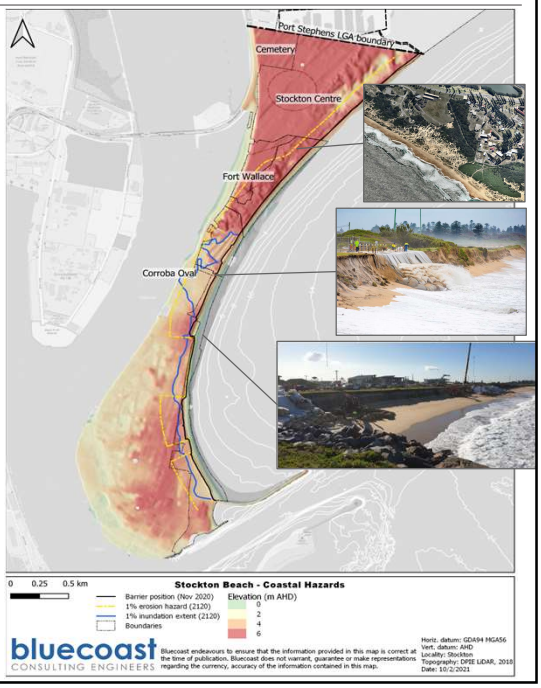
Purpose of this study

- Stage 2 of Stockton CMP - follows sediment compartment wide approach encouraged by Coastal Management Act 2016
- Ultimately, the study seeks to inform sound coastal management into the future



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Sand budget - Stockton Bight

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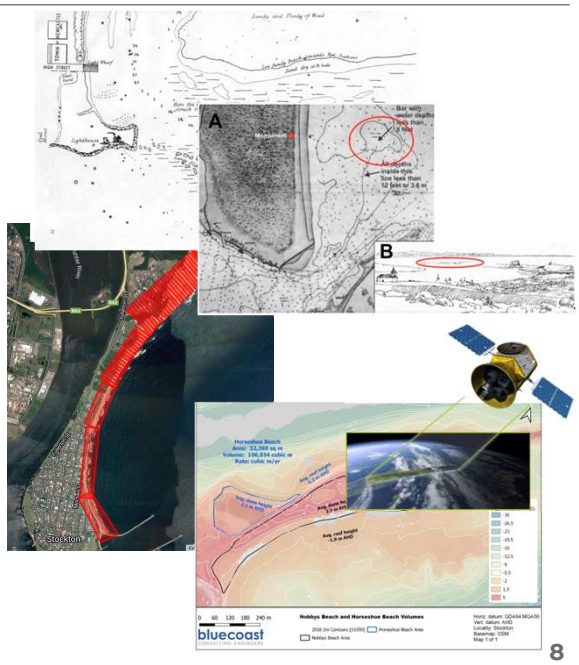
Data used

- **Subaqueous storages**
  - Historical bathymetric surveys from 1866 to 2018.
  - Limited coverage over northern Bight – use of satellite derived bathymetry
- **Subaerial storages**
  - Beach profiles from 1953 to 2020. Stockton + Fern Bay
  - Northern subaerial storages assessed using satellite derived shoreline change (CoastSat)
- **Dune sheet** compartment assessed using Nearmaps 3D and LiDAR
- **Sensitivity analysis** completed



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Sand budget - Stockton Bight

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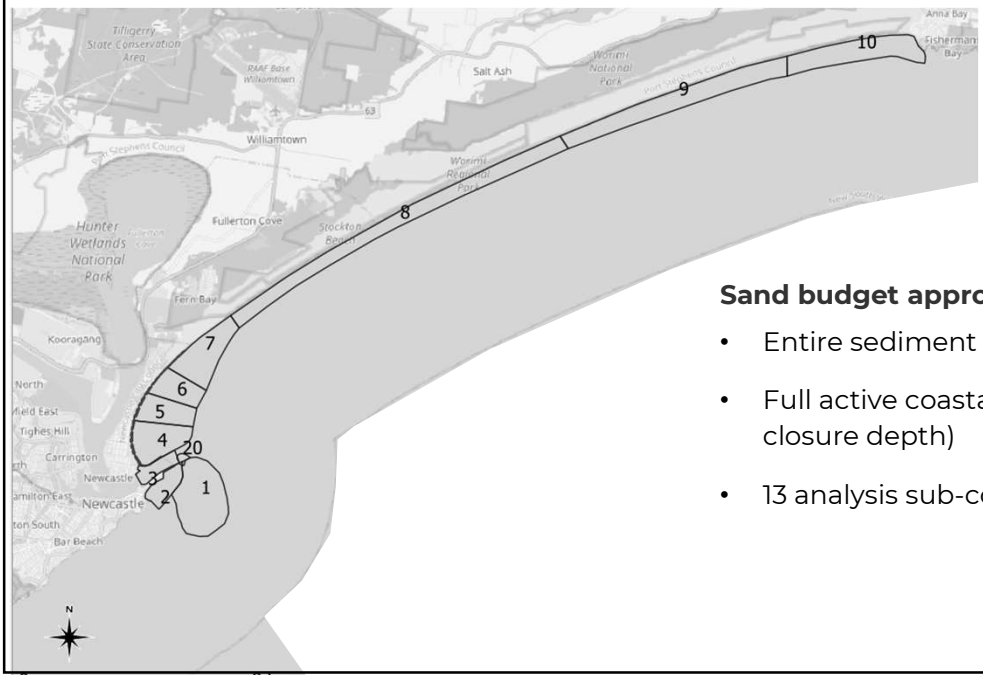

Sand budget approach:

- Entire sediment compartment
- Full active coastal profile (dune to closure depth)
- 13 analysis sub-compartments

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Sand budget - Stockton Bight

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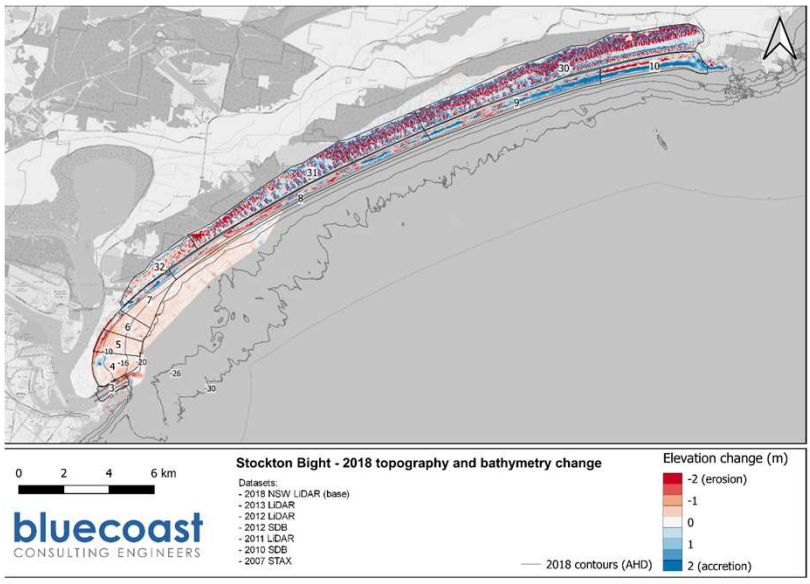
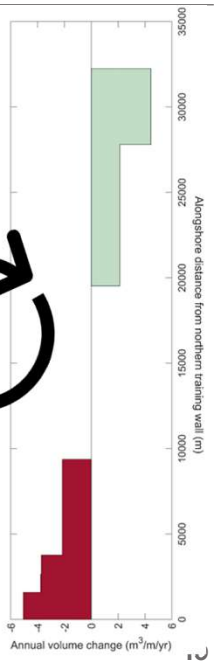
Surveyed net long-term change





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Sand budget - Stockton Bight

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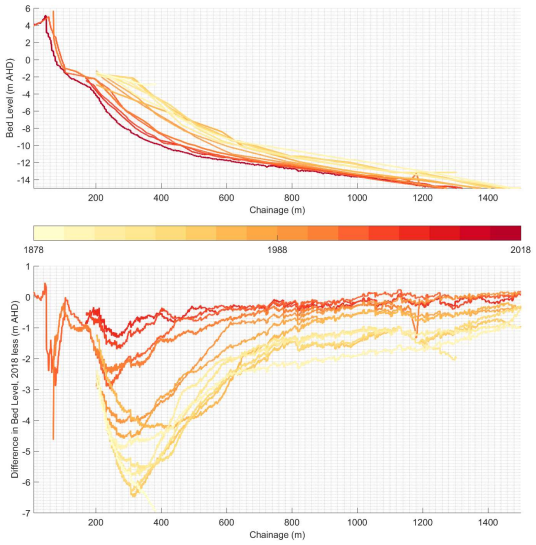
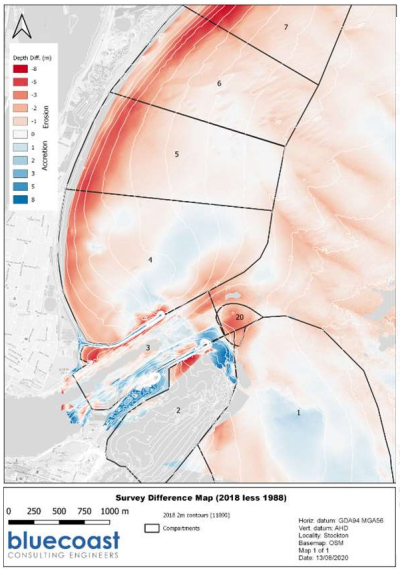
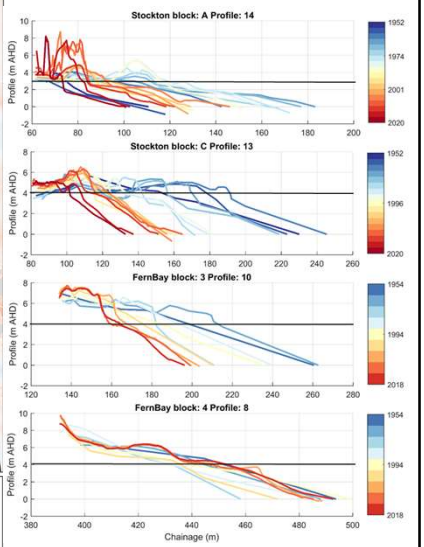
Surveyed elevation differences







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Sand budget - Stockton Bight

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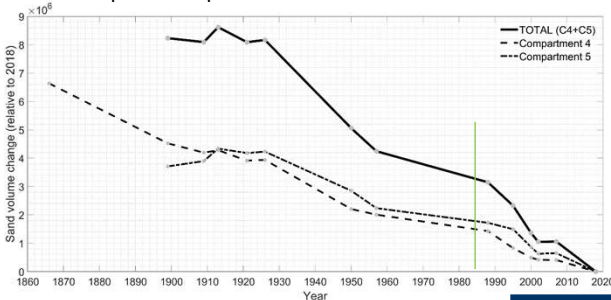
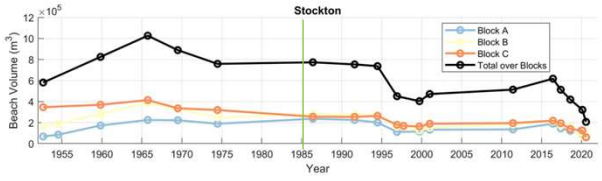
Calculation of long term sand loss rates

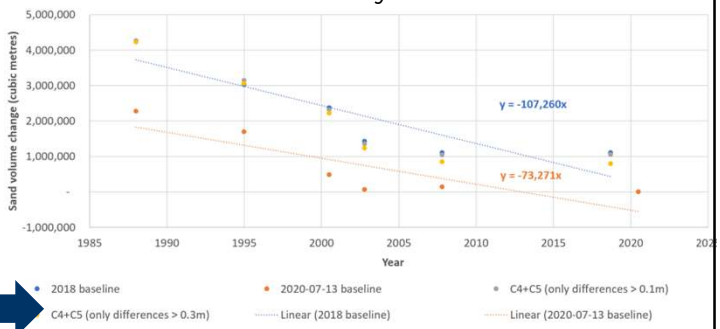
Subaqueous part



Subaerial part



Trend analysis



Net long-term volume trend (loss):

- 1988 to 2018 **-112,000 m³/yr** (incl. port placements) adopted period justified by massive channel deepening project in 1980's

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Sand budget - Stockton Bight

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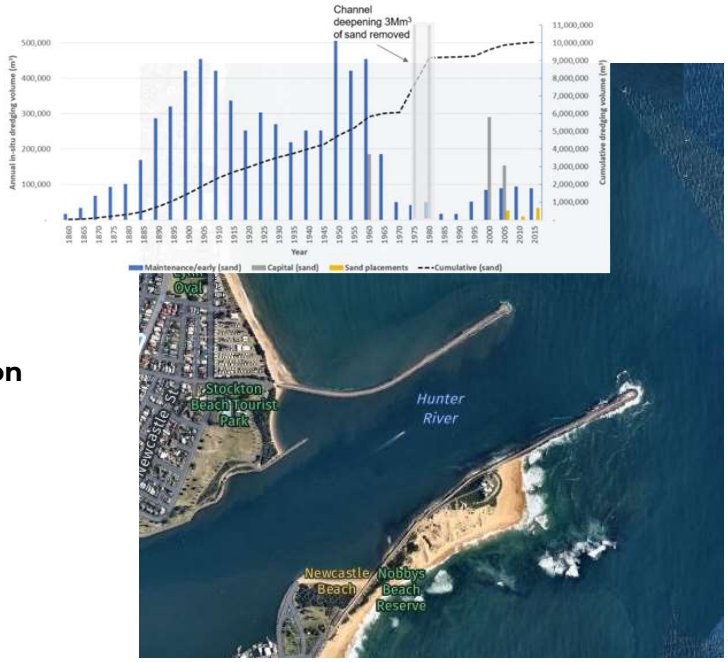
Why?

- Breakwater, deepened channel and maintenance dredging represent a physical barrier to natural sand movement bypassing the river
- Sand at Stockton continues to move northward
- **~Zero (in) – 112,000m³/yr (out) = Erosion**



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Sand budget - Stockton Bight

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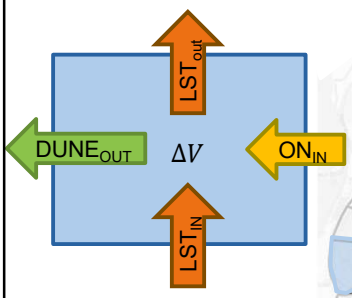
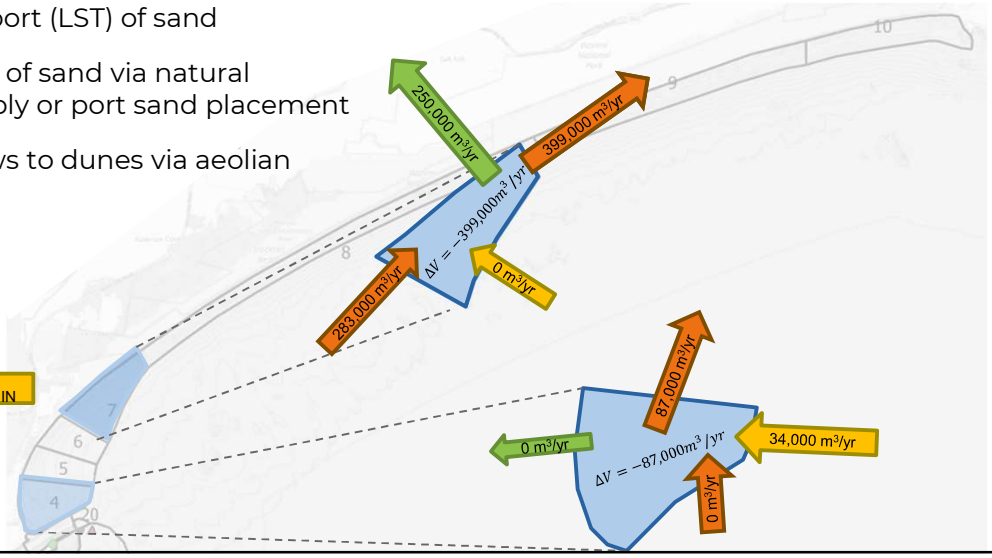
Sediment budget inputs $\Delta V = LST_{IN} - LST_{OUT} + ON_{IN} + DUNE_{OUT}$

- Long Shore Transport (LST) of sand
- Onshore transport of sand via natural onshore sand supply or port sand placement
- Outflow and inflows to dunes via aeolian transport





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Sand budget - Stockton Bight

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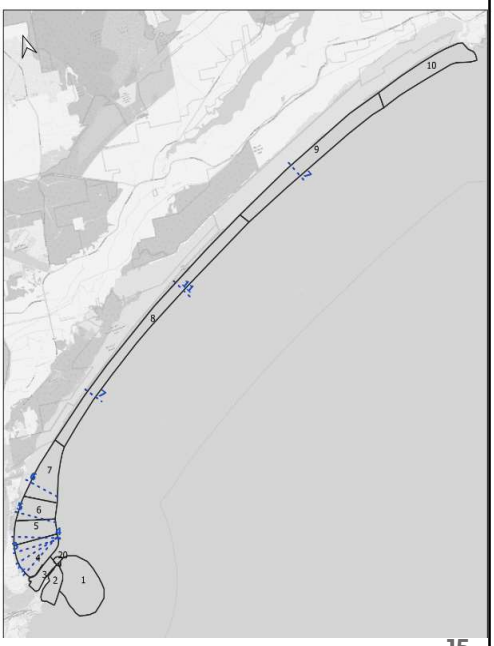
Volume differences

Table 7: Cubic meters of sand relative to 2018 seabed levels in compartments at Stockton Bight.

	Compartment	1	2	3	4	5	6	7	8	9	10
	Compartment Area (m²)	3,842,271	998,478	722,599	2,211,858	1,642,237	1,502,772	2,589,952	6,124,734	4,940,111	3,385,692
	Volume loss (m³) relative to 2018										
Year of survey	1866	-	-	3,557,757	6,635,863	-	--	-	-	-	-
	1899	-	-	3,733,369	4,5217,95	3,710,343	3,314,104	-	-	-	-
	1909	-	-	4,196,072	3,897,621	-	-	-	-	-	
	1913	-	-	4,280,922	4,338,313	-	-	-	-	-	
	1921	-	-	3,507,018	3,910,804	4,180,107	-	-	-	-	-
	1926	-	-	5,597,229	3,938,704	4,230,474	-	-	-	-	-
	1950	-	-	3,132,118	2,206,424	2,850,520	-	-	-	-	-
	1957	-	-2,082,451	3,129,213	2,006,998	2,237,630	1,459,643	-	-	-	-
	1988	162,285		137,695	1,429,336	1,721,124	1,836,225	4,761,267	-	-	-
	1995	-	-	-	829,893	1,494,680	-	-	-	-	-
	2000	-	-	1,891,813	493,237	867,584	-	-	-	-	-
	2002	-167,575	-115,039	244,260	417,654	630,852	454,507	648,598	-	-	-
	2007	-	-	400,192	409,488	651,785	449,090	385,822	-	-	-
	2010	-	-	-	-	-	-	-	-	-	-1,514,630
	2012	-	-	-	-	-	-	-	3,200,982	-1,669,040	-
	2018	0	0	0	0	0	0	0	0	0	0



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Sand budget - Stockton Bight

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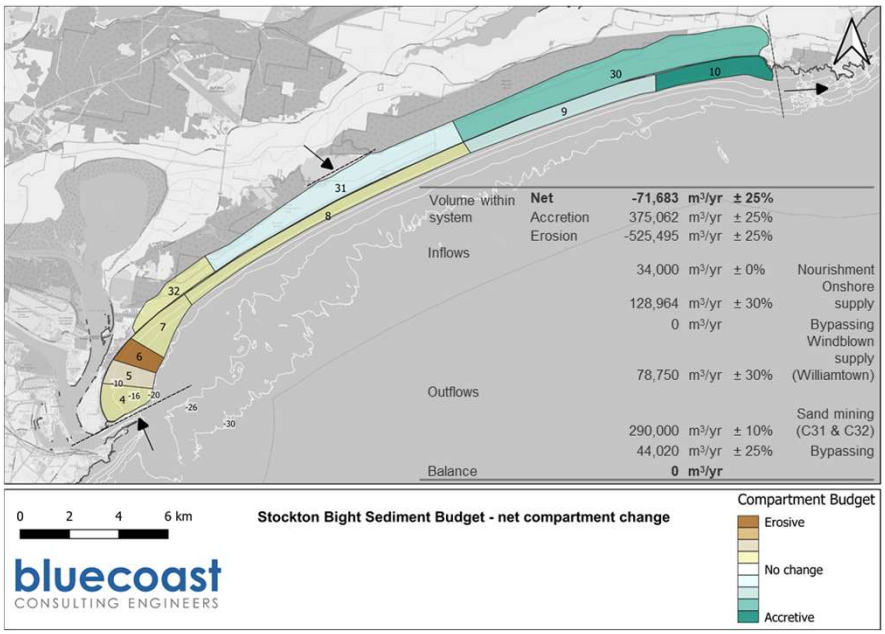
Calculation of average sand transport rates



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Sand budget - Stockton Bight

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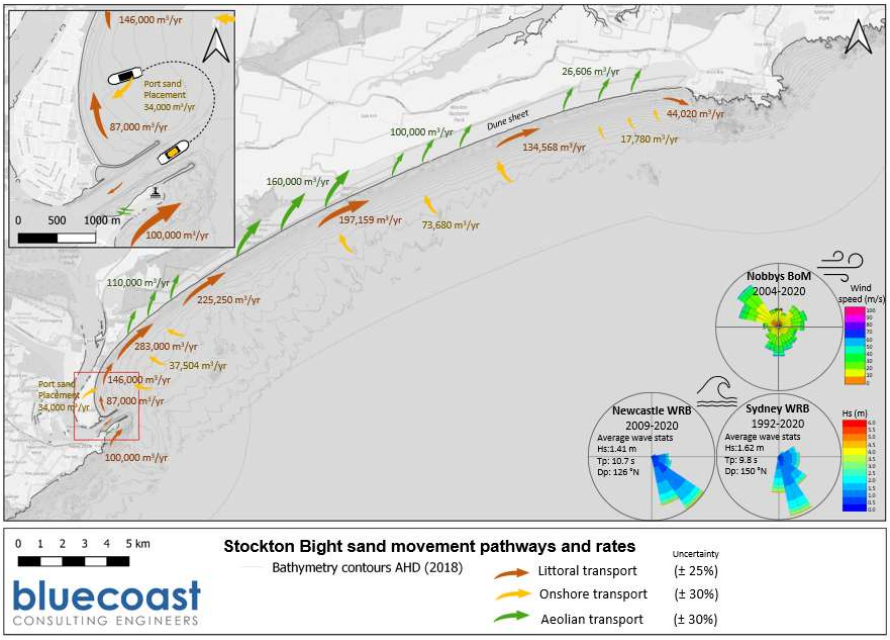
Conceptual model of sand movements



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Sand budget - Stockton Bight

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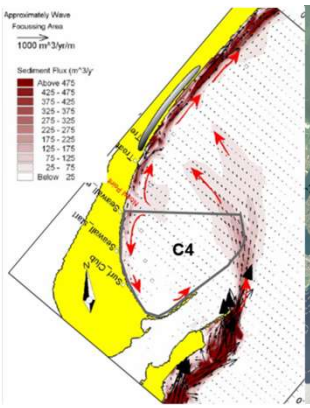
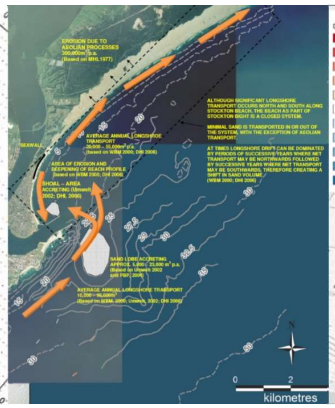
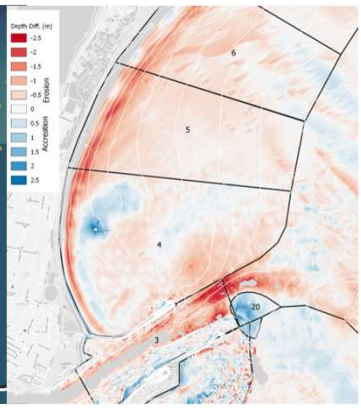
Key outcomes



Previous numerical modelling



Previous conceptual model



2018 less 2002 (@85,000m³/yr would be 1.36M m³ **deposition??**)

- C4 has been eroding at a rate **10x greater** than flux predicted in 2006 work
- **Where has that sand gone?** (spoiler alert: not to the south)
- **100% necessary for development of sound coastal management actions**

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Case study – Letitia Beach

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Study area

- 3.6km long east-northeast facing beach
- Located to the south of the Tweed River entrance
- Training walls extended in 1960s
- Sand collection jetty just south of the Tweed River entrance (commenced in 2001)
- Average annual sand pumping volume of around 425,000m^3/year (since 2008)
- Average annual dredging volume of around 130,000m^3/year (periodic)

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Sand budget – Letitia Beach

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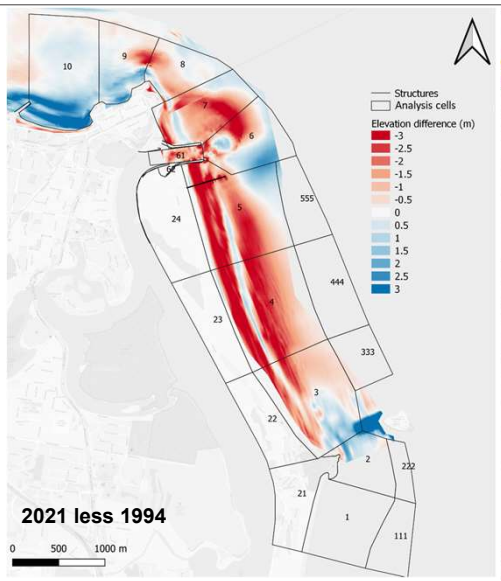
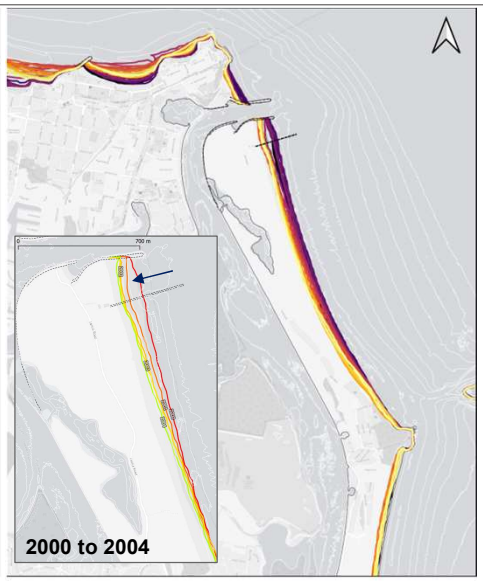
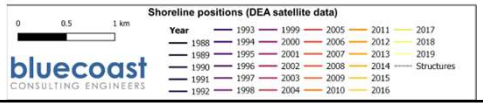
Survey analysis:

- 21 analysis cells
- 40+ beach & hydrosurveys available
- Northern boundary - known sand movement qtys from pumping data
- Southern boundary - periodic headland bypassing from south (Fingal Head)







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Sand budget – Letitia Beach

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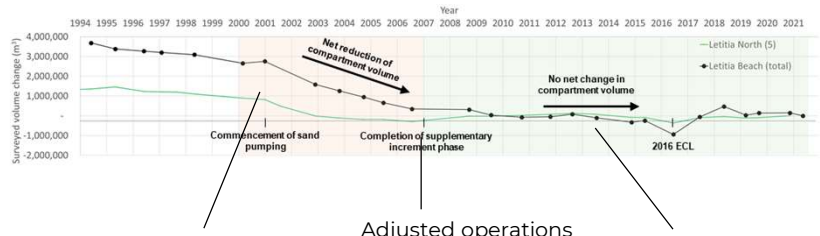
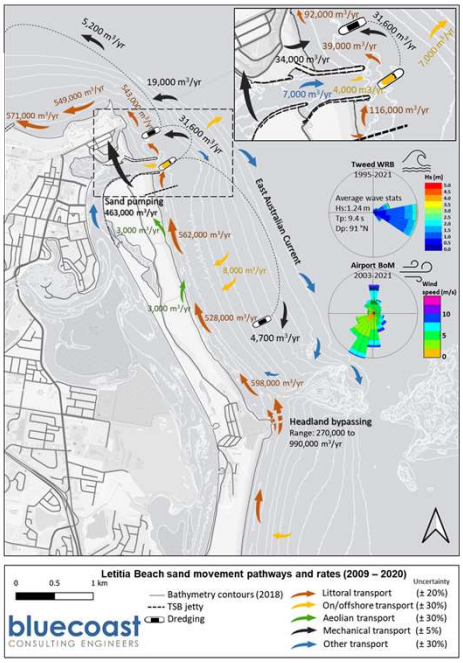
Compartment volume history



Sand extraction > sand volume coming in from south

Adjusted operations

New equilibrium volume



Sand budget outcomes

- New compartment equilibrium volume reached in ~2008
- Evidence that current sand transfer operations are in line with natural sand transport regime
- Highlights importance of ongoing monitoring

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QUESTIONS

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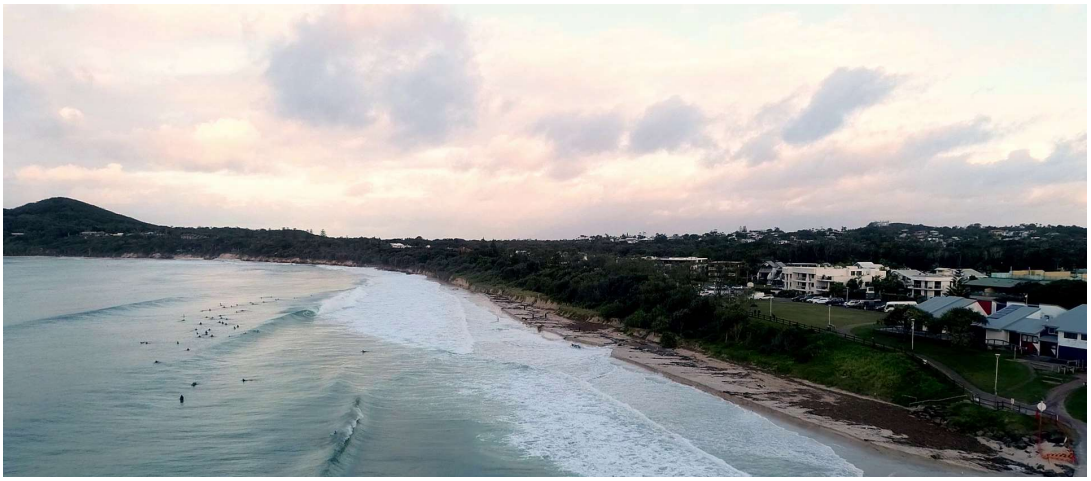

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