Geomorphic background to coastal erosion hazard zoning for Tasmania

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Tasmanian Government

smartline coastal data segmentation

bluewren GROUP

UTAS

Coastal substrate types

Coastal landform substrates (constituents) grouped into four types with notably different erosional responses to coastal processes:

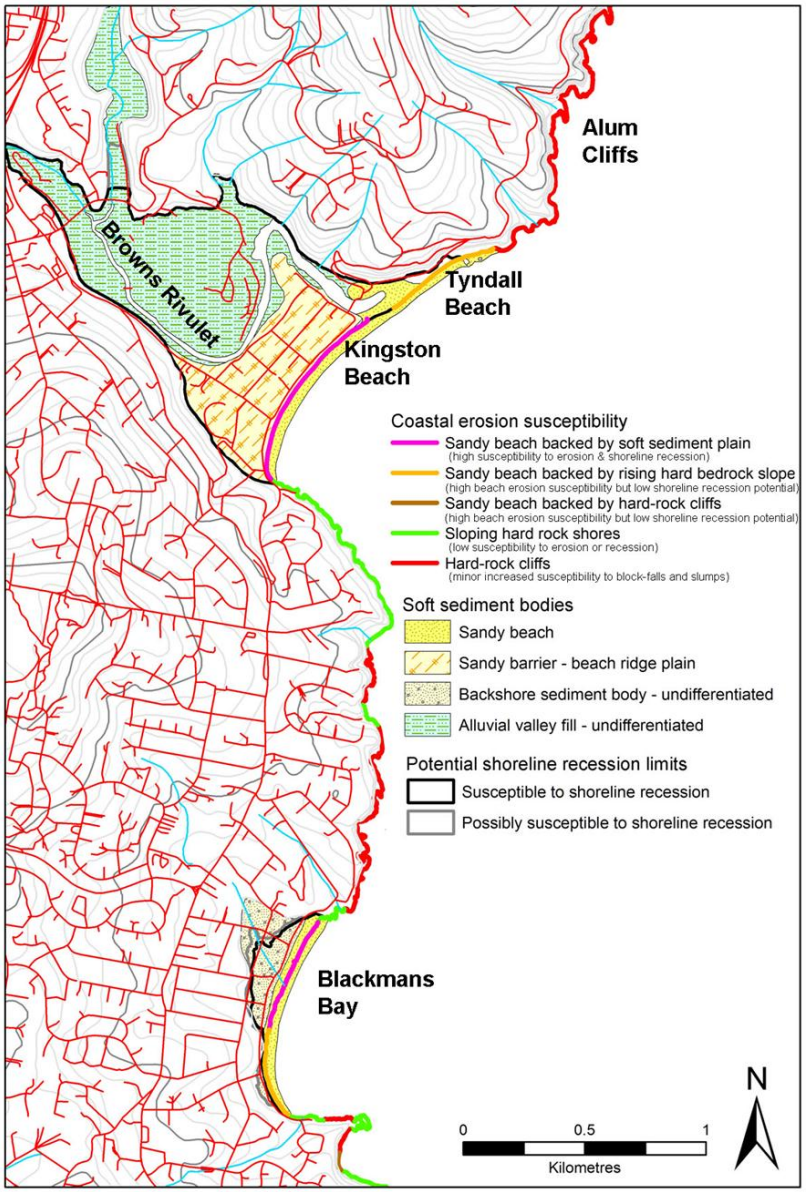
- **Soft sediments (especially sandy beaches)**
- **‘Soft rock’**
- **Hard rock**
- **Artificial shores**

Many coastal erosion hazard zoning schemes (elsewhere) deal only with sandy coasts, however soft rock coasts and hard rock cliffs are also widespread and commonly eroding

Soft sediment coasts

- Loose sediment, easily erodible.
- Mainly sandy beaches, but also some muddy estuarine shores and cobble beaches;
- Sand is highly mobile, eroded shores may recover and “rebuild”

Soft sediment coasts (especially sandy coasts)



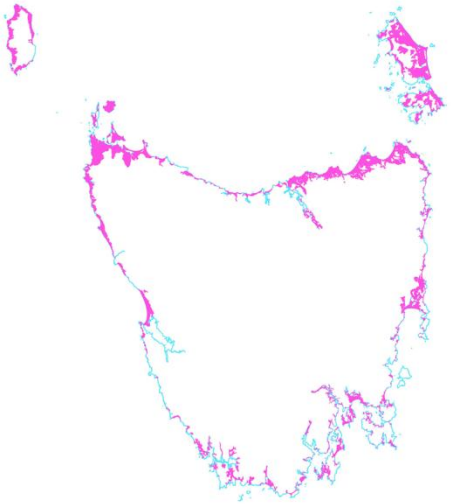
Mapping datasets used:

- Polygon mapping based on Geological Survey mapping (MRT);

plus:

- Additional soft sediment polygons mapped and inferred by C. Sharples & H. Walford (Geological Survey maps omit some to show bedrock beneath);

- Coastal soft sediment mapping provided as single stand-alone GIS layer.



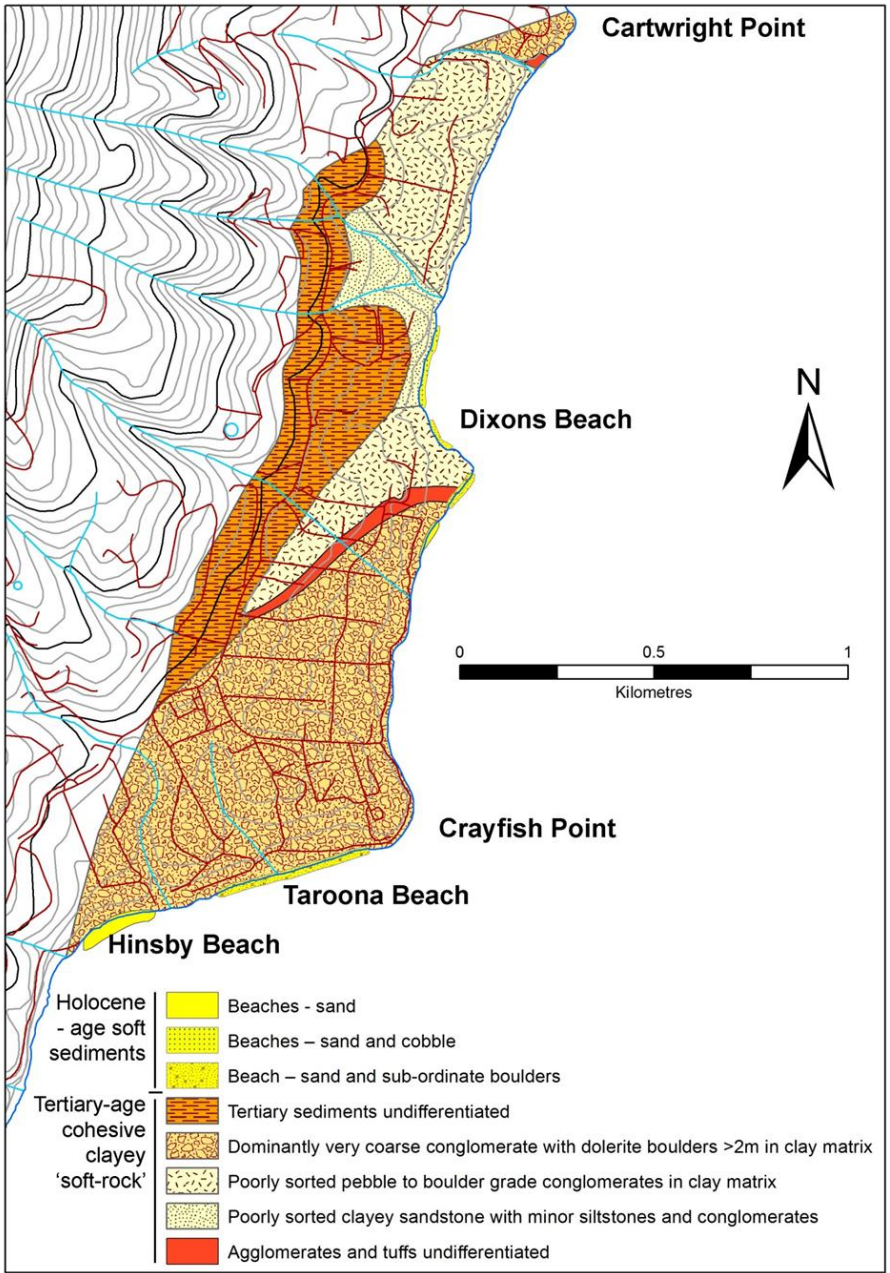
Soft rock coasts


Margate


Taroona

- Cohesive materials, but not hard bedrock, usually clayey;
- Erosion slower than for soft sediments, but no recovery:- soft rock shores recede persistently;
- In Tasmania, mainly Tertiary-age sedimentary rocks

Soft rock coasts



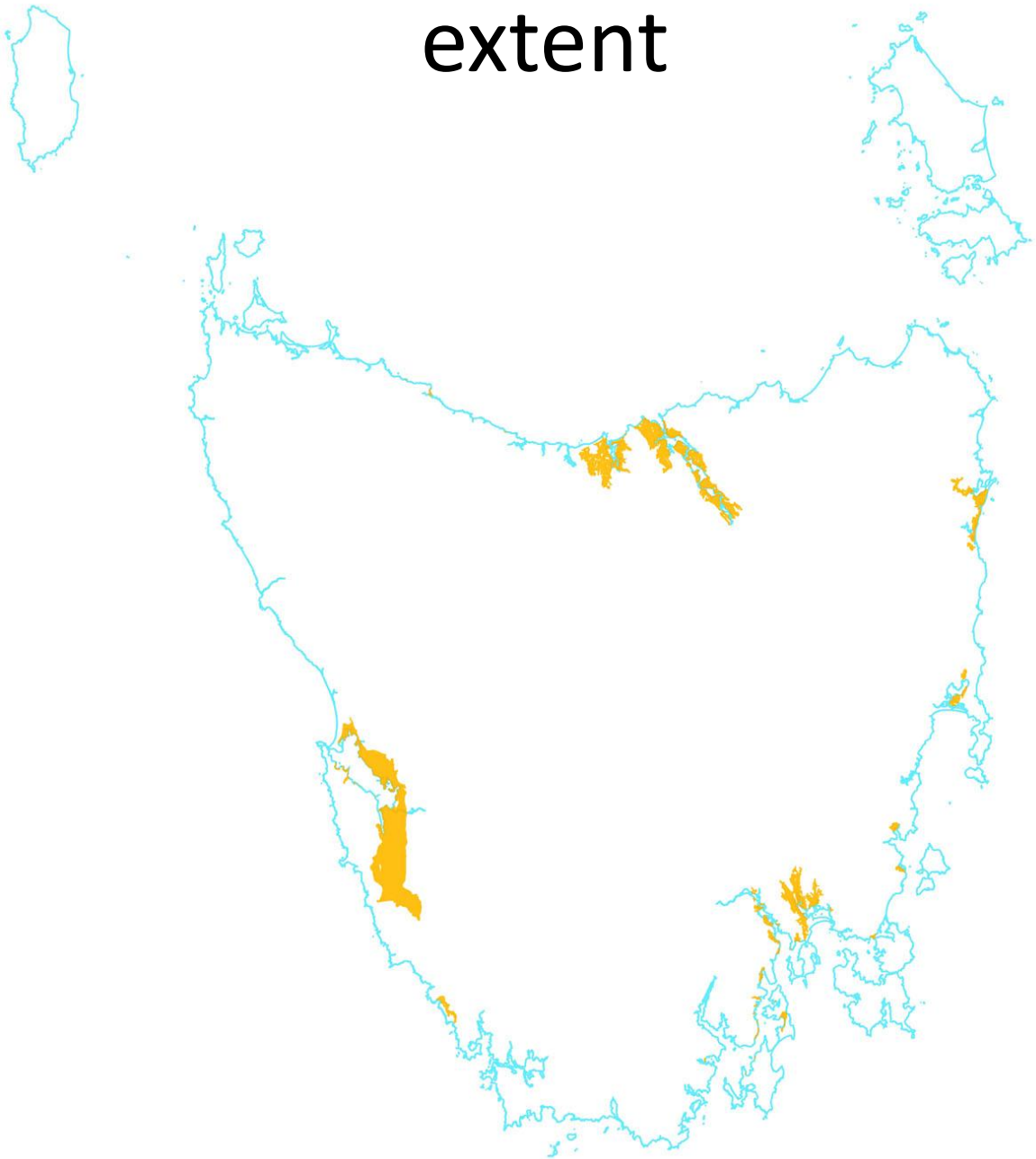
Mapping datasets used:

- Polygon mapping based on Geological Survey mapping (MRT);

plus:

- Soft rock under thin superficial sediments interpreted by C. Sharples & Hannah Walford based on known geological structures and gravity data provided by MRT;
- Interpreted mapping provided as single stand-alone 'soft rock' GIS layer.

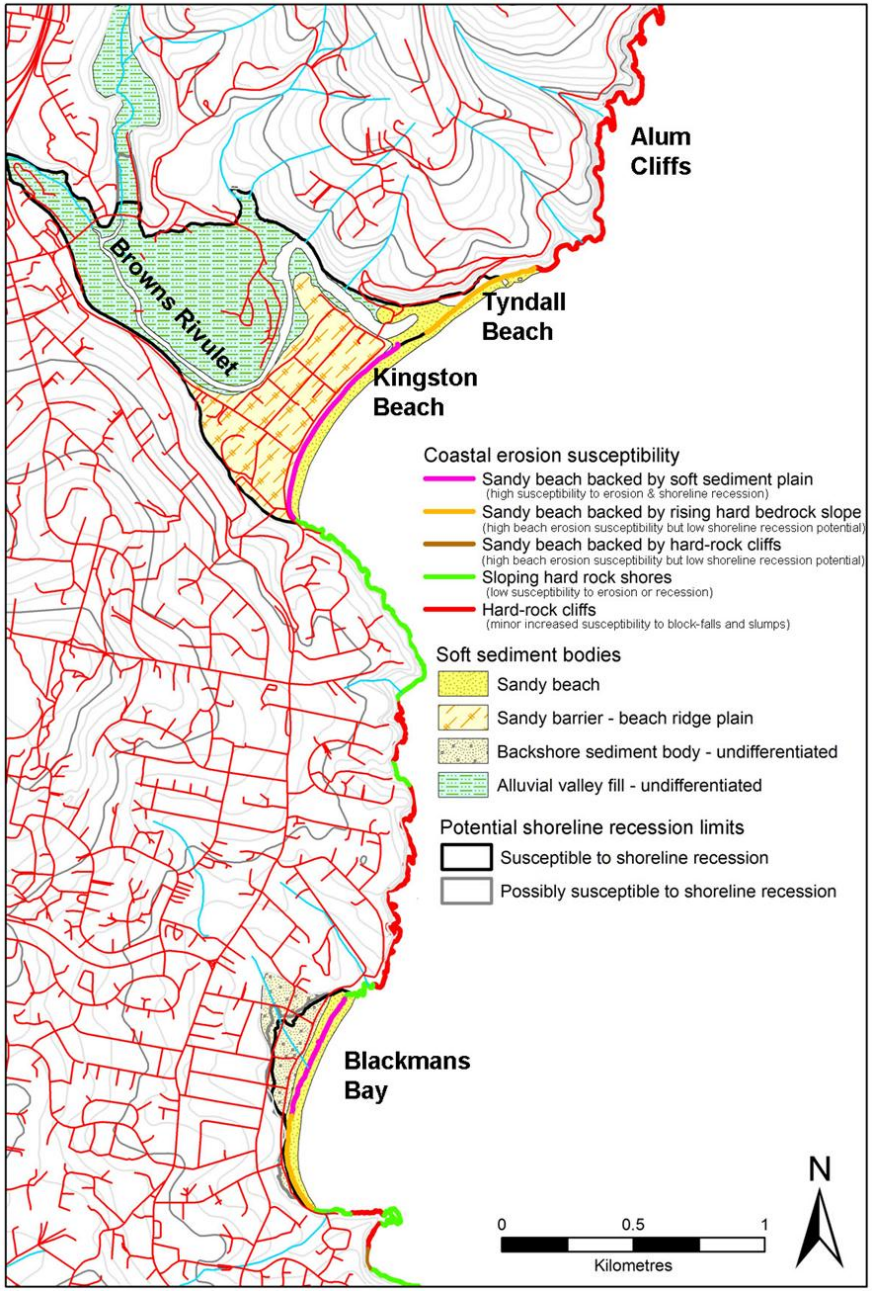
Soft rock coastal mapping – state-wide extent



Hard rock coasts

- Generally the most resilient coastal type – erosion rates mainly negligible on human time scales;
- However hard rock cliffs are more prone to instability (that's why they are cliffs) – may show slumping etc on human time scales

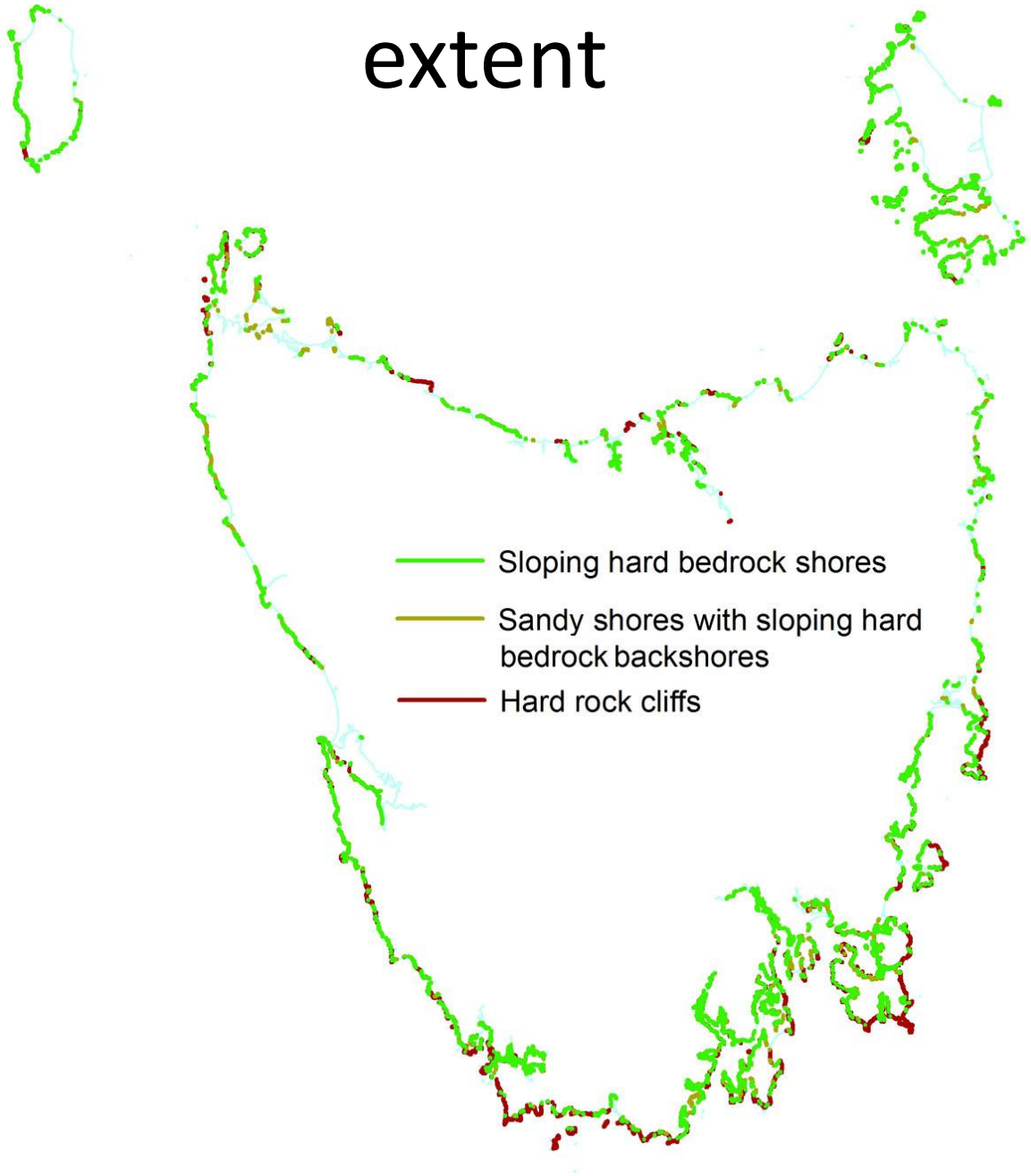
Hard rock coasts



Mapping datasets used:

- Line maps used – landwards extent of substrate not relevant;
- Mapping used: “Smartline” coastal geomorphic line map – includes sloping and cliffed hard rock shores based on geological maps, air photo interpretation and significant ground-truthing by C. Sharples
- State-wide coverage

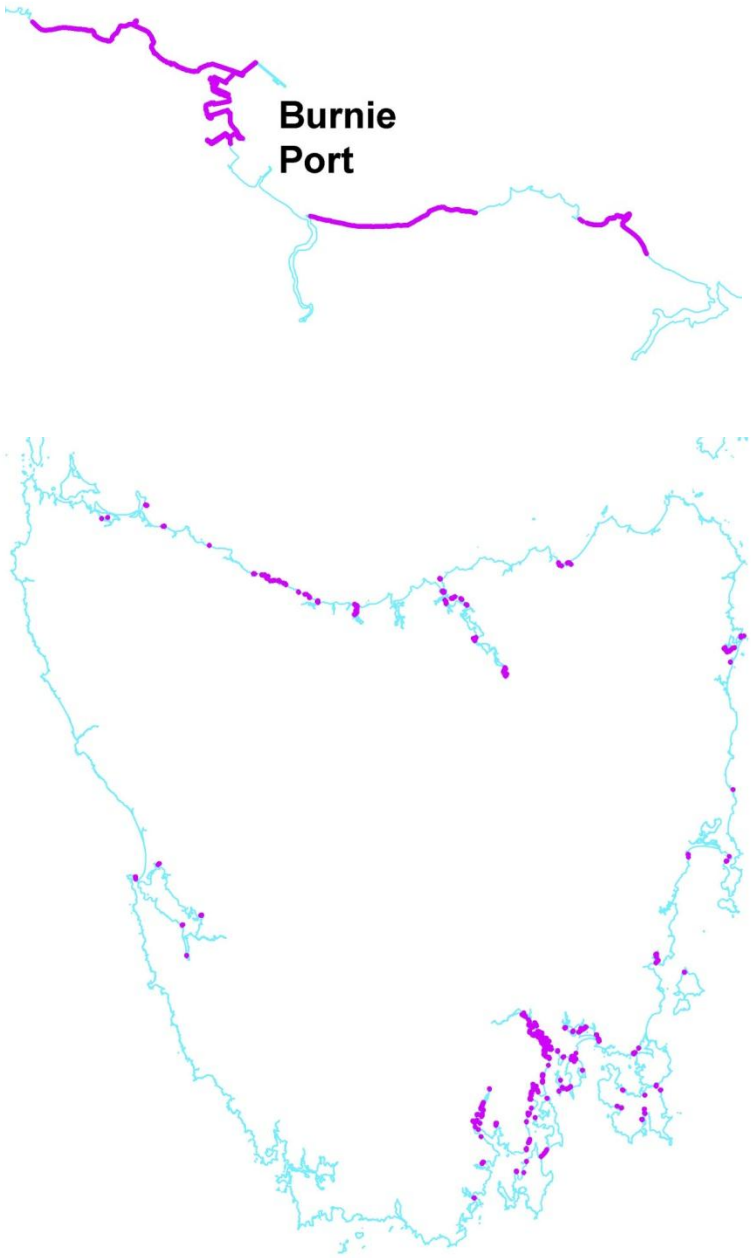
Hard rock coastal mapping – state-wide extent



Artificially protected or modified coasts

- Many are constructed as “quick and dirty” solutions and fail quickly in storms;
- However well-designed and robustly-constructed coastal erosion protection (walls, boulder revetments) may work well;
- Nearly always some ongoing maintenance costs

Artificially protected or modified coasts



Mapping datasets used:

- Line maps used (generally narrow linear features)
- Mapping used: “Smartline” coastal geomorphic line map – includes artificial shores from air photo interp. & some ground mapping;
- Incomplete but no better state-wide dataset

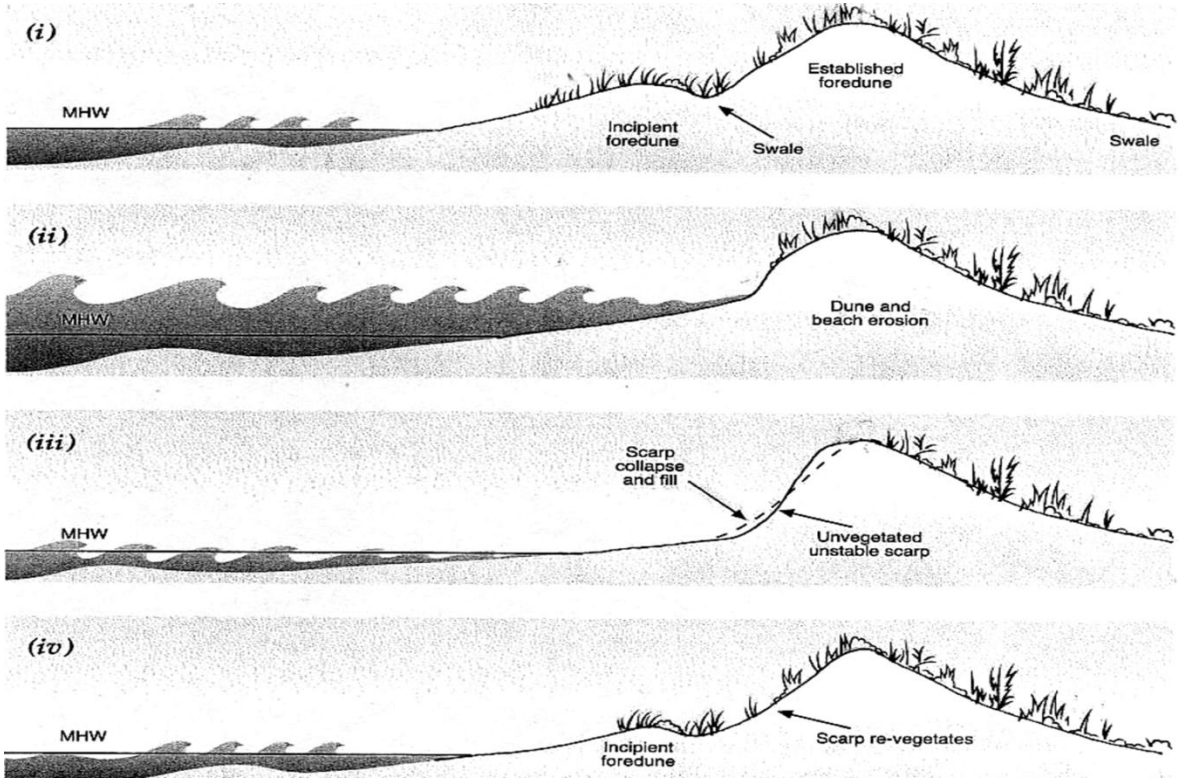
Additional key coastal concepts incorporated into coastal erosion hazard mapping

- Erosion vs. recession
- Natural recession limits
- Swell-exposed vs. sheltered (‘re-entrant’) shores

Erosion vs. Recession

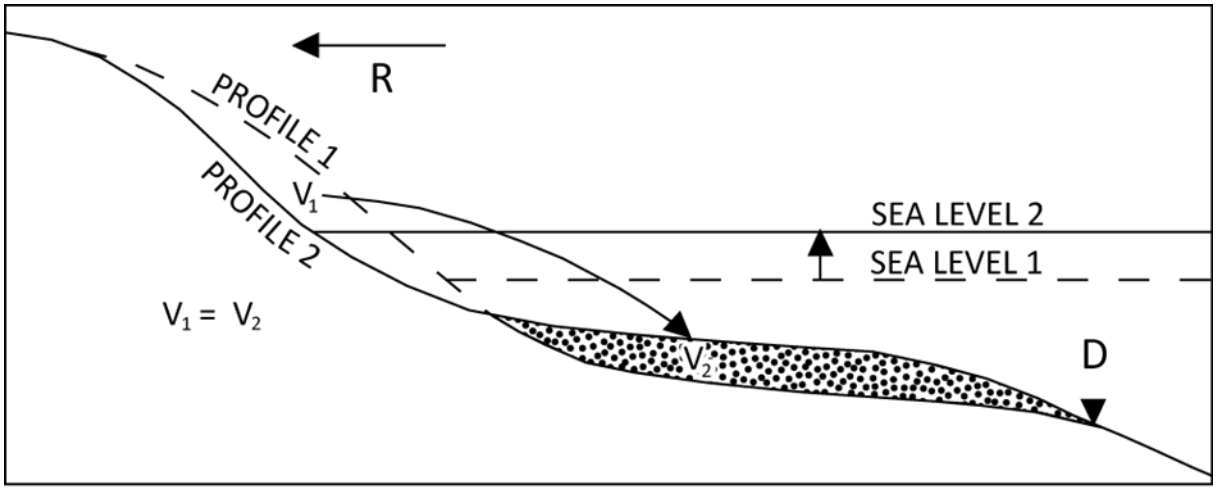
Erosion = episodic storm bites; may be followed by shoreline recovery (esp. on swell-exposed sandy beaches) or else by further erosion leading to long term recession.

Episodic erosion and recovery: the 'cut-and-fill' cycle:



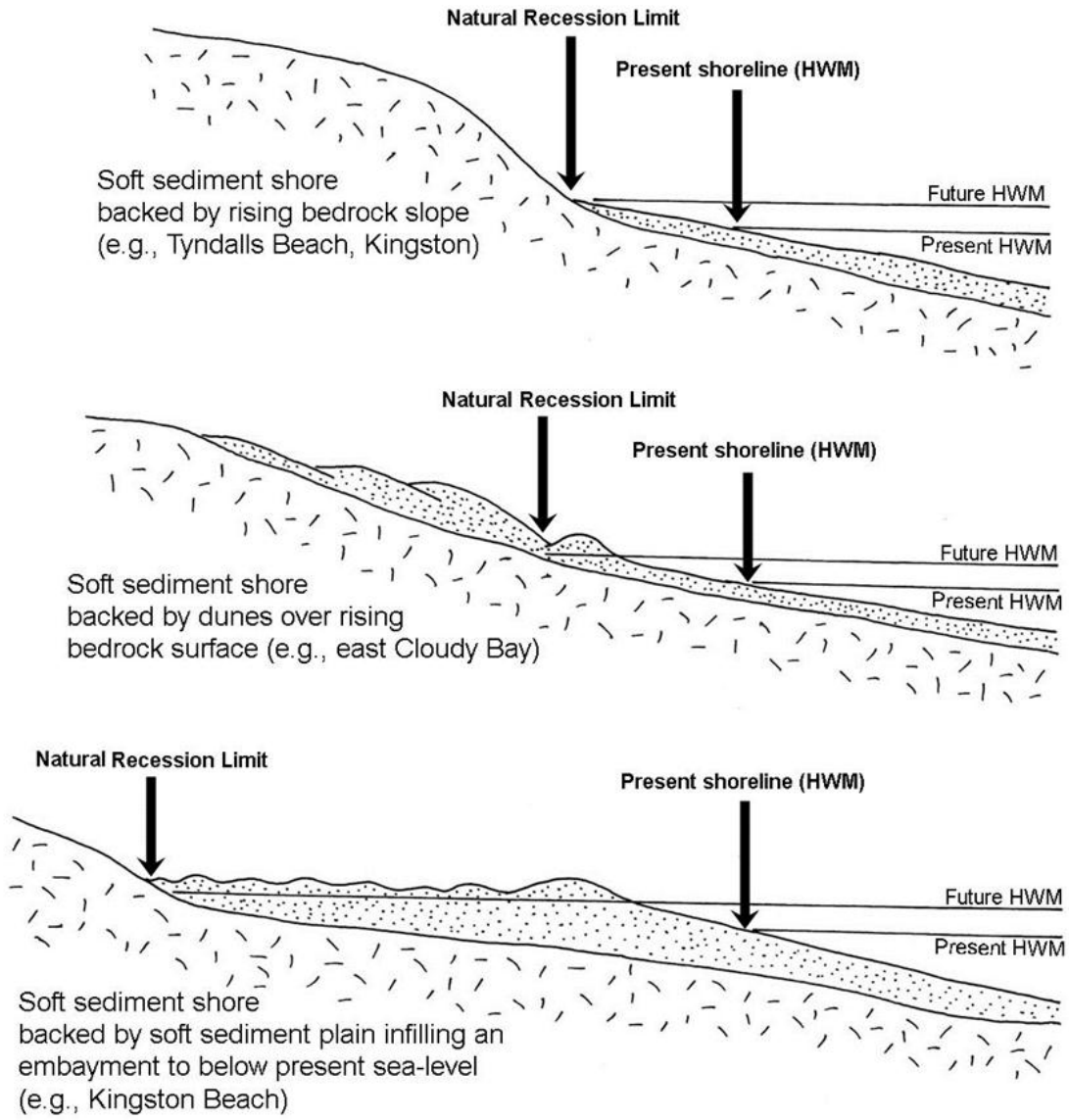
Erosion vs. Recession

- Recession = long term shoreline recession from multiple erosion events
- Shoreline erosion may occur at any time; sandy shorelines may recover, soft rock shores generally recede continuously
- Sea-level rise is expected to increase recession rates on shores already receding, and initiate recession of sandy shores which currently recover after storms.



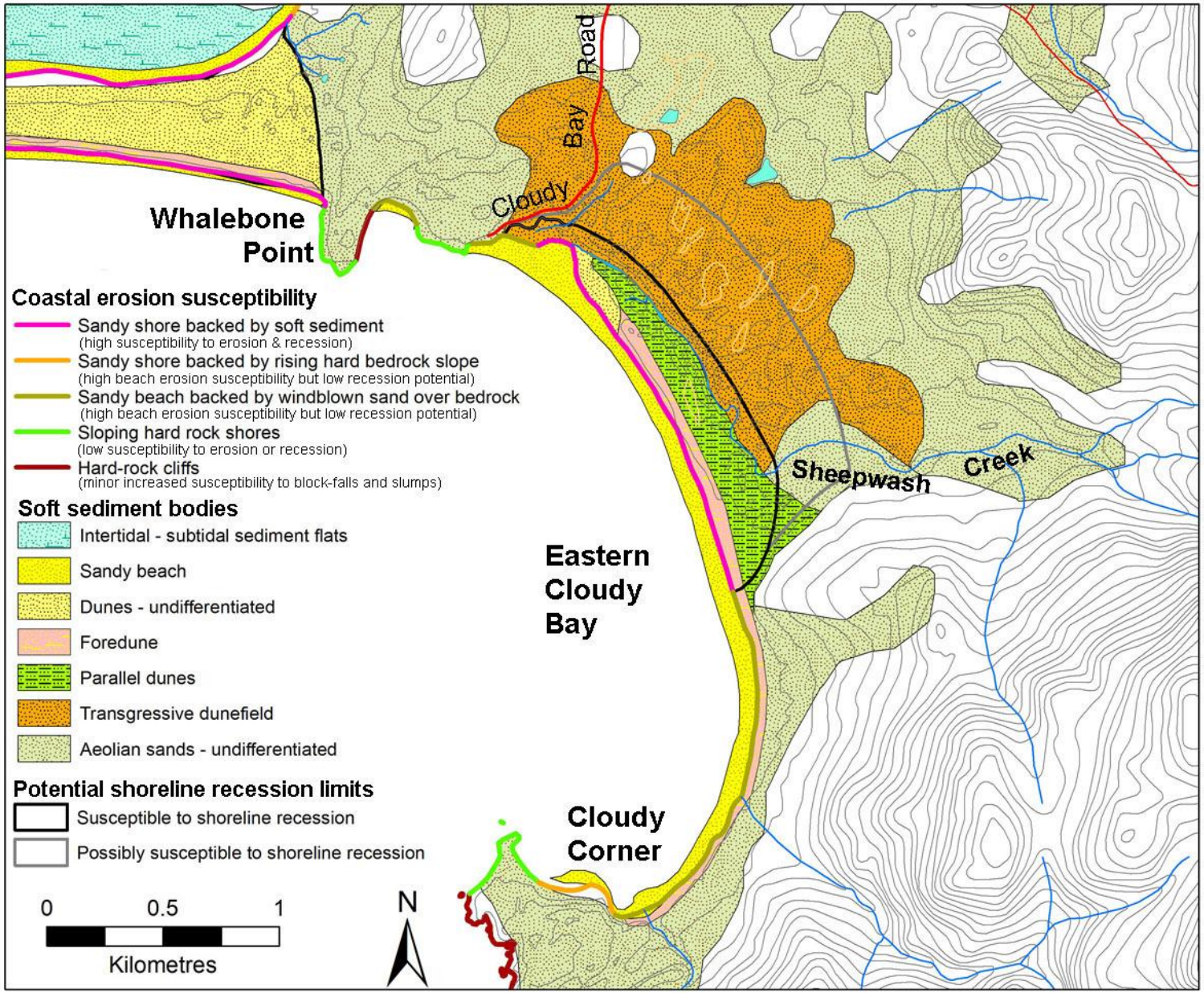
Bruun Rule of shoreline recession with sea-level rise

Natural recession limits



- Relevant to soft-sediment shores only
- Recognises that soft sediment shores will only erode landwards to the point at which underlying bedrock rises above sea-level
- May reduce hazard area in many cases where soft sediment shores have narrow recession limits

Natural Recession Limit mapping – example



Swell-exposed vs. Sheltered re-entrant shores

- Swell-exposed sandy shores may recover from erosion (swell returns sand to beach)
- Swell-sheltered shores unlikely to recover from erosion (no swell to return sand to beach)

Basis for erosion hazard definition for differing coastal substrate types

Four different coastal substrate or type categories:

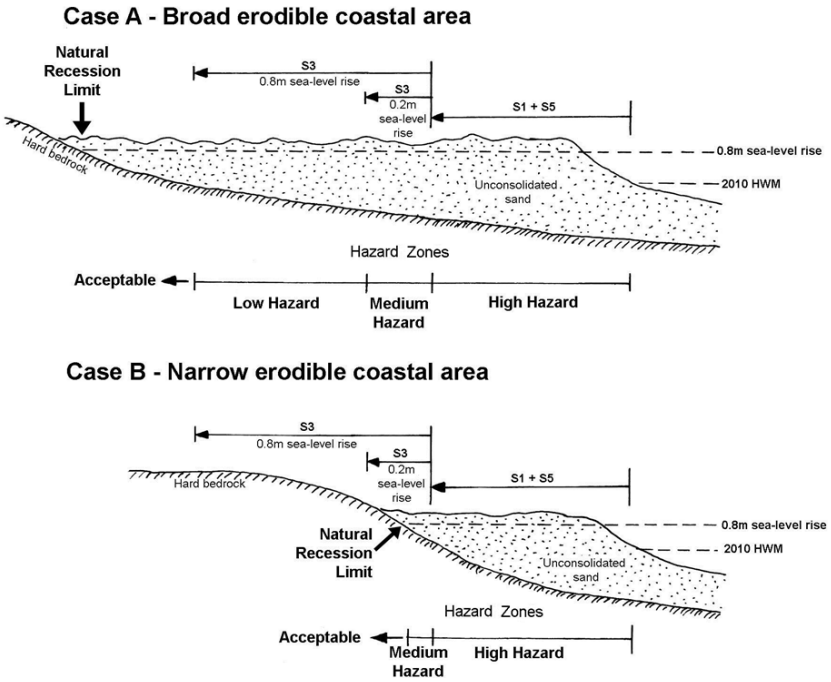
- Soft sediments (especially sandy beaches)
- ‘Soft rock’
- Hard rock
- Artificial shores

For each, four different erosion susceptibility zones defined:

- Near term storm erosion hazard (storm bite & slumping)
- Recession to 2050 (resulting from sea-level rise)
- Recession to 2100 (resulting from sea-level rise)
- Areas not considered susceptible to coastal erosion (to 2100)

Open coast soft sediment shores (mainly swell-exposed sandy beaches) - erosion susceptibility zones

Standard coastal erosion hazard modelling techniques (as used for Clarence, widely used in NSW & Queensland) – Generic hazard zones for Australian coastal regions developed by Water Research Laboratory (UNSW) (Mariani *et al.* 2012)



Near term erosion susceptibility zone:

- Modelled 2 x 1:100 year storm bites for 'generic beach' plus dune instability allowance

Recession to 2050 susceptibility zone:

- Bruun Rule recession modelled to 2050 for 'generic beach'

Recession to 2100 susceptibility zone:

- Bruun Rule recession modelled to 2100 for 'generic beach'

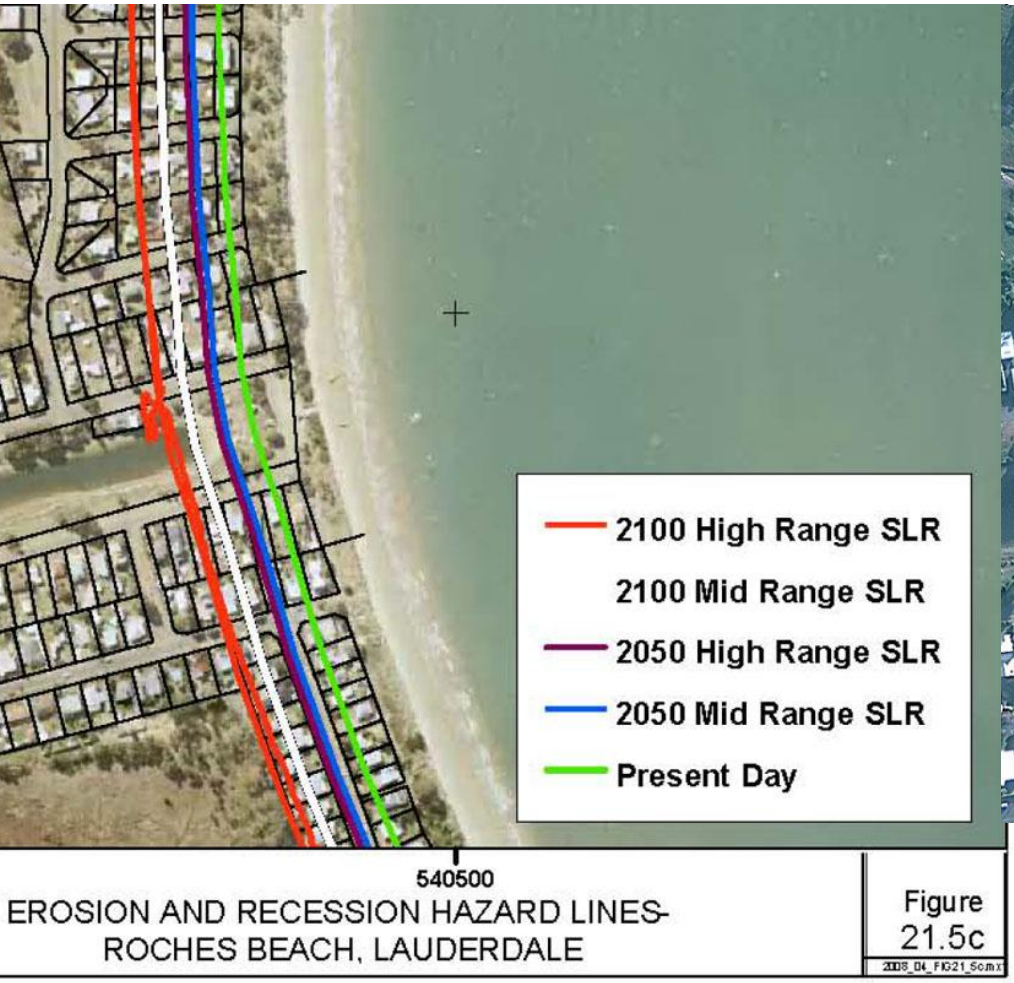
Natural recession limits mapping used to truncate hazard zones to limits of potentially erodible areas.

Open coast soft sediment shores: erosion susceptibility zones

Coastal Region / Erosion susceptibility	Susceptibility zone widths (landwards from High Water Mark) in metres			
	North Tas coast (Region 14): Cape Woolnorth to Cape Portland	East Tas coast (Region 15): Cape Portland to Cape Pillar	Storm Bay, SE Tas coast (Region 15a): Cape Pillar to Southeast Cape	West – South Tas coast (Region 16): Southeast Cape to Cape Woolnorth
Storm bite and consequent reduced foundation stability zone (**S1** + **S5**)	35 m landwards from HWM, or to natural recession limit	48 m landwards from HWM, or to natural recession limit	35 m landwards from HWM, or to natural recession limit	73 m landwards from HWM, or to natural recession limit
Potential shoreline recession to 2050 (**S3** to 2050)	10 m landwards of storm bite hazard zone or to natural recession limit	10 m landwards of storm bite hazard zone or to natural recession limit	10 m landwards of storm bite hazard zone or to natural recession limit	10 m landwards of storm bite hazard zone or to natural recession limit
Potential shoreline recession to 2100 (**S3** to 2100)	40 m landwards of storm bite hazard zone, or to natural recession limit	40 m landwards of storm bite hazard zone, or to natural recession limit	40 m landwards of storm bite hazard zone, or to natural recession limit	40 m landwards of storm bite hazard zone, or to natural recession limit
Unlikely to be susceptible	Landwards of recession to 2100 hazard zone or landwards of natural recession limit	Landwards of recession to 2100 hazard zone or landwards of natural recession limit	Landwards of recession to 2100 hazard zone or landwards of natural recession limit	Landwards of recession to 2100 hazard zone or landwards of natural recession limit

Generic vs. site-specific modelled erosion setbacks: Roches Beach, Clarence

Site-specific setback modelling (2008)



Generic setback modelling (2013)

Swell-sheltered soft sediment shores (sandy and muddy shores)

Five Mile Beach, Pittwater, Tas: Swell-sheltered sandy beach eroding intermittently but without recovery – thus progressively receding

- Open coast hazard modelling techniques not applicable, no widely accepted methods have been developed for swell-sheltered coasts
- We use existing observed storm bite & recession data for Tas (limited)
- Plus x 2 allowance for larger storms than observed (e.g., 1:100 year storm event erosion) + sea-level rise effects

Swell-sheltered soft sediment shores – basis for erosion susceptibility zones

Near term erosion susceptibility zone:

- Maximum observed storm bites plus dune instability allowance

Recession to 2050 susceptibility zone:

- Maximum observed (historic) recession rates extrapolated to 2050 x 2 conservative allowance for acceleration with sea-level

Recession to 2100 susceptibility zone:

- Maximum observed (historic) recession rates extrapolated to 2100 x 2 conservative allowance for acceleration with sea-level

Natural recession limits mapping used to truncate hazard zones to limits of potentially erodible areas.

Swell-sheltered soft sediment shores (sandy and muddy shores)

Erosion susceptibility	Susceptibility zone width (metres)	Rationale
Storm bite and consequent reduced foundation stability zone	22 m landwards from HWM, or to natural recession limit	Potential short term erosion hazard = 12 m (max. recorded sheltered sandy shore storm bite for Tasmania, at Five Mile Beach – see Table 5) + 10 m reduced stability zone (Mariani *et al.* 2012).
Potential shoreline recession to 2050	27 m landwards of storm bite hazard zone or to natural recession limit (i.e., to 49 m landwards of HWM or to natural recession limit)	Potential additional hazard to 2050 relative to 2010 = 0.34 m/yr. (maximum recorded long term sheltered soft sediment shore annual recession rate for Tasmania - Table 6) x 2 (allowance for acceleration of recession with ongoing sea-level rise) x 40 years (2010-2050).
Potential shoreline recession to 2100	61 m landwards of storm bite hazard zone or to natural recession limit (i.e., to 83 m landwards of HWM or to natural recession limit)	Potential additional recession hazard to 2100 relative to 2010 = 0.34 m/yr. (maximum recorded long term sheltered soft sediment shore annual recession rate for Tasmania - Table 6) x 2 (allowance for acceleration of recession with ongoing sea-level rise) x 90 years (2010-2100).
Unlikely to be susceptible	Landwards of recession to 2100 hazard zone or landwards of natural recession limit	Areas deemed to have negligible hazard of coastal erosion or recession before 2100.

Soft rock coasts

- We use existing (historic) observed soft rock shore recession data (limited)
- And x 2 allowance for acceleration with sea-level rise (Trenhaile 2011)

- Different allowance for ‘self-armouring’ boulder clay shores (rare)

Soft rock coasts – basis for erosion susceptibility zones

Near term erosion susceptibility zone:

- Maximum observed (historic) recession rates extrapolated to 2030 x 2 conservative allowance for acceleration with sea-level

Recession to 2050 susceptibility zone:

- Maximum observed (historic) recession rates extrapolated to 2050 x 2 conservative allowance for acceleration with sea-level

Recession to 2100 susceptibility zone:

- Maximum observed (historic) recession rates extrapolated to 2100 x 2 conservative allowance for acceleration with sea-level

Soft rock coasts

Erosion susceptibility	**Dominantly cohesive clayey soft rock shore types** [susceptibility zone widths & rationales]	**Very coarse boulder clays ('self-armouring' shores)** [susceptibility zone widths & rationales]
Potential near-term recession (to 2030)	To 14 metres landwards of HWM or to full landwards extent of soft rock, whichever is less. [Maximum recorded historic recession rate of 0.35 metres per year for Tasmanian soft rock shores x 2 allowance (Trenhaile 2011) for acceleration with sea-level rise to 2030 compared to 2010]	n/a [Not considered to have significant near-term erosion susceptibility.]
Potential recession to 2050	To 28 metres landwards of HWM or to full landwards extent of soft rock, whichever is less. [Maximum recorded historic recession rate of 0.35 metres per year for Tasmanian soft rock shores x 2 allowance (Trenhaile 2011) for acceleration with sea-level rise to 2050 compared to 2010.]	n/a [Not considered to have significant erosion susceptibility to 2050.]
Potential recession to 2100	To 63 metres landwards of HWM or to full landwards extent of soft rock, whichever is less. [Maximum recorded historic recession rate of 0.35 metres per year for Tasmanian soft rock shores x 2 allowance (Trenhaile 2011) for acceleration with sea-level rise to 2100 compared to 2010]	To 20 metres landwards of HWM or to full landwards extent of very coarse boulder clays, whichever is less. [**Arbitrary** low hazard zone for 'self-armouring' boulder clays (allowance for some settling and minor slumping during 'self-armouring' process in response to longer – term sea-level rise to 2100).]
Unlikely to be susceptible	Soft rock areas over 63 metres landwards of HWM, or areas beyond mapped landwards extent of soft rock. [Areas beyond maximum mapped soft rock extent OR soft rock areas landwards of areas potentially susceptible to recession to 2100 band.]	Beyond 20 metres landwards of HWM or beyond full landwards extent of very coarse boulder clays, whichever is less. [Based on assumption that self-armouring-process under credible sea-level rise scenarios will limit zone of settling related to wave-winnowing of clay matrix to less that arbitrarily-defined 20m landwards of HWM to 2100.]

Hard rock coasts

Three groups recognised for susceptibility assessment:

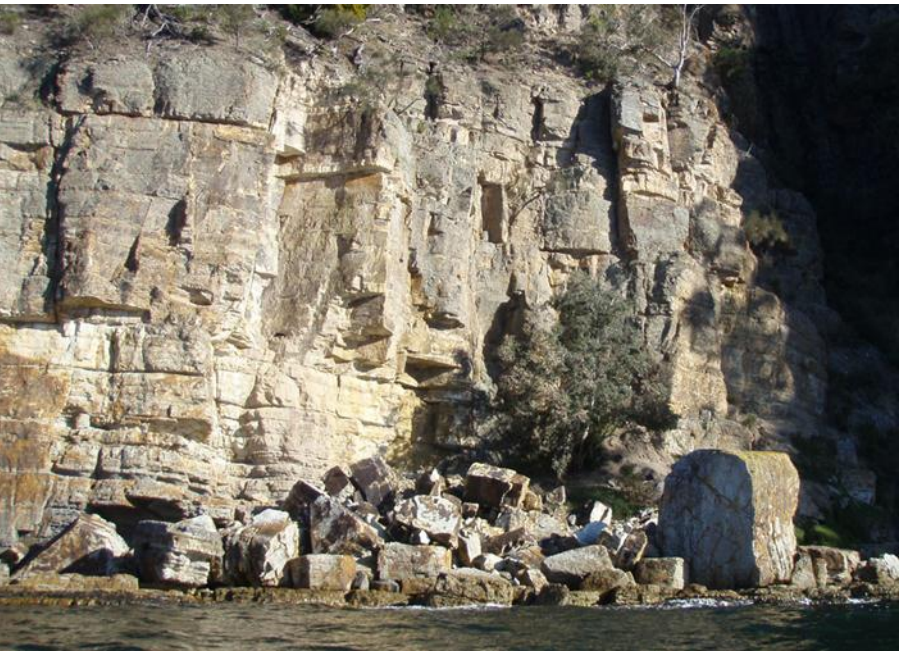
- Gently to moderately sloping hard rock shores and backshores
- Soft sediment shores backed by bedrock above sea-level with some soft sediment over bedrock
- Steeply sloping and cliffed hard rock shores

Hard rock coasts

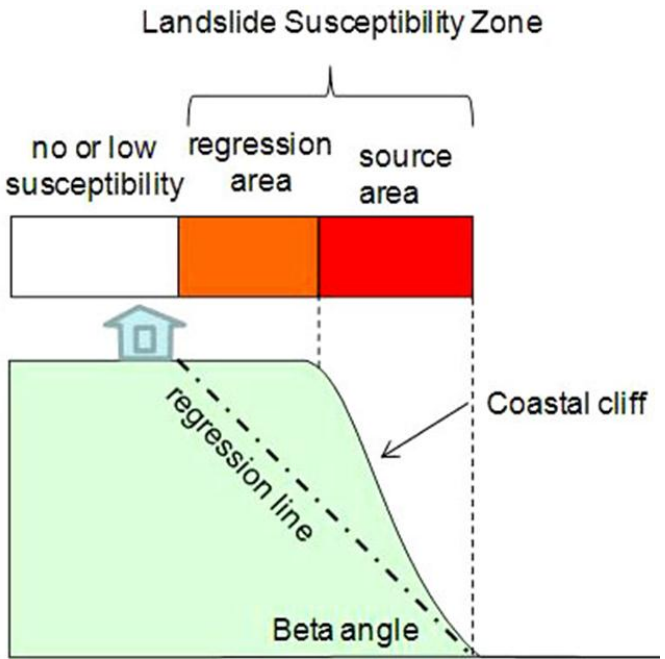
Gently to moderately sloping hard rock shores – unlikely to be susceptible to erosion

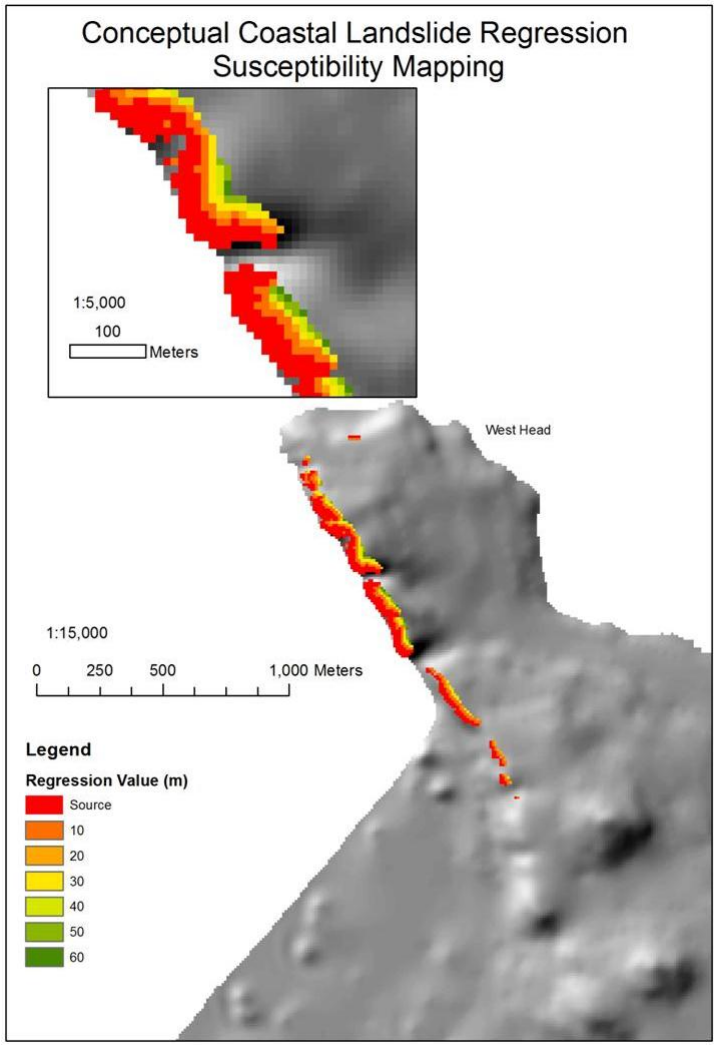
Soft sediment shores backed by bedrock above sea level with soft sediments over backshore bedrock – some erosion potential but unlikely to recede significantly

Hard rock cliffs



Cliff regression modelling based on potential recession by slumping (modelling by Colin Mazengarb, Mineral Resources Tasmania)





Hard rock coasts – basis for erosion susceptibility zones

Sloping hard rock shores:

- All considered ‘acceptable’ (no significant hazard)

Sandy beaches & dunes with bedrock backshores:

- Short-term storm bite susceptibility as for any sandy shore on same coast; but no longer term recession susceptibility

Hard rock cliff:

- Recession (slumping) hazards as modelled assuming 45° slump angle

Hard rock coasts

	Susceptibility zone widths (m) [and rationales]		
Erosion susceptibility / **Hard rock shore category**	**Gently to moderately sloping 'pure' hard rock shores**	**Sandy or soft sediment shores immediately backed by sloping hard bedrock above sea-level**	**Steep to cliffed hard bedrock shores**
Storm bite and consequent reduced foundation stability zone	n/a	If swell-exposed: storm bite & reduced stability (S1 + S5) allowance as for sandy shores in same coastal region (Table 3); If swell-sheltered: 22m landwards of HWM as for swell-sheltered sandy shores (Table 4).	Zoning basis to be resolved
Potential shoreline recession to 2050	n/a	n/a	Zoning basis to be resolved
Potential shoreline recession to 2100	n/a	n/a	Zoning basis to be resolved
Unlikely to be susceptible	All areas from HWM landwards. [erosion hazards with and without sea-level rise probably negligible over human time frames]	All areas landwards of storm bite and consequent reduced foundation stability zone [erosion bites comparable to other sandy shores may occur in dune sands over bedrock behind HWM, but recession unlikely due to rising hard bedrock under dunes]	Zoning basis to be resolved

Artificially protected or modified coasts: basis of erosion susceptibility zones

If artificial shores considered resilient:

- All considered ‘acceptable’ (no significant hazard)

If artificial shores *not* considered resilient:

- Zoned as per natural substrate type without protection

Artificially protected or modified coasts

	Susceptibility zone widths (m) [and rationales]	
Erosion susceptibility / **Artificial shoreline type**	**Resilient artificial shore** (life >10 years) [shores considered as resilient to the distance the shore would otherwise have been zoned susceptible]	**Not resilient artificial shoreline** (life <10 years) or **Unknown quality artificial shores** [treated as per natural substrate category, i.e., as if artificial shoreline absent]
Storm bite and consequent reduced foundation stability zone	Resilient (to the distance the (originally non-protected) shore would otherwise have been zoned susceptible)	As expected for backing substrate without protection
Potential shoreline recession to 2050	Resilient (to the distance the (originally non-protected) shore would otherwise have been zoned susceptible)	As expected for backing substrate without protection
Potential shoreline recession to 2100	Resilient (to the distance the (originally non-protected) shore would otherwise have been zoned susceptible)	As expected for backing substrate without protection
Unlikely to be susceptible	From distance expected for backing substrate without artificial protection	As expected for backing substrate without protection

Thank you