Painkalac Creek Entrance Processes

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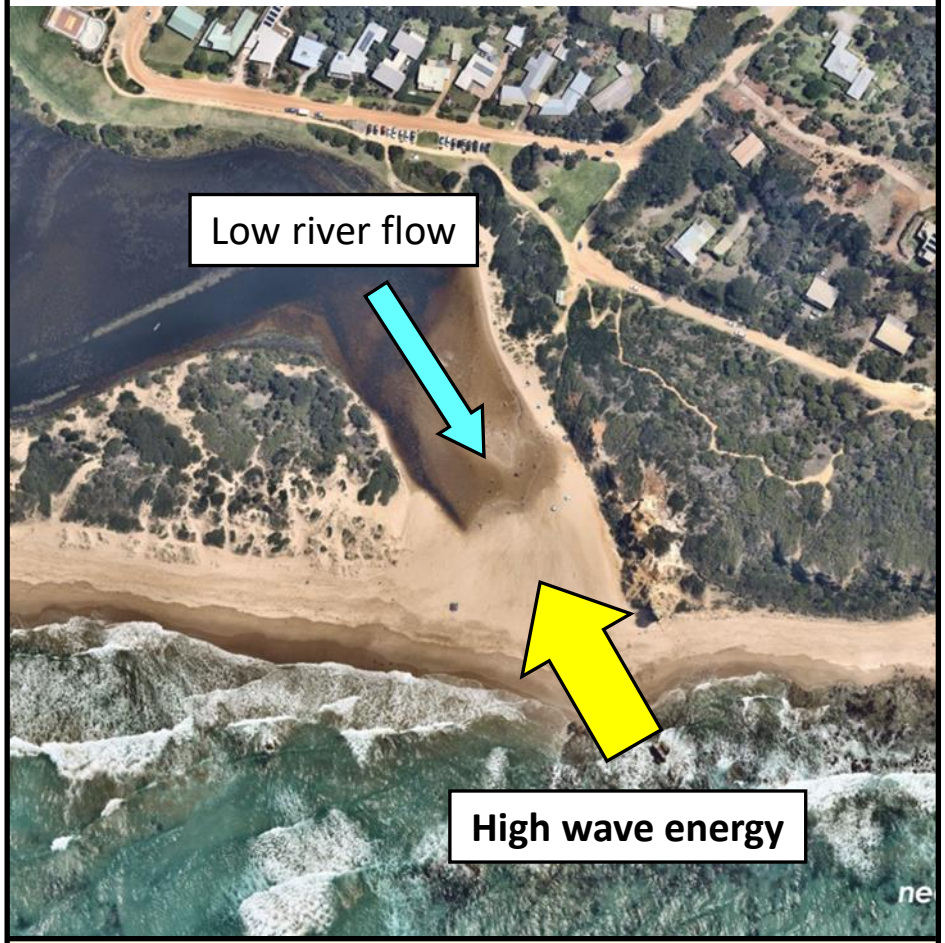
Intermittently Open/Closed Estuaries (IOCEs)

Estuaries which periodically close by formation of a berm (sand bar) at the mouth.

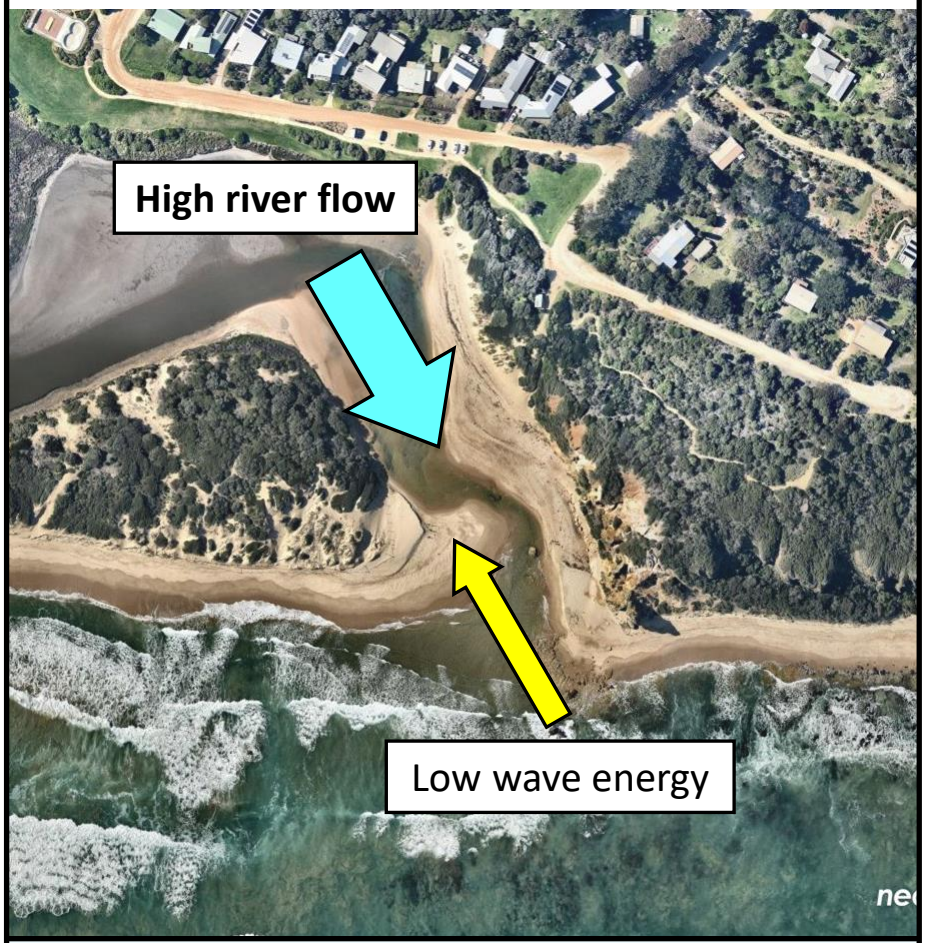
Photos: EstuaryWatch

(a) Closed mouth



- **Wave energy** > river energy
- Net **onshore** sediment transport
- Waves can overwash at high tide.

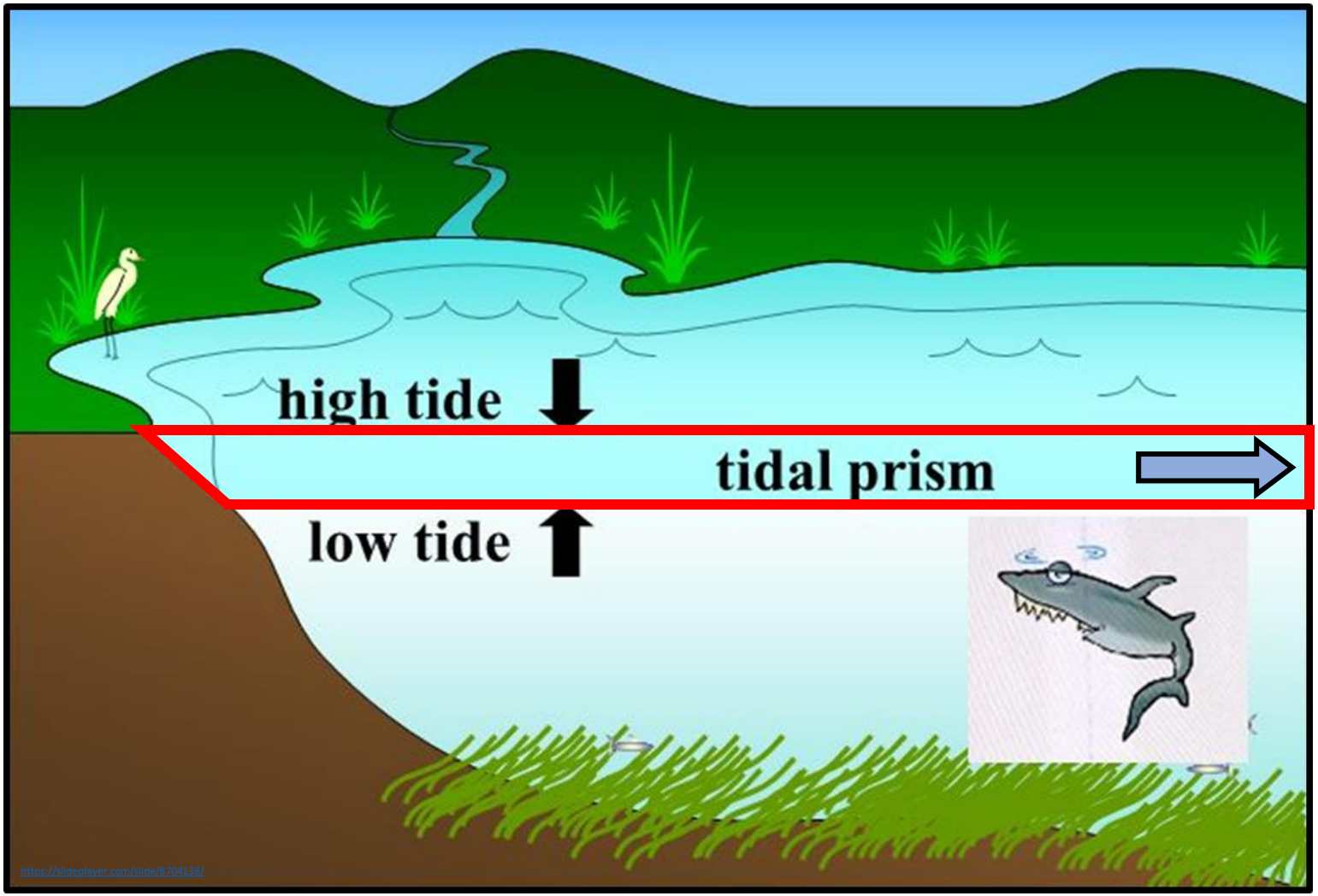
(b) Open mouth



- **River energy** > wave energy
- Net **offshore** sediment transport
- Ebb tidal currents at mouth.

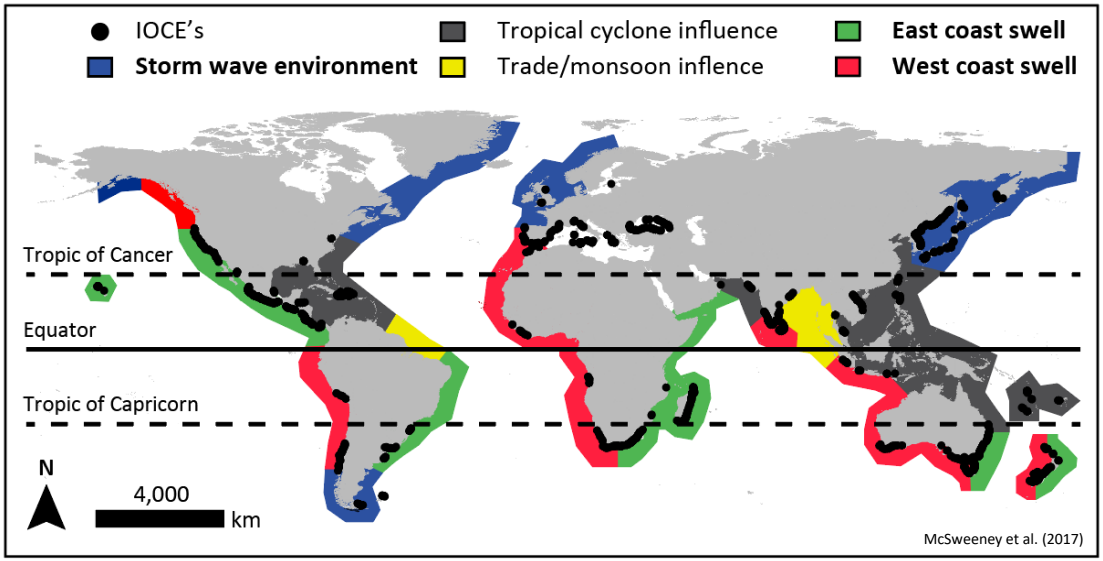
Tidal prism: the volume of water exchanged over a tidal cycle

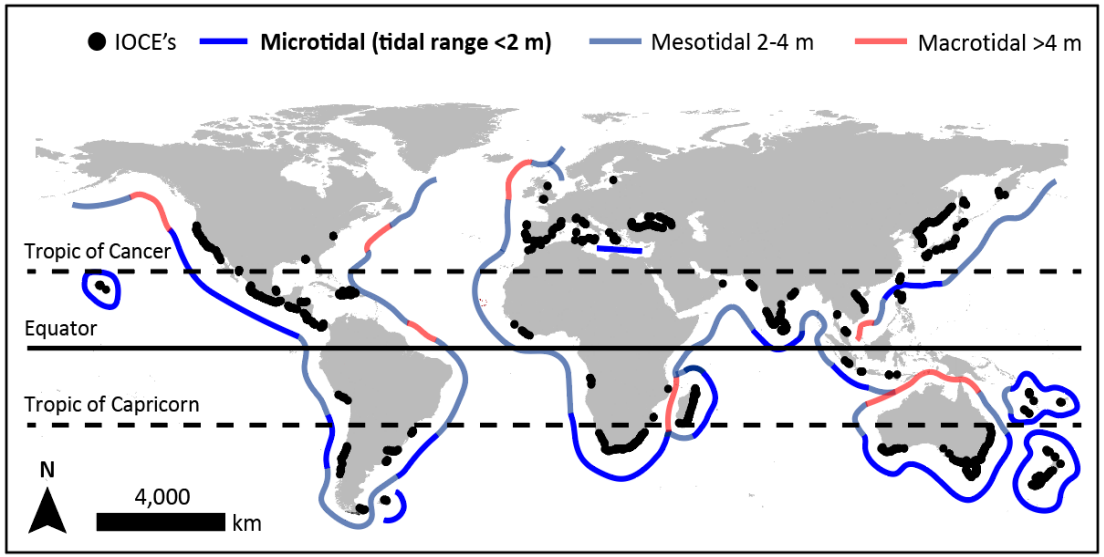
Ebb-tidal prism: tidal prism + outgoing river flow.



Why do some estuaries close?

1. **High wave energy:** enables a berm to form and persist
2. **Small tidal range:** weak tidal currents at the entrance
3. **Variable river flow:** periods of low flow
4. **Temperate or semi arid climates:** where rainfall varies both seasonally and/or interannually.

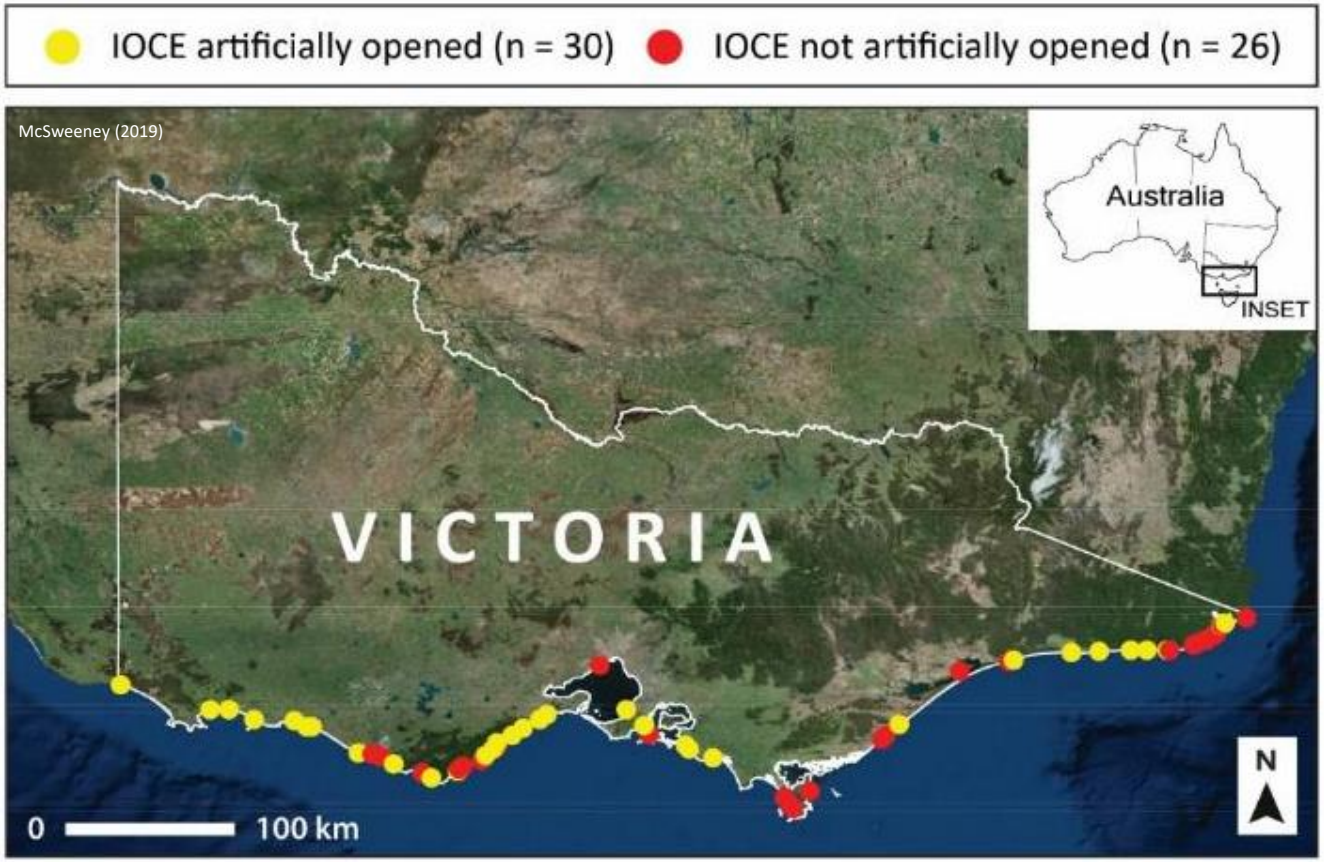




Top: IOCE distribution vs wave climate. **Bottom:** Distribution vs tidal range.

IOCEs in Victoria

- >90% of open coast estuaries close (n = 56)
- High wave energy, a low tidal range, and variable river flows (temperate coastal climate).



1. Small, tidal creeks

e.g. Otways creeks

Kennett River (photo: EstuaryWatch)

- Drain very short and steep river catchments
- Sensitive to variability in rainfall (and river flow)
- Open for most of the time apart from in droughts
- **Close for days to weeks**
- **Small basins/tidal prisms.**

2. Intermediate systems

e.g. Painkalac Creek

- Most common in Victoria
- Open a few times a year on average in natural state
- Remain open for days to months (more variable)
- **Close for weeks-months**
- **Basin/prism size varies with degree of infilling.**

3. Big, tidally influenced

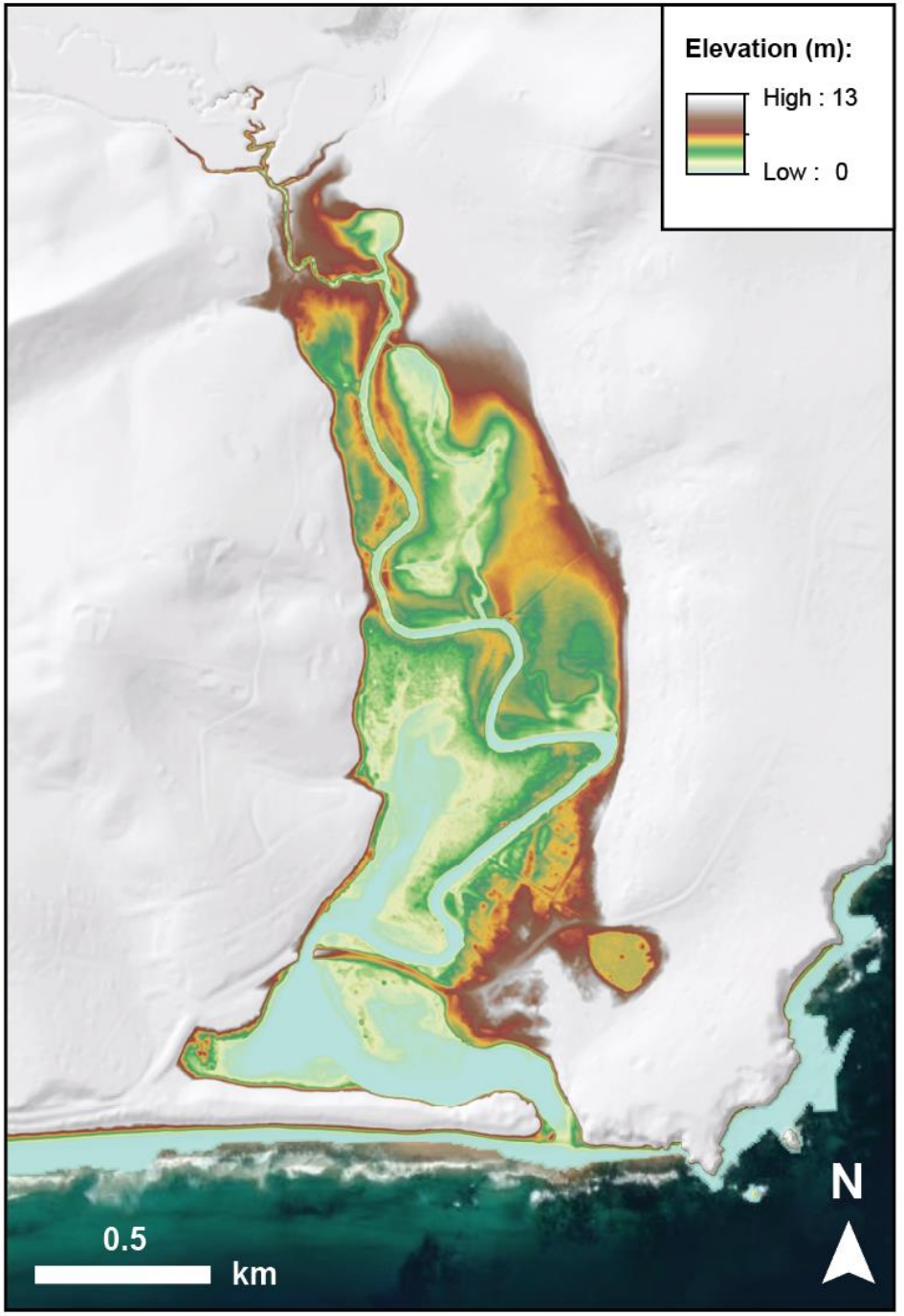
e.g. Curdies Inlet

- Larger catchments/rivers
- Usually tidal when open
- Open 1-2 times a year on average in natural state
- Remain open for months to years on average
- **Close for months-years**
- **Big basins/tidal prisms.**

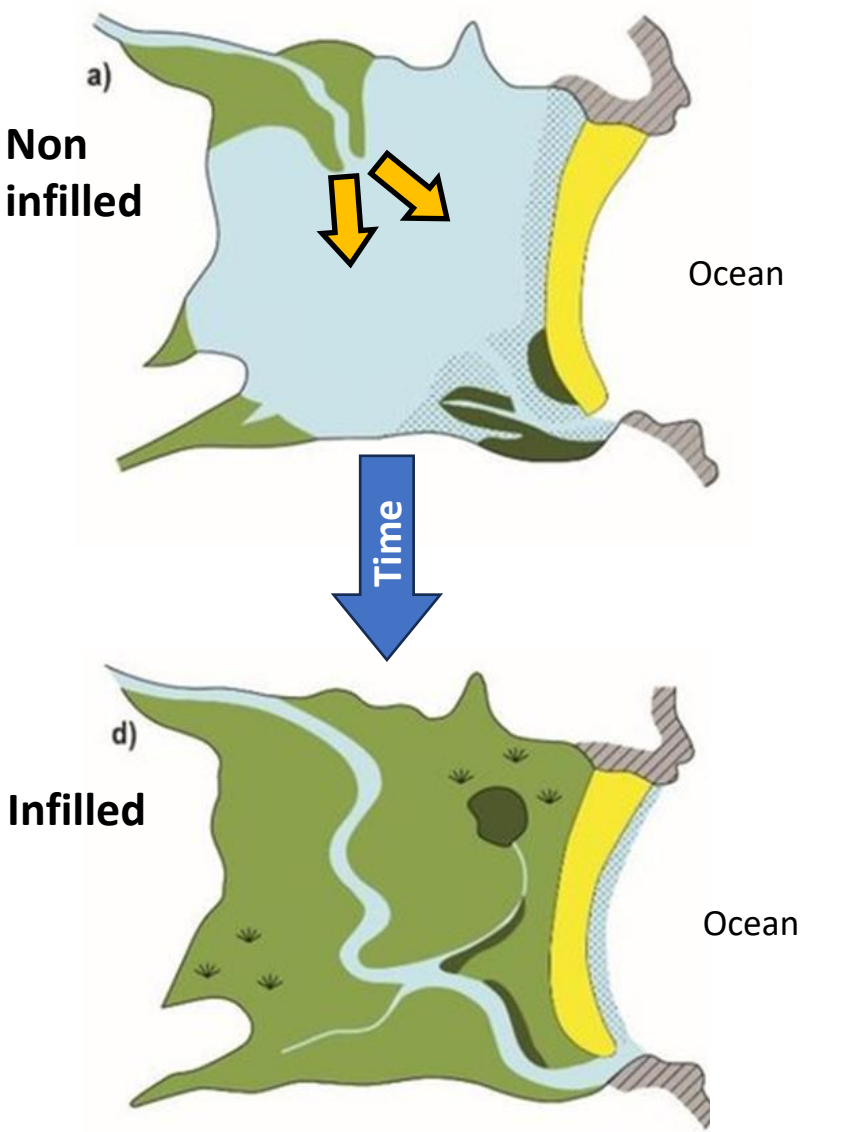
Increasing closure duration →

Increasing basin size →

Painkalac Creek

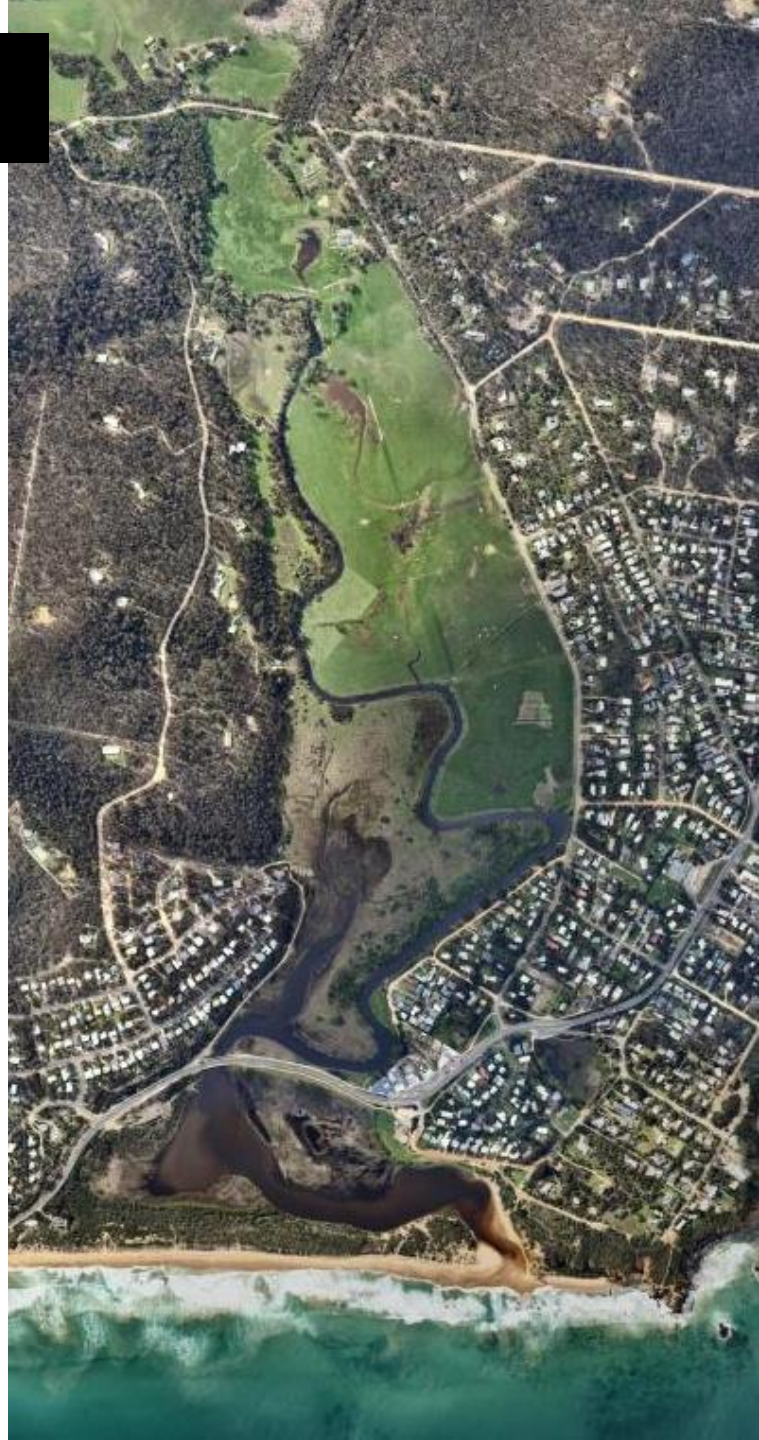



Painkalac Creek
0.5
km
N


a)
Non infilled
Ocean
Time
d)
Infilled
Ocean
Sandy barrier
Open water
Floodplain

Why does it close so quickly?

1. Small river + high wave energy
2. Openings don’t always scour a big channel so it fills in quickly
3. Basin is very infilled and so the estuary has a small tidal prism
4. Means that ebb-tidal currents don’t erode much sediment offshore at the mouth.

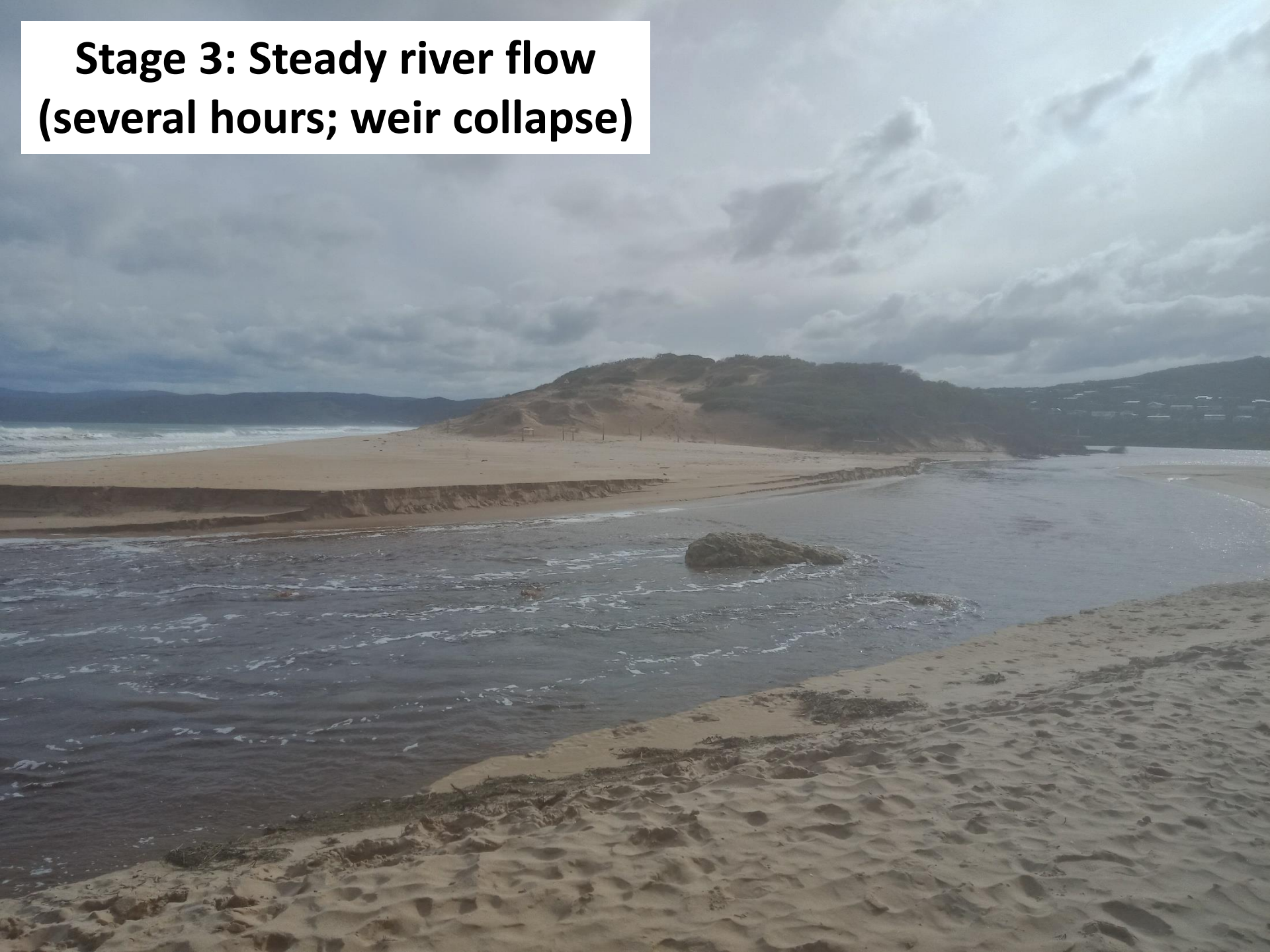


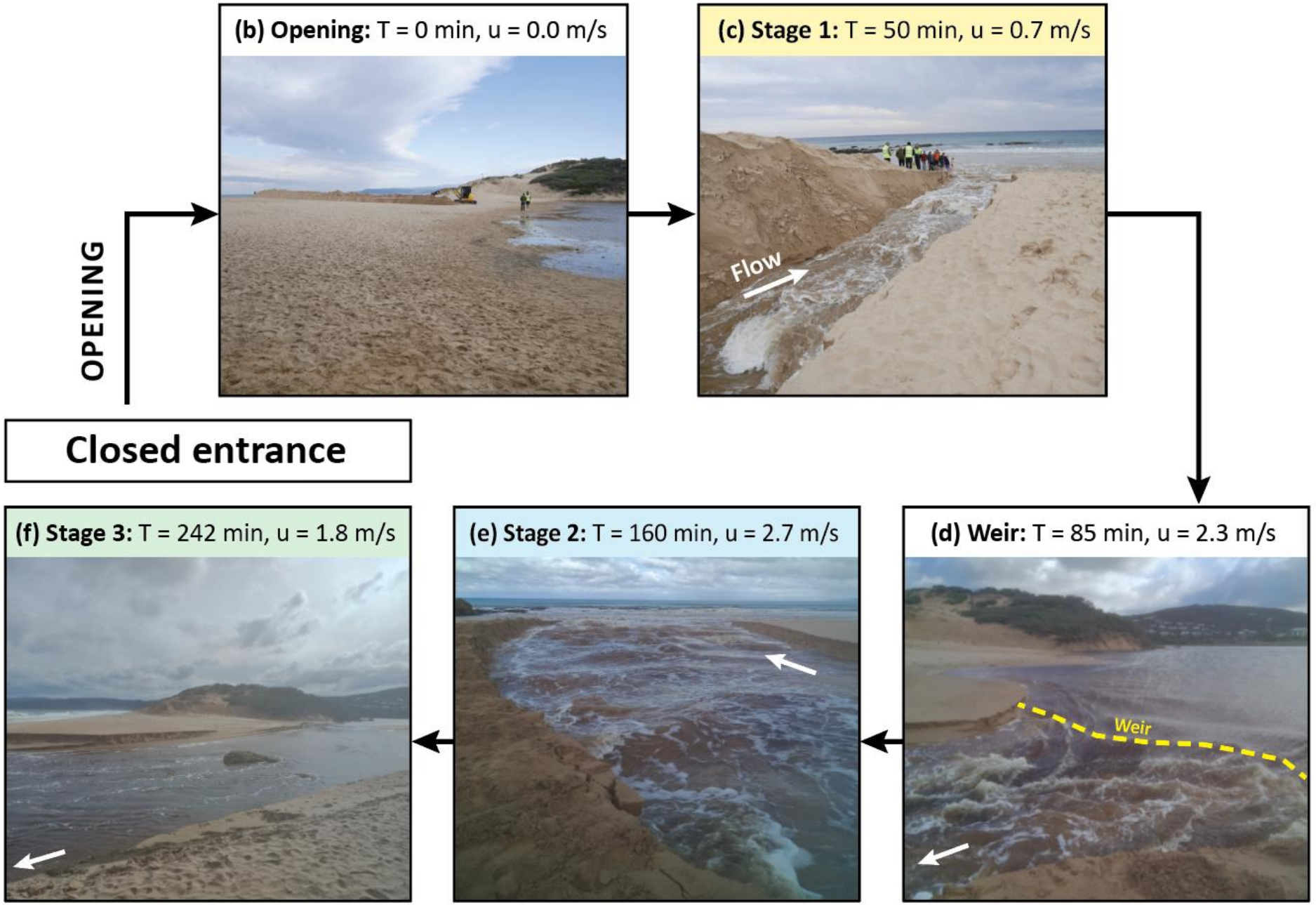
What happens during successful openings?

Stage 1: Pilot channel (30 min - few hours)

Formation of a weir: standing waves, fast flow, energy slope


Stage 2: Supercritical flow
(several hours)


Stage 3: Steady river flow
(several hours; weir collapse)



McSweeney and Stout (2022)

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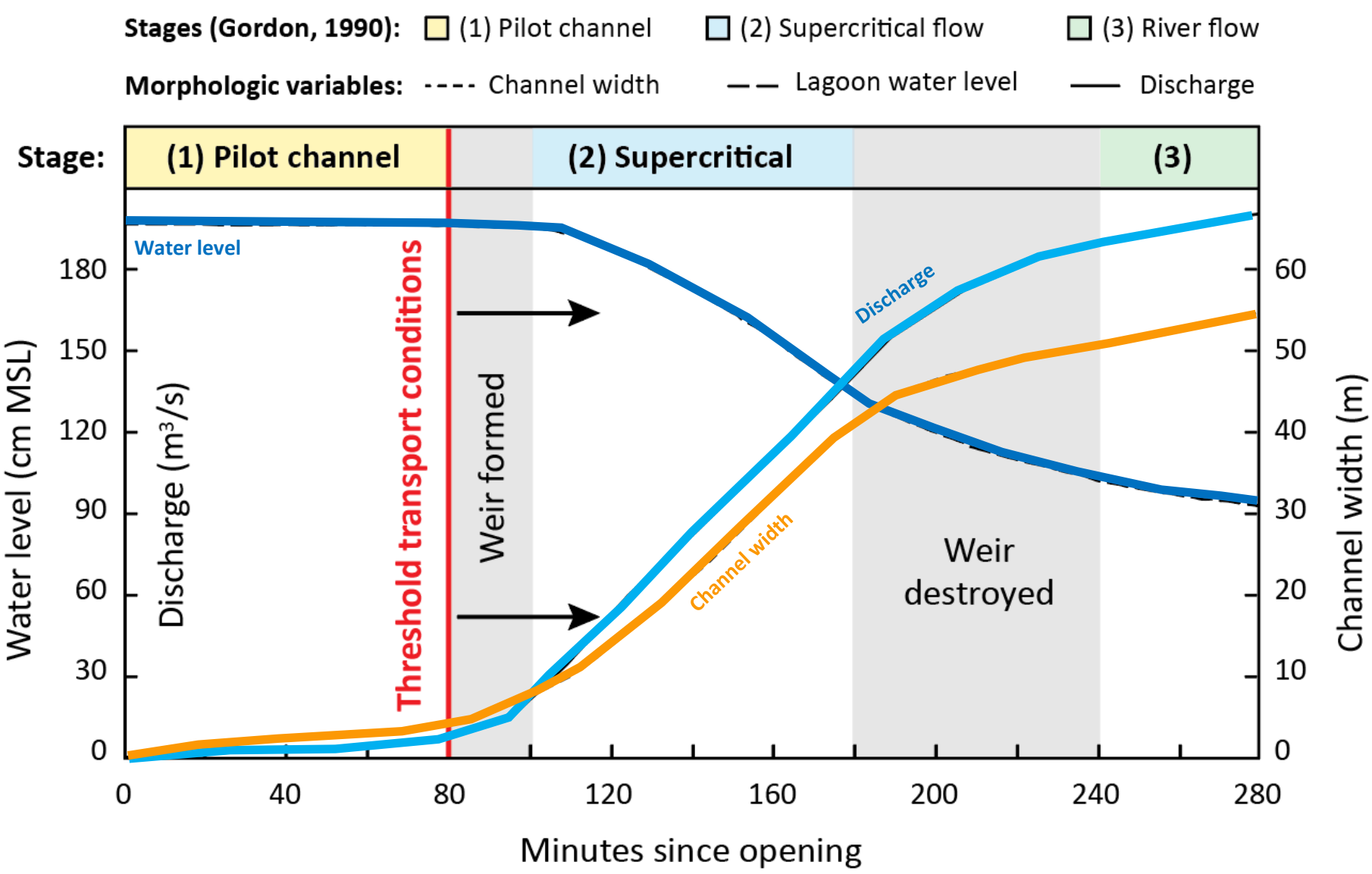


McSweeney and Stout (2022)

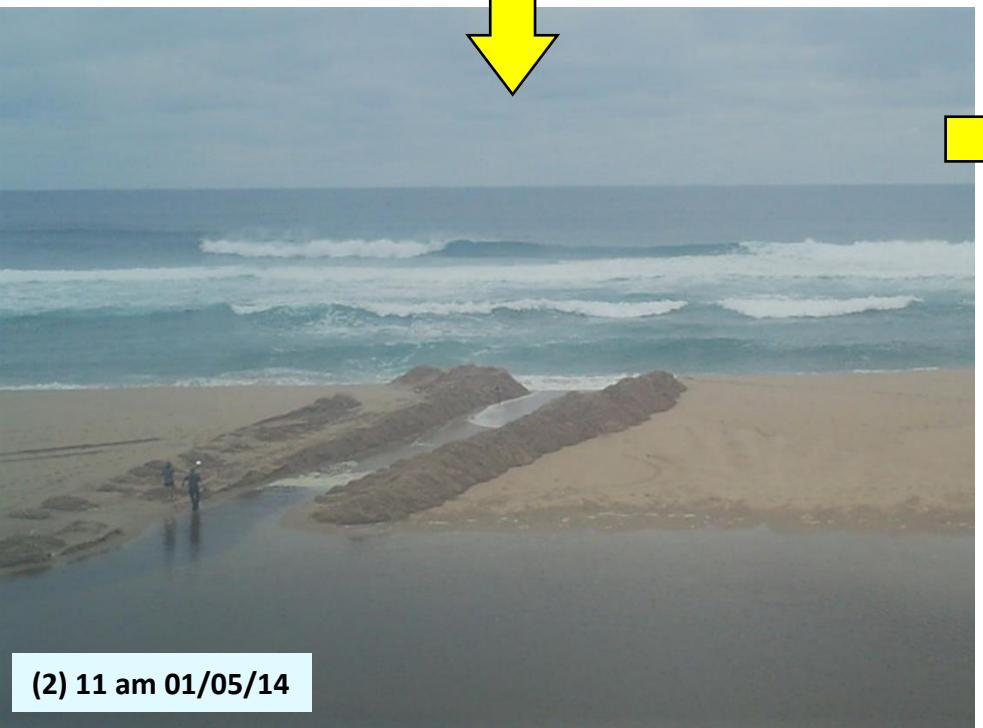
What makes openings be unsuccessful?

(1) Big waves bring sediment onshore to infill the channel

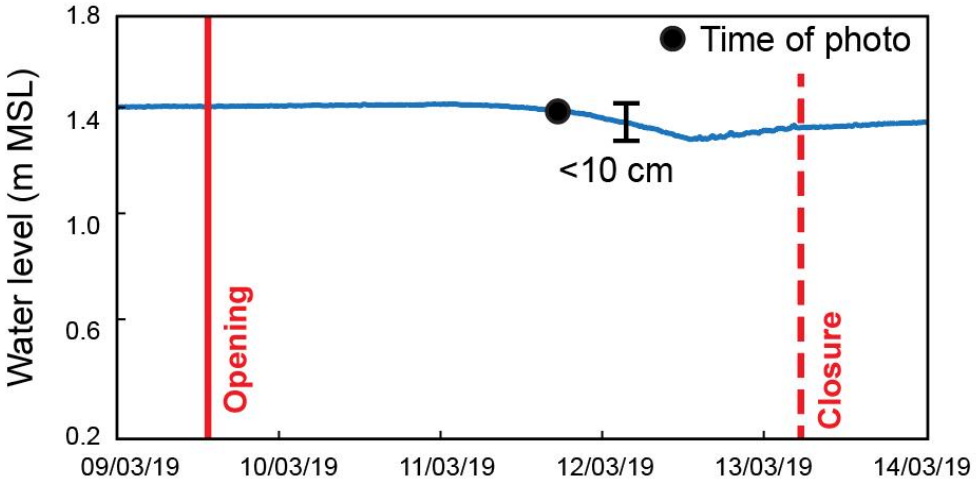
(2) Insufficient energy to maintain offshore transport

(3) Combination of (1) and (2).

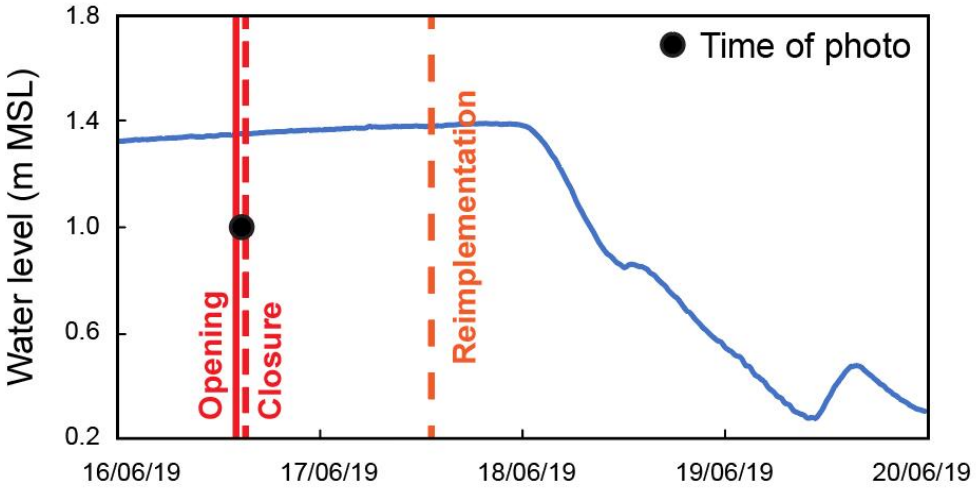
(1) Closure due to big waves



(2) Closure due to insufficient energy to maintain offshore transport



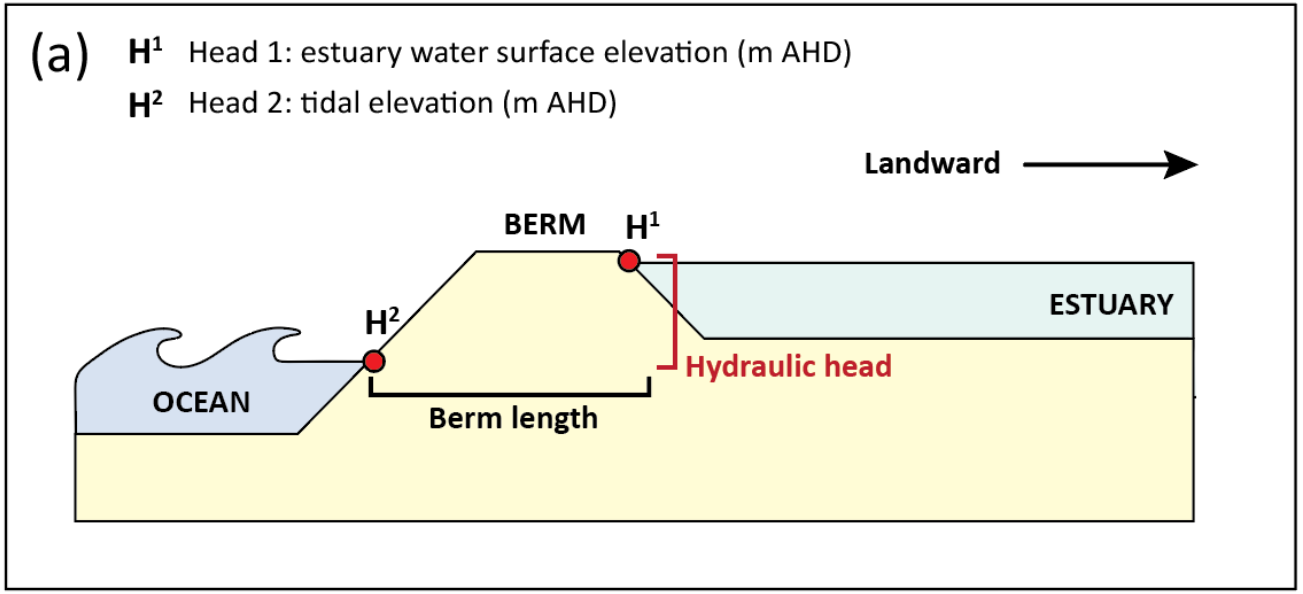
(3) Closure due to insufficient energy AND big waves.

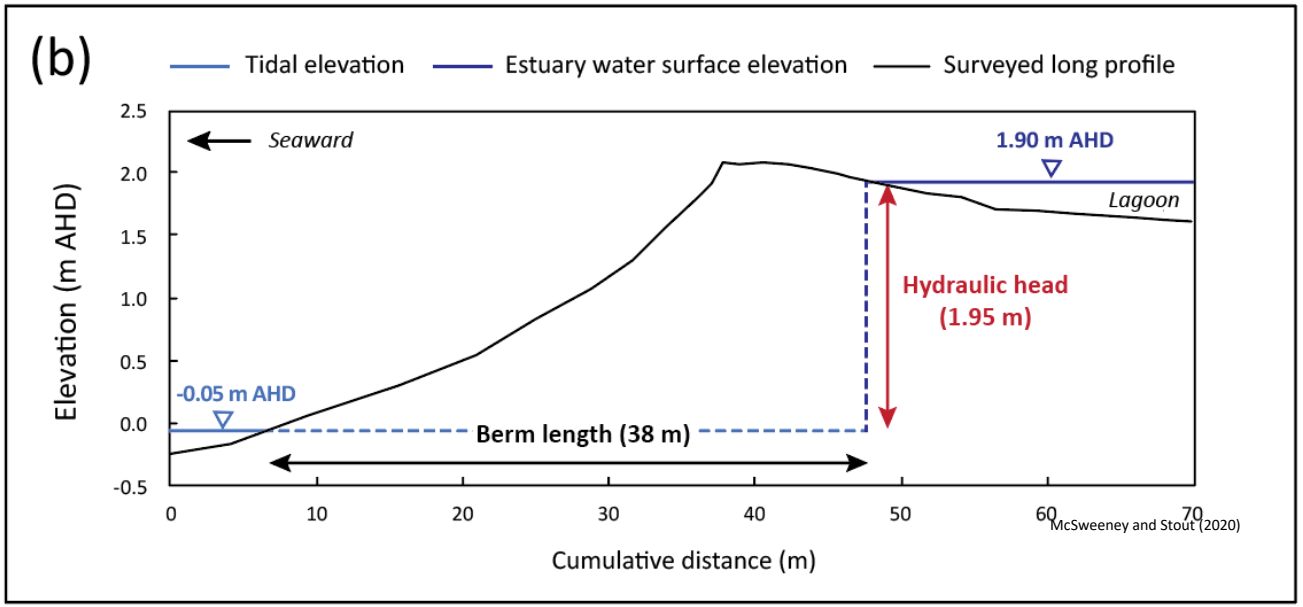


Can we predict if openings will be successful?

Head (H) is the force promoting breaching

Berm length (BL) is the force resisting breaching





McSweeney and Stout (2020)

Can we predict if openings will be successful?

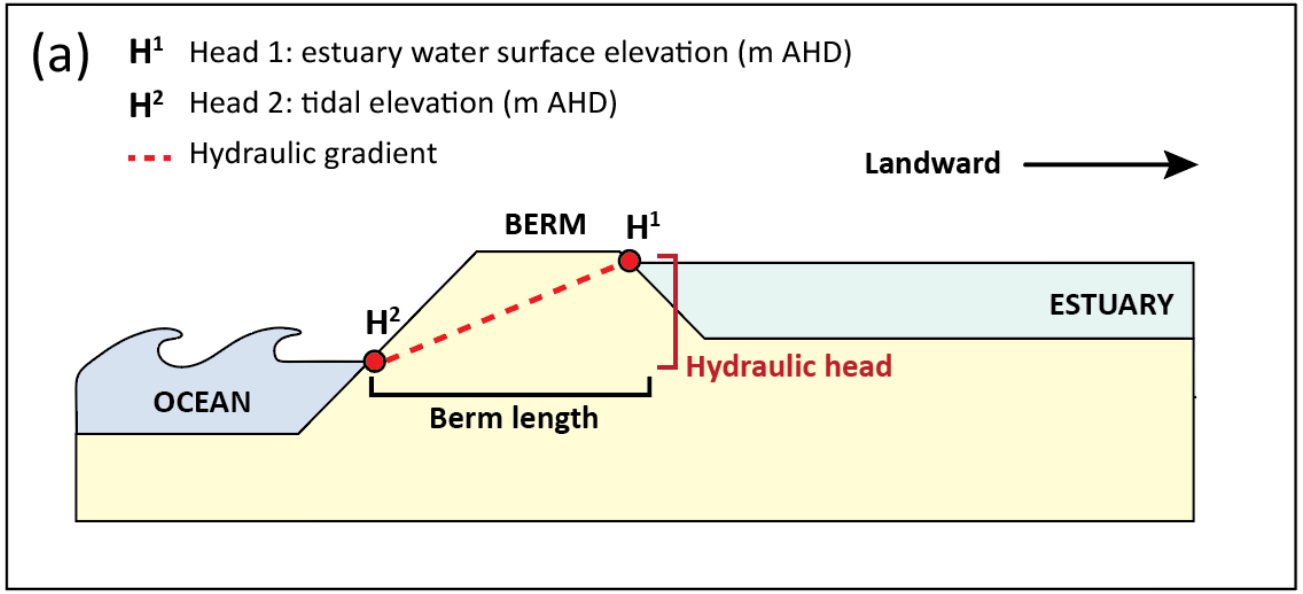
Head (H) is the force promoting breaching

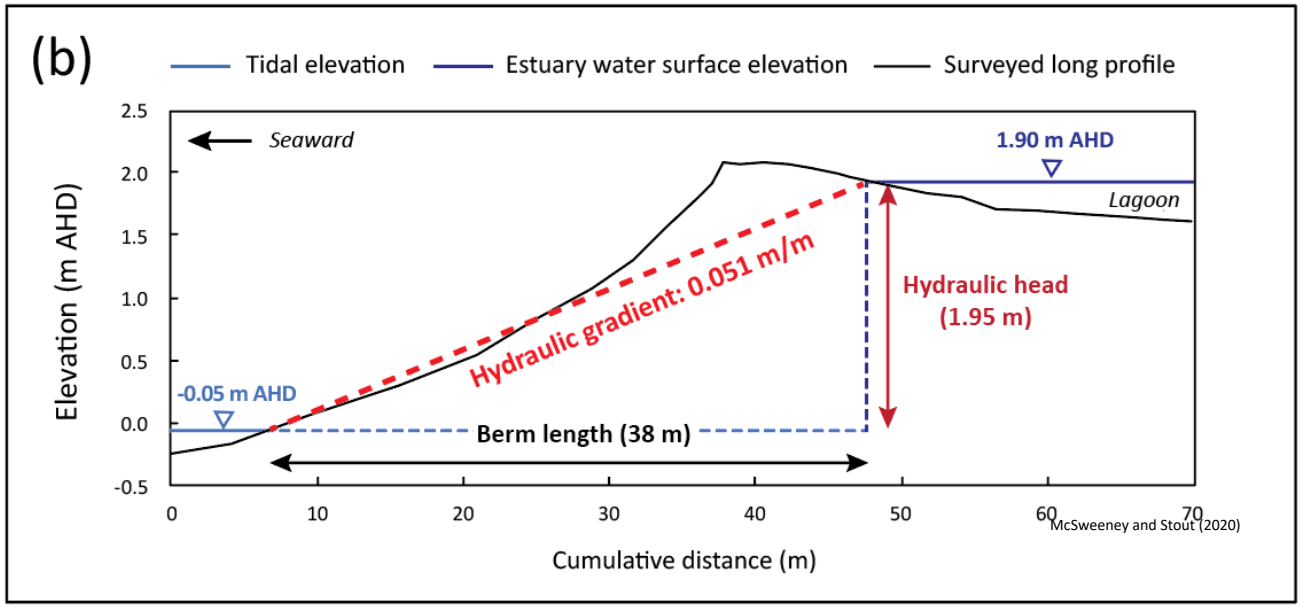
Berm length (BL) is the force resisting breaching

H/BL = hydraulic gradient (HG) (m/m)

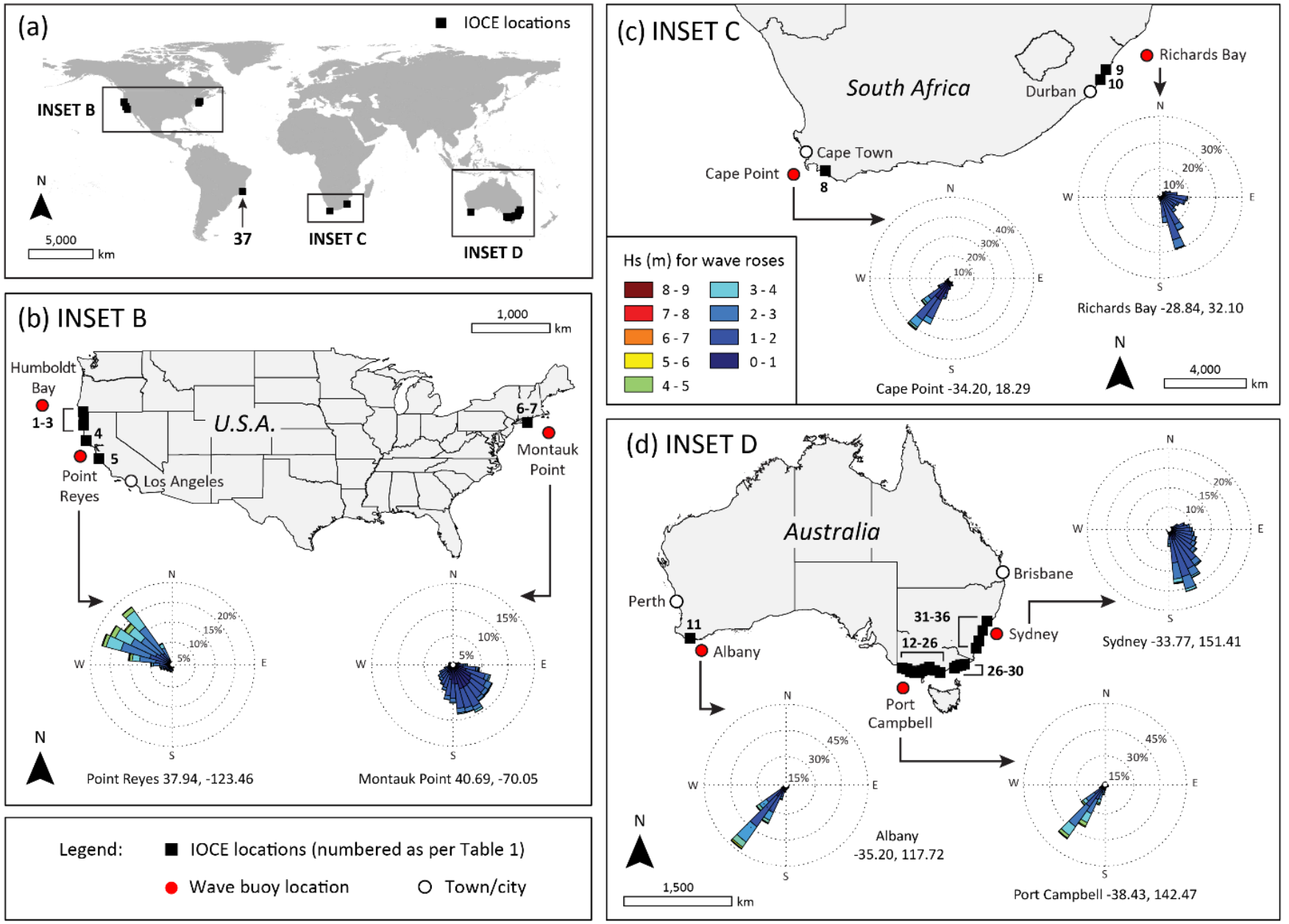
Energy gradient between estuary and the sea

Grade = 1/HG





McSweeney and Stout (2020)



137 openings at 37 sites in Australia, South Africa, and the U.S.A.

https://www.estuarywatch.org.au/observation/ccma/14655

Overview

Estuary	Painkalac Creek Estuary
Site	Painkalac Creek Observation Site
Observation ID	#14655
Date and Time	Saturday 9th April 2022 14:45pm
Approved	Pending

Notes

Unable to do photopoint & berm measurement at preferred time of hightide: 17:20. However there is little variation between high and low tide on this day.

Mouth Observation

Mouth state	Closed
Previous	C C O O O O O O C C O C P
Flow Present?	No
Previous	N N Y Y Y Y Y Y N N Y N Y
Flow Direction	N/A
Previous	N N I I O I O O N N I N I

	Above Sea	Above Estuary
Berm Height (m)	0.8m	0.9m
Berm Length (m)	50.0m	

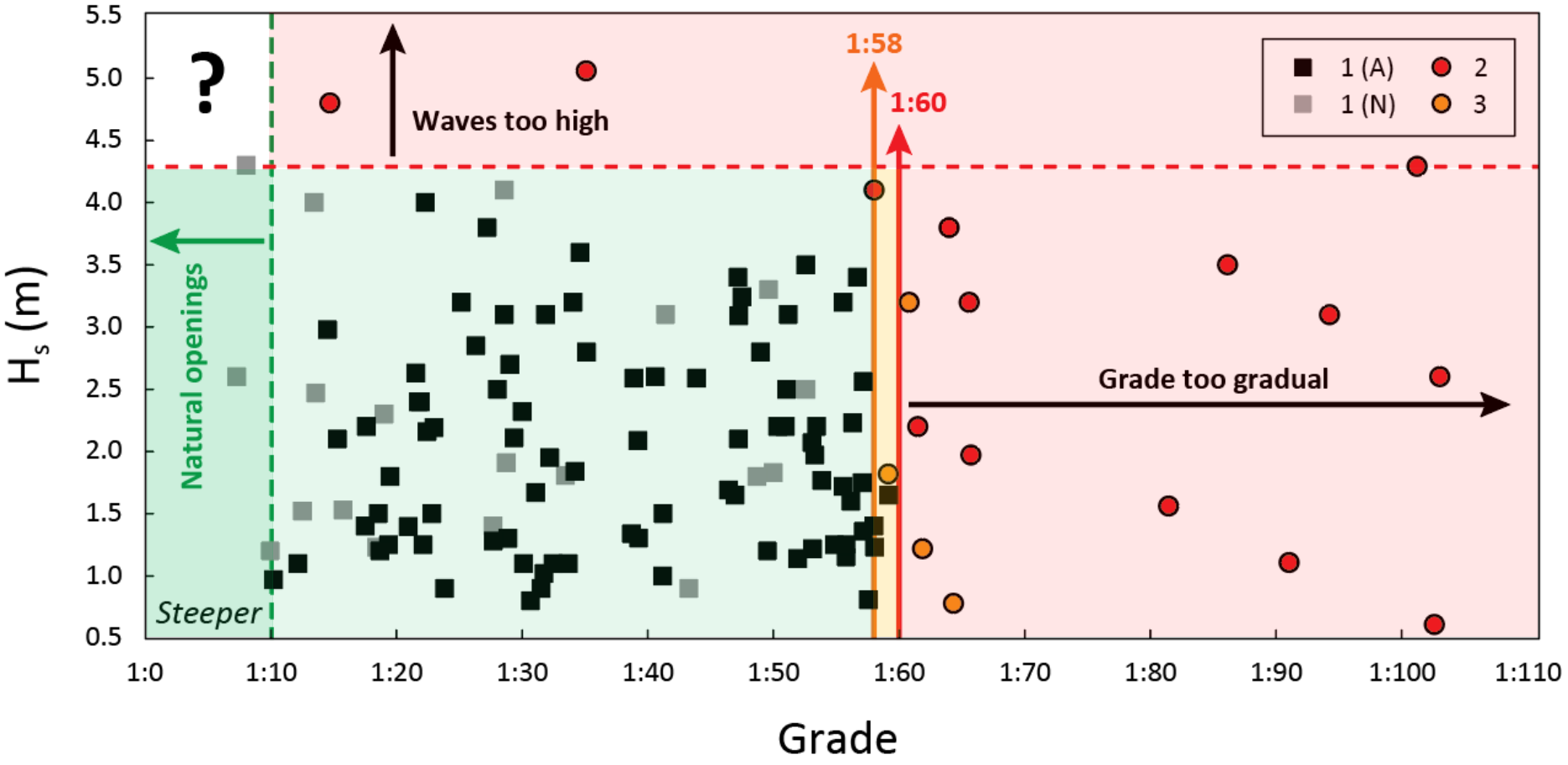
Water Levels and Tides

Water Level	Start	Finish
Height (m)	1.60m	1.60m
Time (hh:mm)	14:45	15:10
Tidal influence	Yes	

Tidal Range	Time	Height
High	17:21	1.530
Low	04:26	1.430

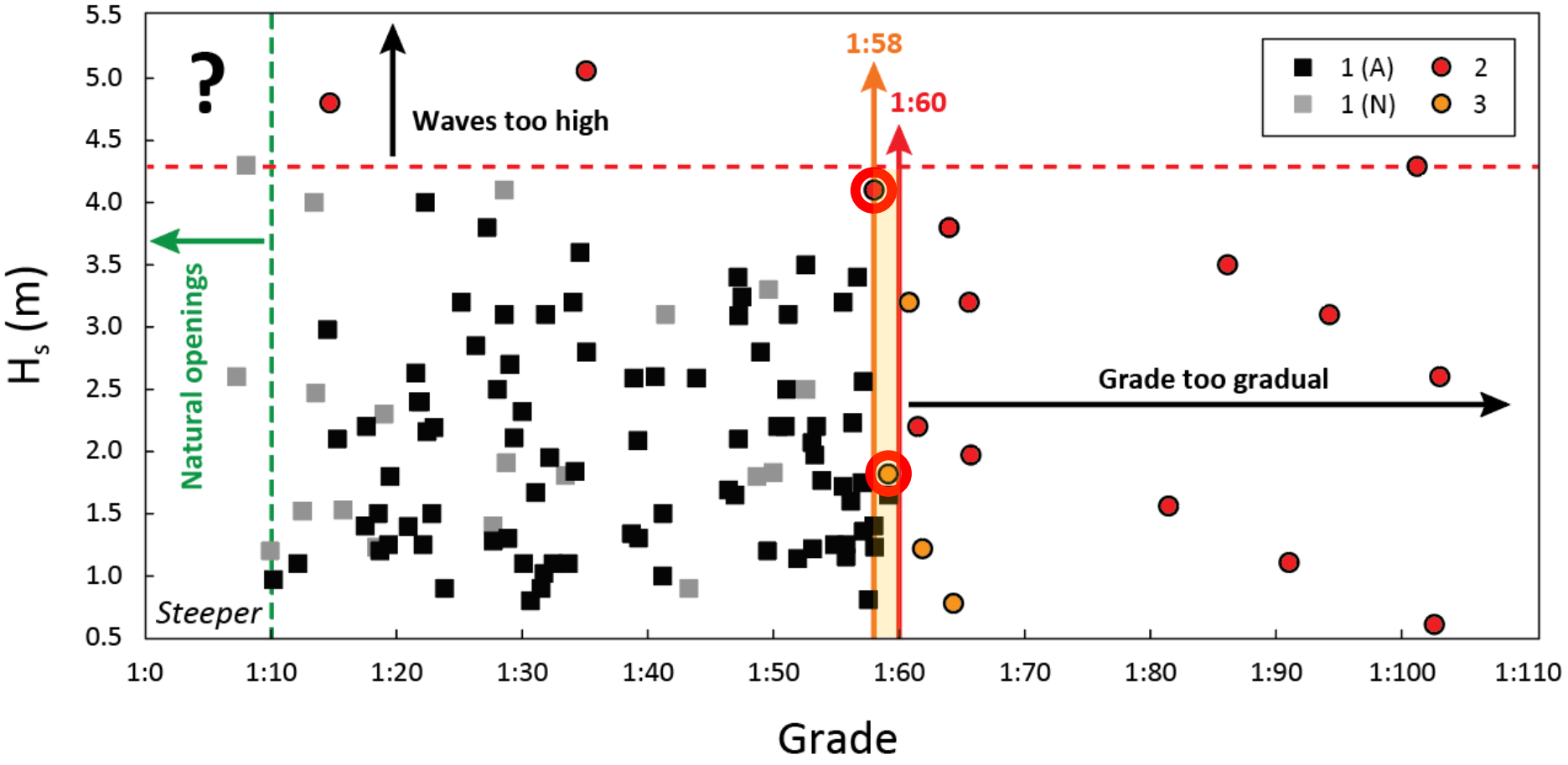
Thank you to EstuaryWatch and CCMA!!

Critical balance between wave height and energy slope

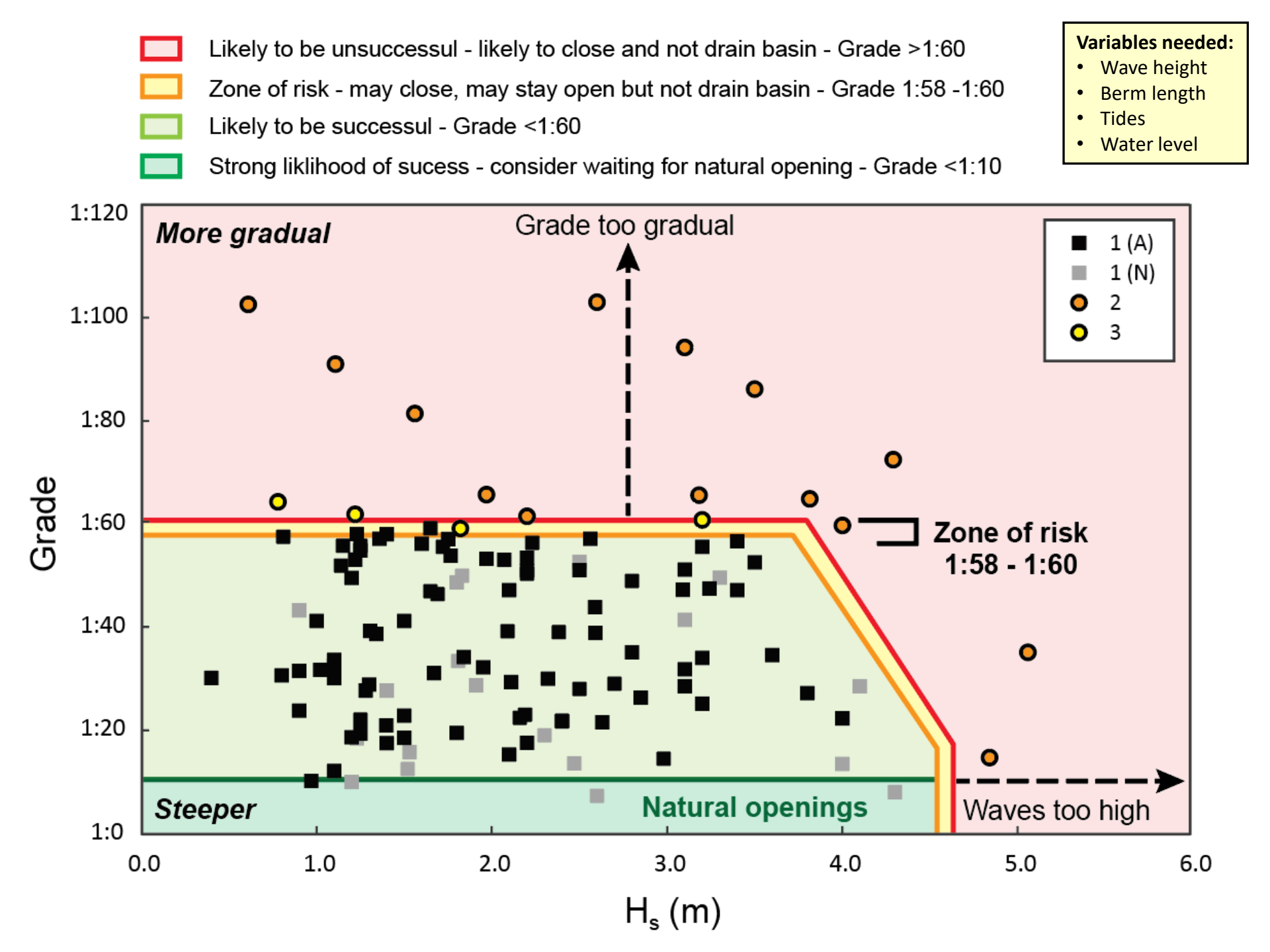


- Hydraulic gradient over 0.017 m/m and a grade below 1:60 needed for openings to stay open and drain the lagoon
- Fail when offshore wave height is >4.3 m = infill from ocean.

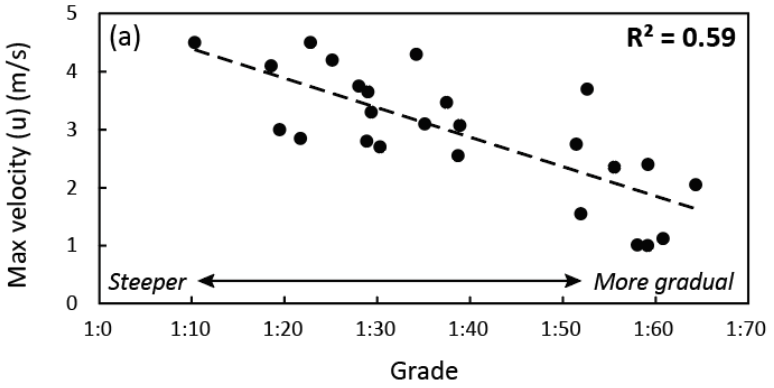
Critical balance between wave height and energy slope

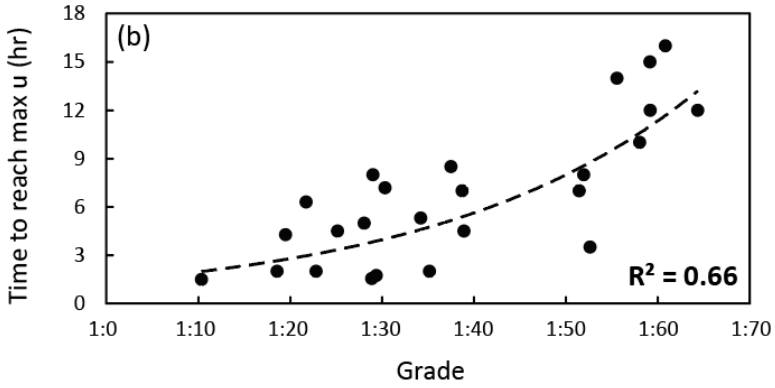


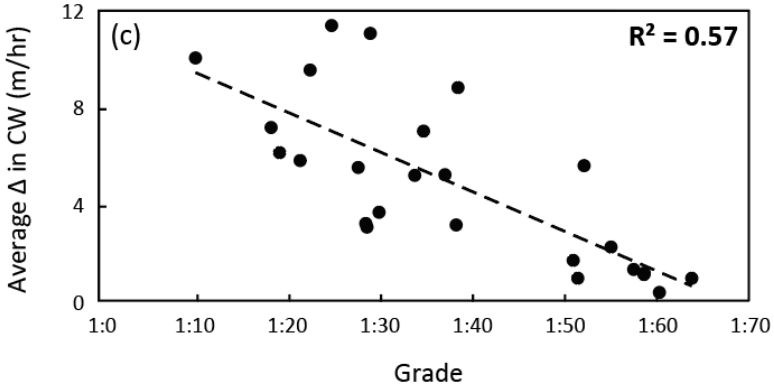
- Opening when the grade is between 1:58 and 1:60 is still risky
- We are continuing this work to test these thresholds across a wider range of sites.

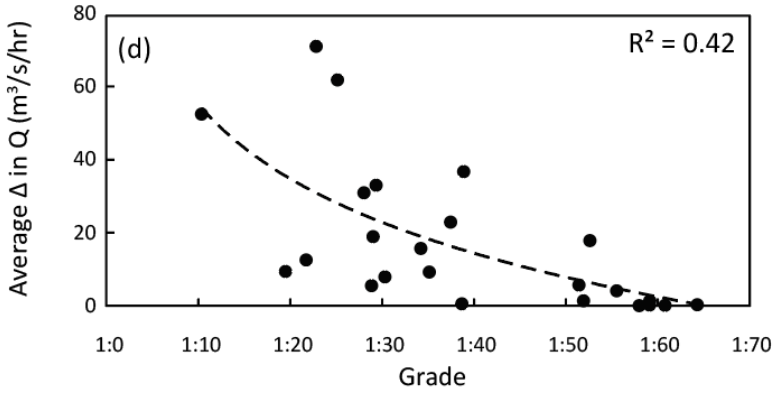

Likely to be unsuccessul - likely to close and not drain basin - Grade >1:60
Zone of risk - may close, may stay open but not drain basin - Grade 1:58 -1:60
Likely to be successul - Grade <1:60
Strong liklihood of sucess - consider waiting for natural opening - Grade <1:10
Variables needed:
• Wave height
• Berm length
• Tides
• Water level
More gradual
Grade too gradual
1 (A)
1 (N)
2
3
Zone of risk
1:58 - 1:60
Steeper
Natural openings
Waves too high
Grade
1:120
1:100
1:80
1:60
1:40
1:20
1:0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
H_s (m)

Grade impacts on rates of geomorphic change and basin drainage!!

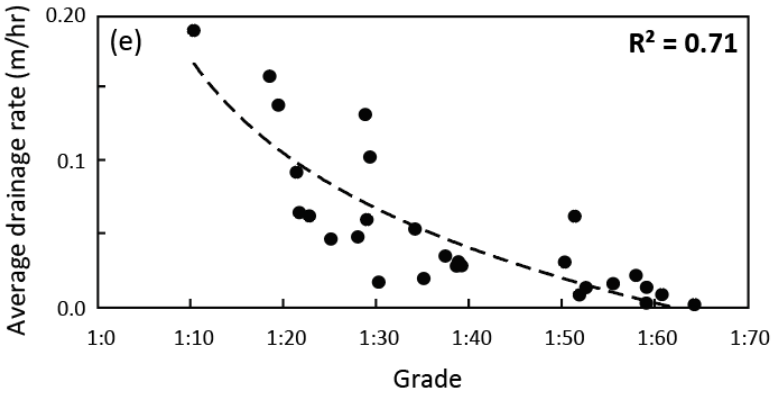








A careful balance between getting it to stay open and not risking rapid drainage!!



Take home points…

- **Our tool is only based on geomorphology and not designed to consider environmental risks - use with caution!**
- Quick drainage can cause rapid change in physicochemical conditions, risking fish kills (Callum will speak more on this)
- Best suited for emergency openings or when keeping it open is the main goal (1:60 grade and low waves,)
- Consider opening on rising tide if perched or steep grade
- Can potentially slow initial drainage and rates of change
- Always use in conjunction with other decision support tools
- To keep an estuary open, implement when forecast rain or higher river flow (use of dam releases?).


Thank you!