



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

ACNA5001



COASTAL, MARINE AND WILDLIFE CONSERVATION

ALISSA FLATLEY & ELANOR ALUN

Elanor Alun



OUTLINE

- 1) Course introduction
- 2) Large scale controls on coastal systems
- 3) Coastal Ecosystems
 - Key management issues
- 4) Assessment(s)

ACNA5001

- In this course we explore coastal and marine ecosystems, and their conservation.
- From a scientific consideration of these pressures, we will evaluate strategies for the protection of the maritime environment and wider conservation of species, ecosystems and natural resources.
- This module is led by Elanor Alun and Alissa Flatley, with additional guest lectures on exciting topics.

INDICATIVE COURSE CONTENT

Why wildlife
conservation

Habitat
Restoration

Species Recovery
and Extinction

Cetacean Science

Animal
Physiology

Adaptation

Abiotic Factors

Engineering and
Coastal
Management

Monitoring

Coastal
Communities

Coastal and
Marine Processes

GIS, Mapping
and Monitoring

Wildlife Ecology

Keystone Species

Overfishing

- Here are some of the key topics we will consider in this subject:

COMMITMENT

Study Time Allocation

The study time for the module is divided as follows:

Activity type	Hours	Percentage
Scheduled learning	48	24%
Independent learning	152	76%
Placement learning		
TOTAL	200	100%

- We will be providing extra content, readings and activities to supplement your in-class learning

ASSESSMENT

ASSESSMENT

Assessment Component 1

(Tick one)

☒ Written exam ☐ Coursework ☐ Practical

Mode of assessment	Volume	Weighting
Examination	2 hours	50%

Assessment Component 2

(Tick one)

☐ Written exam ☒ Coursework ☐ Practical

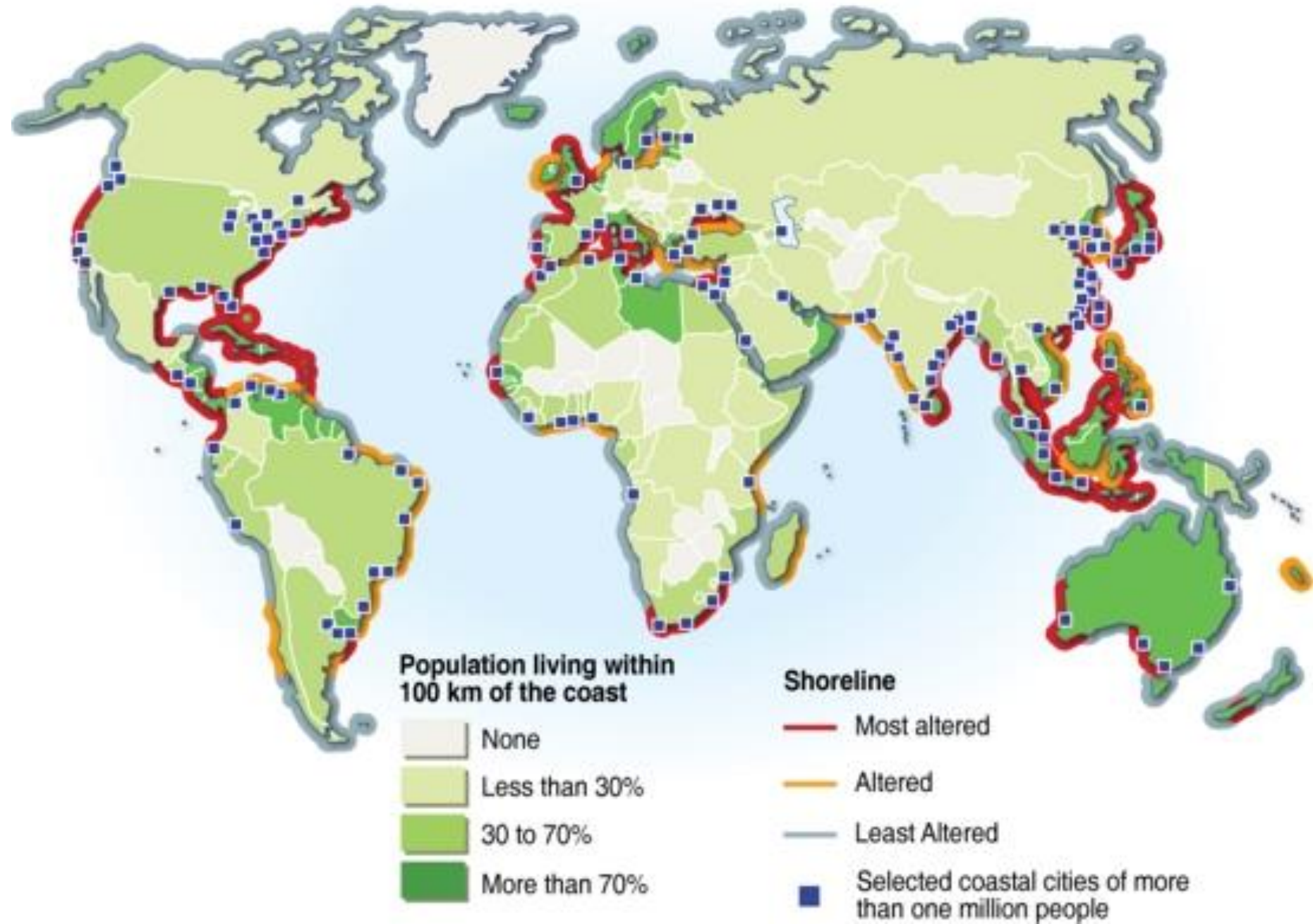
Mode of assessment	Volume	Weighting
Scientific Report	Based upon a practical fieldtrip, students will produce a scientific report of their findings (2500 words)	50%

Assessment Summary

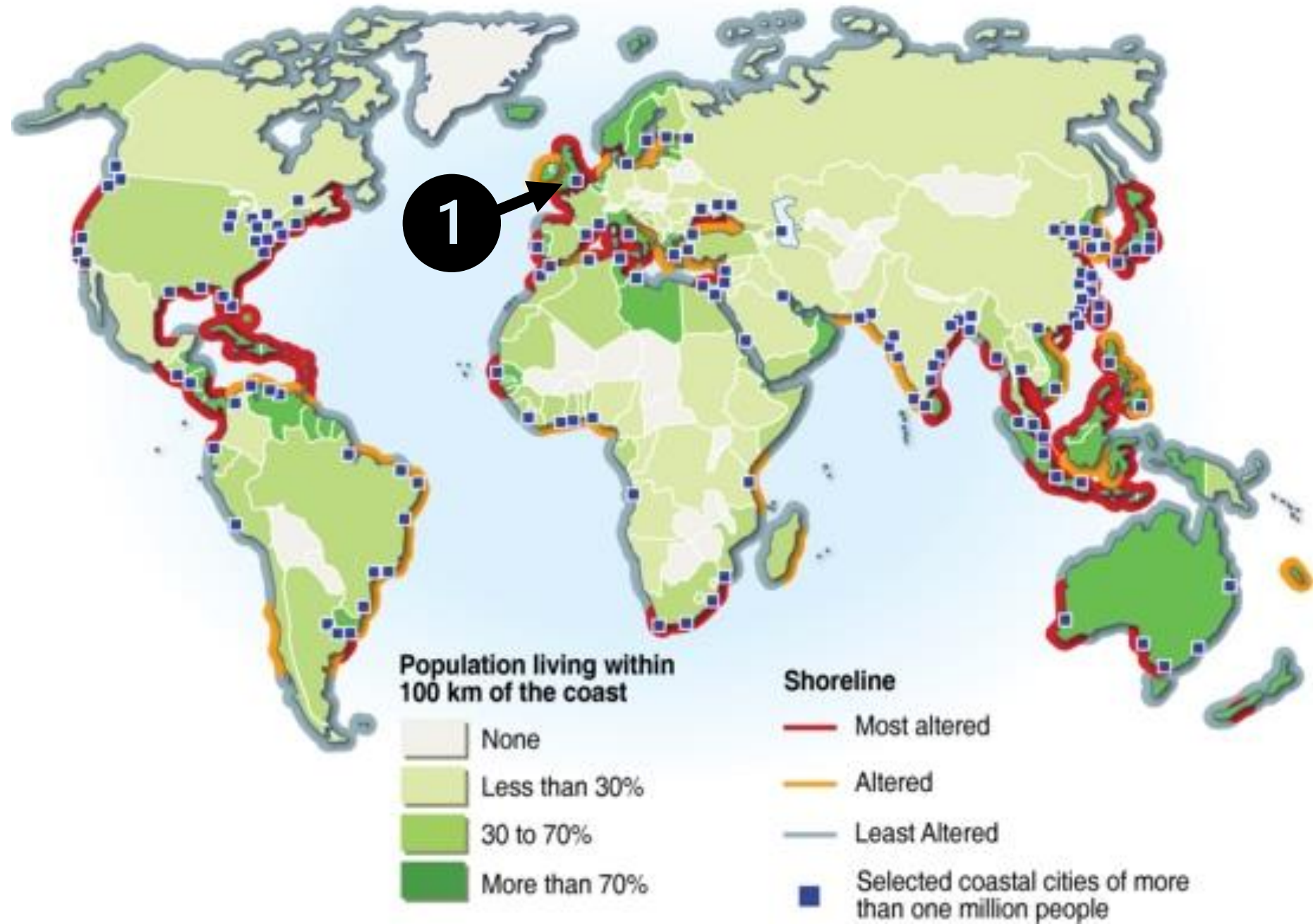
Activity type	Percentage
Written exam	50%
Coursework	50%
Practical	
TOTAL	100%

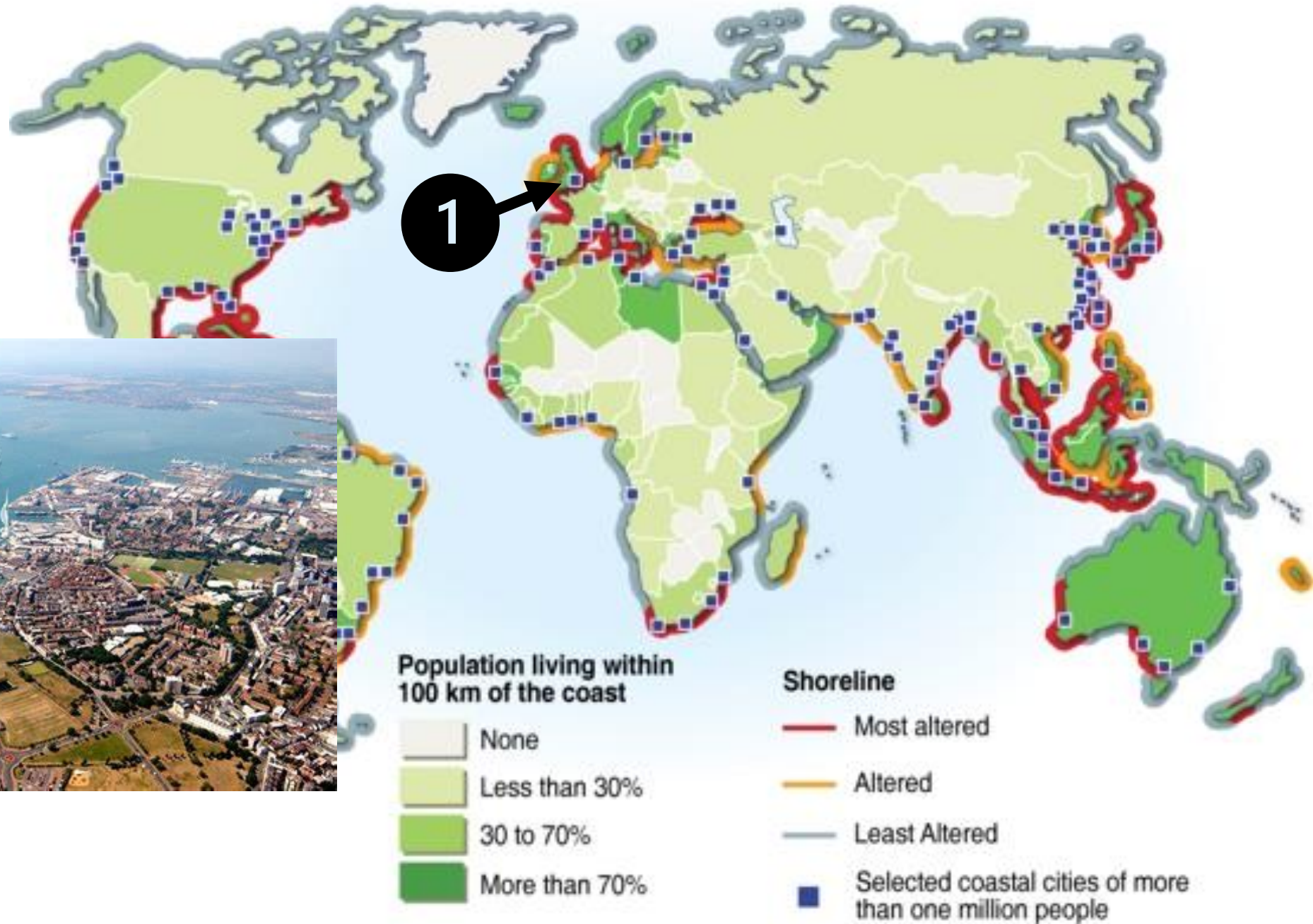
- We will introduce your assignment **TODAY**

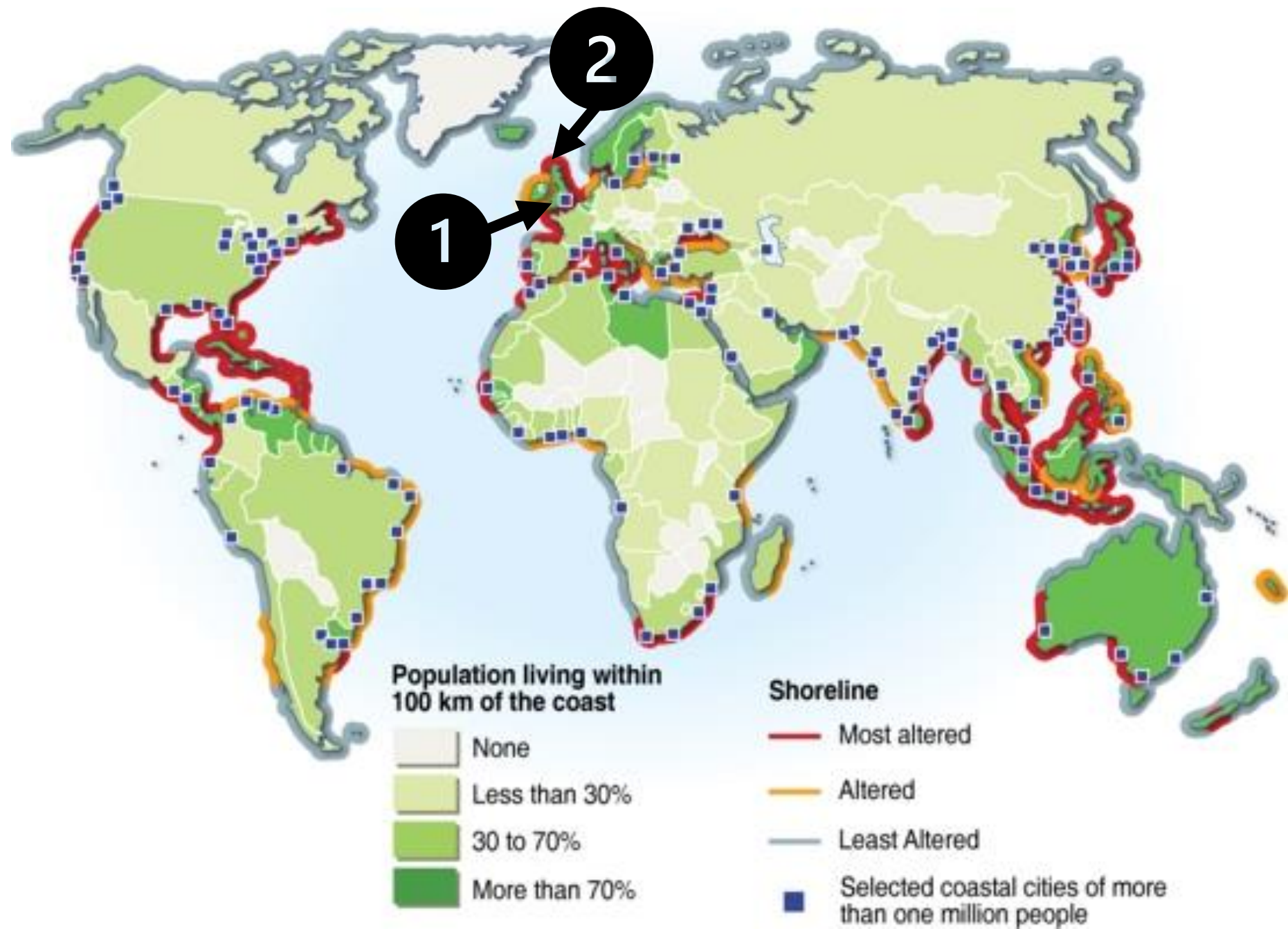
INTRO

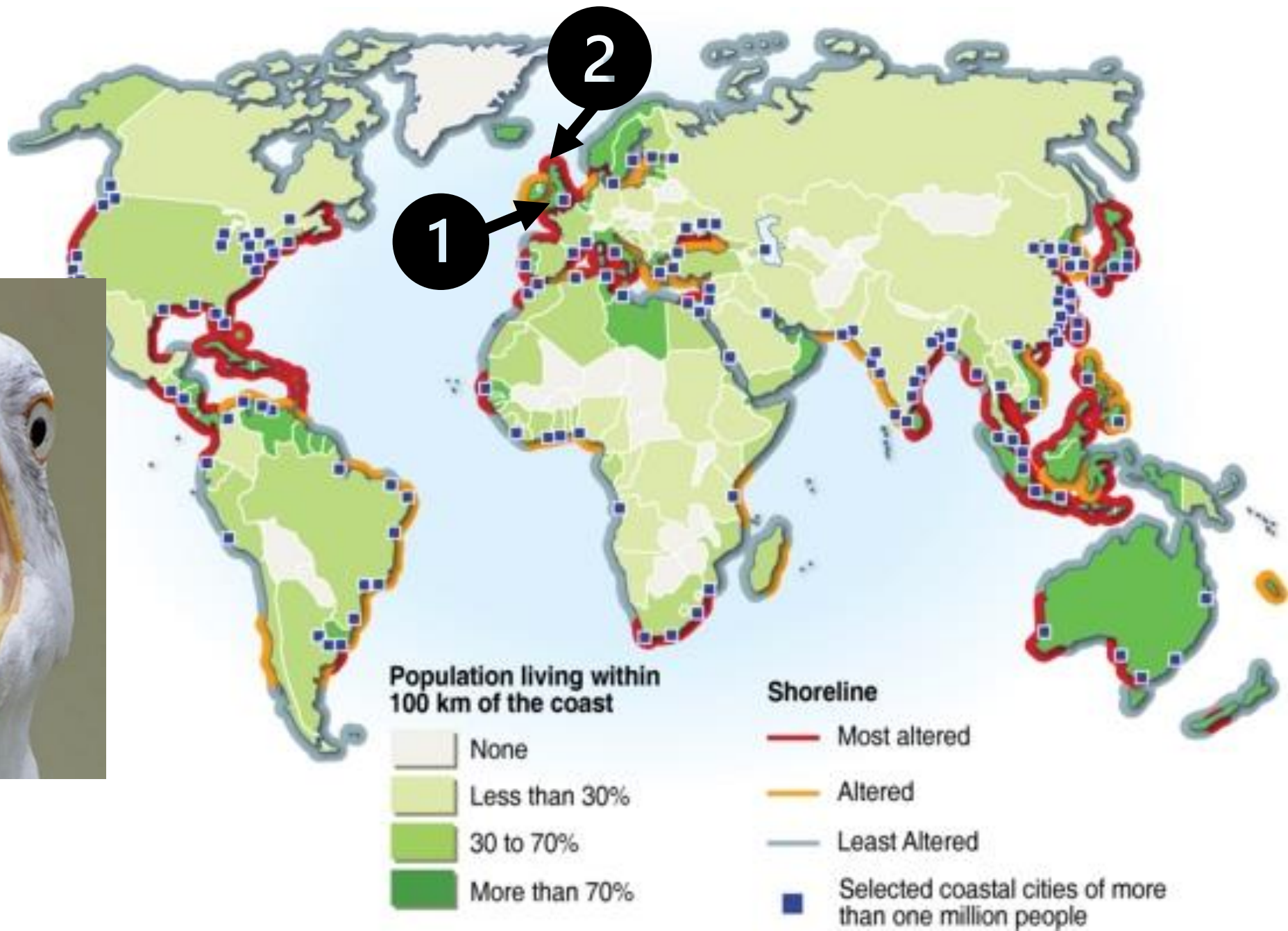


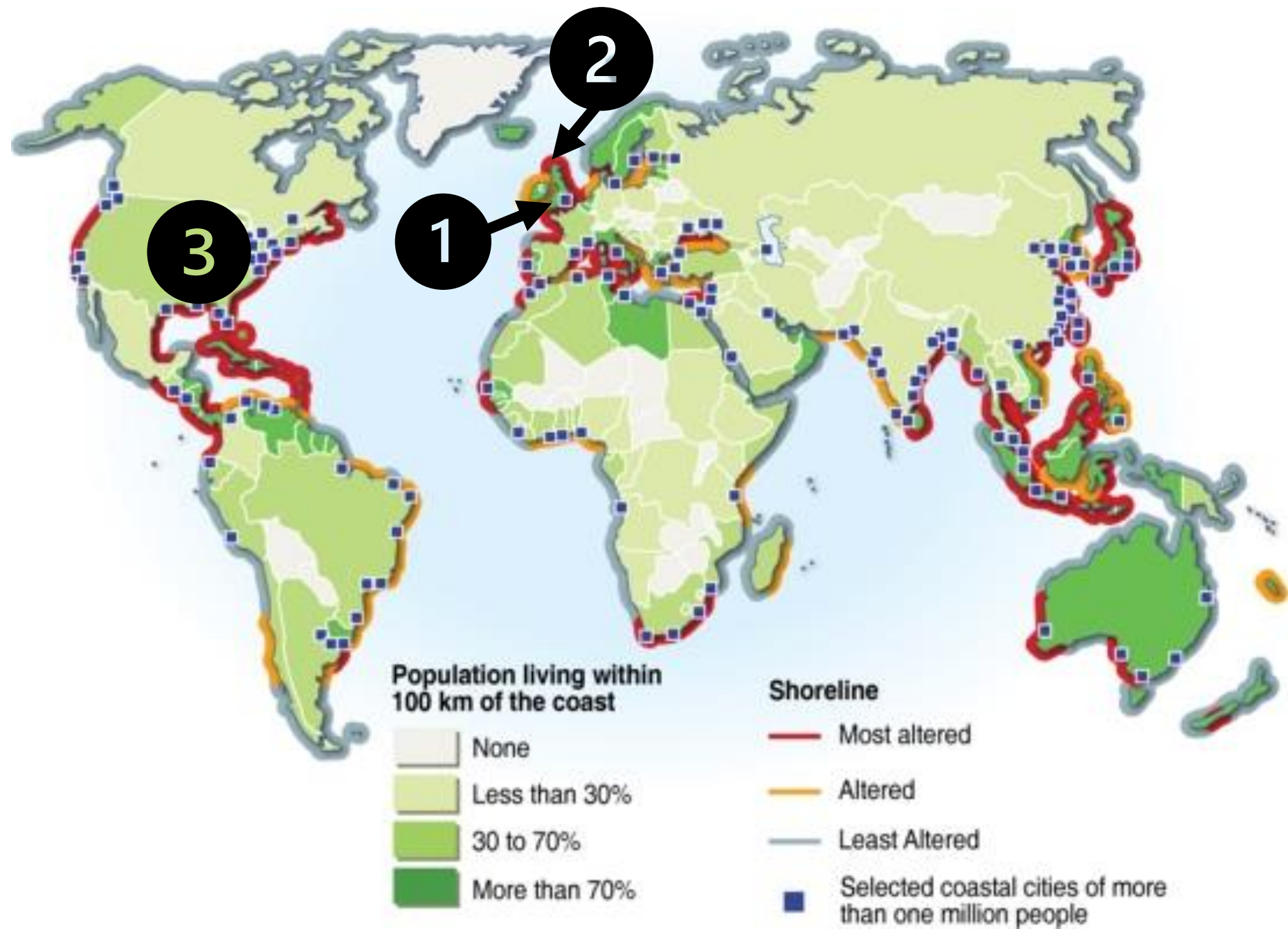
INTRO

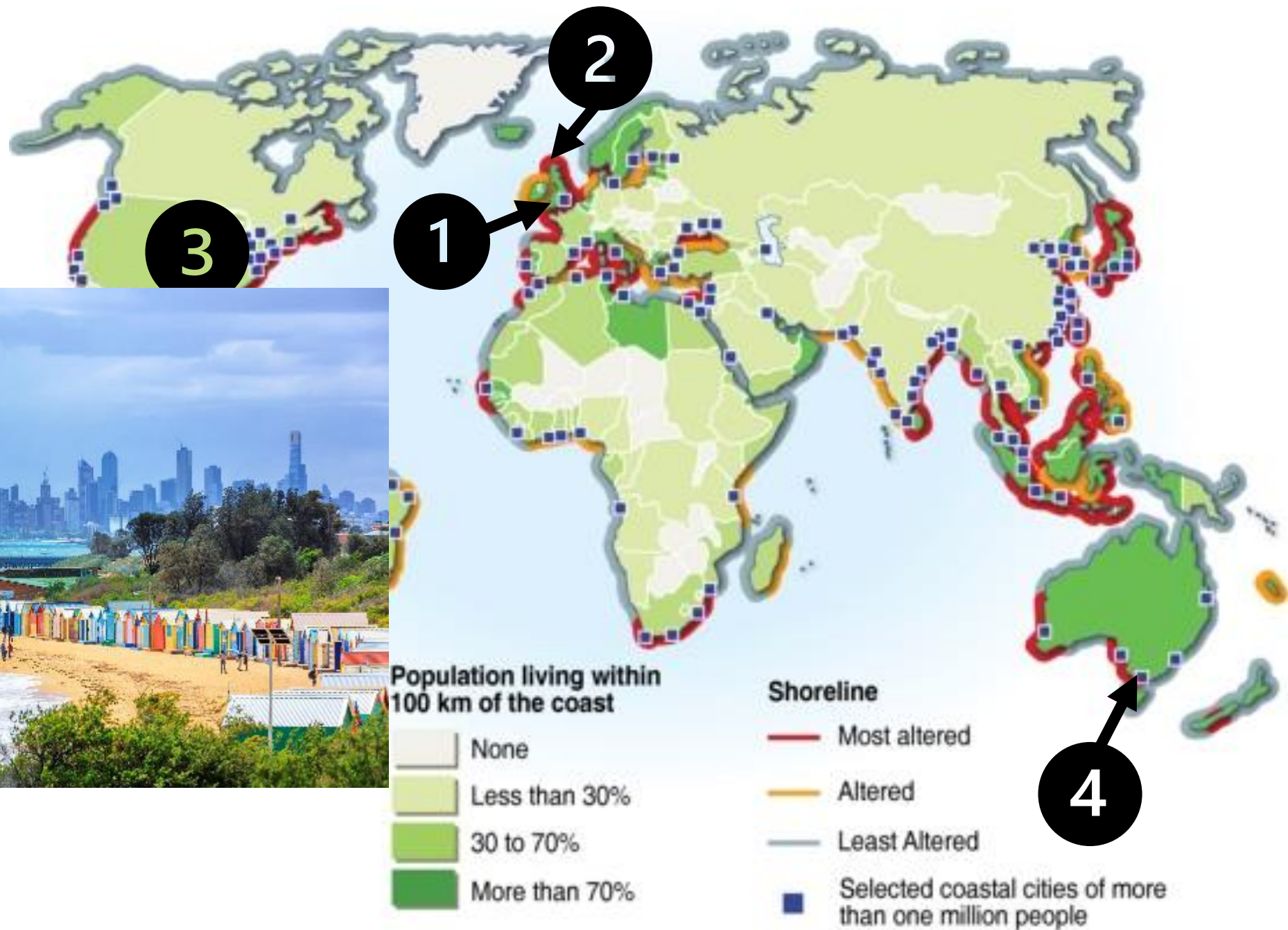










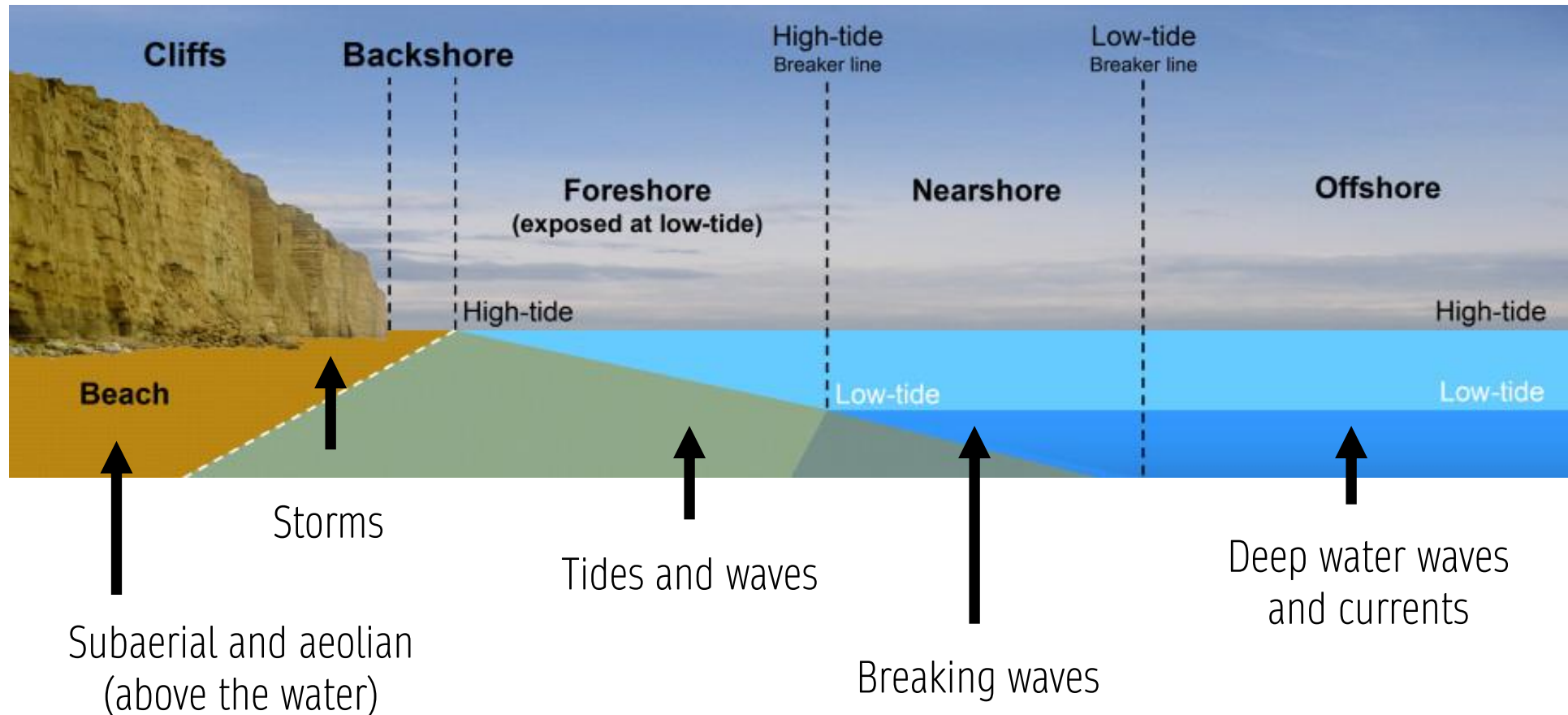


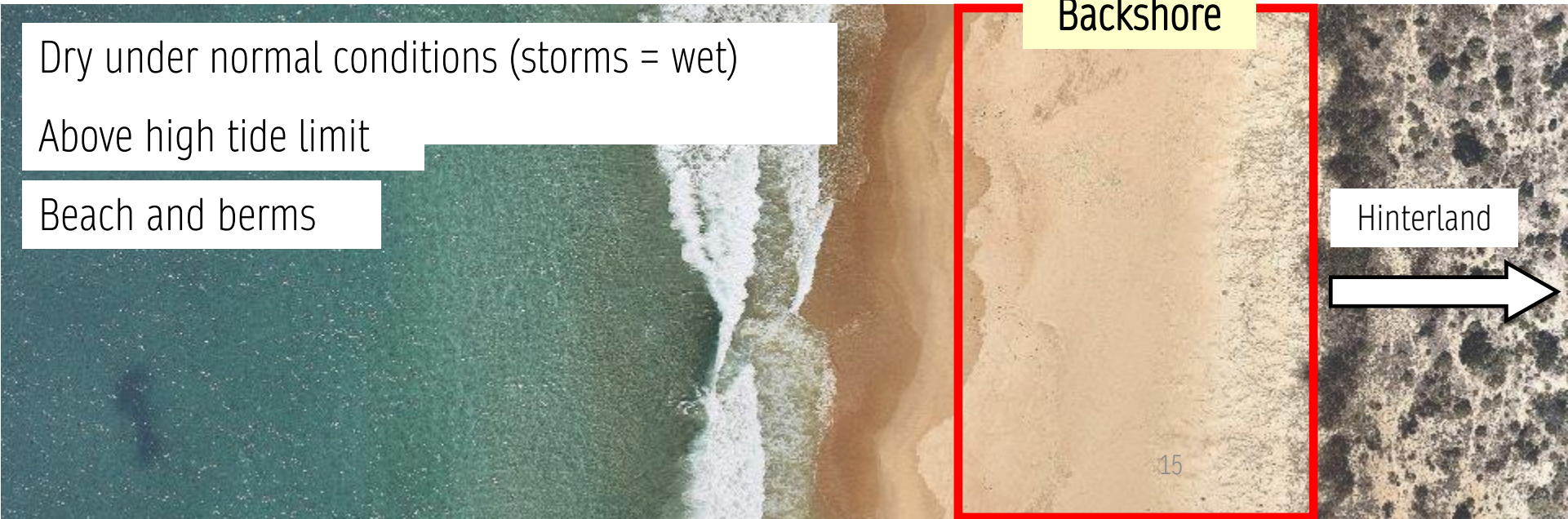
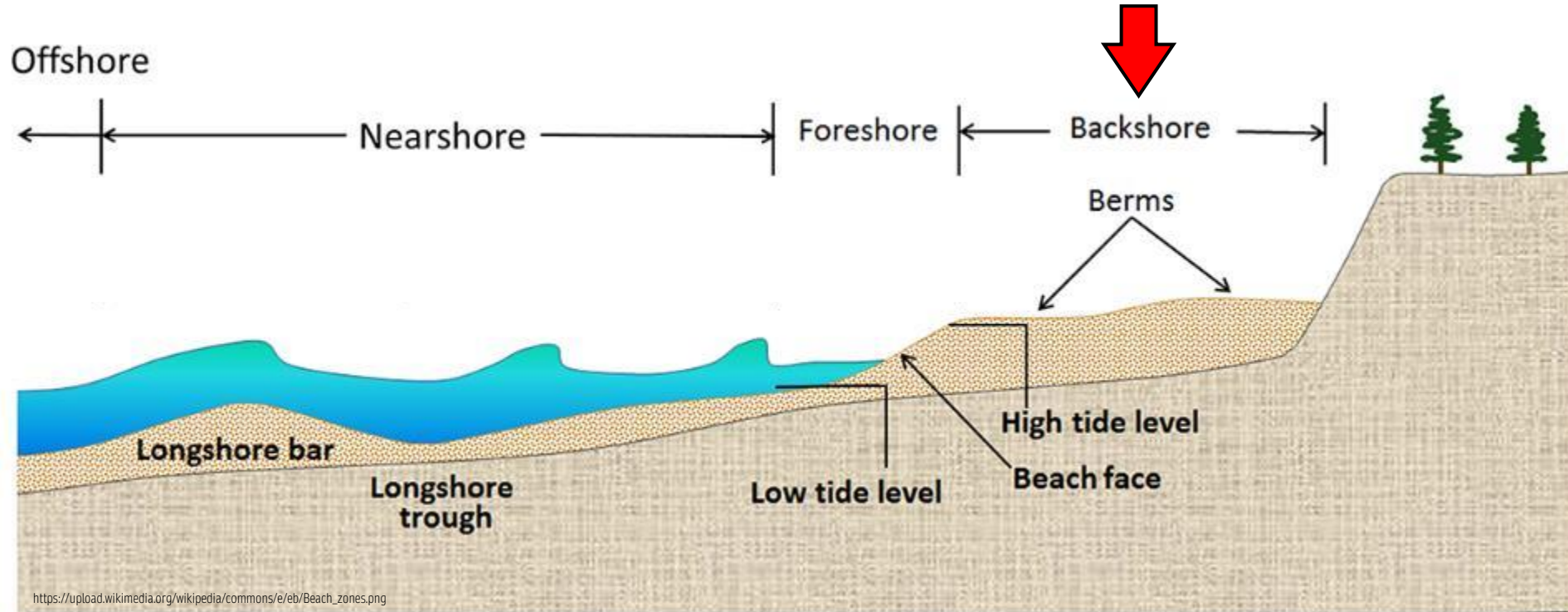
The coastal zone

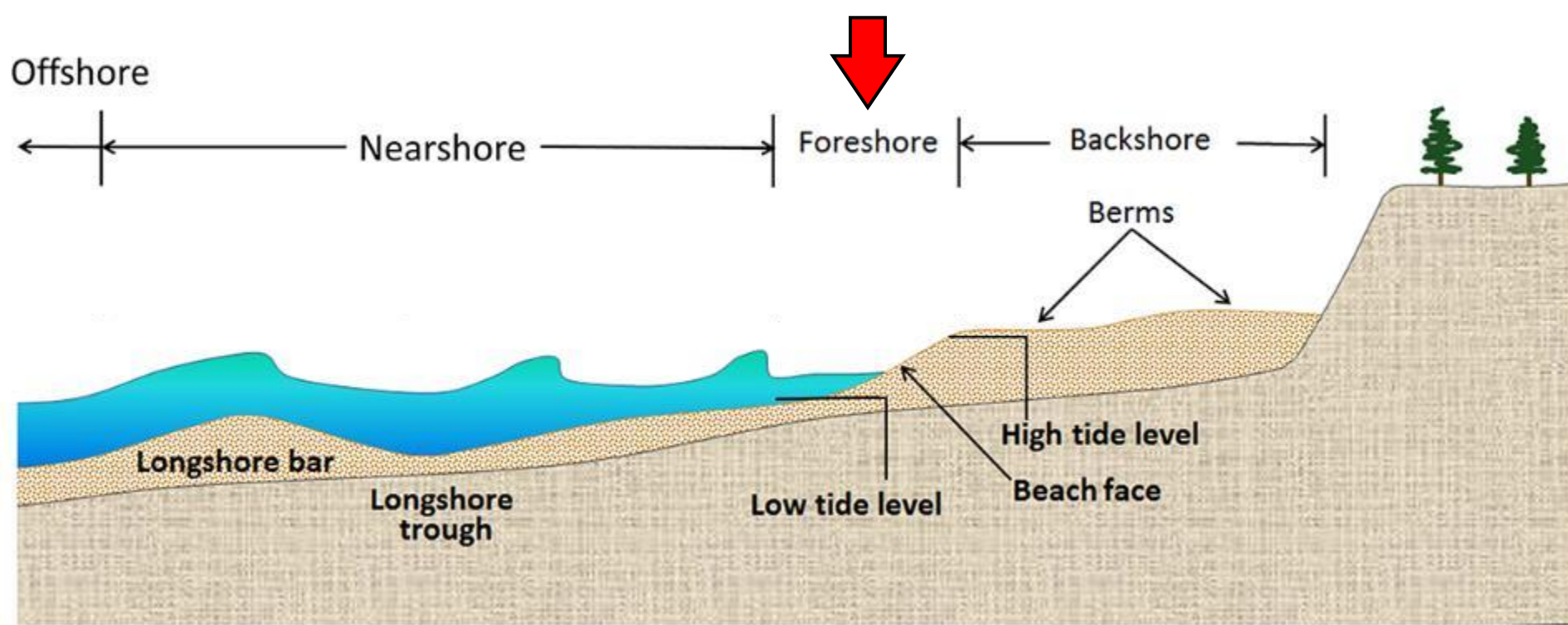
The interface between land and sea

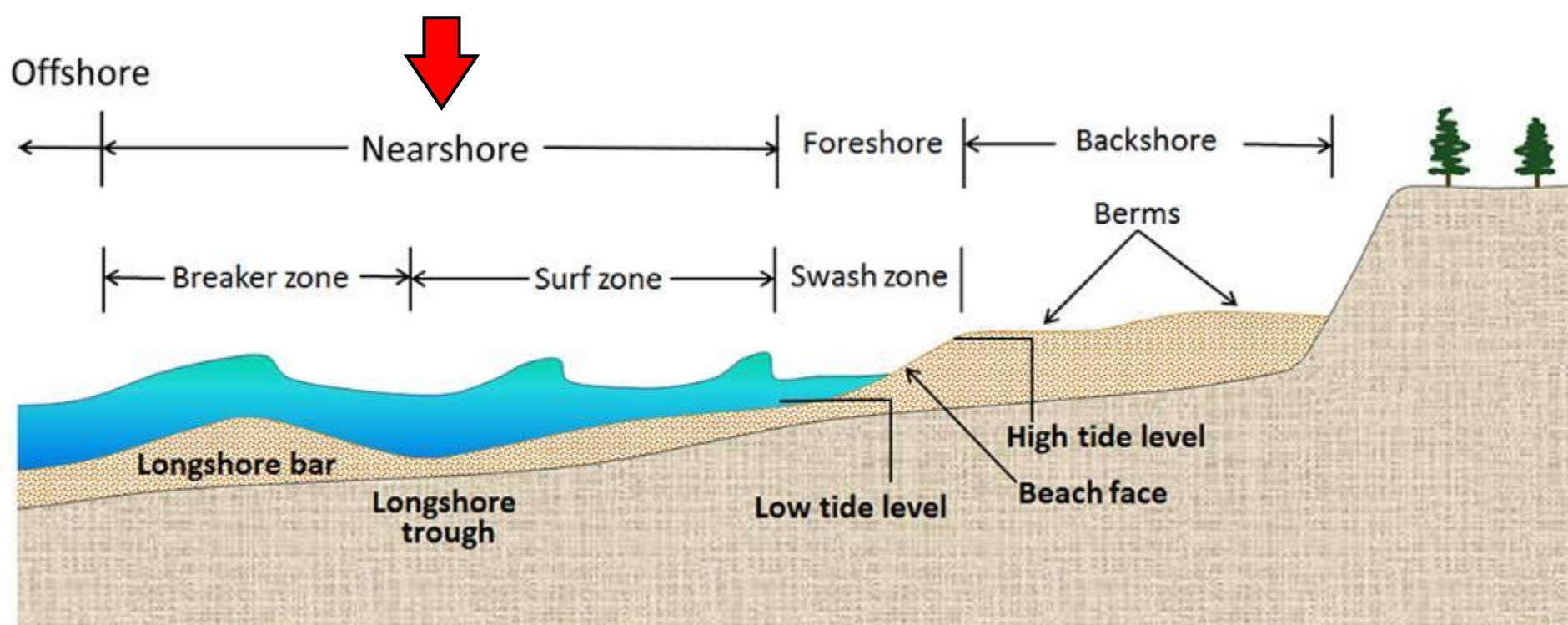
Comprised of several zones - varying processes and energies

KEY TERMS



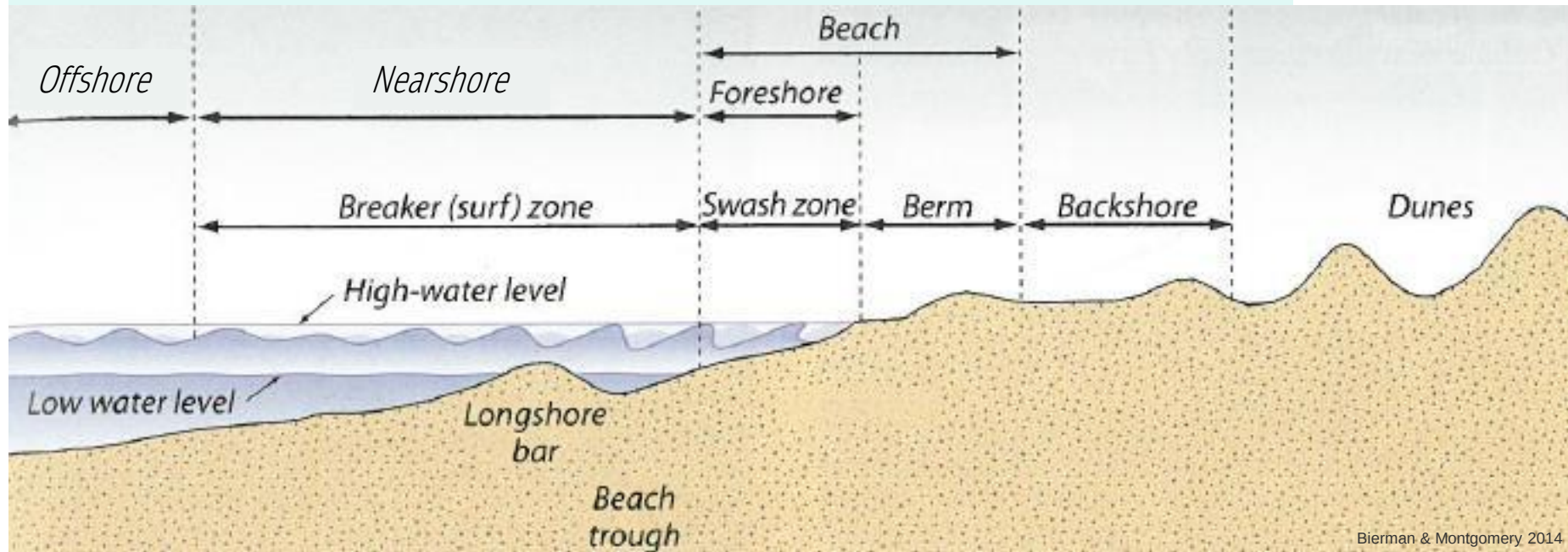






The beach profile

There is an **energy gradient** present across the active profile
Determined by the processes acting within each zone



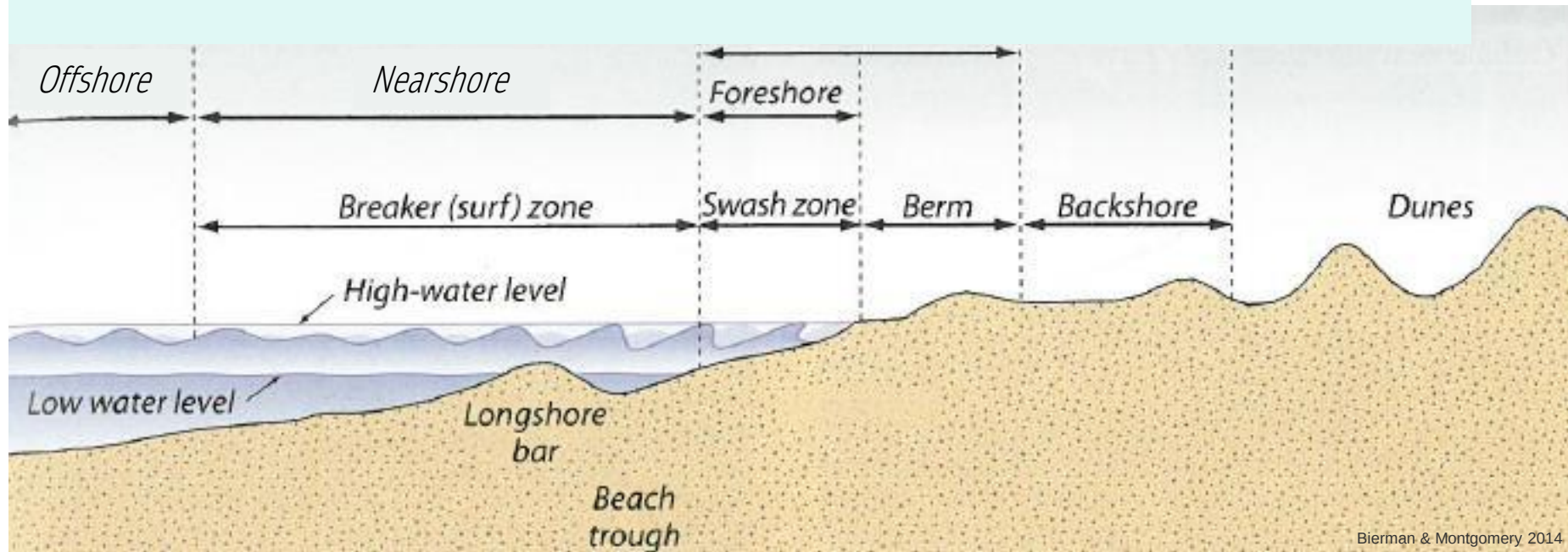
Bierman & Montgomery 2014



The beach profile

Expressed by a change in **grain size**

Coarsest grains are in the **swash zone** and on the **beach berm**



Bierman & Montgomery 2014

Fine grains



Coarse grains



Fine grains

Low energy

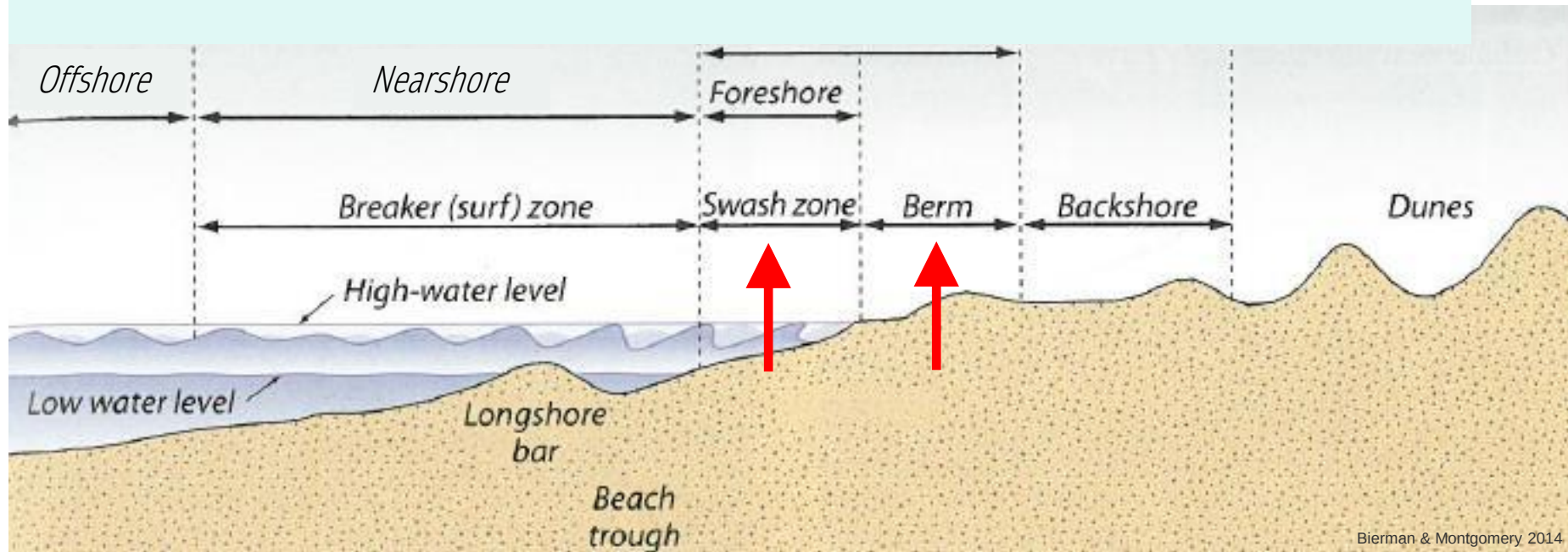
High energy

Low energy

The beach profile

Expressed by a change in **grain size**

Coarsest grains are in the **swash zone** and on the **beach berm**



Fine grains



Coarse grains



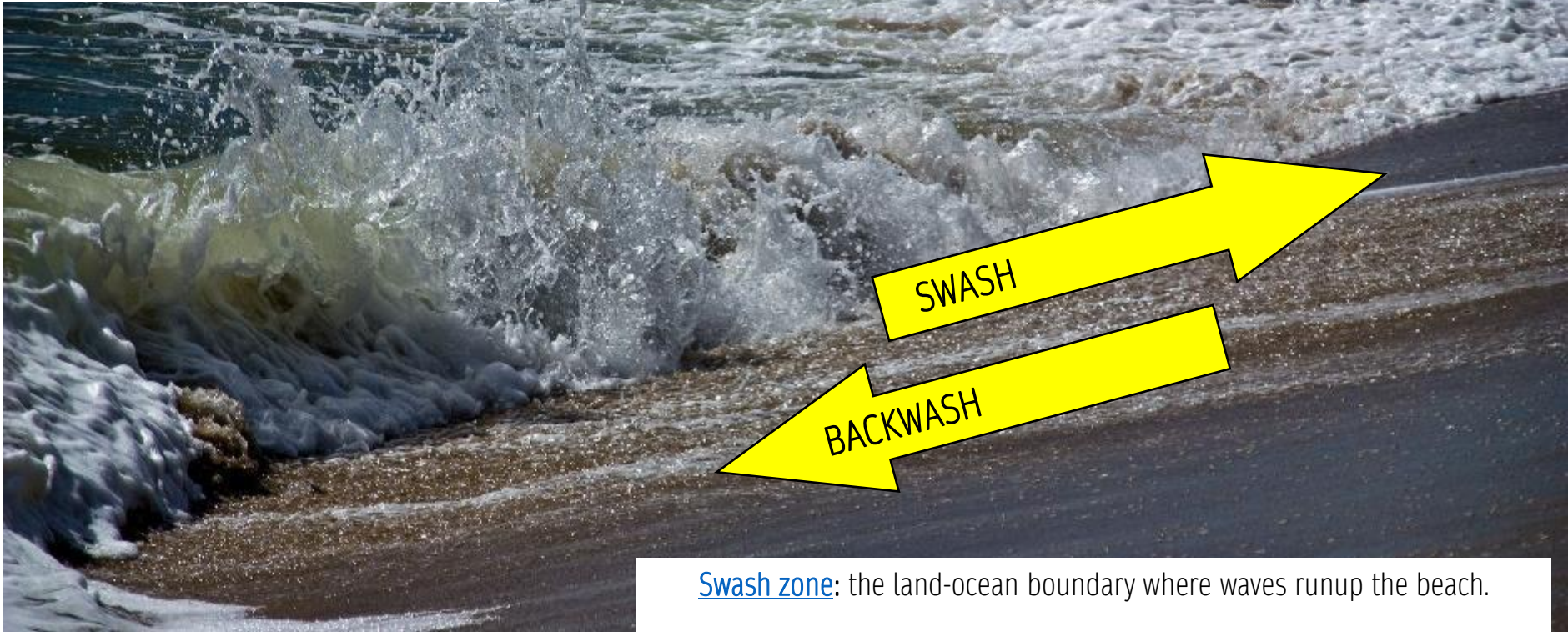
Fine grains

Low energy

High energy

Low energy

(1) Swash zone



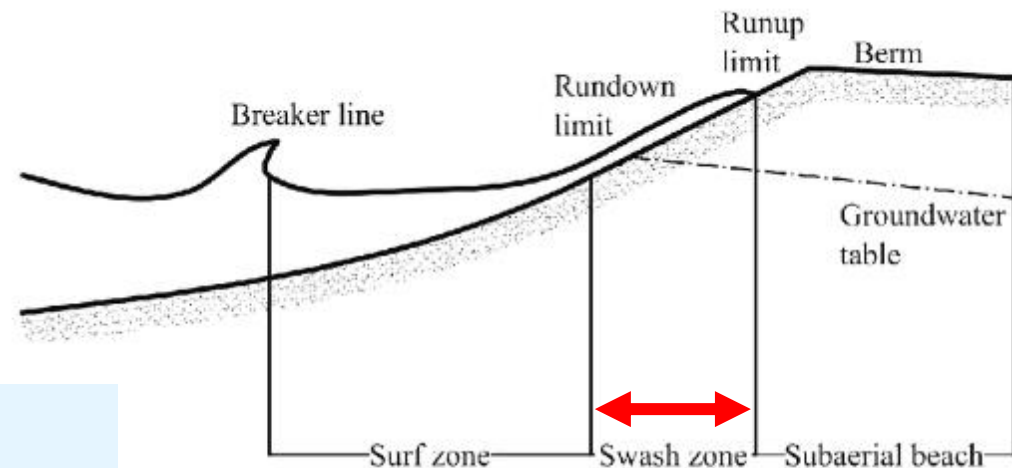
Swash zone: the land-ocean boundary where waves runup the beach.

Uprush (run up) onshore flow

Backwash (return flow) offshore flow

Generally uprush velocities are greater but of shorter duration vs the backwash

<https://www.youtube.com/watch?v=SDHwwNHpSpw>



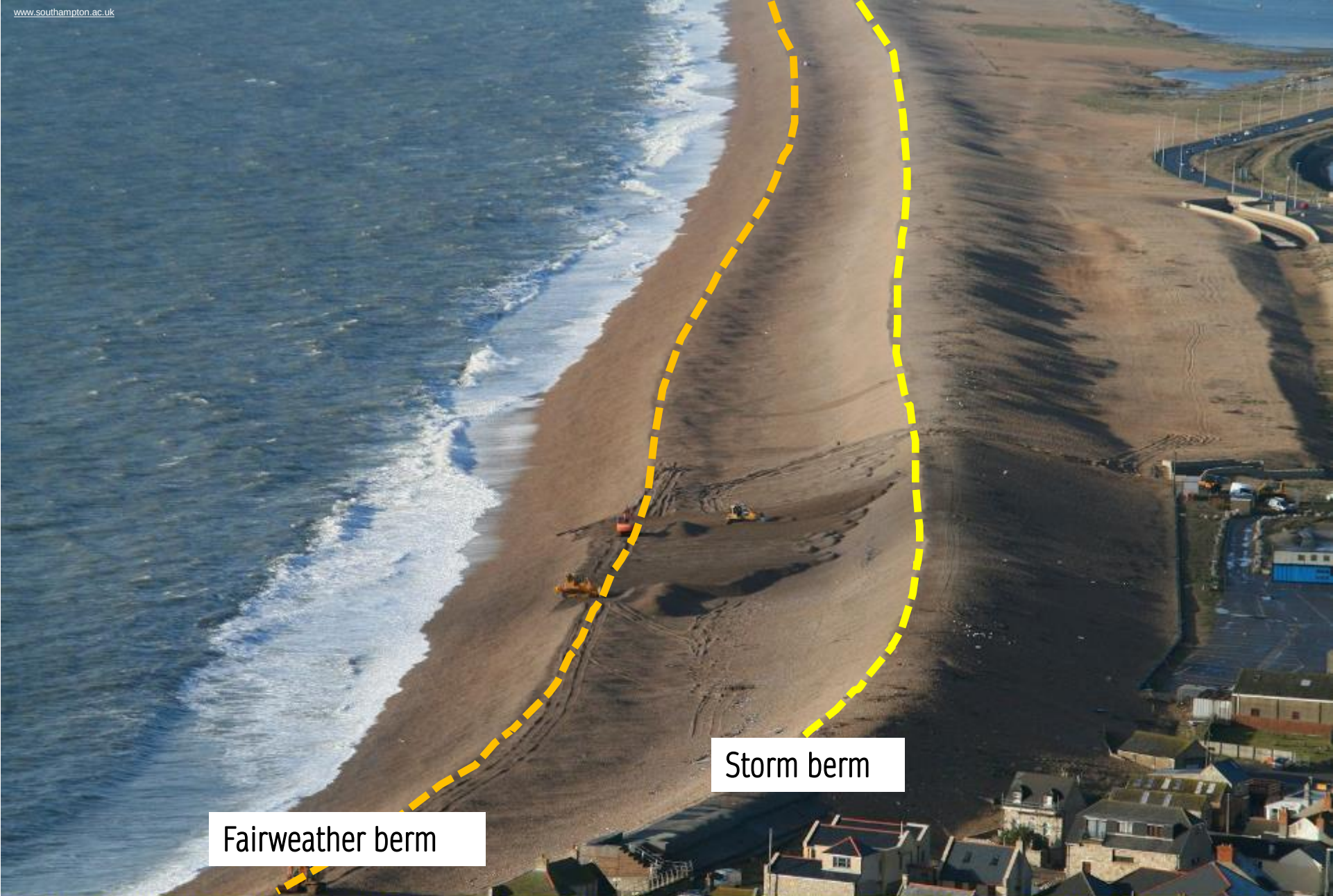
(2) Beach berm



Bascom's (1953) explanation of berm formation:

"After a wave breaks, the water rushes forward up the beach face, carrying sand with it, losing velocity as it goes because it is opposed by gravity and friction and because of water losses through percolation. As the beach builds seaward, it leaves a nearly horizontal berm that corresponds to the elevation to which sand had been carried by the swash runup."

BEACH BERM



Fairweather berm

Storm berm

CHESIL BEACH AFTER THE STORM OF 6-7th JANUARY 2014, SHOWING A STEEP SEAWARD SLOPE IN THE UPPER PART, AND A STORM TRASH-LINE ON THE VERY CREST OF THE BANK. This storm caused erosion of the beach. It was moderately bad storm but not at all on the scale of 1824-type of hurricane, which of course is expected again sooner or later. The beach does not seem to have been seriously overtopped or suffered any major reduction in height of the crest. The main effect in this area was an appreciable steeping of the seaward-sloping surface and an apparent landward retreat of the seaward face. Loss of pebbles has probably been into relatively shallow water on the seaward side. The landward side does not seem to have moved on landward to any significant extent. That will happen when a major overtopping storm occurs and new washover fans are formed in the low landward area. Photo: 17th Jan. 2014. Ian West © 2014.



LARGE SCALE COASTAL CONTROLS

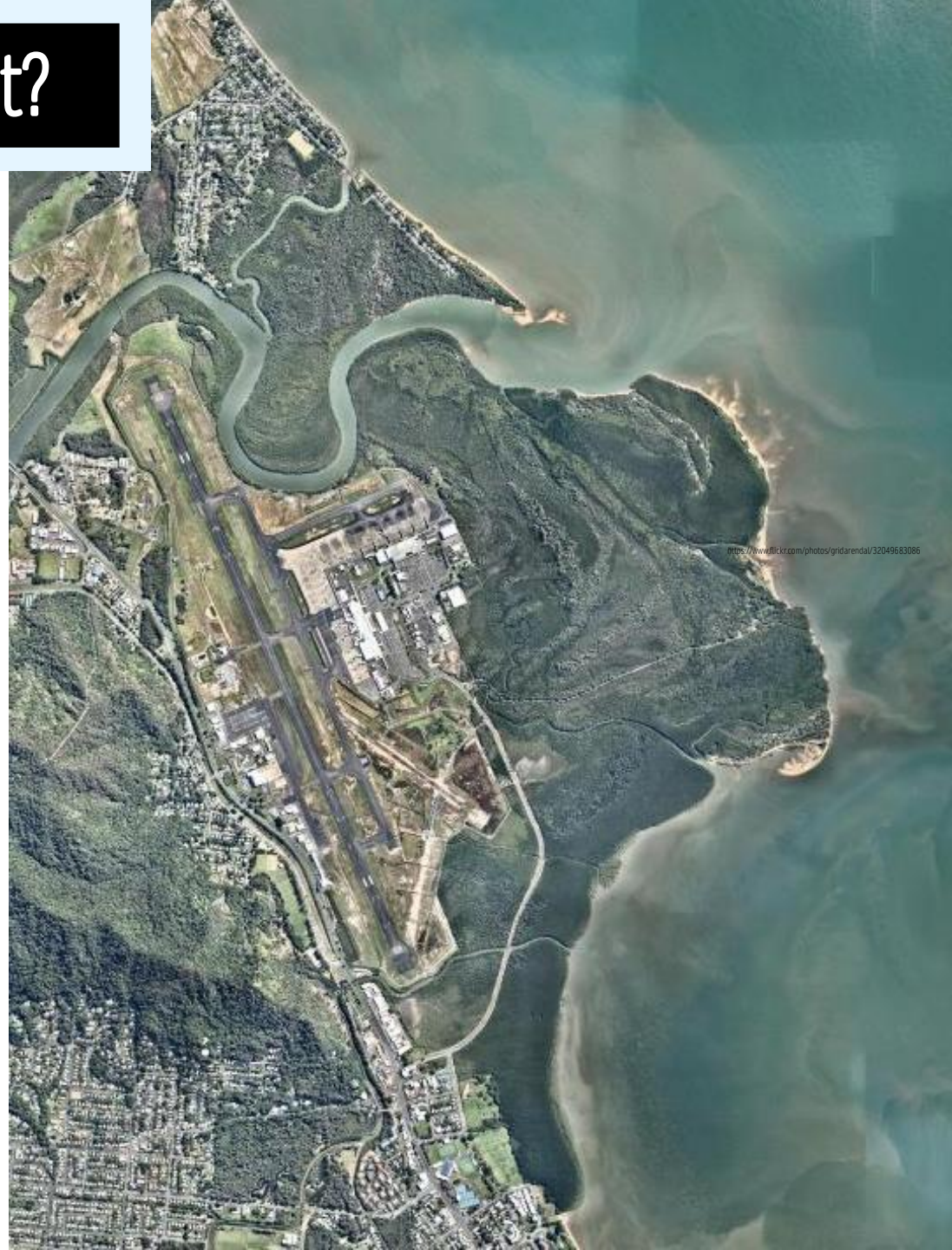


TECTONIC SETTING

SEA LEVEL

PROCESS
DOMINANCE

What shapes a coast?



Coastal boundary conditions

Coastlines are shaped by boundary conditions:

- (1) Tectonics (plate boundary position)
- (2) Sea level (rising or falling)
- (3) Process dominance (waves vs tides).

Large geological scale

Smaller local scale



(1) Tectonic setting

Influence first and second order coastal features (i.e. 1000 - 1 km)

Tectonic setting controls morphology of drainage basins + sed supply

These factors and the age of the coast determine shelf width

Wave energy is greatly dissipated across a wide continental shelf

Active coast = close to plate boundary. Passive = away from it.



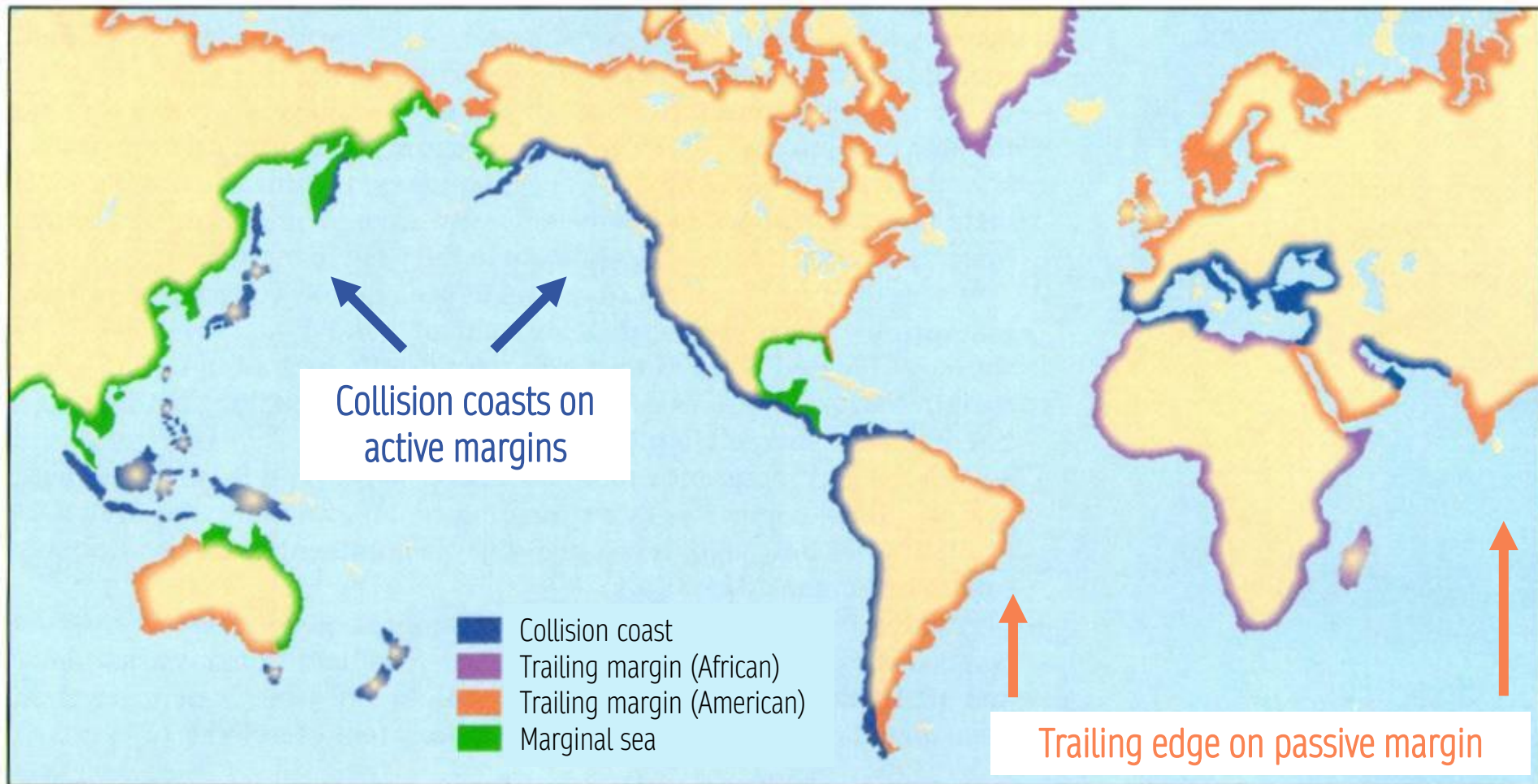
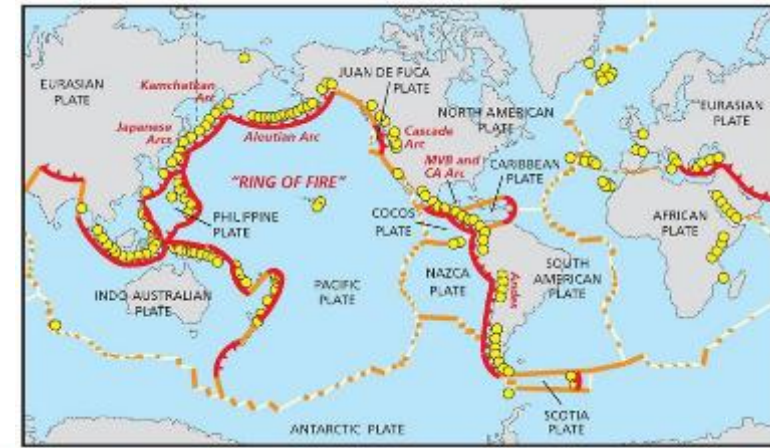
Tectonic setting = location with respect to plate boundaries.

3 coast types globally (Inman & Nordstrom, 1971)

Collision coast; trailing edge coast; marginal seas

Active margin = collision coast.

Passive margin = trailing edge coast.



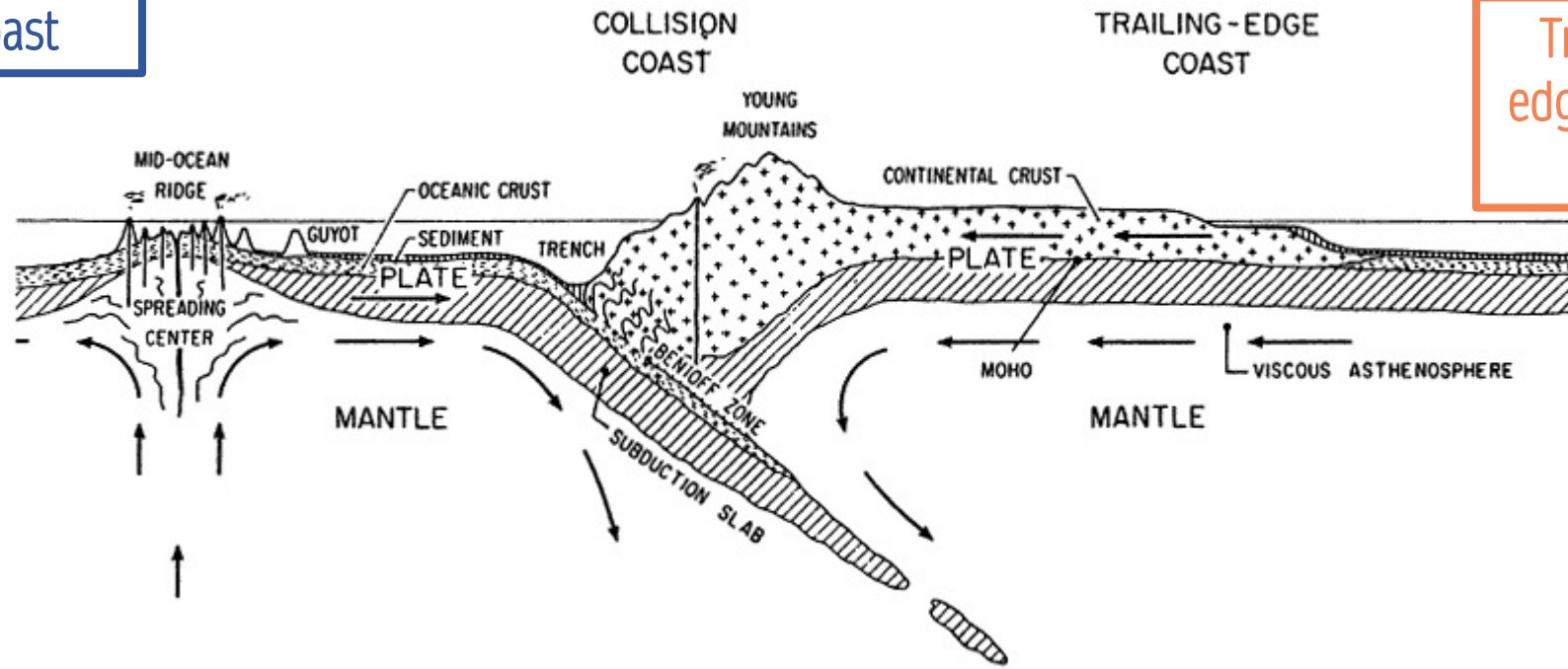
GEOLOGICAL

Collision coast

OCEAN BASIN

CONTINENT

OCEAN BASIN

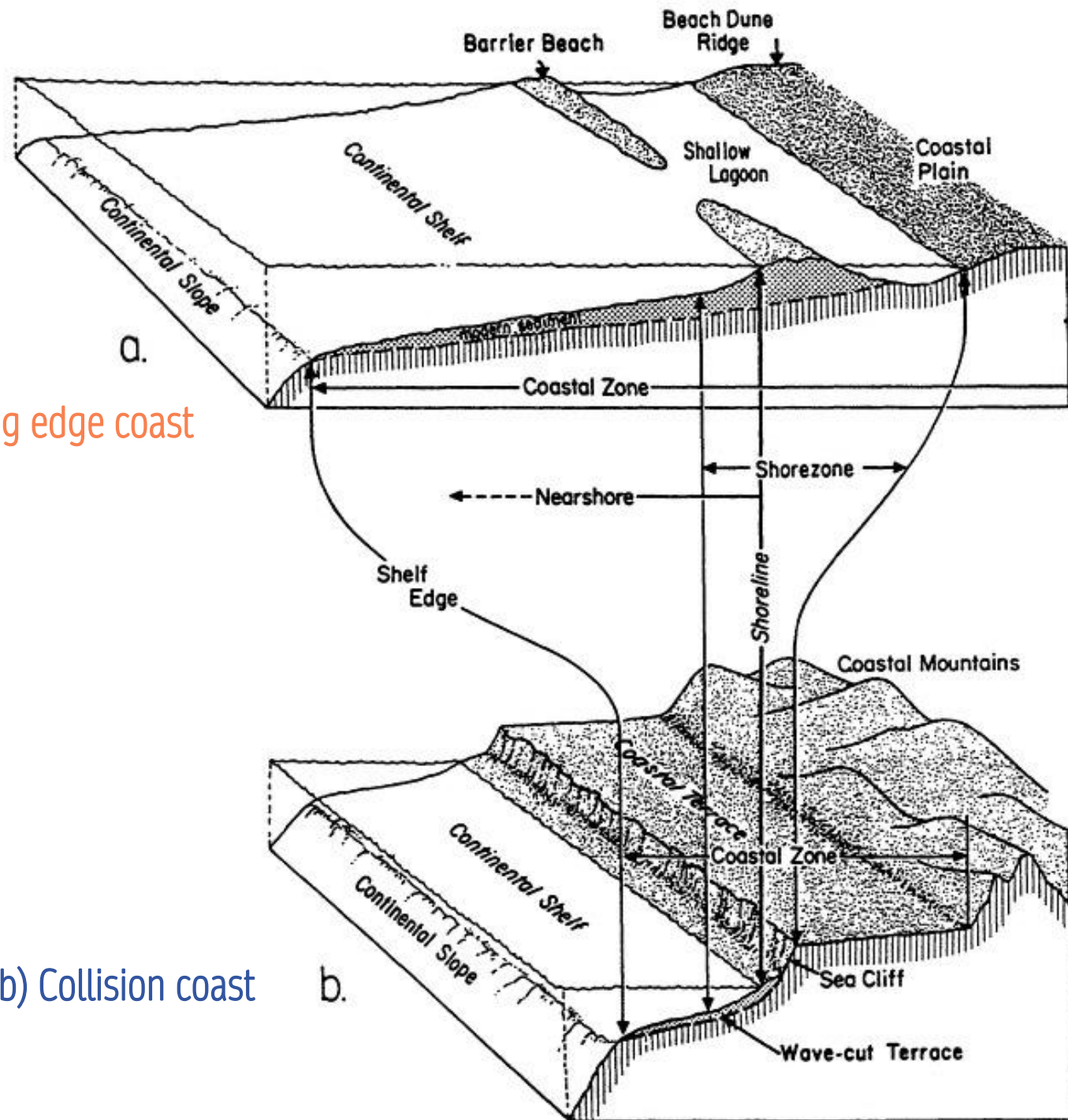


Trailing edge coast

e.g. California (collision coast)

e.g. Louisiana (trailing edge coast)



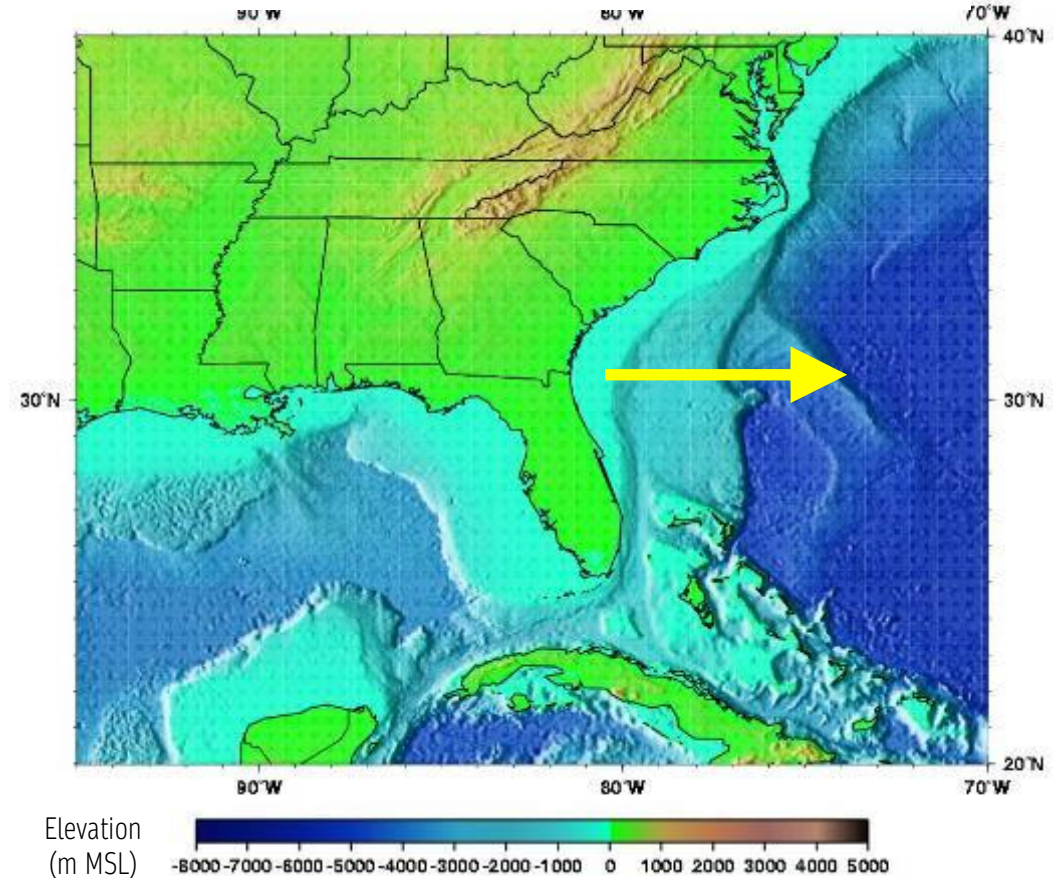


(a) Trailing edge coast

(b) Collision coast

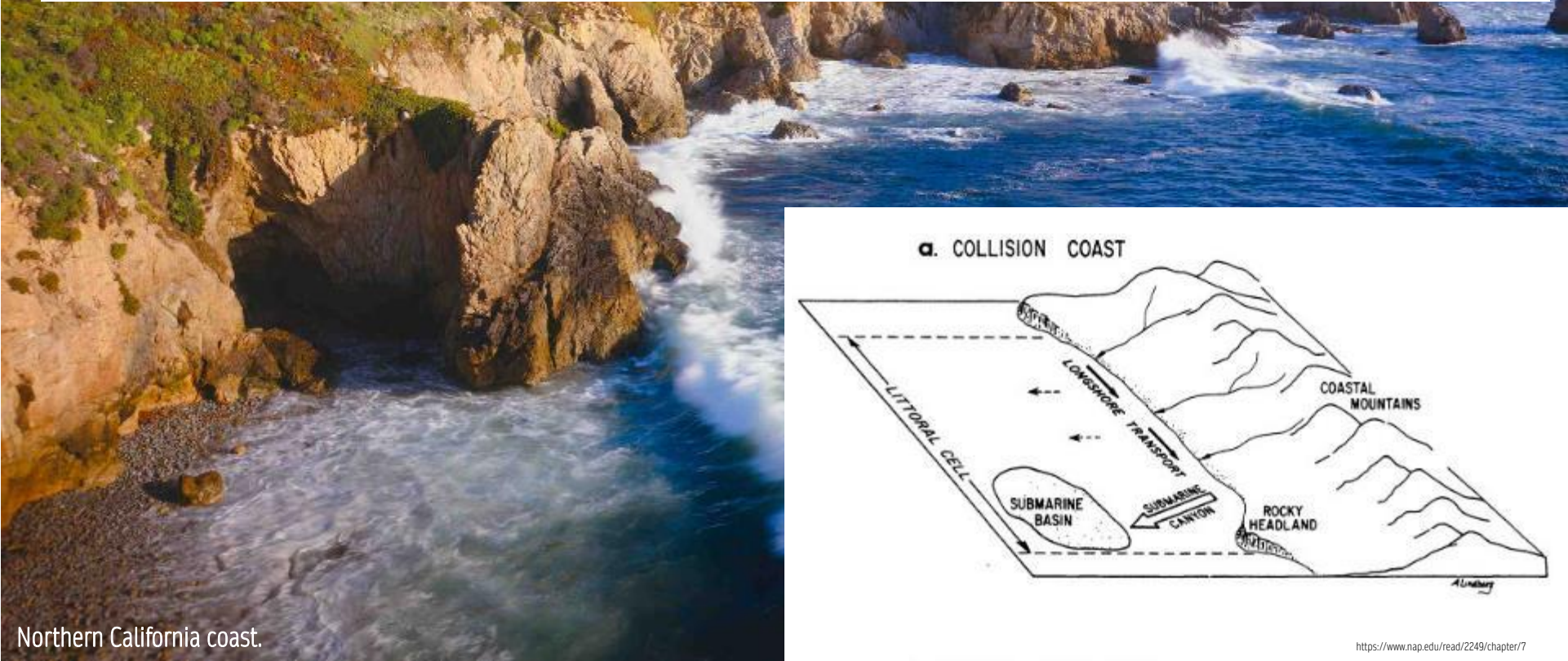
(a) Trailing edge coast (passive margin)

- Located far from the active plate boundary (i.e. passive areas)
- Wide coastal plain and continental shelf (also quite shallow)
- Depositional landforms: deltas, estuaries, barriers, and lagoons.

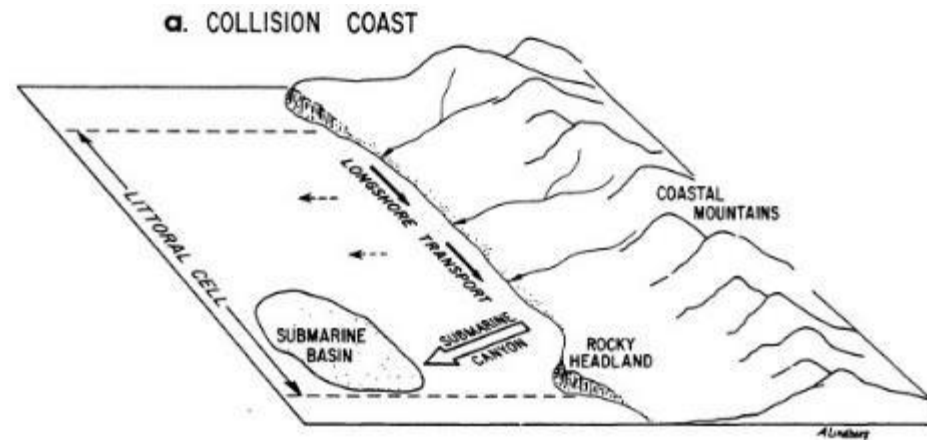


(b) Collision coast (active margin)

- Found on leading edge of the continent where it is crashing into an oceanic plate (i.e. collision) - mountainous and tectonically active
- Narrow continental shelves and steep continental slopes
- Large deltas and barrier islands systems are largely lacking



Northern California coast.

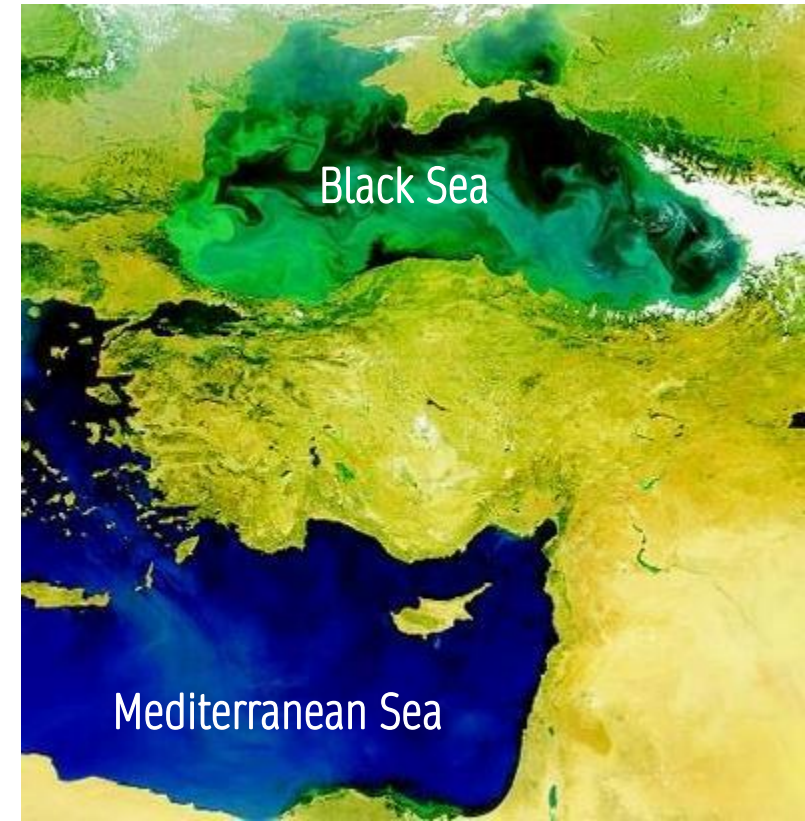


(c) Marginal seas

- Semi connected to the open ocean
- Can be sheltered by islands, barriers or continents - lower waves
- Generally shallow in comparison to the open ocean
- Tend to have irregular shaped shorelines.



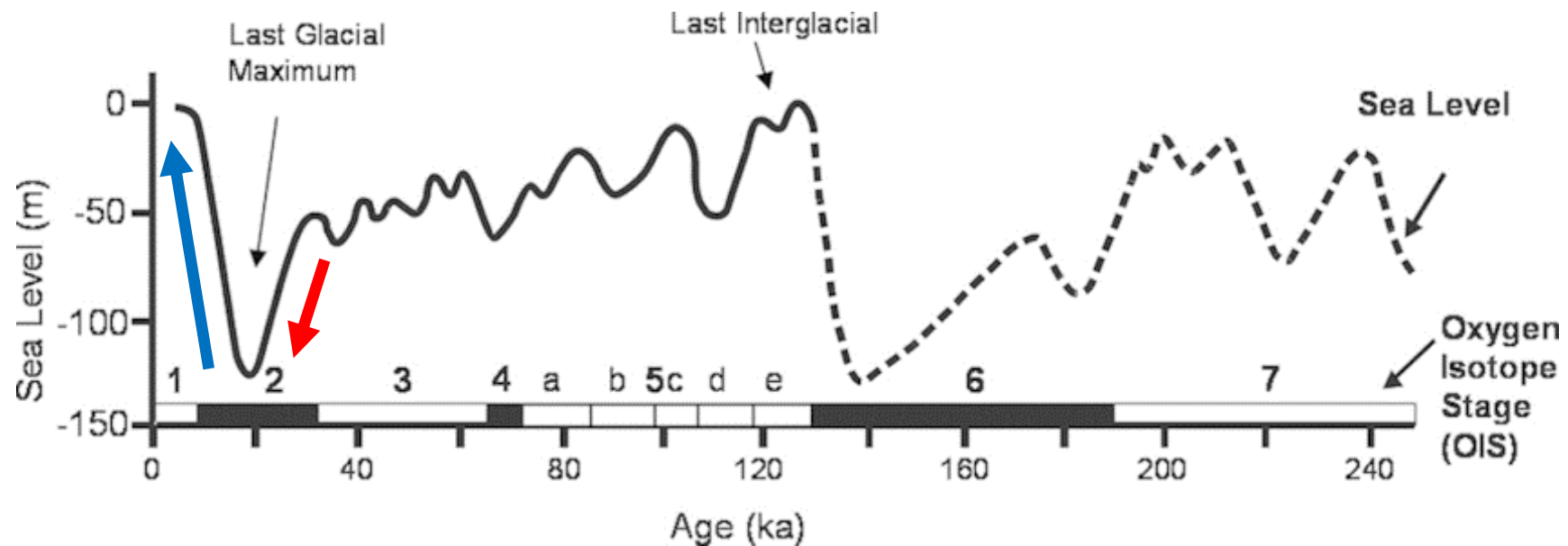
Examples: Mediterranean Sea and Black Sea



(2) Sea level

Sea level can either be stable or rising or falling:

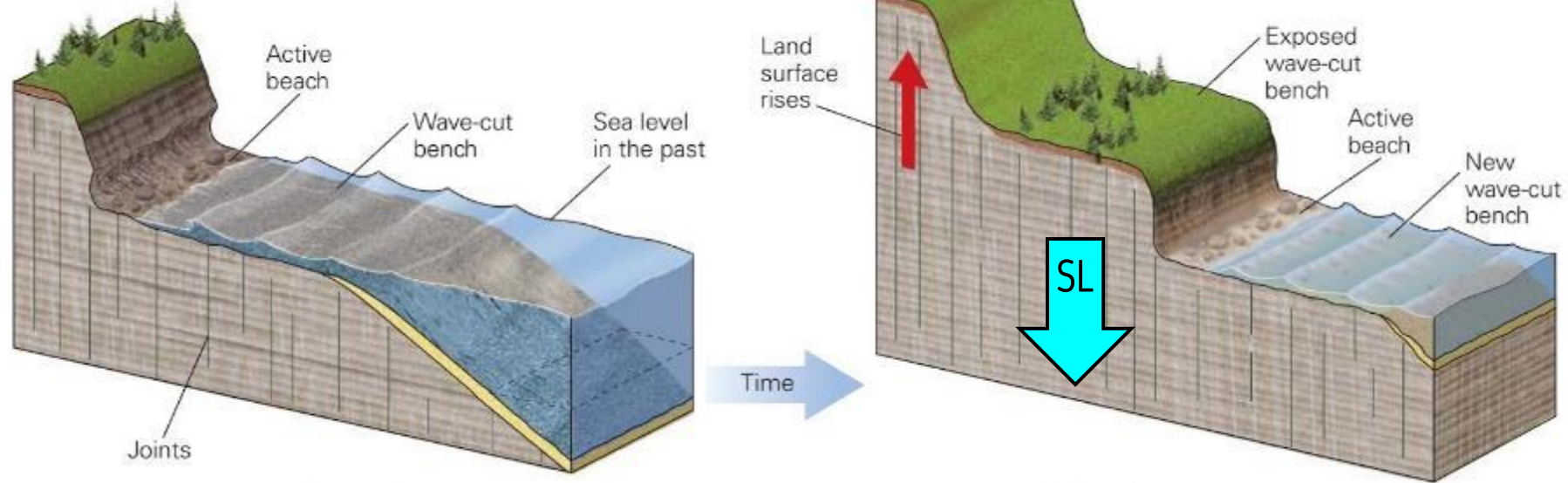
- **Transgression** - rising and forms submergent coasts
- **Regression** - falling and forms emergent coasts.



OIS (or MIS) (the numbers on the bottom of the graph) represent alternating warm and cool periods (which drive sea level change).

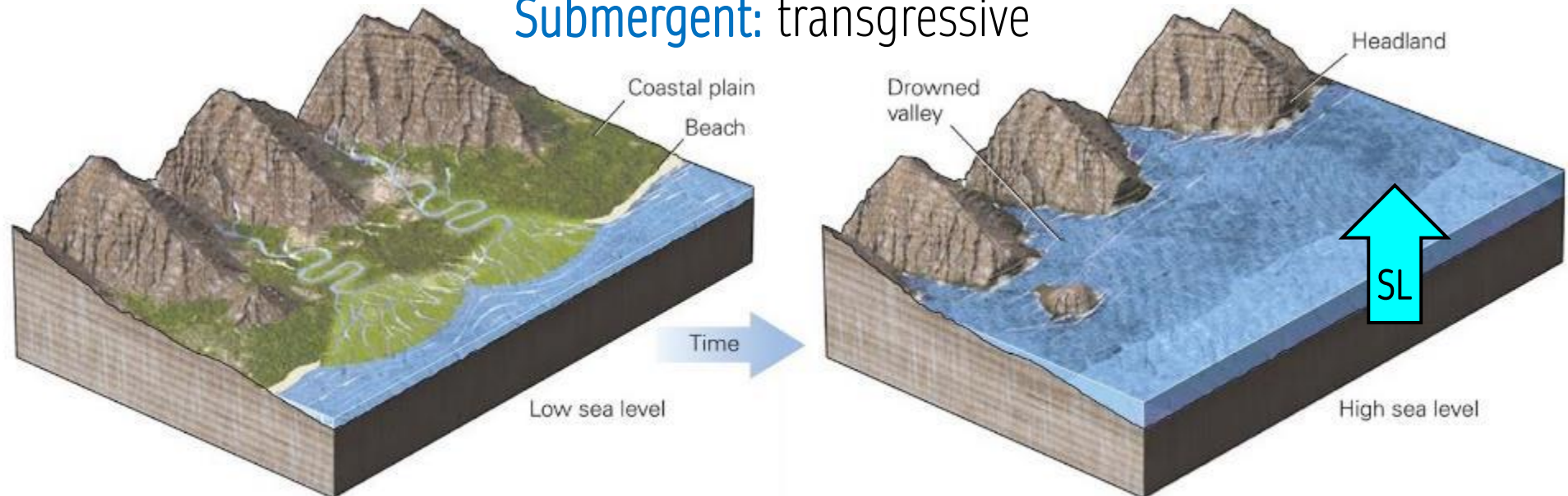
Emergent coast: regressive sea level

SEA LEVEL



(a) Emergent coasts: Wave erosion produces a wave-cut bench along an emergent coast. As the land rises, the bench becomes a terrace, and a new wave-cut bench forms.

Submergent: transgressive

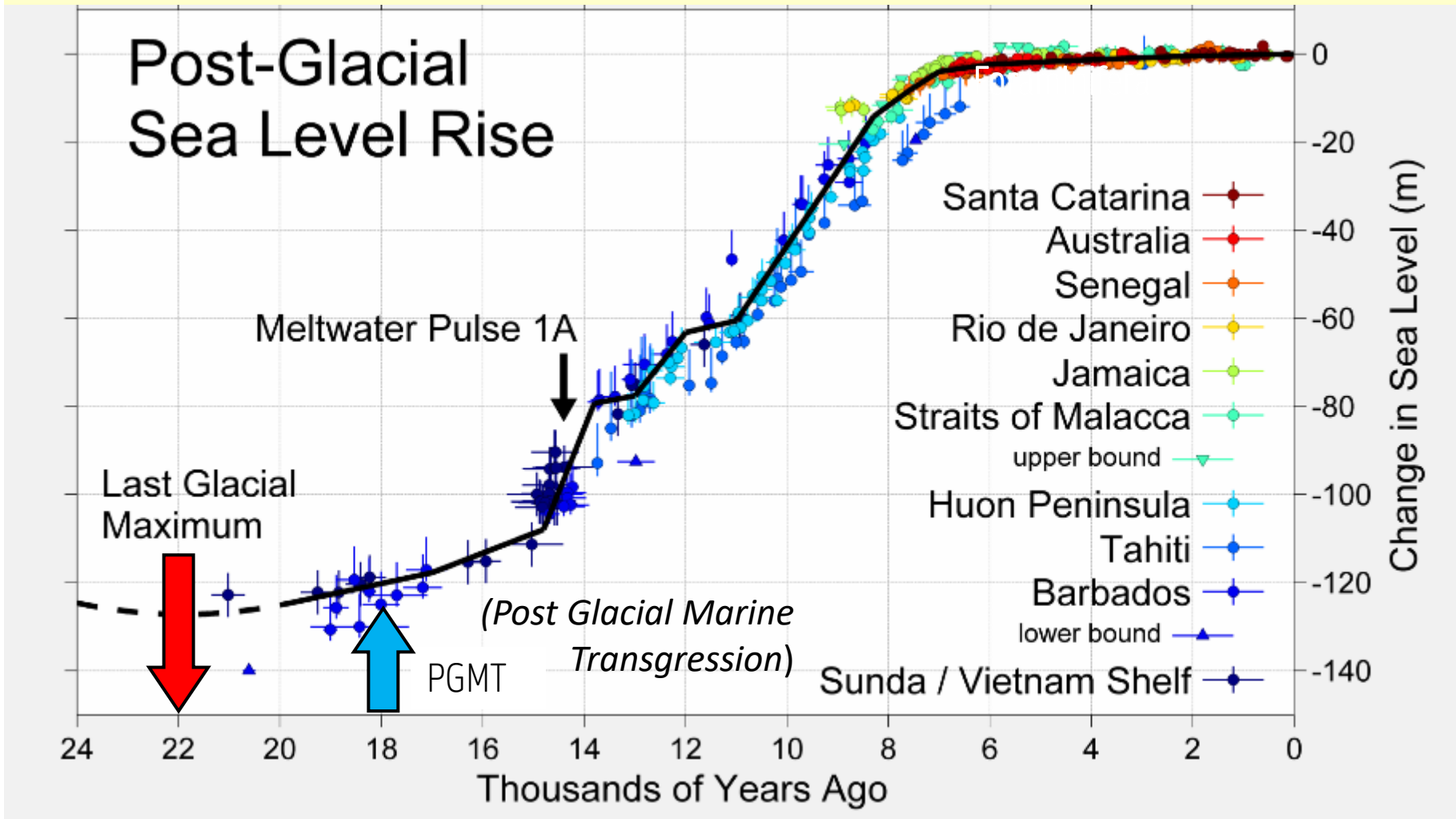


(b) Submergent coasts: A coast before sea level rises. Rivers drain valleys and deposit sediment on a coastal plain. As a submergent coast forms, sea level rises and floods the valleys, and waves erode the headlands.

Sea level (SL) curves

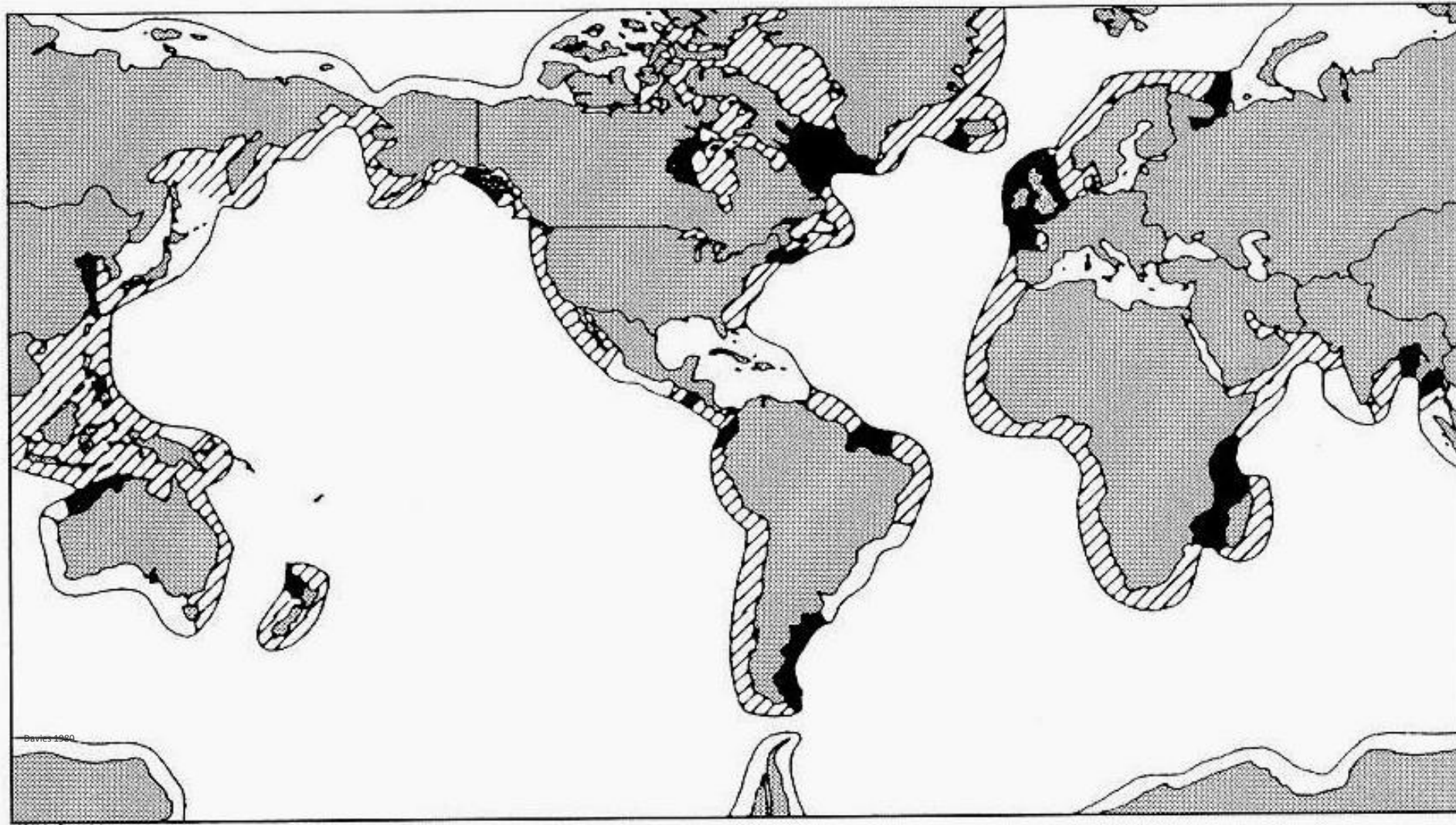
SL curves show the change in SL over time - e.g. the Holocene PGM.T.

SEA LEVEL



Classification of coasts by tidal range

TIDAL RANGE



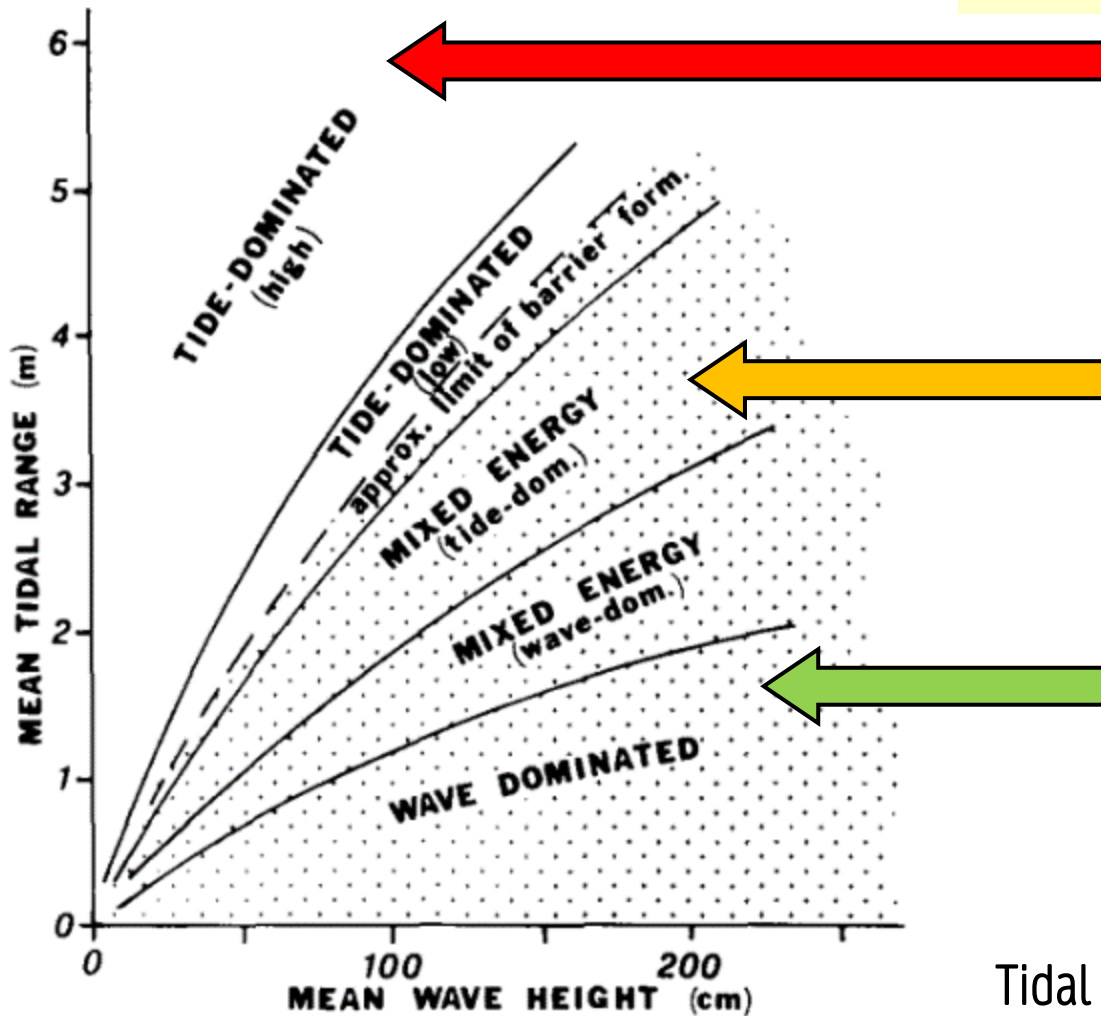
Macrotidal
Tidal range > 4 m

Mesotidal
Tidal range 2 - 4m

Microtidal
Tidal range < 2 m

(3) Waves vs tides

Wave energy vs tidal energy determines coastal morphology



(3) Tide dominated

Low wave energy

TR > 4 m macrotidal

(2) Mixed energy

Mod. wave energy

TR 2-4 m mesotidal

(1) Wave dominated

High wave energy

TR < 2 m

microtidal

Tidal range (TR) (in m) = high - low tide

Relative tidal range (RTR)

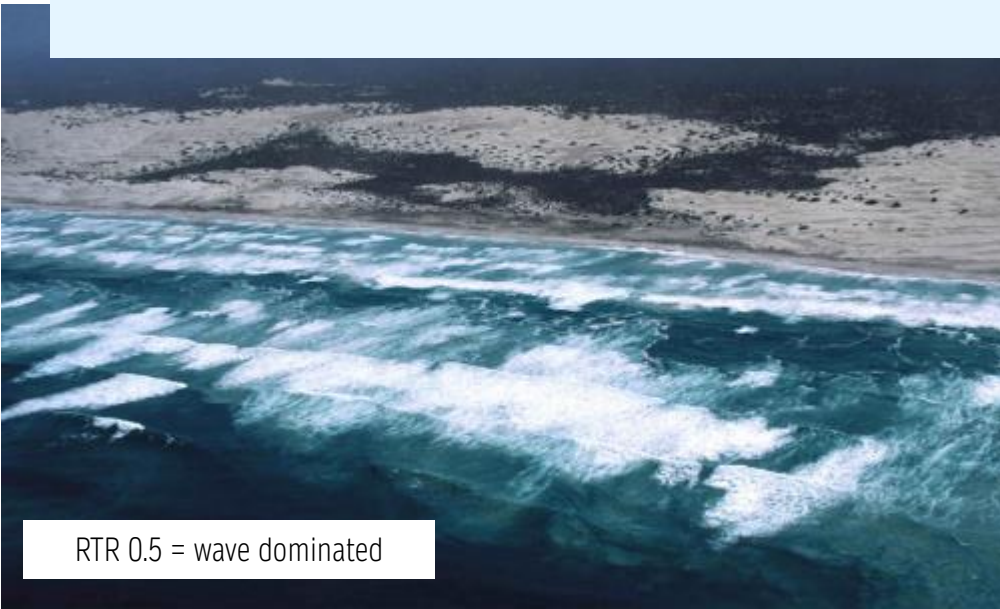
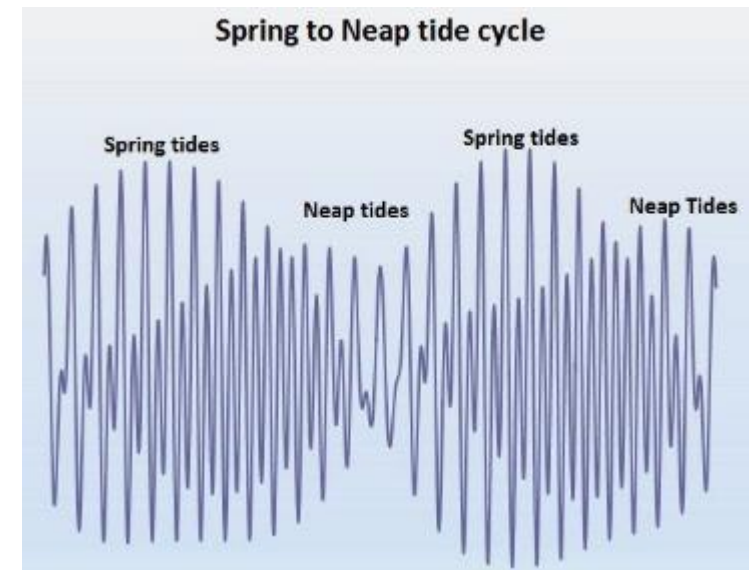
$$\text{RTR} = \text{STR} / H_b$$

STR = Spring tidal range (m)

H_b = Breaking wave height (m)

RTR is dimensionless (no unit)

$\text{RTR} > 3$ = tide dominated and $\text{RTR} < 3$ = wave dominated.



RTR 0.5 = wave dominated



RTR 6 = tide dominated

RTR in Australia:

TIDAL RANGE

RTR = 7.50

Tide-dominated (> 3)

Exmouth

Wave dominated (< 3)

Fraser Island

RTR = 0.50

RTR values



0

2

4

6

8

>10



RTR > 3 (tides dominant)

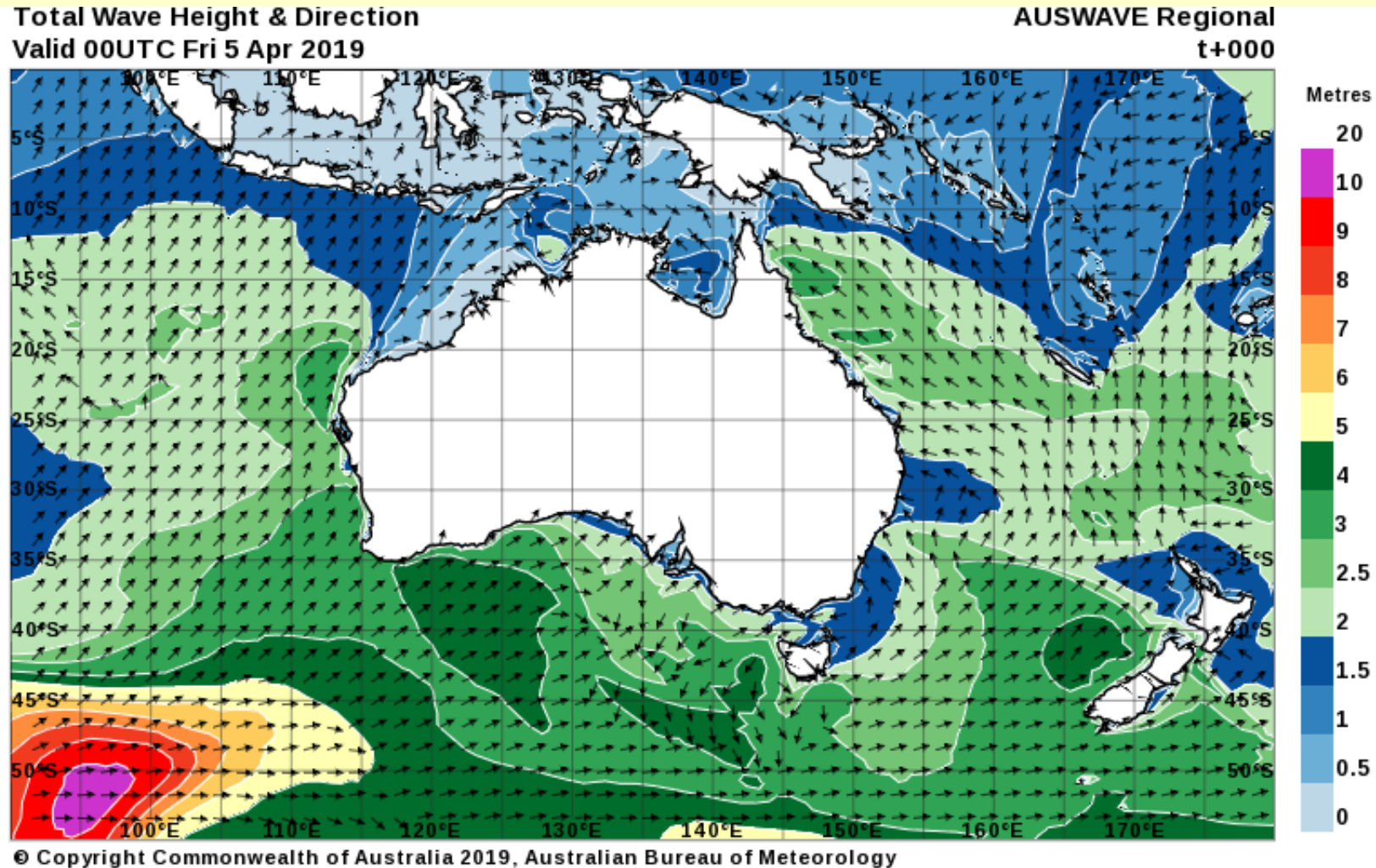


RTR < 3 (waves dominant)

What drives this split?

Southern coast is exposed to persistent high wave energy from the S - SW.

TIDAL RANGE

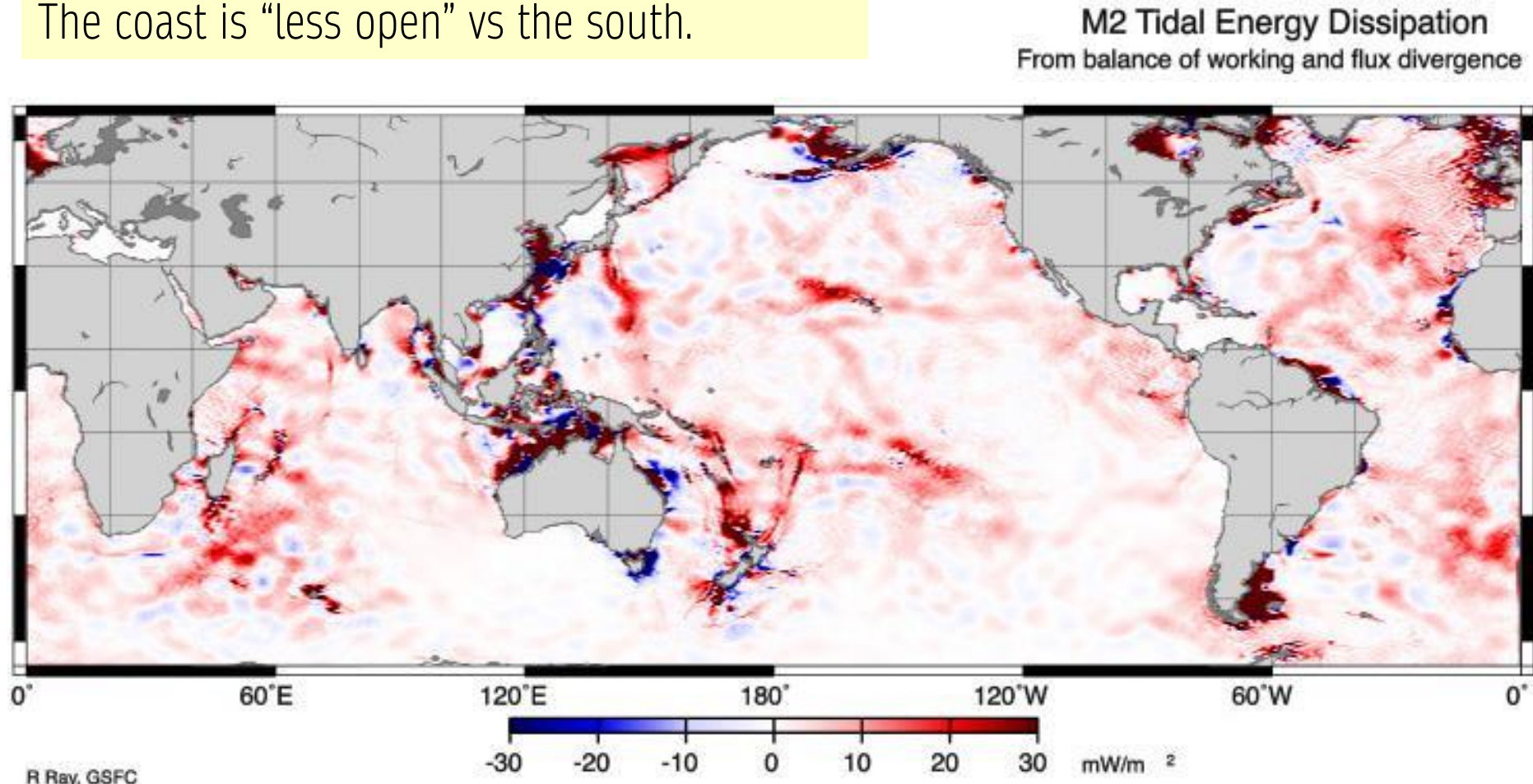


What drives this split?

TIDAL RANGE

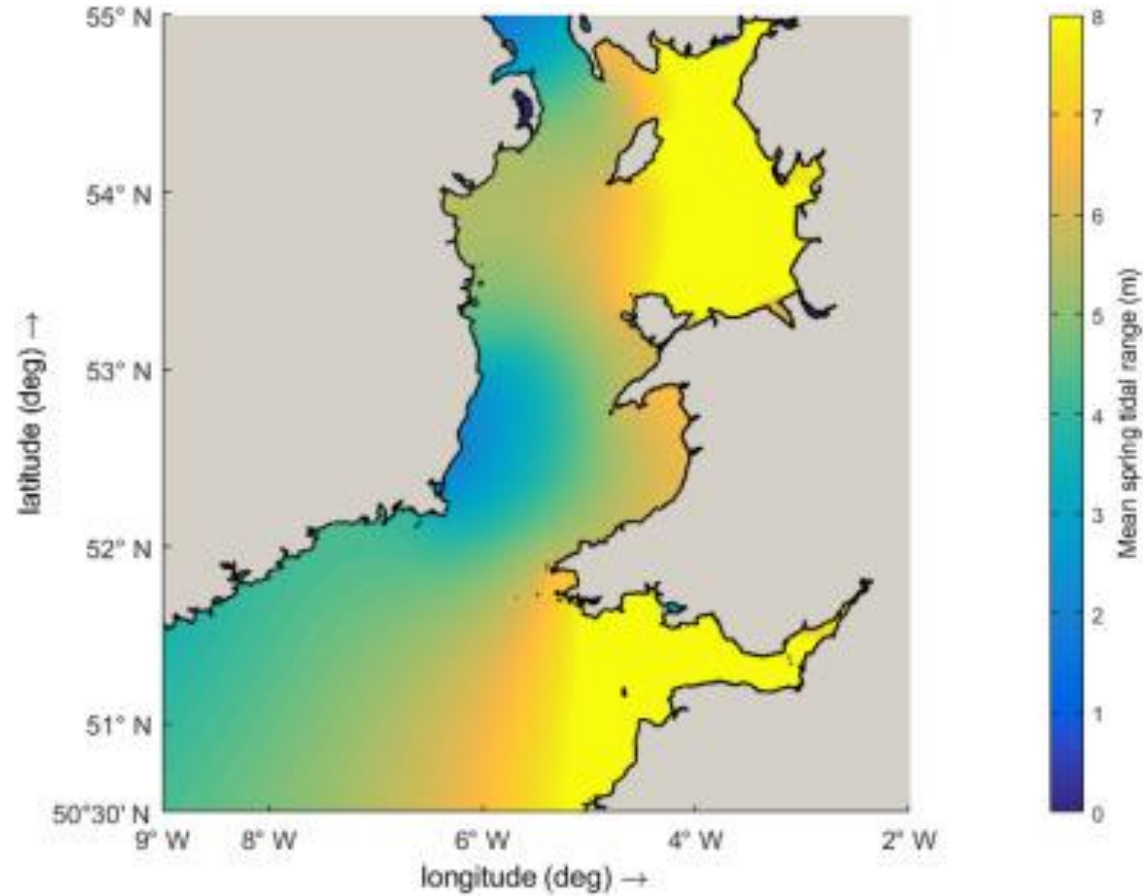
In the northern coast of Australia, there are islands and topography that can:
(1) Distort the tidal wave to amplify tides and (2) block ocean waves.

The coast is “less open” vs the south.



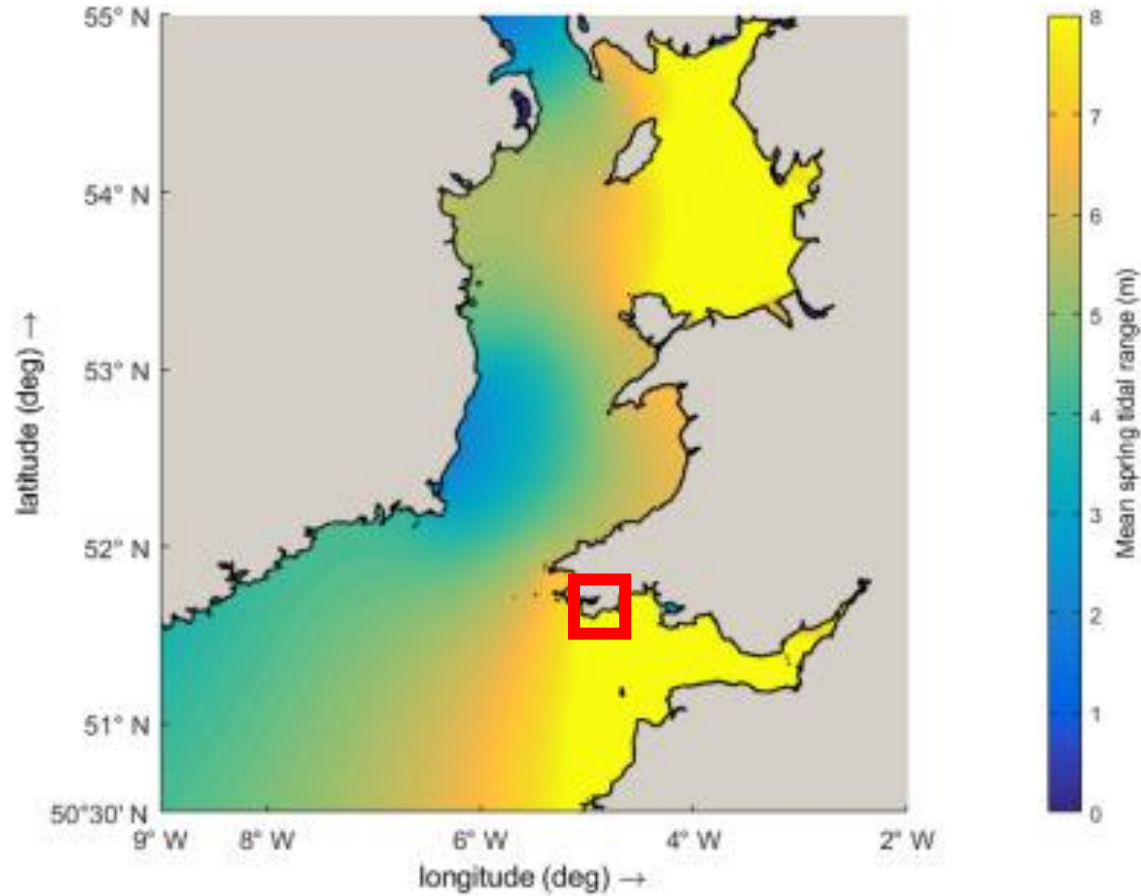
RTR in Wales: Lets do an example: Here we can see a Mean Spring Tidal Range Map from Horrillo-Caraballo et al (2021)

TIDAL RANGE



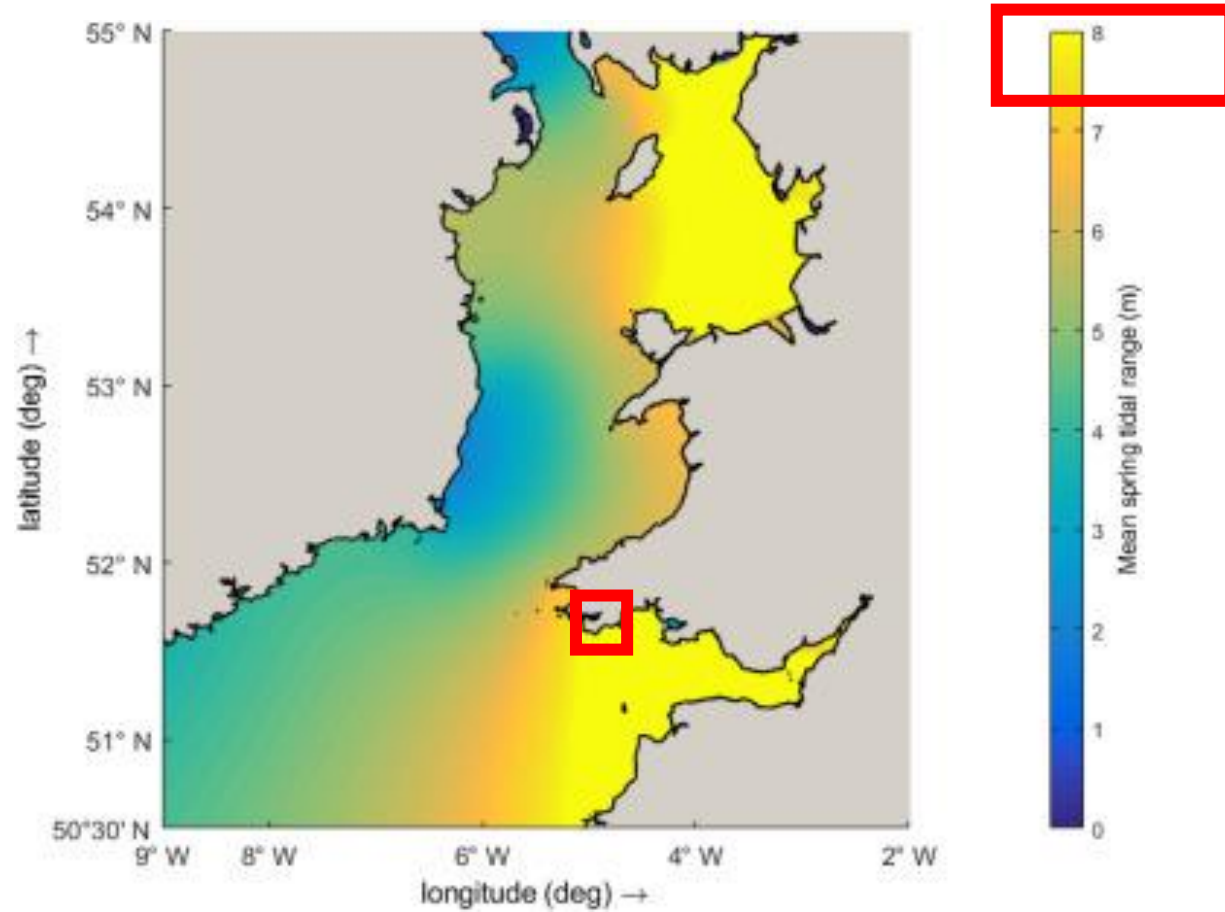
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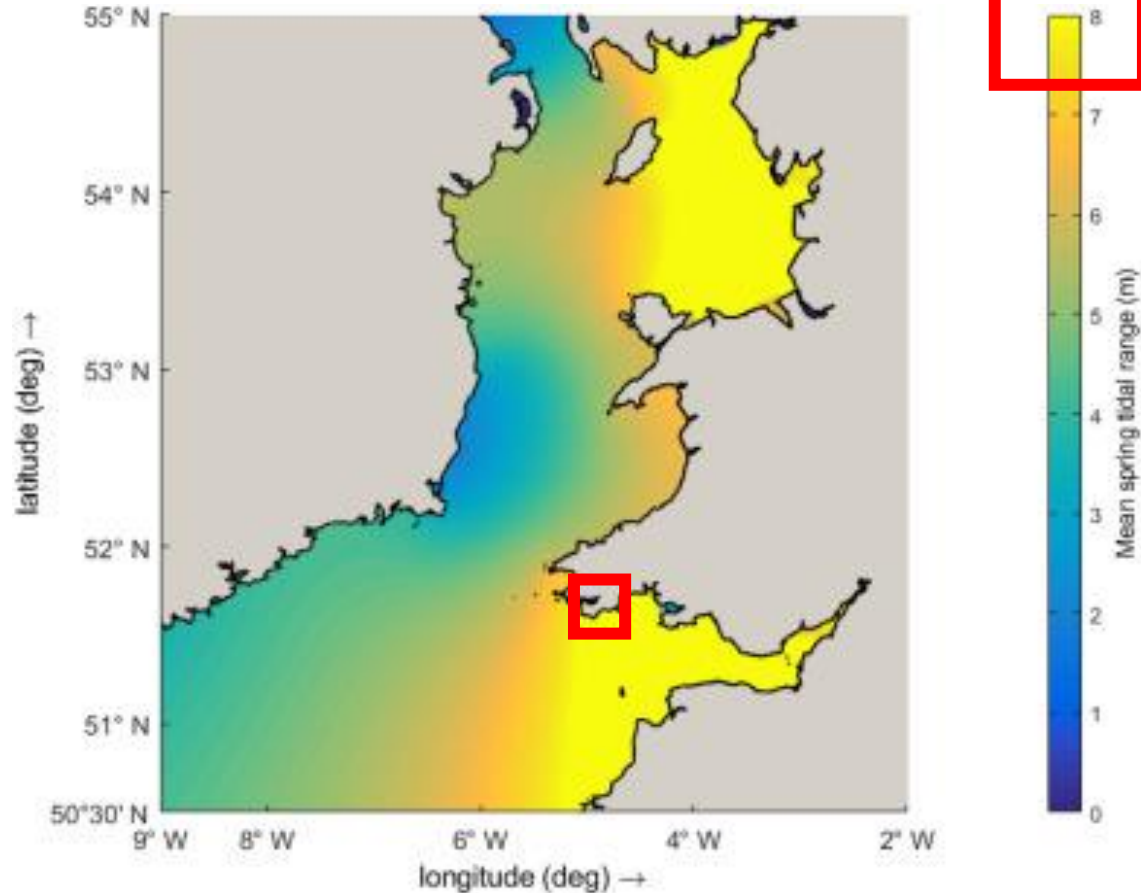
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TIDAL RANGE



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TIDAL RANGE



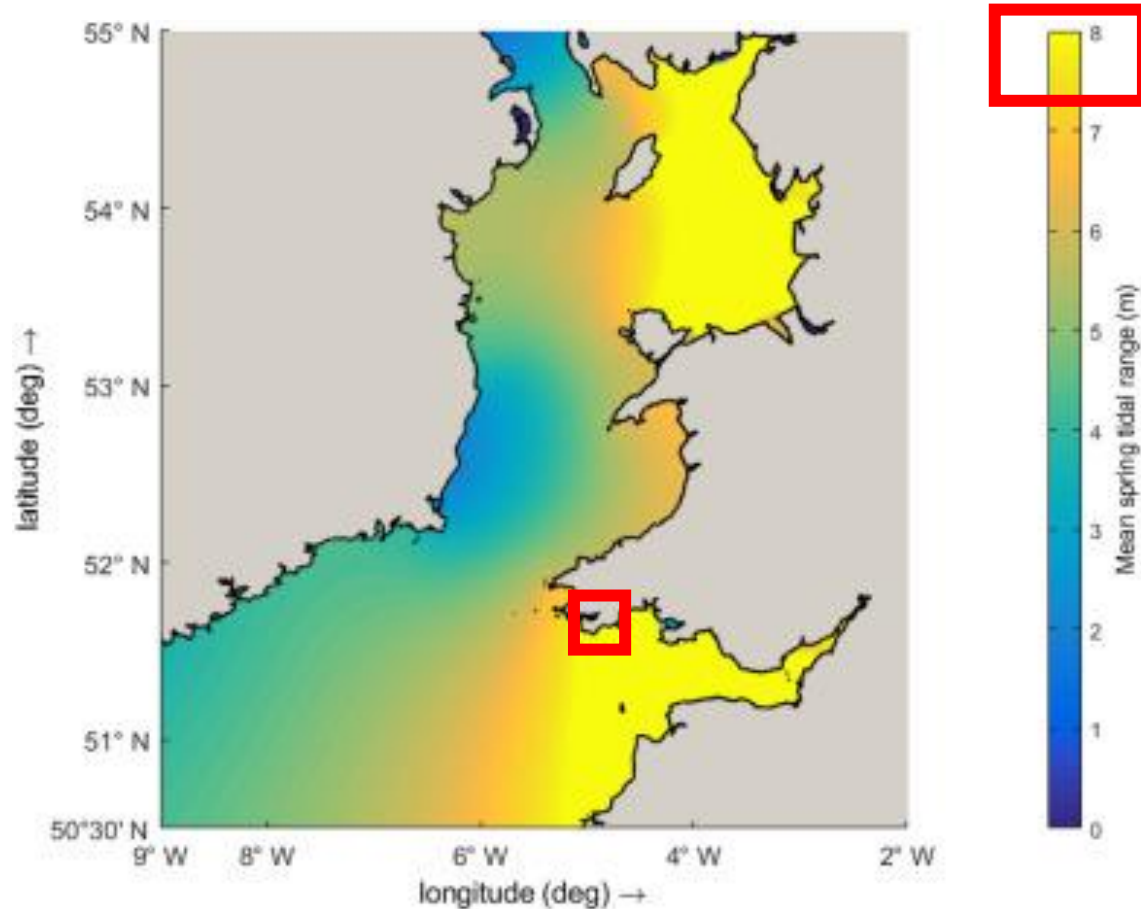
$$RTR = STR / H_b$$

STR = Spring tidal range (m)

H_b = Breaking wave height (m)

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TIDAL RANGE



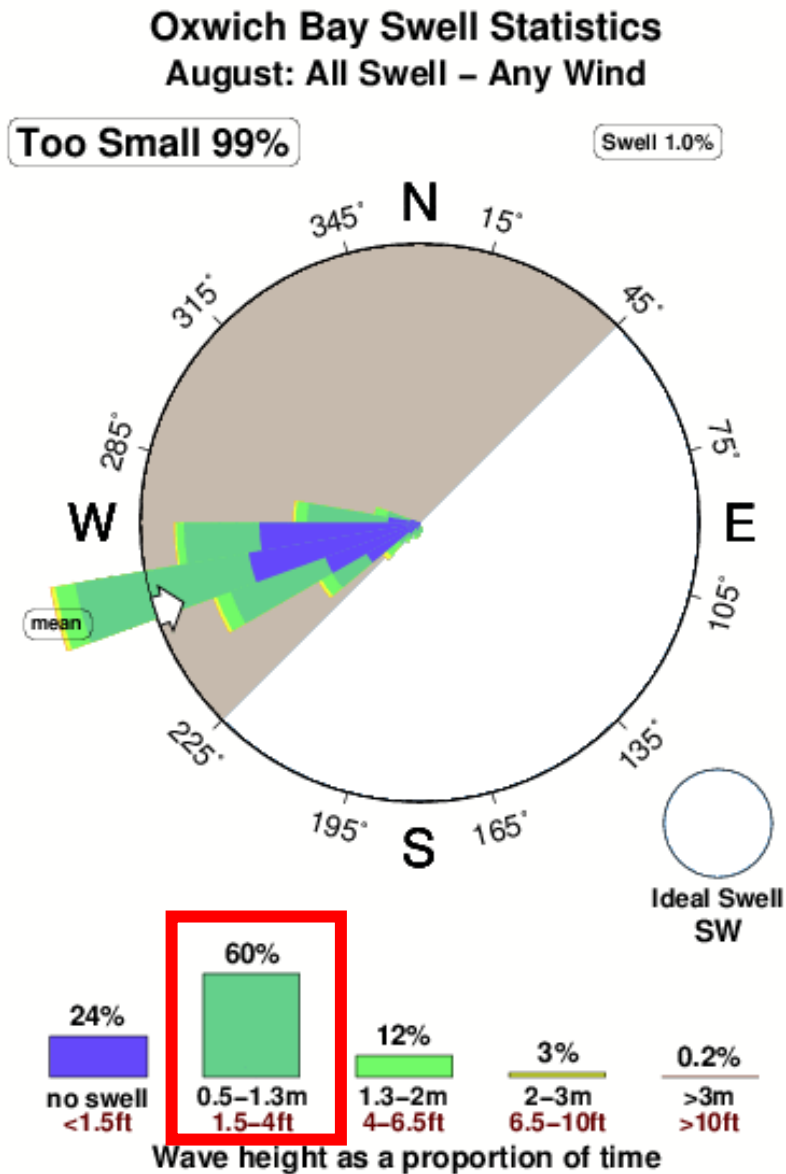
$$\text{RTR} = 8 / H_b$$

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TIDAL RANGE



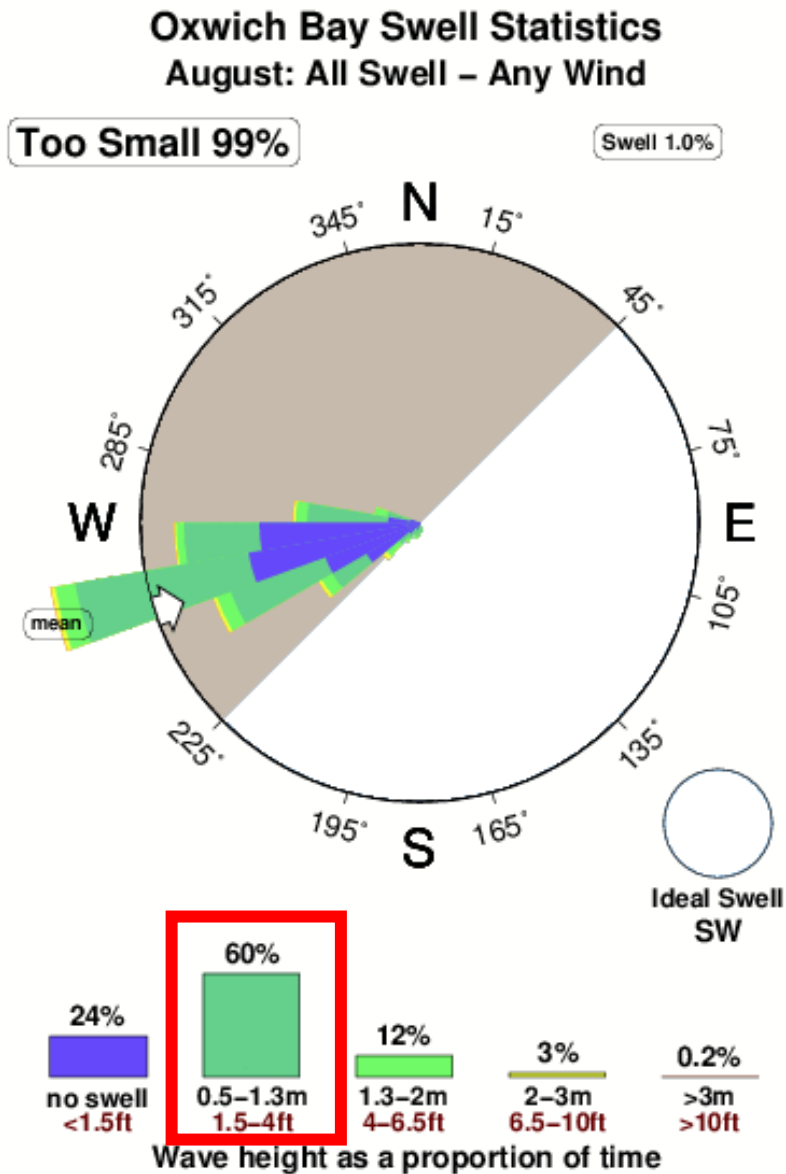
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TIDAL RANGE



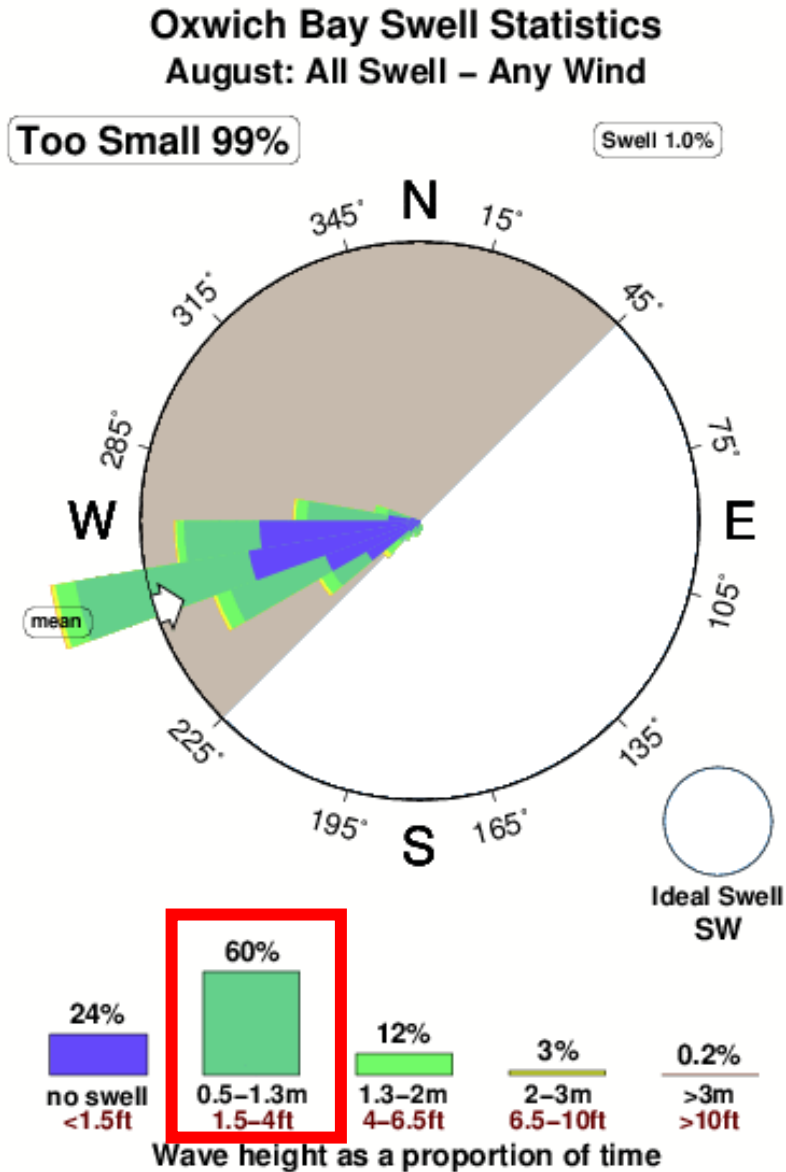
$$RTR = 8 / 1.3$$

STR = Spring tidal range (m)

H_b = Breaking wave height (m)

RTR in Wales: Lets do an example: Here we can see a Mean Spring Tidal Range Map from .Horrillo-Caraballo et al (2021)

TIDAL RANGE



$$RTR = 8 / 1.3$$

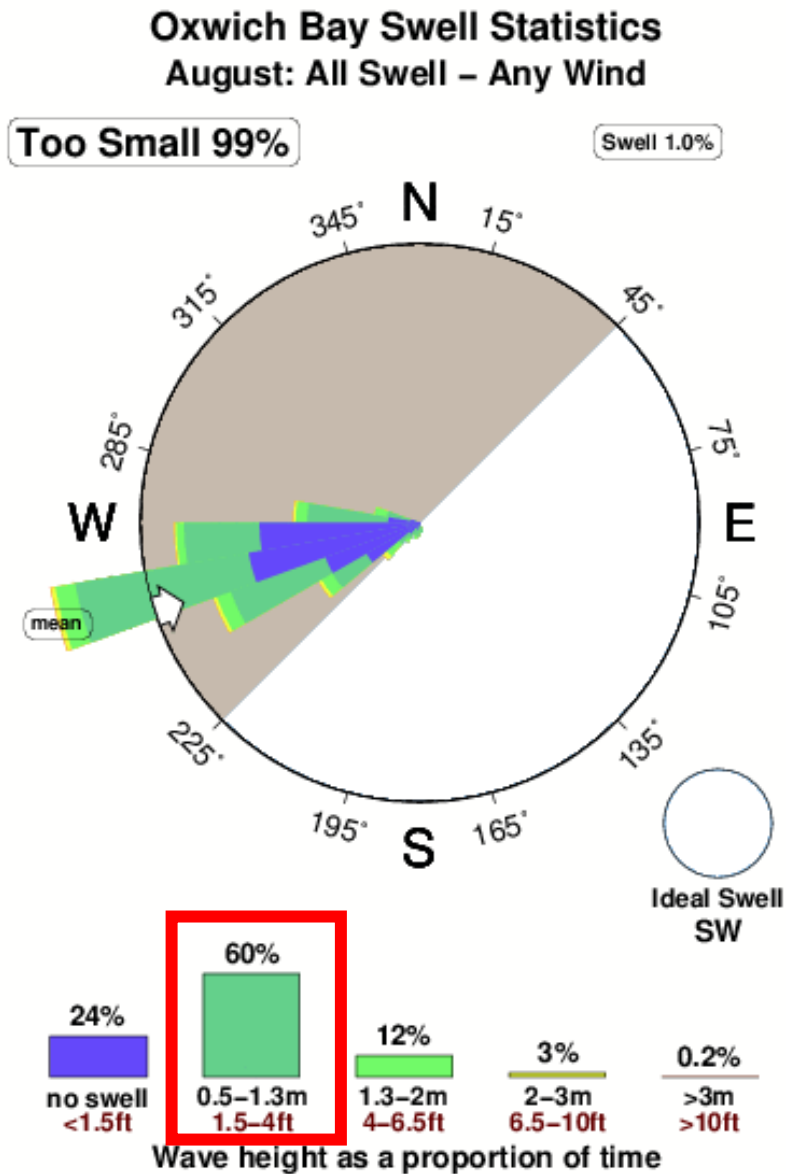
STR = Spring tidal range (m)

H_b = Breaking wave height (m)

$$RTR = 8 / 1.3 = 6.15$$

RTR in Wales: Lets do an example: Here we can see a Mean Spring Tidal Range Map from .Horrillo-Caraballo et al (2021)

TIDAL RANGE



$$RTR = 8 / 1.3$$

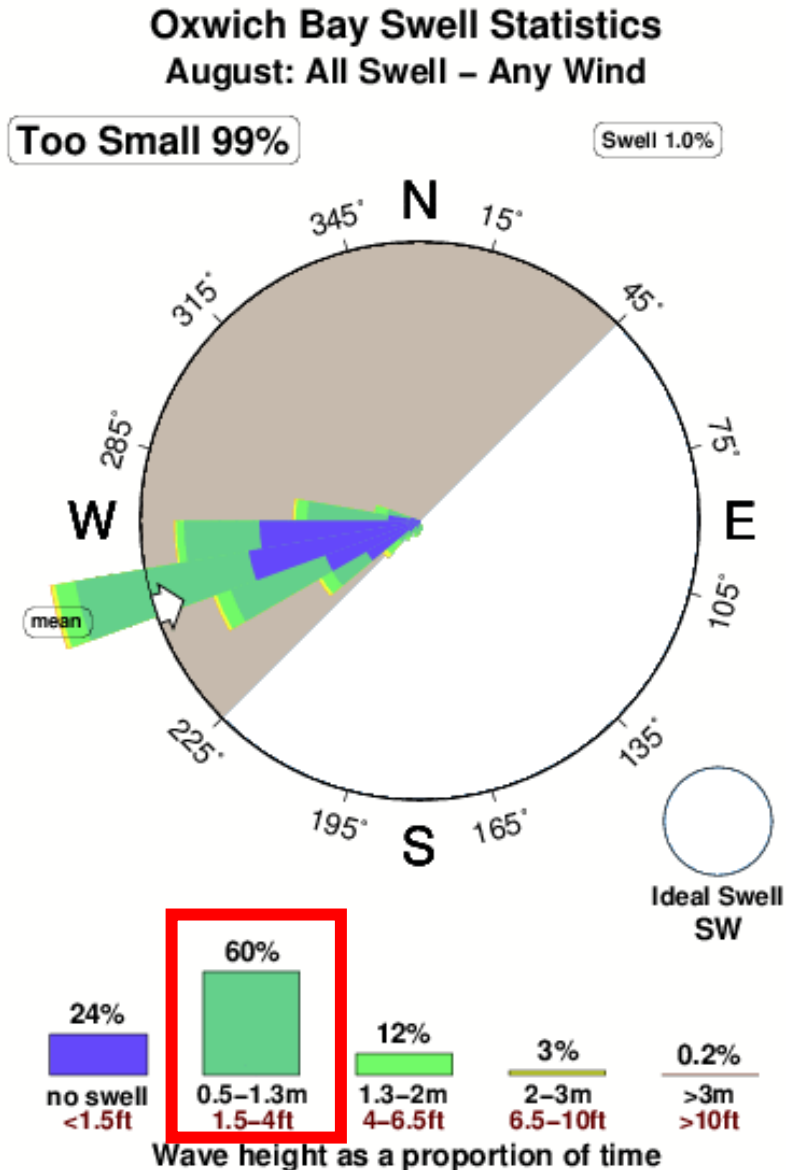
STR = Spring tidal range (m)
 H_b = Breaking wave height (m)

$$RTR = 8 / 1.3 = 6.15$$

$RTR > 3$ = tide dominated and
 $RTR < 3$ = wave dominated.

RTR in Wales: Lets do an example: Here we can see a Mean Spring Tidal Range Map from .Horrillo-Caraballo et al (2021)

TIDAL RANGE



$$RTR = 8 / 1.3$$

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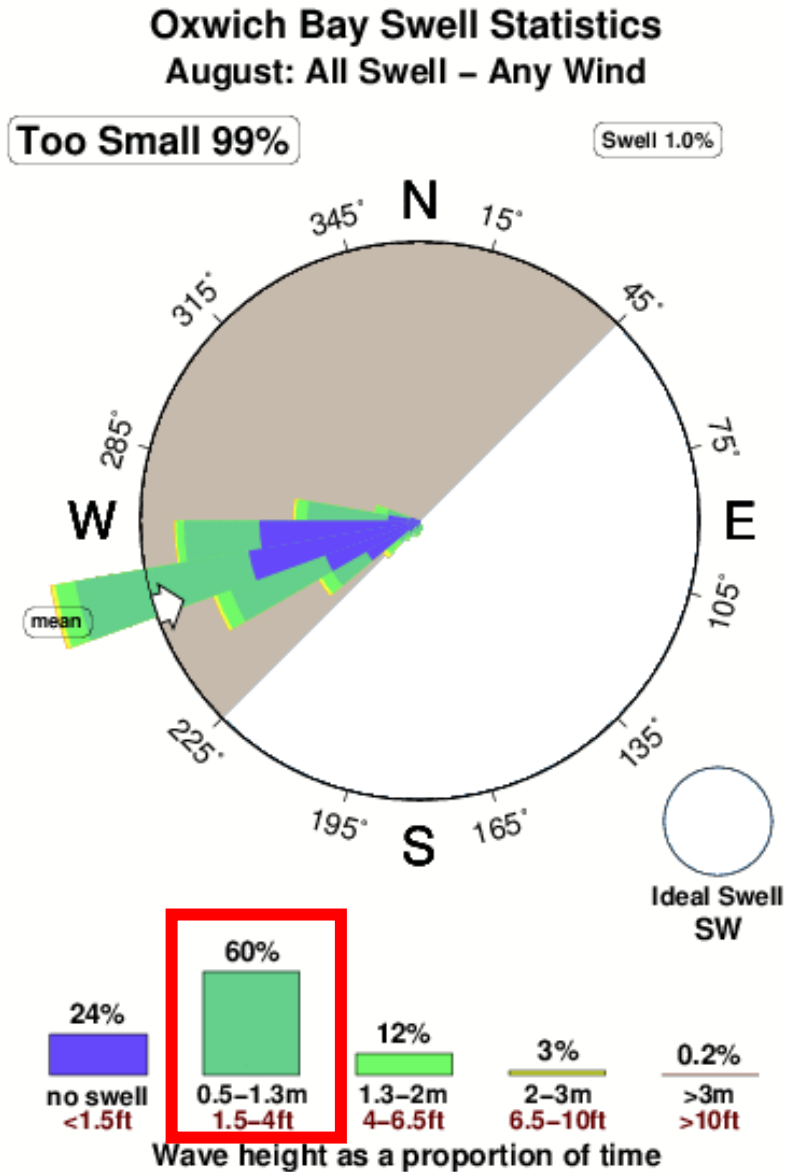
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TIDAL RANGE



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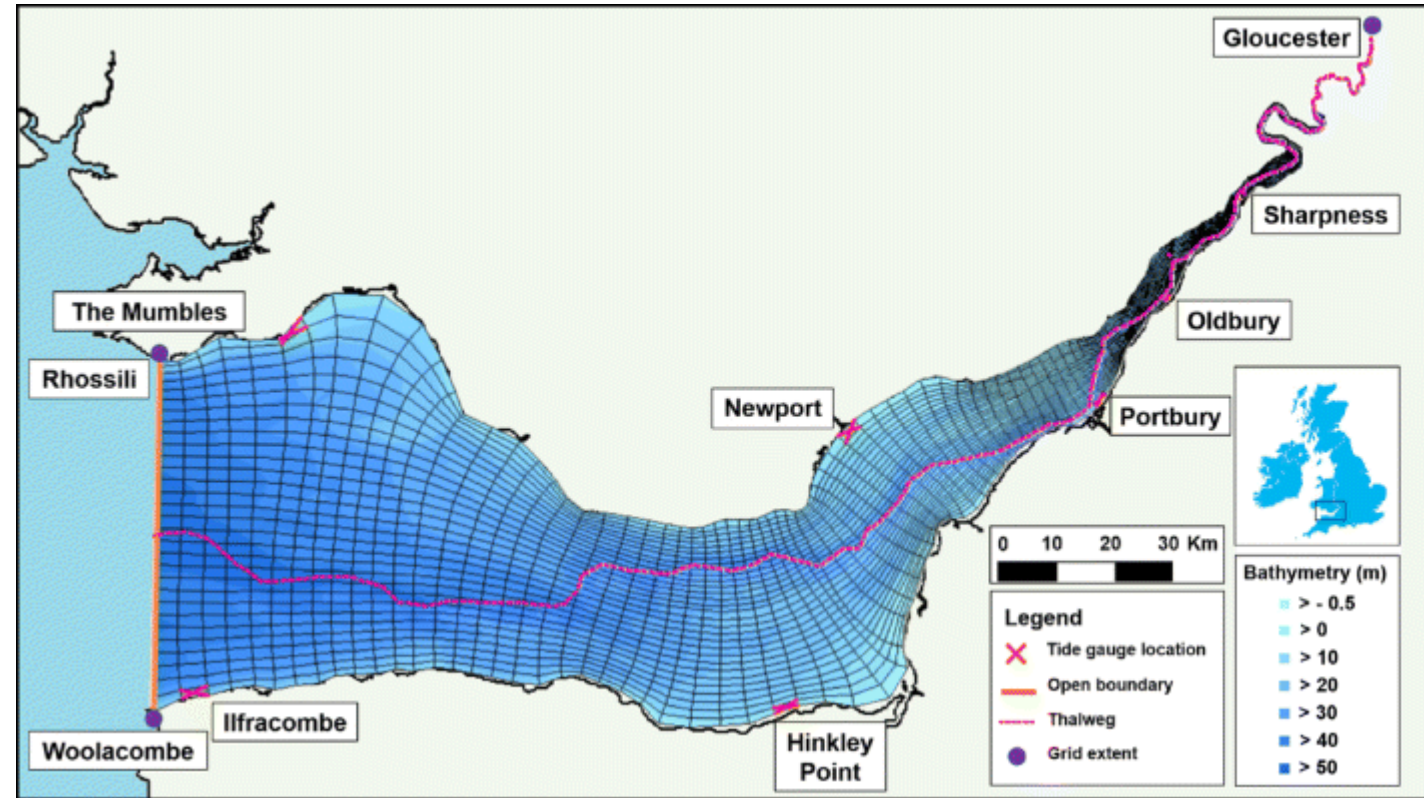
RTR > 3 = tide dominated and
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RTR in Wales:

$RTR > 3$ = tide
dominated.

Extreme tidal dominance

TIDAL RANGE



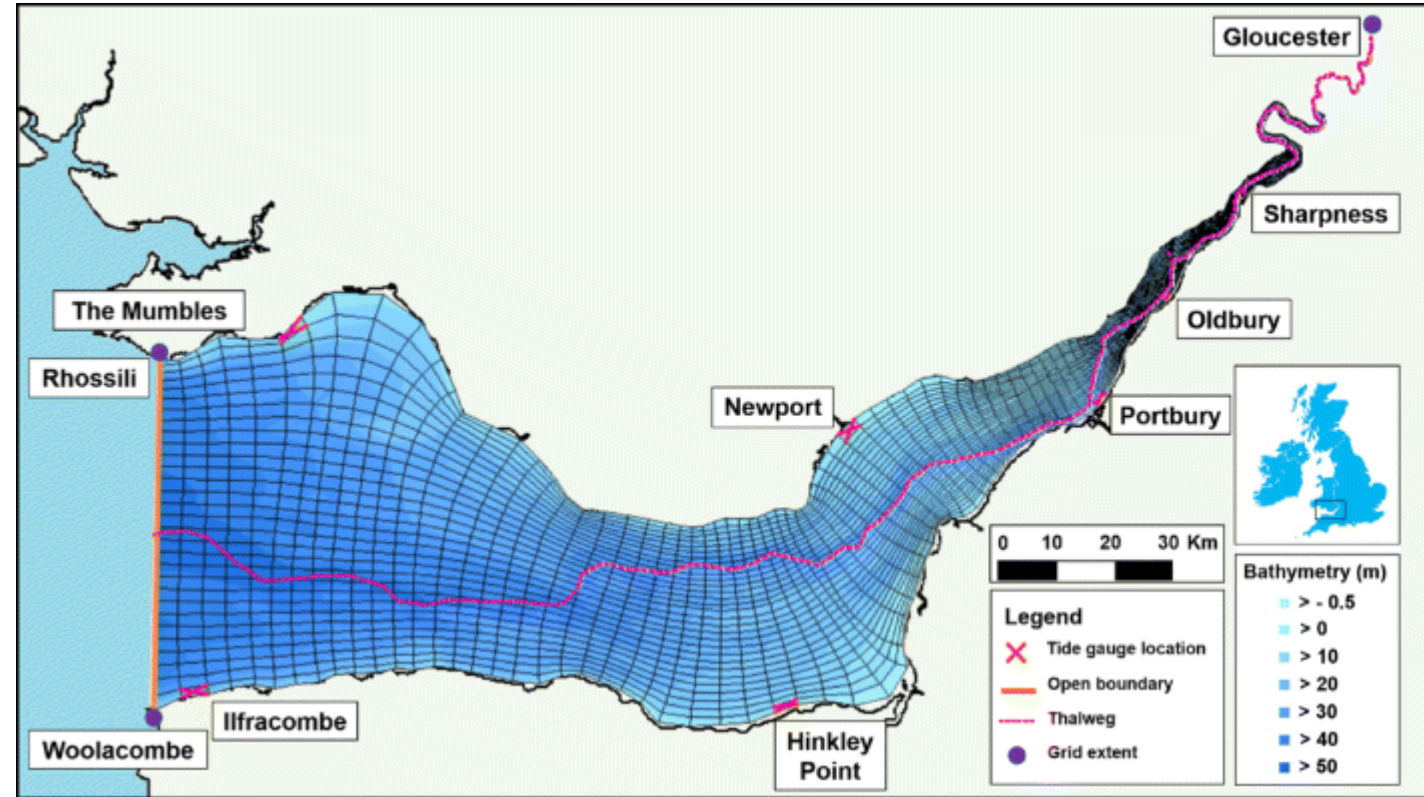
Lyddon et al (2018)

RTR in Wales:

$RTR > 3$ = tide
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Extreme tidal dominance

TIDAL RANGE

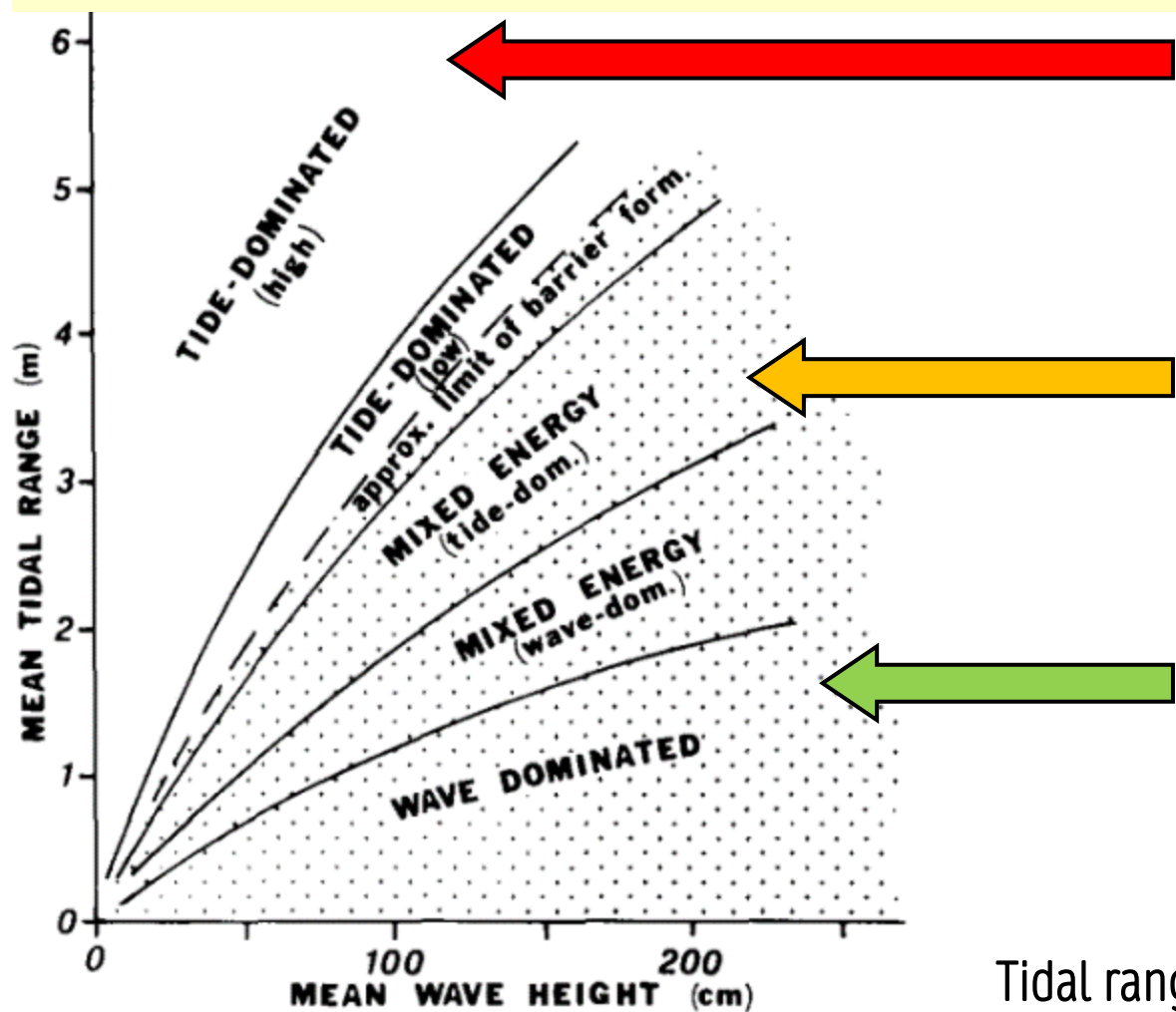


Lyddon et al (2018)

[Windy: Oxwich weather forecast](#)

Summary: What shapes coastlines?

(1) Sea level; (2) tectonic setting; and (3) relative wave vs tide energy



(3) Tide dominated
Low wave energy
TR > 4 m macrotidal

(2) Mixed energy
Mod. wave energy
TR 2-4 m mesotidal

(1) Wave dominated
High wave energy
TR < 2 m
microtidal

Tidal range (TR) (in m) = high - low tide

(1) Wave dominated coasts

TR < 2 m
Microtidal
RTR < 3

Wave-driven sediment transport (e.g. coarser sands)

Spits, bars, berms, and barriers

Wide surf zone

e.g. West Victoria (RTR = 0.9; STR = 0.9 - 1.6 m)
Estuaries close by high wave-energy/transport.

Longshore drift: Common on wave-dominated coasts. Drift occurs under **oblique** waves.



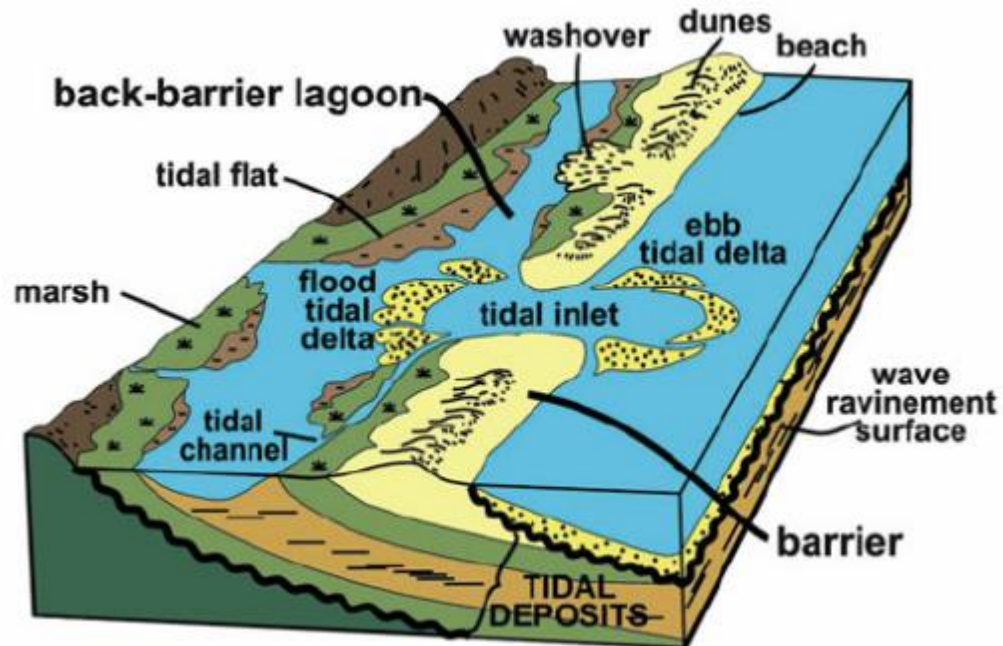
Mixed-energy

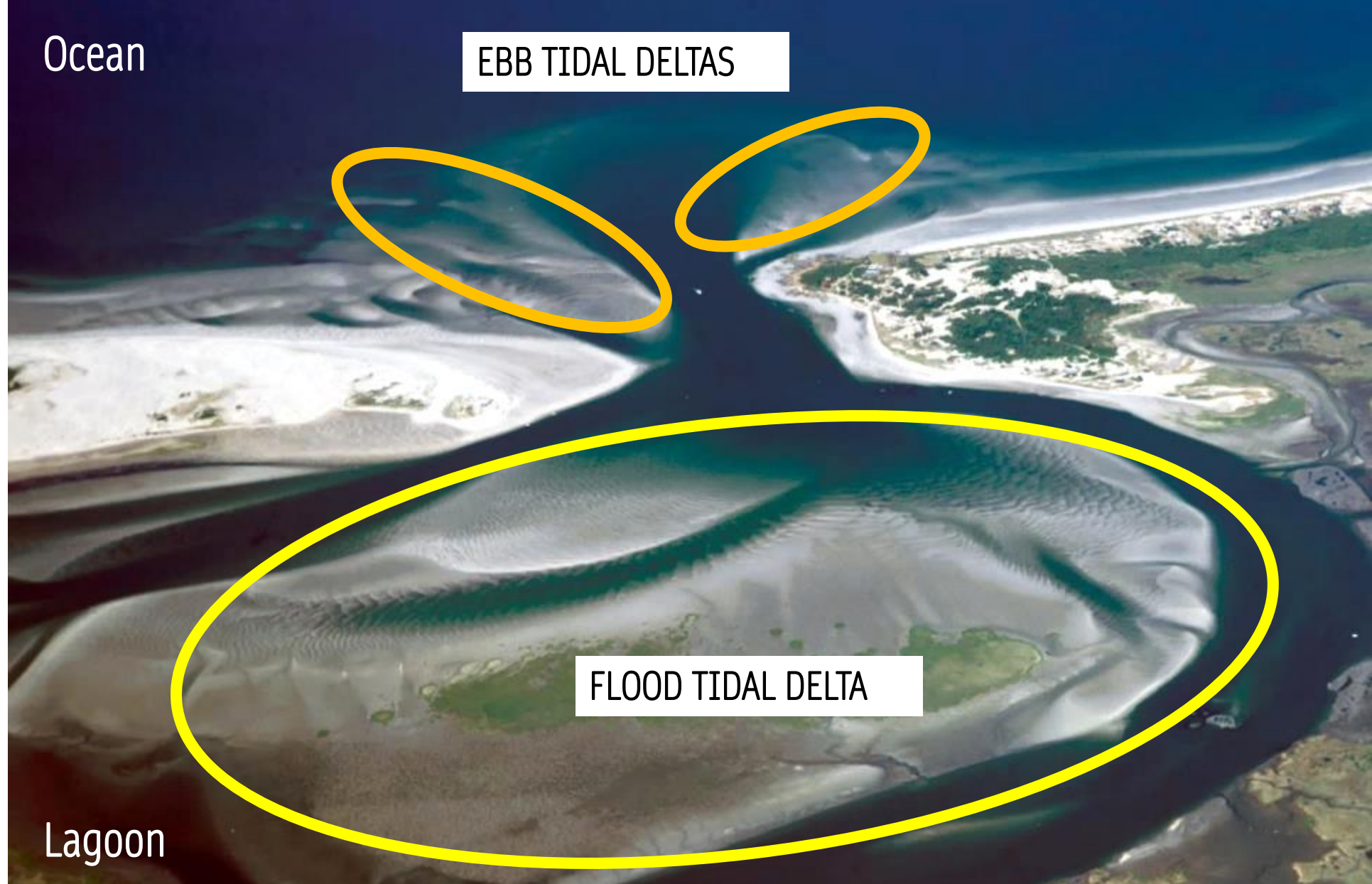
Barrier islands with multiple inlets

A smaller surf zone

Mix of sands and muds

Tidal deltas.



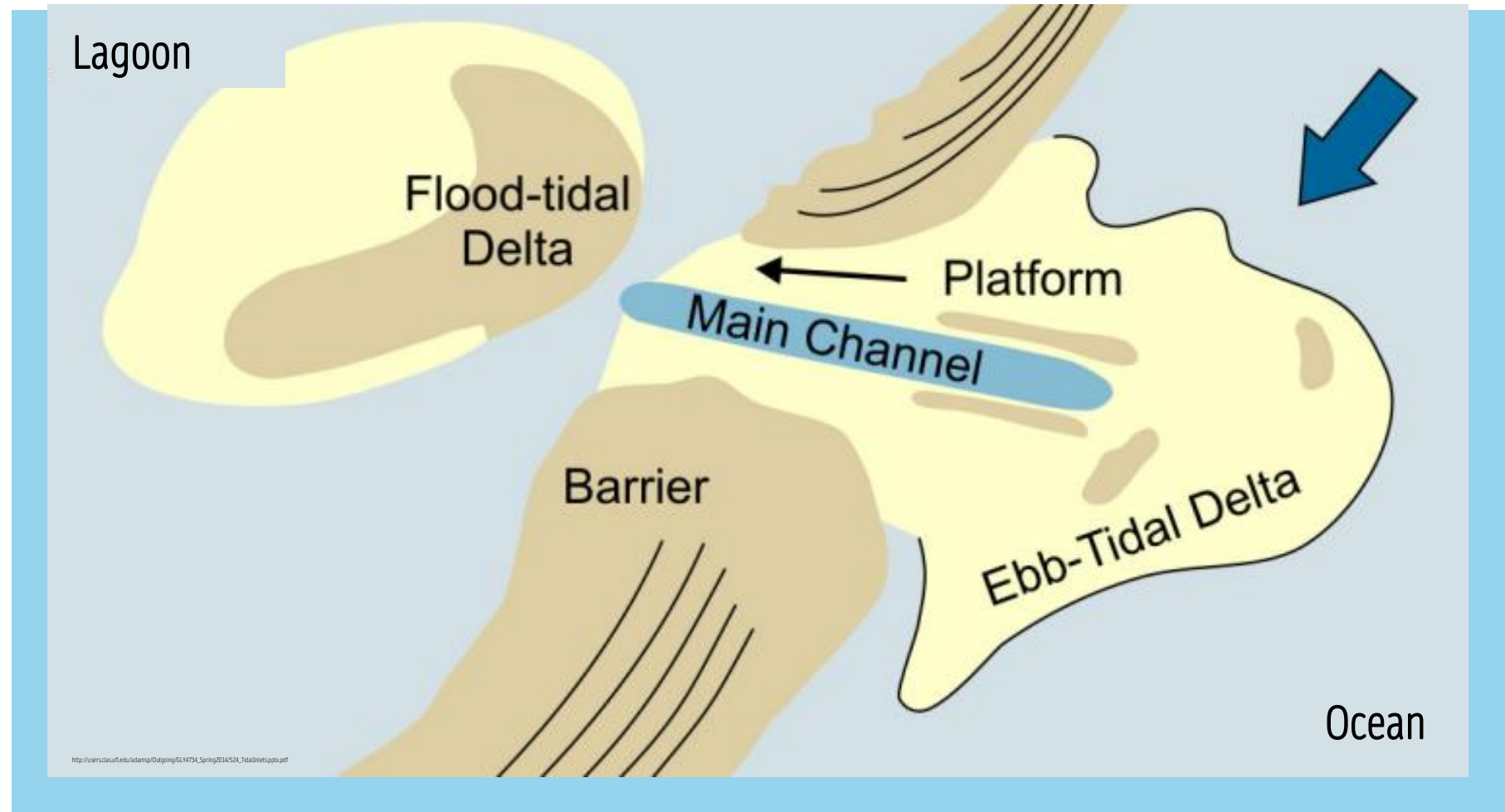


Flood-tidal delta: Shoals deposited by the flood tide (landward side);
Ebb-tidal delta: Deposited by ebb-tidal currents (on the seaward side).

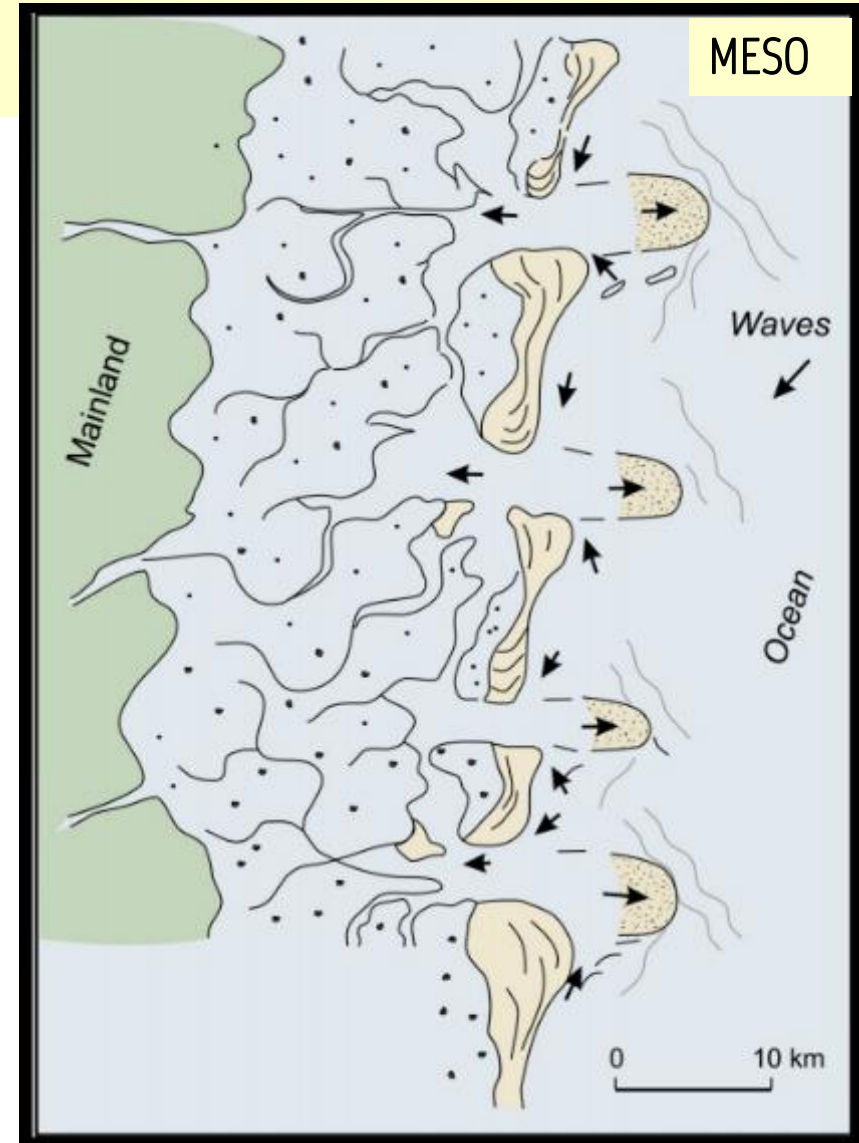
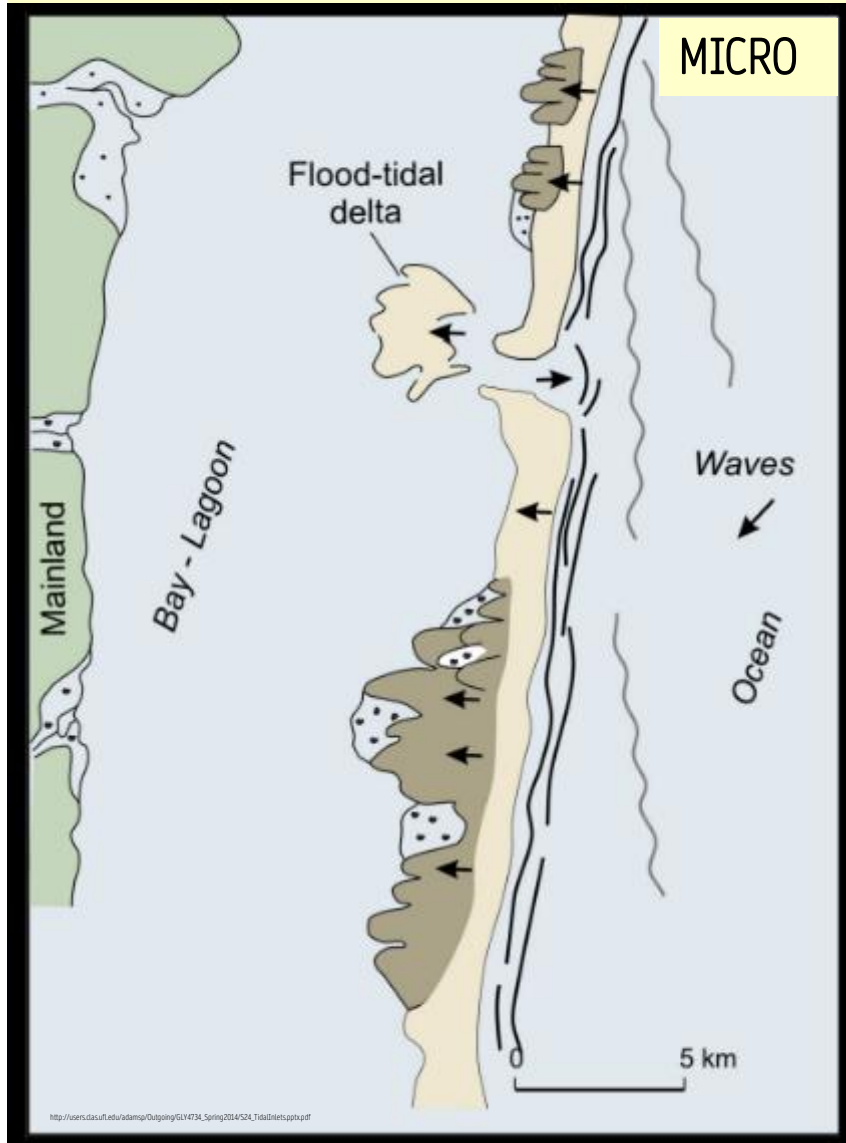
Tidal deltas and barriers can be a visual indicator of coast type:

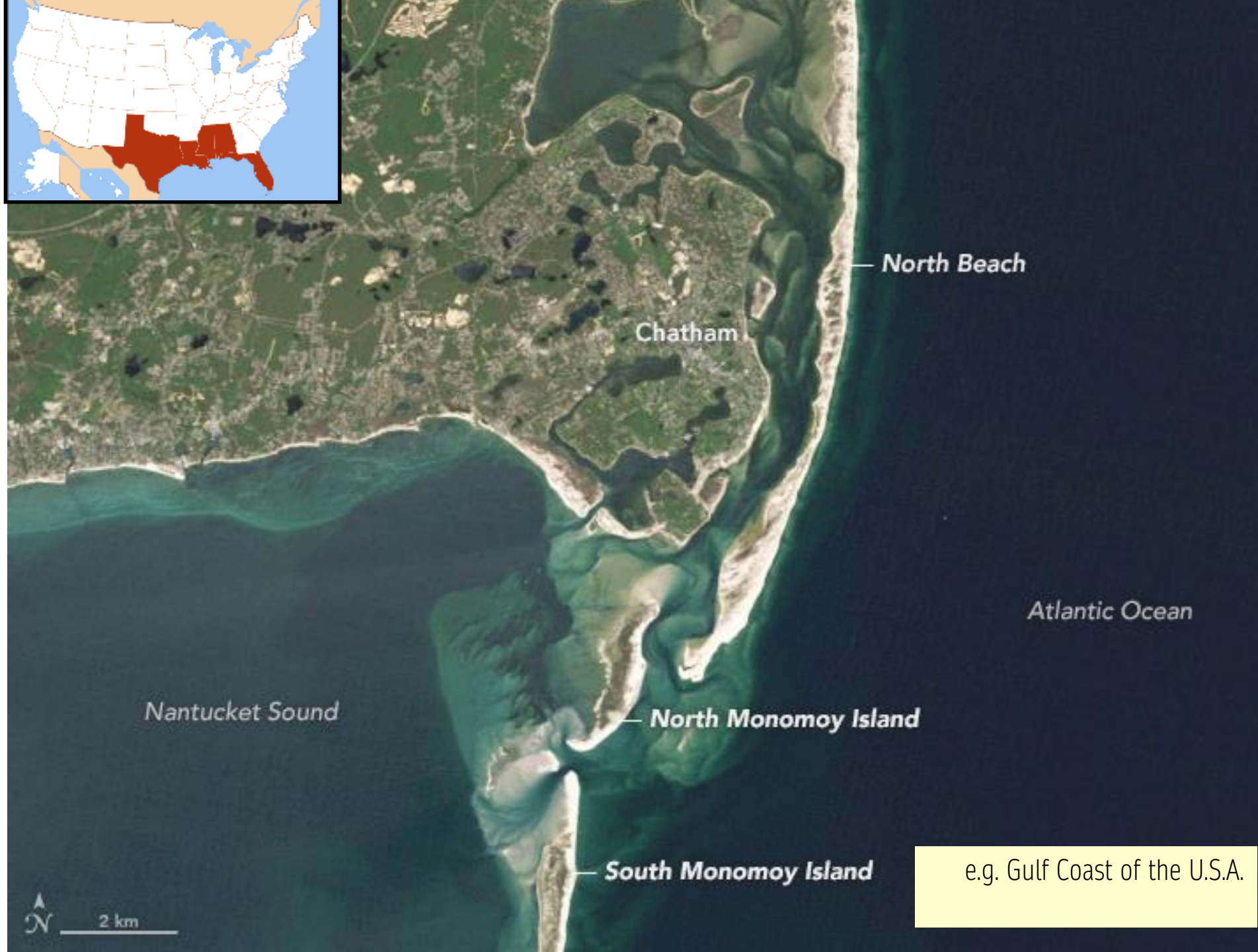
Wave dominated coasts: More pronounced flood tidal deltas;

Mixed energy: More pronounced ebb tidal deltas (seaward).



Microtidal: Barriers are long and thin with little variation in shape;
Mesotidal: Short and narrow in the centre; wider inlet (ebb flows).





Tide dominated coasts

Tides are the dominant process shaping landforms (TR: > 4 m)



- Finer sediments (muds)
- Tidal flats and creeks
- Funnel shaped estuaries with wide mouths
- Flat and low-gradient beaches.



Extreme tide-dominance

Bay of Fundy in Canada = the tidal range is 16 m (come in at 5.1 m/s)

Highest tides in the world

RTR: 32 ($\text{STR}/H_b = 16/0.5$).



Low tide

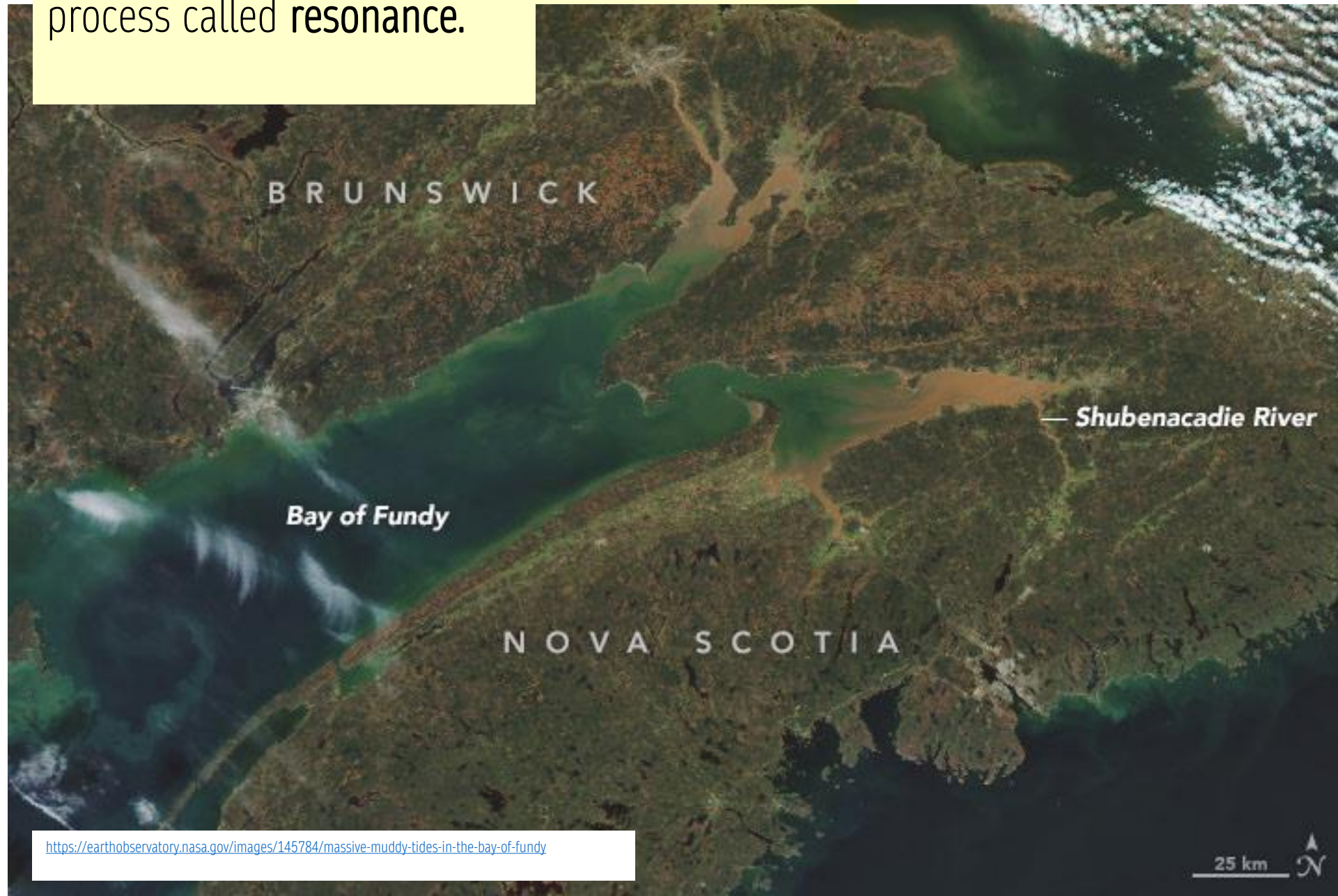


High tide

Watch someone barely out walk the tide:
<https://www.youtube.com/watch?v=lOTqFXiPfuk>

The shape of the bay amplifies the tide by a process called **resonance**.

[Incoming tide](#)
[Time Lapse video](#)

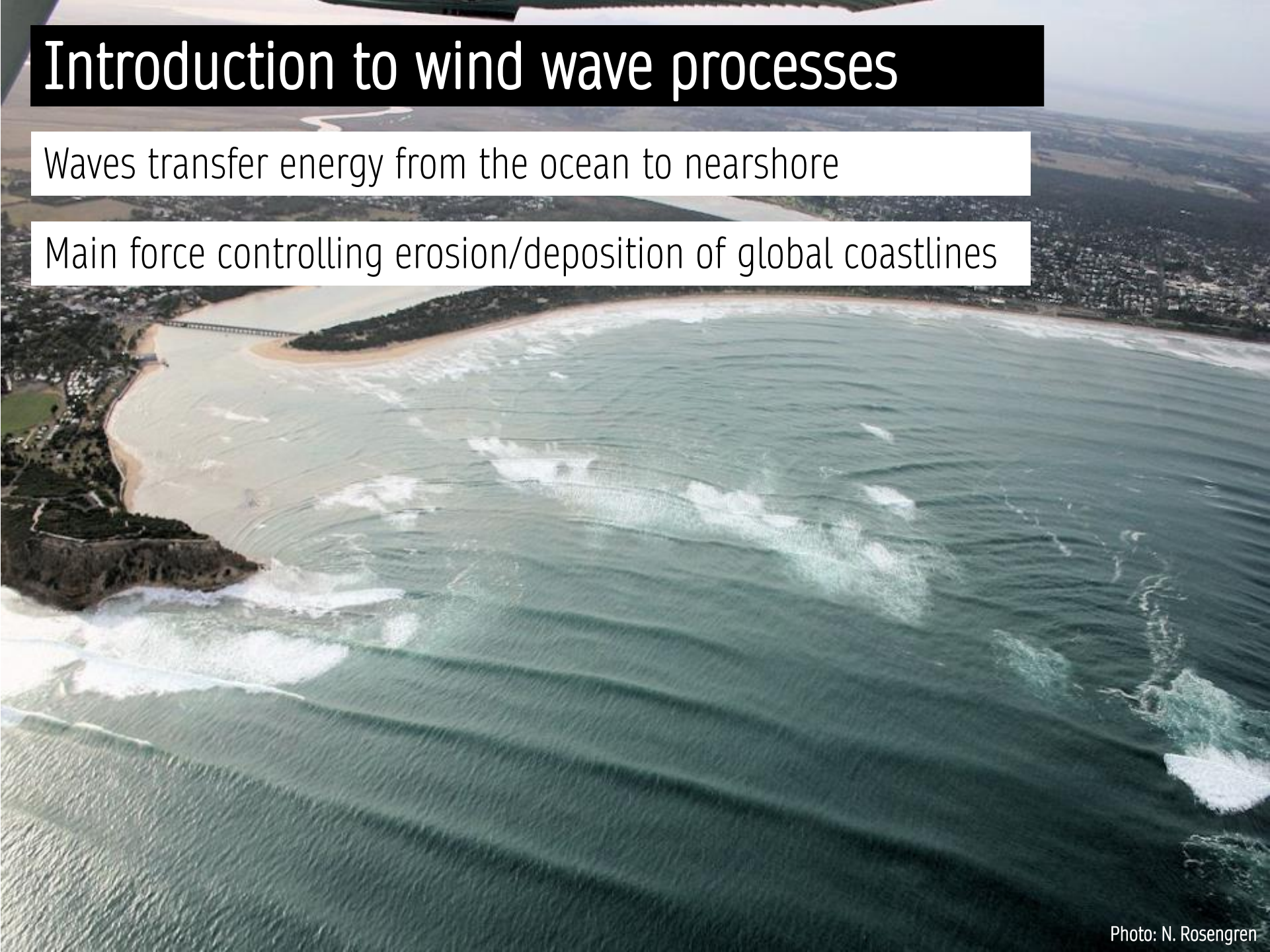


<https://earthobservatory.nasa.gov/images/145784/massive-muddy-tides-in-the-bay-of-fundy>

Introduction to wind wave processes

Waves transfer energy from the ocean to nearshore

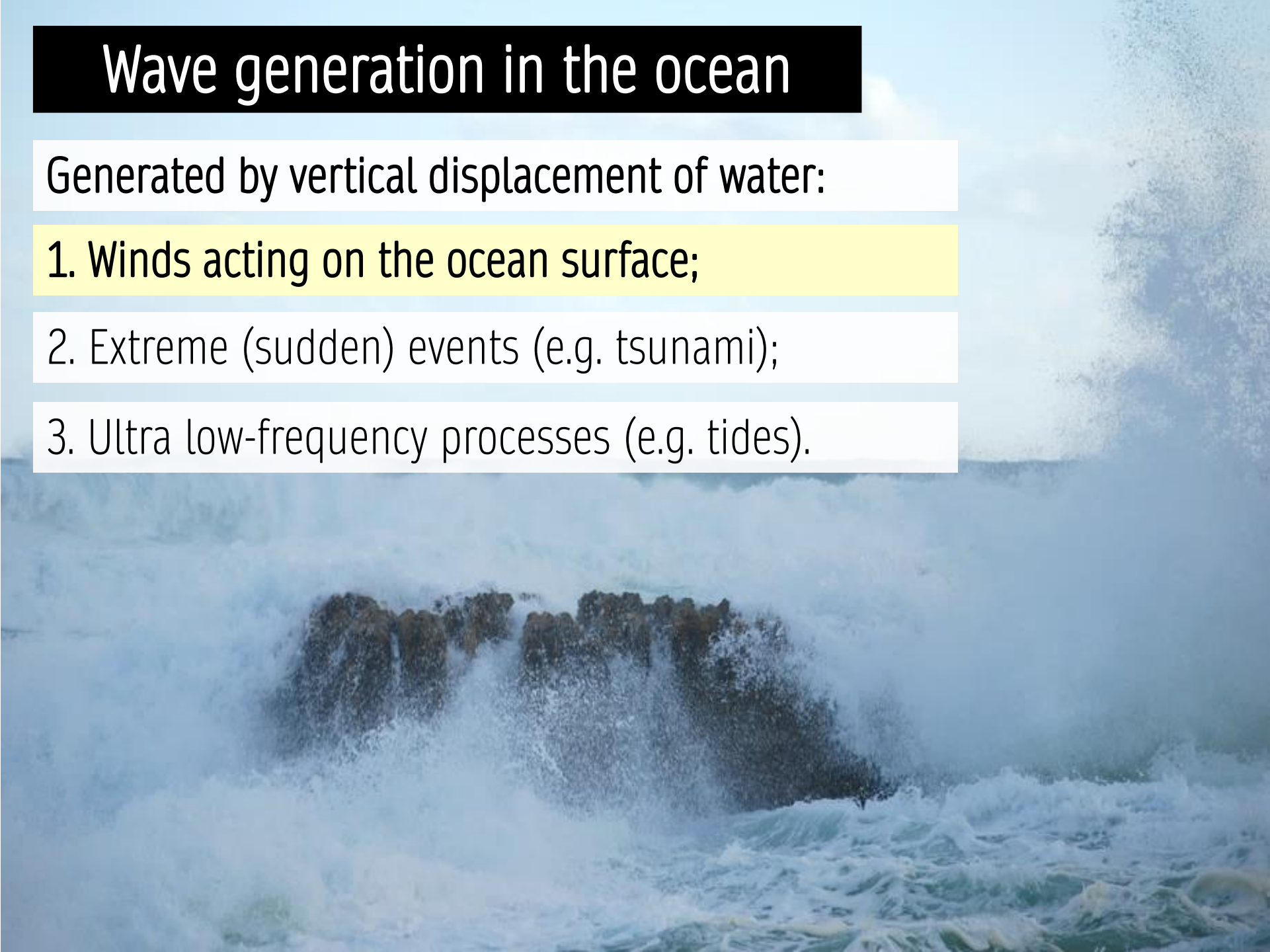
Main force controlling erosion/deposition of global coastlines



Wave generation in the ocean

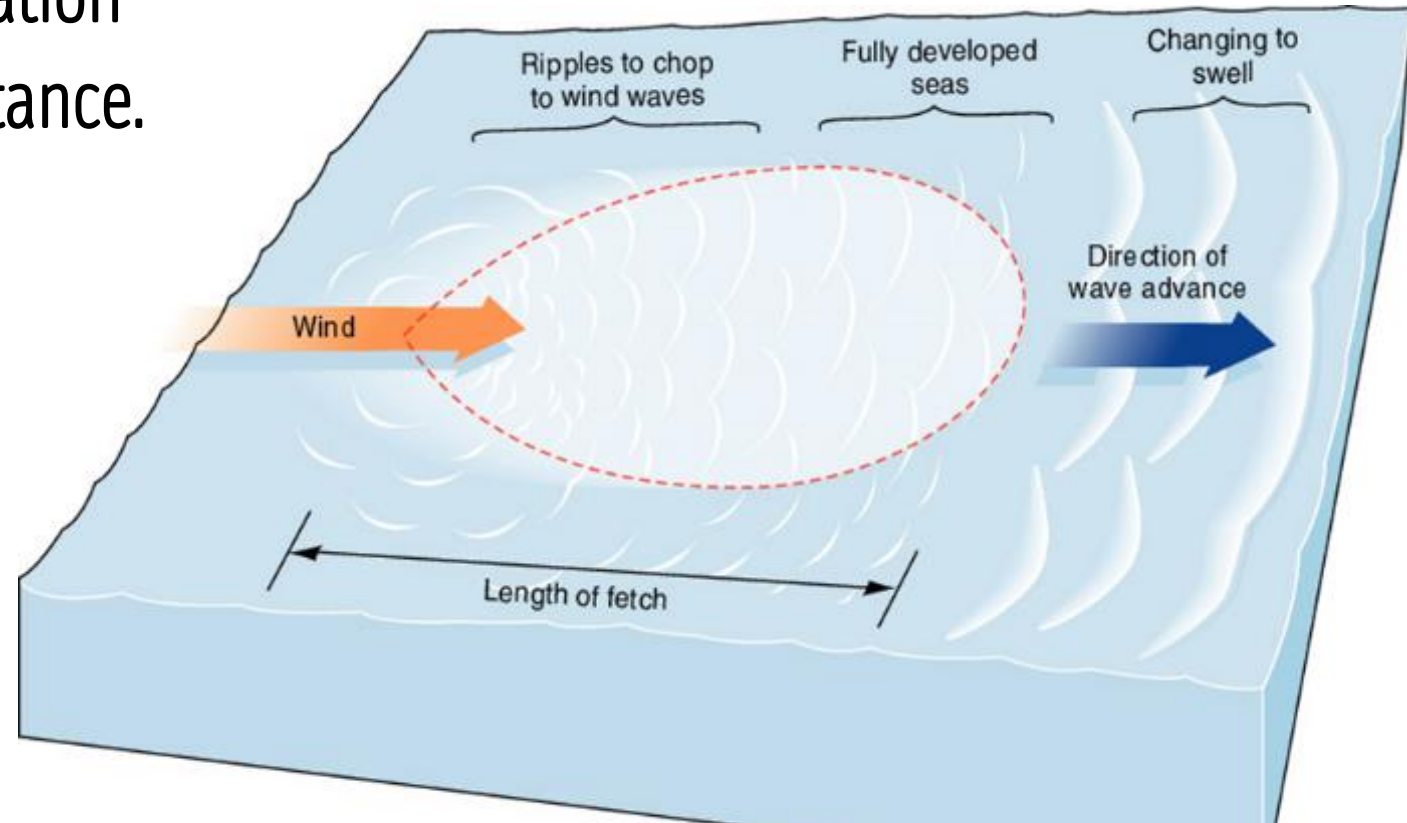
Generated by vertical displacement of water:

1. Winds acting on the ocean surface;
2. Extreme (sudden) events (e.g. tsunami);
3. Ultra low-frequency processes (e.g. tides).



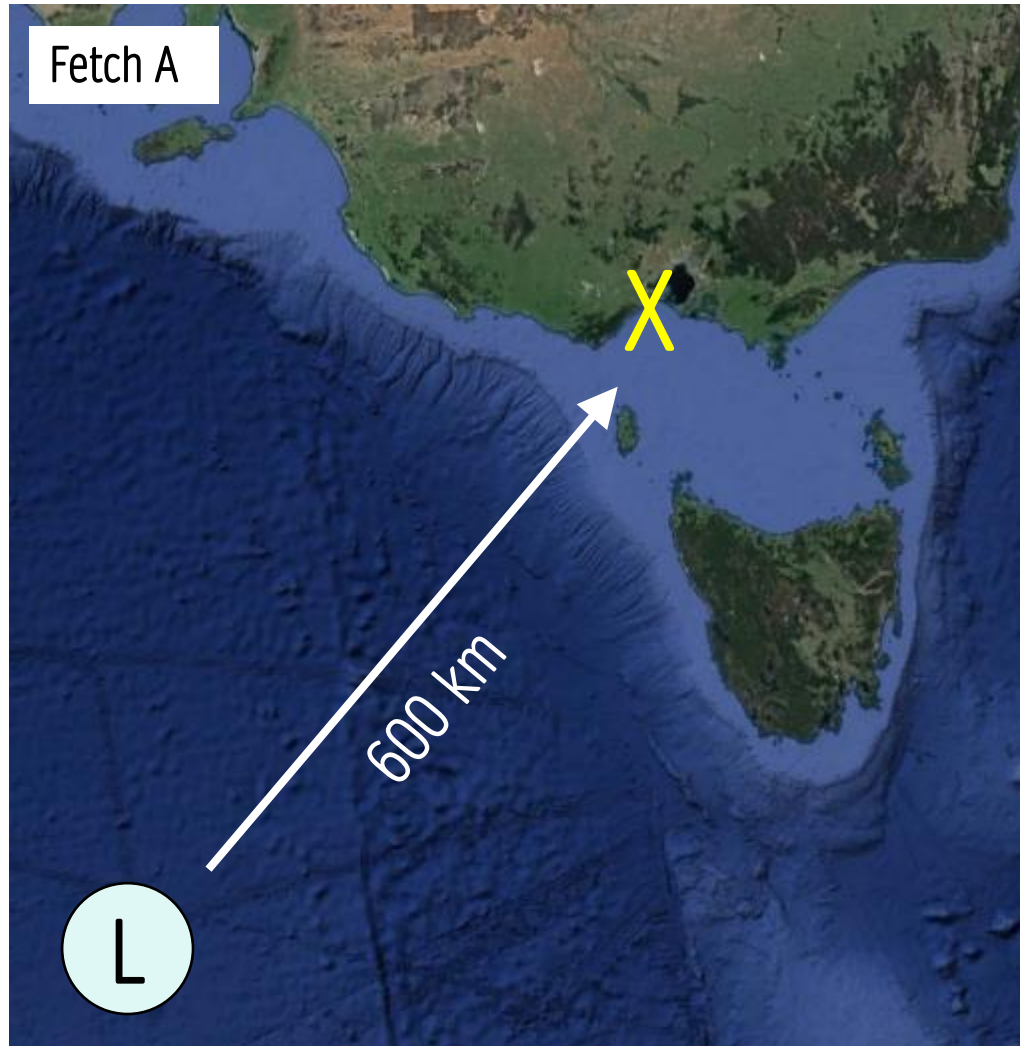
The height of wind waves is dependent on:

- (1) Wind speed.
- (2) Wind duration
- (3) Fetch distance.



Fetch: The distance of water wind can move over in a constant direction to generate waves.

Fetch A > Fetch B... so ocean waves would be higher.



(A) Classic Southern Ocean low hitting SW VIC.

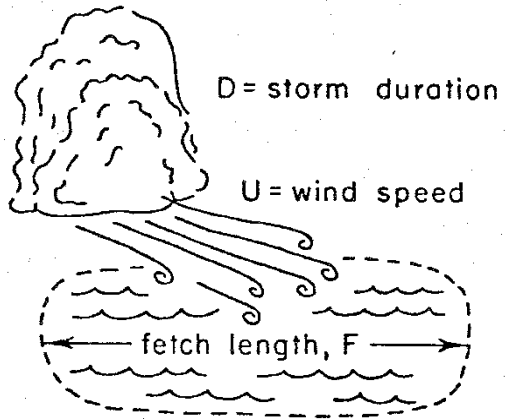


(B) Local wind waves in Port Phillip Bay.

Waves organise themselves by period and length and travel in groups called **swells**.

GENERATION

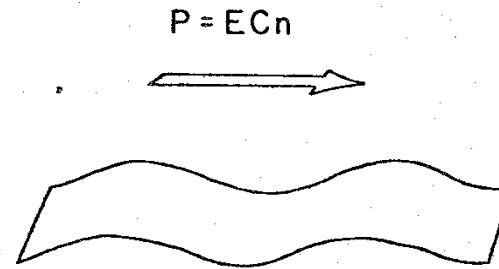
(Sea)



energy transfer from
wind to waves = $f(U, D, F)$

PROPAGATION

(Swell)

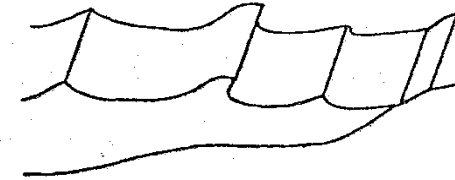


energy carried with
the waves

SHOALING AND

BREAKING

(Surf)

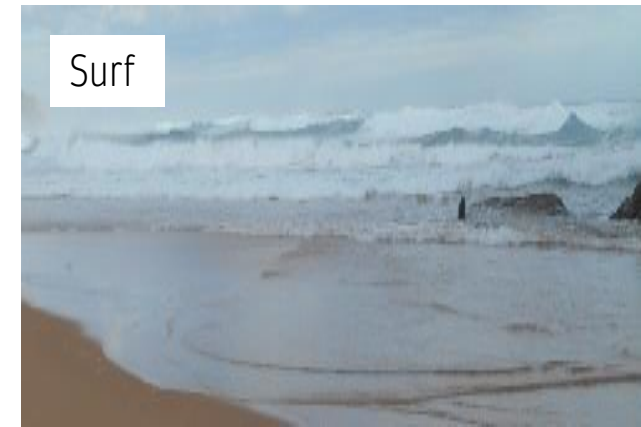
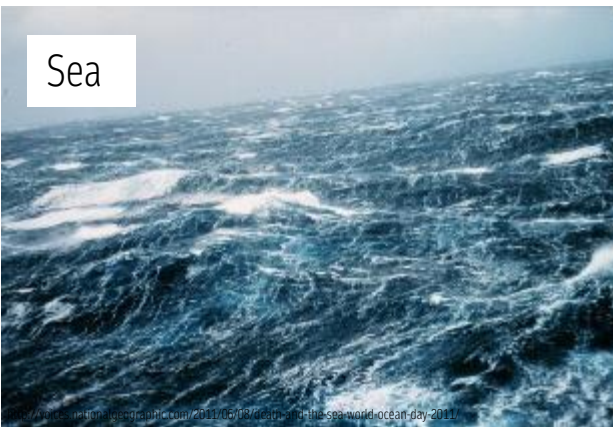


energy delivered to
the nearshore zone

Closer to Source



Closer to Shore



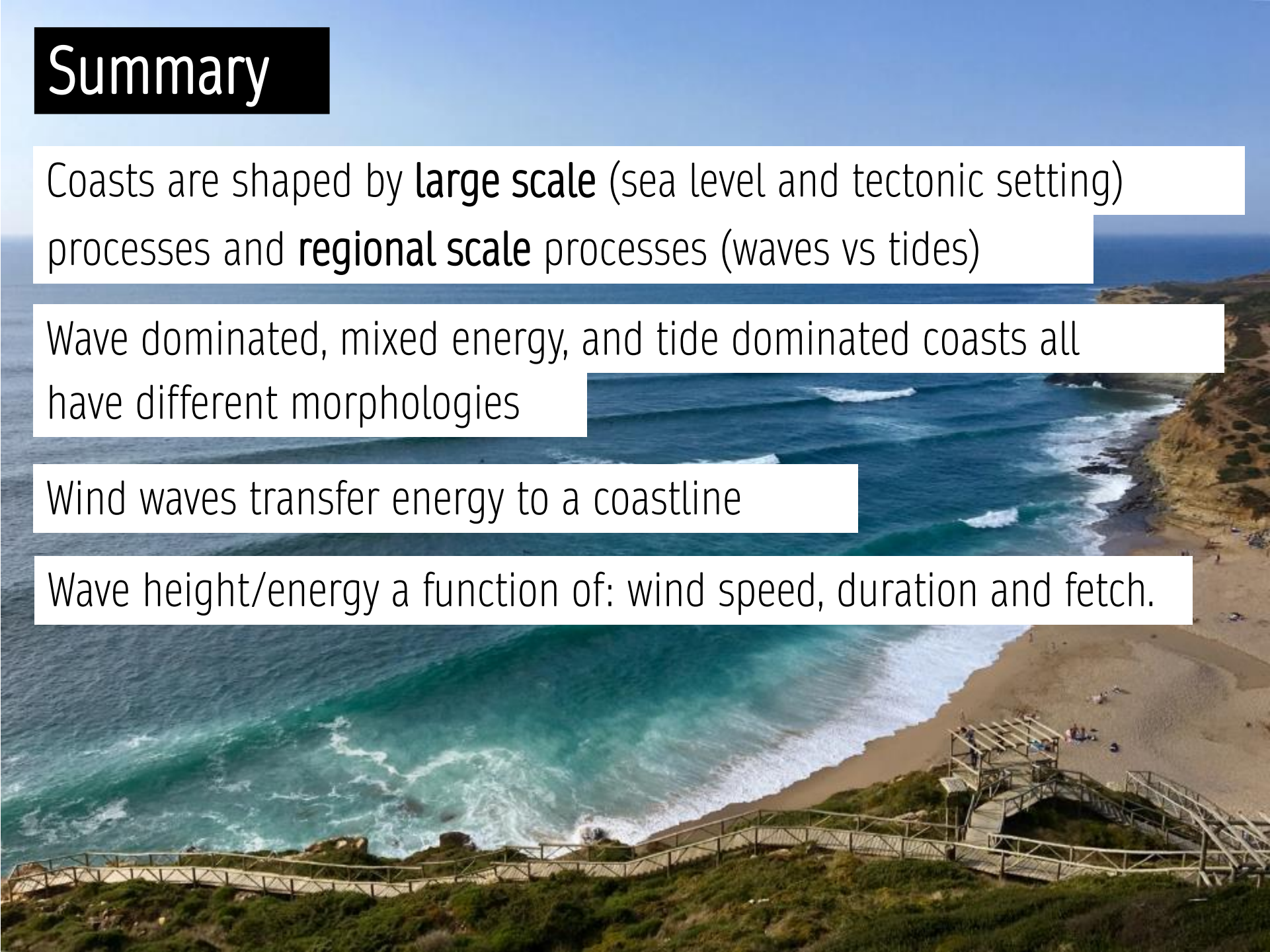
Summary

Coasts are shaped by **large scale** (sea level and tectonic setting) processes and **regional scale** processes (waves vs tides)

Wave dominated, mixed energy, and tide dominated coasts all have different morphologies

Wind waves transfer energy to a coastline

Wave height/energy a function of: wind speed, duration and fetch.



OUTLINE

1) LARGE SCALE CONTROLS ON
COASTAL SYSTEMS ✓

2) COASTAL ECOSYSTEMS

- KEY MANAGEMENT ISSUES
- MANAGEMENT RESPONSES





COASTAL ECOSYSTEMS

ESTUARIES

Estuaries

What is an Estuary?

The interface where a river meets the ocean

Where river, wave, and tidal processes interact



Dalrymple et al., 1992

The seaward portion of a drowned valley which receives sediment from fluvial and marine sources and contains facies influenced by wave, tide and fluvial processes.



Ephemeral systems

Important as a SINK for sediment

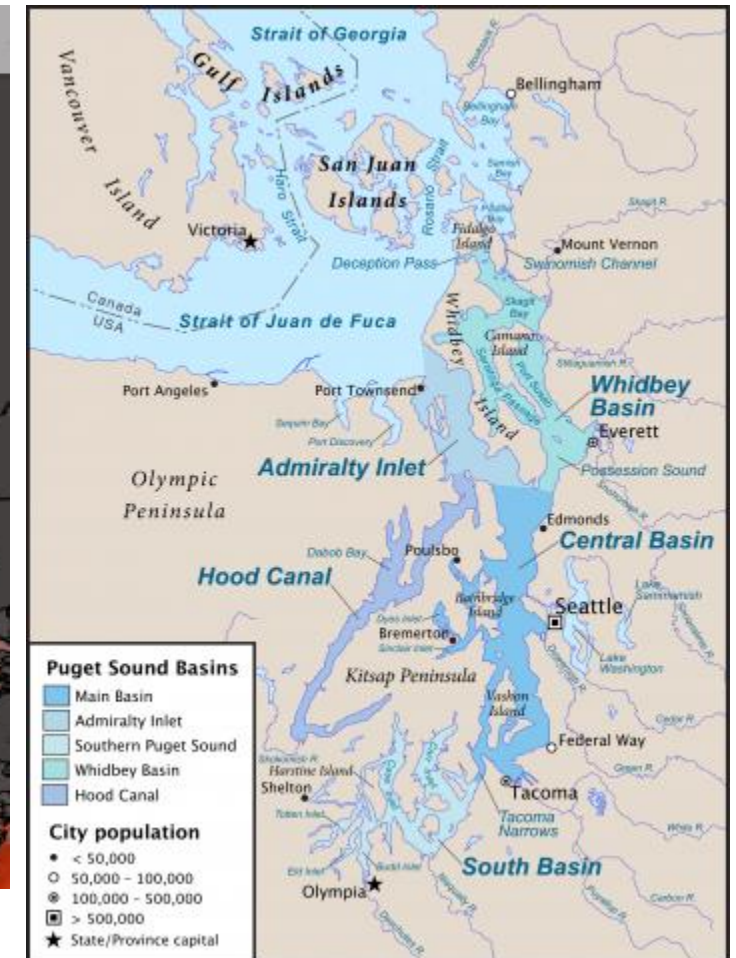
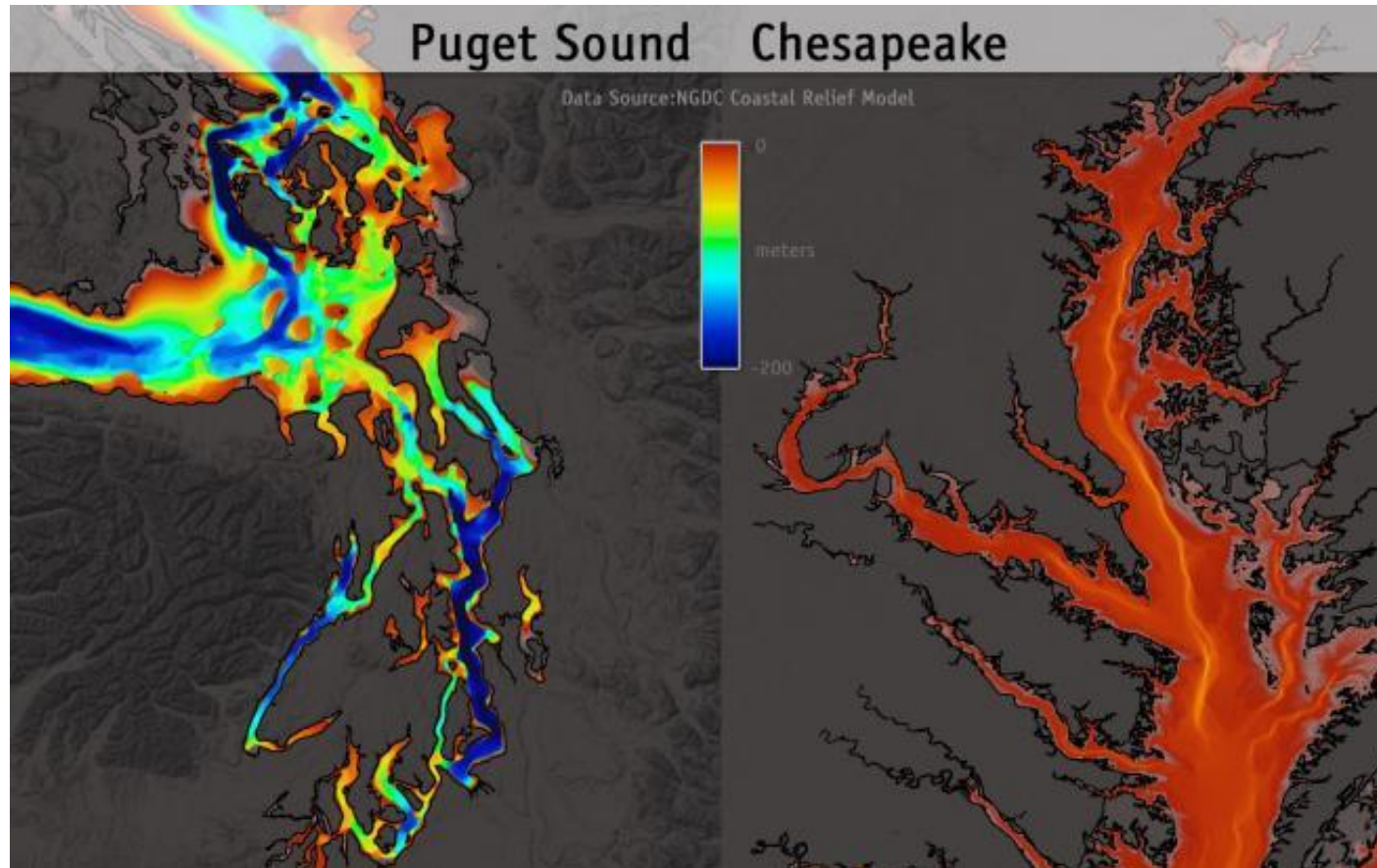
Zones of an estuary

Head (river input); central basin; mouth (enters ocean)



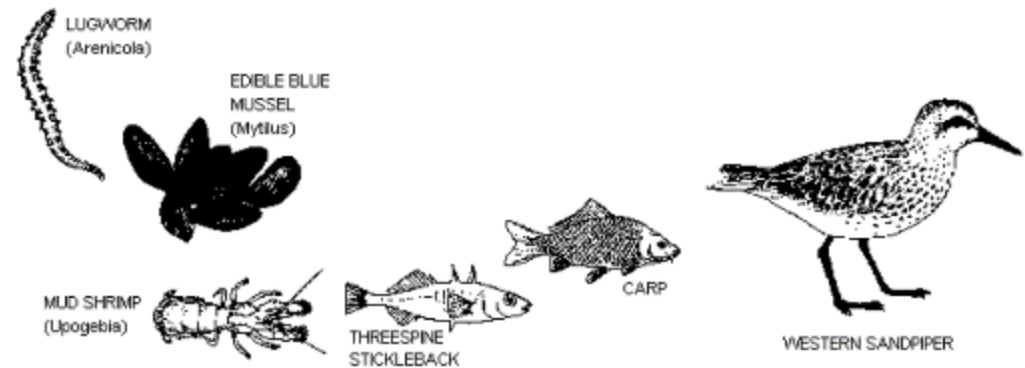
Puget Sound

Comparative bathymetry for Puget Sound and Chesapeake Bay, USA



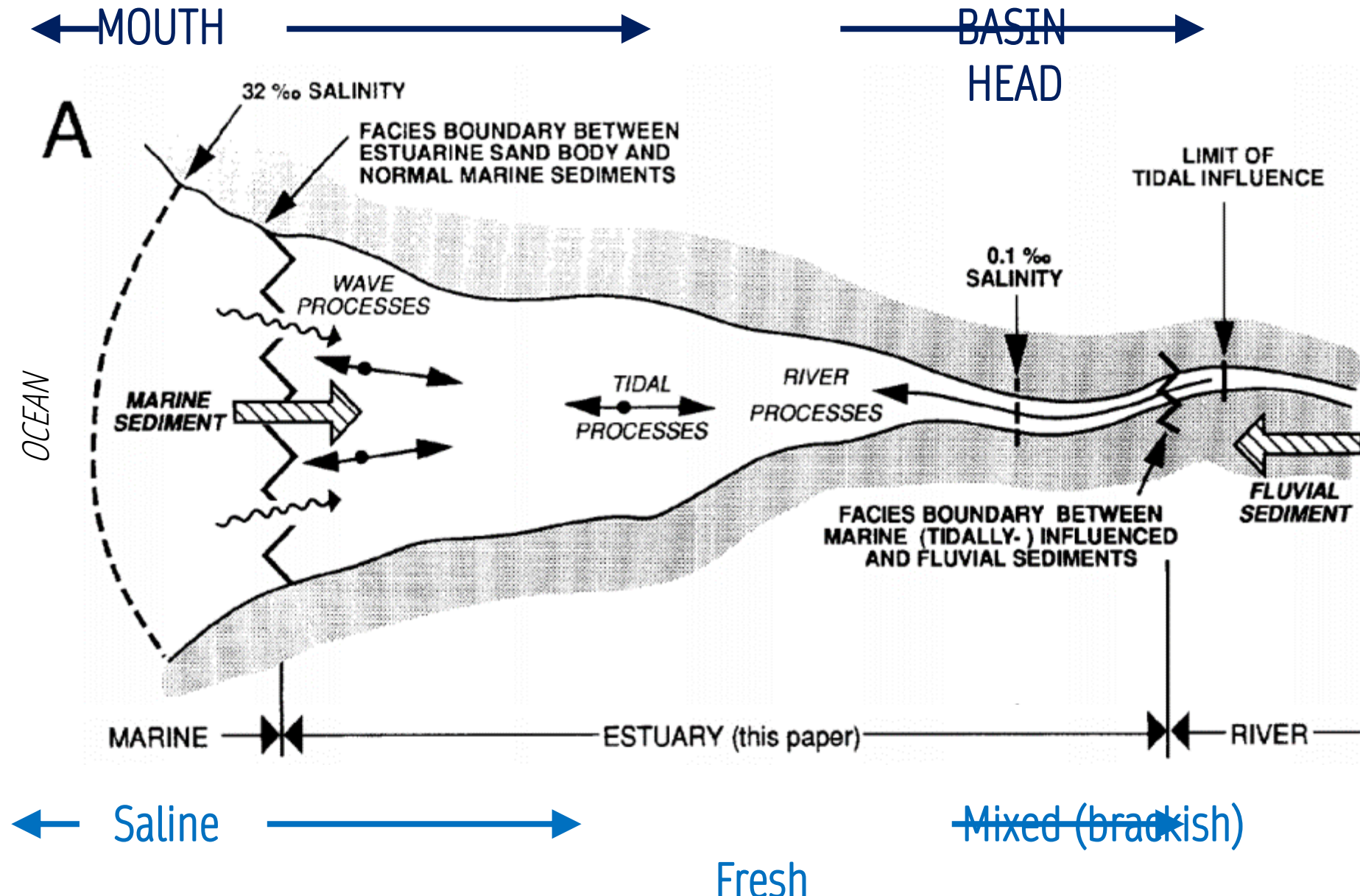
Estuary Ecosystem

One of the most productive ecosystems in the world



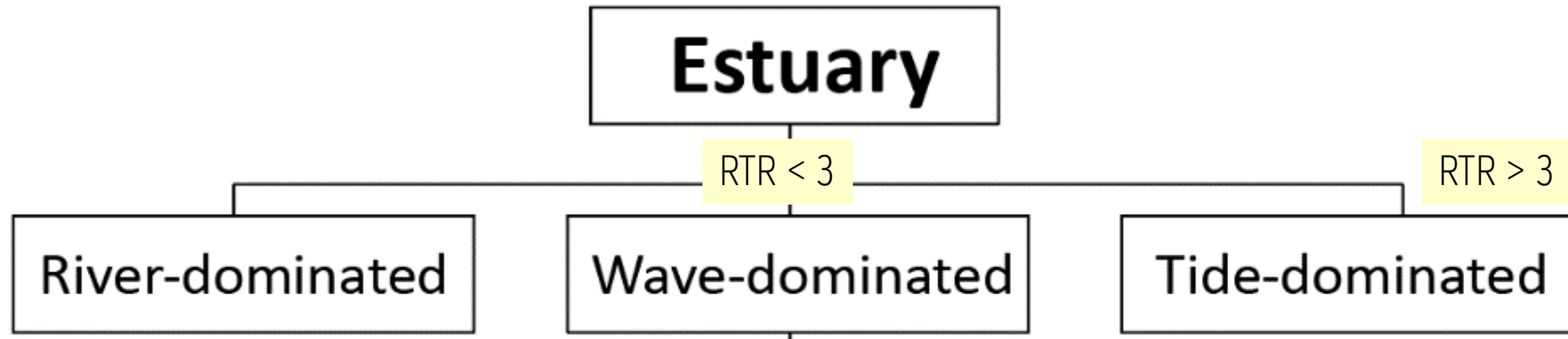
Zones of an estuary

ESTUARIES



Geomorphic classification

e.g. Roy (1984); Cooper (2001); Dalrymple et al., (1992)



IOCE = Intermittently open/closed estuary = one that closes to the ocean [sometimes called a saline coastal lake or lagoon] e.g. Painkalac Creek

Zones of an estuary

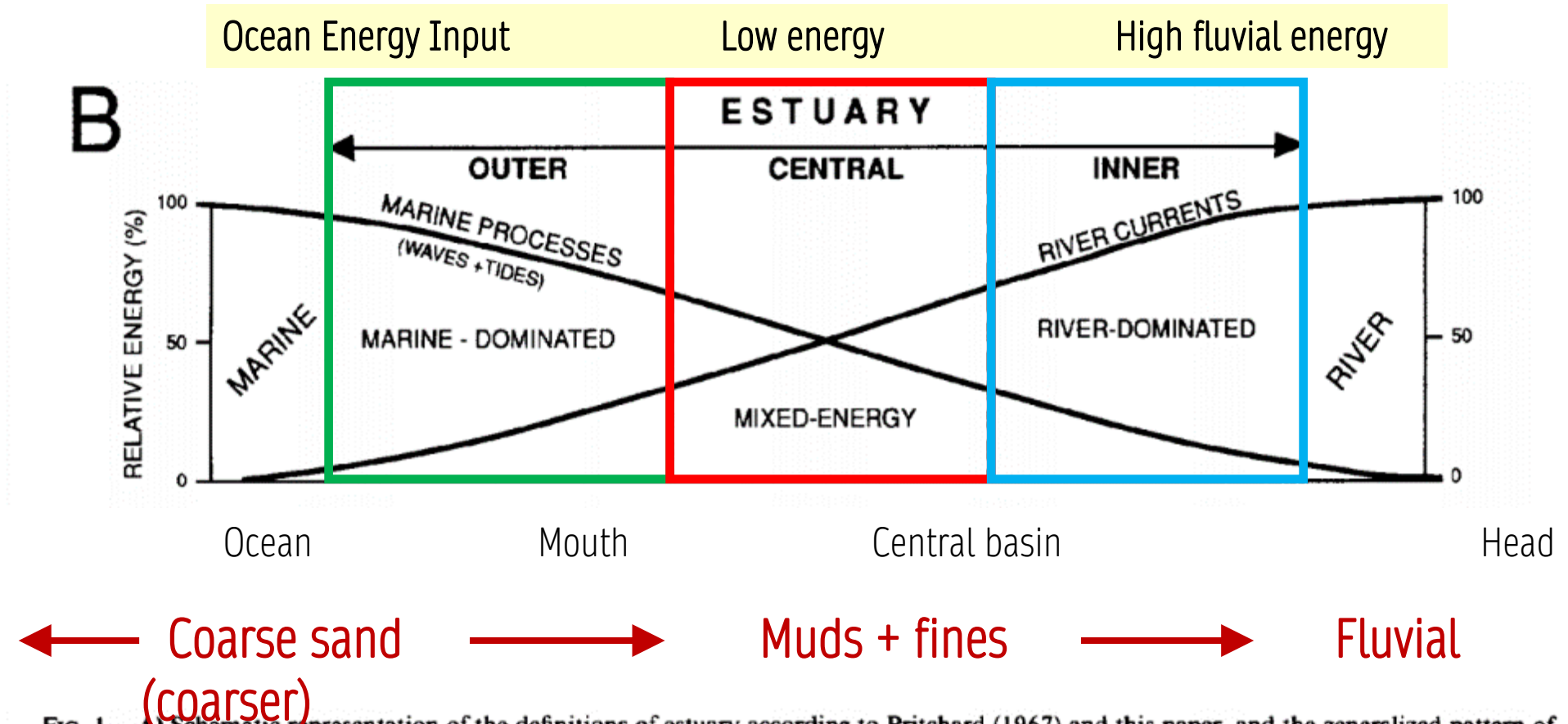
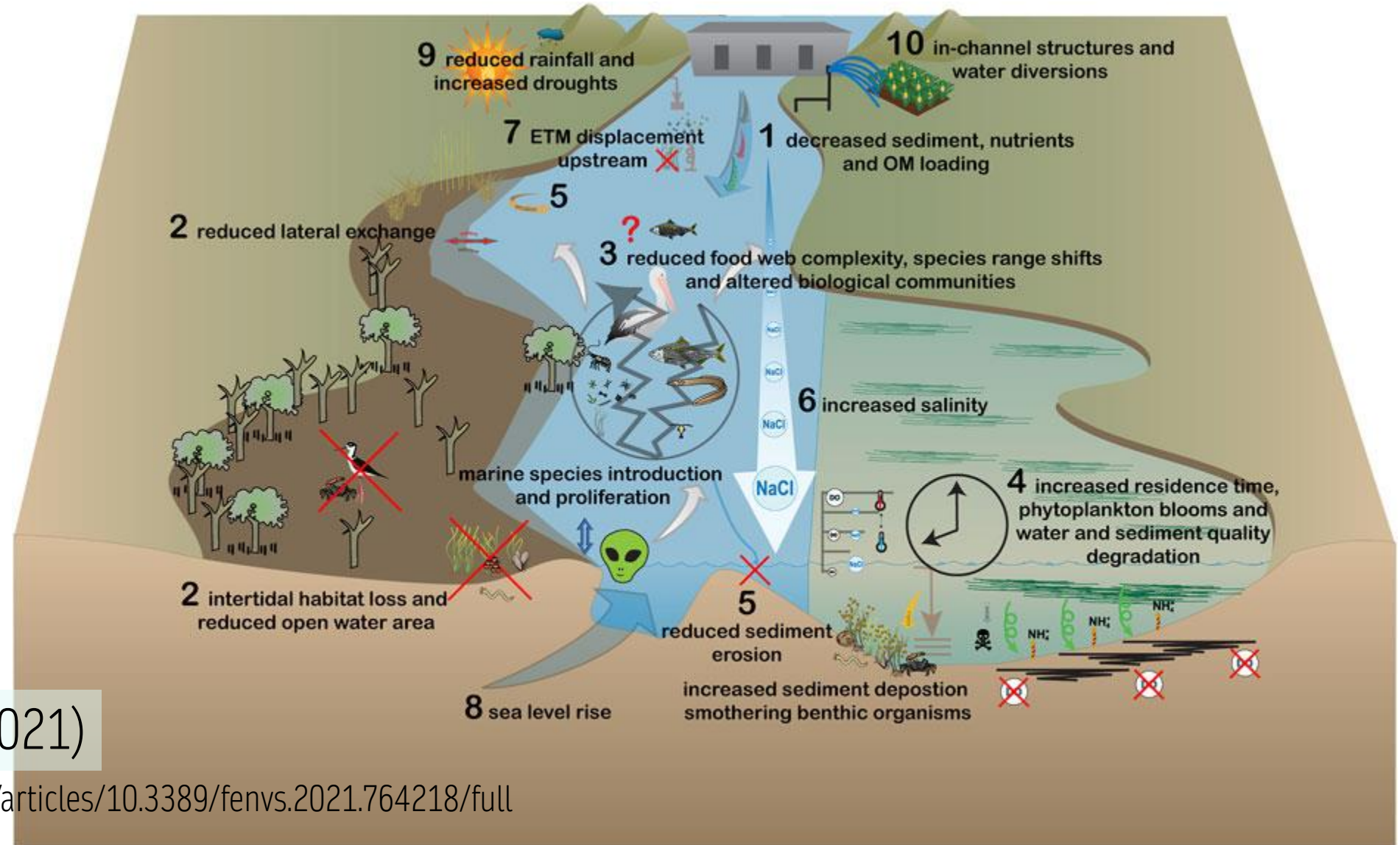


FIG. 1. — A) Schematic representation of the definitions of estuary according to Pritchard (1967) and this paper, and the generalized pattern of net, bed-material transport. The facies boundary marking the landward end of the estuary as defined here almost always lies landward of the 0.1‰ salinity value, but the facies boundary at the outer end may lie either landward (as shown here) or seaward of the limit of normal-marine salinities (~ 32‰). B) Schematic distribution of the physical processes operating within estuaries, and the resulting tripartite facies zonation.

“Tripartite” energy and facies division

Estuary Management

ESTUARIES



Chilton et al. (2021)

<https://www.frontiersin.org/articles/10.3389/fenvs.2021.764218/full>

<https://www.meer.com/en/40723-mangroves-and-their-role-to-ecology>

MANGROVES AND SALT MARSHES

COASTAL ECOSYSTEMS





GLOBAL DISTRIBUTION

D'Odorico, P., et. al (2013)

What is a mangrove?

‘Wetlands formed in the intertidal zone of sheltered coasts, notably in bays, lagoons and estuaries.’

The vegetation of the two environments is quite different: mangroves are composed of a number of tree species,



MANGROVES

MANGROVES SUPPORT BIODIVERSITY AND FISHERIES, REDUCE COASTAL EROSION AND HELP PROTECT THE PLANET FROM CLIMATE CHANGE

BIODIVERSITY HABITAT

Numerous species above and below the water rely on mangroves for food and shelter. Mangroves are important nurseries for fish and crustaceans and support a huge variety of birds, molluscs and insects. They also provide habitat for many mammals. In Tanzania this includes the Zanzibar Red Colobus monkey which is endangered and only found in the Zanzibar archipelago.

RESOURCE STORE

Mangroves can provide wood for building and fuel for cooking. Some mangrove roots and fruits are also used in traditional medicine. It is crucial they are harvested sustainably.

COASTAL PROTECTION

Mangroves protect the coast from erosion by reducing the flow of soil and sediment from the land into the sea. This water filtration helps protect offshore ecosystems such as coral reefs. Mangroves also reduce the impact of waves on the shore. This is increasingly important with the threat of rising sea levels and extreme weather due to climate change.

ECONOMIC BENEFIT

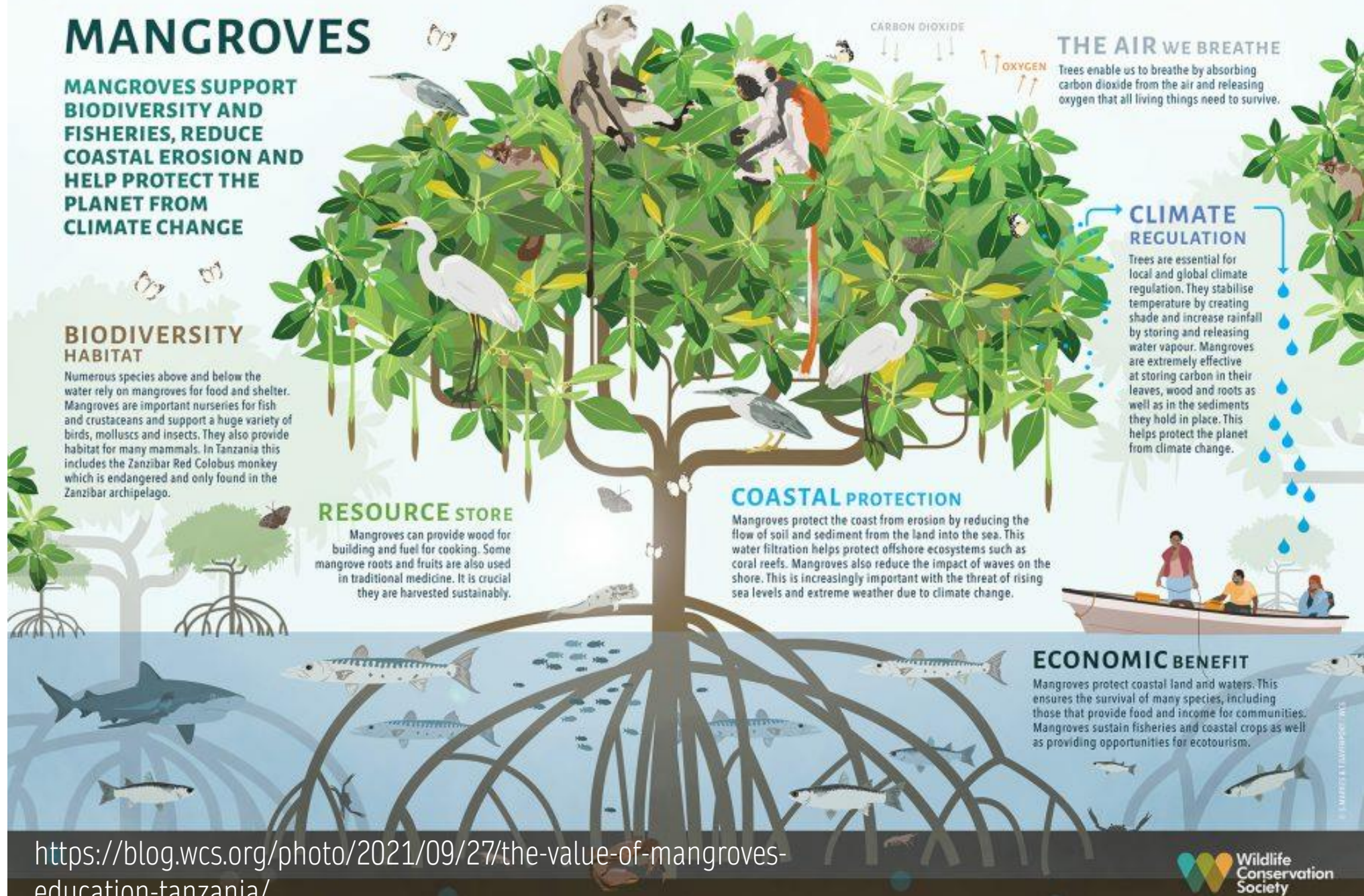
Mangroves protect coastal land and waters. This ensures the survival of many species, including those that provide food and income for communities. Mangroves sustain fisheries and coastal crops as well as providing opportunities for ecotourism.

THE AIR WE BREATHE

Trees enable us to breathe by absorbing carbon dioxide from the air and releasing oxygen that all living things need to survive.

CLIMATE REGULATION

Trees are essential for local and global climate regulation. They stabilise temperature by creating shade and increase rainfall by storing and releasing water vapour. Mangroves are extremely effective at storing carbon in their leaves, wood and roots as well as in the sediments they hold in place. This helps protect the planet from climate change.



Mangrove management?

MANGROVES



<https://theconversation.com/mangrove-forests-can-rebound-thanks-to-climate-change-its-an-opportunity-we-must-take-102823>

Mangrove management?



<https://theconversation.com/mangrove-forests-can-rebound-thanks-to-climate-change-its-an-opportunity-we-must-take-102823>

<https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/>



Mangrove management?



<https://theconversation.com/mangrove-forests-can-rebound-thanks-to-climate-change-its-an-opportunity-we-must-take-102823>

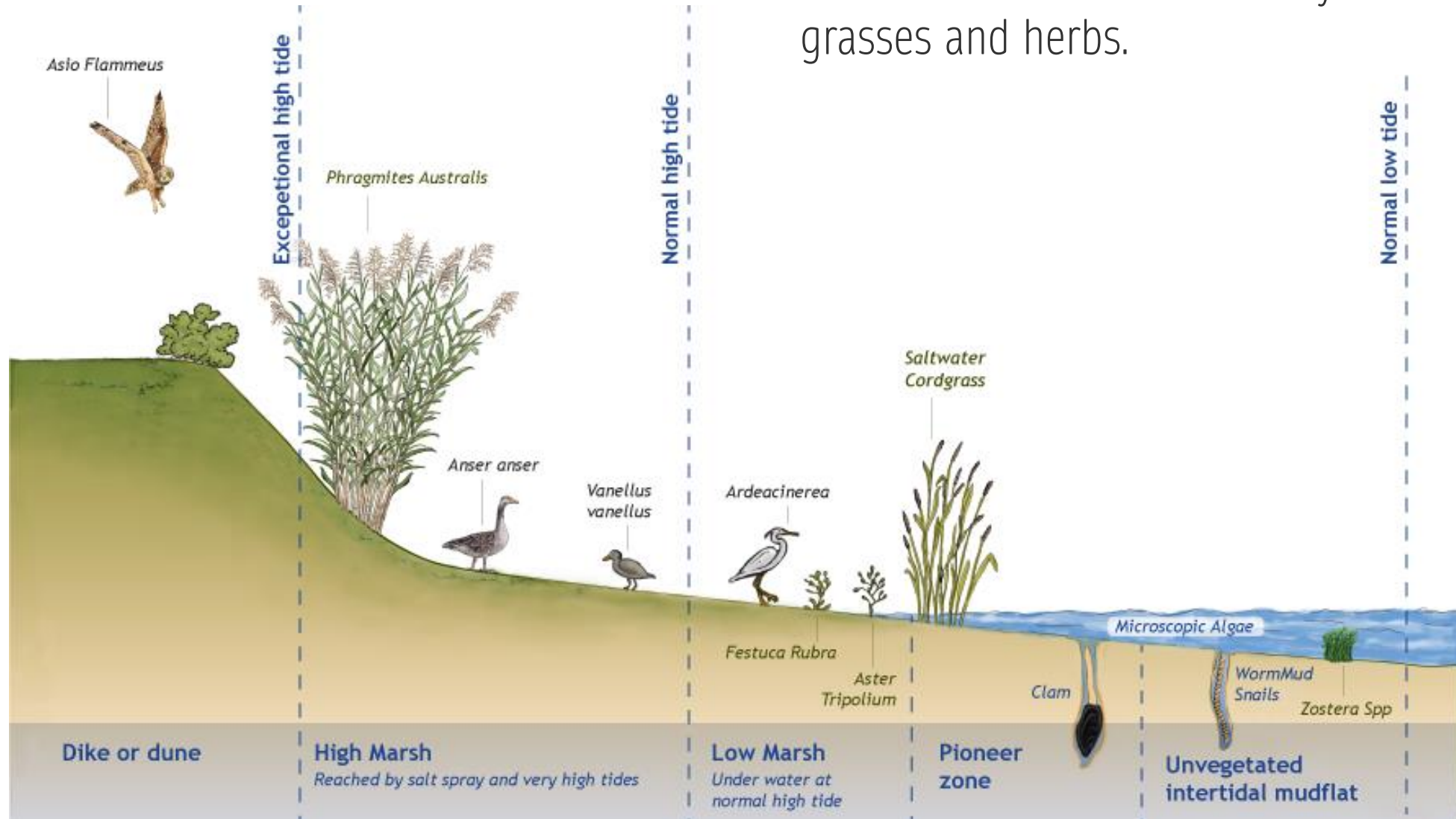
<https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/>



“Even if seedlings are surviving, the ecological value of a monoculture and benefits of the planting efforts for increased community resilience are questionable”

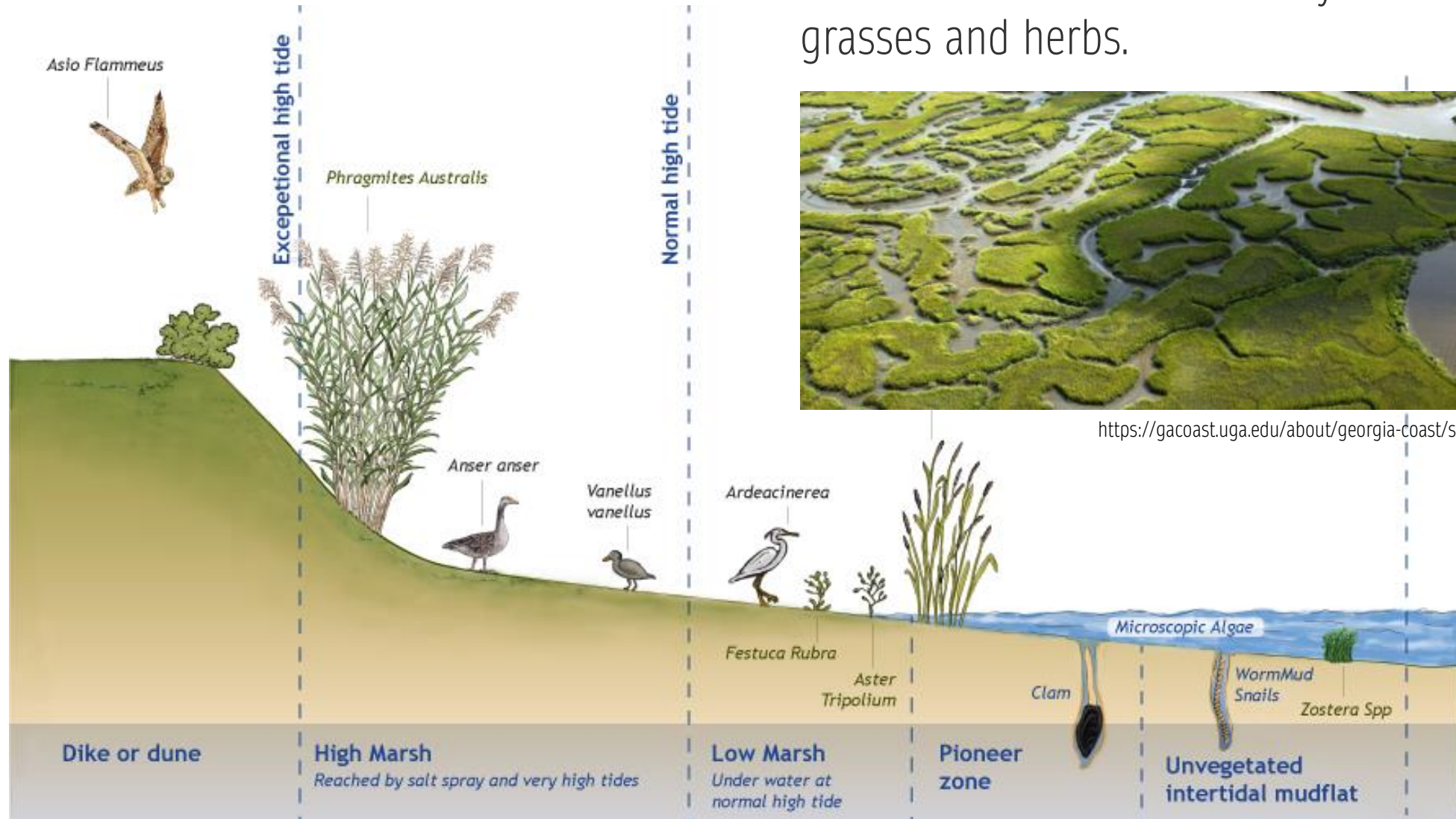
What is a salt marsh?

Saltmarshes are dominated by grasses and herbs.



What is a salt marsh?

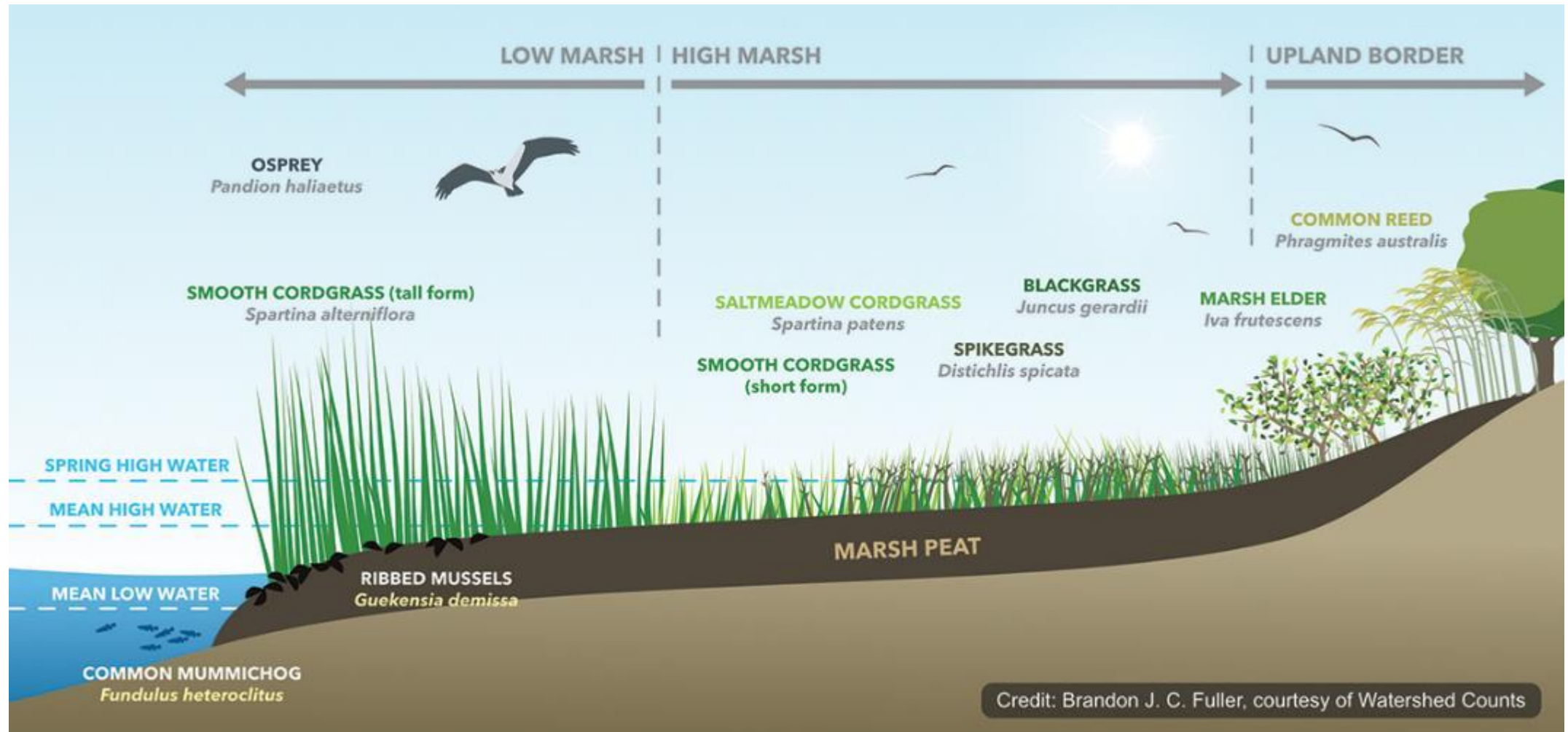
Saltmarshes are dominated by grasses and herbs.



<https://gacoast.uga.edu/about/georgia-coast/salt-marsh-ecology/>

<https://www.ecoshape.org/en/concepts/growing-salt-marshes/hydrosphere-salt-marshes/>

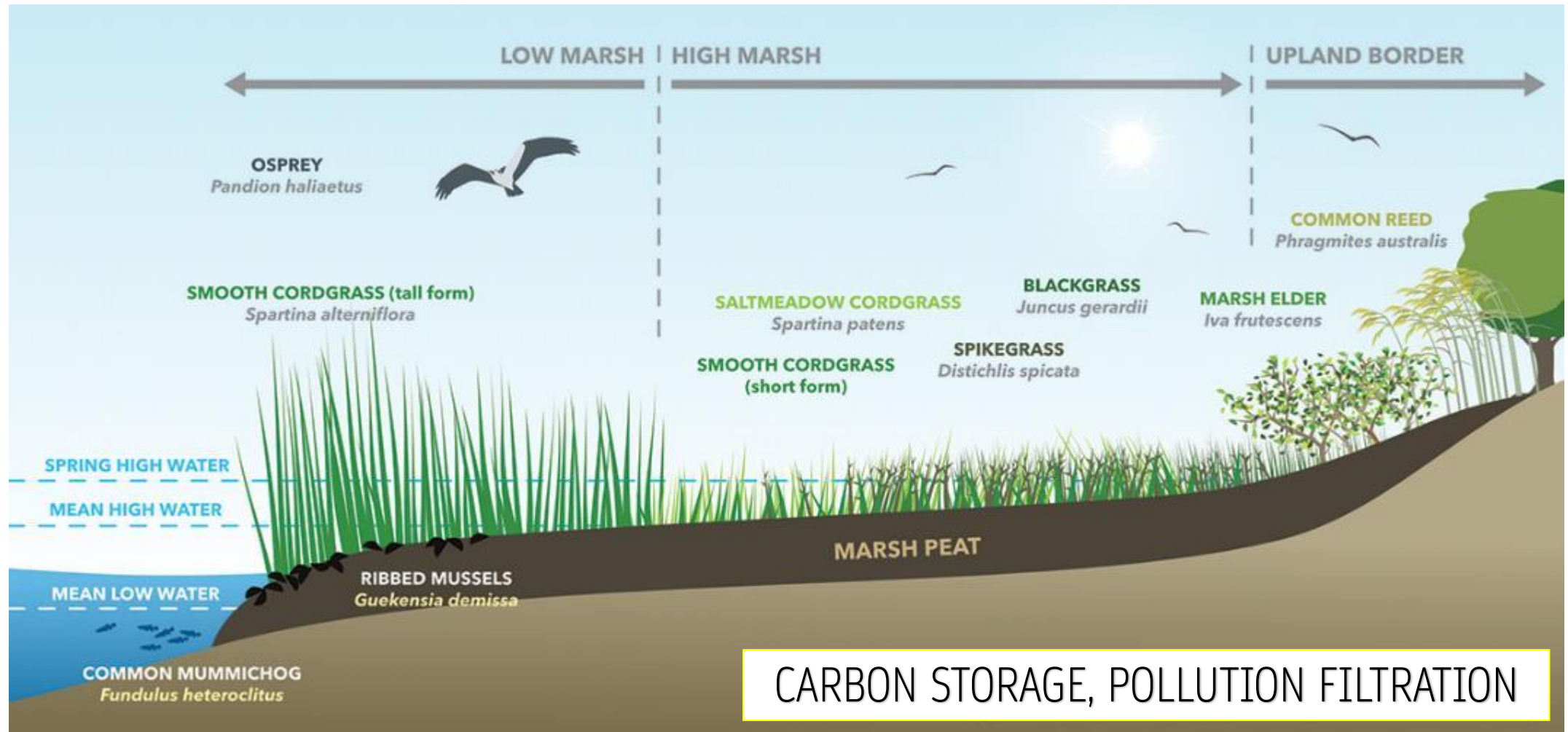
What is a salt marsh?



https://watershedcounts.org/documents/Watershed-Counts-2017--Rising_Seas_and_Salt_Marshes.pdf

http://www.crmc.ri.gov/news/images/2017_1016_wc_rssm2.jpg

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http://www.crmc.ri.gov/news/images/2017_1016_wc_rssm2.jpg

CORAL REEFS

COASTAL ECOSYSTEMS



What is a coral reef?

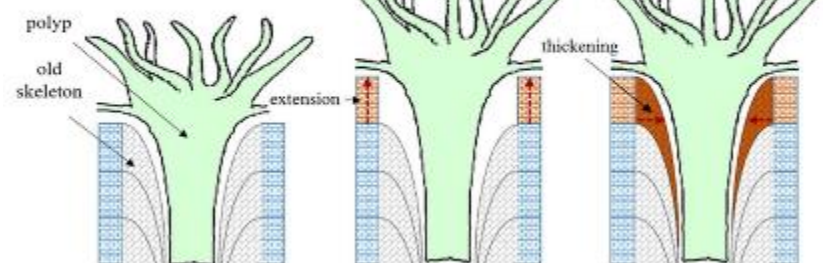
An ecological association of corals and other tropical organisms living atop a substrate

Living organisms (*Cnidaria*) that produce CaCO_3 for exoskeletons.

Constructional.



Hard coral polyp:
Lateral + vertical growth

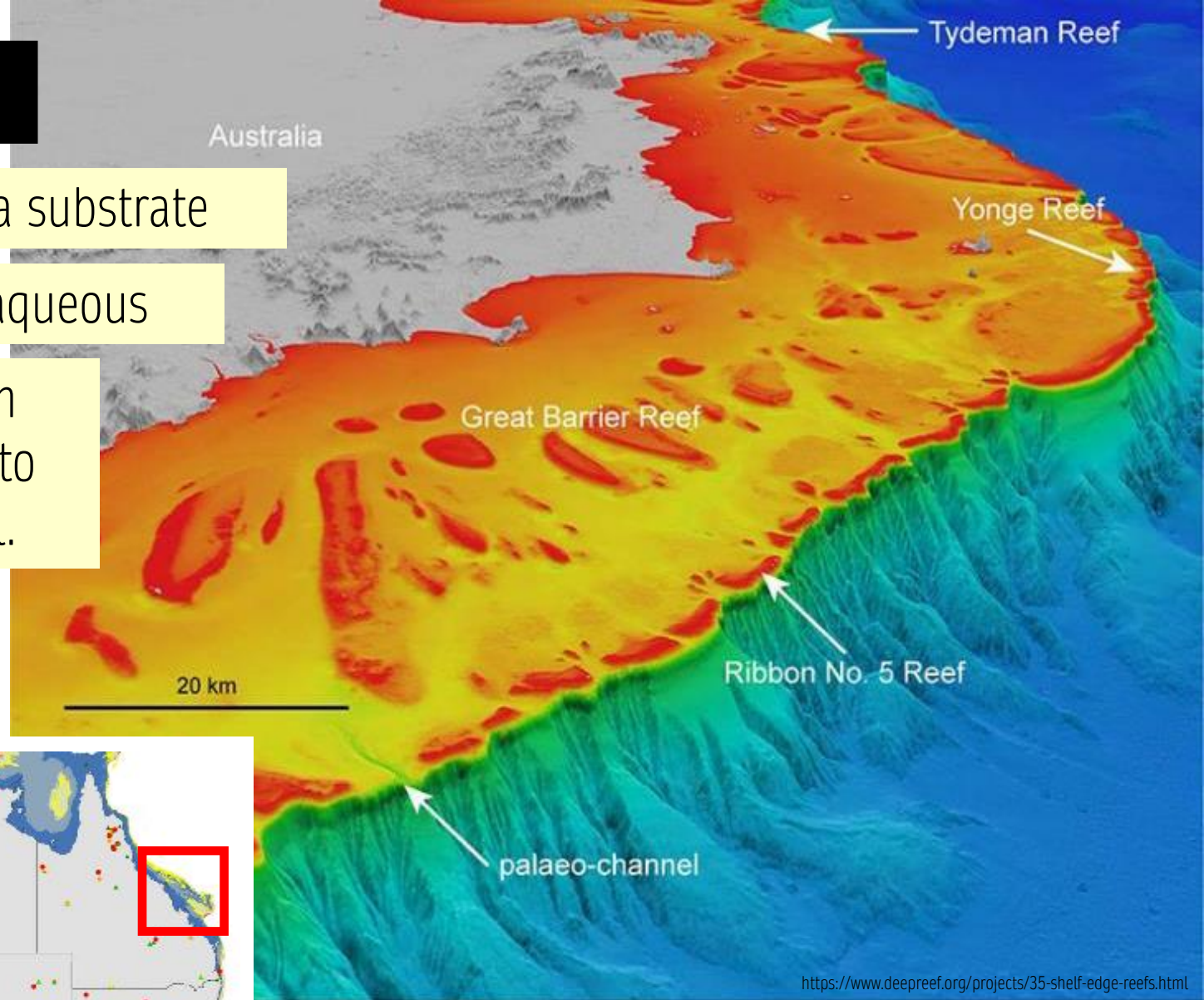
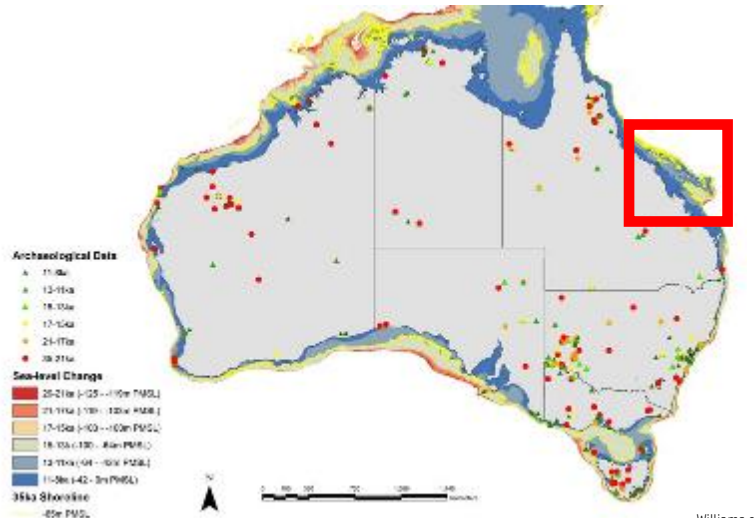


Formation

Reefs form atop a substrate

Needs to be subaqueous

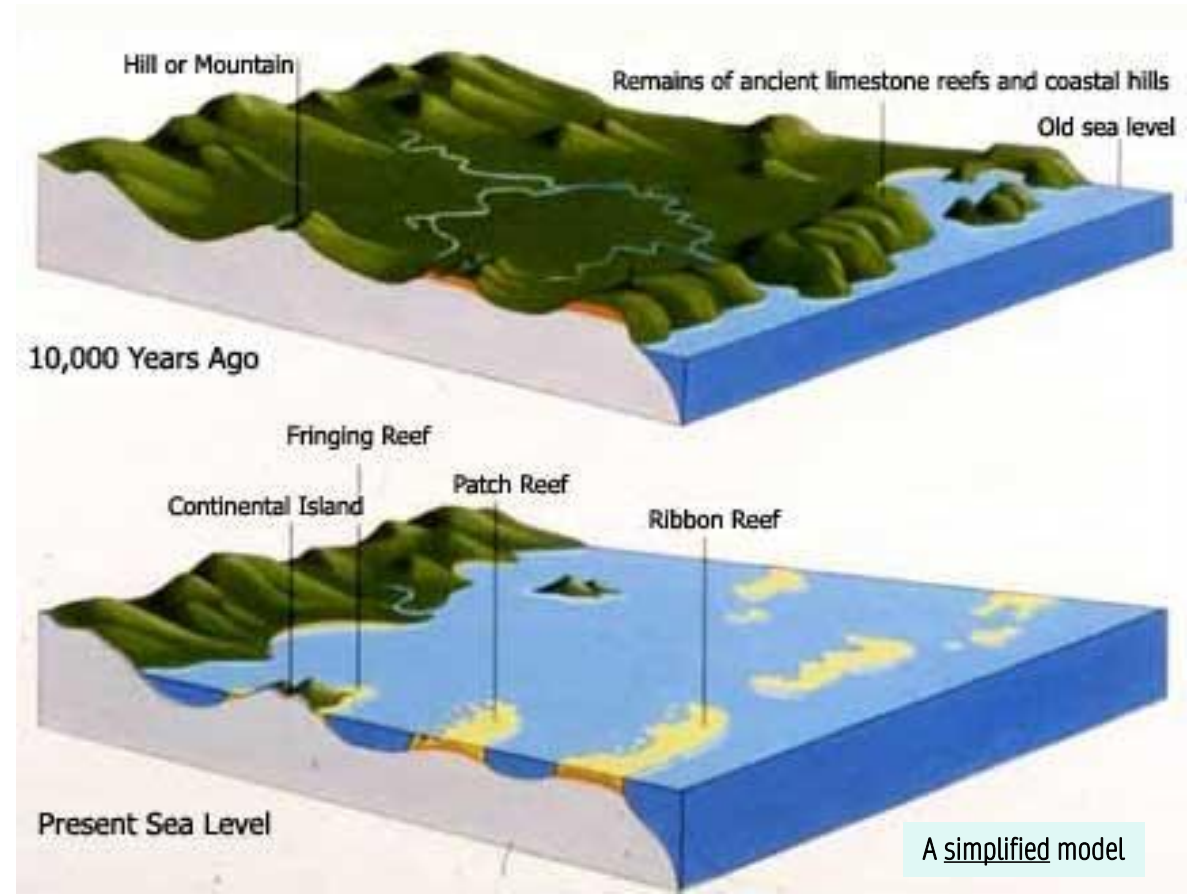
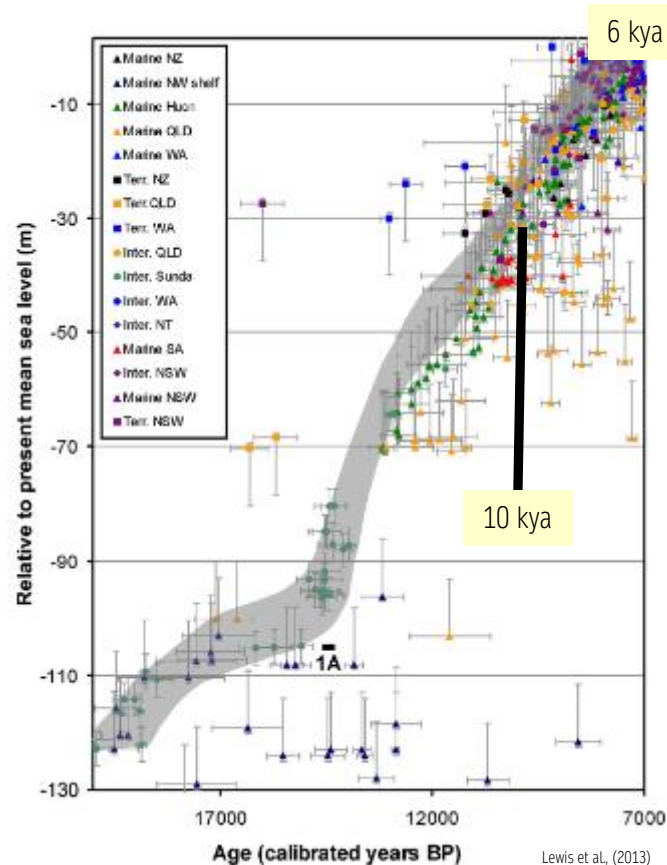
Need an optimum depth-light ratio to persist - sea level.



Coral reefs begin to form when coral larvae attach to submerged rocks or hard surfaces along the edges of islands or continents.

Great Barrier Reef (GBR)

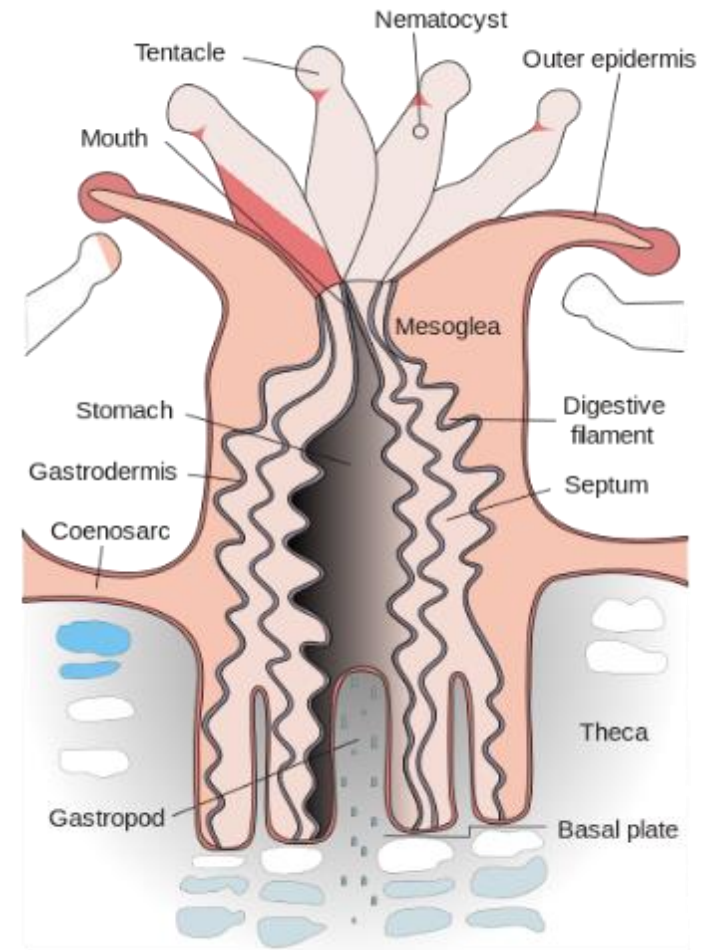
- During PGMT - Great Dividing Range and coastal plain were inundated
- Coral deposits began to grow on a substrate - ancient reefs and drowned land
- By 6 kya, sea level stopped rising - reef accretion continues.



CaCO_3 production

Coral polyps attach to a substrate and secrete CaCO_3 (exoskeletons)

Process builds reef vertically and laterally (as well as cementation).

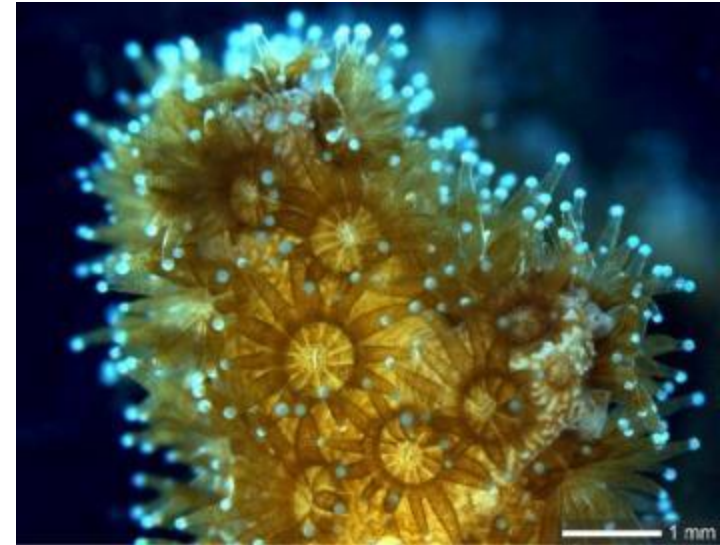
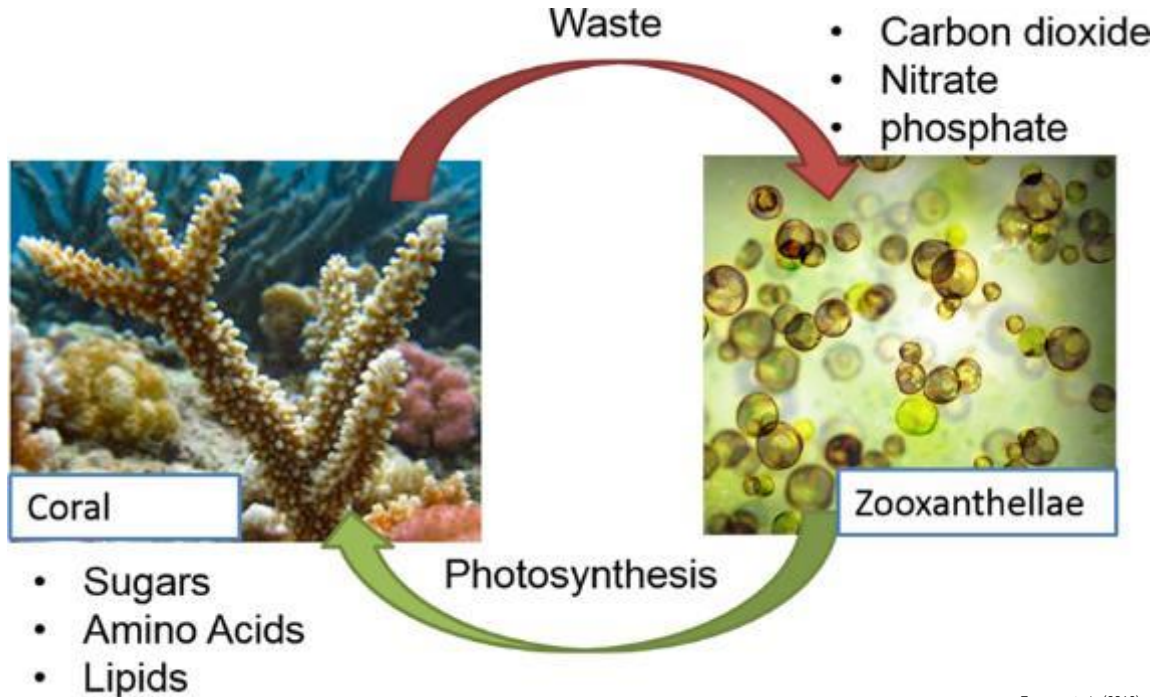


Growth

Symbiosis of coral and a photosynthetic algae (Zooxanthellae) important for growth

Algae gives the coral oxygen and energy from photosynthesis

Algae also gives the coral colour.



CORAL BLEACHING

Have you ever wondered how a coral becomes bleached?

HEALTHY CORAL

1 Coral and algae depend on each other to survive.



Coral have a symbiotic relationship with microscopic algae called zooxanthellae. The live in their tissues. These algae are the coral's primary food source and give them their color.

STRESSED CORAL

2 If stressed, algae leaves the coral.



When the symbiotic relationship becomes stressed due to increased water temperature or pollution, the algae leave the coral's tissue.

BLEACHED CORAL

3 Coral is left bleached and vulnerable.



Without the algae, the coral loses its main source of food, turns white, and is more susceptible to disease.

WHAT CAUSES CORAL BLEACHING?

Changes in ocean temperature: Increased ocean temperatures, caused by global warming, can force zooxanthellae to leave coral, causing coral bleaching.

Runoff and pollution: Runoff from land, including fertilizers and pesticides, can cause coral bleaching. These can also cause other problems.

Overexposure to sunlight: When coral is exposed to high levels of sunlight, it can cause coral bleaching. This is why coral bleaching is often seen in shallow waters.

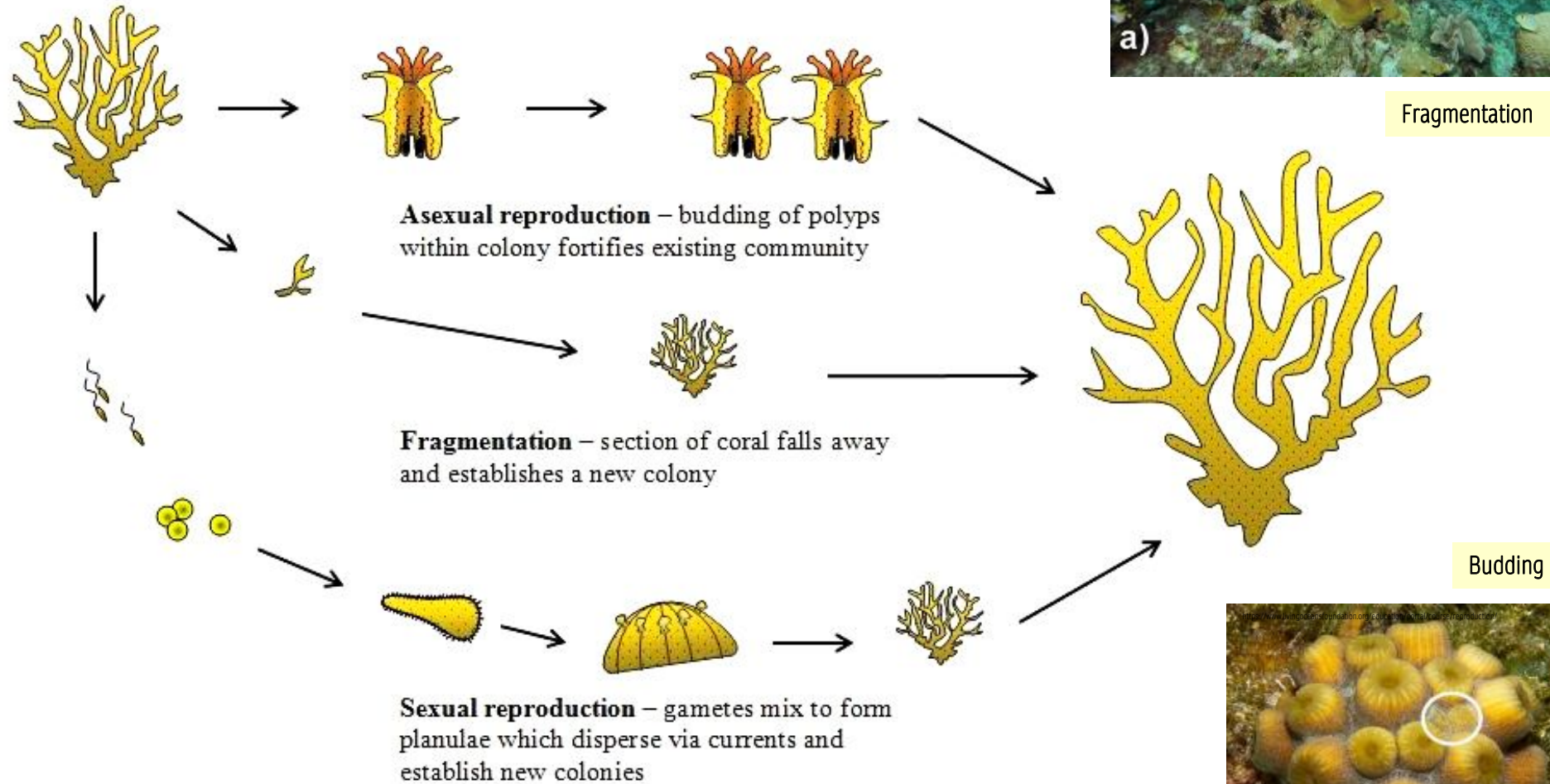
Extreme low tides: Exposure to the sun during extreme low tides can cause bleaching in shallow waters.



Bleaching due to the loss of Zooxanthellae under stress.



Reproduction occurs sexually (by spawning) or asexually (by budding and fragmentation)



Fragmentation



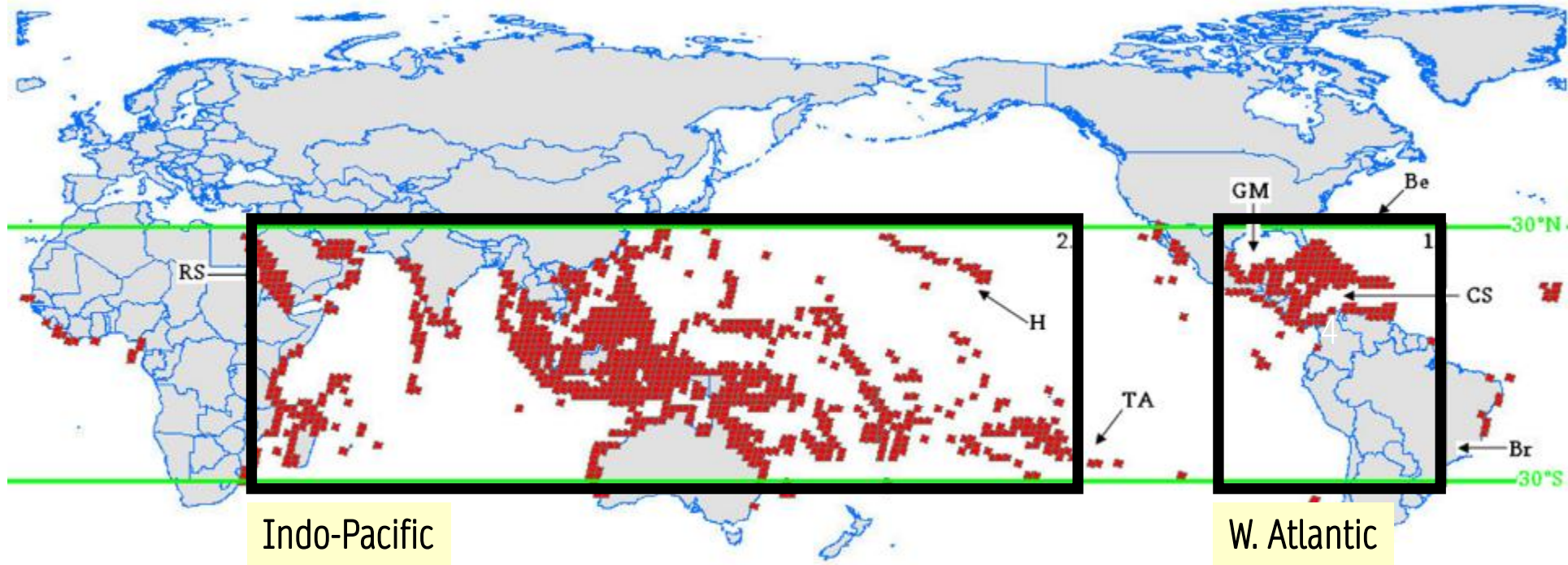
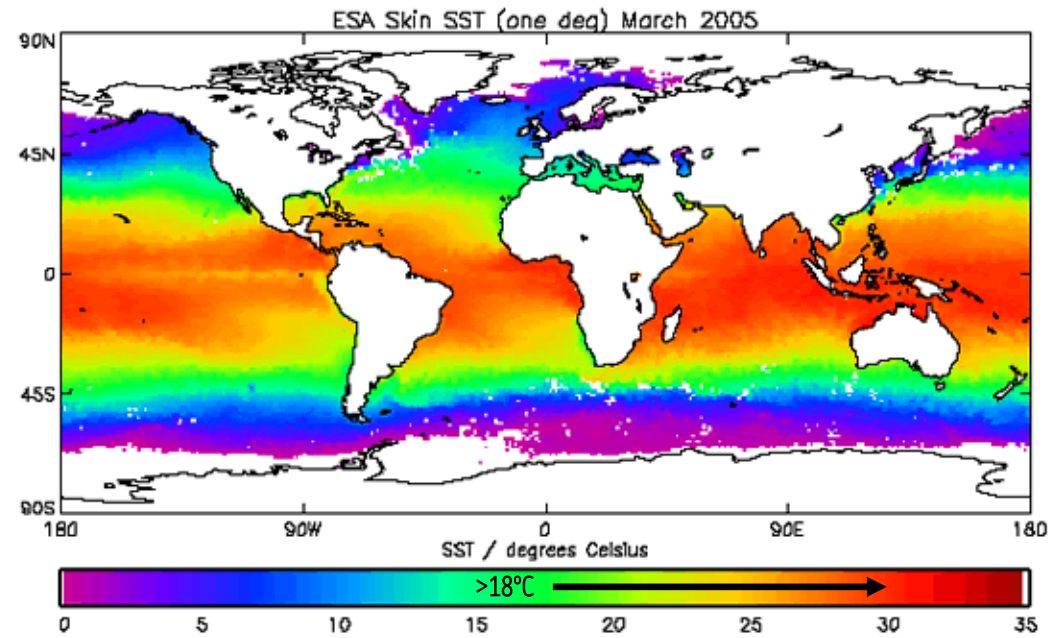
Budding



Distribution

Need: warm water, low turbidity, moving water, salty water, shelter

Two key regions. Rare in tropical Atlantic of South America and Africa due to the influx of fresh water and silt from large rivers.



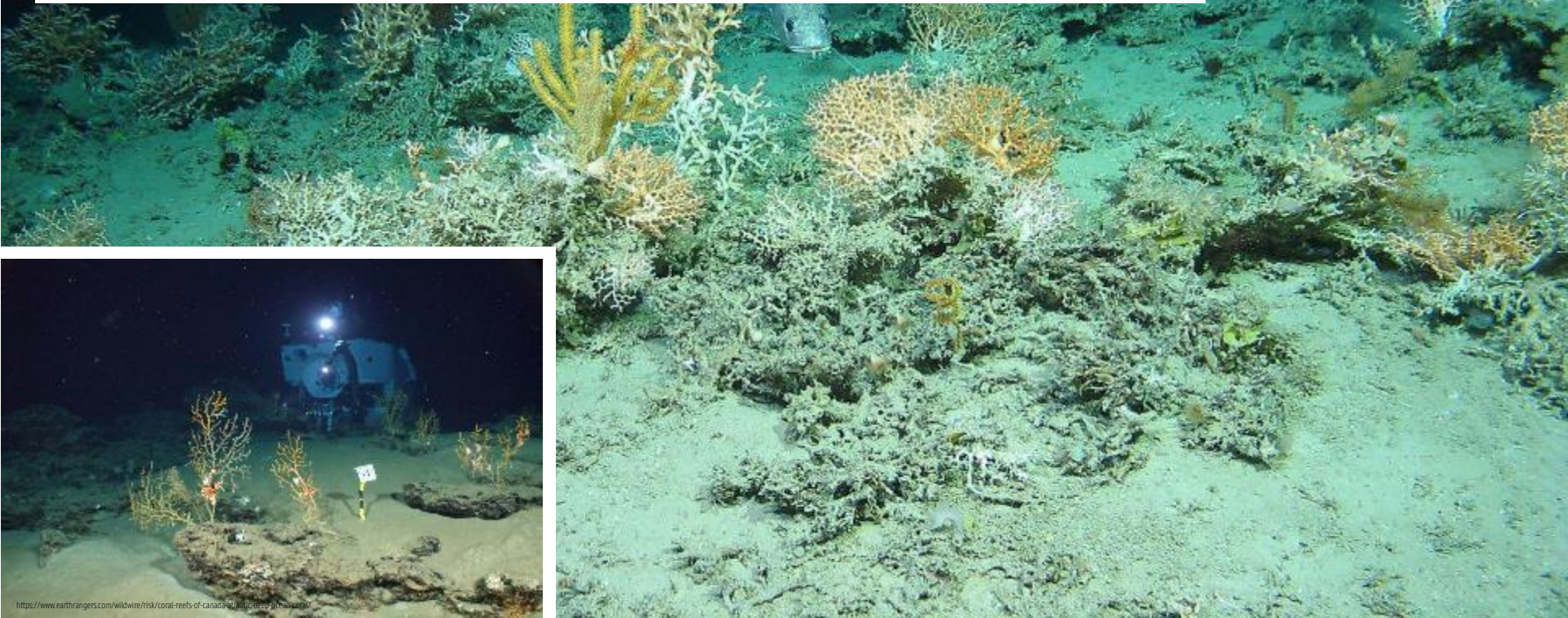
The exception... Deep water corals

Can form at extreme depths (challenges = low light and cold)

Found at depths of 40 - 2000 m and in temperatures 4°C

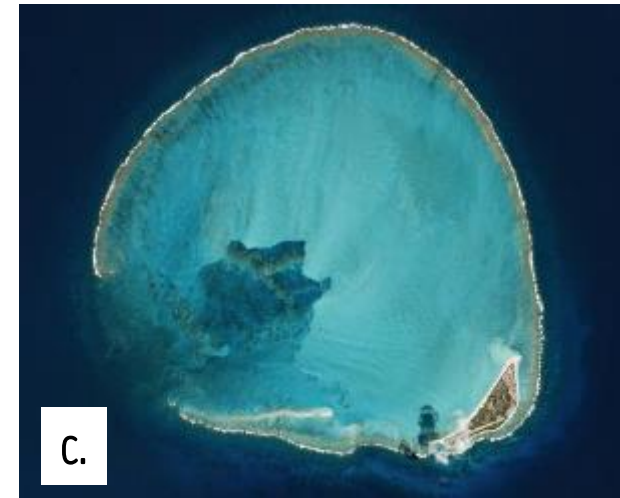
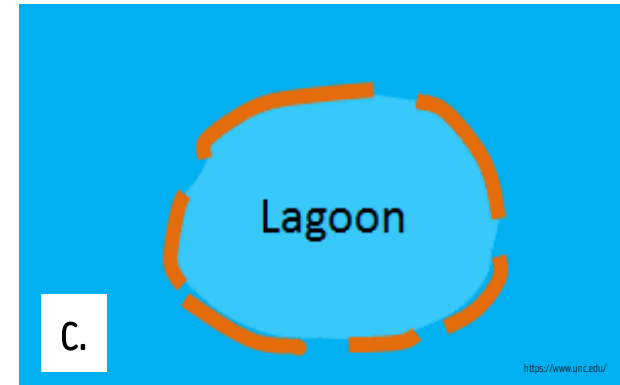
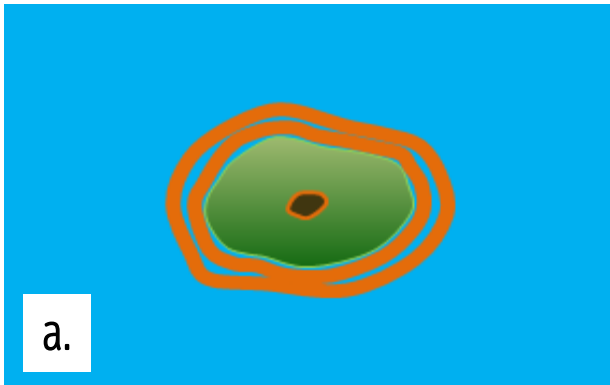
Deep water corals form patches not true reefs - slow growing

Do not typically support a community or have symbiotic algae but feed by capturing food particles from ocean currents.



Reef types

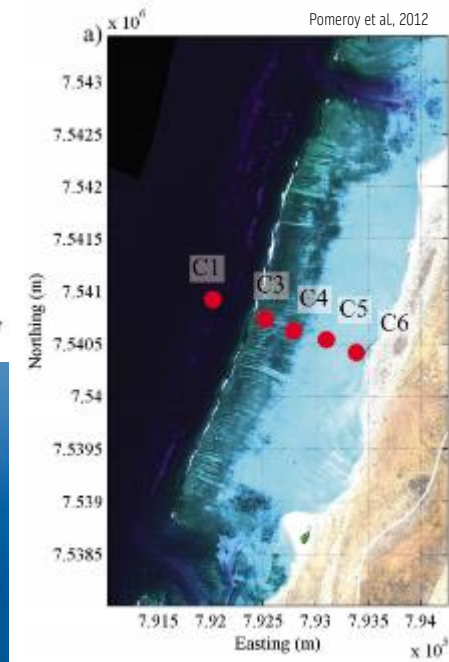
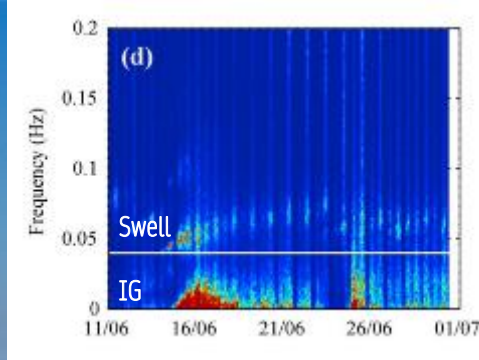
- a. **Fringing** - form borders along shorelines (continent or island);
- b. **Barrier** - separated from the shoreline by a lagoon or ocean;
- c. **Atoll** - ring shaped reefs, islands protrude above sea surface.



a. Fringing reefs

e.g. Ningaloo Reef, WA

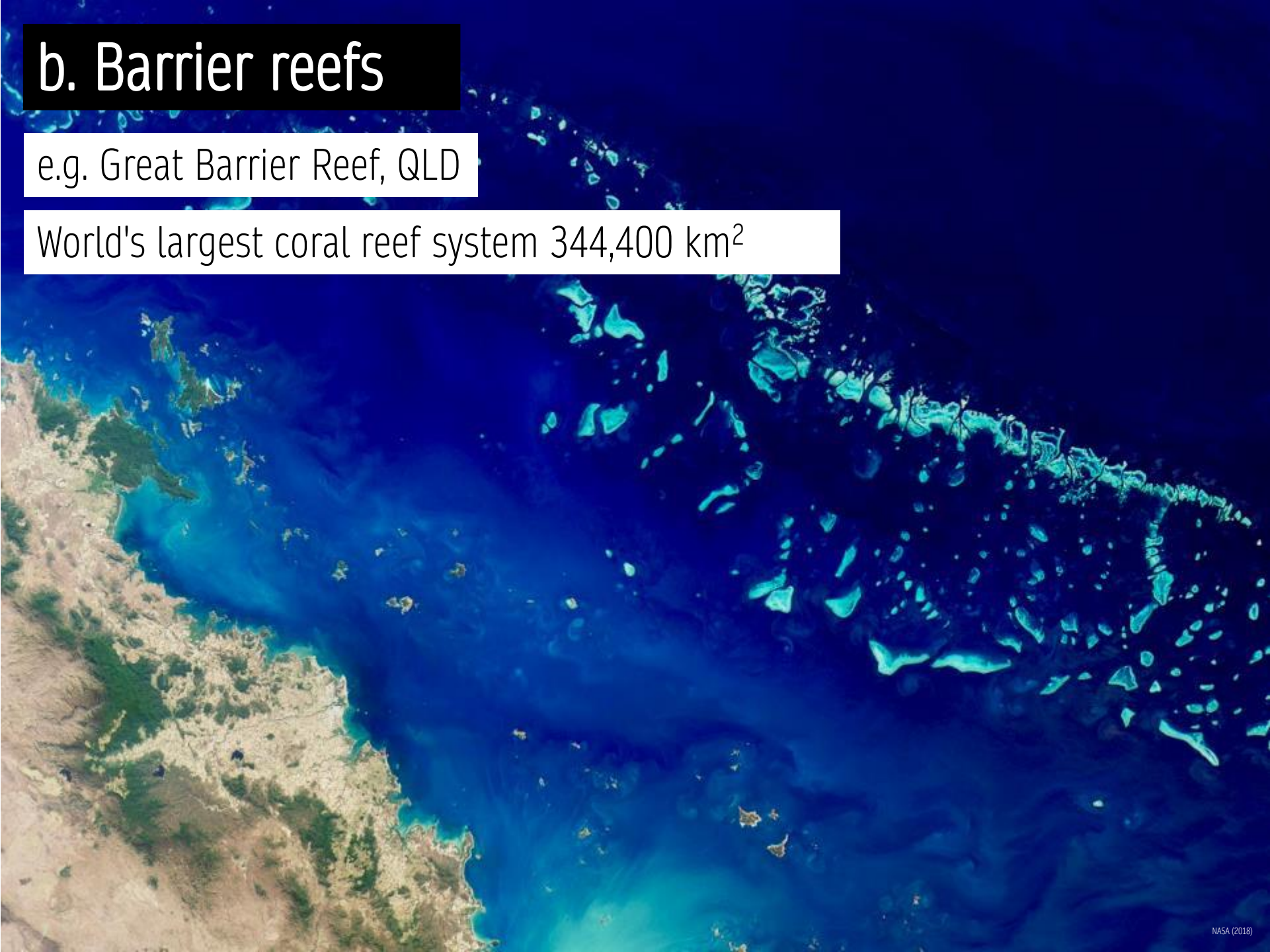
230 km long: Australia's largest fringing reef. Reef is separated by a 200 m - 5 km wide lagoon.



b. Barrier reefs

e.g. Great Barrier Reef, QLD

World's largest coral reef system 344,400 km²



c. Atolls

Found in mid-ocean far continental shelves and large islands

A low, narrow crest enclosing a central lagoon

Most atolls are found in the Indo-Pacific zone on the Pacific Plate and are associated with volcanoes that form at hot spots.



e.g. Bikini Atoll (with bomb crater)

Atoll freshwater lens

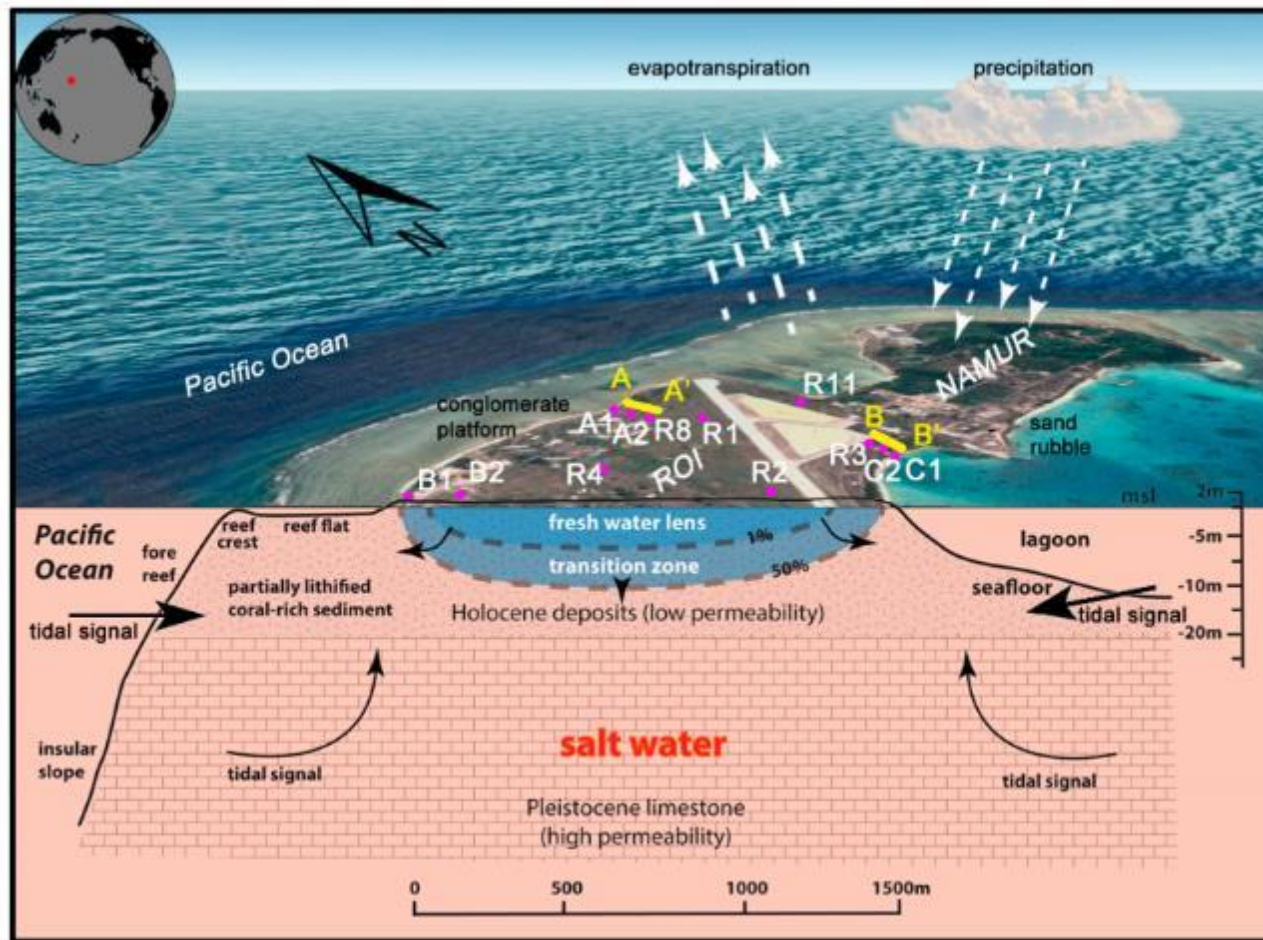
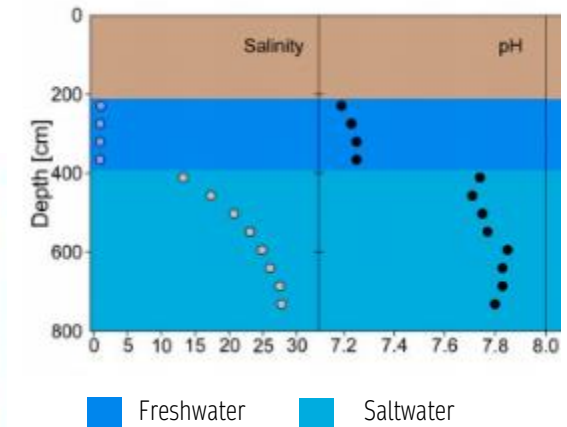


Figure 1. Satellite image and conceptual drawing of the shallow aquifer system of Roi-Namur, Kwajalein Atoll, Marshall Islands. Location of shallow groundwater monitoring wells (magenta dots) and time-series electrical resistivity transects (yellow lines) are indicated.



Oberle et al., 2017



Here a buoyant lens of fresh water (rainfall) sits atop of a more salt water layer.



Figure 7. Photos of wave-driven flooding and overwash on Roi-Namur Atoll, Republic of the Marshall Islands near the north end of the runway. Photo on the left is looking west and photo on the right is looking east. Red dot on subplot (left photo) indicates the photos location on Roi-Namur.

Small overwash events cause an increase in salinity of the fresh water lens that returns to pre overwash conditions usually within one month.

Sea level rise: more frequent overwash and a higher base level may lead to full loss of the freshwater lens.

Oberle et al., 2017

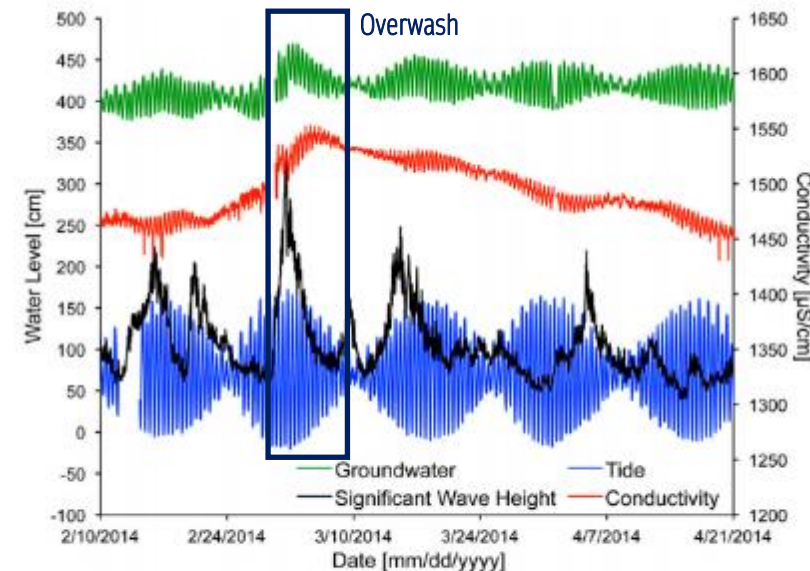


Figure 8. Observed variations in conductivity and ground water level in well A1 following an island overwash event driven by increased significant wave height during 2–3 March 2014.

Most atolls will be uninhabitable by the mid-21st century because of sea-level rise exacerbating wave-driven flooding

Curt D. Storlazzi^{1,*}, Stephen B. Gingerich², Ap van Dongeren³, Olivia M. Cheriton¹, Peter W. Swarzenski⁴, Ellen Quataert³, Cl...

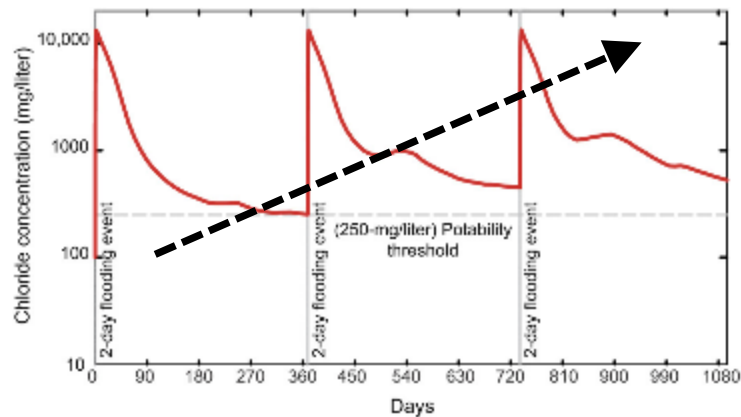
* See all authors and affiliations

Science Advances 25 Apr 2018:
Vol. 4, no. 4, eaap9741
DOI: 10.1126/sciadv.aap9741

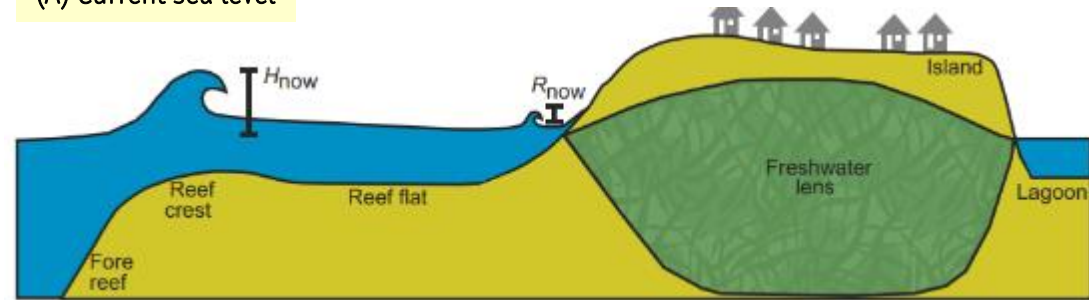
Earlier research, based on sea level rise alone, suggested this wouldn't happen until at least the end of this century.

But regular inundation from coastal flooding could push islands beyond a "tipping point" where groundwater resources cannot recover from infiltration by salty seawater, leaving residents with no drinkable water.

BELOW: Forecasted impact of annual wave-driven flooding events on ground water potability over 3 years for +0.4 m of SLR. Within 2 years of flooding, the island's groundwater is no longer potable because of seawater contamination.



(A) Current sea level



(B) Future higher sea level

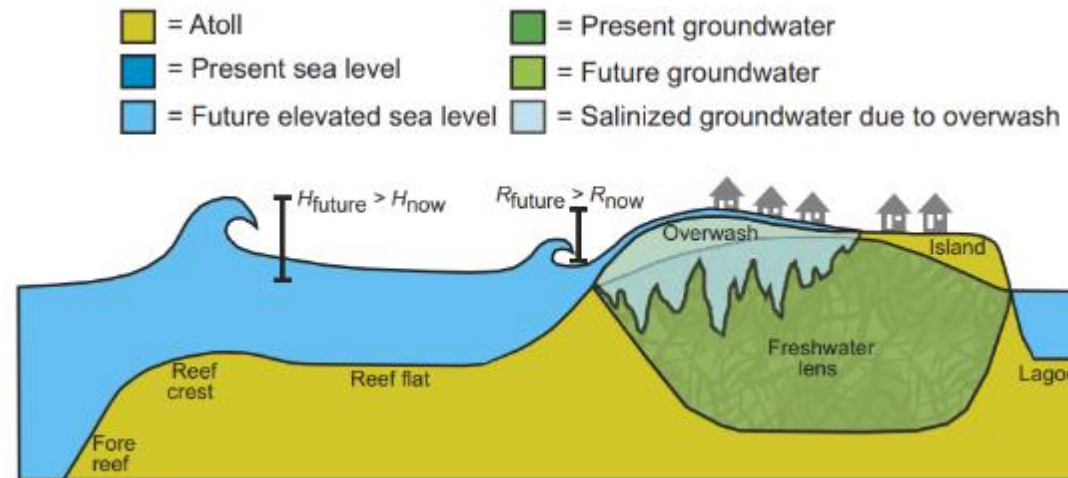
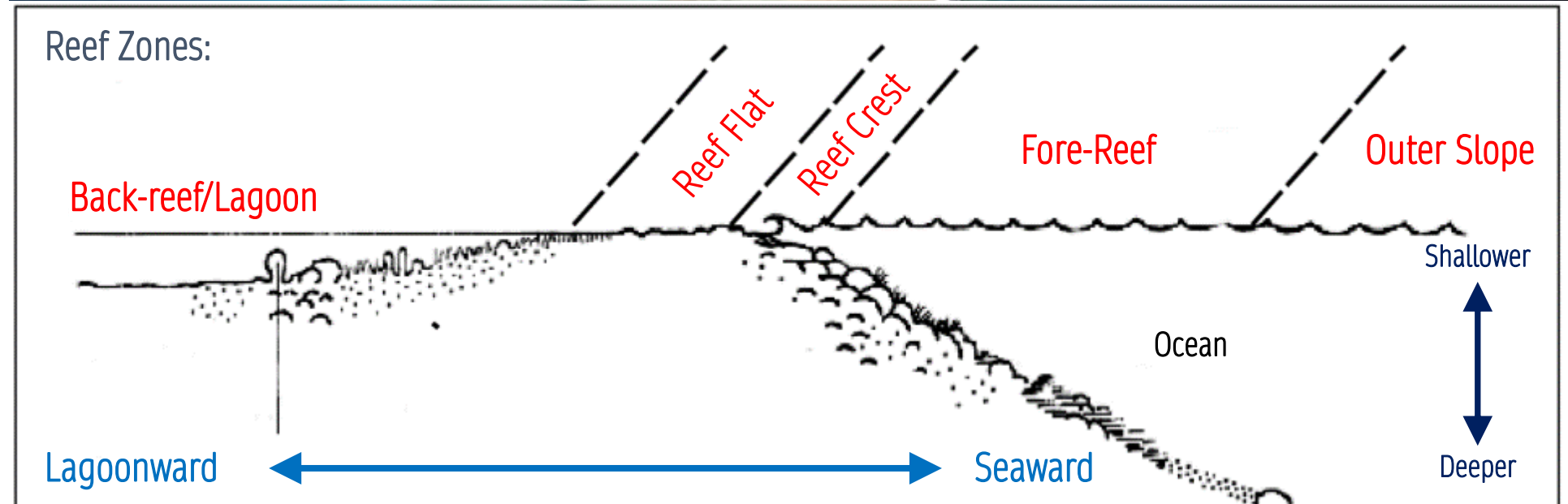


Fig. 1. Conceptual diagram of the influence of SLR on wave heights, wave-driven runoff, and flooding and the resulting impact on atoll island groundwater. (A) Current sea level. (B) Future elevated sea level. SLR will allow for greater wave heights, H , and wave-driven runoff, R , than at present, resulting in frequent overwash that will contaminate the atoll island's freshwater lens. High vertical exaggeration in schematic.

Reef geomorphic zonation

Reefs show zonation due to an energy gradient

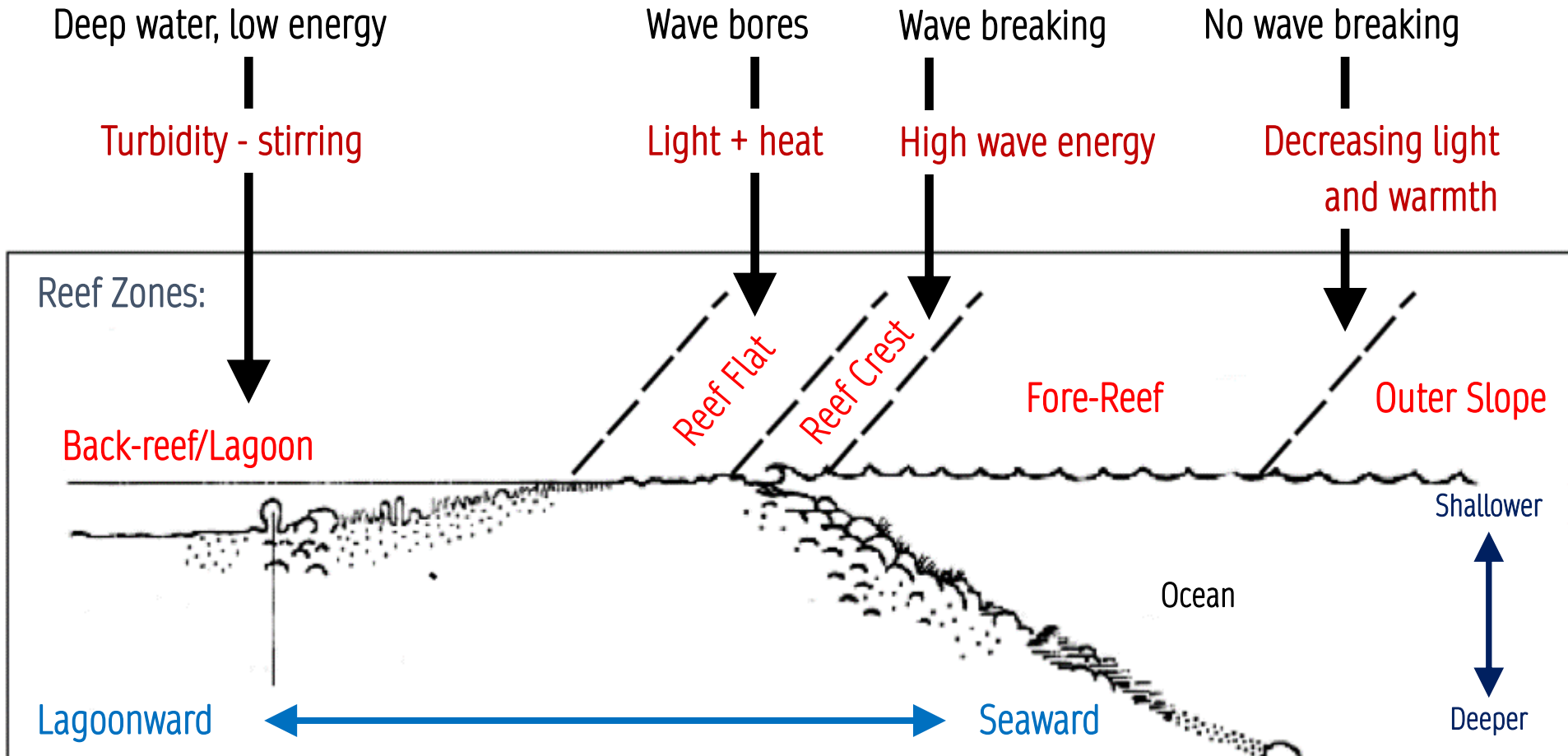


Coral morphology changes across a reef profile

Response to different stresses.

LAGOON

OCEAN



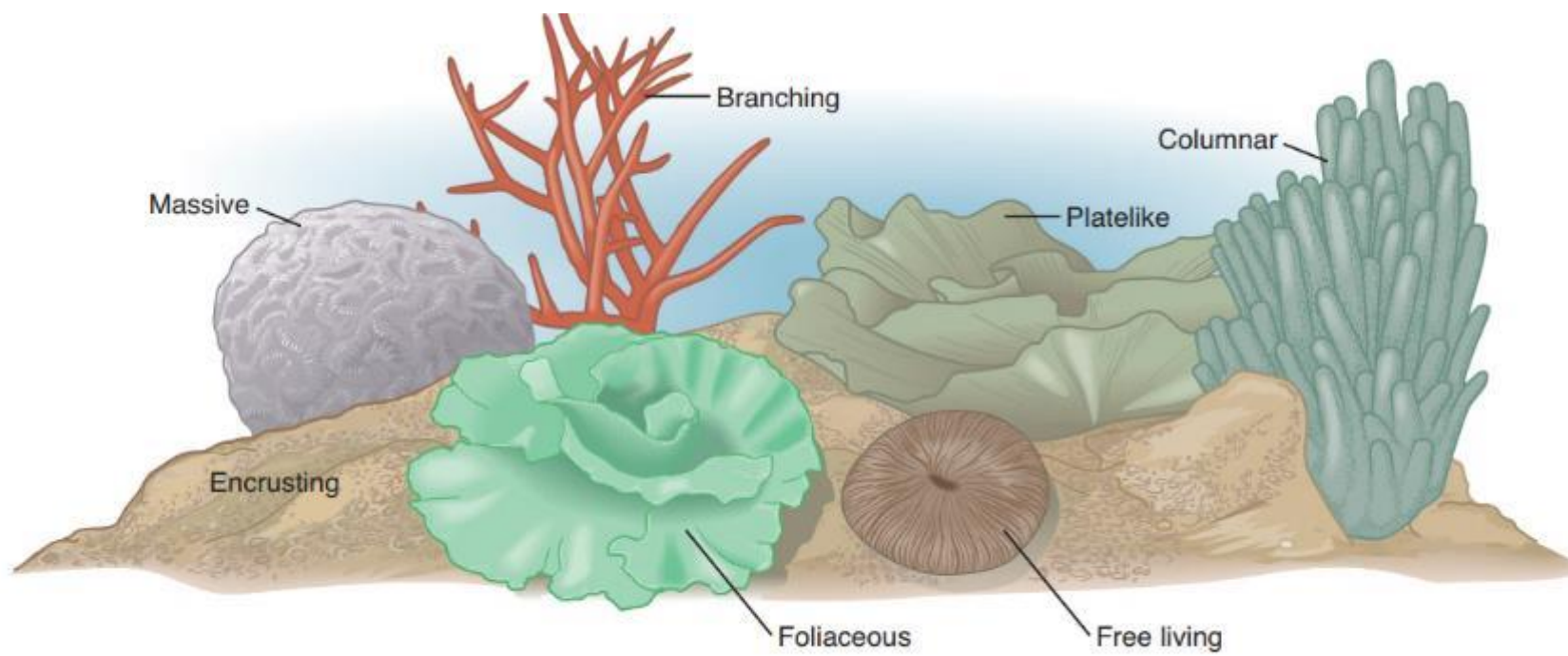
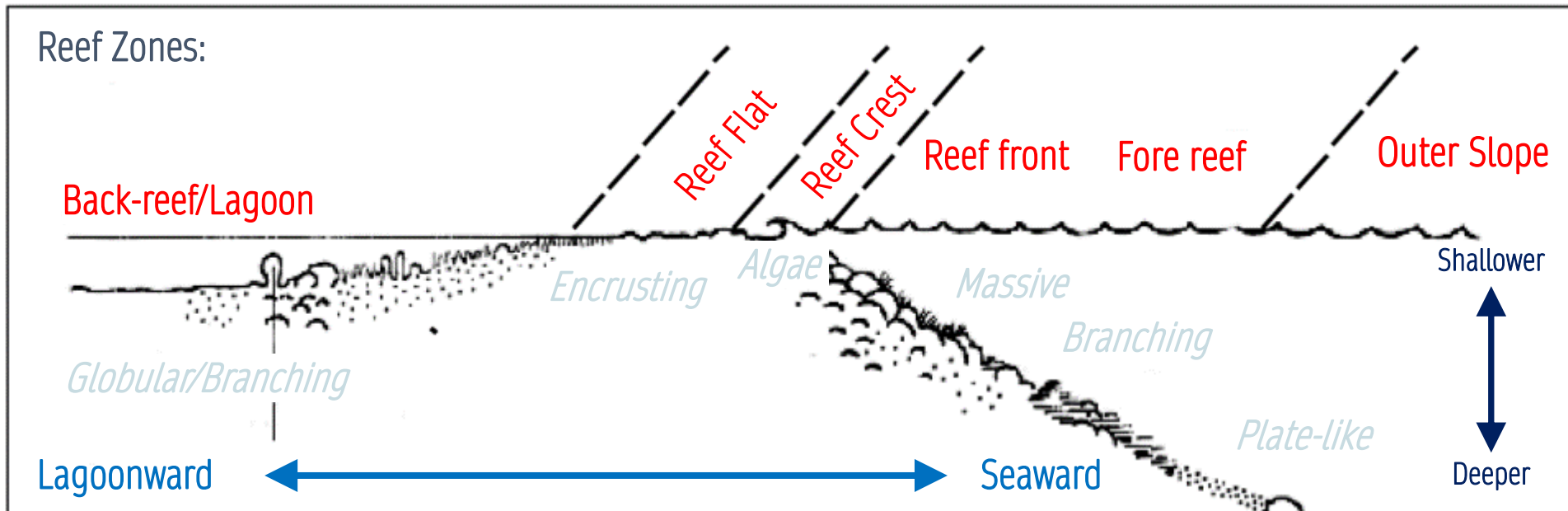
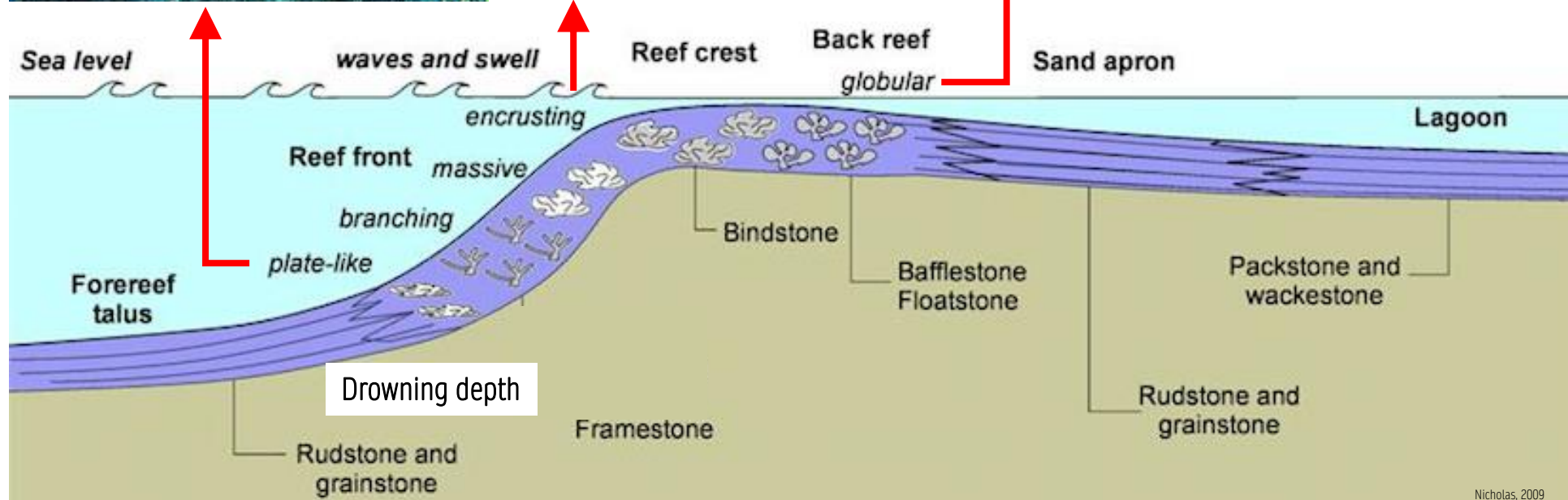
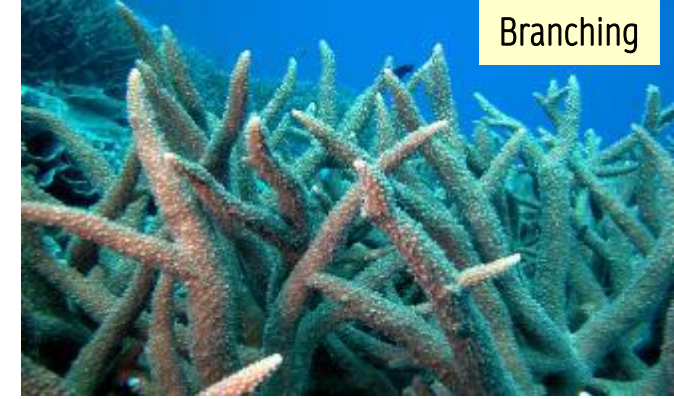


Figure 11.3 Corals exhibit a large variety of growth forms.







COASTAL ECOSYSTEMS

ROCKY COASTS



COASTAL ECOSYSTEMS

ROCKY COASTS

Rocky coasts

Result of marine erosion and subaerial weathering [purely erosional]

Landward retreat of bedrock at the shore

Rock strength vs weathering and erosion.

80 % of global coastlines (Emery, 1982)



Sea stacks and cliffs

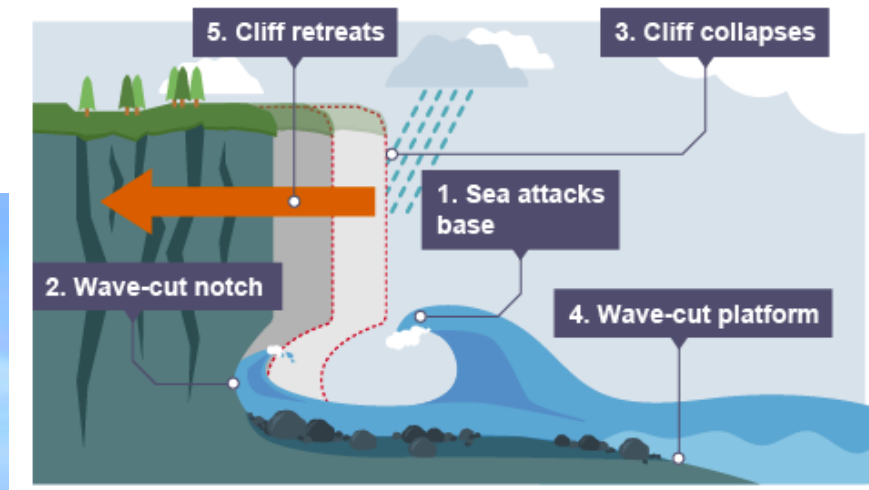


Sea arches



Shore platforms

Cliffs and platforms



Cliff and wave-cut platform along the coast of Southerndown, Wales.

Controls on cliff erosion rates

Rock strength vs weathering and erosion processes

M. Prémaillon et al.: GlobR2C2 (Global Recession Rates of Coastal Cliffs)

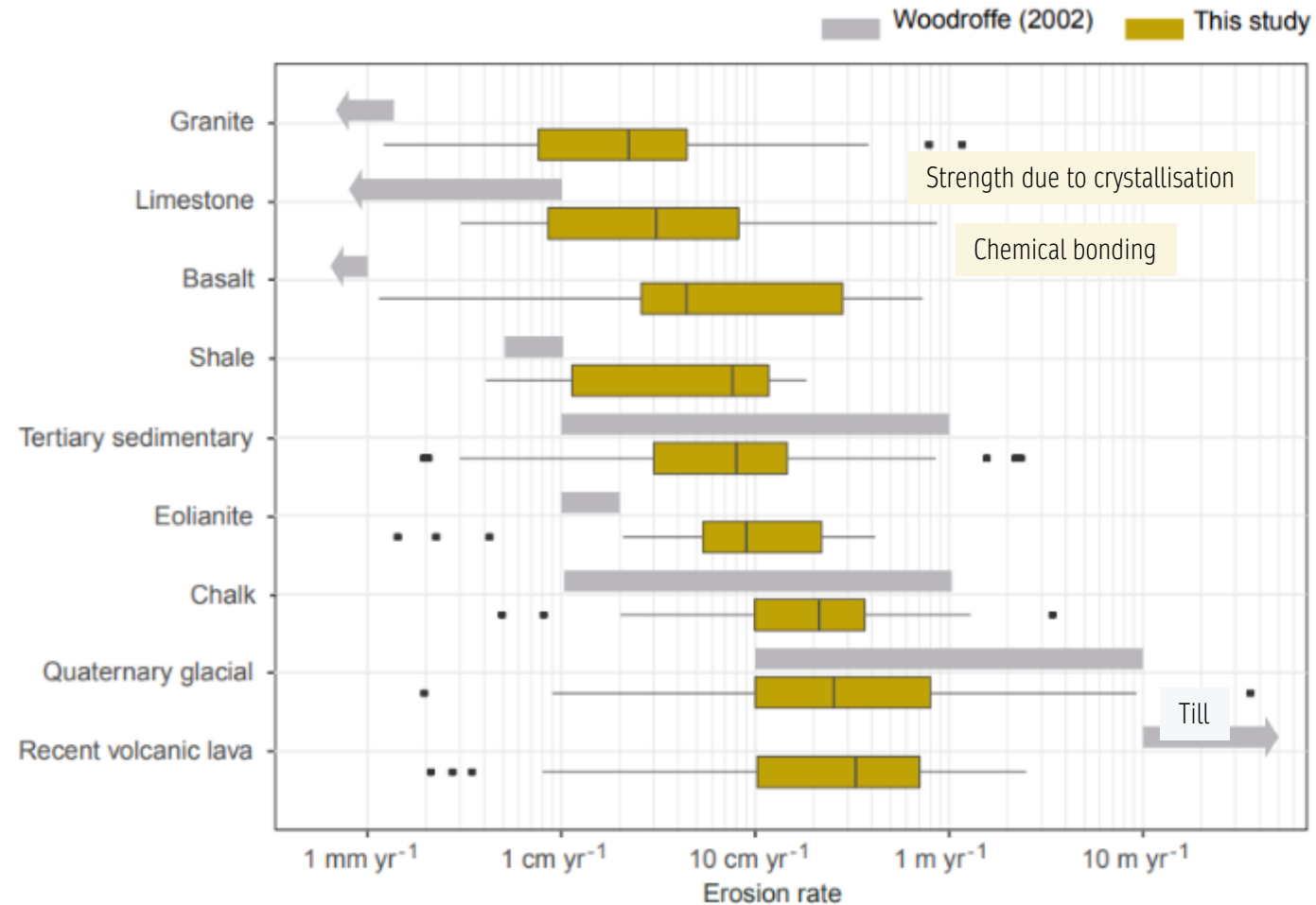


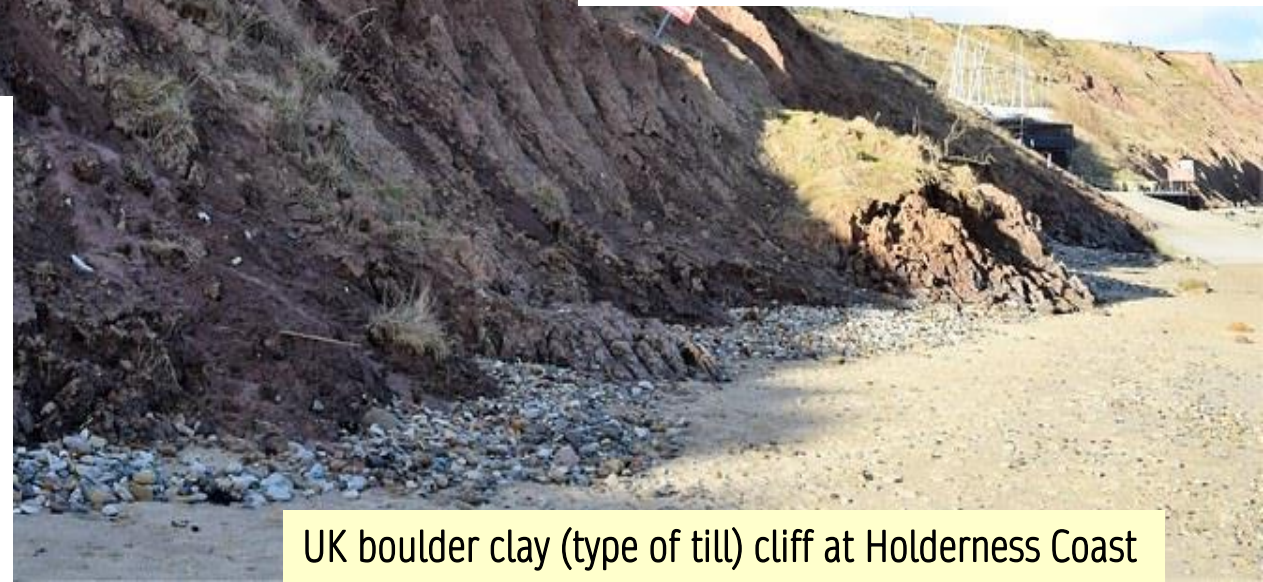
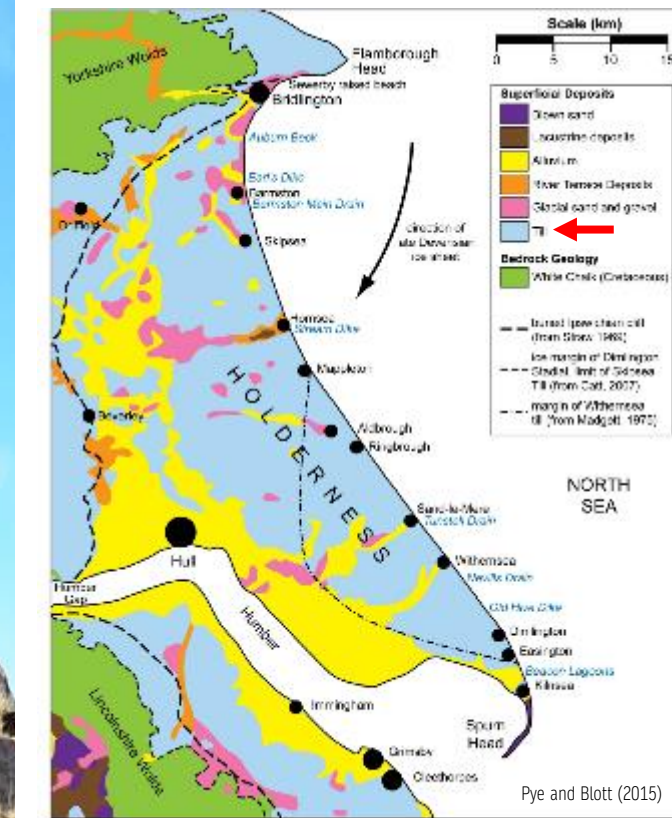
Figure 10. Ranges of erosion rates within different lithology. Comparison between the study by Woodroffe 2002 and this study.

Soft rock



NZ Quaternary glacial till sea cliff - soft and crumbly - clasts in a matrix

Soft rock



UK boulder clay (type of till) cliff at Holderness Coast

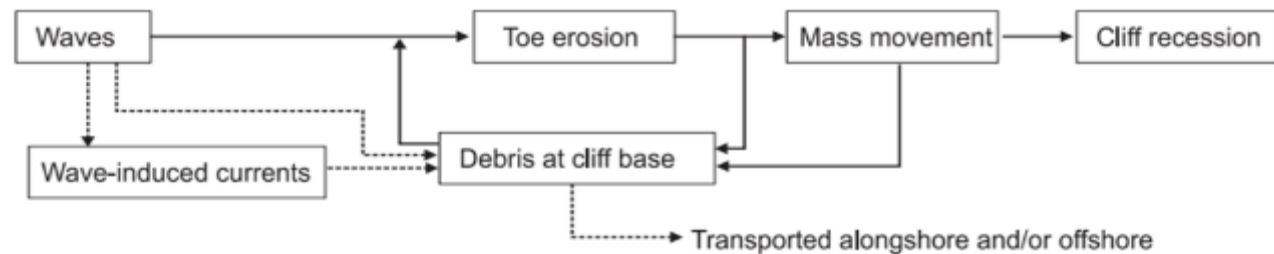
Resistant rock



Granite cliffs (Wilson's Promontory VIC) - more resistant if less fractures or cracks (i.e. weak spots).

Toe armouring

Debris can temporarily reduce toe undercutting





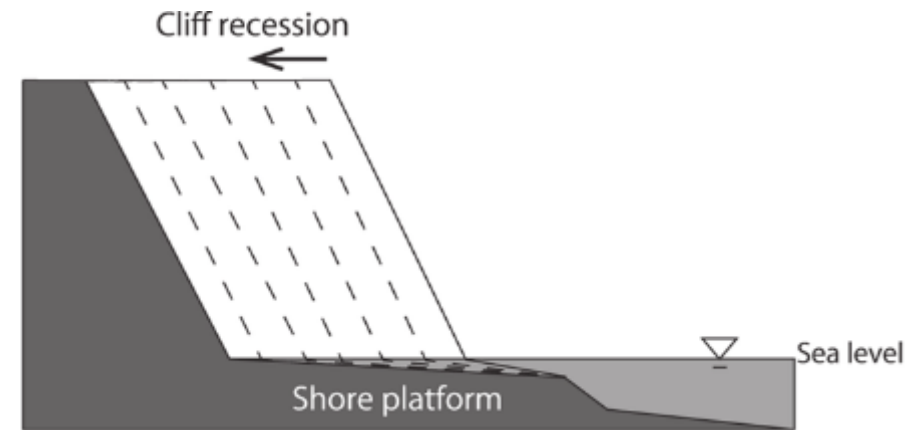
Happisburgh (UK)



Shore platforms

An erosional rocky bench in the intertidal zone [wave-cut]

Can be sloping or horizontal.



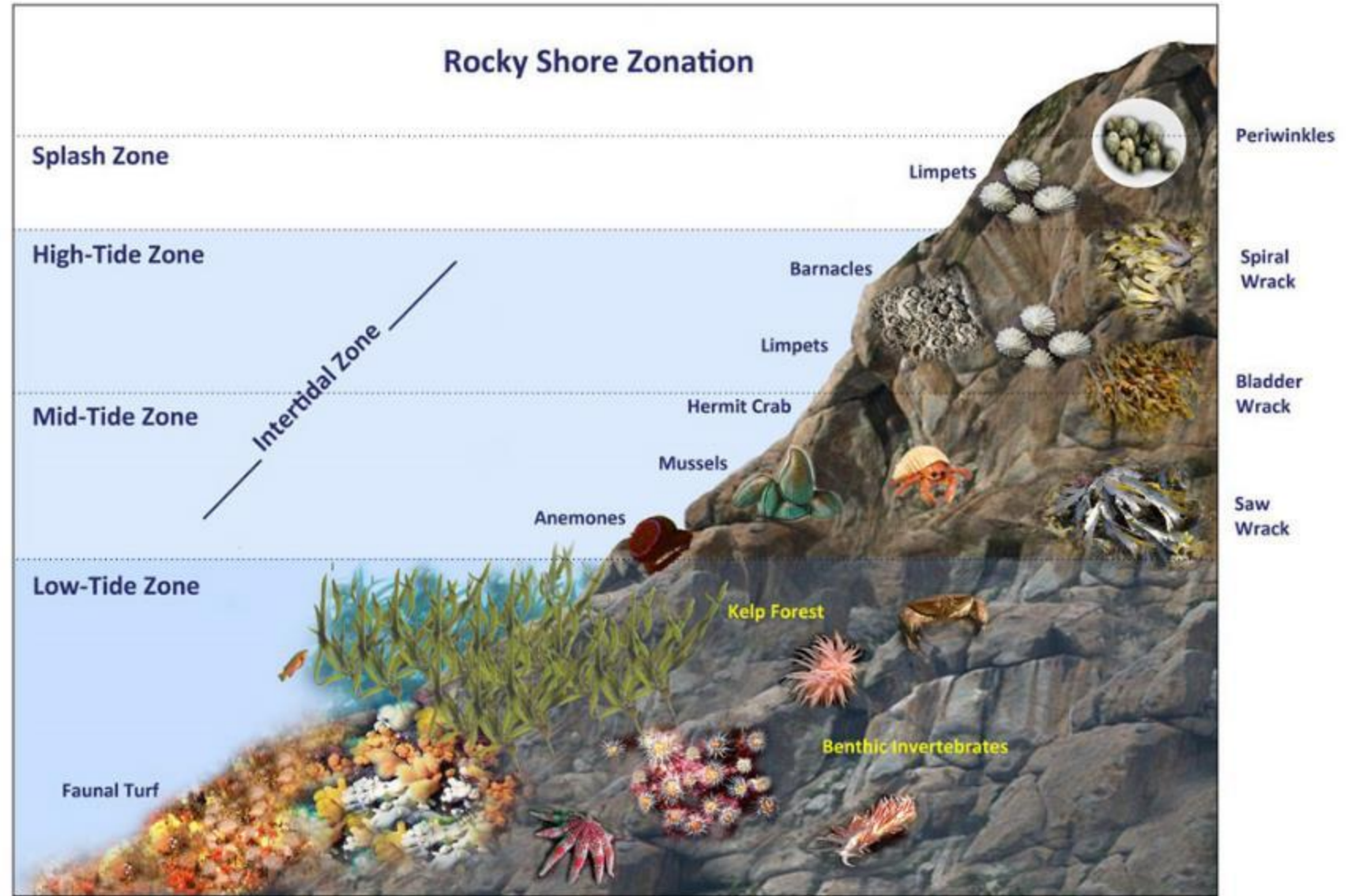
Extends from the cliff toe offshore to the limit of wave erosion.



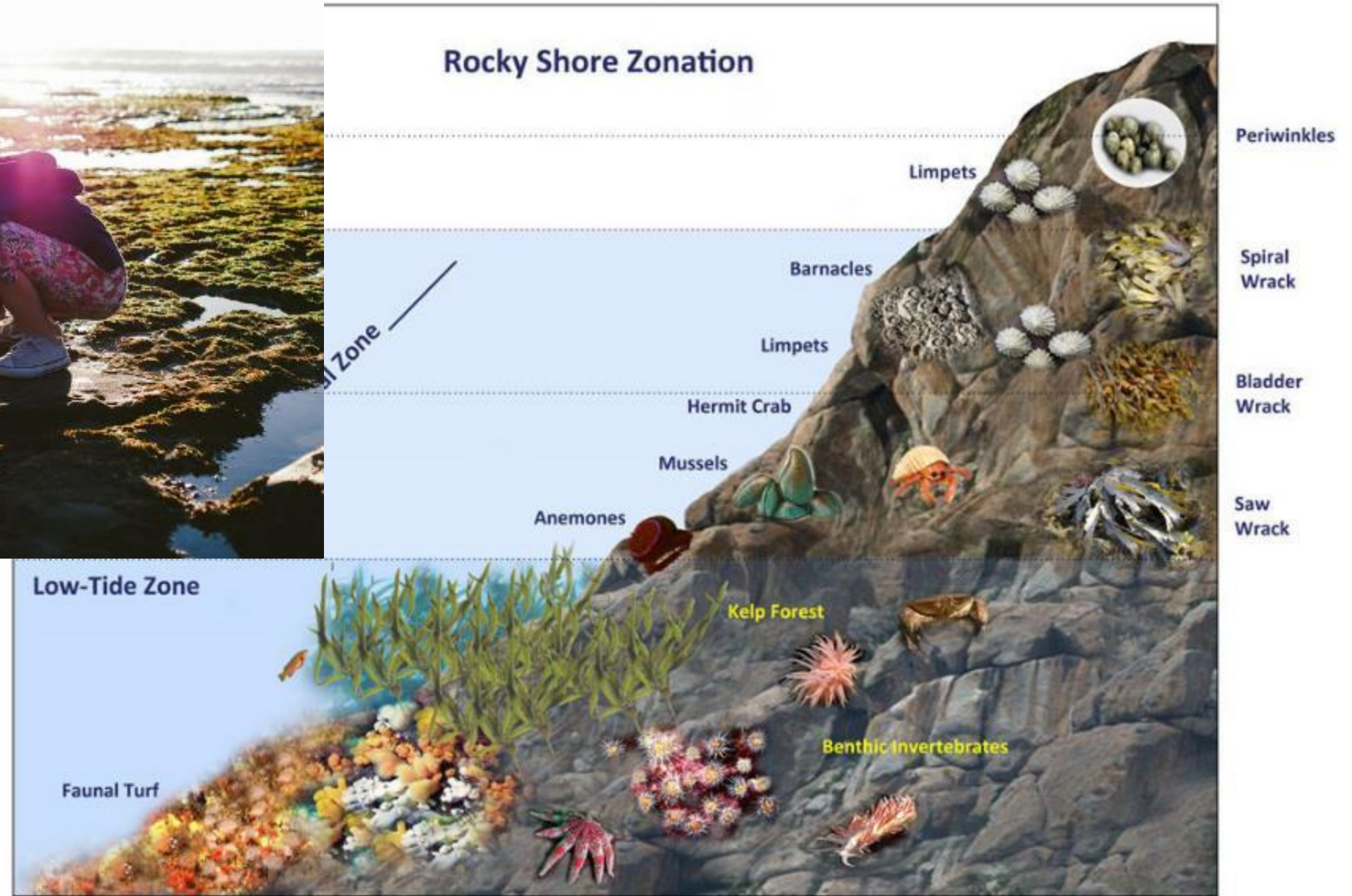
ROCKY COASTS



Rocky Coast Ecosystem



Rocky Coast Ecosystem



Rocky Coast Ecosystem



“Drilling holes in boulders can make a difference for marine life”

Rocky Coast Ecosystem

“There is a real global issue of governments creating sea defences, sea walls and other coastal infrastructure that are less good for wildlife than the nature they are replacing” - Dr Pippa Moore



<https://www.bbc.com/news/science-environment-41665459>



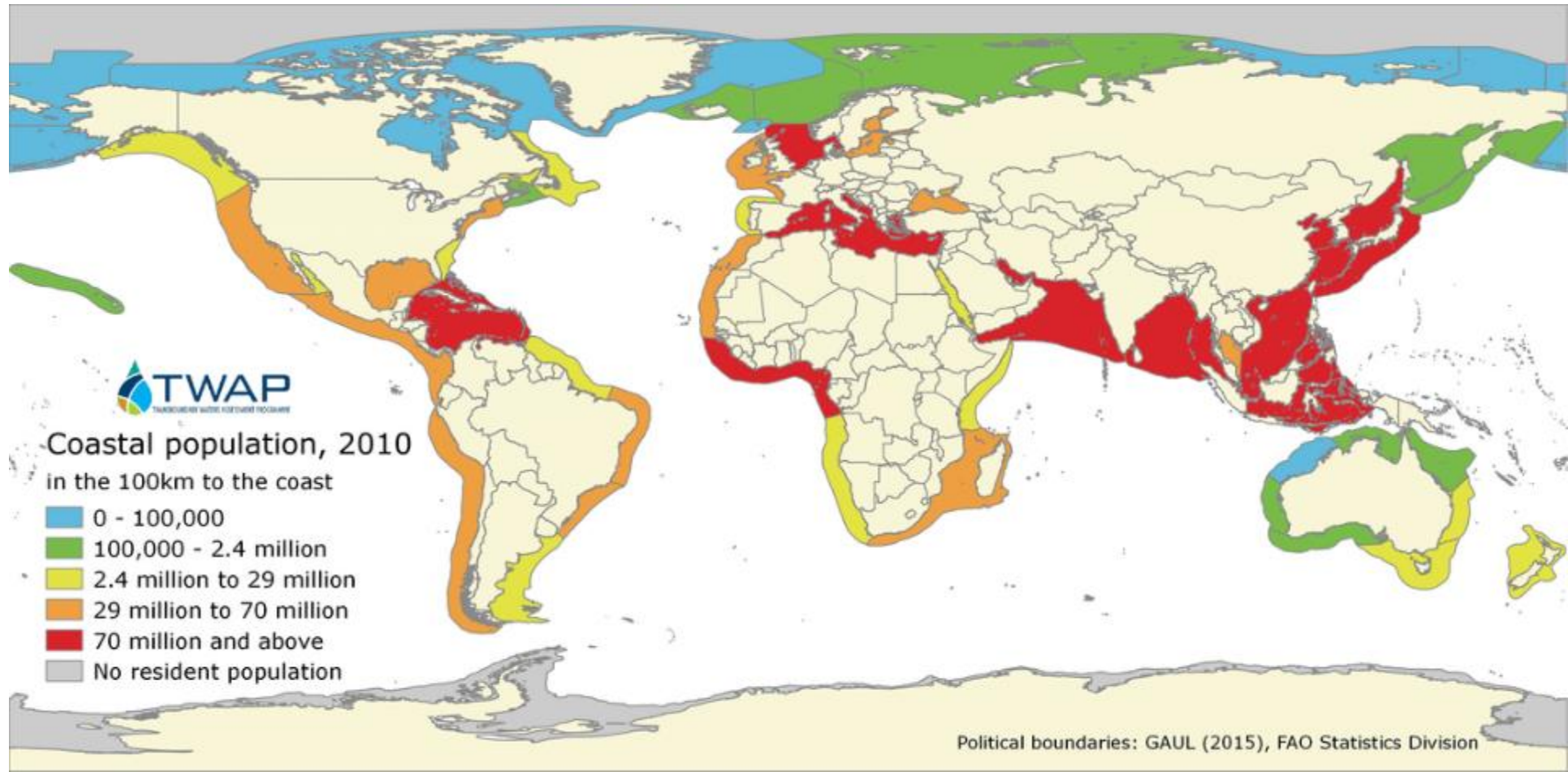
“Drilling holes in boulders can make a difference for marine life”

50 % of global population lives in the coastal zone (Small & Nicholls, 2003)

Coastal population density is **3 x higher** than the global average

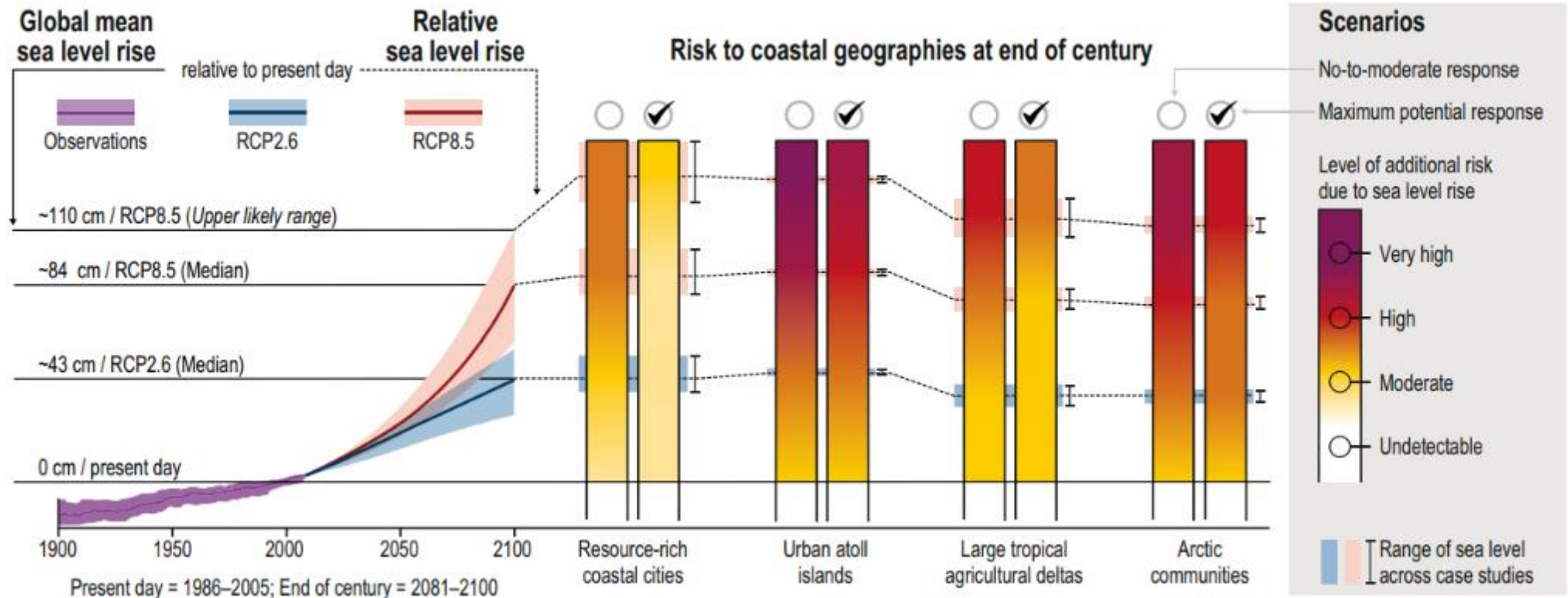
85 % of Australians live within 50 km of the coast (Harvey & Caton, 2010)

¾ of the global population will reside in the coastal zone by 2025.

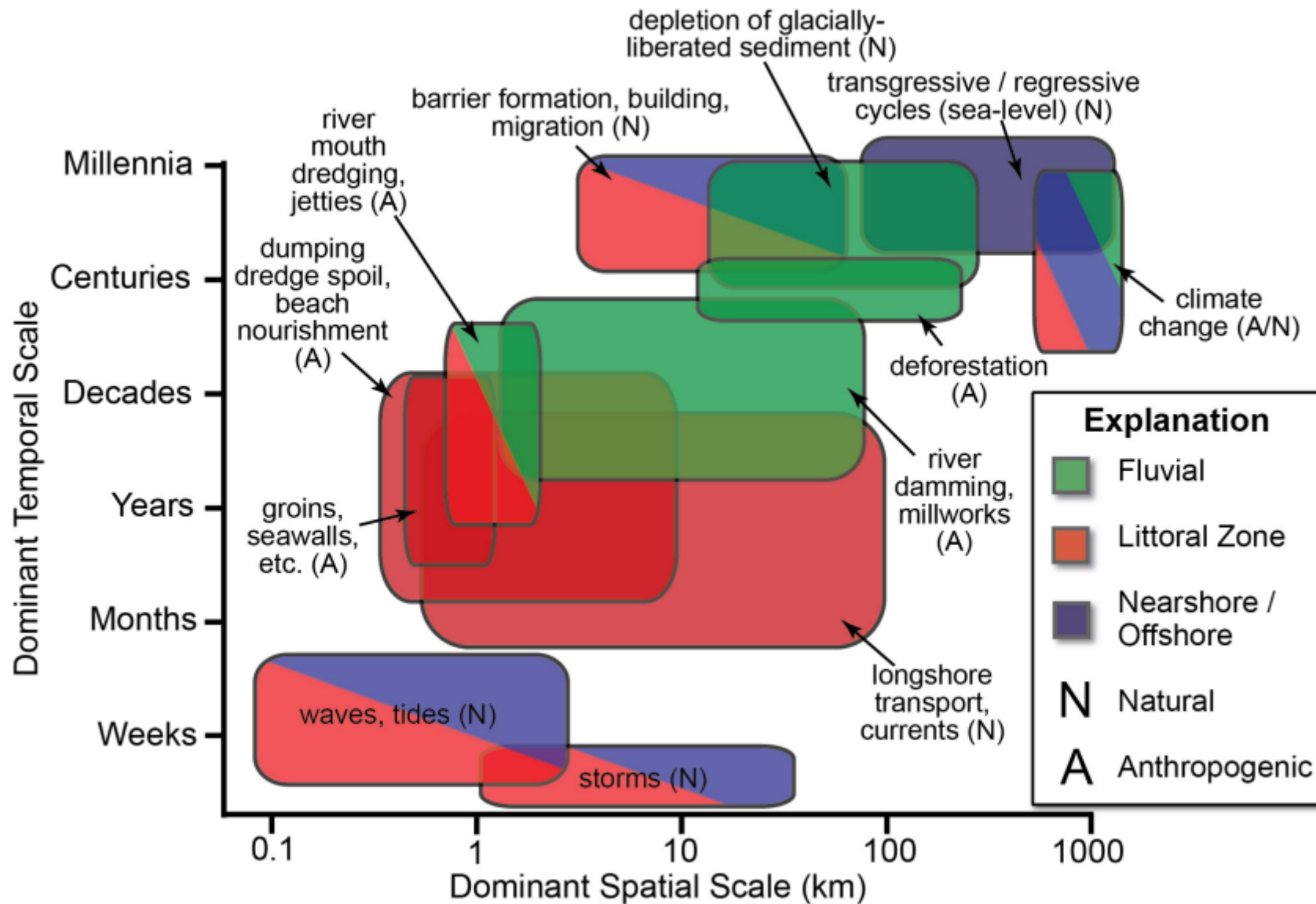


Rates of change are increasing - makes this a very relevant topic and job

Under RCP8.5, the rate of SLR will be 15 mm yr^{-1} (10–20 mm yr^{-1} , *likely* range) in 2100, and could exceed several cm yr^{-1} in the 22nd century. These high rates challenge the implementation of adaptation measures that involve a long lead time, but this has not yet been studied in detail. {4.2.3.2, 4.4.2.2.3}



People can also affect beach stability over multiple scales



Summary

Need a good understanding of **large-scale** controls and **regional scale** processes (waves vs tides)

Briefly explored estuaries, mangroves, salt marshes, coral reefs and rocky coasts

Looked at some common management issues and interventions.

