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4. Students must develop a specific hypothesis related to environmental (likely anthropogenic) change, e.g. global warming, sea level rise, pollution, shoreline development, over-harvesting, etc.
5. Topic can be any feasible, relatively simple project that fits within these guidelines and that we can advise.

Ecology

The distribution & abundance of organisms

Ecology

The distribution & abundance of organisms & how these are shaped by interactions between organisms, other organisms, & their environment.

Intertidal Ecology

Types of intertidal zones

- rocky, soft-sediment, estuaries

Tides

- Lunar & daily cycles

Some major ecological themes

1. Changing abiotic stresses
2. Species interactions
3. Zonation
4. Life cycles

Rocky shore - boulders

Salt Creek, WA

Rocky shore - benches

Soft sediment – sandy beach

Deadman Bay, WA

Soft sediment - mud


Soft sediment w/ hard parts
Dabob Bay, WA

Similarities?

Differences?

Similarities

- Rough texture/complexity of the **substrate**
  - creates **microclimates**
- **Abiotic** gradients perpendicular to shoreline
  - some factors more stressful towards ocean, others more stressful towards land
- Terrestrial input
  - runoff
  - plant detritus
  - humans(!)
- **Biogenic** habitats can be present

Differences

- Intensity of water motion
  - waves?
  - currents?
- Size of **sediment** grains or rock pieces
  - reflects power of wave action
  - affects water absorbed
- Orientation of surface
  - angle
  - NSEW (aspect)


June 4, 2012 19:27

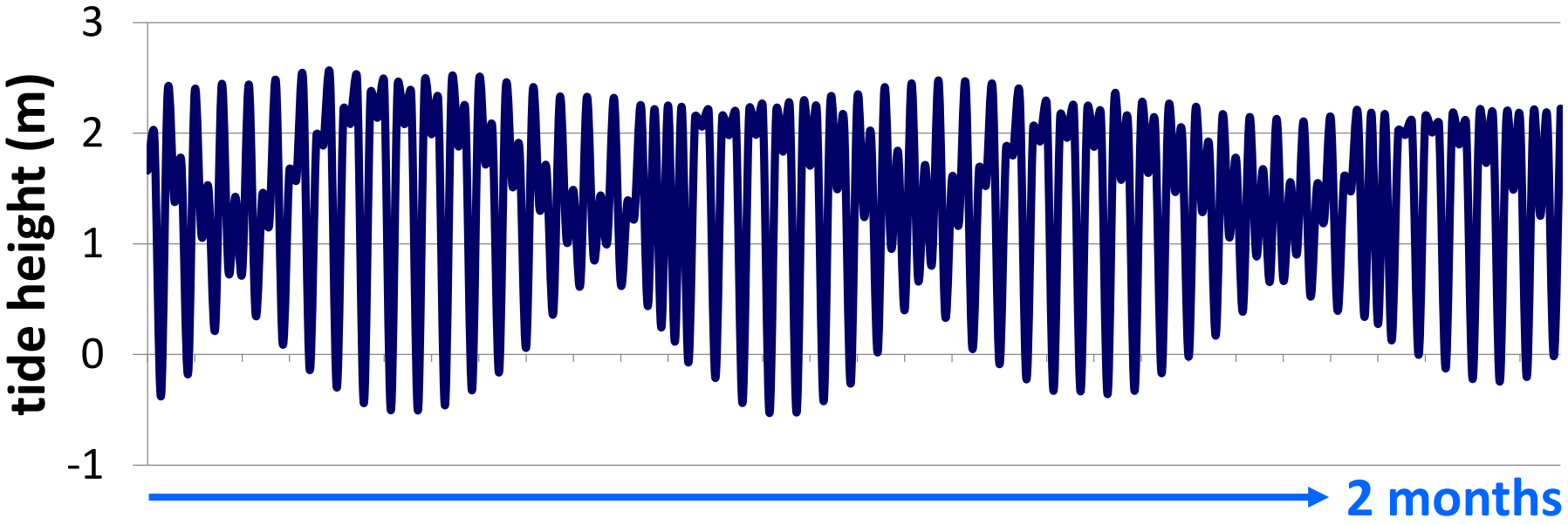

June 5, 2012 11:08


GARDENWATCHCAM 2011/06/16 02:57:31

Tidal timelapse, Friday Harbor Labs

- https://www.youtube.com/watch?v=jVXwLCB-5Fs

Basic lunar tidal cycle



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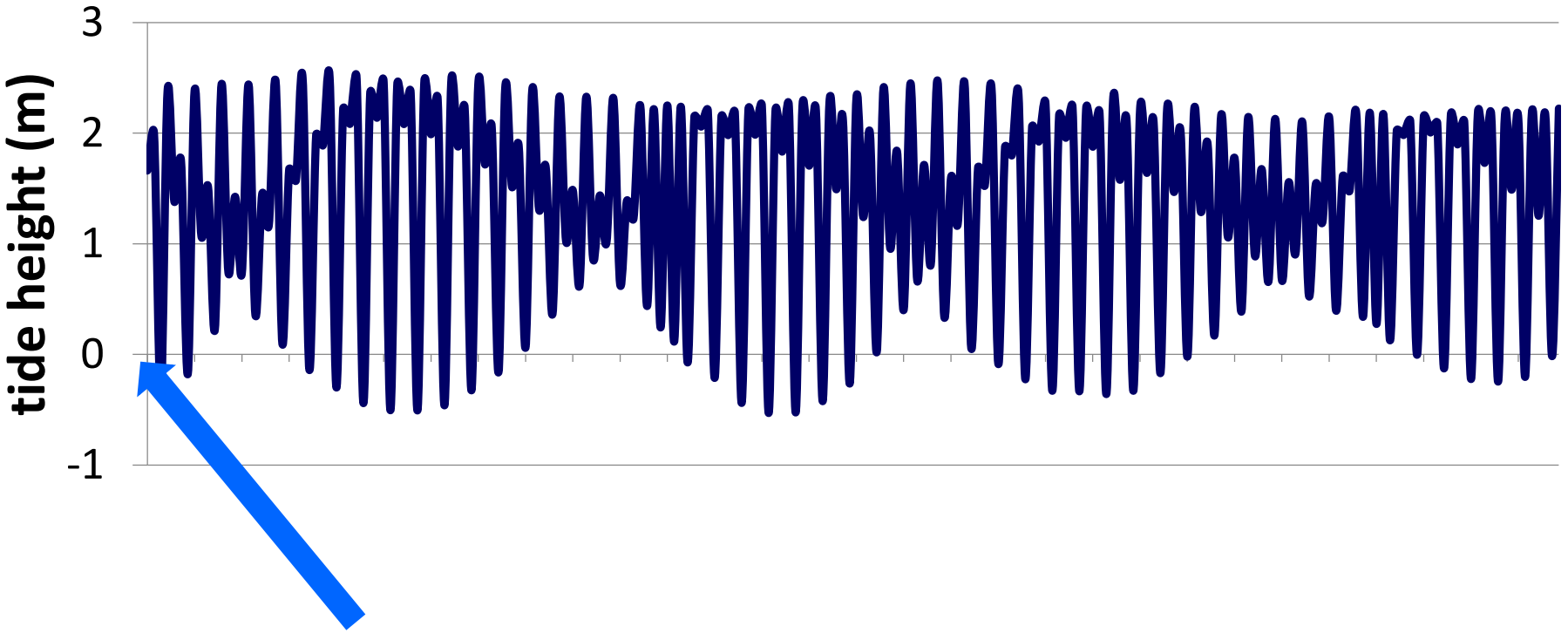
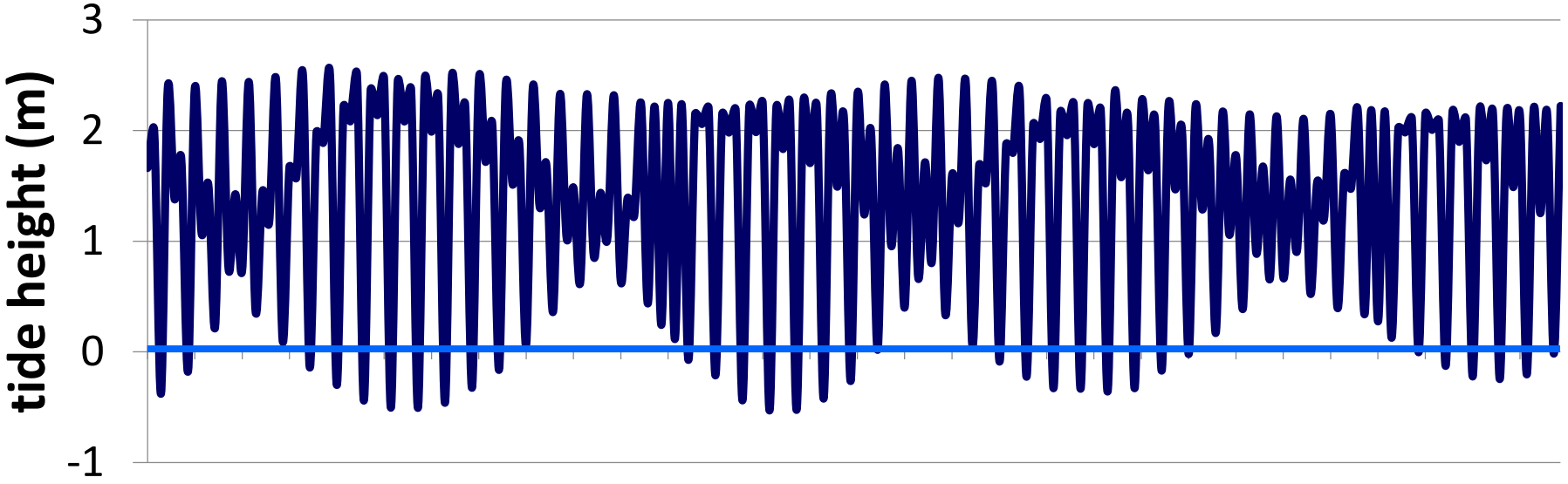


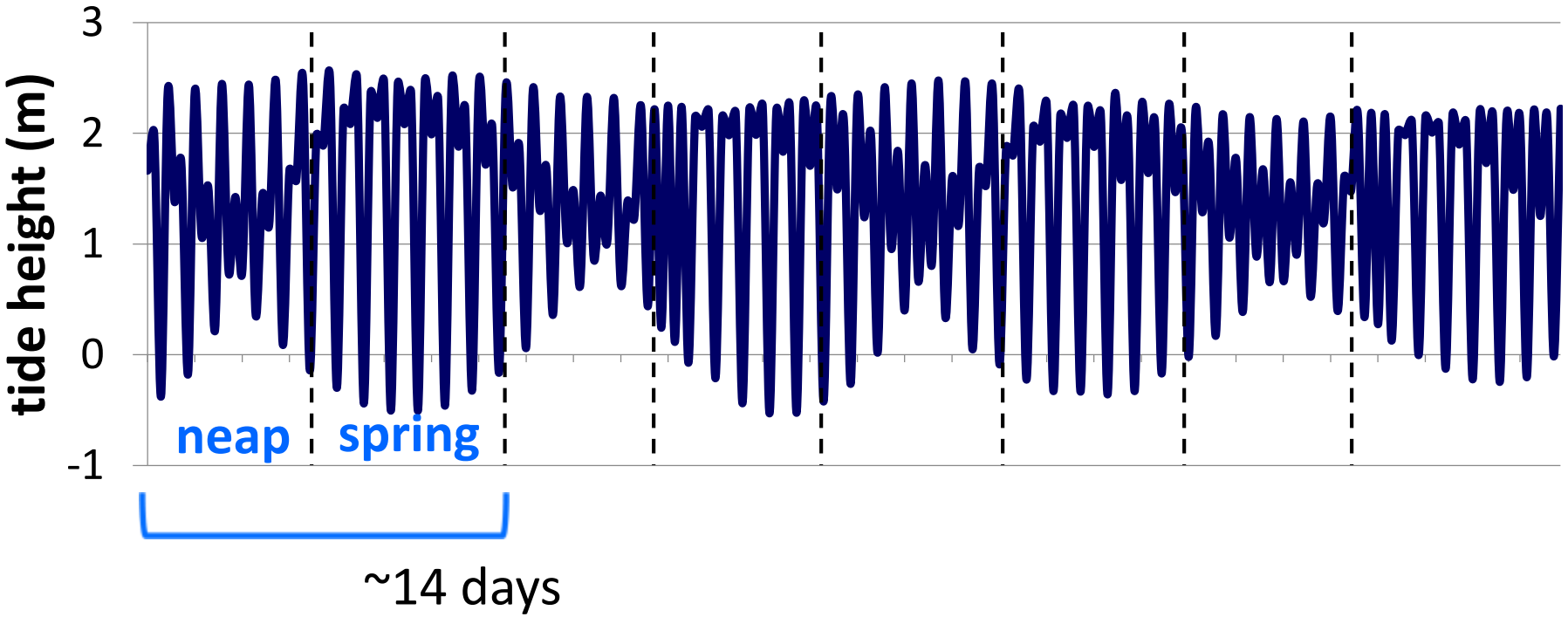
In U.S. “0” tide = Mean Lower Low Water (MLLW)
= the average lower low tide over a ~19 year cycle

Basic lunar tidal cycle



Intertidal ecologists generally consider “negative tides” to be the best days for exploring.

Basic lunar tidal cycle



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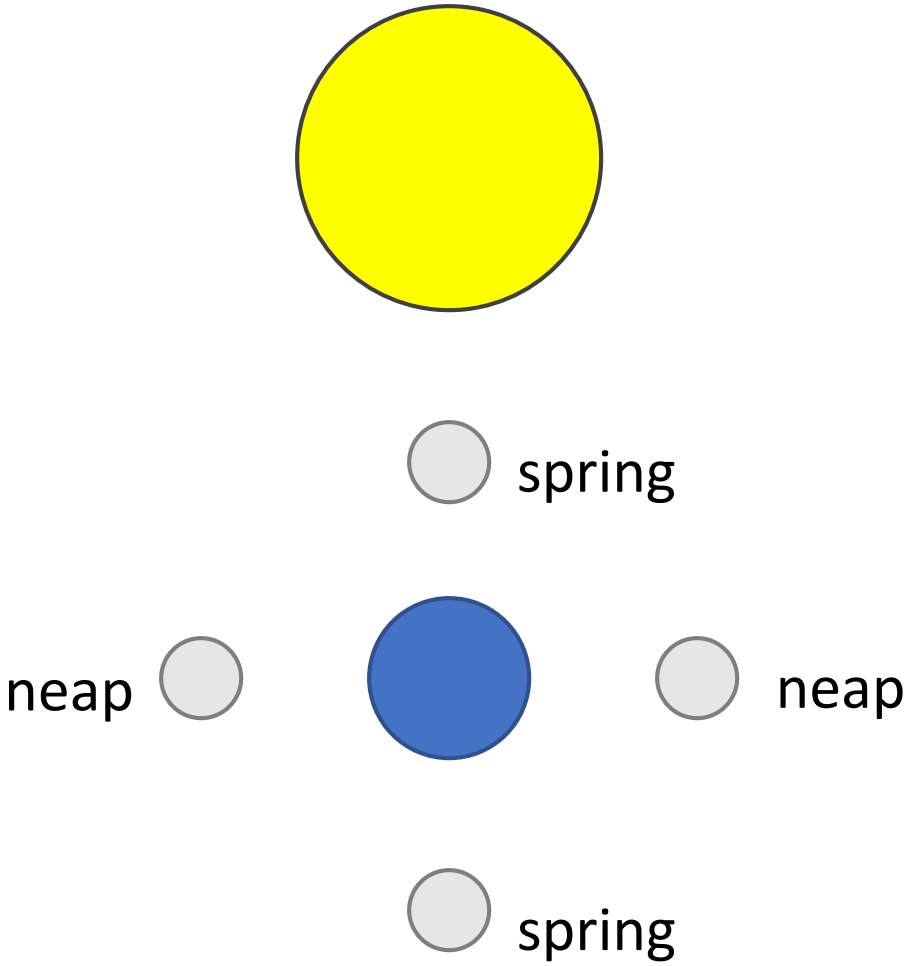
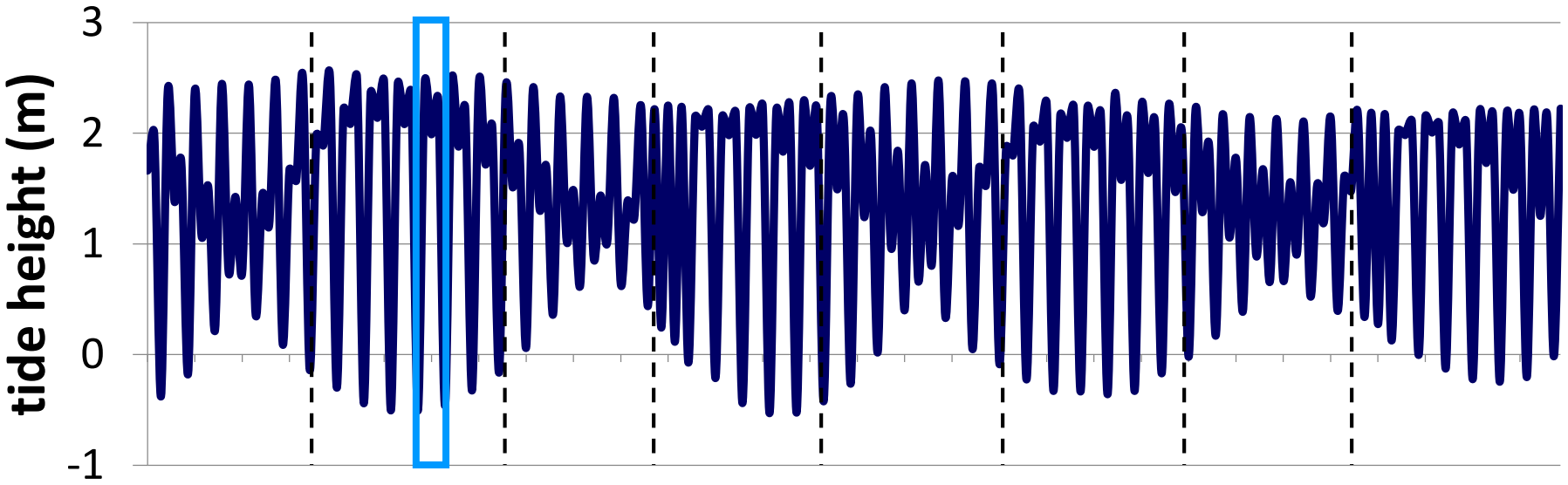
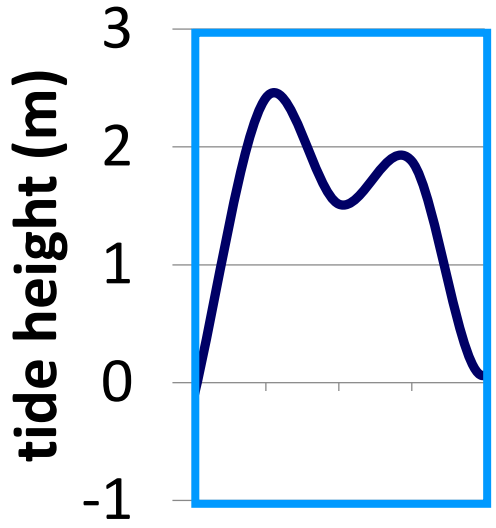
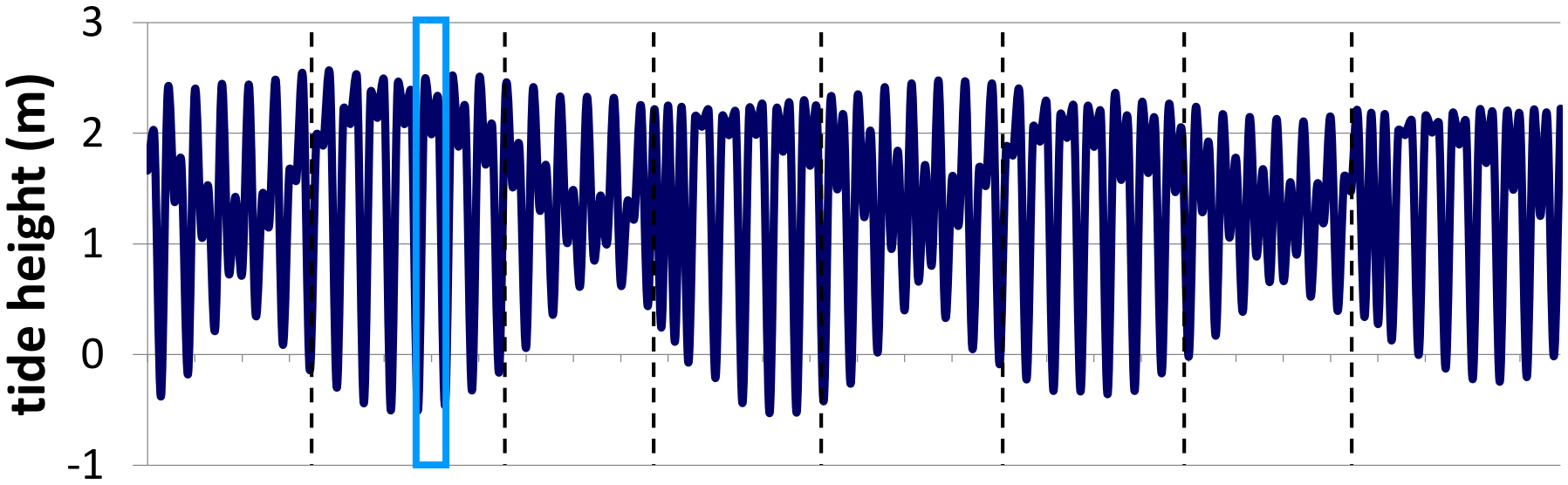


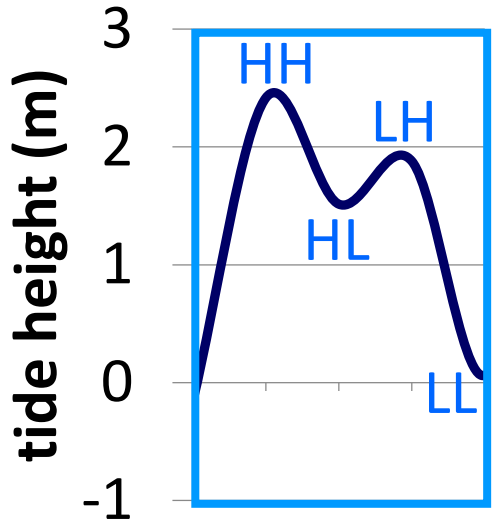
Daily tidal cycle



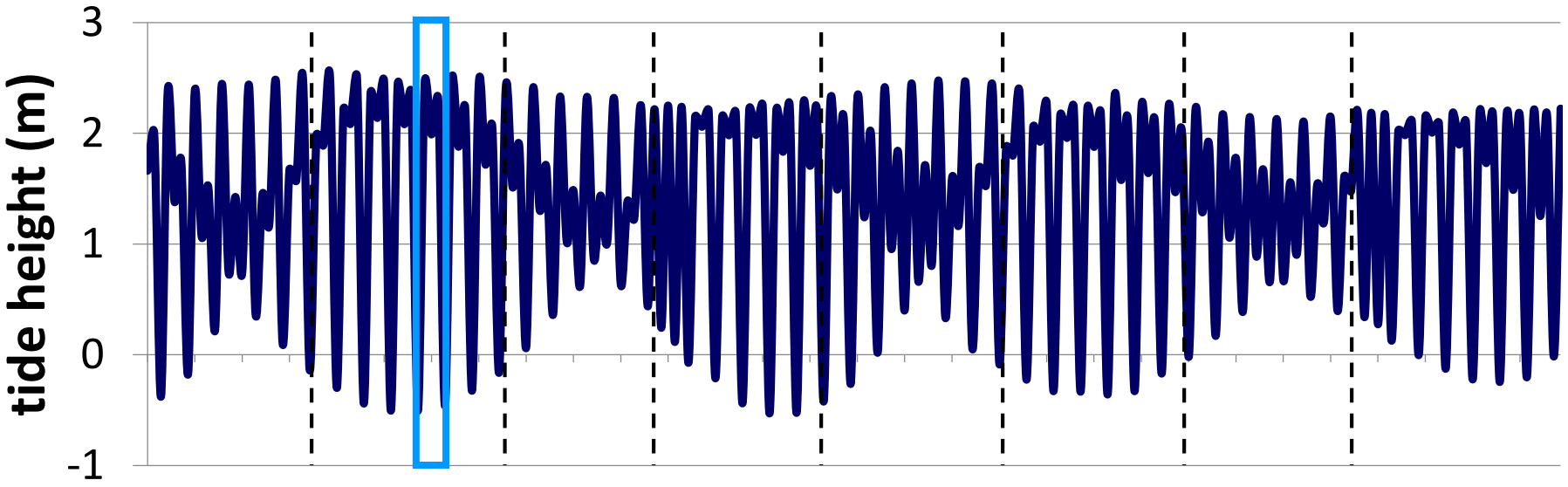


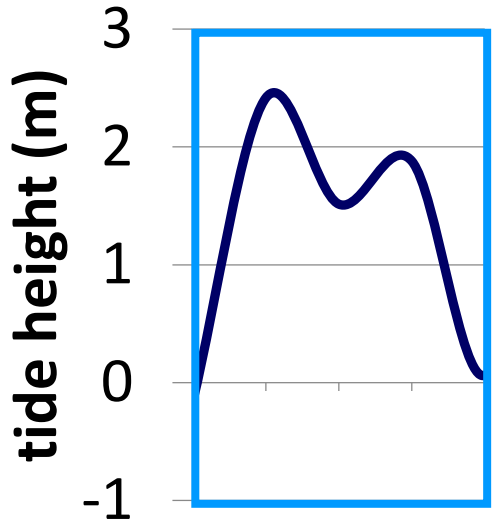
Daily tidal cycle





Daily tidal cycle

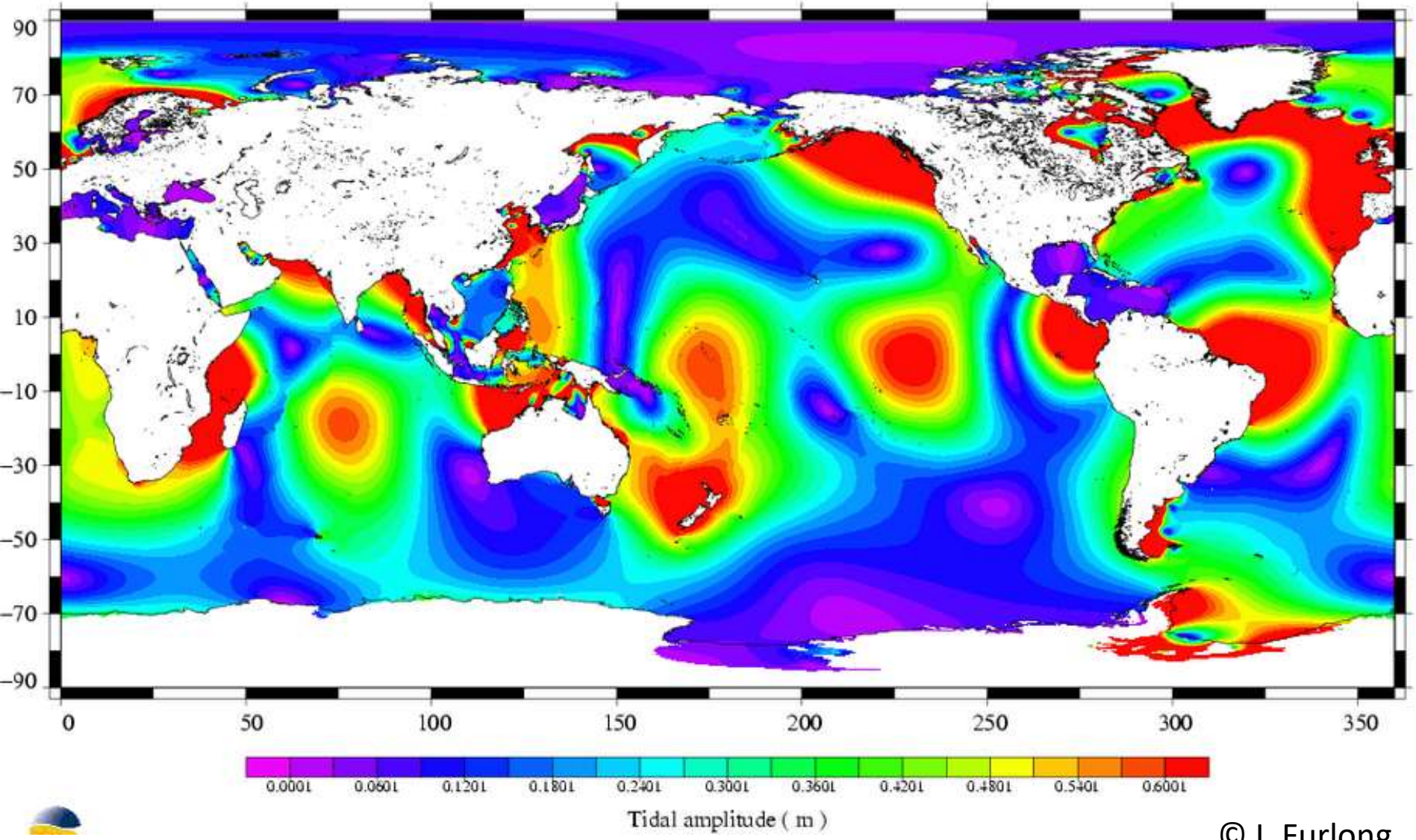




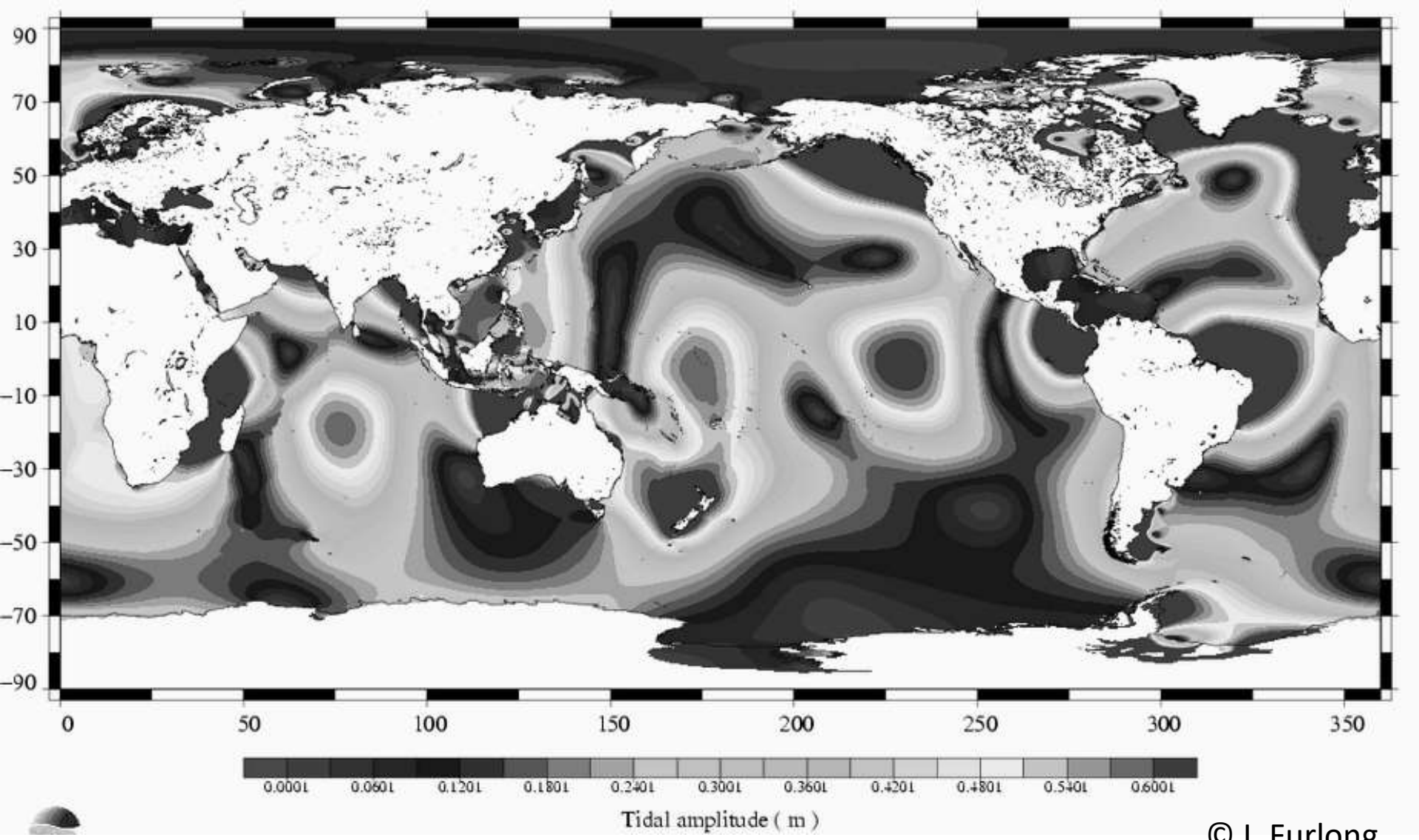
→Semidiurnal = 2 hi-low cycles/day

→Mixed = 2 highs not same level &
2 lows not same level

Global tidal amplitudes

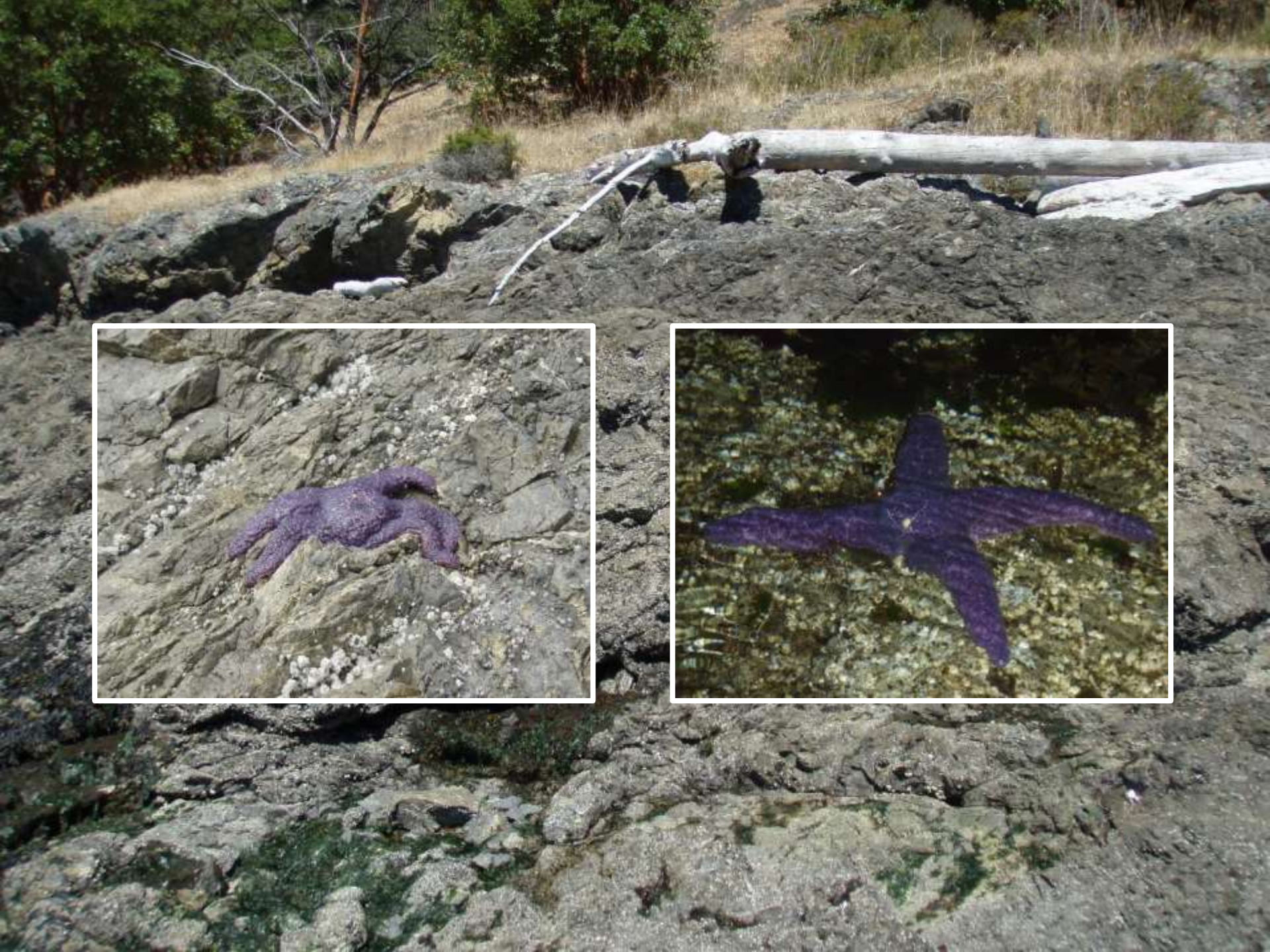


Global tidal amplitudes

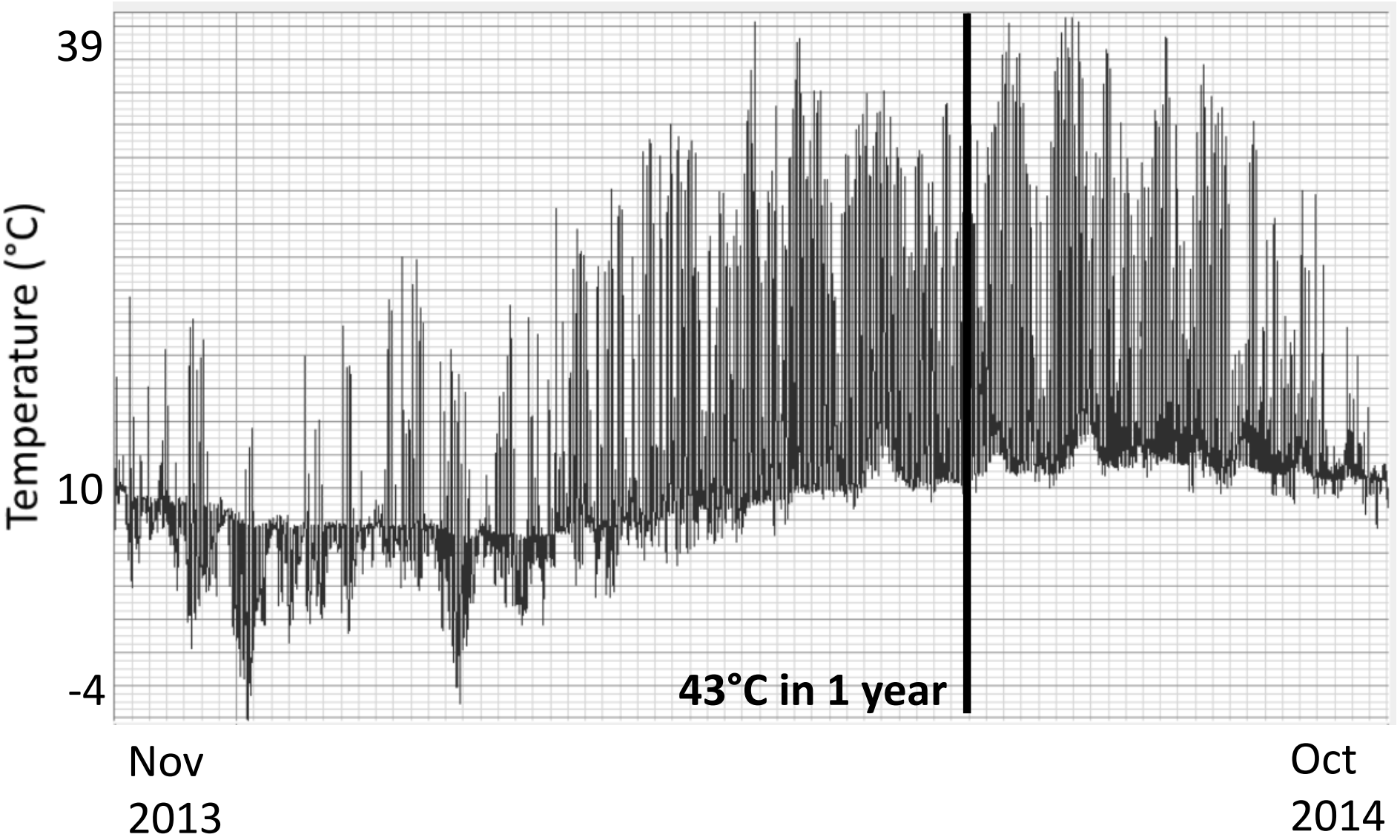


Major ecological theme

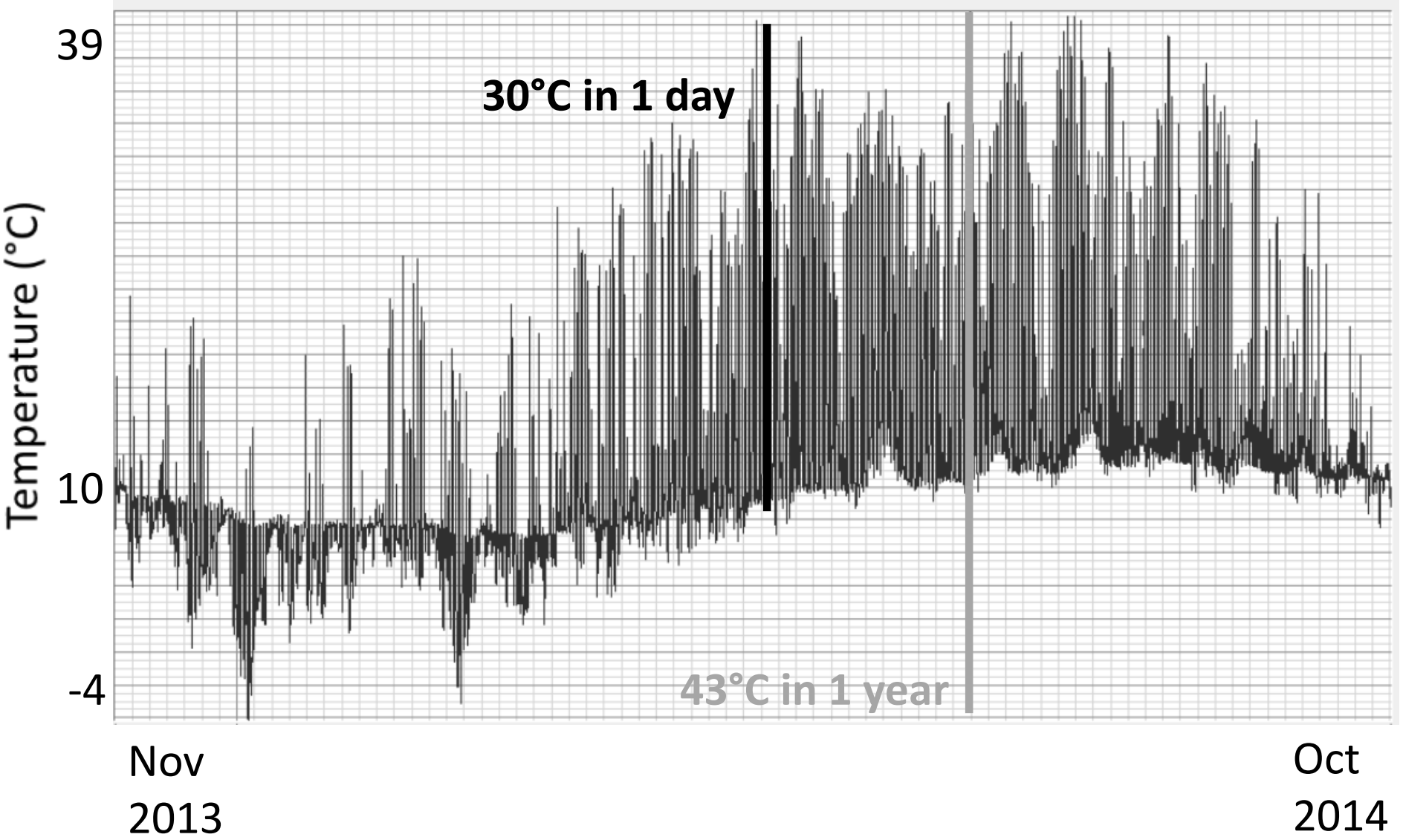
1. Changing abiotic stresses



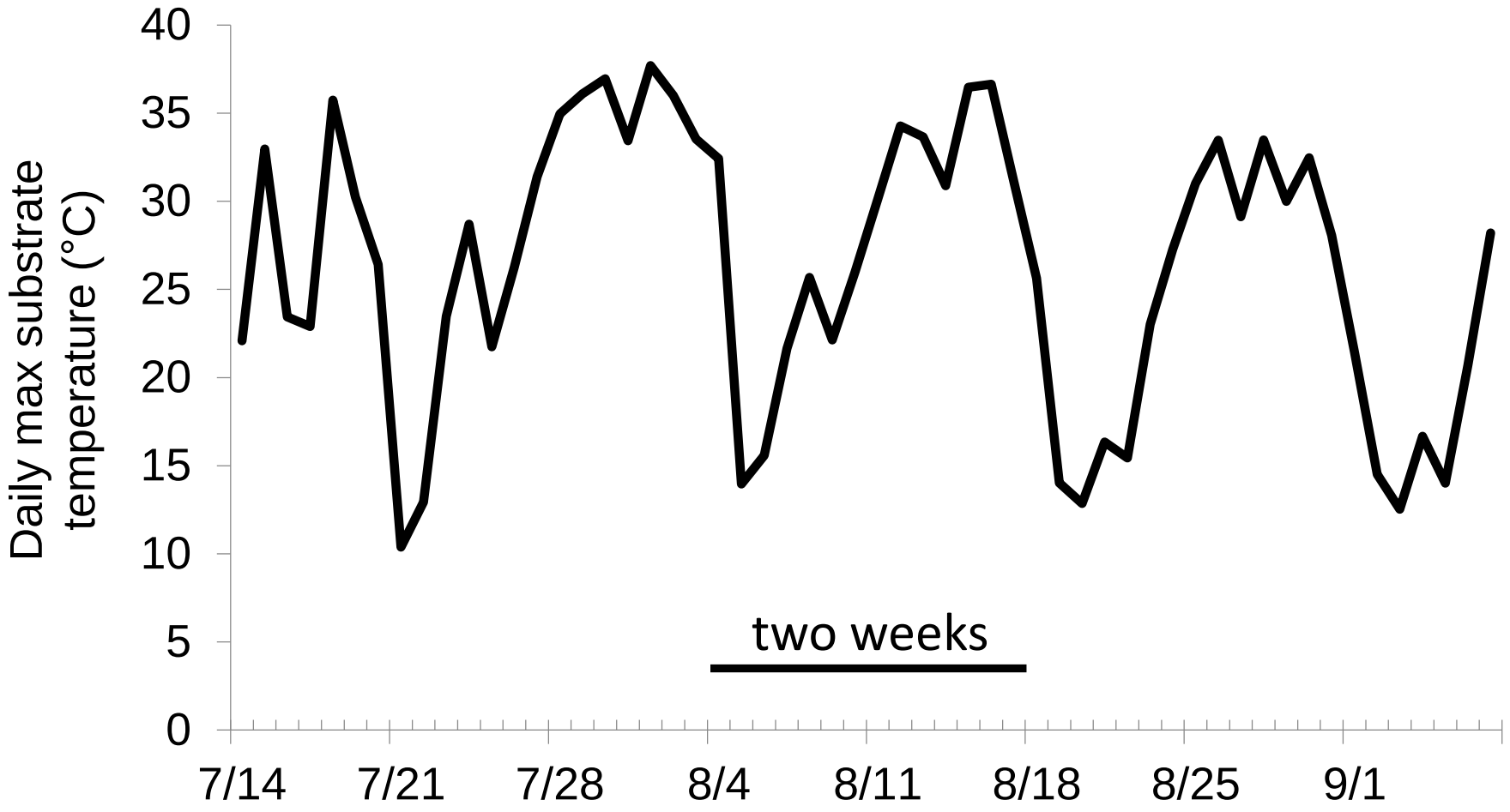
Large temperature range



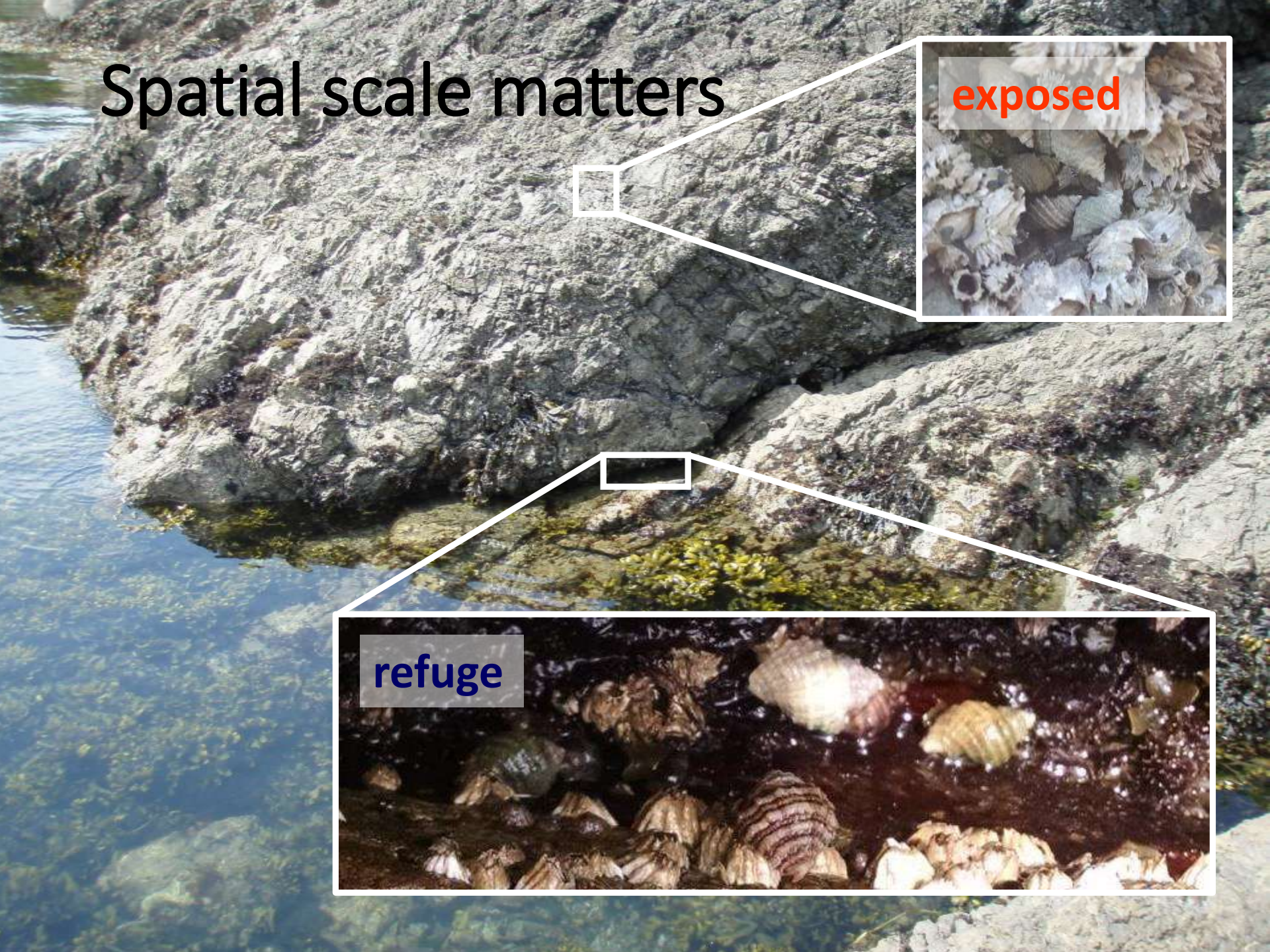
Large temperature range within a day



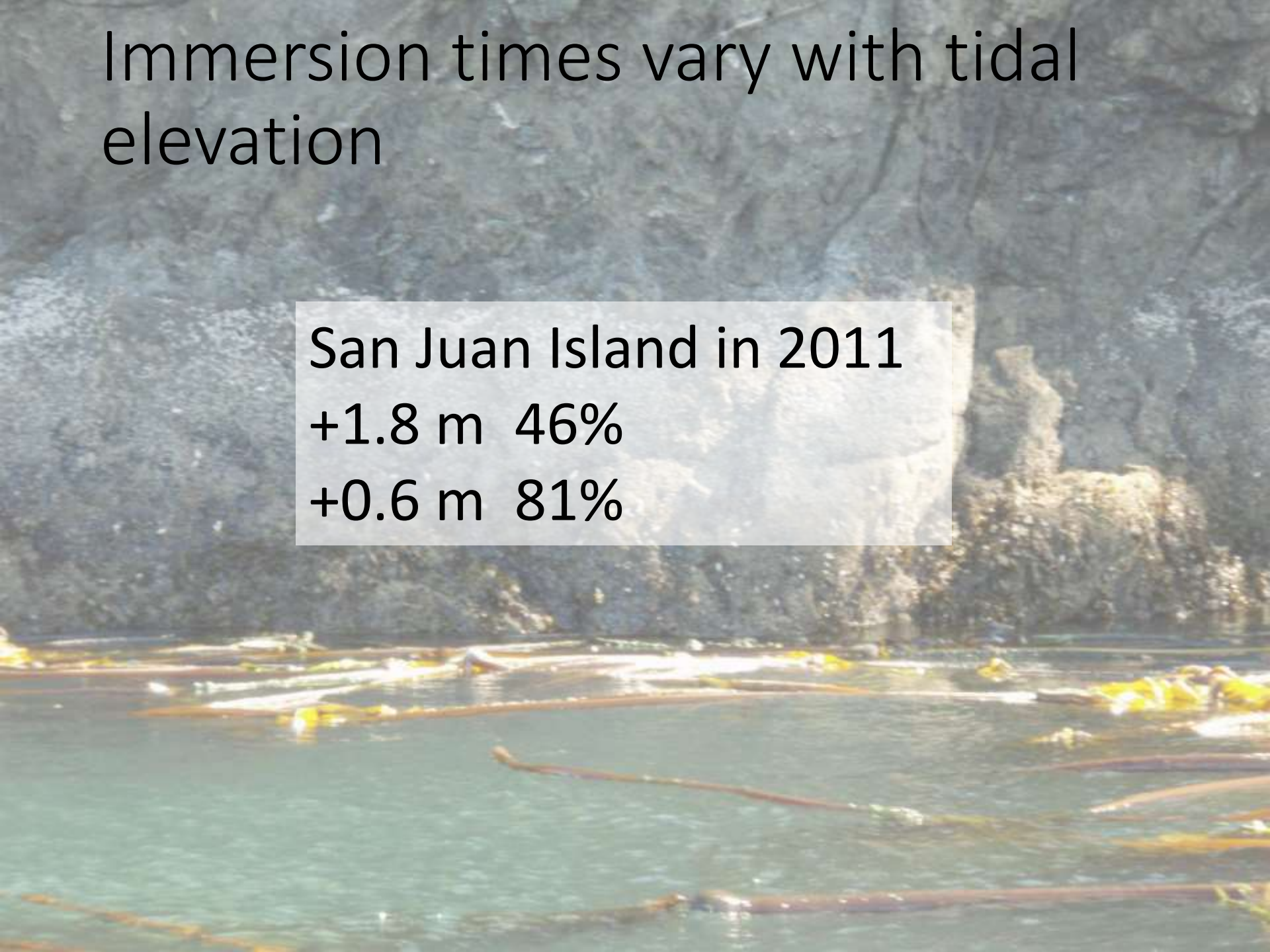
Tidal temperature cycle



Spatial scale matters

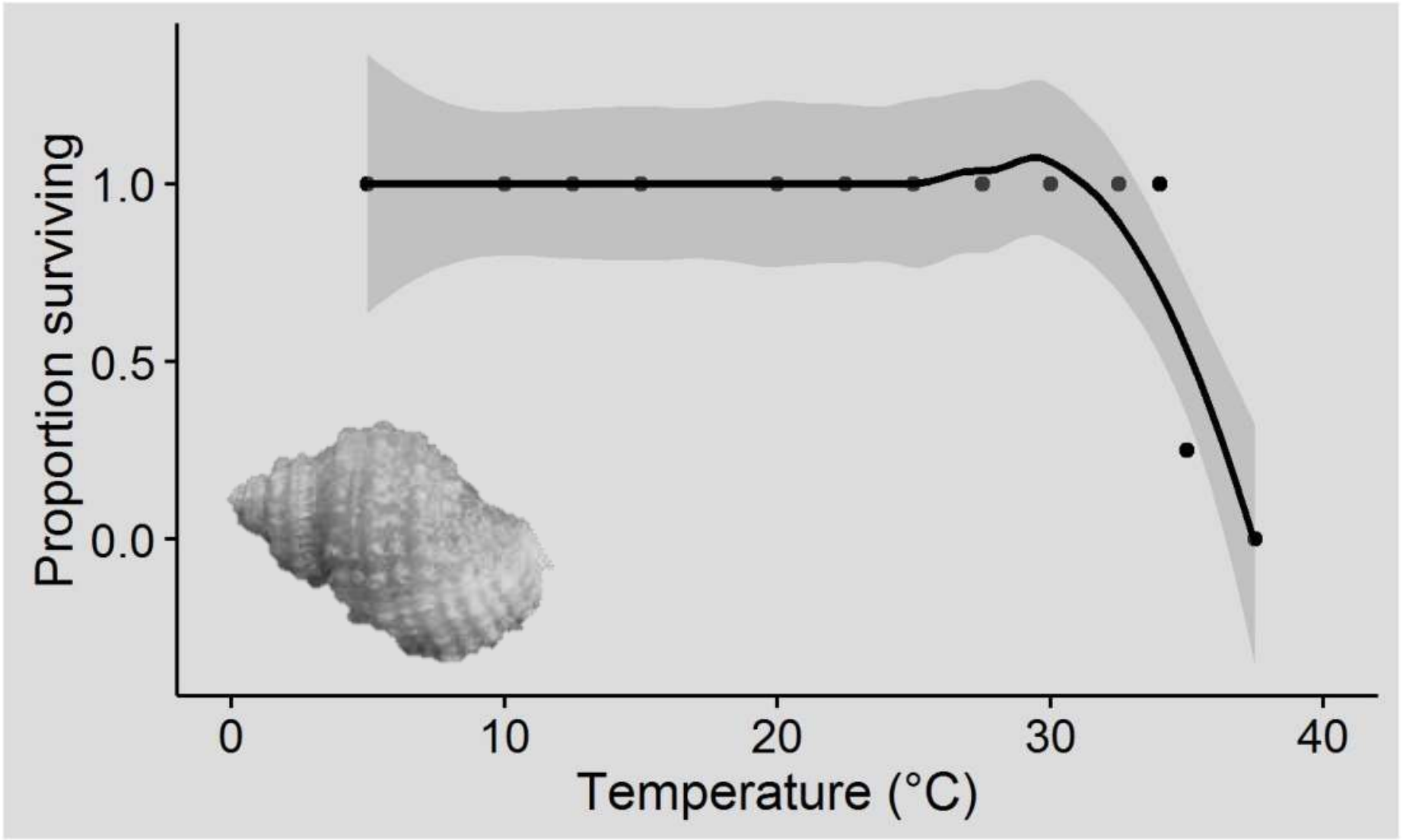


Immersion times vary with tidal elevation



San Juan Island in 2011
+1.8 m 46%
+0.6 m 81%

Low survival *Nucella ostrina* @ ≥35°C



Hayford & Carrington *in prep*

Related projects ideas

→Are populations of temperature-sensitive species declining?

*See work of R Sagarin, B Helmuth, SE Gilman, J Sunday

Major ecological theme

2. Species interactions

Types of species interactions

Type	Species A + / - / o	Species B + / - / o
predation		
competition		
mutualism		
commensalism		
parasitism		

Thais (Nucella)

Balanus

Chthamalus

Say: Tham-uh-lus

Thais (Nucella)

P -

- P

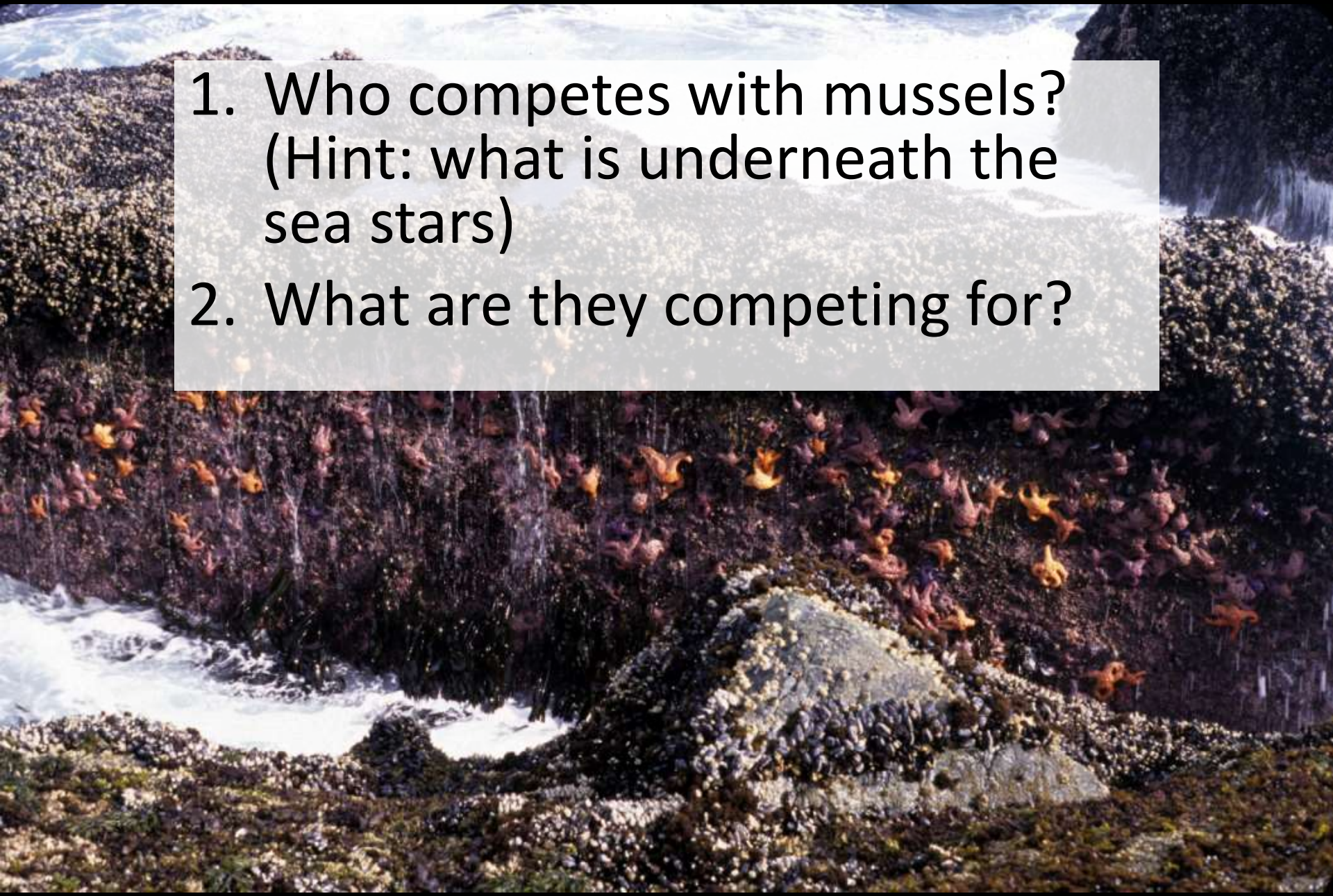
Balanus

Chthamalus

Say: Tham-uh-lus

C -


Pisaster ochraceus eats *Mytilus californianus*



1. Who competes with mussels? (Hint: what is underneath the sea stars)
2. What are they competing for?

1973, Tatoosh Island, WA – RT Paine & K Sebens

What happened when they removed the top predator (sea star)?

1973, Tatoosh Island, WA – RT Paine & K Sebens

Result: **Removal of top predator** (sea star) →

- **increased** the abundance of the **competitive dominant** (mussel) &
- caused **decline** in diversity of **competitive inferiors** (from 15 to 8 species).

Pisaster

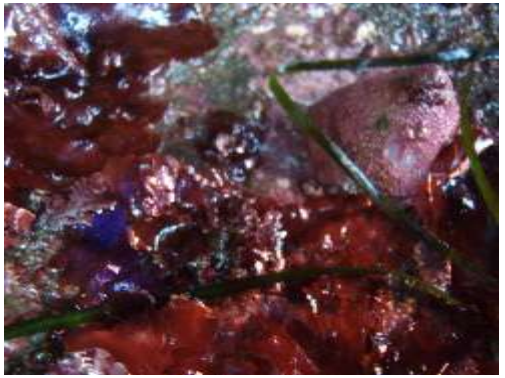
P -

\+

Mytilus

many algal species

C -



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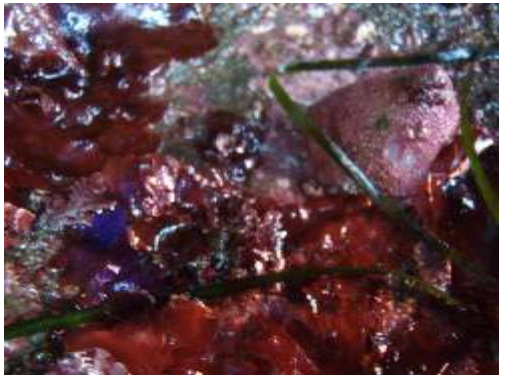


Keystone predation: Predator enhances one or more inferior competitors by reducing abundance of the superior competitor

Related projects ideas

→Are species interactions affected by changes in population sizes?

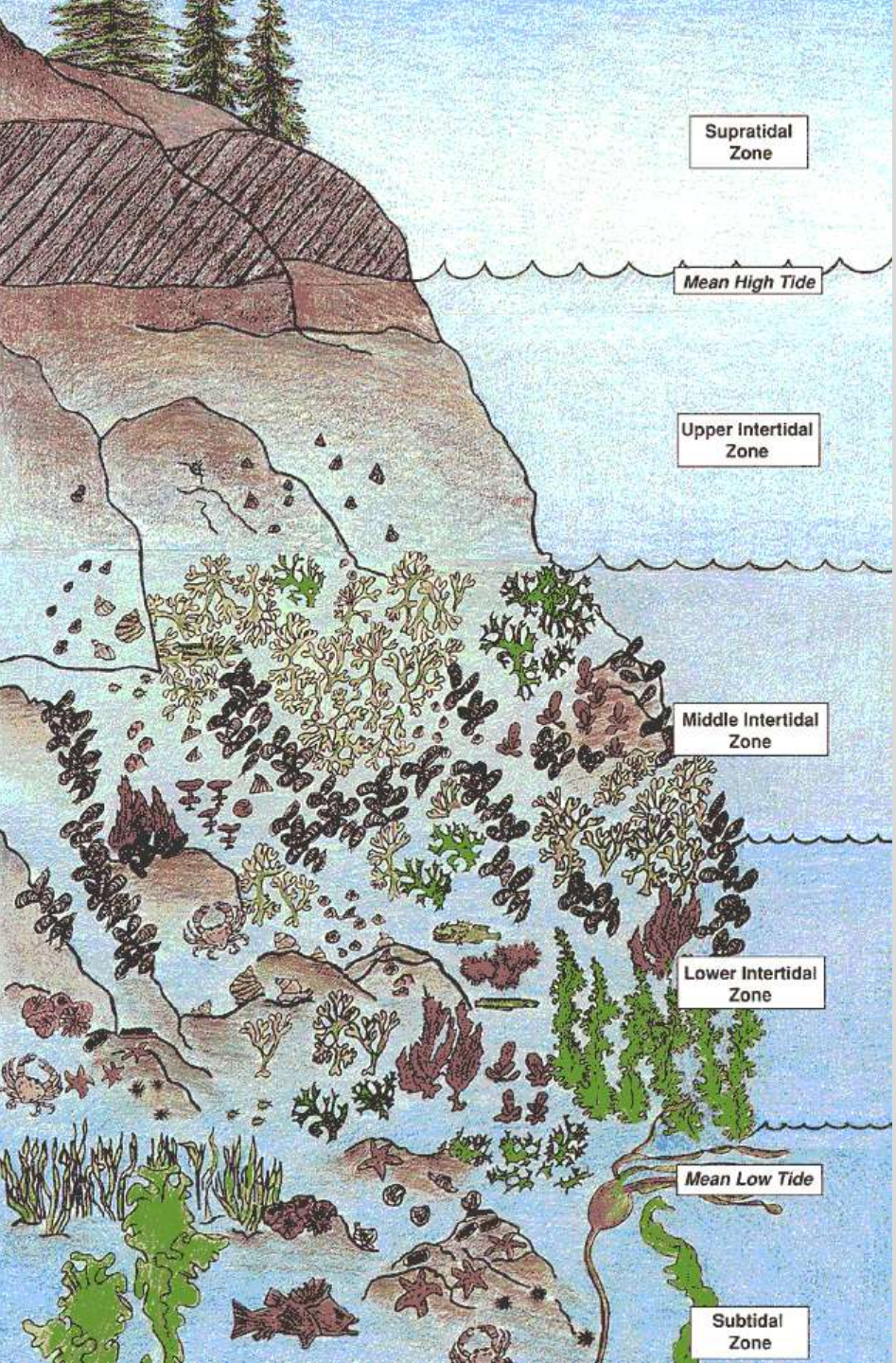
→Removal of a predator due to over-harvesting leads to larger prey population? (trophic interactions)

*See work of DO Duggins, RT Paine, K Sebens, M O'Connor

Major ecological theme

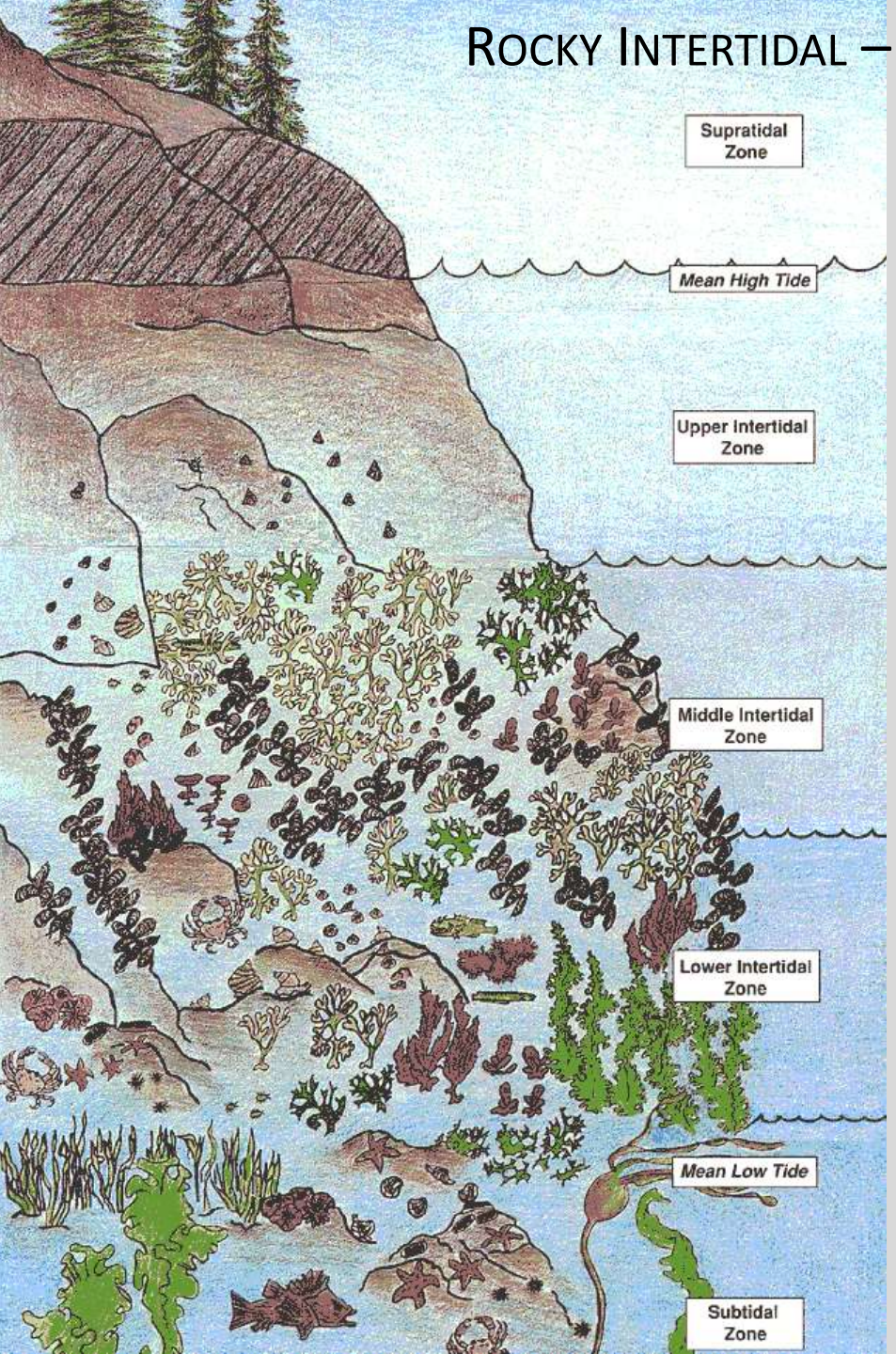
3. Zonation

What creates zonation in the rocky intertidal zone?



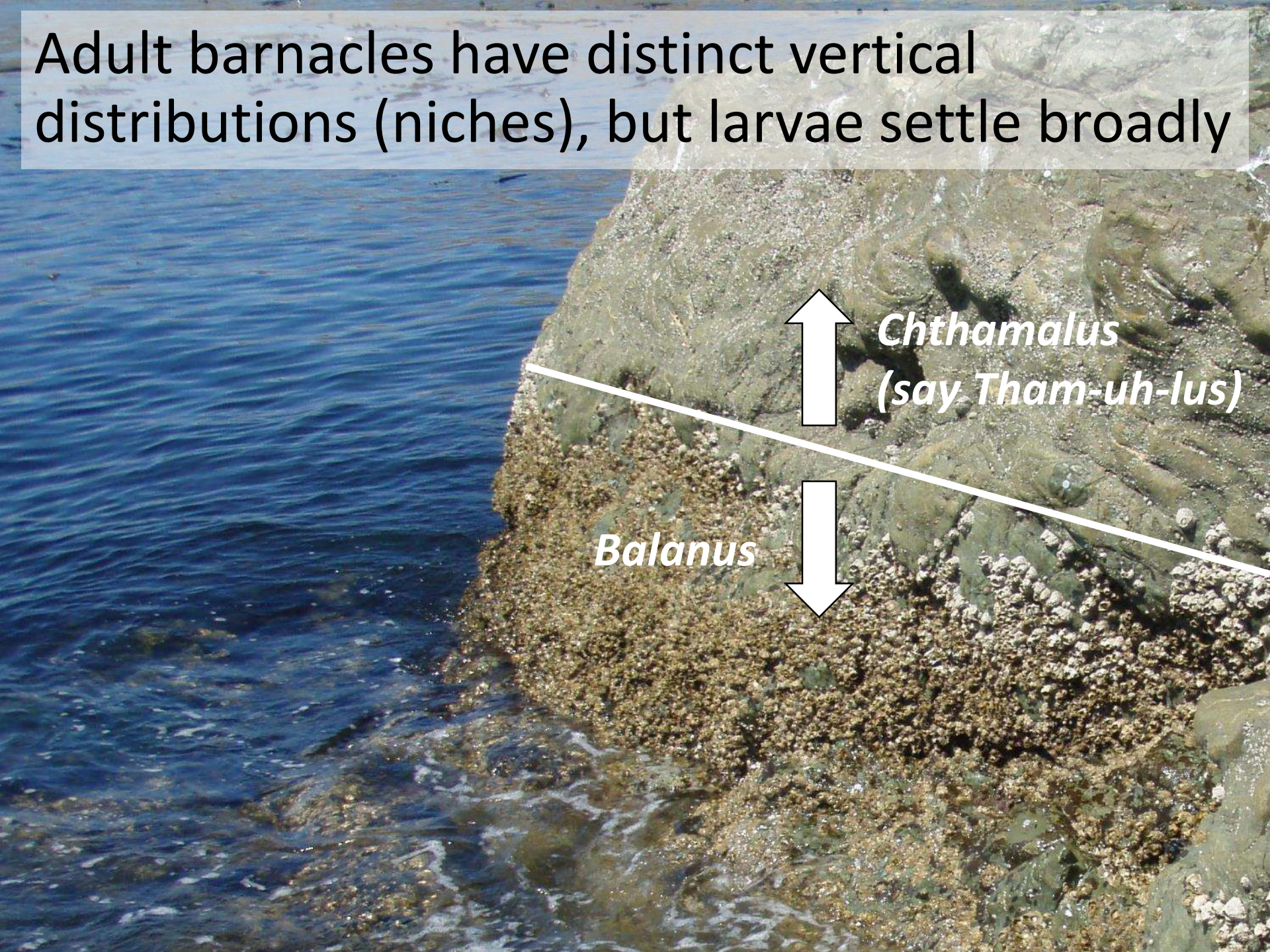
Rocky Intertidal Zone: A model system

ROCKY INTERTIDAL – SOME PNW TAXA COMMON IN EACH ZONE

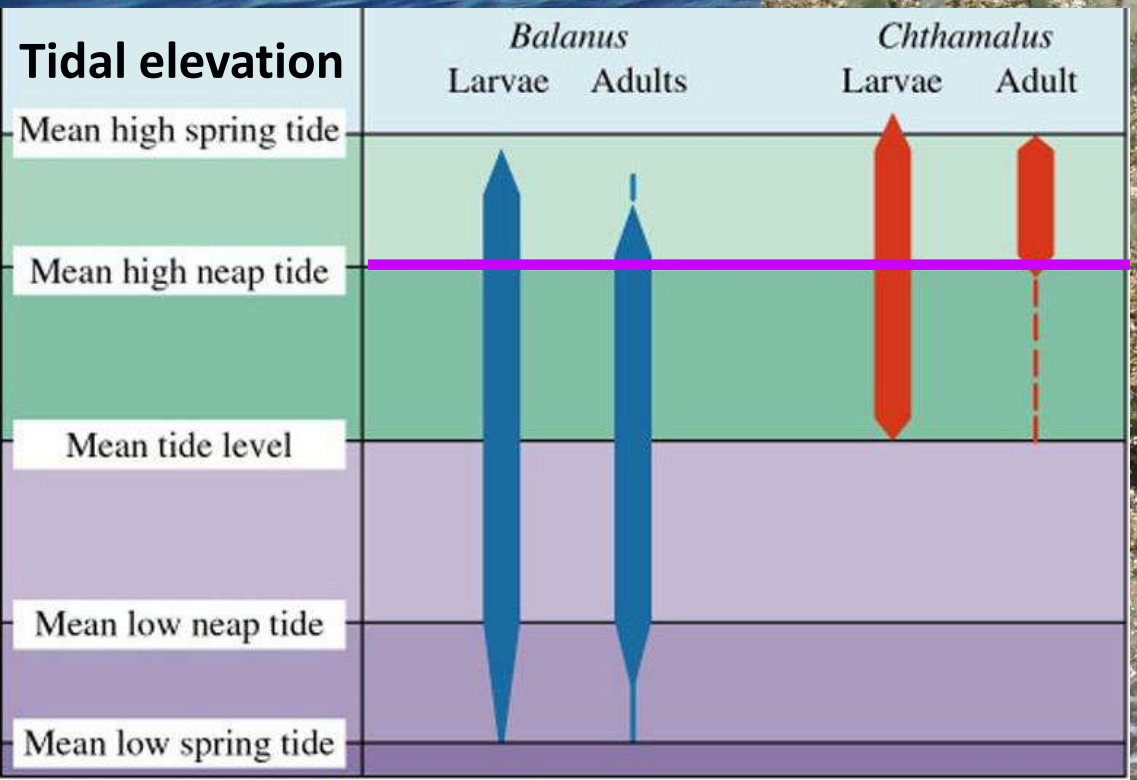


mosses & lichens
rock louse (*Ligia*)
tidepool copepods (*Tigriopus*)
very small littorine snails (*Littorina*)
acorn barnacles (*Chthamalus, Balanus*)
limpets (*Lottia*)
turf algae (*Endocladia*)
rockweeds (*Fucus*)
mussels (*Mytilus*)
larger barnacles (*Pollicipes, Semibalanus*)
small snails (*Chlorostoma, Nucella*)
fleshy (*Mastocarpus*) & turf algae (*Cladophora*)
amphipods (Gammarids)
chitons (*Mopalia, Nuttalina)*
shore crabs (*Hemigrapsus, Petrolisthes*)
fleshy algae (*Ulva, Mazzaella, Odonthalia*)
kelp isopods (*Idotea*)
larger snails (*Calliostoma*, *Nucella, Lirobuccinum*)
seastars (*Henricia, Leptasterias, Pisaster*)
anemones (*Anthopleura*)
coralline algae (*Calliarthron, Corallina,* crusts)
urchins (*Strongylocentrotus*) & stars (*Pycnopodia*)
grasses (*Phyllospadix*)
kelps (*Egregia, Nereocystis, Saccharina*)
crabs (*Cancer, Metacarcinus*)
fishes (*Sebastes*)

Adult barnacles have distinct vertical distributions (niches), but larvae settle broadly



Adult & larval barnacles occupy different tidal elevations



high shore

low shore

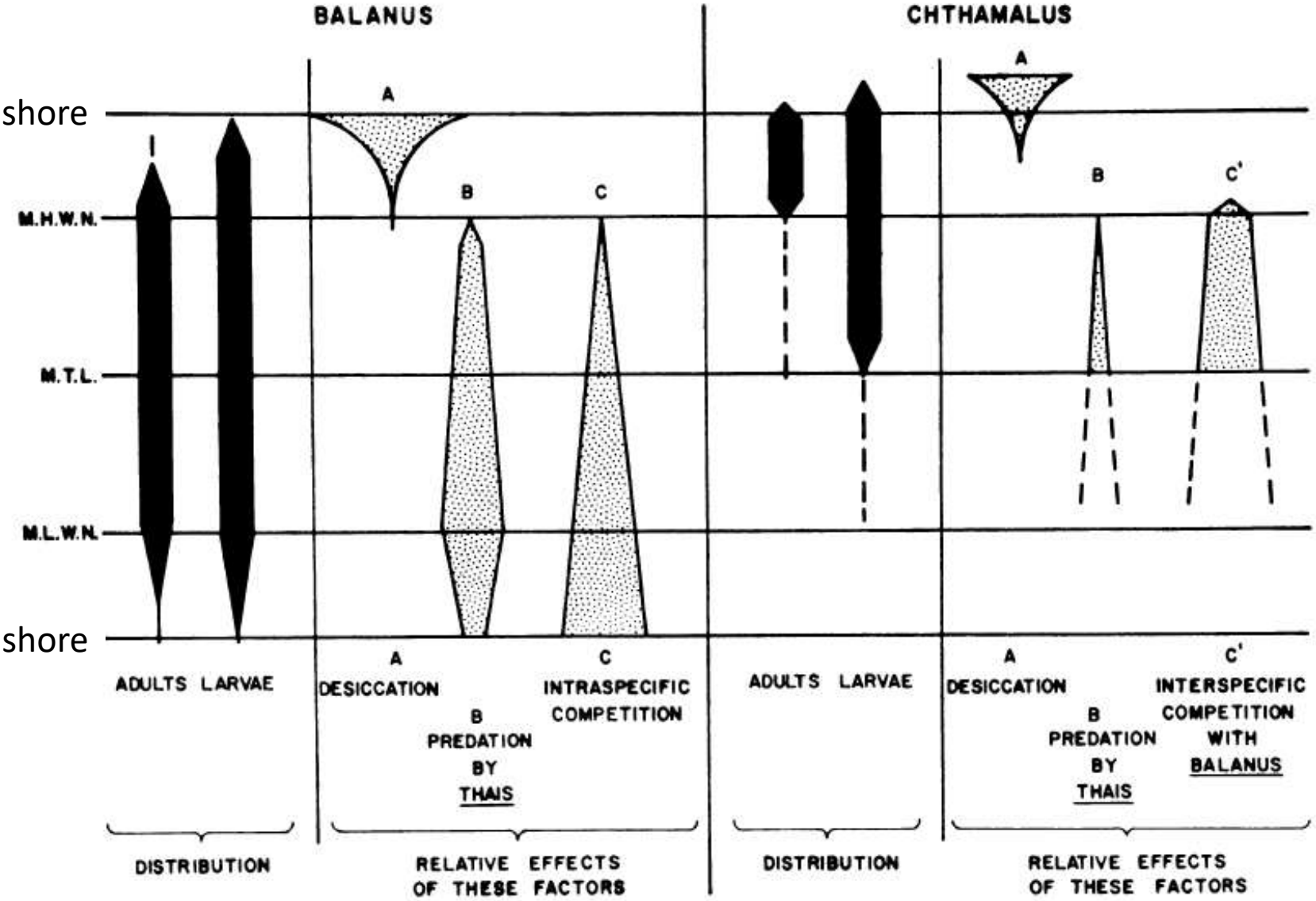
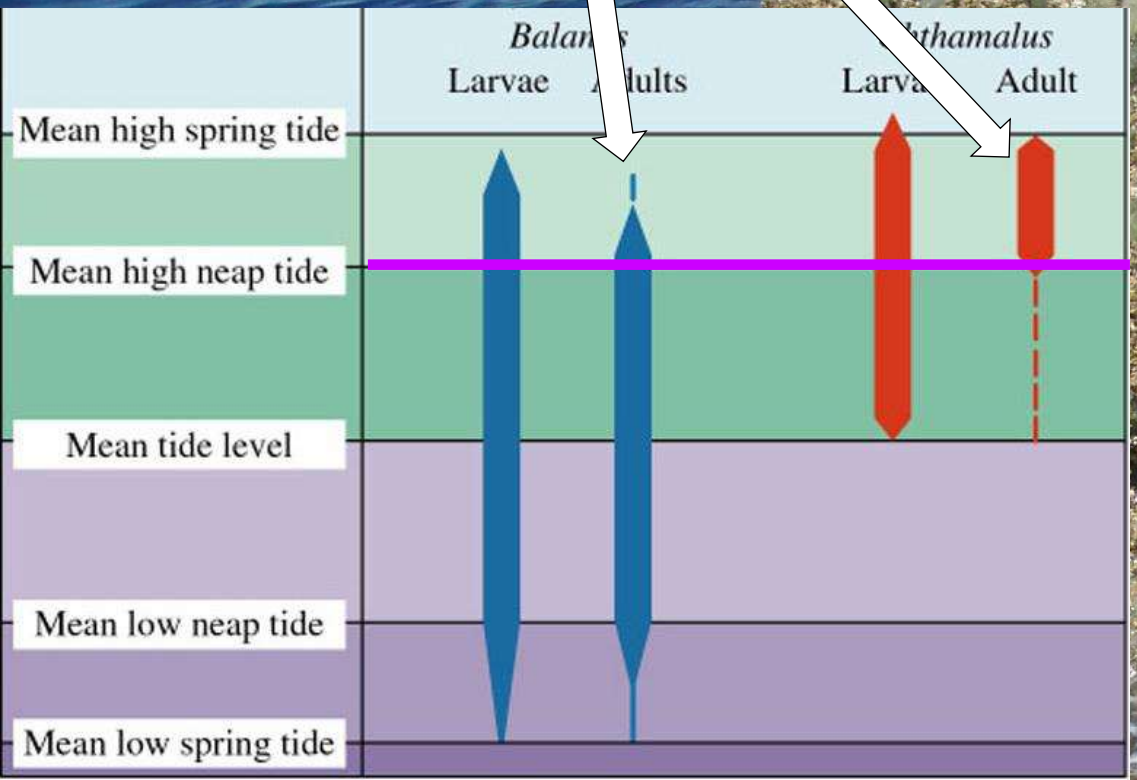


FIG. 5. The intertidal distribution of adults and newly settled larvae of *Balanus balanoides* and *Chthamalus stellatus* at Millport, with a diagrammatic representation of the relative effects of the principal limiting factors. Dashed lines = very few individuals.

Connell *Ecology* 1961

Adult & larval barnacles occupy different tidal elevations

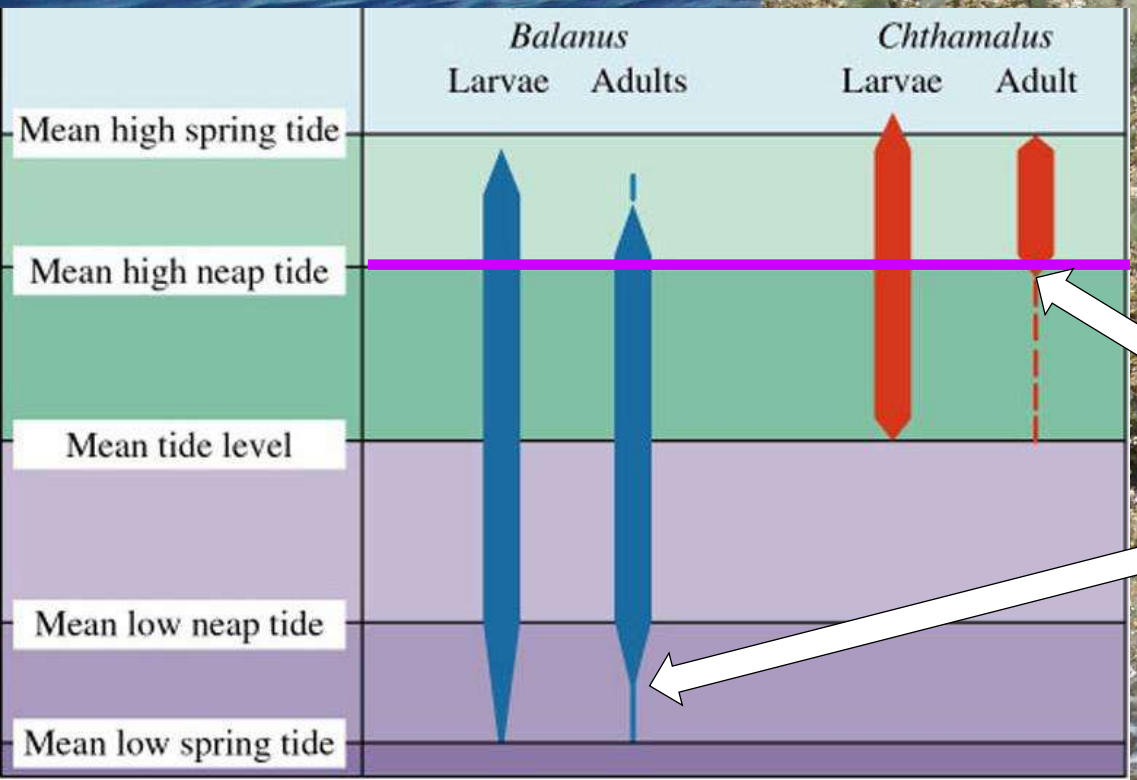
realized niche:
desiccation high shore



Chthamalus

Balanus

Adult & larval barnacles occupy different tidal elevations

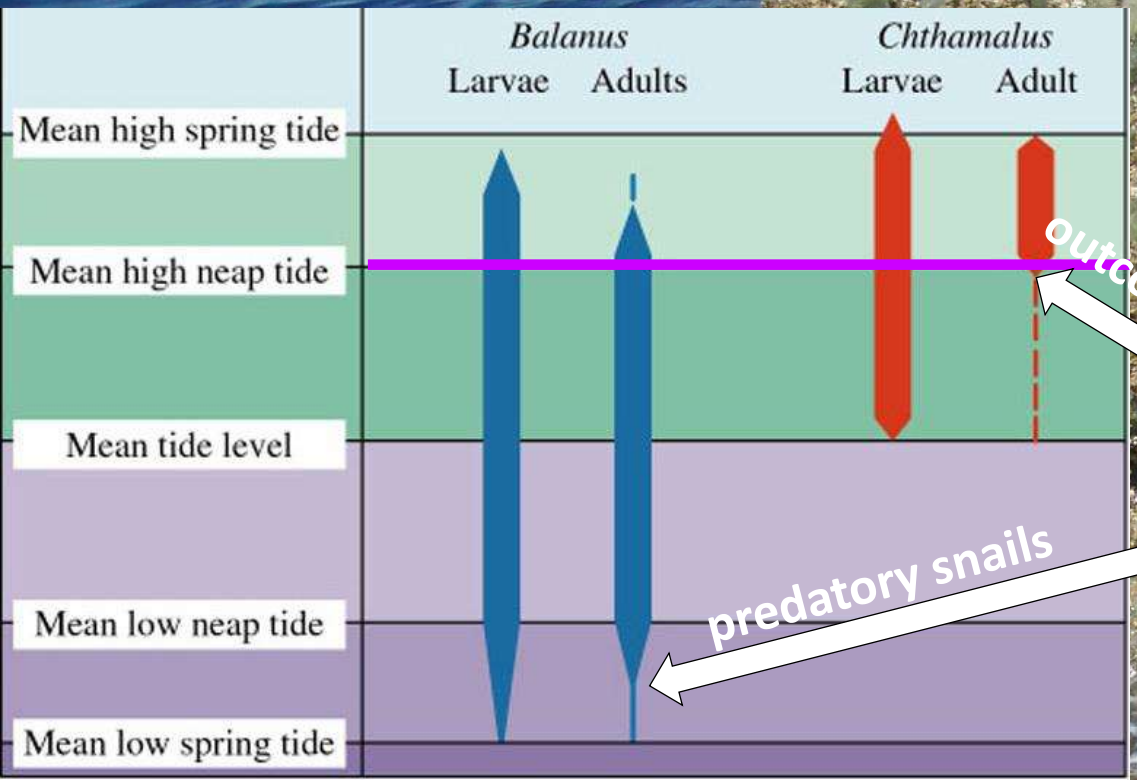


Chthamalus

Balanus

realized niche: species interactions low shore

Adult & larval barnacles occupy different tidal elevations



Chthamalus

Balanus

outcompeted

predatory snails

realized niche: species interactions low shore

Related projects ideas

→Have zones shifted with climate change?

→Upper limits lower? (higher air temperatures)

→All zones shifted higher? (sea level rise)

*See work of CDG Harley, MN Dethier

Major ecological theme

4. Life cycles

Influence of life history on recovery?

- Larval dispersal
- Life span

Life history traits & disturbance recovery

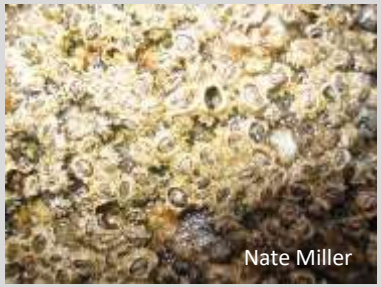
Conway Cranos *Marine Ecol Prog Ser* 2012

Life history traits & disturbance recovery

high

Dispersal potential

low



Chthamalus

Mytilus

red turf alga

rockweed

1 y 3 y 7 y 20 y

Life span

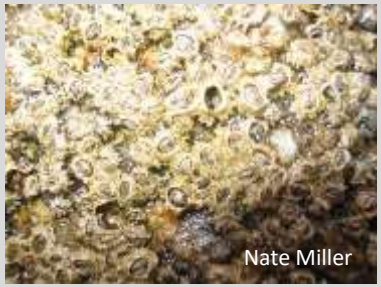
Conway Cranos *Marine Ecol Prog Ser* 2012

Which species do you predict will take longest to recover?

Dispersal potential

high

low



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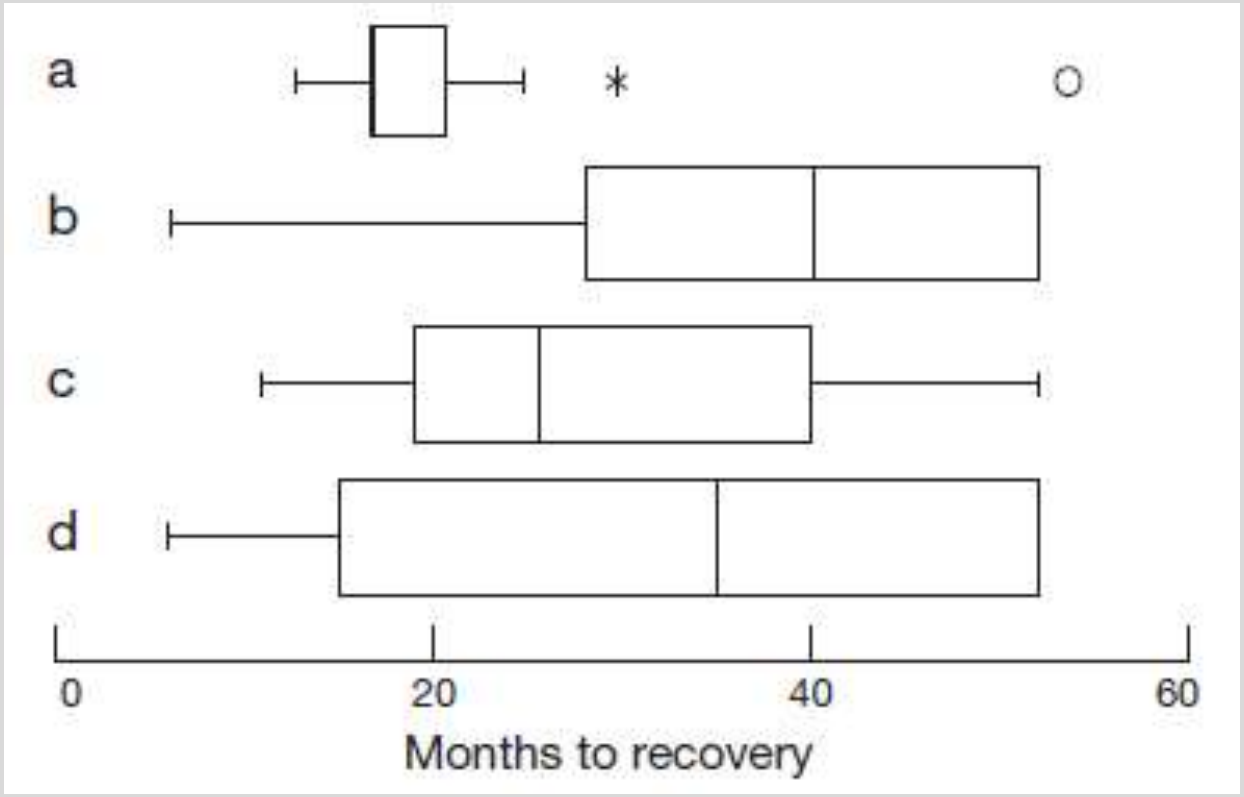

Conway Cranos *Marine Ecol Prog Ser* 2012

Related projects ideas

→Are life cycles different with climate change?

- →Direct developers laying smaller eggs? (size-temperature hypothesis: hotter = smaller)
- →Are species with planktonic larvae reproducing earlier? (change in climate patterns)

*See work of R & M Strathmann

Intertidal Ecology

Types of intertidal zones

- rocky, soft-sediment, estuaries

Tides

- Lunar & daily cycles

Some major ecological themes

1. Changing abiotic stresses
2. Species interactions
3. Zonation
4. Life cycles

Tidal cycling observations