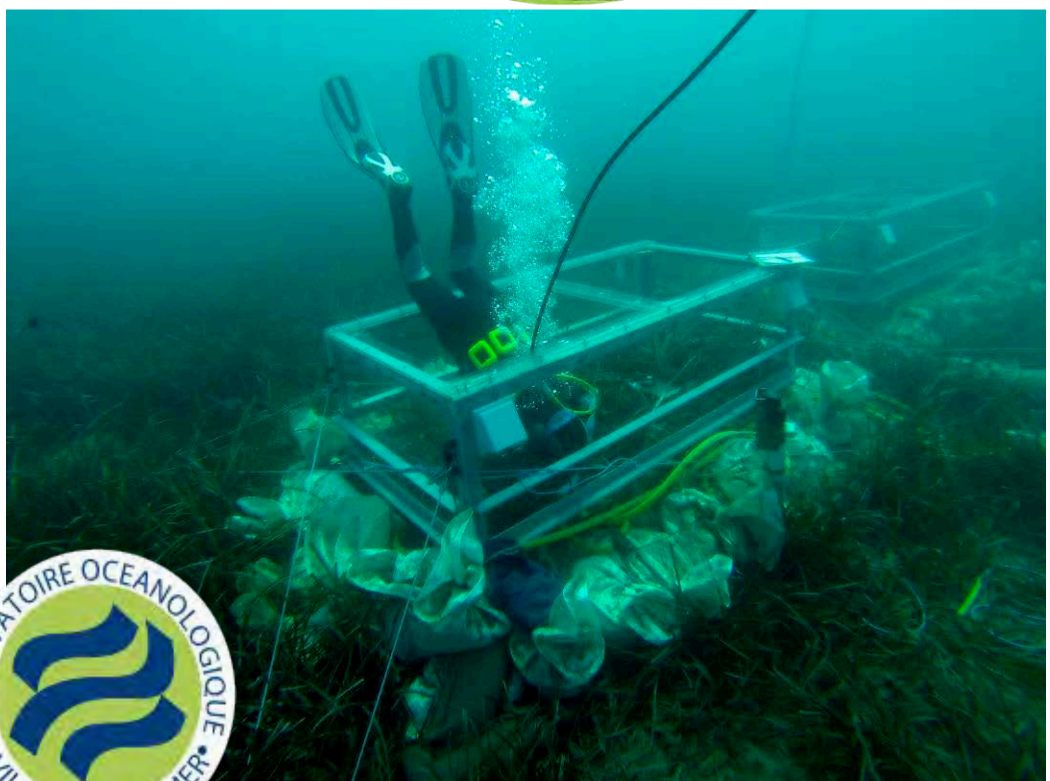
Introductions

Erin Cox, PhD

I currently reside in France

Introductions

Post-doctoral research on seagrass meadow ecology

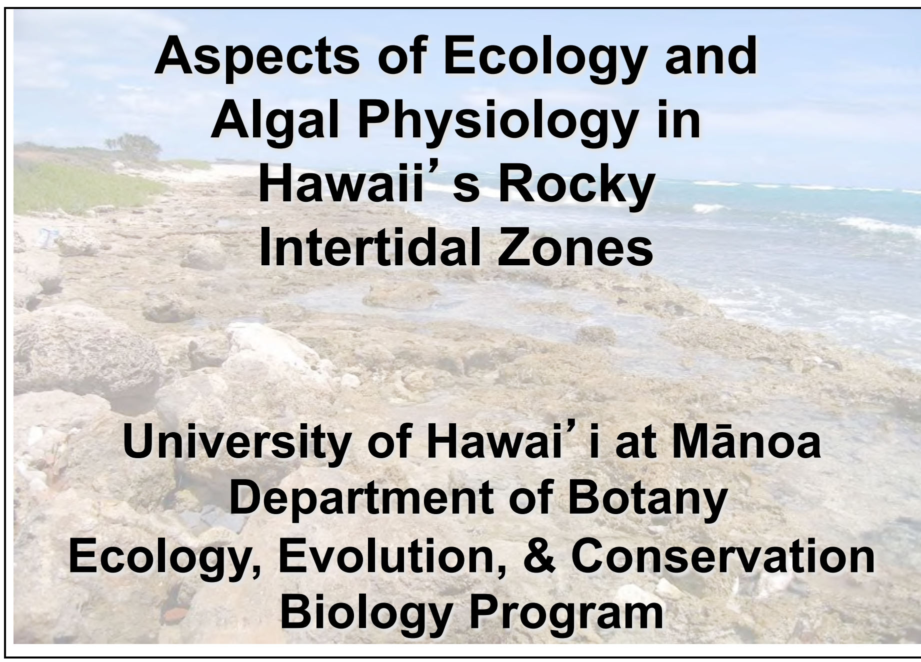


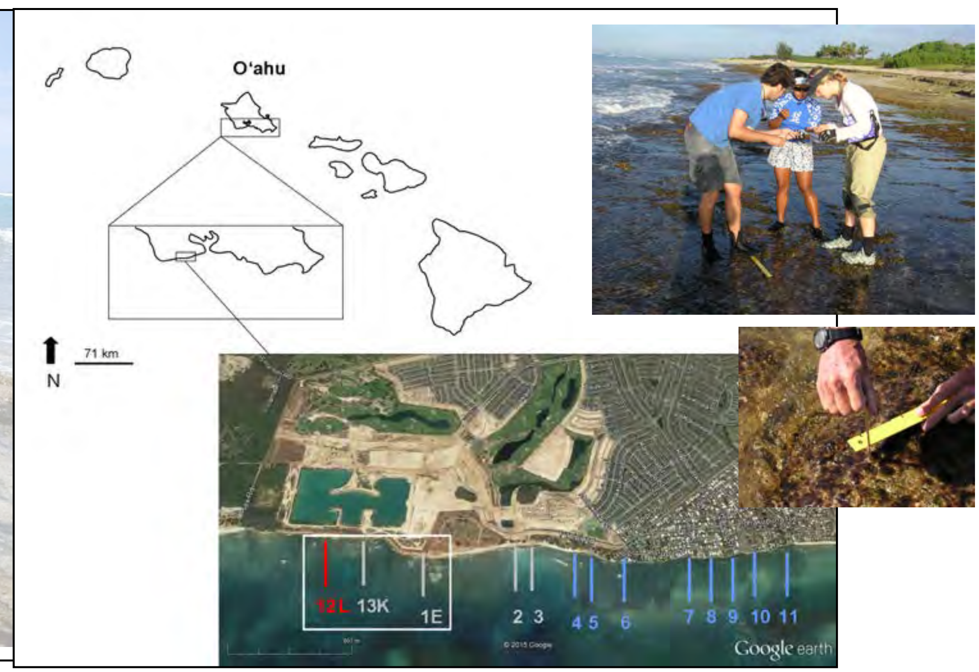
Efoce.eu

Introductions

How am I qualified on intertidal ecology?

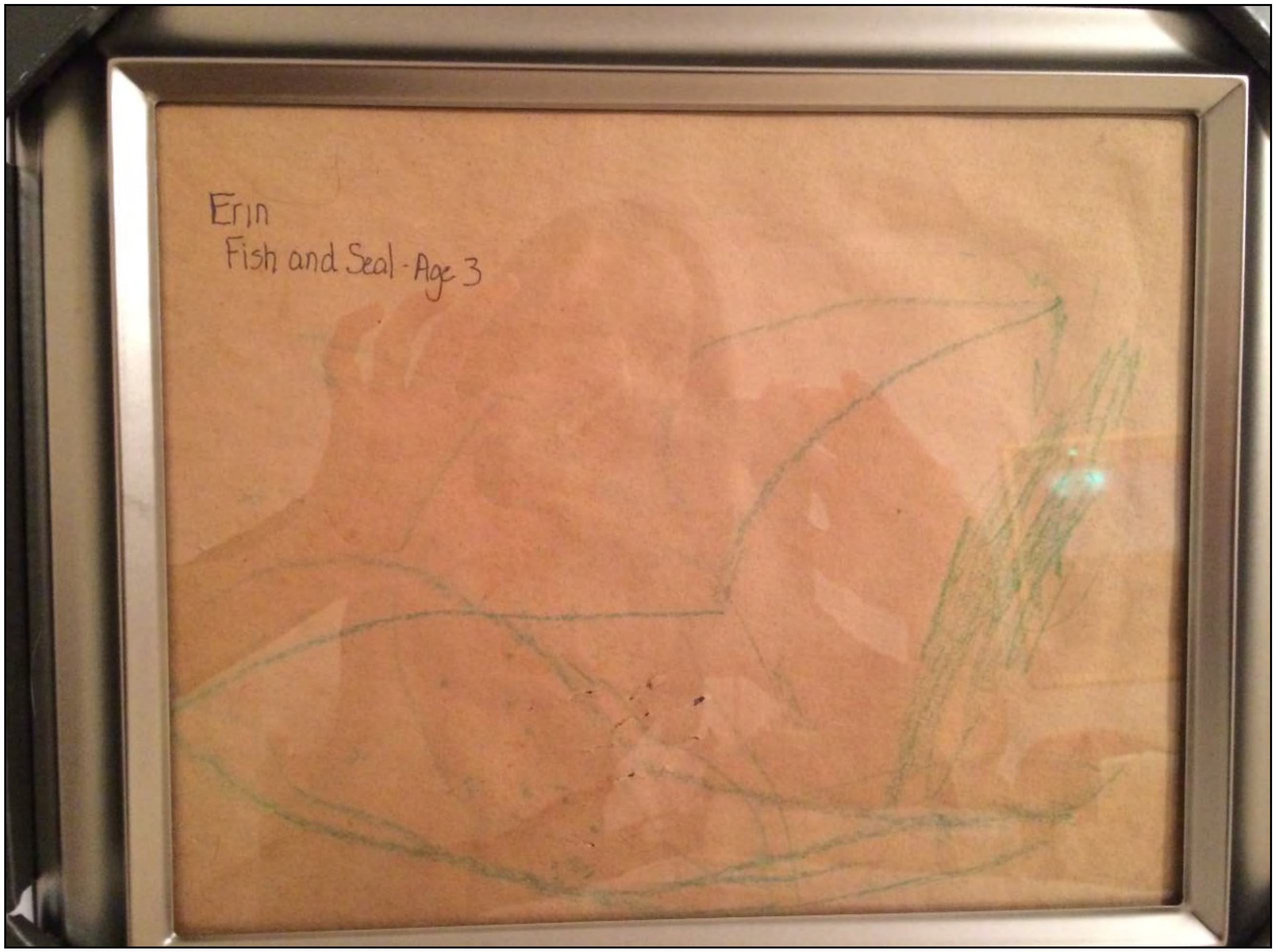
- PhD at UH in 2011
- OPIHI program collaboratively for 2 ½ years
- Since 2006, longterm monitoring in intertidal at Ewa Beach
- MS degree, California State U. Fullerton studying intertidal ecology





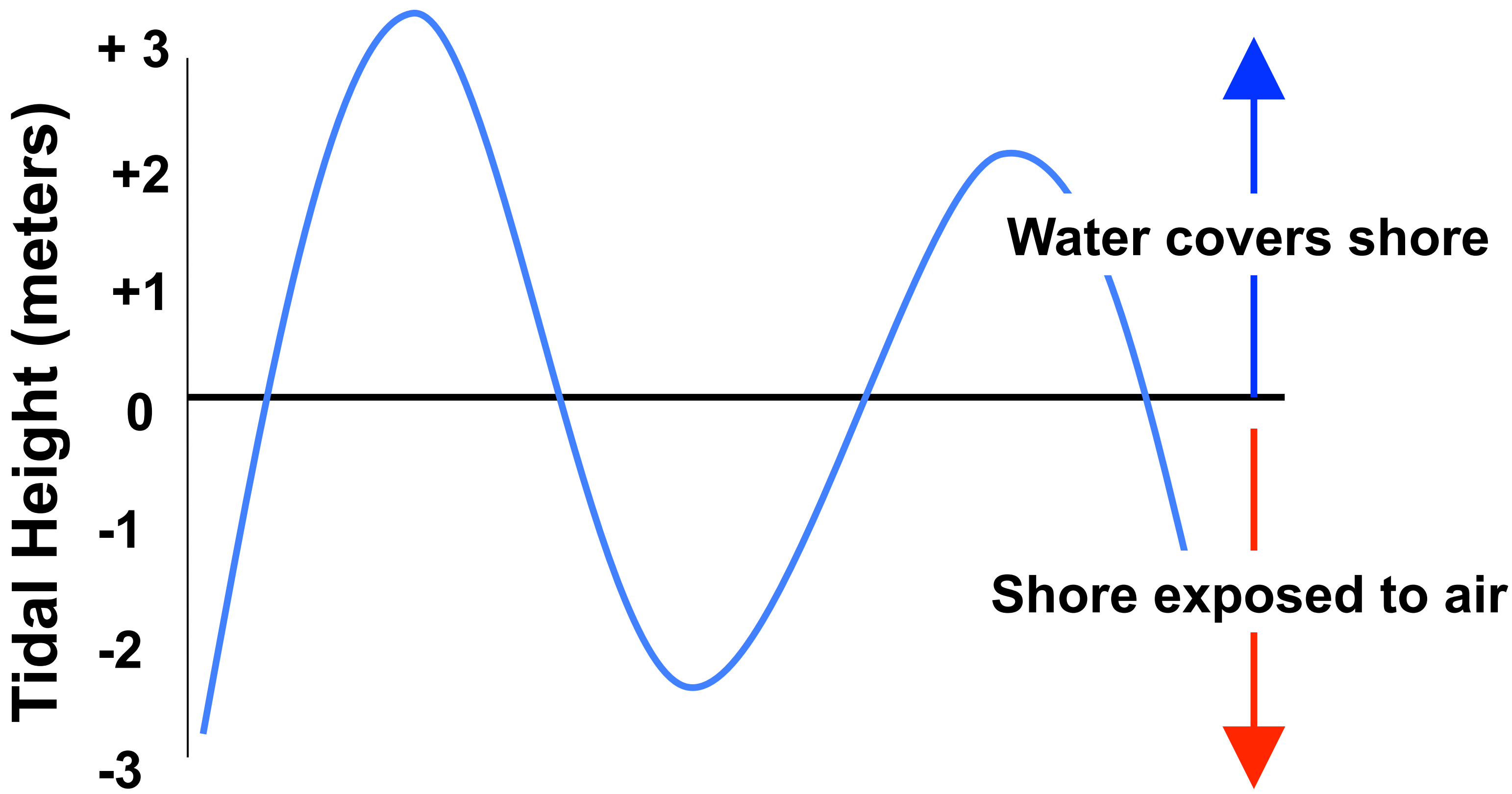
Introductions

How did I get interested in Marine Science & Intertidal Ecology?



Intertidal Zones =
the habitat between high and low tides

Tidal heights determined by position of sun and moon relative to earth

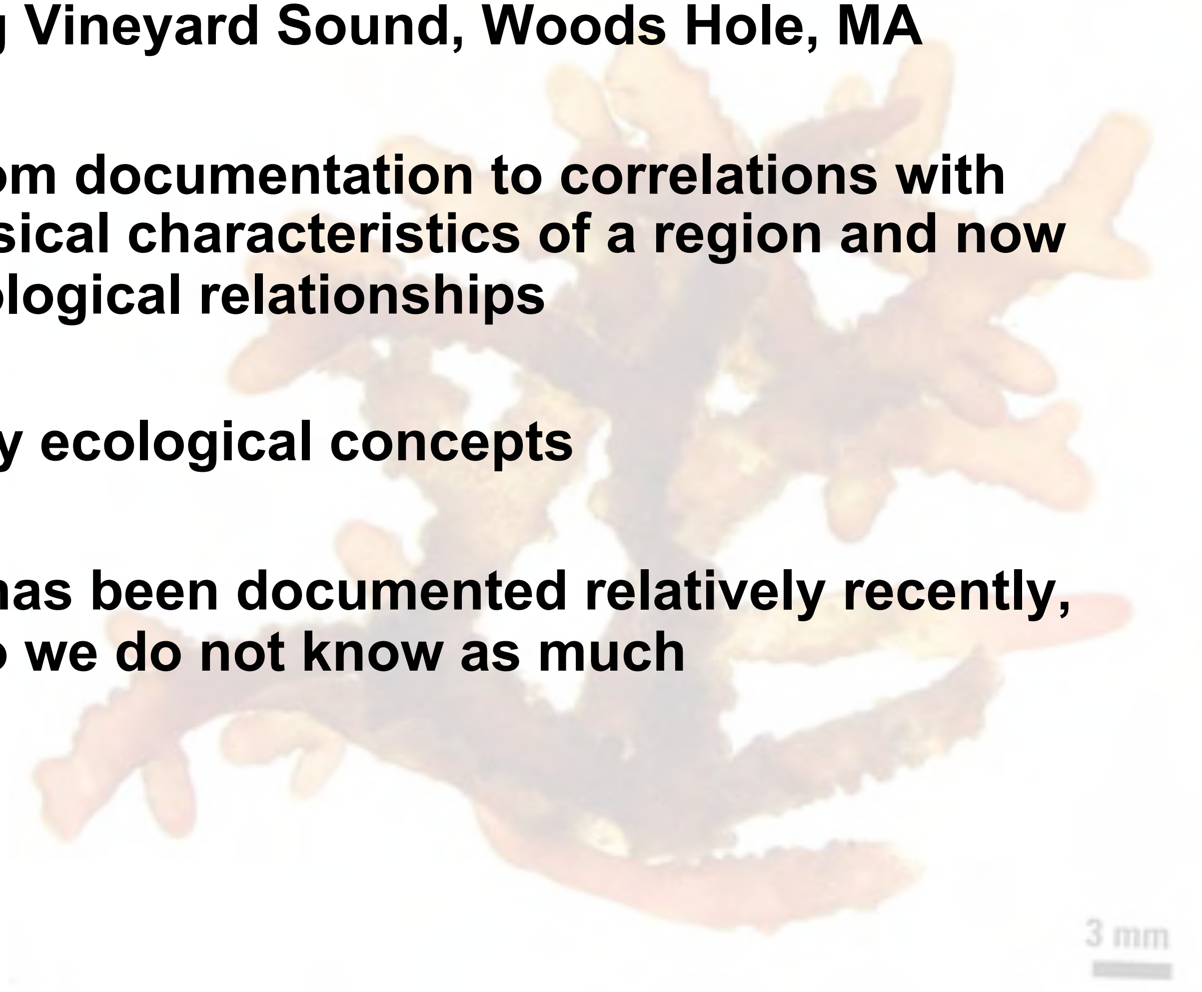


Tidal height measured in distance; when positive covers shore when negative exposes shore to air.

Often patterns in abundance of organisms along shores, called structure

What factors shape patterns we observe in organism abundances in intertidal zones?

- **Studied as long ago as 1870 by A. E. Verrill, patterns of invertebrates along Vineyard Sound, Woods Hole, MA**
- **Focus changed from documentation to correlations with physiology, to physical characteristics of a region and now interaction with biological relationships**
- **Responsible for key ecological concepts**
- **Tropical intertidal has been documented relatively recently, in the mid 1980s so we do not know as much**



Picture from Huisman, Abbott, & Smith 2007

Abiotic factors
= non - living factors

- Temperature
- Irradiance (Sunlight)
  - Quality & quantity
- Ultra-violet radiation
- Desiccation
- Sand scour
- Wave forces
- Water chemistry

As I go through the talk, think about the factors in Hawaii & your observations at the shore

Biotic factors = living biological interactions

- Predation
- Competition
- Facilitation
  - one organism benefits other is unaffected

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Organisms can have adaptations, structures or processes that limit abiotic stress or alter biological interactions

Interplay between organisms and their environment

What factors commonly shapes the patterns in abundance & diversity (structure) observed across the shore?

Structure across the shore is often influenced by the tide. Why?

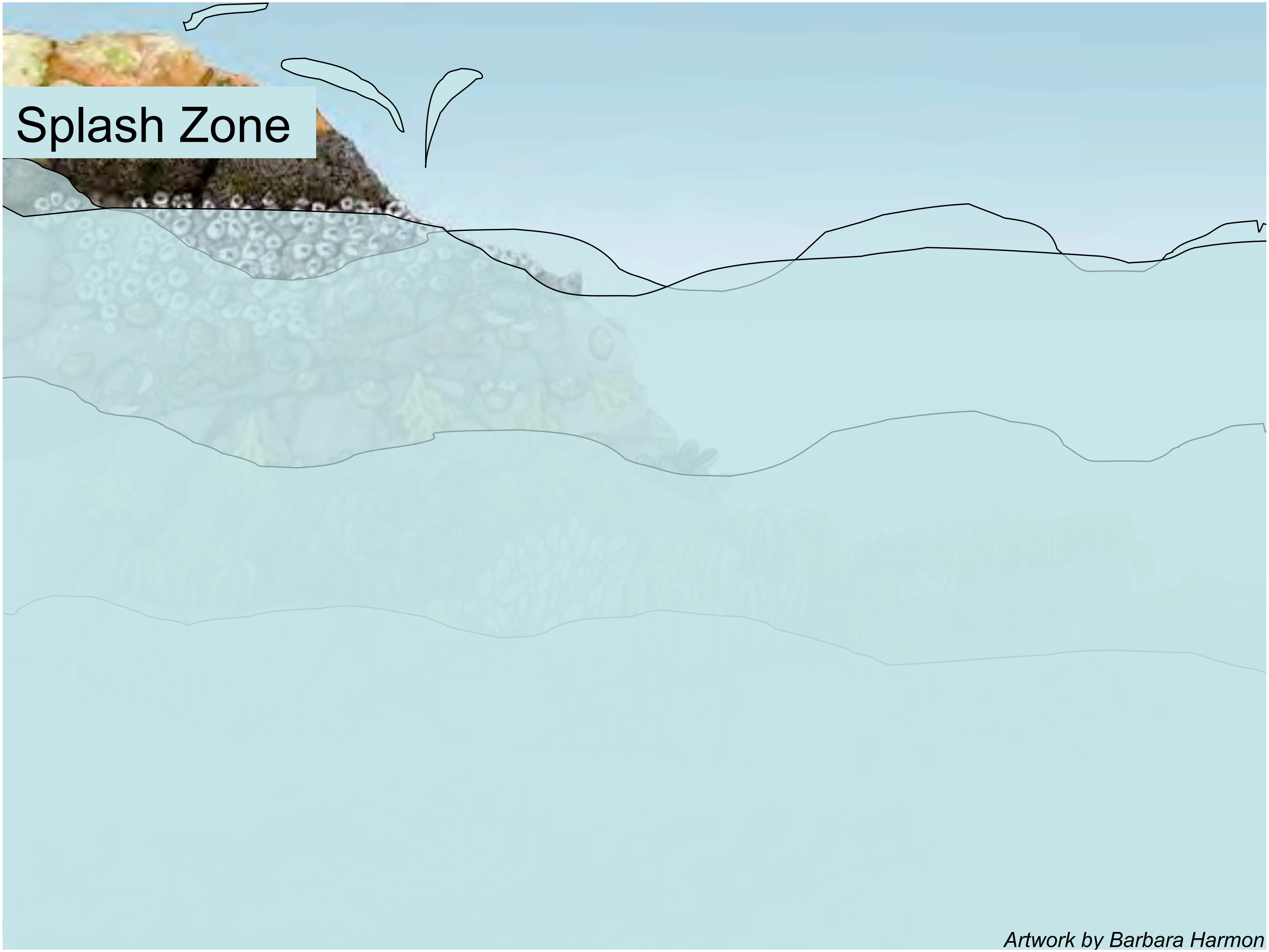
- **Length-Tide can vary in range of magnitude depending upon the region**
    - microtidal (0.0-0.2 m)----1 m
    - mesotidal (2.0-4.0 m)
    - macrotidal (4.0-6.0 m)
    - megatidal (>6.0 m)

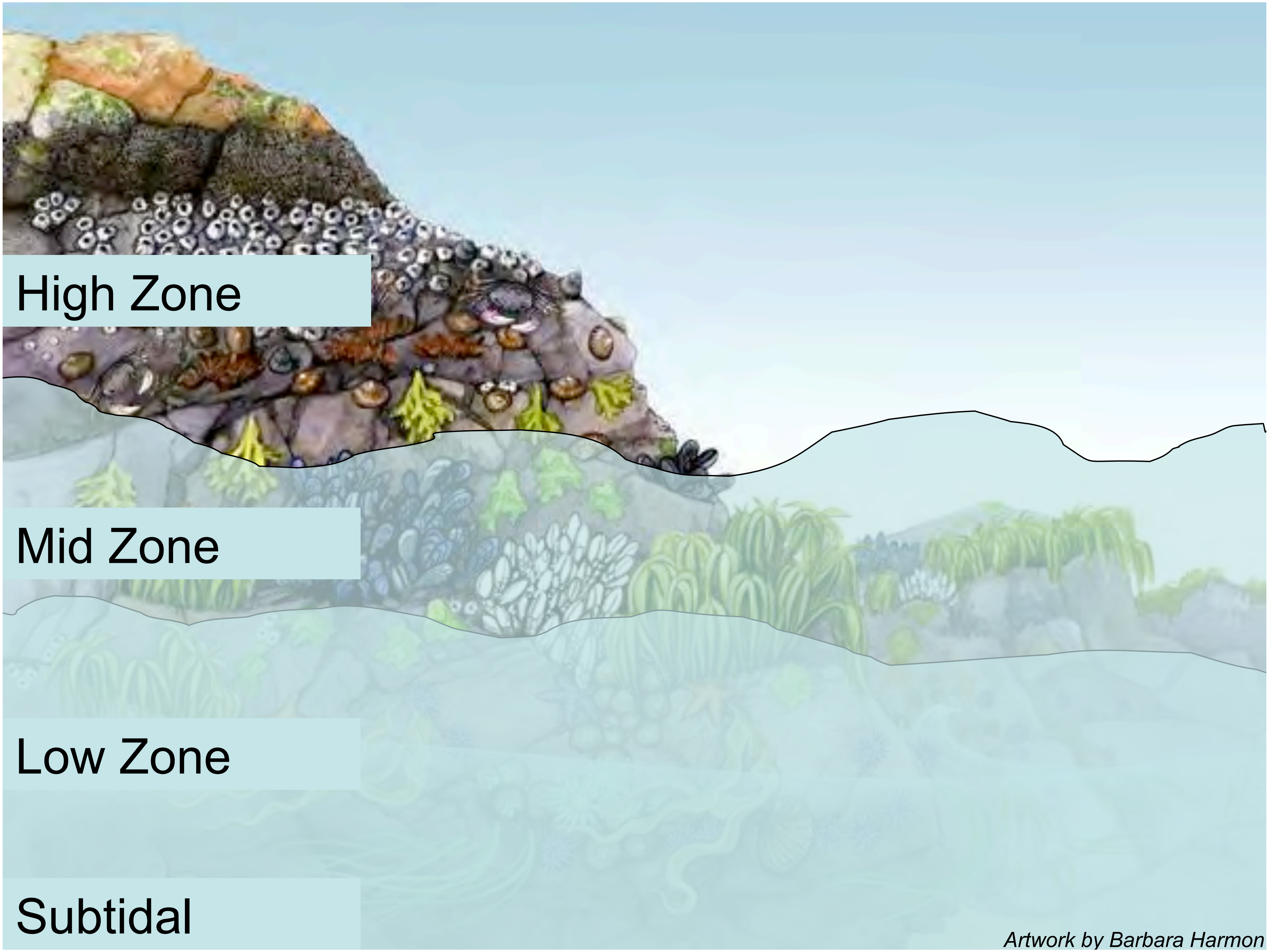
  Influenced by bathymetry shore topography

- **Often-Tide frequency varies**
    - diurnally (1 per day),
    - semi-diurnally (2 per day)

•Time of day

Which combination do you think is more stressful for animals and algae?


Splash Zone
Artwork by Barbara Harmon


High Zone
Mid Zone
Low Zone
Subtidal
Artwork by Barbara Harmon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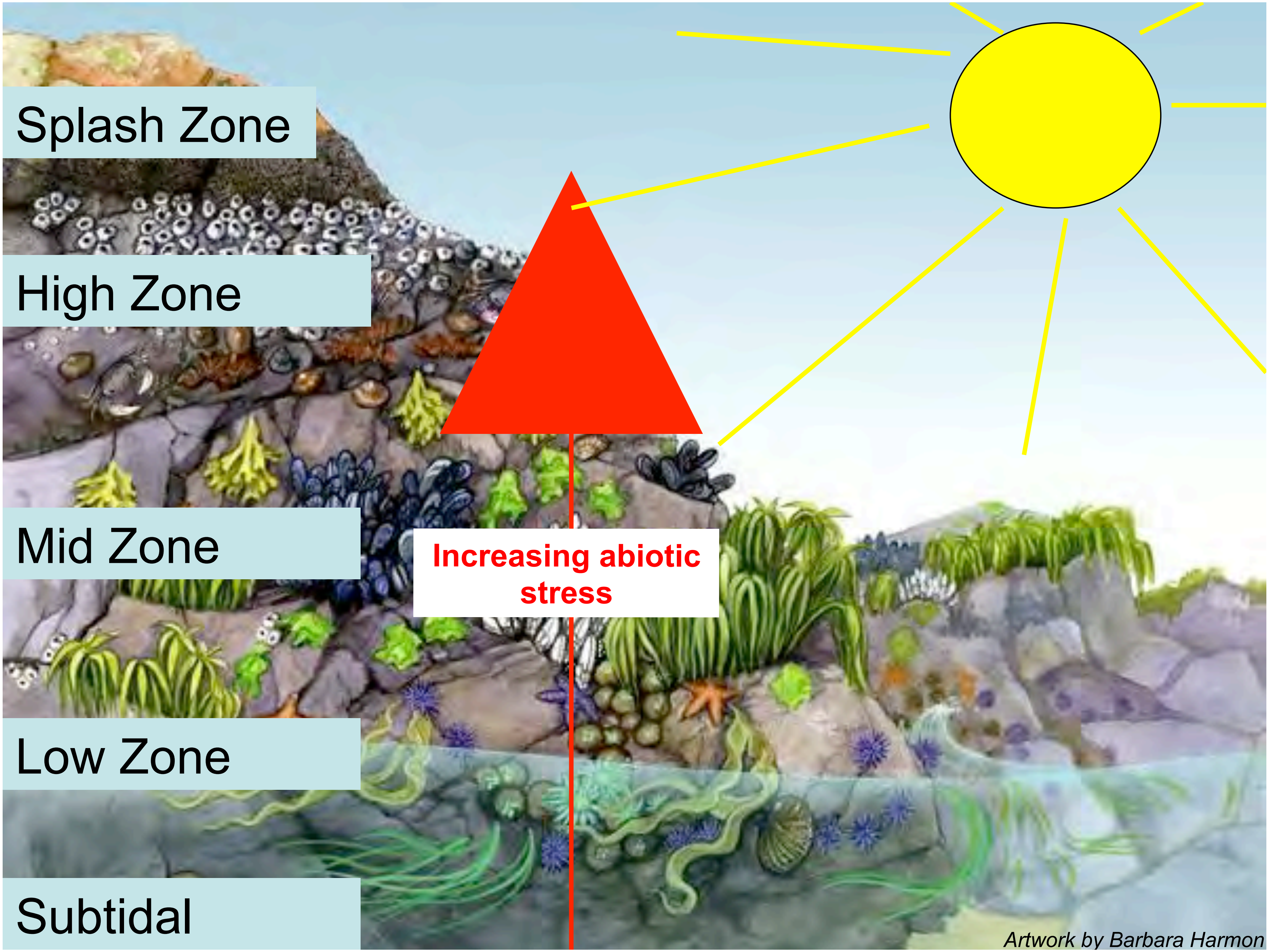
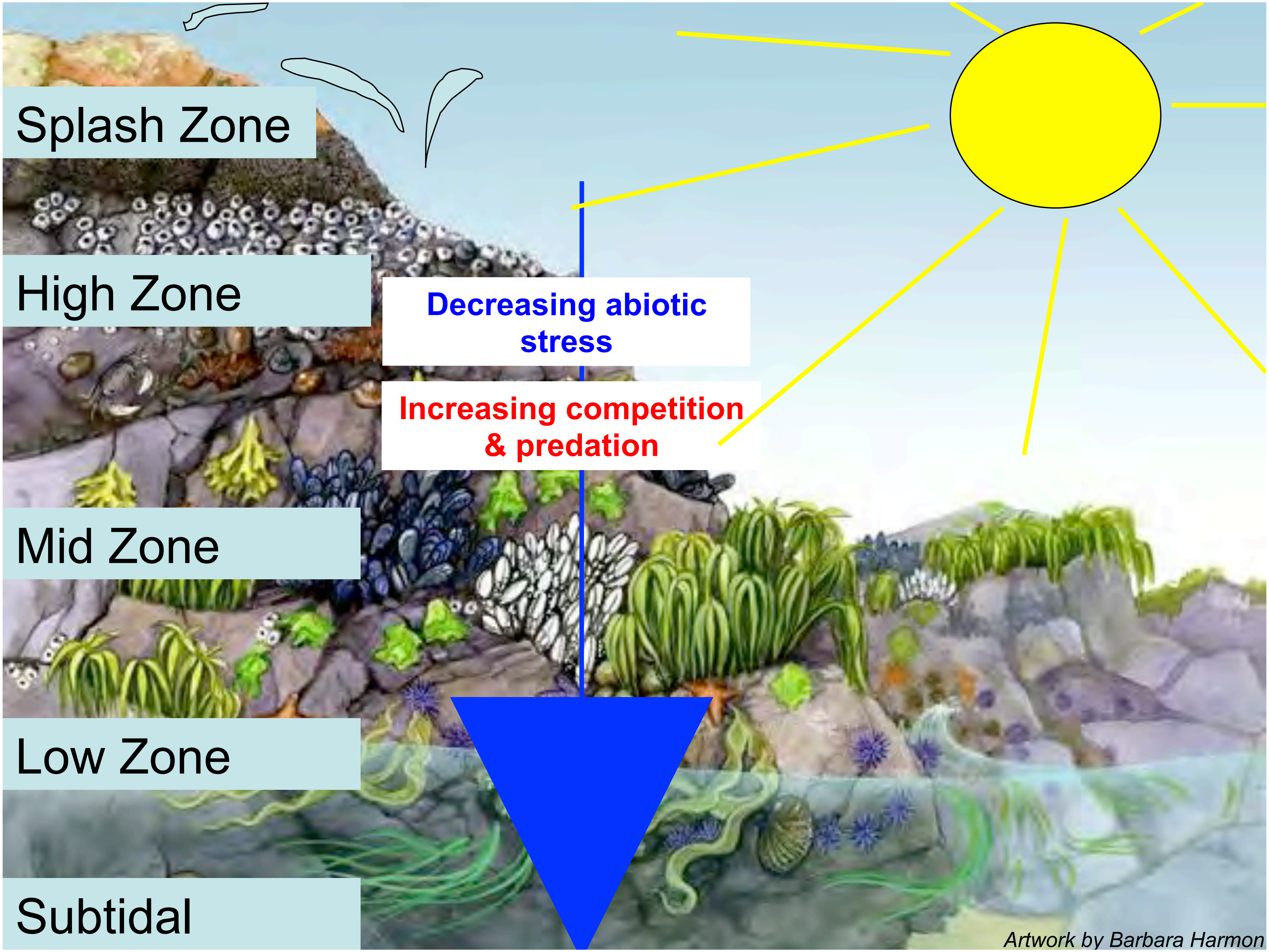


Splash Zone
High Zone
Mid Zone
Low Zone
Subtidal
Increasing abiotic stress
Artwork by Barbara Harmon


Splash Zone
High Zone
Decreasing abiotic stress
Increasing competition & predation
Mid Zone
Low Zone
Subtidal
Artwork by Barbara Harmon

Structure across the shore

is also influenced by wave activity. Why?

Structure across the shore

is also influenced by wave activity. Why?

Waves can keep organisms wet & cool, alter light, cause physical damage

Shore topography, waves, tides, & organisms interact

In temperate, prolonged aerial exposure and desiccation limits algal productivity

Shore topography, waves, tides, & organism abilities interact

Example of biotic factors contributing to structure across shore

What usually shapes structure among shores?

- **Bathymetry & topography**
- **Substrate type**
- **Oceanographic currents (food, nutrients, propagules)**
- **Dispersal & colonization**
- **Rainfall patterns or delivery of terrestrial runoff**

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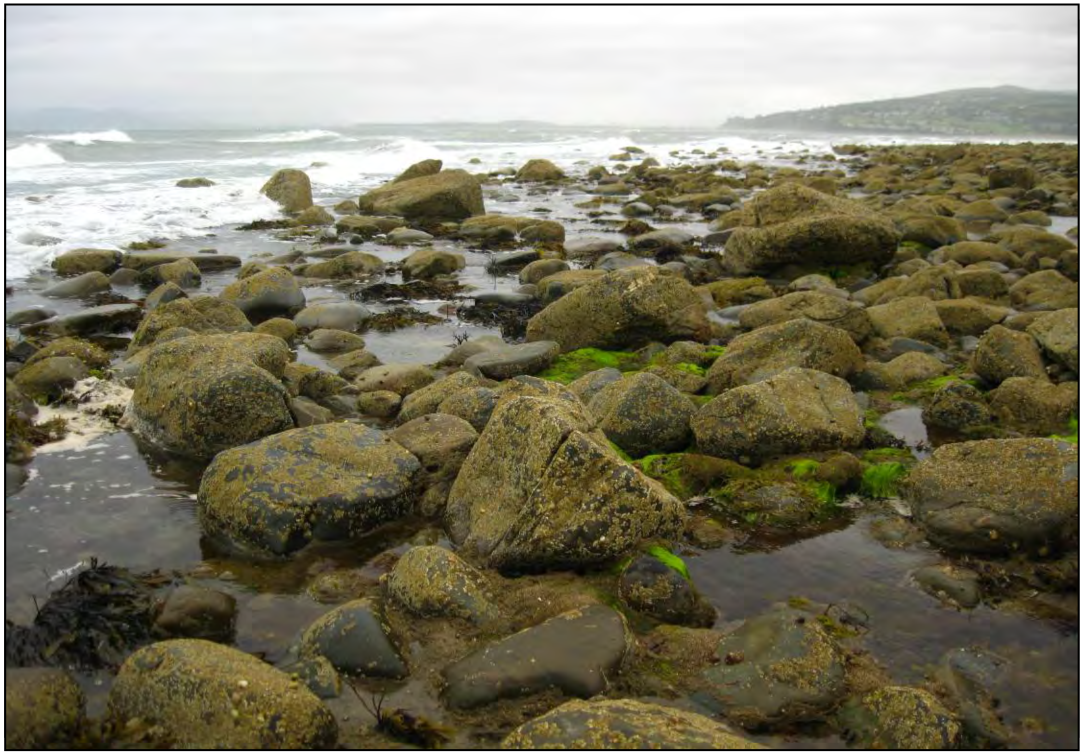

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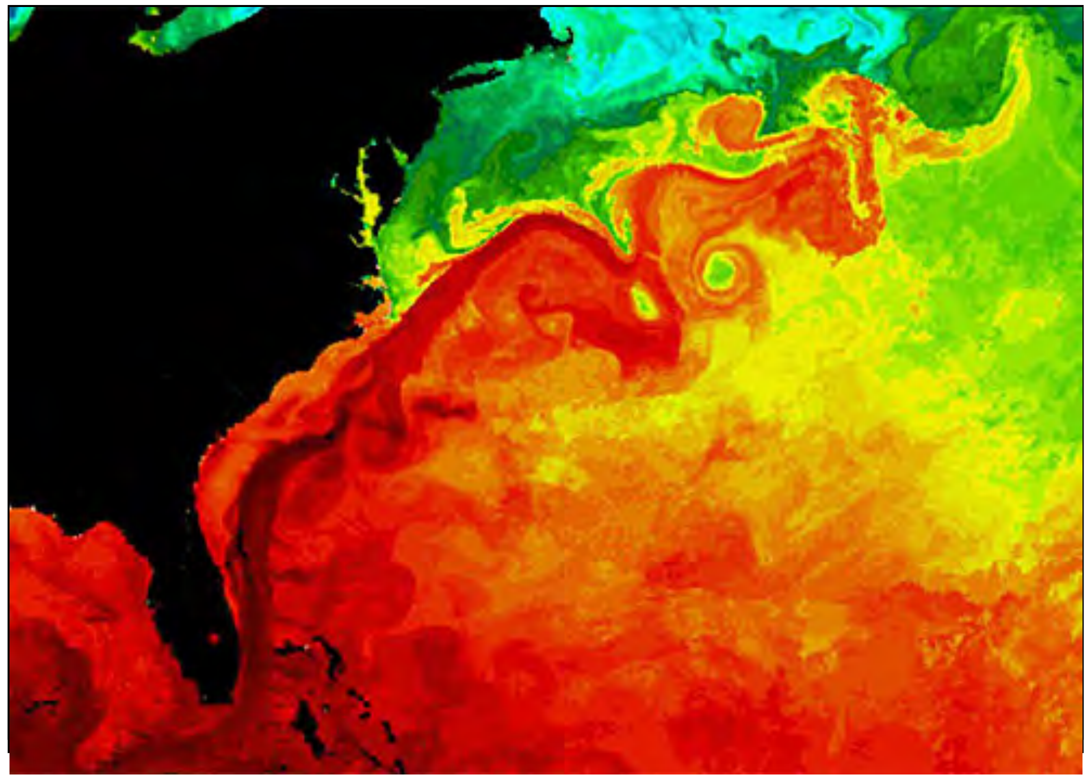

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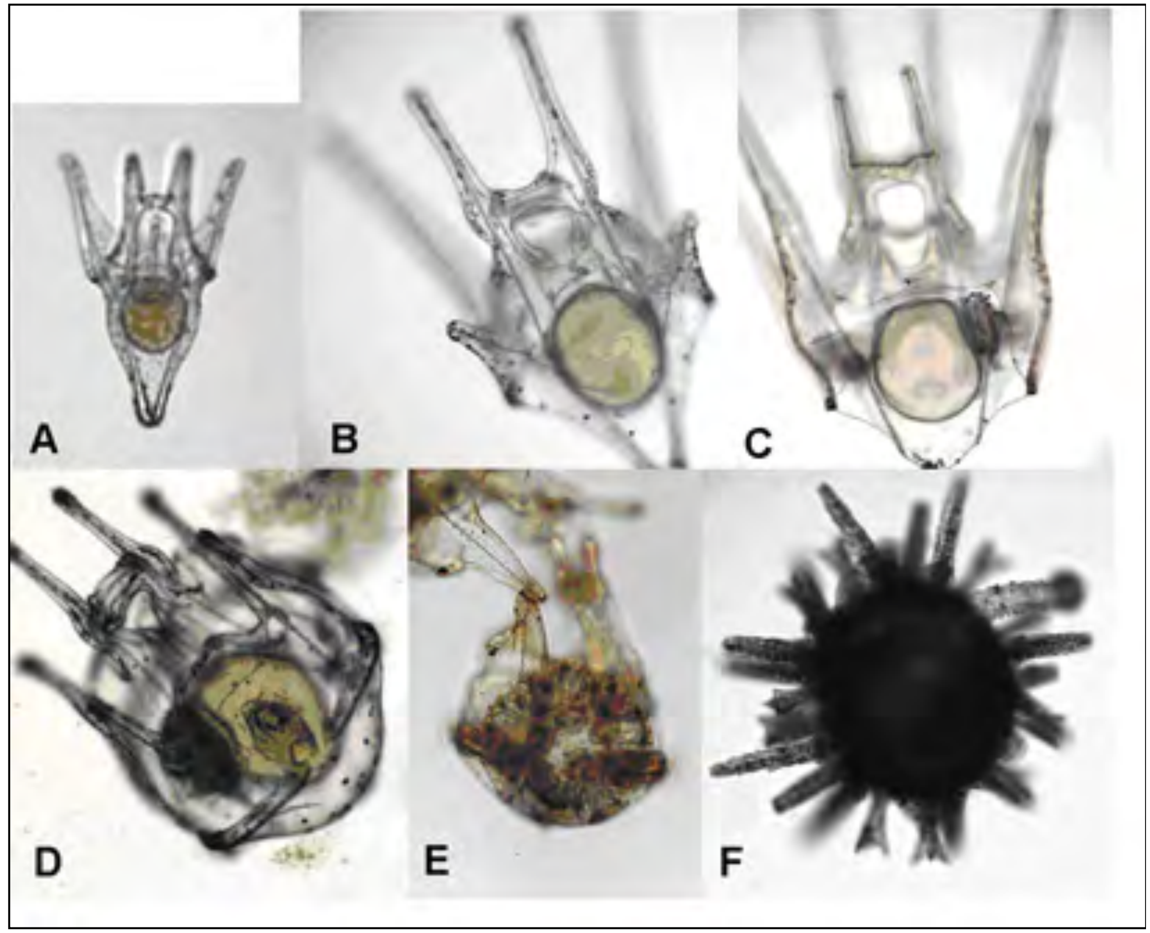

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Anthropogenic Impacts

- Overharvesting
- Trampling
- Eutrophication
- Introductions
- Habitat destruction
- Global changes
  - Temperature, pH

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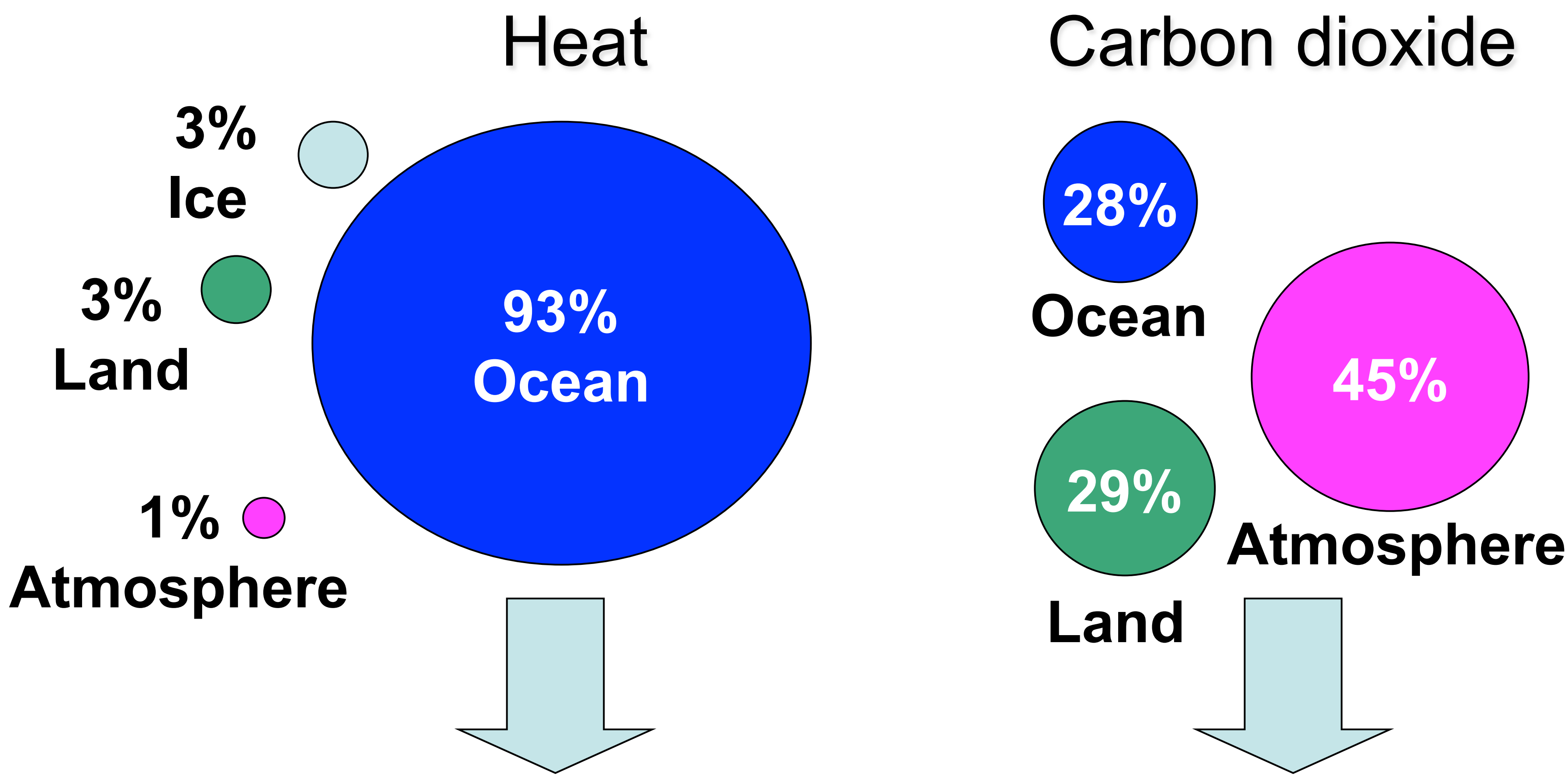
Global alterations in sea surface that can effect climate & physiological processes

Anthropogenic emissions of carbon dioxide (CO_2)

8.6 Pg C^{-1} into the atmosphere

Global alterations in sea surface that can effect climate & physiological processes



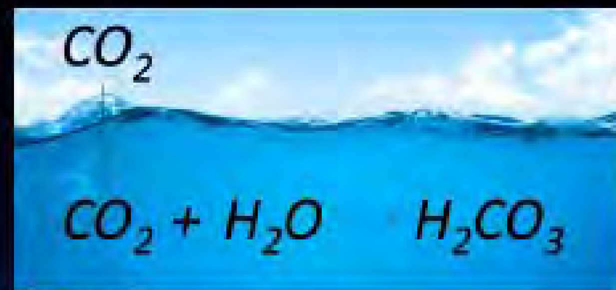
Ocean Warming
2100 yr projected + $2^{o}C$

Ocean Acidification
- 0.3 pH_T units

What is ocean acidification?

More acidity ↑ / Less acidity ↓

Concentrations of Hydrogen ions compared to distilled water (pH)		Examples of solutions and their respective pH
10,000,000	0	Battery Acid
1,000,000	1	Hydrochloric Acid
100,000	2	Lemon Juice, Vinegar
10,000	3	Orange Juice, Soda
1,000	4	Tomato Juice
100	5	Black Coffee, Acid Rain
10	6	Urine, Saliva
1	7	"Pure" Water
1/10	8	Sea Water
1/100	9	Baking Soda, Toothpaste
1/1,000	10	Milk of Magnesium
1/10,000	11	Household Ammonia
1/100,000	12	Soapy Water
1/1,000,000	13	Bleach, Oven Cleaner
1/10,000,000	14	Liquid Drain Cleaner

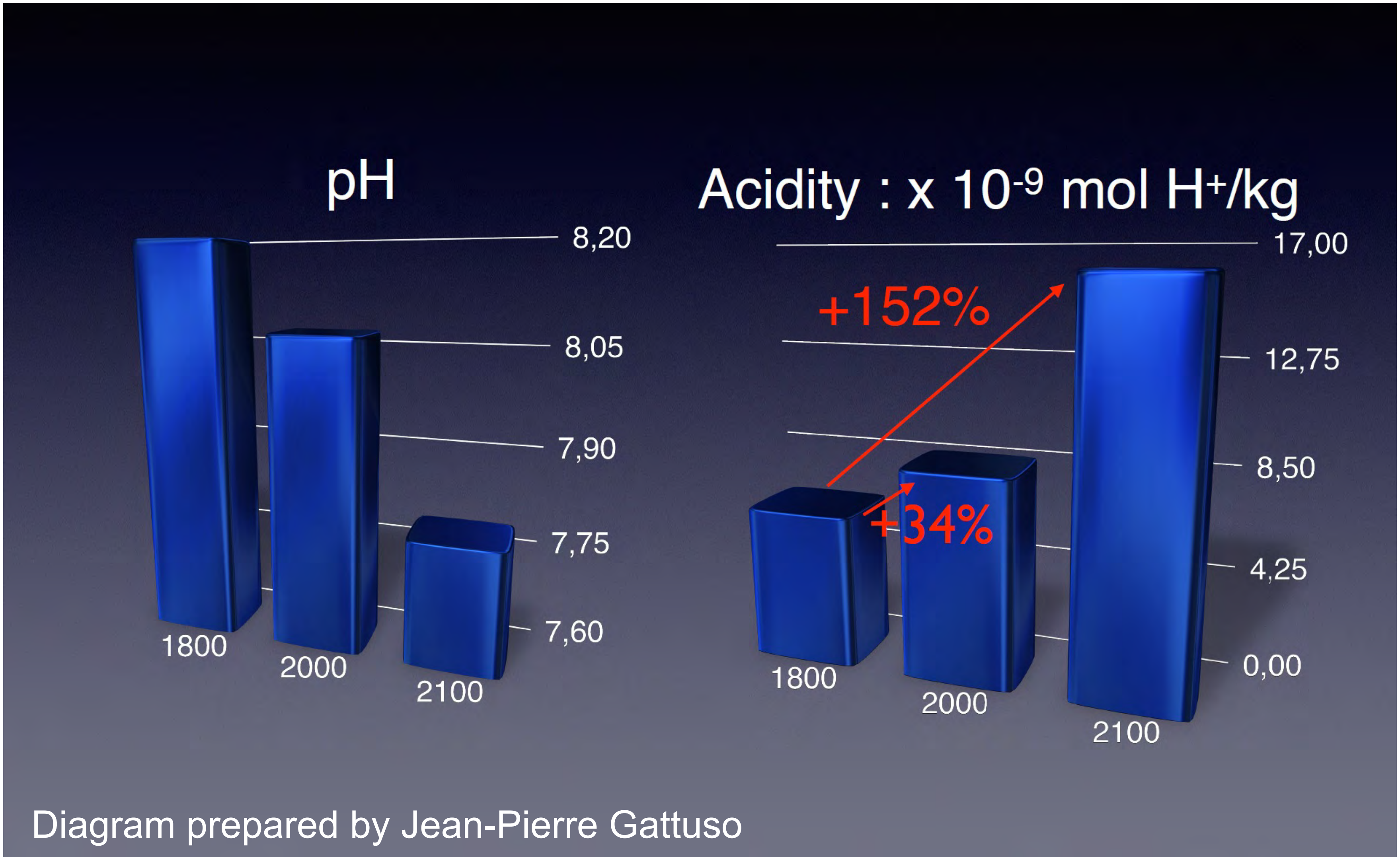


Sam Dupont

- CO_2 is an acid gas (it produces acid when combined with water)
- Each of us adds 4 kg CO_2 per day to the ocean (increasing acidity, reducing pH)

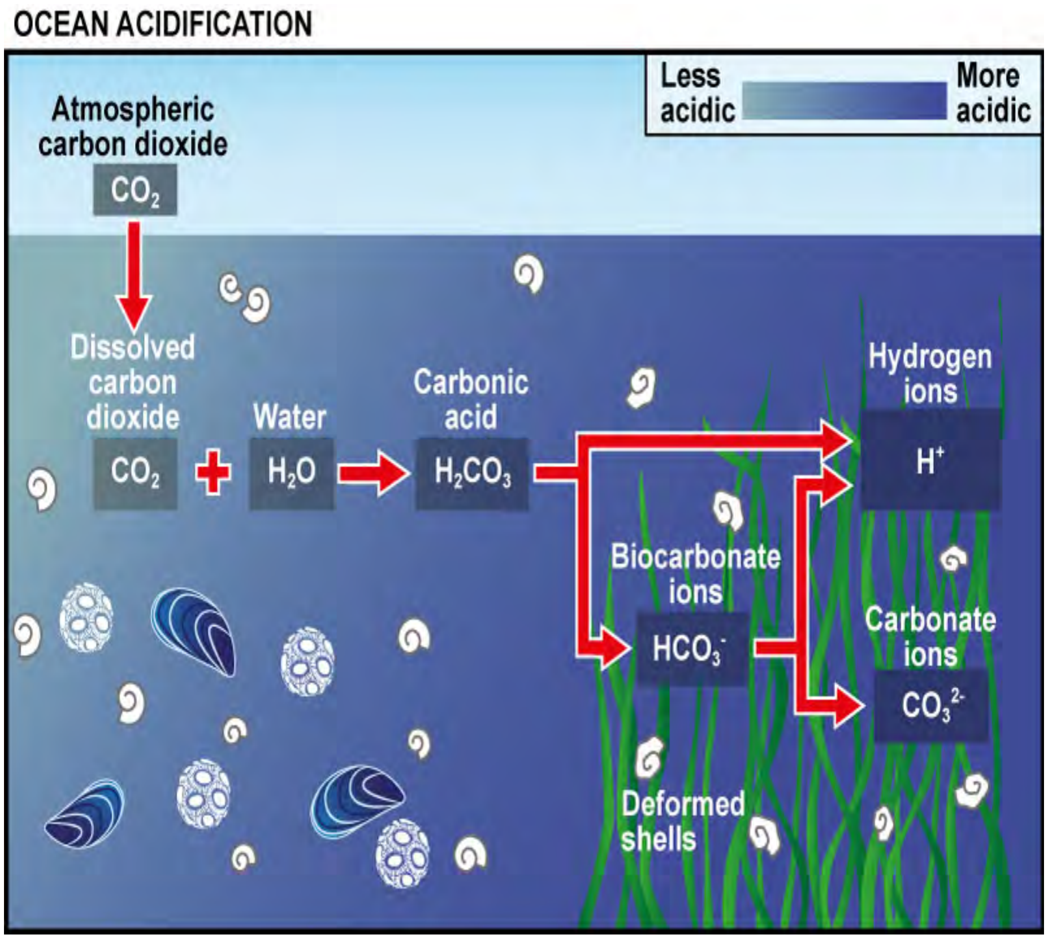
Slide produced by Jean-Pierre Gattuso

pH and acidity



Predicted consequences

Increases in dissolved CO_2 and HCO_2^-



BENEFIT MARINE PRODUCER

- Most can use HCO_2^-

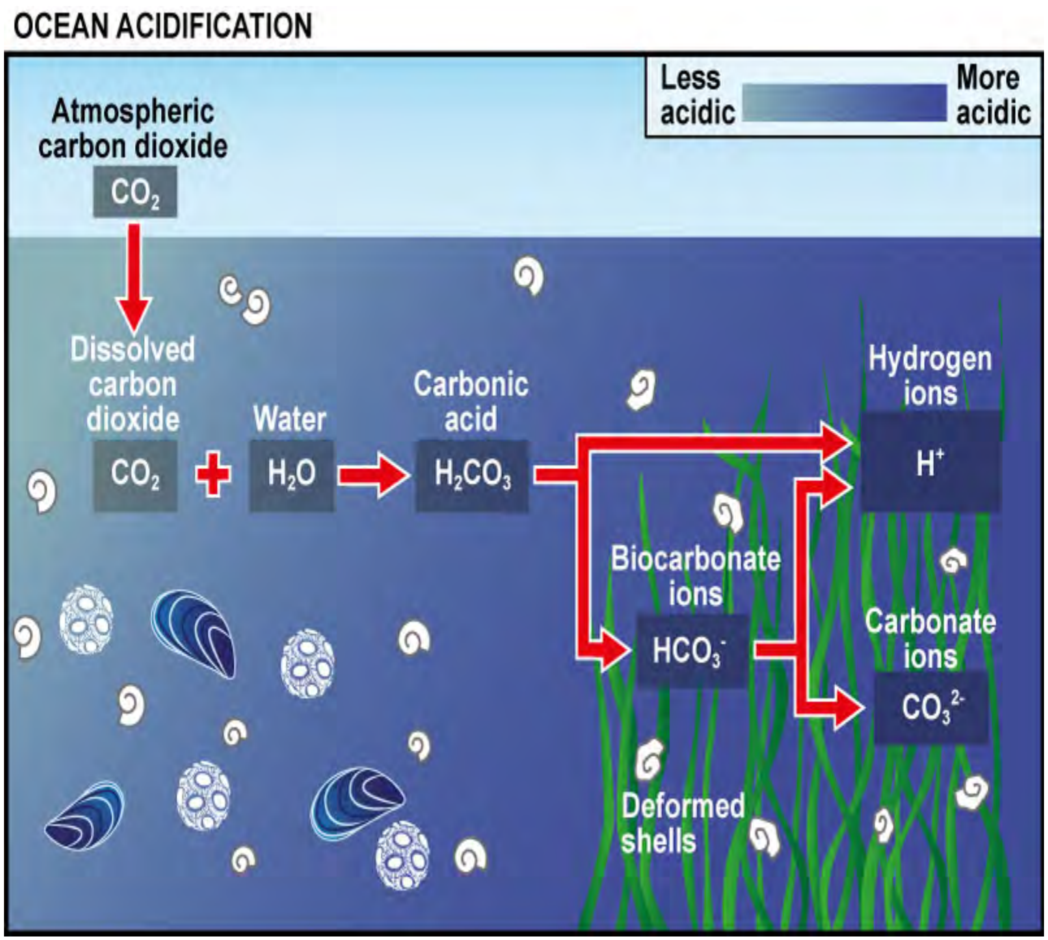
-Many preferentially use CO_2

- Different rates of increase with dissolved CO_2 availability

- Can be carbon limited in natural conditions

Predicted consequences

Decreased CO_3^{-2} & lower pH



NEGATIVELY EFFECTS CALCIFIERS

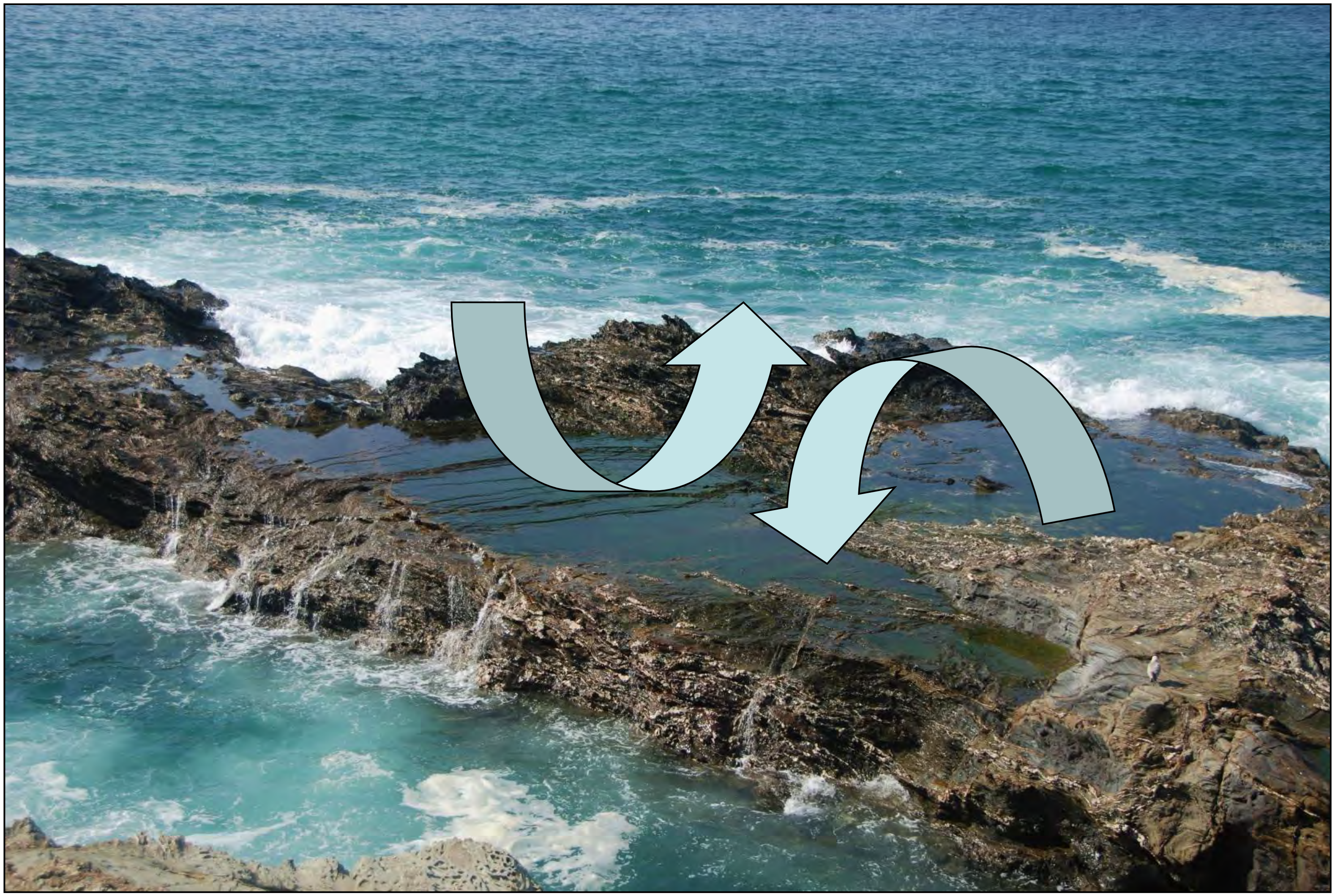
- Needed to build structures

- Increases susceptibility to dissolution

- Differential abilities to control pH at sites of calcification

- Different carbonate minerals

BUT the pH tends to be widely variable in tidepools



Patterns with biogeography – tropical vs temperate

Patterns with biogeography – tropical vs temperate

- Warm air temperature
- Low biomass
- For Hawaii-
Minimal tidal range (± 1 m)

- Seasonal air temperature
- High biomass
- Larger tidal range (± 3 m)

Trends in the tropics

- Thought to be more stressful?
- Temperature more important driver?
- Monsoon like in some regions with wet & dry season
- Different herbivores with higher feeding rates

Picture by J. Smith

Insight into unique system in Hawaii

Algal Ecology

- McDermid 1988
- Smith 1992
- Beach 1996
- Bird 2006

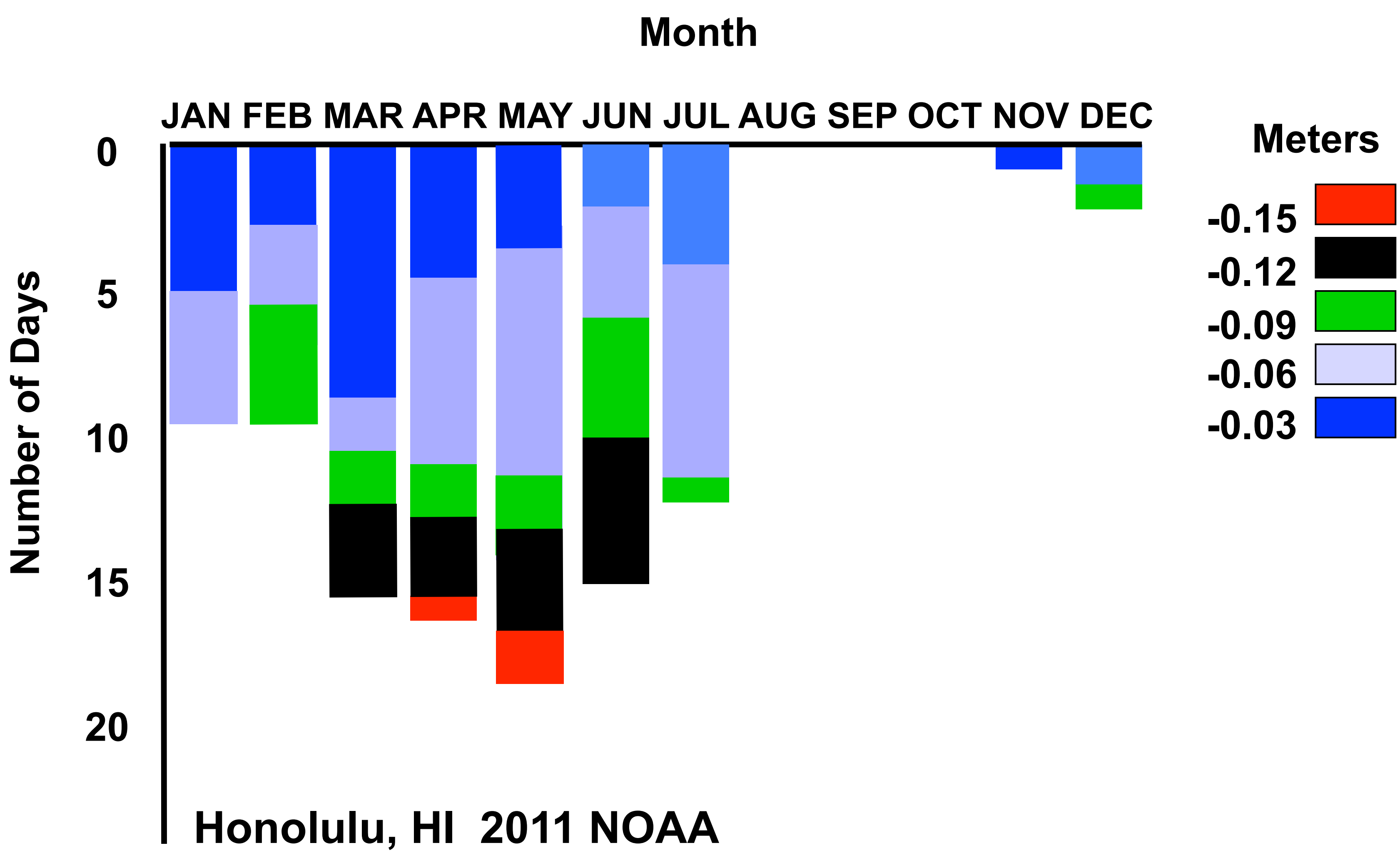
Invertebrate Ecology

- Zabin 2006
- Bird 2006

Tidepool Fish Ecology

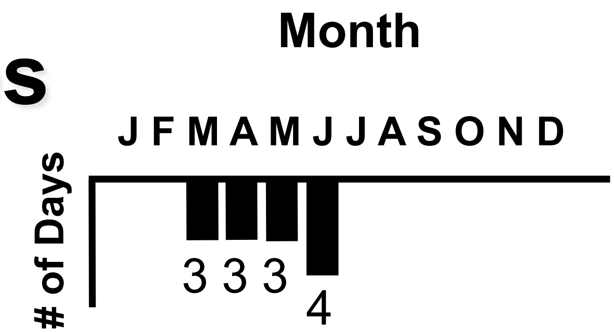
- Gosline 1965

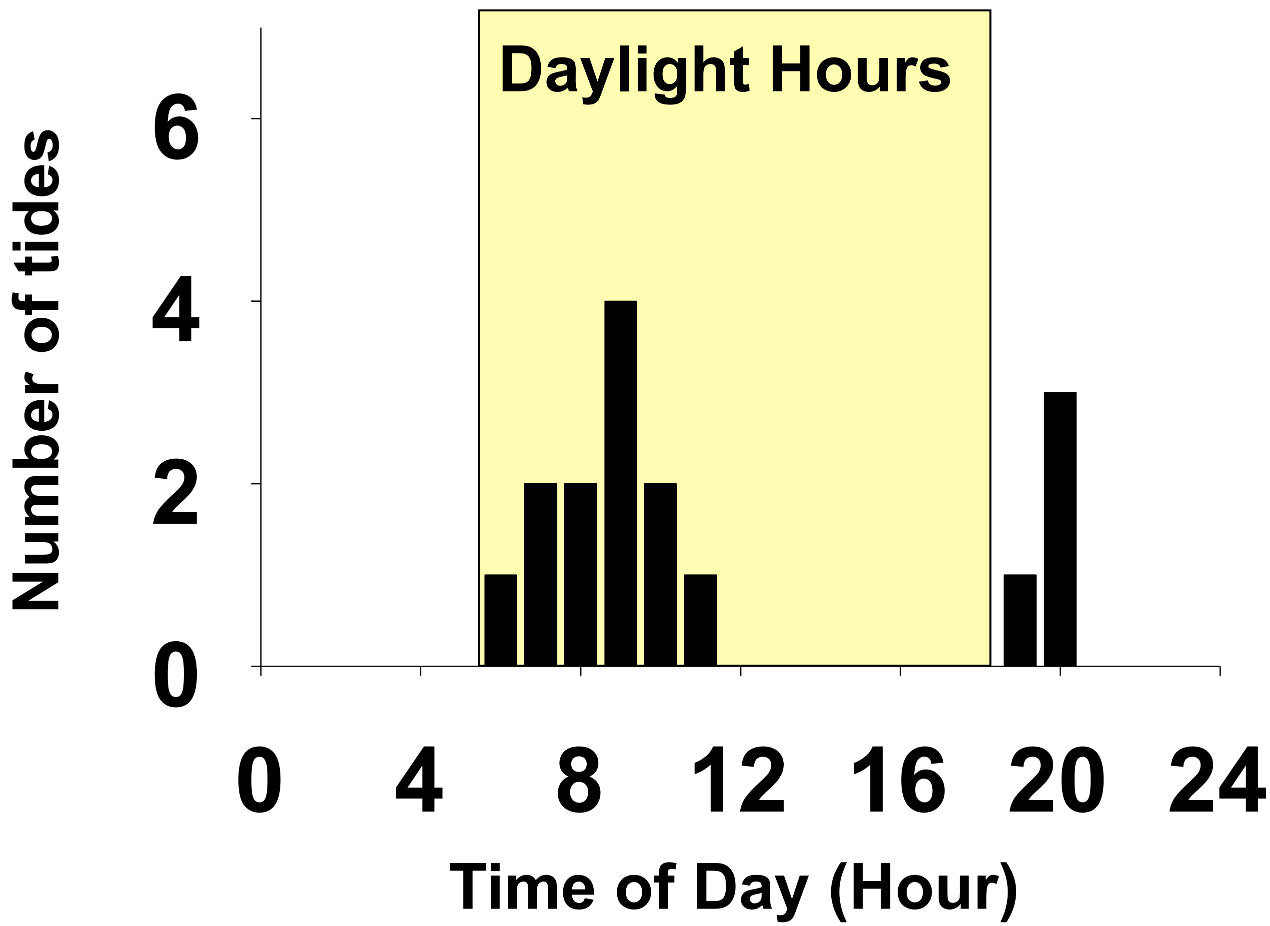
of Negative Low Tides in Daylight Hours



Timing of negative low tides

-0.12 m low tides during
Jan-Dec 2011





How long are algae & invertebrates exposed to air?

Day	MLLW (m)	Time	Exposure to Air (Maximum # of Hours)
1	-0.15	08:34	On = 4, Mid = 4, Off = 5
2	-0.12	10:24	On = 4, Mid = 4, Off = 6
3	-0.09	11:10	On = 4, Mid = 4, Off = 5
4	0.12	14:46	On = 0, Mid = 0, Off = 0

Beach et al. 1996

- *Ahnfeltiopsis concinna*
  - Experiences water loss in canopy, bleached coloration
  - But underneath at the bottom, darker pigmentation and Higher photosynthetic rates

Wave-dominated described by Bird 2006

Citizen scientists reveal diversity of intertidal life & differences among intertidal communities

Diversity of benthic life

- 49 red, brown, & green algae
- 1 bacterium
- 31 invertebrates

13 sites vary in composition & abundance

Cox, TE; Philippoff, J; Baumgartner, E; Zabin, C; and Smith, CM (2013) Spatial and temporal patterns of rocky intertidal communities along the Main Islands of Hawai ʻi. *Pacific Science* 67:23-45, with cover photo

Why might these sites be different??

Picture by K. Dreckmann


What differed?

- Substrate type
  - basalt, limestone, sand, boulders
- Known eutrophication
- Abundance of invasive algae
- Wave activity
- Coloration of the shore
- Amount of tidepools

Need to better quantify the environment & monitor changes

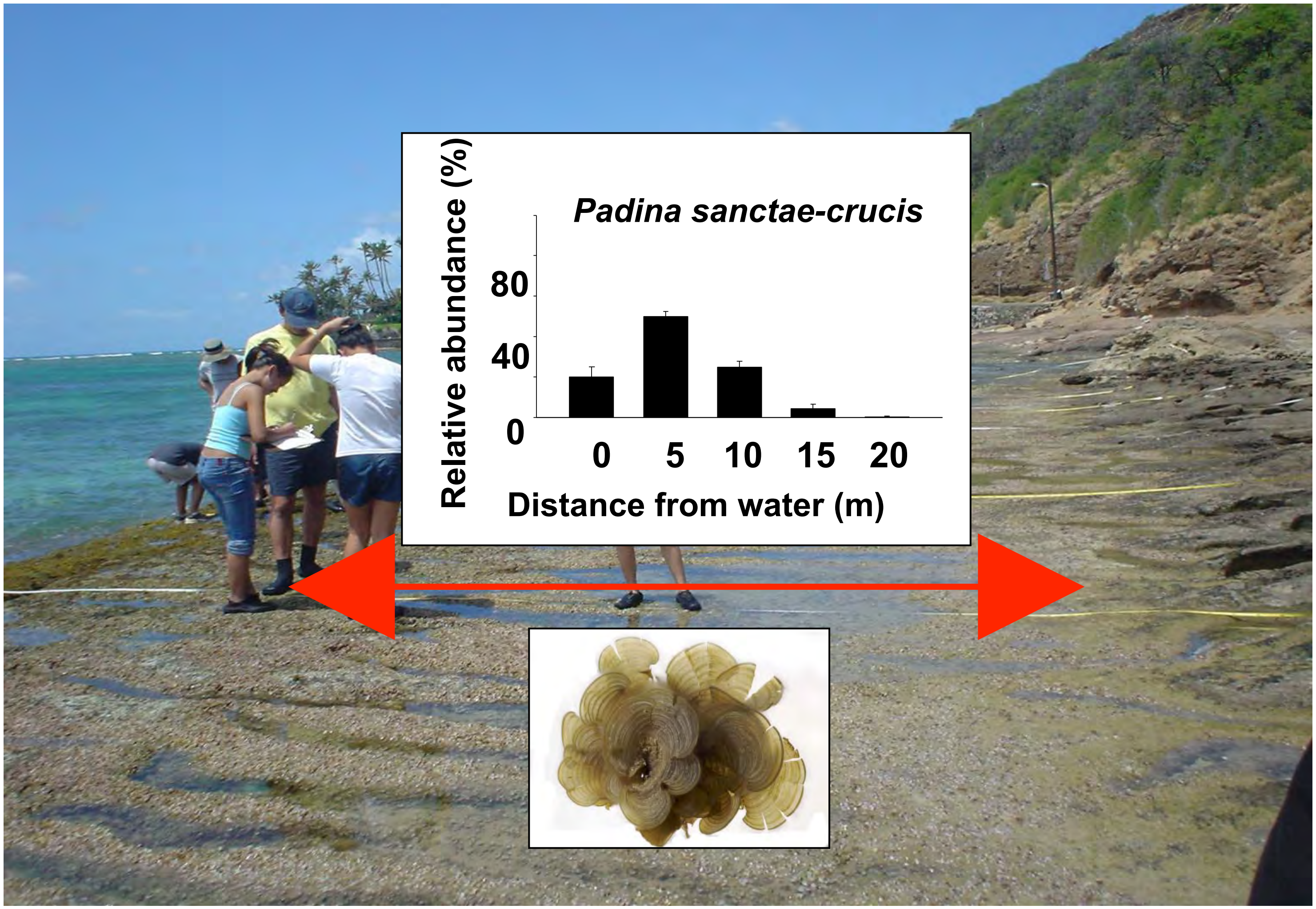
Vertical distribution patterns in benthic assemblages

Off shore → On shore

Vertical distribution patterns in benthic assemblages

Off shore → **On shore**

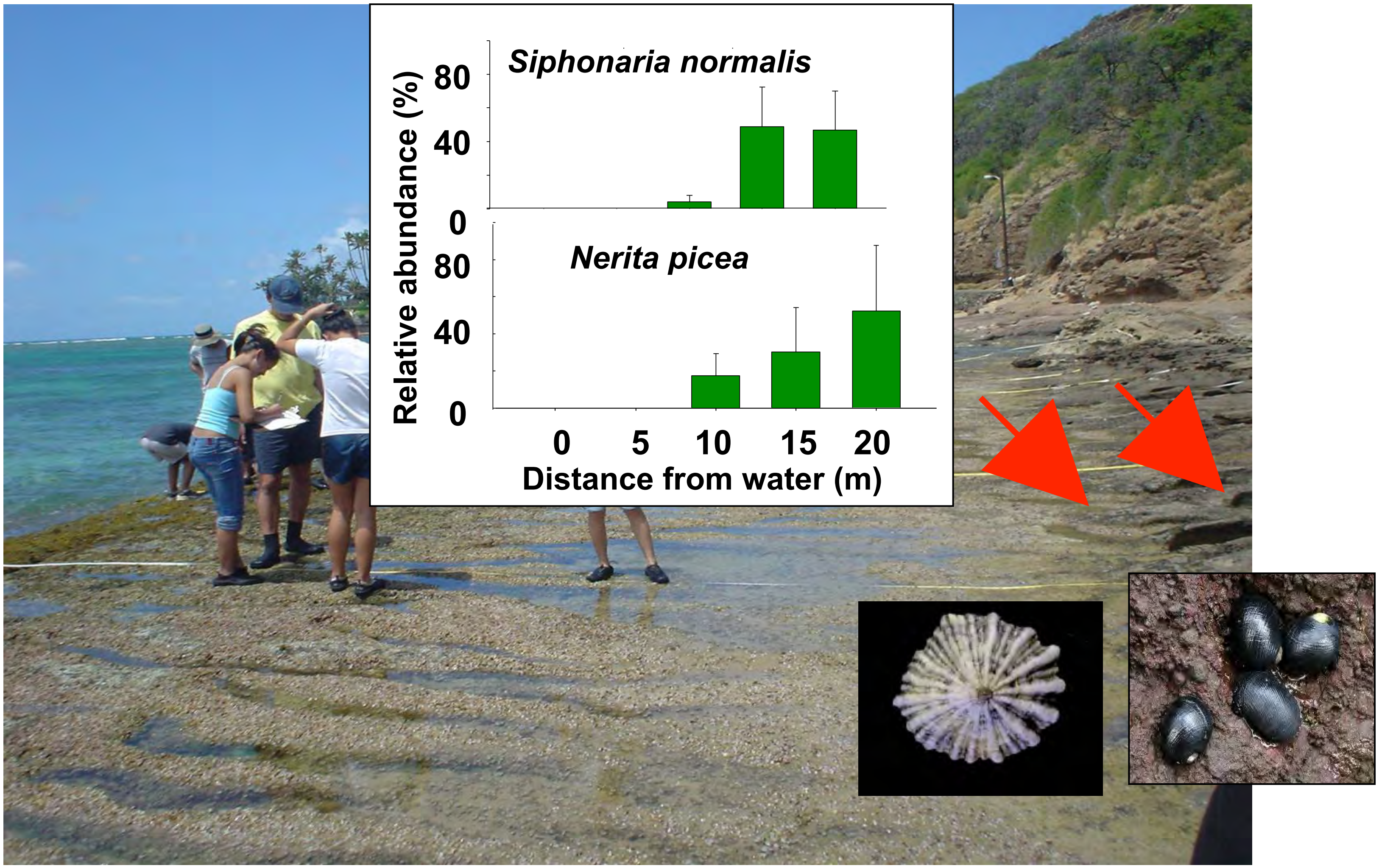
Vertical distribution patterns in benthic assemblages



Off shore

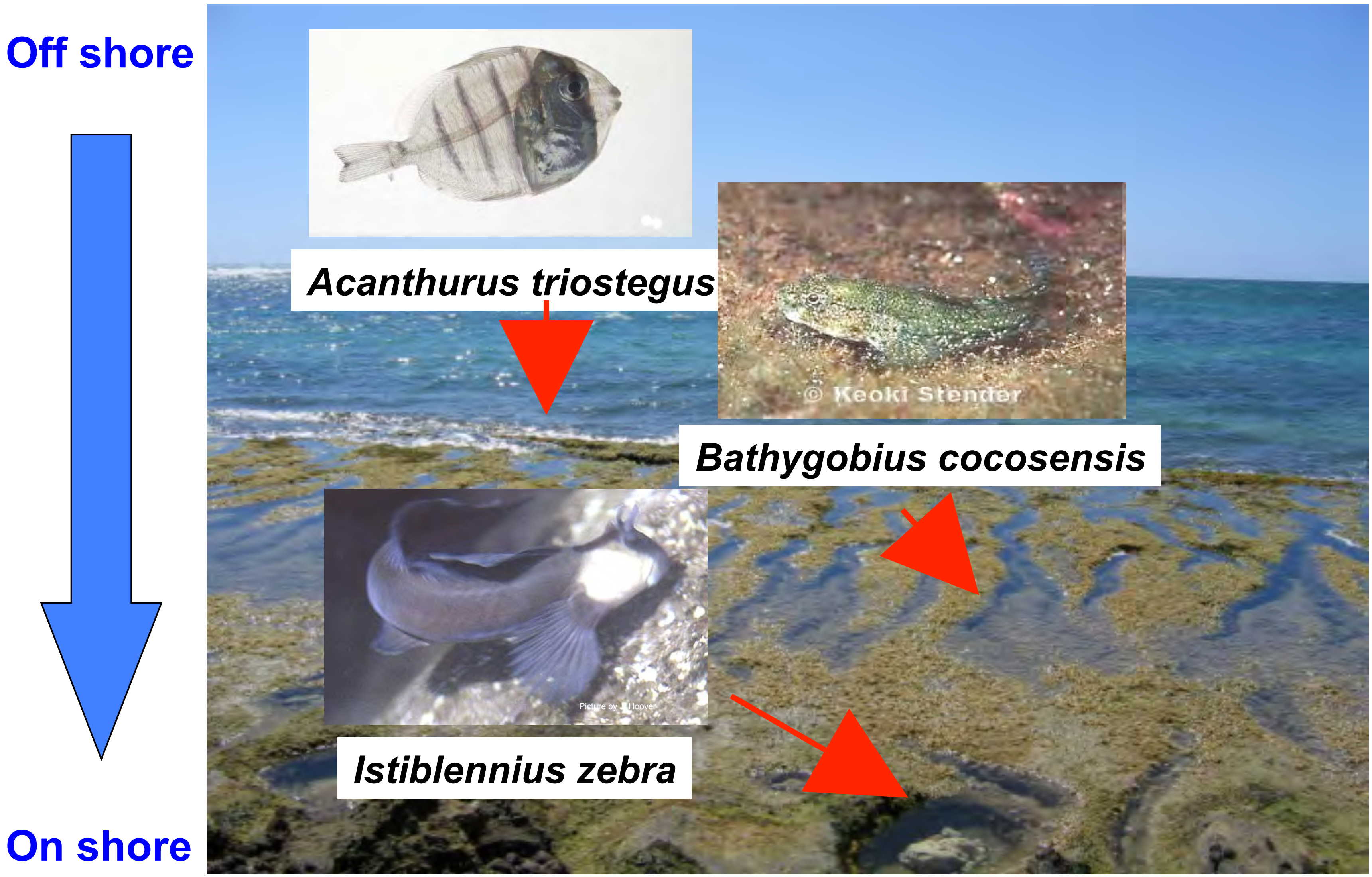
On shore

Vertical distribution patterns in benthic assemblages



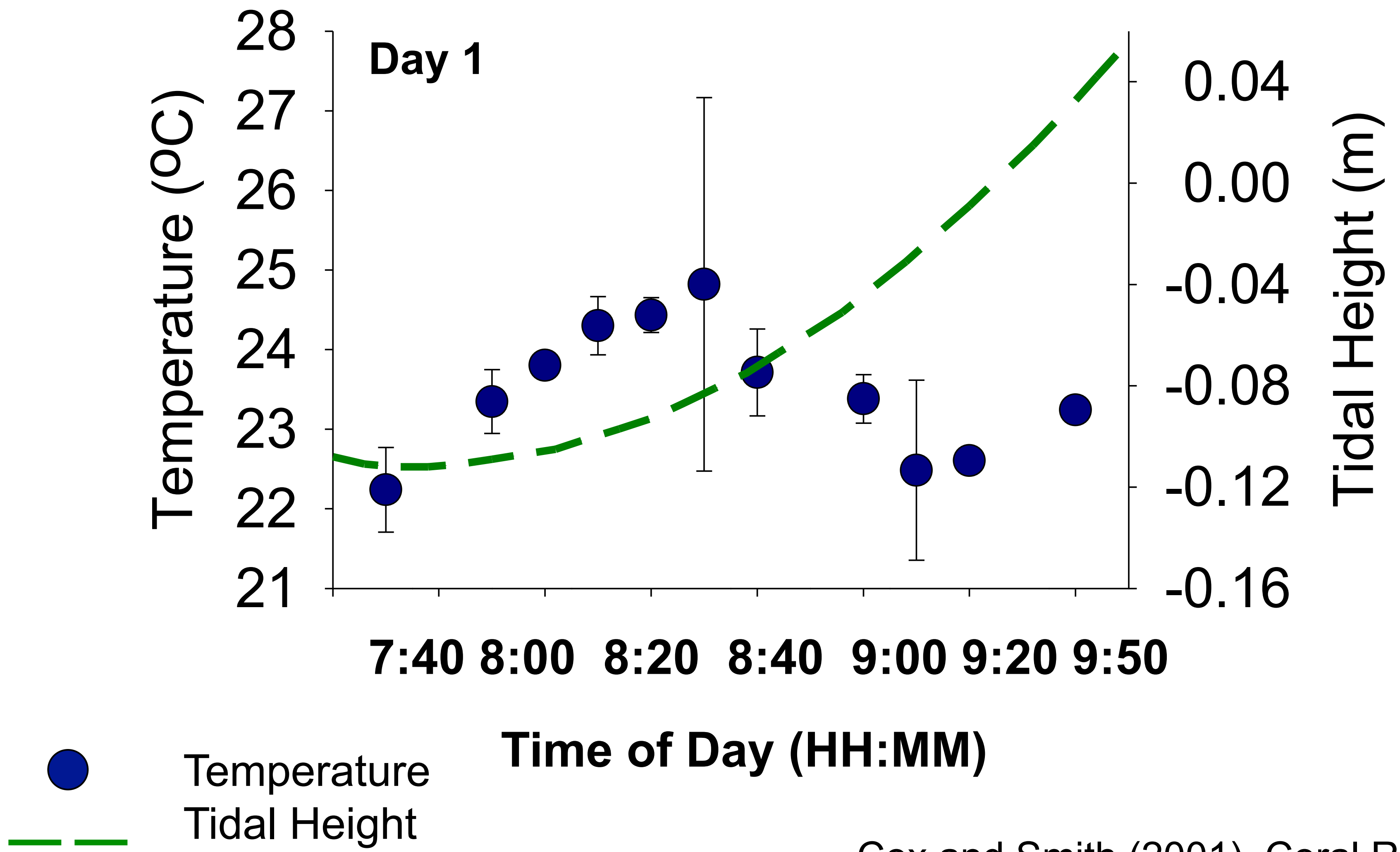
Off shore → On shore

Vertical distribution patterns in tidepool fish assemblages



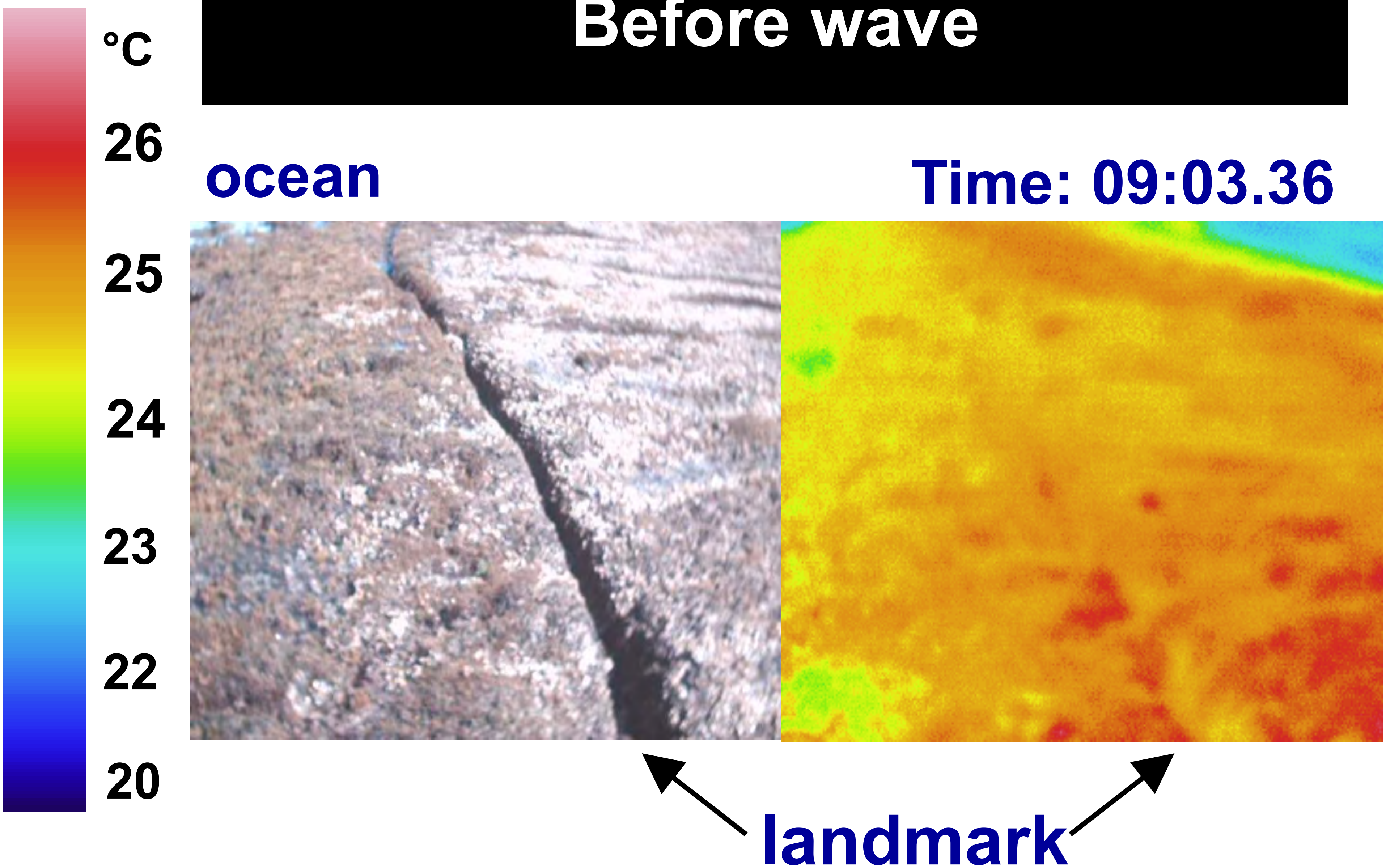
Cox, TE; Baumgartner, E.; Philippoff, J.; Boyle, K (2011) Spatial and vertical patterns in the tidepool fish assemblage on the island of O`ahu. Environmental Biology of Fishes 90: 320-390.

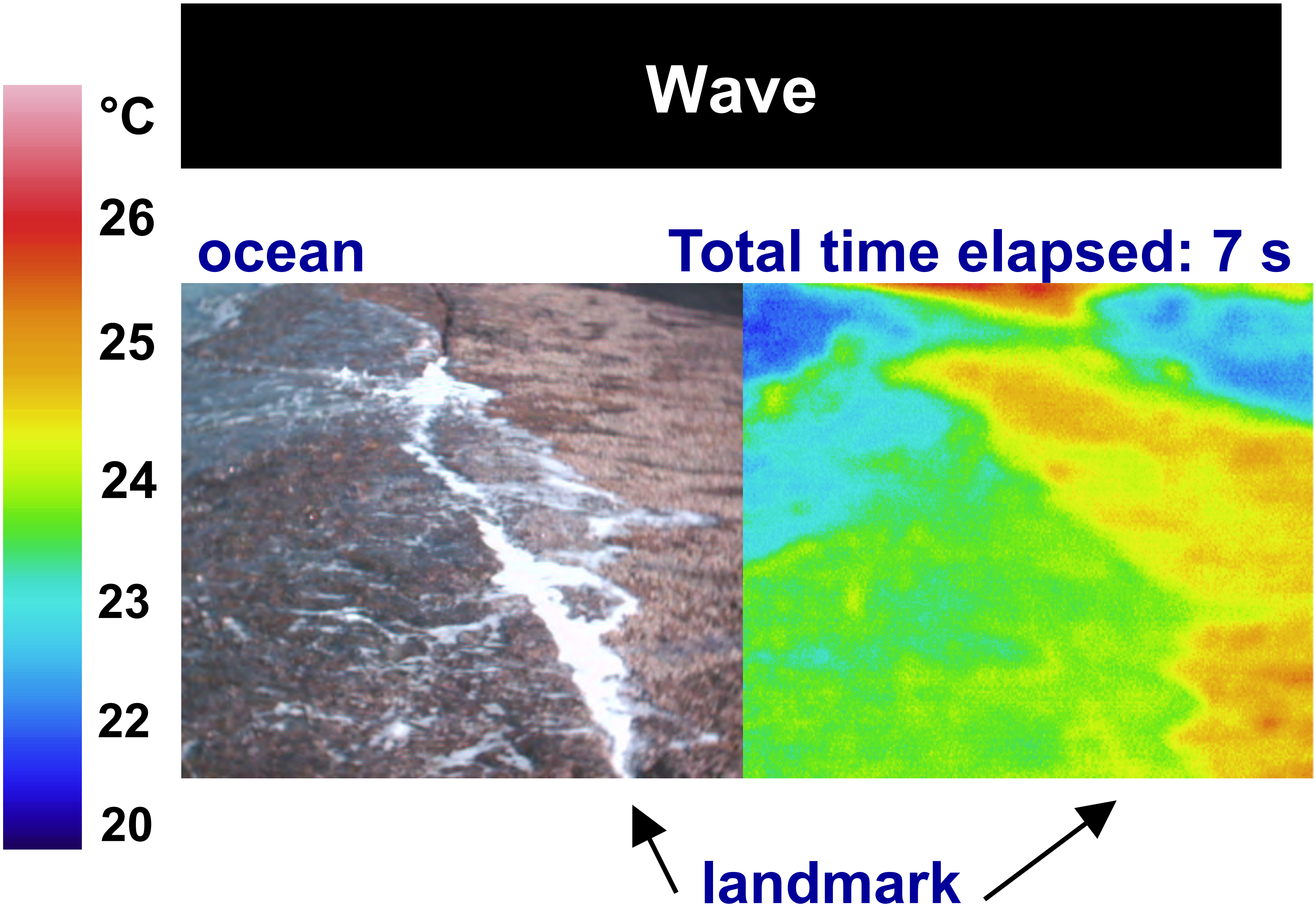
Temporal variation within *Padina* habitat = ± 9° C



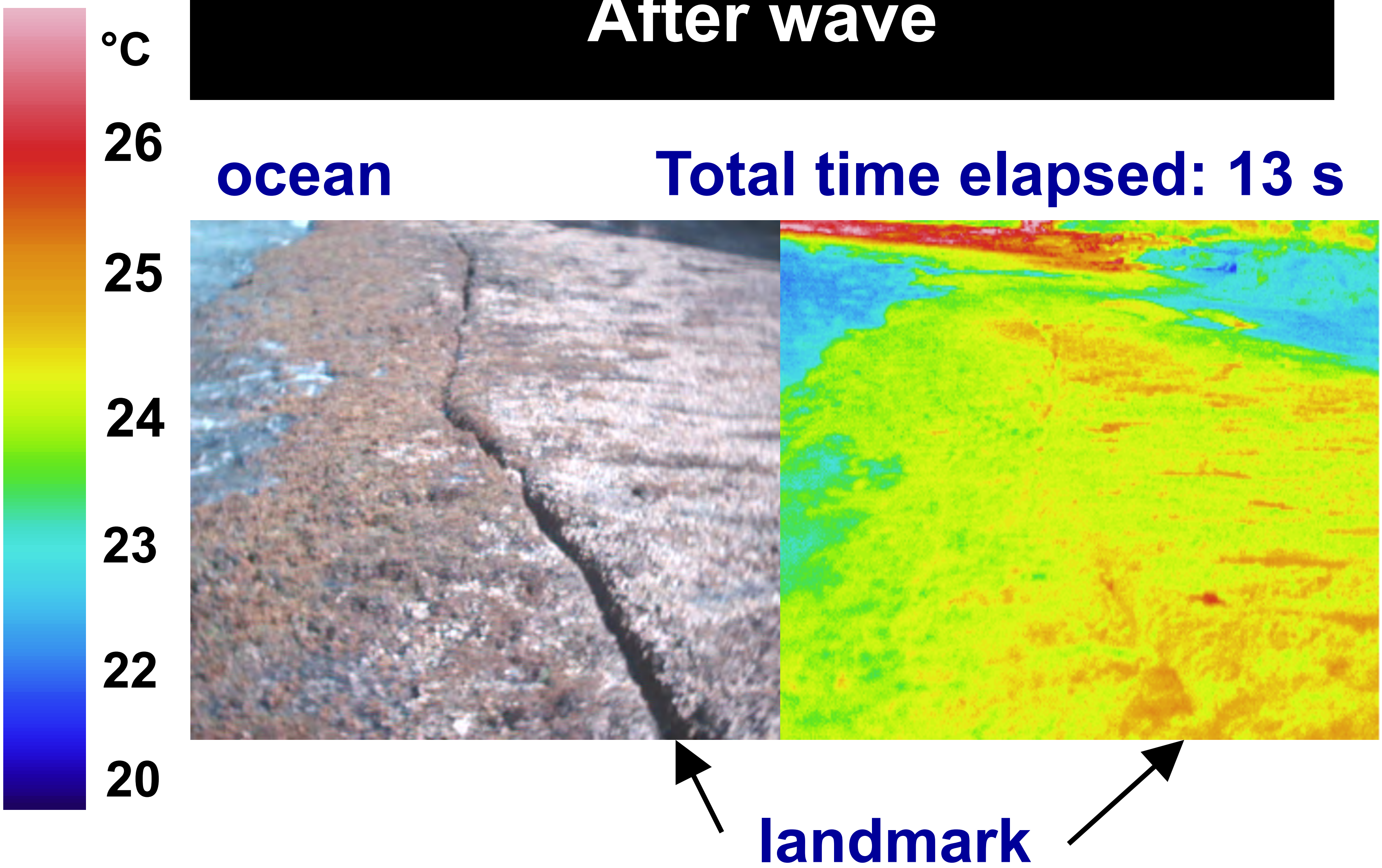
Cox and Smith (2001), Coral Reefs

Before wave

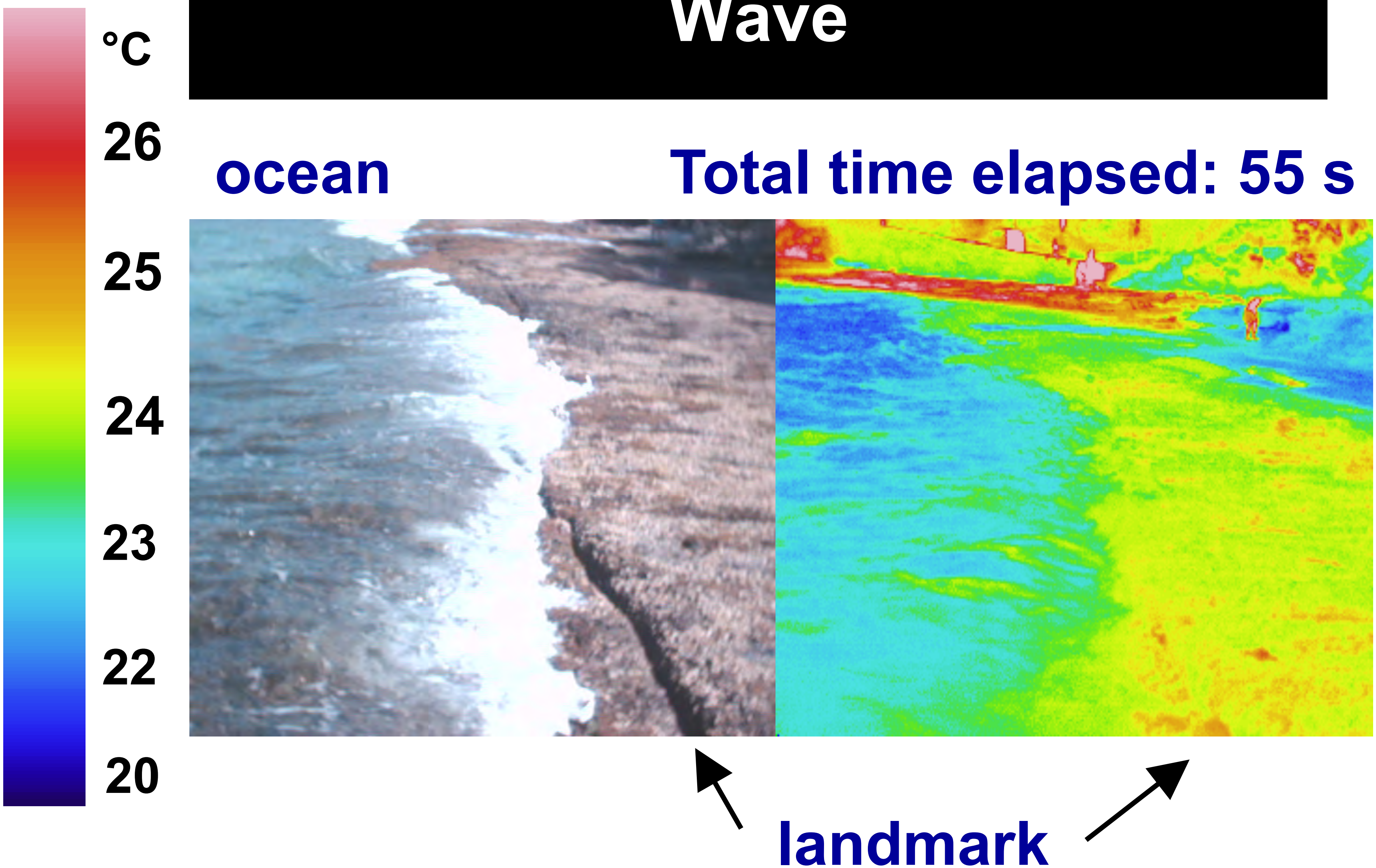



Wave
°C
26
25
24
23
22
20
ocean
Total time elapsed: 7 s
landmark

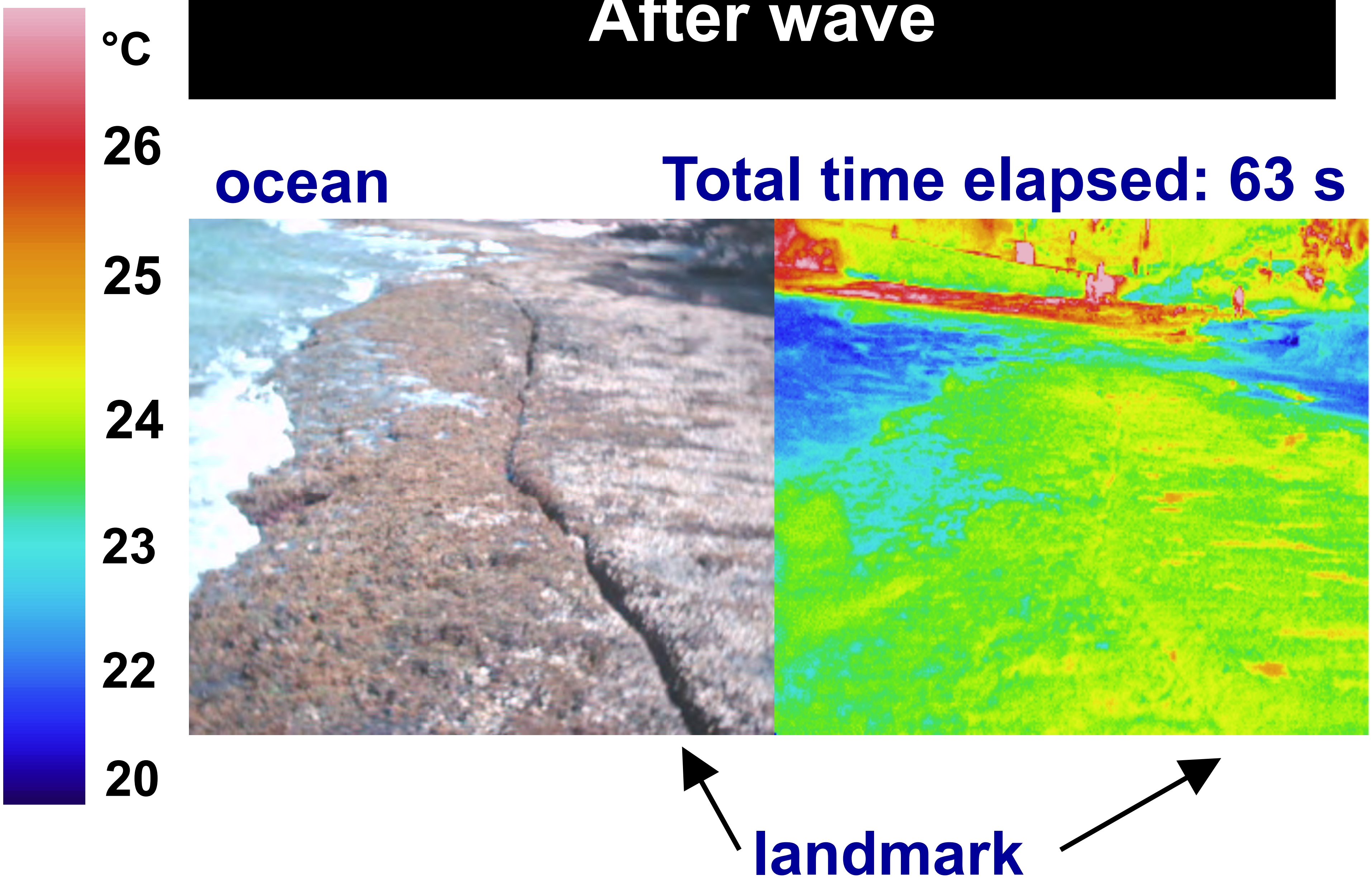
After wave



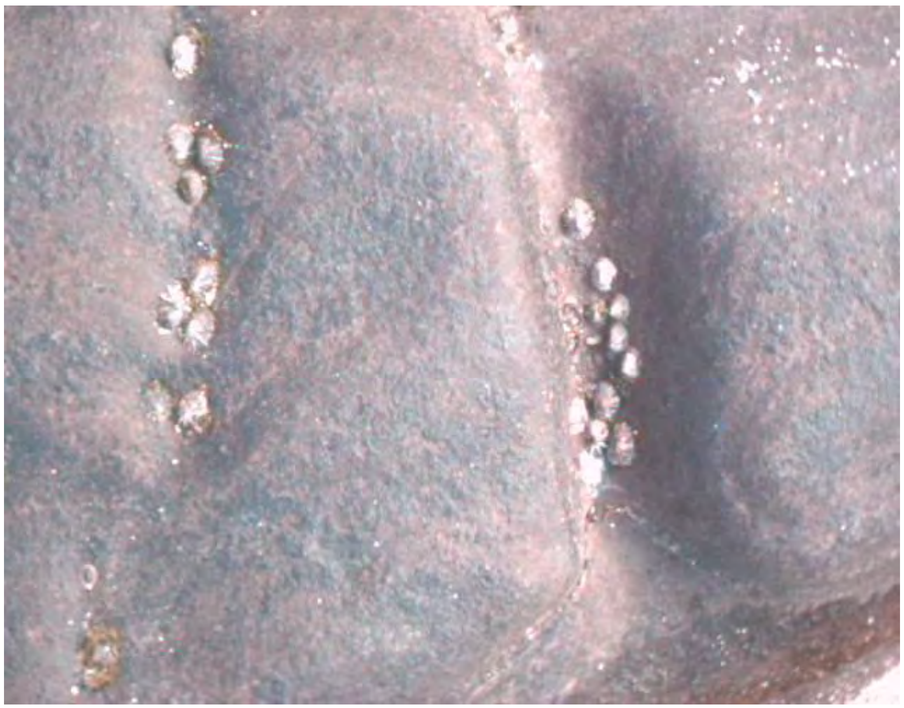
Wave

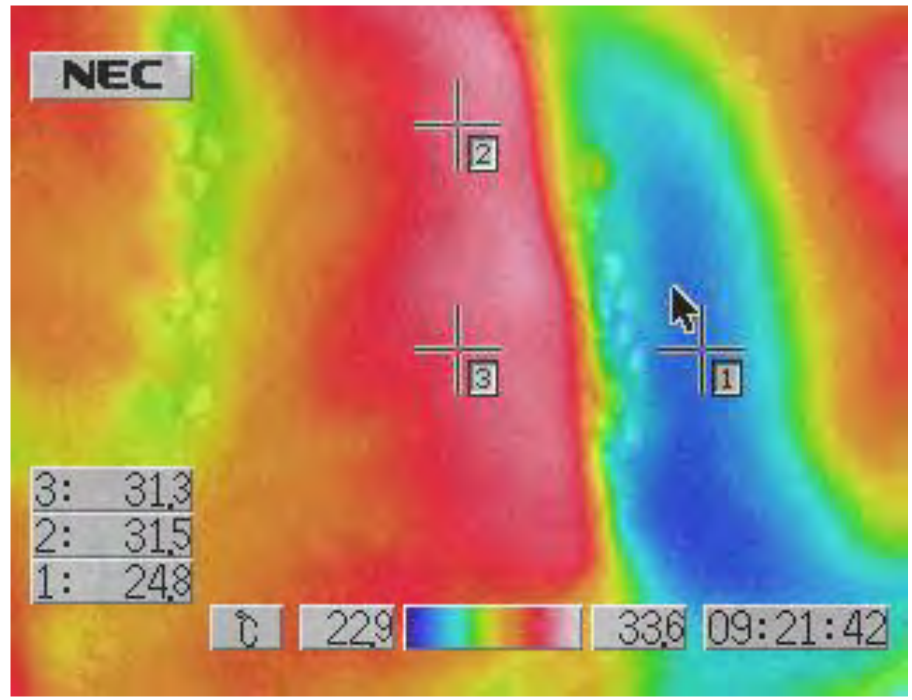


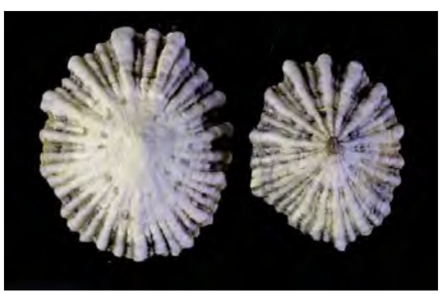
After wave



Association with cooler microhabitat

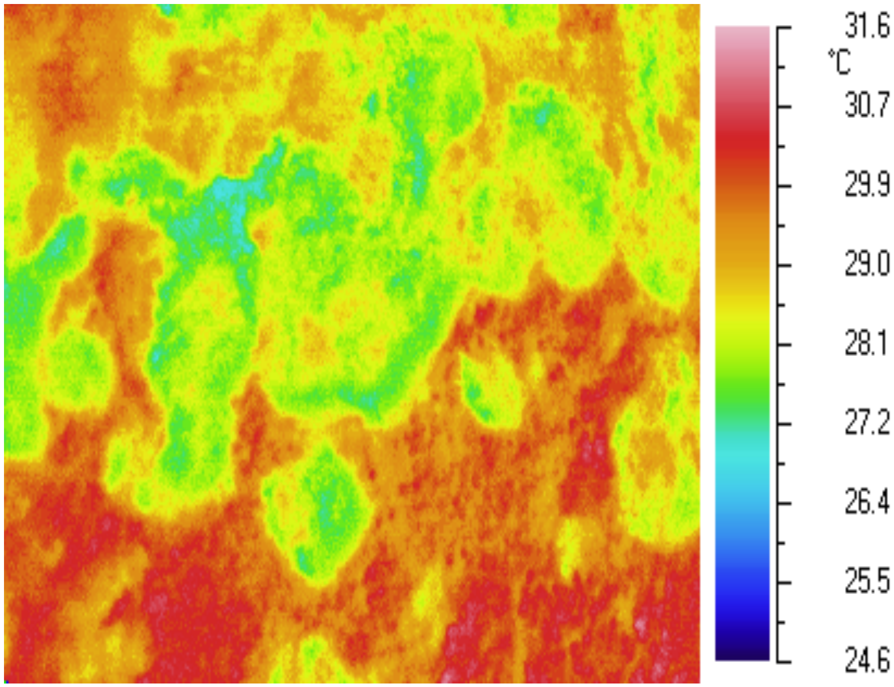






Siphonaria normalis, false opihi
6°C difference across small distance

Liagora spp. lives in hot habitats & ~ two degrees cooler



Calcification of thalli reflects light & perhaps limits heating?

6.7 – 13.0 % reflectance for non-calcified spp.
12.5 - 23.1 % reflectance for calcified spp. (Beach et al. 2006)