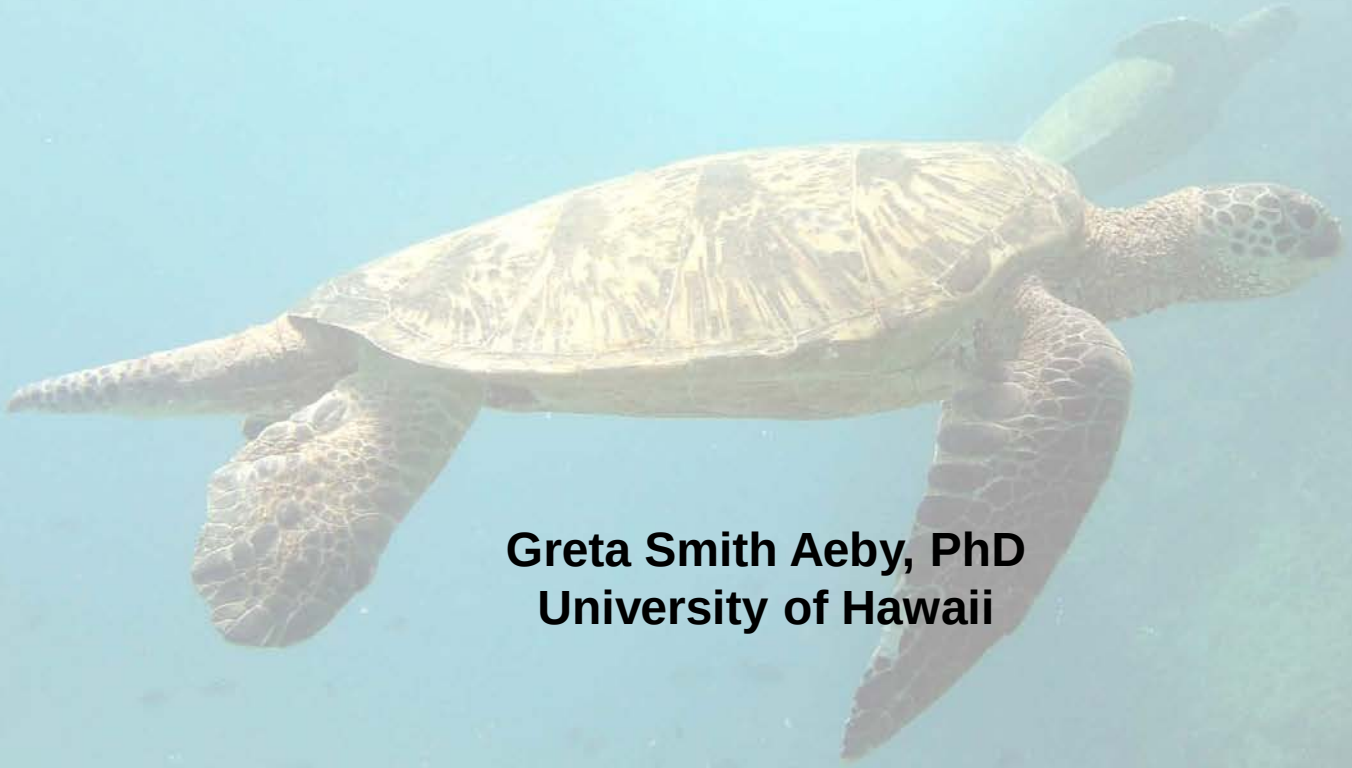
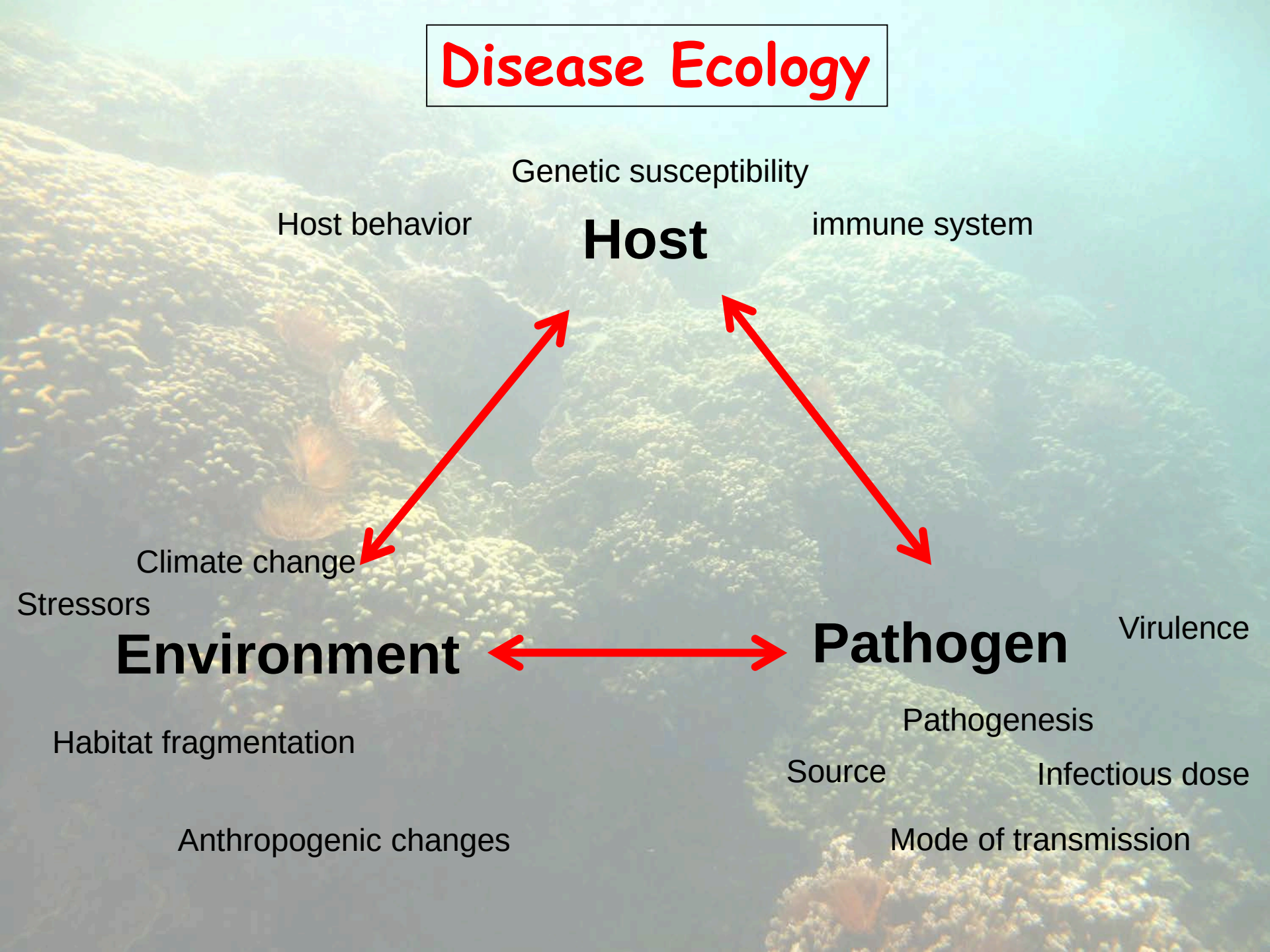
Florida 2017

Ecological investigation of coral disease

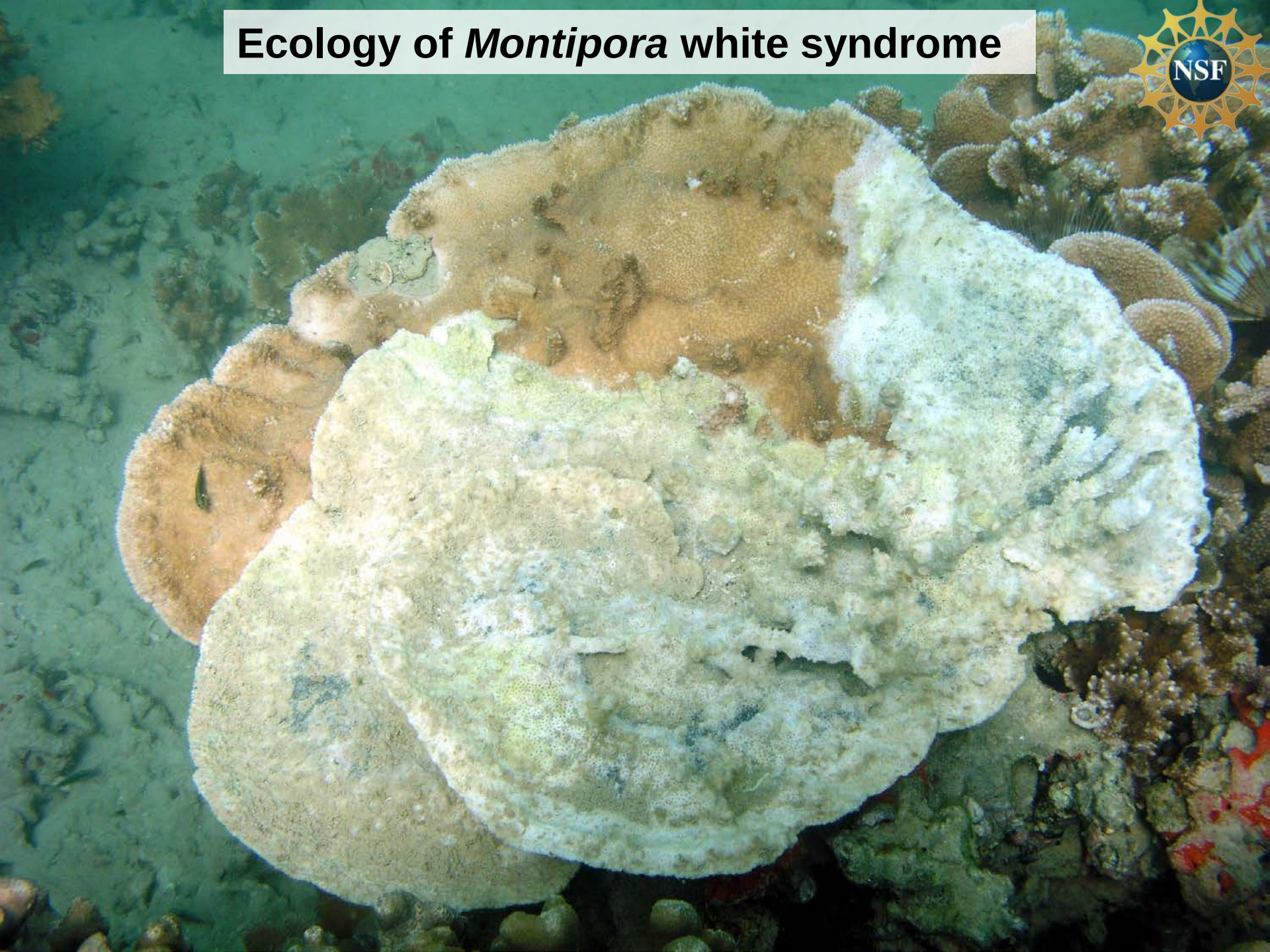


Greta Smith Aeby, PhD
University of Hawaii

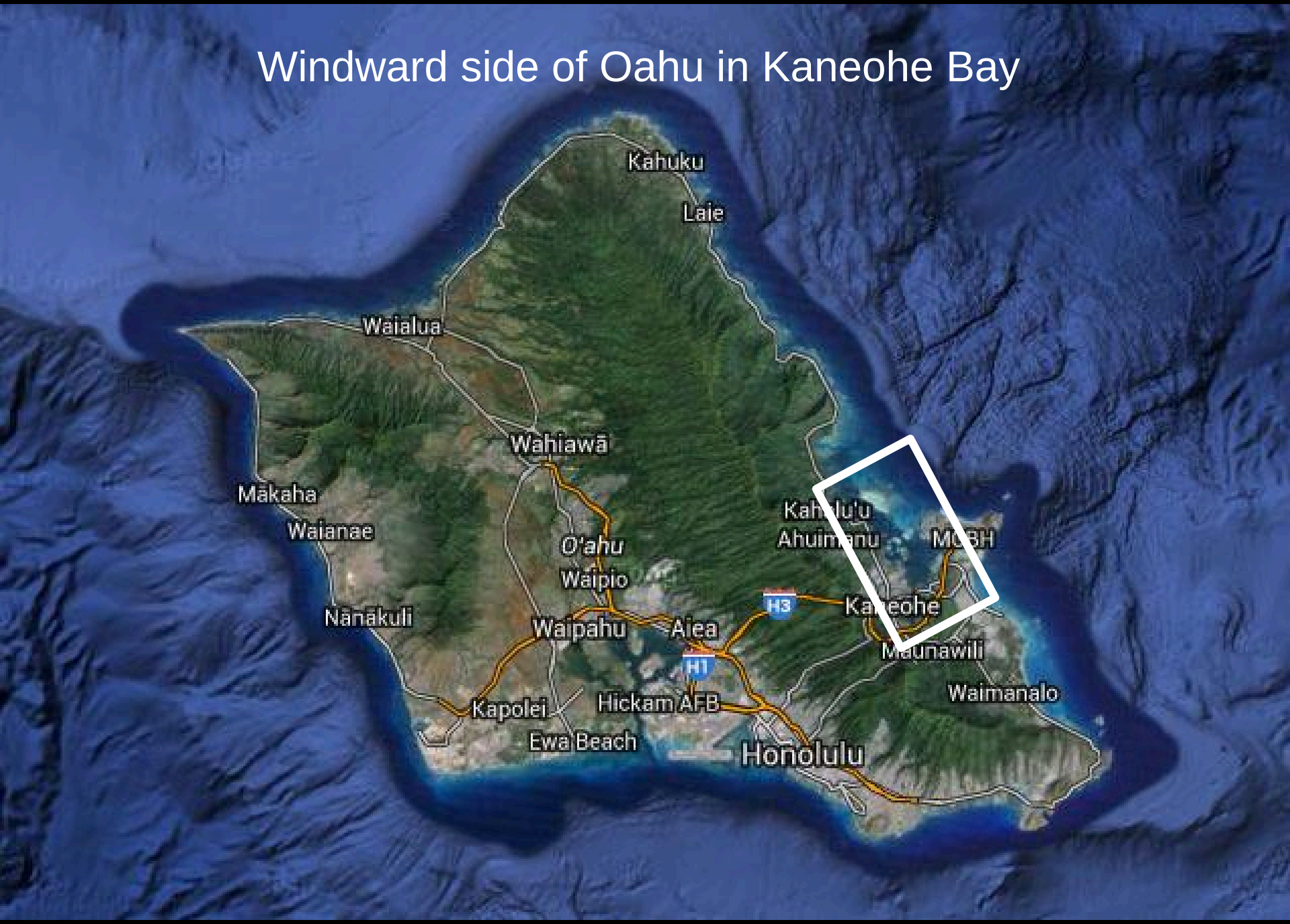
Disease Ecology

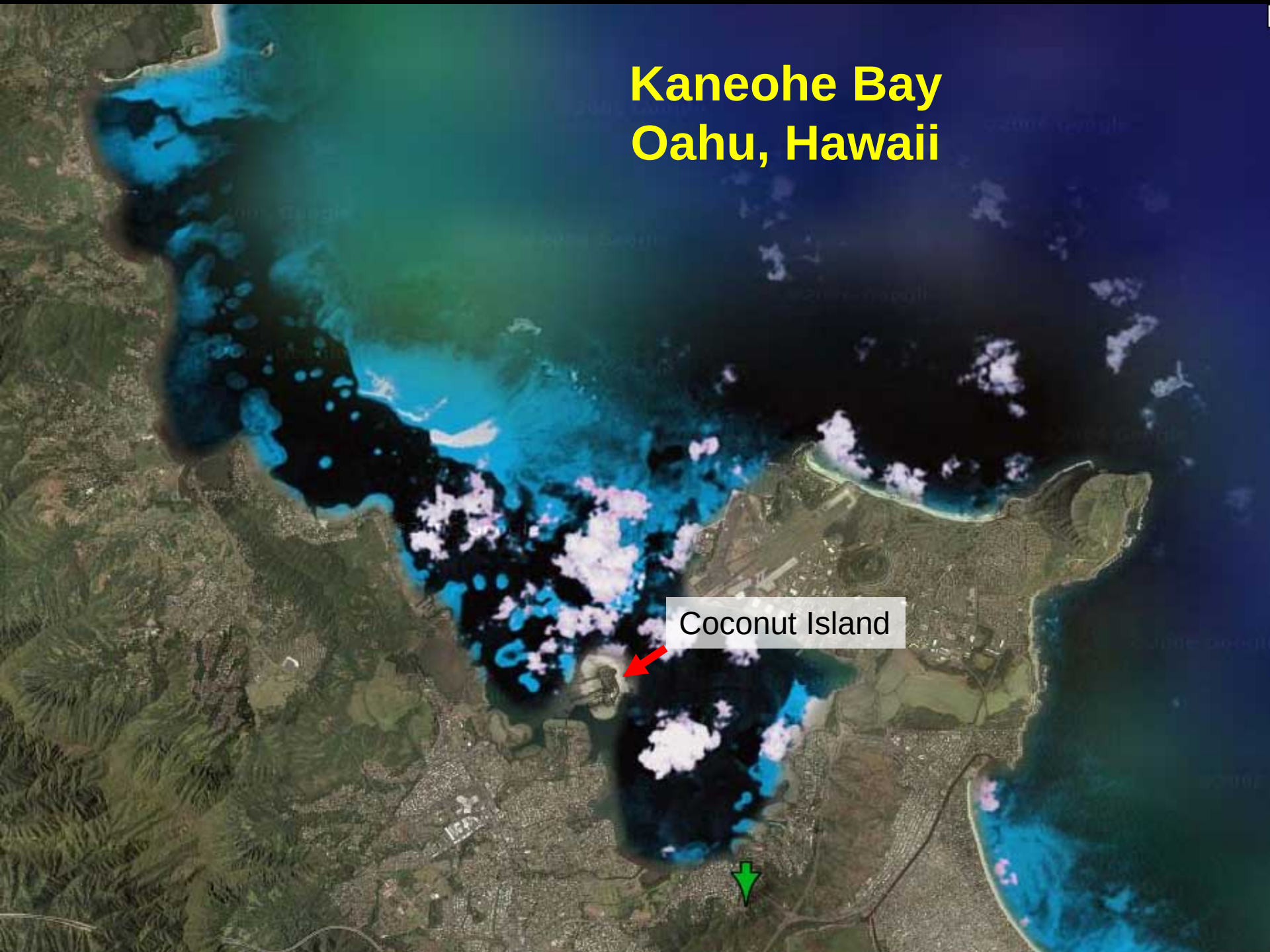


Ecology of *Montipora* white syndrome

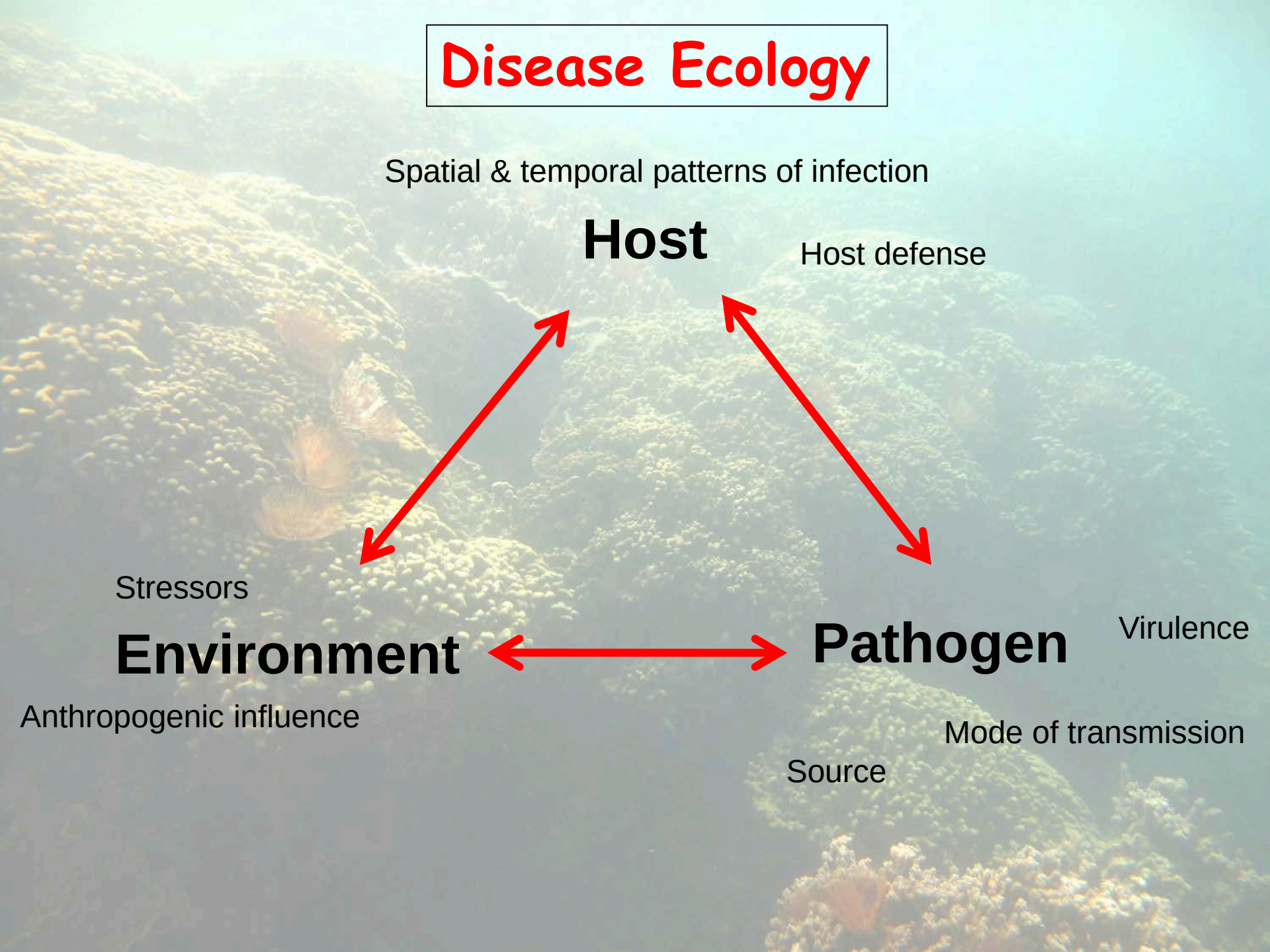


Windward side of Oahu in Kaneohe Bay



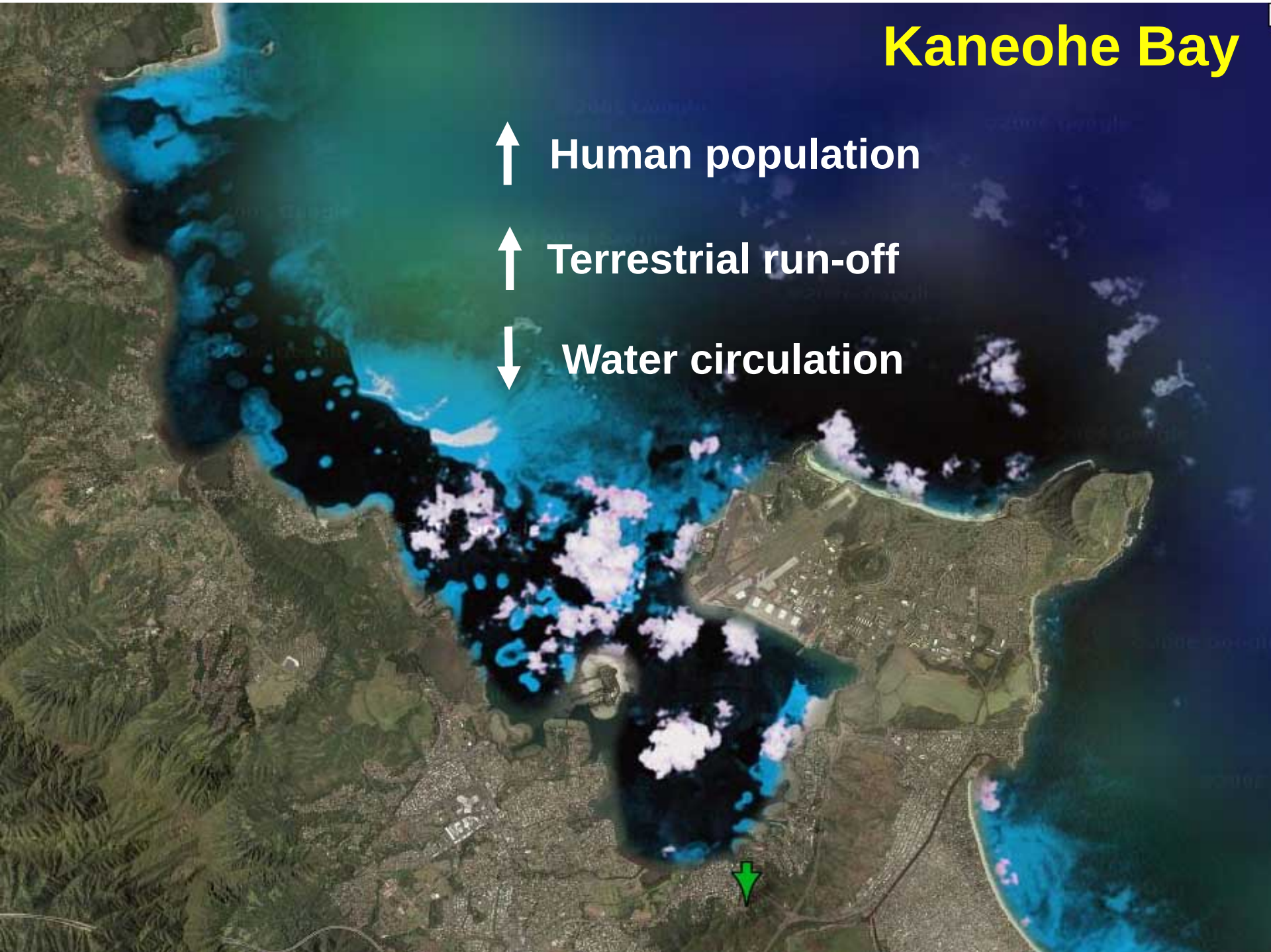

Kaneohe Bay
Oahu, Hawaii
Coconut Island

Disease Ecology

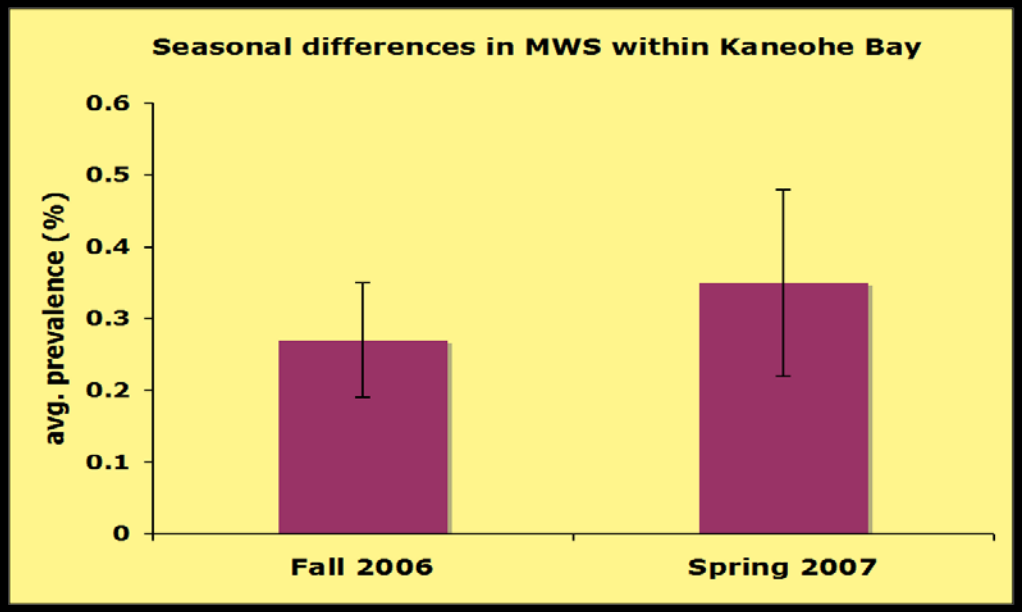


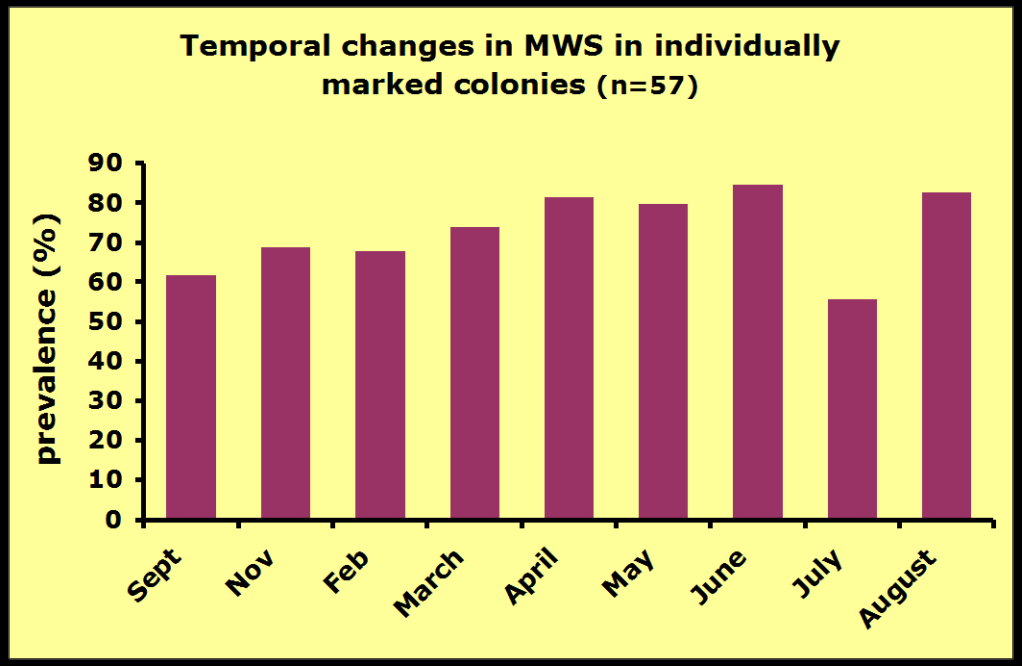
Levels of *Montipora* white syndrome within Kaneohe Bay in Sept. 2006

Aeby et al. 2010


Kaneohe Bay
Human population
Terrestrial run-off
Water circulation

No seasonality in chronic *Montipora* white syndrome





Aeby et al. 2010

Virulence of MWS

Sept 2006
57 colonies tagged

Sept 2007
53 colonies (93%) suffered partial to total mortality

Rate of tissue lost:
~3% of colony/month

Case fatality rate:
2006-2007=7%
2006-2008=28%

Aeby et al. 2010

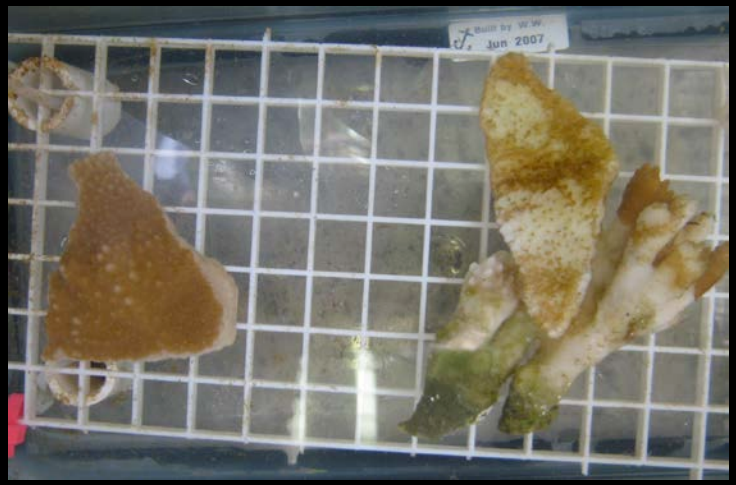
Transmission of MWS

Diseased

Control

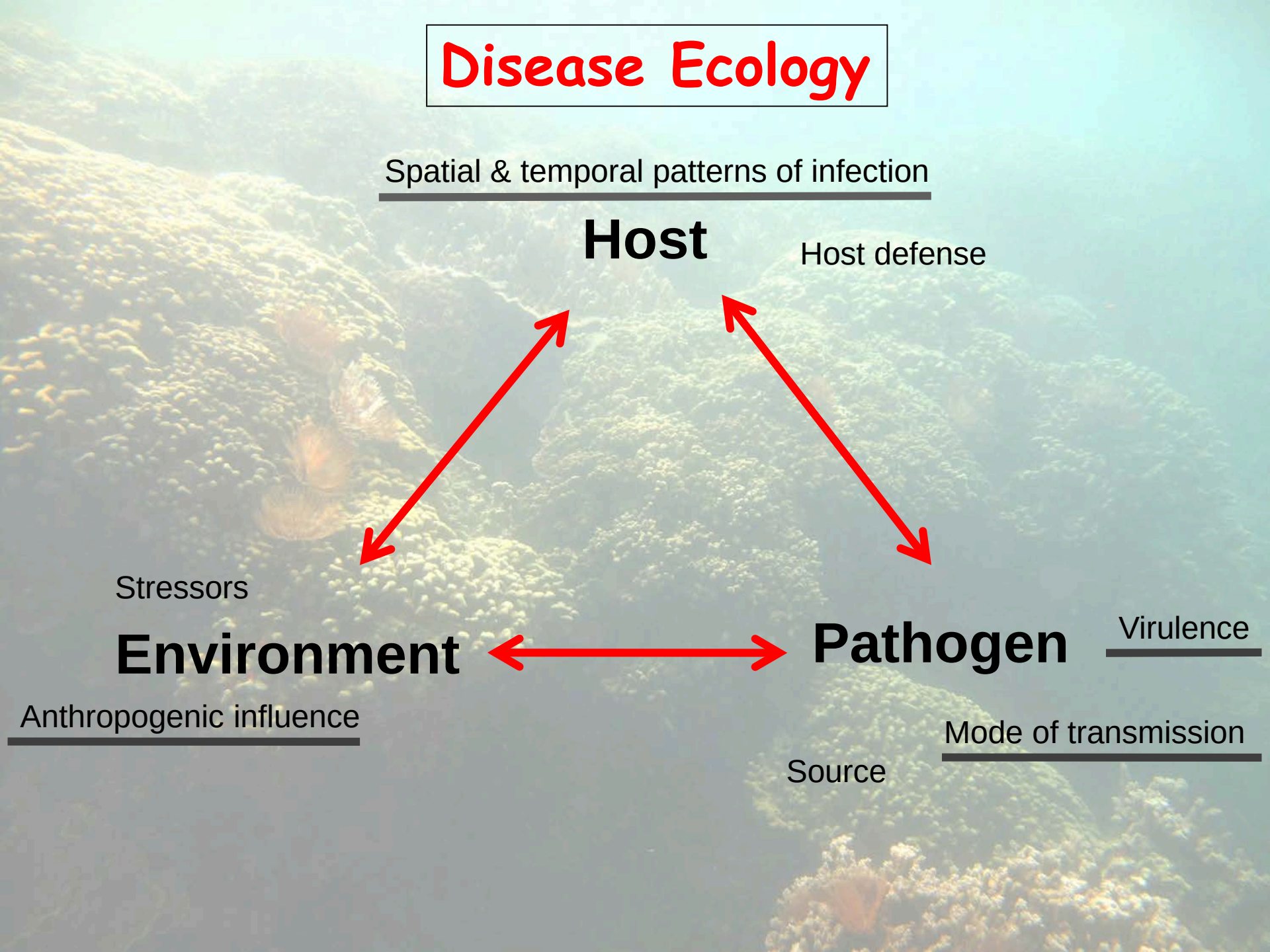
T = 0

T = 28 days



Aeby et al. 2010

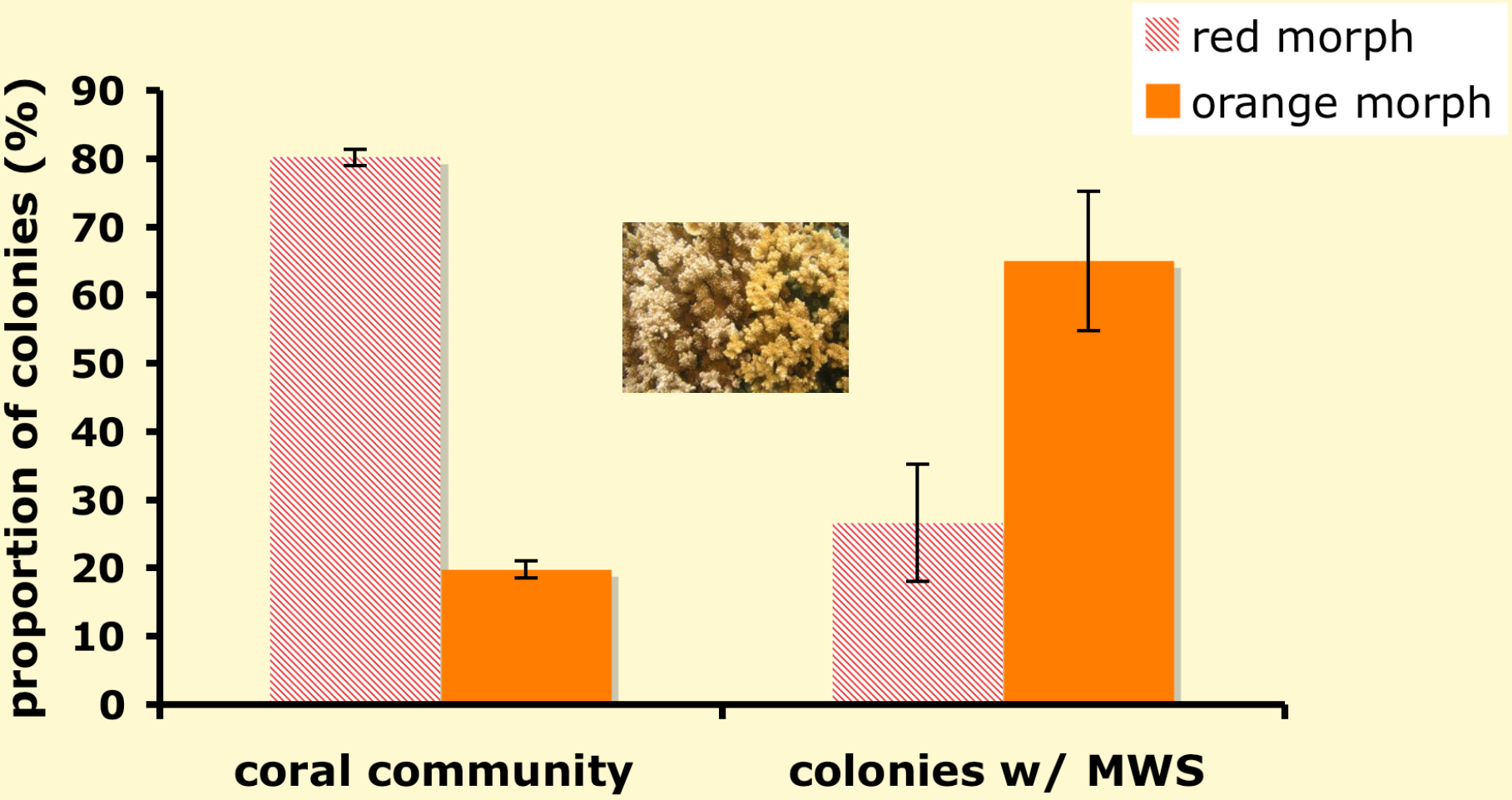
Disease Ecology



Montipora capitata

red morph-clade C orange morph-clade D

Differential susceptibility of different color morphs of *M. capitata* to MWS



Coral Host Defenses

Mucus production/sloughing

Phagocytosis of foreign material

Antimicrobial production

Resident bacterial flora

Photo: National Coral Reef Institute

Bacterial Contribution to Coral Disease Defense

Physical barrier to entry

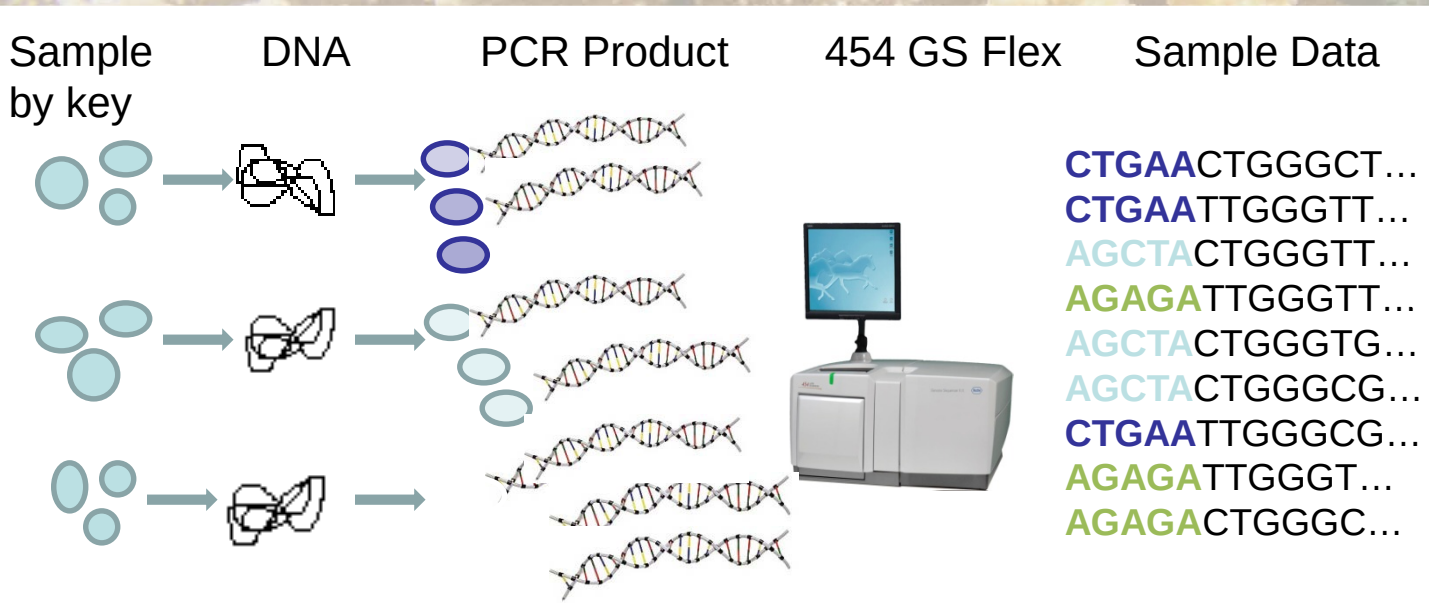
Occupy metabolic niches

Antimicrobial production

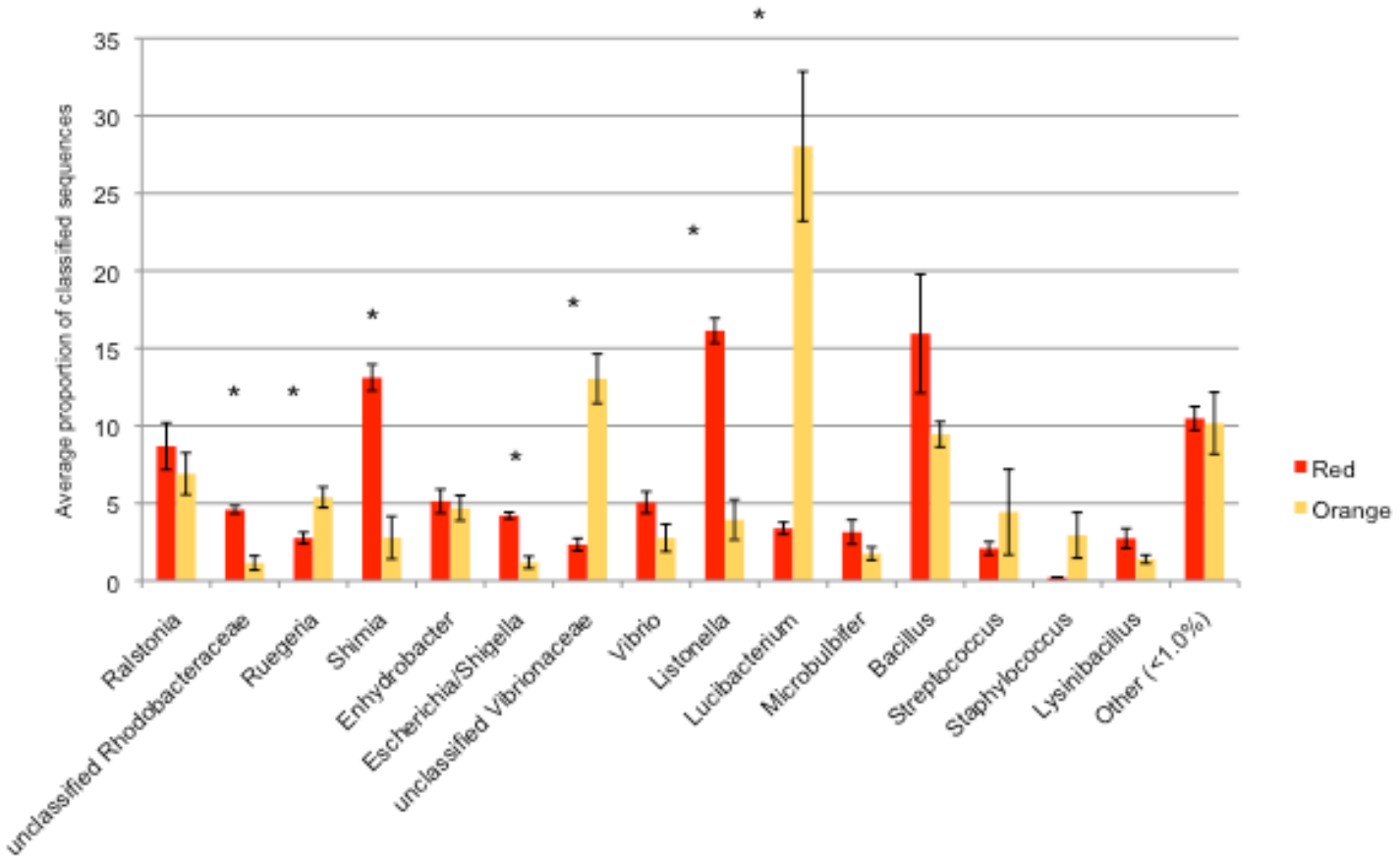
Host:

Normal microbial community: red vs. orange morphs

Amanda Shore-Maggio

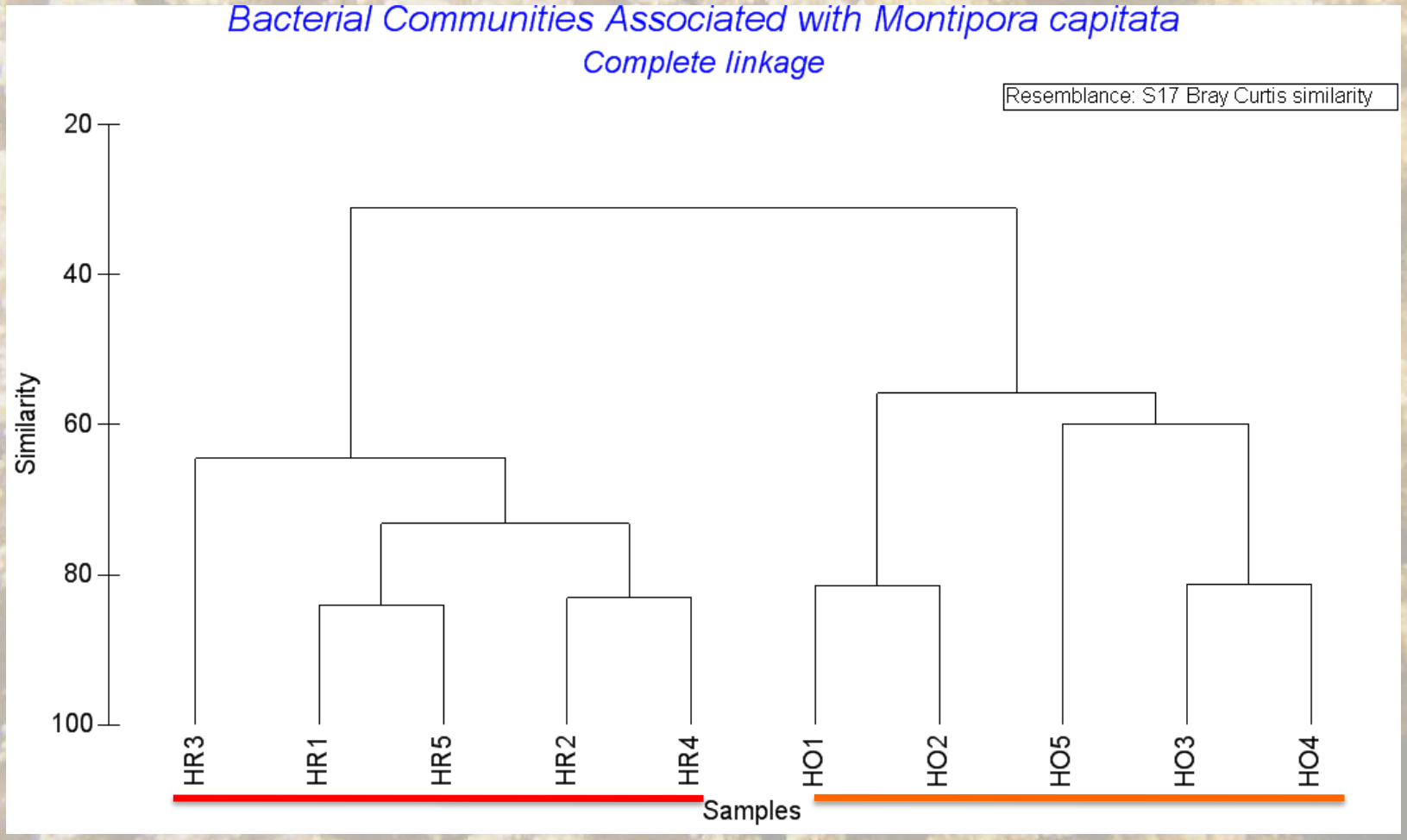


Host:
Normal microbial community: red vs. orange morphs



*(Kruskall-Wallis test, $p < 0.05$, n=20)

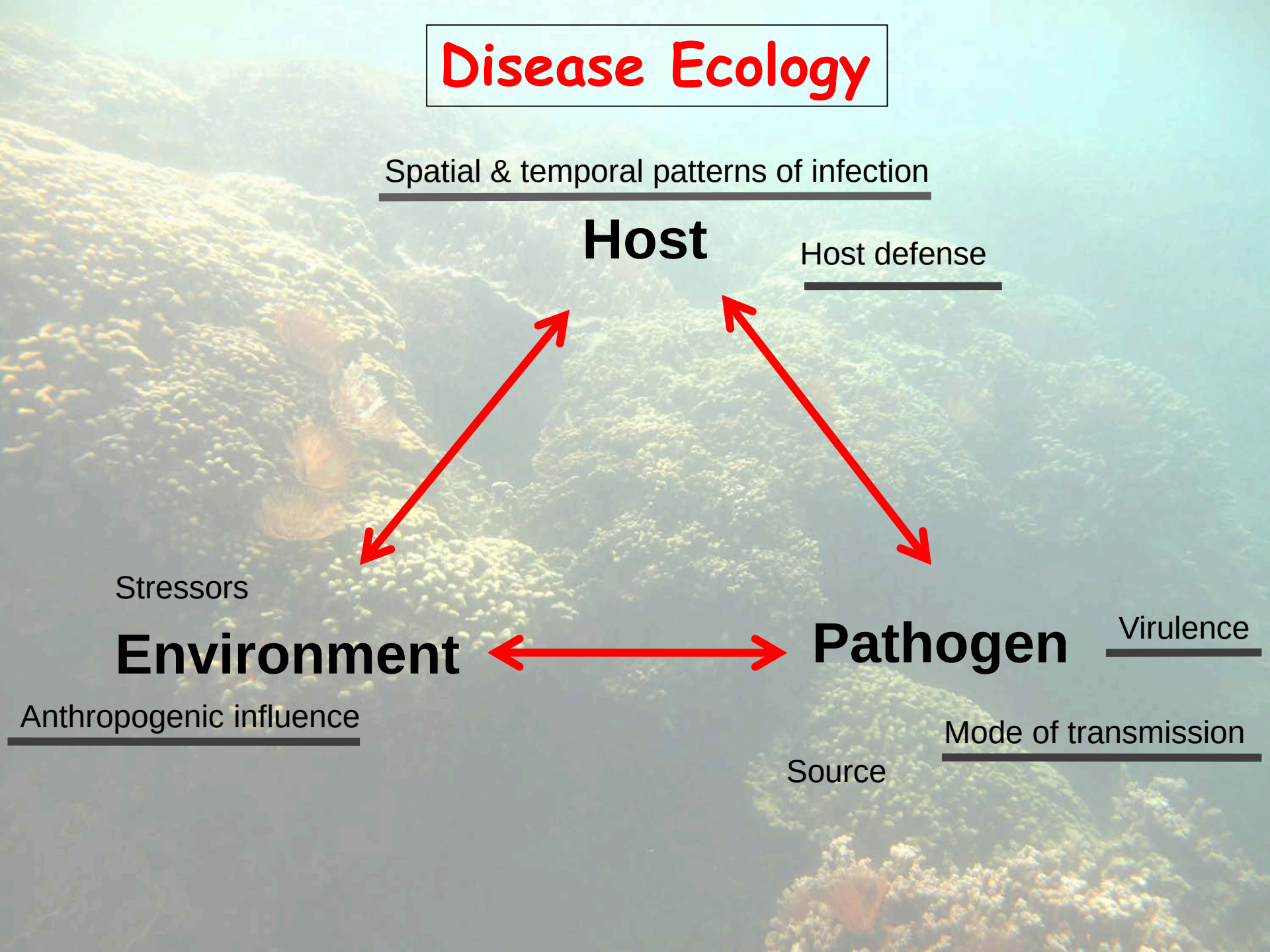
Host:
Normal microbial community: red vs. orange morphs



Complete linkage clustering dendogram representing percent similarity between samples

Shore-Maggio et al. 2015

Disease Ecology



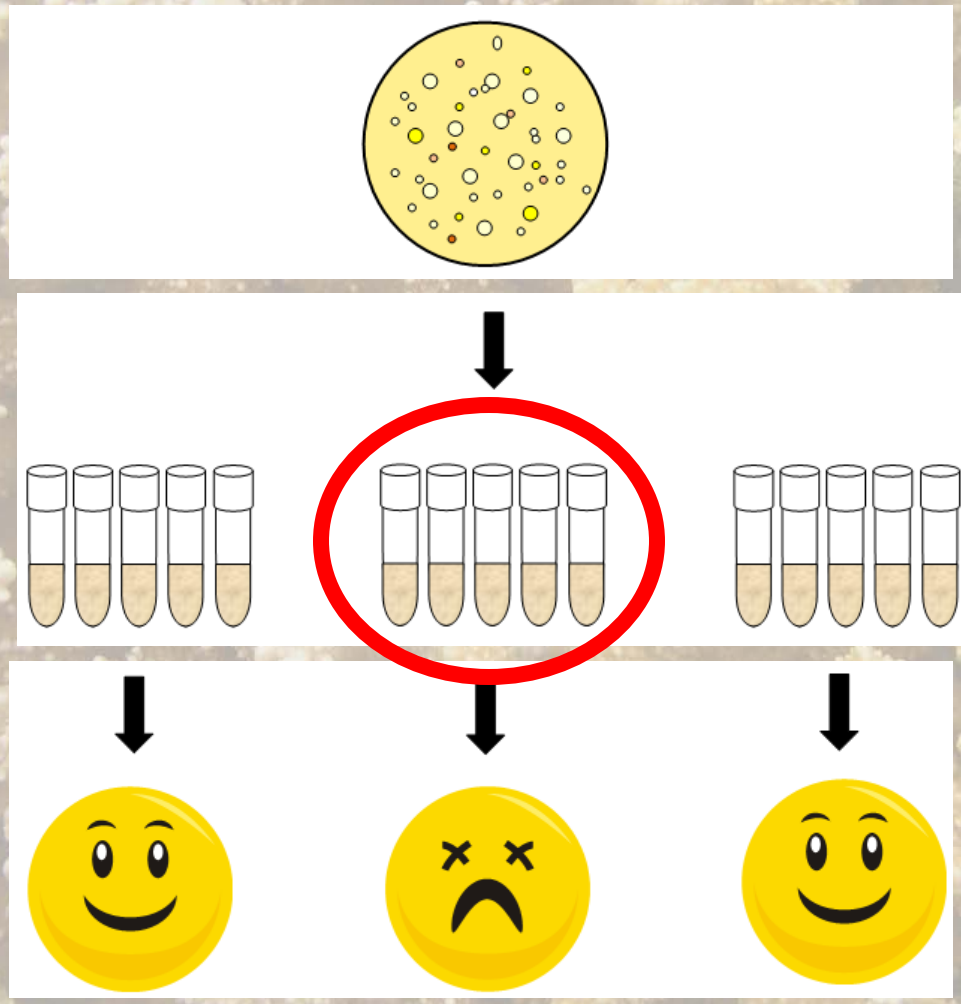
Isolation of Putative Pathogens

Blake Ushijima

1) Bacteria from diseased coral isolated

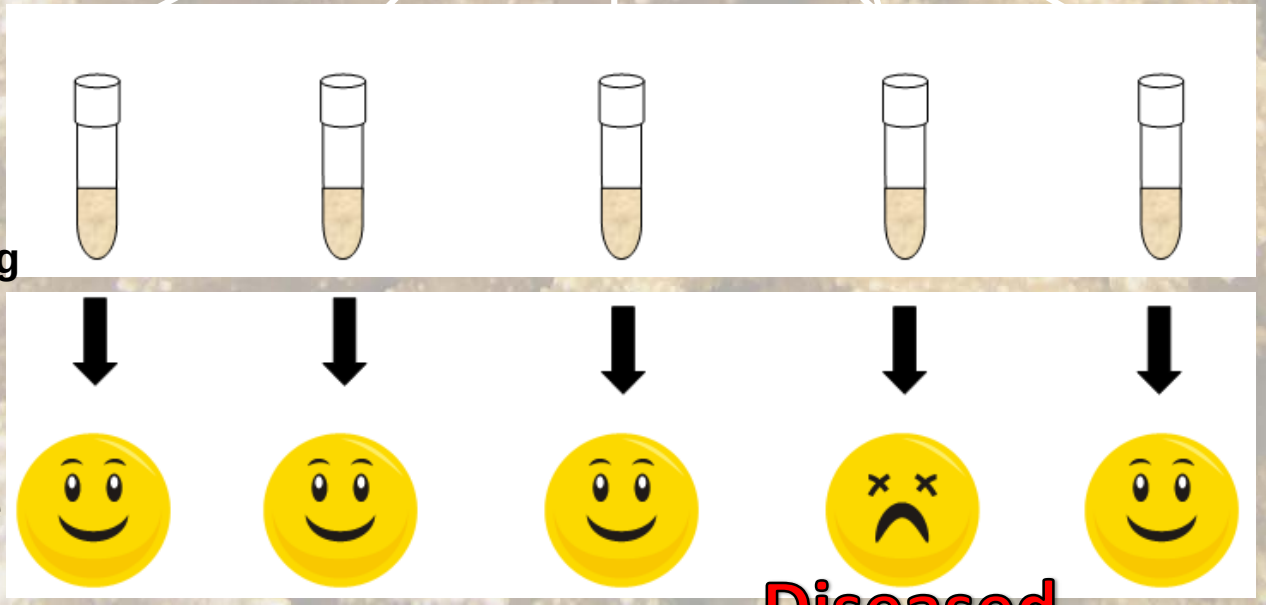
2) Pools of five isolates tested simultaneously

3) Determine which pools cause disease



Isolation of Putative Pathogens

Blake Ushijima



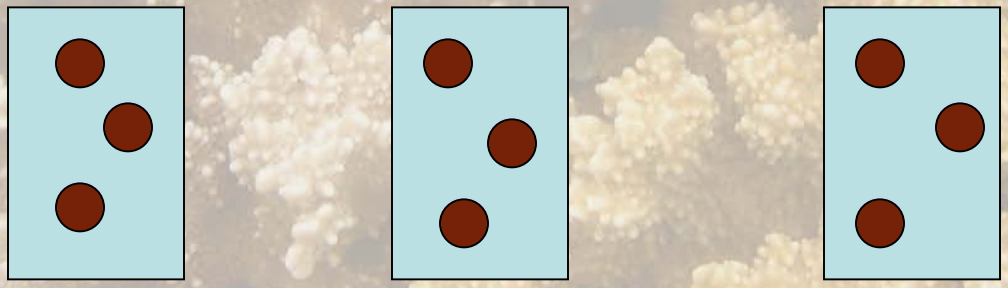
4) Test individual cultures from disease-causing pool

5) Culture that causes disease may be pathogen

Infection trials

- **Further testing on 3 isolates**
  - **OCN001**
  - **OCN002**
  - **OCN003**

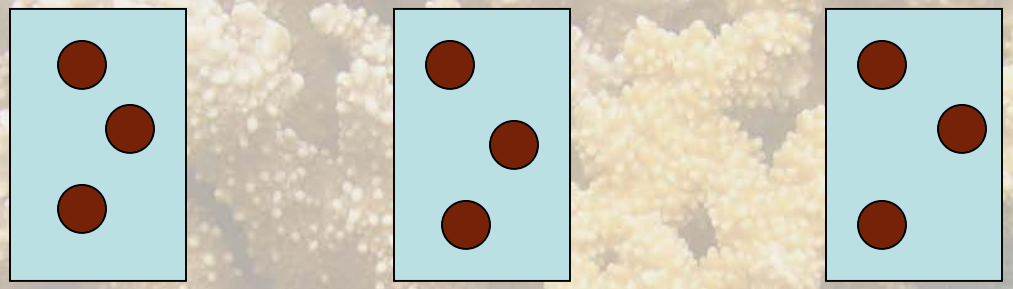
1 Run



Control **Bact. control** **Potential Path.**

Infection trials

1 Run



Control **Bact. control** **Potential Path.**

- 3 isolates showed signs of tissue loss

OCN001 – 23%
OCN002 – 54%
OCN003 – 31%

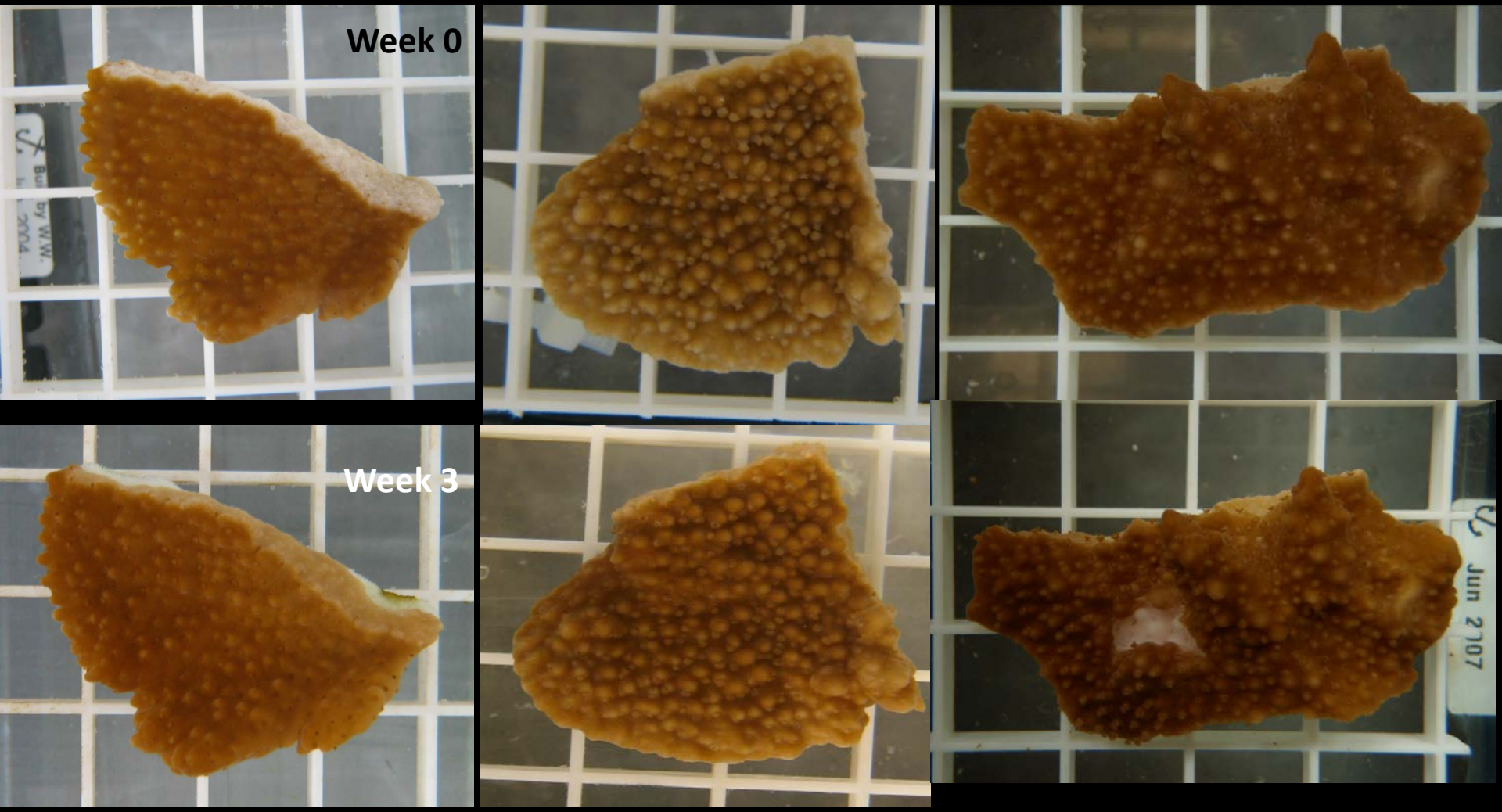
Infection trials
chronic tissue loss (OCN002)

At Time of Inoculation

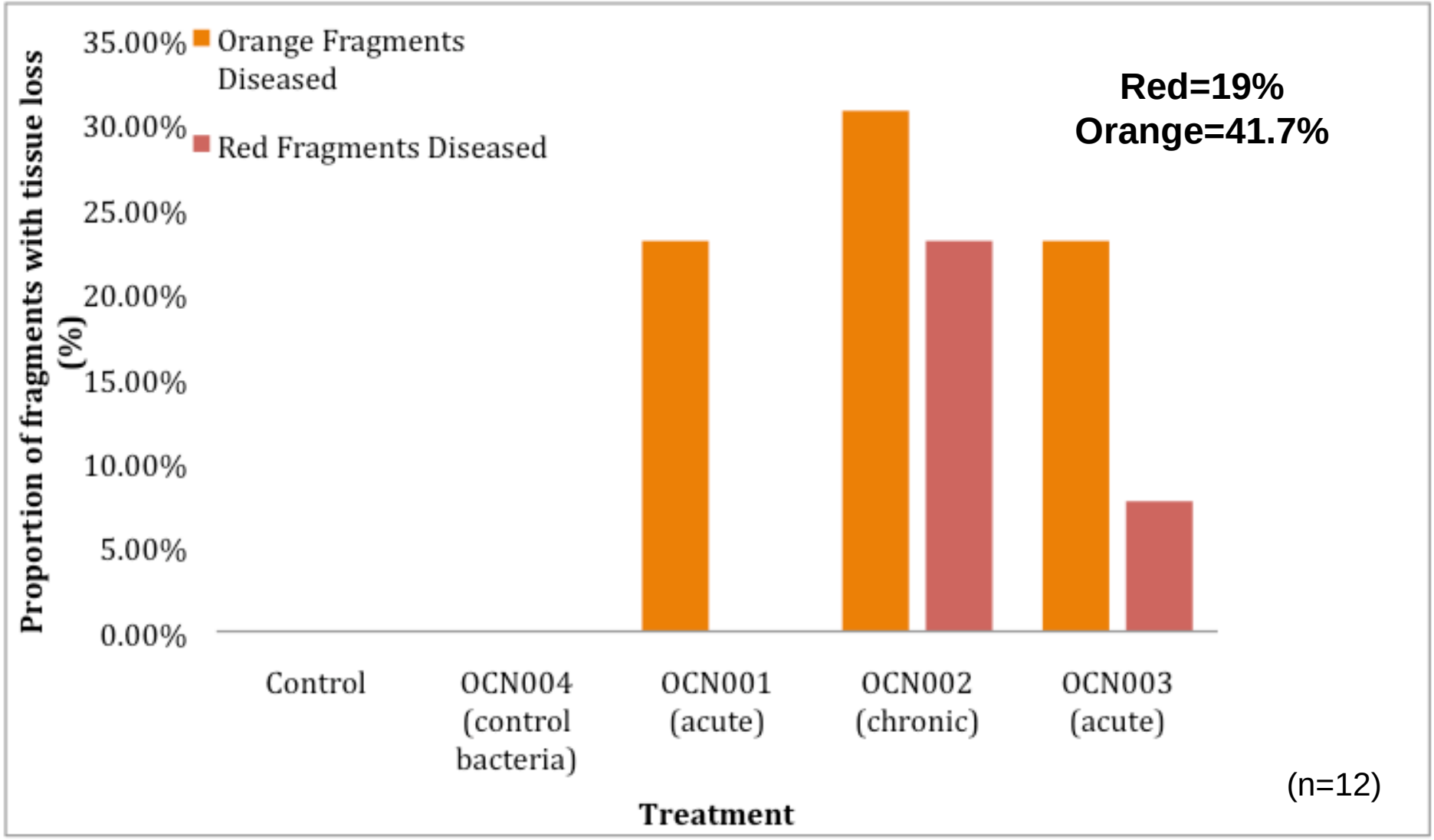
26 Days Post Inoculation (Disease Progression)

Infection trials

acute tissue loss (OCN001, OCN003)

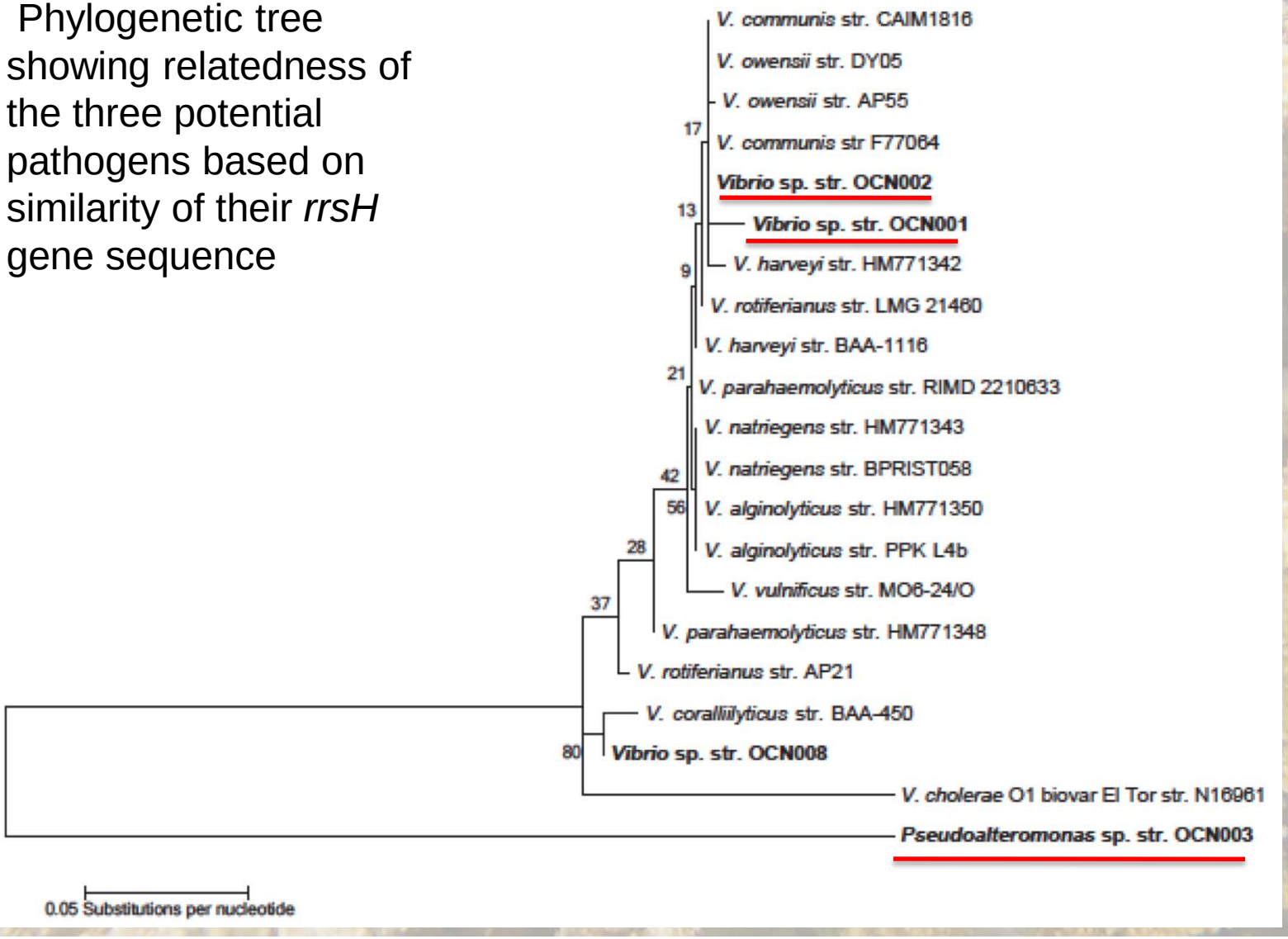


Pathogen:
Differential infectivity of red vs. orange morphs



Pathogen:
Differential infectivity of red vs. orange morphs

Phylogenetic tree showing relatedness of the three potential pathogens based on similarity of their *rrsH* gene sequence



Koch's postulates of disease causation

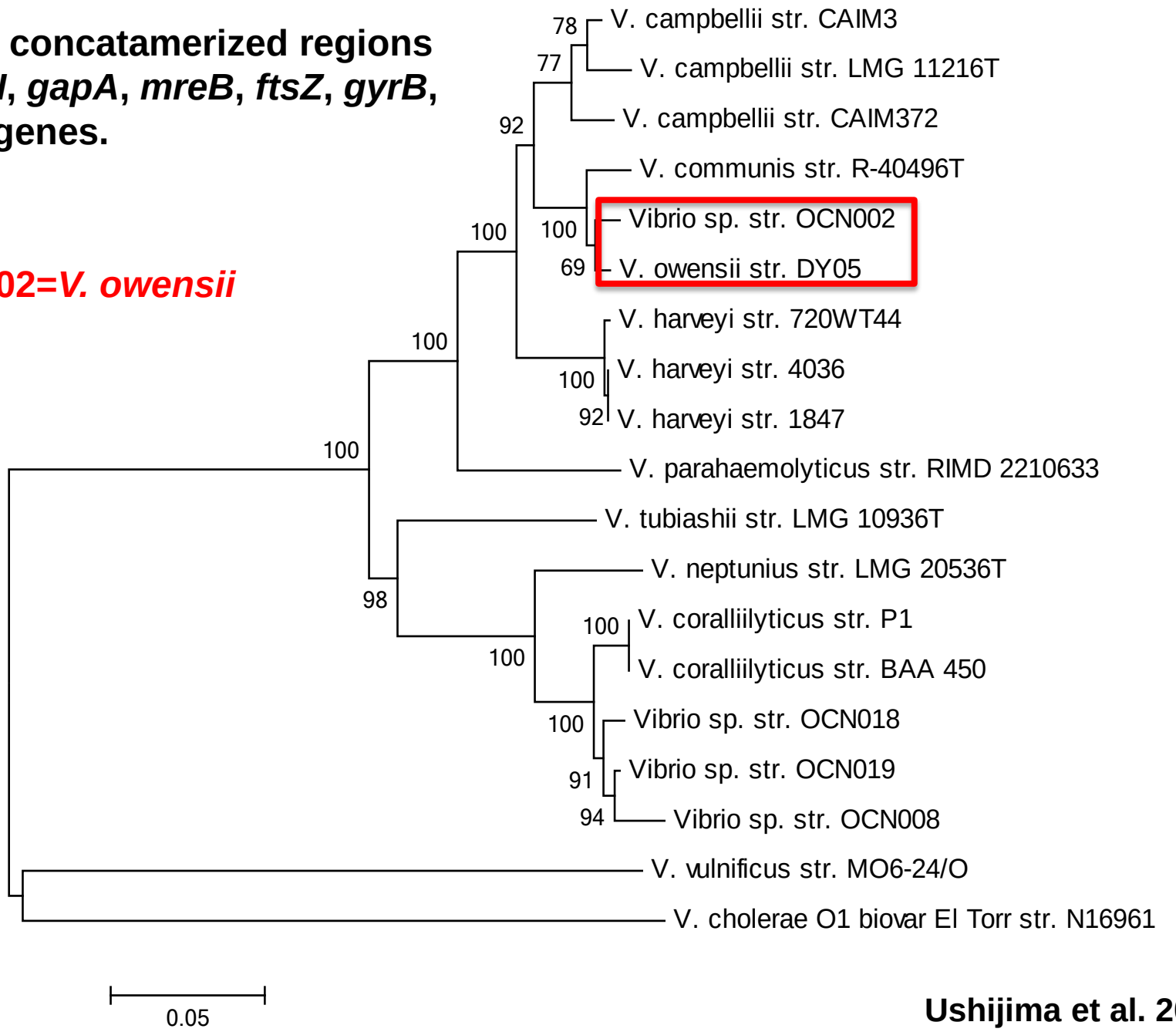
OCN002-*Vibrio* sp.

- **The microorganism must be isolated from a diseased organism and grown in pure culture.**
- **The cultured microorganism should cause disease when introduced into a healthy organism.**
- **The microorganism must be reisolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.**

Ushijima et al. 2012

MLSA with concatamerized regions of the *pyrH*, *gapA*, *mreB*, *ftsZ*, *gyrB*, and *topA* genes.

OCN002=*V. owensii*



Ushijima et al. 2012

Coral bacterial pathogens in Hawaii

Bacterial strain	infectivity	time to infection
OCN001 (*Vibrio* sp.)	23%	21-28 days
OCN002 (*V. owensii*)	54%	21-28 days
OCN003 (*P. piratica*)	31%	21-28 days
OCN008 (*V. coralliilyticus*)	85%	12hrs-4 days

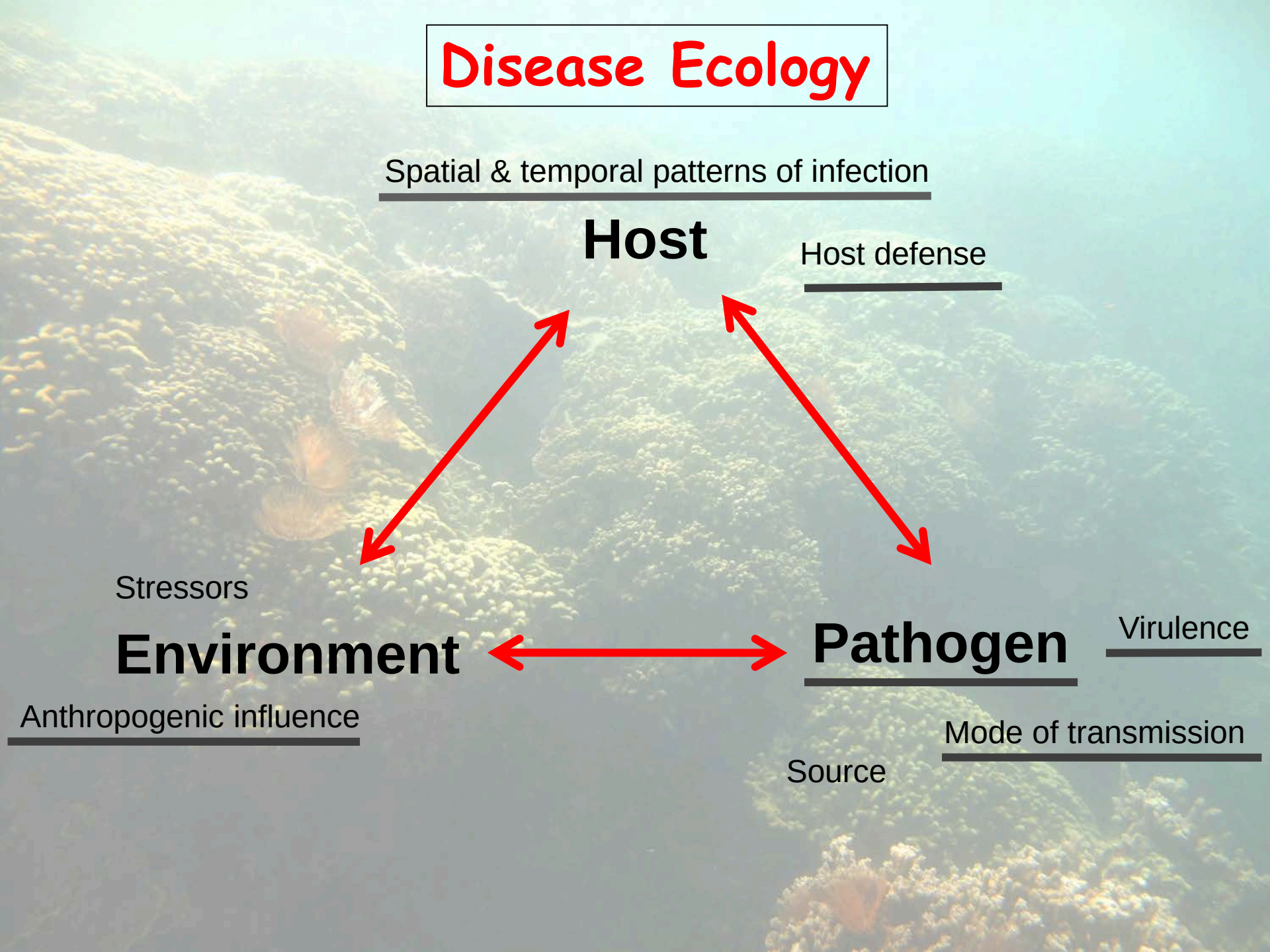
(Koch's postulates fulfilled for *V. owensii, V. coralliilyticus & P. piratica*)

(Ushijima et al. 2012, 2014: Beurmann et al. 2017)

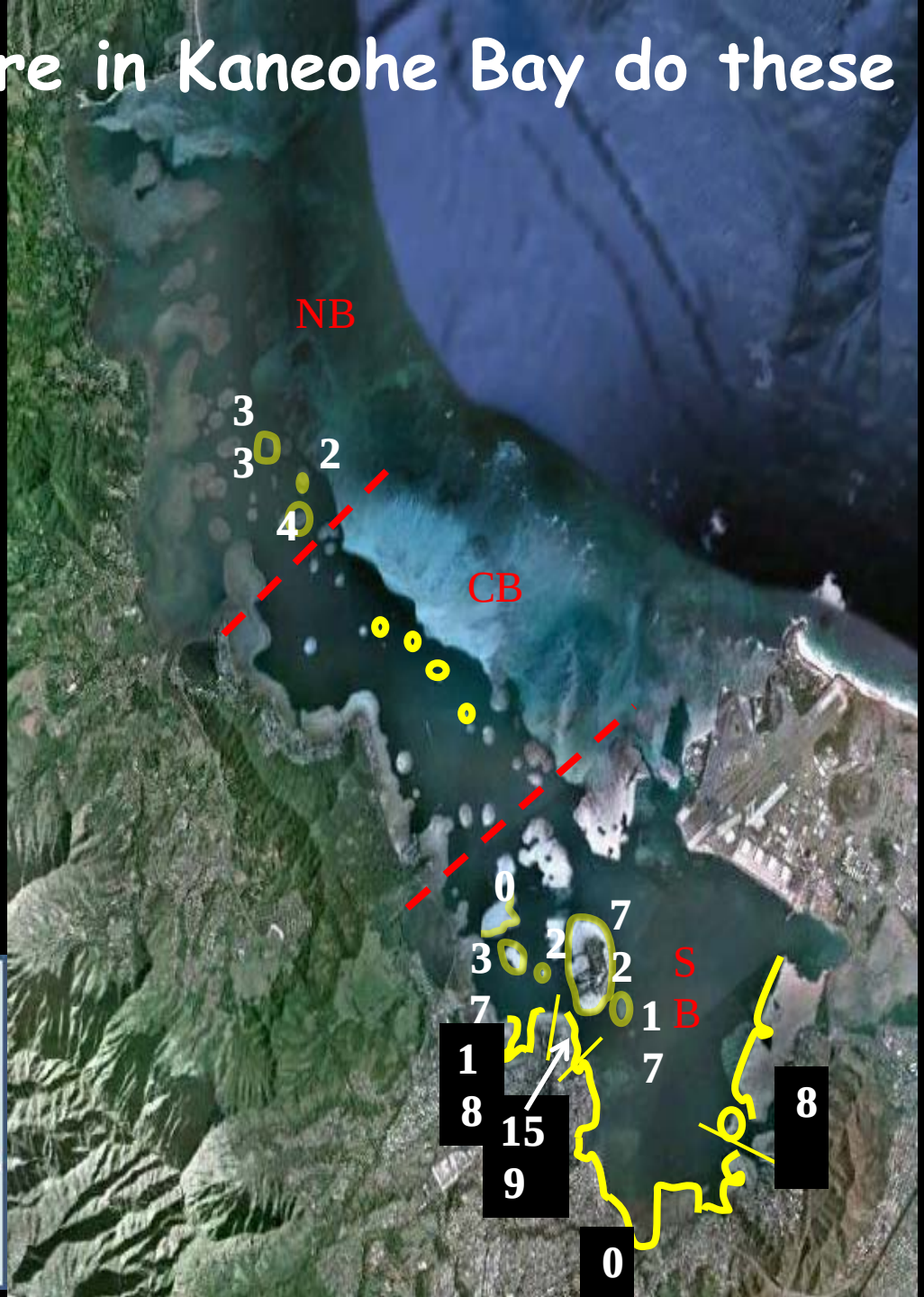
Known Bacterial Pathogens of Coral

1. ***Vibrio owensii*** - Chronic *Montipora* white syndrome
2. ***Vibrio coralliilyticus*** **OCN008** – acute *Montipora* white syndrome
3. ***Pseudoalteromonas piratica*** – acute Montipora white syndrome
4. ***Vibrio coralliilyticus*** **OCN014** –acute *Acropora* white syndrome
5. ***Thalassamonas loyana*** - White Plague Disease
6. ***Aurantimonas coralicida*** - White Plague Disease
7. ***Serratia marcescens*** - Acroporid serratiosis (White Pox)
8. ***Vibrio shiloi*** - Bacterial bleaching
9. ***Vibrio coralliilyticus*** **BAA450**- Tissue loss/bleaching
10. ***Vibrio coralliilyticus*** ***P1-P7*** – acute tissue loss
11. **Bacterial consortium:** ***Phormidium corallyticum/Ocillatoria*** **spp.,** ***Trichodesmium*** **spp.,** ***Desulfovibrio*** **spp.,** ***Beggiatoa*** **spp.** - Black Band Disease
12. **Bacterial consortium:** ***Vibrio rotiferianus, V. harveyi, V. alginolyticus, V. proteolyticus*** - Yellow Band Disease

Disease Ecology



Where in Kaneohe Bay do these pathogens occur?



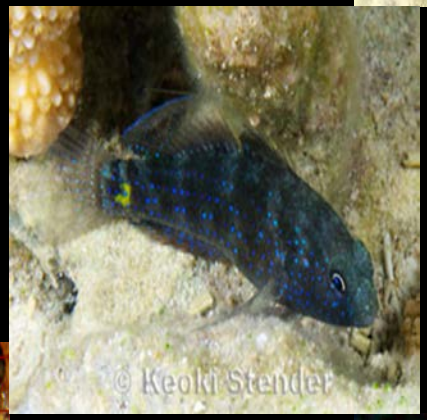
Sea Grant
University of Hawai'i

Amanda Shore-Maggio

Sources screened for coral pathogens

Seawater

Coral host



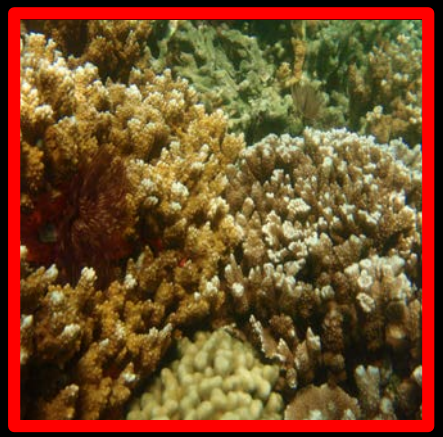
Streams

Critters

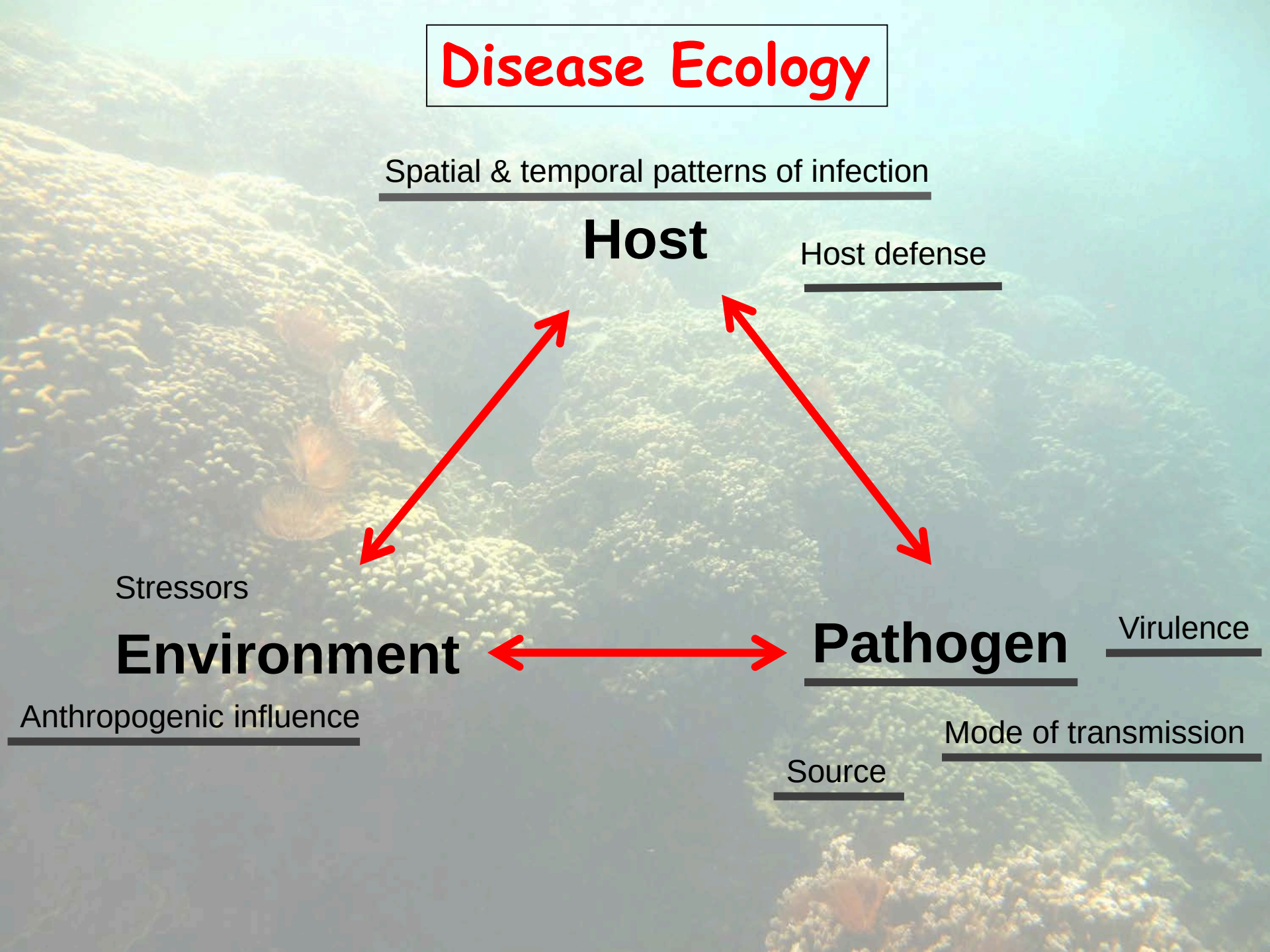
Coral pathogens detected in…..

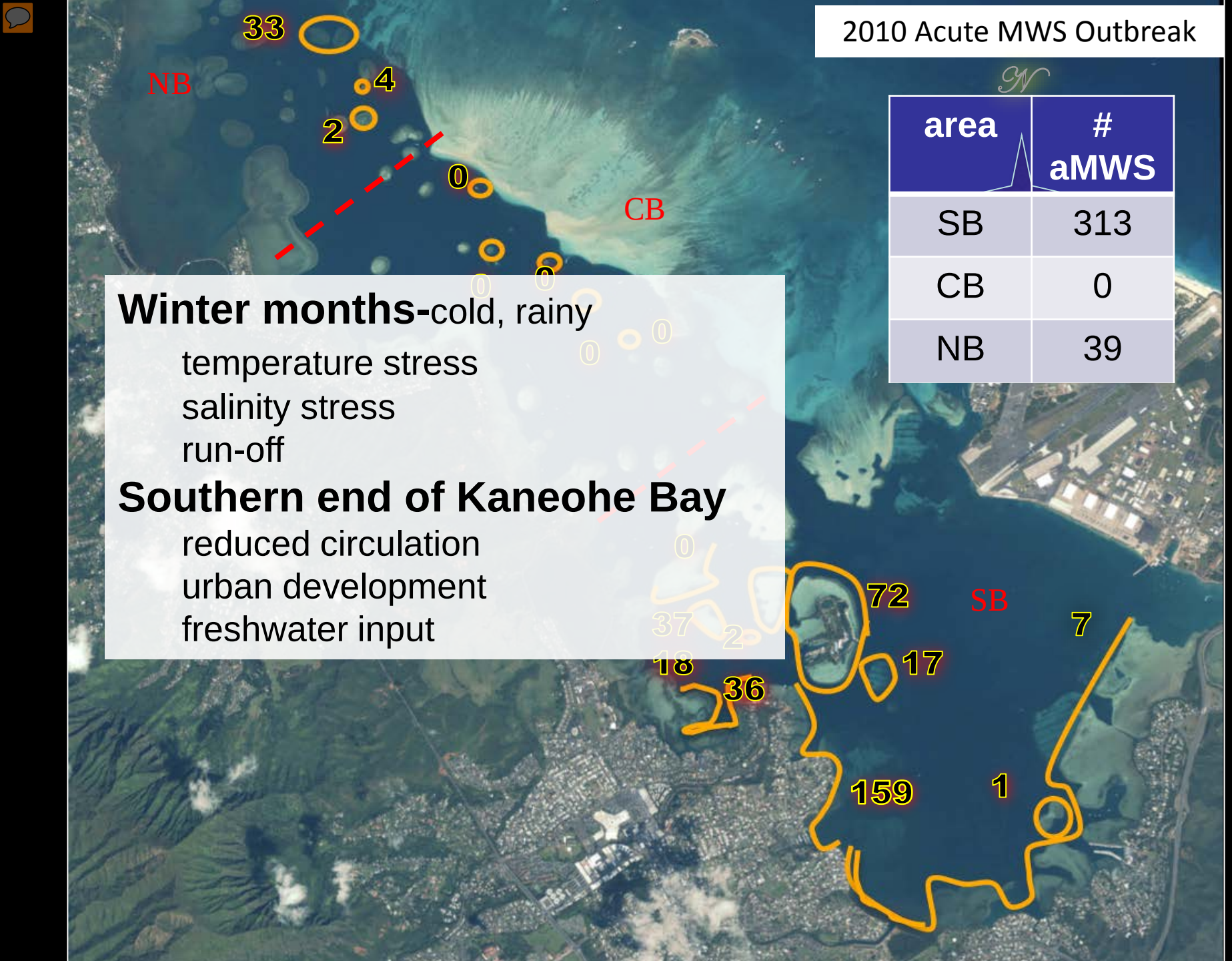
***Pseudoalteromonas* sp. OCN003**

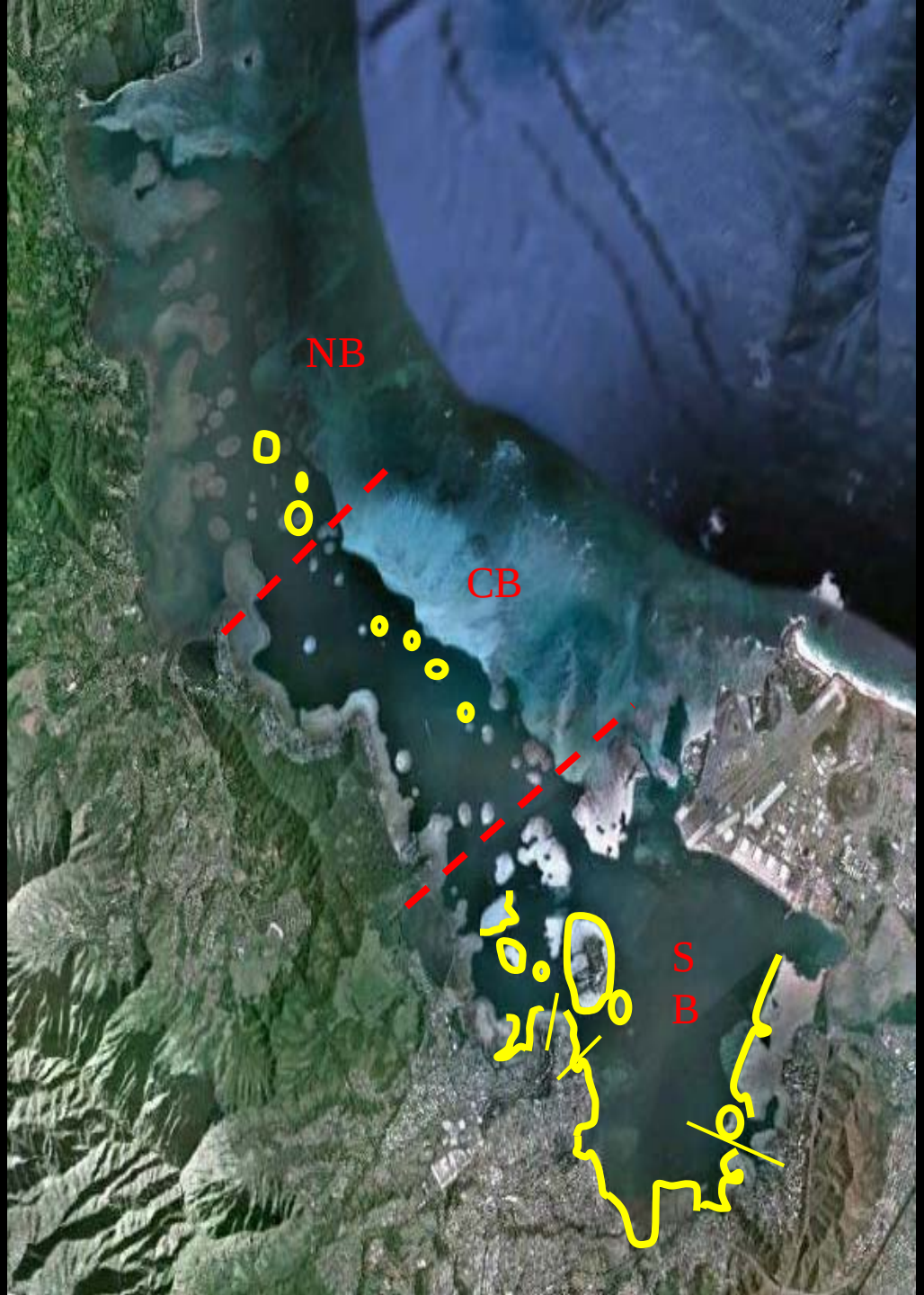
***Vibrio coralliilyticus* strain OCN008**



Disease Ecology




2010 Acute MWS Outbreak
area
aMWS
SB 313
CB 0
NB 39
Winter months-cold, rainy
temperature stress
salinity stress
run-off
Southern end of Kaneohe Bay
reduced circulation
urban development
freshwater input
33
NB
4
2
0
CB
0
0
0
0
0
0
0
72
SB
7
37
2
17
18
36
159
1



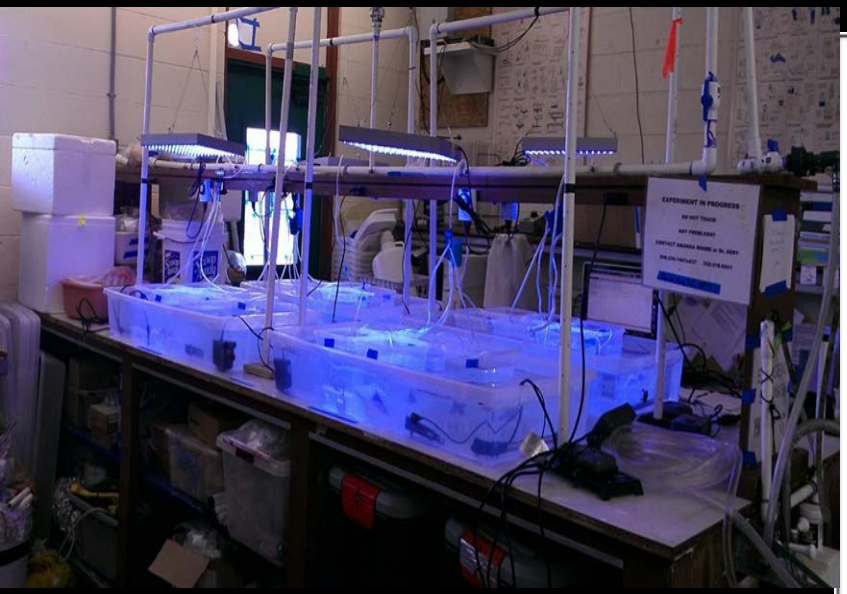
Will a salinity stress on coral affect...?

A) time to infection

B) Dosage of pathogen needed to cause infection

Testing salinity stress on infection with MWS pathogens

Pathogen	Dosage	Time
Vibrio coralliilyticus OCN008	10^8	5 days
Vibrio owensii OCN002	10^8	28 days



C1 no bacteria	C1 OCN008 (10^4)	C1 OCN008 (10^6)	C1 OCN008 (10^8)
E1 no bacteria	E1 OCN008 (10^4)	E1 OCN008 (10^6)	E1 OCN008 (10^8)

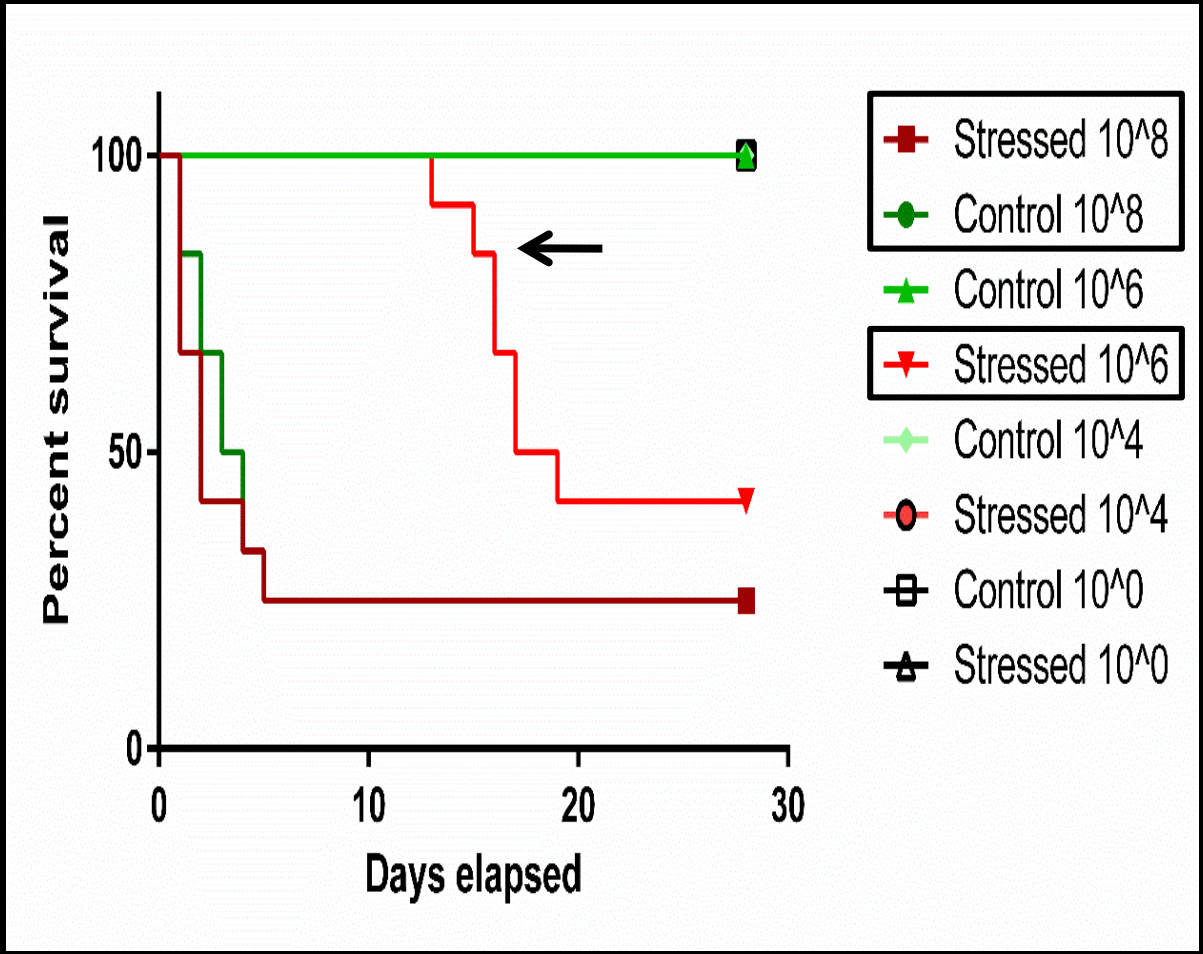
E = 24hr salinity stress at 20ppt

Testing salinity stress on infection with *Vibrio coralliilyticus* OCN008

Salinity Stress did….

A) NOT change time to infection with normal dosage

B) allow infection at lower dosage



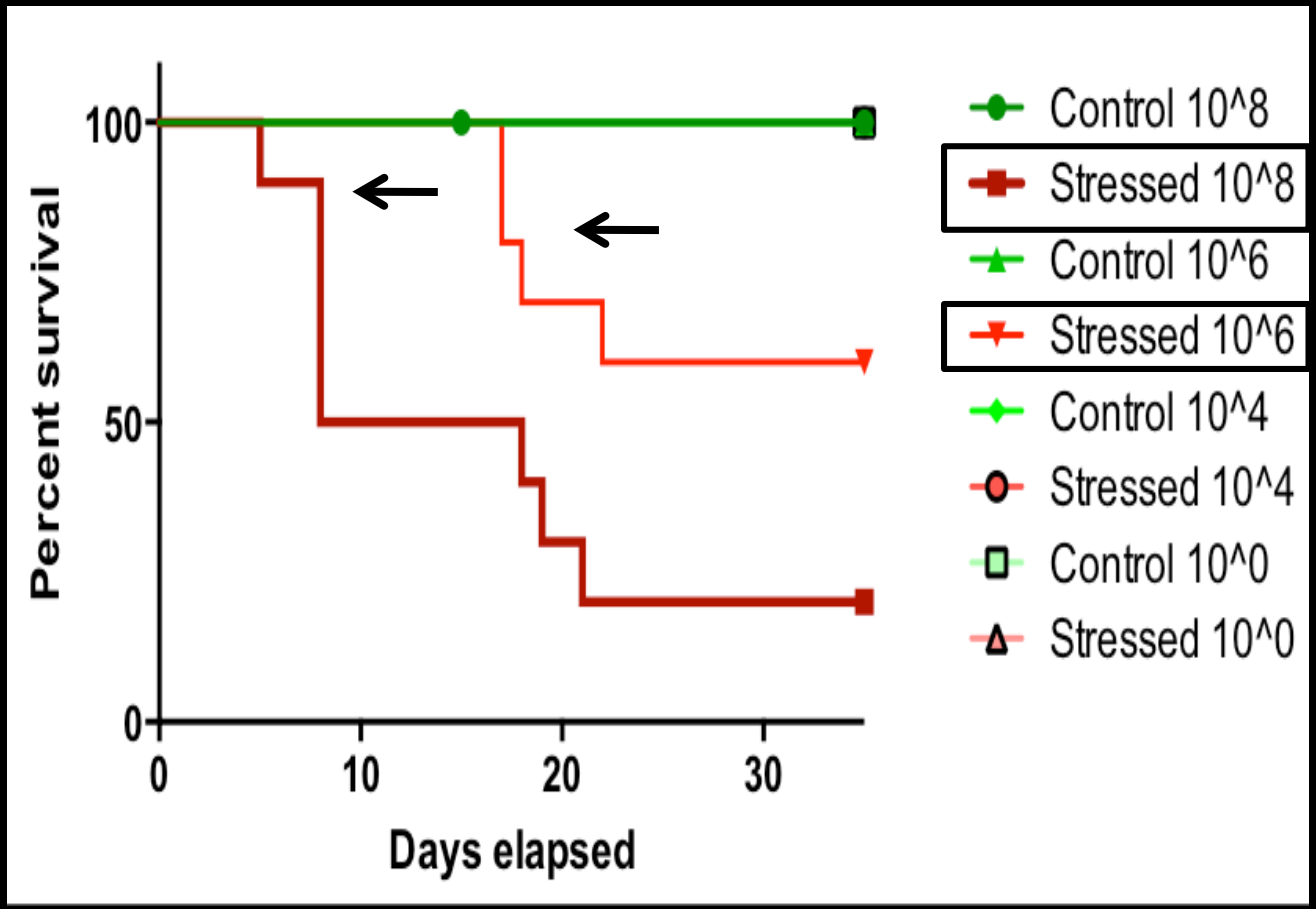
Testing salinity stress on infection with *Vibrio owensii* OCN002

Salinity Stress did….

A) change time to infection with normal dosage

B) allow infection at a lower dose

Normally takes ~28 days!



Disease Ecology

Chronic MWS

acute MWS

Spatial & temporal patterns of infection

Host

Host defense

Resident bacterial flora

Chemical defense

Stressors

Environment

Anthropogenic influence

Winter conditions

Salinity stress

lower infectious dose

decrease time to infection

Pathogen

Virulence

Source

Bacterial pathogens

Direct transmission

pathogens endemic in environment

Sean Callahan
Fenny Cox
Thierry Work
Deborah Gochfeld
Amanda Shore-Maggio
Blake Ushijima
Chris Runyon
Silvia Beurmann
Andy Burger
Frank Stanton
Megan Ross
Steve Coles
Ashley Smith
Mareike Sudek