

BACTERIAL BLEACHING OF CORALS

Vibrio shiloi/Oculina patagonica model system

Vibrio coralliilyticus/Pocillopora damicornis model system

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Importance of Coral Reefs



- **Most spectacular structures made by living organism**
- **Rich in species diversity**
- **High productivity**
 - **Protects coastlines from erosion**
 - **Economically important (fishing & tourism)**
 - **Reservoir for new drugs**

Diseases Of Corals

Coral diseases have significantly increased over the last two decades, causing mass destruction of reefs throughout the world.

~ 30%% mortality worldwide



Coral Bleaching = loss of endosymbiotic algae (Zooxanthellae)



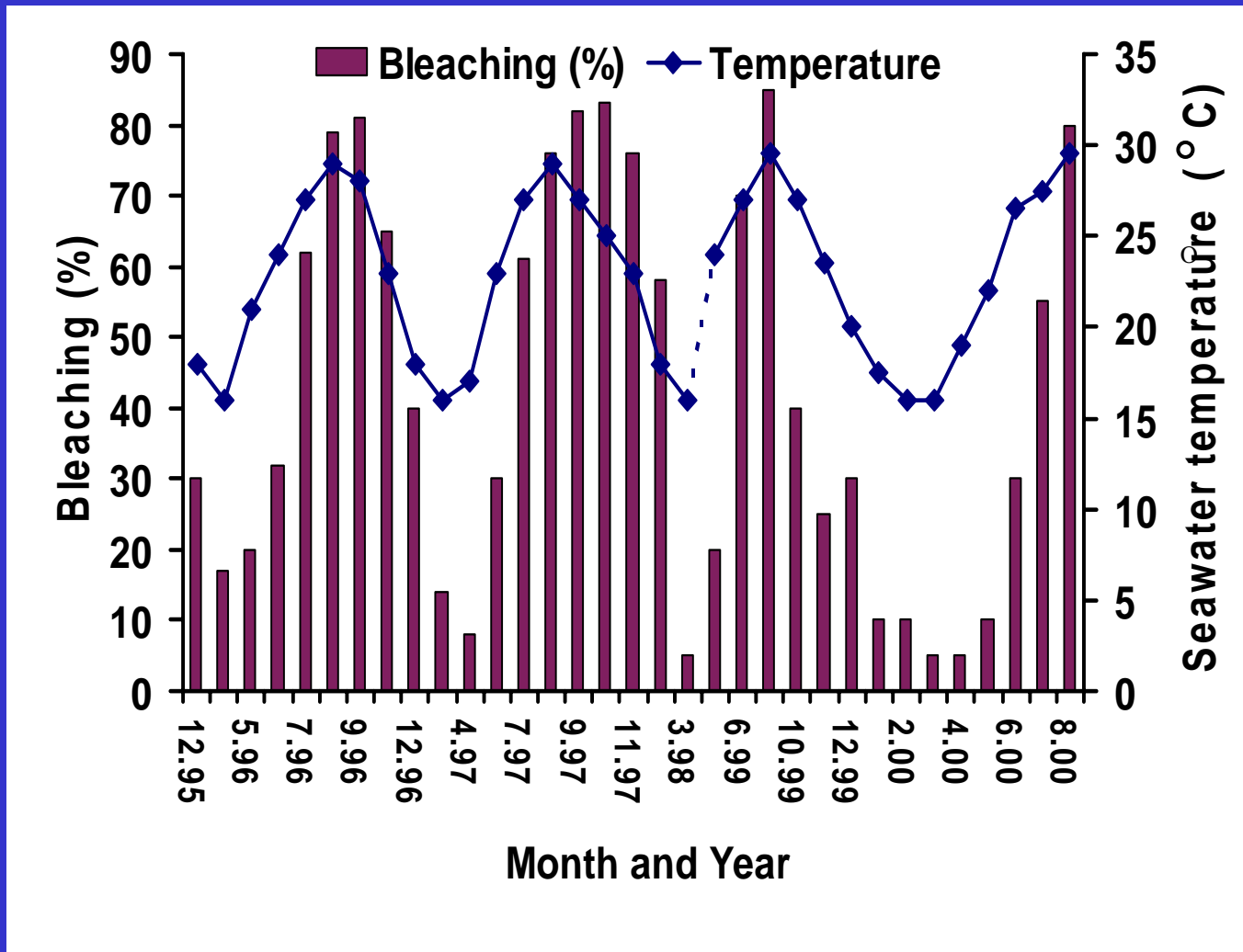
- High correlation with increased seawater temperature (global warming)
- Hypothesis 1: Heat stress on the coral causes it to expel the Zooxanthellae
- Hypothesis 2: Bleaching is an infectious disease



Partially bleached *O. patagonica*

Bleaching of the coral *Oculina patagonica* occurs regularly during the summer

(FINE, KUSHMARO and ISRAELY)



***V. shiloi* is the causative agent of
bleaching of *O. patagonica***

Koch's postulates were applied.



BLEACHING OF *O. PATAGONICA* AS A FUNCTION OF TEMPERATURE AND INOCULUM SIZE

<i>Vibrio shiloi</i> (cells/ml)	Temperature (°C)	Bleaching* (%)
0	29	0
120	29	95
0	16	0
10 ² - 10 ⁸	16	0

* At 3 weeks

QUESTIONS

1. What are the mechanisms?
2. How does temperature affect the process?
3. How general is bacterial bleaching?

Process of infection

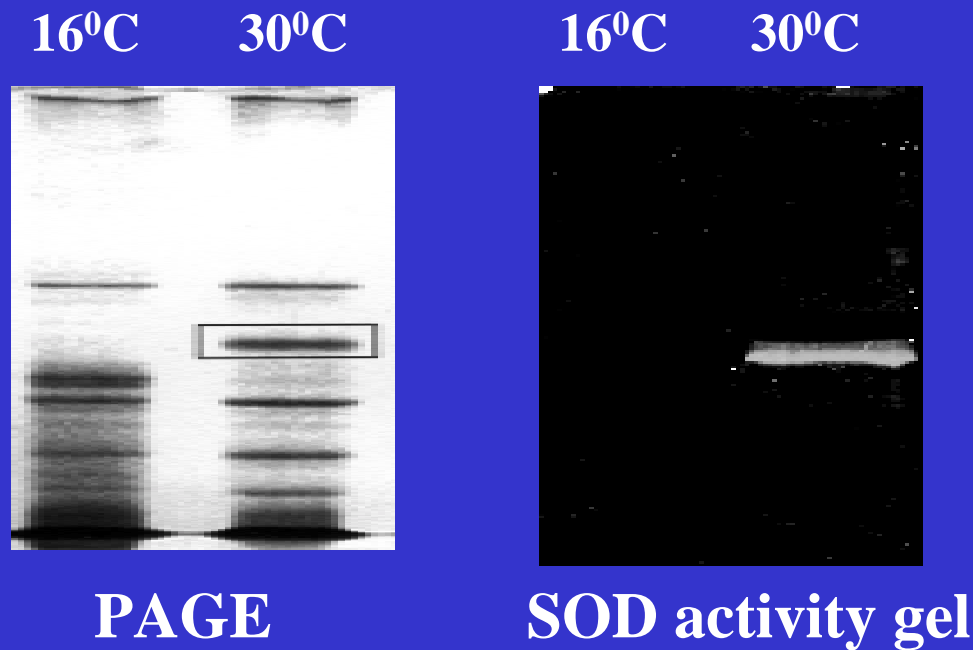
- Adhesion
- Penetration
- Multiplication and differentiation into the VBNC state
- Toxin production (PYPVYAPPPVVP)
- Role of superoxide dismutase (SOD)
- Transmission

Superoxide dismutase a virulence factor in *V. shiloi*

- The coral tissue during the day time is very rich in oxygen (>250% saturation). This can impose oxidative stress on internal bacteria.
- Superoxide dismutase plays an essential role in defense against the potential toxicity of oxygen.

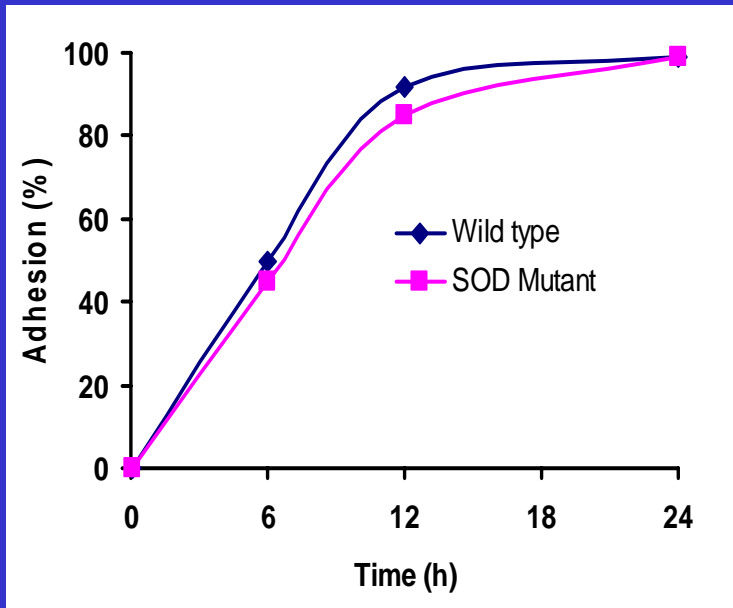


V. shiloi secretes a Superoxide Dismutase (SOD) which is temperature regulated

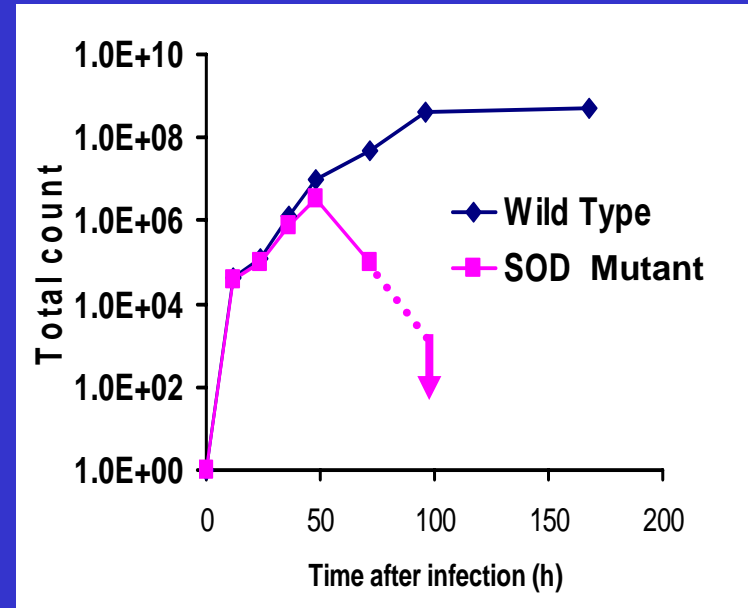


V. shiloi SOD⁻ mutant – avirulent

Adhesion



Penetration



A SOD⁻ mutant adheres penetrates but then dies even at permissive temperature (30⁰C).

Conclusion

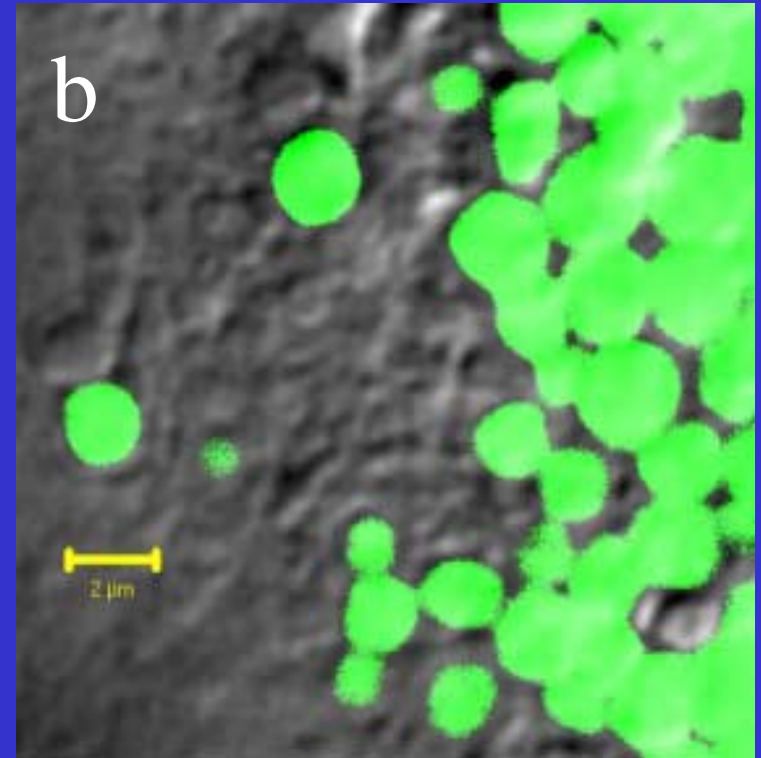
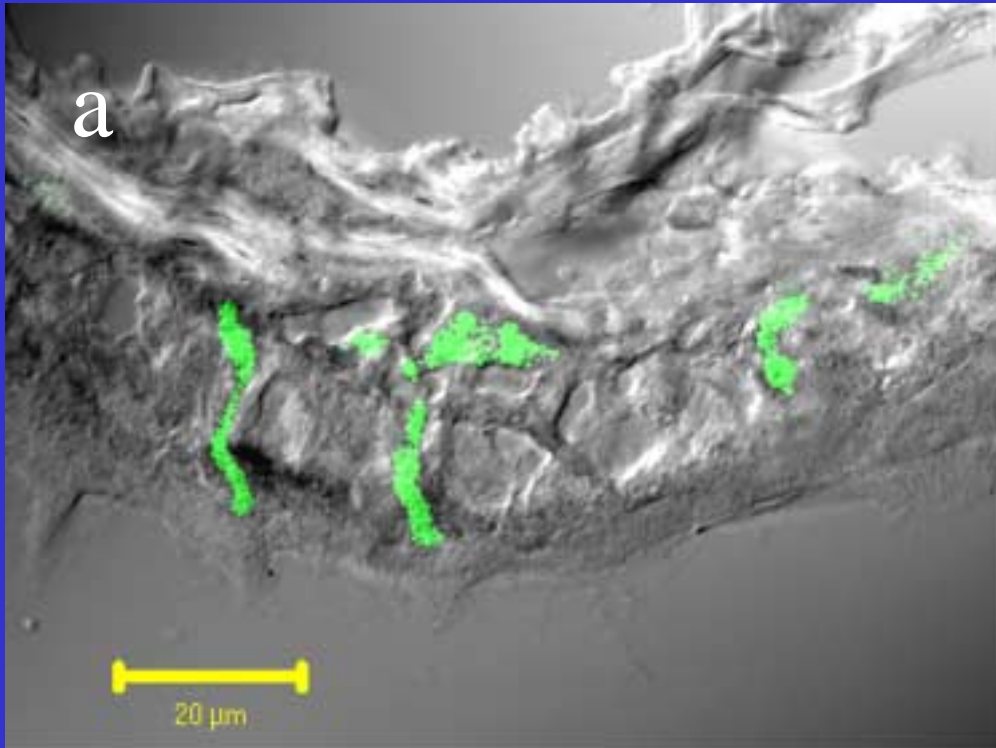
- Adhesion
 - Survival in the tissue
 - Superoxide-dismutase
 - Toxin production
- Temperature dependent

Temperature turns on virulence genes!

V. shiloi can not survive in *O. patagonica* in the winter. Thus, fresh infection is needed each spring.

Where is *V. shiloi* in the winter?

FISH STAINING OF SECTIONS OF THE FIREWORM *HERMODICE CARUNCULATA*



(Sussman et. al. 2003)

Presence of *Vibrio shiloi* in *Hermodice carunculata*.

Worms were collected from different depths during the winter 2001/2002, crushed and analyzed for colony forming units (cfu) and total *V. shiloi* (FISH)

Worm length (cm)	<i>Vibrio shiloi</i> per worm		Ratio (cfu/FISH)
	cfu	FISH	
6	4.1×10^4	1.1×10^8	3.7×10^{-4}
5	4.1×10^4	0.7×10^8	5.8×10^{-4}
13	18.3×10^4	2.9×10^8	6.3×10^{-4}
7	7.8×10^4	0.6×10^8	1.3×10^{-4}
7	8.8×10^4	1.3×10^8	6.8×10^{-4}

BLEACHING OF *O. PATAGONICA* BY INFECTED *H. CARUNCULATA*



7 days



17 days

(Sussman et. al. 2003)



The fireworm *Hermodice carunculata* feeding on *O. patagonica*: a reservoir and vector of *V. shiloi*. (Photograph by M. Fine)

How general is bacterial bleaching of corals ?

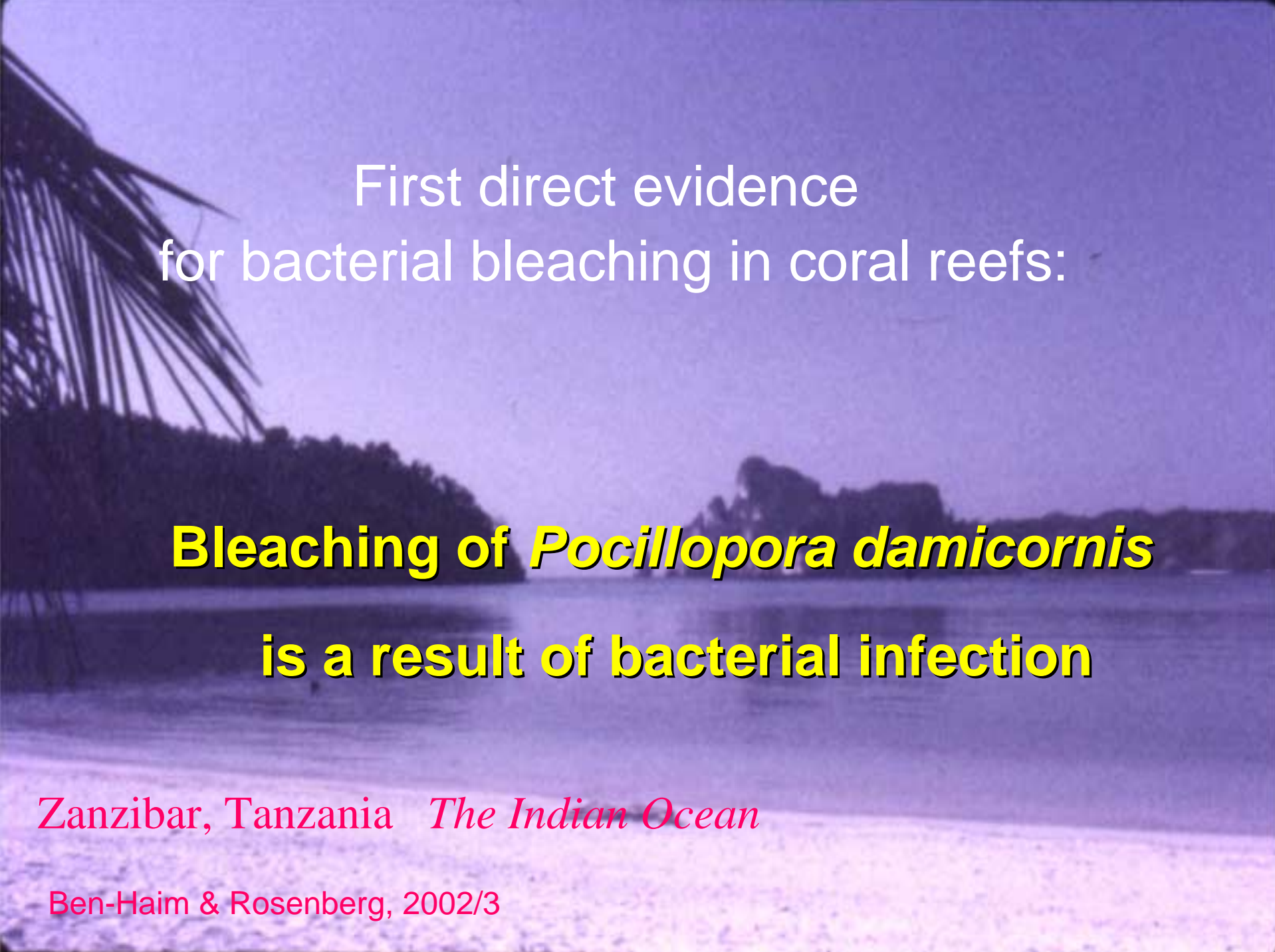


Indirect evidence suggests that
coral bleaching is an infectious disease

◆ Patchy spatial distribution

◆ Spreading nature

highly symptomatic of an infectious disease



First direct evidence
for bacterial bleaching in coral reefs:

**Bleaching of *Pocillopora damicornis*
is a result of bacterial infection**

Zanzibar, Tanzania *The Indian Ocean*

Ben-Haim & Rosenberg, 2002/3

Pocillopora damicornis

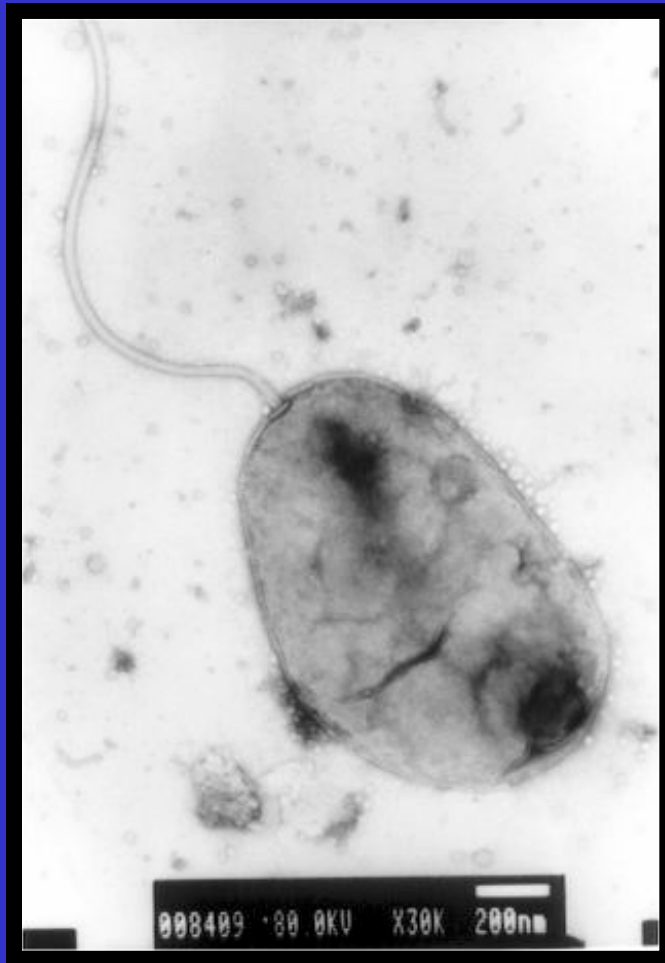
bleached



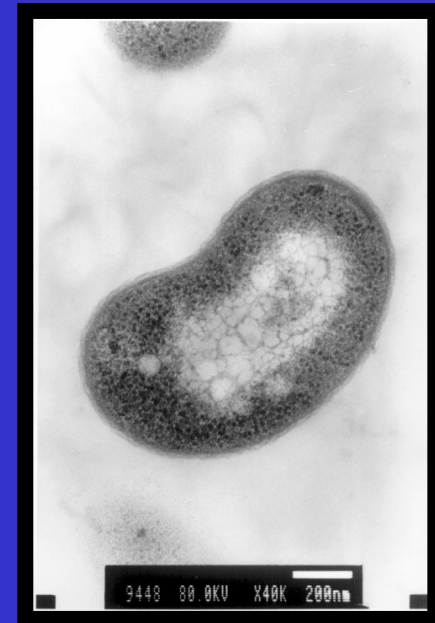
healthy



Vibrio coralliilyticus



negatively stained



sectioned cell

Bleaching of *P. damicornis* by *Vibrio coralliilyticus* at 24-25°C



Infected coral



Control coral

Koch's postulates satisfied

QUESTIONS AND CHALLENGES

“As the area of light increases, so does the circumference of darkness” A. Einstein

- *V. shiloi/O. patagonica*:
 - Nature of VBNC state?
 - Temperature regulation of virulence genes?
- Generality of bacterial bleaching?
- How can coral diseases be controlled?
- What are the roles of indigenous coral bacteria in health and disease?