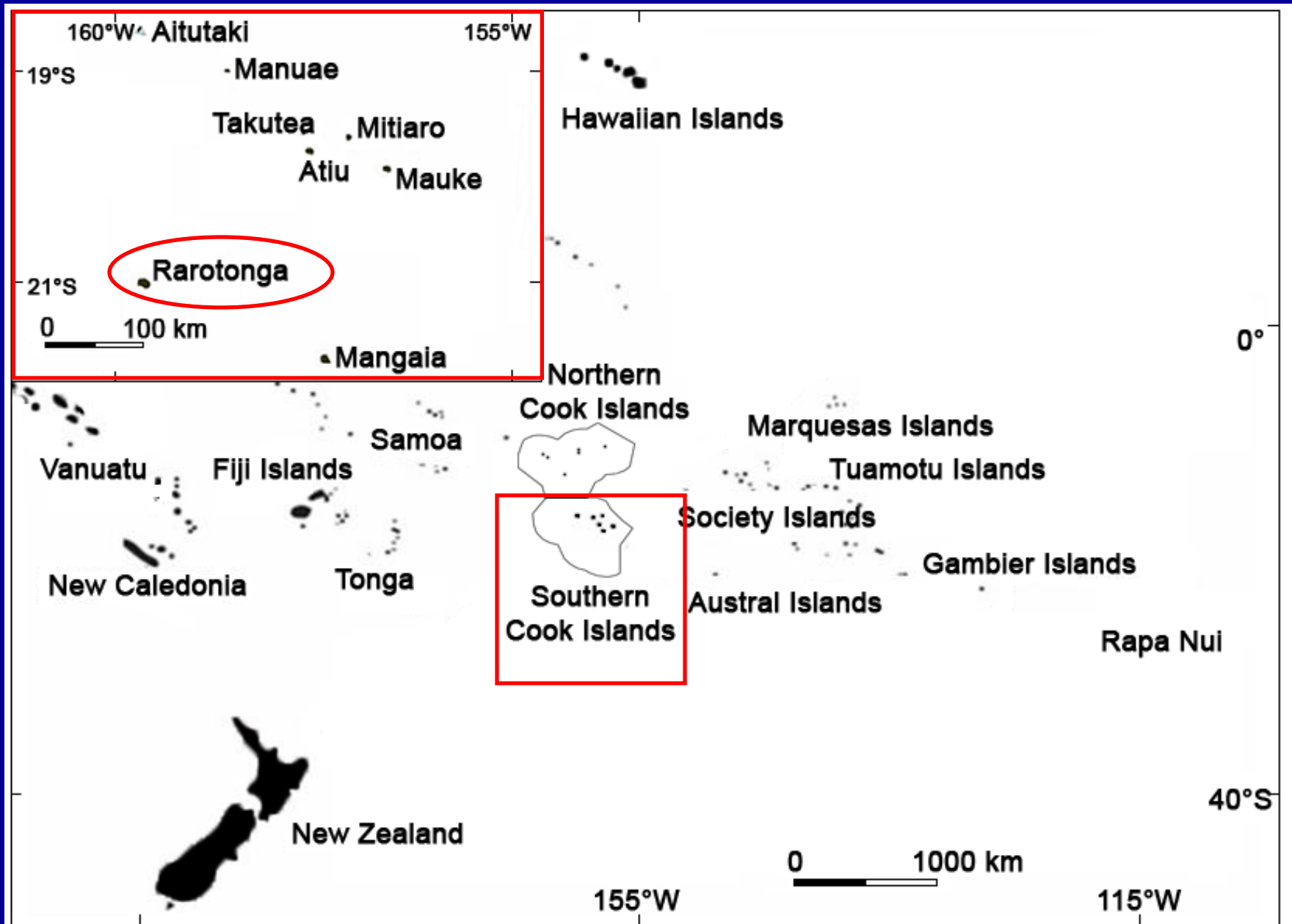


A large school of black and white striped surgeonfish, likely Acanthurus nigrofasciatus, swimming over a coral reef. The fish have black bodies with white vertical stripes and a white spot on the head. They are swimming in a loose formation over a diverse coral reef structure. The water is clear and blue.

CIGUATERA POISONING, CORAL REEFS, AND CLIMATE OSCILLATIONS IN RAROTONGA, SOUTHERN COOK ISLANDS

Teina Rongo

Study location

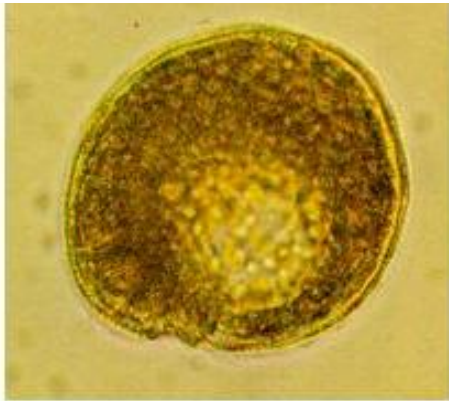


Study location

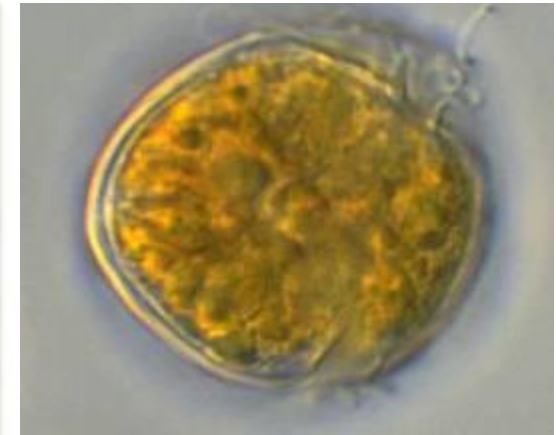
- Ciguatera poisoning has been chronic for over 20 years
- Subsistence fishing
- 52% have experienced ciguatera in the past
- Up to 1,000 people affected annually when ciguatera is severe



Toxic dinoflagellates



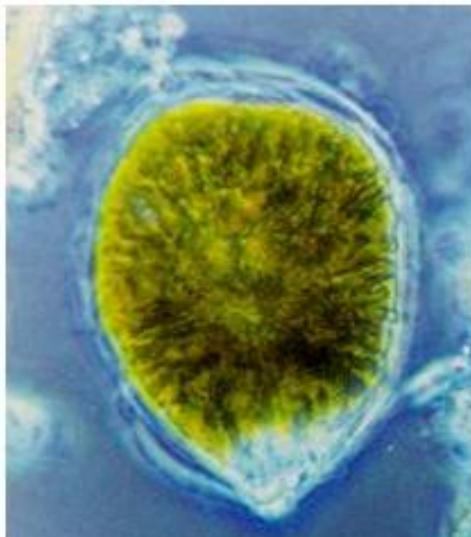
Gambierdiscus toxicus
Adachi and Fukuyo



Coolia monotis
Meunier



Prorocentrum lima
(Ehrenberg) Dodge



Ostreopsis lenticularis
Fukuyo



Amphidinium carterae
Hulburth

Cyanobacteria



Lyngbya majuscula
Gomont

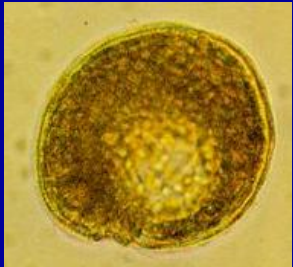
Causative organisms

Vectors

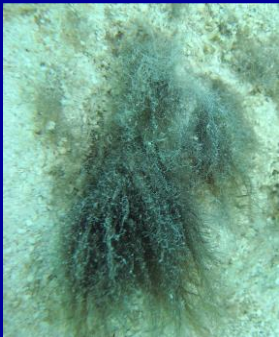
Carnivores

Herbivores

Dinoflagellates



Cyanobacteria



Meiofauna



Benthic invertivores



Filter feeders

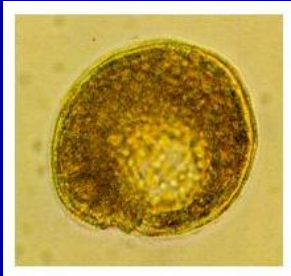


<http://www.hudsonregional.org/mosquito/images/copepod.jpg>

Fish and invertebrate photos by Robert Myers. Cyanobacteria photo by Dr. Robert van Woesik

Bioaccumulation & biotransformation of ciguatoxins

Dinoflagellate



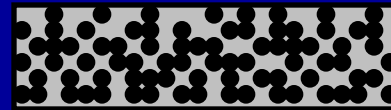
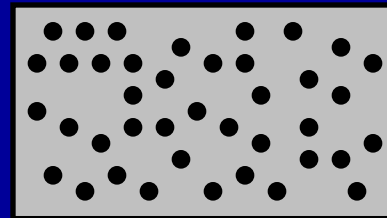
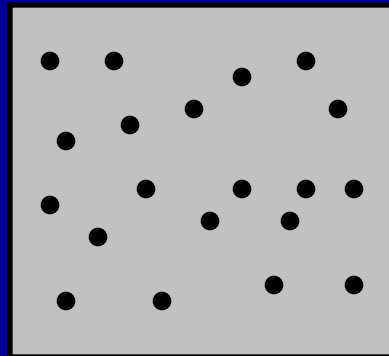
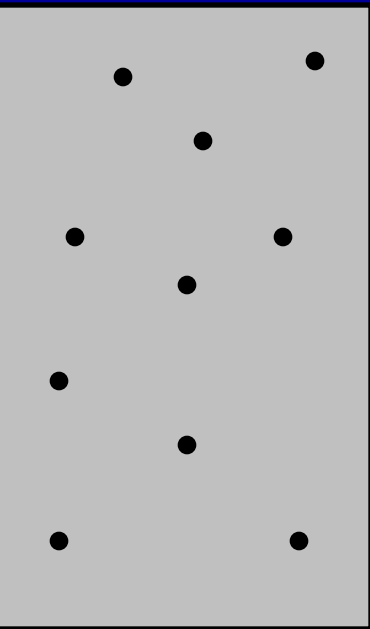
Herbivore



Carnivore



Human



Mataiti: Lindsey Hoshaw

Fish photos: Robert Myers

Dinoflagellate: <http://dinos.anesc.u-tokyo.ac.jp/Jpeg/index.htm>

Symptoms of ciguatera poisoning

Neurological

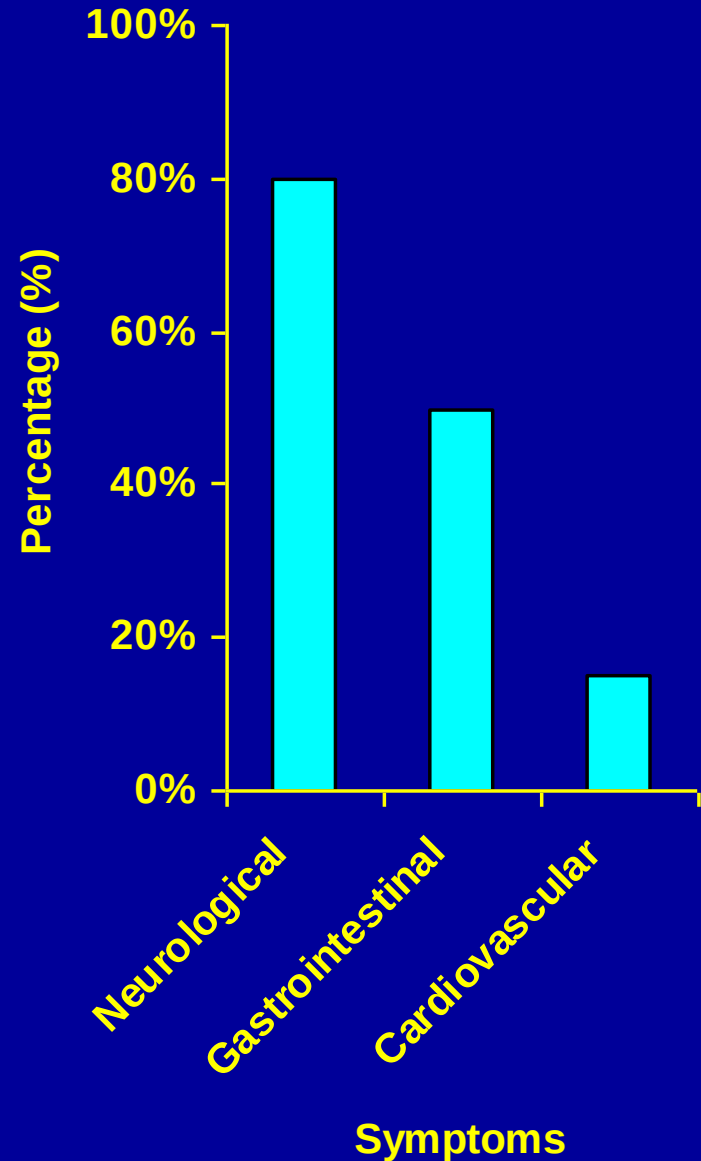
- Numbness & tingling of extremities
- Temperature reversal
- Muscle/joint aches
- Itching
- Memory loss
- Hallucination & nightmares
- Mental depression
- Coma
- Paralysis

Gastrointestinal

- Nausea, diarrhea, & vomiting

Cardiovascular

- Hypotension, tachycardia, & brachycardia

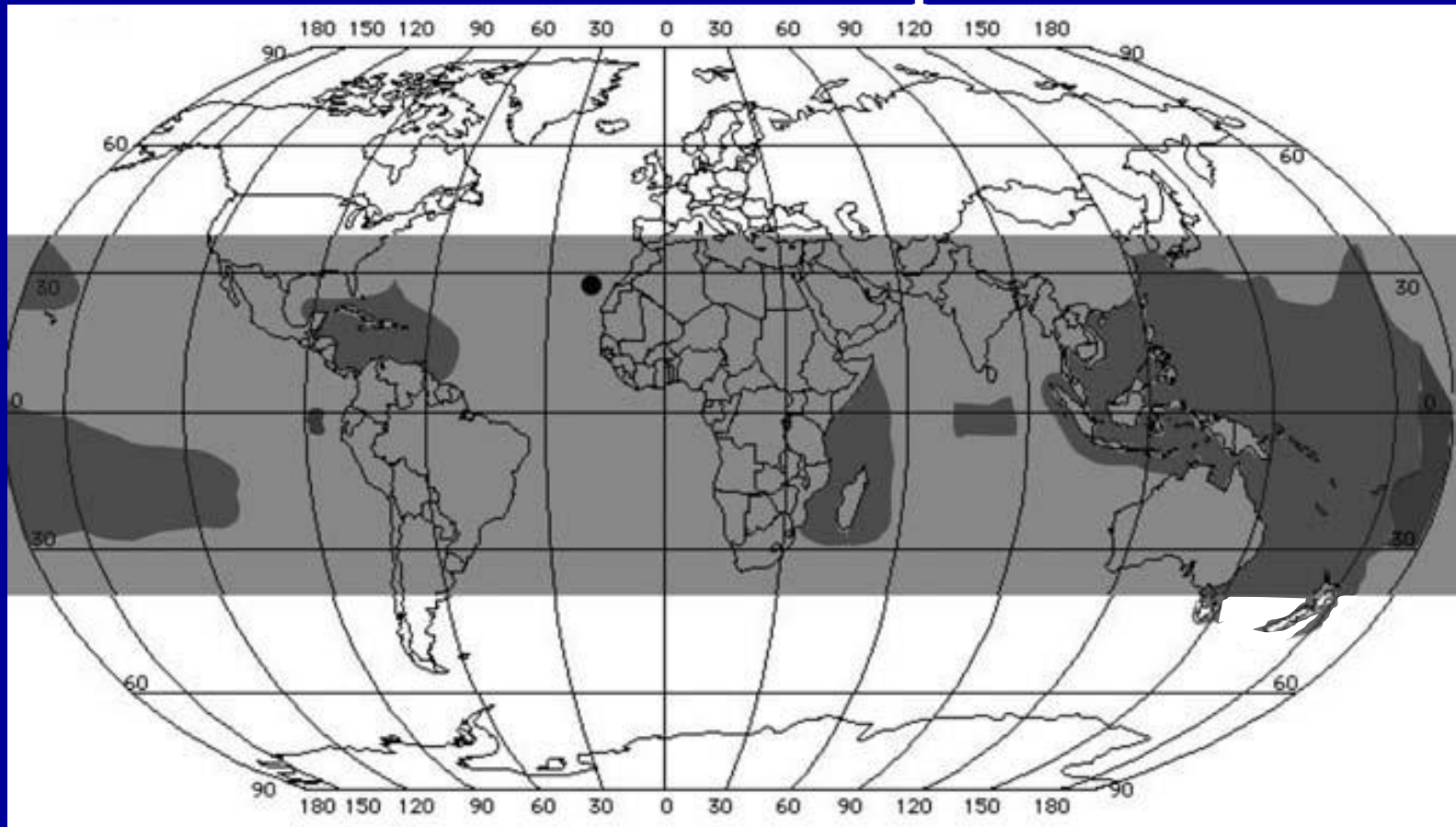


Baumann et al. (2010)

Global distribution

50,000 – 500,000 people per year

10 – 20% of cases reported

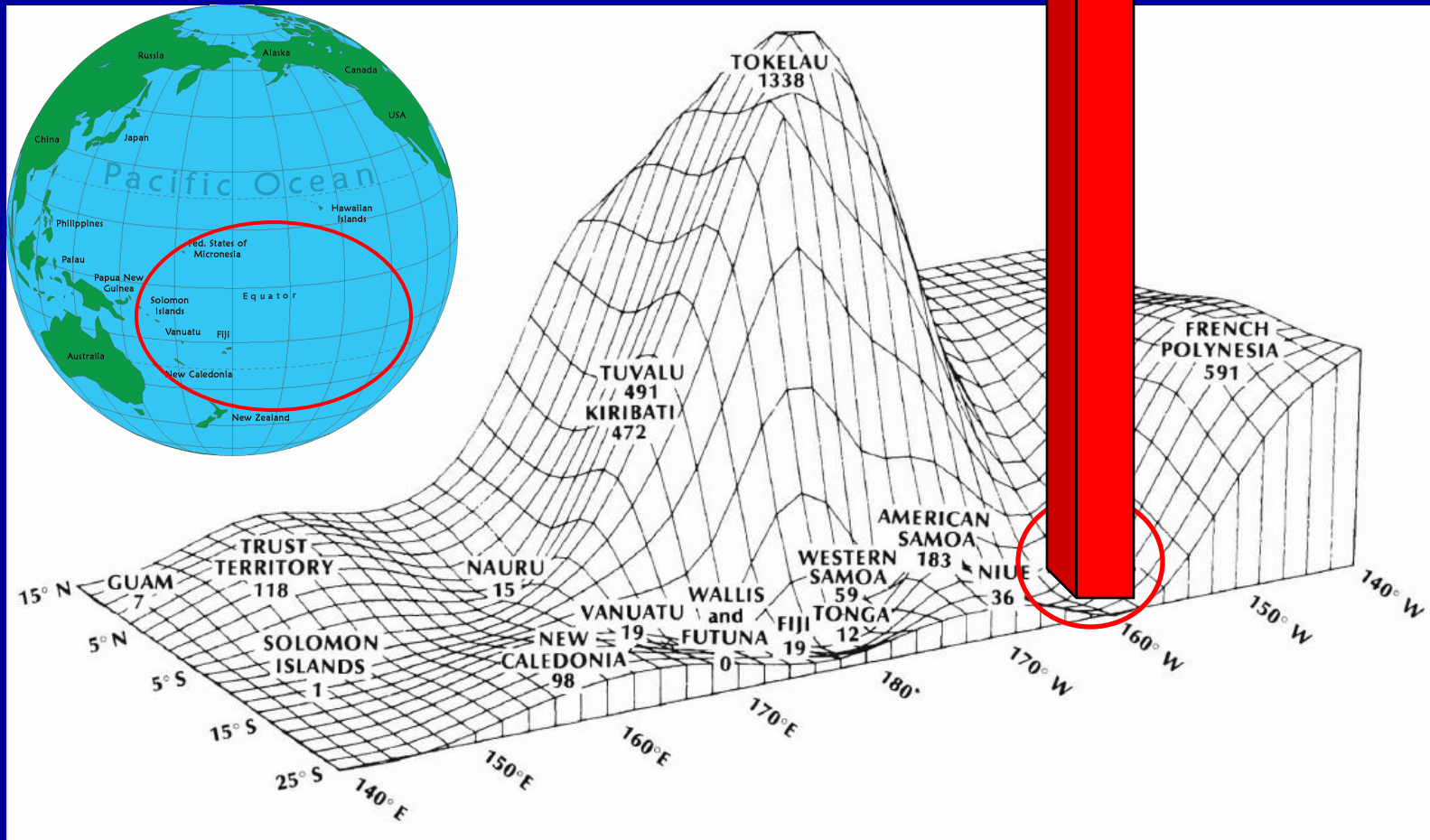


 Coral reef regions between 35° N & 35° S

 Ciguatera-endemic regions

Rarotonga Spatial and temporal distribution

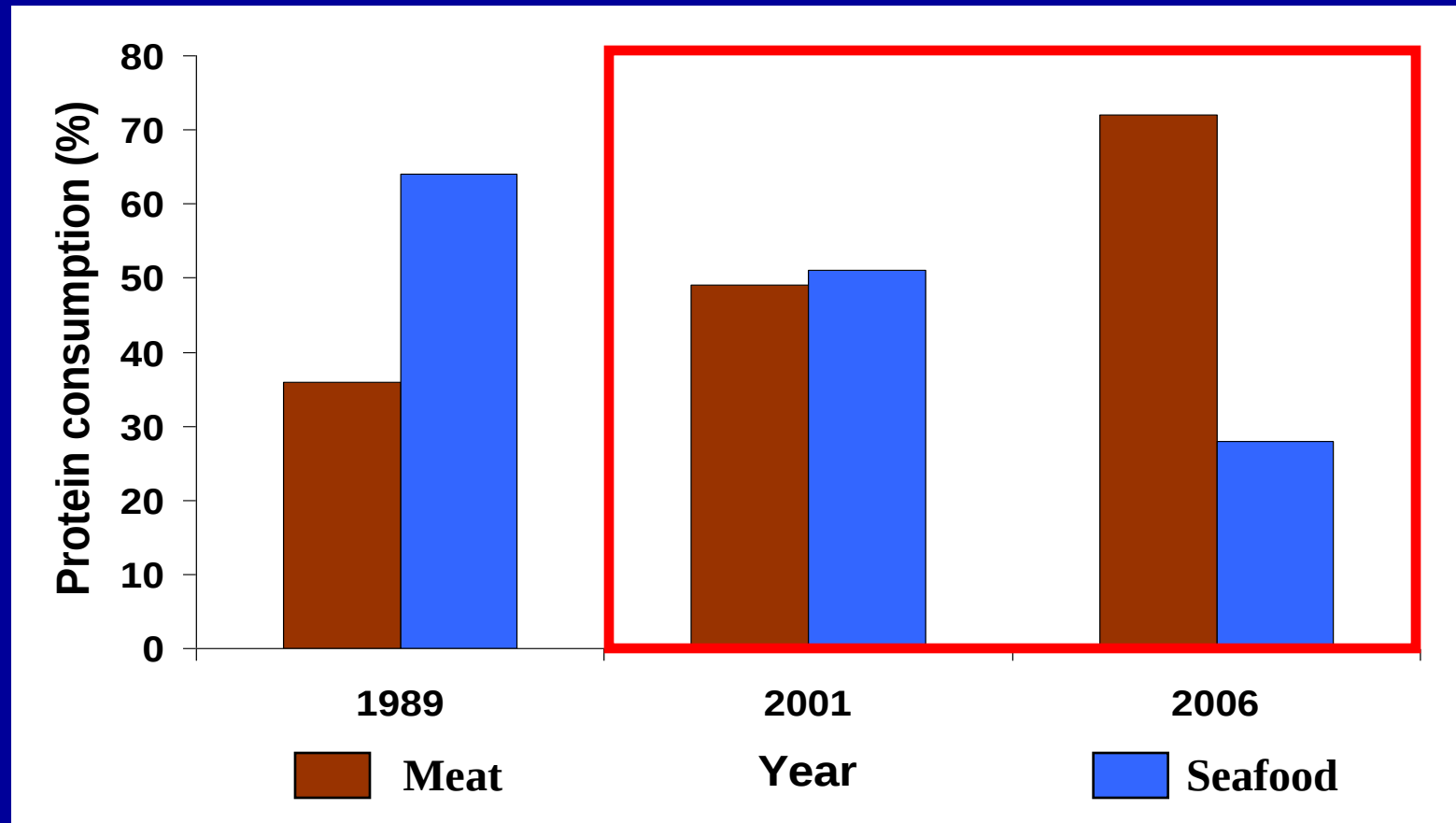
1994 – 2006: 1,790 per 100,000 population per year
 1973 – 1983: Average incidence of ciguatera
 Kong et al. (2009)
 (per 100,000 population per year)



Lewis (1986) *Marine Fisheries Review* 48, p. 8.

Globe: http://www.free-extras.com/images/pacific_ocean_globe-12033.htm

Dietary shifts: Rarotonga, Cook Islands 1989 – 2006



Solomona et al. (2009)
Moore (2006)

Loss of labor productivity & health-related costs

Rarotonga: USD \$372,000 per year
(Rongo and van Woesik, unpublished)



Depopulation



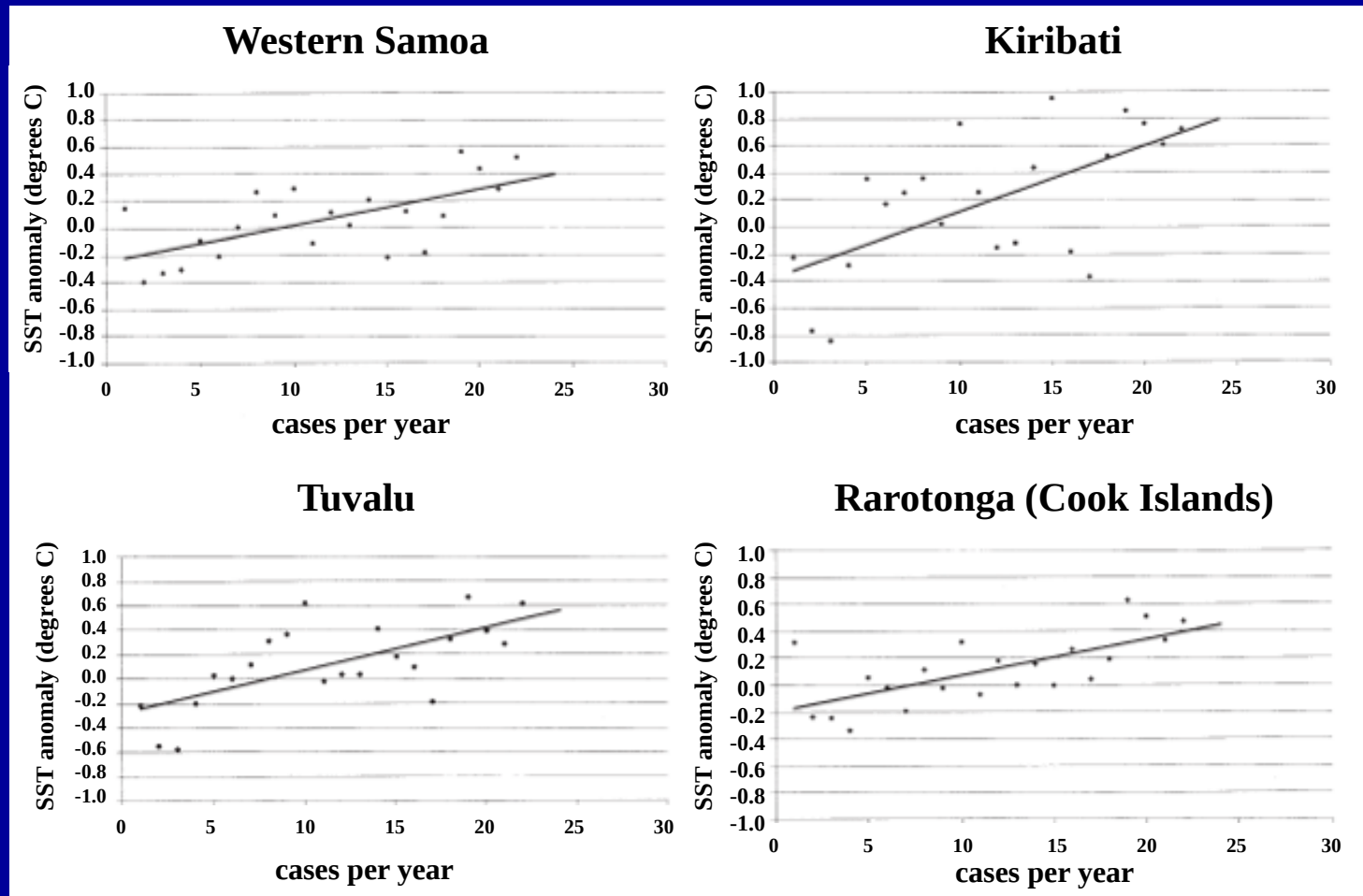
Cook Islands (Rongo et al. 2009)

-Contributed to the migration of 18% of the population to New Zealand and Australia in the 1990s



Is ciguatera poisoning linked to climate?

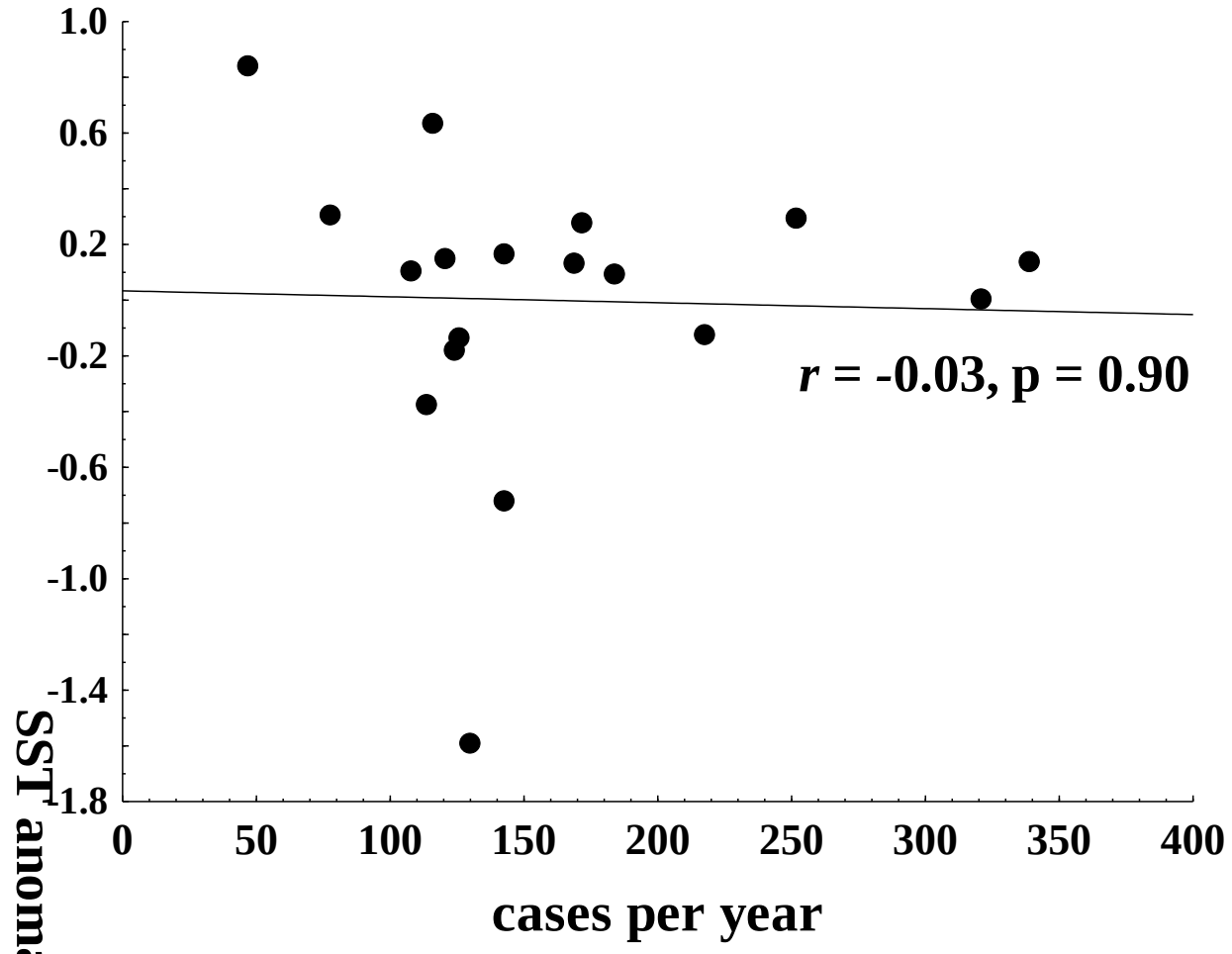
‘Climate oscillation hypothesis’ 1973 - 1994



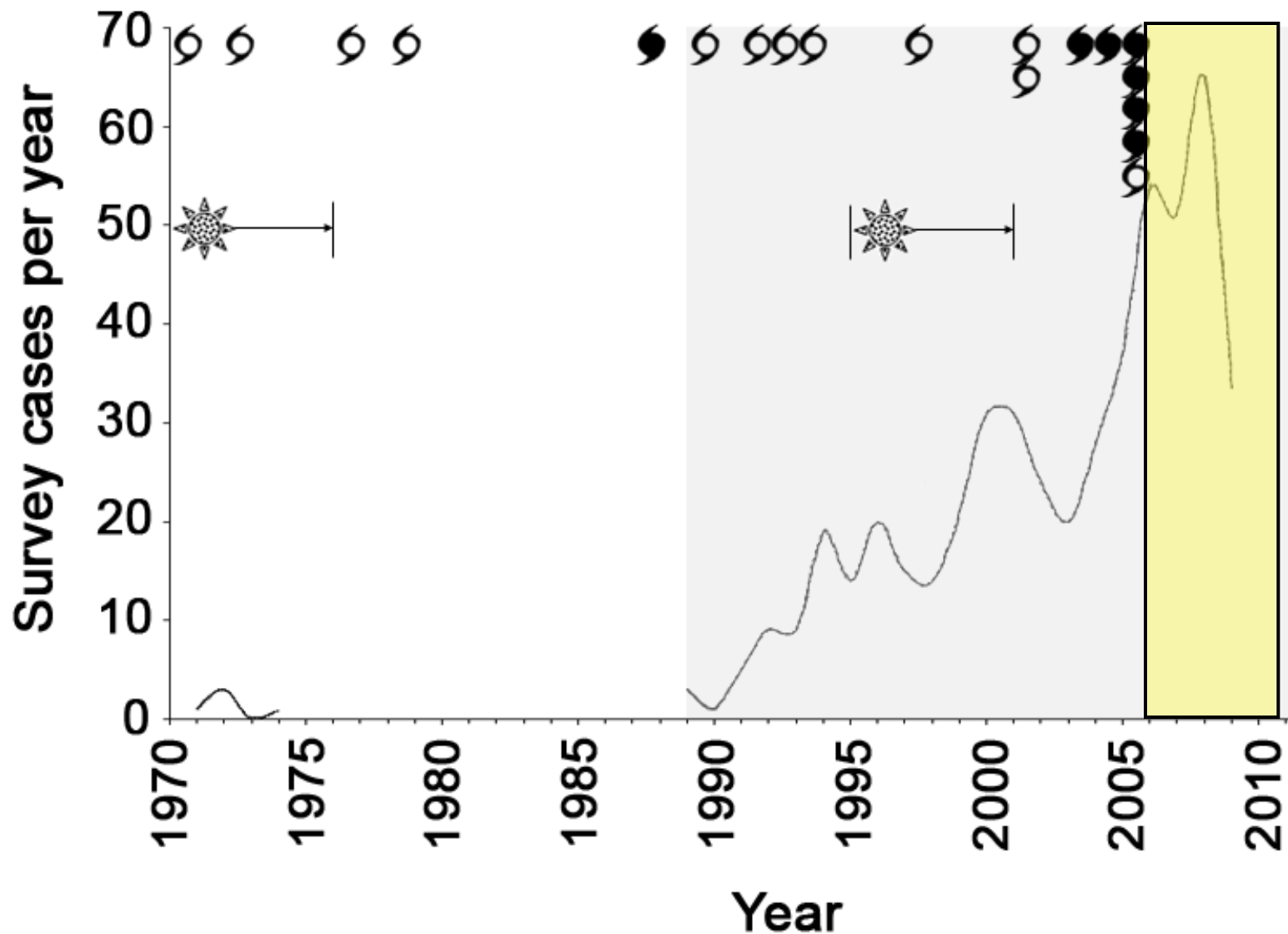
Hales et al. (1999) *Ecosystem Health* 5, p. 23.

Rarotonga (Cook Islands)

1994 – 2011



Reef disturbance events from 1970 to 2011



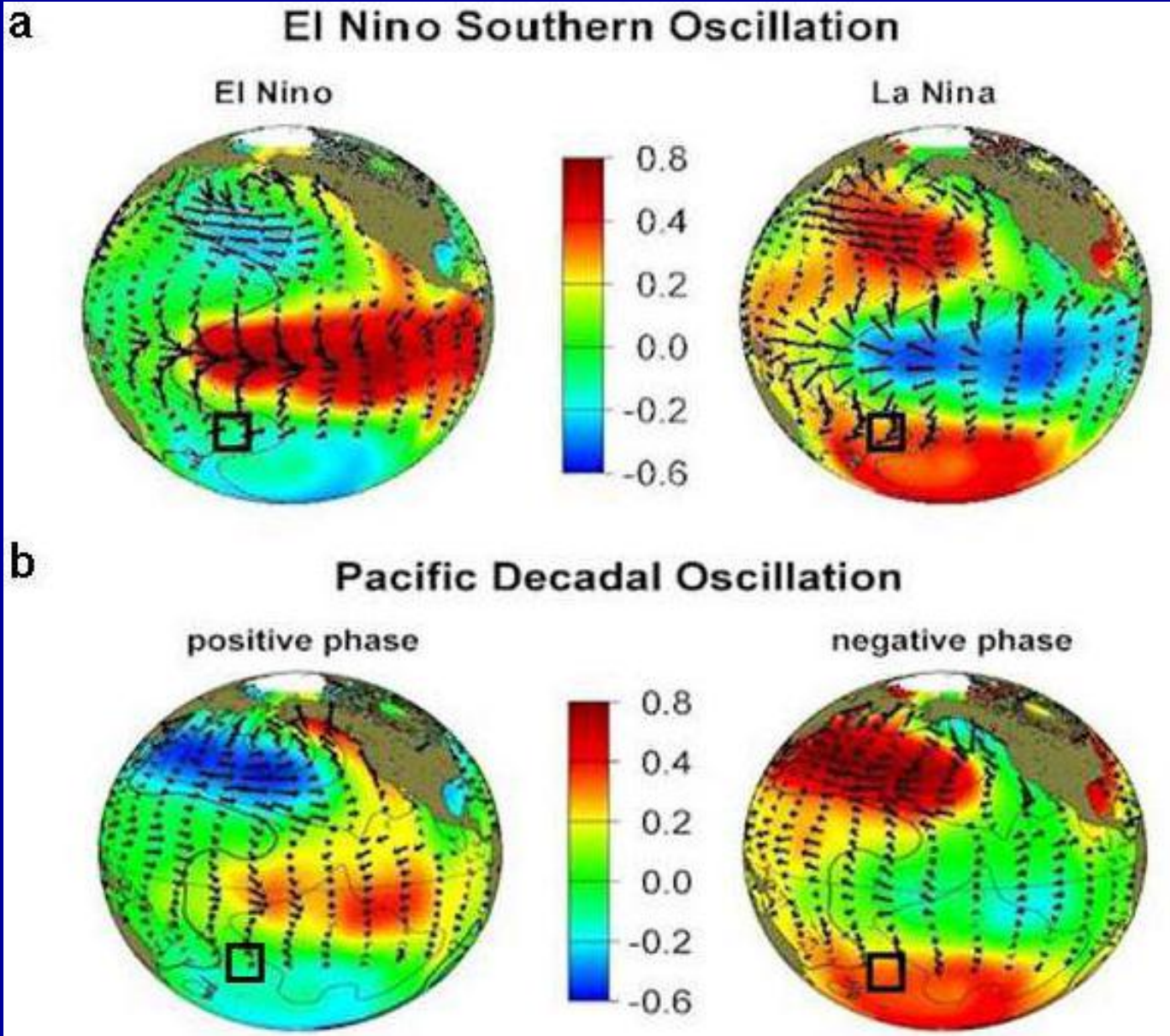
Cyclone occurrence in the Cook Islands

1870 – 2006

ENSO	1870 - 1969	1970 - 2006
El Niño events	28	36
La Niña events	12	6

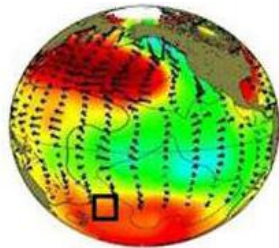
Modified from de Scally (2008)

Coupling effect

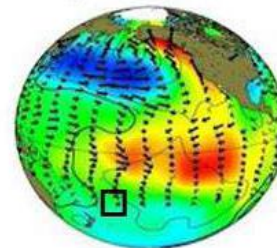


Recent shift in PDO

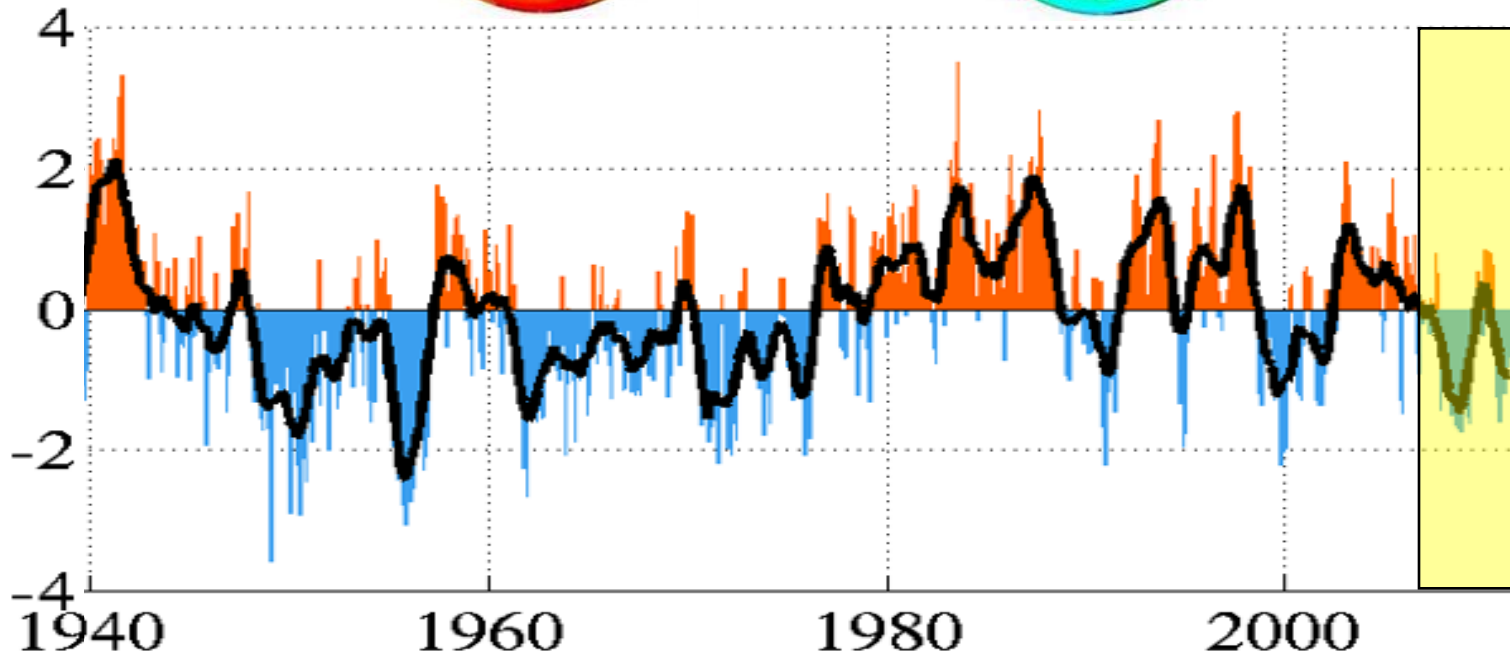
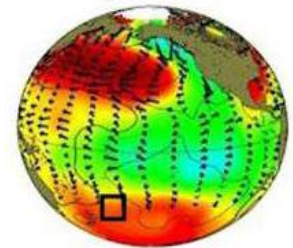
Negative phase



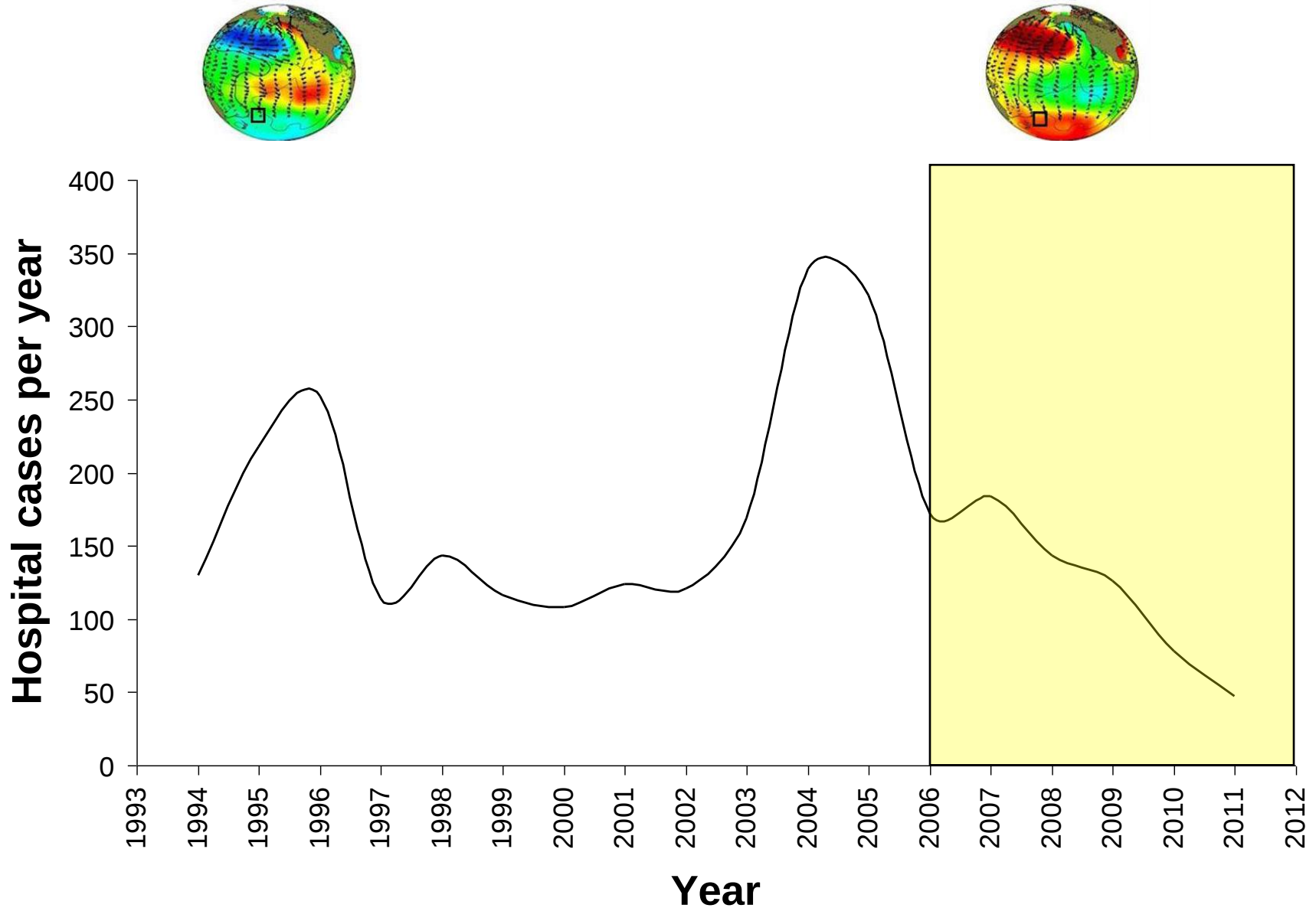
Positive phase



Negative phase



Hospital cases (1994 – 2011)



Is the loss of corals conducive to ciguatera outbreaks?

‘New surface hypothesis’ (Randall 1958)

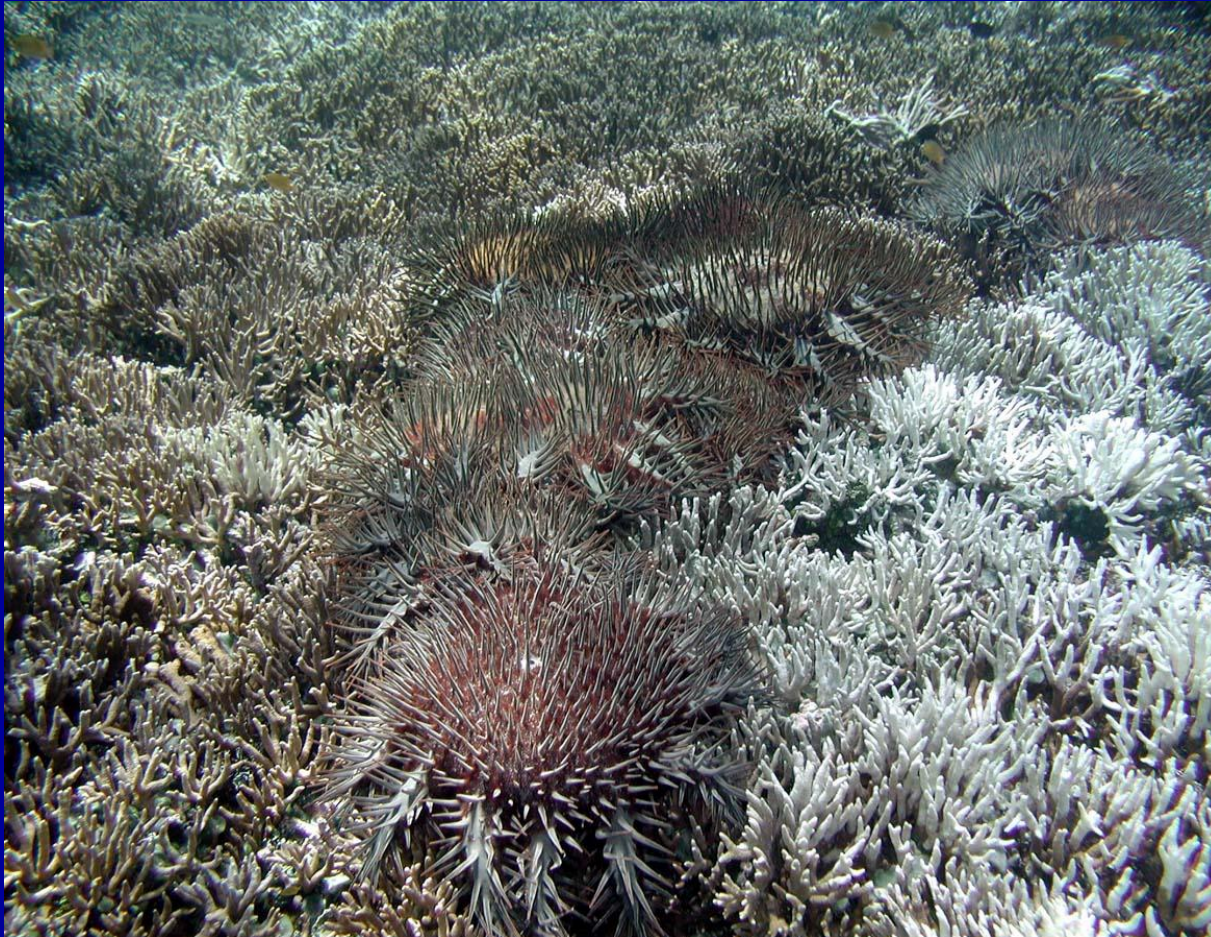
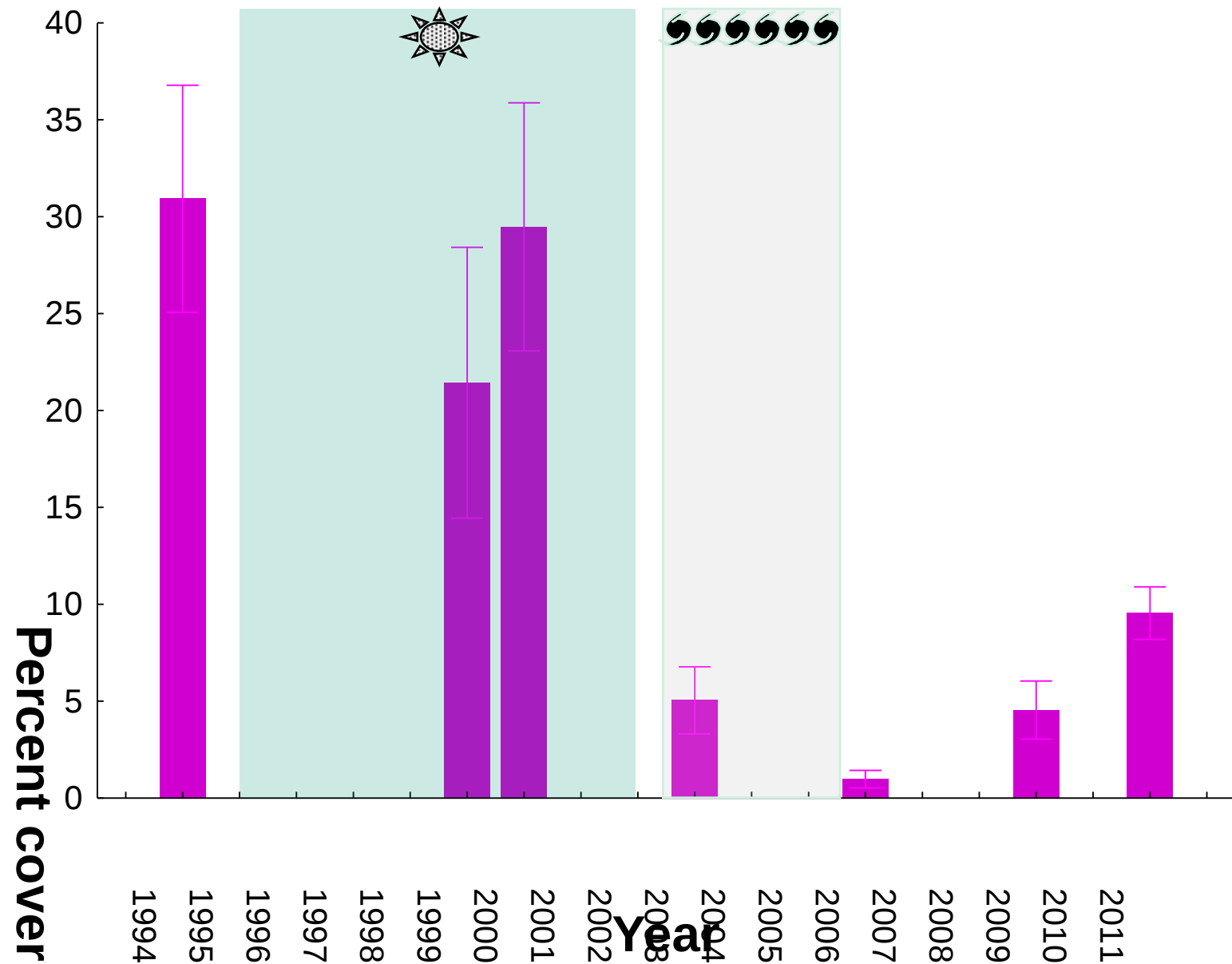


Photo from Dr. Robert van Woesik

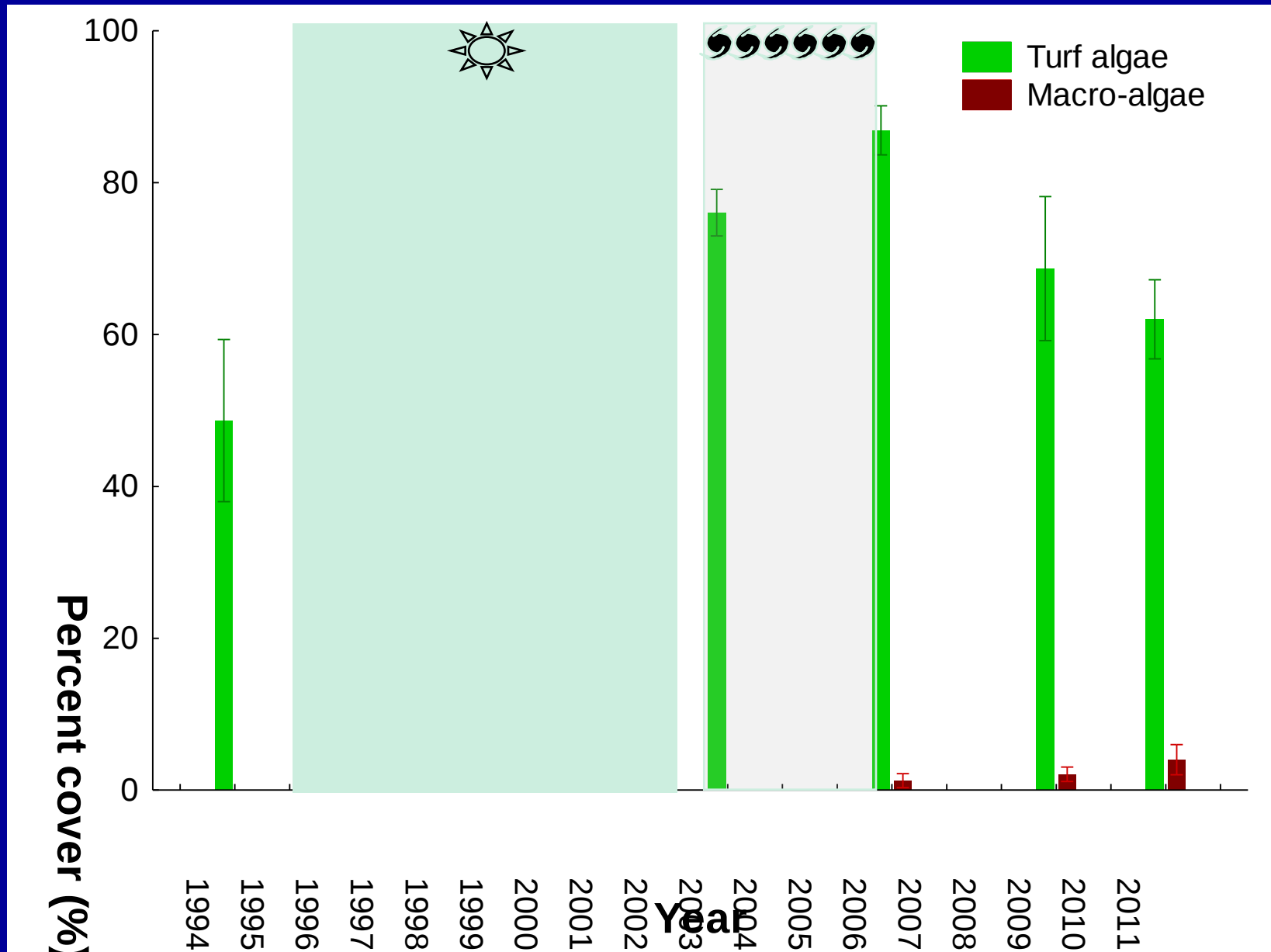
Hard coral



Friedman test (2006 – 2011)

$\chi^2 = 63$, $p < 0.001$

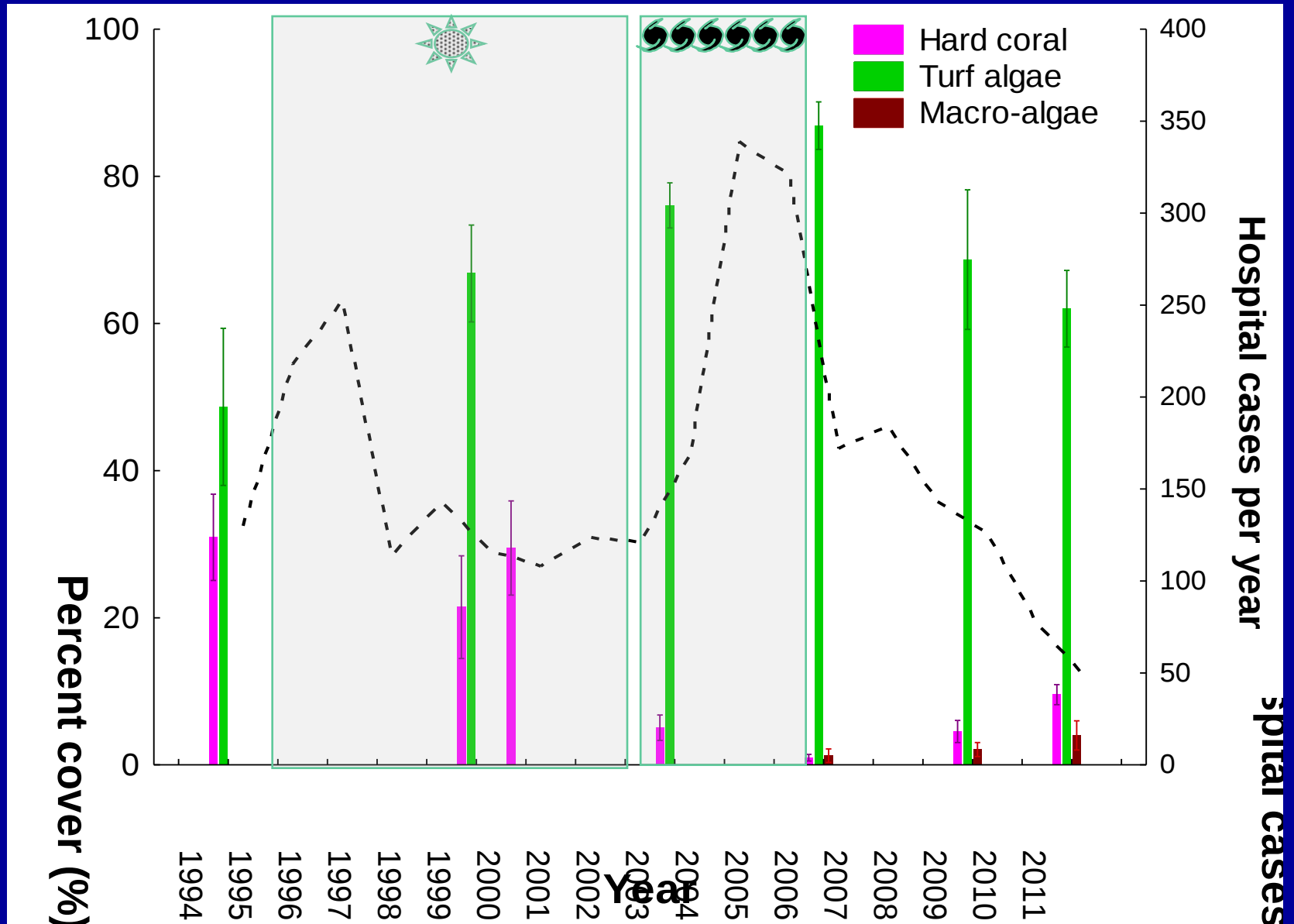
Turf algae & macro-algae



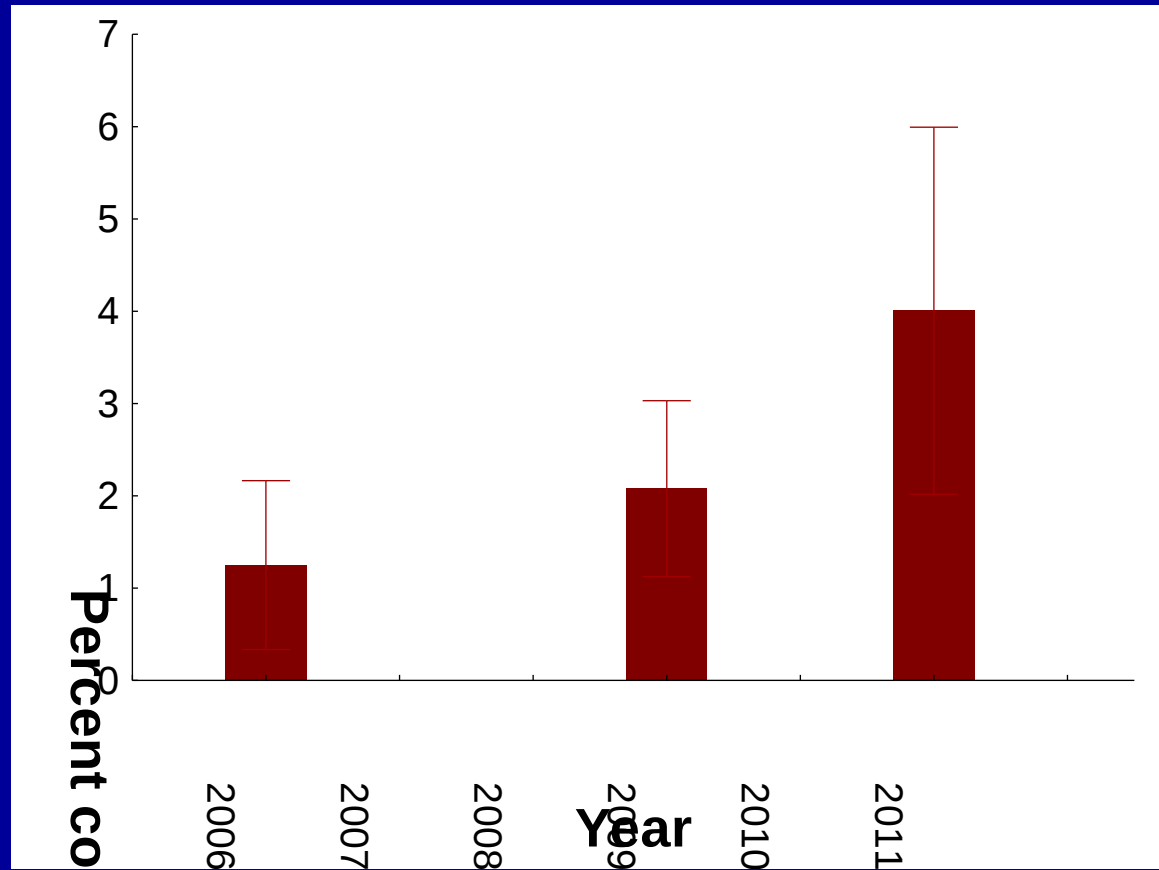
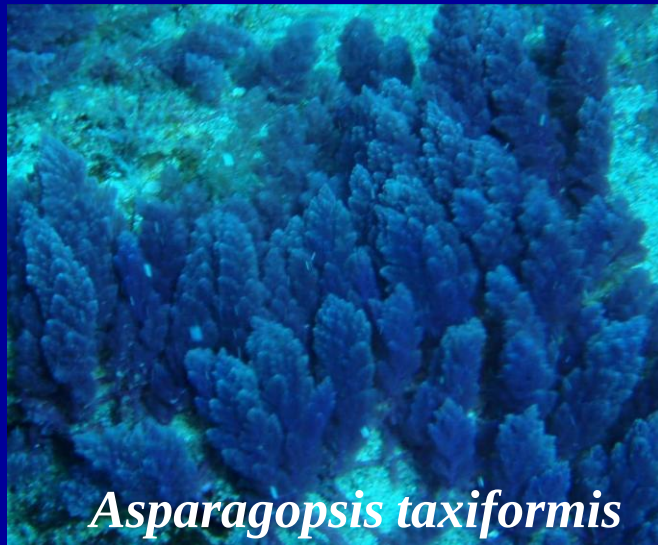
Friedman test (2006 – 2011)

Turf algae: $\chi^2 = 33$, $p < 0.001$
Macro-algae: $\chi^2 = 9$, $p = 0.01$

Hard coral, turf algae, and macro-algae



Macro-algae



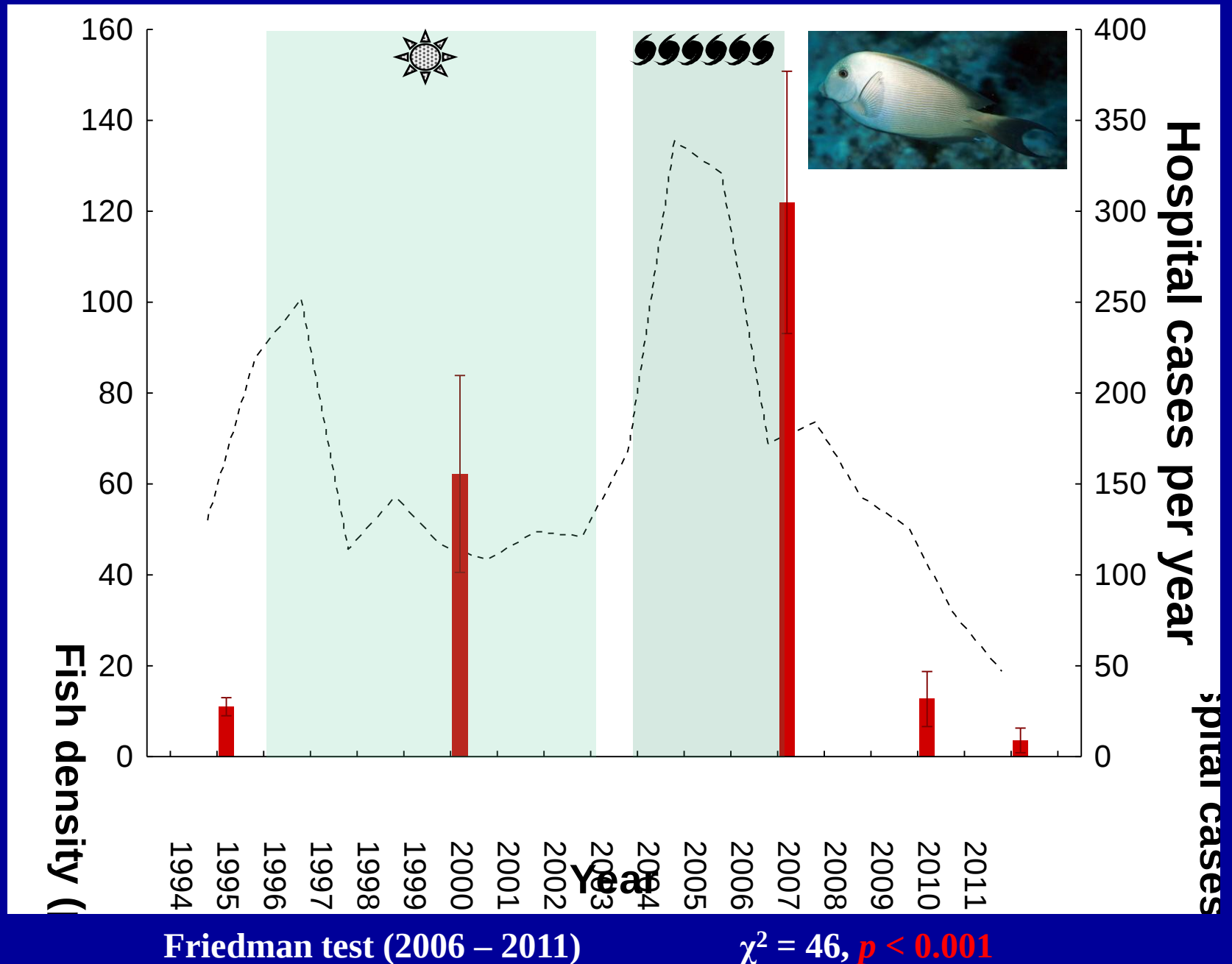
Friedman test (2006 – 2011)

$\chi^2 = 9$, $p = 0.01$

What influence does herbivorous fish density have on the intensity of ciguatera poisoning?



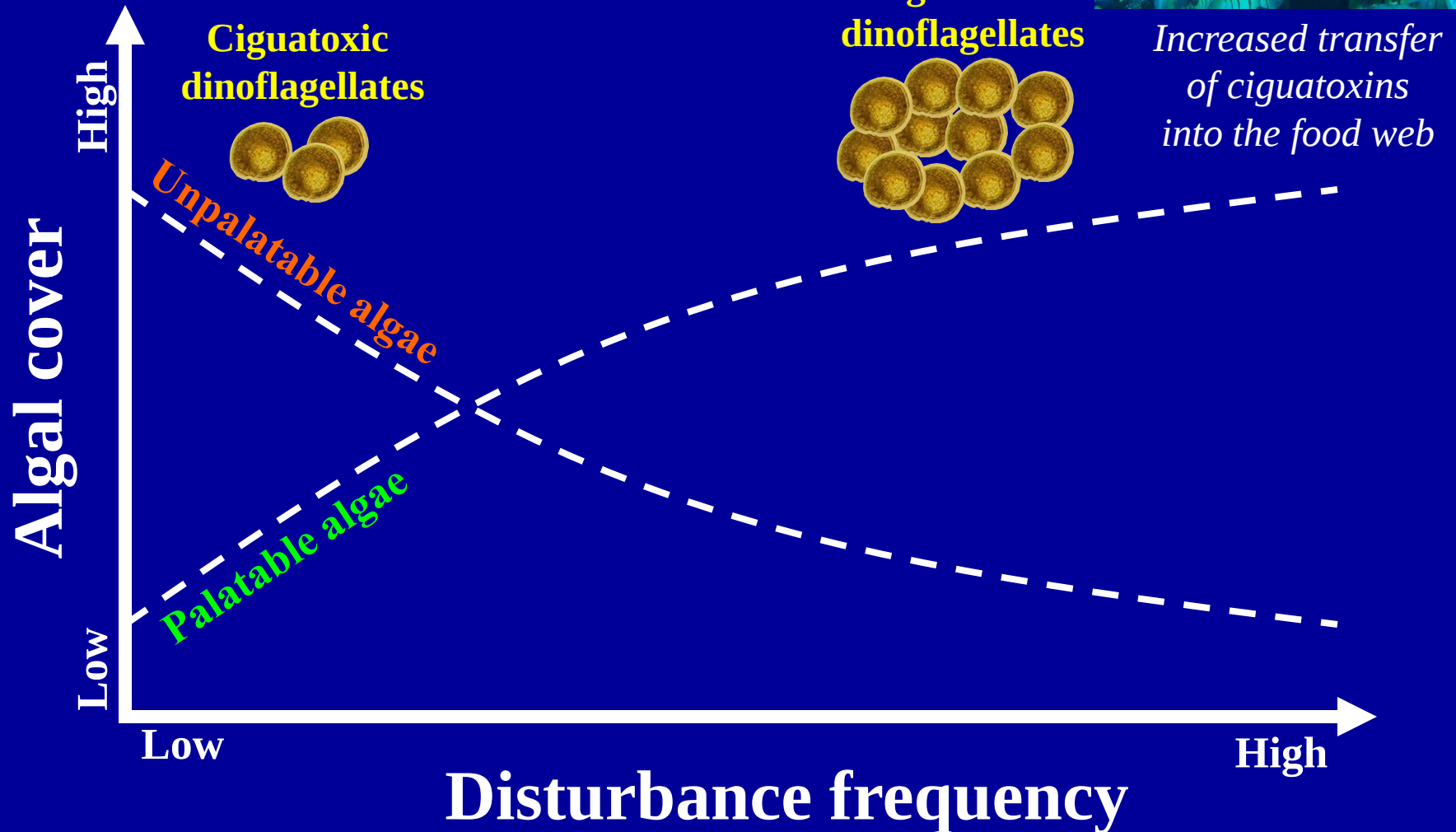
Ctenochaetus striatus



Low fish density



High fish density



Conclusions

- Reef state
 - no influence on cases of ciguatera
- Link with climate
 - cases higher during El Niño & Positive PDO
- Herbivorous fish density
 - increases transfer of ciguatoxin into food web

Predictions

- **Climate oscillation (negative PDO)**
 - Reduces the risk of ciguatera in Rarotonga & southern Cook Islands
- **Global warming**
 - Intensity of cyclones may increase risk of ciguatera
 - Temperature increases may suppress ciguatera in low latitudes
 - Poleward migration of ciguatoxic dinoflagellates may increase the risk of ciguatera in temperate regions

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