

A large school of yellow-striped surgeonfish (Acanthurus lineatus) swimming over a coral reef in clear blue water. The fish are densely packed and move in a coordinated pattern. The coral reef below is diverse, with various species of hard coral visible. The overall scene is vibrant and healthy, typical of a well-maintained tropical reef.

**CIGUATERA POISONING AND
CLIMATE OSCILLATIONS IN
RAROTONGA, SOUTHERN COOK ISLANDS**

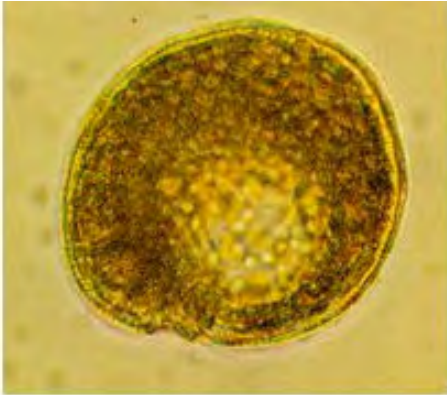
Teina Rongo

What do we know?

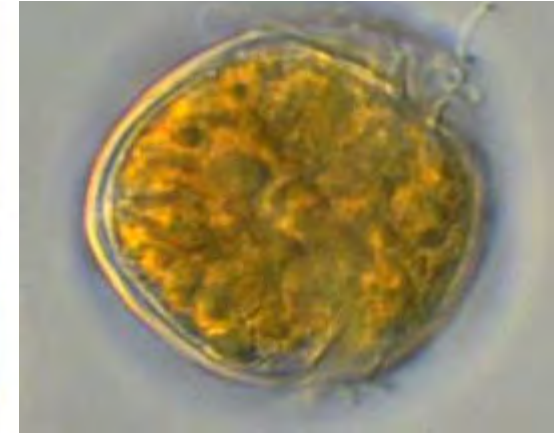
**CIGUATERA
POISONING**



Toxic dinoflagellates



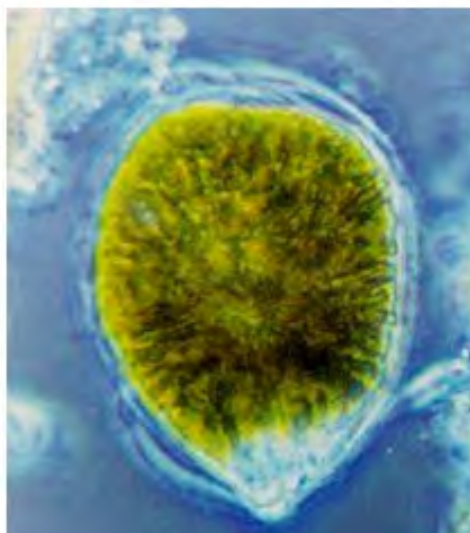
Gambierdiscus toxicus
Adachi and Fukuyo



Coolia monotis
Meunier



Prorocentrum lima
(Ehrenberg) Dodge

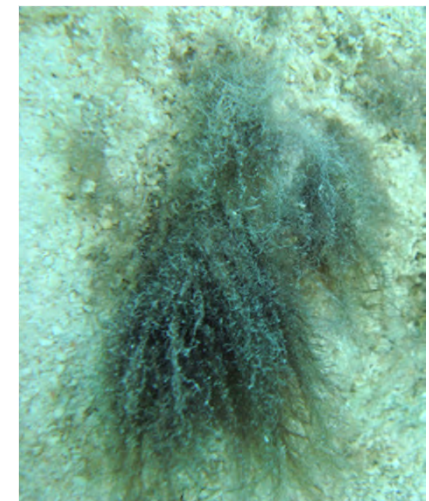


Ostreopsis lenticularis
Fukuyo



Amphidinium carterae
Hulburth

Cyanobacteria



Lyngbya majuscula
Gomont

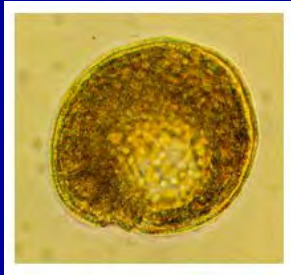
<http://dinos.anesc.u-tokyo.ac.jp/Jpeg/index.htm>

http://content3.eol.org/content/2008/12/10/21/79272_large.jpg

http://biogefahr.shopkeeper.de/cgi-bin/nw/biogefahr-de/process?mv_session_id=EPjayGBj&mv_pc=25&mv_todo=search&fi=bio_db&se=bio_076&sf=code&sp=bio_images&html_wert=2&bild_wert=1

Bioaccumulation & biotransformation of ciguatoxins

Dinoflagellate



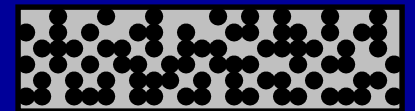
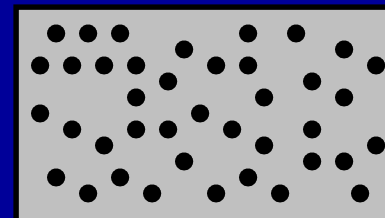
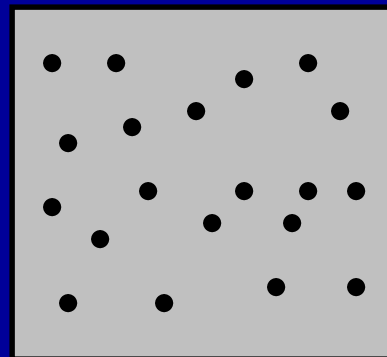
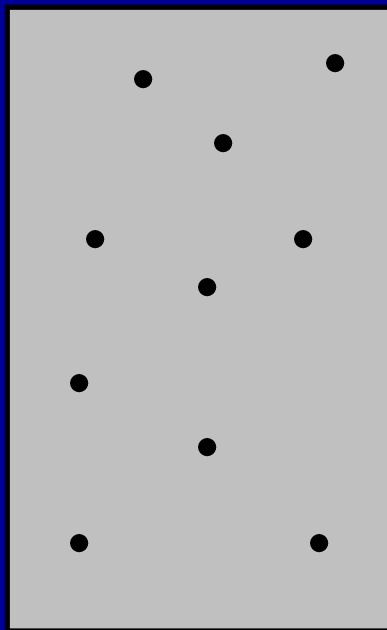
Herbivore



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

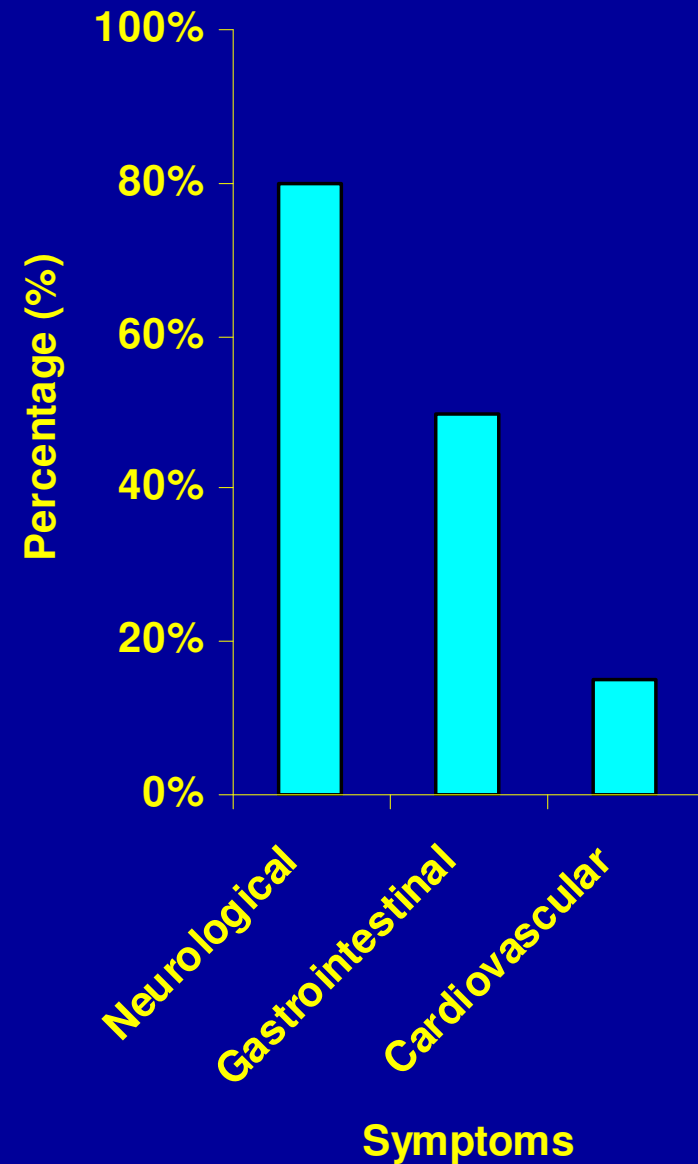
- Numbness & tingling of extremities
- Temperature reversal
- Muscle/joint aches
- Itching
- Memory loss
- Hallucination & nightmares
- Mental depression
- Coma
- Paralysis

Gastrointestinal

- Nausea, diarrhea, & vomiting

Cardiovascular

- Hypotension, tachycardia, & brachycardia



Baumann et al. (2010)

No cure, only supportive treatment

- IV saline



- Herbal remedies

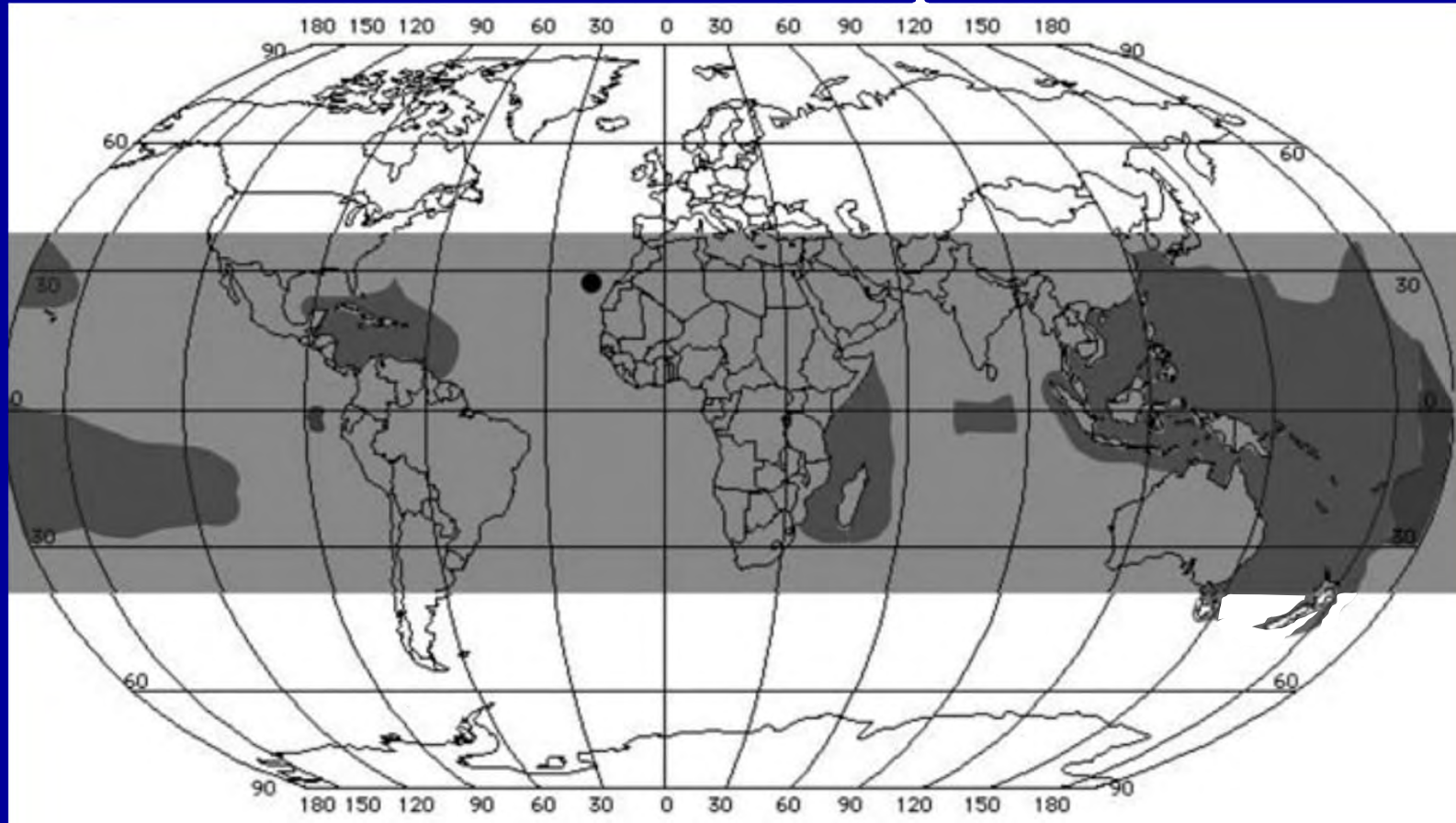


- Live with the problem

Global distribution

50,000 – 500,000 people per year

10 – 20% of cases reported

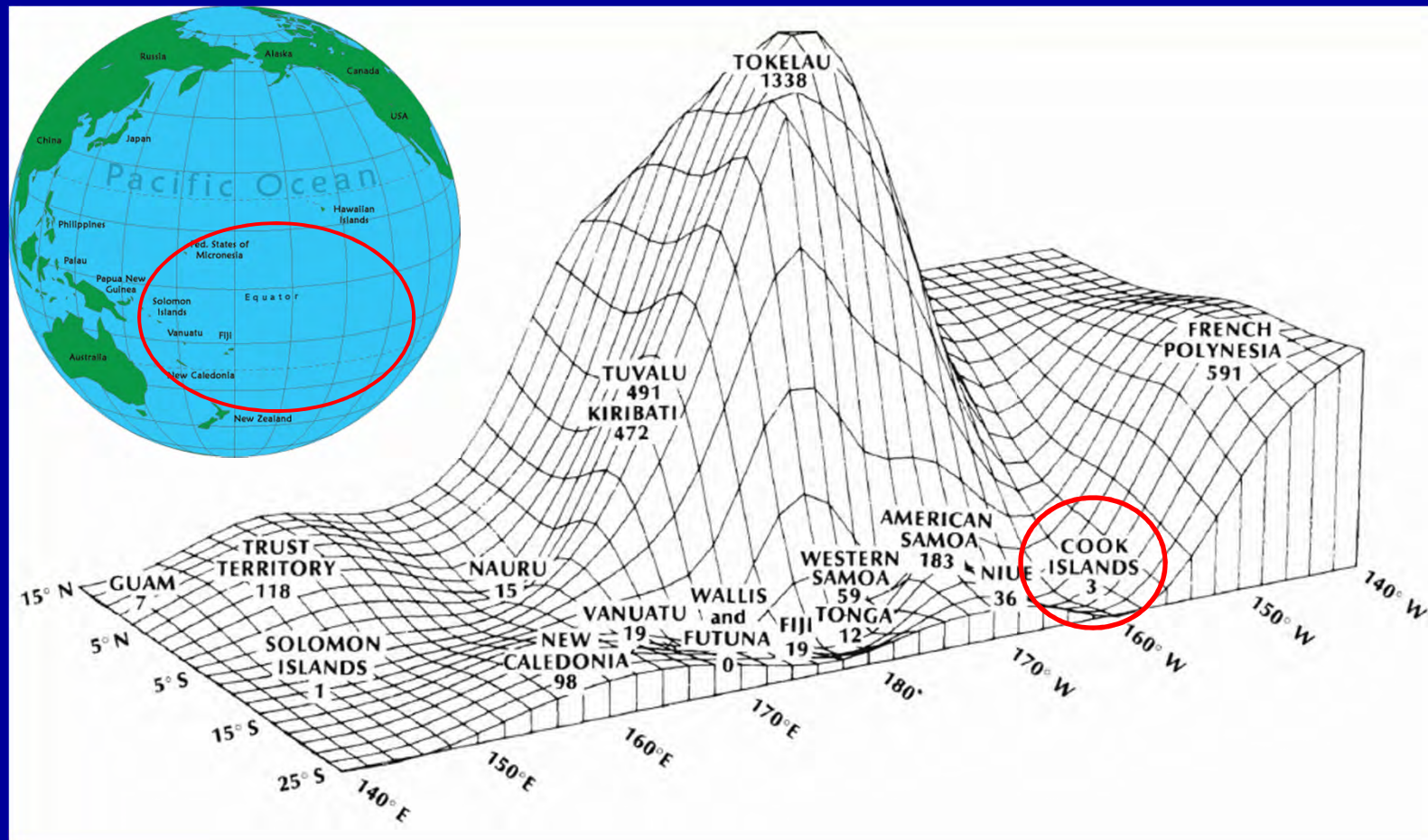


 Coral reef regions between 35° N & 35° S  Ciguatera-endemic regions

Pérez-Arellano et al. (2005) *Emerging Infectious Diseases* 11, p. 1982.

Spatial and temporal distribution

1973 – 1983: Average incidence of ciguatera
(per 100,000 population per year)



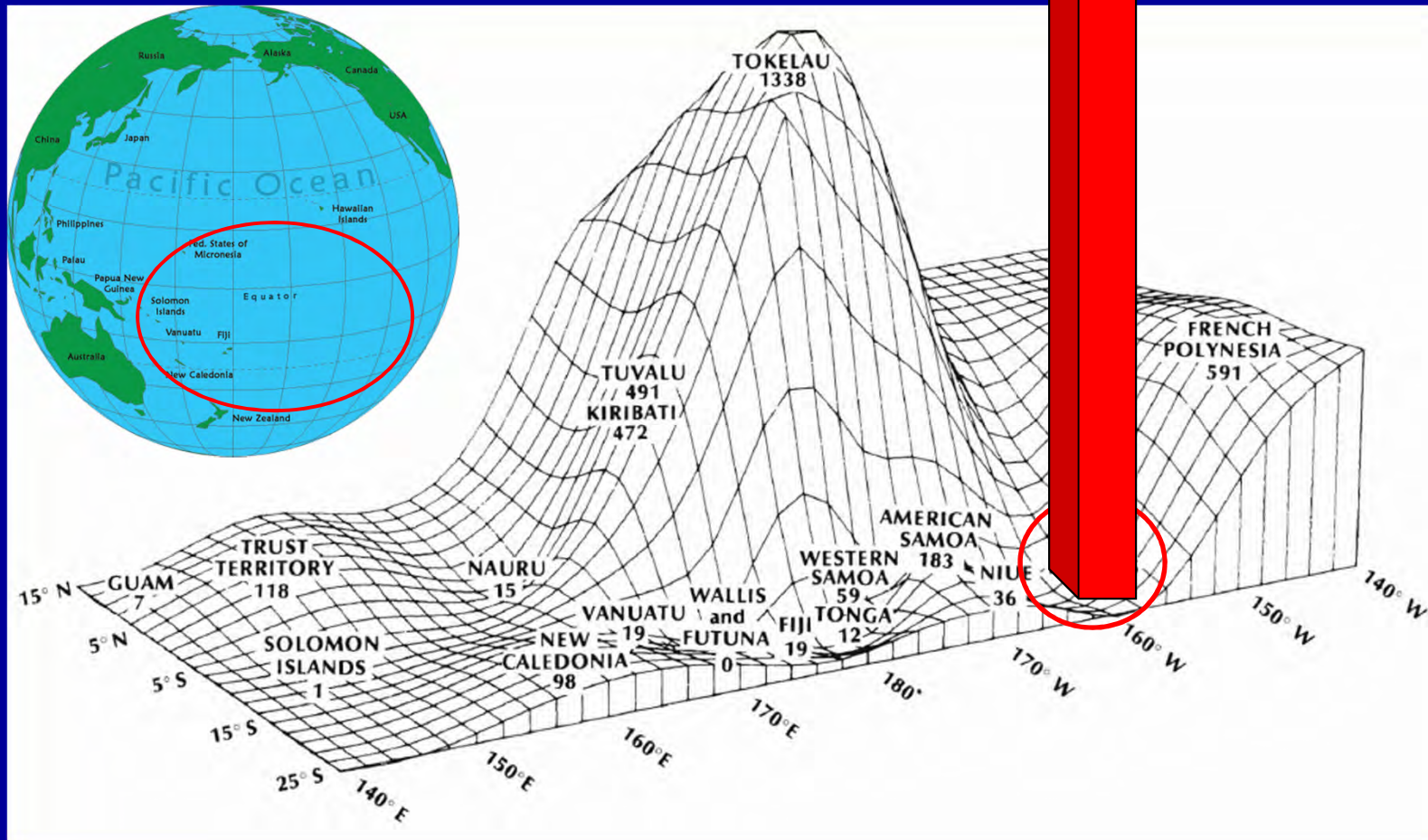
Lewis (1986) *Marine Fisheries Review* 48, p. 8.

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

Rarotonga

1994 – 2006: 1,790 per 100,000 population per year

Rongo et al. (2009)



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

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

What do we know?

**CIGUATERA
POISONING**

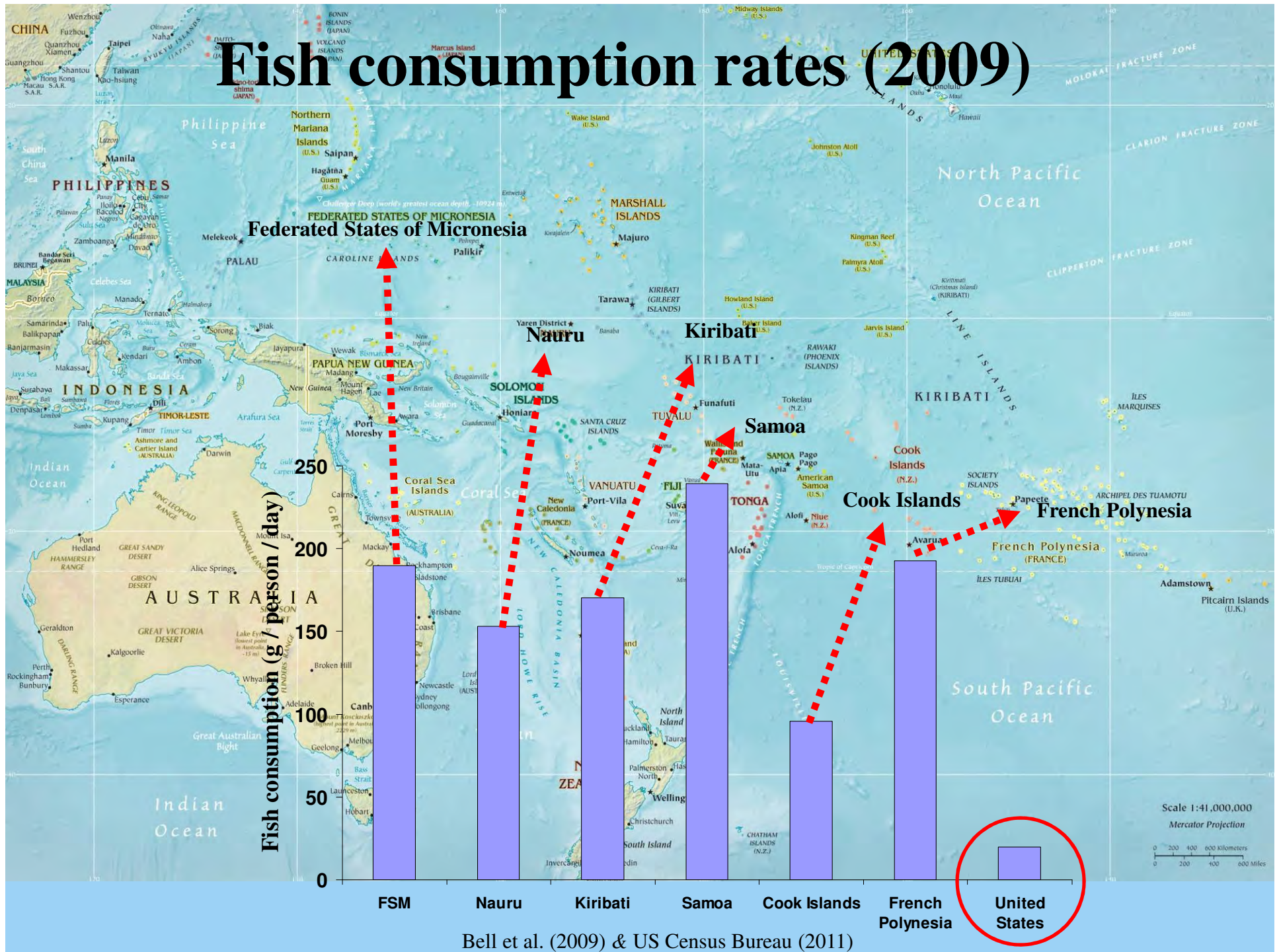
Who cares?

Subsistence fishing lifestyle



Photo from Dr. Peter Houk

Fish consumption rates (2009)



Bell et al. (2009) & US Census Bureau (2011)

Pacific Islands

USA



Loss of labor productivity & health-related costs



http://www.worldofstock.com/stock_photos/SMB1426.php

Lost labor productivity

Tahiti: USD \$1 million per year

(Bagnis et al. 1992)

Health-related costs

Rarotonga: NZD \$730,000 per year

(Rongo and van Woesik 2012)

Loss of revenue



Photo by Dr. Peter Houk

Loss of local reef fish sales

Tahiti: USD \$1 million per year

(Bagnis et al. 1992)

Banned reef fish exports

Kiribati: USD \$256,000 per year

(Yeeting 2009)

Depopulation



Sydney Island, Phoenix Islands (Cooper 1964)

-Abandoned in the 1950s

Cook Islands (Rongo et al. 2009)

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

What do we know?

**CIGUATERA
POISONING**

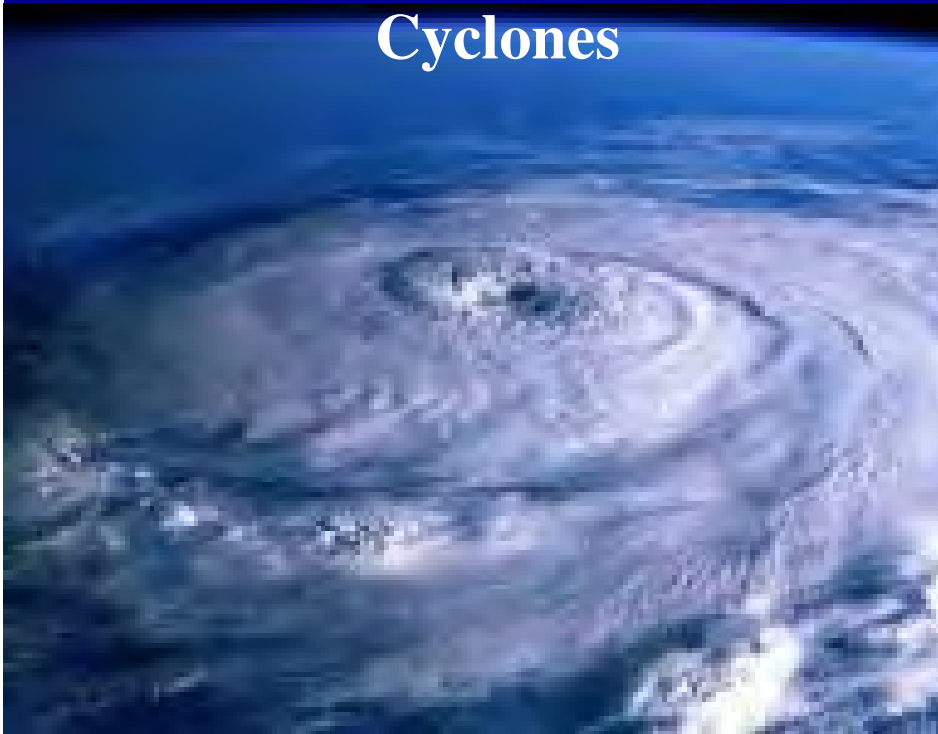
**What do we
need to know?**

Who cares?

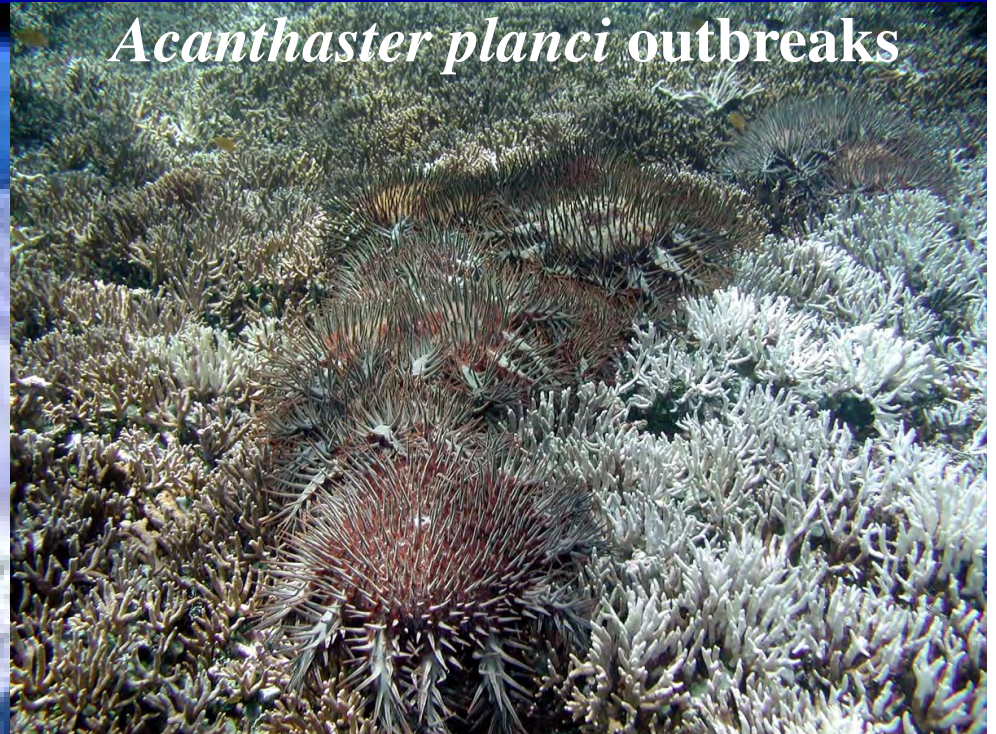
Can reef disturbances lead to outbreaks of ciguatera poisoning?

‘New surface hypothesis’
Randall (1958)

Cyclones

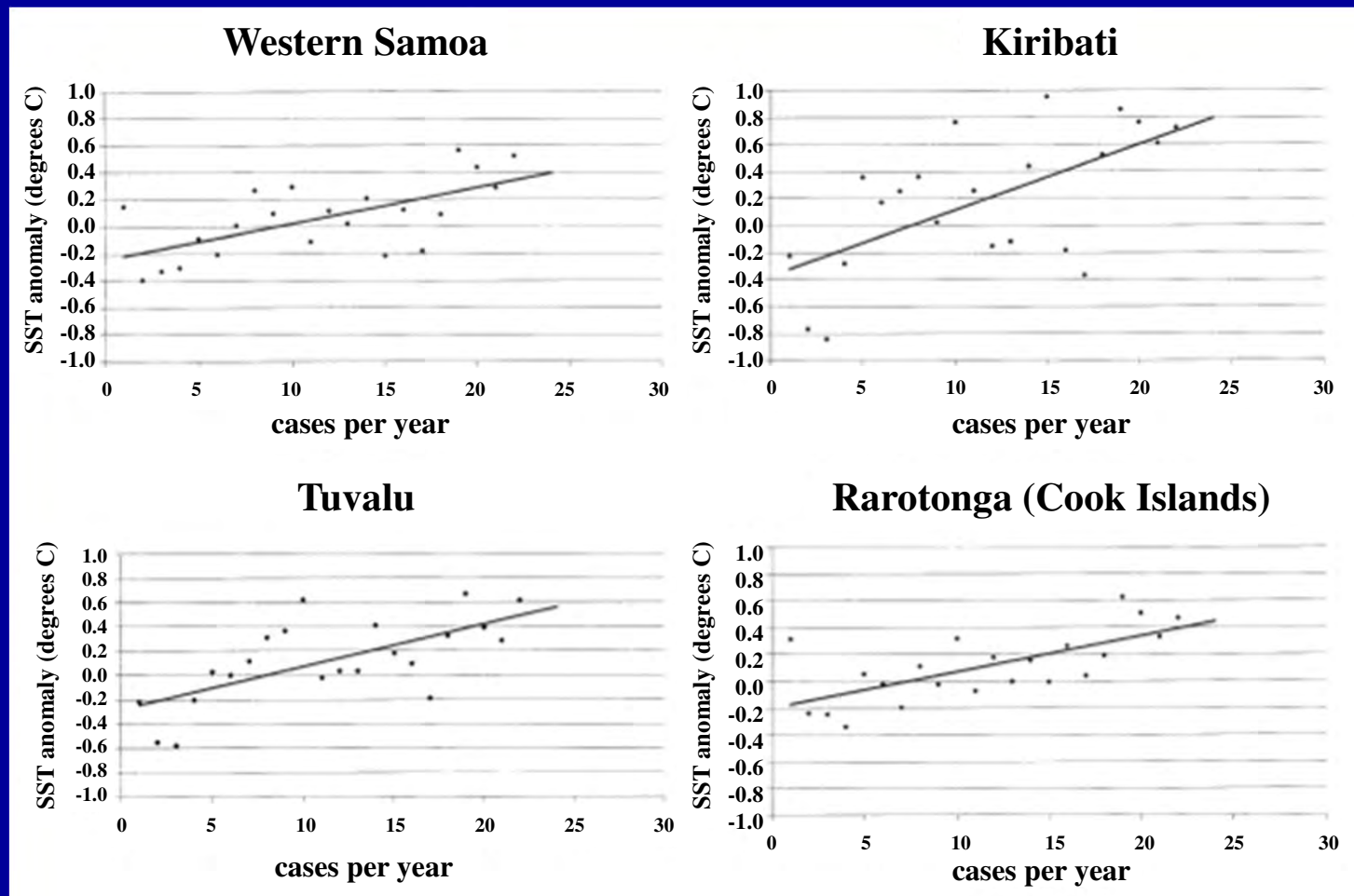


Acanthaster planci outbreaks



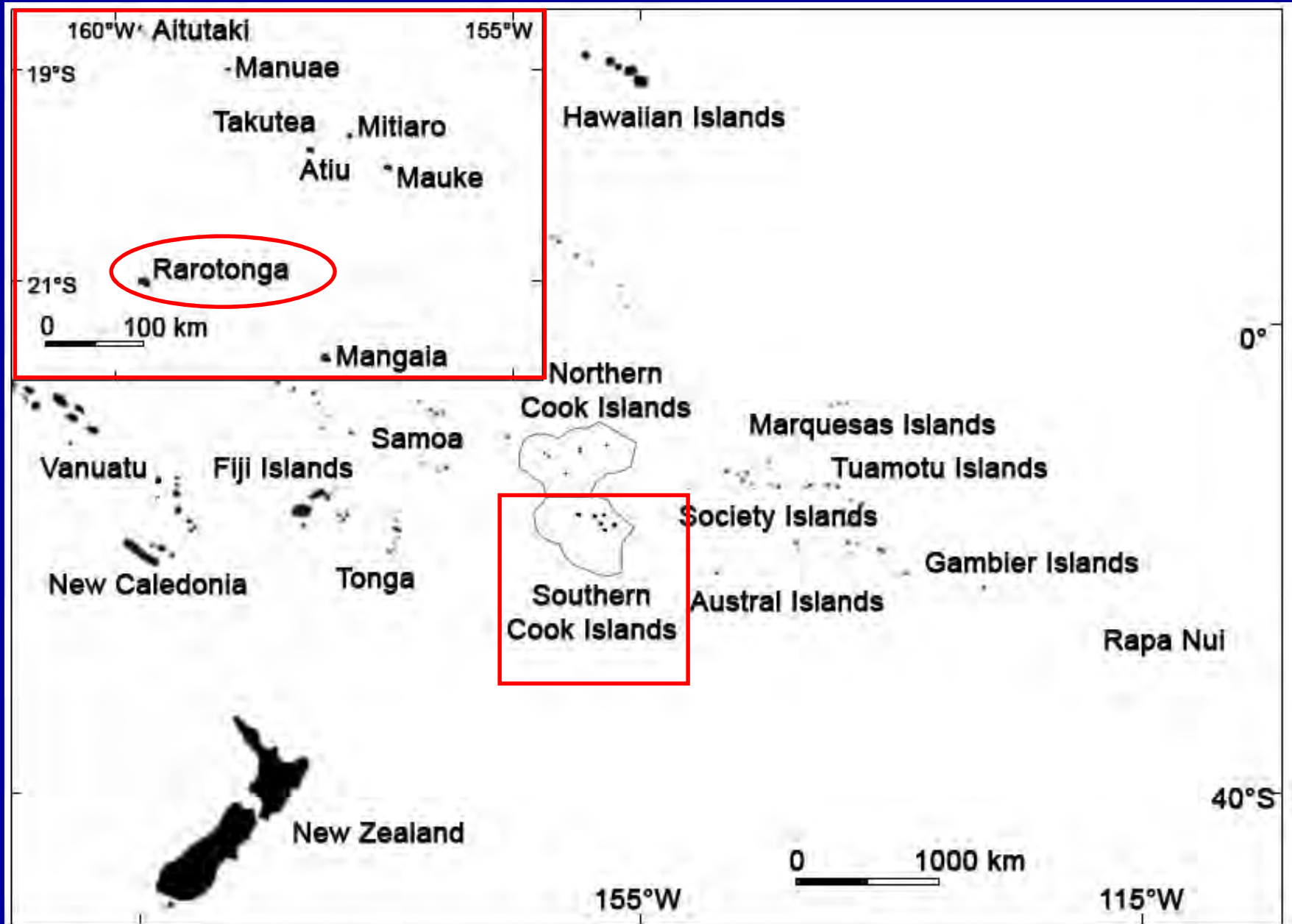
Is ciguatera poisoning linked to climate?

‘Climate oscillation hypothesis’ 1973 - 1994



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

Study location



Study location

- Ciguatera poisoning has been chronic for over 20 years
- 67% of Cook Islanders reside here
- Subsistence fishing

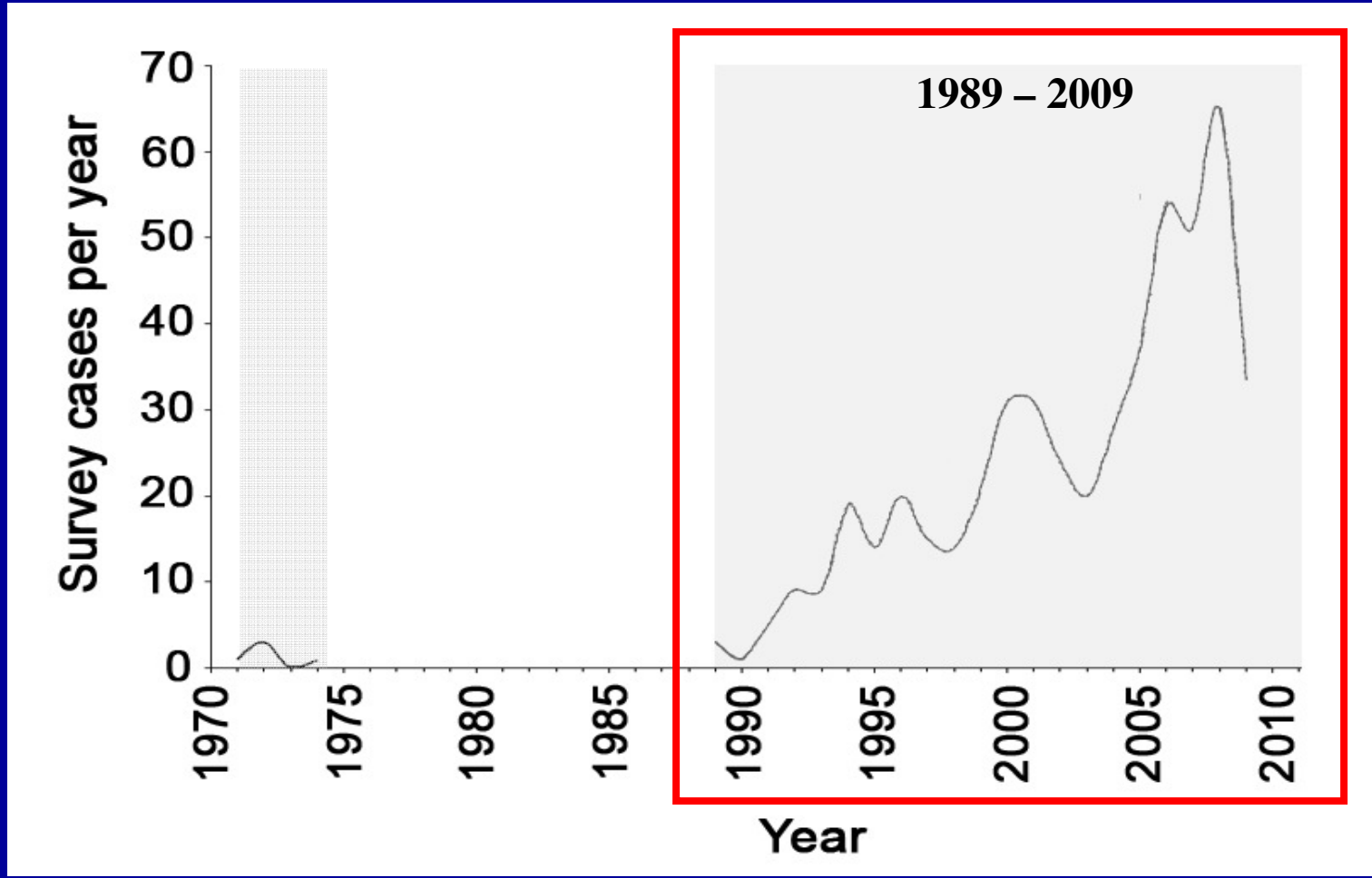


Methods

Questionnaire survey (626 individuals)

- Date of poisoning
 - Reported vs. unreported
- Symptoms
- Species implicated
- Location caught

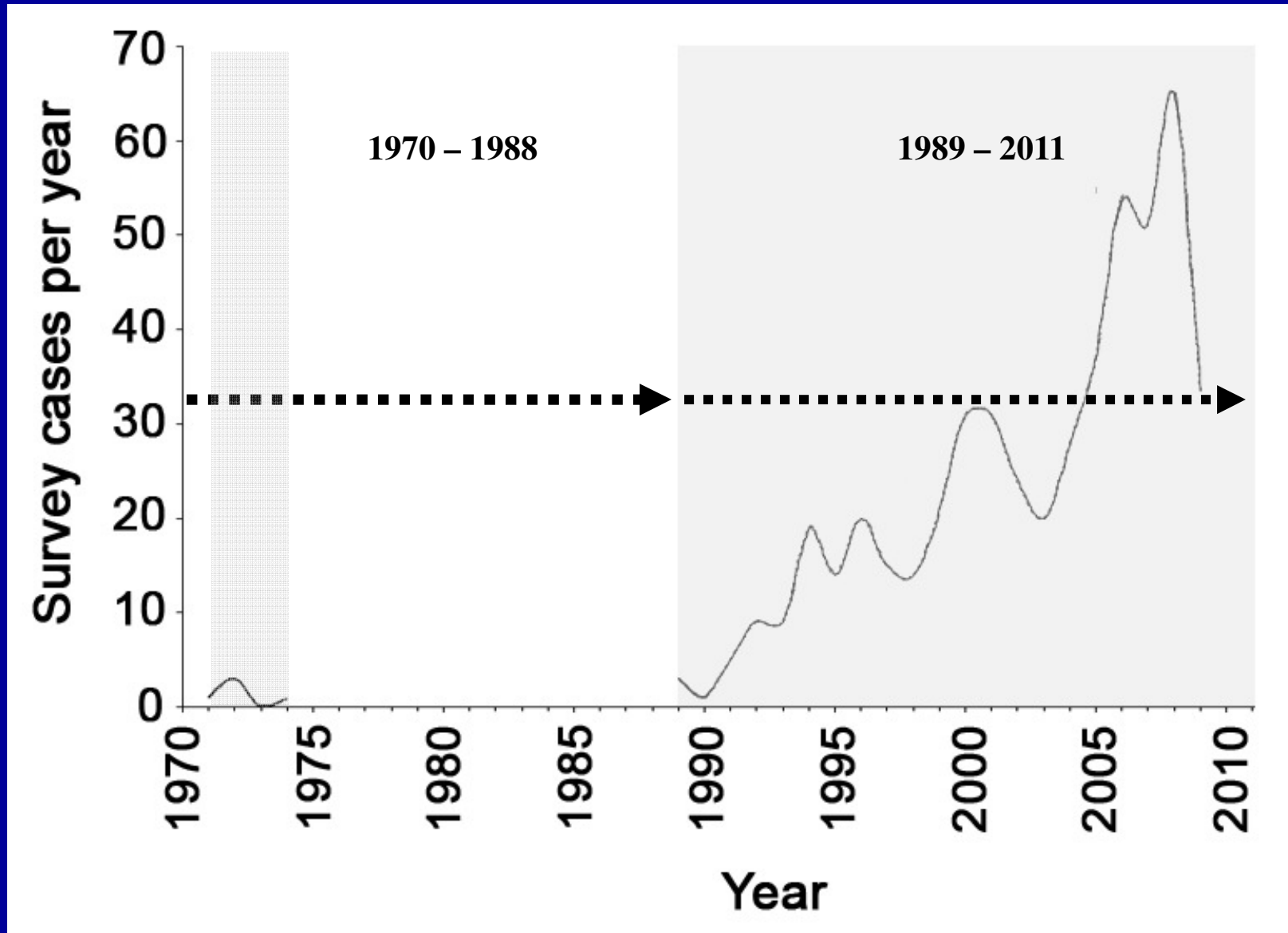
Survey cases



Can reef disturbances lead to outbreaks
of ciguatera poisoning?

‘New surface hypothesis’
(Randall 1958)

Methods



Cyclones



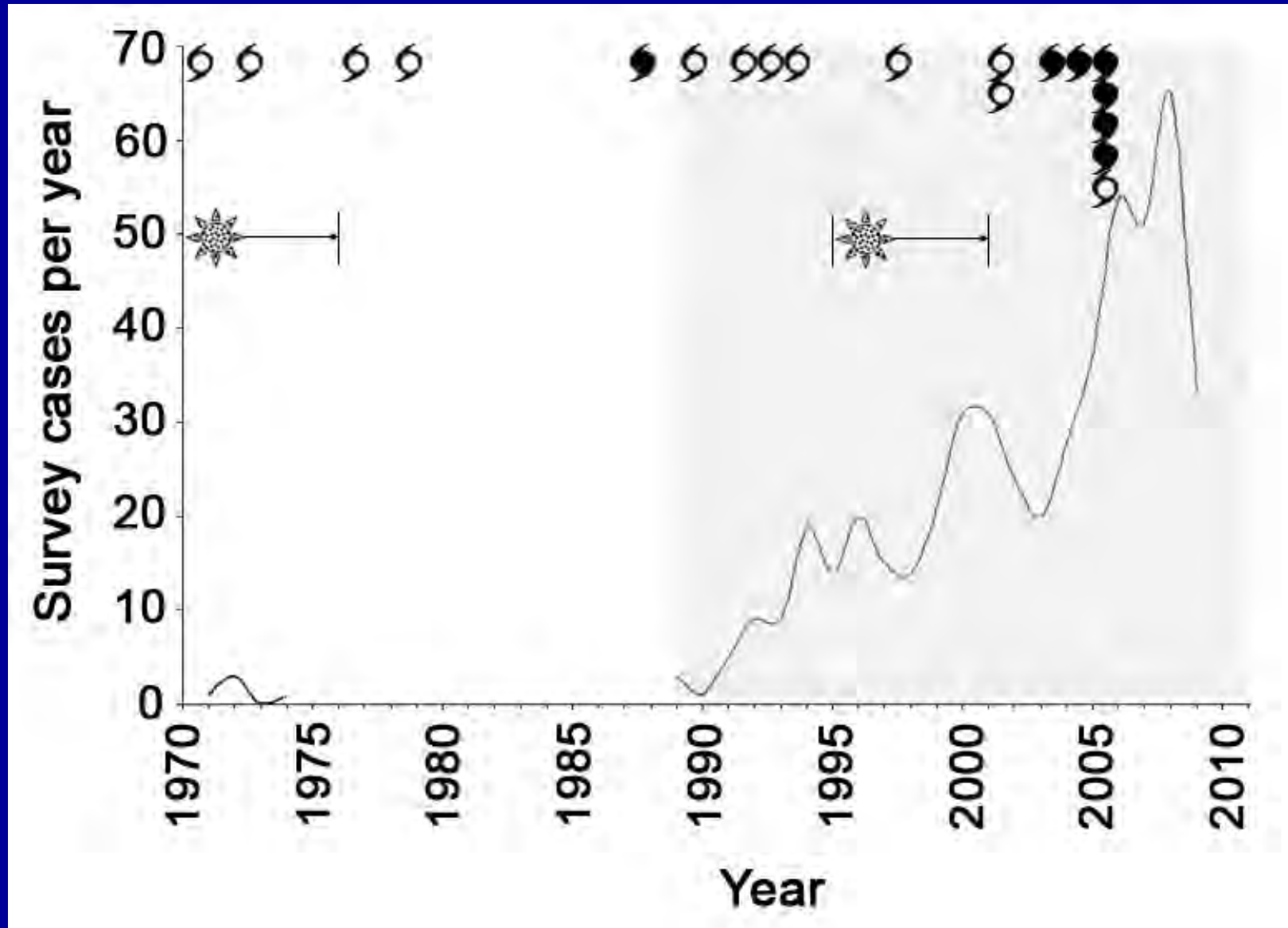
Photos by Cook Islands Herald, pacificbusinessonline.com, & feww.wordpress.com

Acanthaster planci outbreaks

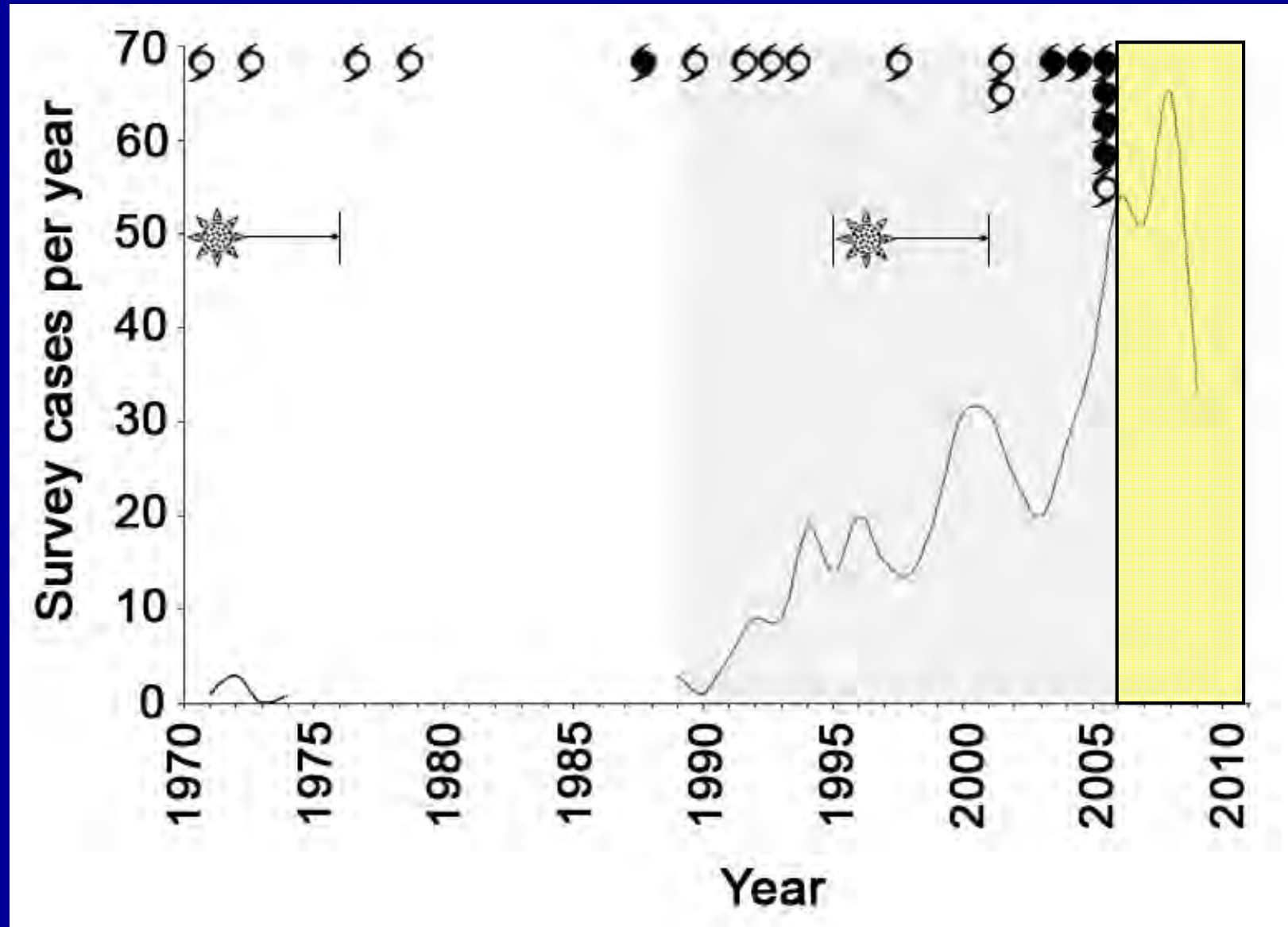


Photo from Dr. Robert van Woesik

Reef disturbance events from 1970 to 2011



No major disturbance after 2005



Is ciguatera poisoning in Rarotonga
linked to major climate cycles?

‘Climate oscillation hypothesis’
(Hales et al. 1999)

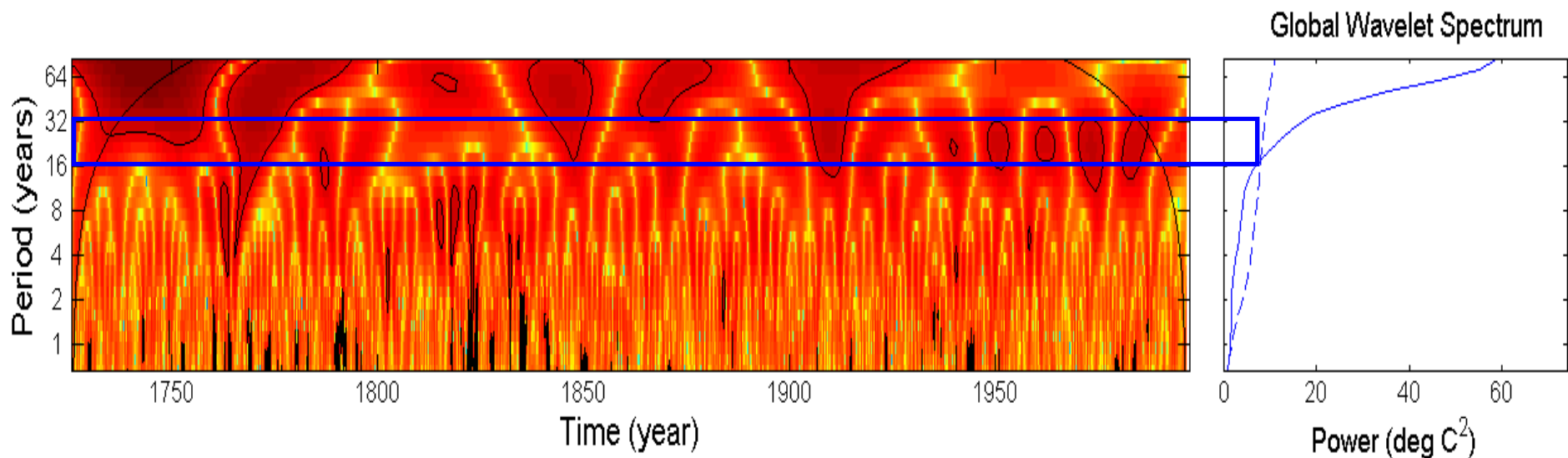
Methods

- SST: ~270-yr dataset from a Rarotonga coral
 - Linsley et al. (2000)
- Southern Oscillation Index (SOI)
 - Australia's National Climate Centre
- Rarotonga Hospital records of ciguatera poisoning (1994 – 2011)
 - Cook Islands Ministry of Health

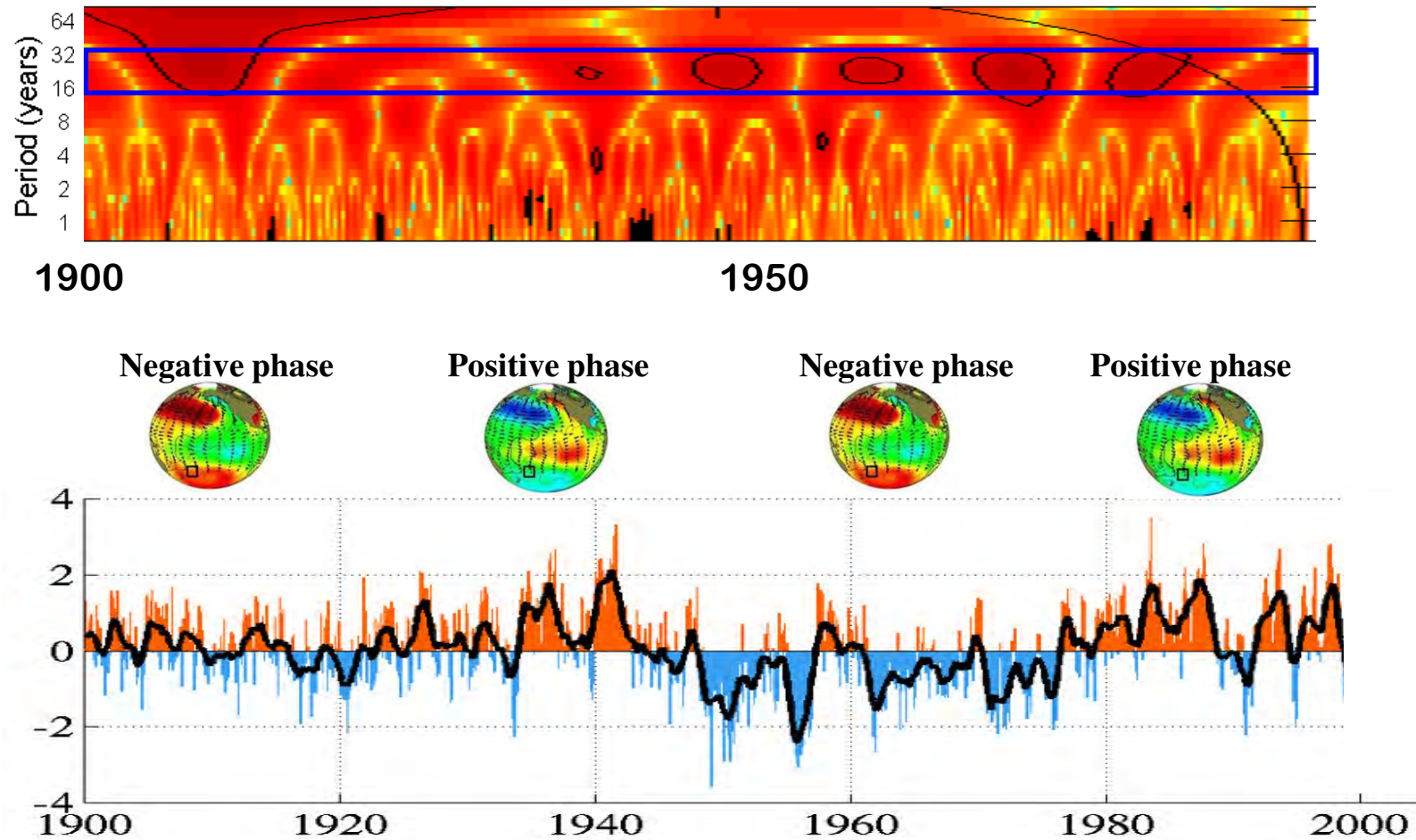
Analysis

- Wavelet
 - amplitude of periodic signals
 - amplitude variability over time
- Cross wavelet
 - common power between two time series data

Wavelet analysis of a ~270-yr SST dataset from a Rarotonga coral (Linsley et al. 2000)



Pacific Decadal Oscillation

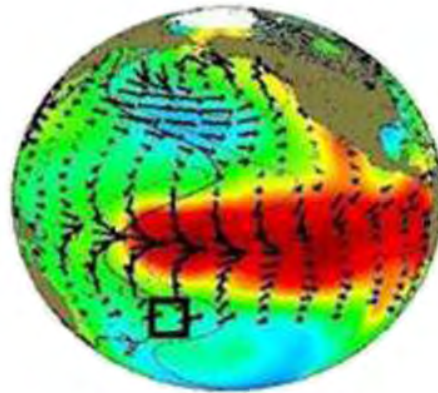


<http://jisao.washington.edu/pdo/>

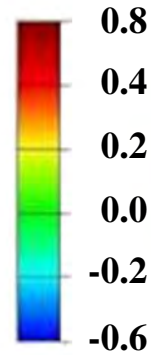
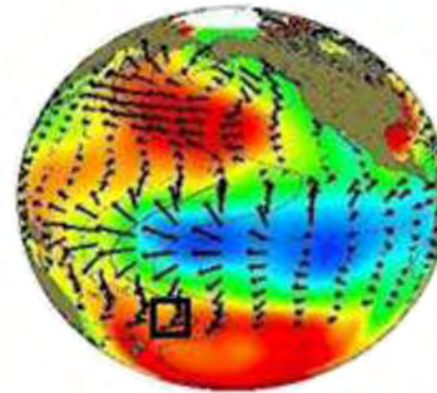
Coupling effect

El Niño Southern Oscillation

El Niño

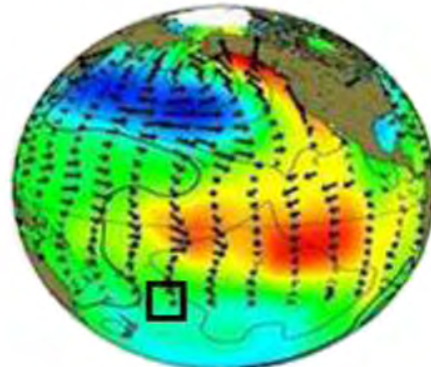


La Niña

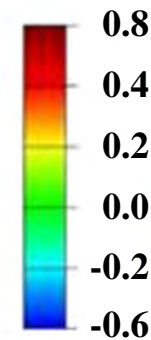
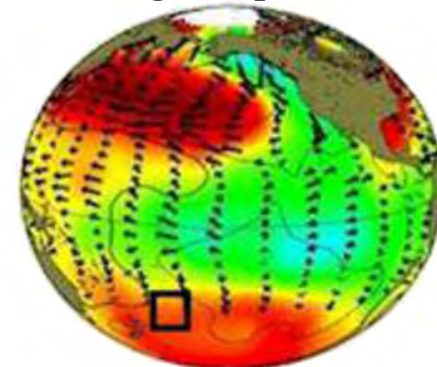


Pacific Decadal Oscillation

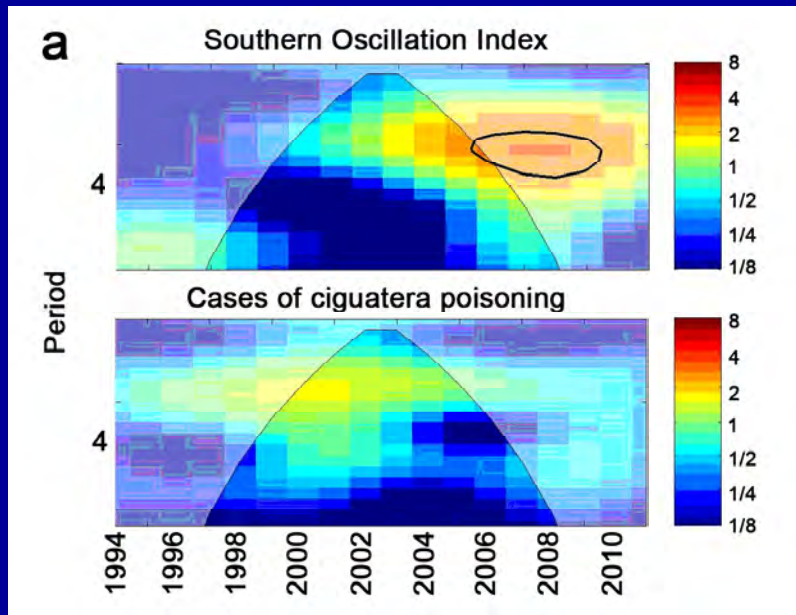
Positive phase



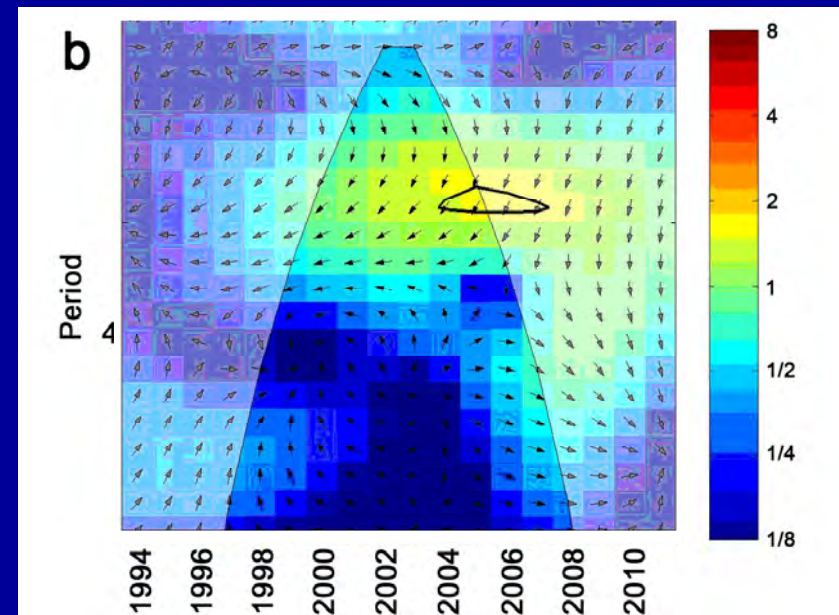
Negative phase



Cross-wavelet analysis of SOI and cases of ciguatera (1994 – 2011)



Wavelet



Cross-wavelet

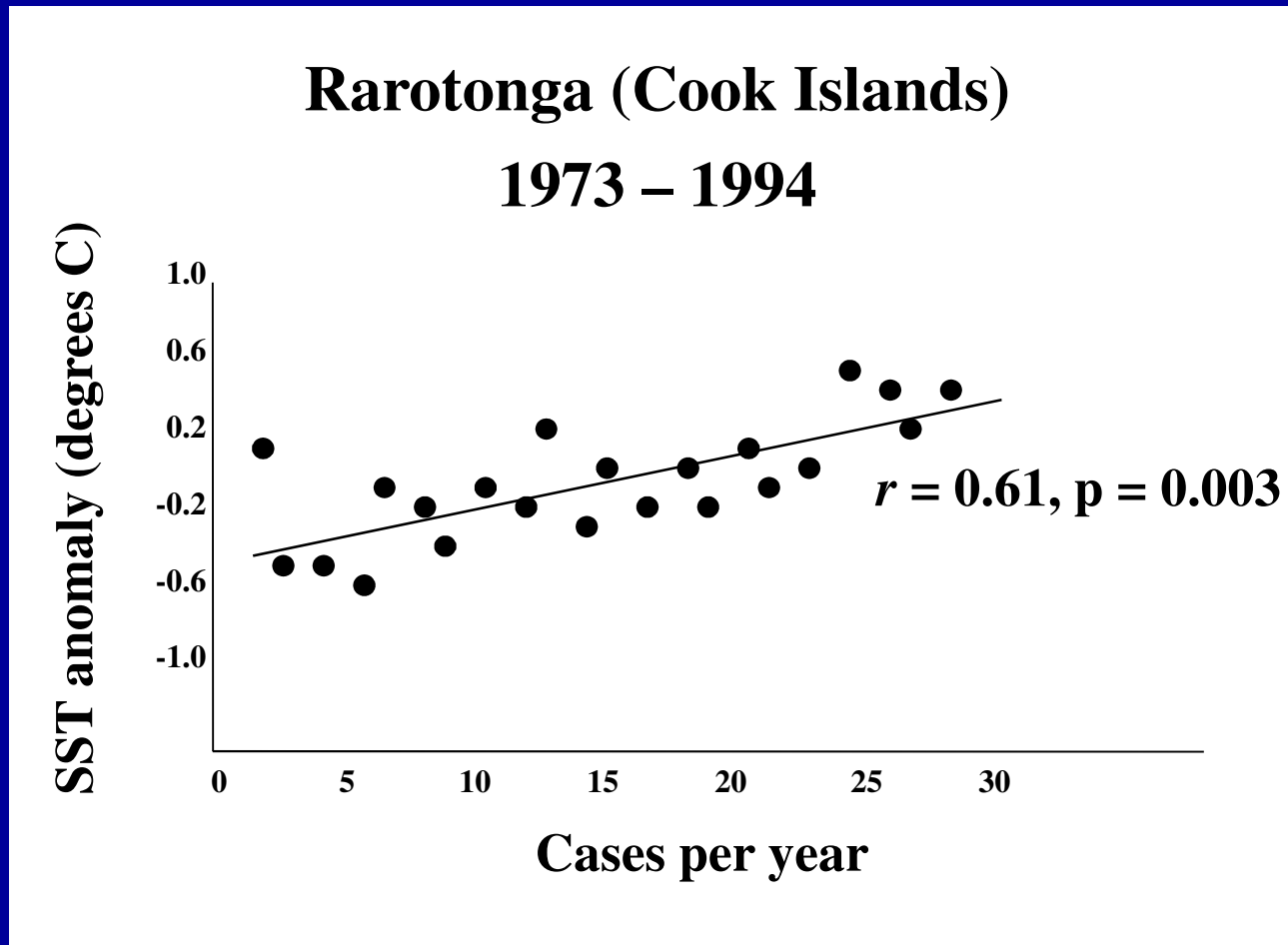
Cyclone occurrence in the Cook Islands 1870 – 2006

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

de Scally (2008) *Pacific Science* 62 (4), 443 – 459.

'Climate oscillation hypothesis' (Hales et al. 1999)

Discrepancies in analysis



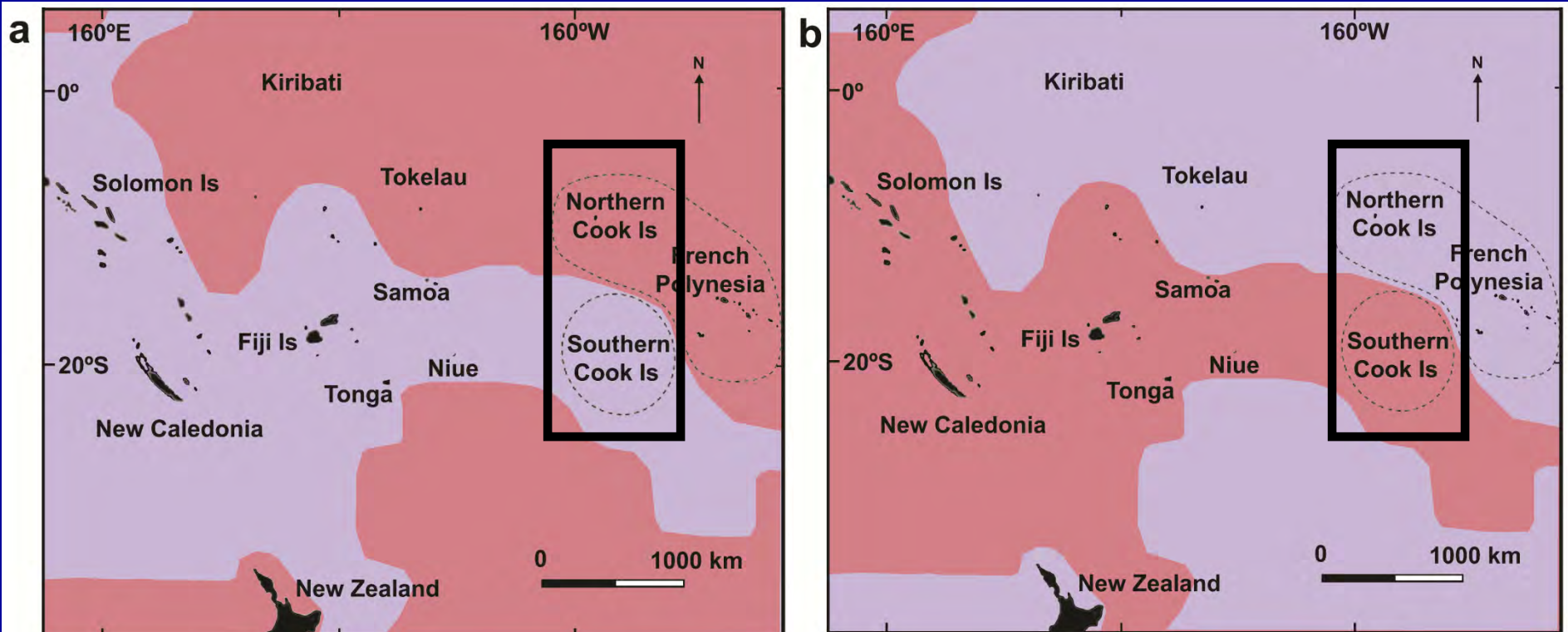
Cases: Northern Cook Islands

SST: Rarotonga (southern Cook Islands)

Regional SST

El Niño

La Niña



Blue = cool regions

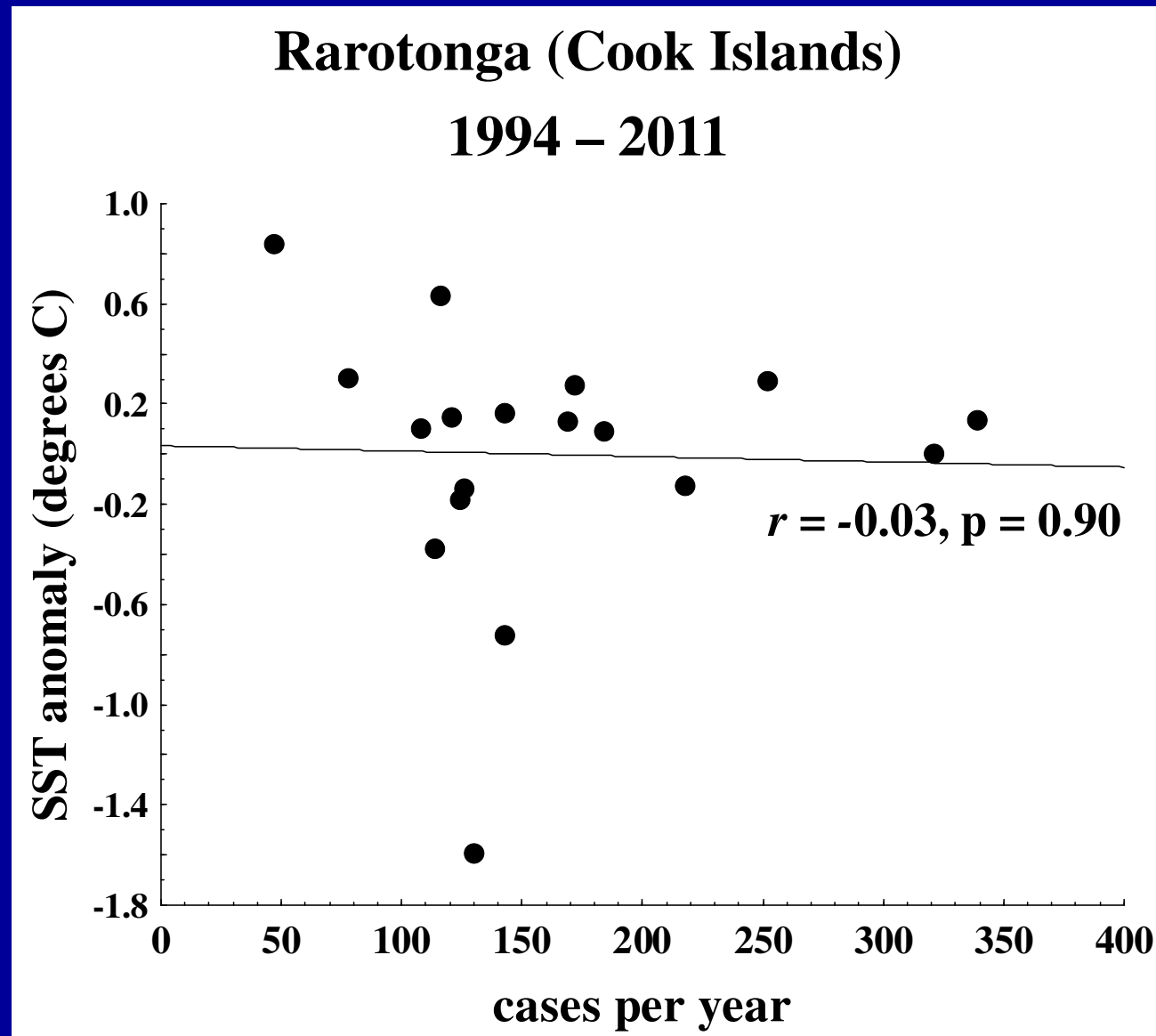
Red = warm regions

**Northern and southern Cooks experience
contrasting climate conditions**

Rongo et al. (2009) J Biogeography

Cases and SST: Rarotonga (southern Cook Islands)

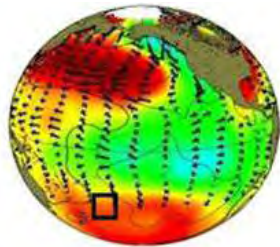
No significant correlation, therefore SST not important



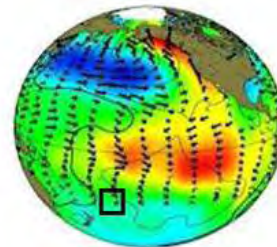
Recent shift to negative PDO

Higher frequency of La Nina = lower cyclone frequency in the southern Cooks

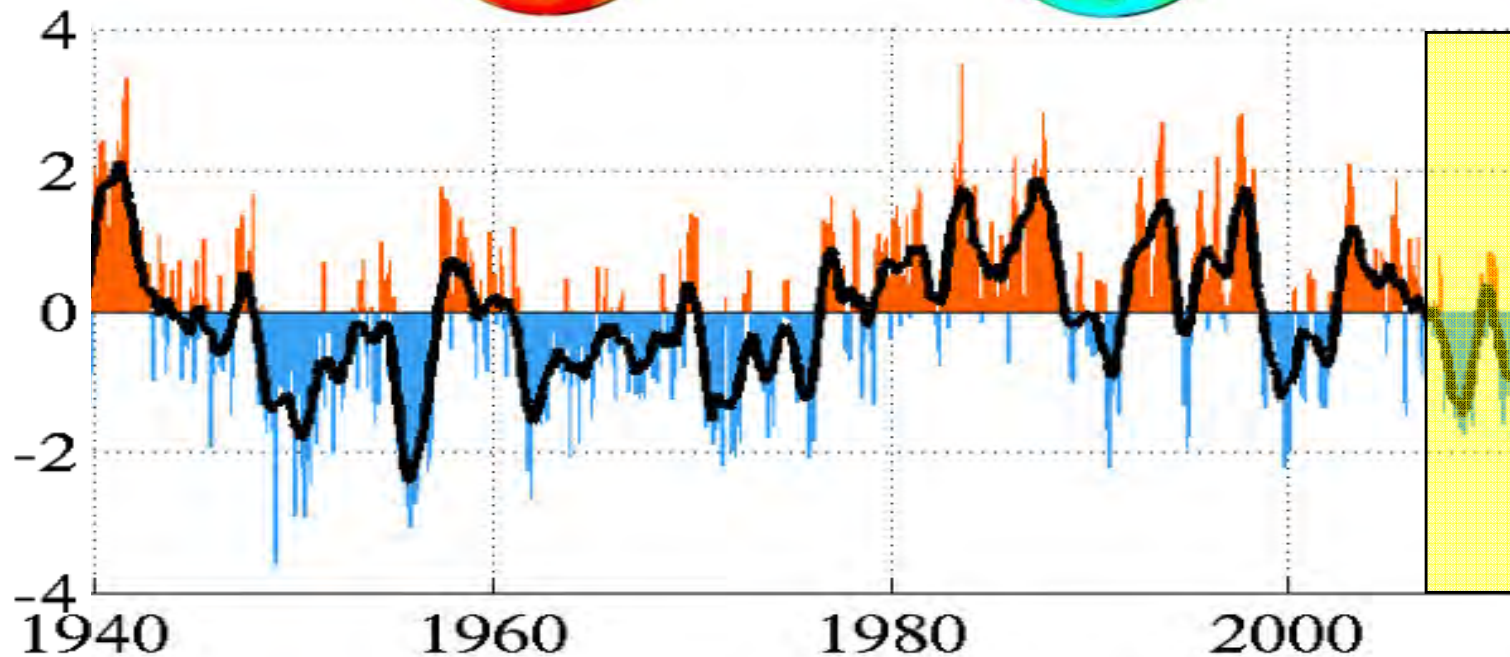
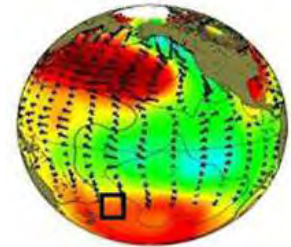
Negative phase



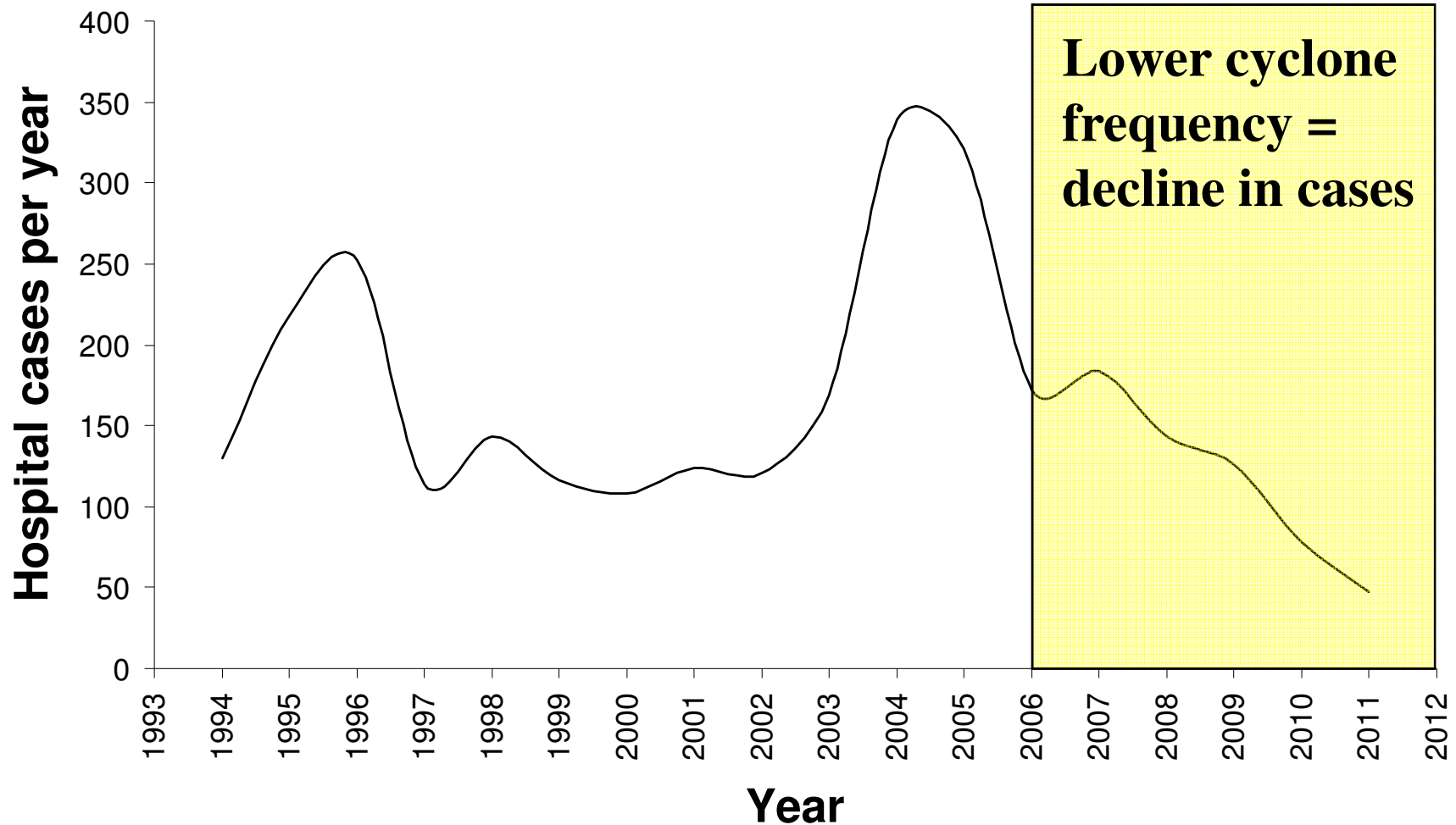
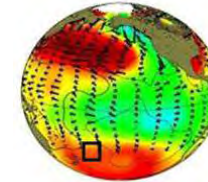
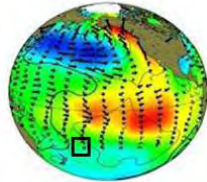
Positive phase



Negative phase



Hospital cases (1994 – 2011)



Did ciguatera poisoning occur in the past?



britannica.com

Historical accounts

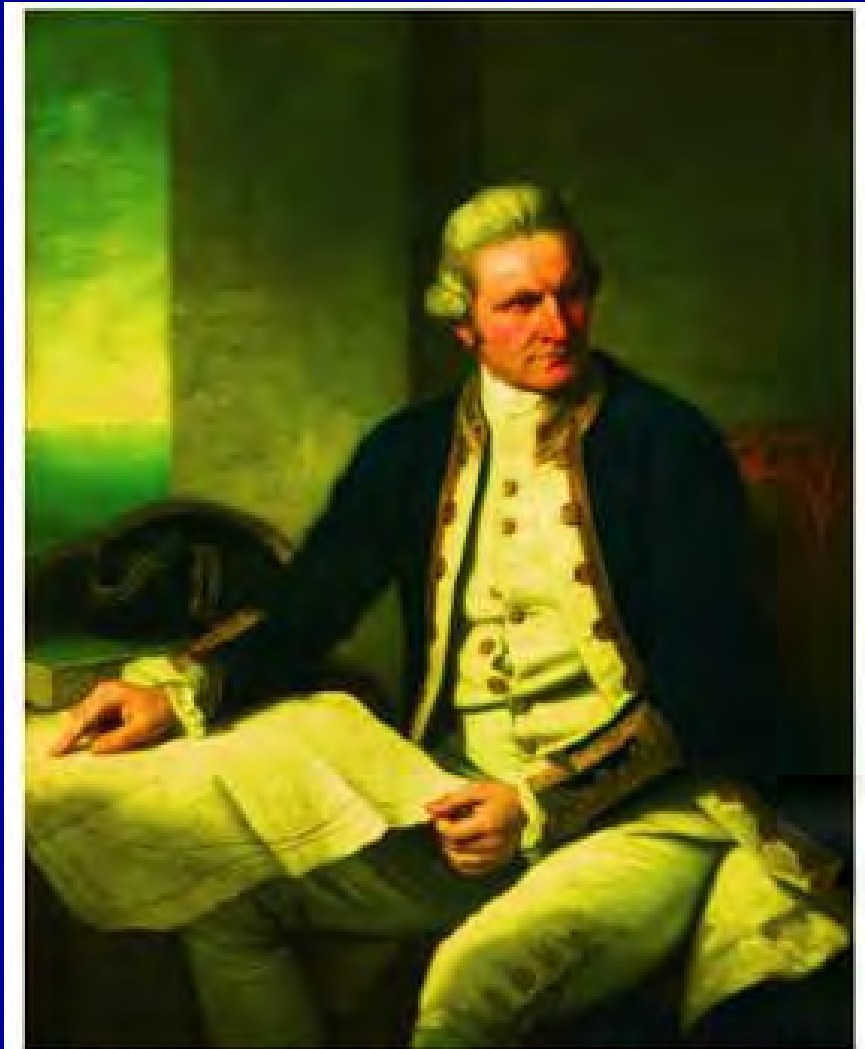
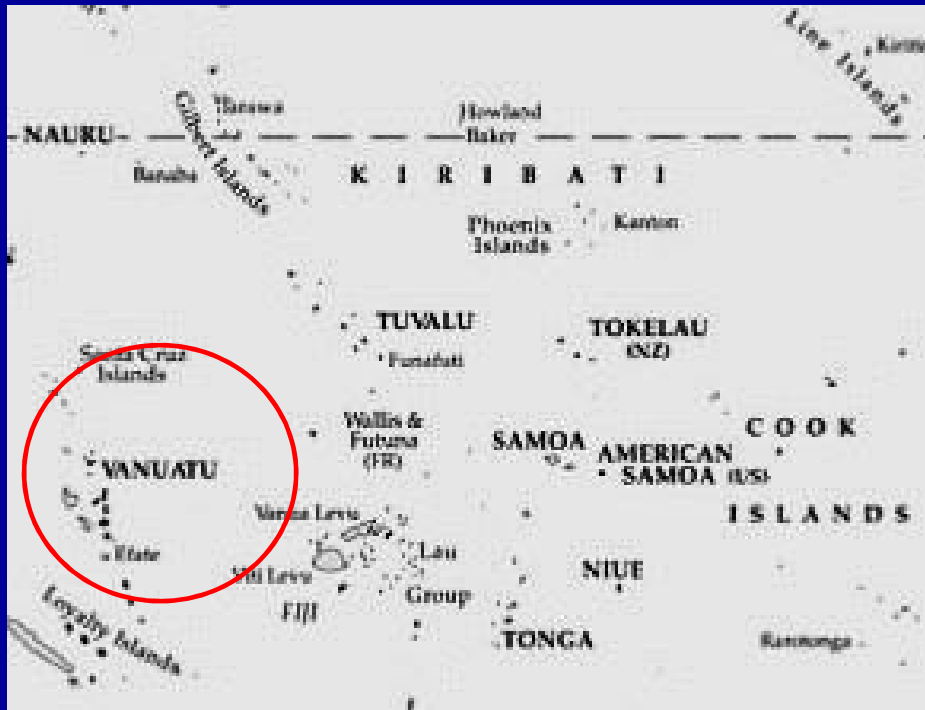
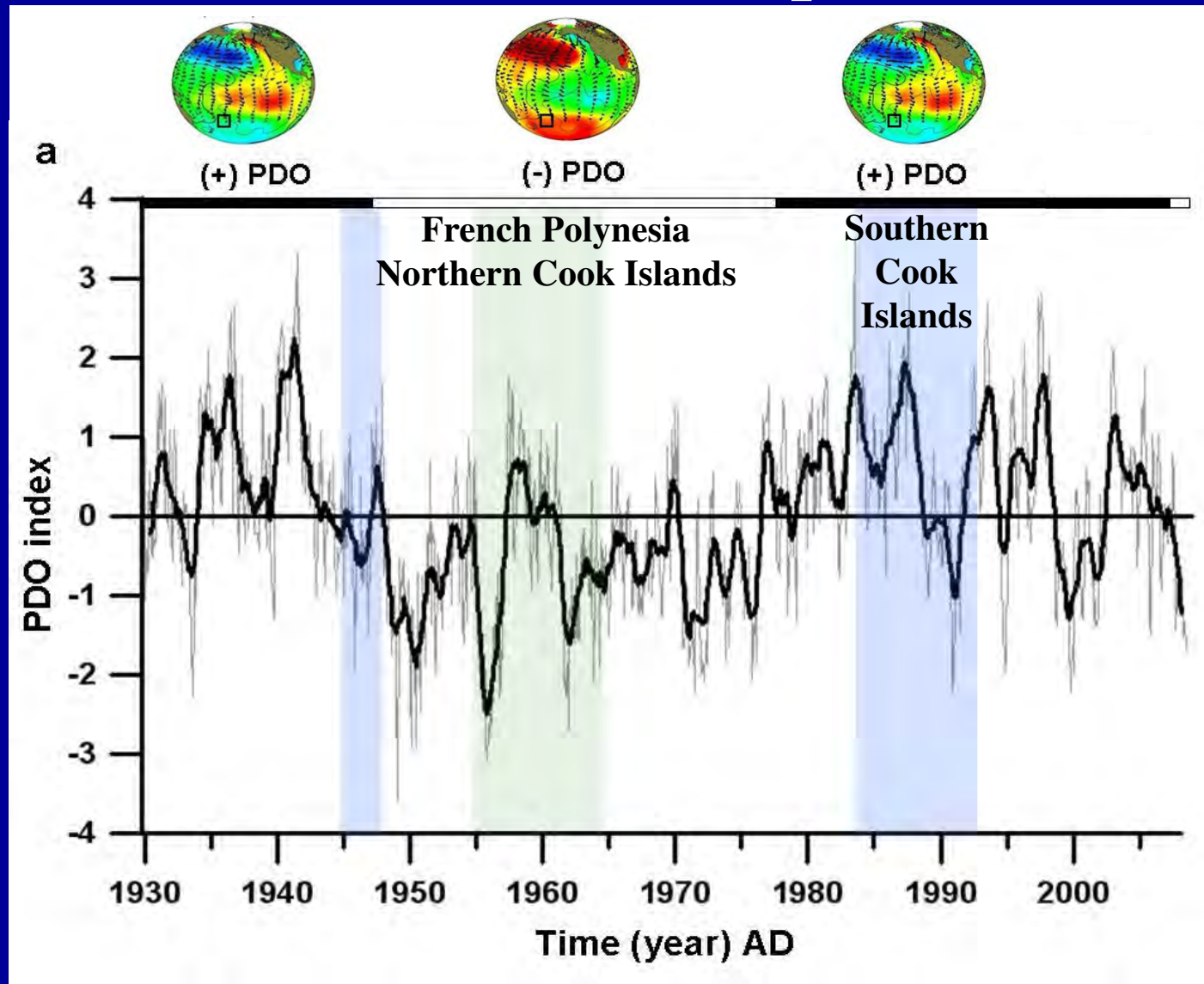


Figure 1. Captain James Cook. Portrait by Nathaniel Dance, 1775 to 1776. (Courtesy of and copyrighted by the National Maritime Museum, London, UK.)

Methods

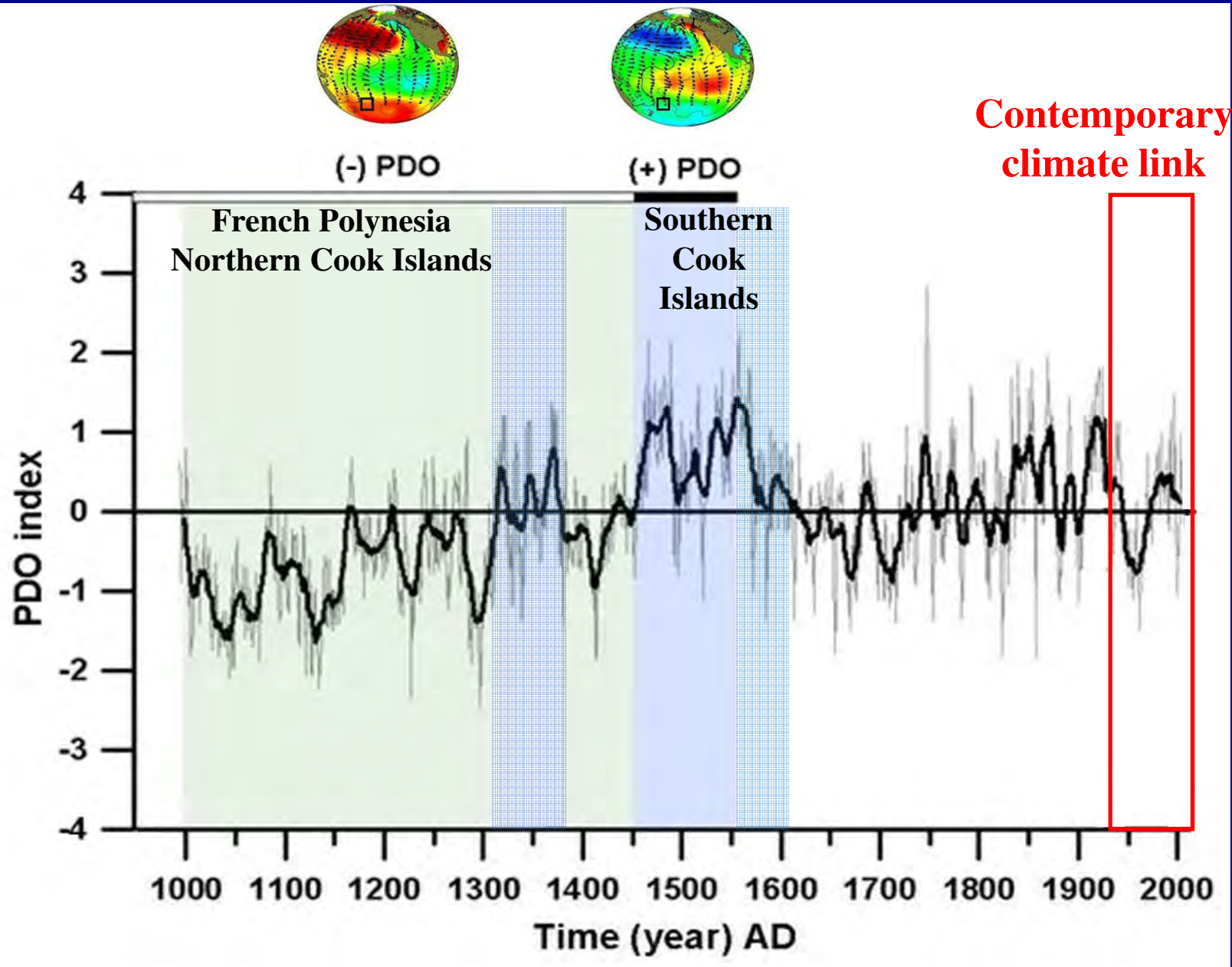
- Obtain information on contemporary ciguatera from other locations in the Cook Islands and French Polynesia
- Examined palaeo-climate datasets extending back to AD 1000
- Review the archaeological literature for evidence of ciguatera in the central Pacific extending back to AD 1000

Initial outbreaks of ciguatera in the three regions relative to PDO phase

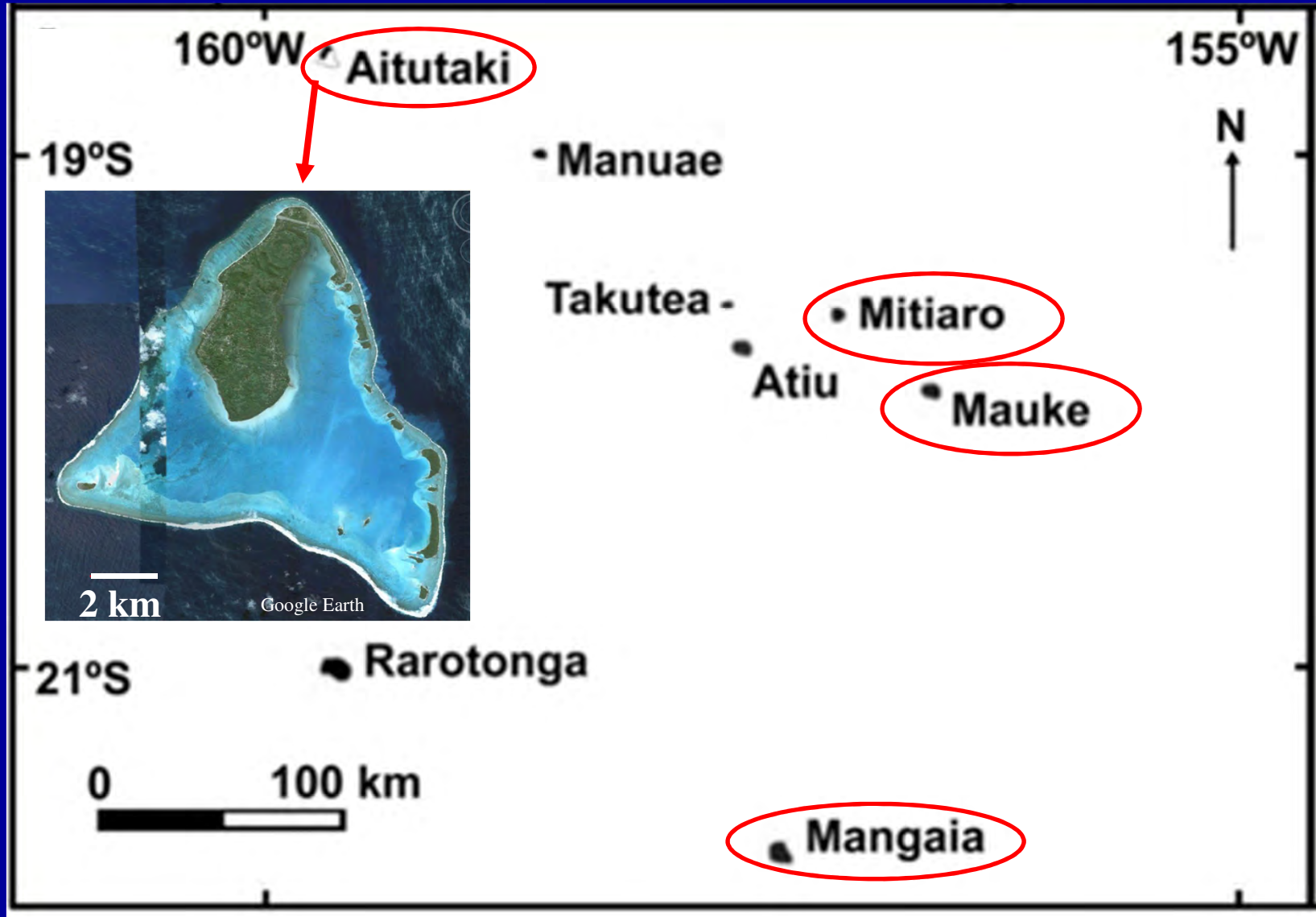


Rongo et al. (2009) *Journal of Biogeography*

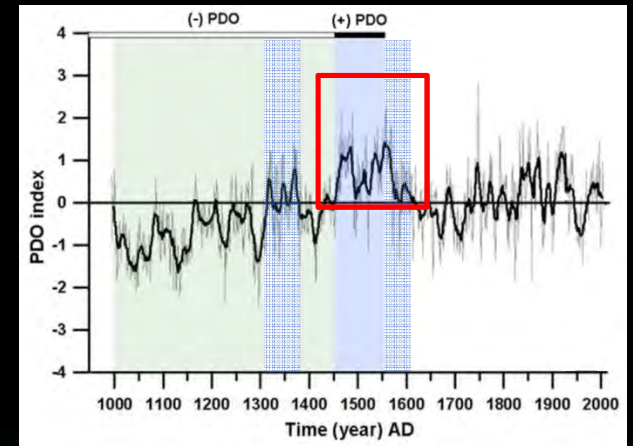
PDO reconstruction back to AD 1000



Midden records from southern Cook Islands obtained from literature



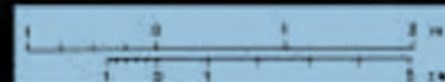
Shift in Fishing Technology (around AD 1450)



Late turban shell hooks

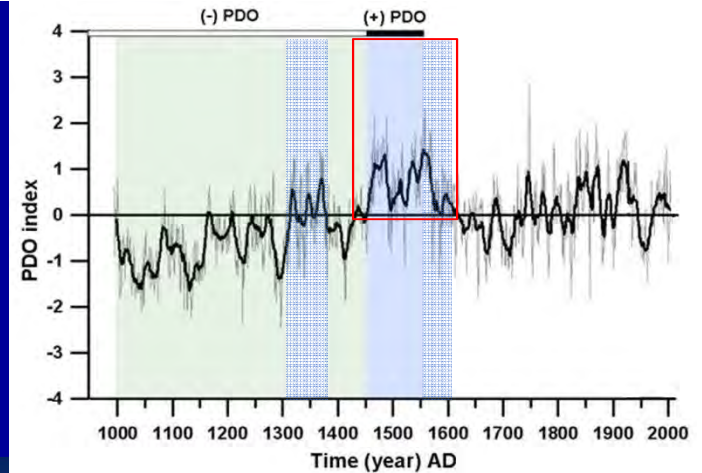
Mid-sequence hooks

Early pearl-shell hooks



Allen (2002)

Shift in target species (around AD 1450)



Decreased (large carnivorous fishes)



Consistent throughout record (small serranids and cirrhitids)



Increased (commensals, domesticates, and freshwater eels)



Fish photos: Robert Myers.
Rat, chicken, and eel photos:
Cook Islands Biodiversity

Migration out of Southeast Asia Paused in western Polynesia



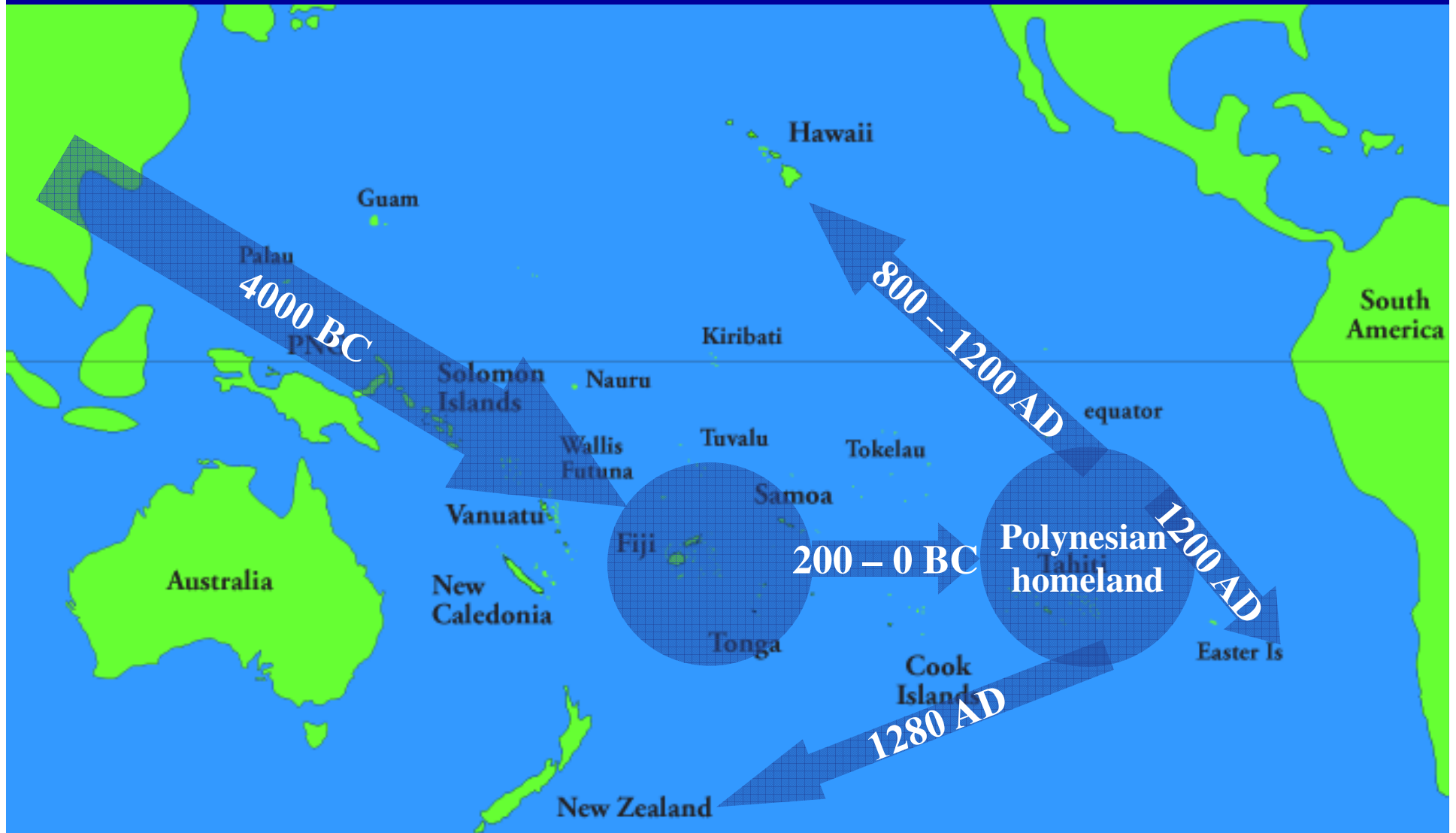
Advanced canoe technology enabled voyaging from western to eastern Polynesia

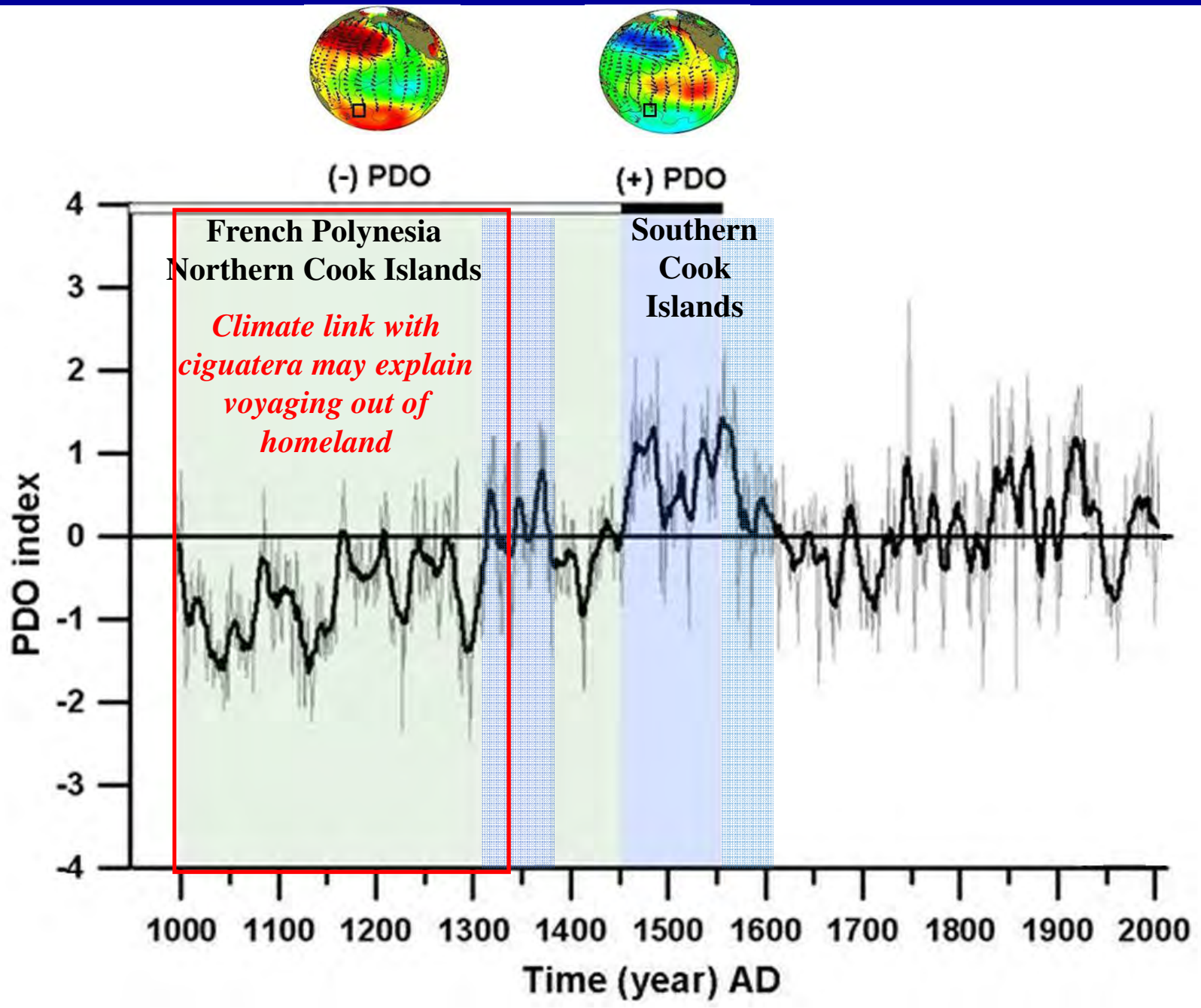


Traditional Polynesian double-hull voyaging canoes

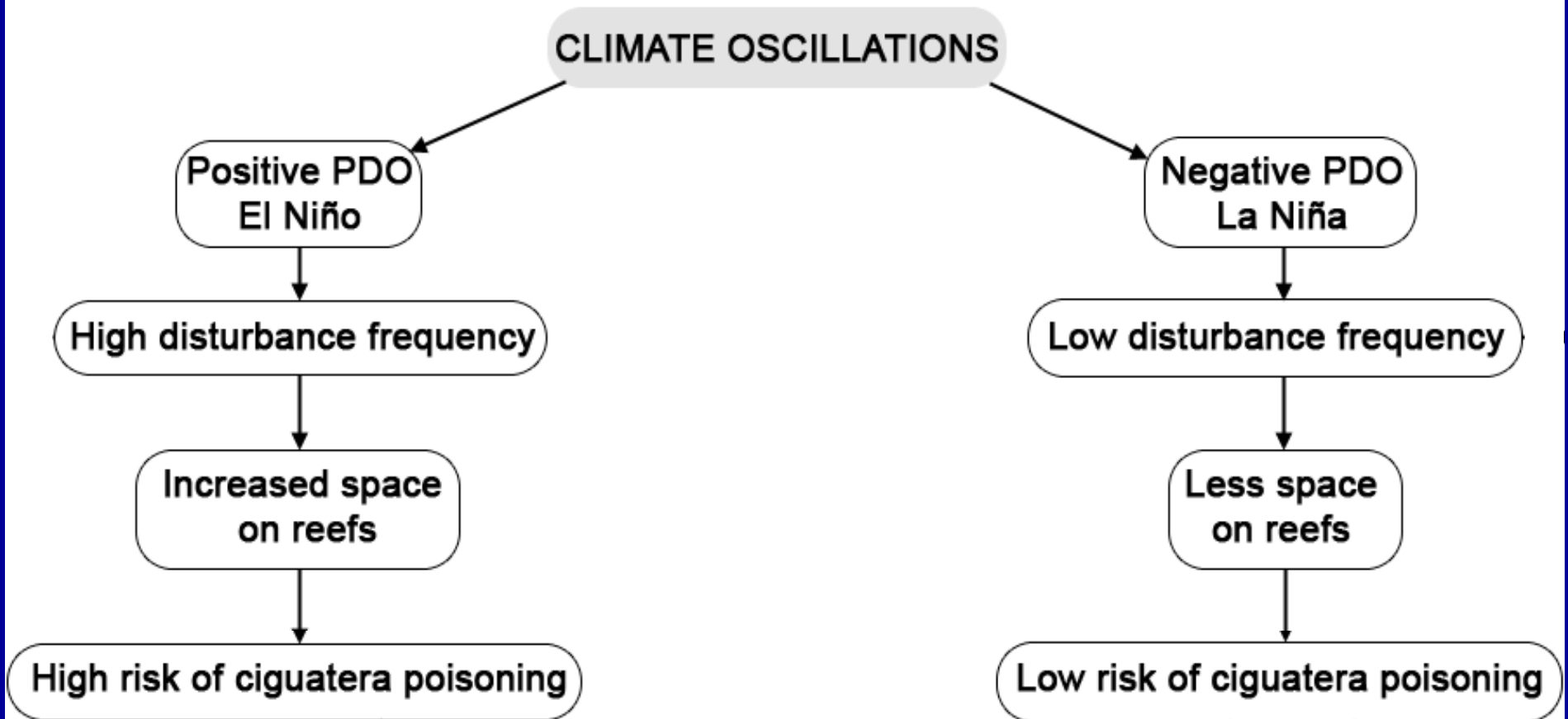
Photos taken by Sepp Steffany and Jackie Rongo

Reasons for extensive voyaging out of Polynesian homeland highly debated in literature





Summary



Predictions

- **Climate oscillation (negative PDO)**
 - Reduces the risk of ciguatera in Rarotonga & southern Cook Islands
 - Increases the risk of ciguatera in French Polynesia & northern Cook Islands
- **Global warming**
 - Intensity of cyclones may increase risk of ciguatera
 - Poleward migration of ciguatoxic dinoflagellates may increase risk in high latitude regions

ACKNOWLEDGMENTS

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My family