Impact of climate on dinoflagellates and Ciguatera Fish Poisoning (CFP)

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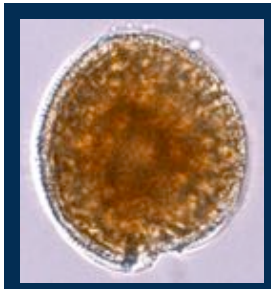
Ciguatera Fish Poisoning: a few facts

- Ciguatera is caused by the consumption of subtropical and tropical marine fish that have accumulated naturally occurring toxins through their diet. The toxins originate from benthic (bottom-dwelling) dinoflagellates

- It is the most frequently reported marine toxin disease in the world, affecting > 50,000 people per year
- Major constraint on fisheries in many regions



herbivorous fish → carnivorous fish → Ciguatoxins, human illness

gambiertoxins (precursor compounds) →

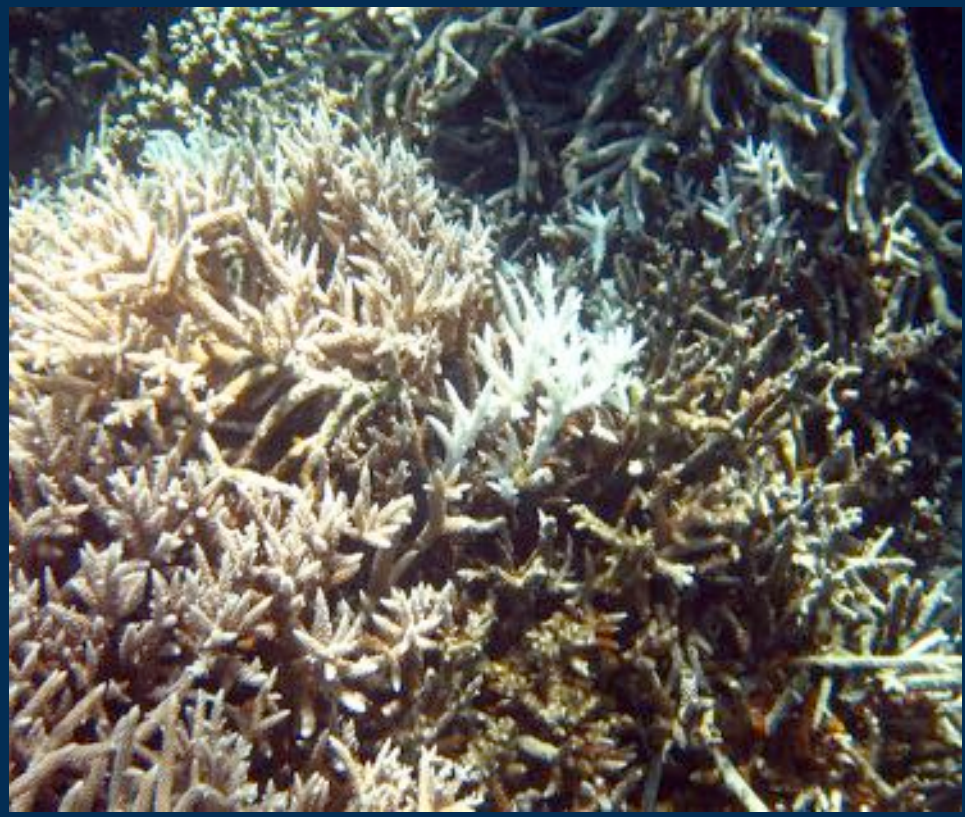
Gambiertoxins —*metabolism*→ **Ciguatoxins**

- genetic variability
- environmental variability

→

- variability in human symptoms
- variability in timing of outbreaks

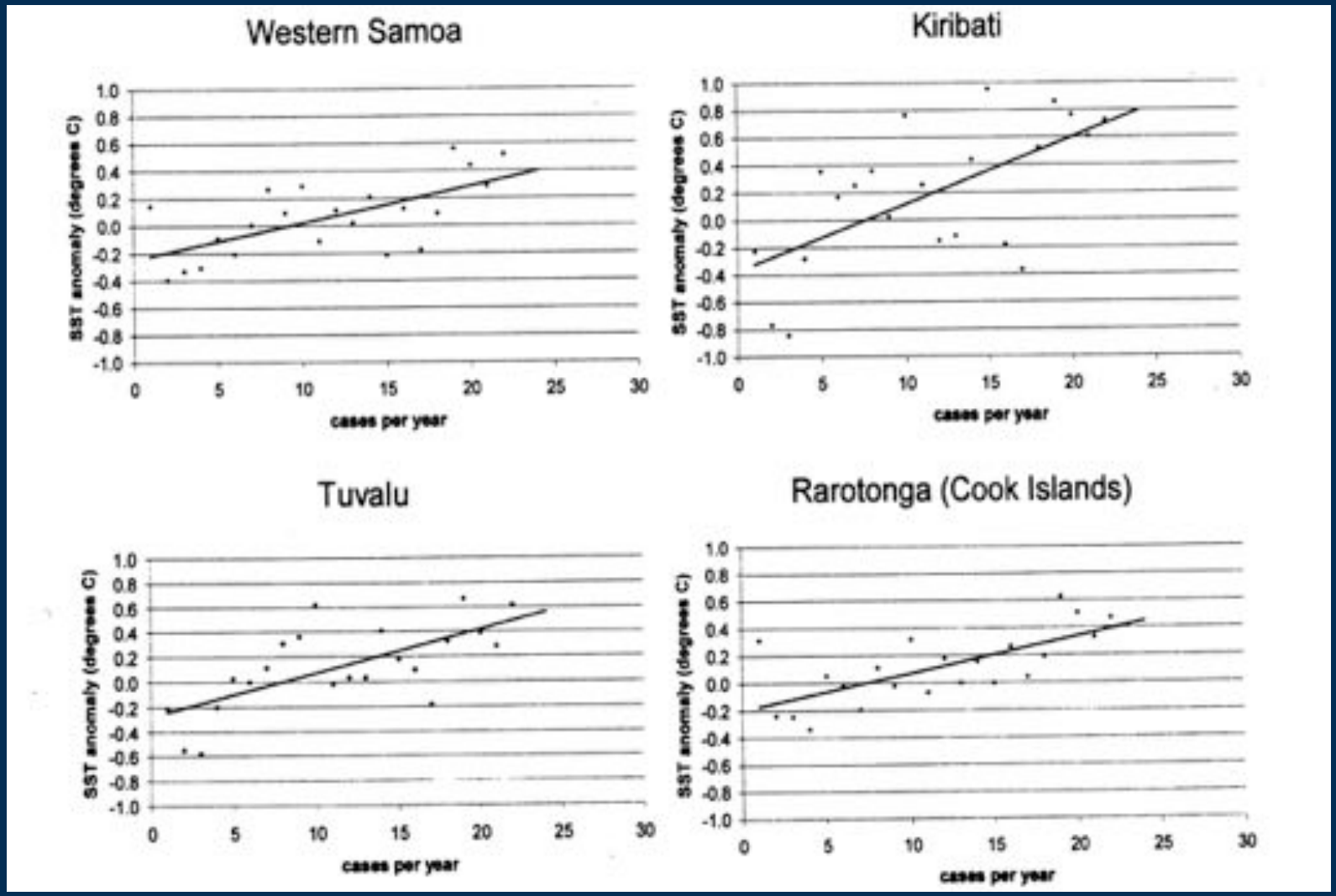
Linkages to climate change and coral reef health



- **Ciguatera is regarded by some as a "sentinel" disease, one that can foreshadow the impact of environmental change in coral reef systems.**

- **Despite this, there are very few long-term datasets that include environmental parameters, *Gambierdiscus* abundance, and human poisoning incidence**

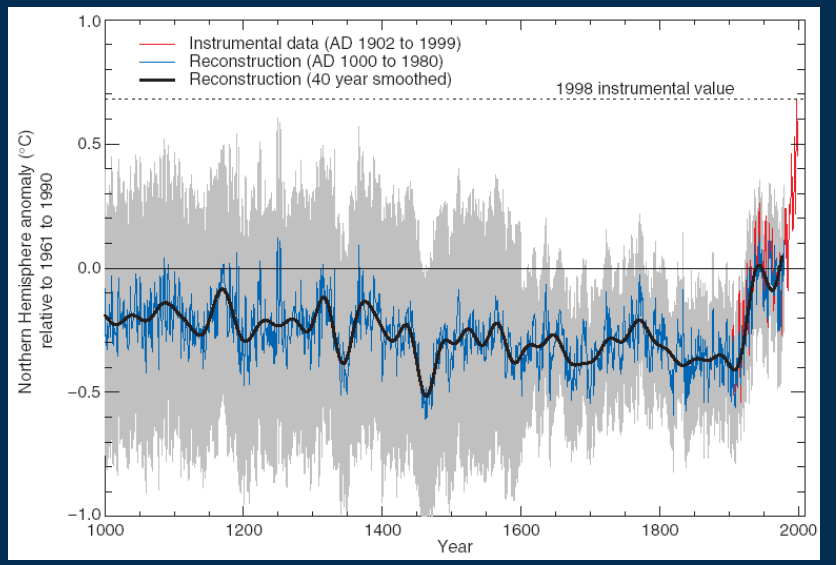
Trends in ciguatera incidence in the tropical Pacific



Relationship between local sea surface temperature anomalies and ciguatera poisonings (Hales et al., 1999)

What are the mechanisms underlying the link between increased sea temperatures and ciguatera disease?

- Stimulation of *Gambierdiscus* growth rates by higher temperatures
- Stimulation of toxin production in *Gambierdiscus* cells;
- Increase in abundance of *Gambierdiscus* due to coral bleaching/disease => opportunistic macroalgal growth



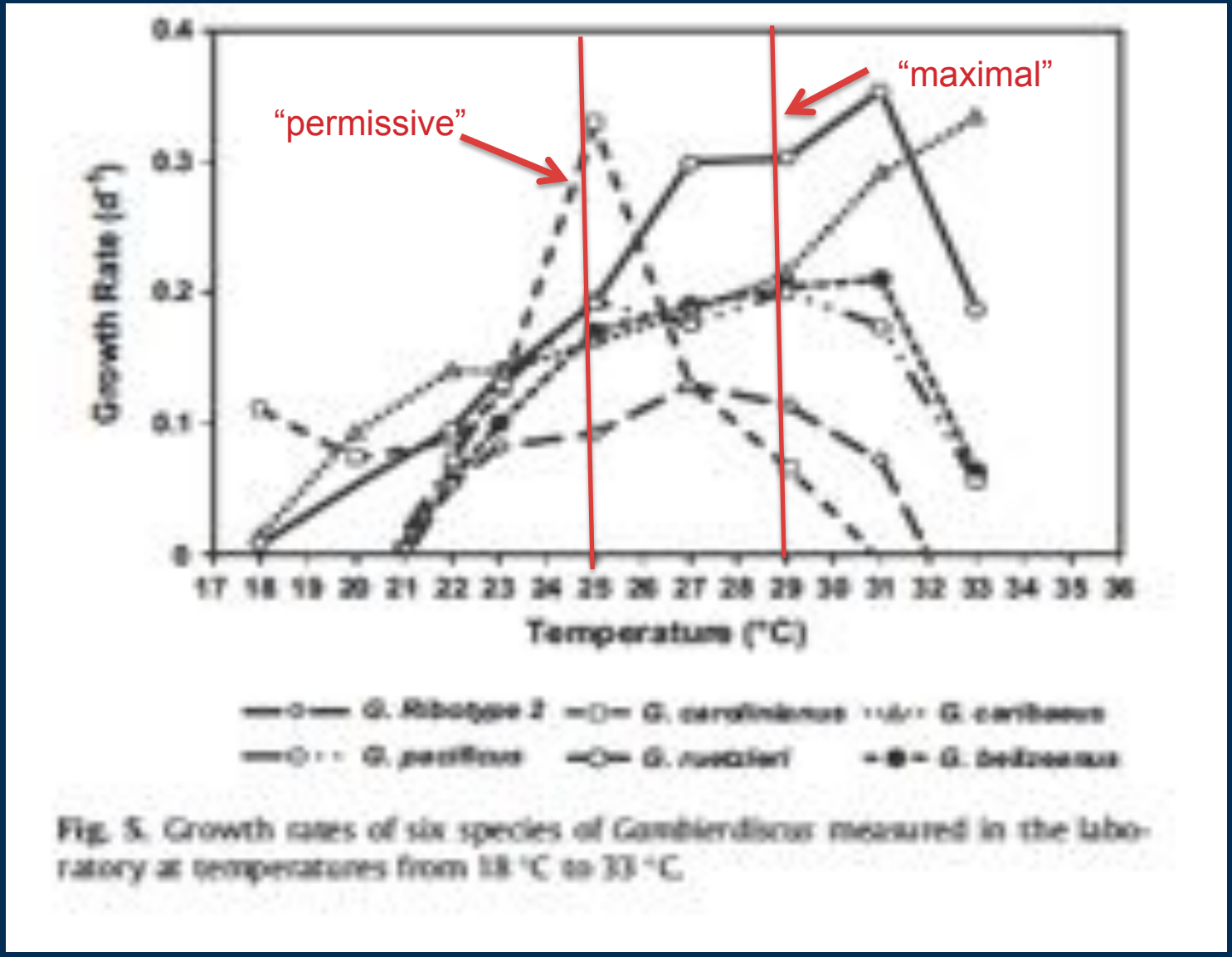


Fig. 5. Growth rates of six species of *Gambierdiscus* measured in the laboratory at temperatures from 18 °C to 33 °C.

Source: Tester et al. 2010

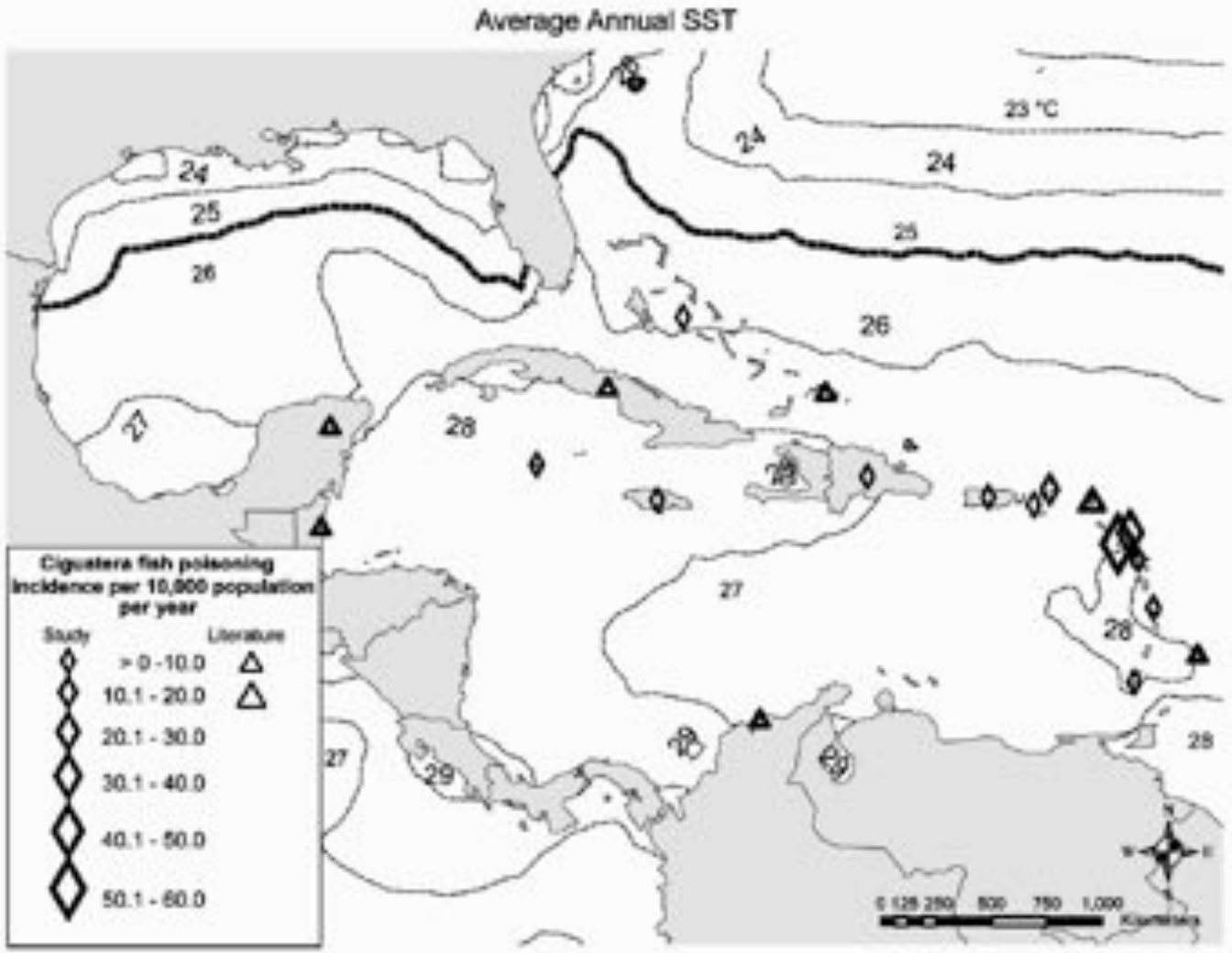
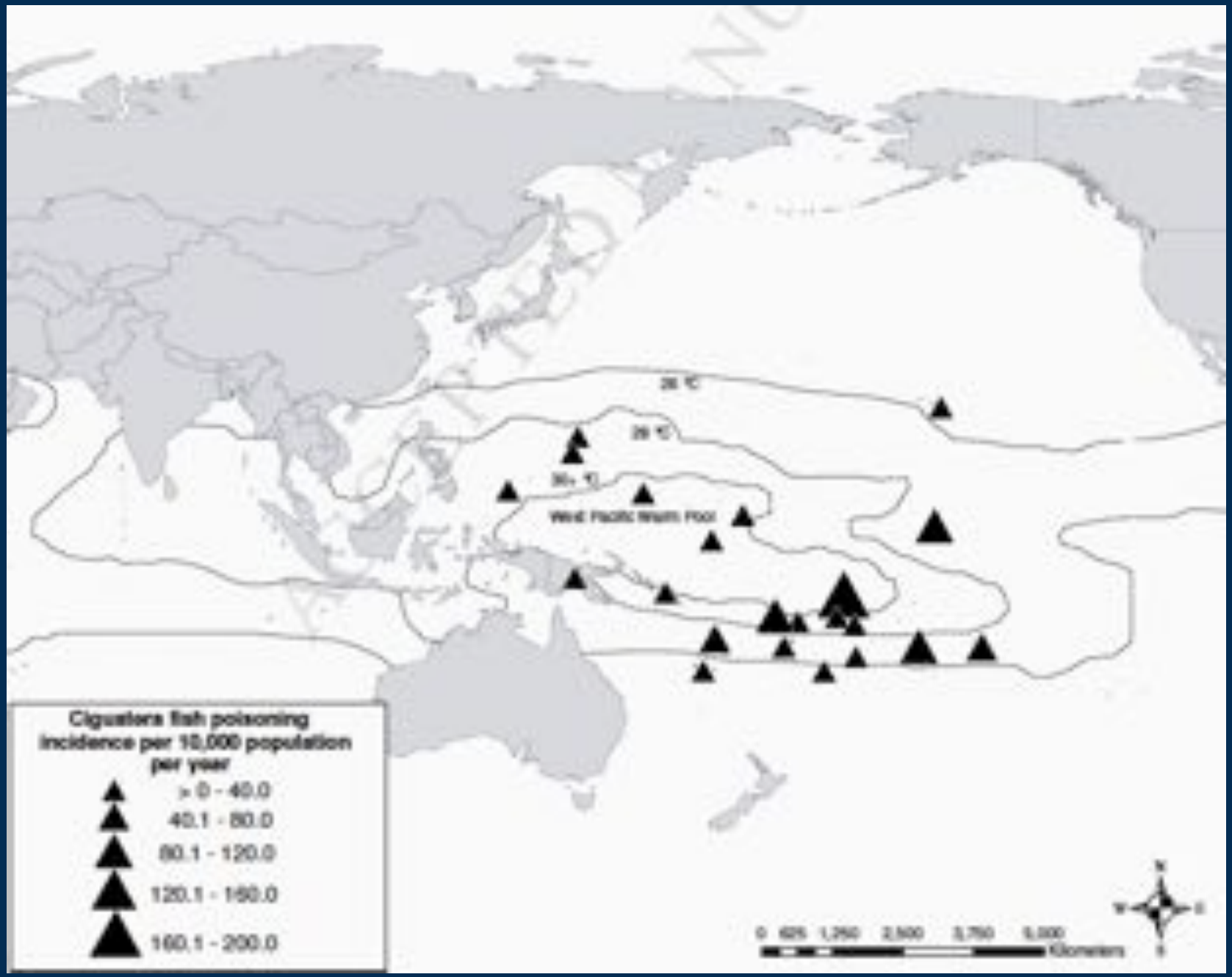
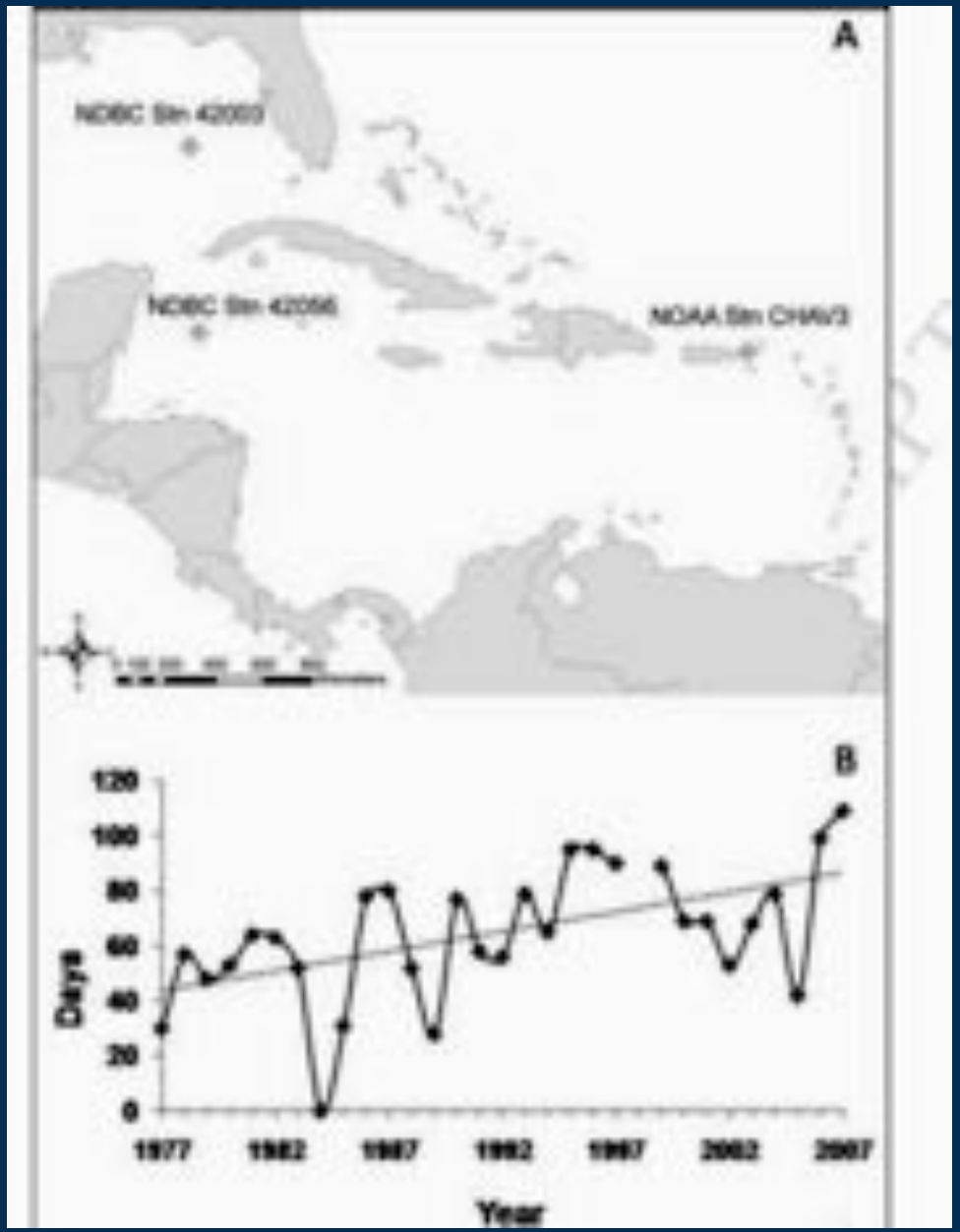


Fig. 2. Average ciguatera fish poisoning incidence rates per 10,000 population per year from 1996–2006 across the Caribbean, plotted with temperature contours (°C) from annual average sea surface temperatures from 2002–2007.

Source: Tester et al. 2010



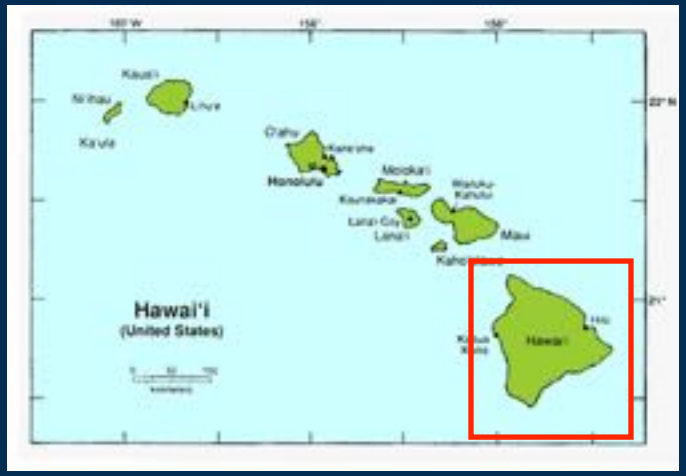
Source: Tester et al. 2010



The number of days with sea surface temperatures > 29 ^{o}C has nearly doubled, from 42 to 81, in the last three decades in the southern Gulf of Mexico

Source: Tester et al. 2010

Case Study: modeling *Gambierdiscus* population dynamics in HI (Parsons et al., 2010)

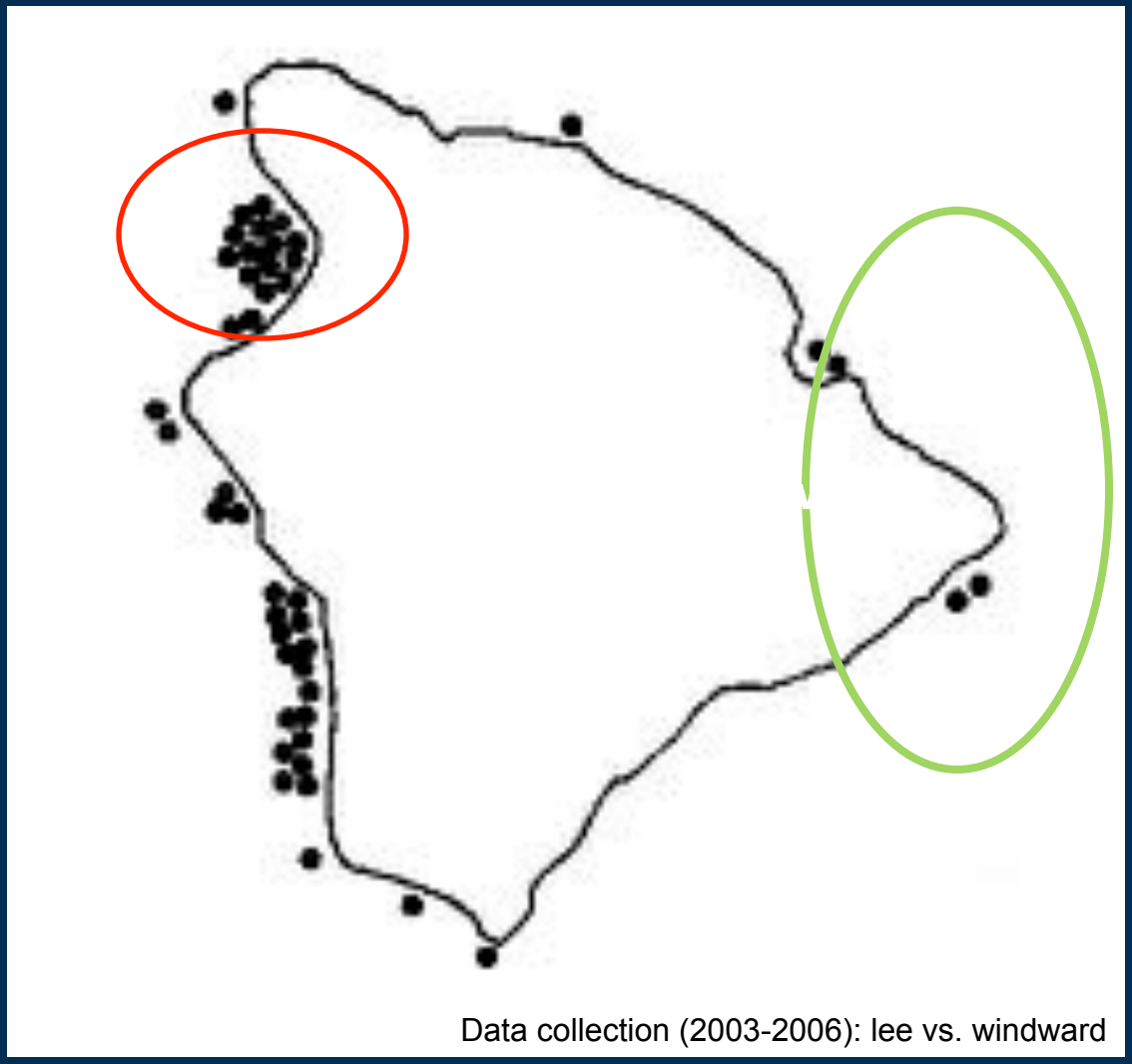


http://www.hawaii.edu/pbcp/images/map/hawaii_map.gif

Purpose:

1. To determine if *Gambierdiscus* population dynamics can be modeled.

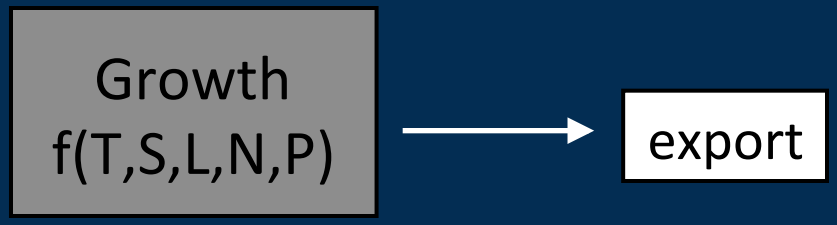
2. Ultimate goal – to understand *Gambierdiscus* population dynamics in order to predict/ forecast ciguatera outbreaks.



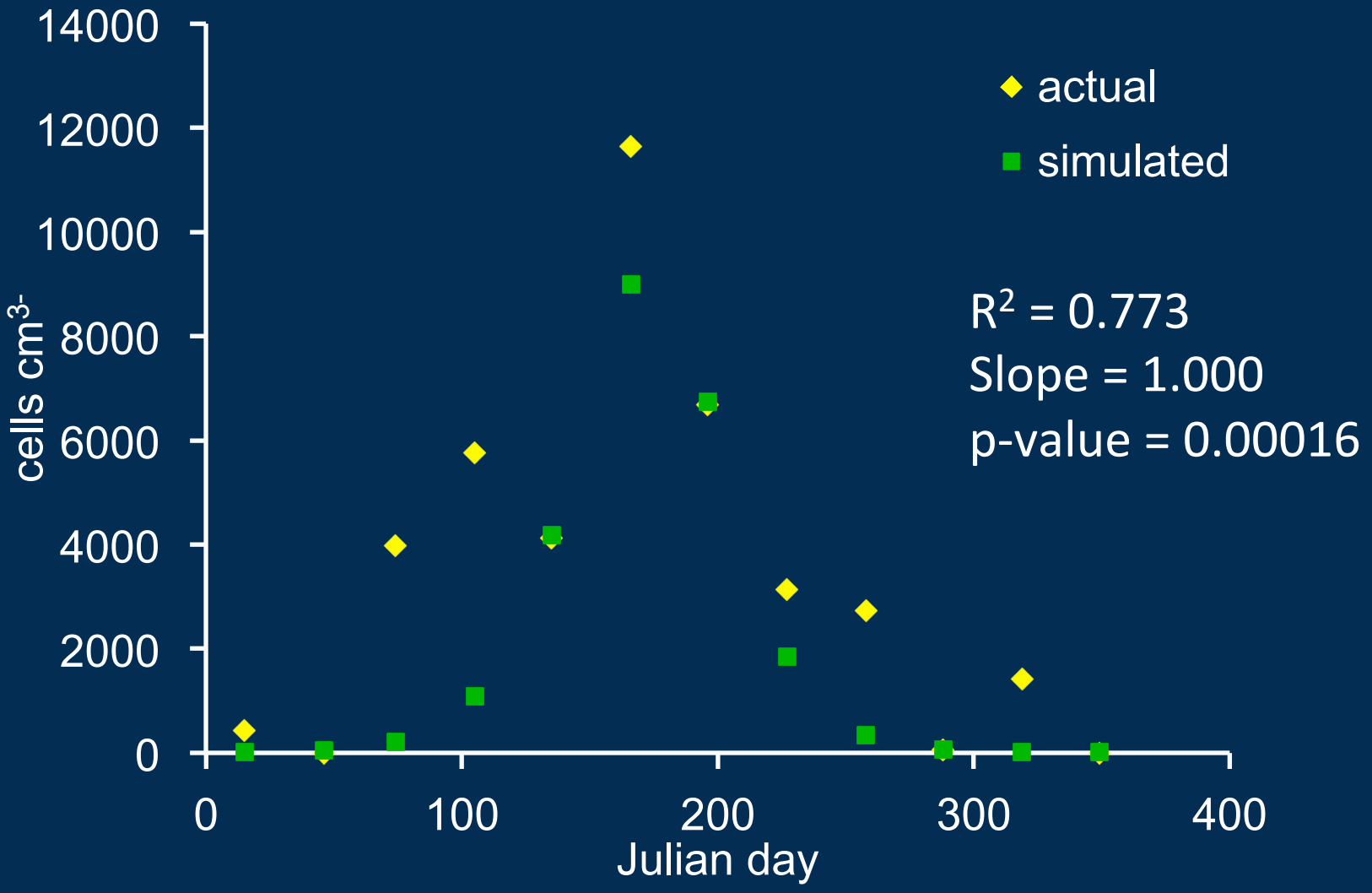
Data collection (2003-2006): lee vs. windward

Model Development

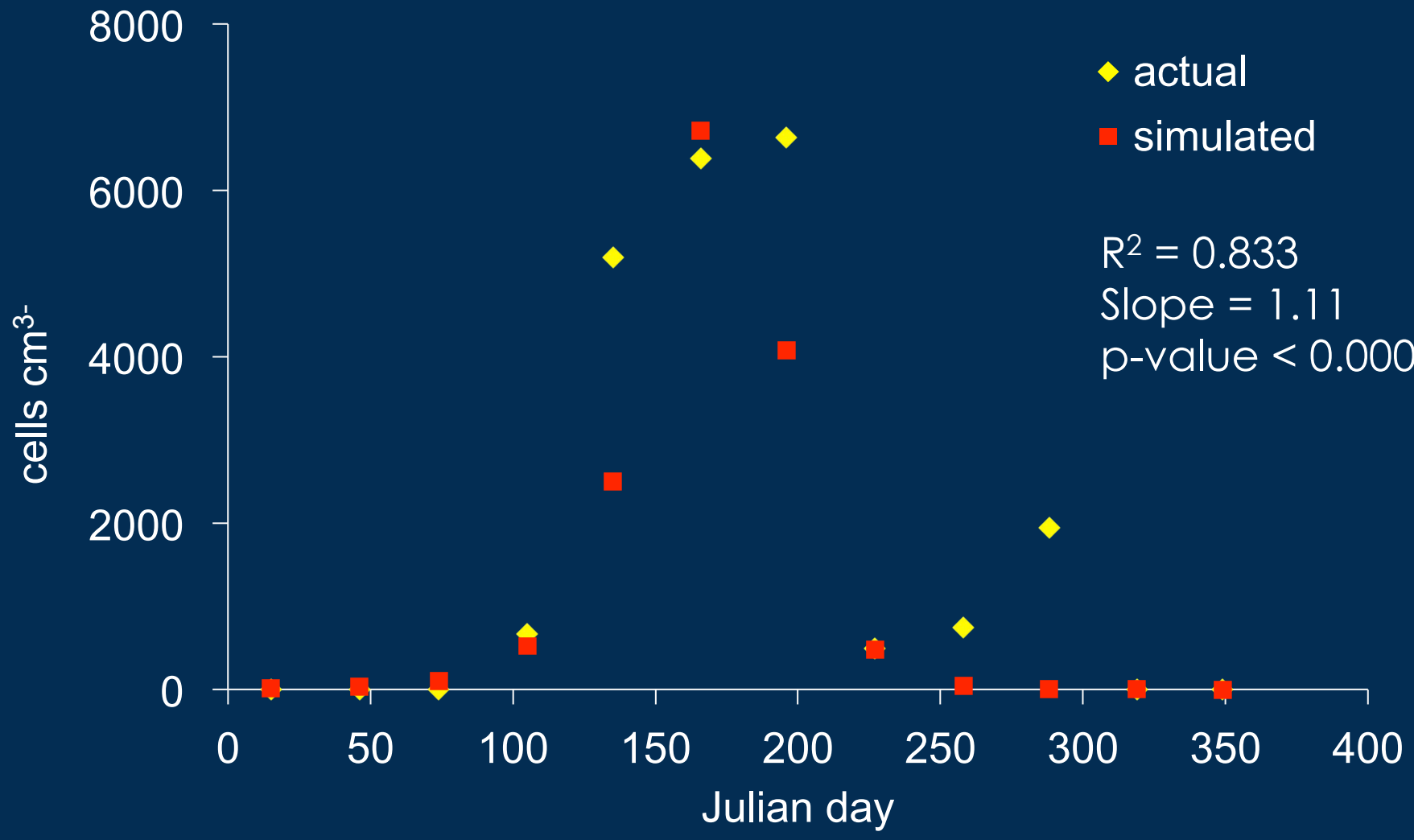
- One box model
  - *Gambierdiscus* growth dependent on T, N, P, light, and salinity
  - Export factor (grazing, disease, transport out of box)



Simulated versus actual *Gambierdiscus* abundance: windward

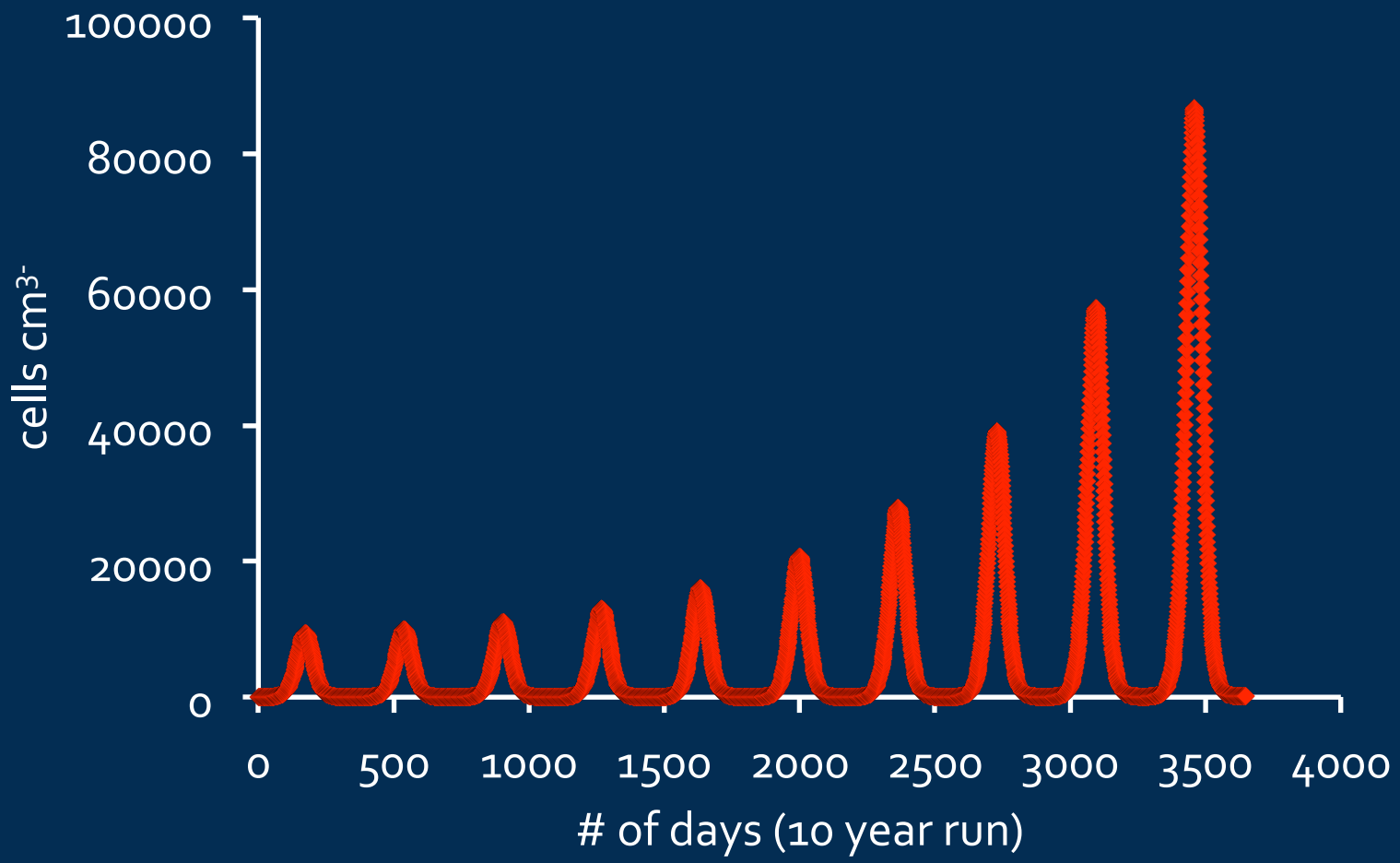


Model confirmation: simulated versus actual *Gambierdiscus* abundance: leeward



Warming scenario

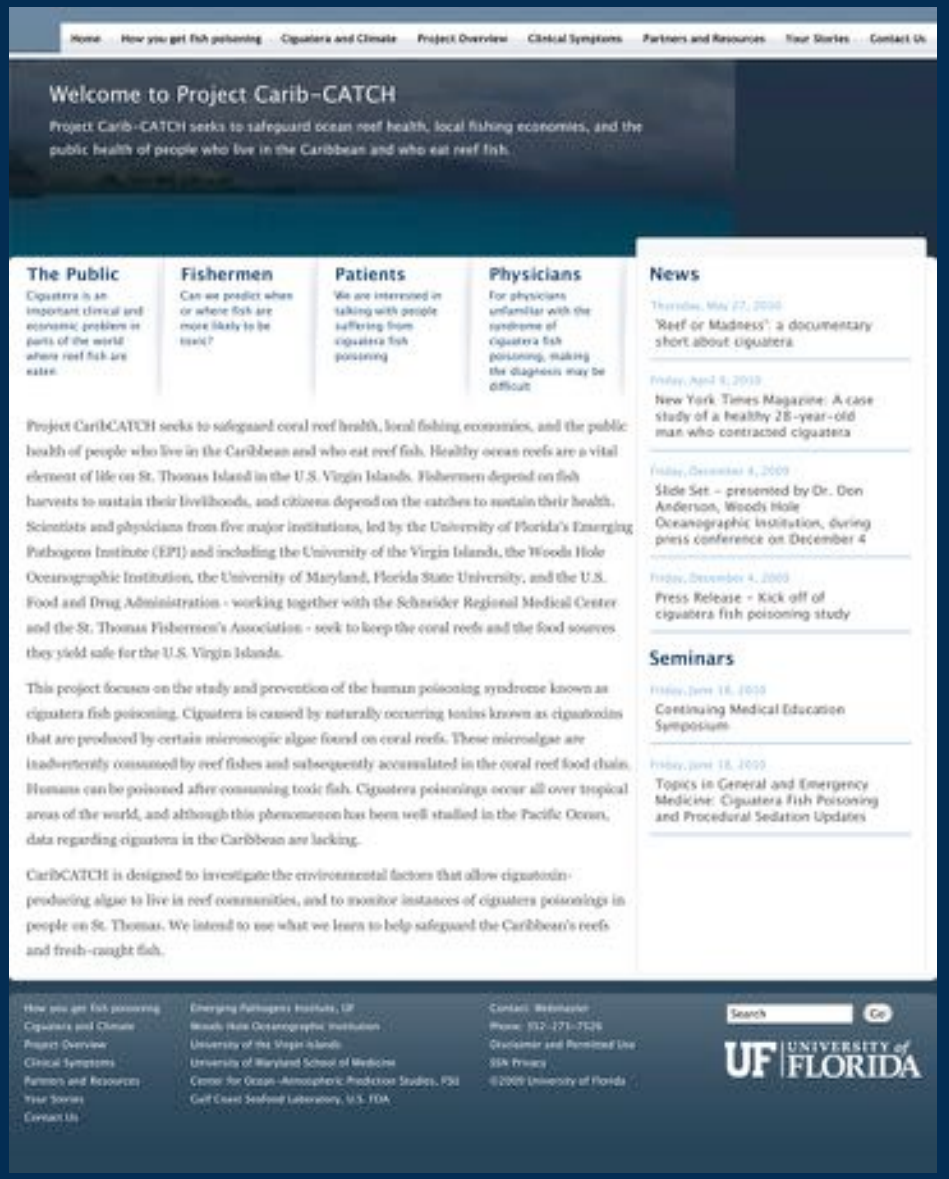
Temperature increase of +0.028 °C per year (Cheng et al. 2008)

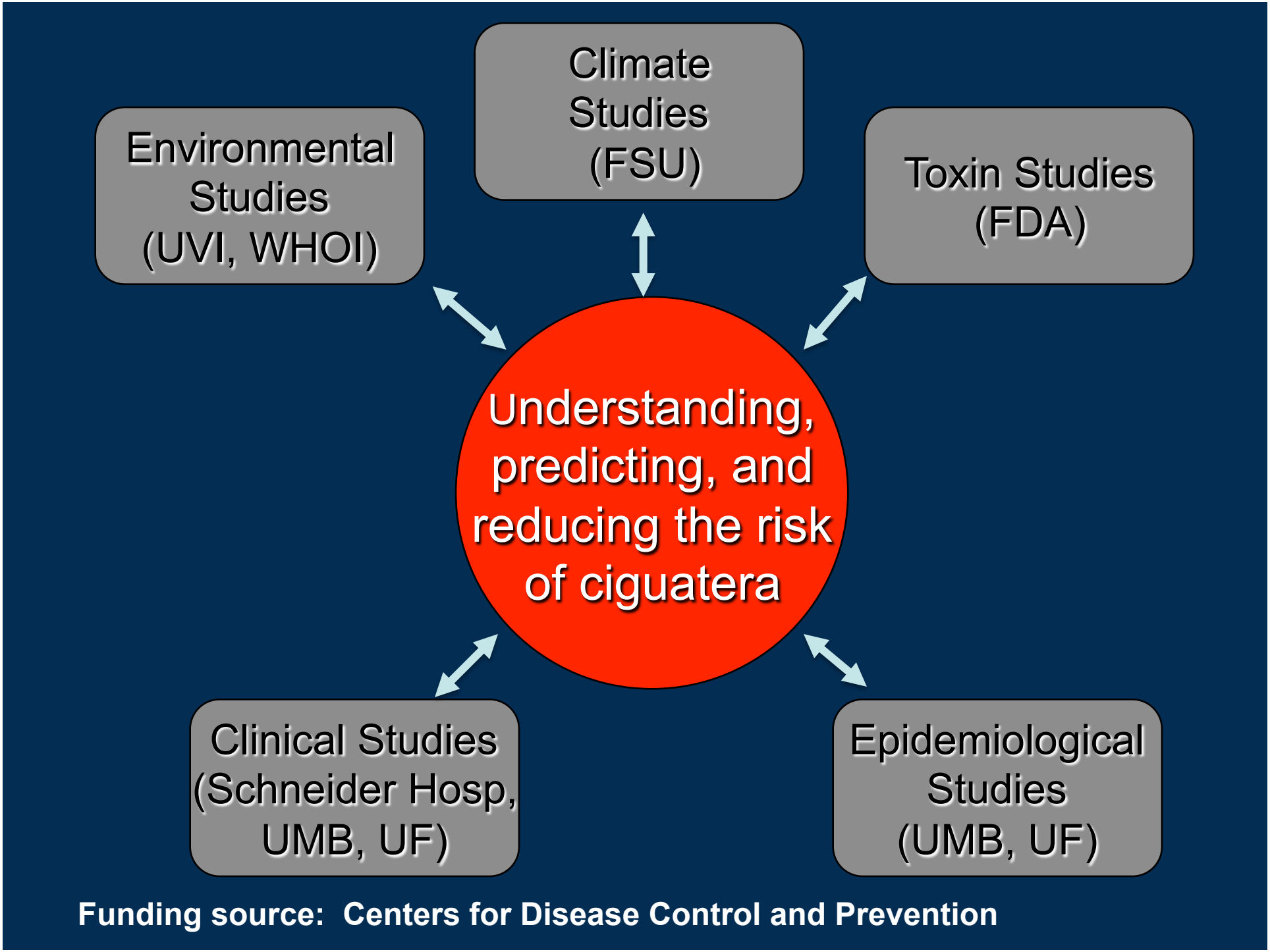


CDC-funded study: *Gambierdiscus* in the USVI: Towards an Integrated Study of Ciguatera Fish Poisoning

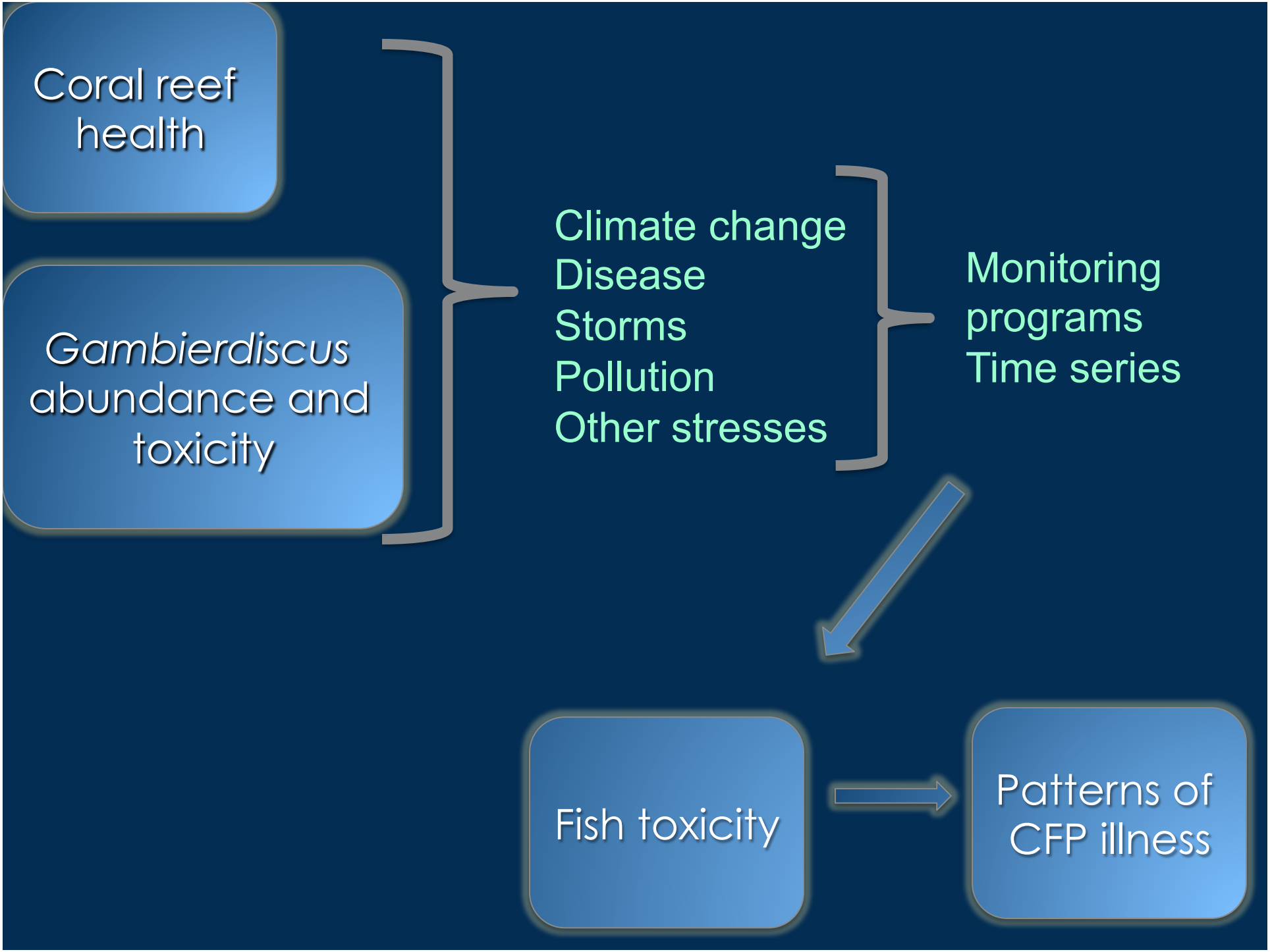
Project is investigating relationships among environmental stresses to coral reefs, population dynamics of *Gambierdiscus*, and associated cases of ciguatera

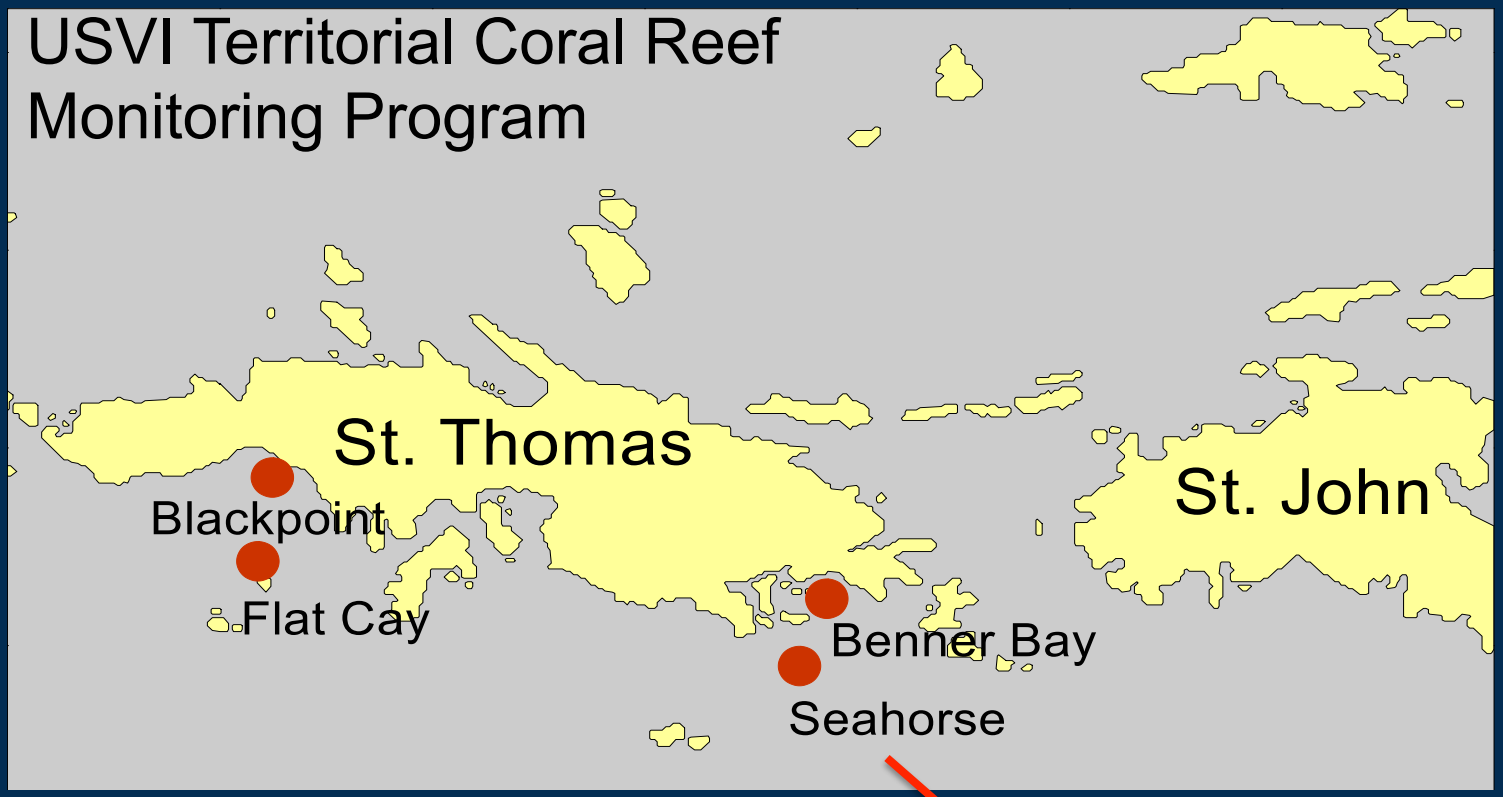
- Time series data collected on:
  - – *Gambierdiscus* abundance and population structure
  - –Changes to reef health at these locations (e.g., extent of coral bleaching, coral disease)
  - – Toxicity of dinoflagellates and fish
  - – Incidence of human poisonings from ciguatera in hospitals and clinics
- Collaboration with UVI, USFDA, UFL



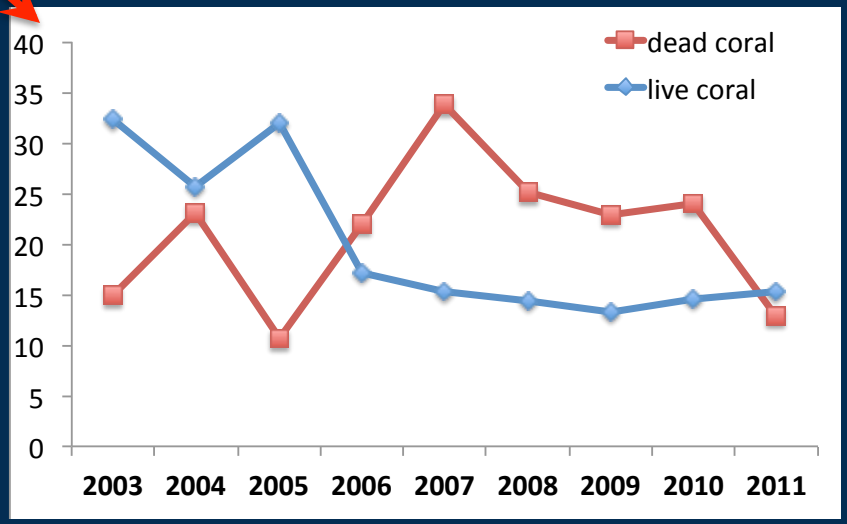


Funding source: Centers for Disease Control and Prevention


Coral reef health
Gambierdiscus abundance and toxicity
Climate change
Disease
Storms
Pollution
Other stresses
Monitoring programs
Time series
Fish toxicity
Patterns of CFP illness



Ciguatera monitoring added to four locations surveyed by the USVI Territorial Coral Reef Monitoring program: augmenting long-term datasets on reef health, oceanographic properties, and anthropogenic impacts

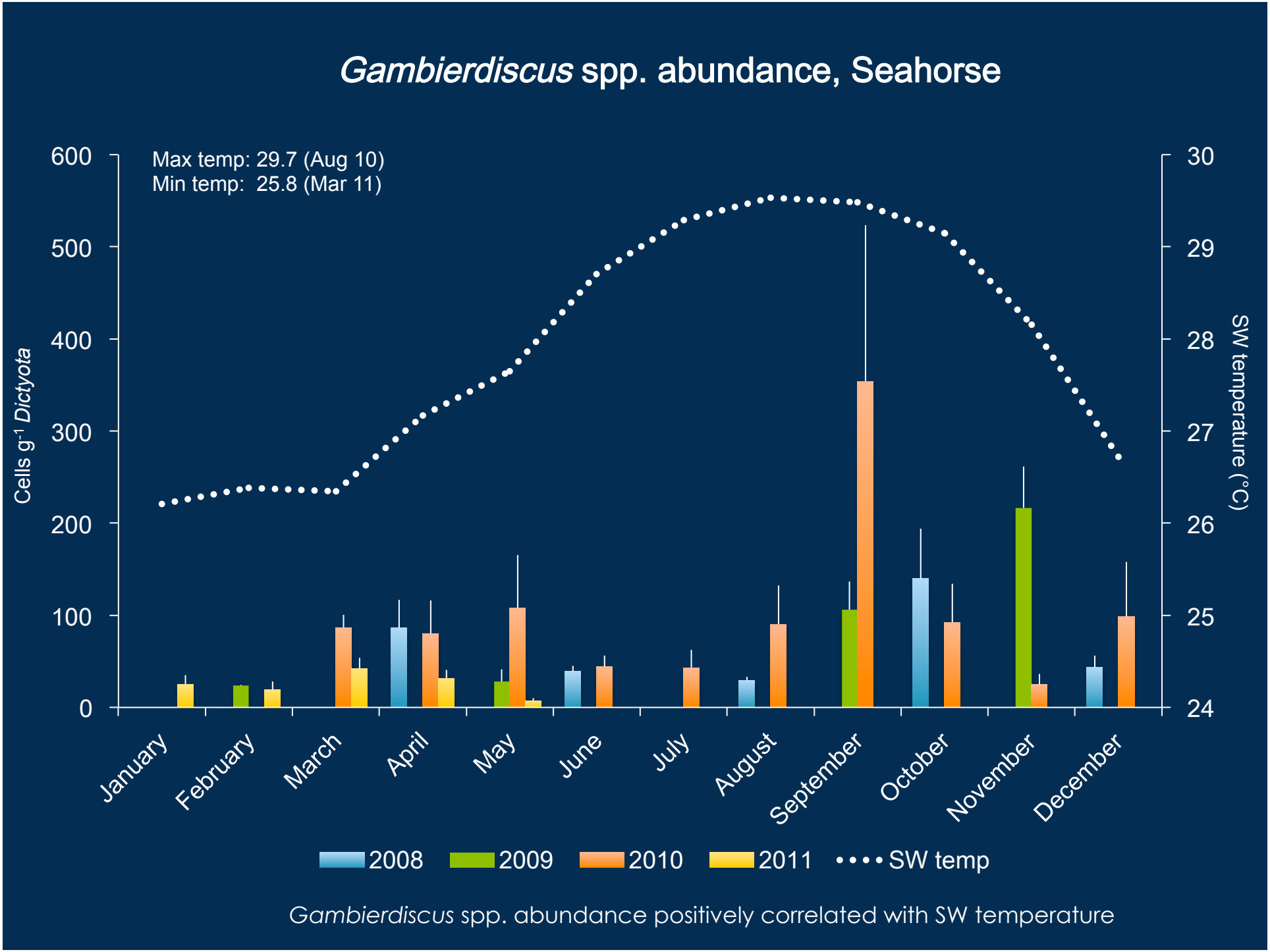


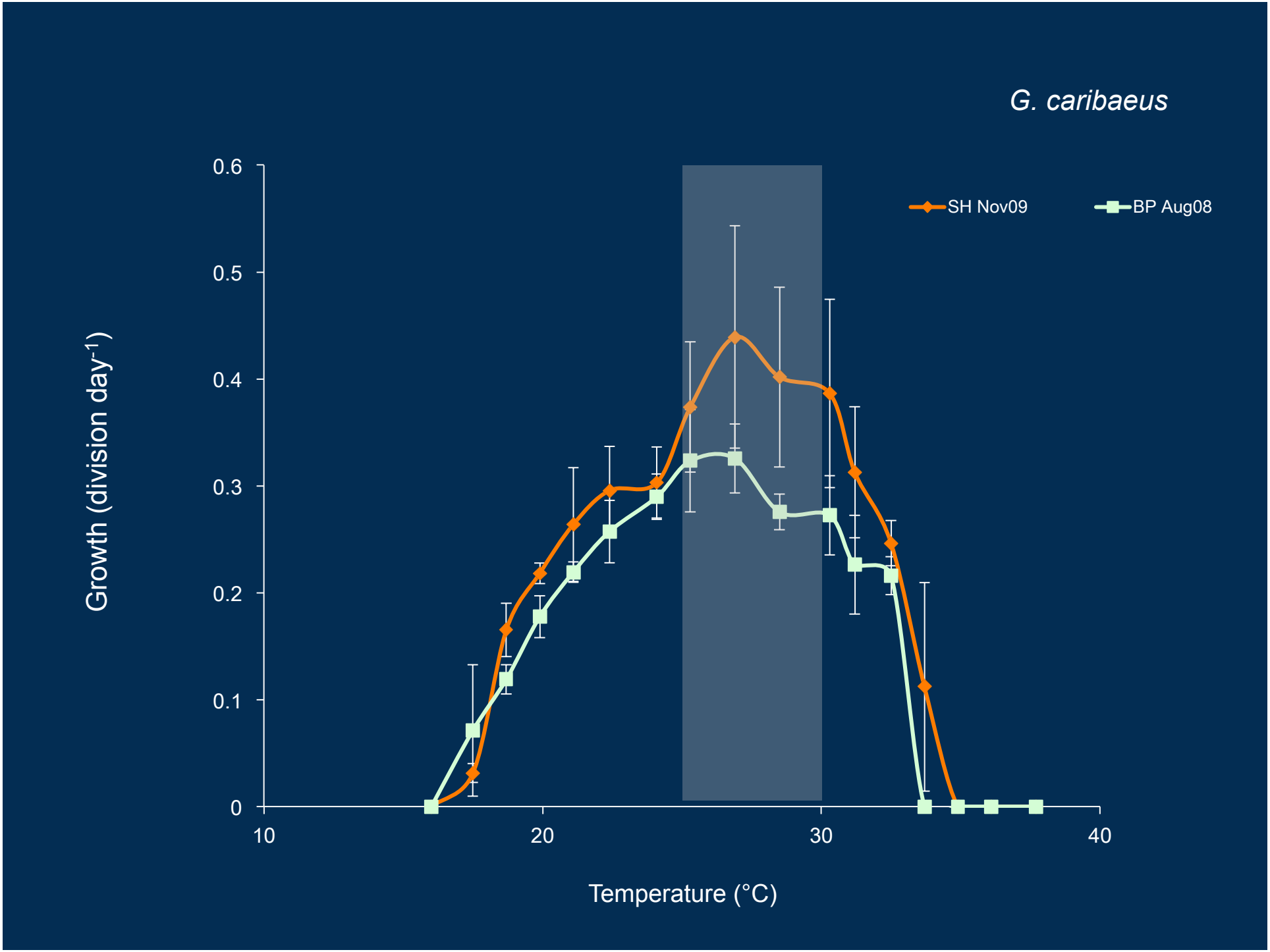
Epidemiological studies

- Medical records review performed at the Roy Schneider Hospital emergency room department to collect data on clinical cases of ciguatera (1995-2011)
- Household surveys collecting estimates of population-based incidence to assess the relationship between numbers of patients who present for medical attention, and number of potential cases in the community, and for identification of risk factors
- Retrospective analysis will develop accurate estimates of the true incidence of ciguatera, for both current and prior years.

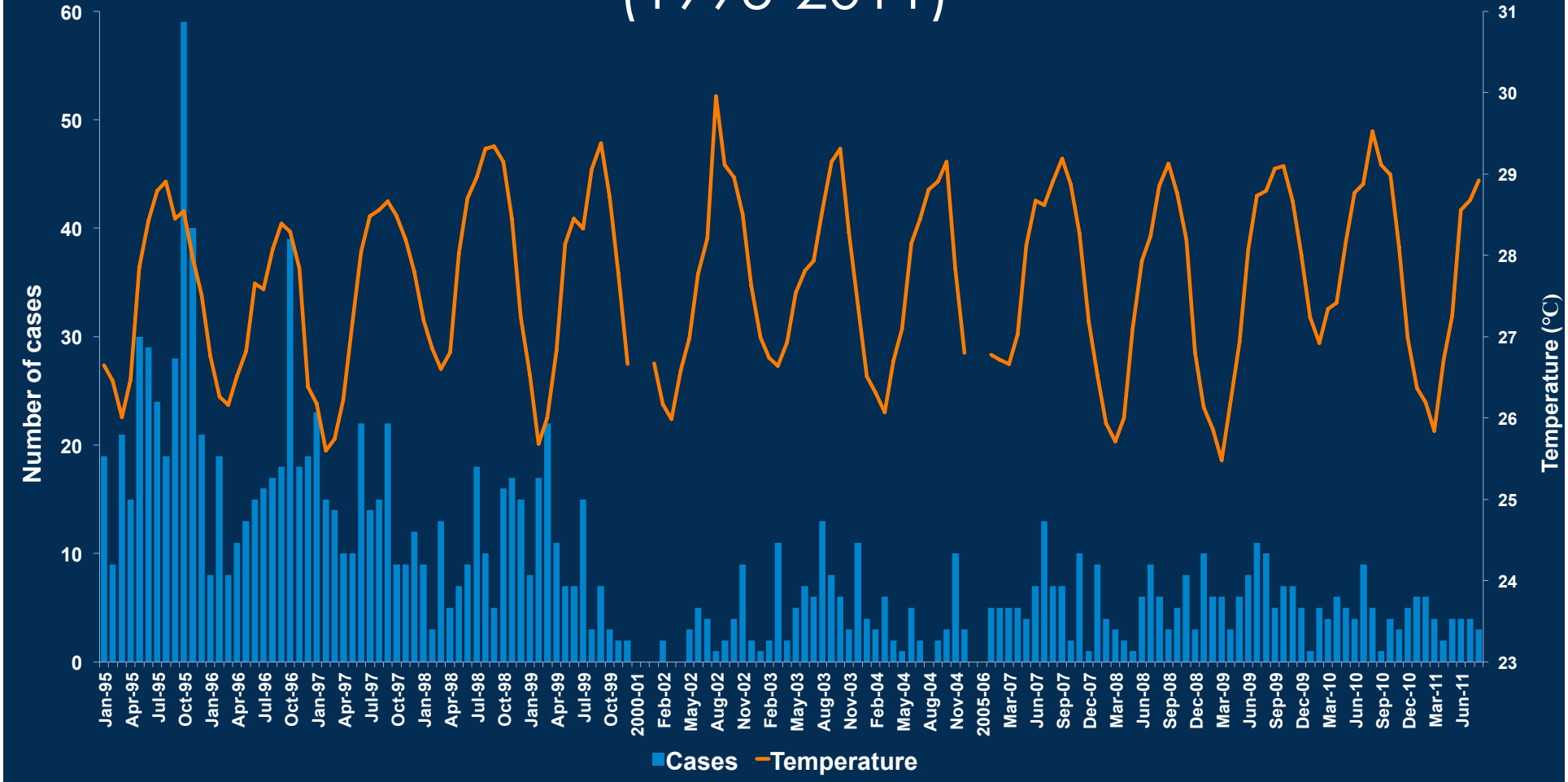
Clinical research in St. Thomas

- Enrolling patients with ciguatera from the emergency room and the community
- Collecting data on symptoms and their severity, sensory perception, cognition, demographics, occupation, fish consumption, medical history, and drug/alcohol use
- Follow up at 3 and 12 months to evaluate chronicity


Gambierdiscus spp. abundance, Seahorse
Max temp: 29.7 (Aug 10)
Min temp: 25.8 (Mar 11)
Cells g-1 Dictyota
SW temperature (°C)
600
500
400
300
200
100
0
30
29
28
27
26
25
24
January
February
March
April
May
June
July
August
September
October
November
December
2008
2009
2010
2011
SW temp
Gambierdiscus spp. abundance positively correlated with SW temperature

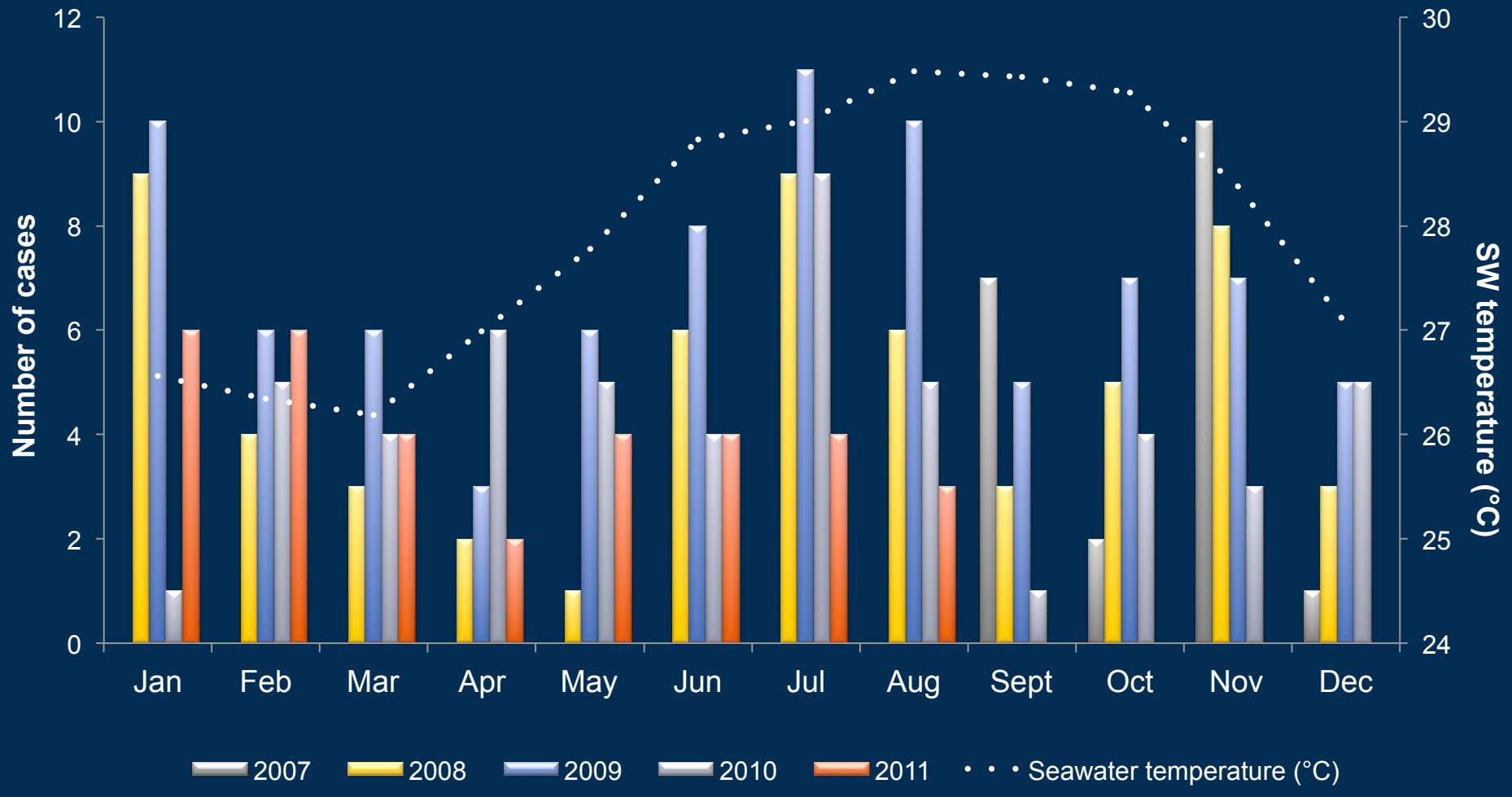

G. caribaeus
SH Nov09
BP Aug08
Growth (division day-1)
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
Temperature (°C)

Cases of CFP and mean SST in St. Thomas (1995-2011)

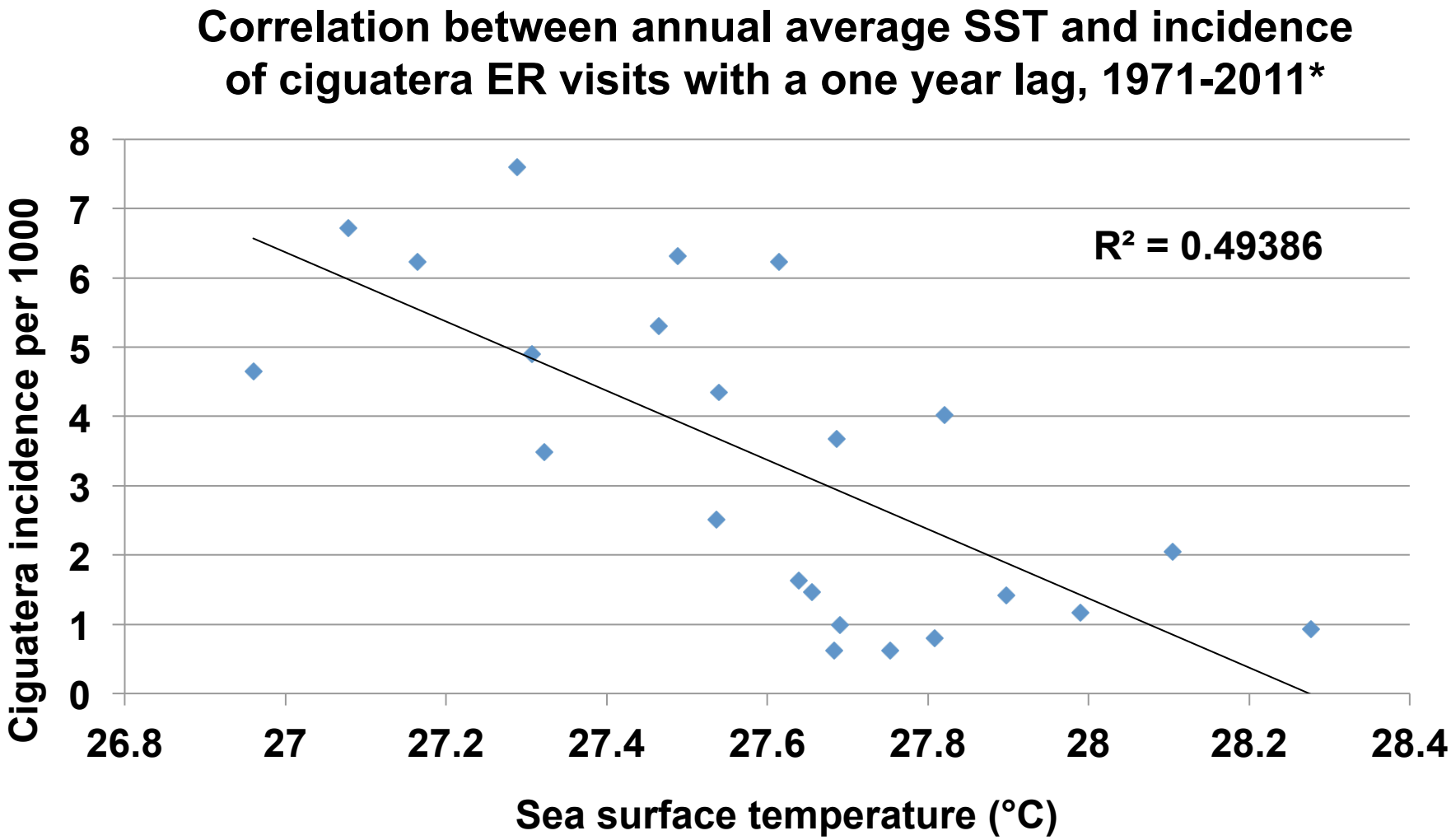


Medical record review: Total of 1335 cases between 1995 and 2010 (gaps from 2000-01 and 2005-06); highest number of ciguatera cases observed in 1995-1996.

Cases of ciguatera fish poisoning and mean seawater temperature (2007-2011)



- Number of ciguatera cases presented to the ER were highest in July 2009.
- No seasonal trend evident during study period; other factors (e.g., “banquet effect”) may affect prevalence of ciguatera cases.



*Data from 1971-1979, 1995-1999, 2002-2005, 2007-2011

Ciguatera incidence estimates among adults in St. Thomas (per 1000 population)

Data source	1980	2011
Emergency room visits*	18	6
Current survey vs. Morris et al. 1982 (age adjusted to nearest Census)	14	12
Current survey vs. Morris et al. 1982 (age adjusted to 1980 survey)	14	8
Current survey vs. McMillan et al. 1980	22% of households	11% of households

*Averaged over 3 years, calculated by dividing the incidence of ER visits by the proportion of survey participants who visited the ER for their most recent ciguatera illness. Assumes 50% of ill individuals visited ER in 1971-71 and 30% visited ER in 2010-11 based on respective surveys.

Future work – CiguaHAB (funded by NOAA CSCOR) – 2011-2015

- Study will characterize *Gambierdiscus* population diversity and connectivity in the greater Caribbean
- Determine effects of environmental factors on the growth and toxicity of *Gambierdiscus*.
- Investigate *Gambierdiscus* population dynamics and the environmental conditions that contribute to blooms.
- Investigate the fate of ciguatera precursors, toxins and metabolites in the coral reef food web.
- Model the population dynamics and toxin production of *Gambierdiscus* under different environmental forcings, including climate change.
- Communicate project results to stakeholders and discuss applications to resource management
- No epidemiological component

Summary

- Ciguatera is a serious threat to human health in many tropical and sub-tropical countries. In many areas, it causes underutilization of much-needed fisheries resources.
- There is a positive correlation between ciguatera incidence and seawater temperature in some regions. There are multiple reasons to expect higher ciguatera incidence as temperatures rise.
- In other areas (e.g., USVI) a negative correlation is emerging between temperature and ciguatera poisoning incidence. This may reflect multiple factors (e.g., education, over fishing, excessive temperatures for *Gambierdiscus* growth, etc.) and argues that simplistic climate forecasts based on temperature alone can be misleading.
- The establishment and maintenance of long term datasets are <u>essential</u> for detecting trends in *Gambierdiscus* populations and ciguatera cases, and unraveling the complex linkages between ciguatera fish poisoning, reef health, and climate change.

Acknowledgements

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