# Ciguatera Poisoning in Florida

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# Key Personnel

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GREATER CARIBBEAN CENTER FOR CIGUATERA RESEARCH

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University of South Alabama

Dauphin Island Sea Lab
Alabama

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University of South Alabama
Mitchell Cancer Institute

The University of Texas Marine Science Institute

Woods Hole Oceanographic Institution
1930

University of the Virgin Islands
1962

CiguaHAB

NSF

NIH National Institute of Environmental Health Sciences
Your Environment. Your Health.

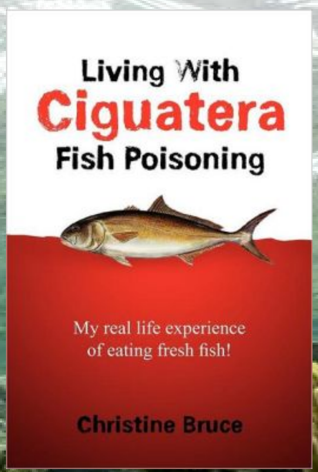
NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

# Ciguatera Poisoning

- Seafood poisoning (primarily reef fish)
- Originates in (sub)tropical regions
- Affects tens of thousands of people annually
- 1,000 people in Florida are afflicted each year
- $30+ million annual impact in the U.S. alone
- Underreported; misdiagnosed

# Ciguatera Poisoning

- Gastrointestinal symptoms
- Neurological  symptoms
- Lasts weeks to years
  - Triggers for relapses




"It was the worst I ever felt"

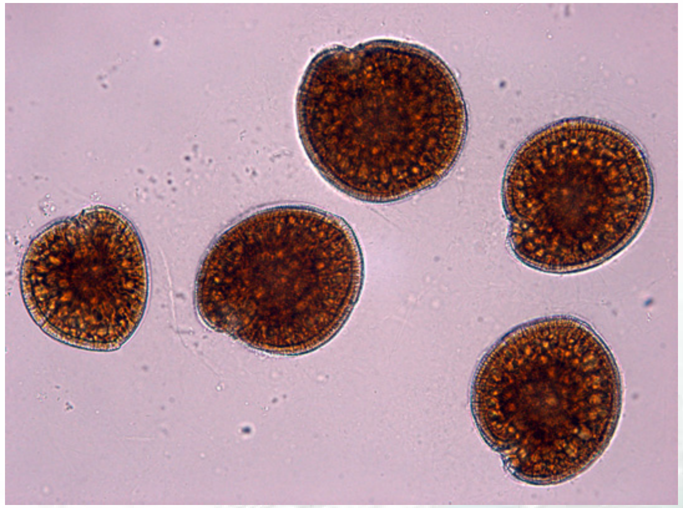
“when I stood up and took a few steps - I felt as if I'd stepped into a hole, so my body didn't seem to register that my feet were actually making contact with the ground!"

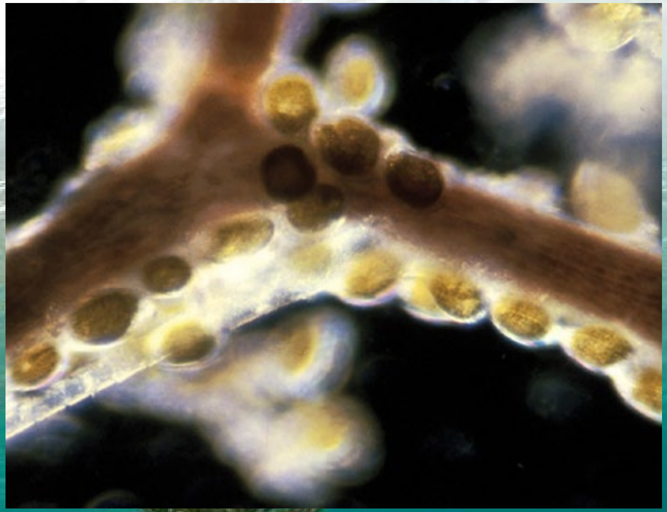
“…my palms and soles started to itch and turn red again”

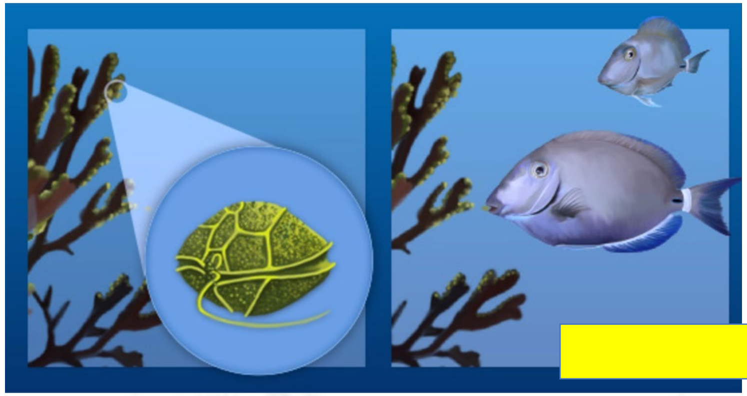
"horrible! I couldn't walk on the tile floor; it felt like it was burning me."

# Ciguatera Poisoning

- Thought to be caused by toxins (or precursors) produced by some members of the dinoflagellate genus, *Gambierdiscus*
  - ciguatoxins (CTX)
  - 18 characterized species
  - Found worldwide in tropical and sub-tropical oceans
- They are epiphytic - known to attach to the surface of macroalgae

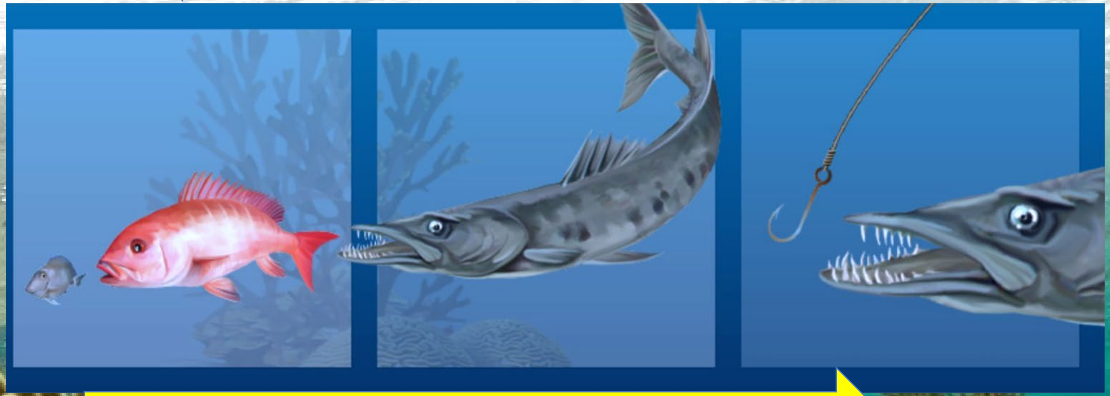






Reef fish and invertebrates eat the toxic cells while grazing on coral reefs

Predatory fish eat the herbivores and make the toxins more potent → **Ciguatoxin**



People consume toxic fish and get **Ciguatera Poisoning**

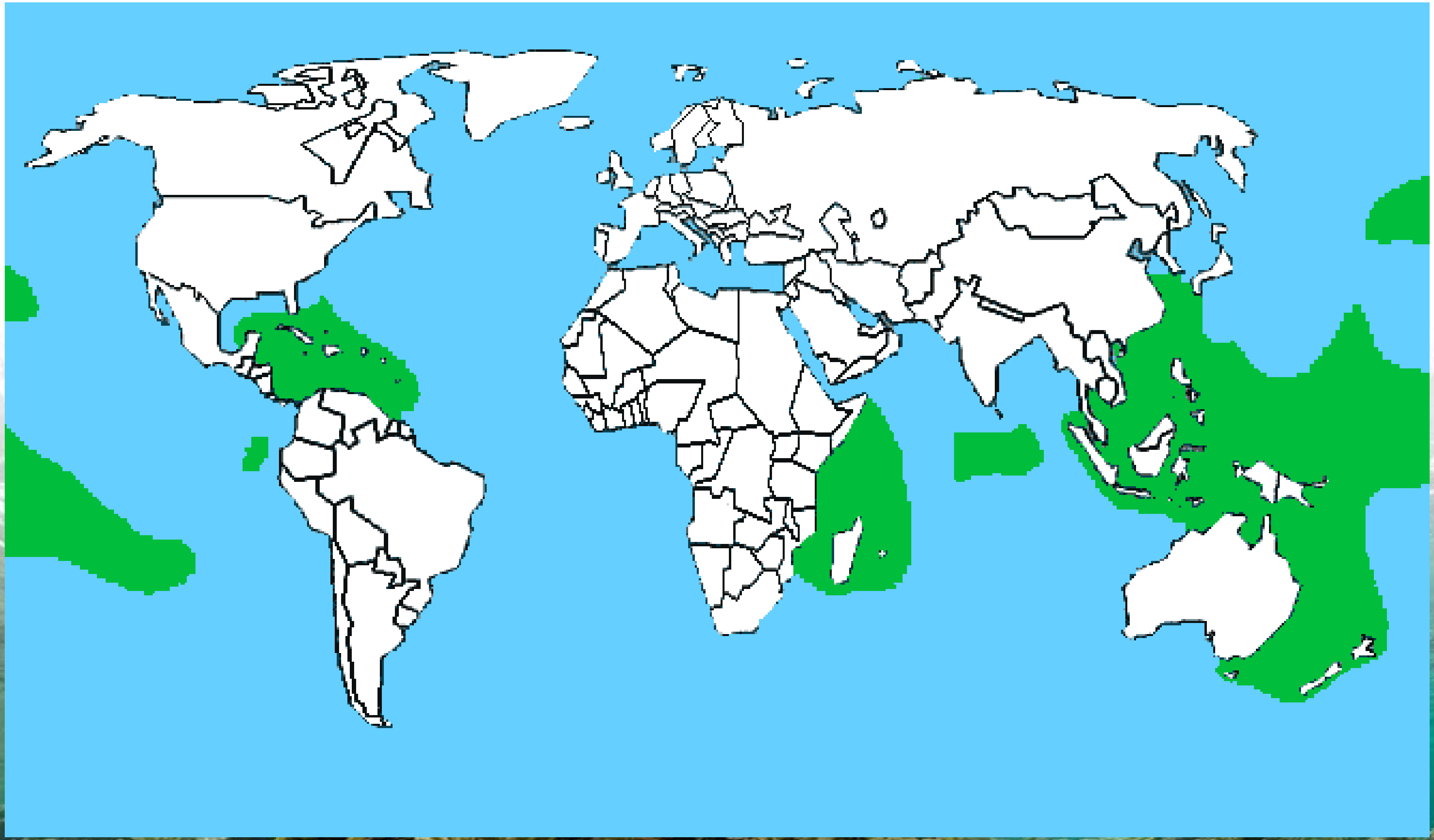
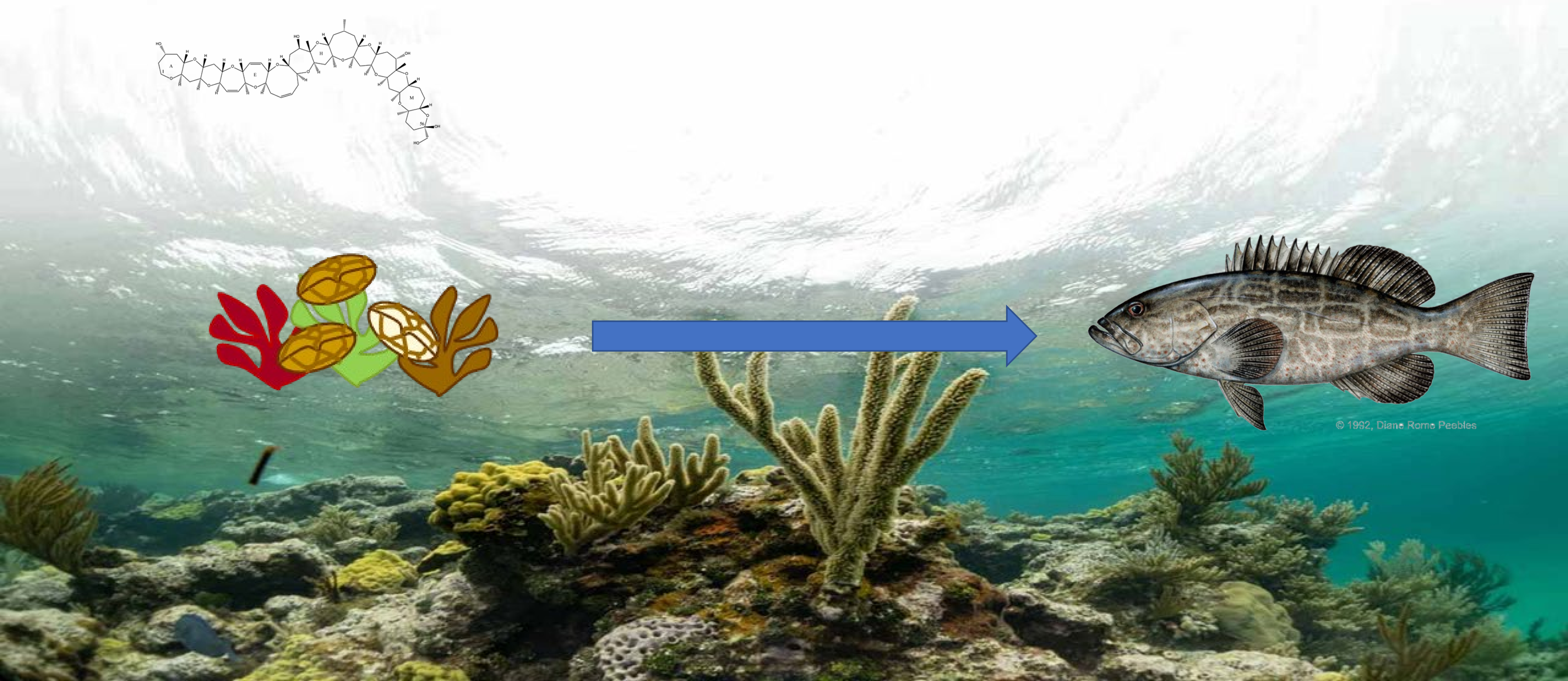


Figure by University of Maryland,
Dept of Emergency Medicine

# US Seafood Imports

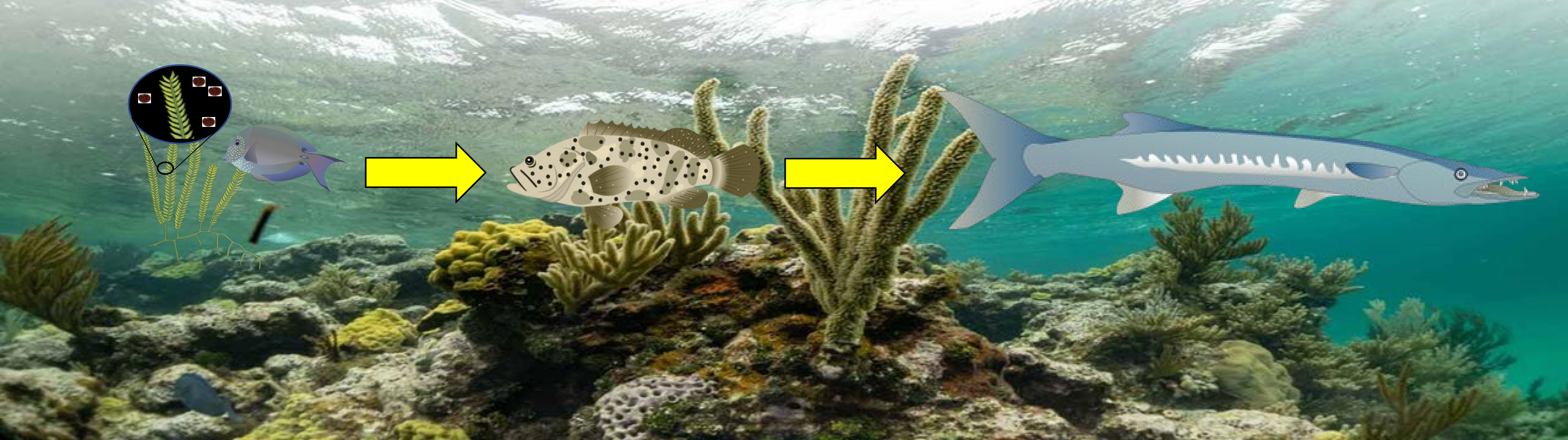
- The US is the largest importer of seafood (by value) in the world (FAO)
- US seafood imports have tripled in the last 20 years (FAO)
- Over 90% of the seafood consumed in the US is imported (NOAA)

# The GOAL:

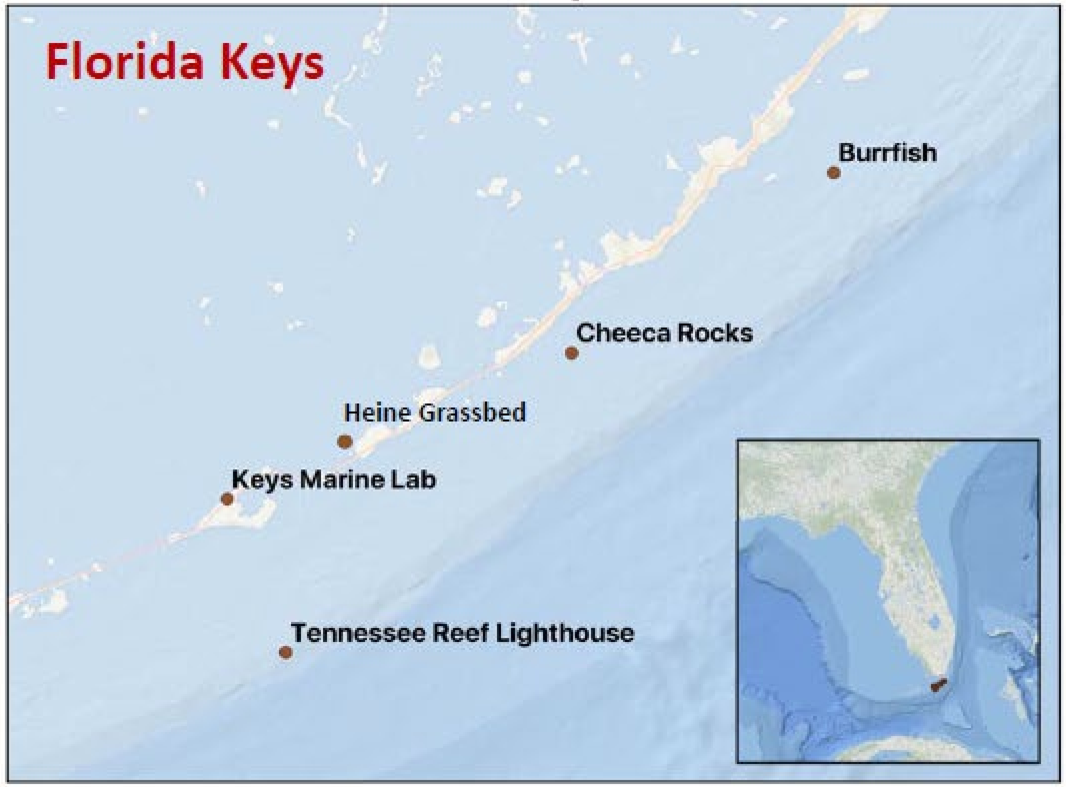


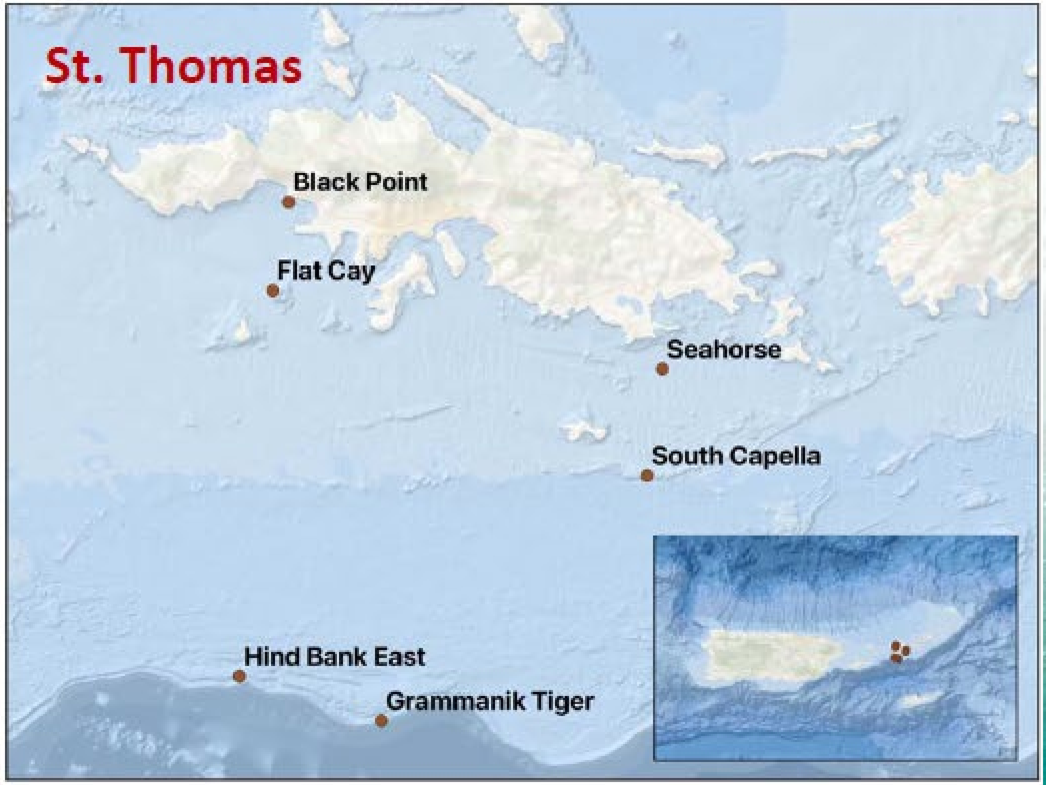
# How can we monitor (or predict) toxin transfer from Dino to Dinner?

- Factors to consider:
  - Cell densities versus algal toxin load
  - Substrate vector (habitat preference, palatability)
  - Trophic transfer dynamics



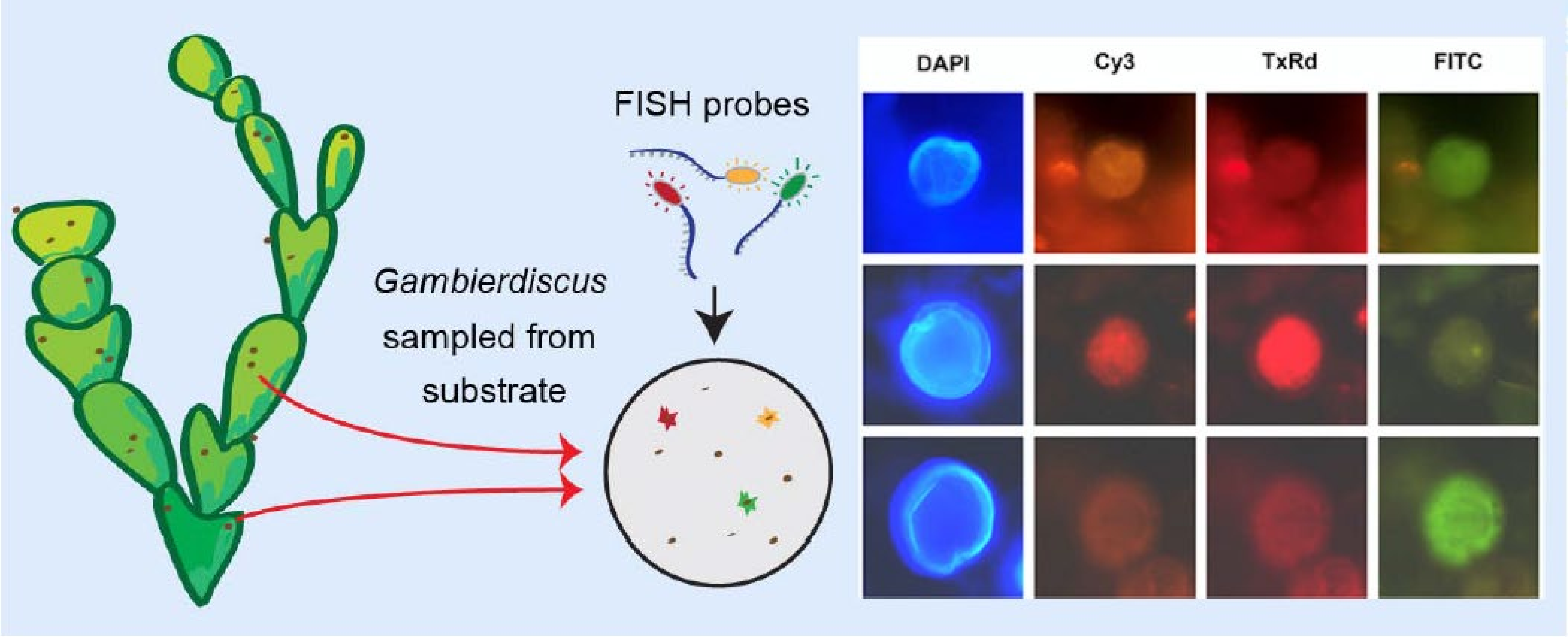
# 2018-2020 Sample Collections



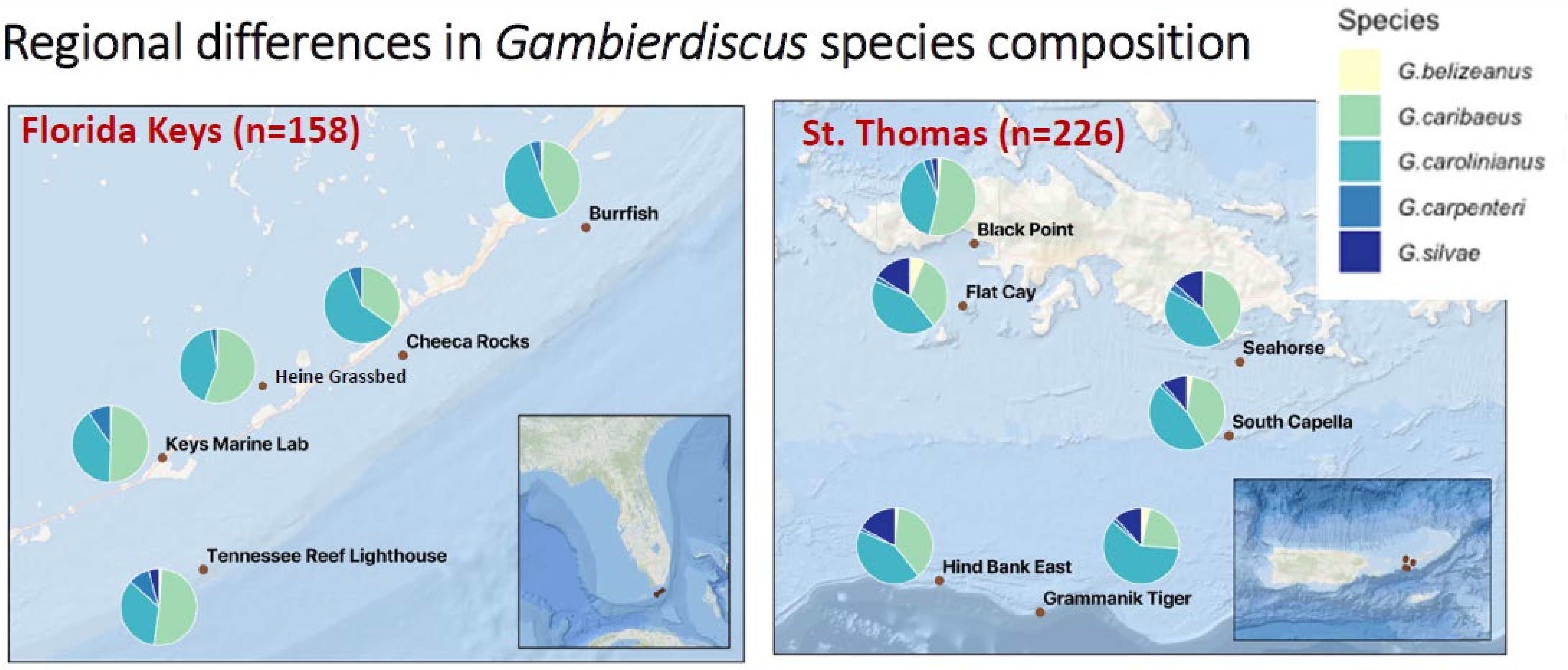

- Sample strategy enables comparisons across geography and over environmental gradients
- Five sites in Florida Keys and six sites in St. Thomas sampled quarterly
- Different habitats (near-shore, off-shore, sea grass beds coral reefs) and depths
- Multiple taxa collected: *Dictyota, Laurencia, Lobophora, Sargassum, Halimeda, Thalassia*

# Assessing *Gambierdiscus* community composition




*Gambierdiscus* species enumerated in samples using fluorescent in situ hybridization (FISH) with molecular probes: *G. belizeanus, G. carpenteri, G. carolinianus, G. caribaeus, G. silvae* (Pitz et al. 2021)

# Regional differences in *Gambierdiscus* species composition




- Proportional abundance of *Gambierdiscus carolinianus* and *G. caribaeus* highest across almost all sites in both locations
- ""Superbug" species *Gambierdiscus silvae* observed at all field sites in St. Thomas; absent or scarce in the Florida Keys

# Cell Counts Versus Algal Toxin Load: Cell Toxicity

| Species* | # Isolates Tested | Origin | Toxin Cell Quota (pg C-CTX-1/cell) |
|---|---|---|---|
| *G. caribaeus* [#] | 16 | USVI | 0.001—0.01 |
| *G. caribaeus* [#] | 1 | FLK | ND |
| *G. carolinianus* [#] | 6 | USVI | 0.001—0.012 |
| *G. carolinianus* | 1 | FLK | ND |
| *G. carpenteri* | 2 | USVI | ND |
| *G. carpenteri* | 1 | FLK | ND |
| *G. belizeanus* [#] | 20 | USVI | 0.003—0.28 |
| ***G. silvae*** | **37** | **USVI** | **2.1—4.8** |
| ***G. silvae*** | **1** | **FLK** | **ND** |

ND: Below detection, not detected

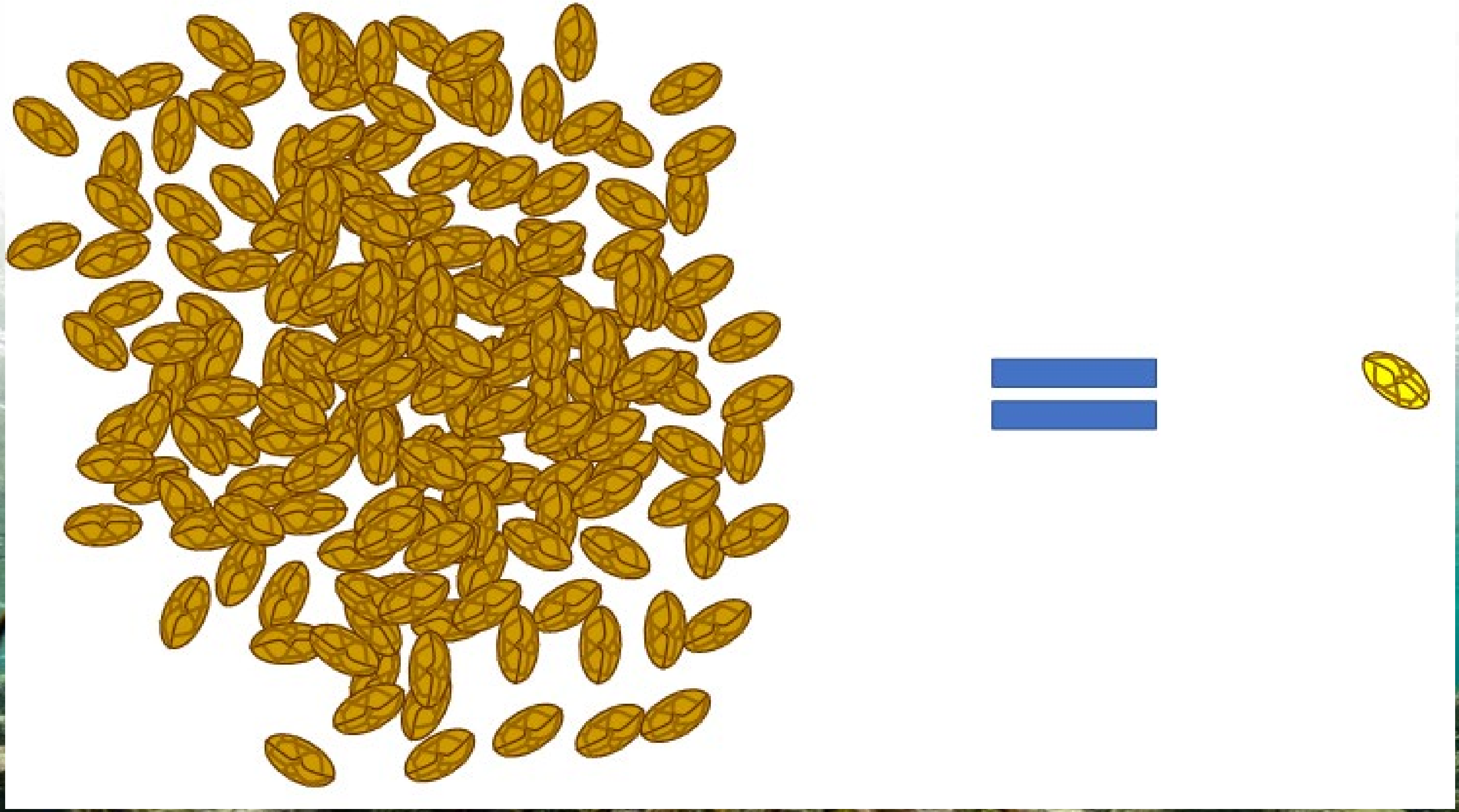
[#] Other toxins detected in some isolates, batch purification in process

* Species confirmed by ribosomal sequencing

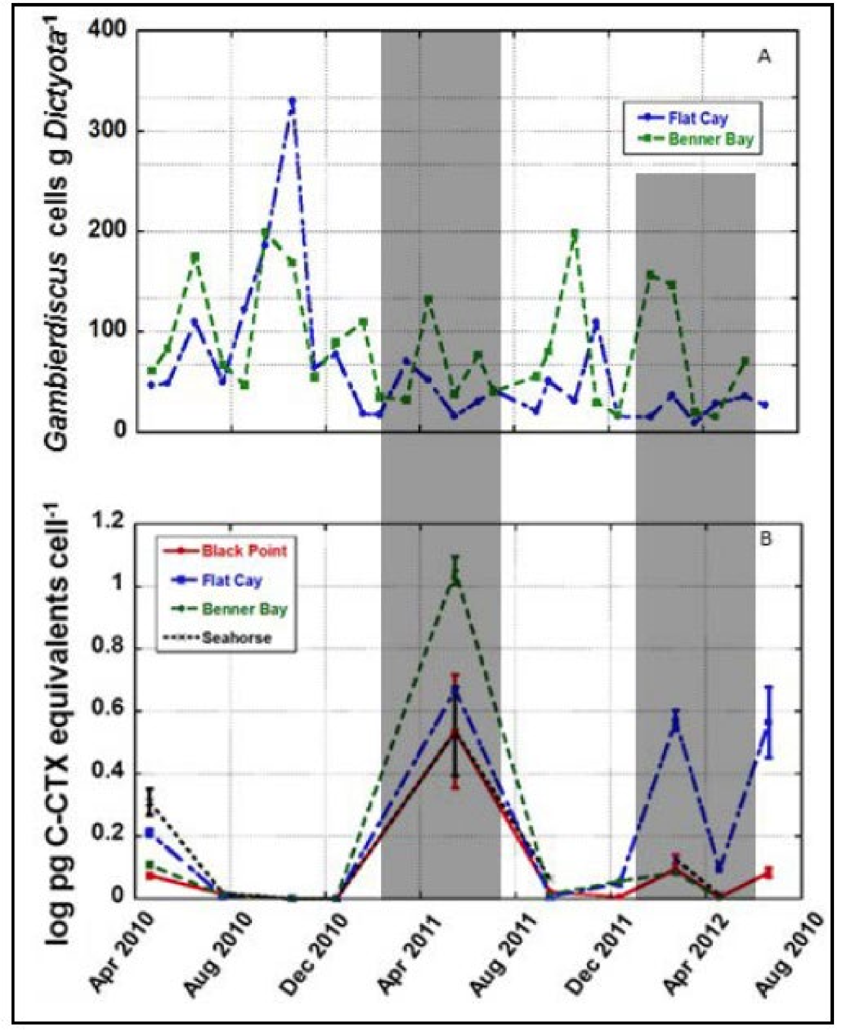
USVI: United States Virgin Islands (Caribbean)
FLK: Florida Keys

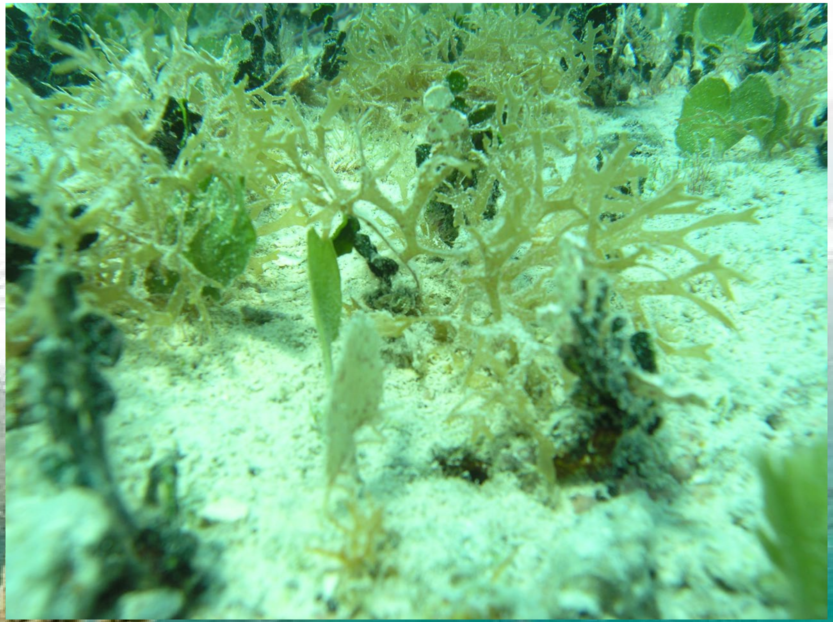
Robertson et al., in prep.

# Cell Counts Versus Algal Toxin Load



# Cell counts may not match up with algal toxin load



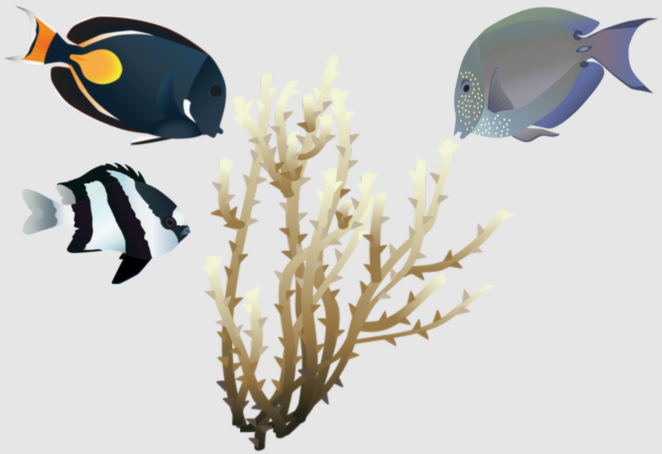



Robertson et al., in prep.:
*Gambierdiscus*; St. Thomas; USVI

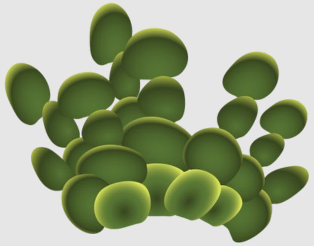
# Algal Palatability

- Not all algae are equally palatable

Based on Cruz-Rivera and Villareal (2006)



Palatable = vector



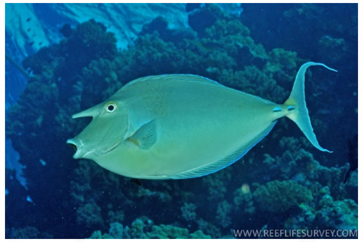
Unpalatable = refuge

# The various *Gambierdiscus* species may exhibit host preferences

(Rains & Parsons 2015)

What if the most toxic *Gambierdiscus* cells ( ) prefer to settle on the most palatable host algae?

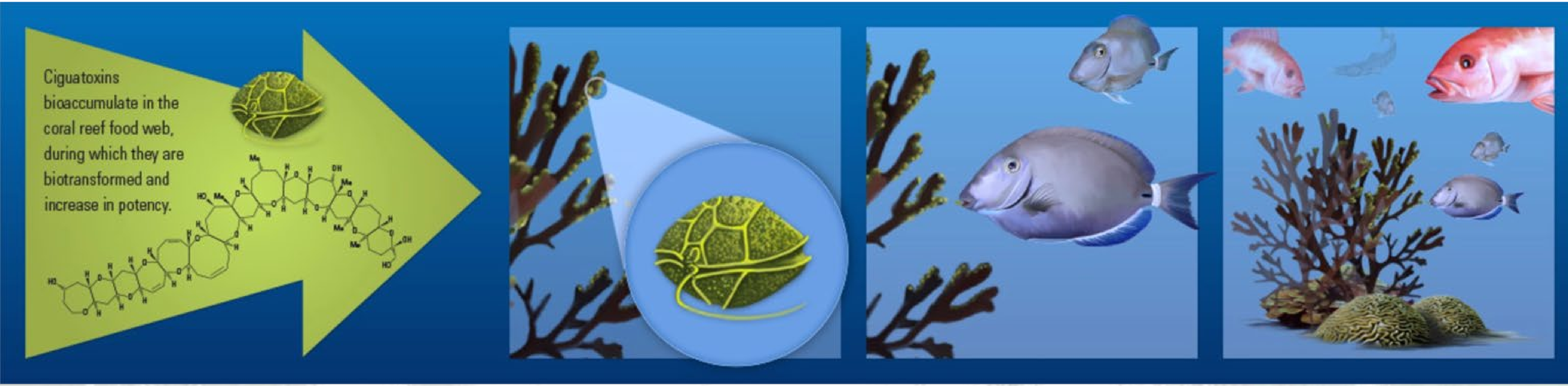
# *Naso* feeding preferences influence toxin loading




(based on data provided by Meyer and Holland, 2005 & Clausing et al., 2016a)

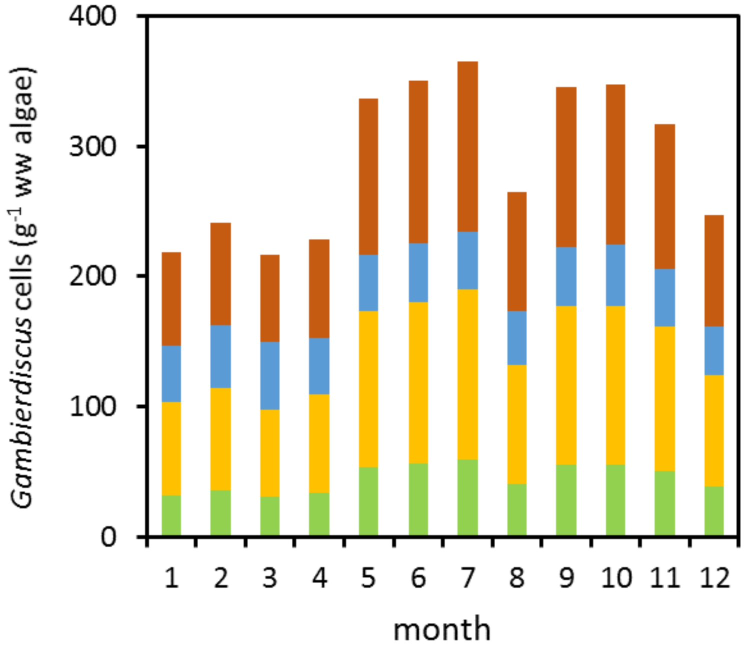
| Parameter | Average consumption rate (cr) | Median cr | Most-preferred algae cr (*Valonia fastgiata*) | Least-preferred algae cr (*Halimeda macroloba*) |
|---|---|---|---|---|
| g ww algae consumed $d^{-1}$ | 2.4 | 0.8 | **27.2** | **0.5** |
| # *G. silvae* needed (cells $g^{-1}$ wet wt algae) | 155 | 463 | **16** | 772 |
| # *G. belizeanus* needed (cells $g^{-1}$ wet wt algae) | 2262 | 6775 | 226 | **11292** |

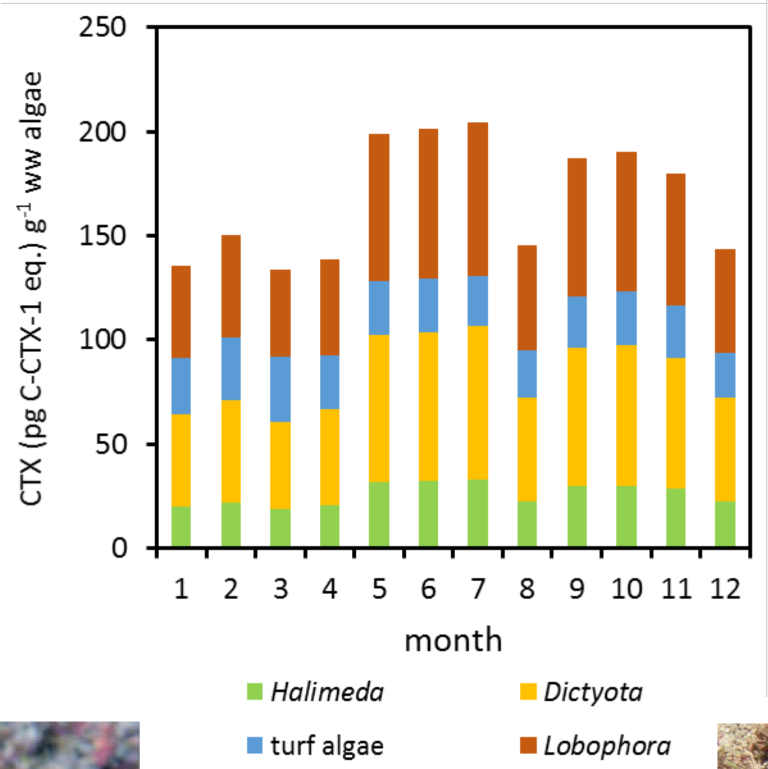
* Cell concentrations are rarely above 1,000 cells $g^{-1}$ wet wet algae.

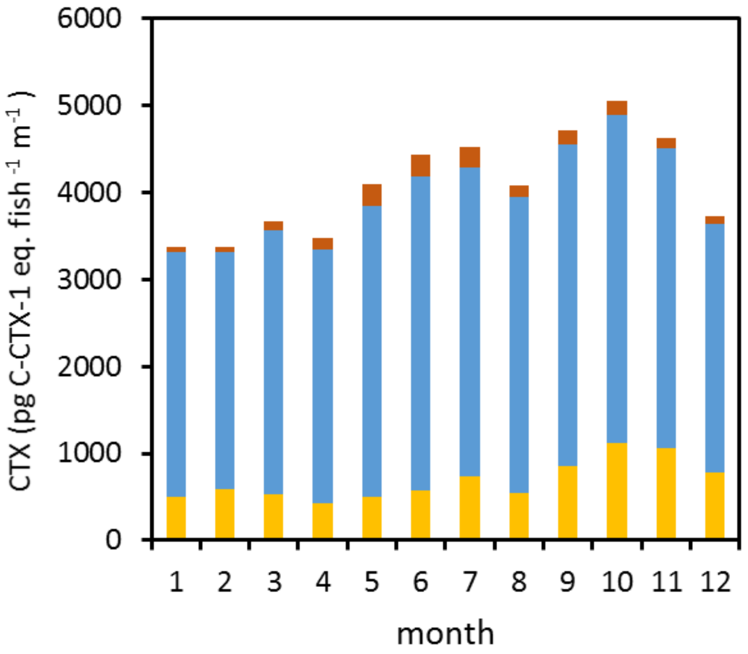



- **Modeling ciguatoxin flux:**
- Benthic community composition & macroalgal assemblage
- Abundance and species composition of *Gambierdiscus* populations within region and sites (derived from FISH), and across different algal substrates (e.g., *Dictyota, Halimeda,* turf algae)
- Toxin potential of *Gambierdiscus* assemblages based on community composition and cellular toxin content of *Gambierdiscus* species
- Herbivorous fish grazing preferences on algal substrates and grazing rates

# Turf continues to demonstrate it is a primary vector



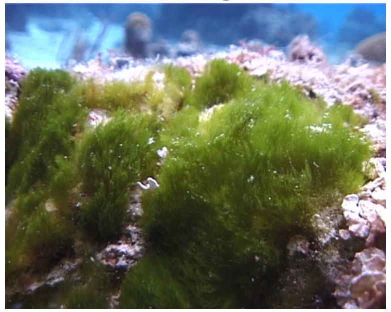




*Halimeda*

*Dictyota*


*Lobophora*


turf algae



| Grazing Target | *Gambierdiscus* abundance: High | *Gambierdiscus* abundance: Low |
| --- | --- | --- |
| High | Turf<br>**Vector – Worst for CP** | *Dictyota* ? |
| Low | *Halimeda*<br>**Refuge – Best for *Gambierdiscus* growth** | Sand |

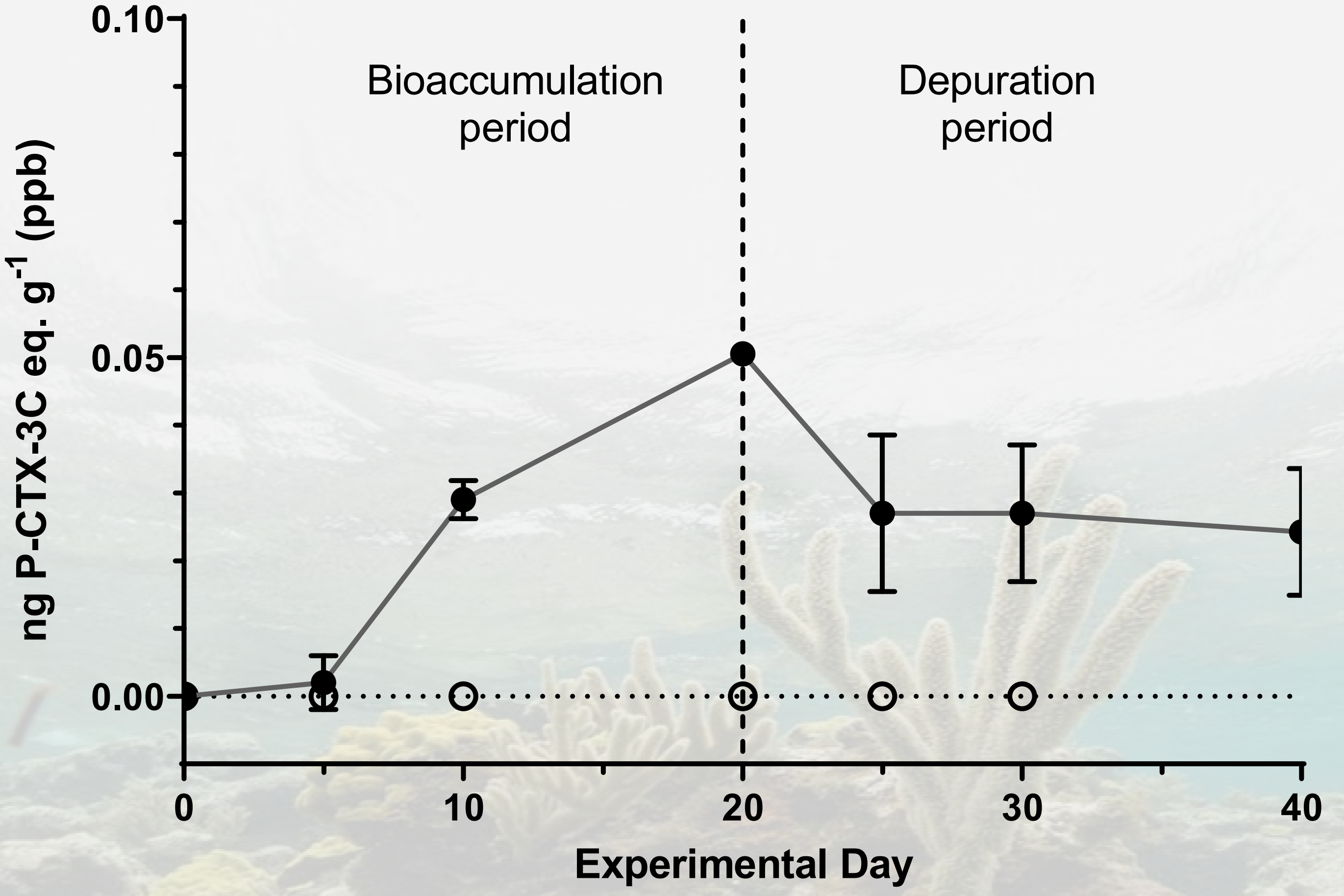
Which algal hosts are vectors and which are refuges?

Based on: Littler et al. 1983; Cruz-Rivera & Villareal 2006; Parsons et al. 2011

# Bioaccumulation

- Clausing et al. (2016a)
  - Herbivorous fish can reach CTX thresholds within weeks
  - ~8% of toxin was retained

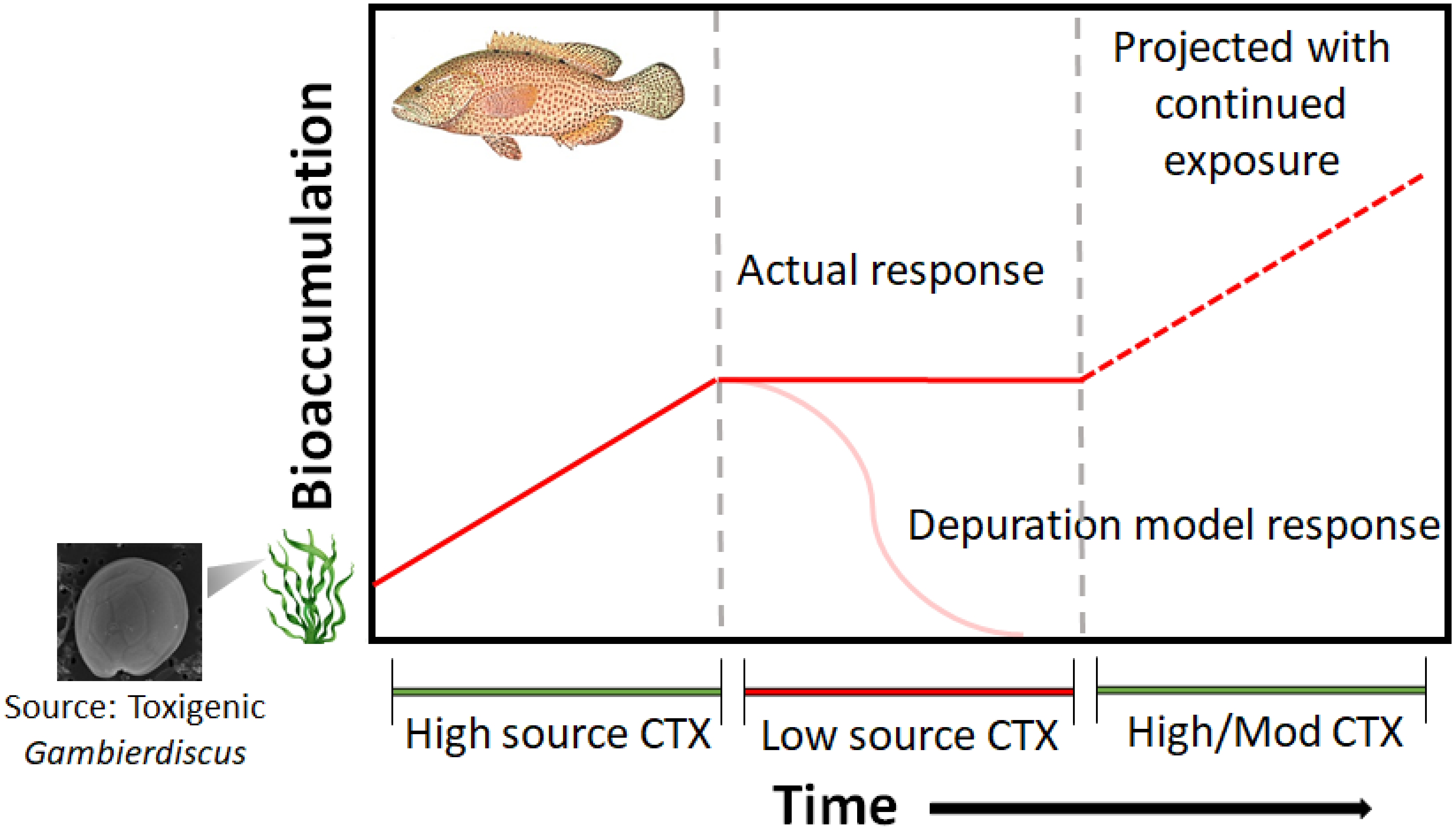
# Bioaccumulation & Depuration of CTXs




Bennett & Robertson *in prep.*

*Lagodon rhomboides*

# Bioaccumulation: Conceptual Model



# Bioaccumulation and Depuration

- Ciguatoxins can reach threshold levels within weeks
  - But can also be depurated within months
- Does trophic transfer of CTX have to be relatively quick, then (months)?

Clausing et al. (2016b)

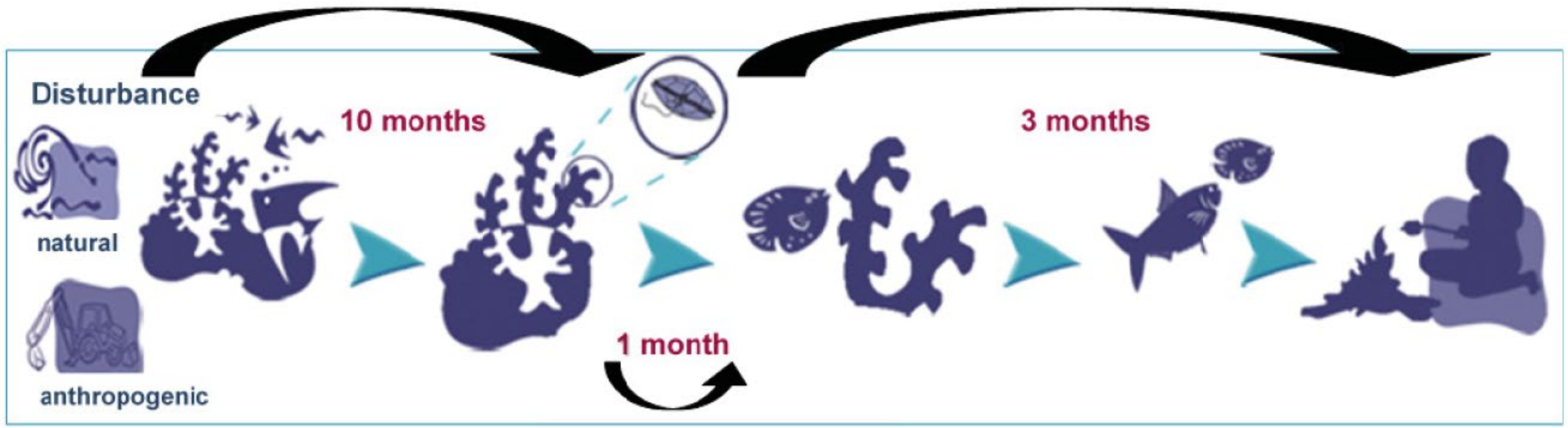



**Figure 4.** Graphic depicting the lag-time from environmental disturbances to occurrence of Gambierdiscus cells and transfer of ciguatoxins into the food web and ultimately to humans.

# Trophic pathways

- Herbivores
  - As mentioned earlier
- Detritivores
  - Including some surgeonfishes
- Planktivores
- Piscivores

# Fish Types associated with ciguatera cases in Florida: 2000 – 2011 (Radke et al. 2015)

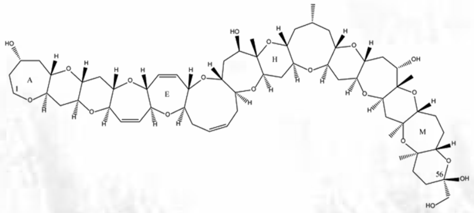
| Fish | # of CFP cases (%) | Average landings lbs (%) | %CFP cases : %landings |
|---|---|---|---|
| Hogfish | 30 (7) | 296,154 (0.3) | 28 |
| Barracuda | 75 (18) | 897,461 (0.8) | 23 |
| Amberjack | 32 (8) | 2,638,570 (2) | 4 |
| Grouper | 129 (31) | 8,942,747 (8) | 3 |
| Snapper | 34 (8) | 8,200,017 (7) | 1 |
| Other jack | 11 (3) | 4,717,613 (4) | 0.6 |
| Mackerel/kingfish | 22 (5) | 16,825,185 (15) | 0.4 |
| Mahi mahi | 8 (2) | 6,731,426 (6) | 0.3 |

# Hogfish (*Lachnolaimus maximus*)

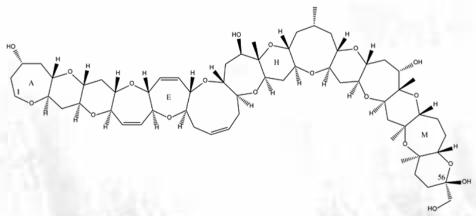
**From Randall (1967) (49 stations; 80 individuals; USVI and Puerto Rico)**

| Diet | Volume (%) |
|---|---|
| Bivalves | 42.6 |
| Gastropods | 39.7 |
| Crabs | 6.1 |
| Hermit crabs | 4.9 |
| Echinoids | 4.6 |
| Amphipods | 1.0 |
| Scaphopods | 0.6 |
| Barnacles | 0.5 |

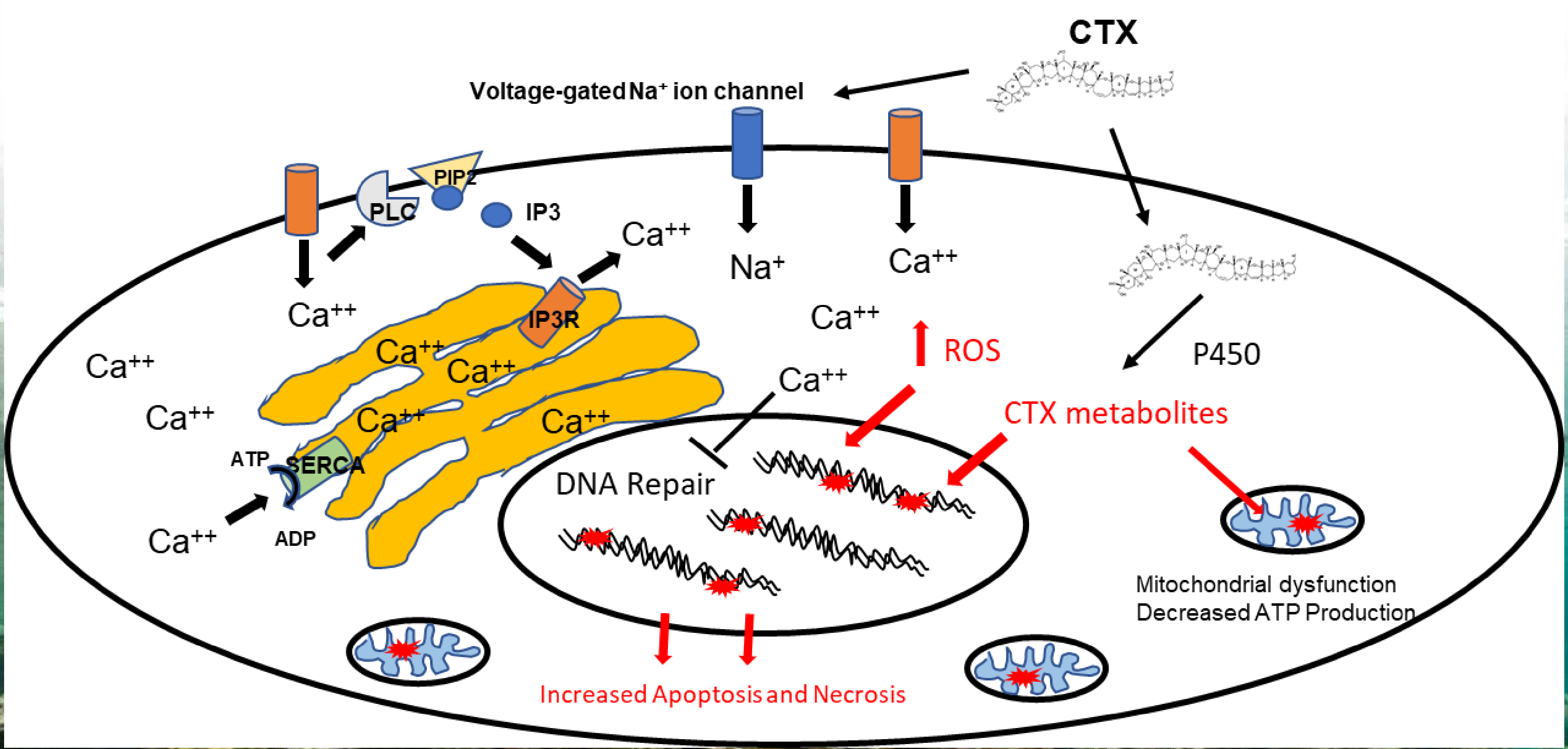
# The GOAL:



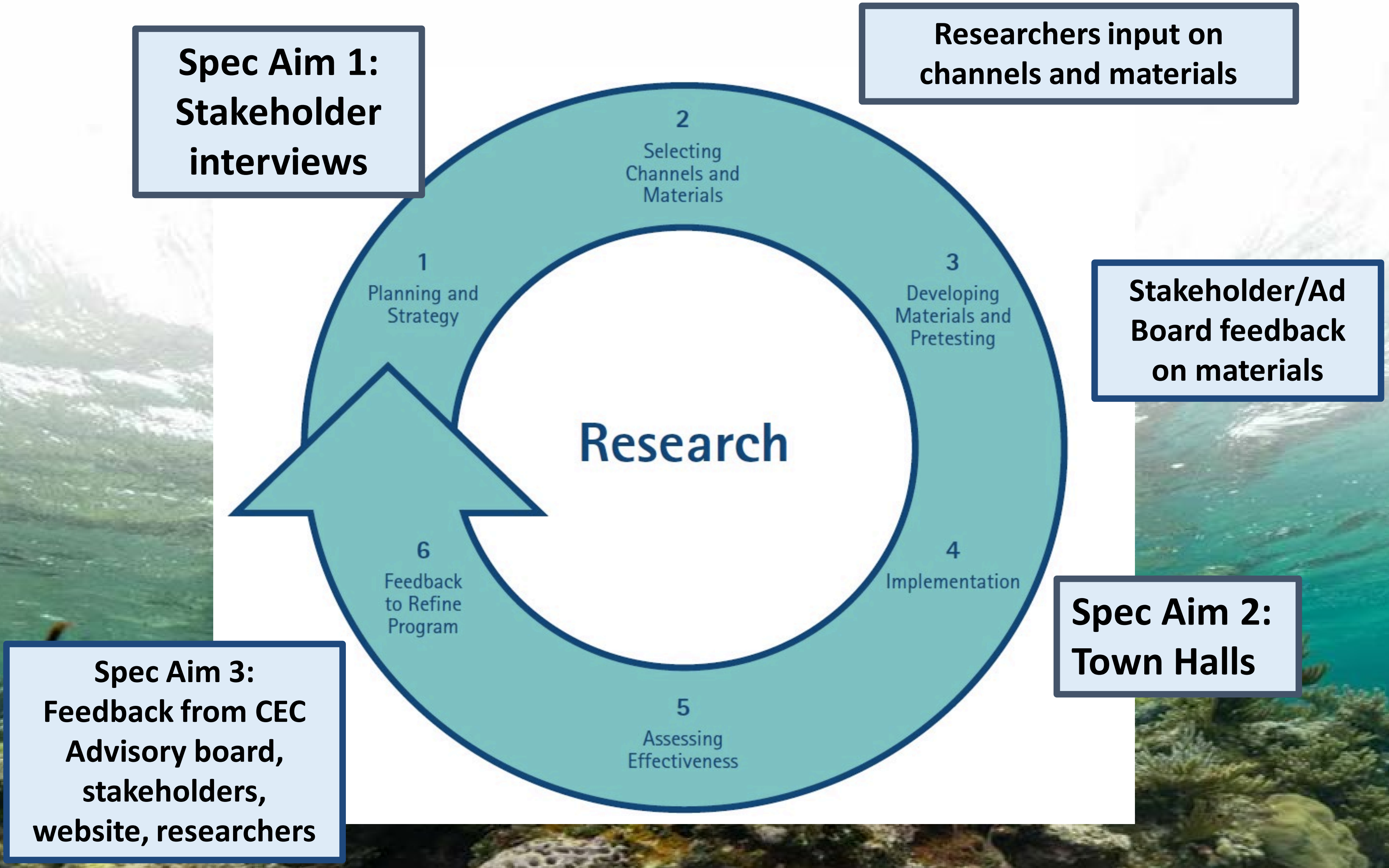
# Reality:



# Proposed model depicting cellular genotoxic responses following CTX exposure (Rob Sobol: USA)



# CEC Dissemination Research

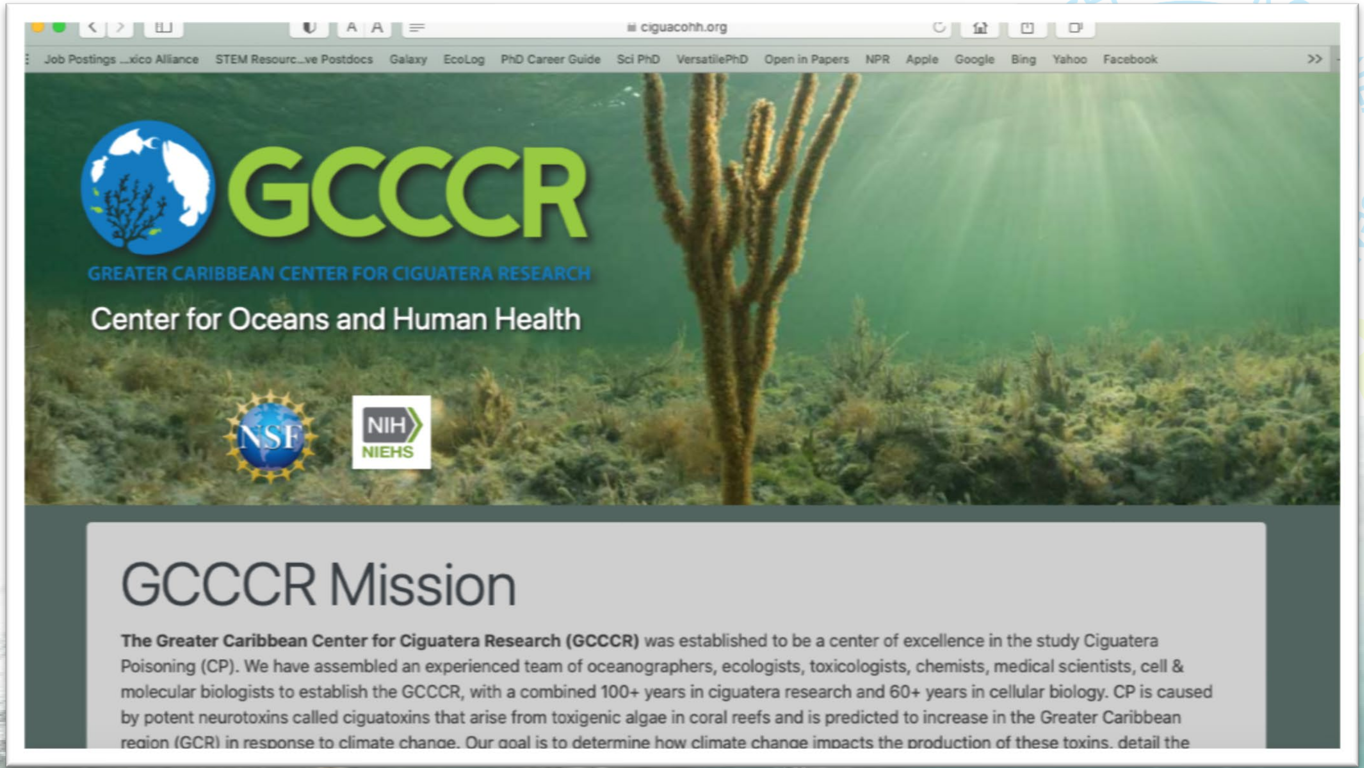


# How to Connect

www.ciguacohh.org

Greater Caribbean Center for Ciguatera Research

@ciguacohh

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