


A Changing Environment: Impacts on Seafood Safety

Moderators:

Jessica Jones, U.S. Food and Drug Administration, Gulf Coast Seafood Laboratory

Lorraine McIntyre, BC Centre for Disease Control in Vancouver, British Columbia

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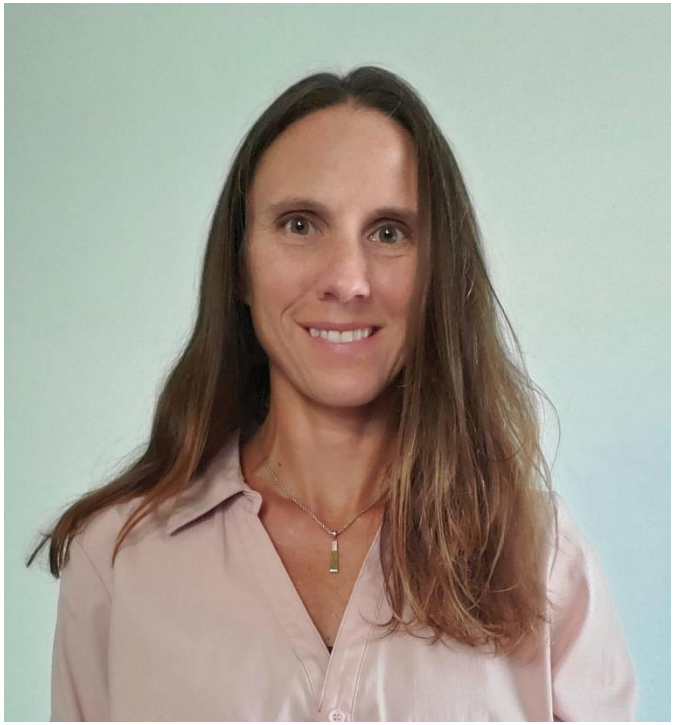
International Association for Food Protection® WEBINAR

Jessica L. Jones, Ph.D.



Dr. Jessica Jones is located in the FDA's Gulf Coast Seafood Laboratory (GCSL) in Dauphin Island, Alabama. GCSL is the FDA's primary seafood safety research group. In her current supervisory role, Jessica is involved with multiple areas of seafood safety research including pathogenic *Vibrio* species, assessment of human sewage impacts on shellfish growing areas, and microbial aspects of seafood decomposition.

Previously, Jessica was a Research Microbiologist focusing on development, validation, and application of molecular methods for detection and characterization of seafood-borne *Vibrio* spp..

Lorraine McIntyre, M.Sc.

Ms. McIntyre is a Food Safety Specialist with Environmental Health Services at the BC Centre for Disease Control in Vancouver, British Columbia. Ms. McIntyre has worked for BCCDC for over 25 years. Ms. McIntyre investigates shellfish and other outbreaks, conducts applied research, and serves as a technical specialist providing advice to health inspectors.

BC Centre for Disease Control

Provincial Health Services Authority

A Changing Environment: Impacts on Seafood Safety

Oct 16, 2020

Introduction: Lorraine McIntyre

Food Safety Specialist, Environmental Health Services, BC Centre for Disease Control

Vancouver, British Columbia, Canada

BC story since 2015

2015

Vibrio parahaemolyticus

2015-2016

domoic acid

(ASP)

2016-2017

norovirus

2018

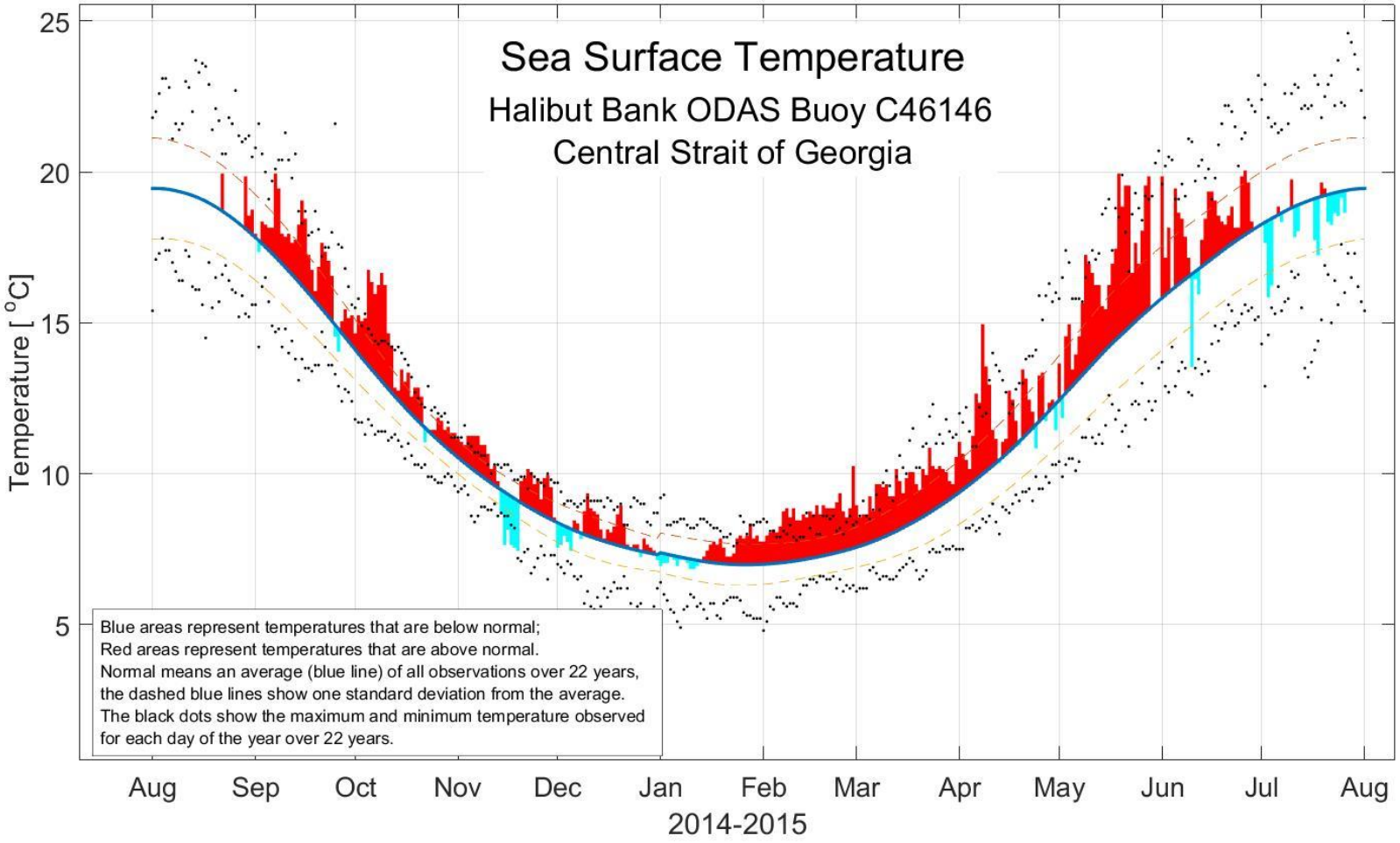
Vibrio cholerae

(and norovirus)

Herring eggs on hemlock branches. Herring eggs are eaten in a variety of ways. They might be eaten fresh, as soon as they are out of the water. They are often cooked – the branch with the eggs on it is dipped once or twice into boiling water.

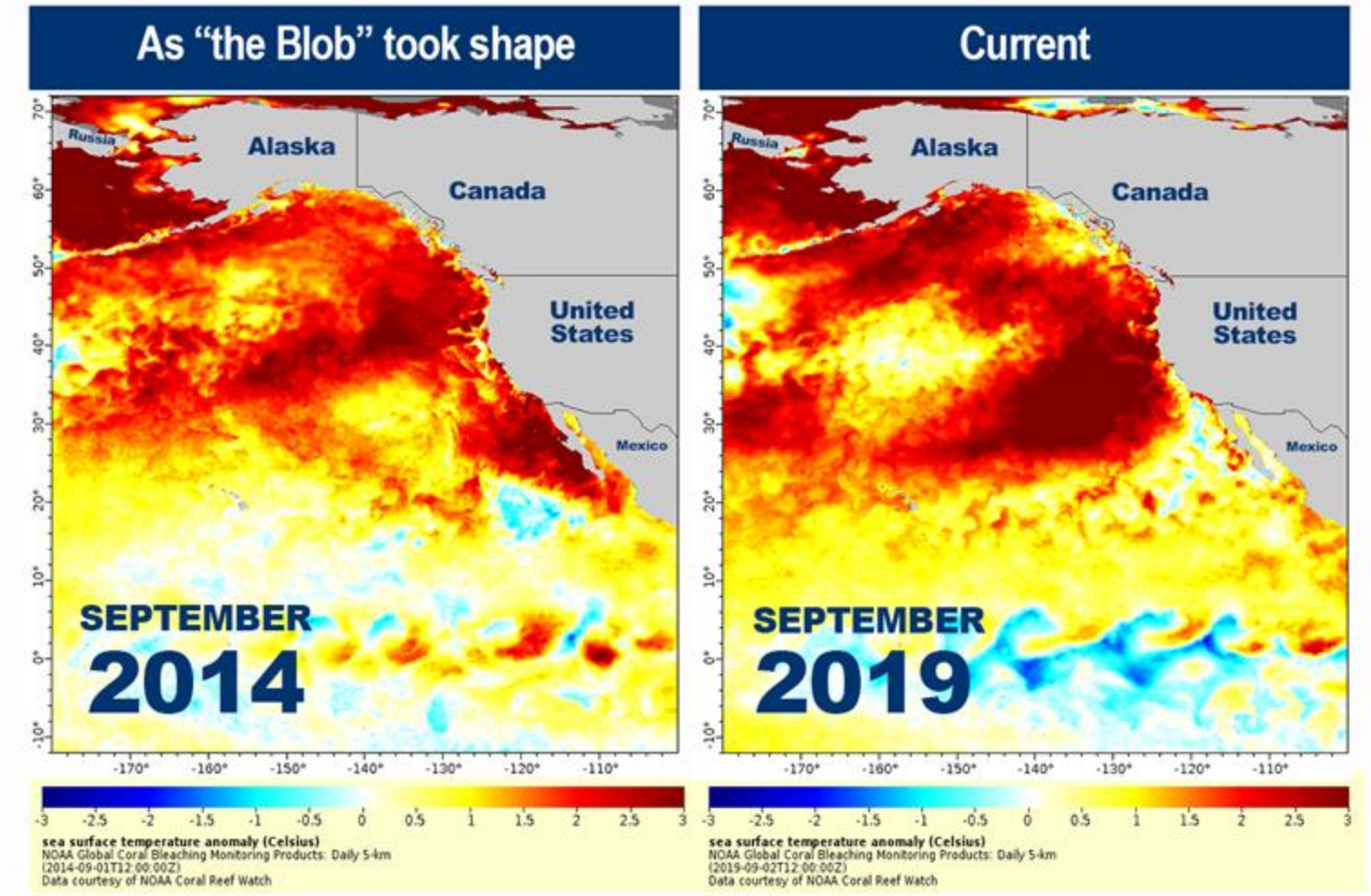
2018/19

paralytic shellfish poisonings (PSP)



Map courtesy of Peter Chandler, Institute of Ocean Sciences

Konrad, S., et al. (2017). "Remote sensing measurements of sea surface temperature as an indicator of Vibrio parahaemolyticus in oyster meat and human illnesses." Environ Health **16**(1): 92.



Sea surface temperature anomaly maps show temperatures above normal in orange and red. Credit: NOAA.

https://climate.nasa.gov/effects/

Craig Baker-Austin, Ph.D.

Dr Craig Baker-Austin is a microbiologist in the Food Safety group at Cefas (Centre for Environment, Fisheries and Aquaculture Sciences). His research interests bridge the gap between marine microbiology, molecular biology and waterborne/foodborne disease emergence. He is especially interested in the dynamics of pathogenic marine bacteria - in particular microbes such as vibrios. Craig is the Director of the UK national reference laboratory and leads an international methods working group on pathogenic vibrios (ISO WG27).

Previous to working at Cefas (since 2008) Craig was a post-doctoral scientist working at the Savannah River Ecology Laboratory, SC, USA.

Vibrio risk assessment – a moving target

Dr Craig Baker-Austin
Principal Microbiologist, Cefas Weymouth Laboratory

Centre for Environment Fisheries & Aquaculture Science

World Class Science for the Marine and Freshwater Environment

Cefas

Previous background of RA on *Vibrio* pathogens in seafood

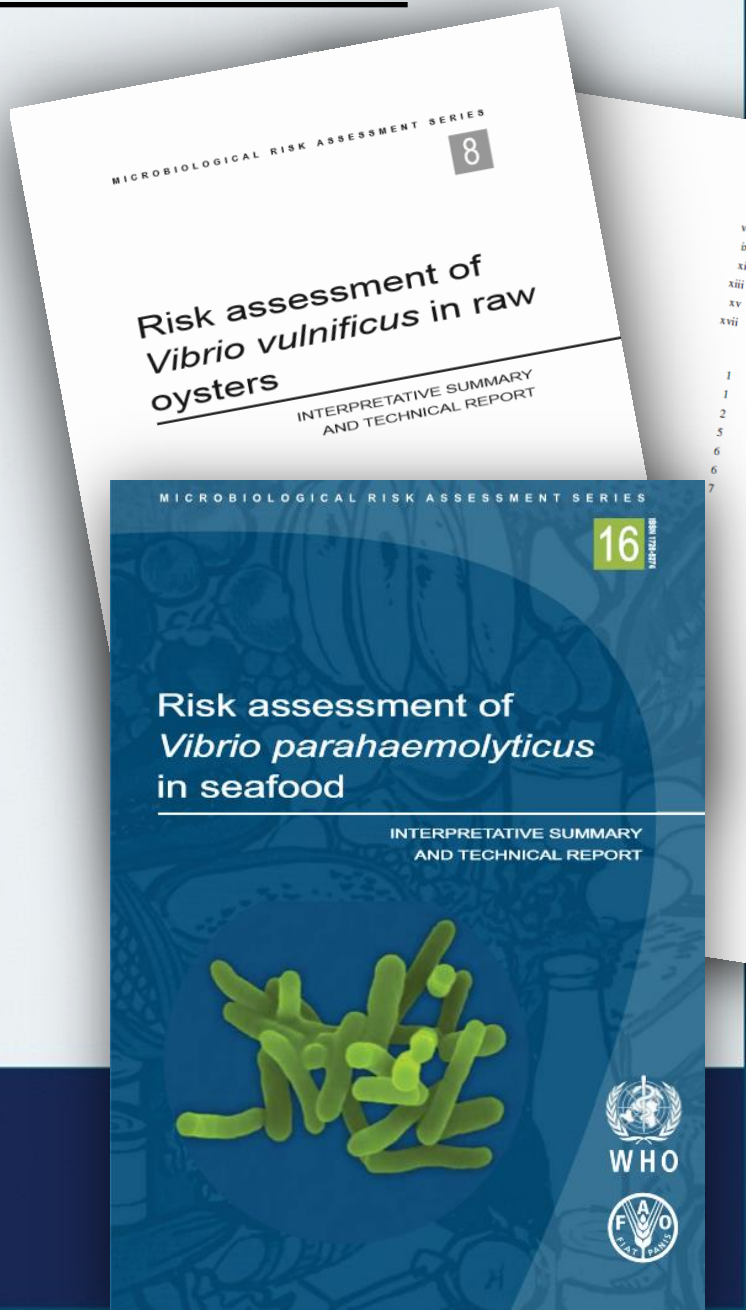
FAO/WHO risk assessments regarding *Vp* and *Vv* have previously been published, and form the basis of international control measures frequently adopted to reduce risk from seafood.

In 2001 FAO/WHO initiated a more comprehensive series of *Vibrio* risk assessments including:

2005: Risk assessment of *Vibrio vulnificus* in raw oysters (VVRA) (https://www.who.int/foodsafety/publications/mra8/en/

2005: Risk assessment of choleragenic *V. cholerae* O1and O139 in warm water shrimp in international trade (https://www.who.int/foodsafety/publications/mra9/en/)

2011: Risk assessment of *Vibrio parahaemolyticus* in seafood (http://www.fao.org/3/a-i2225e.pdf)



New data, and challenges

The previous risk assessment documents for *Vv* (2005) and *Vp* (2011) were published some time ago.

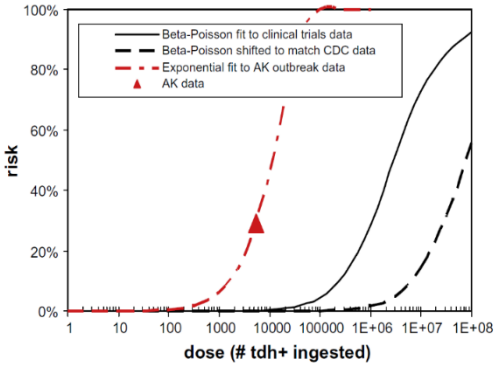
Since the publication of these RA documents, a huge amount of data has been generated on *Vv* and *Vp.*

This incorporates almost all aspects related to these pathogenic bacteria – encompassing ecology, genomics, bioinformatics, microbiology, epidemiology, risk assessment, and biological oceanography among others.

The emergence of new strains, including highly pathogenic clones and elusive variants of *Vibrio* have also occurred since the most recent RA documents were published.

These advances have clear implications for RA work on these pathogens and on future evolution of guidance for *Vv* and *Vp.*

ST36 *V. parahaemolyticus*



Estimated dose–response for *V. parahaemolyticus* in raw oysters using PNW (red) as well as clinical trial and epidemiological study strains (black). Martinez-Urtaza *et al.* 2010.

- In 2012 a new variant of *Vp* – a highly pathogenic strain normally restricted to Pacific NW region of the USA emerged – jumping to the East Coast of the USA and then to Europe.

- This particular strain (PNW) is of huge concern. Caused major shutdown of US shellfish in 2012 and 2013.

- Pandemic spread of *Vp* is a major global food safety and economic issue.

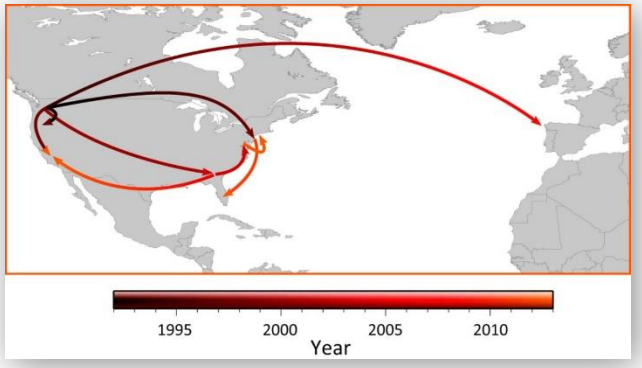
- These strains were not included in previous RA work published in 2011. Pandemic emergence of these strains will have significant impacts on guidance for this pathogen.

High resolution genomic tools

It is now cheaper and faster to sequence bacteria than carry out traditional subtyping methods (e.g. PFGE, MLST, serotyping etc).

Whole genome sequence data can now be used to examine the evolutionary divergence that has occurred over the course of transcontinental expansion of strains, and the epidemic ignition of a major foodborne pathogen e.g. Vp.

This kind of high resolution data was not available in 2011 and 2005 when the previous RA documents were produced. Incredibly powerful and useful tools that have revolutionised microbiology in the last decade.

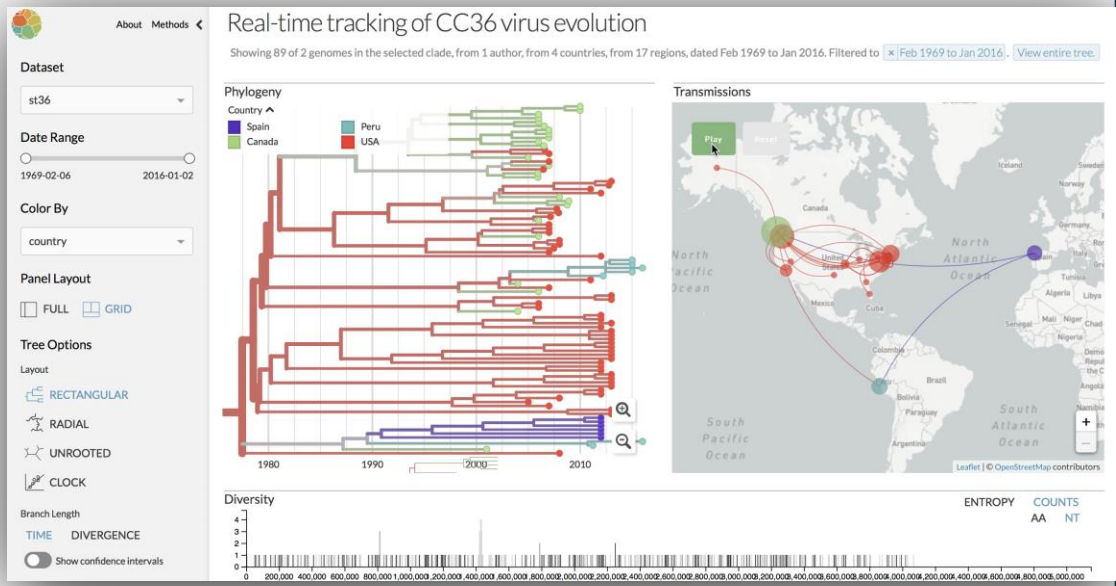


Temporal spread of ST36 *V. parahaemolyticus* clone. Source: Martinez-Urtaza *et al.* 2016.

Developing new tools to investigate foodborne outbreaks

New sequencing and bioinformatic platforms can now be used to reconstruct the emergence, dispersal, and evolution of pathogens such as *V. parahaemolyticus.*

The unparalleled resolution of sequencing methods has enormous practical applications such as inferring mechanisms of transmission, unravelling the evolution of strains, as well as pinpointing outbreaks for risk management purposes.

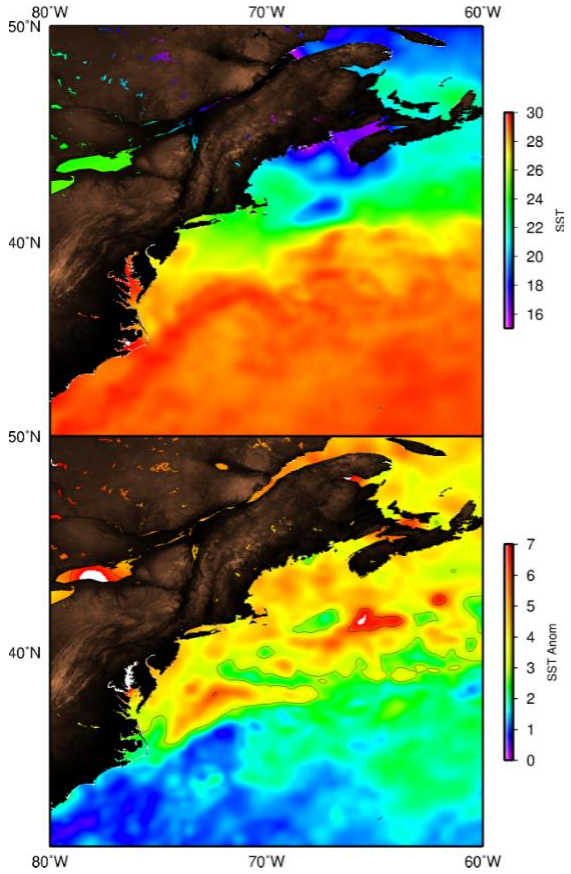


New advances in remote sensing and risk assessment

- A far greater understanding of the environmental conditions that drive *Vibrio* risk, and conditions associated with outbreaks has subsequently emerged in the last decade.

- The ability to be able to retrospectively scrutinise environmental conditions, prior to, during, and after outbreaks has been central to building up our understanding in this area.

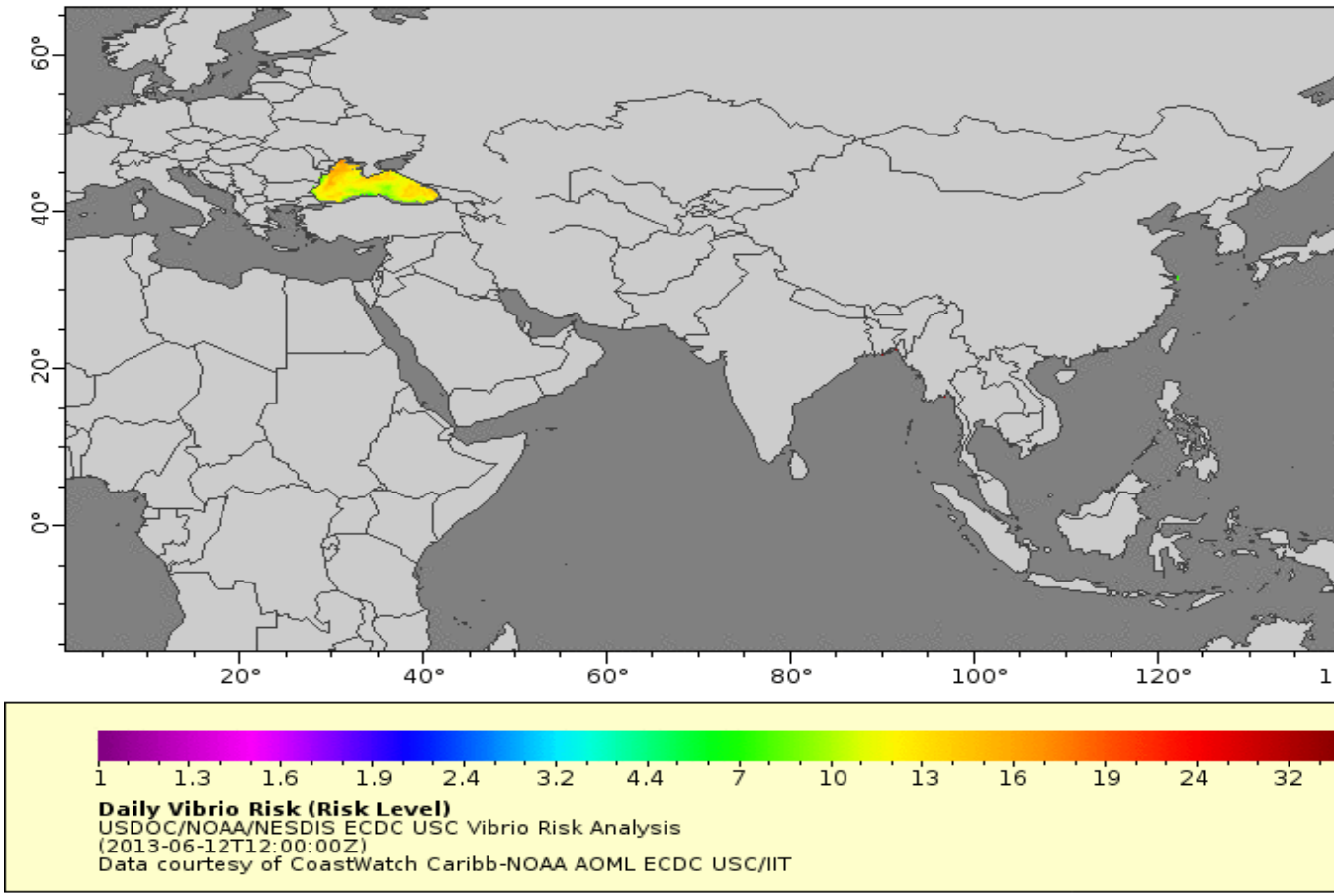
- Certainly, several key physio-chemical features such as increased sea surface temperature (SST), increased sea surface temperature anomaly (SSTa) coupled to low sea surface salinity (SSS) tend to be associated with elevated risks.



Vibrio parahaemolyticus emerged on NE coast of USA during an extreme heatwave, Spring 2012 (Baker-Austin and Martinez-Urtaza *et al.* unpublished).

New advances in remote sensing and risk assessment

- This data has subsequently been used to develop and refine online risk assessment tools, such as those developed by the FDA, ECDC, NOAA Cefas and others.
- Based on this work, we have developed a free web portal that updates *Vibrio* risk daily, for the entire surface of the globe.
- Scrutiny of previous outbreaks (so far) seems to show these methods are robust, accurately predicting incidents.



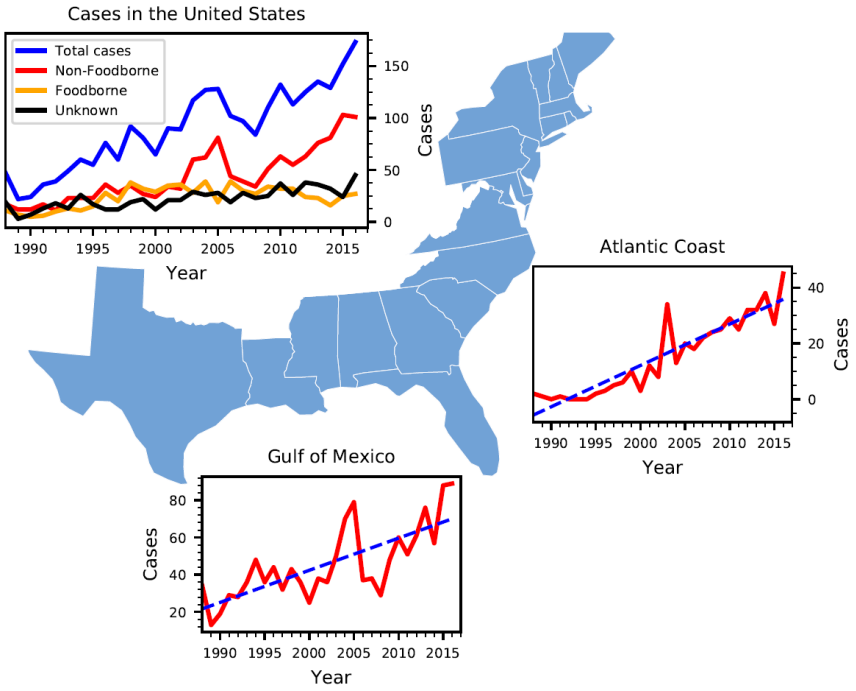
Vibrio suitability too l(summer 2013), courtesy ECDC & NOAA

Changing/interesting epidemiological observations

Aspects related to changing epidemiology are extremely relevant from a risk assessment perspective.

Examples of this include the following:

1. Flatlining *Vv* foodborne infections e.g. USA (see fig)
2. Increasing non-foodborne *Vv* cases (e.g. wounds)
3. Increasing non O1 *Vc* infections
4. Lack of *Vv* (foodborne) infections in Europe, however some wound cases.
5. *Vp* in China (compared to other foodborne pathogens)
6. Rapid regional increases in infections e.g. *Vibrio* infections in Chesapeake Bay.



Vibrio vulnificus infections in the USA, 1988-2015
Source: Baker-Austin *et al.* unpublished.

Summary

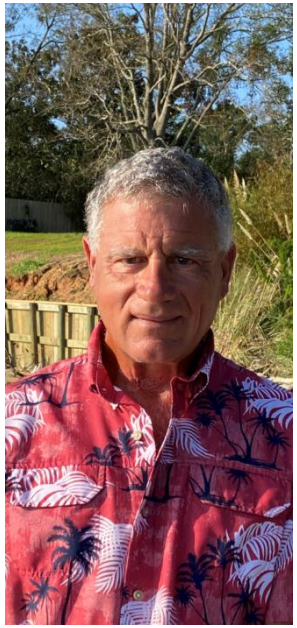
- This presentation provides a brief overview of recent FAO/WHO risk assessment documentation for *Vibrio* pathogens.
- A variety of new developments and challenges have emerged in this area since the last RA documents were published almost a decade ago.
- These include changing epidemiology of disease (*Vv*), the emergence of new strains *(Vp)* such as highly pathogenic clones and elusive variants of *Vibrio* that have occurred recently.
- New data, and new tools have emerged in the last few years that greatly improved our ability to study and predict risks associated with these bacteria, such as whole genome sequencing and remote sensing analysis.

A Changing Environment: Impacts of Seafood Safety Industry Perspective

Andy DePaola

IAFP 2020

Andy DePaola

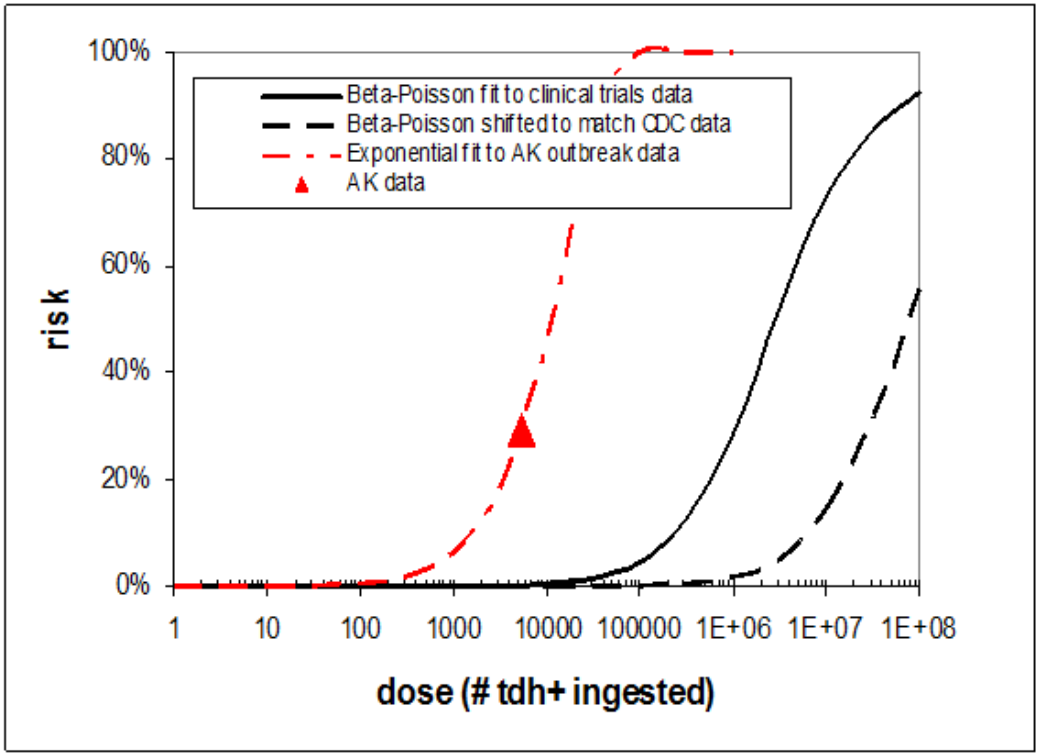


Andy DePaola's FDA career spanned 37-years where he published over 100 journal articles on vibrio ecology, virulence, typing, methodology and risk assessment. He was also active in field work and responded to disasters including vibrio outbreaks/epidemics/pandemics, Hurricane Katrina and Deep Water Horizon oil spill. Andy was FDA's Lead Seafood Microbiologist and National Vibrio Coordinator when he retired in 2015. Upon retirement he established Depe Oyster Farm in Mobile Bay, Angelo DePaola Consulting and invented the Shellevator, an automated submersible oyster culture platform.

Climate Change: Scientist View
2004 Alaska Vp Outbreak

- McLaughlin et al, 2005 NEJM
- 1000 Km latitude expansion of Vp outbreak risk
- Water temperature >15C
- PWS cruise ship
- 3 cruises with ~30% attack rate
- 1-6 oysters consumed
- Clinical strain dominant oyster strain ~10/g

AK Attack Rate <1000-Fold Higher than VPRA



Oyster Grower's View
2018 National Climate Assessment

- Storms
- Floods
- Pollution
- HABs
- Hypoxia
- Vibrio

Sally

Crystabol

2018:Can’t Remember

Floods

- Fresh water kills oysters
- Oyster mass mortality Mobile Bay
  - June 2017: Hurricane Cindy (100% mortality)
  - May 2019: Late flooding (Eastern Mobile Bay)
  - March 2020: Normal flood period but record temperature >30C
- Oyster mass mortality Mississippi River
  - Bonnet Carre 2019
  - Mass oyster East of River to Mississippi Sound MS/AL border
  - Blue-green algae bloom closes MS beaches until October

Pollution

- Gulley washing rainfall anomalies
  - Watersheds: Soils laden with fertilizers and pathogens
  - STP bypasses from stormwater infiltration
  - River stage & rainfall closures
- Harvest closures Mobile Bay
  - December 14, 2018 to May 4, 2019
    - Closed 103 days
    - Open 41 days
  - December 27, 2019 to May 8, 2020
    - Closed 110 days
    - Open 24 days

HABs

- K brevi (Alabama)
  - 1979-2014 (2 closures)
  - 2015 Nov-Dec
  - 2016 Jan-Feb
  - 2018 Nov-Dec
- 2016 Pseudonitzia (Alabama)
- 2019 Blue-green (Louisiana & Mississippi)
  - Bonnet Carre spillway opened
  - Fresh water wiped out oysters
  - Bloom closed beaches and seafood harvest (May-October)

Hypoxia

Sustaining Safe Shellfish in Changing Climate

- Storm resilient gear and operations
- Risk Calculators
  - Best available science (Vibrio model)
  - Updated and regionalized
  - Norovirus
  - HABs
  - Hypoxia
- Novel risk management strategies
  - Preharvest purification (AK Vp outbreak: Lower gear to colder water)
  - Relocate crop to prevent contamination and maintain cash flow

Stacey Wiggins, Ph.D.

Dr. Stacey Wiggins is the Science Advisor for the Division of Seafood Safety (DSS) at FDA's CFSAN. She is responsible for formulating, guiding, and leading science and technology policy activities related to seafood safety. She serves as the lead scientific reviewer and advisor on science-based seafood safety issues, including chemical and microbiological contaminants.

Stacey previously served as a principal investigator for seafood safety research, which included developing and validating detection methods for foodborne toxins, investigating traditional and emerging sources and vectors of marine biotoxins, and understanding the dynamics of toxin transfer to seafood.

Stacey Wiggins, Ph.D.
Office of Food Safety/Division of Seafood Safety
Center for Food Safety & Applied Nutrition
Food & Drug Administration

FRESHWATER TOXINS IN THE MARINE ENVIRONMENT

AN EMERGING PUBLIC HEALTH ISSUE?

Freshwater Toxins

Neurotoxins

- Anatoxins
- Saxitoxins

Hepatotoxins

- Cylindrospermopsin
- Microcystins
- Nodularin

Dermatoxin

- Lyngbyatoxin

Dermatoxins & Gastrointestinal Toxins

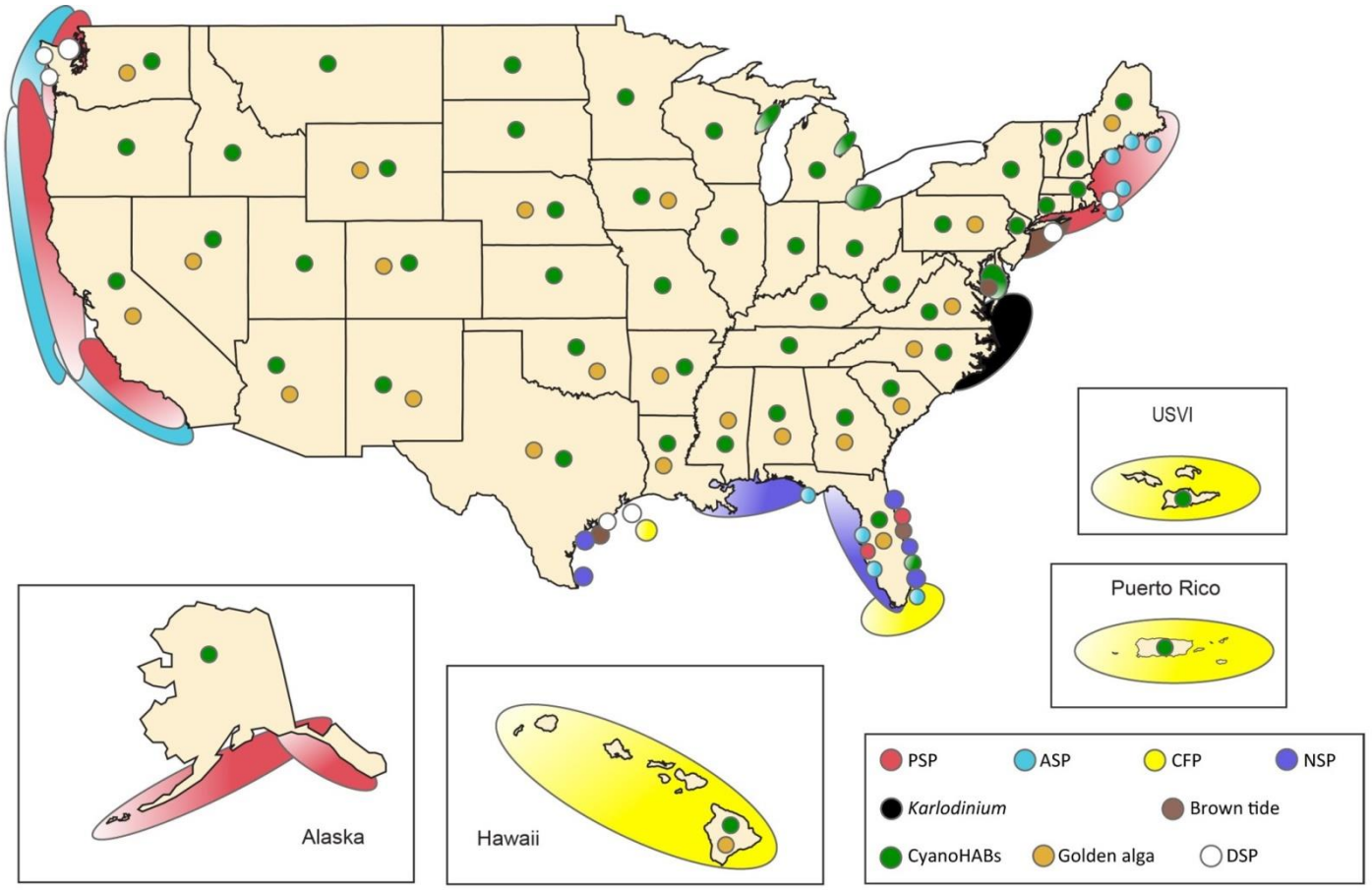
- Aplysiatoxin
- Debromoaplysiatoxin

Freshwater Toxin-Producing Organisms

- *Anabaena* spp./*Dolichospermum* spp.
- *Aphanizomenon* spp.
- *Nostoc* spp.
- *Cylindrospermopsis* spp.
- *Lyngbya* spp.
- *Microcystis* spp.
- *Planktothrix* spp.

Cyanobacteria (Blue-green algae)

Previous CyanoHAB Schematic



Toxins & Seafood Safety

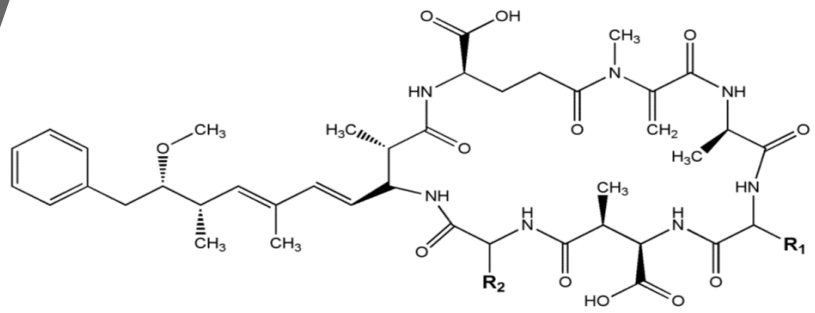
Shellfish resources for interstate commerce are primarily harvested from marine/estuarine environments

Control measures for marine biotoxins

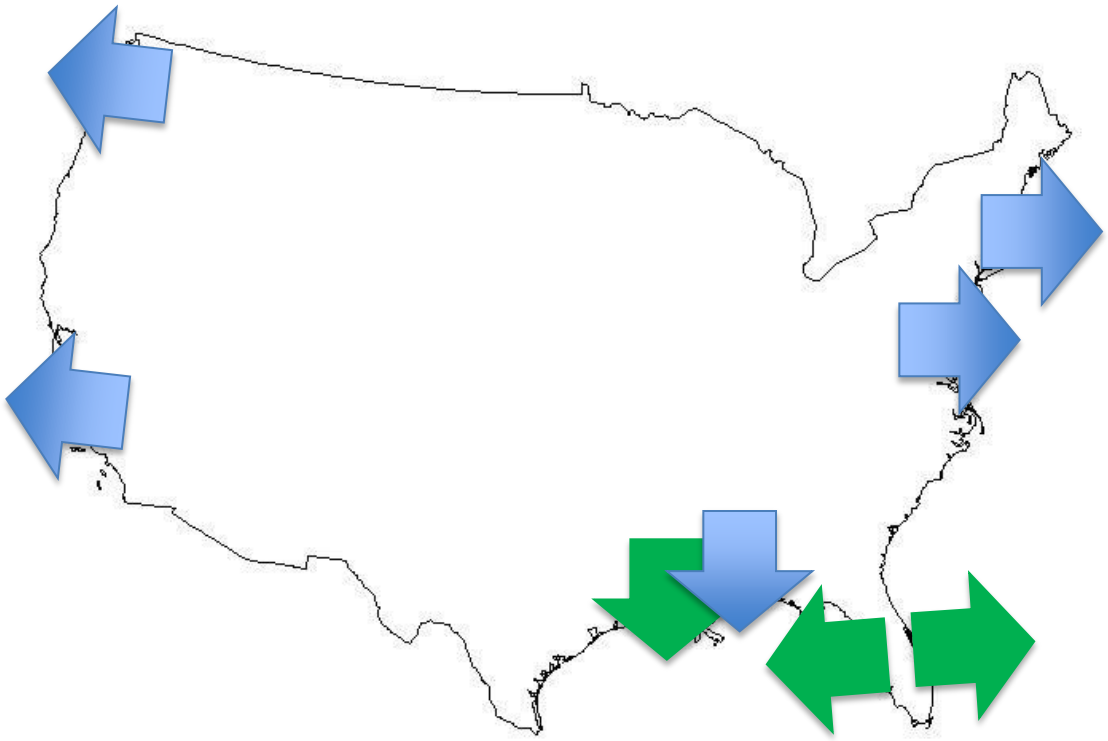
Paralytic Shellfish Poisoning (PSP) toxins	Amnesic Shellfish Poisoning (ASP) toxins	Diarrhetic Shellfish Poisoning (DSP) toxins	Neurotoxic Shellfish Poisoning (NSP) toxins	Azaspiracid Shellfish Poisoning (AZP) toxins

Emerging Issue & Commodity Pair

- Microcystins
- Molluscan shellfish



Emerging Issue: Transfer of Freshwater Toxins into Estuaries/Marine Waters



Microcystin Uptake by Shellfish

Location	Shellfish	Microcystin ng/g	Source
Laboratory	Mussels	39.11	Gibble et al. 2016
Laboratory	Oysters	4.88	Gibble et al. 2016
Washington	Mussels	6.5	Preece et al. 2015
California	Oysters	6.6	Tatters et al. 2019
Virginia	Clams	25	Bukaveckas et al. 2017

Web of Science

Cause of Freshwater Toxin Transfer?

- MS River diversions for flood control
- Bonnet Carre Spillway
- *Dolichospermum* and *Microcystis* blooms

http://gcrl.usm.edu/bonny.carre.spillway/2019%20june.28.Bonnet%20Carre%20Spillway%20Overview.pdf

Cause of Freshwater Toxin Transfer?

- Increase in drought
- 4th driest year on record for San Francisco estuary
- Highest *Microcystis* biomass and toxin concentrations
- Earlier and longer bloom

Harmful Algae 63 (2017) 94–108

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Impacts of the 2014 severe drought on the *Microcystis* bloom in San Francisco Estuary

P.W. Lehman[a,*], T. Kurobe[b], S. Lesmeister[c], D. Baxa[b], A. Tung[c], S.J. Teh[b]

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[b] Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine, 1089 Veterinary Medicine Dr., Vet Med 3B, University of California, Davis, CA, 95616, USA
[c] Division of Environmental Services, California Department of Water Resources, 3500 Industrial Blvd., West Sacramento, CA, 95691, USA

Fourth National Climate Assessment

"Rising water temperatures, ocean acidification, retreating arctic sea ice, sea level rise, high-tide flooding, coastal erosion, high storm surge, and heavier precipitation events threaten our oceans and coasts."

https://nca2018.globalchange.gov

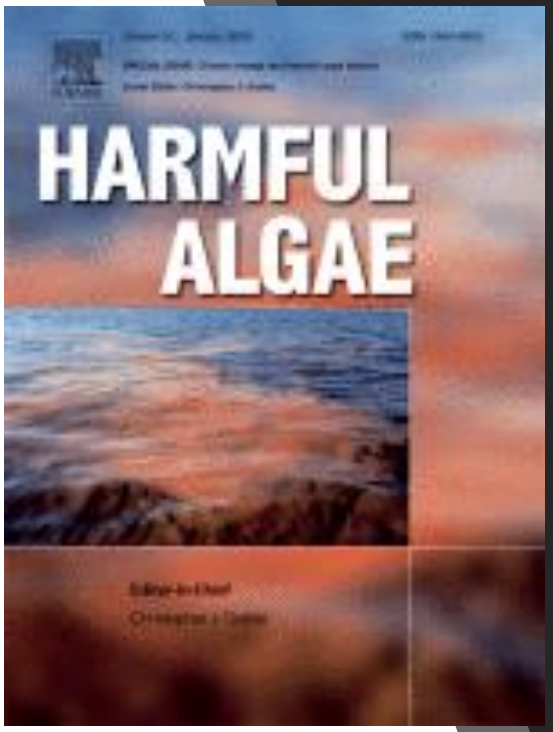
United Nations Intergovernmental Panel on Climate Change

Special Report on the Ocean & Cryosphere in a Changing Climate

- HABs display ↑ range expansion and frequency in coastal areas
  - Driver: riverine nutrient run-off
- Trend in HABs attributed to ocean warming, marine heat waves, oxygen loss, eutrophication, and pollution

www.ipcc.ch/srocc/

Climate Change and Harmful Algal Blooms



Harmful Algae
Volume 91
January 2020

www.journals.Elsevier.com/harmful-algae

Climate Change and Cyanobacteria

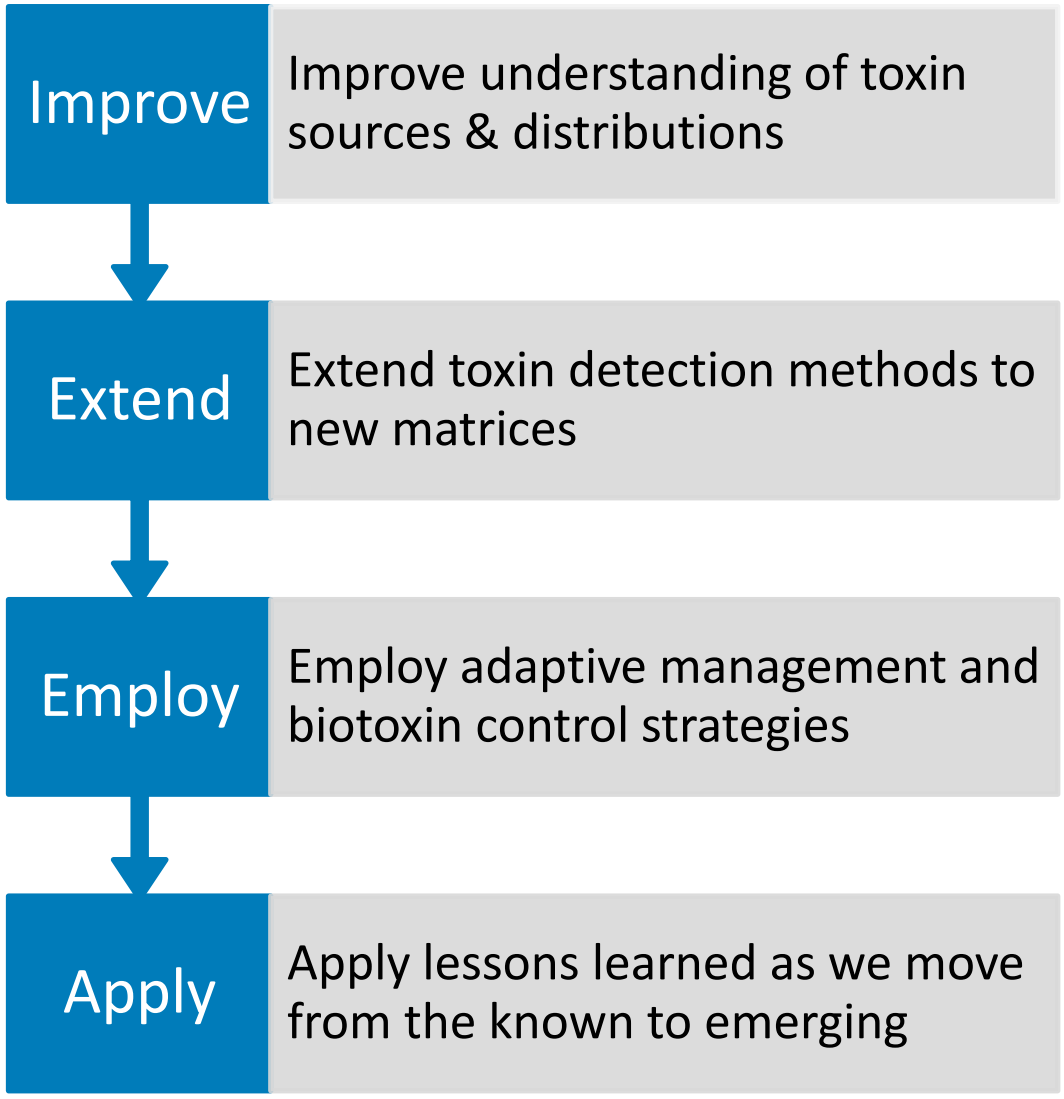
Climate Driver(s)	Cyanobacteria	Source
↑ Temperature ↑ Stratification	↑	Carey et al. 2012
↑ Temperature	↑	Griffith & Gobler 2020
↑ Drought	↑	Lehman et al. 2017
↑ Temperature ↑pCO2 ↑ N & P relative to Si	↑	Wells et al. 2020
Multiple stressors	May vary	Richardson et al. 2019

Web of Science

Summary

- Freshwater toxins have been transferred to marine waters
- Molluscan shellfish have accumulated freshwater toxins at low levels
- Climate change may increase freshwater toxin transfer to marine waters

Next Steps


Improve
Improve understanding of toxin sources & distributions
Extend
Extend toxin detection methods to new matrices
Employ
Employ adaptive management and biotoxin control strategies
Apply
Apply lessons learned as we move from the known to emerging


FDA
U.S. FOOD & DRUG
ADMINISTRATION

Mike Parsons

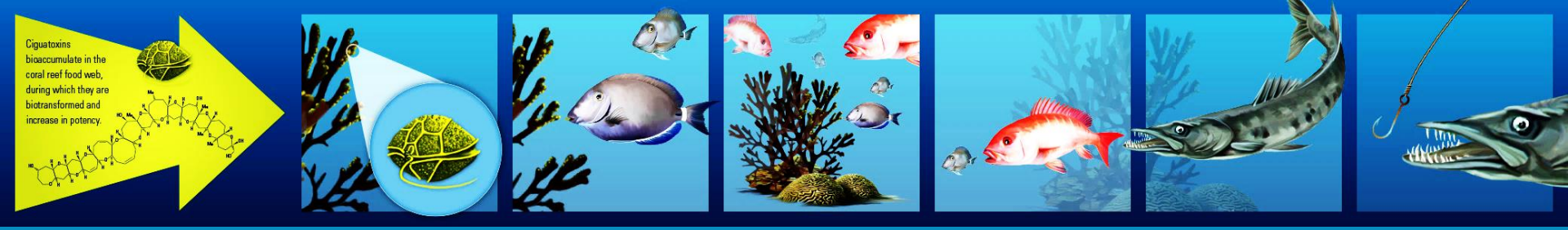
Michael Parsons is a Professor of marine science in the Water School at Florida Gulf Coast University and Director of FGCU's Vester Field Station. In addition to his teaching duties focused on marine ecology, Parsons has built a successful research career, receiving over $25 million of extramural funding to study harmful algal blooms and ecosystem health. His work has been cited over 2,700 times in the scientific literature, demonstrating the quality of his work. In addition to building collaborations with researchers around the state, he was appointed to the Blue-Green Algae Task Force by Florida Governor Ron DeSantis in 2019 to work to reduce the impacts of harmful algae in our region.

Ciguatera Poisoning

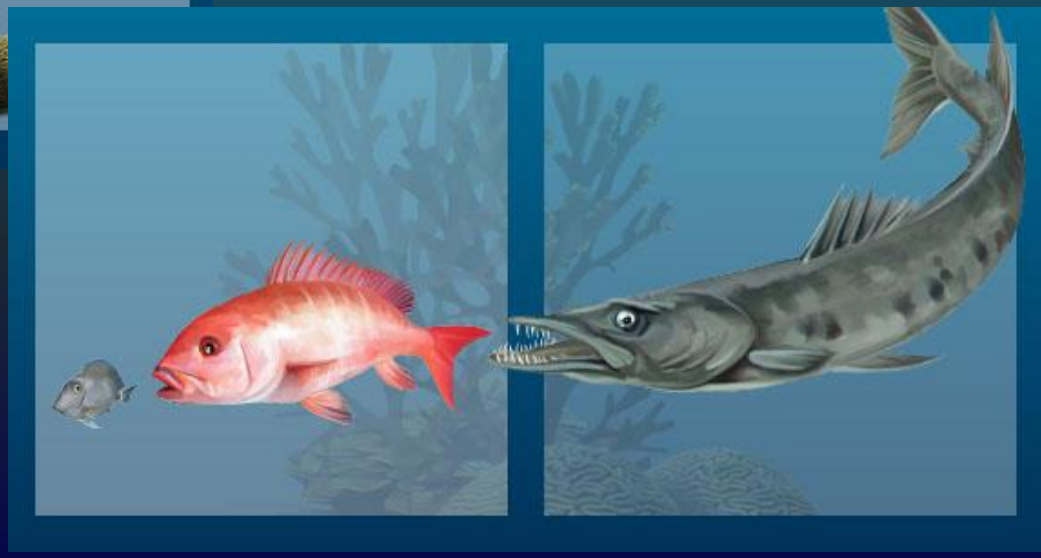
Michael L. Parsons
The Water School
Florida Gulf Coast University

Ciguatera Poisoning

- Seafood poisoning (primarily reef fish)
- Originates in (sub)tropical regions
- Affects thousands of people annually
- Tens of thousands of people affected globally
- $30+ million annual impact in the U.S.
- Underreported; misdiagnosed

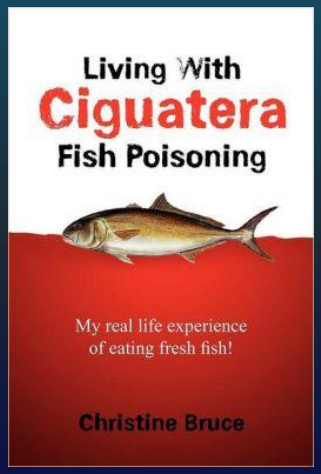


Ciguatera Poisoning



Ciguatera Poisoning

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



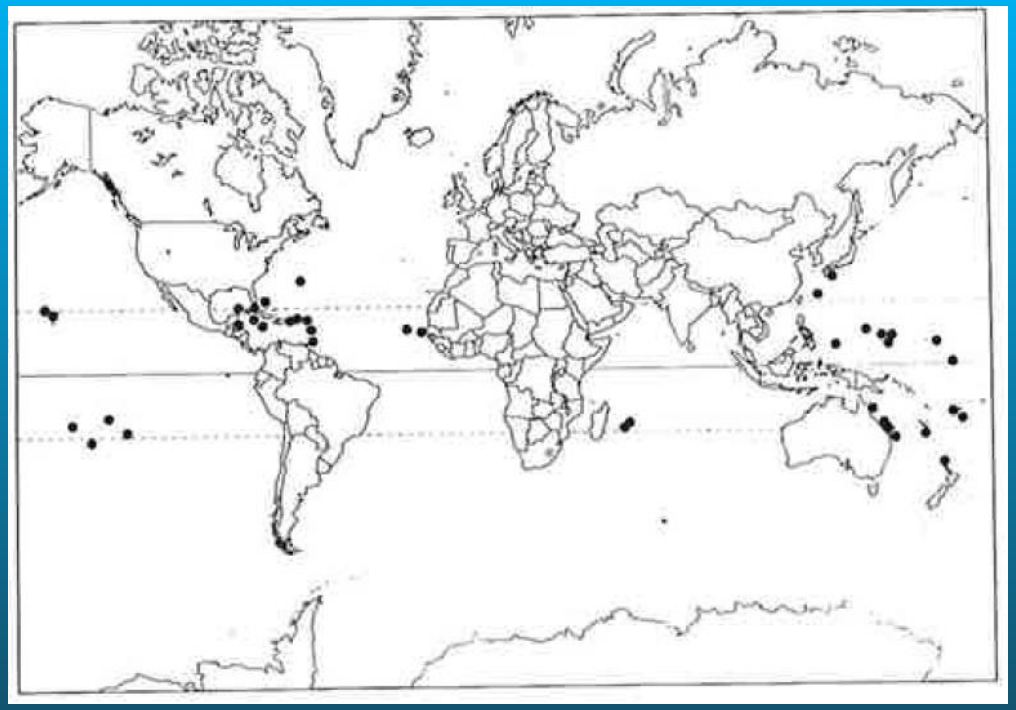
"It was the worst I ever felt"

"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!"

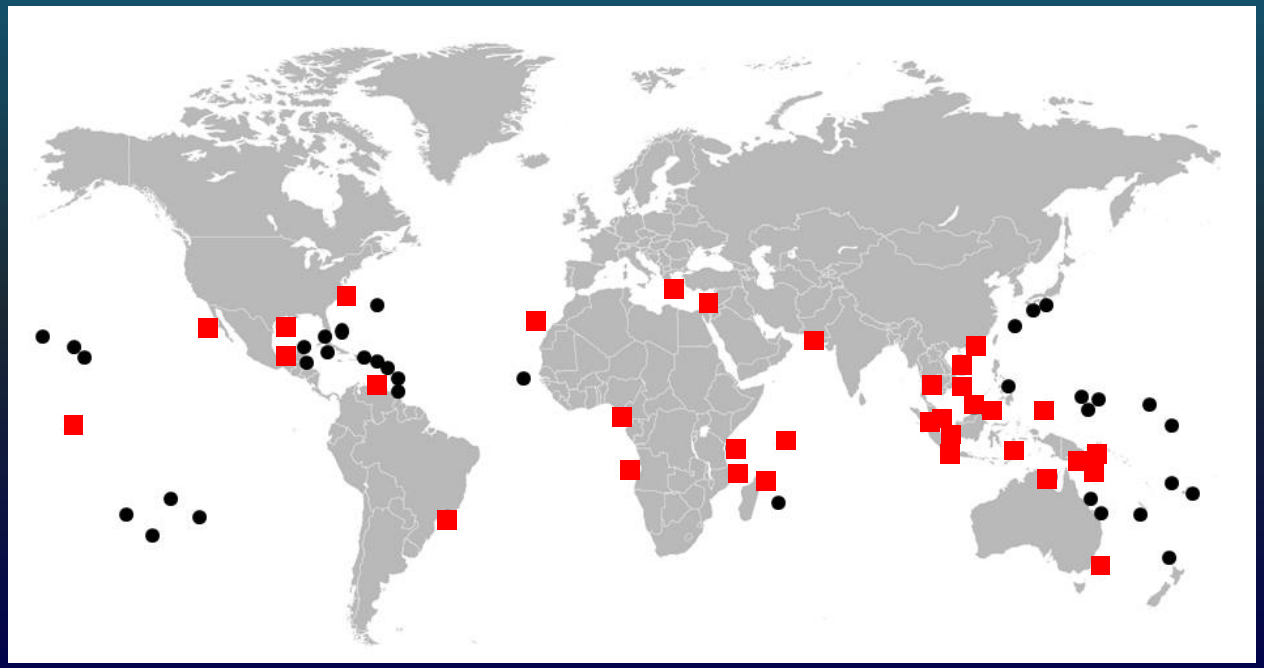
"...my palms and soles started to itch and turn red again"

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

Olander, 2011



Tindall and Morton 1998



Modified from
Parsons et al. 2012

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)

FROM THE CENTERS FOR DISEASE CONTROL AND PREVENTION

MMWR
Morbidity and Mortality Weekly Report

Ciguatera Fish Poisoning—New York City, 2010-2011

MMWR. 2013;4:61-65.

1 table omitted. http://www.cdc.gov/mmwr/pdf/wk/mm6204.pdf.

What is added by this report?

During August 2010-July 2011, New York City experienced 28 ciguatera fish poisoning cases occurring in six outbreaks and a single case, more than occurred in the previous 10 years combined. Early detection and outreach led to additional cases being identified and treated.

TABLE. Frequency of reported symptoms among ciguatera patients (N = 28) — New York City, August 2010–July 2011

Symptom	No.	(%)
Cramps	20	(71)
Diarrhea	20	(71)
Nausea	17	(61)
Weakness	16	(57)
Pruritus	16	(57)
Numbness/Tingling	16	(57)
Vomiting	15	(54)
Difficulty walking	12	(43)
Headache	7	(25)
Myalgia	6	(21)
Dizziness	6	(21)
Paradoxical dysesthesias	6	(21)
Heart palpitations	6	(21)
Bradycardia	6	(21)
Hypotension	6	(21)

A Toxic Fish Dinner

Two patients ate the same fish dinner and now have life-threatening symptoms. This case highlights the risks associated with ciguatoxin and other toxins that bioaccumulate in certain fish and shellfish.

Zhanna Livshits, MD, and Lewis S. Nelson, MD

2011

Case

A 48-year-old woman and her 16-year-old daughter present to the ED with diarrhea and vomiting approximately 5 1/2 hours after eating dinner. They report having eaten a steamed fish that was purchased at a local fish market. Their symptoms started with diarrhea approximately 4 hours following dinner. The mother also complains of light-headedness and perioral tingling.

The mother's initial vital signs are as follows: blood pressure, 90/65 mm Hg; heart rate, 48 beats/min; respiratory rate, 16 breaths/min; and temperature, 37.3°C. Her Spo_2 level is 99% on room air. The daughter's initial vital signs include a blood pressure of 83/41 mm Hg; heart rate, 45 beats/min; respiratory rate, 17 breaths/min; and temperature, 37.5°C. Her Spo_2 level is 98% on room air. Findings on physical examination, including the neurologic examination, are normal in both patients.

The combined findings of perioral paresthesia and the vital sign abnormalities suggest that the toxin alters the normal function of neuronal sodium channels. The small unmyelinated nerve fibers in and around the mouth and in the distal extremities are highly sensitive to the effects of sodium channel blockers. In the myocardium, sodium channels are responsible for normal electrical conduction through the His-Purkinje system. Both activating and inhibiting sodium channel function can produce neurotoxic and cardiotoxic effects.

Barracuda caught in Florida waters, sold to an NYC restaurant!

"Ciguatera fish poisoning (CFP) is becoming an increasing risk in Europe with a 60% rise of ciguatoxin (CTX) cases in the last decade, according to AESAN (Spanish Agency for Food Safety and Nutrition)."

https://www.foodnavigator.com/Article/2019/08/28/Ciguatera-fish-poisoning-is-becoming-an-increasing-risk-in-Europe?

Seafood Safety Concerns

- Forecasting ciguatera events
- Screening seafood for ciguatoxins
- Seafood chain of custody
- Public awareness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Questions?

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