

Dinos, Toxins and Fears, Oh My!

**(a new algae adventure...
we're not in Delaware anymore)**

The Cast of Characters:

UD Citizen Monitoring Program- Ed Whereat, Muns Farestad

Graham Purchase, Capt. Dick Peoples and the "Spectacle"

AG Robbins, and other volunteers.

DNREC- Jack Pingree, Glenn King Jr., and DNREC's HAB Monitoring Program

UNCW- Dr, Carmelo Tomas

FWRI-Leanne Flewelling and Jennifer Wolny

Also, thanks to Bill Winkler Sr., and Dave Munchel (deceased)

“Red Tide”

Most “red tides” are caused by dinoflagellates which have a variety of pigments ranging from yellow-red-brown in addition to the green of Chlorophyll, so blooms of some dinoflagellates actually appear as red water.

The dinoflagellate, *Karenia brevis*, is commonly called the “Florida red tide” even though blooms are usually yellow-green. The toxicity of *K. brevis* is well-documented. Blooms are associated with massive fish kills, shellfish toxicity, marine mammal deaths, and human respiratory irritation if exposed to salt-spray aerosols.

There are several newly described species of *Karenia*, one being *K. papilionacea*, formerly known as *K. brevis* “butterfly-type”. *Karenia papilionacea*, *K. brevis*, and a few others are commonly found in the Gulf of Mexico, but these and yet other *Karenia* species are also found throughout the world. This summer, *K. papilionacea* and *K. brevis* were detected in Delaware waters. The potential for toxicity in *K. papilionacea* is low, but less is known about the newly described species.

Blooms of *K. brevis* have migrated to the Atlantic by entrainment in Gulf Stream waters. Occasional blooms have been seen along the Atlantic coast of Florida since 1972. Previously, the northern-most coastal landfall of a toxic *K. brevis* bloom in the U.S. was in North Carolina during the fall and winter 1987-88. During this persistent bloom, 48 cases of Neurotoxic Shellfish Poisoning were documented and the economic losses due to the closure of shellfish beds exceeded \$24 million dollars.

Karenia brevis



J. Wolny, FIO

20.0 μ m

Live

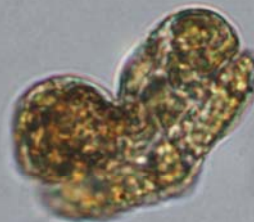
K. papilionacea



J. Wolny, FIO

20.0 μ m

K. papilionacea



Preserved

K. brevis



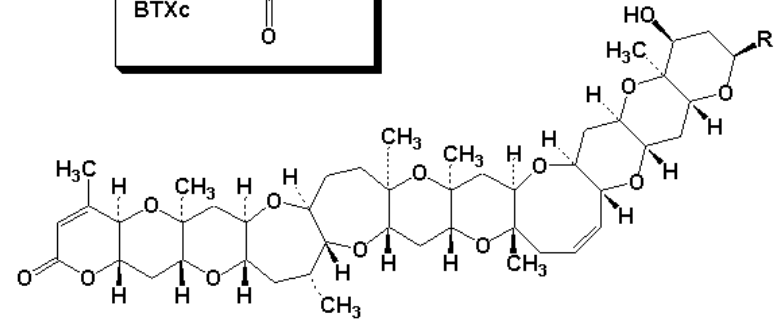
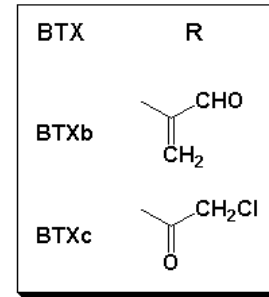
J. Wolny, FIO

20.0 μ m

Photographs
from Delaware
samples courtesy
of J. Wolny,
FWRI FIO

Brevetoxin

Brevetoxins are polyether neurotoxins that bind to voltage sensitive sodium channels, an important protein structure of cell membranes. Binding results in persistent activation of neuronal and muscle cells. Brevetoxins are tasteless odorless, heat and acid stable. *K. brevis* makes 10 forms; 3 are most common.



Neurotoxic Shellfish Poisoning (NSP) is caused by consumption of molluscan shellfish contaminated by brevetoxins. NSP is characterized by tingling, reversal of hot-cold temperature sensations, muscle pain, vertigo, loss of coordination, abdominal pain, nausea, diarrhea, headache, slow heart rate and dilated pupils. It is likely that NSP is under reported and under diagnosed, especially for mild cases.

Aerosolized Toxin- Cells are fragile, break open in surf, and salt spray aerosols can become contaminated and carried inland (how far is uncertain). Inhalation of brevetoxin aerosols causes bronchial constriction, watery eyes, runny nose and a non-productive cough. In the normal population, these effects are usually rapidly reversible by leaving the beach area or entering an air conditioned area. However, asthmatics and those with chronic lung disease are particularly susceptible.

Guidelines from Florida

Description	<i>Karenia brevis</i> (cells/liter)	Possible Effects (<i>K. brevis</i> only)
PRESENT	background levels of 1,000 cells or less	None
VERY LOWa	>1,000 to <5,000	Possible respiratory irritation in sensitive individuals
VERY LOWb	5,000 to 10,000	Possible respiratory irritation in sensitive individuals and shellfish harvesting closures*
LOWa	>10,000 to <50,000	Respiratory irritation more likely in general population; but not widespread. Chlorophyll levels too low to be detected by satellites (in GOM).
LOWb	50,000 to <100,000	Respiratory irritation more likely; possible fish kills. Chlorophyll levels probably detected by satellites (in GOM).
MEDIUM	100,000 to <1,000,000	Respiratory irritation likely in general population; probable fish kills
HIGH	≥1,000,000	As above, plus discoloration

* Shellfish beds are reopened following results of a mouse bioassay on toxin extracts from shellfish meat

Counting caveats

Since 2001, our focus has been on ichthyotoxic algae in the tributaries which need to occur at high cell densities to cause fish kills (millions/L). The droplet method on live samples is coarse, but adequate, to characterize these phenomena. The lower detection limit of our method is between 8,300-12,500 cells/L (in 3 or 2 drops of water).

This is not adequate to quantify significant levels of *Karenia* (or a few other algae with very potent toxins). More rigorous methods of counting typically involve settling preserved samples. We will acquire the needed materials and training to do this properly.

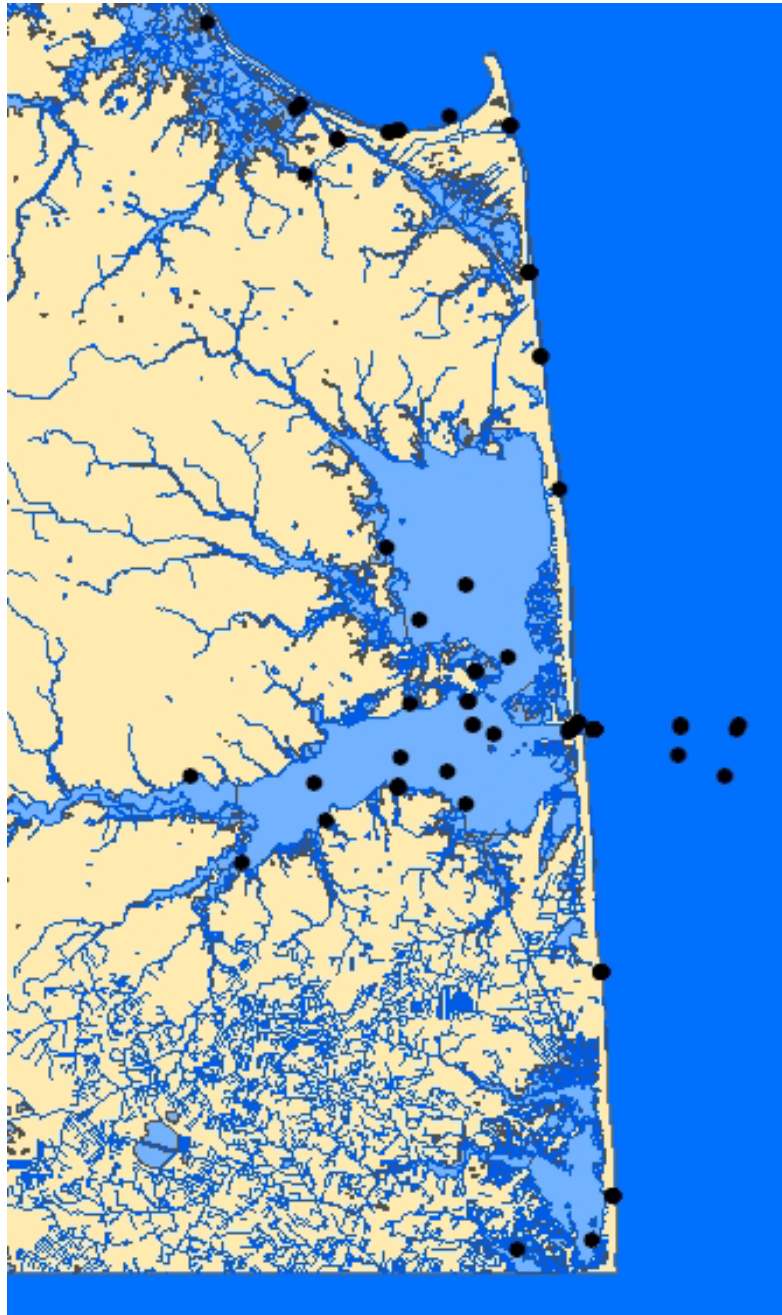
However, the quick screening method can provide a rapid assessment of a relatively large number of samples in a limited time.

All samples collected during this event were preserved and will be analyzed by rigorous counting methods used to protect shellfish resources in Florida, so the saga is far from over.



Sites sampled for *Karenia spp.* Aug 30-Sept 26, 2007





August – September 2007 IR39: Indian River Inlet

Water samples to Carm Tomas
K pap confirmed @ 71K.

Water samples from ocean beaches sent to Carm Tomas for toxin tests.

Water samples from ocean beach and off-shore locations sent to J. Wolny, FWRI for species ID.

Shellfish samples collected from inside the IR Inlet sent to Leanne Flewelling, FWRI for toxin tests.

26	27	28	29	30	31	1
<i>Chattonella</i> bloom - White Creek						
Hi @ 7:30				67	75	
2	3	4	5	6	7	8
Hi @ 13:00	25	17	83	42 308	33 117	
9	10	11	12	13	14	15
Hi @ 7:40						
16	17	18	19	20	21	22
23	24	25	26	27	28	29

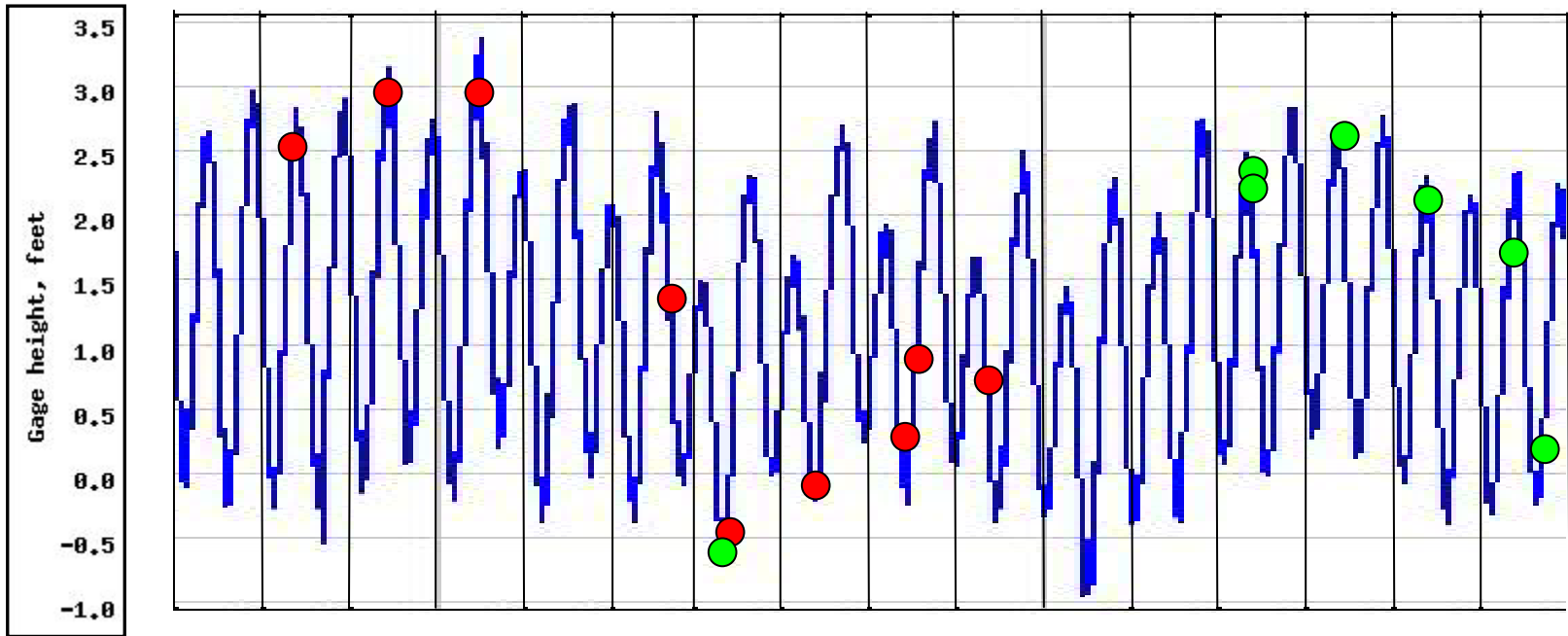
On 9/7 FWRI reports that shellfish meats are negative for toxin by ELISA.
On 9/12 FWRI reports that shellfish meats are negative for toxin by mouse bioassay.

Not Found detection limit = 8
(blank) Not Looked For

Karenia brevis: left column
Karenia papilionacea: right column
Cell densities: thousands of cells per liter




Indian River Inlet Tide Chart



August | September

Karenia spp. ● Not Found
● Present

First Bay Transect in Shellfish Harvesting Areas





Indian River Bay						Miles to Inlet						
	7.9		5.8		3.9		3.5		2.4		0	
1-Sep		 *		13		13		75		50		38

Approved shellfish harvesting areas

* Not Found detection limit = 12.5
(blank) Not Looked For

Karenia brevis: left column
Karenia papilionacea: right column
Cell densities: thousands of cells per liter

Inland Bays Shoreline Sites - September 4

<u>Inlet</u>		K_b	K_p
	Within Rosevelt Inlet		
	RB02: Lewes - Rehoboth Canal at Lewes		
	Rehoboth Bay		
	ML: Massey's Landing		
	Indian River Bay		
	IR11: Pot Nets Seaside Pier		
↓	IR07: Holt's Landing State Park		

Farthest from Inlet

 Not Found detection limit = 8
(blank) Not Looked For

Karenia brevis: left column
Karenia papilionacea: right column
Cell densities: thousands of cells per liter

Beaches Part 1

Water samples to Carm Tomas for toxin tests.

9/5 - *K brevis* possibly present.

9/13 - Very low toxin levels detected.

Water samples to J. Wolny for species

ID-confirmed on 9/8

K brevis = 14

K pap = 425

August September

	31	4	5	6	7	8
Slaughter						
Prime Hook						
Broadkill						
Lewes North						
Lewes South						
Cape Shores						
Cape Henlopen						
Gordon pond		133	17	8	17	192
Rehoboth						
Tower Rd						
Surfing		158	92	42	292	108
Bethany Beach		125	92	17	33	8
Fenwick Island			8			



Not Found detection limit = 8



Not Found detection limit = 12.5

(blank) Not Looked For

Karenia brevis: left column

Karenia papilionacea: right column

Cell densities: thousands of cells per liter

Water samples to J.
 Wolny for species
 ID.
 K brevis = 4
 K pap = 213

First Ocean Transect

Miles from the Indian River Inlet

		0		1		2		3		5		7		9		10.7	
6-Sep	Flounder 1	25	233	225	2062	8	8	25	17	50	167	33	17		17	8	



Not Found detection limit = 8

Karenia brevis: left column
Karenia papilionacea: right column
 Cell densities: thousands of cells per liter

Second Bay Transect in Shellfish Harvesting Areas

Delaware Bay at Mispillion Inlet

	1.3		2.7		3.3		5.9		7		7.9	
7-Sep												50

Miles to Shipping Channel

All Delaware Bay transect samples were collected > 12 miles inland from Cape Henlopen at the seaward extent of the Delaware Bay oyster beds.

Approved shellfish harvesting areas

 Not Found detection limit = 8
(blank) Not Looked For

Karenia brevis: left column
Karenia papilionacea: right column
Cell densities: thousands of cells per liter

Beaches Part 2
























September

	8	9	10		11		12		19	
Slaughter										
Prime Hook										
Broadkill										
Lewes North			8	92		8				
Lewes South				25						
Cape Shores			8	8						
Cape Henlopen										
Gordon pond*			33	17	8					
Rehoboth										
Tower Rd										
Surfing										
Bethany Beach		8								
Fenwick Island										

Not Found detection limit = 8
(blank) Not Looked For

Karenia brevis: left column
Karenia papilionacea: right column
Cell densities: thousands of cells per liter

Survey of Inland Bays - September 10 - 12

















<u>Inlet</u>			K_b	K_p
↓	Within Roosevelt Inlet			
	12-Sep	BR01: Broadkill river @ PEL dock.		
	12-Sep	BR40: Canary Creek at Pilottown Rd		
↓	11-Sep	RB02: Lewes - Rehoboth Canal at Lewes		
	Rehoboth Bay			
	10-Sep	RB72B: Rehoboth Bay South, Center by boat		
↓	10-Sep	RB73B: Between Natts Cove and Burtons Point by boat		
	11-Sep	RB07: West Bay Park		
↓	Indian River Bay			
	10-Sep	IR68B: Coast Guard Station, IR Inlet by boat		
	10-Sep	IR67B: South of Middle Island, West of Inlet by boat		
	10-Sep	IR11: Pot Nets Seaside Pier		
	10-Sep	IR69B: Walter Bluff by boat		
	10-Sep	IR70B: 200 yards NE of Robinson Island by boat		
	10-Sep	IR21: Entrance to Boat House Pond, Indian River Bay		
	10-Sep	IR07B: Holt's landing by boat		
	10-Sep	IR20: Bay Colony		
	10-Sep	IR04: Warwick Cove		
↓	Little Assawoman Bay			
	11-Sep	BA01: Keenwick on Bay, Roy Creek		
	11-Sep	LA45: Fenwick Island Bayside		









Farthest from Inlet

 Not Found detection limit = 8

Second and Third Ocean Transects

Miles from the Indian River Inlet

		0		1.1		2		5.1		10.1		25		38		48	
13-Sep	Tuna																

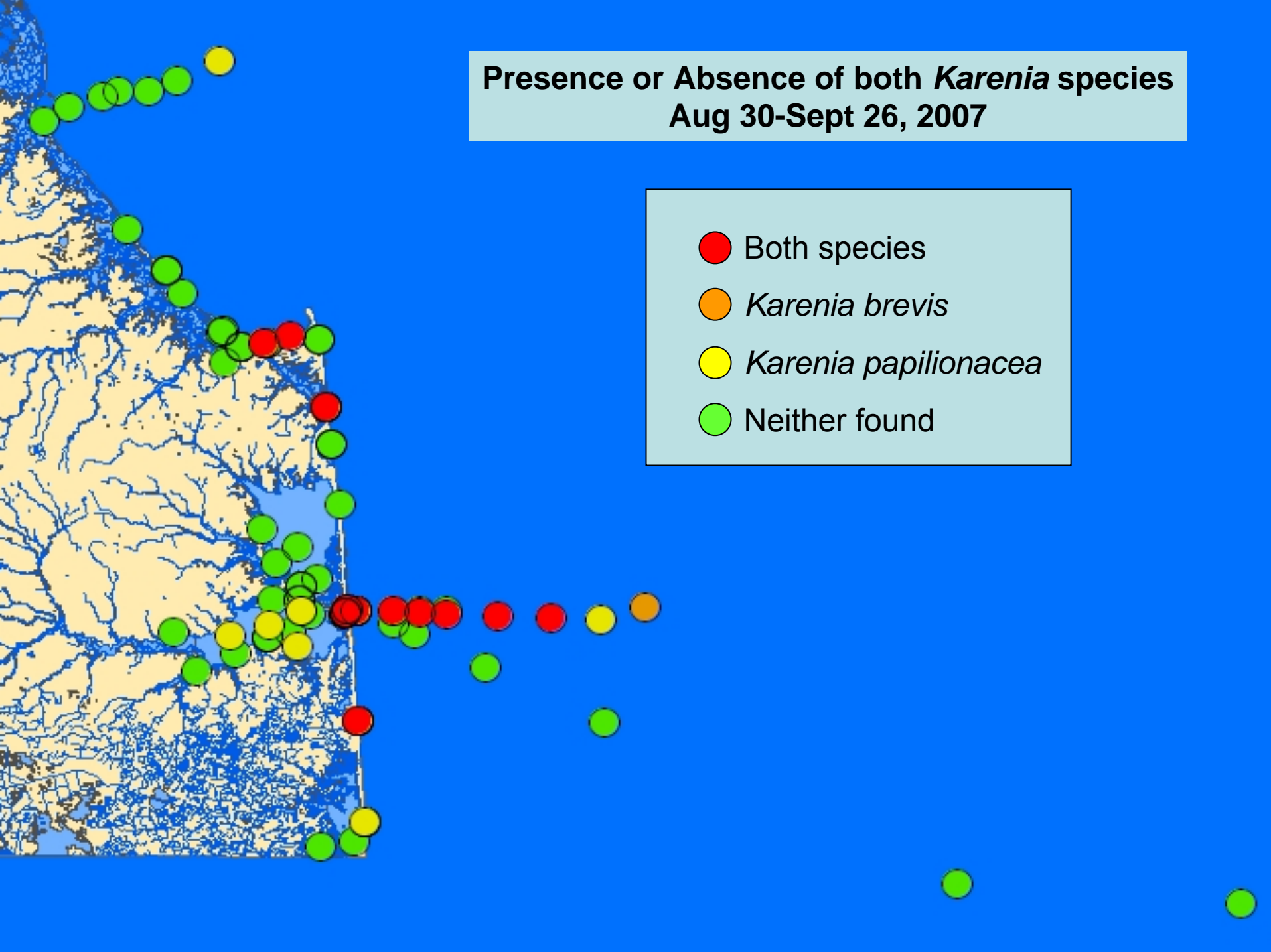
		0		1		2		3	
20-Sep	Flounder 2								

 Not Found detection limit = 8

Karenia brevis: left column
Karenia papilionacea: right column
 Cell densities: thousands of cells per liter

Presence or Absence of both *Karenia* species
Aug 30-Sept 26, 2007

- Both species
- *Karenia brevis*
- *Karenia papilionacea*
- Neither found



Conclusions

Dinos: With the help of experts, the organisms were identified and the appropriate tests were performed rapidly. However, we need further training in identification and counting techniques, and need to monitor the coast as well as the bays.

The UD expertise with molecular probes would be valuable for detecting cells at low cell density.

Bloom detection via remote sensing is somewhat limited at this point (at low cell densities in GOM and certainly for the mid-Atlantic region). Remote sensing may provide a retrospective look at this event and its relationship to events in the south.

Toxins There was no evidence of toxicity in shellfish meat or water samples, or from observations of those collecting samples in the field. However, the issue of brevetoxin aerosols and their potential effects on sensitive individuals deserve more attention. Public health information is available from FL (shellfish and aerosols).

Techniques to detect aerosolized toxins are experimental, but offer great promise in terms of gauging threats to human health.

Fears *Pfiesteria*, *Chattonella*, “Brown tide”, now *Karenia* in DE, what’s next?

No doubt this is scary stuff, but the perception of risk for each of these algae has swayed rather wildly among scientists, the press, and the general public. Let’s reign in our fears, stay rational, monitor, and be prepared to get out of the way of biological phenomenon that we have little or no control of when necessary.

The major Shellfish Poisoning Syndromes (and potentially toxic algae in our shellfish harvesting waters)

Syndrome	Causative organisms	Toxins produced	Clinical manifestations
Paralytic shellfish poisoning (PSP)	<i>Alexandrium</i> spp., <i>Gymnodinium catenatum</i> , <i>Pyrodinium bahamense</i> , and others	Saxitoxin and derivatives	Acute paresthesias and other neurological manifestations may progress rapidly to respiratory distress, muscular paralysis, and death
Neurotoxic shellfish poisoning (NSP)	<i>Karenia (Gymnodinium) brevis</i>	Brevetoxins	Gastrointestinal and neurological symptoms; respiratory and eye irritation with aerosols
Diarrhetic shellfish poisoning (DSP)	<i>Dinophysis</i> spp., <i>Prorocentrum</i> spp.	Okadaic acid and dinophysis toxins (DTXs)	Acute gastroenteritis
Amnesic shellfish poisoning (ASP)	<i>Pseudo-nitzschia</i> spp.	Domoic acid and isomers	Gastroenteritis, neurological manifestations, leading in severe cases to amnesia (permanent short-term memory loss), coma and death