Harmful Algal Blooms Along the Southern California Coast: What are They, What are Their Causes, What are Their Impacts

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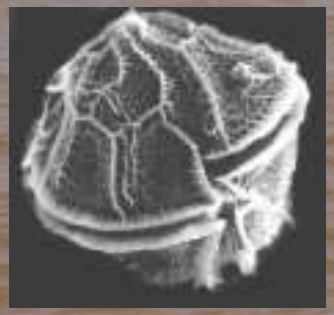
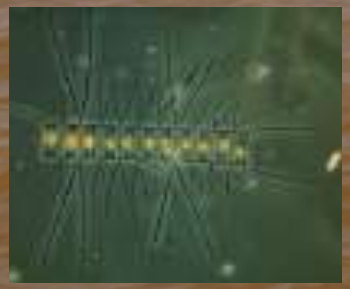
Marine Environmental Biology

Department of Biological Sciences

University of Southern California





What's the diagnosis???

April 5, 2010
Jacobi Medical Center (the Bronx, NY)

The patient was 28 and said he was healthy until three days ago, when he and his girlfriend went to the Bahamas to celebrate his birthday. After a long day of swimming and snorkeling, they decided to try a restaurant they had heard good things about. They both ordered seafood — she had the red snapper, he the barracuda — and then went out dancing. Out on the dance floor the patient doubled over, caught off guard by an intense pain that knifed through his gut and took away his breath. Then…
Abdominal cramps, diarrhea, vomiting, fever. (food poisoning, right?)

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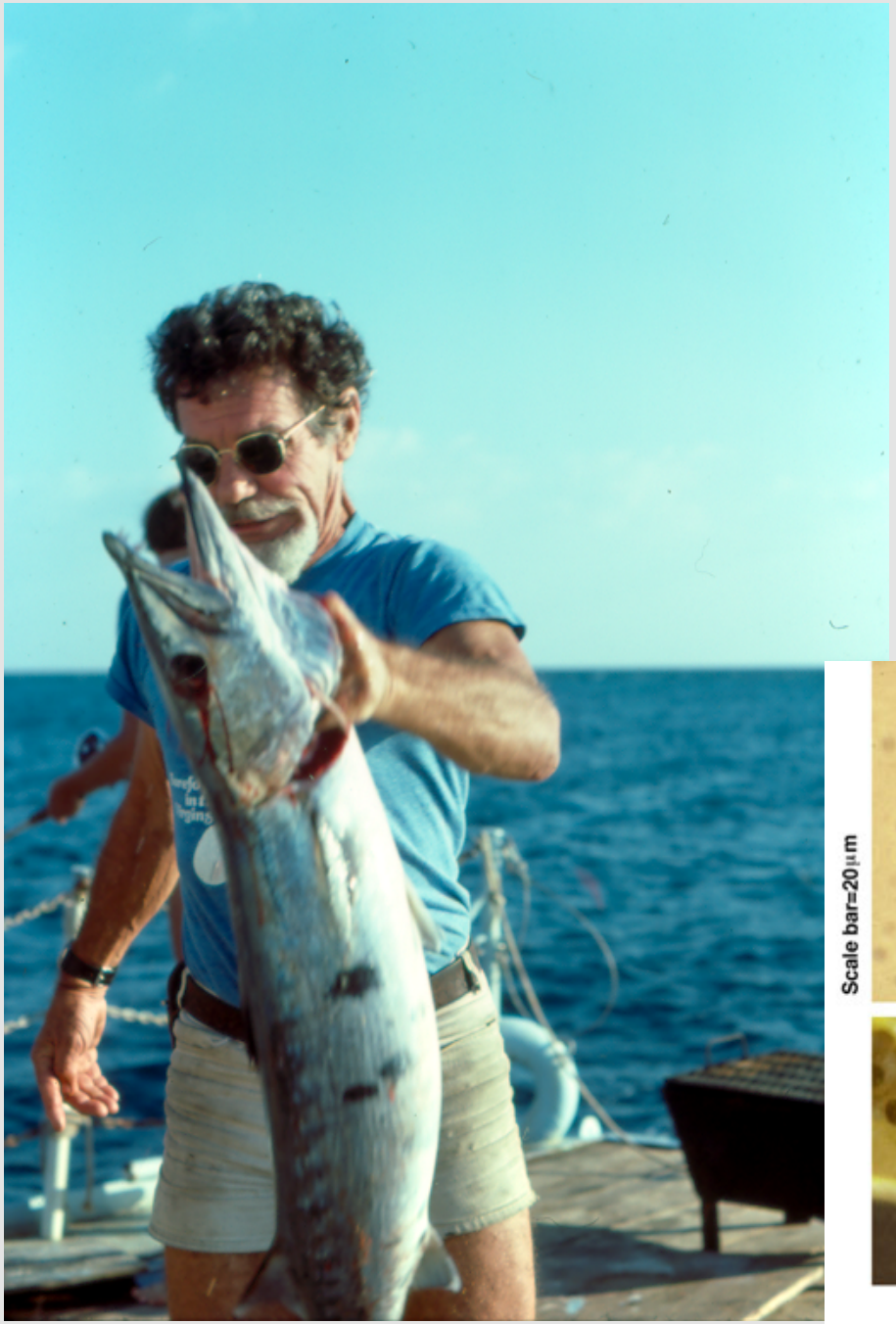
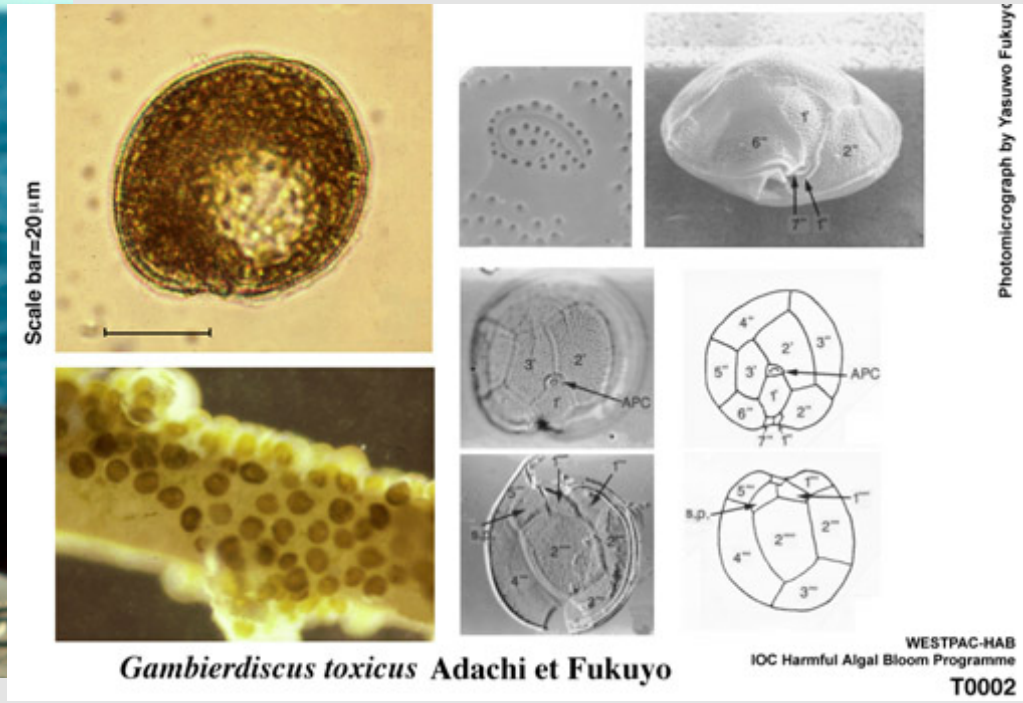
He slept for the next two days. Finally he felt well enough to venture out. As he dressed he noticed that his hands seemed clumsy, and his feet felt as if they were asleep, as if he were walking on a carpet of tiny nails.

His girlfriend bought him a smoothie from a juice stand. The fruit drink smelled delicious. He took a sip and immediately spit it out. ***The icy cold drink felt as if it had come straight off the stove*** — as if it were boiling hot rather than freezing cold. He took another sip. His mouth burned. It felt too hot to swallow.

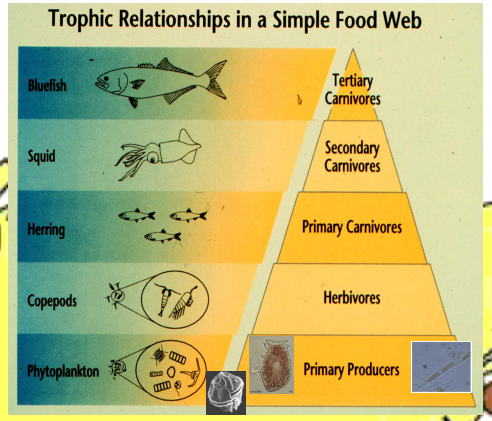


Ciguatera, an illness caused by the toxin of a microalga that lives on some macroalgae in the tropics & subtropics.

Eating ‘high in the food chain’ is a problem due to <u>bioaccumulation</u> of toxin.



Major HAB-related Events in the Coastal U.S.



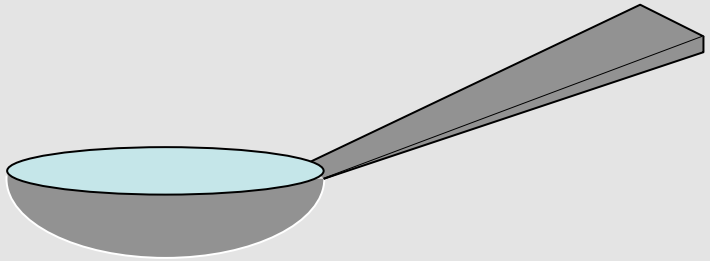
- Neurotoxic Shellfish Poisoning
- Paralytic Shellfish Poisoning
- Amnesic Shellfish Poisoning
- Ciguatera Fish Poisoning
- Pfiesteria complex
- Brown Tide
- Macroalgae proliferation
- Fish, bird, mammal & submerged aquatic vegetation kills

PR

A growing problem worldwide

Source: NOAA COP/National HAB office-WHOI

What's in a teaspoon of seawater?



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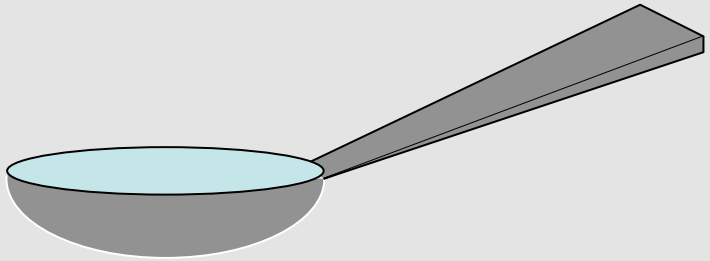
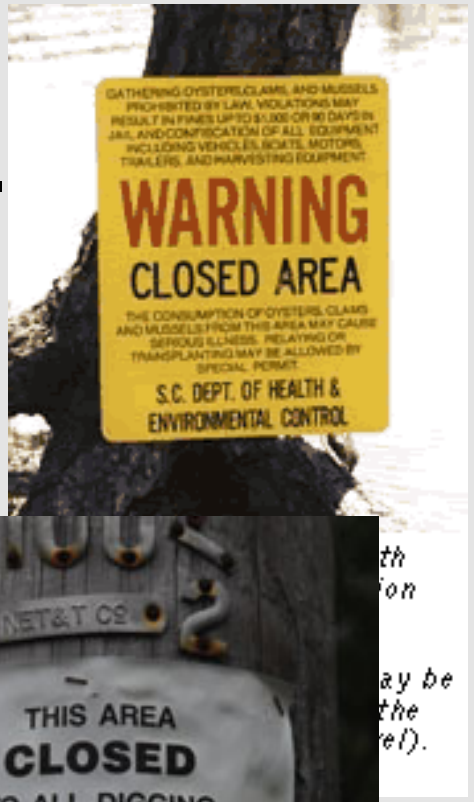


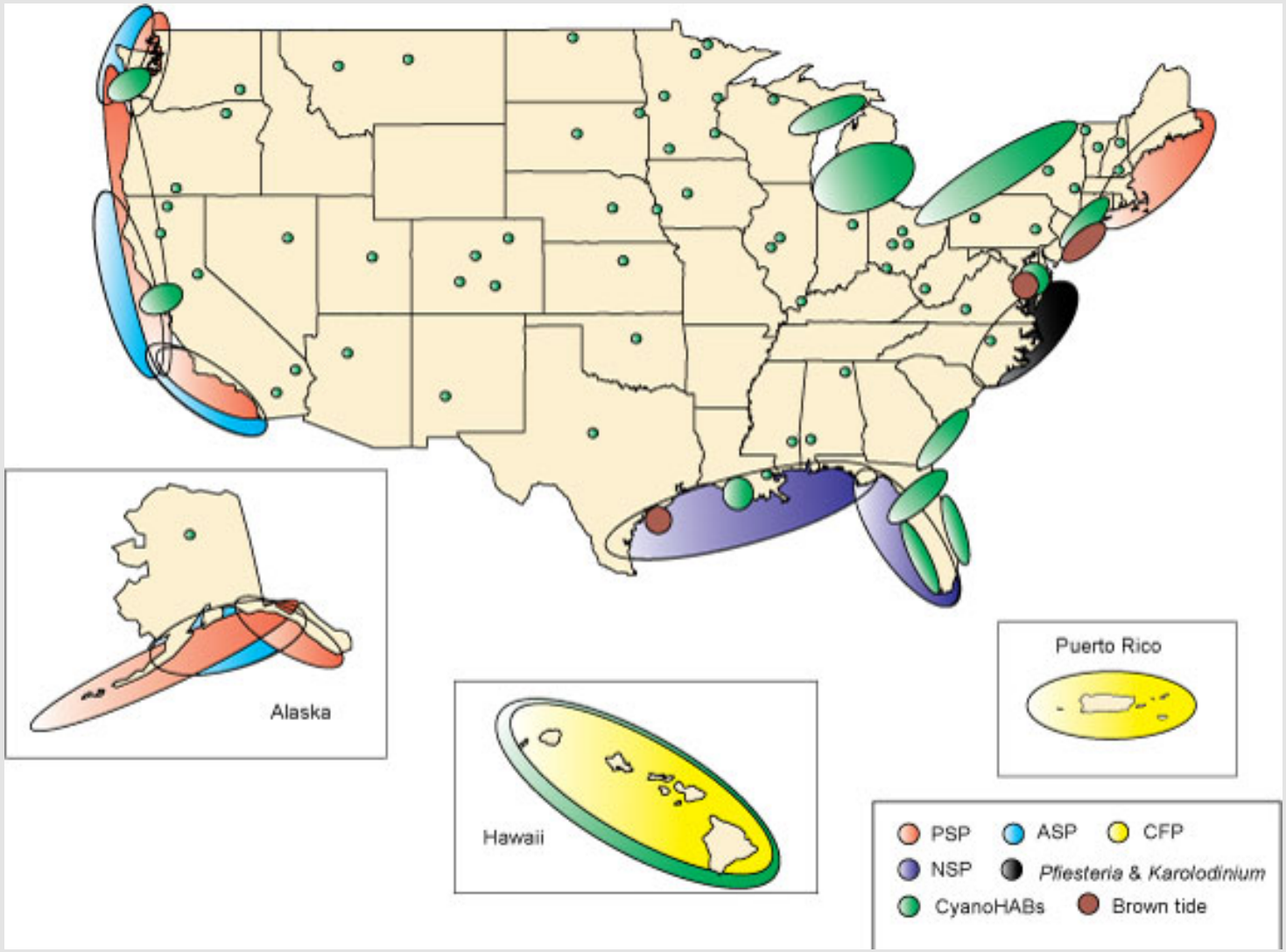
1 tsp of seawater ≈ 5 milliliters
≈ 100,000,000 viruses
≈ 10,000,000 bacteria
≈ 5,000 microalgae
≈ 3,000 protozoa

most are harmless, even beneficial…
…a few are not.

Algal toxins can present a problem to humans when concentrated in seafood.



HABs Occur Throughout the U.S.



From: Woods Hole Oceanographic Institution HAB Page
(http://www.whoi.edu/redtide/page.do?pid=9257)

What are our 'Local' HAB issues?

(from bad-to-worst)

Fairly innocuous 'red tides' (but they can deplete oxygen)

Nocticula scintillans

Lingulodinium polyedrum

Noxious 'foams' and 'scums' (food web disruption)

Phaeocystis globosa

Tetraselmis sp.

Truly toxic species

Dinophysis spp. (Diarrhetic Shellfish Poisoning)

**_Alexandrium spp._ (Paralytic Shellfish Poisoning)

**_Pseudo-nitzschia spp._ (Amnesic Shellfish Poisoning)

Are these events new? …not really.

AN UNUSUAL OCCURRENCE OF DINOFLAGEL-
LATA ON THE CALIFORNIA COAST.

HARRY BEAL TORREY.

DISCOLORATIONS of the sea due to the presence of minute organisms, and often many miles in extent, have been seen in various parts of the world, along the shore and in the open sea. Deep-water sailors are familiar with such appearances, which they call "whale food," or "brim." The cause of the color is not always the same organism, though perhaps most frequently some species of Dinoflagellata, in enormous numbers.

This phenomenon was observed at San Pedro, Cal., during the present summer, and, according to the testimony of old

Torrey HB (1902) An unusual occurrence of Dinoflagellata on the California coast. Am. Nat. 36:187-192

Gregorio, D. E. and Pieper, R. E. 2000 Investigations of red tides along the southern California. Bulletin of Southern California Academy of Sciences, 99, 147-160.

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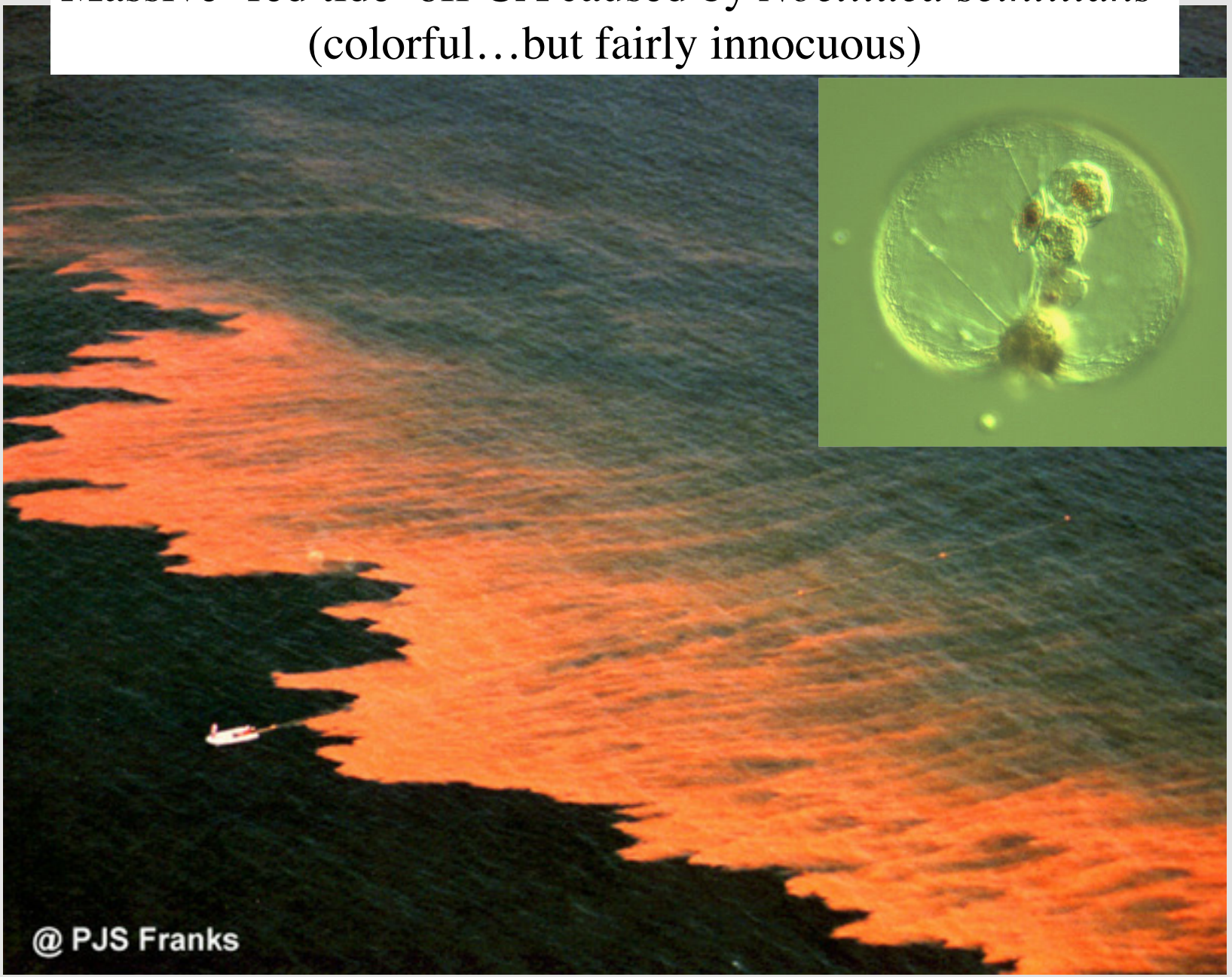
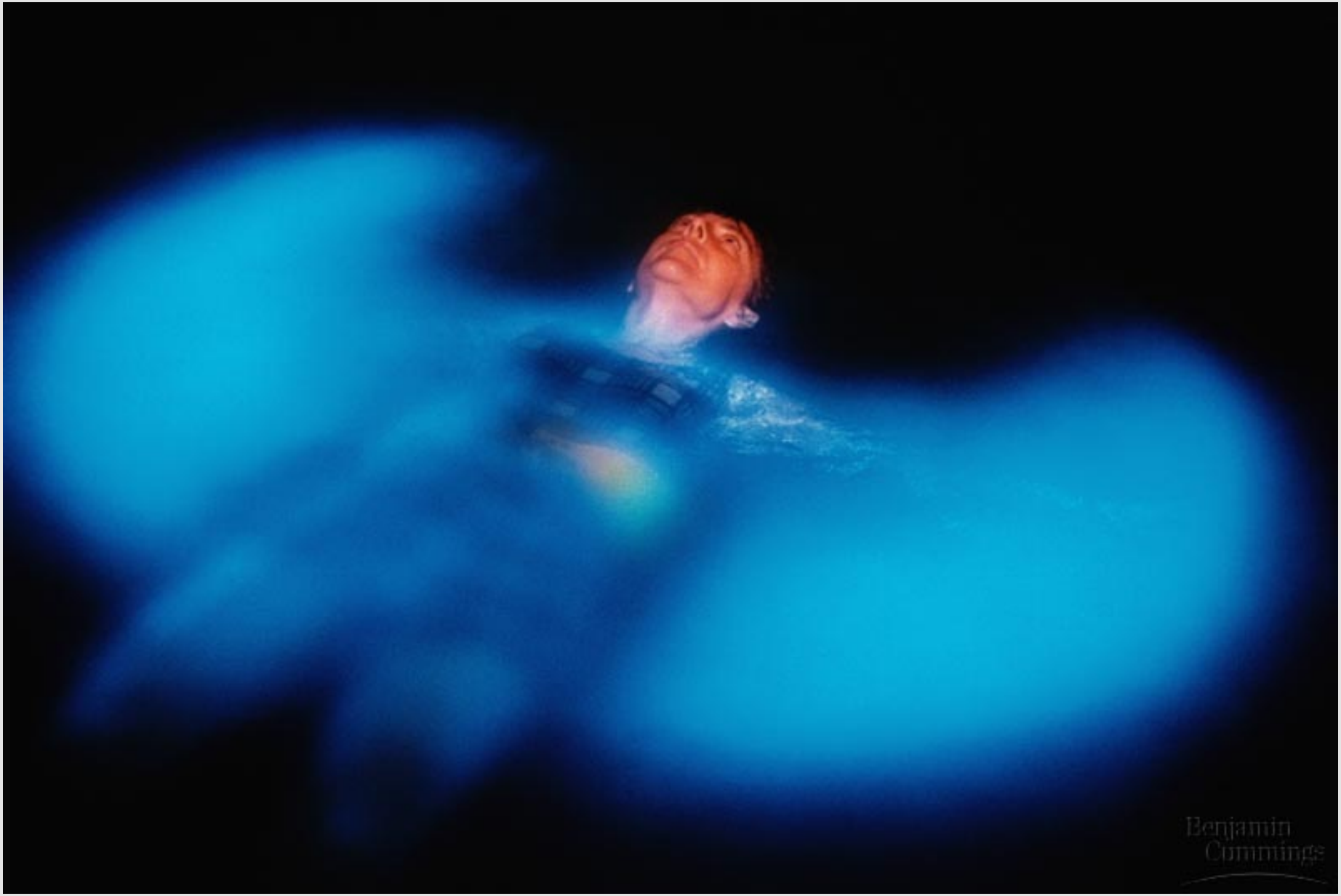
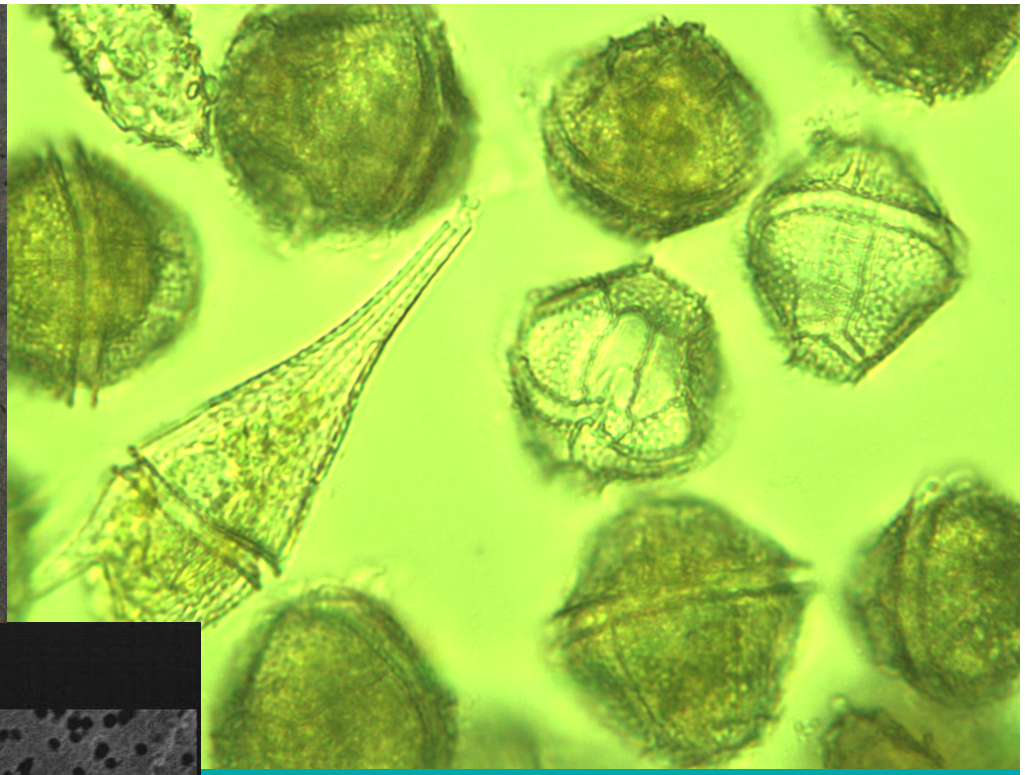
Massive ‘red tide’ off CA caused by *Noctiluca scintillans*
(colorful…but fairly innocuous)

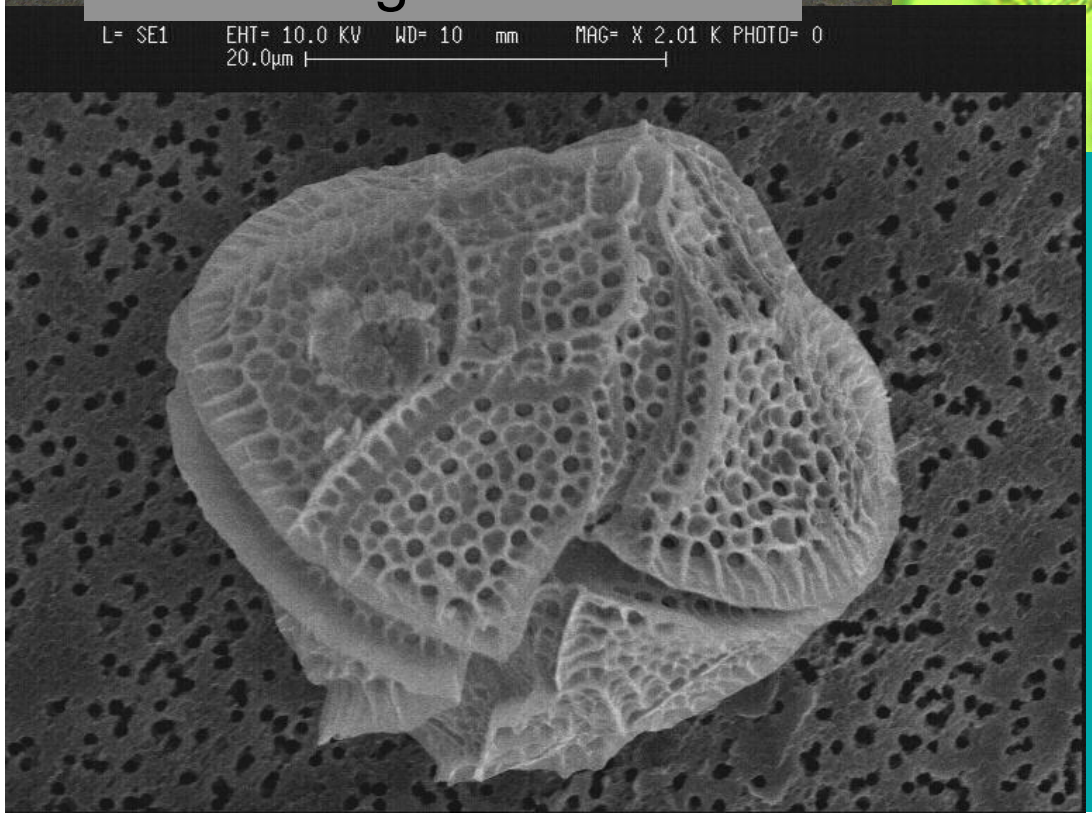


Swimming with bioluminescent dinoflagellates



From Long Beach shore





Lingulodinium polyedrum

A ‘red tide’ without toxic consequences…
…so far.

Yessotoxin: affects muscles

Red Tides Close Desal Plants

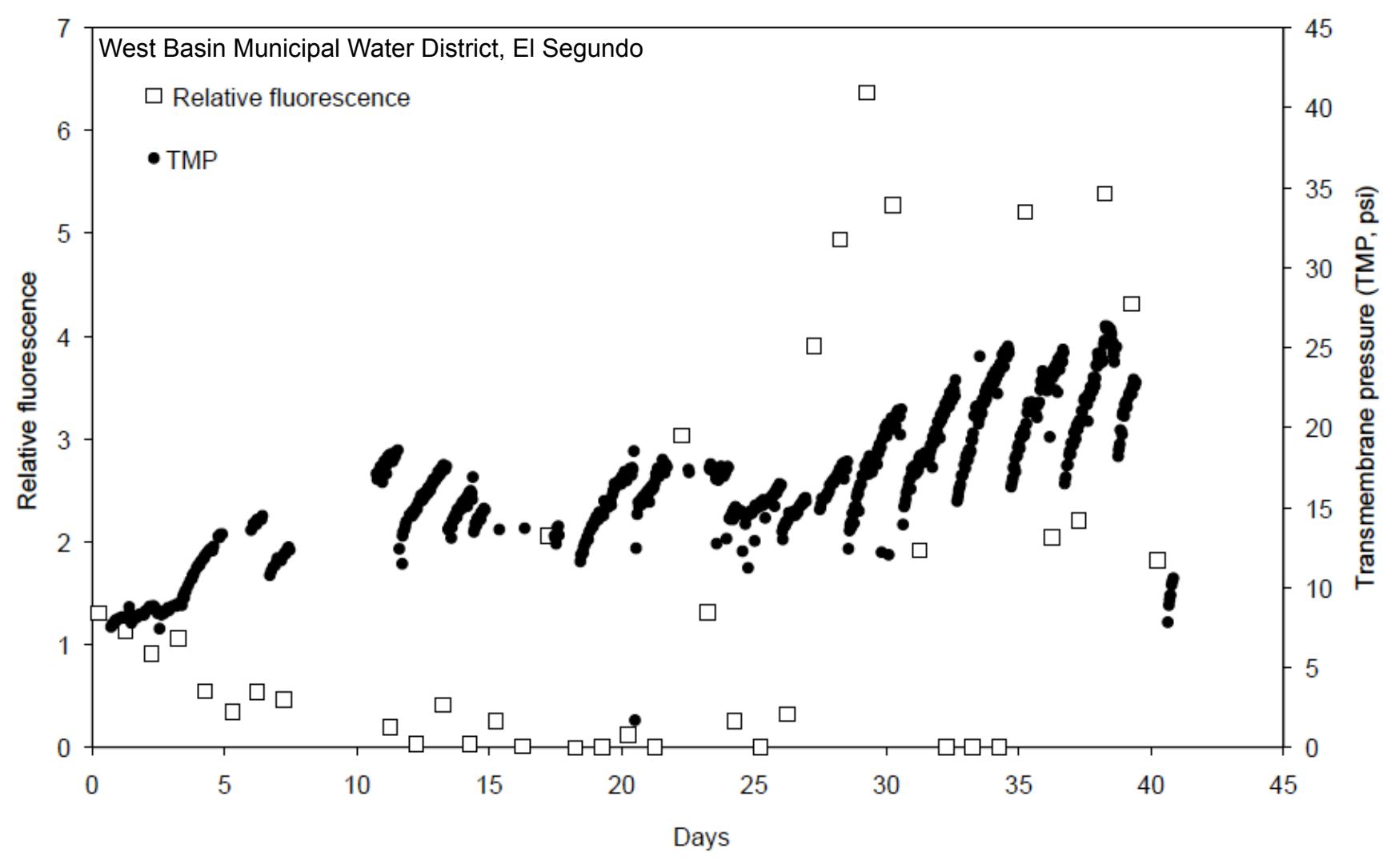
Water Desalination Report
Vol. 44 Dec 2008

United Arab Emirates

"A red tide that local officials described as being 'the worst in years' has closed several seawater desalination plants and has impacted operations…"

"In Dibba, over 650 tons of dead fish washed ashore, and in Khor Fakkan more than 700 tons were reported…

Loading of phytoplankton biomass (relative fluorescence) onto a pilot-scale reverse osmosis desalination system and resulting increase in transmembrane pressure (TMP).



Caron et al. 2009

King Harbor,
Redondo Beach
(May 2006)

(unknown if a toxin was produced during this bloom)

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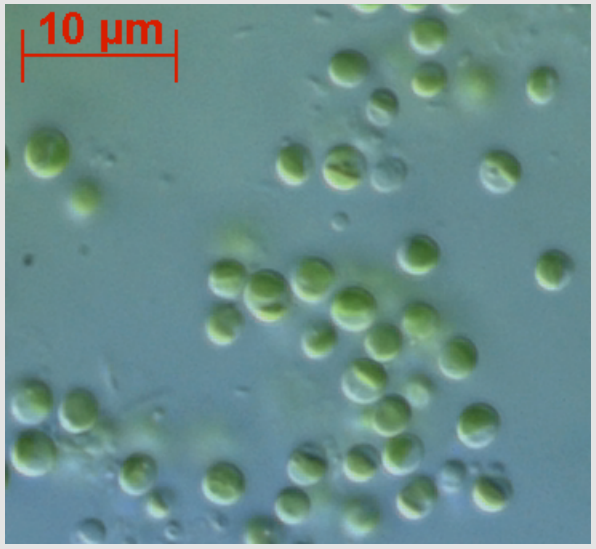
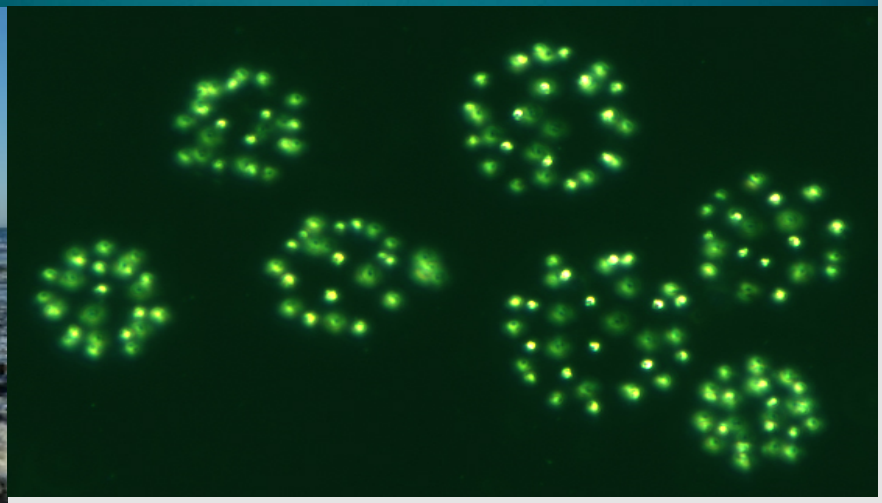
Tetraselmis : The ‘green scums’ of recent summers.

[Scientist IDs mysterious ocean scum](#)
The Orange County Register, July, 2010





Noxious species; disruption of normal food web structure and function.

Sea foam off Australia in 2008

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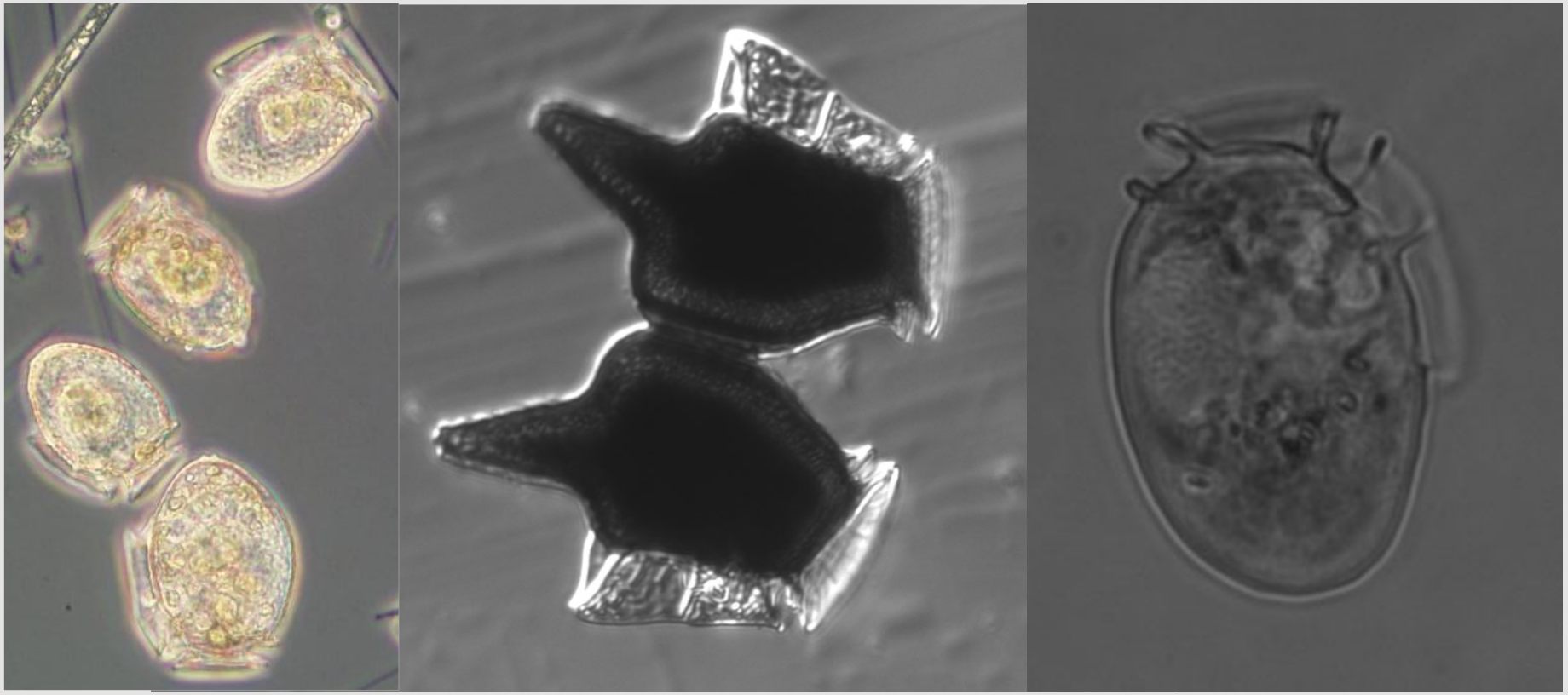
Okadaic Acid (Diarrhetic Shellfish Poisoning)

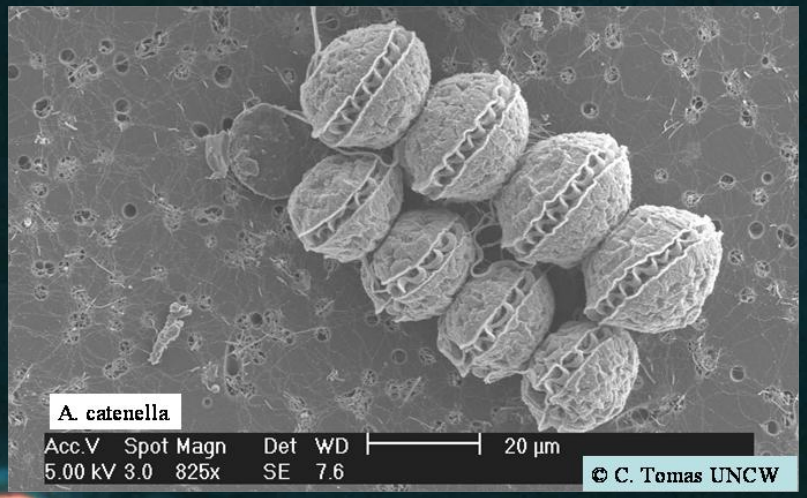
Causes diarrhea, nausea, vomiting, moderate to severe abdominal pain and cramps, and chills. No known fatalities.

But it is known to be a strong tumor promoter! Affects enzymes controlling cell cycle regulation.

Dinophysis species

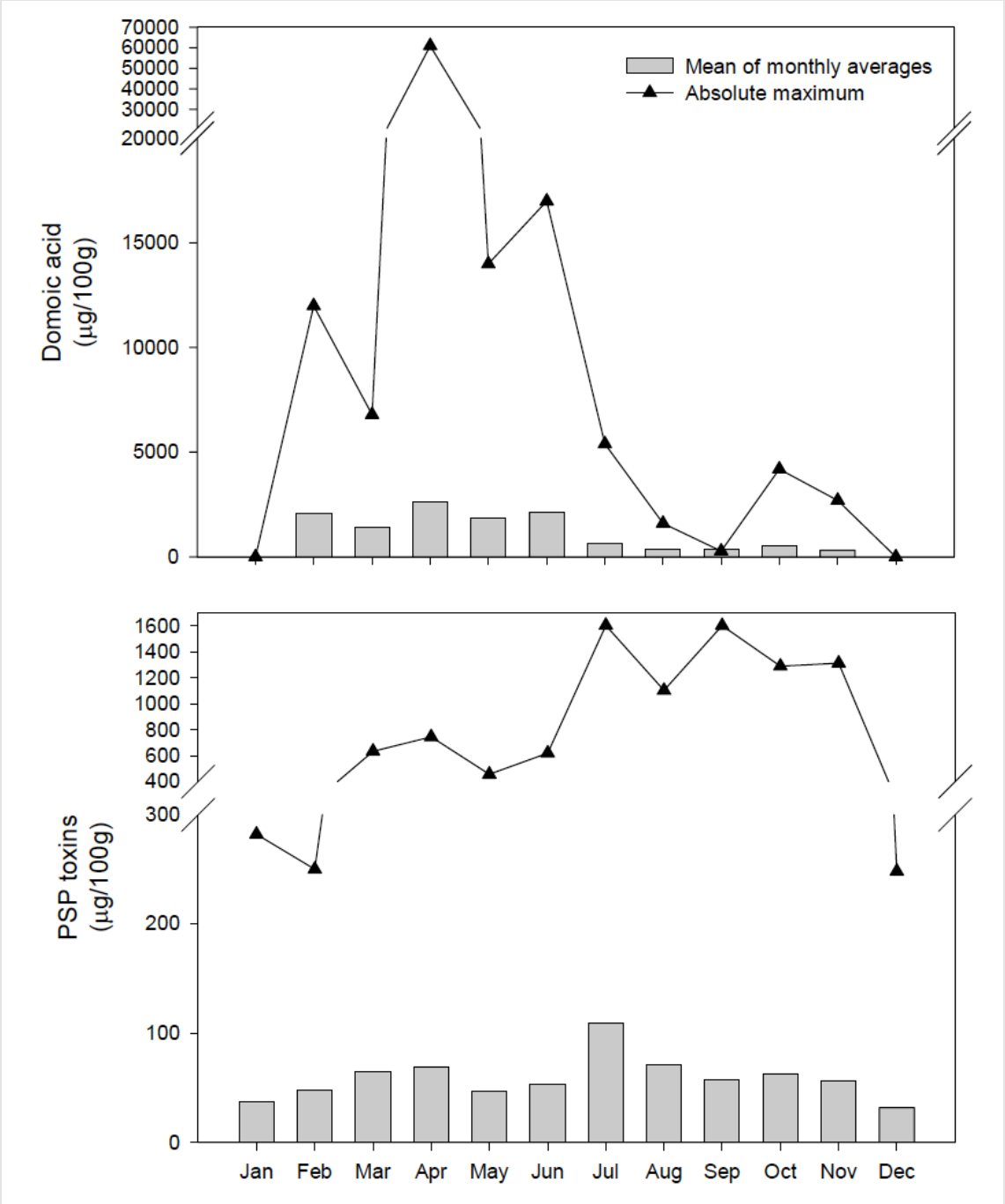


Alexandrium spp.
Cochlodinium (Gymnodinium) catenatum
Pyrodinium bahamense var. *compressa*



Saxitoxin (Paralytic Shellfish Poisoning)
A group of compounds, varying in toxicity.

They blocks passage of nerve impulses.



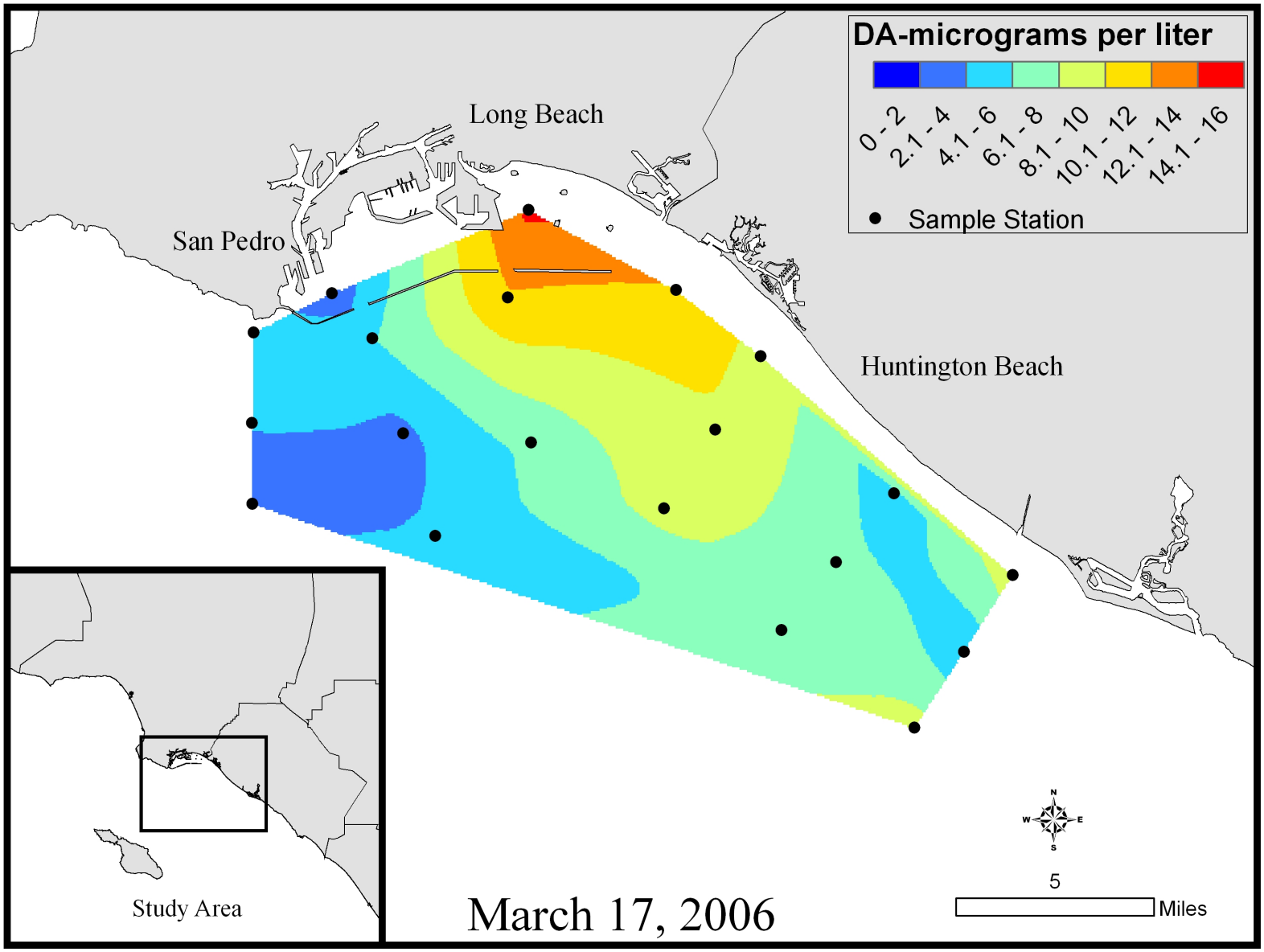
Seasonality of Domoic acid (Amnesic Shellfish Poisoning) and Saxitoxins (Paralytic Shellfish Poisoning) along the California Coast.

Caron et al. 2009

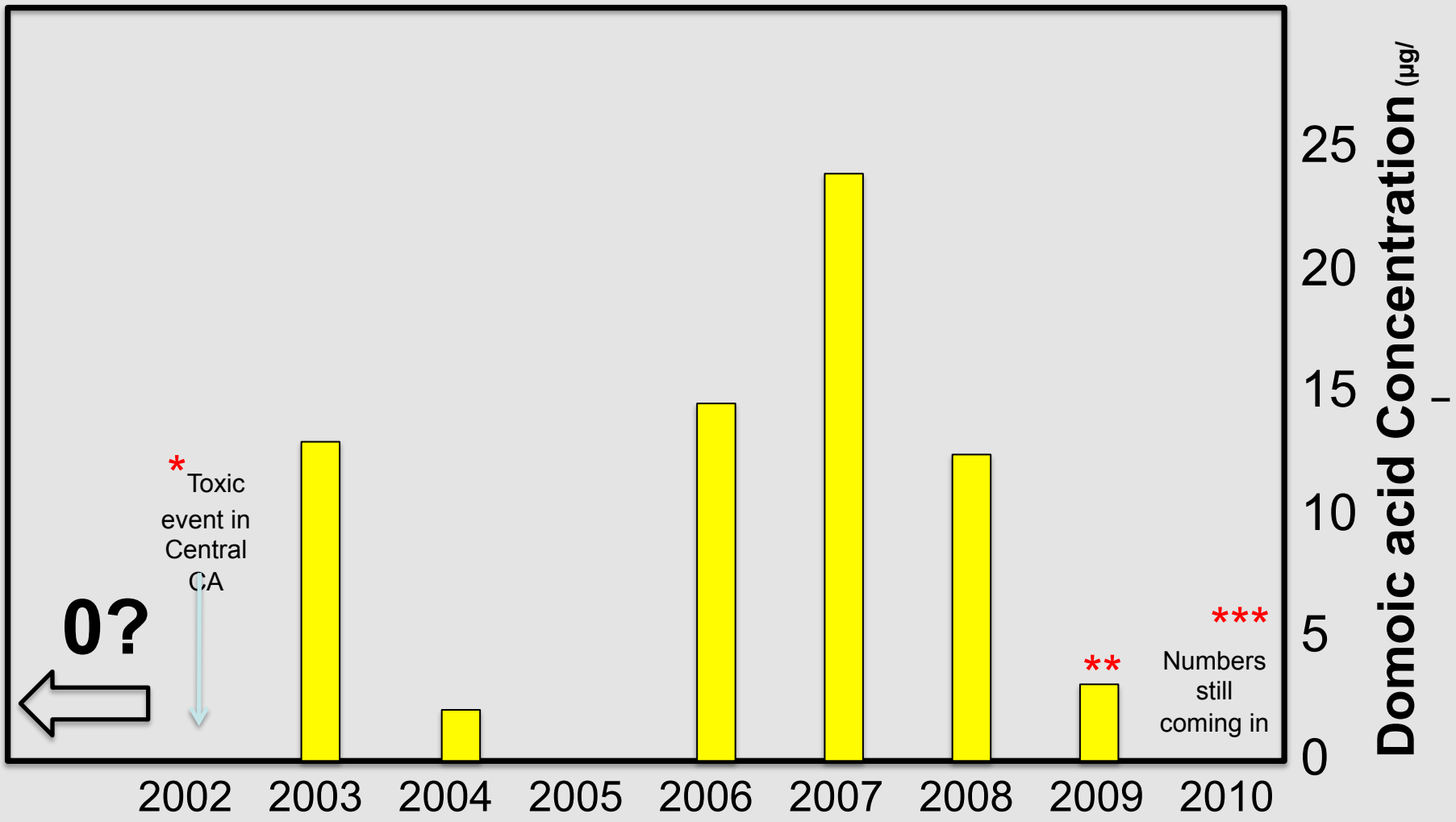
Domoic Acid (“demonic acid”)
A neuro-exciter.
Amnesic Shellfish Poisoning (ASP)

Symptoms in humans:
Nausea, vomiting, abdominal cramps, headache, dizziness, confusion, disorientation, short term memory loss motor weakness, seizures, cardiac arrhythmia, coma, rarely death.

In SoCal, marine mammals and seabirds take the worst of it. Responsible for thousands of strandings and deaths during last decade.


DA-micrograms per liter
0 - 2
2.1 - 4
4.1 - 6
6.1 - 8
8.1 - 10
10.1 - 12
12.1 - 14
14.1 - 16
Sample Station
Long Beach
San Pedro
Huntington Beach
Study Area
March 17, 2006
N
W
E
S
5
Miles

Maximal values of domoic acid in the region of the San Pedro – Long Beach shelf



From: Santa Cruz Sentinel (2006)

150 years of the Sentinel: Thousands of birds floundering in streets

EDITOR'S NOTE: The Sentinel is celebrating its 150th year in 2006 by reaching into our archives to republish some of the noteworthy stories out of the past. The following story was printed in the Santa Cruz Sentinel on Aug. 18, 1961.

By Wally Trabing

A massive flight of sooty shearwaters, fresh from a feast of anchovies, collided with shore side structures from Pleasure Point to Rio del Mar during the night.

Residents, especially in the Pleasure Point and Capitola area were awakened about 3 a.m. today by the rain of birds, slamming against their homes.

Dead, and stunned, seabirds littered the streets and roads in the foggy, early dawn. Startled by the invasion, residents rushed out on their lawns with flashlights, then rushed back inside, as the birds flew toward their light.

Television aerial supports were severed, and one power line was shorted out about 4 a.m. on Merrill avenue when the birds hitting the lines slapped them together…

The word of the bird invasion spread fast throughout the state. Cameramen from San Francisco papers were out in the early morning fog, and a phone call came to the Sentinel from Alfred Hitchcock from Hollywood, requesting that a Sentinel be sent to him. He has at home in the Santa Cruz Mountains.

DA constitutes a significant risk for humans...

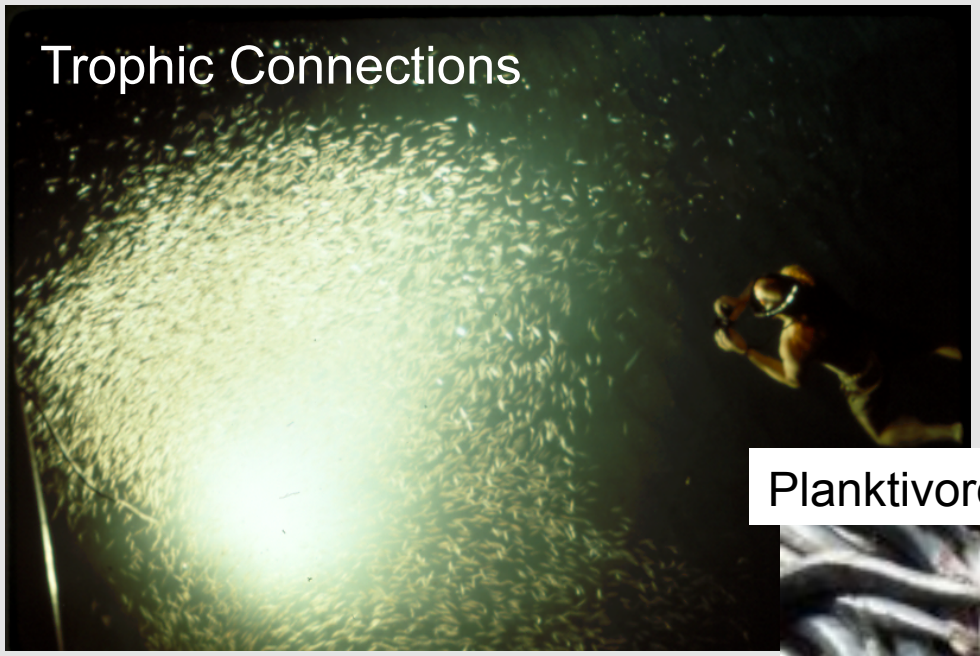
… but effective monitoring keeps it an issue primarily for marine animals in SoCal, via links in food-webs.

Some important prey items that concentrate the microalga…

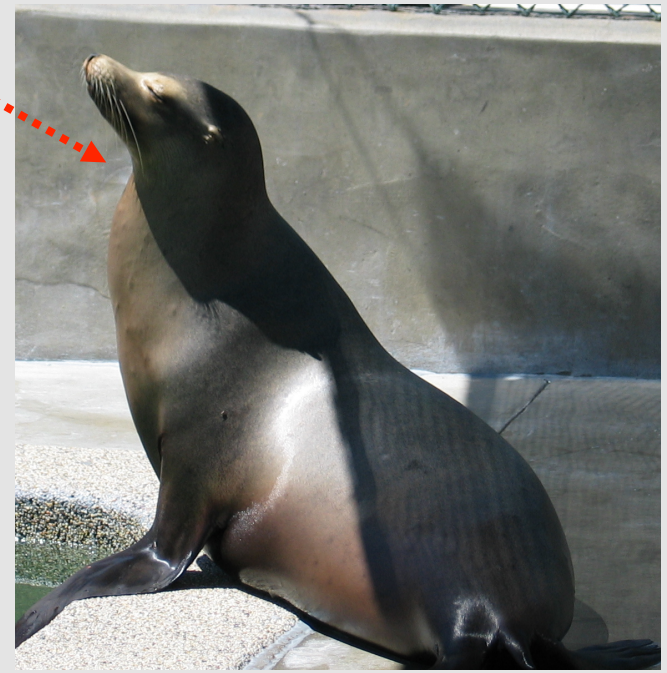
Planktivorous fish (e.g. anchovy, sardines)

Pacific sand crab

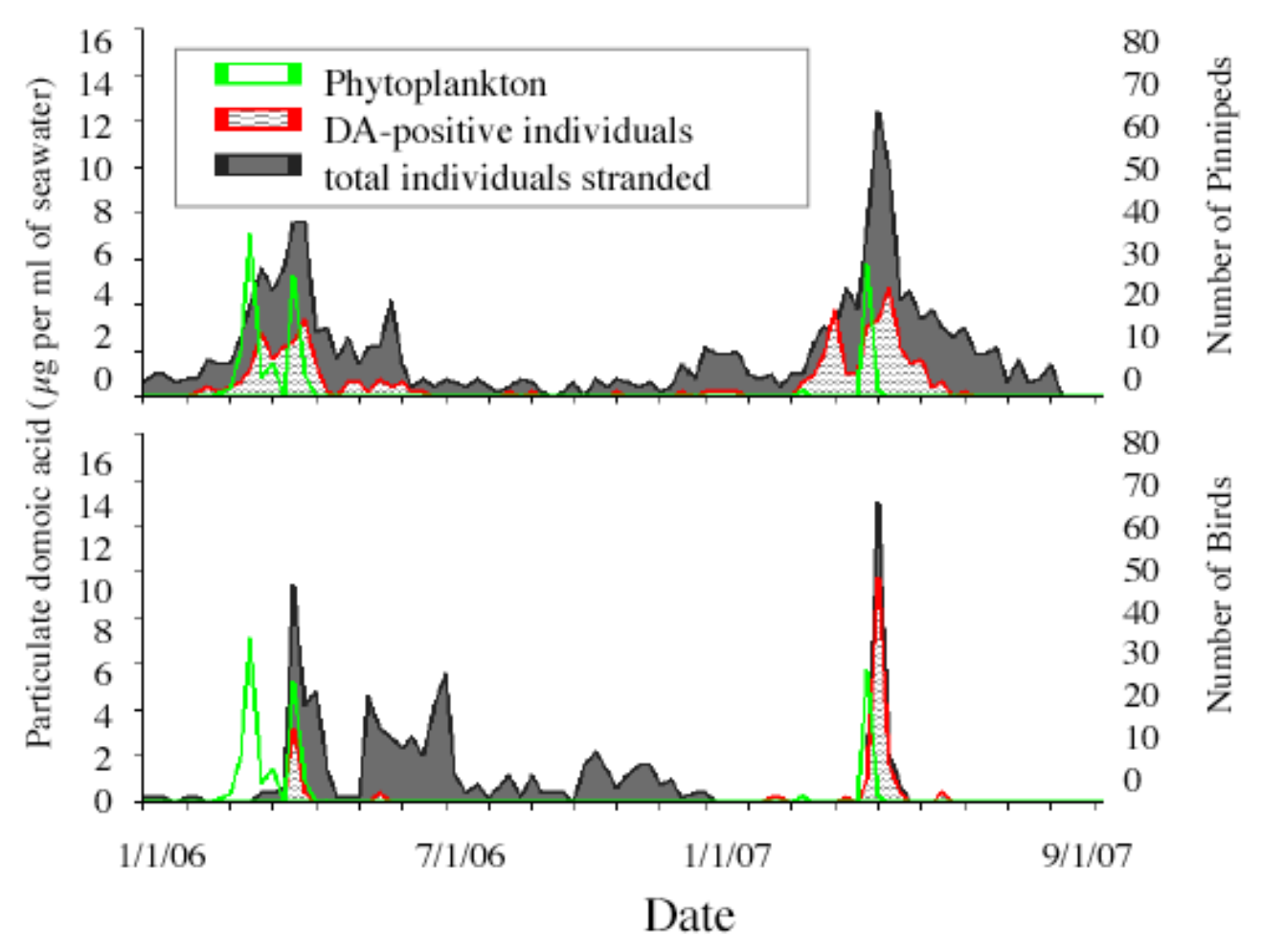
Trophic Connections



Planktivorous fish



Strong correlation between toxins in surface waters and marine mammals and birds testing positive for domoic acid in 2006 and 2007



Conclusions

HABs in California coastal waters have increased in frequency and severity during the last decade.
(has increased awareness contributed to this?)

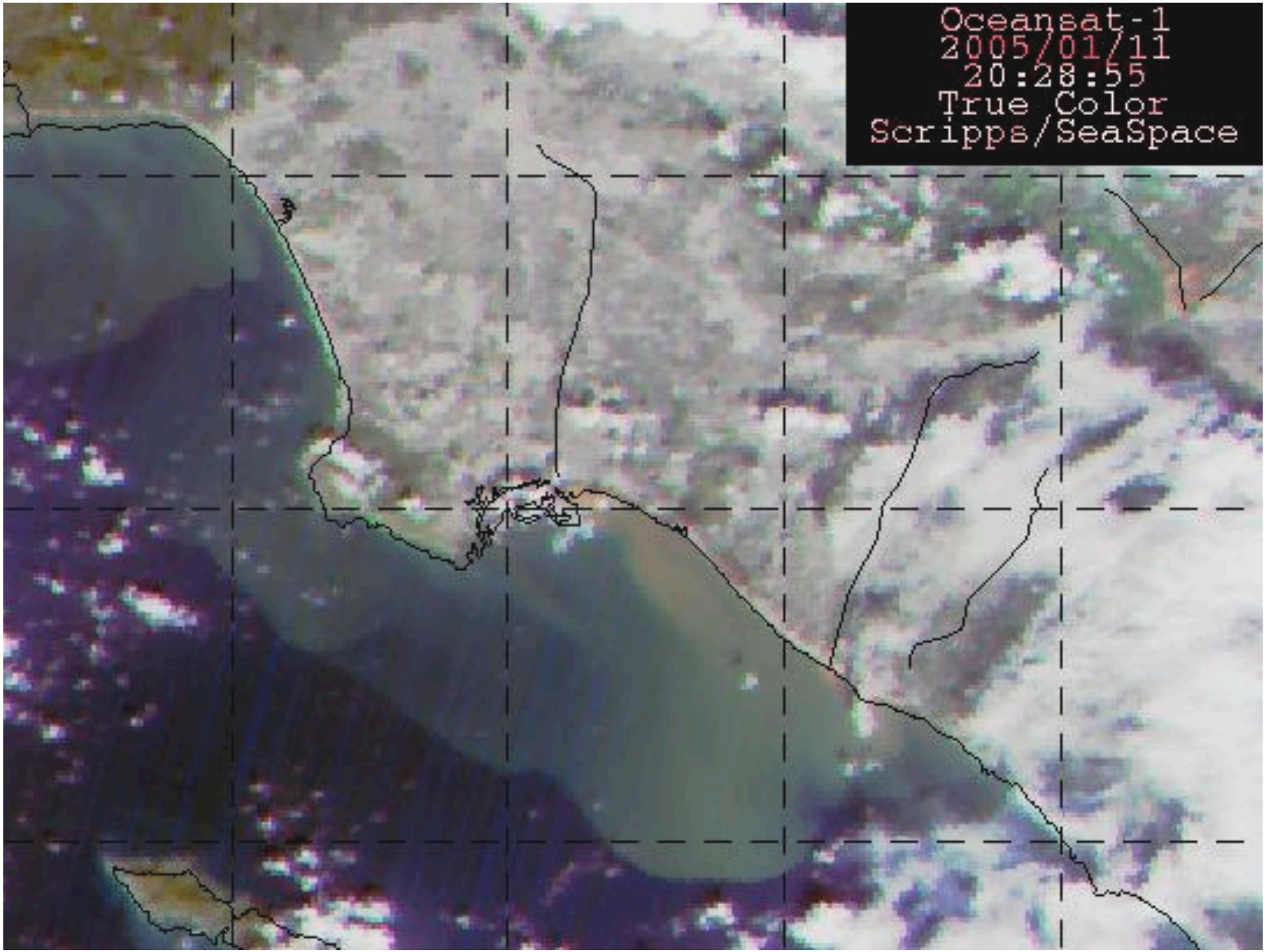
Some perennial HAB 'hot spots' are appearing. They may hold the key to understanding the causes of these events.

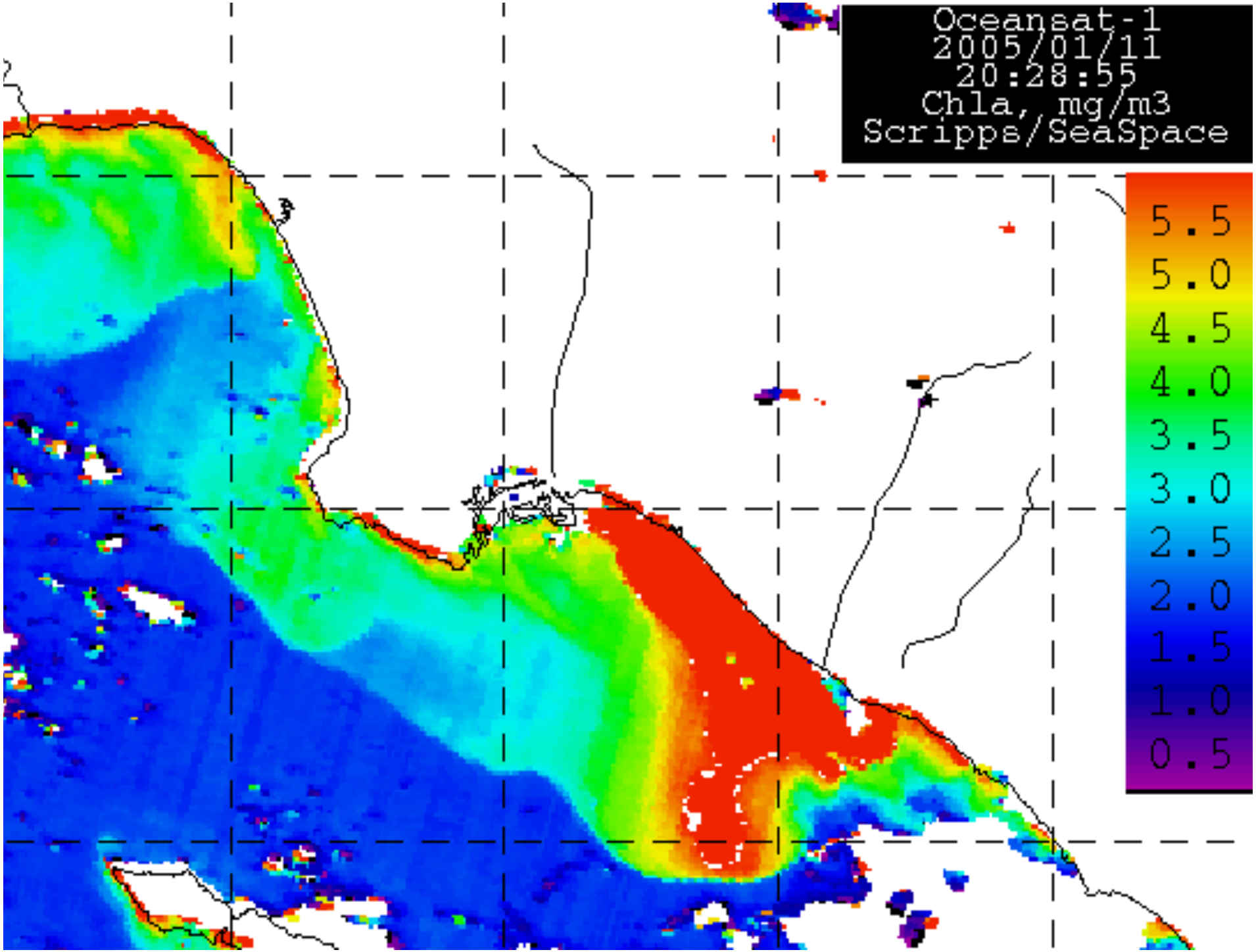
Animal strandings show a strong relationship to toxic events, and analysis of animal samples are revealing high levels of contamination in some cases.

Challenges
(moving toward solutions)

Why, when & where are toxins produced?

- What conditions lead to toxic blooms?
  - (no 'silver bullet' so far)
  - 'Natural' vs 'Anthropogenic' sources
- What ecological roles do toxins serve?
  - (varied, no absolute answers yet)
    - allelopathy
    - grazer deterrence
    - micronutrient acquisition (e.g Fe)
- What are temporal & spatial distributions?
  - (regional and national monitoring)


Oceansat-1
2005/01/11
20:28:55
True Color
Scripps/SeaSpace


Oceansat-1
2005/01/11
20:28:55
Chla, mg/m3
Scripps/SeaSpace
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

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(no 'silver bullet' so far)

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(varied, no absolute answers yet)

What are temporal & spatial distributions?

(regional and national monitoring)

Can we mitigate their effects?

(possible in some cases; but fixes have 'costs'

Can we prevent blooms, or toxin production?

(on the horizon! Understanding is the key)

What can be done *now*?

Improve our understanding of HABs

Identify environmental triggers for blooms & toxin production.
Characterize temporal & spatial patterns of blooms.

Strengthen the Alert Network

Marine Mammal Care Center, 3601 S.Gaffey St., San Pedro, CA 90731

Pacific Marine Mammal Center, 20612 Laguna Canyon Rd., Laguna Beach, CA 92651

Improve animal rehabilitation

Interaction between HAB researcher, rescue groups and care providers to improve treatment