

Harmful Algal Blooms (HABs)



- Types of microalgae that:
 - Multiply rapidly to form dense aggregations in sea water
 - Are toxic or cause other nuisance or lethal effects
- Includes a wide variety of types of single-celled algae
 - Diatoms (uncommon)
 - Dinoflagellates (many species)
 - Microflagellates (a few species)
- Also some cyanobacteria (in fresh water)

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Local HAB Species



Dinoflagellates

Alexandrium catenellum
Ceratum fusus
Dinophysis spp.
Noctiluca scintillans

Can Potentially Cause:

Paralytic shellfish poisoning (PSP)
Anoxic events, oyster larvae mortality
Diarrhetic shellfish poisoning
Anoxic events, non-toxic red tides

Diatoms

Chaetoceros spp.
Pseudo-nitzschia spp.

Can Potentially Cause:

Net-pen salmon mortality
Amnesic shellfish poisoning (ASP)

Microflagellates

Heterosigma akashiwo

Can Potentially Cause:

Net-pen salmon mortality

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Source: Jan Rines <http://thalassa.gso.uri.edu/Esphyto/habtaxa.htm>

HAB Effects on Humans



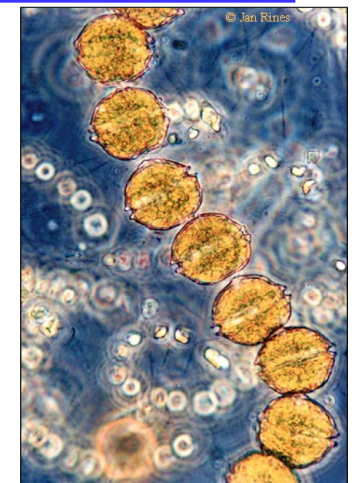
- No harmful effects from drinking, swimming, or other contact
 - Organisms are too dilute
- Organisms must be consumed by filter-feeding shellfish
 - Mussels, clams, oysters
 - Toxins concentrate in shellfish tissue
 - Humans eat shellfish & get large dose of toxin
 - Hence name ____ (paralytic, diarrhetic, amnesic) shellfish poisoning

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Puget Sound HAB Species



- *Alexandrium catenellum*, a chain-forming toxic dinoflagellate
 - Secretes a potent mix of neurotoxins (saxitoxins)
 - 1 clam can be fatal
 - PSP paralyzes vertebrate central nervous system
 - Including breathing
 - Death by suffocation can occur within 12 hours
 - Unless aided by a respirator



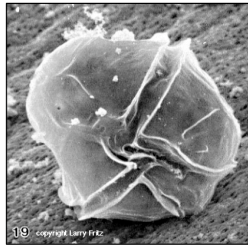
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<http://thalassa.gso.uri.edu/Esphyto/list/pplist.htm>

Paralytic Shellfish Poisoning



- PSP toxins apparently do not affect invertebrate shellfish
- No practical method to detoxify shellfish
 - No antidote in vertebrates
- Only 1 method to detect toxicity
 - Inject tissue extract into sacrificial white mouse
 - Length of time it takes mouse to die is a measure of toxicity
 - At 80 parts/million Health Dept. closes beaches



Alexandrium catenellum

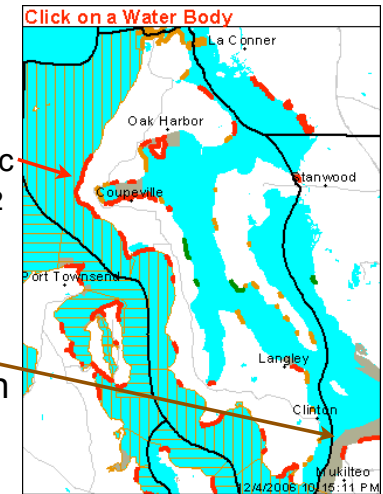
Source: Northwest Fisheries Science Center, National Marine Fisheries Service
 "Red Tides" Newsletter <http://www.nwfsc.noaa.gov/hab/Newsletter/RedTides99.pdf>
 Woods Hole Red Tide Page (<http://www.whoi.edu/redtide/species/species.html>)

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Paralytic Shellfish Poisoning



- Wa Dept. Health monitors beaches for PSP & other problems
 - Reports closures to public
 - Red tide hotline 1-800-562-5632
 - ww4.doh.wa.gov/gis/mogifs/biotoxin.htm
- Some permanent closures due to pollution
 - Outer coast: seasonal closure April-October



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Paralytic Shellfish Poisoning



- *A. catenellum* prefers stratified waters
 - Temperatures above ~15°C
 - Often when rain follows a warm, dry spell
- Blooms often begin in poorly flushed "breeding bays"
 - Quartermaster Harbor (Vashon Island) & Sequim Bay (Olympic Peninsula)
 - Exported to surrounding waters
- After blooming, it forms resting cysts
 - Reside in the sediments
 - Becomes permanent wherever it blooms

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Paralytic Shellfish Poisoning

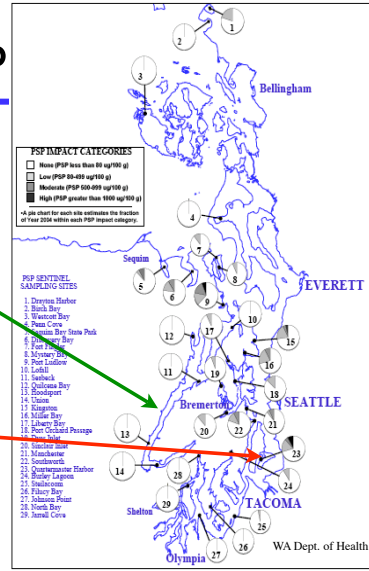


- PSP first detected on the coast and Strait of Juan de Fuca in the 1940s
 - Identified phytoplankton cause 1960's
 - Invaded north Puget Sound in 1978
 - Invaded the south Puget Sound 1997
- No proven relationship between PSP & any known pollutants
 - 1st reported by Capt. Vancouver in northern Canada 1793
 - Most severe in pristine waters of BC & Alaska
 - Exact conditions that cause blooms uncertain

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Puget Sound PSP

- PSP now blooms everywhere in Puget Sound
 - Except Hood Canal (so far)
- 2004 results
 - Most severe in Quartersmaster Harbor (Vashon)
- Don't take chances
 - Cooking, tasting, etc. are not safe precautions



Slide courtesy of Jesse Port, UW School of Marine Affairs 2006

Puget Sound HABs

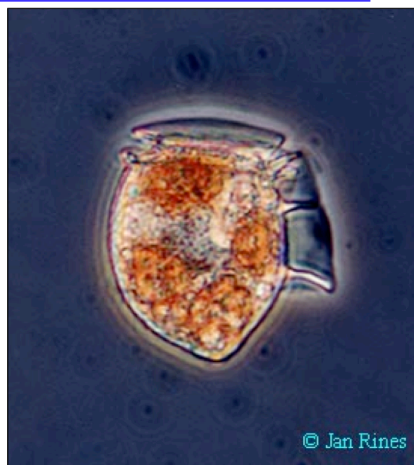
- *Ceratium fusus*, a solitary spined dinoflagellate
 - Reported to pierce tissues & gills of oyster larvae
 - Can kill directly
 - Can lead to infection & mortality
 - Possibly gills of salmon as well
 - No known toxin
 - Can be profuse enough to sink, decay, & cause subsurface anoxia



Puget Sound HAB Species



- *Dinophysis sp.*, a solitary dinoflagellate
 - Reported to cause severe diarrhea, presumably from an unidentified toxin
 - Observed in Puget Sound but no poisoning incidents have been reported



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Puget Sound HAB Species



- *Noctiluca scintillans*, an anomalous non-toxic heterotrophic "red-tide"-forming dinoflagellate
 - Tomato-soup-colored luminescent patches
 - One of the only "red tides" actually visible
 - A consumer as well as a primary producer
 - Eats small phytoplankton
 - May cause anoxia



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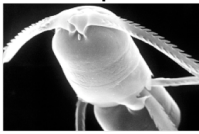


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Puget Sound HAB Species



- *Chaetoceros spp.*, forms of a common chain-forming spiny centric diatom
 - Spines puncture gills of salmon grown in net-pens
 - Mucus production & bacterial infection cause mortality
 - Wild fish can escape



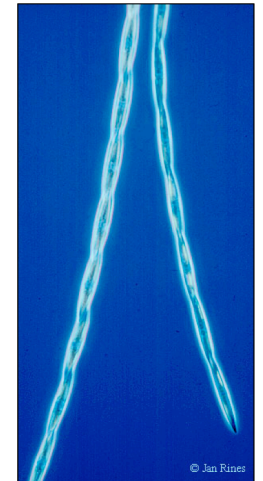
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<http://thalassa.gso.uri.edu/Esphyto/list/pplist.htm>, thalassa.gso.uri.edu/HABChaet/ecology.htm

Coastal HAB Species



- *Pseudo-nitzschia spp.*, chain-forming pennate diatoms, some forms of which are toxic
 - Difficult to identify toxic forms
 - Contain domoic acid, which causes amnesic shellfish poisoning (ASP)
 - Low doses: gastric upset
 - Moderate doses: confusion, permanent loss of short-term memory
 - High doses: can be fatal



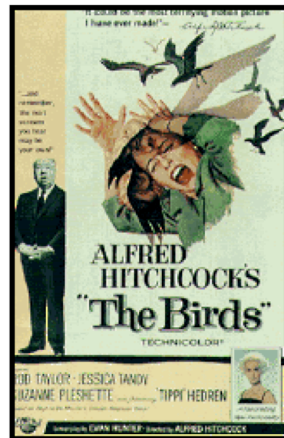
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<http://thalassa.gso.uri.edu/Esphyto/list/pplist.htm>

Coastal HAB Species



- *Pseudo-nitzschia spp.* present on W. Coast for decades
 - Cause of 1961 incident in CA?
 - 3 deaths E. Canada 1987
 - 1st detected WA coast 1991
 - Now occasional closures
 - Affects razor clams & Dungeness crabs
 - Probable cause of recent mammal & bird kills
 - No effect on fish & shellfish



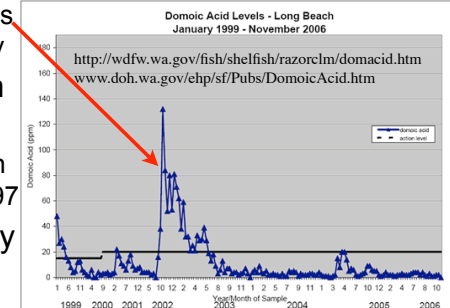
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<http://wdfw.wa.gov/fish/shellfish/razorclm/domacid.htm>

Coastal HAB Species



- Domoic acid detected using chemical method
 - 20 ppm in shellfish tissue = closure by Dept. Health
 - Occasional large blooms offshore reach beaches
 - 2002-2003 last time
 - Millions of \$\$ losses to coastal economy
 - Low levels found in Puget Sound
 - *Pseudo-nitzschia* in Whidbey Basin 1997
 - No antidote, no way to detoxify meat

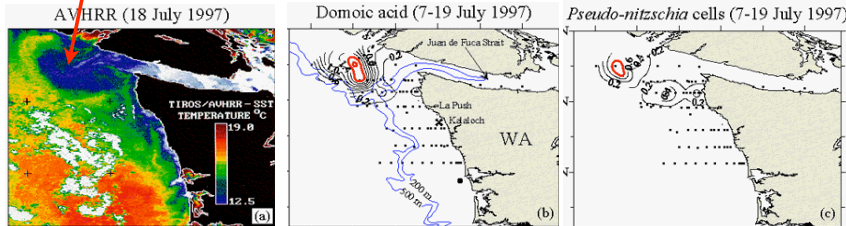


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Coastal HAB Species



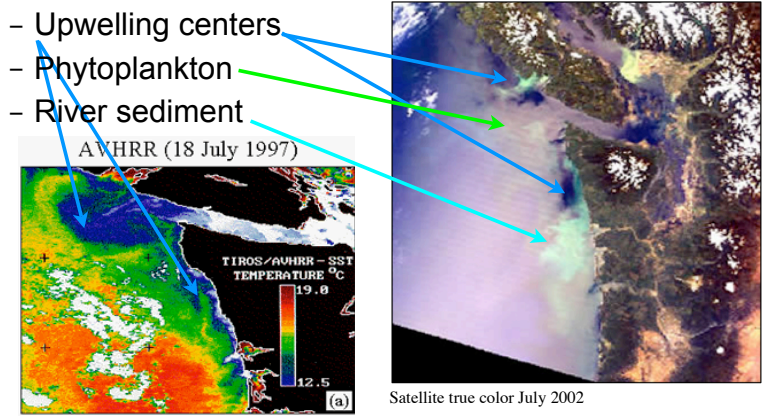
- *Pseudo-nitzschia* believed to breed offshore
 - Juan de Fuca eddy confined center of upwelling
 - Harmless to humans as long as it stays offshore
 - But may cause mortalities of seabirds & mammals
 - Cause shellfish poisoning when blown ashore



Coastal HAB Species



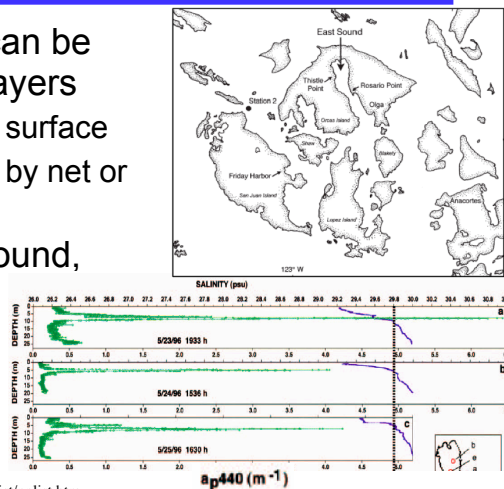
- Consistent oceanographic features
 - Upwelling centers
 - Phytoplankton
 - River sediment



ASP in Puget Sound



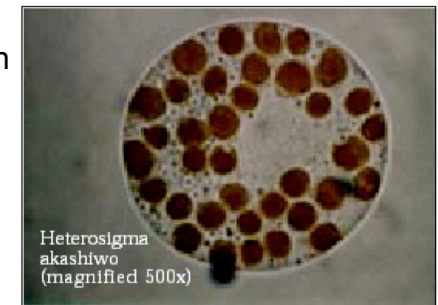
- Phytoplankton can be present in thin layers
 - Often below the surface
 - Rarely detected by net or bottle samples.
- Study in East Sound, Orcas I. 1996
 - Fraser River water layer on top of salt water



Puget Sound HABs



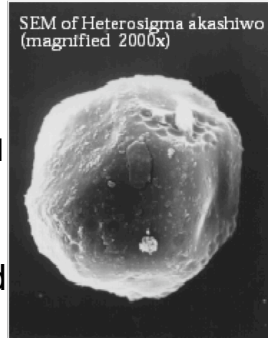
- *Heterosigma akashiwo*, a microflagellate
- Affects salmon in net pens
 - Causes loss of equilibrium, gill damage, & respiratory paralysis
 - Mechanism uncertain
- Present naturally
 - Not know to cause fish kills until salmon net-pens became common in 1980s
- “Brown tide”



Heterosigma akashiwo



- May prefer warmer, stratified, nutrient-poor water column after heavy rainfall.
 - Now observed to kill wild as well as penned salmon
 - But most wild fish avoid
- \$8 million loss to Puget Sound salmon farms in 1989-1990
- Drifts with the current into net-pen sites
 - Visible blooms monitored by airplane
 - With warning, growers tow nets to safety



Heterosigma akashiwo



- Dense blooms may originate in sheltered bays
 - Optimal temperature 17.5-20°C
 - Can cross strong thermoclines & haloclines
- Mechanism of mortality uncertain
 - May secrete a toxin
 - May secrete a dissolved organic carbon compound that fosters bacterial growth.
 - Bacteria must be present for toxicity to occur
 - Gill lesions present in dead fish

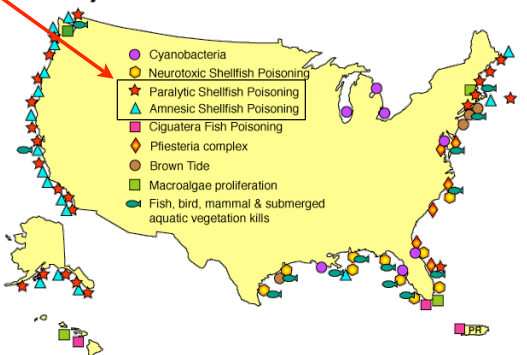


HABs Nationally



- Problems along the entire U.S. coast 2006
 - Mainly PSP & ASP on west coast
 - A variety of other HABs on east & Gulf coasts

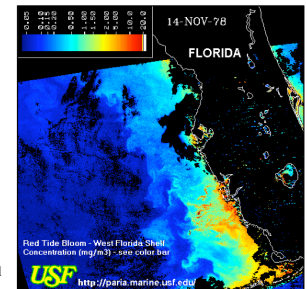
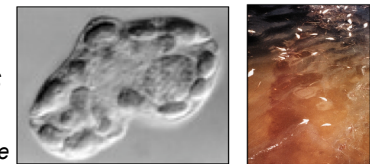
Major HAB-related Events in the Coastal U.S.



Neurotoxic Shellfish Poisoning



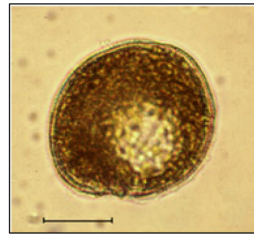
- U.S. east & Gulf coast
 - Caused by *Karenia brevis*
 - Dinoflagellate
 - Formerly *Gymnodinium breve*
- Intoxication & gastric upset
 - Toxin carried by salt spray
 - Asthma-like symptoms
 - No fatalities recorded
 - Recovery in a few days
 - Economic harm from beach closures



Ciguatera



- Occurs in meat of tropical reef fish predators
 - E.g. barracuda
 - Toxins by produced by several species of dinoflagellate
 - e.g. *Gambierdiscus toxicus*
 - Transmitted through food chain
- Intoxication & gastric upset
 - Can be fatal
 - Recovery takes weeks to years
 - A risk at restaurants



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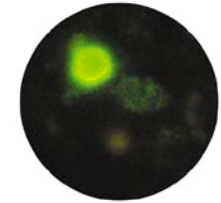
www.whoi.edu/redtide/rtpphotos/rtpphotos.html
www.whoi.edu/redtide/illness/illness.html

Slide courtesy of Jesse Port, UW School of Marine Affairs 2006

“Brown Tide”



- Similar to *Heterosigma* blooms
 - Visible discoloration of water
 - Microflagellates
 - *Aureococcus anophagefferens*
 - *Aureoumbra lagunensis*
- No health effects on humans
 - Blocks light & kills seagrasses
 - Suffocates shellfish
- May be example of HAB stimulated by excess nutrients



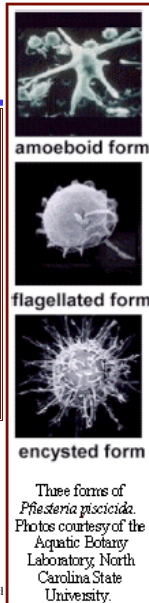
www.whoi.edu/redtide/rtpphotos/rtpphotos.html
www.ocean.udel.edu/seagrant/Research/marinebiotech.html
<http://aquaticpath.umd.edu/toxalg/btb.html>

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Slide courtesy of Jesse Port, UW School of Marine Affairs 2006

Pfiesteria piscicida

- A bizarre dinoflagellate
 - Up to 24 different life-cycle forms
- Some stages toxic
 - Some stages attack fish
 - Cause lesions
 - Bloom ends within hours
 - But weakened fish die later
 - Humans sickened by airborne toxins
 - Nausea, memory loss



These forms of *Pfiesteria piscicida*. Photos courtesy of the Aquatic Botany Laboratory, North Carolina State University.

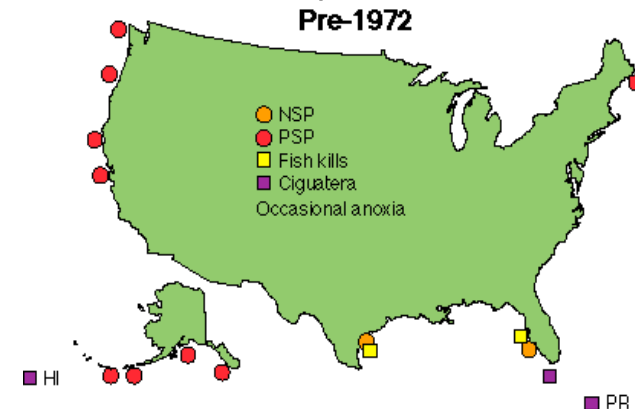
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www.dnr.state.md.us/bay/cblife/algae/dino/pfiesteria/facts.htm
www.sciencecases.org/fishkill/fishkill.asp

HABs Nationally



- Problems have expanded over last 35 years



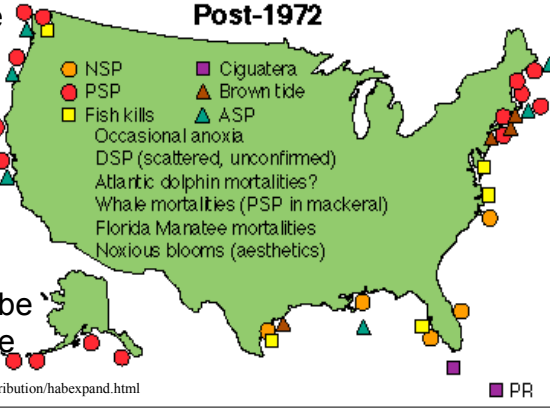
<http://www.whoi.edu/redtide/HABdistribution/habexpand.html>

Slide courtesy of Jesse Port, UW School of Marine Affairs 2006

HABs Nationally



- Problems have expanded over last 35 years
 - Spread & frequency of PSP & NSP
 - Appearance of ASP & brown tide
 - Spread of fish kills
- Partly just more data?
 - Believed to be true increase

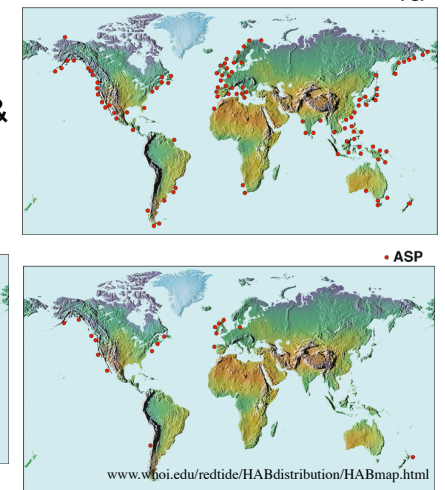


<http://www.whoi.edu/redtide/HABdistribution/habexpand.html>

HABs Globally



- Increased incidence around the world
 - Geographic spread & frequency of PSP, ASP, fish kills (2005)
 - Ballast water?



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www.whoi.edu/redtide/HABdistribution/HABmap.html

Link to Pollution?



- Nutrients are increasing in neritic zone



Fig. 1. Locations of regions of large-scale nutrient over-enrichment.

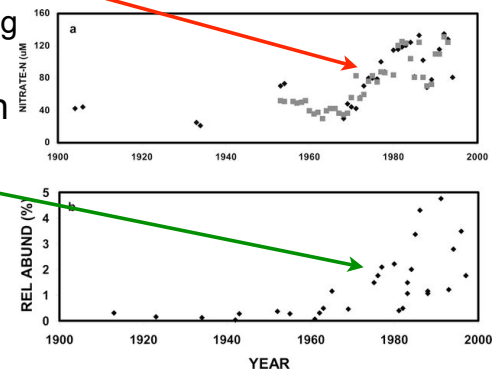
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ffairs 2006

Link to Pollution?



- Agricultural runoff & atmospheric N deposition are major sources
 - Point sources (e.g. a concern)
- Increased growth of all types of phytoplankton
 - No proof that PSP, ASP are stimulated by nutrients



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• Evidence that others are

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