

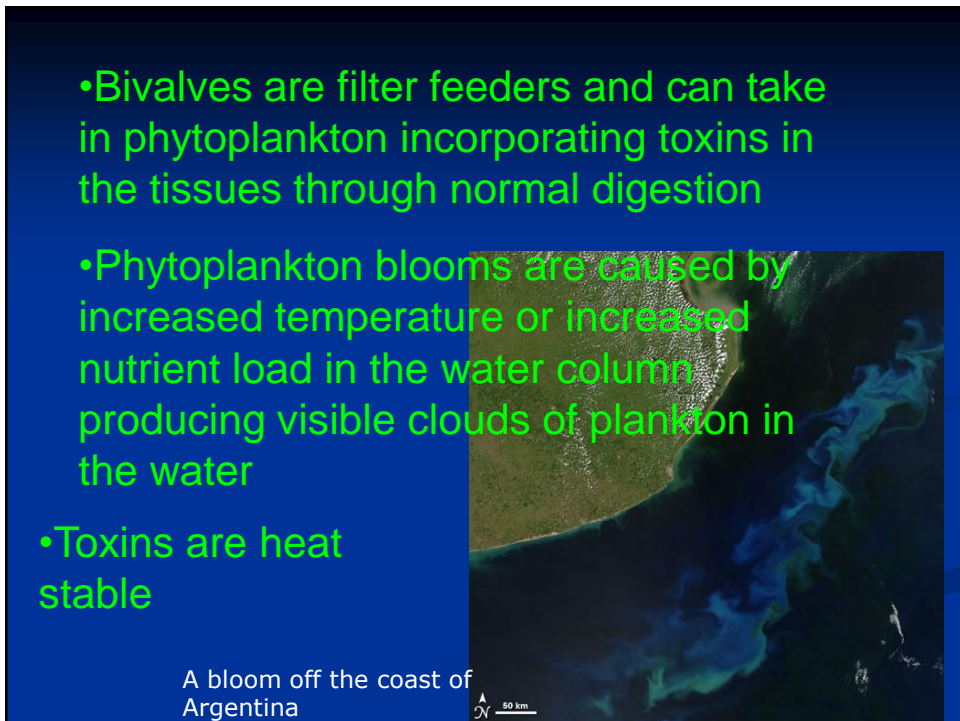
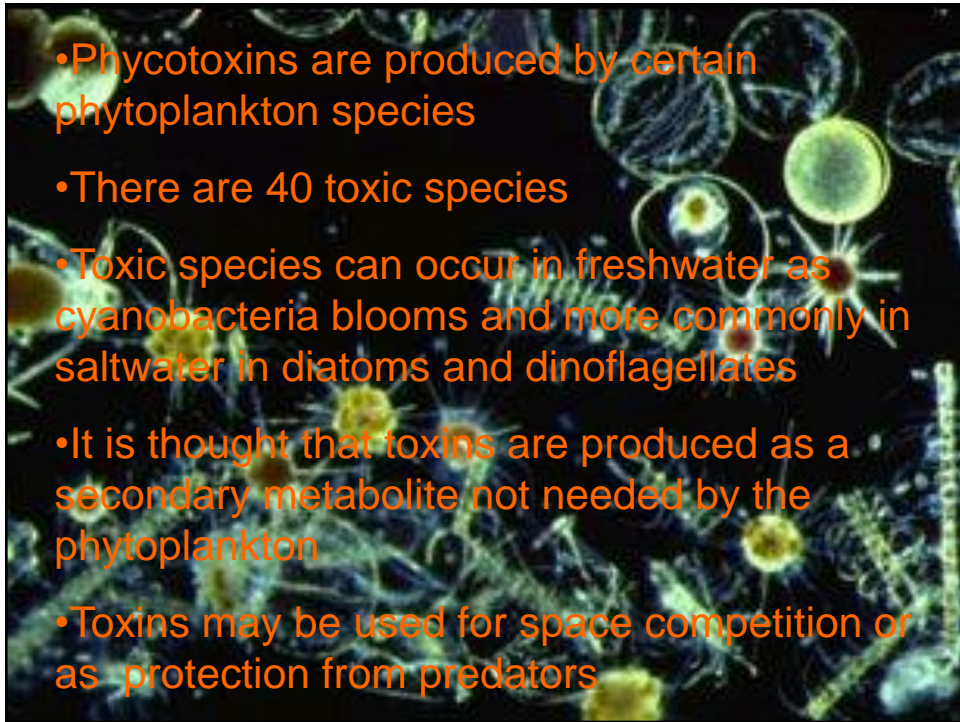
# Marine phycotoxins and their impacts on bivalve mollusk physiology

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Shellfish culture and enhancement  
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## Outline

- What are phycotoxins ?
- How do toxins accumulate in bivalves ?
- Types of poisoning and effects on humans
- Physiological effects on bivalve species
- Prevention of potential problems
- Economical impacts

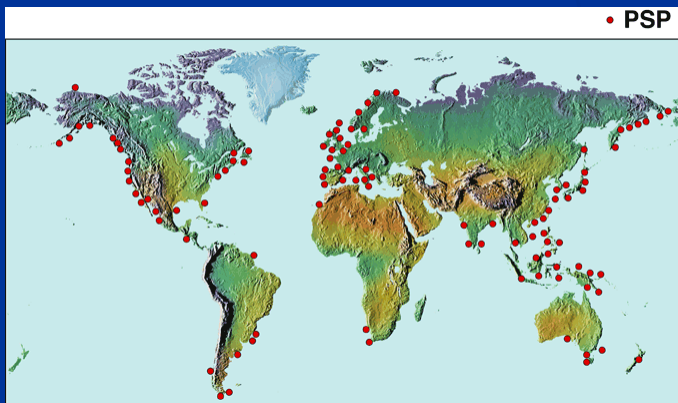
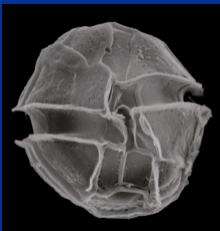


## There are 5 groups of toxic algae that affect shellfish:

1. Paralytic shellfish poisoning
2. Diarrhetic shellfish poisoning
3. Amnesic shellfish poisoning
4. Neurotic shellfish poisoning  
(Endemic to the Gulf of Mexico)
5. Azaspiracid shellfish poisoning  
(Similar to DSP)

### PSP: Paralytic Shellfish Poisoning

- Dinoflagellate of genus *Alexandrium* , motile
- 21 Tetrahydropurines, the most toxic is saxitoxin
- Produce cysts
- Toxin blocks ions from entering voltage gated sodium channels inhibiting muscle contraction in vertebrates, bivalves use voltage gated calcium channels



## PSP: Paralytic Shellfish Poisoning in Humans

- Serious and potentially fatal
- Symptoms can occur a few minutes to 10 hours after consumption of contaminated shellfish
- Tingling sensation or numbness around the lips, spreading to the face and neck
- Severe cases experience incoherent speech, prickly sensation in the arms and legs, problems coordinating movement, weak and rapid pulse, respiratory distress, nausea and vomiting
- In severe cases paralysis occurs in the respiratory muscles resulting in respiratory and cardiac failure and death within 2 – 10 hours of consumption
- If hospitalized in time those affected will survive with respiratory care in the hospital

## PSP

### Scallops

- Physical damage to eggs
- Impaired hatching rate
- Slow growth, paralysis or lethargy in juveniles after ingestion
- Impaired climbing rates and metamorphosis
- Toxin accumulation in digestive gland and viscera
- Juveniles avoid surface
- Adults can change toxin form
- Adults will close and stop eating



### Mussels

- Found more in adults than juveniles
- Slow growth and decreased absorption efficiency and clearance rates
- More exposure=higher tolerance and faster detoxification
- Biotransformation to store toxin in another form
- Can act as a vector to higher crustaceans
- Depth determines toxicity and clearance rate



## PSP

### Clams

- Juveniles more susceptible
- Alexandrium does not supply adequate nutrition for larvae
- Toxins accumulate 1<sup>st</sup> in the viscera then in the siphon
- Butter clam has resistant neurons and can store high amounts of toxin in siphon as a defense mechanism
- Can retain toxins for up to 2 years

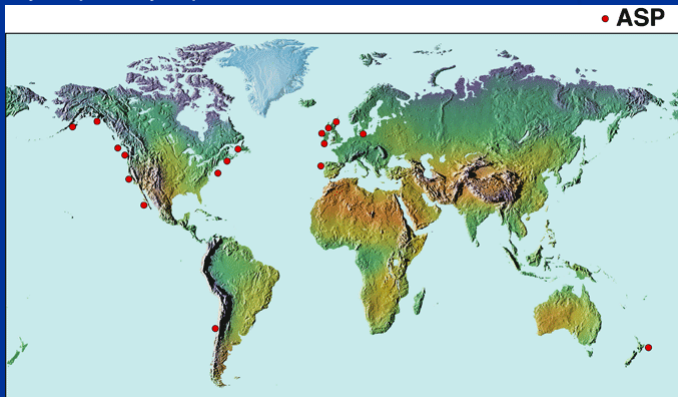
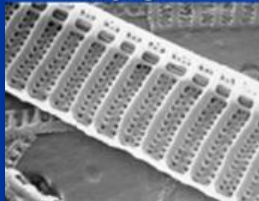


## ASP: Amnesic Shellfish Poisoning

- Diatom *Pseudo-nitzschia pungens*, non motile
- Produce neurotoxin domoic acid (amino acid) with 10 isomers found in phytoplankton
- Can survive cold temperatures
- Toxin binds to synaptic receptors of kainic acid receptor inhibiting sodium entry and calcium entry to post synaptic membrane



(3) *pungens*



## ASP: Amnesic Shellfish Poisoning in Humans

- Symptoms occur within 30 minutes to 6 hours after consumption of contaminated shellfish
- Symptoms include nausea, vomiting to muscle weakness, disorientation and memory loss
- This type of poisoning is not fatal and symptoms disappear within a few days in a healthy person
- Extreme cases can result in death
- The last known case of death from ASP was in 1987

## ASP

### Scallops

- Variable in different species
- Sea scallops accumulate in digestive gland
- Spiny scallop accumulate in digestive gland dying within 12 hours of exposure



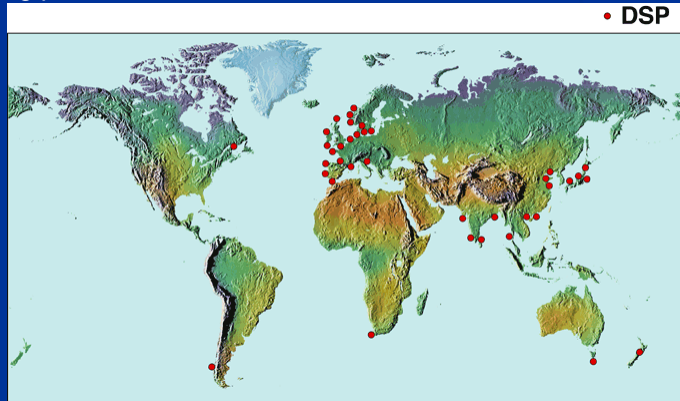
### Mussels

- Blue mussels accumulate in the digestive gland with no physiological effects
- Autochthonous bacteria may be factor for elimination
- Green shelled mussels ingest and eliminate the same amount of food so have no accumulation



## DSP

- Dinoflagellates of the genera *Dinophysis*, motile
- 3 types of toxins: acidic- okadaic acid and dynophysis toxin, neural toxins- polyether-lactones and sulphated polyethers and yessotoxins
- Okadaic acid inhibits protein phosphatases resulting in hyperphosphorylation of proteins that regulate sodium secretion by intestinal cells causing passive loss of fluids



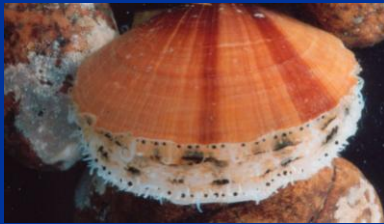
## DSP: Diarrhetic Shellfish Poisoning in Humans

- There have never been any fatal cases of this poisoning reported
- Symptoms occur within 30 minutes to 12 hours after consumption of contaminated shellfish
- Symptoms are gastrointestinal illness mostly diarrhea and nausea with some vomiting
- Symptoms disappear within 3 days

## DSP

### Scallops

- Accumulate some in visceral tissue and gonads
- Avoid blooms by closing and having an innate immune response by circulating hemocytes and hyalinocytes
- Can ingest, process and detoxify quickly with advanced immune response



### Mussels

- Accumulate in adults digestive gland only, juveniles unaffected
- Mussels have a polyphyletic organ for treating okadaic acid
- Mussels esterify toxins before accumulation so they are not harmful to the bivalve
- Blue mussels have a lower % of esters and eliminate a different form compared to green mussels



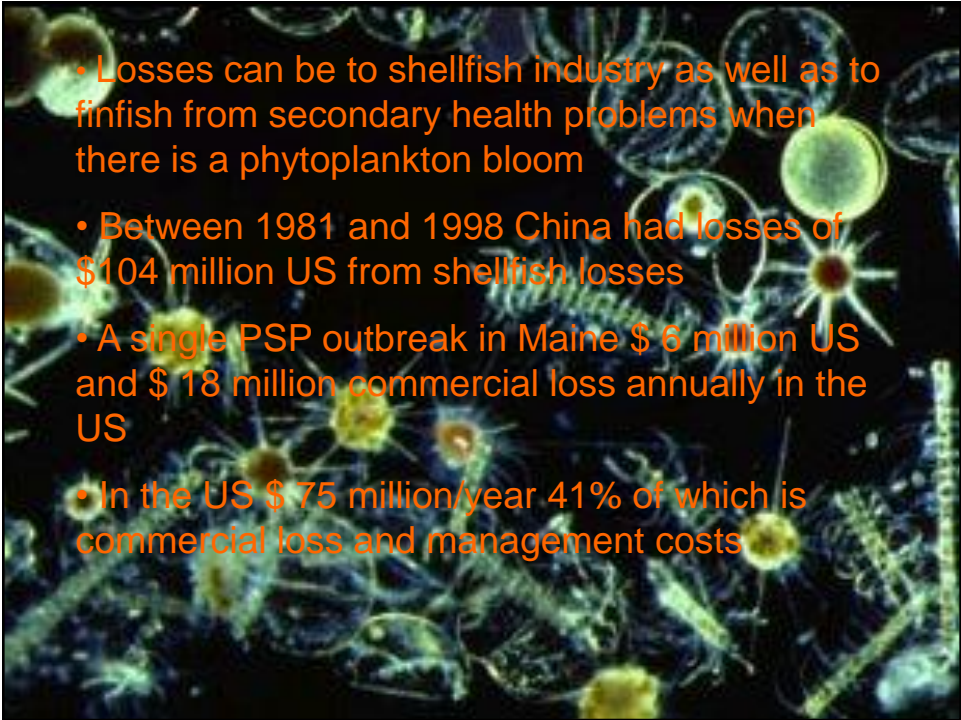
## Prevention of phycotoxin influence on aquaculture site

- Proper site selection and history of toxic blooms in the area, near by and currents directions
- Constant monitoring of site with plankton tows, and bioassays for potential toxins in bivalves (Canadian buoyed monitoring network)
- control the amount of toxin ingested and elimination rate with position in the water column during a bloom
- More than adequate time allotted for detoxification after a bloom for growth to return to normal



## Economic Impact

- If a site is prone to blooms monitoring and testing is an expensive necessity
- Poor seed collection can affect future harvests
- Slower growth of adults decreases meat yield at harvest decreasing the value of a harvest
- Detoxification time can cause harvest to miss the best time for high market prices
- If toxic products make it to market resulting fatalities or illness consumers need to be compensated

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- Losses can be to shellfish industry as well as finfish from secondary health problems when there is a phytoplankton bloom
  - Between 1981 and 1998 China had losses of \$104 million US from shellfish losses
  - A single PSP outbreak in Maine \$ 6 million US and \$ 18 million commercial loss annually in the US
  - In the US \$ 75 million/year 41% of which is commercial loss and management costs

- There are programs in place to monitor toxic algae and its presence in shellfish
- The federal government has a program the **Canadian Shellfish Sanitation Program CSSP** which monitors areas where wild harvests occur as well as shellfish growing operations
- Under CSSP Environment Canada samples water to check for sanitation standards, the Canadian Food Inspection Agency CFIA monitors for biotoxins in harvesting, growing and processing and DFO patrols and closes areas that are found to be unsafe for human consumption of shellfish
- There are guidelines for what levels of biotoxins and bacteria are unacceptable, and when they are found in an area signage is posted as warnings to prevent poisonings

- There have been no reported cases of death from eating contaminated shellfish in Newfoundland
- In 1987 there were 4 deaths from ASP in PEI, and there has not been a case since then when a monitoring program was implemented
- DSP is the most common and is reported worldwide but most cases are in Europe and Japan
- There are many other contaminants that can accumulate in filter feeding shellfish including bacteria and heavy metals that can cause health risks to people who consume them
- The monitoring programs check for tolerable levels of these other contaminants as well as biotoxins
- Newfoundland is within geographical range for both PSP and ASP but not DSP