FAO Reference Centre for Bivalve Sanitation workshop on the development of bivalve production in Africa

8th – 10th July 2025, Nairobi, Kenya

Public hazards associated with bivalve molluscs

Dr James Lowther and Dr Andrew Turner

Food and Agriculture Organization of the United Nations

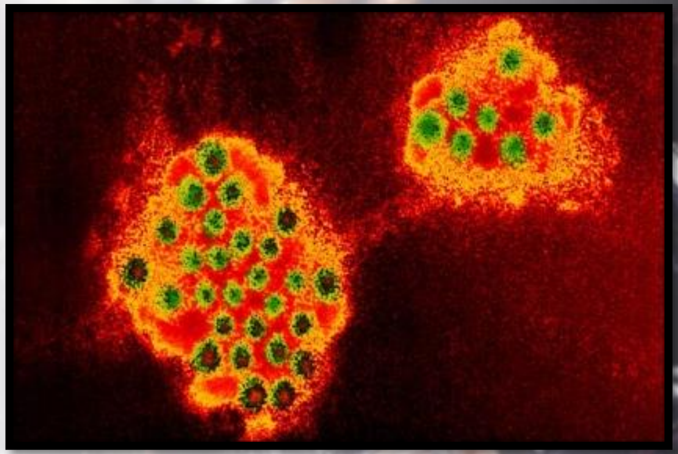
Centre for Environment, Fisheries & Aquaculture Science

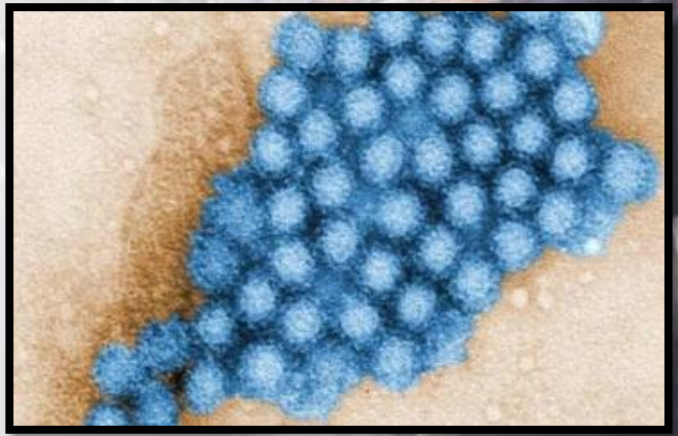
Shellfish and disease risk

- Shellfish are an established route of transmission for a range of important human pathogens and other agents of illness. First outbreaks linked to shellfish consumption emerged in the 19th Century

- Filter feeding bivalves (oysters, mussels, clams etc.) very efficient at concentrating microbes, algal toxins and other chemicals. Bivalve shellfish can concentrate microbial pathogens >100 times compared with overlying waters

- Outbreaks can be very large: Hepatitis A outbreak in China in 1988 due to contamination of clams was responsible for almost 300,000 cases – one of the largest foodborne outbreaks ever reported





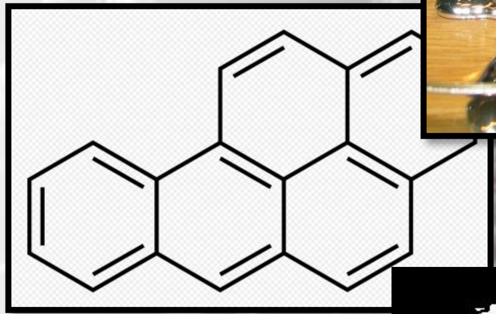
Types of hazard associated with bivalve shellfish

TYPE OF HAZARD	SOURCES	GUIDANCE
CHEMICAL; e.g. pesticides, heavy metals	Agricultural run-off, industrial discharges etc.	Codex Alimentarius, General Standard for Contaminants and Toxins in Feed and Food, 2009
MICROBIOLOGICAL; i.e. pathogenic bacteria, viruses, parasites	Human sewage, animal faeces, some naturally occurring in seawater	FAO/WHO Technical Guidance for the Development of Sanitation Programmes
BIOTOXINS; i.e. toxins produced by marine microalgae	Naturally occurring in seawater, blooms	Assessment and management of biotoxin risks in bivalve molluscs, FAO Technical Paper, 2011

Chemical hazards

A variety of different toxic chemicals can accumulate in shellfish

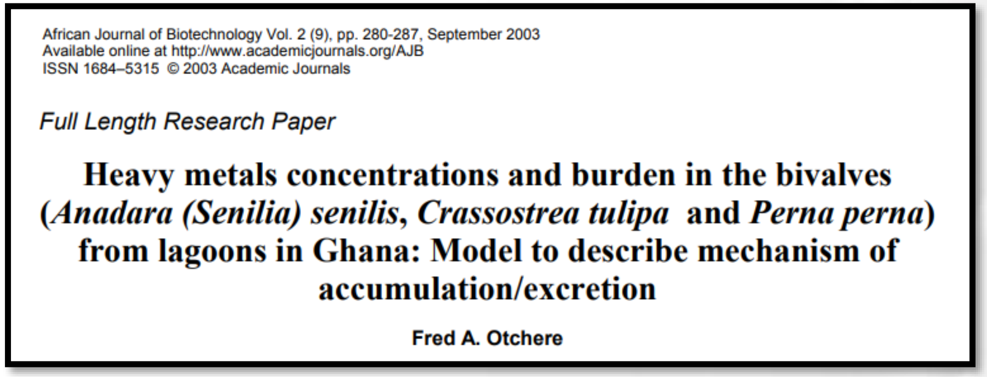
HEAVY METALS	Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As) etc.
PERSISTENT ORGANIC POLLUTANTS	Polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, furans etc.
RADIONUCLIDES	Radioisotopes of Polonium (Po), Lead (Pb), Thorium (Th), Uranium (U) etc.



Chemical hazards

- Toxic chemicals derive from heavy industry, waste disposal, mining, agriculture (pesticides) etc.

- Studies have shown heavy metals and organic pollutants in African shellfish

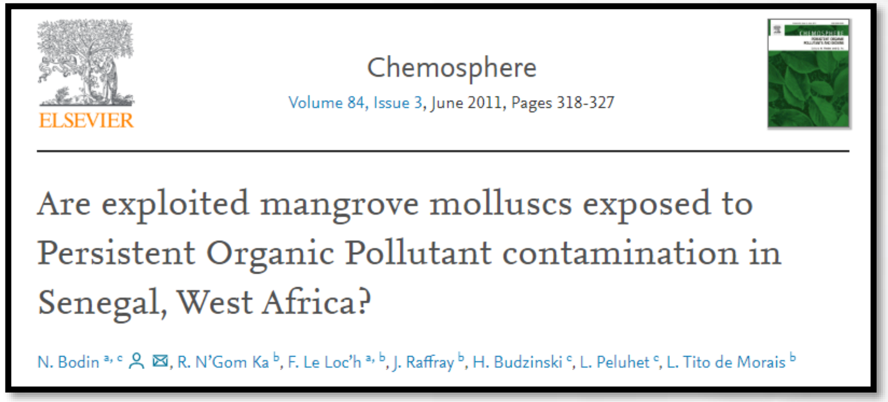


African Journal of Biotechnology Vol. 2 (9), pp. 280-287, September 2003
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2003 Academic Journals

Full Length Research Paper

Heavy metals concentrations and burden in the bivalves (*Anadara (Senilia) senilis*, *Crassostrea tulipa* and *Perna perna*) from lagoons in Ghana: Model to describe mechanism of accumulation/excretion

Fred A. Otchere



ELSEVIER
Chemosphere
Volume 84, Issue 3, June 2011, Pages 318-327

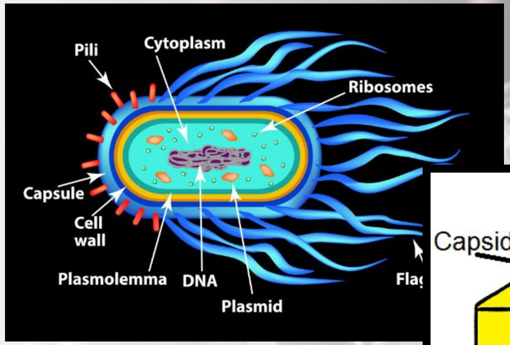
Are exploited mangrove molluscs exposed to Persistent Organic Pollutant contamination in Senegal, West Africa?

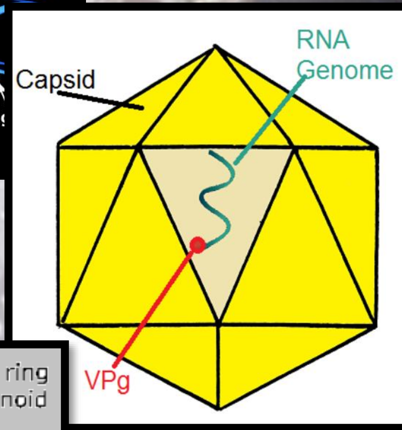
N. Bodin [a, c], R. N'Gom Ka [b], F. Le Loc'h [a, b], J. Raffray [b], H. Budzinski [c], L. Peluhet [c], L. Tito de Morais [b]

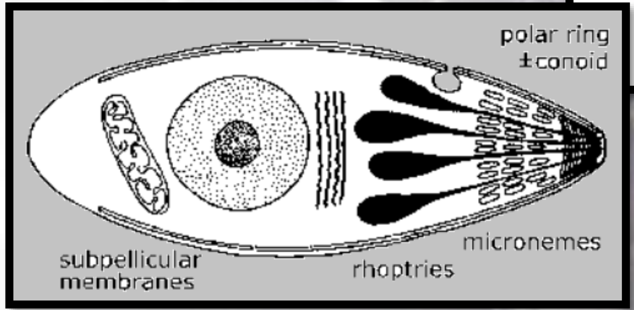
Microbiological hazards

Numerous microbiological pathogens potentially linked to shellfish consumption

BACTERIA	*Salmonella* spp., *Vibrio* spp., *Campylobacter* spp., *Listeria monocytogenes*
VIRUSES	Norovirus, hepatitis A virus, sapovirus, hepatitis E virus
PARASITES	*Giardia intestinalis, Cryptosporidium parvum, Schistosoma* spp.







Microbiological hazards

Numerous microbiological pathogens potentially linked to shellfish consumption

BACTERIA

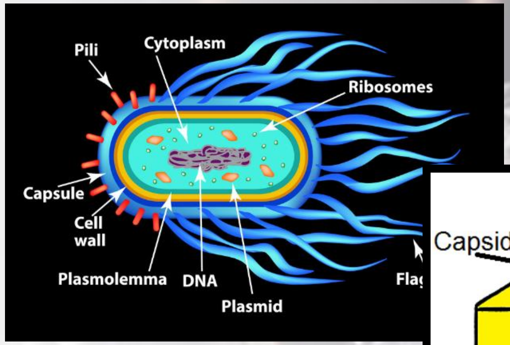
***Salmonella* spp.**, ***Vibrio* spp.**, *Campylobacter* spp., *Listeria monocytogenes*

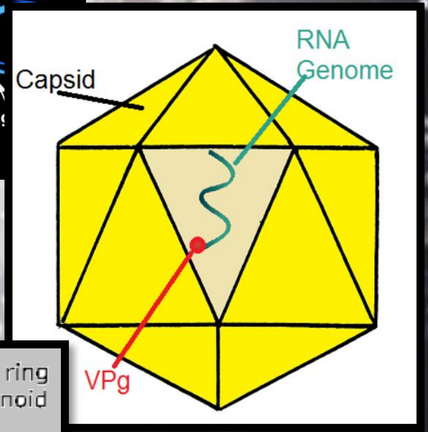
VIRUSES

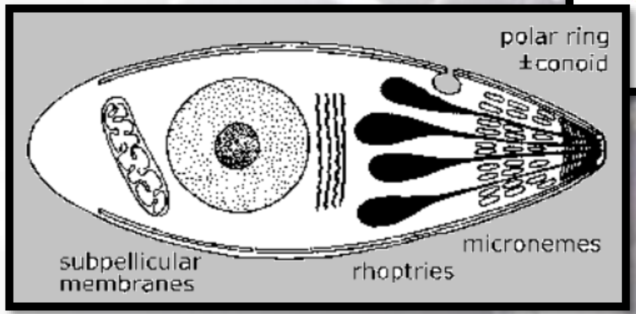
Norovirus, **hepatitis A virus**, sapovirus, hepatitis E virus

PARASITES

Giardia intestinalis, Cryptosporidium parvum, Schistosoma spp.

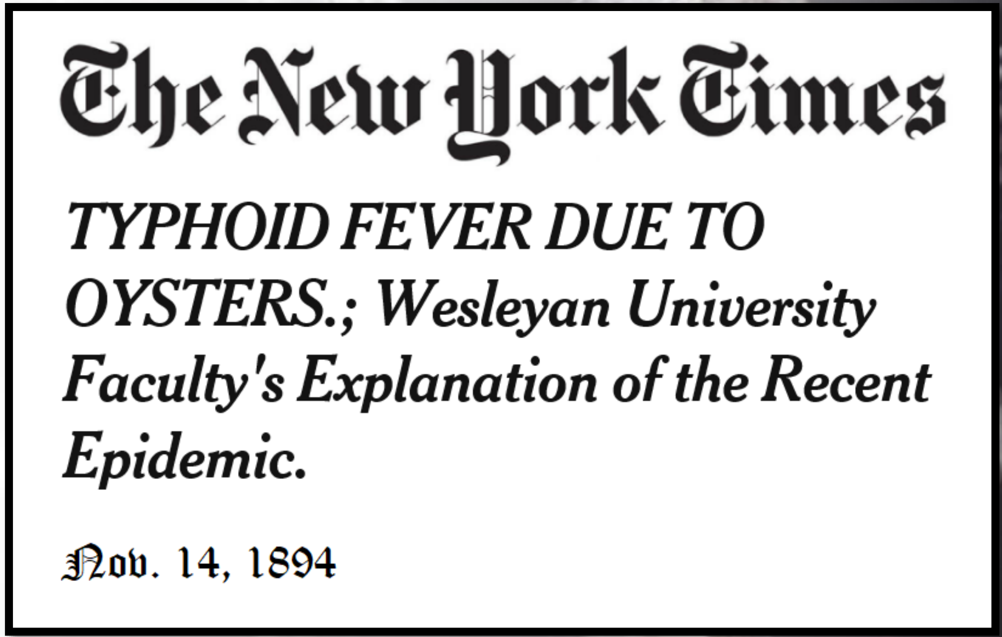






Salmonella spp.

- Gram negative bacterium
- Many types (serovars) – most types cause gastroenteritis (mild to moderate illness)
- Serovars Typhi and Paratyphi cause enteric fever (severe illness)
- Transmitted in human or animal faeces (depending on serovar)
- First recorded outbreak (serovar Typhi) due to shellfish consumption in 1894


The New York Times

TYPHOID FEVER DUE TO OYSTERS.; Wesleyan University Faculty's Explanation of the Recent Epidemic.

Nov. 14, 1894

Vibrio spp.

- Gram negative bacterium

- Depending on species, causes gastroenteritis (mild to severe illness) or sepsis (severe illness with high mortality in susceptible cases)

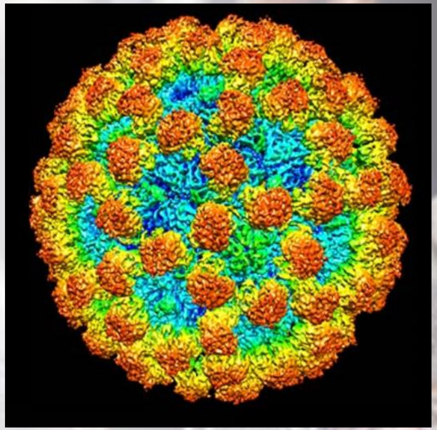
- Naturally occurring in marine environment; associated with low salinity, high temperature coastal waters

- Commonest shellfish–related pathogen in e.g. USA (*Vibrio parahaemolyticus*)

- Other species including *V. cholerae* and *V. vunificus* are frequently linked to shellfish consumption

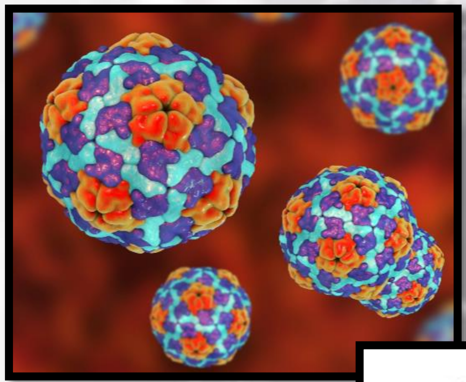
Norovirus

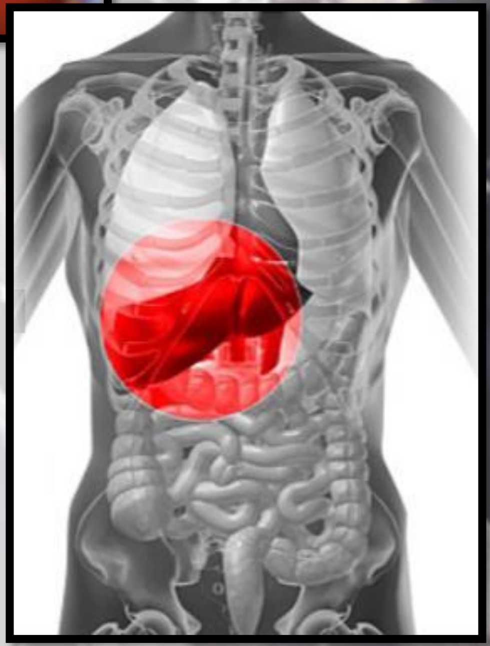
- Single stranded RNA virus
- Causes gastroenteritis (normally mild illness)
- Transmitted in human faeces
- Widespread worldwide
- Commonest shellfish-related pathogen in e.g. Europe
- Highly seasonal occurrence **<u>in some regions</u>**



Hepatitis A virus

- Single stranded RNA virus
- Causes hepatitis – inflammation of the liver (moderate illness)
- Transmitted in human faeces
- Frequency in human populations varies widely across the globe





Shellfish-related pathogens in Africa

- Very few reports in scientific literature of shellfish-related transmission of microbial pathogens in Africa

Salmonella spp.

High incidence of typhoid fever in Africa

OPEN ACCESS Freely available online — PLoS one

Population-Based Incidence of Typhoid Fever in an Urban Informal Settlement and a Rural Area in Kenya: Implications for Typhoid Vaccine Use in Africa

Robert F. Breiman[1*], Leonard Cosmas[1,2], Henry Njuguna[1,2], Allan Audi[1,2], Beatrice Olack[1,2], John B. Ochieng[1,2], Newton Wamola[1,2], Godfrey M. Bigogo[1,2], George Awiti[1,2], Collins W. Tabu[3], Heather Burke[1], John Williamson[1], Joseph O. Oundo[1], Eric D. Mintz[4], Daniel R. Feikin[1]

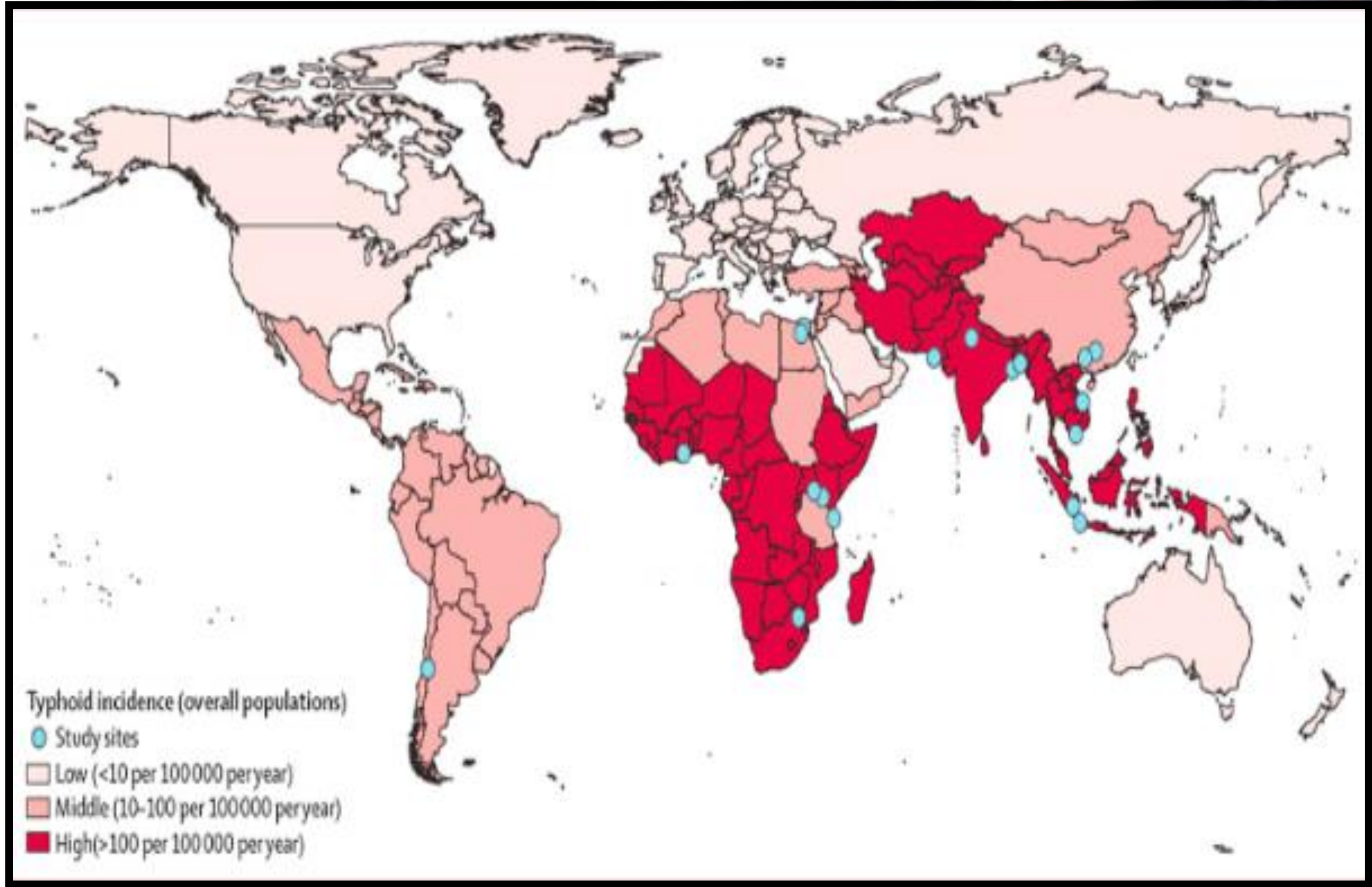
1 Global Disease Detection Division, Kenya Office of the US Centers for Disease Control and Prevention, Nairobi and Kisumu, Kenya, 2 Kenya Medical Research Institute (KEMRI), Nairobi and Kisumu, Kenya, 3 Kenya Ministry of Public Health and Sanitation, Nairobi, Kenya, 4 National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America

PLOS | ONE

RESEARCH ARTICLE

Spatial and temporal heterogeneities of district-level typhoid morbidities in Ghana: A requisite insight for informed public health response

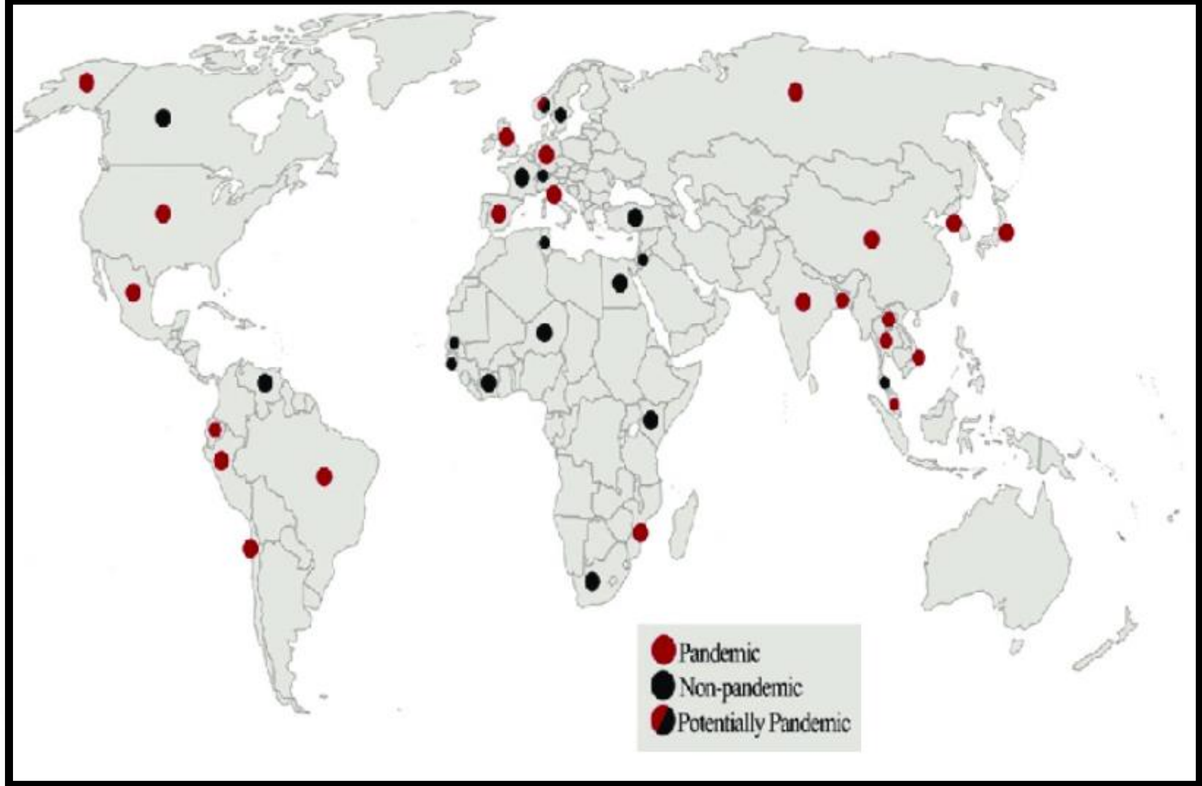
Frank Badu Osei[1*], Alfred Stein[1], Sylvester Dodzi Nyadanu[2]



Vibrio spp.

Vibrio parahaemolyticus recorded in many African countries (including pathogenic strains)

Vibrio spp. detected in seafood in some countries



Journal of Medical Case Reports

CASE REPORT Open Access

Surveillance and laboratory collaboration in response to an outbreak of *Vibrio parahaemolyticus*, *Plesiomonas shigelloides*, and *Aeromonas hydrophila* in Sekondi-Takoradi, Ghana: a case series

Michael Owusu[1,7*], Bernard Nkrumah[2*], Ebenezer Kofi Mensah[3], Jones Lamptey[1], Godfred Acheampong[1], David Sambian[1], Augustina Sylverken[7,8], Shannon Emery[4], Lucy Maryogo Robinson[4], Solomon Asante Sefa[3], Eric Amoako[3], Irene Amedzro[3], Slyvester Chinbuah[3], Kwame Asante[4], Yaw Adu-Sarkodie[5] and David Opare[6]

Foodborne Pathogens and Disease > VOL. 10, NO. 12 | Original Articles

Vibrio cholerae and *Vibrio parahaemolyticus* Detected in Seafood Products from Senegal

Ignace Coly, Amy Gassama Sow, Malang Seydi, and Jaime Martinez-Urtaza

Published Online: 21 Nov 2013 | https://doi.org/10.1089/fpd.2013.1523

Norovirus

- Norovirus a common cause of gastroenteritis in Africa
- Small number of studies showing detection of norovirus in shellfish grown in African countries

PLOS | ONE

COLLECTION REVIEW

Norovirus Epidemiology in Africa: A Review

Janet Mans[1]*, George E. Armah[2], A. Duncan Steele[3¤], Maureen B. Taylor[1]

1 Department of Medical Virology, University of Pretoria, Pretoria, South Africa, 2 Noguchi Memorial Institute for Medical Research, University of Ghana, Legon, Ghana, 3 MRC Diarrhoeal Pathogens Research Unit, University of Limpopo, Pretoria, South Africa

¤ Current address: Bill and Melinda Gates Foundation, Seattle, Washington, United States of America
* janet.mans@up.ac.za

Tropical Medicine and International Health

VOLUME 21 NO 1 PP 2–17 JANUARY 2016

Review

Human Norovirus prevalence in Africa: a review of studies from 1990 to 2013

Jean Pierre Kabue[1], Emma Meader[2], Paul R. Hunter[2,3] and Natasha Potgieter[1]

1 Department of Microbiology, School of Mathematical and Natural Sciences, University of Venda, Thohoyandou, RSA
2 School of Medicine, Health Policy and Practice, University of East Anglia, Norwich, UK
3 Department of Environmental Health, Tshwane University of Technology, Pretoria, RSA

Food and Environmental Virology

Norovirus Detection at Oualidia Lagoon, a Moroccan Shellfish Harvesting Area, by Reverse Transcription PCR Analysis

Original Paper | Published: 13 April 2019

Volume 11, pages 268–273, (2019)

N. El Moqri, F. El Mellouli, N. Hassou, M. Benhafid, N. Abouchoaib & S. Etahiri

Hepatitis A virus

- High prevalence of HAV in Africa
- May be low levels of symptomatic HAV disease due to high population immunity
- Small number of reports showing HAV detection in African shellfish
- Export to low prevalence countries potentially risky e.g. exports from Peru have caused HAV outbreaks in Europe

Food and Environmental Virology (2020) 12:274–277
https://doi.org/10.1007/s12560-020-09432-2

LETTER TO THE EDITOR

Contamination of Clams with Human Norovirus and a Novel Hepatitis A Virus in Cameroon

Patrice Bonny[1,2,3] · Marion Desdouits[1] · Julien Schaeffer[1] · Pascal Garry[1] · Jean Justin Essia Ngang[2] · Françoise S. Le Guyader[1,4]

Shellfish-related pathogens in Africa

- Very few reports in scientific literature of shellfish-related transmission of microbial pathogens in Africa
- All major shellfish-related pathogens found in the African general population
- Under-reporting probable – microbiological risks from shellfish in Africa likely as significant as those in other regions

Methods for pathogen testing

- International Standard Methods for all major shellfish-related pathogens are available

Salmonella spp.	ISO 6579-1	Detection by growth on selective bacteriological media – confirmation using biochemical/serological tests
Vibrio spp.	ISO 21872-1	Detection by growth on selective bacteriological media – confirmation using biochemical/PCR tests
Norovirus and Hepatitis A virus	ISO 15216-1	Quantification using real-time RT-PCR

Methods for pathogen testing

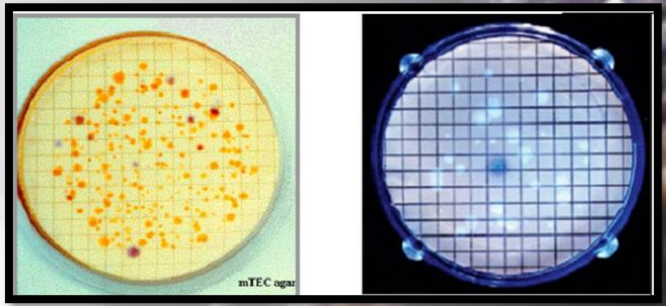
- Methods for direct pathogen testing tend to be complex and demanding in terms of laboratory equipment and reagents

  - Method for ***Vibrio* spp**. requires mutliple incubators at different temperatures, 2 different chromogenic solid media for *Vibrio* isolation, biochemical or PCR reagents to confirm putative *Vibrio* isolates etc.

  - Method for **norovirus** and **HAV** (quantitative RT-PCR) requires specialised RNA extraction and PCR reagents, real-time PCR machine etc.

- Normal approach in bivalve sanitation programmes in Europe, North America etc. is to use simpler methods for enumeration of a single faecal indicator organism

Faecal indicator testing



- In European Union reference method is Most Probable Number (MPN) test for ***E.coli* in shellfish flesh**

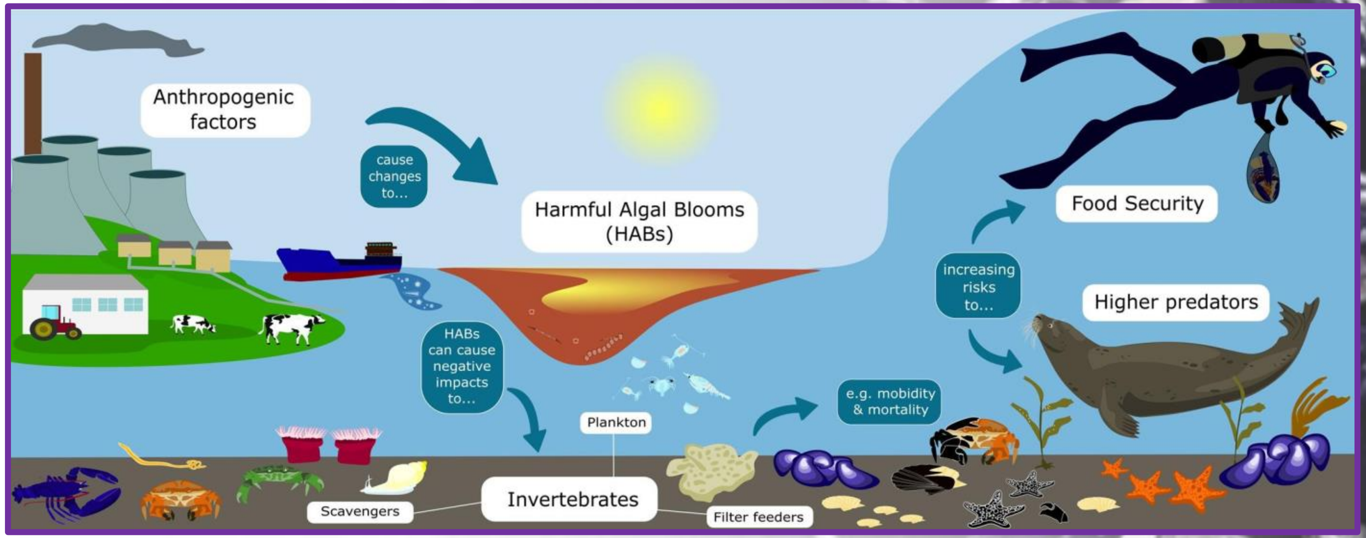
- In United States reference method is MPN or membrane filtration test for **faecal coliforms in seawater**

- In all cases a robust monitoring programme requires:-
    - regular taking of samples from all shellfish growing areas
    - rapid transport of samples to laboratories under temperature control
    - testing of samples by competent (accredited) microbiology laboratories using appropriate methods

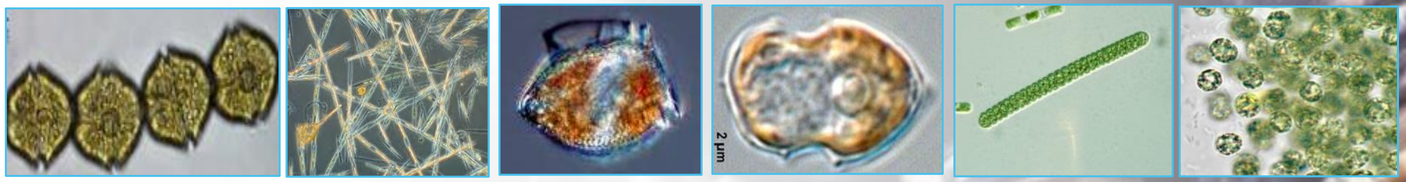
Biotoxin hazards associated with bivalve mollusc consumption: Risks and Responses

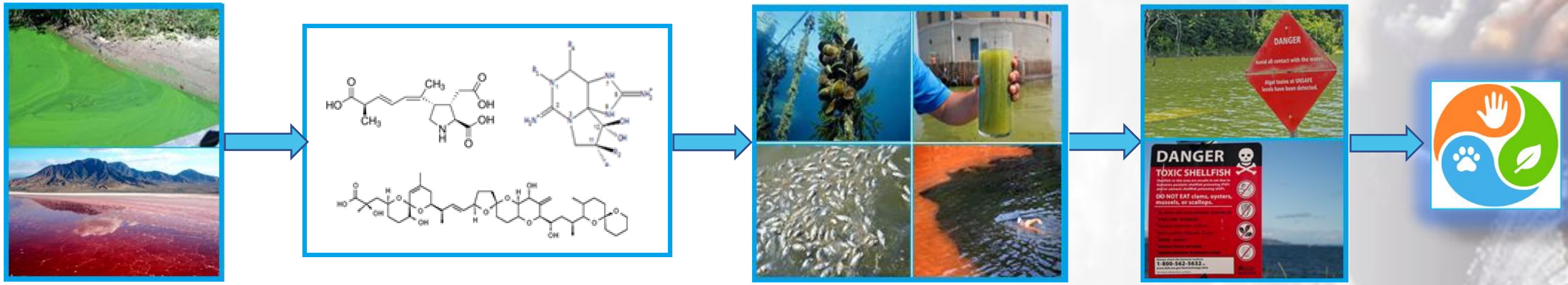
Overview

- Harmful Algal Blooms
- EU regulated marine toxins
- Monitoring programme requirements
- Additional toxins of concern



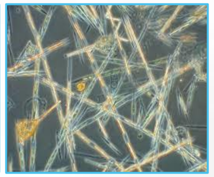
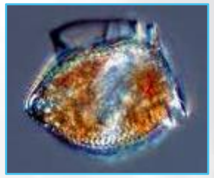
Algal blooms

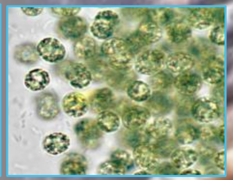




- Microscopic algae (phytoplankton) can periodically form blooms
- Some species can naturally produce harmful toxins
- Toxins can affect water quality or accumulate in shellfish or fish
- Toxins can affect human health, animal health, environmental health

Impacts

Human health

- Shellfish toxin poisonings
- Ciguatera Fish Poisoning (CFP)
- Toxin aerosols – respiratory illness
- Recreational exposure sickness
- Drinking water poisoning

- ~60,000 annual intoxications (~1.5% mortality)*
- Heat-stable
- No antidotes
- No clinical tests
- Very low levels can cause toxicity

Animal Health

- Marine mammal deaths
- Aquatic bird deaths
- Fish kills
- Invertebrate health/growth/reproduction
- Drinking water poisoning
- Genetic impacts

- Increasing global reports of morbidities & mortalities

Ecosystem Health

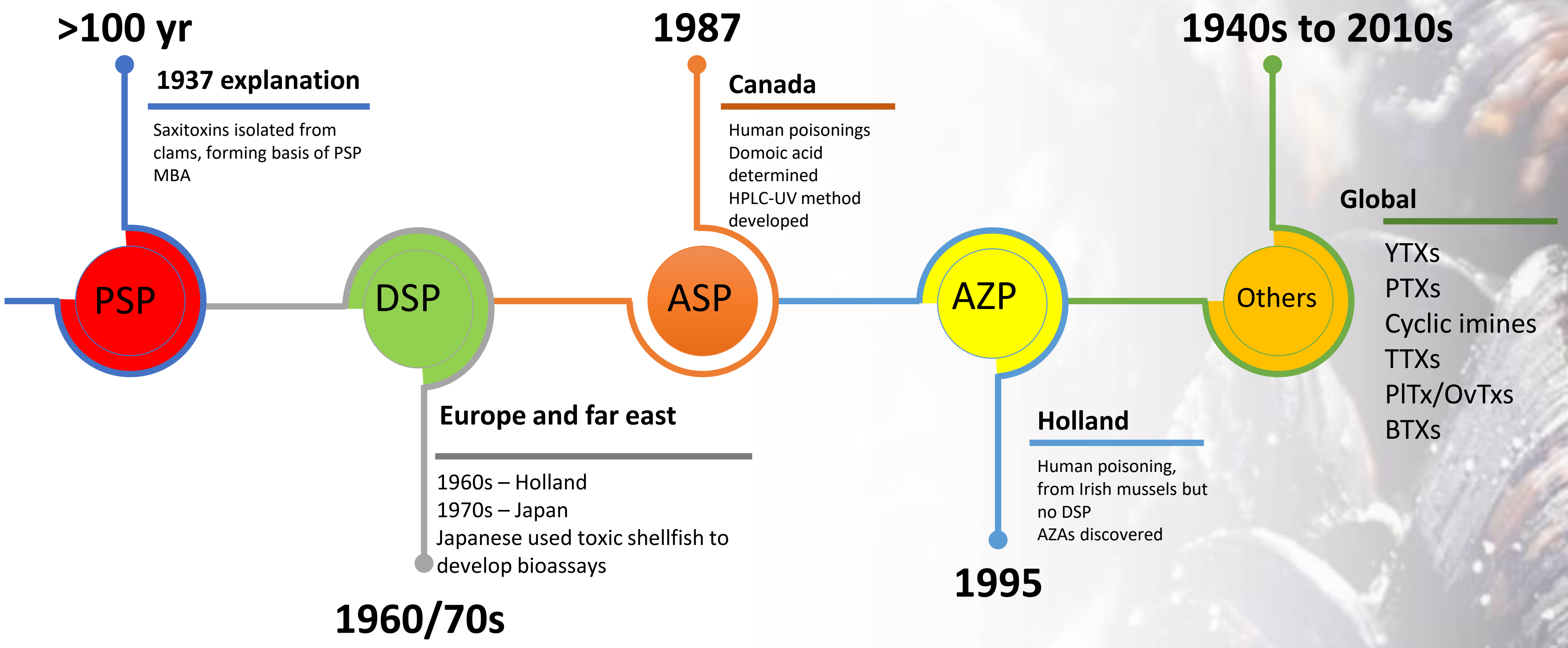
- Mass mortalities
- Aquatic chemistry changes
- Population structures
- Behavioural changes
- Habitat/substrate changes
- Ecosystem recovery rates

- 1/8 of "marine disturbances" from toxin exposure**

*Kantiani, L., *et al.* 2010. Emerging food contaminants: A review. *Anal. Bioanal. Chem.* https://doi.org/10.1007/s00216-0103944-9

**Sherman, B.H., 2000. Marine ecosystem health as an expression of morbidity, mortality and disease events. *Mar. Pollut. Bull.* https://doi.org/10.1016/S0025-326X(00)00113-2

Shellfish toxin discovery



1947 – Brevetoxins (Gulf of Mexico); 1986 – Yessotoxins (Japan); 1989 – Pectenotoxins (Japan); 1980s – Palytoxin/ovatoxins (Hawaii, Japan, Mediterranean); 1990s – Cyclic imines (Canada, NZ); 2000s – Tetrodotoxins (Japan, NZ, UK);

EU regulated marine biotoxins

<u>Why are these important?</u>

- In-country consumption of hazardous seafood

- Exporting fishery products to EU – legal requirements

30.4.2004 EN Official Journal of the European Union L 139/1

I

(Acts whose publication is obligatory)

REGULATION (EC) No 852/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 29 April 2004

on the hygiene of foodstuffs

REGULATION (EC) No 853/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 29 April 2004

laying down specific hygiene rules for on the hygiene of foodstuffs

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

II

(Non-legislative acts)

REGULATIONS

COMMISSION DELEGATED REGULATION (EU) 2019/624

of 8 February 2019

concerning specific rules for the performance of official controls on the production of meat and for production and relaying areas of live bivalve molluscs in accordance with Regulation (EU) 2017/625 of the European Parliament and of the Council

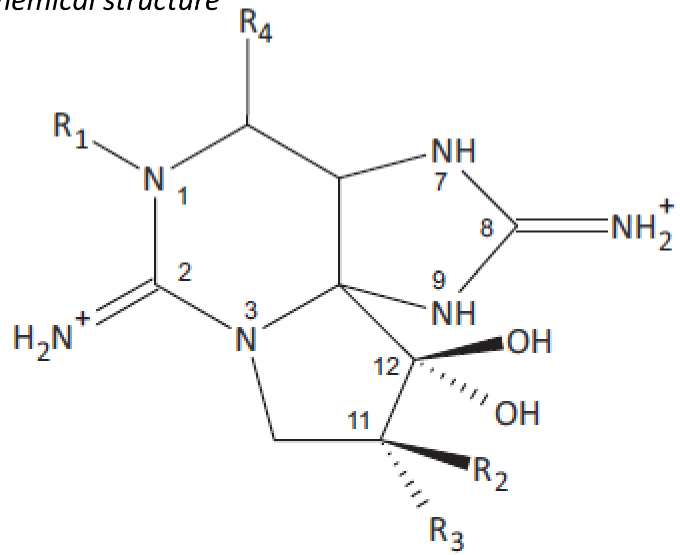
(Text with EEA relevance)

- Exporting to other regions (e.g. US/Can, Aus/NZ) –some differences in legal/practical requirements

Paralytic Shellfish Poisoning (PSP) - Saxitoxins

Source phytoplankton

Chemical structure



- *Alexandrium* sp.
- *Gymnodinium catenatum*
- *Pyrodinium bahamense*
  (all dinoflagellates)

- >57 analogues
- Wide ranging toxicities
- Water soluble

- Blocks voltage-dependent Na channels in motor nerves
- Tingling/numbness ⟶ muscle paralysis and death

Human health

- Primary cause of marine toxin related mortality
- ~2,000 intoxications pa; ~15% mortality
- Global distribution 800 µg STX eq/kg maximum permitted level

Animal Health

- Mass mortalities of some bivalve species
- Seabird deaths
- Marine mammal deaths
- Sub-lethal & genetic chronic effects

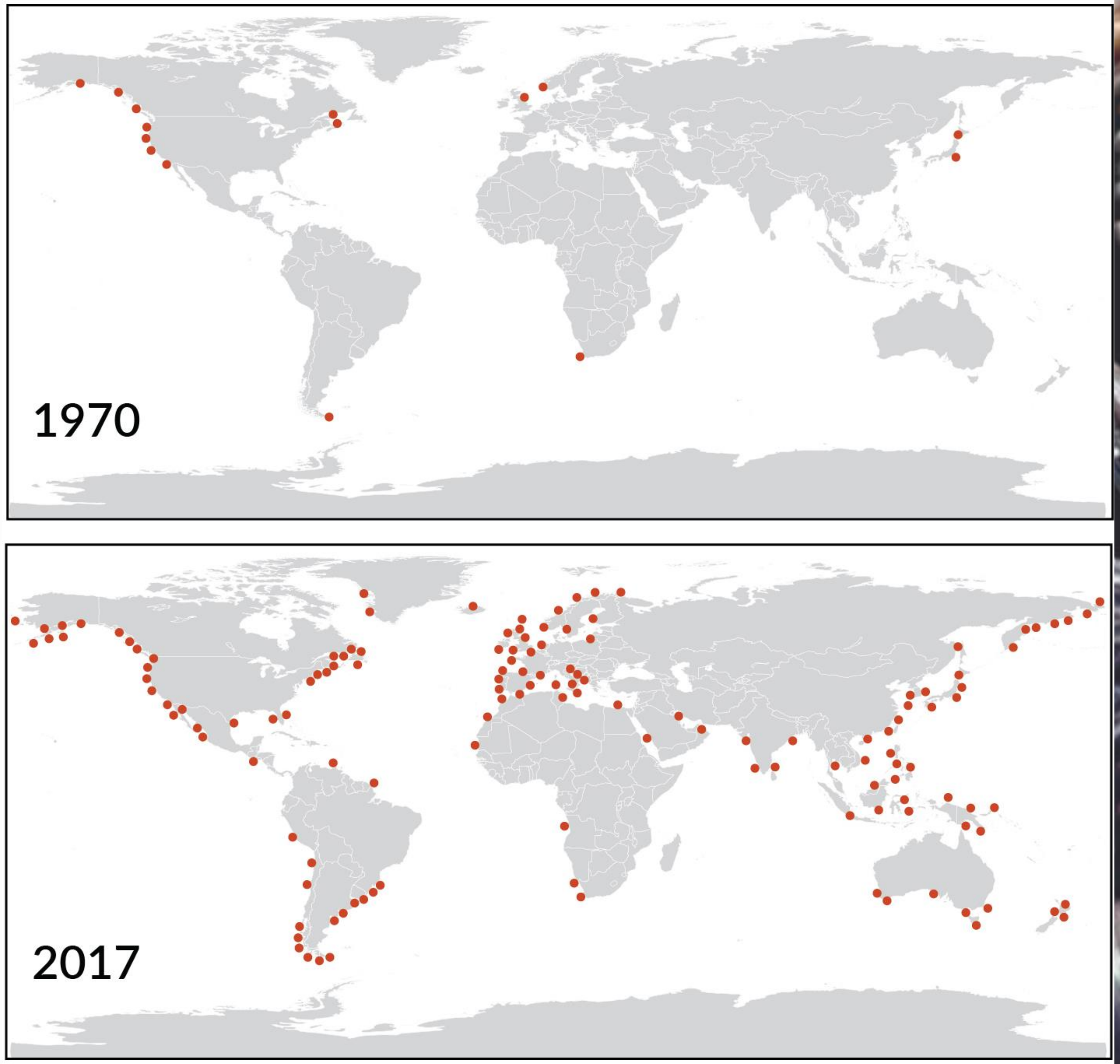
Ecosystem Health

- Trophic impacts following die-offs
- Entire trophic web can be affected (from plankton to whales)

Global distribution of PSP

- Notable changes over time

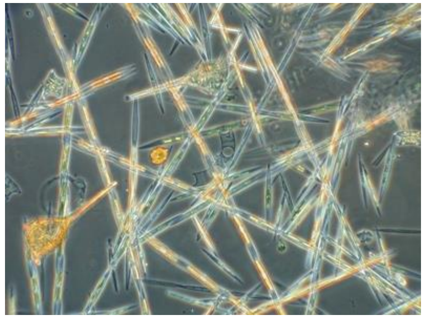
- Increased/improved monitoring and detection capabilities
    AND/OR
- Global expansion of HABs
    - Anthropogenic inputs
    - Environmental/climatic change
    - Water/shellfish stock movements



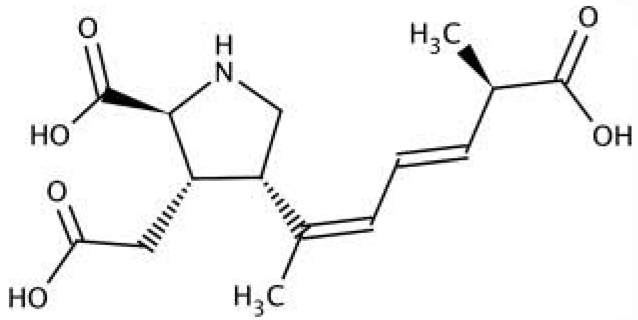
Courtesy of U.S. National Office for Harmful Algal Blooms (https://hab.whoi.edu/maps/regions-world-distribution)

Amnesic Shellfish Poisoning (ASP) – Domoic acid(s)

Source phytoplankton



- *Pseudo-nitzchia* sp. (diatom)



- Neuroexcitatory amino acid
- Nine isomers

- Antagonistic effects at glutamate receptor, neuron damage activation of AMPA & kainate receptors
- Gastric, neurological, cardiac and memory loss + death

Human health

- 1987 Canada outbreak, including fatalities
- No subsequent known poisonings
- Causative diatoms found globally
- 20 mg/kg maximum permitted limit

Animal Health

- 1961 California – "chaotic, attacking seabirds"
- Behavioural changes in sea mammals
- Widespread seabird/mammal mortalities
- Sub-lethal chronic exposure effects

Ecosystem Health

- Mass mortality impacts on trophic web

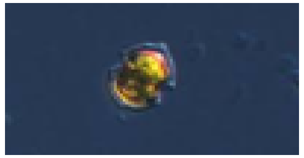
ASP global distribution

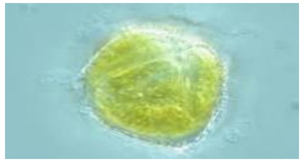
- 2016 map
- Temperate oceanic zones
- Australia /New Zealand
- Less in tropical/sub-tropical areas

Courtesy of U.S. National Office for Harmful Algal Blooms (https://hab.whoi.edu/maps/regions-world-distribution)

Diarrhetic Shellfish Poisoning (DSP) – Lipophilic Toxins

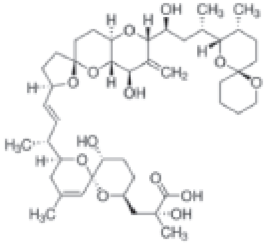
Source phytoplankton



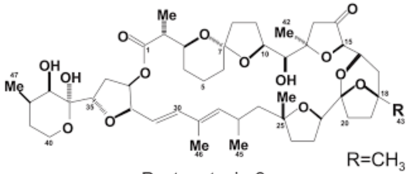


- *Dinophysis* sp.
- *Prorocentrum* sp.
- *Azadinium* sp.
- *Amphidoma* sp.
- *Lingolodinium* sp.

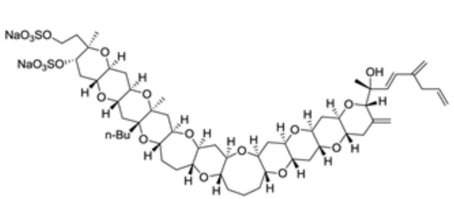
All dinoflagellates



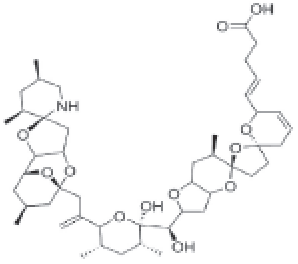
Okadaic acid



Pectenotoxin-2



Yessotoxin



Azaspiracid 1

- 11 Okadaic acid (OA) analogues
- >60 Azaspiracids (AZAs)
- Multiple yessotoxins (YTXs)
- Pectenotoxins (PTXs) now deregulated

- Inhibition of protein phosphatases
- Intense gastric symptoms (temporary), tumour promotion

Human health

- DSP = Most common shellfish toxin poisoning
- 2001-2015 ~1200 reported intoxications globally
- Actual impact much higher, lack of clear symptoms
- Azaspiracid shellfish poisoning (AZP) – most recent ~200 intoxications to date
- YTXs/PTXs – no known acute health impacts

Animal Health

- Yessotoxin impact on mass invertebrate mortalities

Ecosystem Health

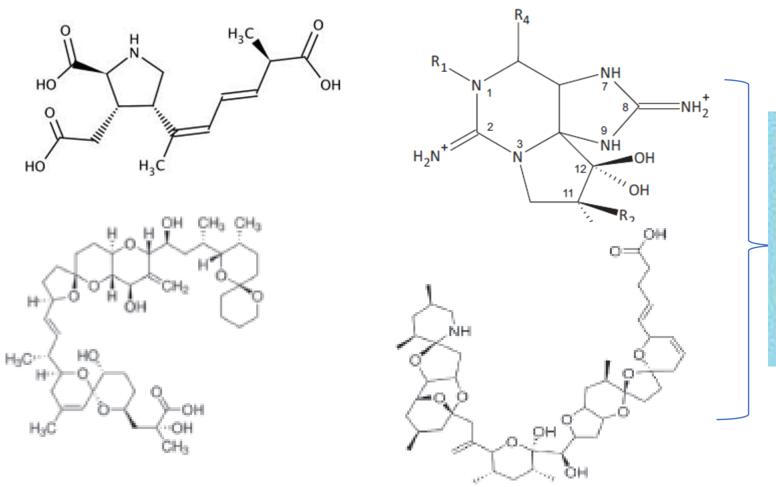
- Trophic impacts following die-offs

Global distribution of DSP

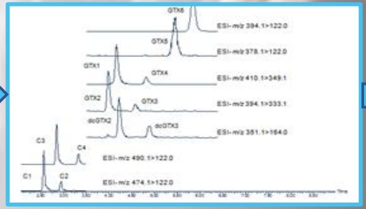
Global distribution Dinophysis toxin detection (ICES-IOC HAEDAT, 2014)

Courtesy of U.S. National Office for Harmful Algal Blooms
(https://hab.whoi.edu/maps/regions-world-distribution)

Risk management through monitoring

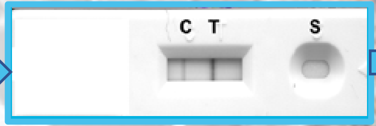


Official controls

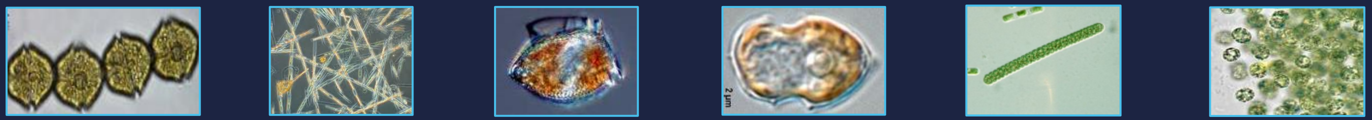


Competent Authority

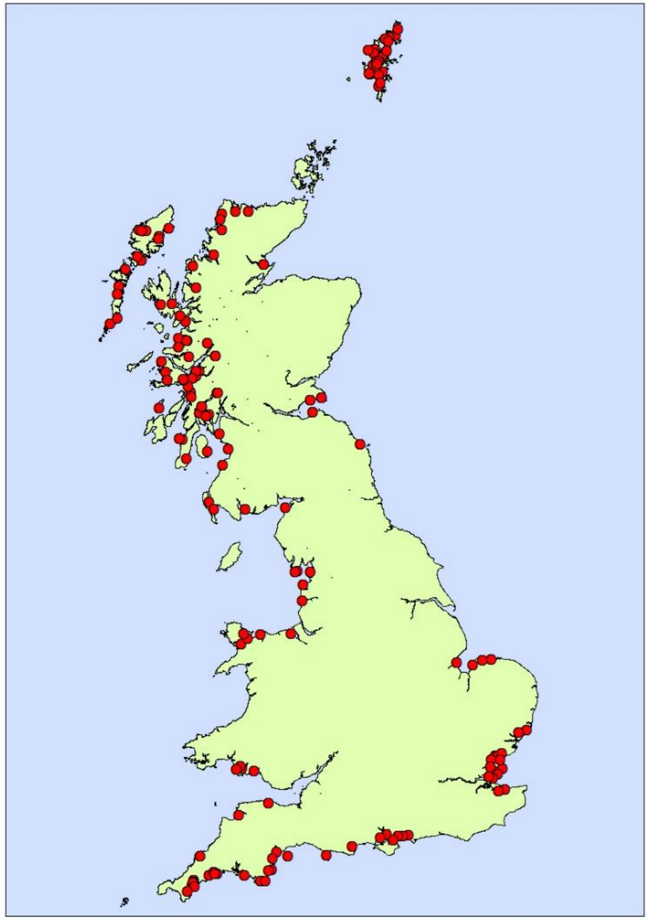
End Product Tests



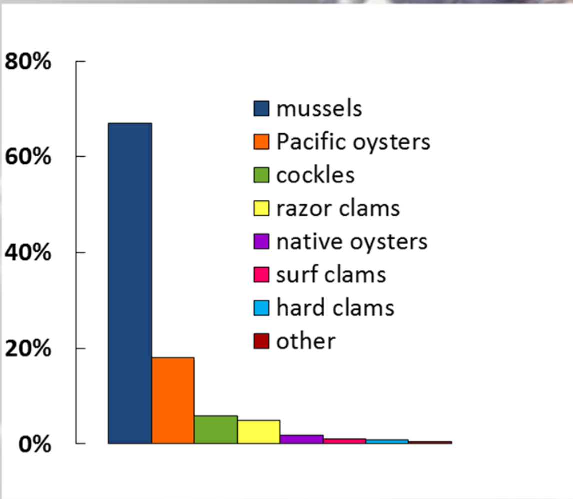
Industry



Official control monitoring



- OC phytoplankton and biotoxin monitoring programme
  - Samples are collected from pre-determined monitoring points (weekly-monthly)
  - From designated shellfish harvesting areas
  - Wide variety of shellfish species
  - Toxins results reported 1 day after receipt
  - Phytoplankton 2 days after receipt



What happens if toxins/harmful plankton is detected ?

Shellfish flesh – EU regulatory limits

PSP: 800 µg/kg flesh

ASP: 20 mg/kg flesh

OA/DTXs: 160 µg/kg flesh

AZAs: 160 µg/kg flesh

YTXs: 3.75 mg/kg flesh

If regulatory limit exceeded

close area/recall product

Continue monitoring -- 2 negative results allow reopening of area

Water - Trigger levels (UK example)

PSP producing algae: Presence (40 cells/L)

ASP prod. algae: *e.g.* 150,000 cells/L

DSP prod. algae: 100 cells/L

If trigger levels exceeded

Increase monitoring

Toxin testing – OC process overview

- **<u>Representative</u>** samples collected
- Shipped to laboratory in cool boxes with ice packs and foam padding
- Live shellfish arrive at testing lab
- Homogenisation (blending)
  - >50 grams tissue; minimum 10 animals
- Weigh into three samples (ASP, LT, PSP)

All tests involve

- Solvent extraction (to remove toxins from shellfish tissue)
- Clean-up (chemical and/or physical)
- Analysis overnight on instrument
  - Separation
  - Detection
- Reporting results to CA

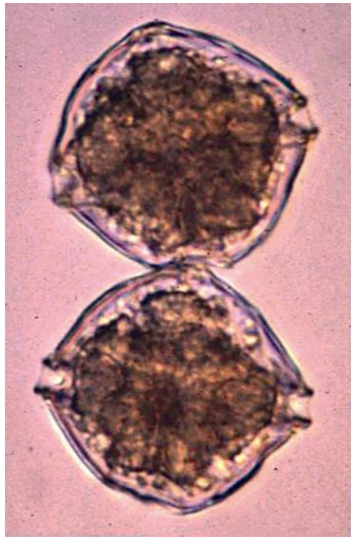
Regulatory testing methods - toxins

[Methods defined in EC 2017/625 – Annex V]

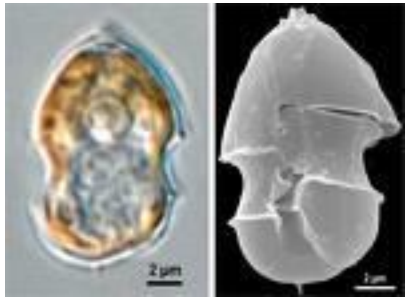
- ASP – Liquid Chromatography with Ultraviolet Detection (LC-UV)
- PSP – Pre-column oxidation LC with Fluorescence Detection (pre-cox LC-FLD)
- LTs – LC with tandem mass spectrometry (LC-MS/MS)

Advantages	Disadvantages
Thoroughly validated	Intensive work, highly trained staff
Highly specific (targeted)	Overnight run
Accurate concentration assessment	Expensive purchase & maintenance
Reproducible	Specific targets – other toxins could be missed
Ethically sound	Currently no toxicity screen

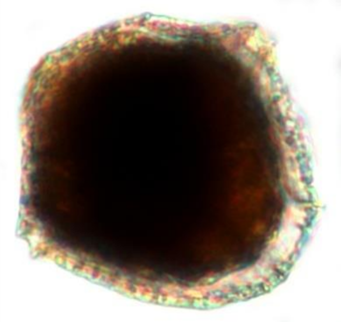
Water testing - Toxin-producing phytoplankton



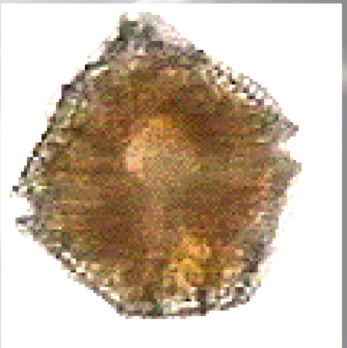
Alexandrium sp.



Azadinium spinosum



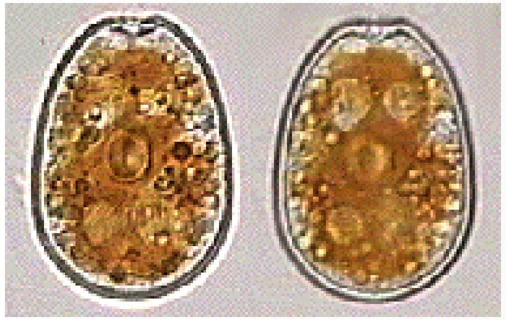
Protoceratium reticulatum



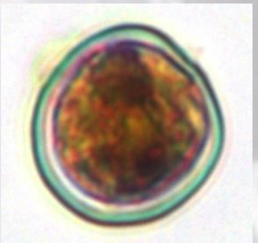
Lingulodinium polyedrum

Pseudonitzschia sp.

Dinophysis sp.



Prorocentrum lima



Prorocentrum minimum

Water sample collection

Samples must be **representative** of the algal community in the water body being sampled

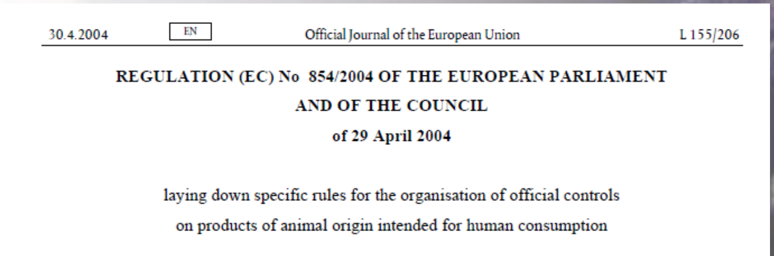
- Sampling methods
  - Tube / pole samplers
  - Nets
  - Surface water
- Cells are easily damaged – sample must be fixed as soon as possible after collection to keep cell integrity

Phytoplankton testing

- Representative samples collected
  - Fixed with Lugol's iodine
- Shipped to laboratory
- Homogenisation (mixing)
- Dispense into Utermöhl chambers
  - Leave for 24hours to settle

- Analysis by base plate count of algal taxa
- Qualitative – species assessment
- Quantitative – cell density

End product testing


30.4.2004 EN Official Journal of the European Union L 155/206

REGULATION (EC) No 854/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 29 April 2004

laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption

ELISA/PP2A

LFA

Food businesses required under EU law to ensure that shellfish placed on the market are safe for consumption and do not exceed the MPLs stipulated in the EC regulations

ELISA/Functional	Lateral Flow Assays (LFA)
Multiple suppliers e.g. ZeuLab, Abraxis, Beacon, Gold Diagnostics, R-Biopharm	Two suppliers – Sensoreal (Canada) and AquaBC (Chile)
More expensive	Cheapest monitoring approach
Plate readers, multi-channel pipettes, incubators	Pipettes + scanner
Higher level of personnel training	Easy to use by non-scientists
Require laboratory to use	Can operate in field

Requirements

OC testing

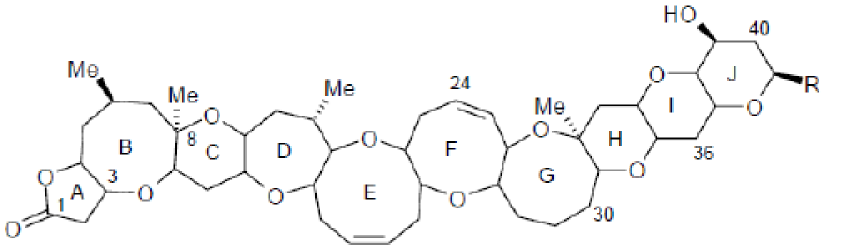
- **Laboratory**
  - LC-MS/MS and HPLC instruments + PCs
  - Reliable electrical power
  - Maintenance servicing
  - Apparatus and consumables
  - Chemicals and reagents
  - Toxin standards
  - Validation and accreditation
- **Personnel**
  - Shellfish Sampling Officers
  - Trained chemists and phycologists
  - Health and Safety
  - Quality Managers
  - Project Managers
  - Reporting & Customer service
- **Samples**
  - Access to representative samples (live molluscs)
  - Effective transportation

End Product Testing

- **“Laboratory”**
  - Small power supply
  - Basic consumables (pipettes)
  - Basic reagents
  - Ability to import tests
- **Personnel**
  - Samplers
  - Operative (basic training only)
  - Knowledge to respond to results
- **Samples**
  - Access to representative samples (live molluscs)
  - Effective transportation
  - Can be done on-site at farm

Other biotoxin hazards

Brevetoxins



The classic “Red Tide”

Brevetoxins from *Karenia brevis*

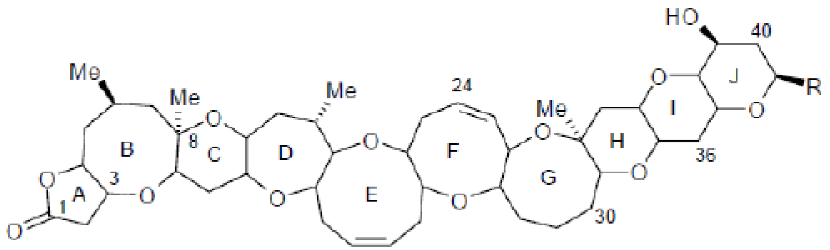
Until recently associated with USA and NZ event

Now found in parts of Mediterranean Sea

- Brevetoxins include both algal and shellfish metabolites
- BTX B2, B4, B5; PbTx2, PbTx3, S desoxy BTX B2

Brevetoxins

- Due to regular occurrence in parts of USA, brevetoxins are regulated
- A regulatory limit of 800 µg BTX-2 equivalents is established by US-FDA
- Brevetoxins have been detected in Europe (France) but are not yet regulated in the region



- Brevetoxins include both algal and shellfish metabolites
- BTX B2, B4, B5; PbTx2, PbTx3, S desoxy BTX B2

Toxins summary

- Three main regulated groups – PSP, ASP, LTs including DSP
- Importance of both OC testing and EPT for risk management
- Processes are complex and expensive
- Setting up toxin/phytoplankton monitoring & risk management programme is complex, time-consuming and expensive

Dr Andrew D. Turner CChem CSci

Principal Chemist

Head of Toxins and Contaminants

FAO Reference Centre Marine Toxins Advisor

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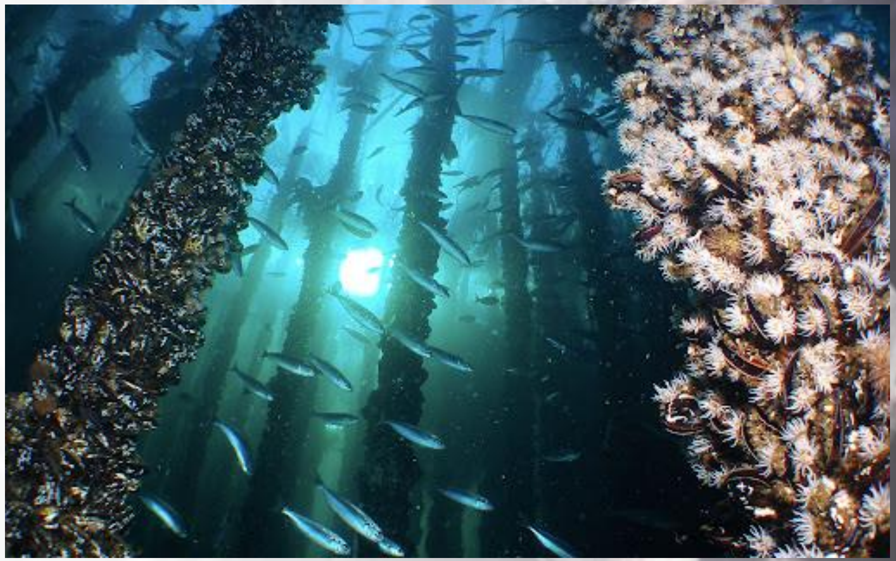
Food and Agriculture Organization of the United Nations

Centre for Environment, Fisheries & Aquaculture Science



Summary – all hazards

- Wide variety of microbiological, biotoxin and chemical hazards associated with shellfish consumption

- Microbiological hazards include bacteria (*Salmonella*, *Vibrio*), viruses (norovirus, hepatitis A virus), parasites
- Toxins – ASP, PSP, LTs (and BTXs)
- Chemicals – Metals, Radioisotopes, Organic compounds

- Evidence of shellfish-related hazards in several African countries – limited but expanding knowledge

- Risks posed by different hazards may depend on the characteristics of the growing area

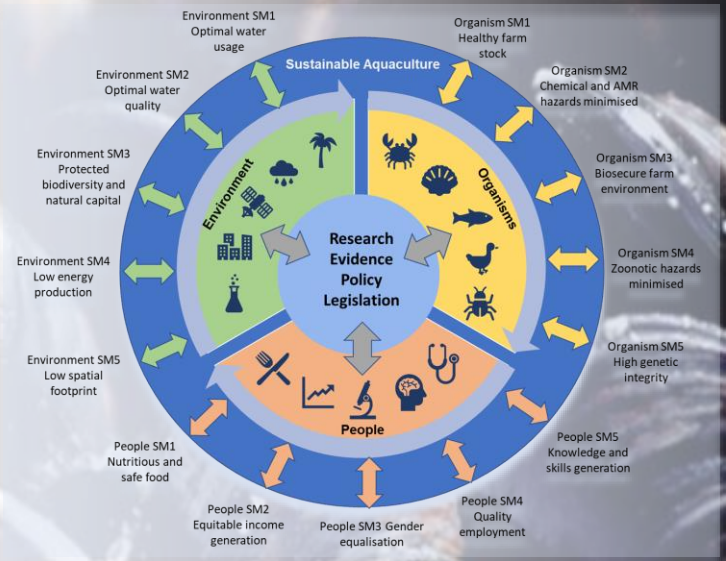
International Conference on Molluscan Shellfish Safety

Theme = “One Health”

16th ICMSS

September 6th- 11th 2026

The Venue
‘University of Exeter’
Southwest England



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