



Food and Agriculture
Organization of the
United Nations



Cefas

VIRTUAL REGIONAL WORKSHOP ON BIVALVE MOLLUSCS SANITATION

9, 10, 11 December 2020

**Understanding and tackling
emerging shellfish risks**

Craig Baker-Austin

Microbial risks in the marine environment

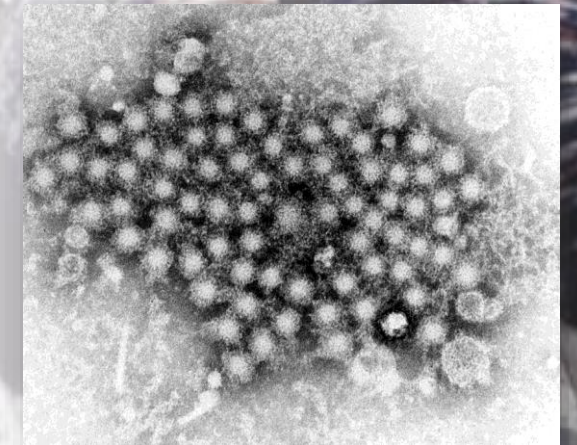
A wide variety of pathogen risks are present in the marine environment. For example, faecal contamination of water can introduce a variety of pathogens, including bacterial, viral, protozoan agents.

Introduced agents include viruses such as enteroviruses, poliovirus, hepatitis A, norovirus and rotavirus. Bacterial pathogens include *Salmonella*, *Campylobacter*, *Shigella*, *Vibrio cholerae* O1/O139 and *E. coli*.

Naturally occurring agents include certain vibrio species as well as harmful algal biotoxin (HABs) producing organisms. Many are also widespread in marine waters worldwide.

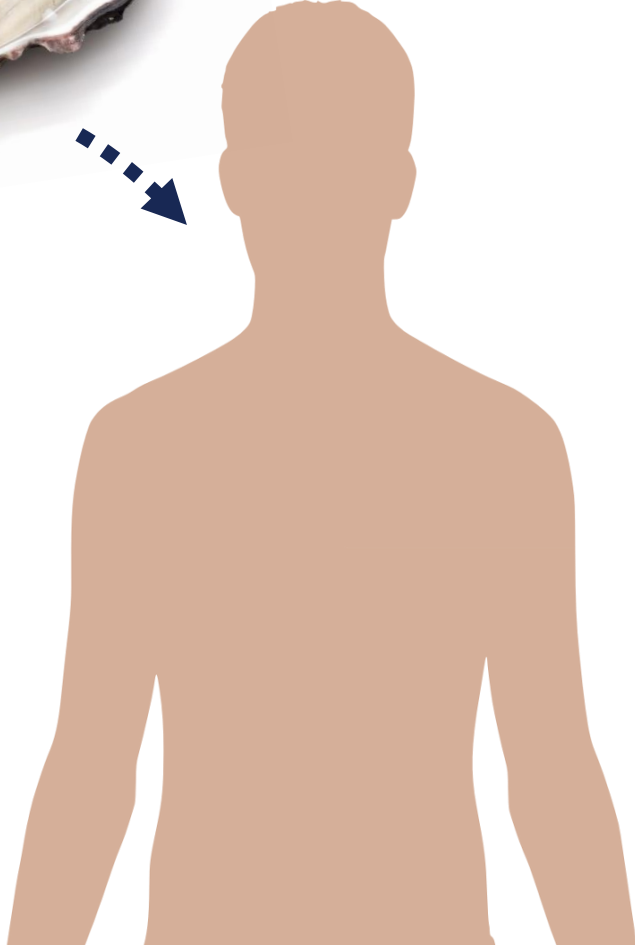
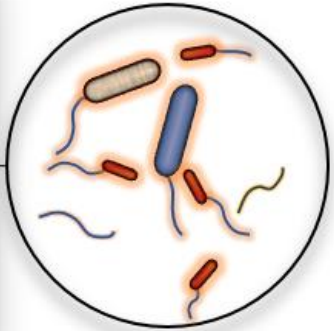
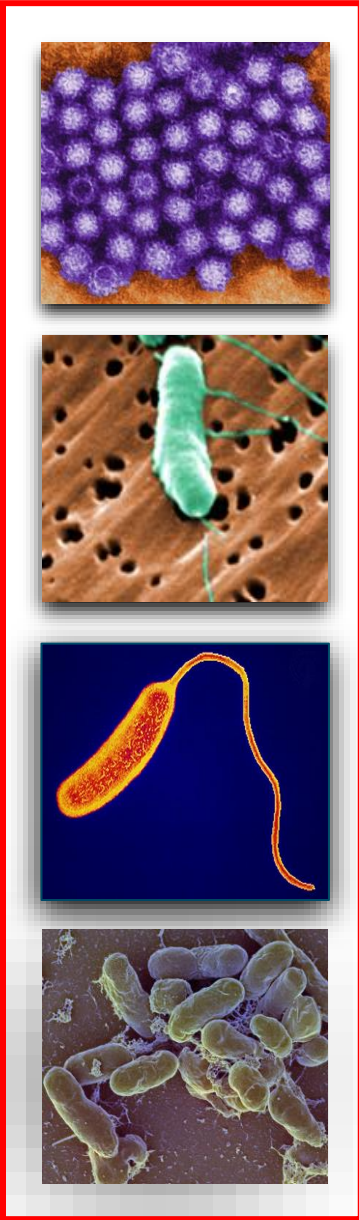


Vibrio cholerae – the causative agent of cholera



Hepatitis A virus

Shellfish are an effective vehicle in disease transmission

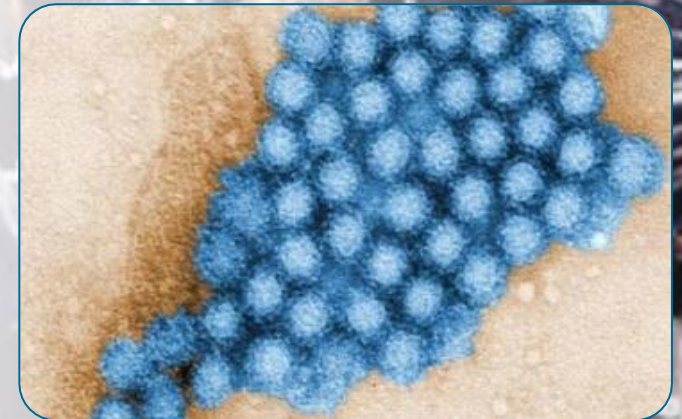
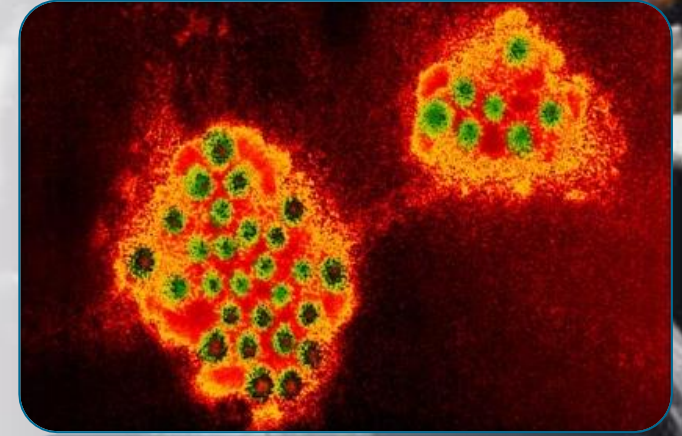


Shellfish and disease risk

Shellfish represent an established route of transmission for a range of important human pathogens. First outbreaks epidemiologically-linked to shellfish consumption emerged in the early 19th Century.

Bivalve filter feeding shellfish species such as oysters, mussels and clams very efficient at filtering and concentrating both bacterial, viral and HABs toxins. Studies have shown that bivalve shellfish can concentrate microbial pathogens >100 times the concentrations found in overlying waters.

Outbreaks often not trivial: Hepatitis A outbreak in China in the early 1990s was responsible for almost 300,000 cases – one of the largest foodborne outbreaks ever reported.



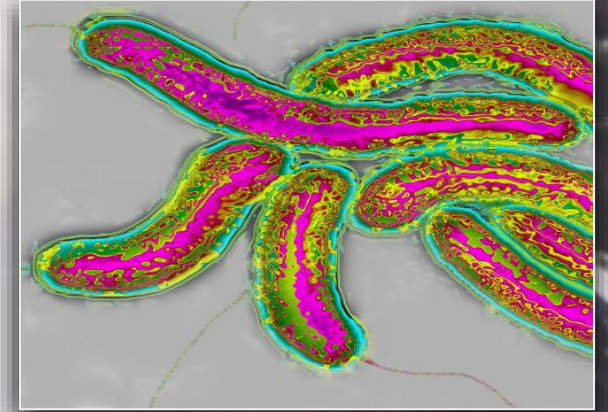
Emerging risks (1) – vibrios

Widespread distribution: Globally vibrios are one of the leading groups of human pathogens responsible for shellfish and waterborne-associated illness.

Climate change: These pathogenic bacteria are especially sensitive to climate change – outbreaks are now being observed in temperate areas.

Pandemic potential: Certain strains of vibrios are more pathogenic than others, and capable of rapid pandemic spread.

Changing demographics: Various factors including more at risk/vulnerable groups and greater potential for exposure may increase risks in the future.



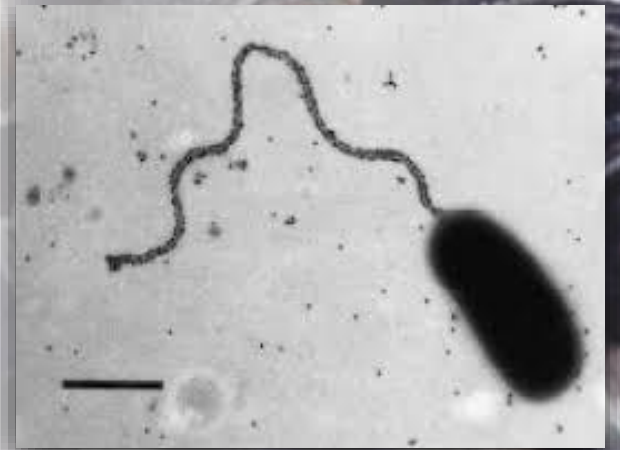
Vibrio parahaemolyticus



Vibrio vulnificus wound infection.
Baker-Austin *et al.* *Nature Disease Reviews*, 2018.

Vibrio parahaemolyticus (Vp)

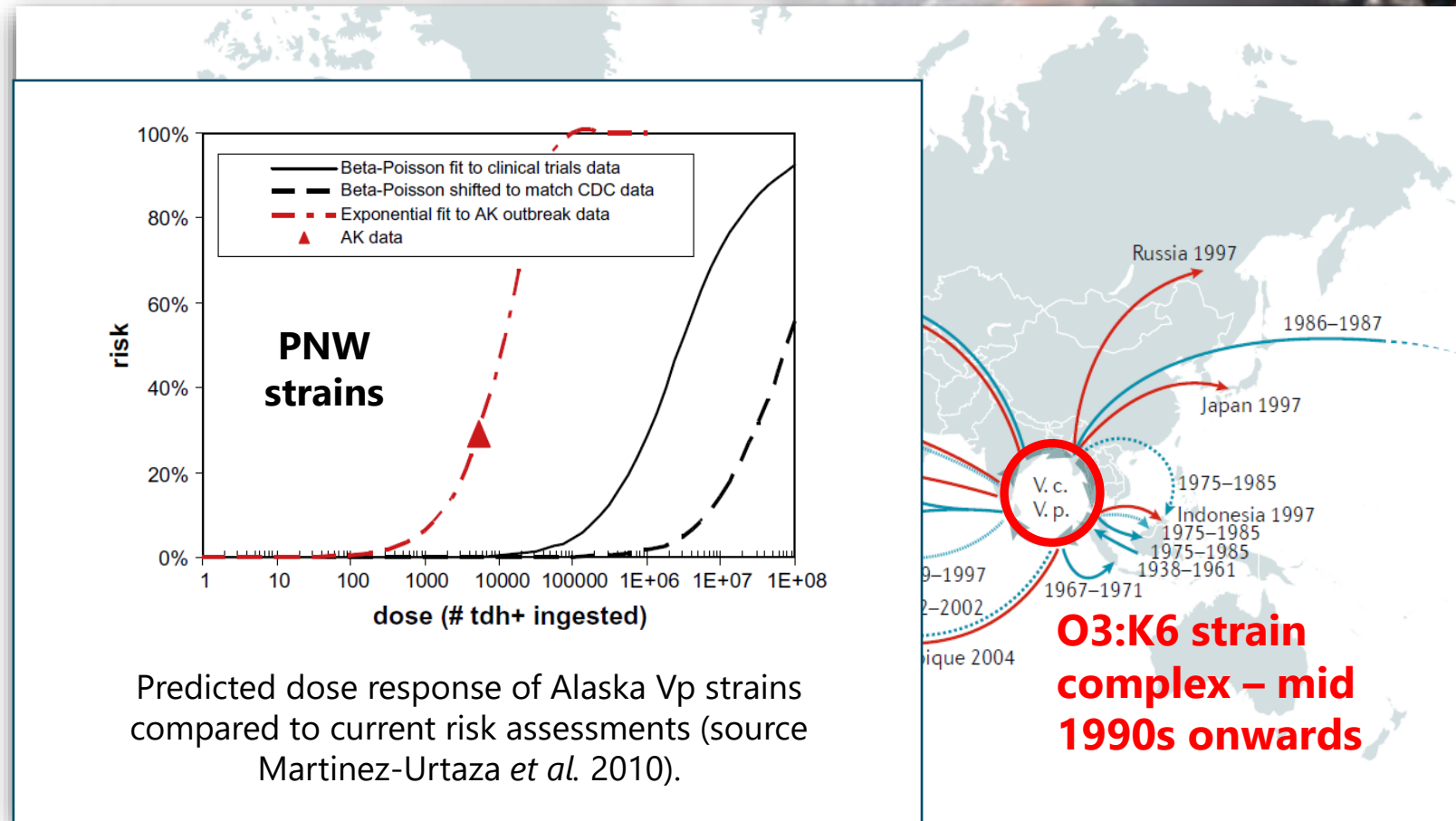
- *Vp* is a common and naturally occurring marine and estuarine bacterium. *Vp* concentrates in bivalve shellfish such as oysters and clams. Globally the most common bacterial infection associated with the consumption of seafood, and often associated with large foodborne outbreaks.
- In 2012 a new variant of *Vp* – a highly pathogenic strain normally restricted to Pacific NW region of the USA emerged – jumping to the East Coast of the USA and then Europe. Not present in Peru and NZ. This particular strain (PNW) is of huge concern. Caused major shutdown of US shellfish in 2012 and 2013.
- Pandemic spread of *Vp* is a major global food safety and economic issue.



Pandemic spread of Vp

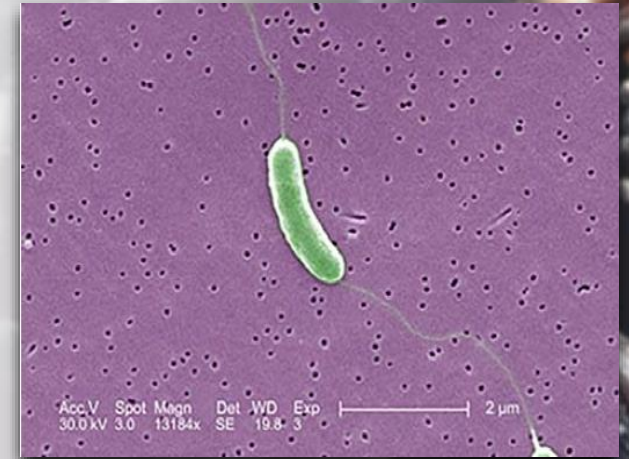
Vp outbreaks are currently undergoing a global process of expansion with infections emerging in areas where these diseases have not been previously observed.

Only pathogen (alongside *V. cholerae* which causes cholera) to spread pandemically from the marine environment. O3:K6 pandemic strain emerged in Asia.



Vibrio vulnificus (Vv)

- Vv is a bacterium common in warm, low salinity marine waters. Found where surface seawater temperatures exceed 15 °C.
- Vv occurs in high numbers in seafood, such as bivalve shellfish, particularly in warmer months - an important opportunistic pathogen that can cause both wound infections and sepsis, typically via exposure to seawater or through consumption of seafood.
- **Vv carries the highest case fatality rate of any foodborne pathogen.** Infections mostly involve males (nearly 90% of cases) the elderly, and at-risk persons. **Increase in reported infections in Europe and USA recently observed. Regularly reported infection in Asia.**



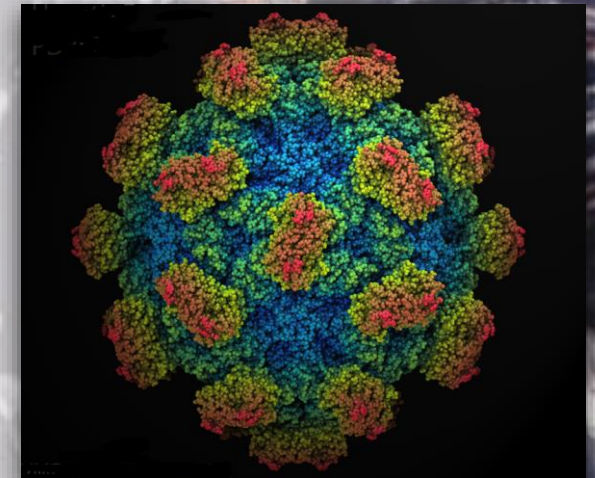
Baker-Austin and Oliver (2019), *Vibrio vulnificus*, *Trends in Microbiology*.



Vibrio vulnificus wound infection. Baker-Austin et al. *Nature Disease Reviews*, 2018.

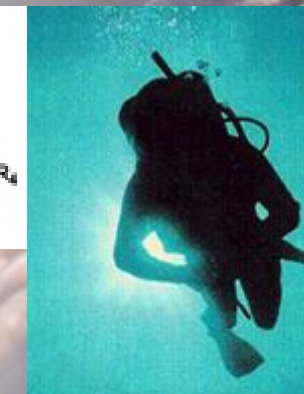
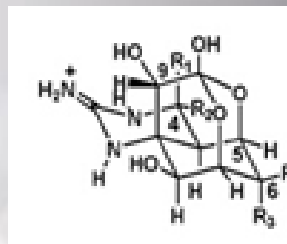
Emerging risks (2) – HEV

- Hepatitis E virus (HEV) is an important and emerging zoonotic pathogen. Worldwide, 20 million human infections annually in 2005, with 44,000 associated deaths attributed to HEV in 2015. Large increase in reported infections in the last decade.
- The virus spreads in a faeco-oral route of transmission, being shed in both faeces and urine. Infection with the virus usually occurs either through the consumption of faecally-contaminated water or undercooked or raw meat products from infected animals. Other transmission routes have been identified and theorised.
- Several studies have found HEV in live bivalve shellfish. Potential route of human transmission?



Emerging risks (3) TTX in shellfish

- Tetrodotoxin (TTX) is a potent neurotoxin. TTXs are normally associated with pufferfish poisoning (Japan).
- Produced by marine bacteria – although the pathways of TTX production are not well understood.
- In 2013-2014 – TTXs found in UK mussels. First time TTX detected in shellfish.
- 2016 – formal Cefas method validation and 2017 – Cefas screen / risk assessment in UK.
- Subsequent studies have detected TTX in LBS across Europe and also in Asia.
- EFSA opinion on risks recently published.



RAPID COMMUNICATIONS

Detection of the pufferfish toxin tetrodotoxin in European bivalves, England, 2013 to 2014

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² Department of Chemistry, University of Hull, Hull, United Kingdom

TURNER ET AL.: JOURNAL OF AOAC INTERNATIONAL VOL. 100, NO. 5, 2017 1

FOOD CHEMICAL CONTAMINANTS

Development and Single-Laboratory Validation of a Liquid Chromatography Tandem Mass Spectrometry Method for Quantitation of Tetrodotoxin in Mussels and Oysters

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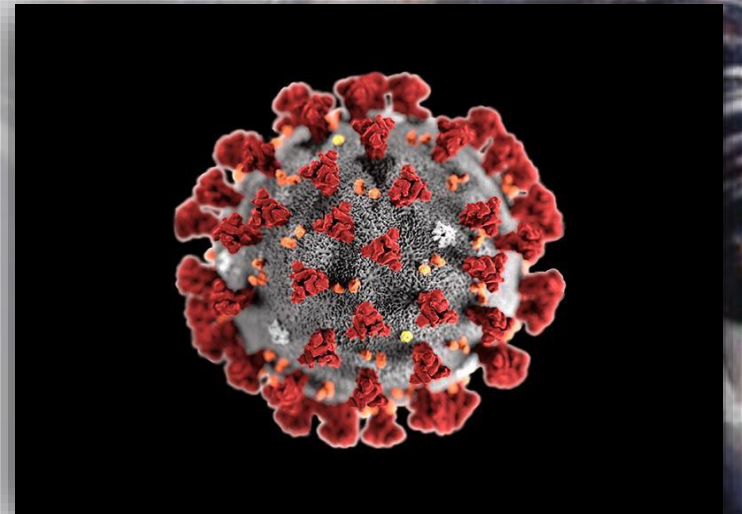
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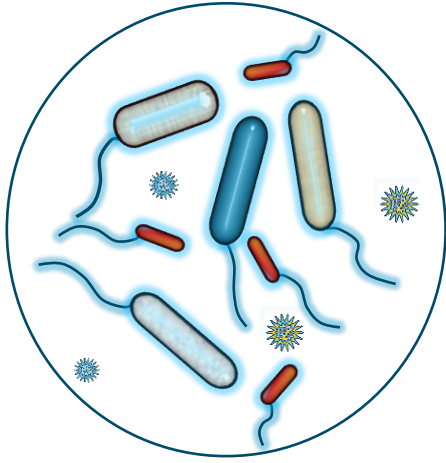
Detection of Tetrodotoxin Shellfish Poisoning (TSP) Toxins and Causative Factors in Bivalve Molluscs from the UK

Andrew D. Turner ^{1,*}, Monika Dhanji-Rapkova ¹, Lewis Coates ¹, Lesley Bickerstaff ¹, Steve Milligan ¹, Alison O'Neill ¹, Dermot Faulkner ², Hugh McEneny ², Craig Baker-Austin ¹, David N. Lees ¹ and Myriam Algoet ¹

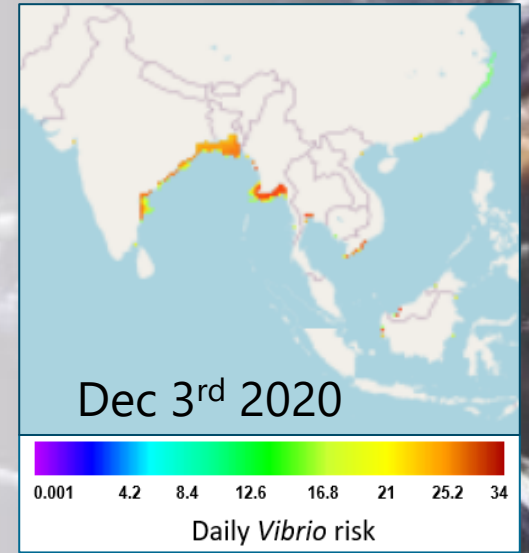
Emerging risks (4) SARS-2 Covid-19 in shellfish

- Covid-19 is shed in both faeces and urine of infected individuals. Various studies have identified (by qPCR) Covid-19 in wastewater.
- No current evidence of transmission of Covid-19 via food vehicle, and no evidence to date on the presence of Covid-19 in bivalve shellfish. Encapsulated viruses like Covid-19 have lower environmental stability (e.g. compared to NoV).
- **However**, limited data available to date. Recent risk assessments in this area suggest VERY LOW risk, but levels of uncertainty of these RA's are high.



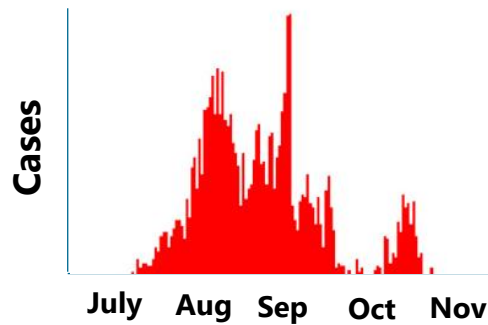


**Microbiology
and virology**

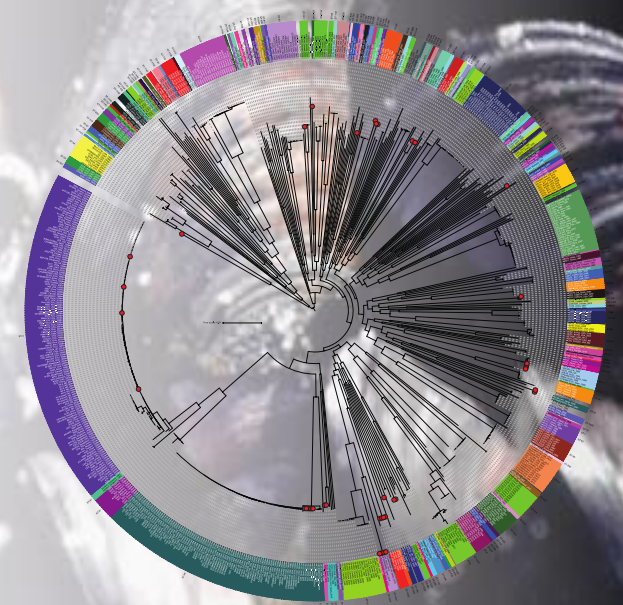


Risk assessment

New approaches to tackle emerging shellfish risks



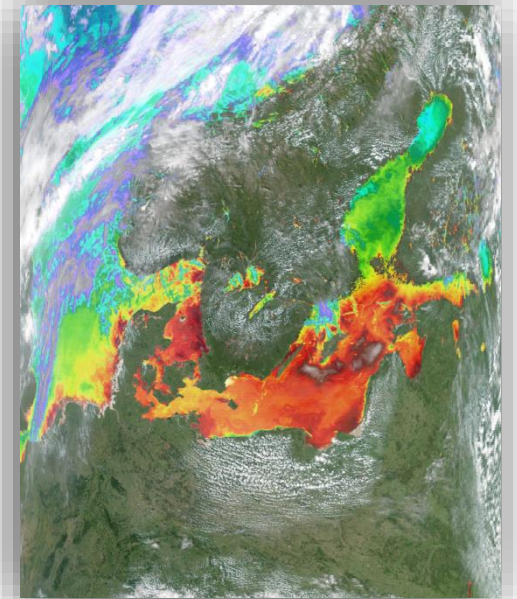
Epidemiology



Genomics

Risk prediction tools: (*Vp*)

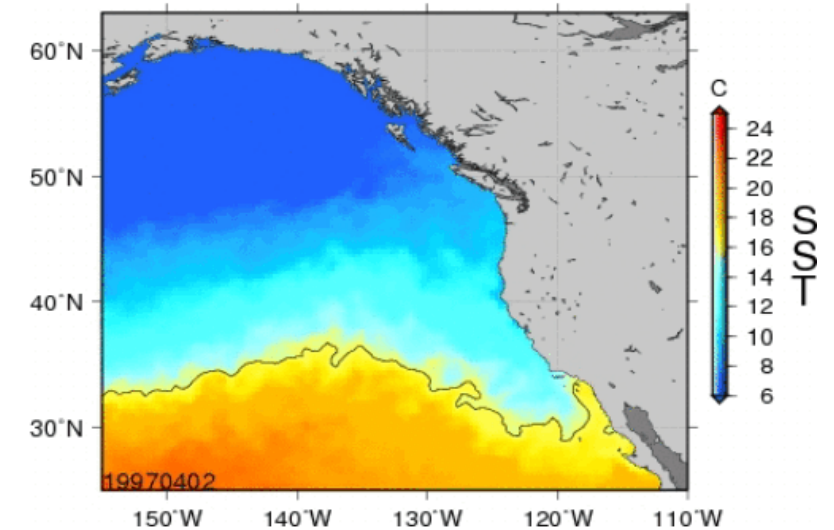
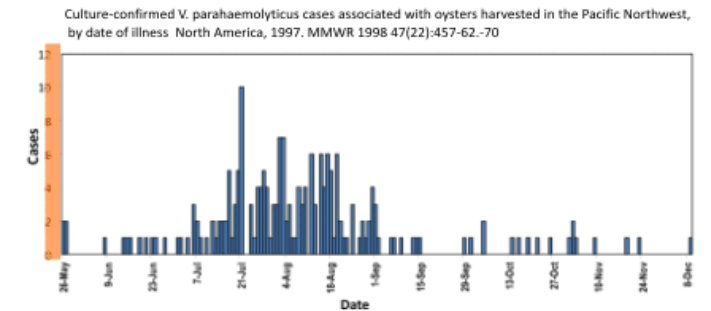
- Remote sensing makes use of satellites to detect infrared radiation emitted from the Earth's surface.
- Several satellites (from Europe and the USA) have been carrying out global studies of sea surface temperature (SST) for the last 3 decades. These datasets allow you to look at any region on the surface of Earth with a high degree of resolution.
- Some case studies presented here that I'll show you suggest that it may be possible to predict *Vibrio* outbreaks using remote data from retrospective studies.
- **We believe that there are often discernible environmental 'signatures' prior to outbreaks.**



Risk prediction tools: (*Vp*)



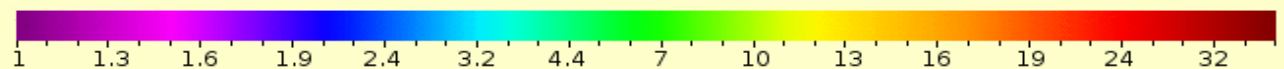
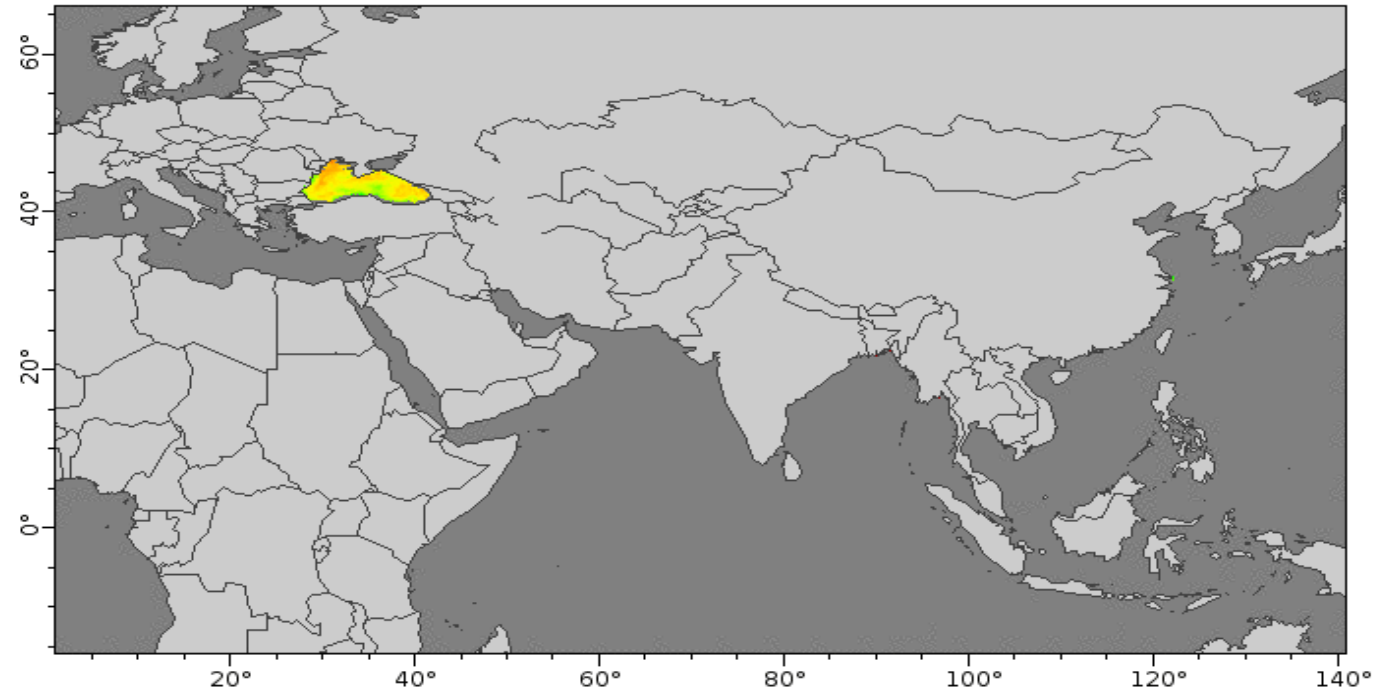
- During the summer of 1997, the largest reported outbreak in North America of culture-confirmed *Vp* infections occurred.
- 209 infections reported, all associated with eating seafood harvested from California, Oregon, and Washington in the United States and from British Columbia (BC) in Canada; one person died.
- Mean Pacific coastal sea surface temperatures were significantly higher (typically 3-5 °C) in areas where cases were subsequently reported.



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University of Santiago de Compostela, Spain

Risk prediction tools: vibrios, and HABs

- Risk prediction tools using remote sensing data have been developed in the last decade.
- Most of these approaches use temperature and salinity data and are updated daily. HABs models can also incorporate other variables.
- Extremely useful, and can produce risk-based mapping in near real-time. Some limitations e.g. granularity near coastal regions.



Daily Vibrio Risk (Risk Level)
USDOC/NOAA/NESDIS ECDC USC Vibrio Risk Analysis
(2013-06-12T12:00:00Z)
Data courtesy of CoastWatch Caribb-NOAA AOML ECDC USC/IIT

***Vibrio* risk prediction tool**

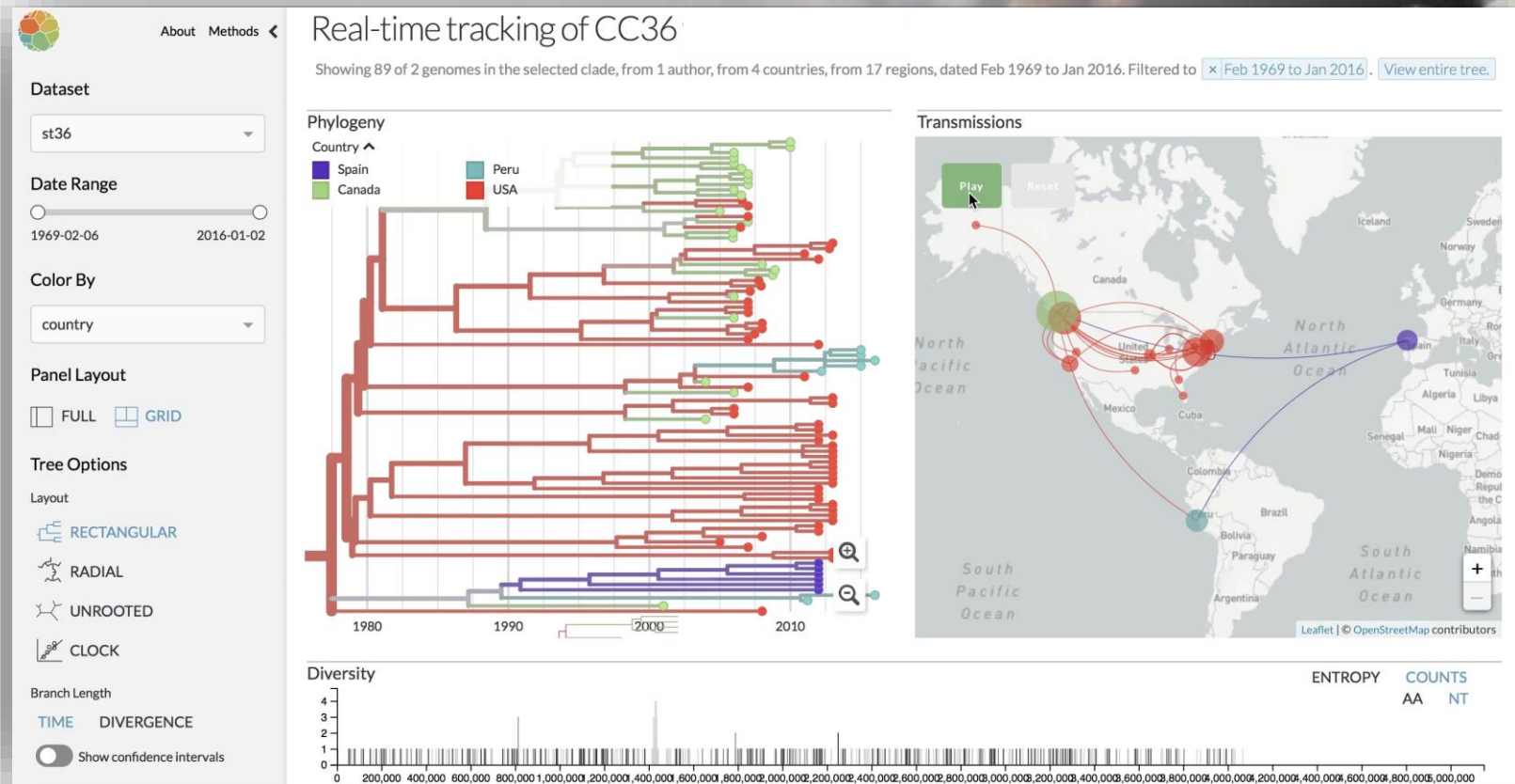
<https://cwcgom.aoml.noaa.gov/cgom/OceanViewer>

High-resolution tools: Genomic analysis of Vp

Recent sequencing and bioinformatic approaches can reconstruct the emergence, dispersal, and evolution of these important pathogens.

The unparalleled resolution of sequencing methods has enormous practical applications such as inferring mechanisms of transmission, unravelling the evolution of strains, as well as pinpointing outbreaks for risk management purposes.

Can be applied to bacteria and viral pathogens.



Changing risk factors increasing shellfish risk

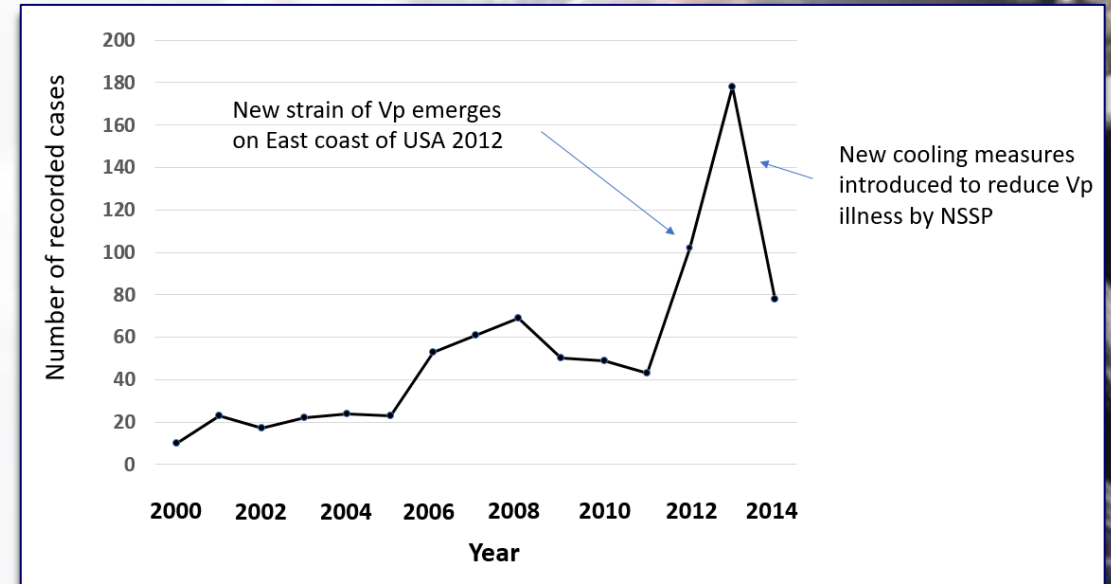
- 1. Rapidly ageing population.** The percentage of people aged over 65 has increased steadily in the last 3 decades. Age is a major risk factor for more aggressive/systemic *Vibrio* infections, such as *V. vulnificus* and *V. cholerae* (non-O1/O139).
- 2. Underlying conditions.** The number of people with underlying risk factors for *Vibrio* infections are increasing steadily – these include individuals with liver dysfunction, diabetes and compromised immune systems.
- 3. Exposure.** More people living by, and in direct contact with water.
- 4. Shellfish consumption.** Globally there is increasing consumption of raw/undercooked shellfish. High shellfish consumption in region. **Greater international trade in shellfish commodities = trade implications to risk.**

Tackling emerging risks

Both V_v and V_p are temperature sensitive and appropriate cooling of seafood greatly reduces human health risk.

Studies from USA and Japan have demonstrated this is an effective risk reduction strategy.

For other pathogen risks (e.g. HEV, TTX etc), the availability of environmental and baseline quantification data, coupled to effective surveillance and epidemiology datasets will be critical to both identify and then tackle potential risks.



V_p infections from seafood (Atlantic region of USA, 2000-2014), Source: Baker-Austin unpublished.

Emerging shellfish-related pathogens in Asia Pacific

- All major emergent shellfish-related pathogens described here have been found in this region. Shellfish-associated diseases have also been reported highlighting the
- In the case of certain pathogens (e.g. O3:K6 *Vp*) these strains likely emerged in this region and moved extensively throughout Asia Pacific
- Frequently simple yet effective risk reduction strategies can be utilised to tackle emergent risks. Interventions such as rapid icing and cold-chain (vibrios) and enhanced testing (viral and bacterial pathogens) have been shown to be extremely effective at reducing risks.
- Coordinated and trans-boundary sharing of data esp epidemiological information critical.

Summary

- Wide variety of emerging microbial and HABs risks in shellfish – both globally as well as in Asia Pacific region.
- Dire need for improved systems of epidemiology, surveillance and reporting of shellfish-associated disease – again globally and also specifically in Asia Pacific region.
- Increased international trade of shellfish may be very important in developing science in this area, and driving improvements in best practise.
- Variety of different methods for tackling emerging diseases have been developed in the last decade, including risk prediction tools (e.g. remote sensing, genomics), detection and quantification methods etc. Simple interventions may available for most risks but requires data.

Analysing and understanding disease emergence using a combination of approaches

