

CLIMATE CHANGE, HARMFUL ALGAL BLOOMS AND HEALTH RISKS IN ONE HEALTH CONTEXT

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The One Health vision is a unifying force to safeguard human and animal health, to reduce disease threats and to ensure a safe food supply through effective and responsible management of natural resources

"Part of FAO's global mandate is to prevent, detect, contain and eliminate animal and human health risks that originate from existing, emerging or re-emerging diseases that threaten lives, livelihoods, food security and trade."
Dr Juan Lubroth,
Chief Veterinary Officer, FAO

One Health represents a holistic vision to address complex challenges that threaten human and animal health, food security, poverty and the environments where diseases flourish. These problems threaten global health and economic well-being, including international trade. Many of the dangers stem from diseases circulating in animals, transmitted by food or carried by vectors.

FAO is a hub of technical knowledge that embraces One Health across its various areas of expertise:

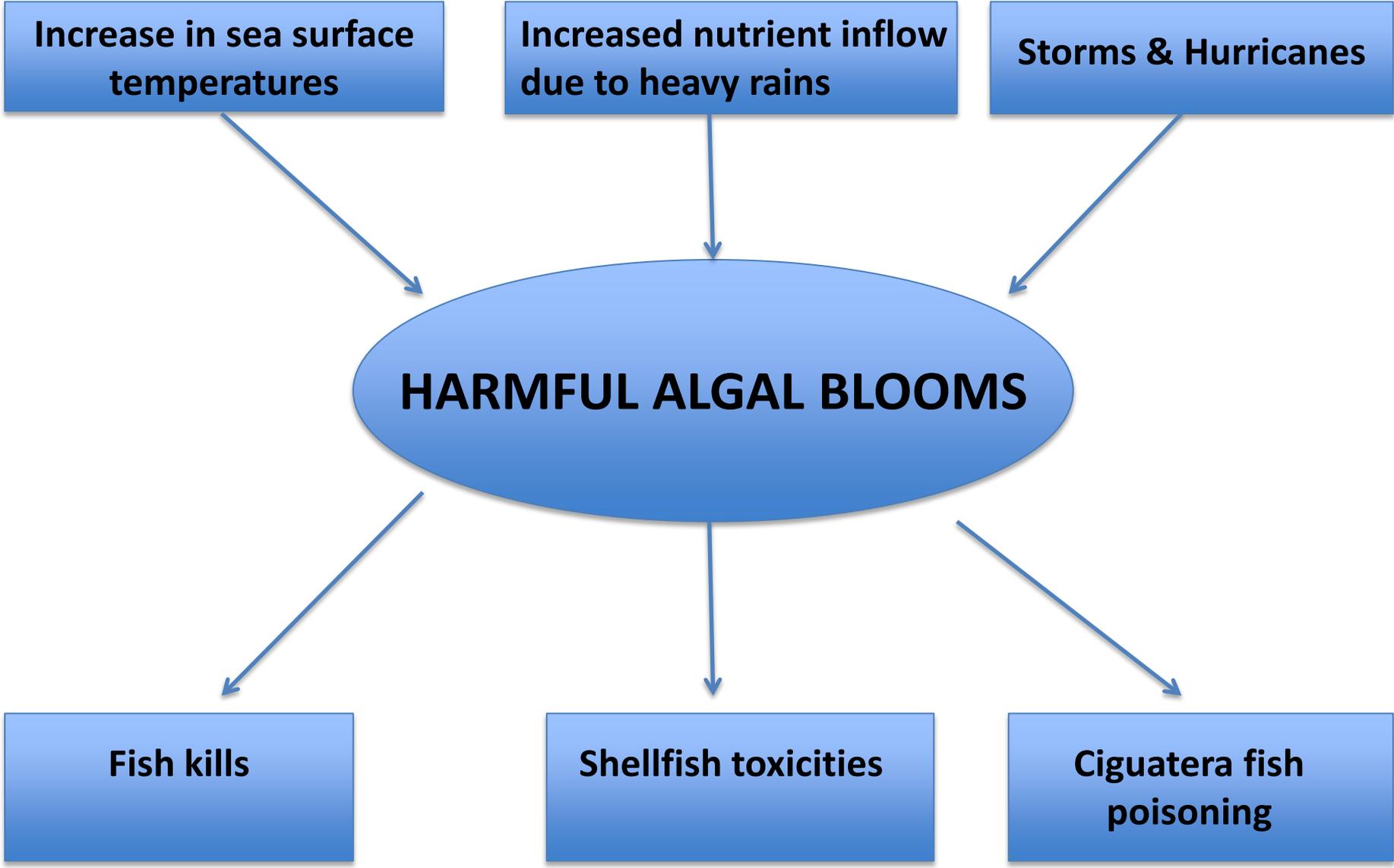
- Managing animal health, natural resources, fisheries and forestry;
- Promoting access to safe, nourishing food;
- Adapting to climate change and mitigating its effects;
- Formulating policies for sustainable agricultural production; and
- Advocating for gender equality.

FAO's priorities in One Health

- Leverage the lessons learned in combating H5N1 highly pathogenic avian influenza to tackle a host of animal diseases that threaten human health and livelihoods at the disease source;
- Strengthen surveillance systems at the regional, national and local levels to prevent and detect disease emergence and contain disease spread;
- Understand disease risk factors, including the socio-economic context, to prevent and manage disease outbreaks;
- Develop capacities at regional, national and local levels; and
- Reinforce safe animal production practices and veterinary infrastructure in the long term to defend against high-impact diseases.

Climate change and human health

- During 1997-2006, it is estimated that 524,000 people lost lives due to 11,000 extreme weather events with financial losses of 3.16 trillion\$.
- In 2016, India reported 2119 deaths due to extreme weather events and suffered losses estimated to be \$21 billion, 1% of India's GDP.
- During 1997-2016, the number of extreme weather events that occurred in some of the countries in Asia: Philippines – 289; Vietnam – 216; Bangladesh – 187; Pakistan – 141; Thailand – 137; Myanmar - 83



Increase in sea surface temperatures

Increased nutrient inflow due to heavy rains

Storms & Hurricanes

HARMFUL ALGAL BLOOMS

Fish kills

Shellfish toxicities

Ciguatera fish poisoning

Wells et al., 2015. Harmful Algae 49: 68-93

Environmental Factor

↑ T°C ↑ Stratification ↑ OA ↑ Cultural Eutroph. Grazing

HAB Type

Diatoms
(e.g., *Pseudo-nitzschia* spp.)

Toxic Flagellates
(e.g., *Alexandrium*,
Pyrodinium, *Gymnodinium*)

Benthic
(e.g., *Gambierdiscus* spp.)

Fish Killing
(e.g., *Heterosigma* spp.)

High Biomass
(e.g., mixed spp.)

Cyanobacteria
(e.g., *Nodularia* spp.)

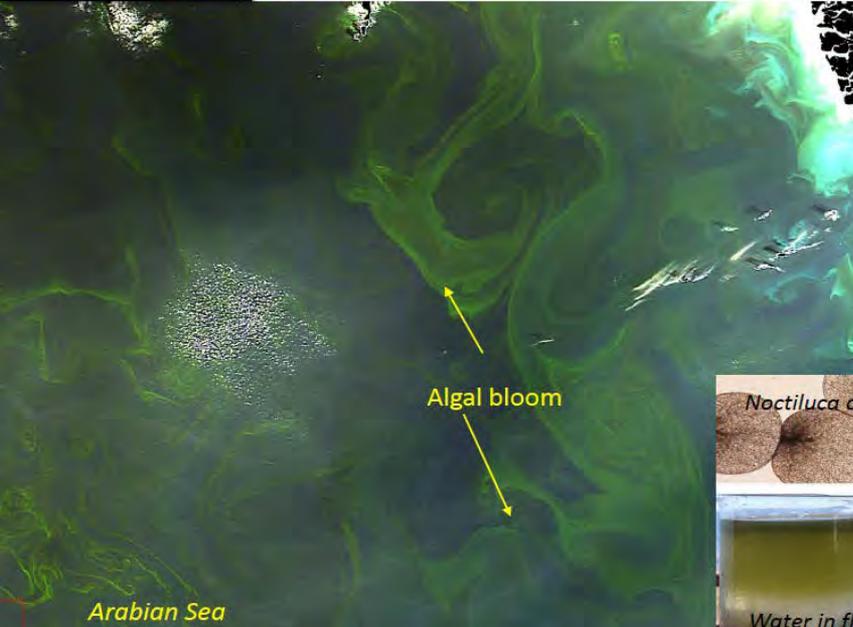
Cell Toxicity

↑ T°C	↑ Stratification	↑ OA	↑ Cultural Eutroph.	Grazing
↕ +	↓ ++	↕	↓	↕
↑	↑ ++	↕	↑	↕
↕ ++	↑ ++	?	↑	↕
↑	↑ ++	?	↑ +	↑ +
↕	↕	↕	↑ ++	↕
↑ +	↑ ++	↕	↑ ++	?
?	?	⋮	↕	↕

Algal bloom events becoming more frequent and driven by extreme weather events

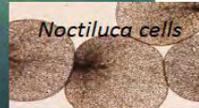


Forest of the Sea : Massive Outbreak of Noctiluca algal blooms in the Arabian Sea as captured by Indian OCEANSAT-2 OCM on Feb 8, 2018

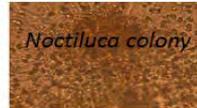


Every year during winters north-western Arabian Sea experiences outbreak of Noctiluca algal blooms. This bloom at times causes fish mortality on Oman coast due to hypoxia.

This image is captured by Indian OCM sensor on OCEANSAT-2 satellite on Feb 8, 2018.



Noctiluca cells



Noctiluca colony



Water in flask



Field Photo

Arabian sea – UAE coast, 2016



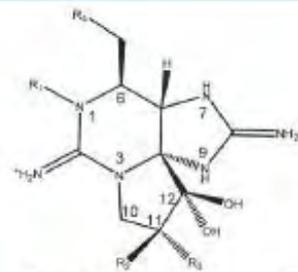
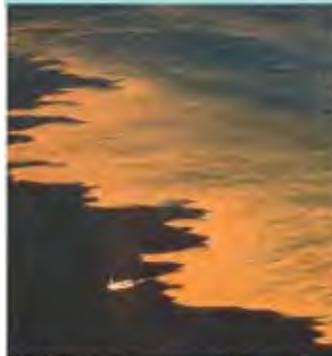
Paralytic Shellfish Poisoning caused by saxitoxin group of toxins



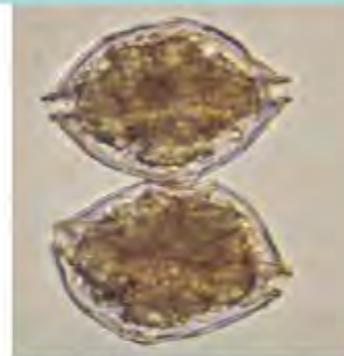
Source: Woods Hole Institute of Oceanography



Assessment and management of biotoxin risks in bivalve molluscs



R ₁	R ₂	R ₃	R ₄	Toxin
H	H	H		STX
H	H	OSO ₃ ⁻		GTX2
H	OSO ₃ ⁻	H		GTX3
CH	H	H		NEO
CH	H	OSO ₃ ⁻		GTX1
CH	OSO ₃ ⁻	H		GTX4
H	H	H		GTX5 (B1)
H	H	OSO ₃ ⁻		C1
H	OSO ₃ ⁻	H		C2
CH	H	H		GTX6 (B2)
CH	H	OSO ₃ ⁻		C3
CH	OSO ₃ ⁻	H		C4
H	H	H		dcSTX
H	H	OSO ₃ ⁻		dcGTX2
H	OSO ₃ ⁻	H		dcGTX3
CH	H	H		dcNEO
DH	H	OSO ₃ ⁻		dcGTX1
CH	OSO ₃ ⁻	H		dcGTX4



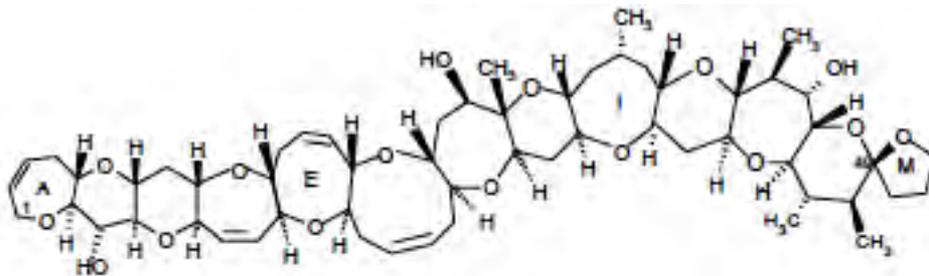
Ciguatera fish poisoning

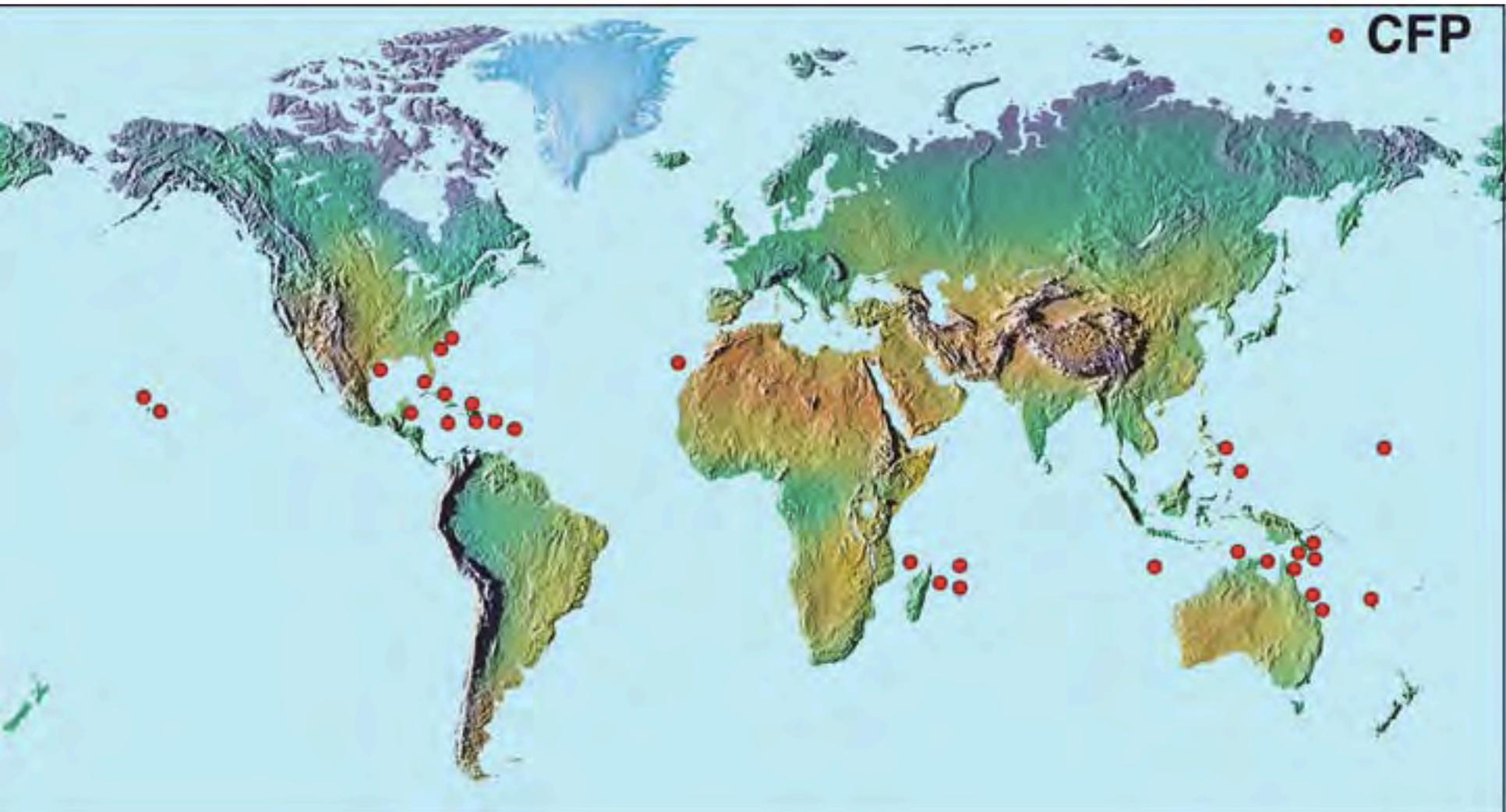
- Caused by consumption of fish from coral reef area that contain toxins produced by dinoflagellate *Gambierdiscus* spp.
- Over 400 fish species can be carriers of ciguatoxin, but the common ones are red snapper (*Lutjanus* spp), reef cod/ grouper (*Epinephelus* spp), barracuda (*Sphyraena* spp), king fish, trevally (*Caranx* spp), parrotfish, wrasse and giant moray (*Gymnothorax* spp).



Ciguatoxin

- Heat stable lipophilic molecules
- Ciguatoxins are highly potent - ingestion of as little as 0.1 μg toxin can cause illness in a human adult.
- The symptoms usually start between one to 48 hrs of eating toxic fish.
- The symptoms include both gastrointestinal, neurological as well as cardiological





Source: Woods Hole Institute of Oceanography

Fish head meal makes over 100 sick in Ullal in M'luru

Condition Of 4 Of A Family Is Critical

TIMES NEWS NETWORK

Mangaluru: More than a hundred people, including employees of a fish-exporting company, were taken ill on Saturday after eating fish heads that were supplied from the firm in Ullal, Dakshina Kannada district.

The affected people are being treated at hospitals in



People undergoing treatment at a private hospital at Deralakatte

Deralakatte and Mangaluru. The condition of four members of a family is reported to be critical.

The PRO of KS Hegde Hospital, Deralakatte, said 15-20 persons, most of them wo-

men, are being treated at the hospital. Fifty persons have been treated as out-patients.

“Owing to non-availability of beds, some patients have been sent to other private hospitals,” he said. The hospitals have asked jurisdictional police to file a complaint against the export firm.

According to sources, workers and locals in Ullal fell ill after dinner on Friday. Most of them had diarrhoea and cramps in their hands and legs. They had consumed fish heads – considered waste in a fish-export factory.

► **Firm denies sale, P 3**

Ciguatera fish poisoning in Mangalore confirmed

- Clinical presentation, fish species involved – red snapper
- Mouse bioassay
- Receptor binding assay
- Liquid chromatography mass spectrometer study
- *Gambierdiscus* involved in CFP produces two types of toxins: water soluble maitotoxins and lipid soluble ciguatoxins. Maitotoxins can kill mice, but they have no role in CFP.
- Effective extraction and clean up procedures necessary for detection of ciguatoxins.



Ciguatera in East Asia and South East Asia, Chan, 2015
Now extended to Indonesia, India

Geographic range of ciguatera fish poisoning expanding

- Range was considered tropical and subtropical (35N -35S)
- Now known to occur in temperate regions of
- Japan,
- Southern Australia (NSW),
- Europe (Canary Islands, Spain, Madeira, Portugal, Greece)
- Gulf coast
- Even incidence in endemic regions increasing: In French West Indies, incidence during 2013 – 2016 five times higher than incidence during 1996-2006 (Boukaud-Maitre et al., 2018) – reef disturbance due to cyclones

Fish species that can carry ciguatoxins

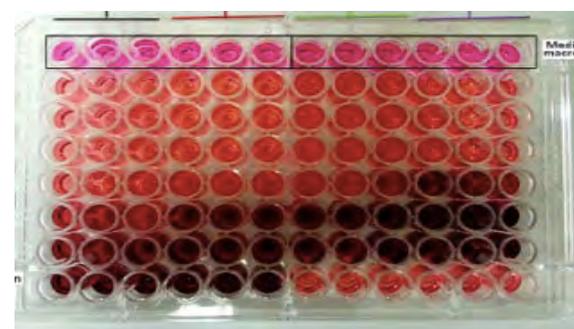
- Over 400 fish species may be involved.
- Both herbivorous and carnivorous species may be involved.
- Identifying fish species that can carry toxins is important for public health management.
- There is significant variation in toxin content between individual fish of a species and between geographic areas.
- New fish species are being identified as carriers eg sharks in Indian ocean (Diogene et al., 2017)

Ciguatoxin- complex molecule

- Ciguatoxin is a polyether toxin
- Three major groups are known depending on origin: Pacific type (P-CTX), Caribbean type (C-CTX) and Indian Ocean type (I-CTX).
- There are two families of P-CTX (types 1 and 2) and several congeners of each groups (P-CTX-1 to P-CTX-4; C-CTX-1, C-CTX-2; I-CTX-1 to I-CTX-4).
- P-CTX considered most potent, being 10-fold more potent than C-CTX. I-CTX variants are considered 60% potent compared to P-CTX.



Ciguatoxin detection



- Mouse bioassay
- Neuroblastoma cytotoxicity assay
- Receptor binding assay
- LC-MS/MS analysis
- Reference standard toxins available in only a few laboratories. Purified I-CTX not available
- Acceptable levels of CTX not agreed internationally. FDA action level 0.01ppb for Pacific ciguatoxin and 0.1 ppb for Caribbean toxin



Current public health management practices

- Monitoring reef areas for presence of Gambierdiscus spp (there can be >100 fold variation in toxicity between species and 2-9 fold variation within species due to growth conditions)
- Identification of susceptible fish species of importance in the region (there can be large variations in toxicity even within a fish species in the region)
- Avoidance of large fish (>2kg) of susceptible species

C O D E X A L I M E N T A R I U S

International Food Standards



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What is the Codex Alimentarius?

The Codex Alimentarius, or "Food Code" is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. The Commission, also known as CAC, is the central part of the Joint FAO/WHO Food Standards

Recent Codex Standards

[CAC/GL 2](#) Nutrition Labelling

[CAC/GL 87](#) Salmonella

[CAC/GL 19](#) Food Safety Emergencies

[CAC/GL 88](#) Control of Foodborne Parasites

[CAC/MISC 6](#) Specifications for Food Additives

Latest news

[Safer Food Training for effective participation in Codex](#)

11 Oct 2017 - Bangkok October 11 2017 In some ways the premise is very simple: build stronger Codex coordination [\[...\]](#)

[Codex standards for safe food and access to trade](#)

2 Oct 2017 - Experts meet in Kampala to discuss standards for fresh fruits and vegetables Kampala, 2nd October 2017 [\[...\]](#)

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30 Sep 2017 - The Director-General of the Food and Agriculture Organization of the United Nations (FAO), José Graziano [\[...\]](#)

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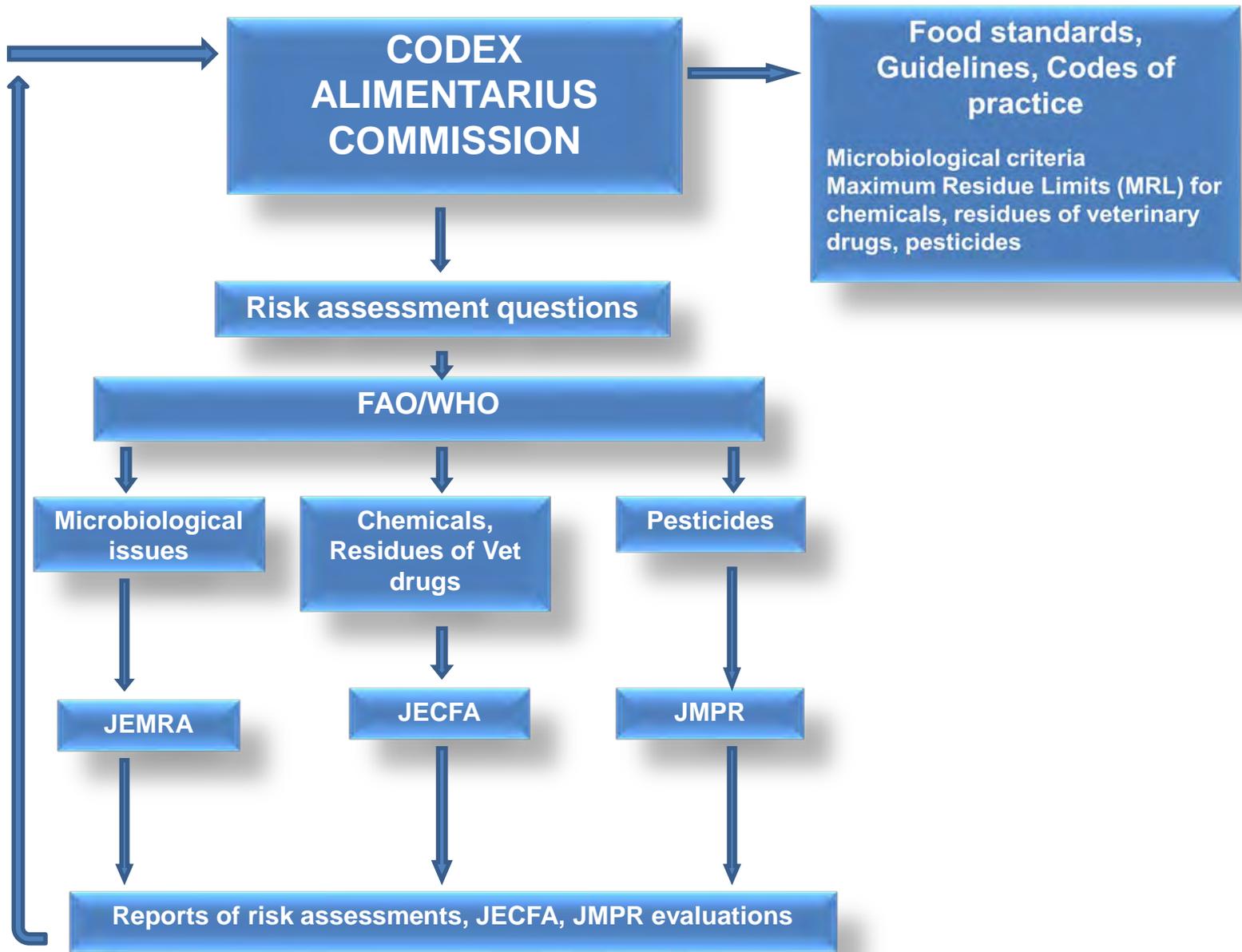
Tweets by [@FAOWHOCodex](#)



Codex Alimentarius

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Request for scientific advice from 11th Session of Codex Committee on Contaminants, 2017

- Full evaluation of known CTXs (toxicological assessment and exposure assessment) including geographic distribution, rate of illness, congeners, method of detection;
- Based on these guidance on risk management options



Food and Agriculture
Organization of the
United Nations



World Health
Organization

CALL FOR EXPERTS ON CIGUATERA FISH POISONING

Deadline: 1 April 2018

Background

Ciguatera fish poisoning (CFP) is one of the most common food-borne illnesses related to seafood consumption. While CFP has been known for centuries, its true incidence remains unclear; few years ago, it was estimated that 10 000–50 000 people per year suffer from this illness (Lehane, L. 2000)¹.

Climate change and global spread of pathogens

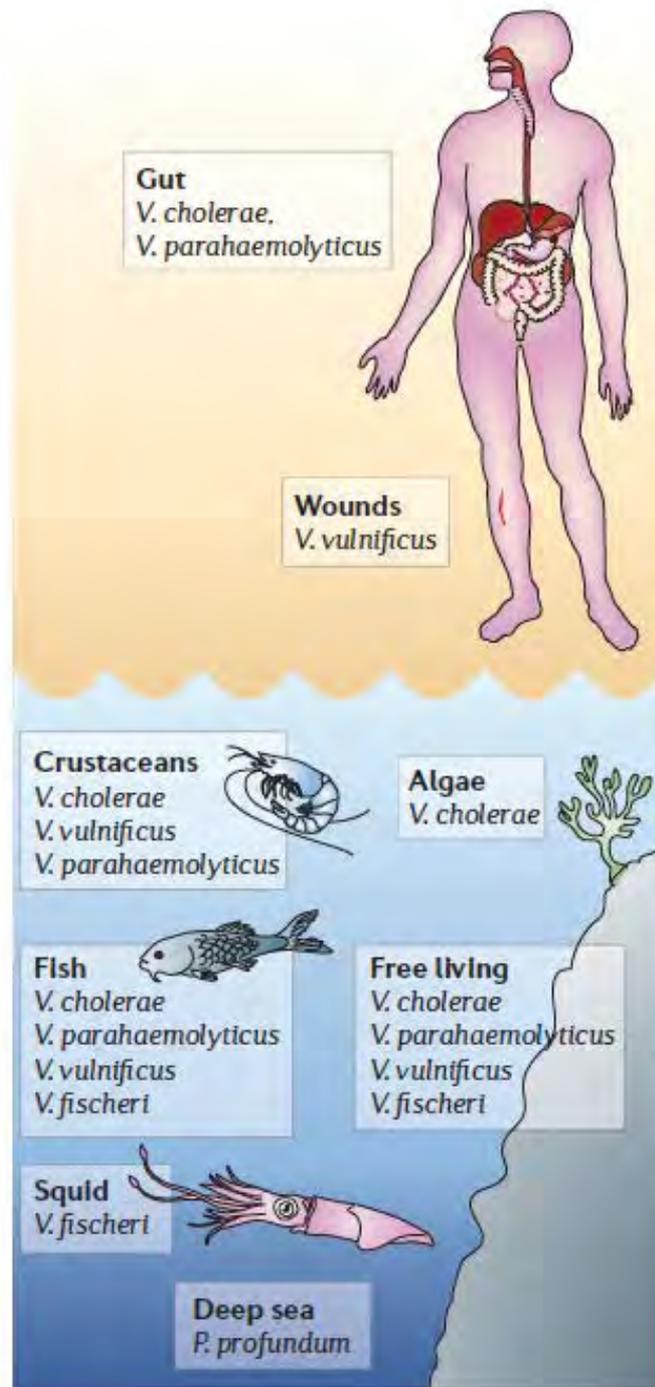
- *Vibrio* spp are mesophilic bacteria associated with warm water environments.
- *V. cholerae*, *V. parahaemolyticus* and *V. vulnificus* are important human pathogens.
- Not all environmental strains are pathogenic.
- Of over 200 serovars, only serovars O1 and O139 cause the disease cholera.
- Among *V. parahaemolyticus*, only about 1-2% of environmental strains produce virulence factors required to cause disease in humans.

Modified from Reen et al, 2006



Molluscs

V. cholerae
V. parahaemolyticus
V. vulnificus



V. cholerae
V. parahaemolyticus
V. vulnificus

***V. parahaemolyticus* – occurrence and distribution**

- Estuarine and coastal environments
- Global occurrence
- Associated with all types of animals in brackish water environments – zooplankton, molluscs, crustaceans, shellfish and finfish
- Ecology influenced by temperature and salinity.
- In tropical environments, detected throughout the year, provided salinity and other conditions are available.
- In temperate climate, detected mostly in summer. The organism undergoes overwintering in sediments.

***V. parahaemolyticus* – occurrence and distribution**

- During the 1990's, the organism was considered mainly tropical.
- In international fish trade, there were even rejections due to the mere presence of the organism (though most environmental organisms are non-pathogenic to humans)
- An outbreak of *V. parahaemolyticus* gastroenteritis in Alaska in 2004 from locally grown oysters changed the thinking on the distribution of this organism.
- Alaska is 1000KM north of places from where any previous *V. parahaemolyticus* illness was reported.
- In 2004, temperatures in Alaska were higher than 15°C.

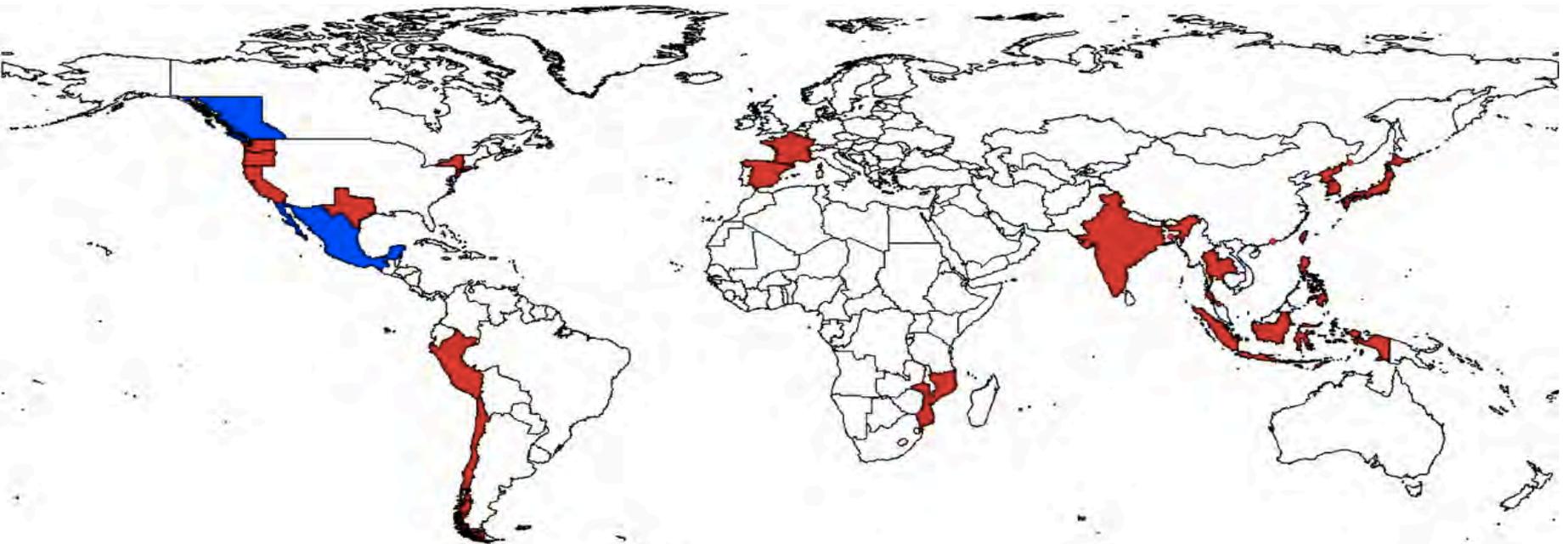
Interaction between *V. parahaemolyticus* and plankton

- *V. parahaemolyticus* can adhere to and degrade chitin and adsorption of the organism to chitin or plankton occurs with higher efficiency under conditions of low estuarine salinity.
- Chlorophyll-A may influence the ecology of the organism by influencing the population of zooplankton.
- Studies done in Galecia, Spain indicate that *V. parahaemolyticus* is found even in off-shore areas in association with zooplankton.
- Genetically similar organisms were found in zooplankton in estuaries and off-shore regions spread over 1500 KM suggesting a role for zooplankton in the spread of this organism.

Vibrio parahaemolyticus strains with pandemic potential

- *Vibrio parahaemolyticus* strain of serotype O3:K6 with pandemic potential was first detected in India in 1996.
- In 1997, diseases caused by this variety was detected in Peru and spread southward along more than 1500 KM of the coast till it reached the Chilean city of Antofagasta.
- Several thousands of cases were reported again in 2003-2004
- Over 10,000 people were affected by this strain in Chile

Global spread of pandemic strain of *V. parahaemolyticus*



 Areas where outbreak of *V. parahaemolyticus* has occurred or presence in the environment has been reported but the pandemic statuses of the strains are not clear

 Areas or countries where the pandemic *V. parahaemolyticus* clone has spread

Global spread of pathogenic strains

- Molecular studies of the strains suggest that the 1997 El Nino episode provided the corridor for the displacement of the Asian pandemic *V. parahaemolyticus* strains to America (Martinez-Urtaza et al, 2016).
- The El Nino phenomenon is characterized by the arrival of equatorial warm waters in a sequence of waves. In 1997, El Nino affected South American coast for about 6 months.
- It has been suggested that recurrent invasion of tropical masses of water might have resulted in repetitive sources of *V. parahaemolyticus* populations that would have established there.

Emergence of Asiatic Vibrio Diseases in South America in Phase With El Niño

Jaime Martinez-Urtaza,^a Blanca Huapaya,^b Ronnie G. Gavilan,^b Veronica Blanco-Abad,^a Juan Ansedo-Bermejo,^a Carmen Cadarso-Suarez,^c Adolfo Figueiras,^{d,e} and Joaquin Trinanes^f

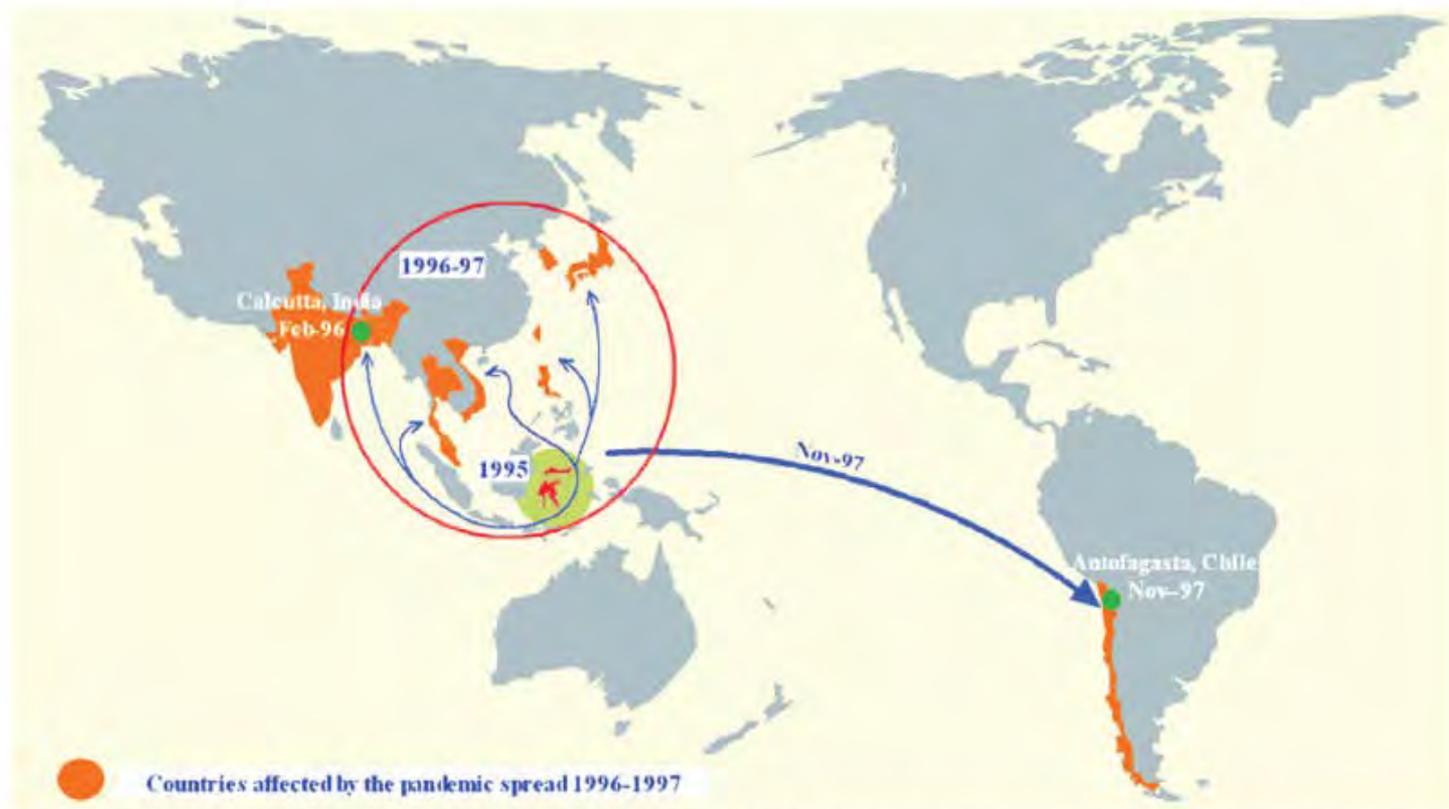


FIGURE 1. Distribution of pandemic *V. parahaemolyticus* 1996–1997 when infections were detected outside of Asia in northern Chile.

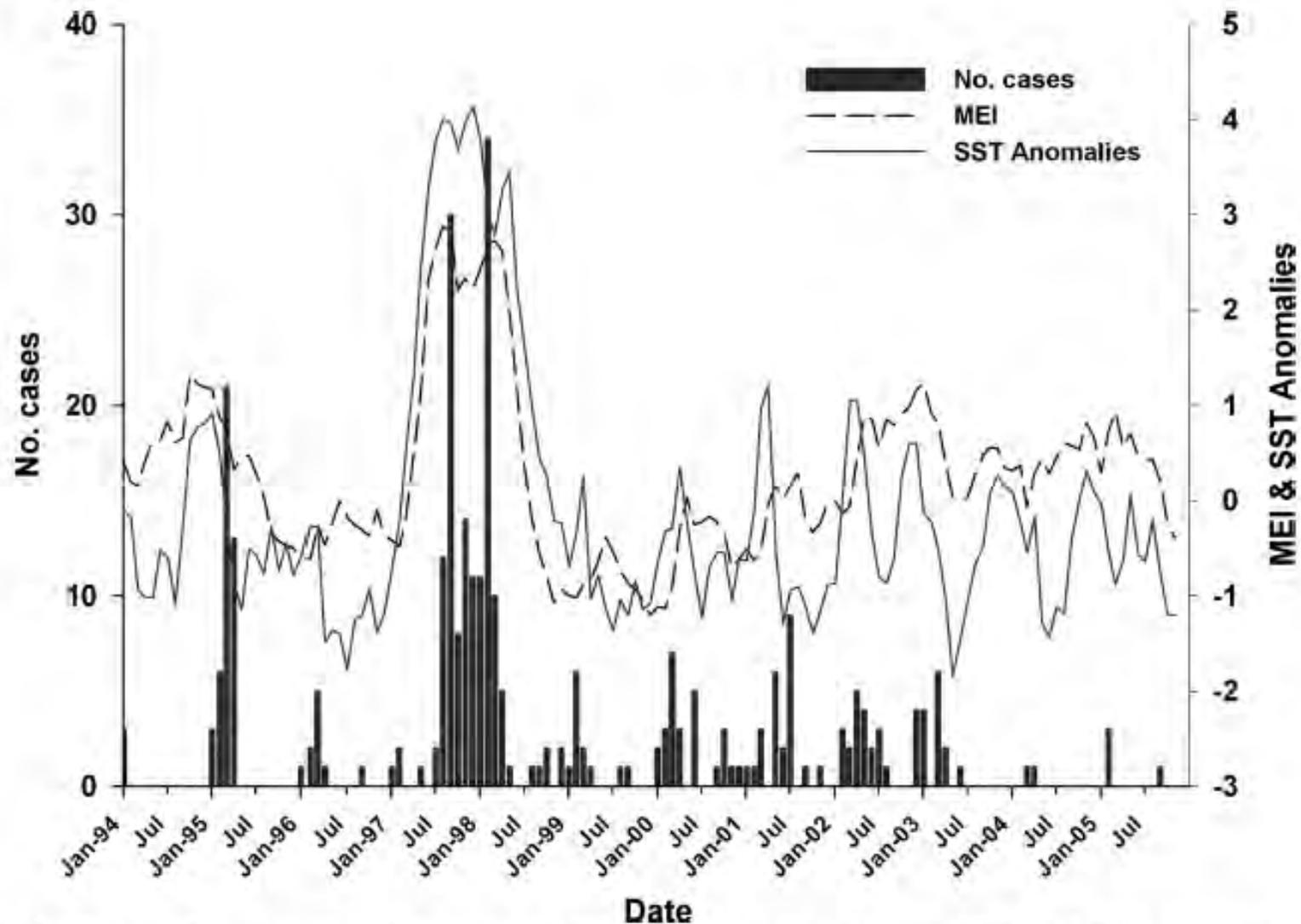
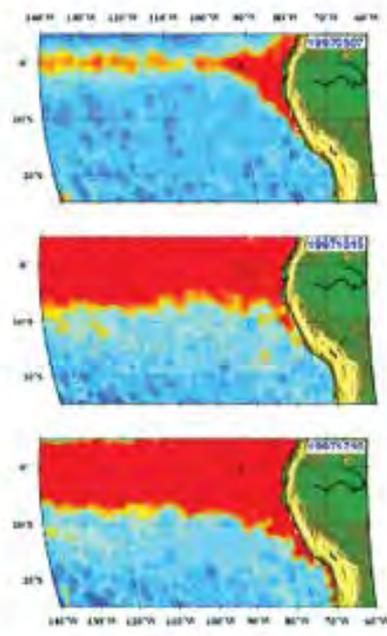


FIGURE 2. Monthly number of cases of *V. parahaemolyticus* reported in Peru between 1994 and 2005 according to the data provided by the Instituto Nacional de Salud in Lima. Sea Surface Temperature anomalies and Multivariate ENSO index data for the same period were provided by NOAA-CIRES Climate Diagnostic Center (<http://www.cdc.noaa.gov/>).

A

V. parahaemolyticus 1997

V. cholerae 1990-1



Shrimp pathogenic *V. parahaemolyticus* emerges in Asia

- Acute Hepatopancreatic Necrosis disease (AHPND) caused several billion \$ losses to shrimp aquaculture industry. Commercial shrimp production reduced by 50% in affected countries.
- Strains of *V. parahaemolyticus* carrying a 70kb plasmid containing genes encoding a Photorhabdus-insect related toxin (PIR) emerged in Asia in 2009. Causes AHPND.
- First detected in China, then spreads to Vietnam, Thailand, Malaysia, Philippines.
- Has also been detected in Mexico
- Shrimp pathogenic strains lack virulence factors related to human pathogens.

Shrimp pathogenic *V. parahaemolyticus* emerges in Asia

- 70kb plasmid carrying *pirAB* genes found in other related Vibrios: *V. campbelli*, *V. harveyi*, *V. owensii*
- What caused the emergence of these pathogens – eutrophic conditions caused by intensive aquaculture might have led to proliferation of these pathogens.
- Implementation of Good Aquaculture Practices needed.

Summary

- Events related to climate change have caused increased incidence of harmful algal blooms, fish and shellfish toxicities.
- Geographical range of certain harmful algae is extending and ciguatera fish poisoning is occurring in regions not known to be endemic.
- El Nino has caused trans-oceanic spread of bacterial pathogens like *Vibrio* spp.
- New pathogens of animals like shrimp are emerging due to nutrient rich conditions in aquaculture environments.



THANK YOU