TECHNICAL ASSISTANCE TO BUILD FOOD SAFETY CAPACITY

FOR THE FISHERIES SECTOR

Introduction to Food Safety

Train-the-Trainer Course for Ocean Delight, Suriname

Prepared by: Megapesca Lda Portugal

Outline

- Classification of food safety hazards
- Significant food safety hazards in Caribbean fishery products
- Examples of hazards and their control

Classification of food safety hazards

Hazard: a biological, chemical or physical agent that is reasonably likely to cause illness or injury in the absence of its control

- **Microbiological hazards:** organisms, or substances produced by organisms(e.g. *C. botulinum* toxin) that pose a threat to human health.
- **Chemical hazards:** elements or compounds that can cause illness or injury due to immediate or long-term exposure (e.g. heavy metals).
- **Physical hazards:** include foreign objects in food that can cause harm when eaten, such as glass or metal fragments.

Microbiological hazards

Examples of microbiological hazards in fish and fishery products

Bacteria (spore-forming)

Clostridium botulinum

Bacteria (non-spore-forming)

Pathogenic *Escherichia coli* (e.g. E. coli 0157)
Listeria monocytogenes
Salmonella spp. *(S. typhimurium, S. enteriditis)*
Shigella spp.
Staphylococcus aureus
Streptococcus pyogenes
Vibrio cholerae
Vibrio parahaemolyitcus
Vibrio vulnificus
Yersinia enterocolitica

Viruses

Hepatitis A and E
Norwalk virus group
Rotavirus

Protozoa and parasites

Diphyllobothrium latum
Entamoeba histolytica
Giardia lamblia
Clonorchis sinensis

Control of pathogens

Bacteria of aquatic origin

Clostridium botulinum (type E) (spore forming)

Marine *Vibrio*

- *Vibrio cholera*
- *Vibrio parahaemolyticus*
- *Vibrio vulnificus*

Bacteria of environmental origin

Listeria monocytogenes

Mesophilic *Clostridium botulinum* (type A and B)

Bacteria of human/animal origin

Salmonella spp. (S. typhimurium, S. enteriditis)

Shigella (S. dysenteriae)

Pathogenic *Escherichia coli* (e.g. *E. coli* 0157)

Staphylococcus aureus

Streptococcus pyogenes

Yersinia enterocolitica

Group B *Streptococcus*

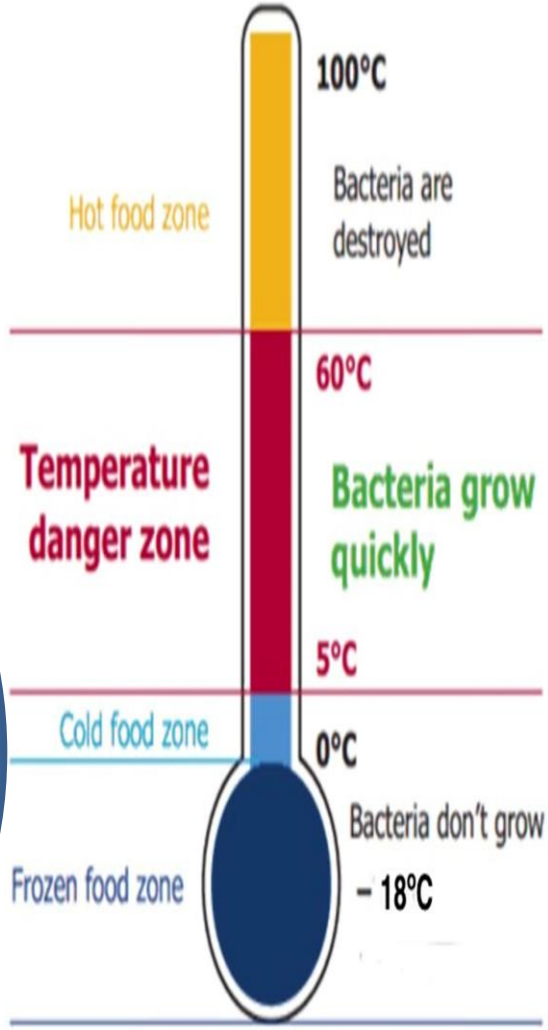
- Pathogens of human or animal origin
  - Origin control (quality of water)
  - Serves to minimize but does not fully eliminate the risk
  - Elimination of hazard can also be done by processing methods (properly cooking, pasteurizing, retorting)

- Naturally occuring pathogens
  - Naturally occurring pathogens may be present in relatively low levels at the time of harvesting but may increase to more hazardous levels if they are exposed to **time and temperature abuse**
  - Controls may include temporarily close of waters
  - As with pathogens of sewage origin the controls do not eliminate the risk

Pathogenic bacterial growth and toxin formation (other than *Clostridium botulinum*) as a result of time and temperature abuse

Pathogenic bacteria can enter the process on raw materials

Introduced into foods during processing from the air, unclean hands, insanitary utensils and equipment, contaminated water and through cross-contamination



Time and temperature abuse occurs when a product is allowed to remain at temperatures favorable to pathogenic bacterial growth for suficient time to result in unsafe levels of pathogenic bacteria or their toxins in the product

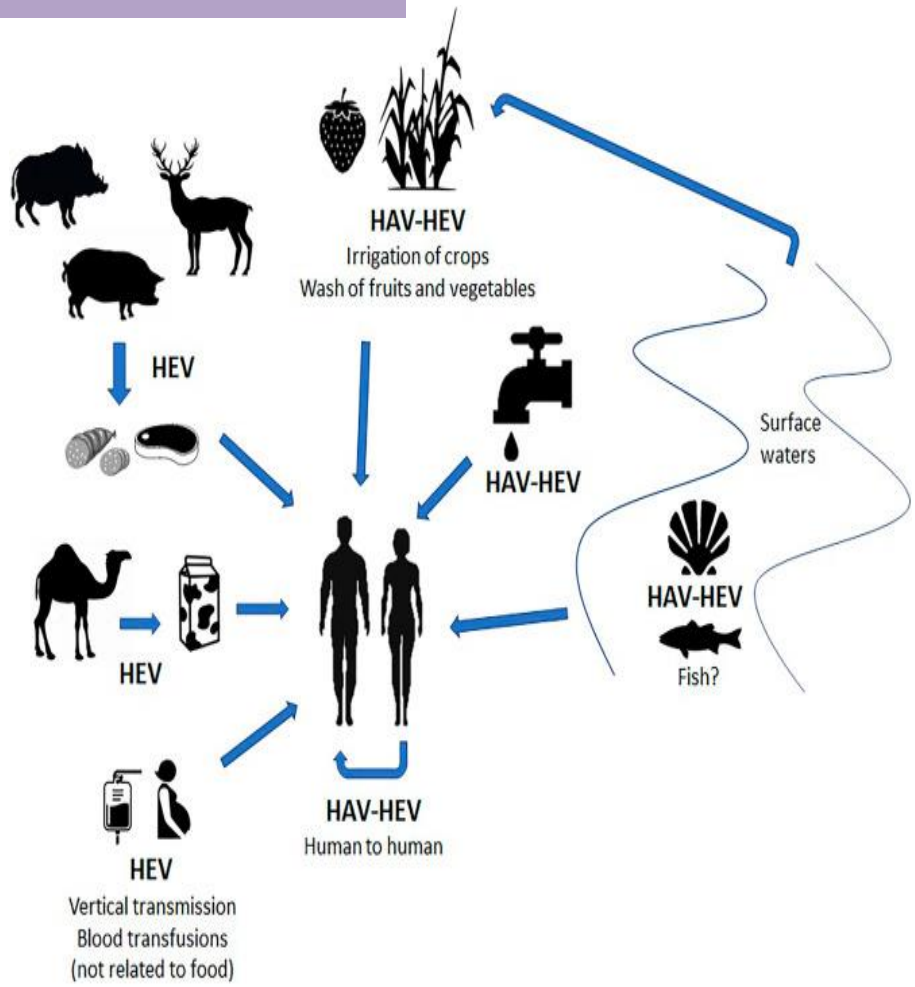
TABLE A-1
LIMITING CONDITIONS FOR PATHOGEN GROWTH

PATHOGEN	MIN. A_w (USING SALT)	MIN. pH	MAX. pH	MAX. % WATER PHASE SALT	MIN. TEMP.	MAX. TEMP.	OXYGEN REQUIREMENT
BACILLUS CEREUS	0.92	4.3	9.3	10	39.2°F 4°C	131°F[1] 55°C	facultative anaerobe[4]
CAMPYLOBACTER JEJUNI	0.987	4.9	9.5	1.7	86°F 30°C	113°F 45°C	micro-aerophile[2]
CLOSTRIDIUM BOTULINUM, TYPE A, AND PROTEOLYTIC TYPES B AND F	0.935	4.6	9	10	50°F 10°C	118.4°F 48°C	anaerobe[3]
CLOSTRIDIUM BOTULINUM, TYPE E, AND NON-PROTEOLYTIC TYPES B AND F	0.97	5	9	5	37.9°F 3.3°C	113°F 45°C	anaerobe[3]
CLOSTRIDIUM PERFRINGENS	0.93	5	9	7	50°F 10°C	125.6°F 52°C	anaerobe[3]
PATHOGENIC STRAINS OF ESCHERICHIA COLI	0.95	4	10	6.5	43.7°F 6.5°C	120.9°F 49.4°C	facultative anaerobe[4]
LISTERIA MONOCYTOGENES	0.92	4.4	9.4	10	31.3°F -0.4°C	113°F 45°C	facultative anaerobe[4]
SALMONELLA SPP.	0.94	3.7	9.5	8	41.4°F 5.2°C	115.2°F 46.2°C	facultative anaerobe[4]
SHIGELLA SPP.	0.96	4.8	9.3	5.2	43°F 6.1°C	116.8°F 47.1°C	facultative anaerobe[4]
STAPHYLOCOCCUS AUREUS GROWTH	0.83	4	10	20	44.6°F 7°C	122°F 50°C	facultative anaerobe[4]
STAPHYLOCOCCUS AUREUS TOXIN FORMATION	0.85	4	9.8	10	50°F 10°C	118°F 48°C	facultative anaerobe[4]
VIBRIO CHOLERAE	0.97	5	10	6	50°F 10°C	109.4°F 43°C	facultative anaerobe[4]
VIBRIO PARAHAEMOLYTICUS	0.94	4.8	11	10	41°F 5°C	113.5°F 45.3°C	facultative anaerobe[4]
VIBRIO VULNIFICUS	0.96	5	10	5	46.4°F 8°C	109.4°F 43°C	facultative anaerobe[4]
YERSINIA ENTEROCOLITICA	0.945	4.2	10	7	29.7°F -1.3°C	107.6°F 42°C	facultative anaerobe[4]

1. Has significantly delayed growth (>24 hours) at 131°F (55°C).
2. Requires limited levels of oxygen.
3. Requires the absence of oxygen.
4. Grows either with or without oxygen.

Viruses as a food safety hazard

Hepatitis A and E
Norwalk virus group
Rotavirus



Viruses are unable to reproduce outside a living cell so cannot replicate in food

Viruses being implicated in seafood-borne diseases all have their niche in the human gastro-intestinal (GI) tract and their presence in water and seafood is a **consequence of poor hygiene**; either <u>water being contaminated with sewage or products being contaminated by food handlers.</u>

Control of seafood-borne viral disease

SHOULD BE simple since the source of disease is indirect or direct faecal contamination.

Measures that prevent this contamination control the disease

Good Hygiene practices (e.g good personal hygiene; food handlers nust not handle food for at least 2 days following and outbreak of viral disease)

Thoroughly cooking food (might not be sufficient in for example molluscs) and **prevention of cross contamination**

Depuration in case of molluscan shellfish

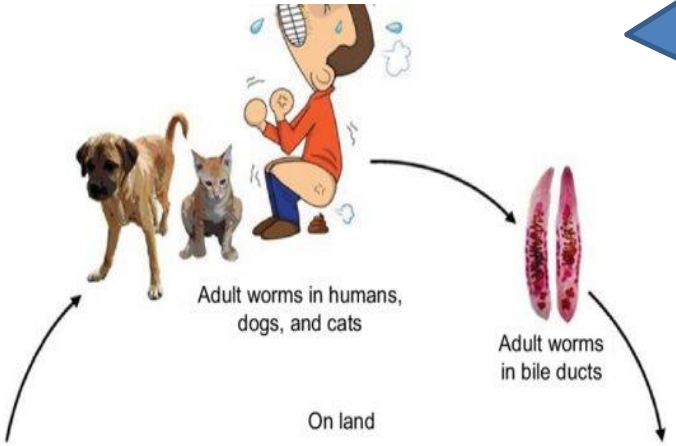
- Filter feeding animals and viruses and other pathogenic agents accumulate
- Involves transfer to clean water

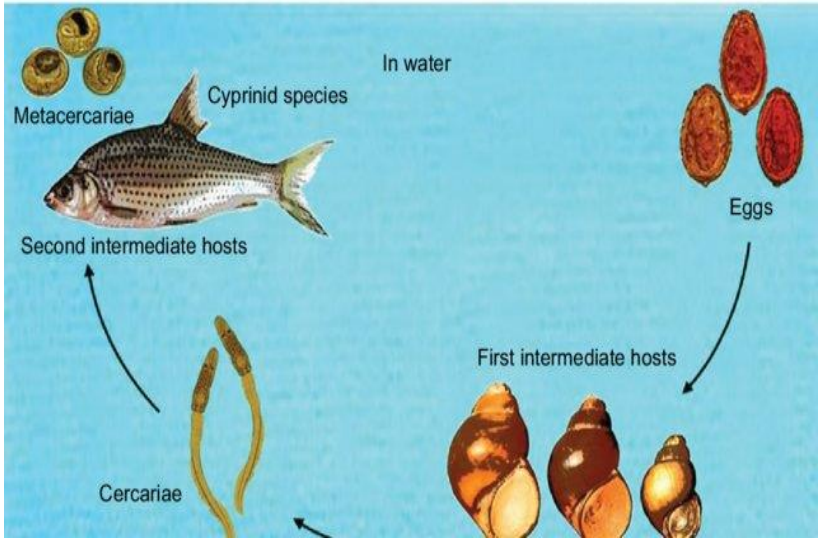
Parasites

Consumed (in the larval stage) via uncooked or undercooked seafood can present a human health hazard

Animal host-specific and can include humans in their life cycles

<u>Protozoa and parasites</u>
Opisthorchiasis felinea
Anisakis simplex
Gnathostoma sp.
Diphyllobothrium latum
Entamoeba histolytica
Giardia lamblia





Helminths in the families Opisthorchiidae and Heterophyidae (class Trematodea, subclass Digenea) are considered to be the major hazard

Zoonotic nematoda such as Anisakidae and Gnathostomidae are more frequently associated with marine species

Parasitic infections

Infection in humans is associated with the consumption of fish containing live parasites

Fish roundworms cause a condition in humans called anisakiasis

Fish flatworms or flukes cause a condition in humans called trematodosis

Fish tapeworms cause a condition in humans called diphyllobothriasis

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Short communication

Risks for fishborne zoonotic trematodes in Tilapia production systems in Guangdong province, China

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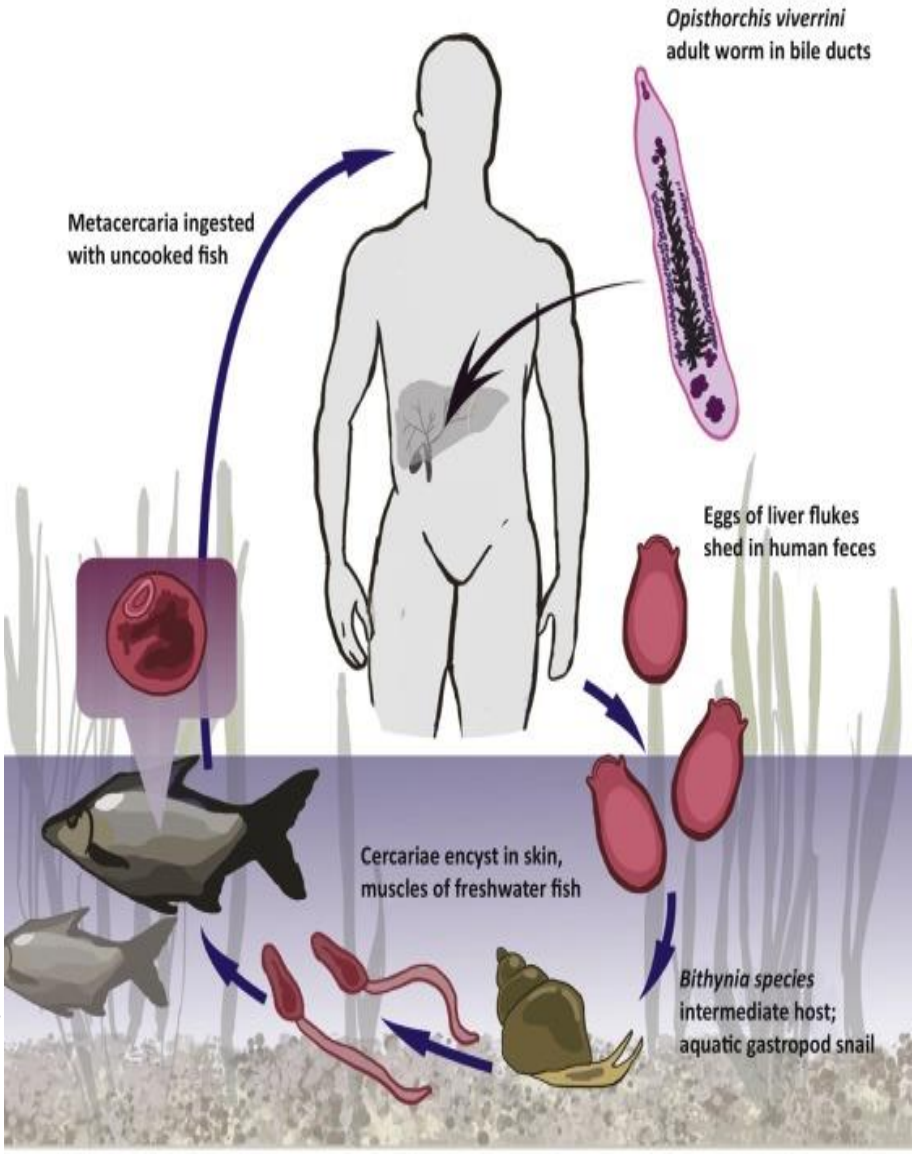
ABSTRACT

Guangdong province is the most important region for tilapia culture in China. However, it is also an endemic region for fishborne zoonotic trematodes (FZT), which pose a risk to human food safety and health. A study was designed to assess the status of trematode parasite infections in tilapia aquaculture systems as an indicator of potential risks from FZT associated with consumption of tilapia. Tilapia from nursery and grow-out ponds were sampled from monoculture, polyculture and integrated aquaculture systems. The results from 388 tilapia examined revealed a very low prevalence (1.5%) of trematode infections (Heterophyidae and Echinostomatidae). Integrated systems using animal manure and latrine wastes as fertilizer did not show a higher prevalence of FZT. Because it was not clear whether the low risk of infection was attributable to existing effective pond management practices or a low risk of spillover of FZT from area sylvatic reservoir hosts, a survey of local wild-caught fish



Fish flatworms or flukes are normally associated with fresh water fish in temperate and warm waters

Controlling parasites in fish products

- ✓ The processing of **heating** fish sufficiently to kill bacterial pathogens is also sufficient to kill parasites
- ✓ Effectiveness of freezing depends on several factors including:
  - ✓ Temperature of freezing process
  - ✓ Length of time needed to freeze the fish tissue
  - ✓ Length of time the fish is held frozen
  - ✓ The species and source of the fish
  - ✓ Type of parasite present

Freezing and storing <-20ºC for 7 days

Freezing and storing <-35ºC for 15hours

Heating 60ºC for at least 1 minute

Fungi

Fungi include moulds and yeasts.

- Fungi can be beneficial, as they can be used in the production of certain foods (e.g. cheese).

- Some fungi produce toxic substances (mycotoxins) which are toxic for humans and animals and can enter the food chain via animal feeds.

Chemical hazards

Examples of chemical hazards in fish and fishery products

Naturally occurring chemicals

Allergens
Mycotoxins (e.g. aflatoxin)
Scombrotoxin (histamine)
Ciguatoxin

Will be covered in detail in session 2

Shellfish toxins:

- Paralytic shellfish poisoning (PSP)
- Diarrhoeic shellfish poisoning (DSP)
- Neurotoxic shellfish poisoning (NSP)
- Amnesic shellfish poisoning (ASP)

Contaminants, additives and residues

Environmental contaminants:

Polychlorinated biphenyls (PCBs)
Agricultural chemicals
- Pesticides
- Fertilizers
- Antibiotics
- Growth hormones

Toxic heavy metals:

- Lead
- Cadmium
- Mercury

Food additives

- Polycyclic aromatic hydrocarbons
- Carbon Dioxide
- Sulphur

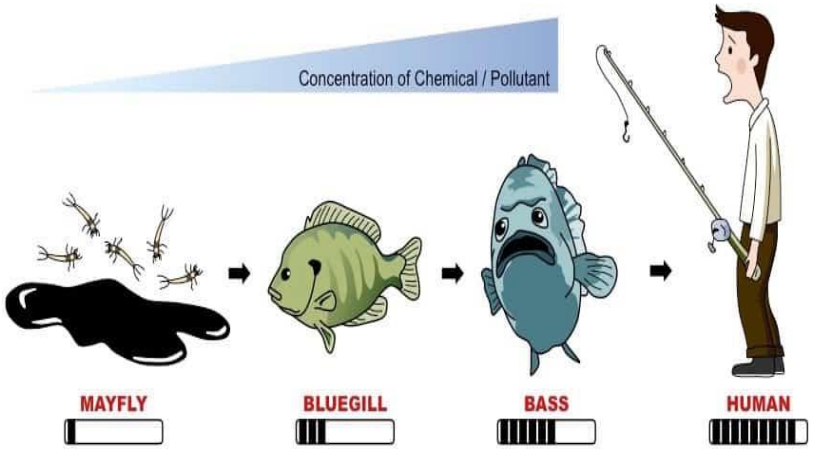
Contaminants

- Lubricants
- Cleaners
- Sanitizers
- Paints
- Refrigerants
- Water or steam treatment chemicals
- Pest control chemicals

From packaging materials

Plasticizers
Vinyl chloride
Printing/coding inks
Adhesives
Lead
Tin

Many contaminants accumulate in the edible fatty tissues of fish. Concentrations of these contaminants can **vary considerably in individual fish of the same species from the same location**, depending on factors such as their **fat content, size, age, and sex**



Components or extract may contain higher or lower concentrations of environmental chemical contaminants and pesticides than the whole fish from which it was derived.
For example, organochlorine contaminants, such as PCBs, are oil soluble.

ENVIRONMENTAL CHEMICAL HAZARDS

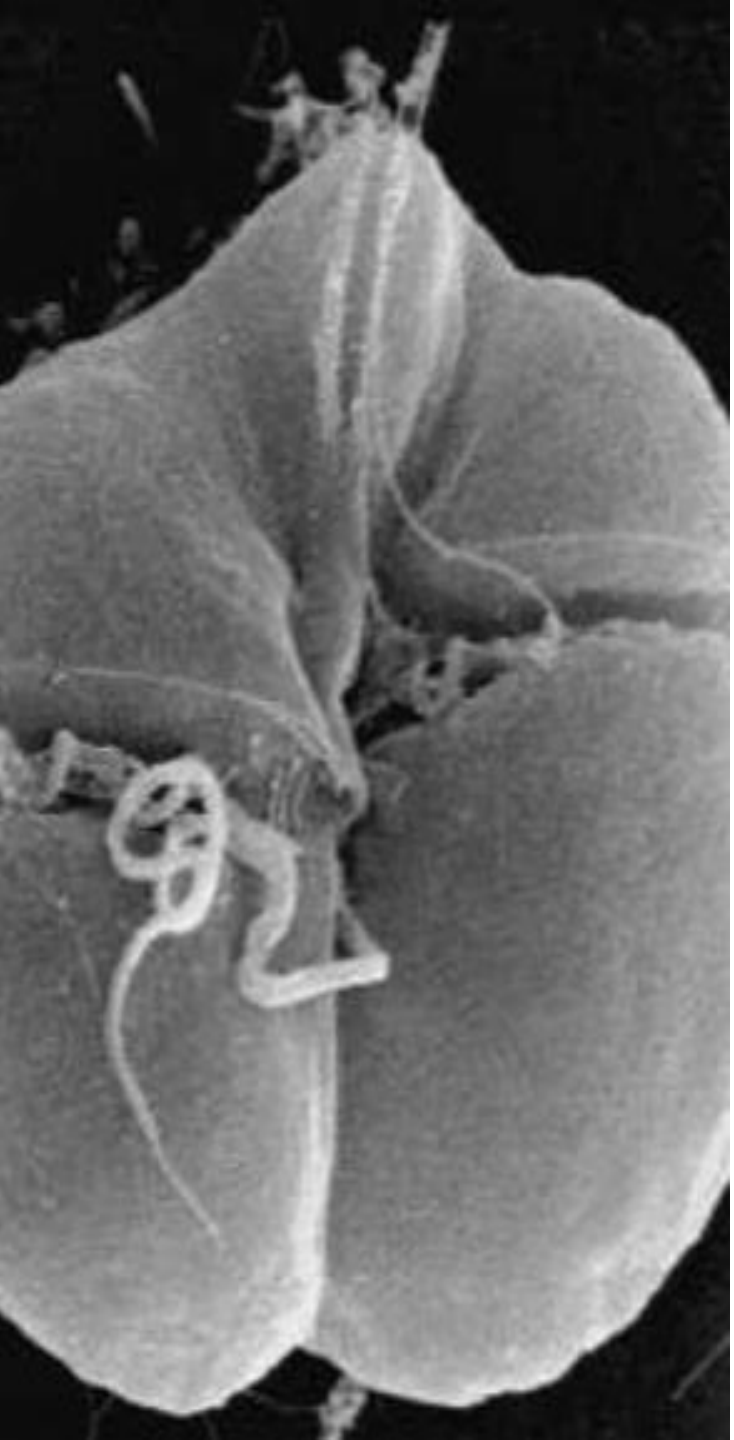
- Herring
- Alligator
- Amberjack
- Barracuda
- Barramundi
- Basa
- Bass
- Bonito
- Bream
- Buffalofish
- Butterfish
- Carp
- Catfish
- Char
- Cisco
- Croaker
- Drum
- Eel
- Flounder
- Goby
- Grouper
- Herring
- Mullet
- Pangasius
- Perch
- Chad
- Salmon
- Silverside
- Skate
- Sturgeon and caviar
- Tilapia
- Trout

https://www.fda.gov/food/seafood-guidance-documents-regulatory-information/fish-and-fishery-products-hazards-and-controls

NATURAL TOXINS

SIX RECOGNISED NATURAL TOXIN POISONING SYNDROMES (**MARINE ONLY**)

- AMNESIC SHELLFISH POISONING (ASP)
- AZASPIRACID SHELLFISH POISONING (AZP)
- CIGUATERA FISH POISONING (CFP)
- DIARRHETIC SHELLFISH POISONING (DSP)
- NEUROTOXIC SHELLFISH POISONING (NSP)
- PARALYTIC SHELLFISH POISONING (PSP)



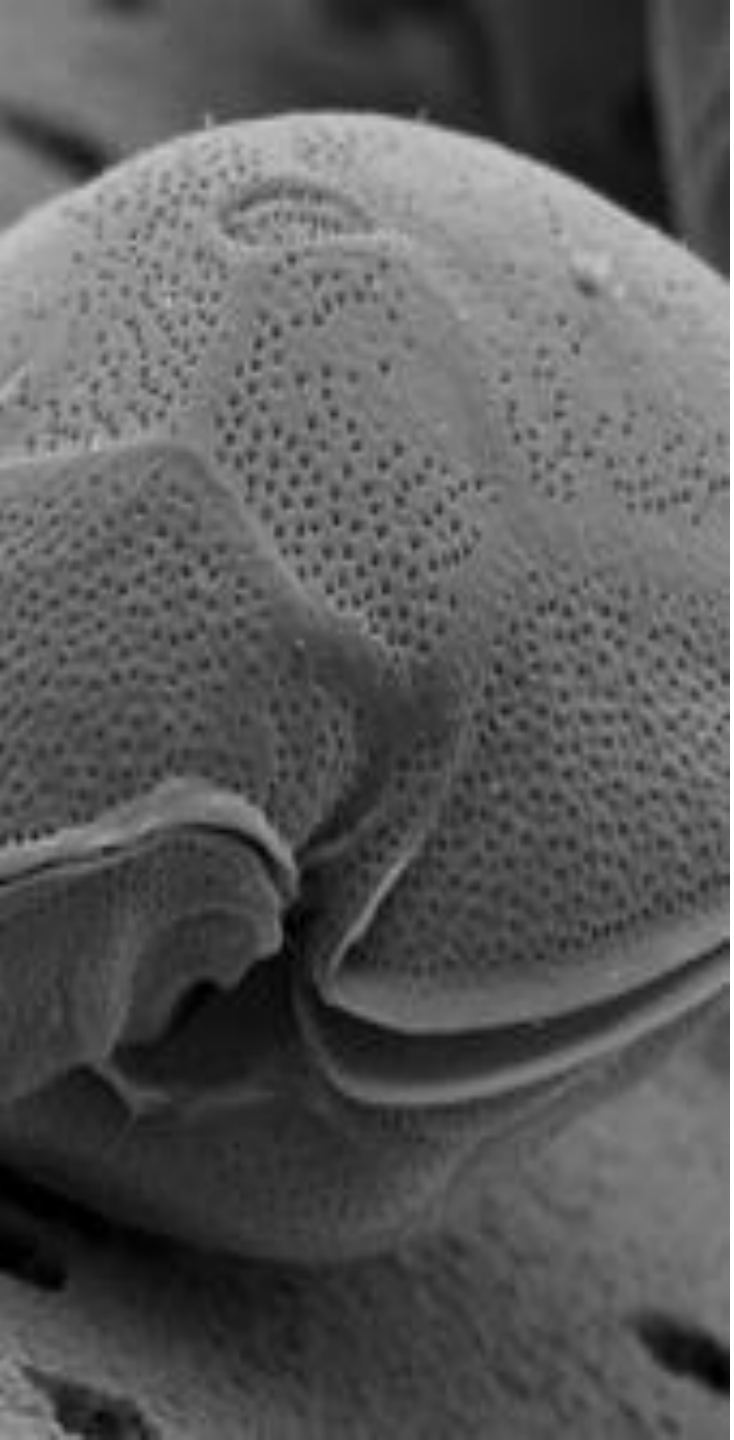
Marine biotoxins

Shellfish toxins:

- **Paralytic** shellfish poisonings (PSP): Marine dinoflagellates of the *Gonyaulax* species
- **Diarrhetic** shellfish poisoning (DSP) e.g.okadaic acid; species *Dinophysis* and *Prorocentrum*.
- **Neurotoxic** shellfish poisoning (NSP); brevetoxins produced by the dinoflagellate *Karenia brevis*;
- **Amnesic** shellfish poisoning (ASP) domoic acid; produced by the diatom *Nitzschia pungens*

Pathology of shellfish poisons

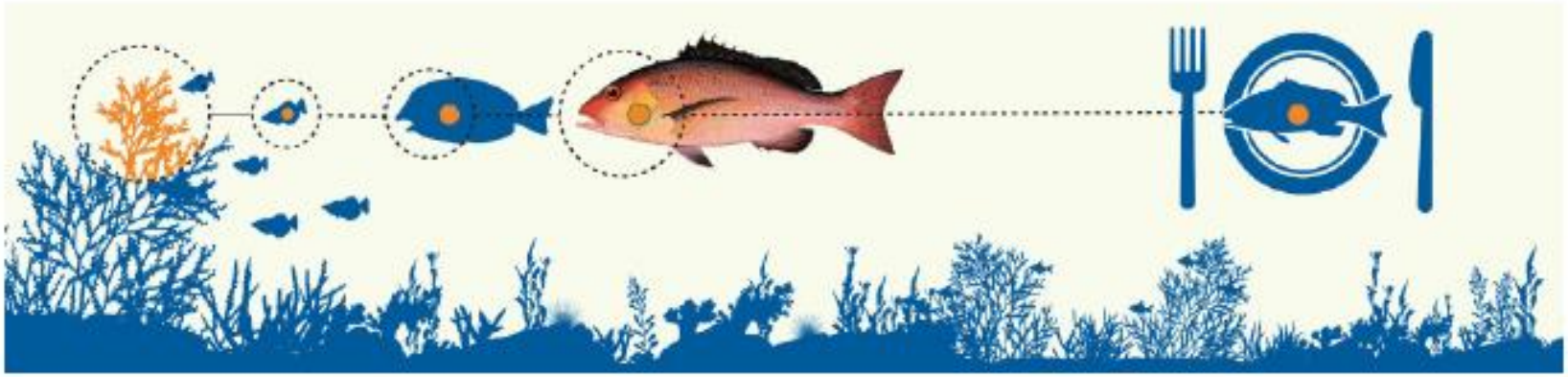
- Affects filter feeding shellfish and browsing/carnivorous gastropods/echinoderms (e.g. conch, whelk and abalone)
- Cumulative over time
- Levels not affected by depuration for bacterial safety
- Heat stable (toxicity not affected by cooking)
- No change in organoleptic characteristics
- Control by:
  - Defining harvest areas
  - Monitoring phytoplankton levels and species in seawater
  - Monitoring toxicity of shellfish (bioassay, HPLC, GLC)
  - Closure of the area
- Most authorities set limits on content



Ciguatera

- *Gambierdiscus toxicus* a tropical marine benthic dinoflagellate, growing on the surface of dead coral and on macro algae
- Ciguatoxin: lipid-soluble, membrane depolarization induces respiratory arrest
- lethal does 0.45 µg/kg in mice
- Oral intake of as little as 0.1µg ciguatoxin can cause illness in human
  - Bio-accumulation in food chain and in human body
  - Range of neurological symptoms; respiratory, muscular, sensory, often prolonged over years

Changes in coral reefs



Proliferation of toxic dinoflagellates → Toxic dinoflagellates eaten by small herbivorous fish → Small fish eaten by larger carnivorous fish → Fish eaten by human

The toxic dinoflagellates, mainly *Gambierdiscus*, can produce Ciguatoxins (CTXs)

Ciguatera fish poisoning (CFP)

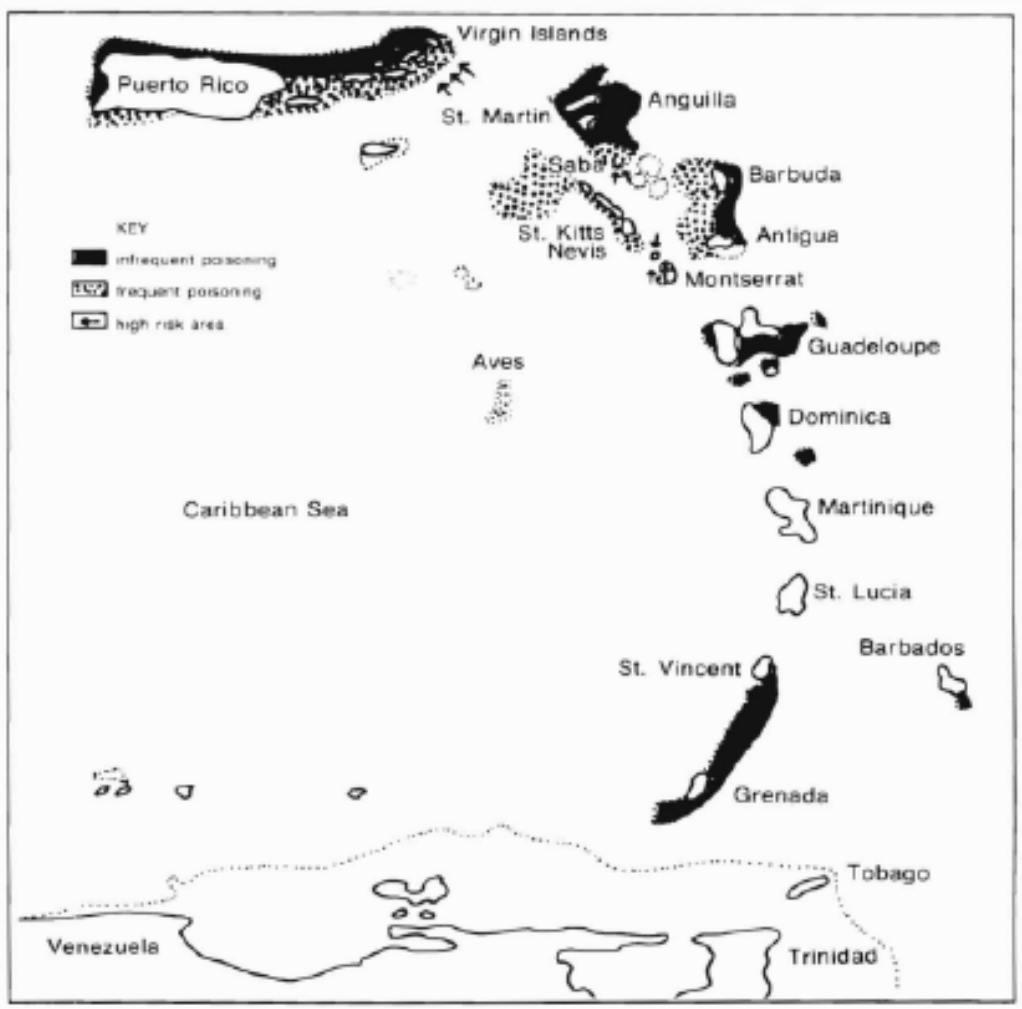


FIGURE 2: DISTRIBUTION OF CIGUATERA IN THE CARIBBEAN

Source: Ciguatera in the Eastern Caribbean David A. Olsen, David W. Nellis, And Richard S. Wood, Marine Fisheries Review, 46(1), 1984

Reproduced from: Guide to Food Safety Hazards in Caribbean Fishery Products CRFM Special Publication. No.11. 34pp.

Ciguatera increase prompts alert in British Virgin Islands

By News Desk on June 16, 2021

Authorities in the British Virgin Islands have issued a warning after a surge in Ciguatera fish poisoning (CFP) within the past few weeks.

Cases until the week of June 6 were sporadic, but within three weeks there have been eight confirmed infections with other suspected cases also being investigated.

National Epidemiologist Harmony Massiah said CFP is not uncommon in tropical and sub-tropical areas and is mainly associated with consumption of big coral reef fish like snapper, bass and perch that have accumulated ciguatoxin in the body.

Heavy metals in fishery products - Hg

- Methylmercury [CH3Hg]+
- Non-organic Hg is not generally toxic.
- Bio-accumulates
- Sources:
  - industrial processes
  - burning of fossil fuels (e.g.coal) and incinerators
  - natural sources such as volcanoes, forest fires and mercury-bearing rocks
- Highest levels in flesh of certain large pelagic fishes such as tunas, sharks and swordfishes
- Limits 0.5 ppm (except for certain species 1.0 ppm)

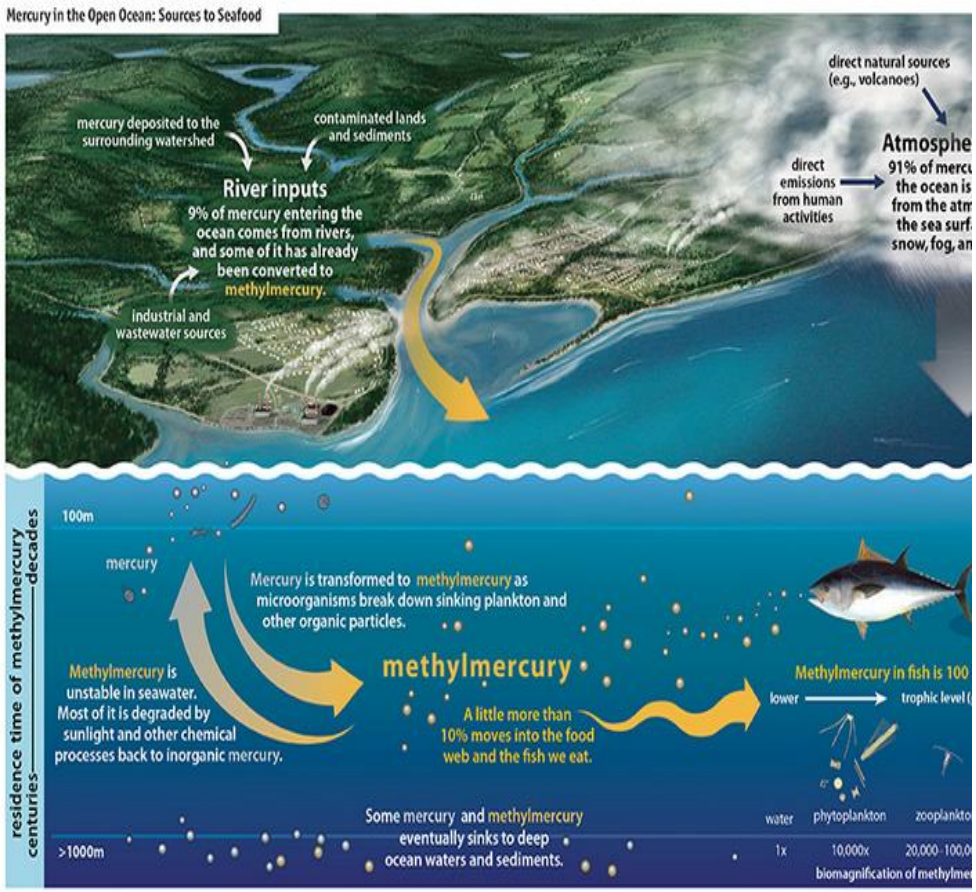


TABLE 6: EU MAXIMUM LIMITS OF MERCURY ALLOWED IN FISH FOR HUMAN CONSUMPTION

Substrate	Maximum Limit (ppm) Mercury
Muscle meat of all fish except where indicated below:	0.5
Little tuna (*Euthynnus* spp.) Marlin (*Makaira* spp.) Sail fish (*Istiophorus platypterus*) Rays (*Raja* species) Shark and dogfish (all species) Tunas (*Thunnus* spp, and *Katsuwonus pelamis*) Bullet tuna *(Auxis species)* Swordfish (*Xiphias gladius*)	1.0
Crustaceans (excluding brown meat of crabs and thorax meat of lobsters of the genus *Palinuridae*)	0.5
Bivalve Molluscs	0.5
Cephalopods (without viscera)	0.5

Source: Commission Regulation (EC) No 1881/2006 of 19 December 2006

Cadmium – Cd in fishery products

- By-product from mining, smelting, and refining sulfide ores of zinc
- Widely distributed in the earth's crust, present naturally in seawater
- Bio-accumulates
- Highest levels in flesh and viscera of crustaceans and cephalopod molluscs, also and in the flesh of certain large pelagic fishes such as tunas, sharks and swordfishes
- Limits 0.05 ppm (except certain species up to 1.0 ppm)

TABLE 7: MAXIMUM LIMITS OF CADMIUM ALLOWED IN FISH FOR HUMAN CONSUMPTION

Substrate	Maximum Limit (ppm) Cadmium
Muscle meat of all fish except where indicated below:	0.05
Mackerels (Scomber spp) (*Thunnus species*, *Katsuwonus pelamis*, *Euthynnus species*),	0.1
Bullet tuna *(Auxis species)*	0.15
Swordfish (*Xiphias gladius*)	0.25
Crustaceans (excluding brown meat of crabs and thorax meat of lobsters of the genus *Palinuridae*)	0.5
Bivalve Molluscs	1.0
Cephalopods (without viscera)	1.0

Source: Commission Regulation (EC) No 1881/2006 of 19 December 2006

Lead (Pb) in fishery products

- Sources burning fossil fuels, mining, lead compounds fuel additives (tetra-alkyl lead)
- Not substantially bioaccumulative
- Lead concentrations are usually highest in benthic sessile organisms living close to point sources (pollution)
- Limits 0.3 ppm (except some species up to 1-5 ppm)

TABLE 8: MAXIMUM LIMITS OF LEAD ALLOWED IN FISH FOR HUMAN CONSUMPTION

Substrate	Maximum Limit (ppm) Lead
Muscle meat of all fish except where indicated below:	0.3
Crustaceans (excluding brown meat of crabs and thorax meat of lobsters of the genus *Palinuridae*)	0.5
Bivalve Molluscs	1.5
Cephalopods (without viscera)	1.0

Source: Commission Regulation (EC) No 1881/2006 of 19 December 2006

Heavy metals – control methods

- Cannot reduce heavy metal content
- Main control is to target sizes, species and fishing zones not affected with the hazards
- To allow effective targeting, sampling and testing of fish should include data on:
  - Species
  - Catch location
  - Size
  - Sex

(i.e. traceability)

Carcinogens in smoked fish

- 3,4 benzpyrene is a marker for the occurrence and effect of carcinogenic polycyclic aromatic hydrocarbons (PAH) in smoked foods
- Derived from partial combustion of wood
- Consumption of smoked food implicated in bowel and liver cancer
- Unresearched public health issue in many developing countries

TABLE 11: RISK AND SEVERITY OF HAZARDS IN CARIBBEAN FISHERY PRODUCTS.

		Severity of hazard		
		High	Medium	Low
Probability of occurrence	High	1,2	4,5	
	Medium	3	6	7
	Low			8

1	Histamine in *Scomber, Decapterus* spp., Spanish mackerel *Scomberomorus* spp. *Coryphaena* spp., Carangids, Tunas: *Auxis spp. Thunnus* spp & *Euthynnus* spp
2	Ciguatera in reef fishes
3	Marine biotoxins in shellfish (conch)
4	Mercury in grouper/tunas/sharks
5	Cadmium in demersal fish/lobsters/swordfish
6	Bisulphites in shrimp and lobster
7	Residues of veterinary medicines in farmed shrimp/tilapia
8	Lead in tuna

Physical hazards

PHYSICAL HAZARDS

- Hard or sharp objects that can result in injuries such as:
  - broken tooth;
  - lacerations of the mouth, tongue, throat; intestines;
  - choking.
- Most common items (FDA);
    - Metal (fish-hooks, knife tips)
    - Wood/splinters
    - Glass
    - Plastics
    - Stones
    - Shell/pits

SOURCES AND CONTROL OF POTENTIAL PHYSICAL HAZARDS

- Potential physical hazards in finished products may arise from sources such as:
  - Contaminated raw materials
  - Poorly designed or maintained facilities
  - Faulty procedures during production
  - Improper employee practices
- Certain processes/operations
  - Metal-to-metal contact, e.g. grinding
  - Glass filling operations
  - Fish hooks, knives
- Control via GMPs/metal detection/X ray

SGR 129

Fish and Fishery Products Hazards and Controls Guidance

Fourth Edition – MARCH 2020

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
CENTER FOR FOOD SAFETY AND APPLIED NUTRITION
OFFICE OF FOOD SAFETY

http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm2018426.htm

HAZARD ANALYSIS WORKSHEET					
FIRM NAME:			PRODUCT DESCRIPTION:		
FIRM ADDRESS:			METHOD OF DISTRIBUTION AND STORAGE:		
			INTENDED USE AND CONSUMER:		
(1)	(2)	(3)	(4)	(5)	(6)
INGREDIENT/PROCESSING STEP	IDENTIFY POTENTIAL BIOLOGICAL, CHEMICAL, AND PHYSICAL HAZARDS ASSOCIATED WITH THIS PRODUCT AND PROCESS	ARE ANY POTENTIAL FOOD SAFETY HAZARDS SIGNIFICANT AT THIS STEP? (YES/NO)	JUSTIFY YOUR DECISION FOR COLUMN 3	WHAT PREVENTIVE MEASURE(S) CAN BE APPLIED FOR THE SIGNIFICANT HAZARDS?	IS THIS STEP A CRITICAL CONTROL POINT? (YES/NO)