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- MEP&M -

Know-how transfer related to the latest topics in climate change and marine pollution effects on marine ecosystems (dev.3.4.2)

SEAFOOD SAFETY : HAZARDS AND RISK ANALYSIS

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ECOSEAS
ECOLOGY AND CONSERVATION SCIENCE FOR SUSTAINABLE SEAS

RÉPUBLIQUE FRANÇAISE
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Virtual meeting via Zoom application

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Project no. 619239-EPP-1-2020-1-ME-EPPKA2-CBHE-JP

Seafood

Includes fish and shellfish


finfish


crustaceans


cephalopods


echinoderms


Bivalve molluscs


Gastropods molluscs

Activities

- Seafood farming and aquaculture
- Land based seafood processing
- Fishing vessels
- Vessels processing seafood at sea

Hazard related to food safety

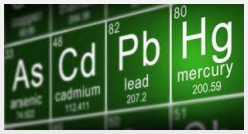
A hazard is conditions or contaminants that can cause illness or injury.

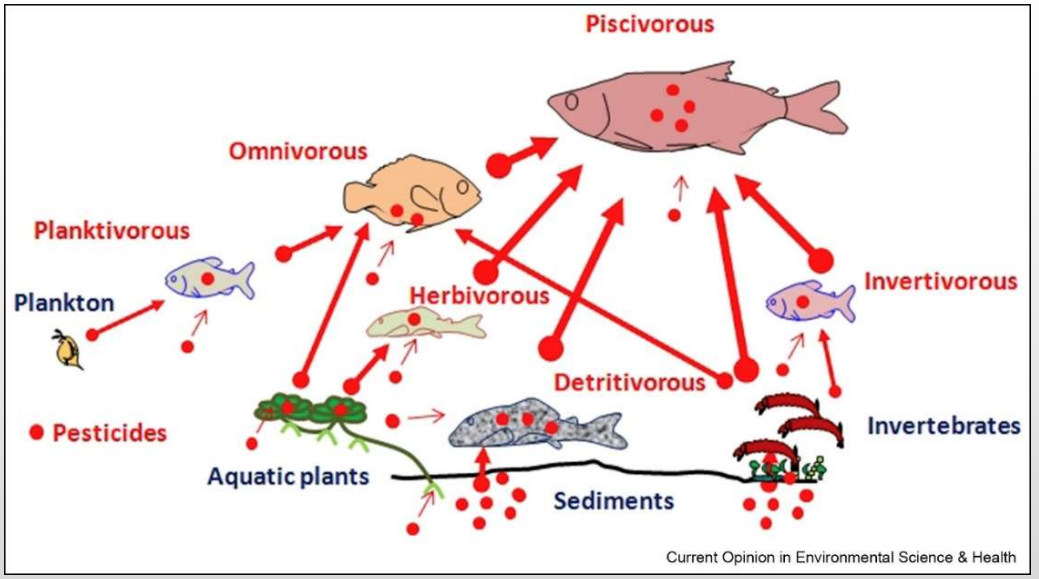
Contaminant : Any biological or chemical agent, foreign matter or other substances not intentionally added to food that may compromise food safety or suitability.

Chemical contaminants

Any substance, either natural or synthetic, that can affect live fish, their pathogens, the water, the equipment used for production or the land within the aquaculture establishment

- Pesticides
- Herbicides
- Algicides
- Fungicides
- Antioxidants
- Heavy metals
- Organochlorides
- Fertilizers (Nitrates, phosphates)
- Biotoxins
- Petrochemical substances
- Nanoparticules (plastics, …)

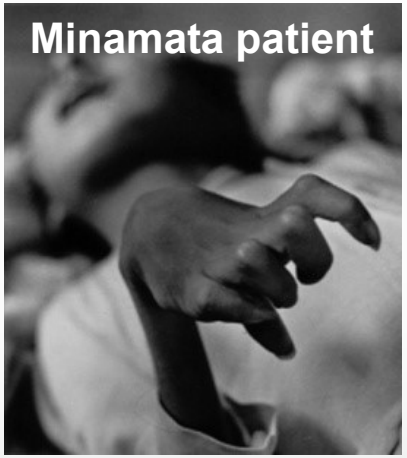




Perez Prada et al, 2018

Methyl mercury $[CH_3Hg]^+$

Photos, William Eugene Smith, 1970



Between 1932 and 1968 Chisso plant released methyl mercury contaminated industrial waste that accumulated in seafood. 2265 cased of Minamata disease, 1784 died (skeletomuscular deformity, loss of motor function, of vision, hearing, speech capability, insanity, paralysis, coma and death

Mercury Levels in Ahi Tuna Rise Four Percent Each Year

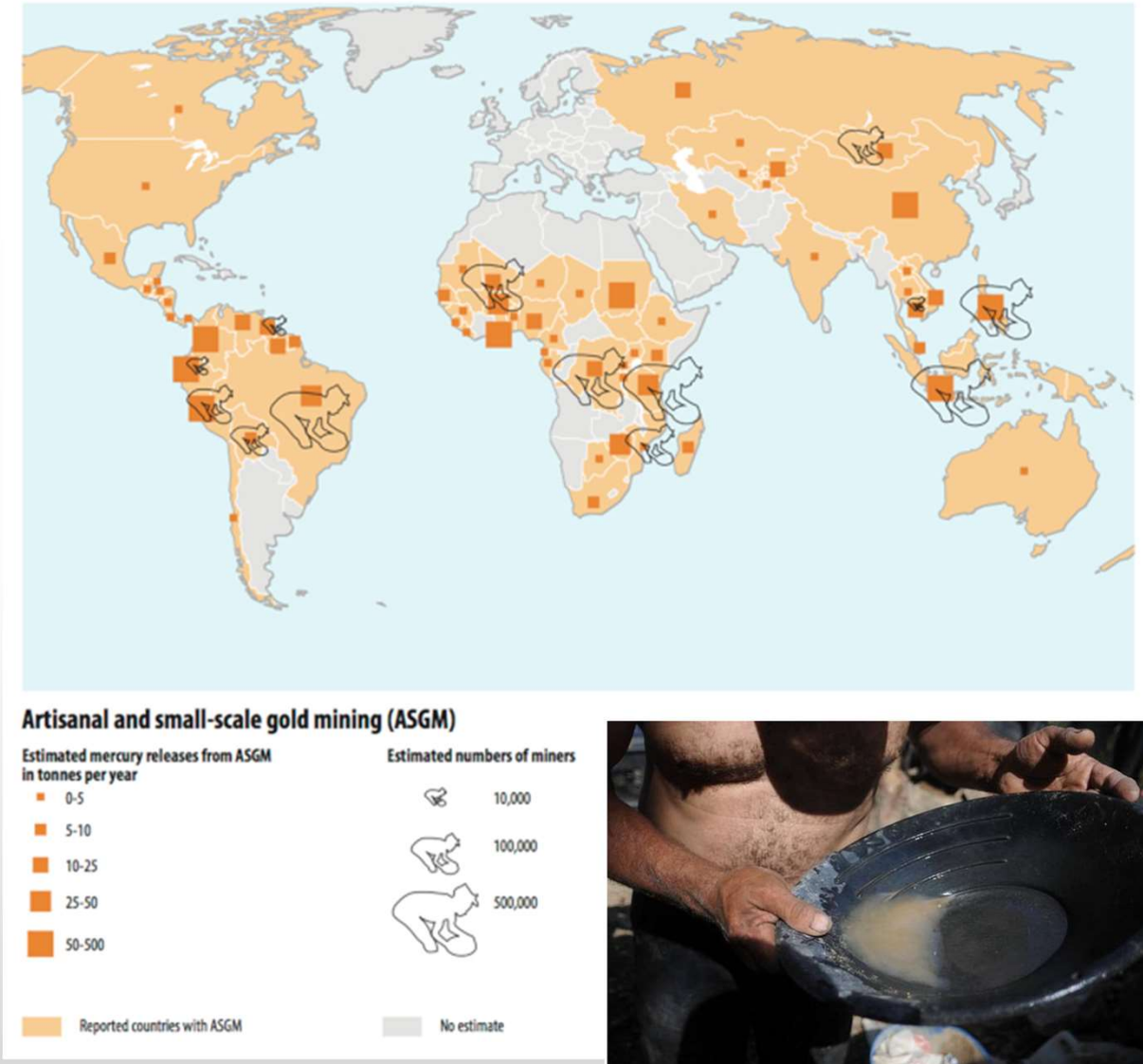
BY DOUGLAS MAIN ON 2/2/15 AT 8:32 PM EST

08-07-2019

Warming temperatures are causing an increase in toxic methylmercury

Mining

- Much of the mercury found in the environment comes from human activities such as artisanal gold mining or coal combustion
- **Minamata convention** (agreement concluded in writing between States and governed by international law): adopted in 2013, the convention came into force in **2017**. Currently, the Convention has 128 signatories and 107 Parties.

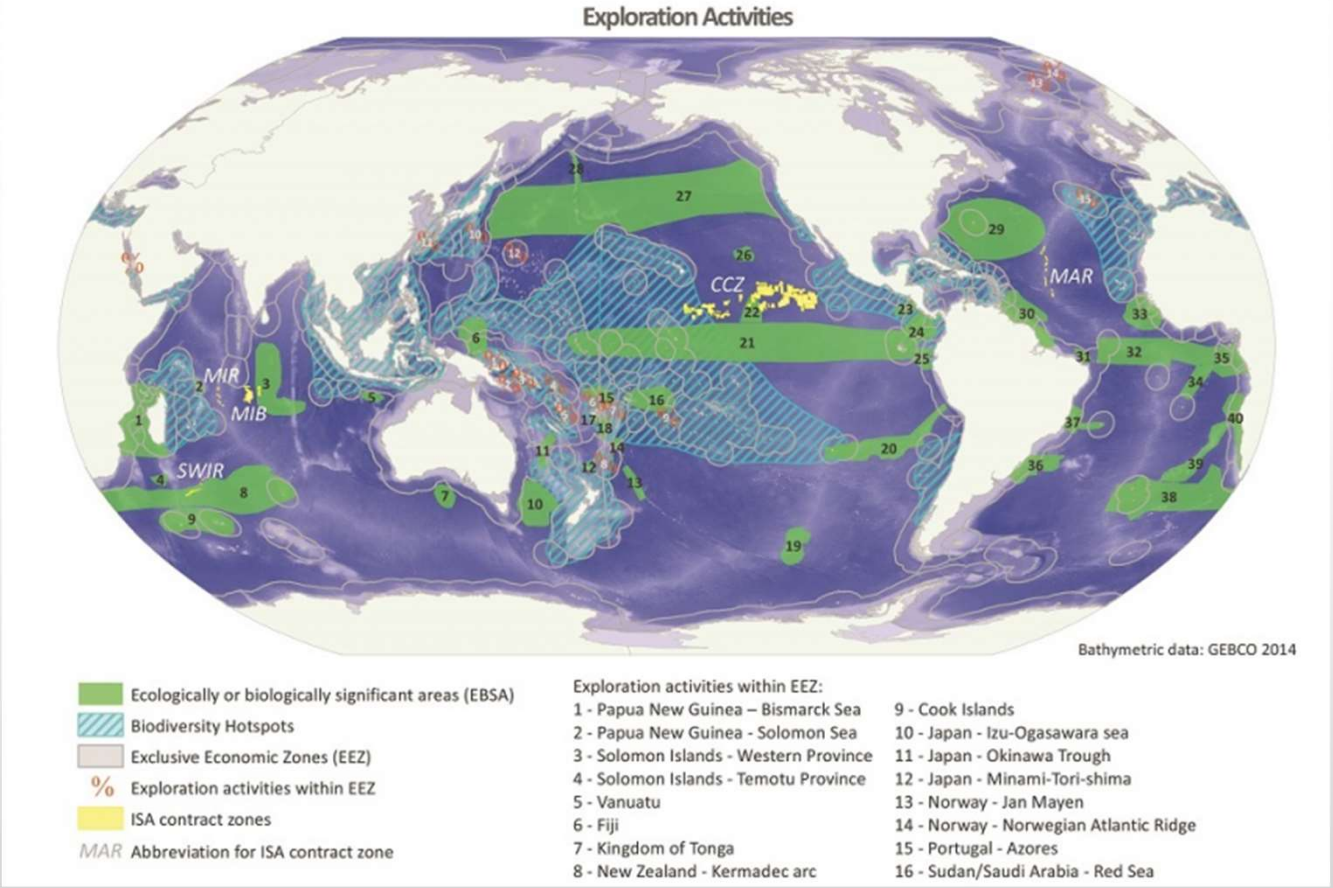


Artisanal gold mining in Latin America uses mercury, a practice that should be modified in countries that have ratified the international Minamata Convention for the control of this toxic metal. Credit: Thelma Mejía/IPS

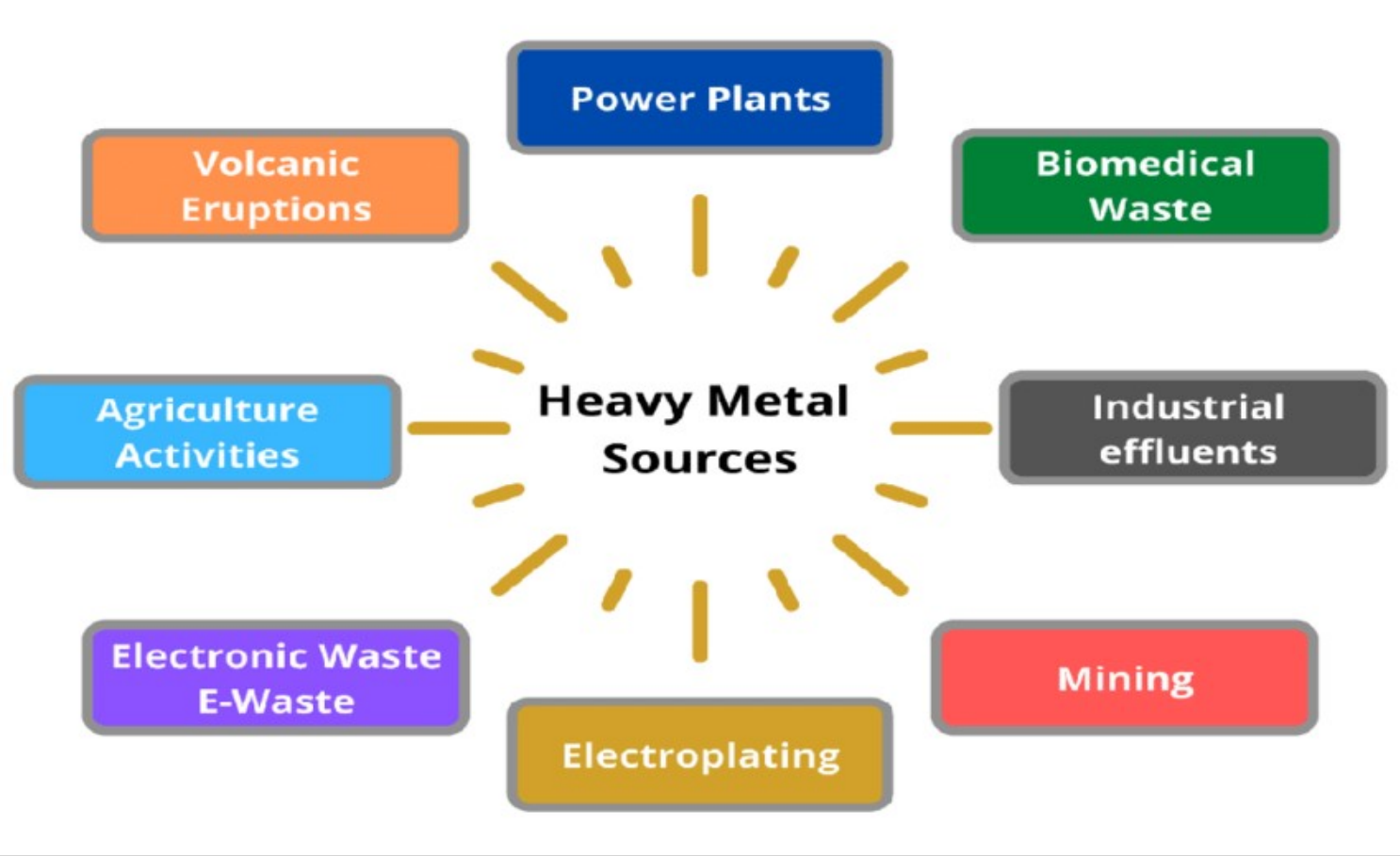
MINAMATA CONVENTION ON MERCURY

Deep see mining

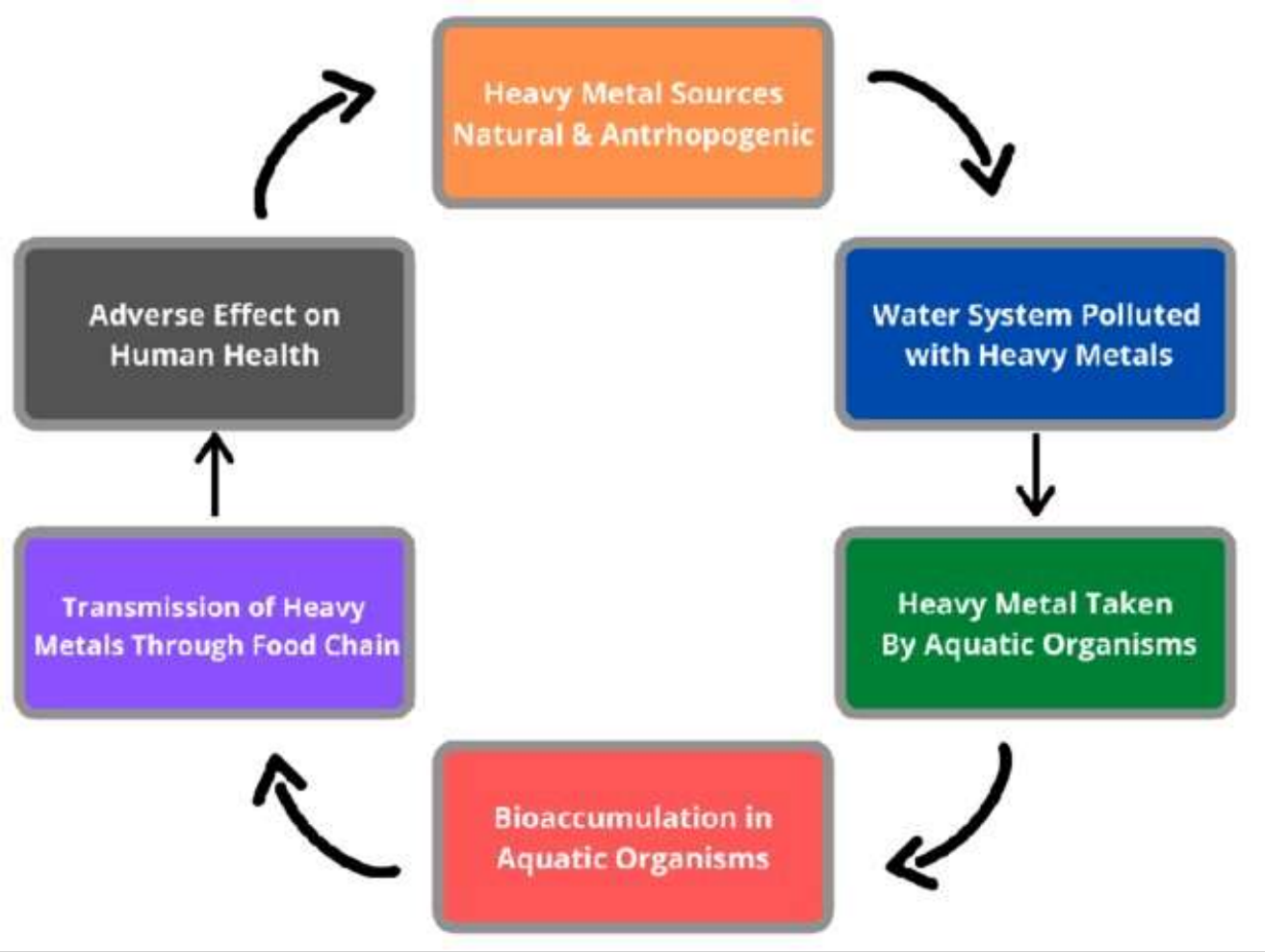
- Retrieving minerals deposits from areas < 200m (65% of earth surface)
- Copper, Nickel, Aluminum, Manganese, Zinc, Lithium, Cobalt (high tech application and green technologies e.g. wind turbine, solar panels, batteries)
- So far, focus has been exploring deep sea (assessing size and extent of deposits)
- By May 2018, the International Seabed Authority (ISA) has issued 29 contracts (1.5 M km²)



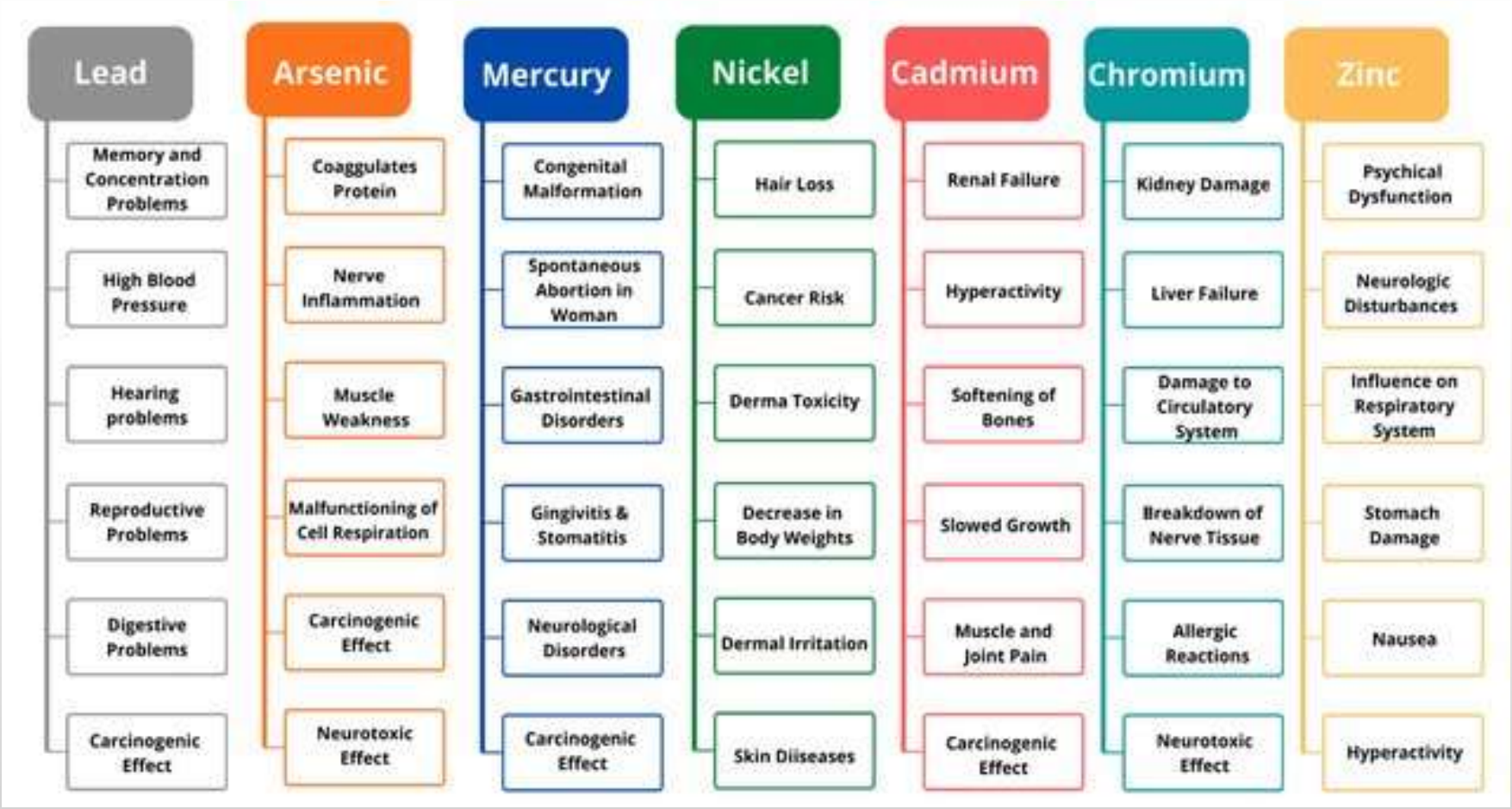
Different sources of heavy metals



Transmission of Heavy Metals through Food Chain.

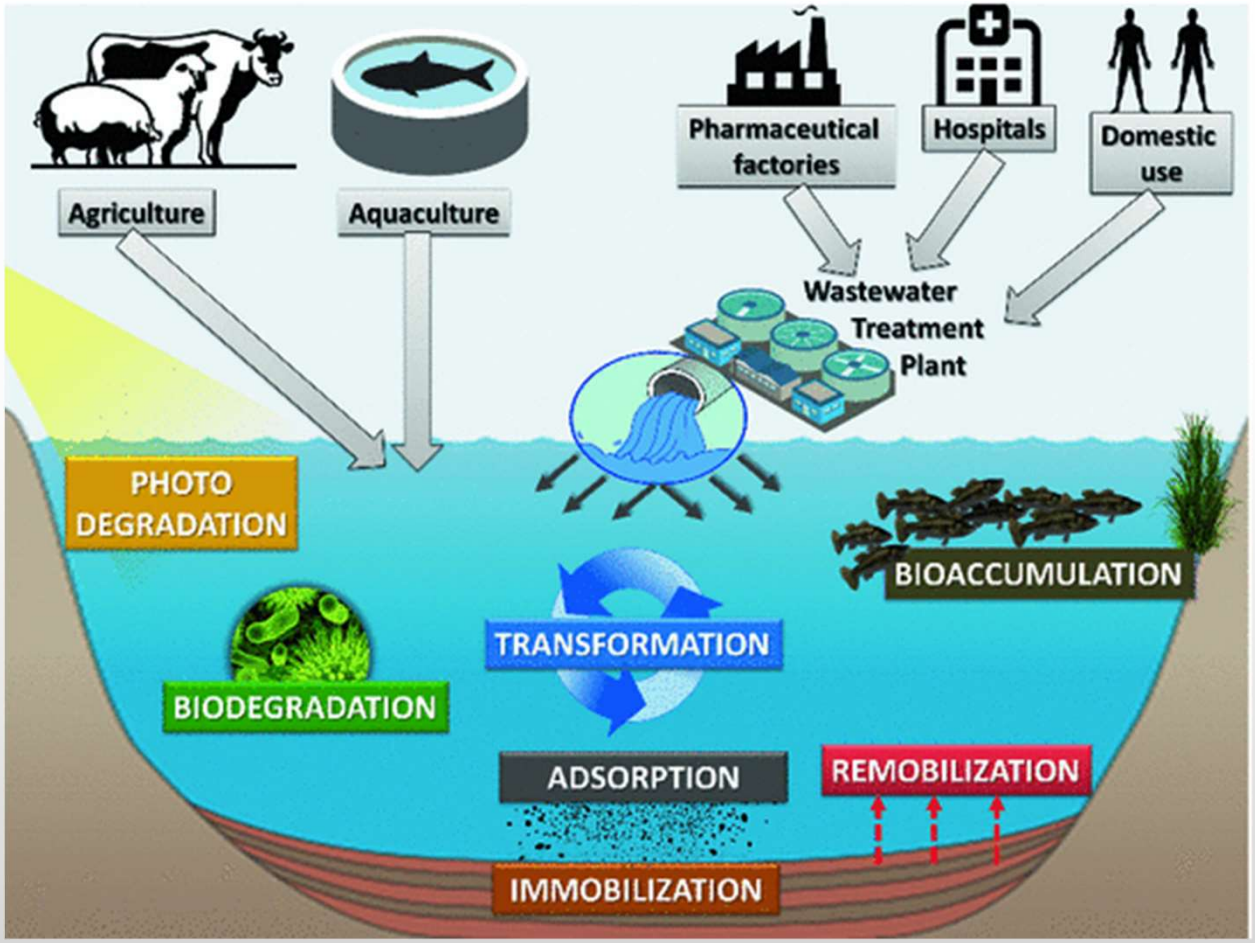


Toxic Effects of Heavy Metals on Human Health.



Veterinary drugs

- Antibiotics
- growth promoters (hormones)
- other veterinary drugs
- feed additives



The main types of pollutants in the Mediterranean sea

- oxygen-depleting substances
- heavy metals
- persistent organic pollutants (POPs)
- Hydrocarbons
- Microorganisms
- nutrients
- marine litter

Figure 119 - Pollution hot spots and areas of environmental concern on the Mediterranean coast
(Source: UNEP/MAP, 2012)

Microbiological/biological contamination

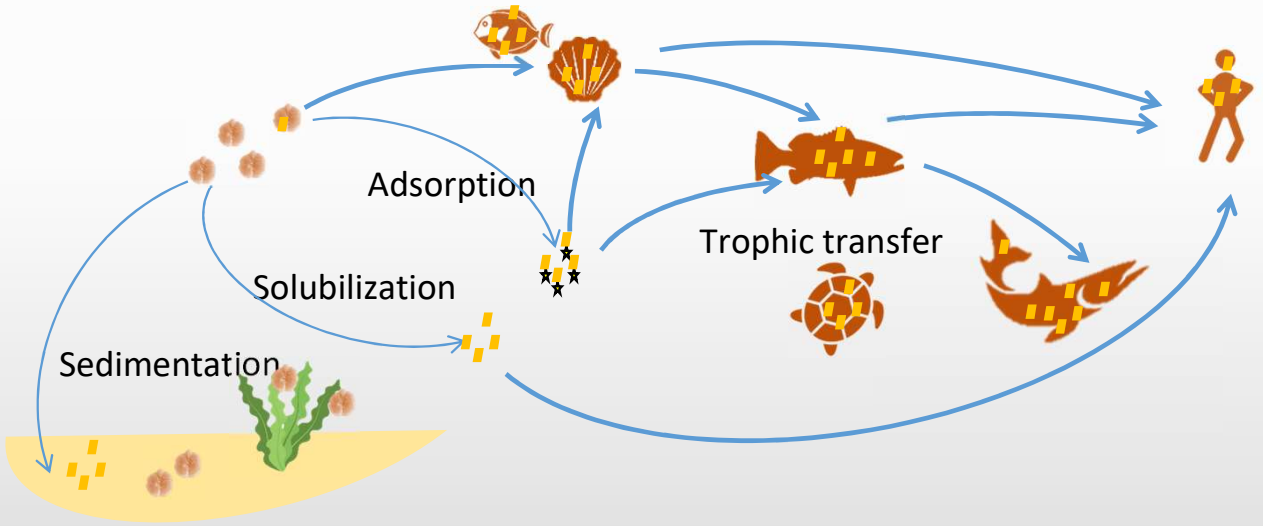
- The presence, introduction, reintroduction, growth and/or survival of pathogens of public health concern
  - Parasites roundworms (nematodes), flatworms or flukes (trematodes) and tapeworms (cestodes).
  - Bacteria
  - Enteric viruses
- Especially when intended to be eaten raw
- From agricultural runoff and/or sewage contamination
  - Enteric bacteria, viral pathogens (e.g. norovirus, viruses causing hepatitis
- Or naturally occurring bacterial pathogens (Vibrio spp.)

Vibrio cholerae
Deadly bacteria that invades the intestinal mucosa and cause diarrhea and vomiting. Causes cholera from the consumption of undercooked or raw marine life species

Biotoxins

Poisonous substances naturally **present or accumulated** in fish and fishery products

- Scombrotoxins (histamine often in spoiled scombroid fish ie tuna, mackerels etc..) produced by bacteria
- Biotoxins associated with harmful algal blooms

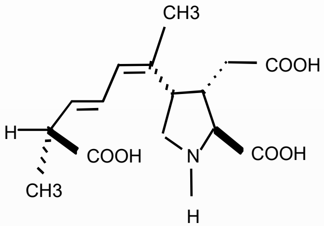


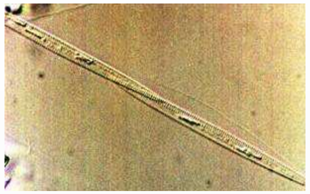
Bioaccumulation (through food or *via* bioconcentration from water)
Bioamplification along the food web

Toxic phytoplankton – Biotoxins – Human syndromes

Domoic Acid *(pseudo-Nitzschia)*

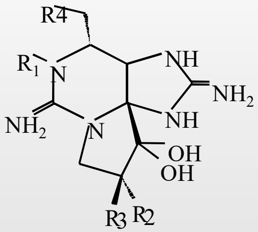
ASP

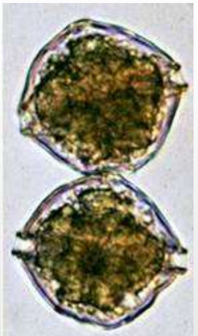




Saxitoxins
(alexandrium)

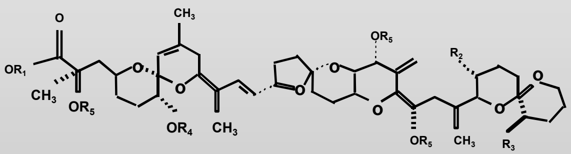
PSP





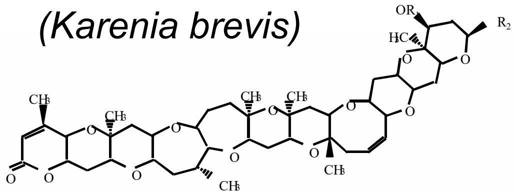
Okadaic Acid
(Dinophysis)

DSP



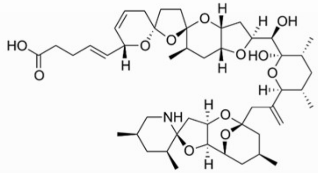
Brevetoxins
(Karenia brevis)

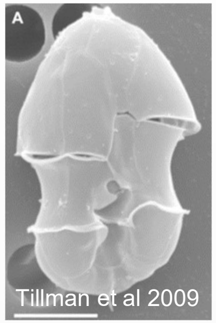
NSP



Azaspiracid
(Azadinium spinosum)

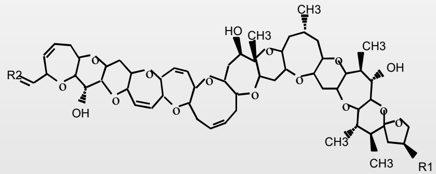
AzaSP

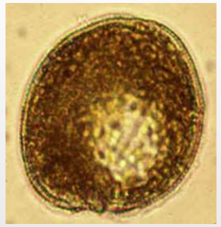




Ciguatoxins
(Gambierdiscus spp)

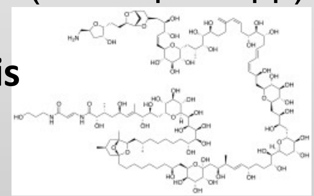
CP



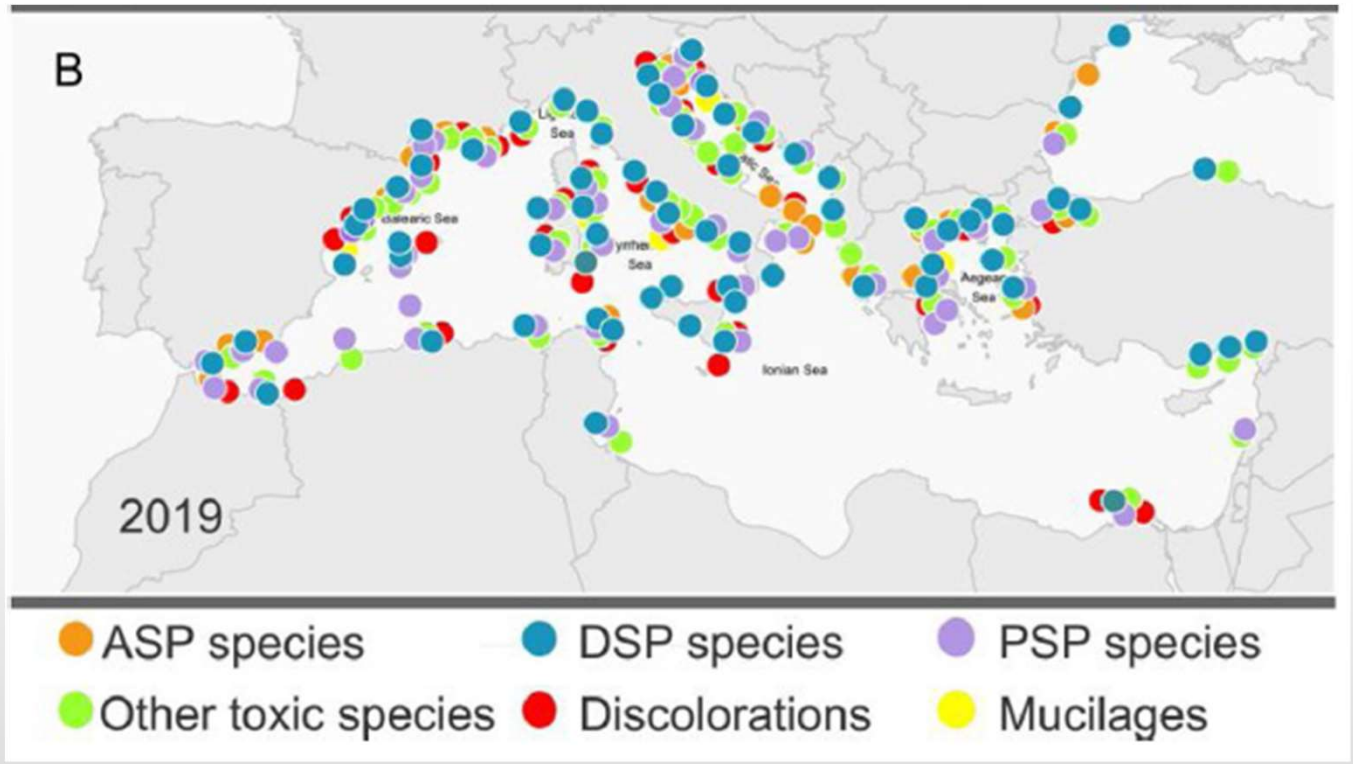


Palytoxins (ovatoxins)
(Ostreopsis spp)

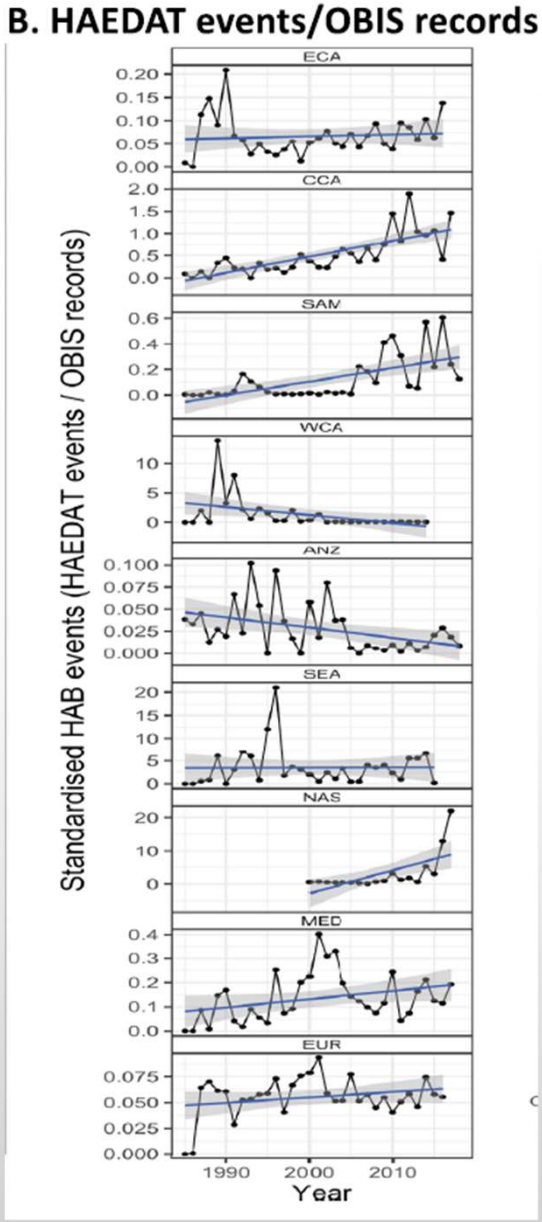
Palytoxicosis



HABss and biotoxins in the Mediterranean sea



Distribution of potentially toxic species, mucilages and discolorations in the Mediterranean Sea.



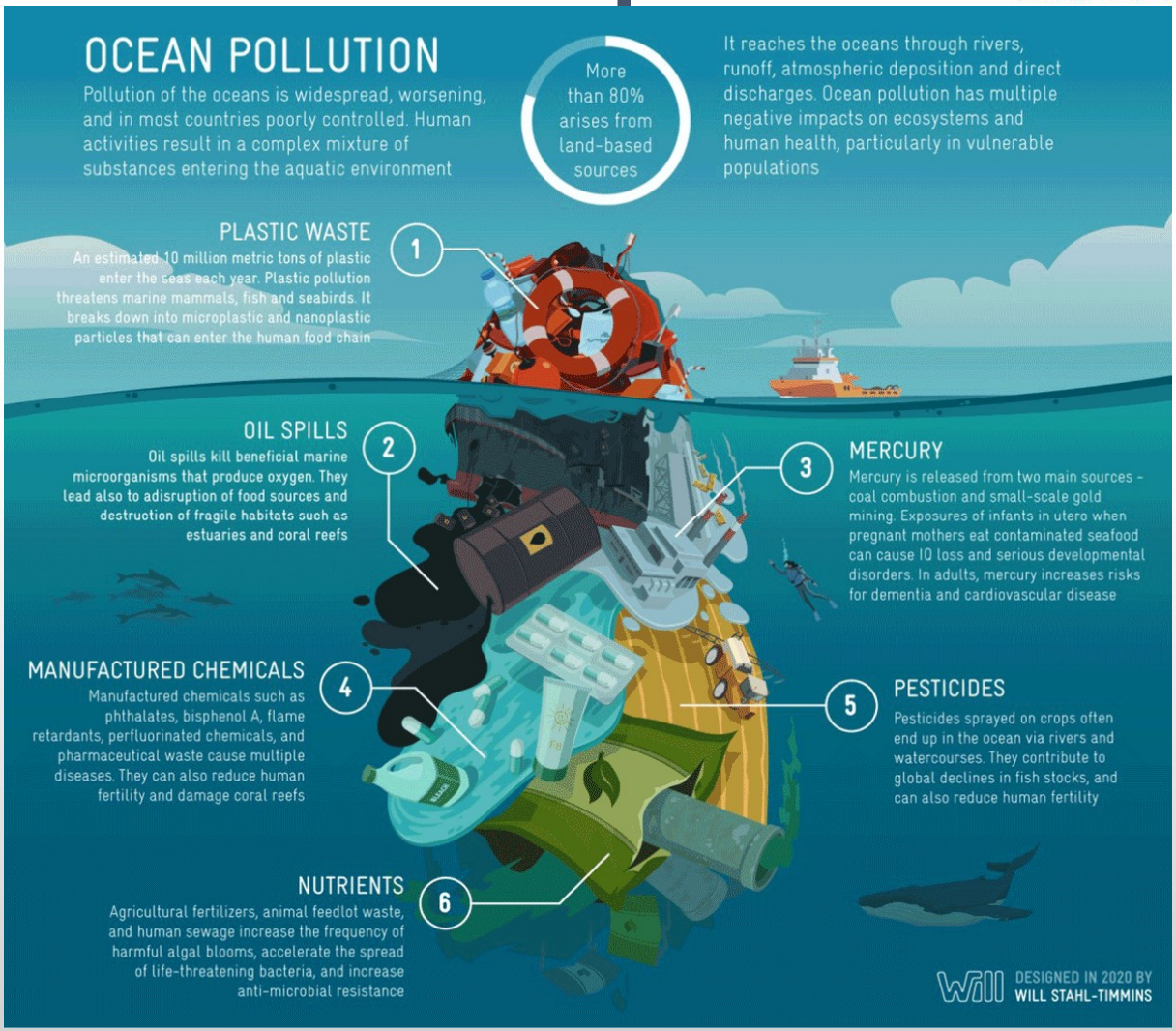
Human health and ocean pollution

Annals of GlobalHealth

Landrigan PJ, et al. Human Health and Ocean Pollution. *Annals of Global Health*. 2020; 86(1): 144, 1–64. DOI: https://doi.org/10.5334/aogh.2831

REVIEW

Human Health and Ocean Pollution



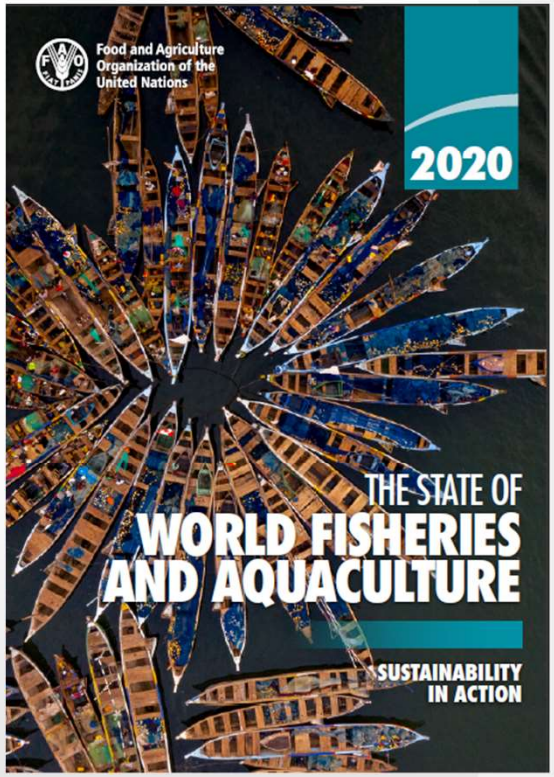
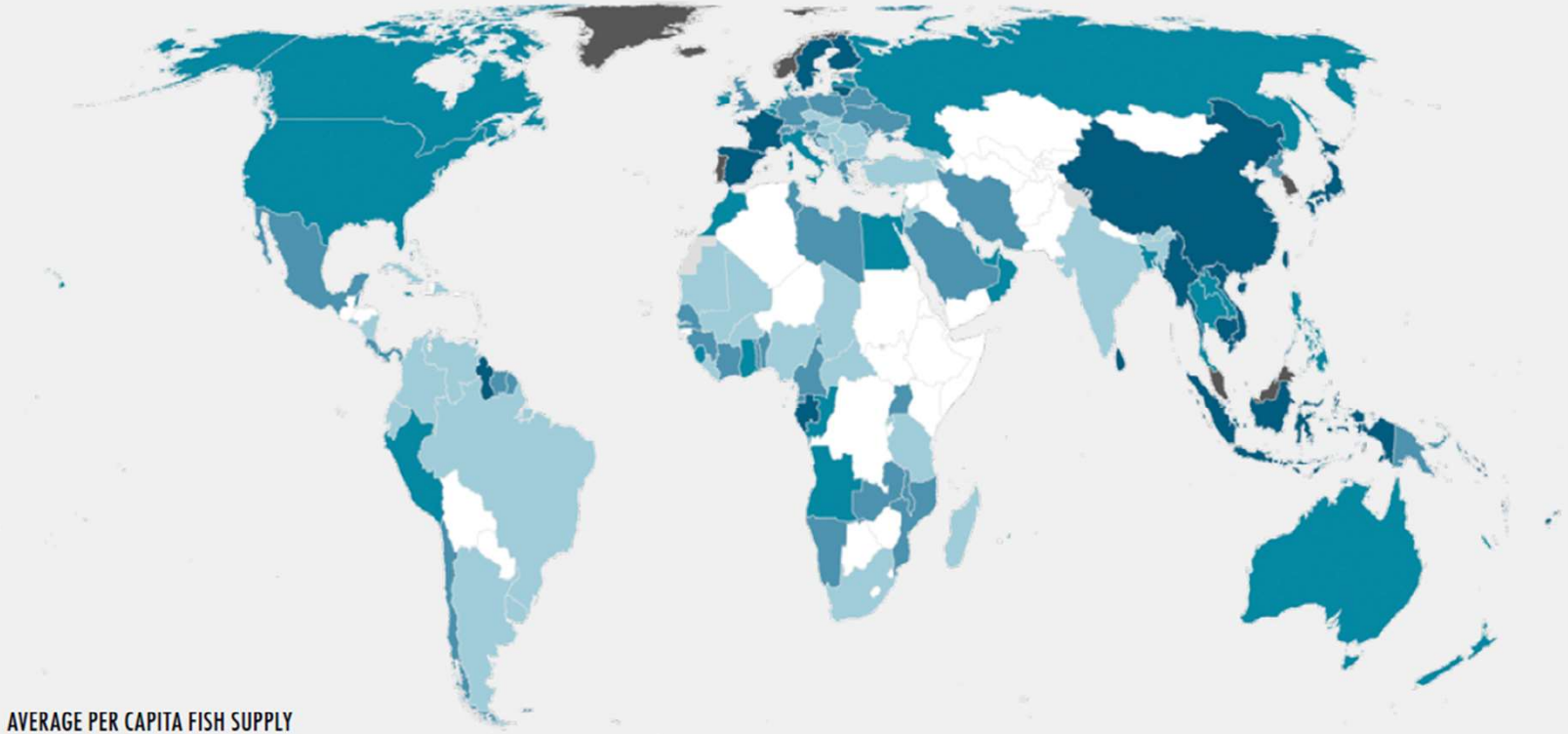


FIGURE 26
APPARENT FISH CONSUMPTION PER CAPITA, AVERAGE 2015–2017



AVERAGE PER CAPITA FISH SUPPLY
(IN LIVE WEIGHT EQUIVALENT)

< 5 kg/year | 5–10 kg/year | 10–20 kg/year | 20–30 kg/year | 30–50 kg/year | > 50 kg/year | No data

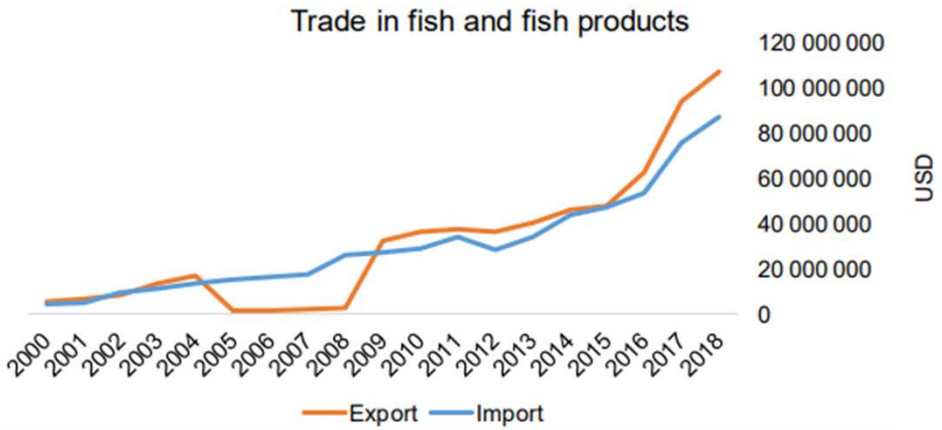
NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.
SOURCE: FAO.

Food and Agriculture Organization of the United Nations

Albania

GLOBEFISH Market Profile - 2018

COUNTRY BRIEF	
Population	Ease of doing business rank
2 884 170	88th
Length of coastline	Exclusive fishing zone
649 km	6 210 km²
Average GDP growth	GDP per capita
4.01%	USD 5 224



GDP from fisheries	Fish available for consumption	Imports of fish and fish products - 2018
N/A	8.6 kg/capita	USD 87 079 005

Agricultural GDP from fisheries	Fishing and aquaculture production		Exports of fish and fish products - 2018
N/A	Total	14 905 tonnes	USD 107 503 003
	Capture	58%	
	Aquaculture	42%	

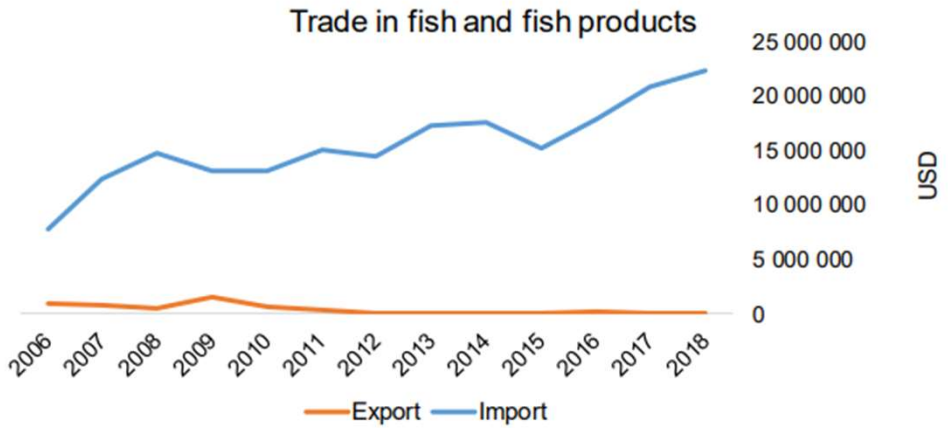
Profile compiled by GLOBEFISH – June 2021

Food and Agriculture Organization of the United Nations

Montenegro

GLOBEFISH Market Profile - 2018

COUNTRY BRIEF	
Population	Ease of doing business rank
627 560	52nd
Length of coastline	EEZ/EFZ
N/A	N/A
Average GDP growth	GDP per capita
7.77%	USD 8 772



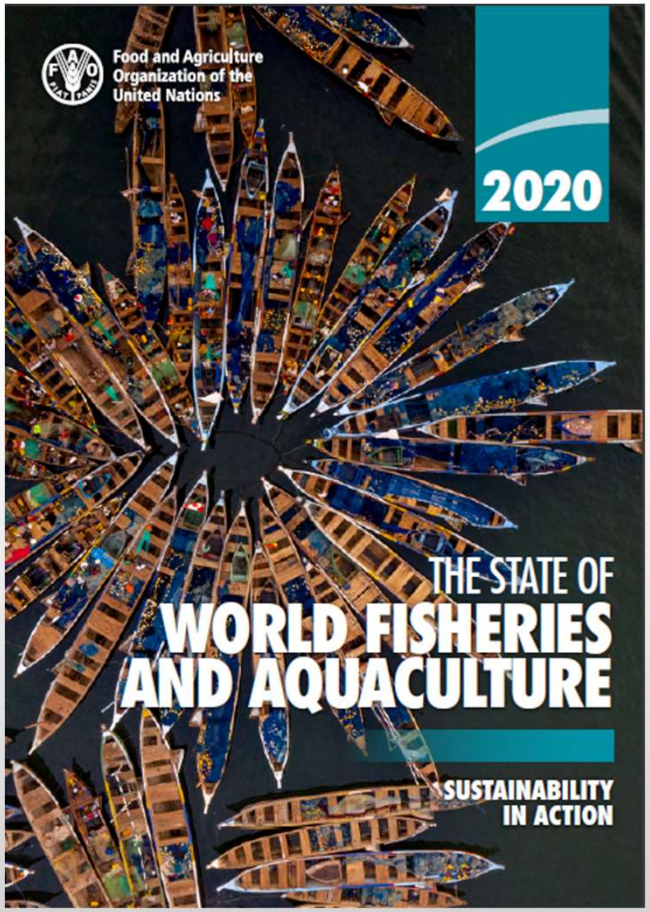
GDP from fisheries	Fish available for consumption	Imports of fish and fish products - 2018
0.00%	14.1 kg/capita	USD 22 424 000

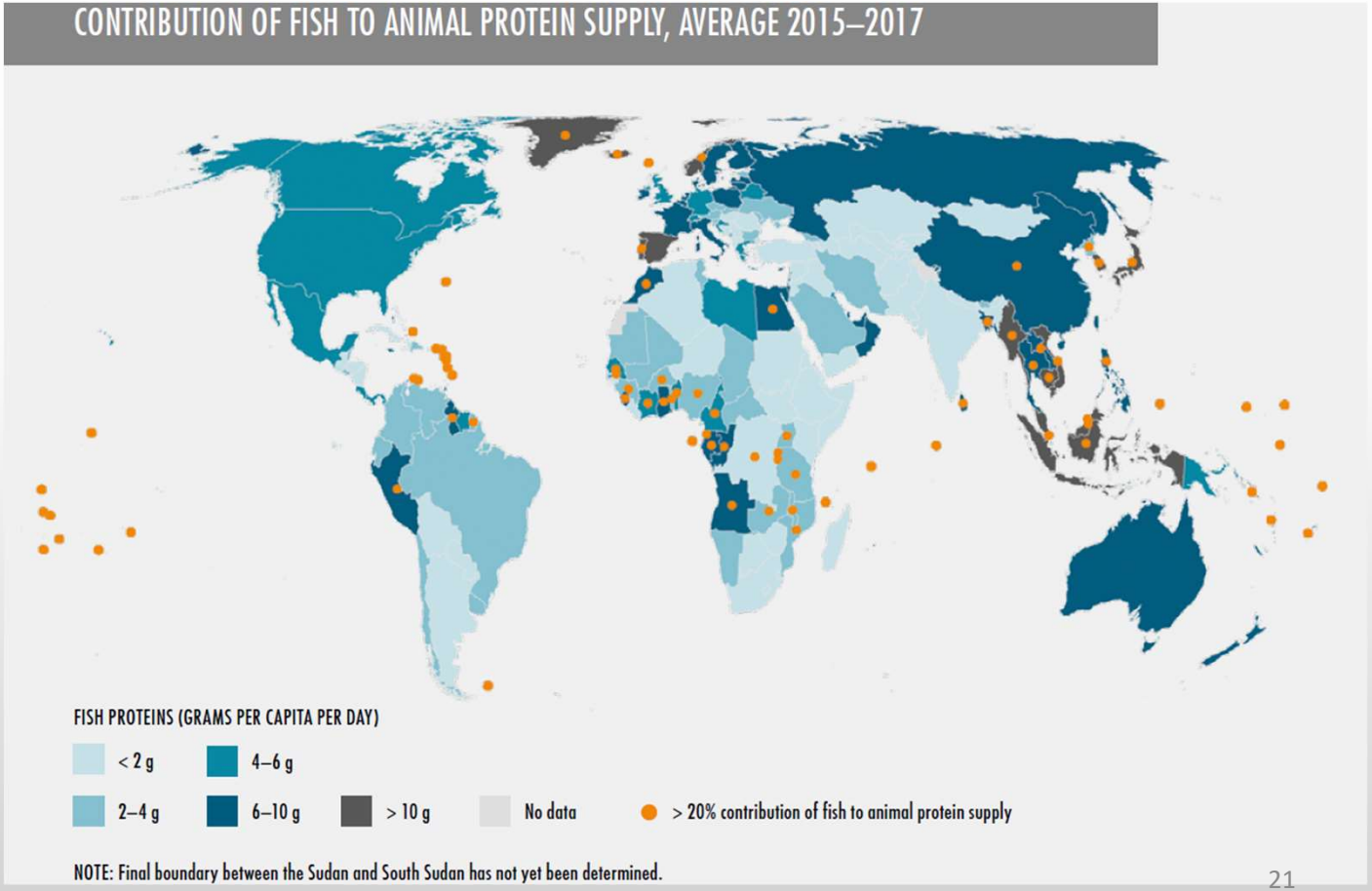
Agricultural GDP from fisheries	Fisheries and aquaculture production		Exports of fish and fish products - 2018
0.01%	Total	2 389 tonnes	USD 65 000
	Fisheries	54%	
	Aquaculture	46%	

Profile compiled by GLOBEFISH – June 2021

Contribution of fish and fisheries to animal protein supply, average 2015–2017

in 2017 fish provided about 3.3 billion people with almost 20 percent of their average per capita intake of animal protein.
Can exceed 50 percent of an adult ’s daily protein requirement in small islands





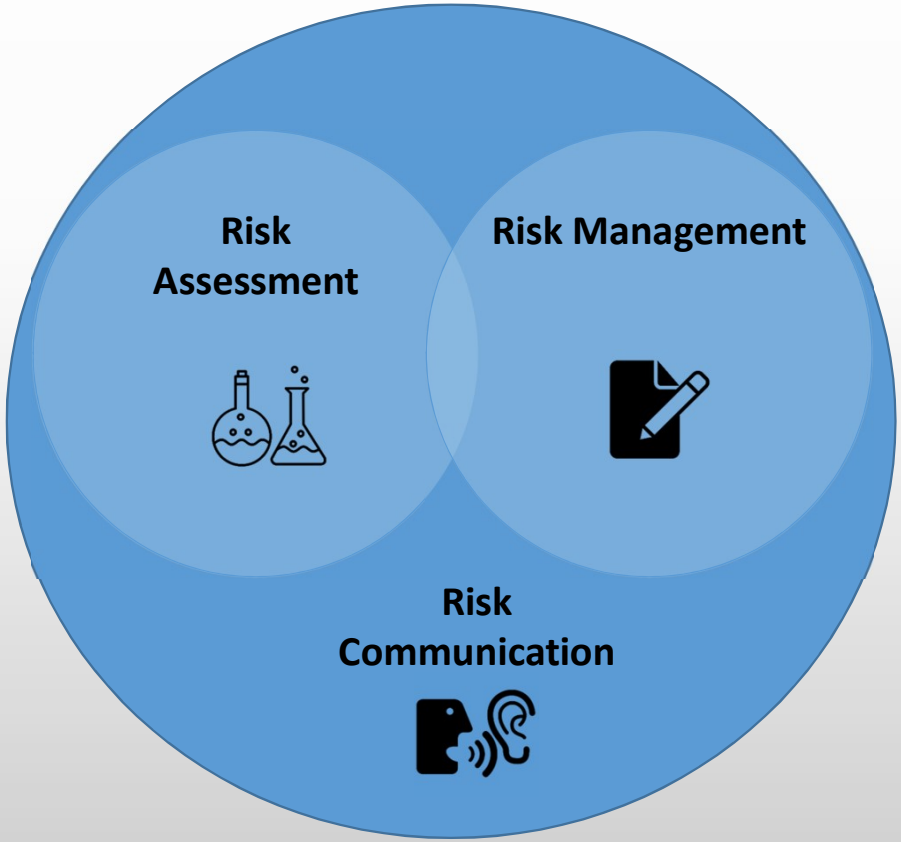
Source: The State of World Fisheries and Aquaculture 2020.

Seafood safety : hazards and risk analysis

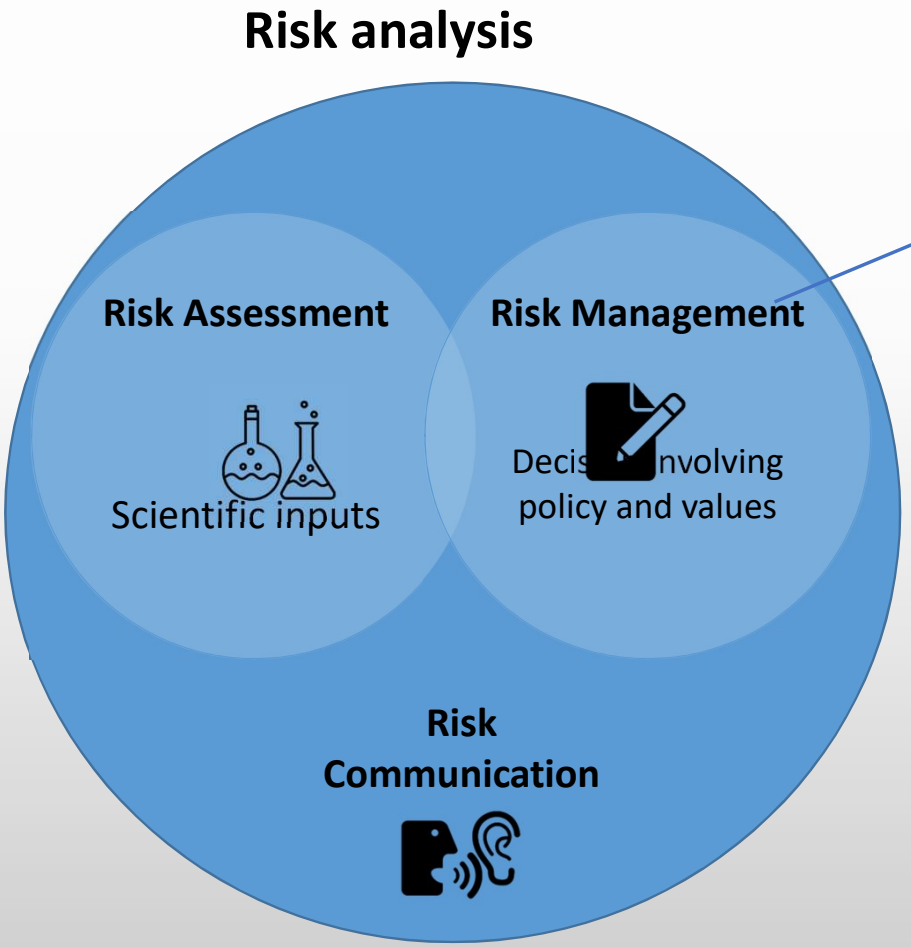
2. Risk analysis

Risk analysis

- The structure of risk analysis makes up the foundation of **sound** food safety practices, decision and policies.
- It is a systematic approach grounded in **science-based** analysis of risk



Risk analysis: systematic processes to ensure health protection and fair trade practices

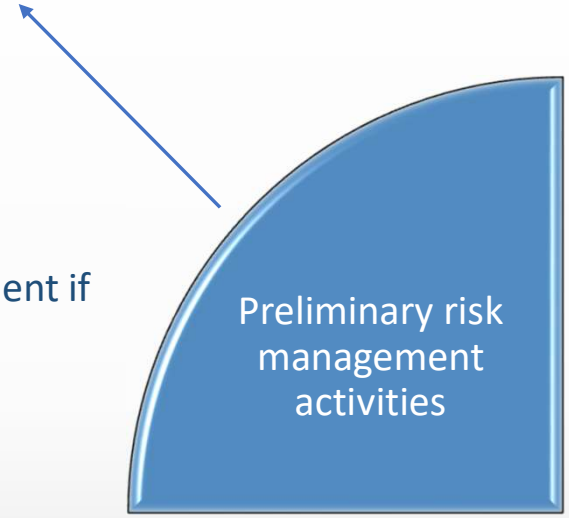


Process of weighing policy alternatives

- in consultation with interested parties,
- considering risk assessment and other factors relevant for **health protection of consumers** and for the promotion of **fair trade practices**, and
- selecting appropriate **prevention and control options**

Risk Management

- Identify food safety issues
- Develop a **risk profile**
- Establish goals of risk management
- Decide on need for risk assessment
- Establish risk assessment policy
- Commission risk assessment if necessary
- Consider results of risk assessment rank risks if necessary



Risk profile : example of information

- Description of the hazard and food(s) involved.
- How and where the hazard enters the food supply.
- Which foods expose consumers to the hazard and how much of those foods are consumed by various populations.
- Frequency, distribution and levels of occurrence of the hazard in foods.
- Identification of possible risks from the available scientific literature.
- Distribution of the risk (who produces, benefits from, and/or bears the risk).
- Public perceptions of the possible risks.

Risk Management

- Identify food safety issues
- Develop a **risk profile**
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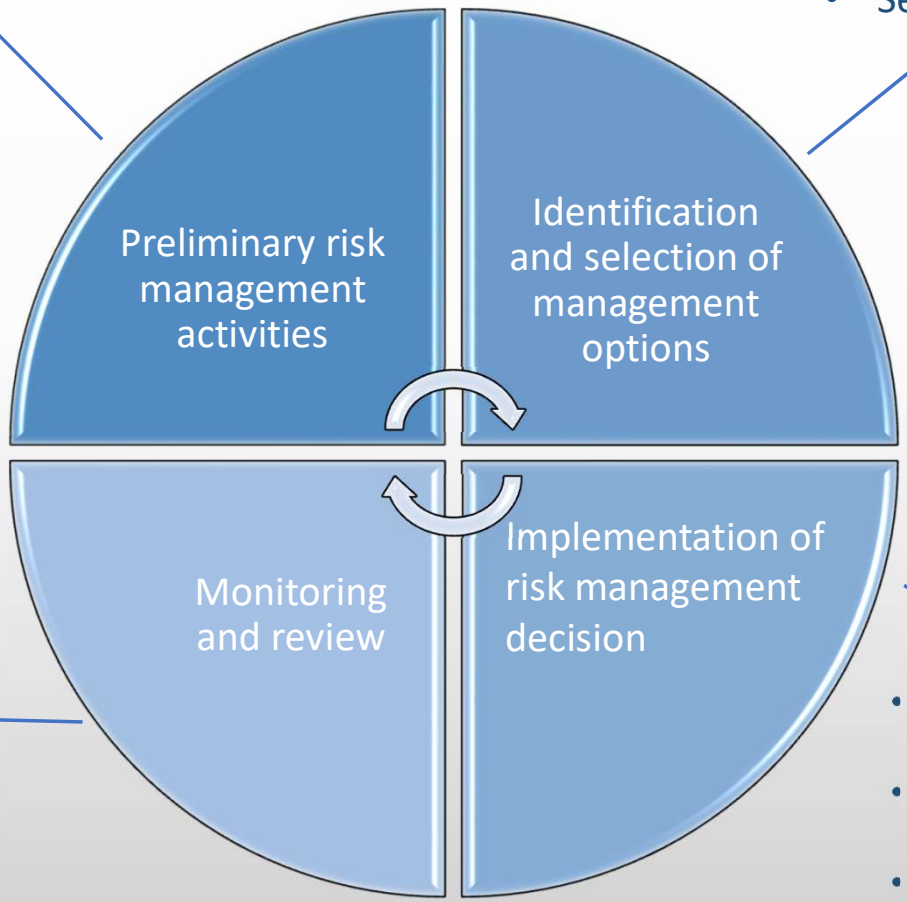


- Identify possible options
- Evaluate options
- Select preferred option(s)

- Validate control(s) where necessary
- Implement selected control(s)
- Verify implementation

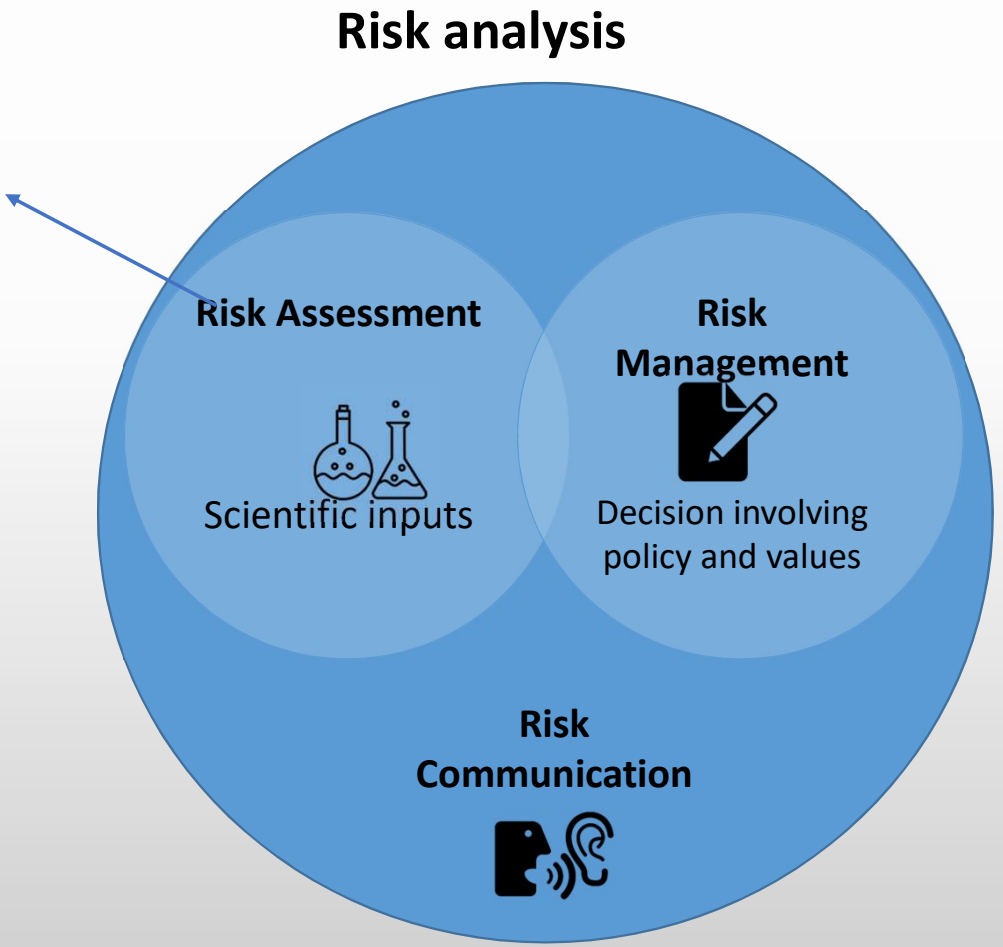
- Monitor outcomes of control(s)
- Review control(s) where indicated

Risk analysis: systematic processes to ensure health protection and fair trade practices

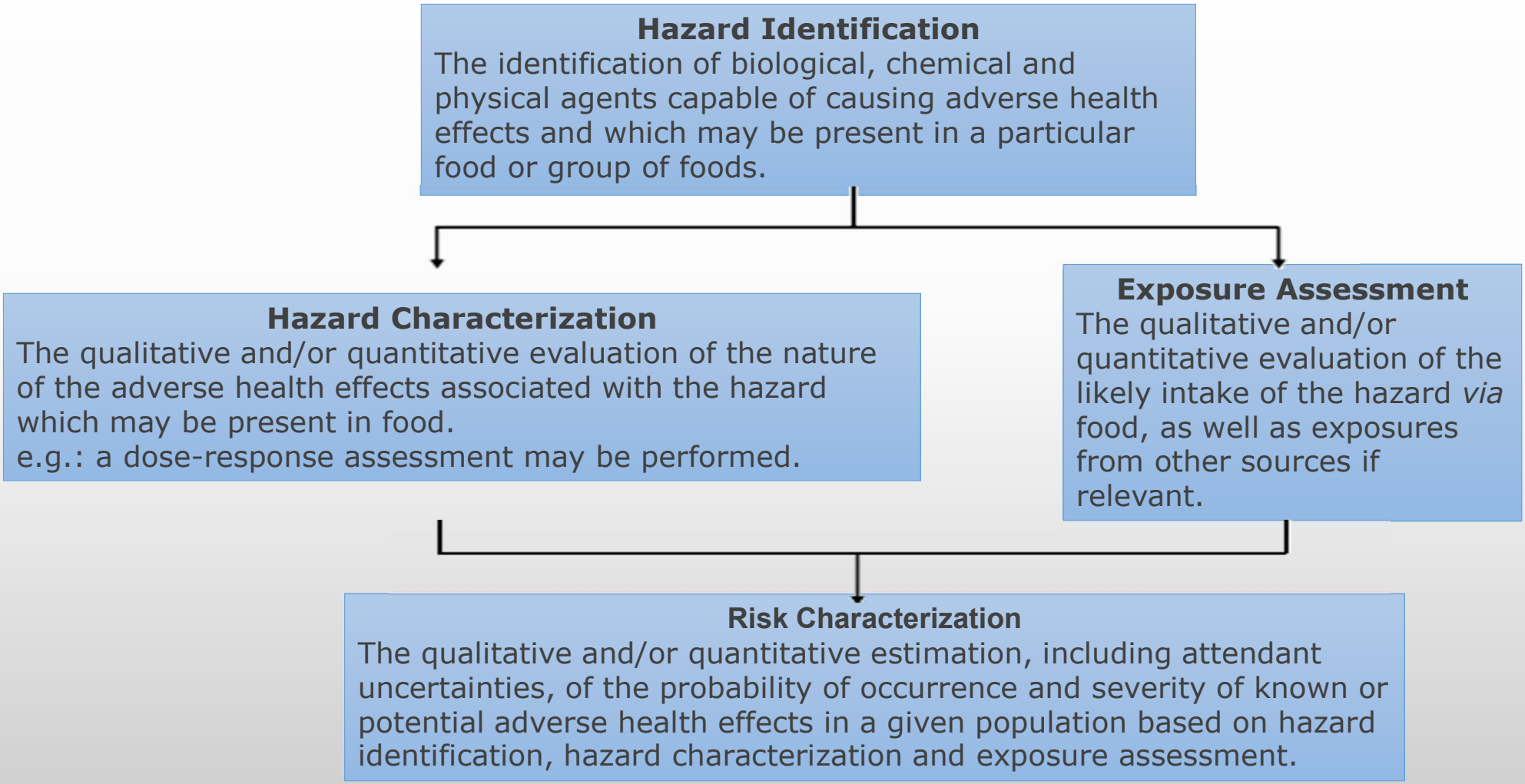
Systematic process for determining the risk associated with a hazard such as toxins in a food.

4 steps:

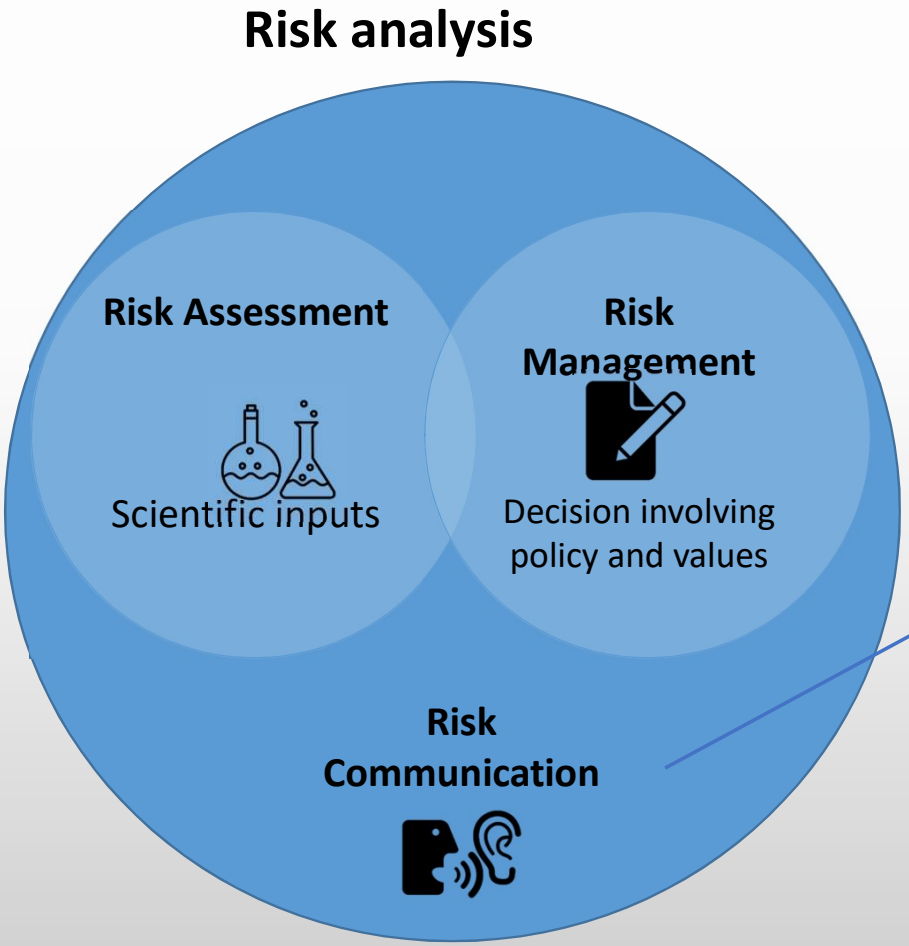
1. Hazard identification
2. Hazard characterization
3. Exposure Assessment
4. Risk Characterization (recommendation of health guidance values)



Components of risk assessment



Risk analysis: systematic processes to ensure health protection and fair trade practices



Exchange of information about risk assessment findings and the basis of risk management decisions among risk assessors, risk managers, consumers, industry, academic community and other interested parties

Seafood safety : hazards and risk analysis

3. Reducing the risk of contamination

Risk management decision

- **Hazard Analysis and Critical Control Point (HACCP)**
  - A system that identifies, evaluates and controls hazards that are significant for food safety.
- **Hazard analysis**
  - The process of collecting and evaluating information on hazards and conditions leading to their presence in order to decide which are significant for food safety and, therefore, should be addressed in the HACCP plan.
- **Critical Control Point**
  - A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.
- **Critical Limit**
  - A maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard.

HACCP

Systematic approach to the identification, evaluation, and control of food safety hazards based on the following seven principles

It is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

It designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption.

= from production to the plate

Reducing the risk of contamination in fish

- **Site selection for aquaculture**
  - Fish farms should be located in areas where the risk of contamination by chemical, physical or microbiological hazards is minimal and where sources of pollution can be controlled.
- **Growing water quality**
  - The water quality should be monitored regularly so that the health and sanitation of the fish is continuously maintained to ensure aquaculture products are safe for human consumption.
  - Fish farms should not be sited where there is a risk of contamination of the water in which fish are reared.
- **Source of fry and fingerlings**
  - The source of post-larvae, fry and fingerlings should be such to avoid the carryover of potential hazards into the growing stocks.
- **Feed supplies**
  - should not contain unsafe levels of pesticides, chemical contaminants, microbial toxins or other adulterating substances

Reducing the risk of contamination in fish

- **Veterinary drugs**
  - All veterinary drugs for use in fish farming should comply with national regulations and international guidelines
  - For fish found to have drug residue concentrations above the maximum residue limit (MRL), harvesting should be postponed until MRL compliance is met.
- **Growing**
  - Adapted stocking fish densities; Diseased fish should be quarantined when necessary and appropriate
  - Good water quality should be maintained by using stocking and feeding rates that do not exceed the carrying capacity of the culture system.
- **Harvesting**
  - Fish should be handled in a sanitary manner
- **Holding and transportation**

Reducing the risk of contamination in bivalve molluscs

- **Conditioning and storage of bivalve molluscs**
  - Before conditioning or storage, bivalve molluscs should be washed to remove mud and soft commensal organisms
  - The oxygen content in the seawater should be maintained at an adequate level at all times.
- **Washing, declumping, debyssing and grading**
  - All steps in the process, including packaging, should be performed without unnecessary delay and under conditions that will prevent the possibility of contamination, deterioration and the growth of pathogenic and spoilage microorganisms.
- **Packaging and labelling**
- **Storage, distribution/transportation**
- **Shucking and washing**

Critical limits for chemical contaminants in the US

Tolerance Levels		
DELETERIOUS SUBSTANCE	LEVEL IN EDIBLE TISSUE	FOOD COMMODITY
PCBs	2 ppm	All fish
Carbaryl	0.25 ppm	Oysters
Diquat	2 ppm	Fish
Diquat	20 ppm	Shellfish
Diuron and its metabolites	2 ppm	Farm-raised, freshwater finfish
Endothall and its monomethyl ester	0.1 ppm	All fish
Fluridone	0.5 ppm	Finfish and crayfish
Glyphosate	0.25 ppm	Fish
Glyphosate	3 ppm	Shellfish
2,4-D	0.1 ppm	Fish
2,4-D	1 ppm	Shellfish
Action Levels		
DELETERIOUS SUBSTANCE	LEVEL IN EDIBLE TISSUE	FOOD COMMODITY
Aldrin and dieldrin[1]	0.3 ppm	All fish
Benzene hexachloride	0.3 ppm	Frog legs
Chlordane	0.3 ppm	All fish
Chlordecone[2]	0.3 ppm	All fish
Chlordecone[2]	0.4 ppm	Crabmeat
DDT, TDE, and DDE[3]	5 ppm	All fish
Methylmercury[4]	1 ppm	All fish
Heptachlor and Heptachlorepoxide[5]	0.3 ppm	All fish
Mirex	0.1 ppm	All fish

Critical limits for biological contaminants in the US

Products	Levels
All fish [10]	*Clostridium botulinum:* • Presence of viable spores or vegetative cells in products that will support their growth; OR • Presence of toxin [12]
All fish [10]. that is Ready-to-eat (RTE) as defined in 21 CFR 117.3 (including raw and cooked)	*Listeria monocytogenes:* • Presence of organism [12]
All fish [10]	*Salmonella* spp.: • Presence of organism [12]
All fish [10]	*Staphylococcus aureus:* • Positive for staphylococcal enterotoxin; OR • ≥ 10^4/g (MPN); OR • Levels indicative of insanitary conditions [12]
All fish [10] that has been previously cooked	*Vibrio* spp.: • Presence of organism [12]

Products	Levels
Raw bivalve shellfish [11]	*Vibrio cholerae:* • Presence of toxigenic organism
Raw fish [10] other than raw bivalve shellfish that is ready-to-eat (RTE) as defined in 21 CR 117.3	*Vibrio cholerae:* • Presence of organism [12]
Post-harvest processed clams, mussels, oysters, and whole and roe-on scallops, fresh or frozen, that make a label claim of "processed to reduce *Vibrio parahaemolyticus* to non-detectable levels."	*Vibrio parahaemolyticus:* • ≥ 30 MPN/g
Raw bivalve shellfish [11]	*Vibrio parahaemolyticus:* • ≥ 1 x 10^4/g
Post-harvest processed clams, mussels, oysters, and whole and roe-on scallops, fresh or frozen, that make a label claim of "processed to reduce *Vibrio vulnificus* to non-detectable levels."	*Vibrio vulnificus:* • ≥ 30 MPN/g

Critical limits for biotoxins (USA)

Products	Levels
Bivalve shellfish [11]	Azaspiracid [3, 6] (Azaspiracid Shellfish Poisoning (AZP)): • ≥ 0.16 mg/kg azaspiracid-1 equivalents (i.e., combined azaspiracid-1, -2, and -3)
Clams, mussels, oysters, and whole and roe-on scallops, fresh, frozen, or canned [11]	Brevetoxin [5, 6] (Neurotoxic Shellfish Poisoning (NSP)): • ≥ 0.8 mg/kg (20 mouse units/100 g) brevetoxin-2 equivalent or 5,000 cells/L
Finfish (primarily reef fish)	Ciguatoxin [4] (Ciguatera Fish Poisoning (CFP)): • Caribbean ciguatoxins: ≥ 0.1 µg/kg Caribbean ciguatoxin-1 (C-CTX-1) equivalents; • Indian ciguatoxins: Guidance levels have yet to be established; • Pacific ciguatoxins: ≥ 0.01 µg/kg Pacific ciguatoxin-1 (P-CTX-1) equivalents
All fish [10]	Domoic acid [6] (Amnesic Shellfish Poisoning (ASP)): • ≥ 20 mg/kg domoic acid (except Dungeness crab viscera); • > 30 mg/kg domoic acid (Dungeness crab viscera ONLY)
Clams, mussels, oysters, and whole and roe-on scallops, fresh, frozen, or canned [11]	Okadaic acid [3] (Diarrhetic Shellfish Poisoning (DSP)): • ≥ 0.16 mg/kg total okadaic acid equivalents (i.e., combined free okadaic acid, dinophysistoxins-1 and -2, and their acyl-esters)
All fish [10]	Saxitoxin [3, 6] (Paralytic Shellfish Poisoning (PSP)): • ≥ 0.8 mg/kg saxitoxin equivalent (80 µg/100 g)

Sanitary certificate

MODEL SANITARY CERTIFICATE
COVERING FISH AND FISHERY PRODUCTS

(LETTERHEAD or LOGO) Identification number: _____

Country of Dispatch:
Competent Authority:
Certifying Body:

I. Details identifying the fishery products

Description of product	Species (scientific name)	State or type of processing	Type of packaging	Lot Identifier/ date code	Number of packages	Net weight
				Sum :		

Temperature required during storage and transport: _____ °C

II. Provenance of the fishery products

Address(es) and/or the Registration number(s) of production establishment(s) authorized for exports by competent authority:

Name and address of consignor:

III. Destination of the fishery products

The fishery products are to be dispatched from: _____
(Place of dispatch)

to: _____
(Country and place of destination)

by the following means of transport:

Name of consignee and address at place of destination:

IV. Attestation

The undersigned certifying officer hereby certifies that:

1) The products described above originate from (an) approved establishment(s) that has been approved by, or otherwise determined to be in good regulatory standing with the competent authority in the exporting country and

2) have been handled, prepared or processed, identified, stored and transported under a competent HACCP and sanitary programme consistently implemented and in accordance with the requirements laid down in Codex Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003)

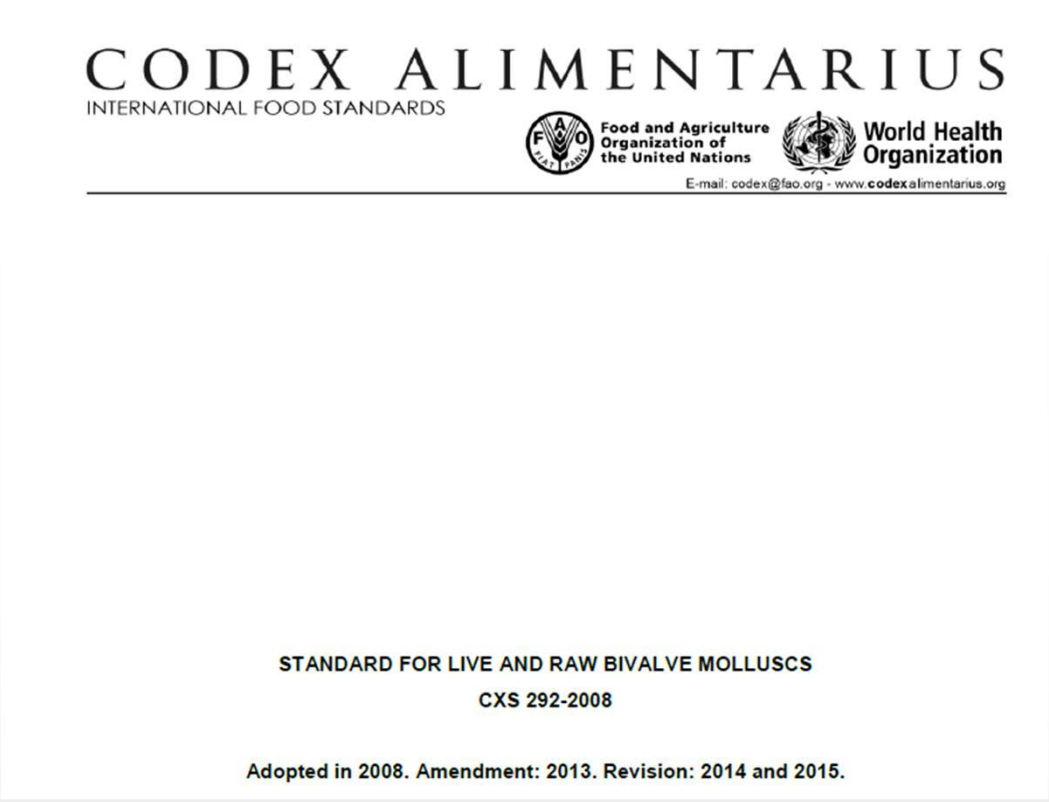
Done at _____ on _____ 20__
(Place) (Date)

(SEAL)

_____ _____
(Signature of certifying officer) (Name and official position)

Tel:
Fax:
E-mail: (optional)

- **The Codex Alimentarius, "the food code", has a fundamental role in protecting consumers all around the world and ensuring fair practices in food trade.**
- **The Code of Practice for Fish and Fishery Products is the essential reference point for technical guidance on the harvesting, processing, transport and sale of fish and fishery products.**



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 was established by **FAO** and **WHO** to protect **consumer health** and **promote fair practices in food trade**.