BIOMAGNIFICATION AND BIOACCUMULATION

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Biomagnification

It is also known as **bioamplification** or **biological magnification**

It is **the increase in concentration of a pollutant** that occurs in a food chain as a consequence of:

1. **Persistence** (can't be broken down by environmental processes)
2. **Bioenergetics** in the food chain
3. **Low rate of internal degradation/excretion** of the substance often due to water-insolubility

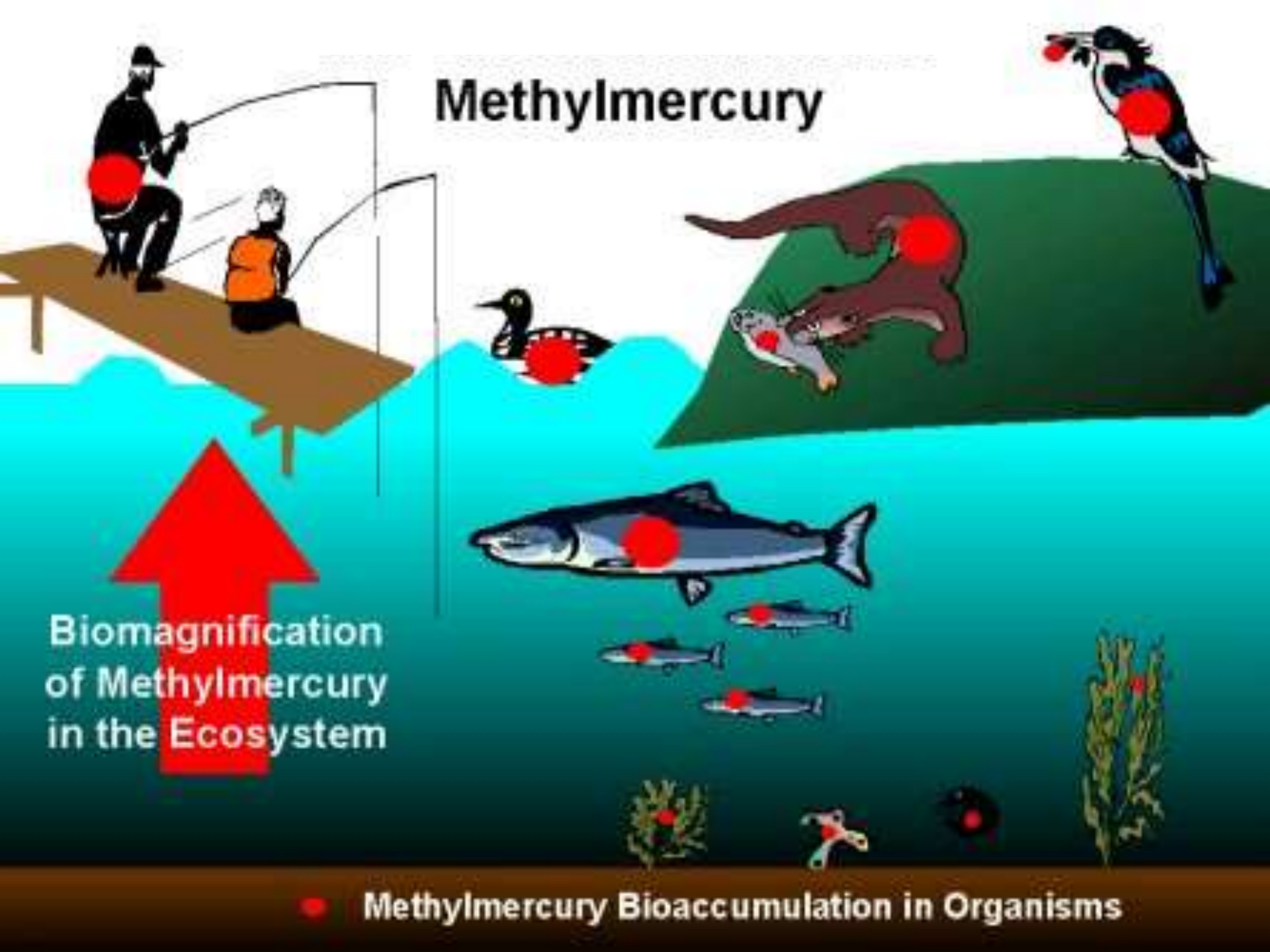
•Biomagnification occurs when substances such as **pesticides or heavy metals** move up the food chain by working their way **into the environment.**

• **e.g. Pollutants in rivers or lakes** are taken up by microorganisms like **plankton** and are eaten by aquatic organisms such as **fish**, which in turn are eaten by **large birds**, **animals** and **humans**. The substances become **concentrated in tissues or internal organs** as they move up the chain.

As a result,organisms at the top of the food chain generally suffer greater harm from a persistent toxin or pollutant than those at lower levels

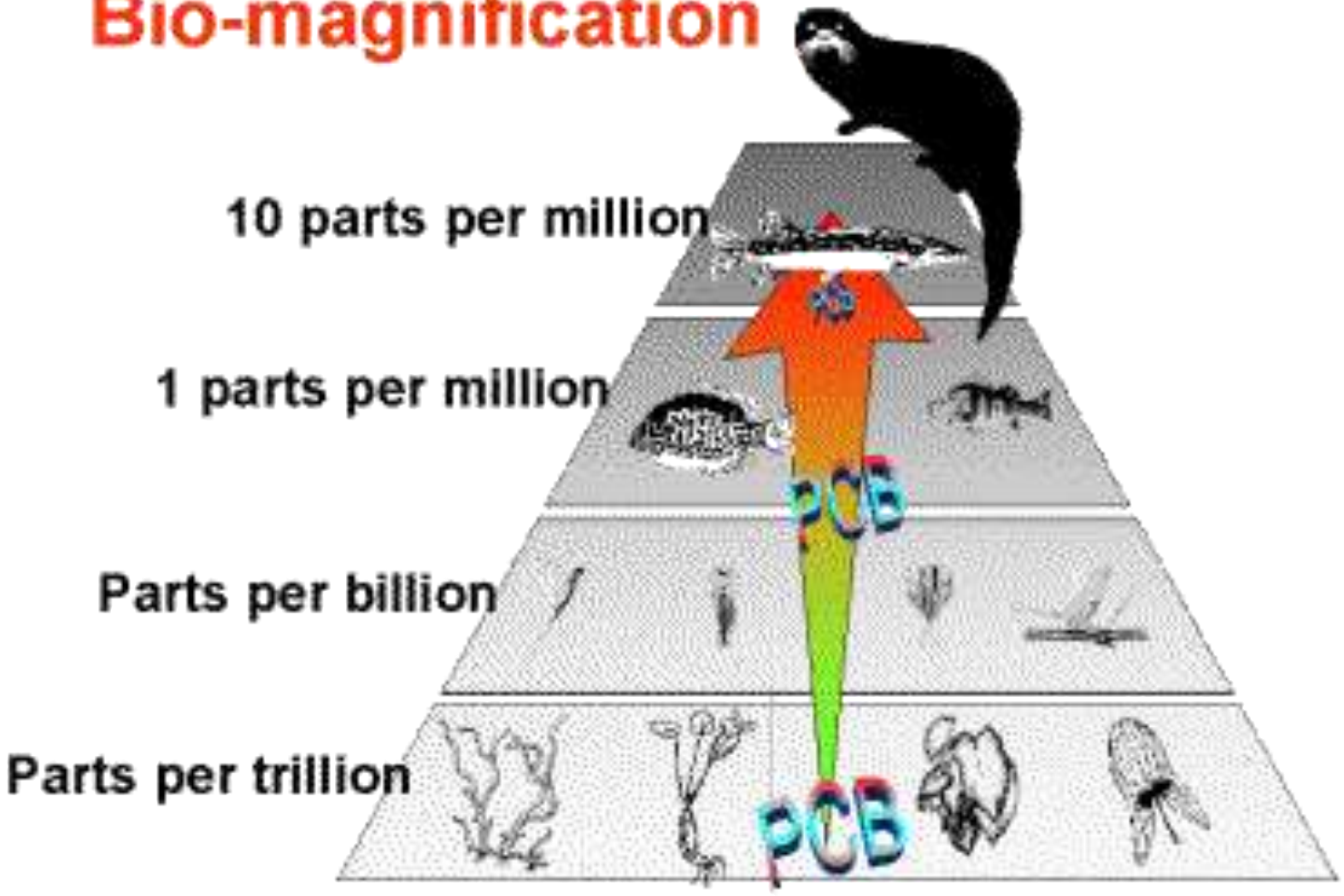
Because

- At each level of the food chain there is a lot of energy loss, a predator must consume many prey, including all of their lipophilic substances and fats which carries the pollutant, which then accumulates in the fats of the predator.

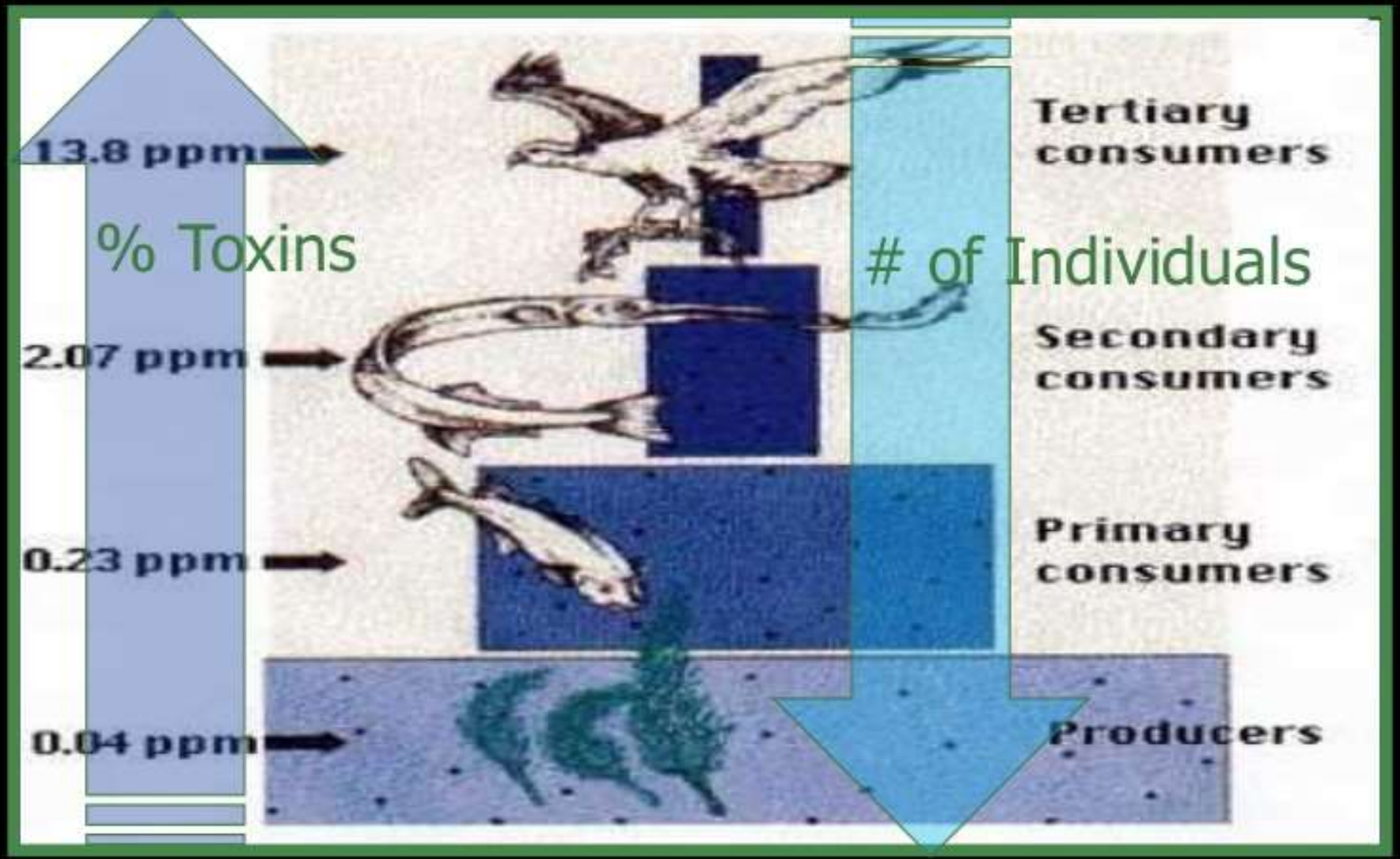

Methylmercury
Biomagnification
of Methylmercury
in the Ecosystem
Methylmercury Bioaccumulation in Organisms

•Biomagnification can occur in almost all types of ecosystems.e.g terrestrial,aquatic

Bio-magnification



- Biomagnification: When contaminants increase at each step of the food chain.



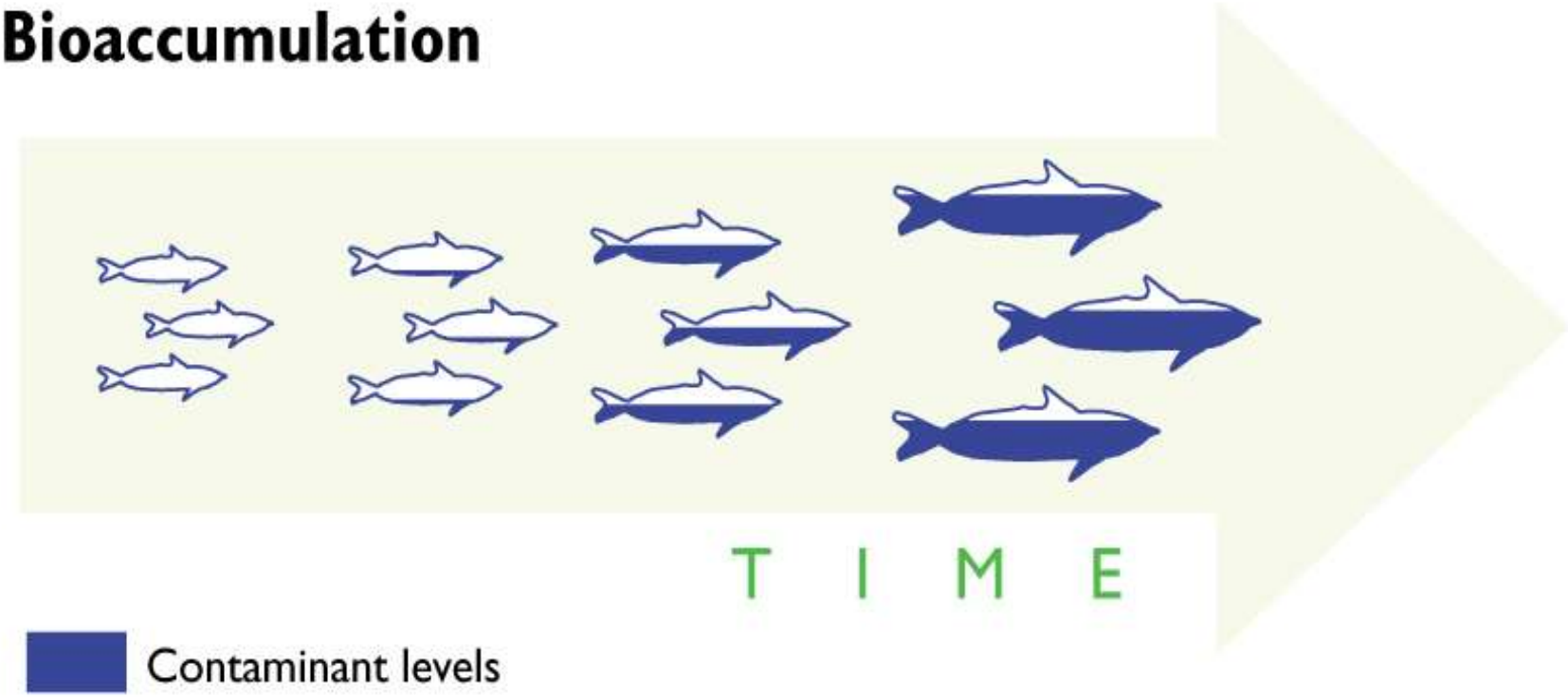
•**Bioaccumulants** are toxic substances that increase in concentration in tissues of living organisms. They enter the organism through **contaminated air, water, or food** and are very slowly metabolized or excreted.

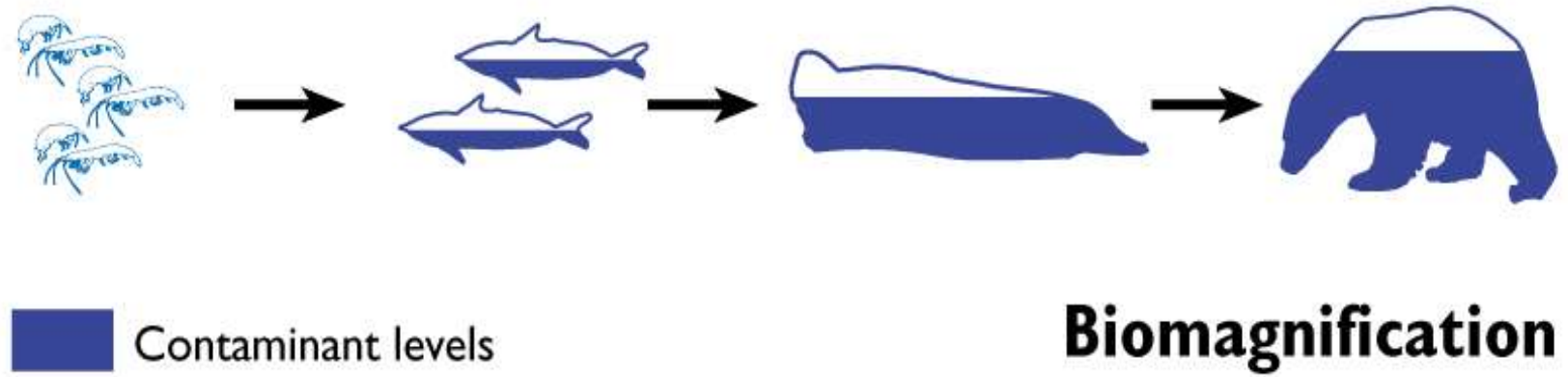
- Bioaccumulation vs. Biomagnification

•**Bioaccumulation** is the concentration of pollutant from the environment which occurs **within a trophic level**, i.e. one level of a food chain, usually the first organism in the food chain

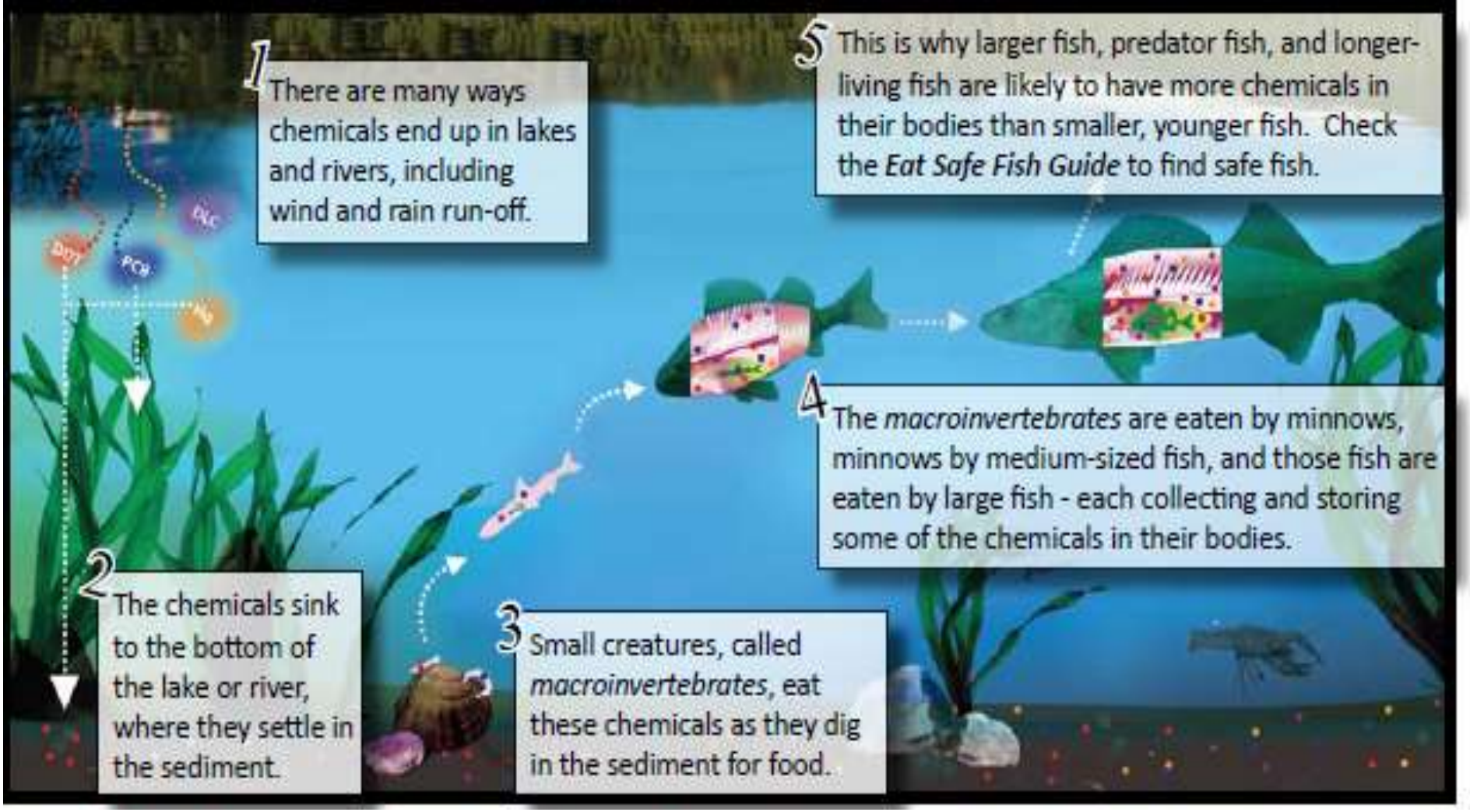
•Where as **biomagnification** is the **concentration of pollutant across the food chain**

Bioaccumulation





Biomagnification



We are concerned about these phenomena because ***together*** they mean that even small concentrations of chemicals in the environment can find their way into organisms in high enough dosages to cause problems.

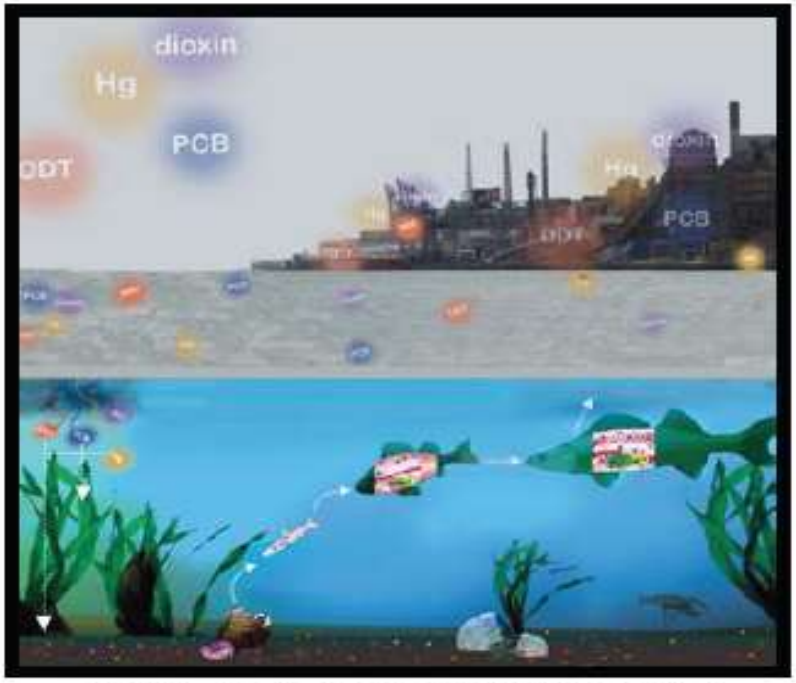
In order for biomagnification to occur, the **pollutant** must be:

1. long-lived
2. mobile
3. soluble in fats
4. biologically active

Persistent

Persistent Chemicals in Action

In 1970, a factory puts out a lot of persistent chemicals through its smoke stacks.



In 2011, the factory has pollution control devices on its smoke stacks, but the chemicals put out in past years still remain behind.

Persistent pollutant vs. short lived pollutant

- **Pollutants that dissolve in fats(Persistent pollutants)** are retained for a long time.
- Lipid or fat soluble substances cannot be diluted, broken down, or excreted in urine.
- They accumulate in fatty tissues of an organism if the organism lacks enzymes to degrade them.

- **If a pollutant is short-lived**, it will be broken down before it can become dangerous.
- If it is not mobile, it will stay in one place and is unlikely to be taken up by organisms.
- If the pollutant is soluble in water it will be excreted by the organism.

•DDT :dichloro diphenyl trichloroethane.

•chlorinated hydrocarbon,used as pesticide

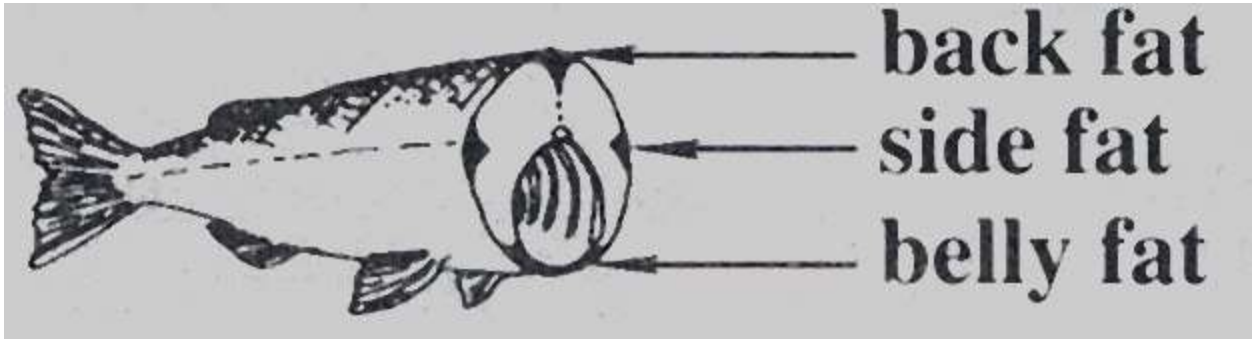
•DDT has a half-life: 15 years, which means if you use 100 kg of DDT, it will break down as follows:

Year	Amount Remaining
0	100 kg
15	50 kg
30	25 kg
45	12.5 kg
60	6.25 kg
75	3.13 kg
90	1.56 kg
105	0.78 kg
120	0.39 kg

Substance	Use & **Problems**
PCBs (polychlorinated biphenyls)	•insulators in transformers •plasticizer •fire retardant •**impairs reproduction**
PAHs (polynuclear aromatic hydrocarbons)	•component of petroleum products •**carcinogenic**
•Heavy metals: •mercury •copper •cadmium •chromium •lead •nickel •zinc •tin (TBT or tributyltin)	•mercury from gold mining •many from metal processing •**affect nervous system** •**affect reproduction**
cyanide	•used in leaching gold •used in fishing •**toxic**
selenium	•concentrated by farming desert soils •reproductive failures •**toxic**

Measuring pollutants

•The amount of pollutants is measured in fatty tissues of organisms such as fish.



•In mammals, we often test the milk .

BIOCONCENTRATION

Bioconcentration

- Bioconcentration is a term used specifically in reference to **aquatic environments** and aquatic organisms, in contrast with the related “bioaccumulation,” which can refer to toxins and organisms found in a variety of environments.

- The substance(pollutant) can also be taken up by organism from surrounding water by non dietary routes.

e.g. through the gills of a fish,which travels through blood to the lipid tissue.

Bioconcentration factor can be expressed as:

The ratio of the concentration of a chemical in an organism to the concentration of the chemical in the surrounding environment.

$$BCF = \frac{Concentration_{Biota}}{Concentration_{Water}}$$

It can also be defined as the rate of substance uptake/rate of substance elimination

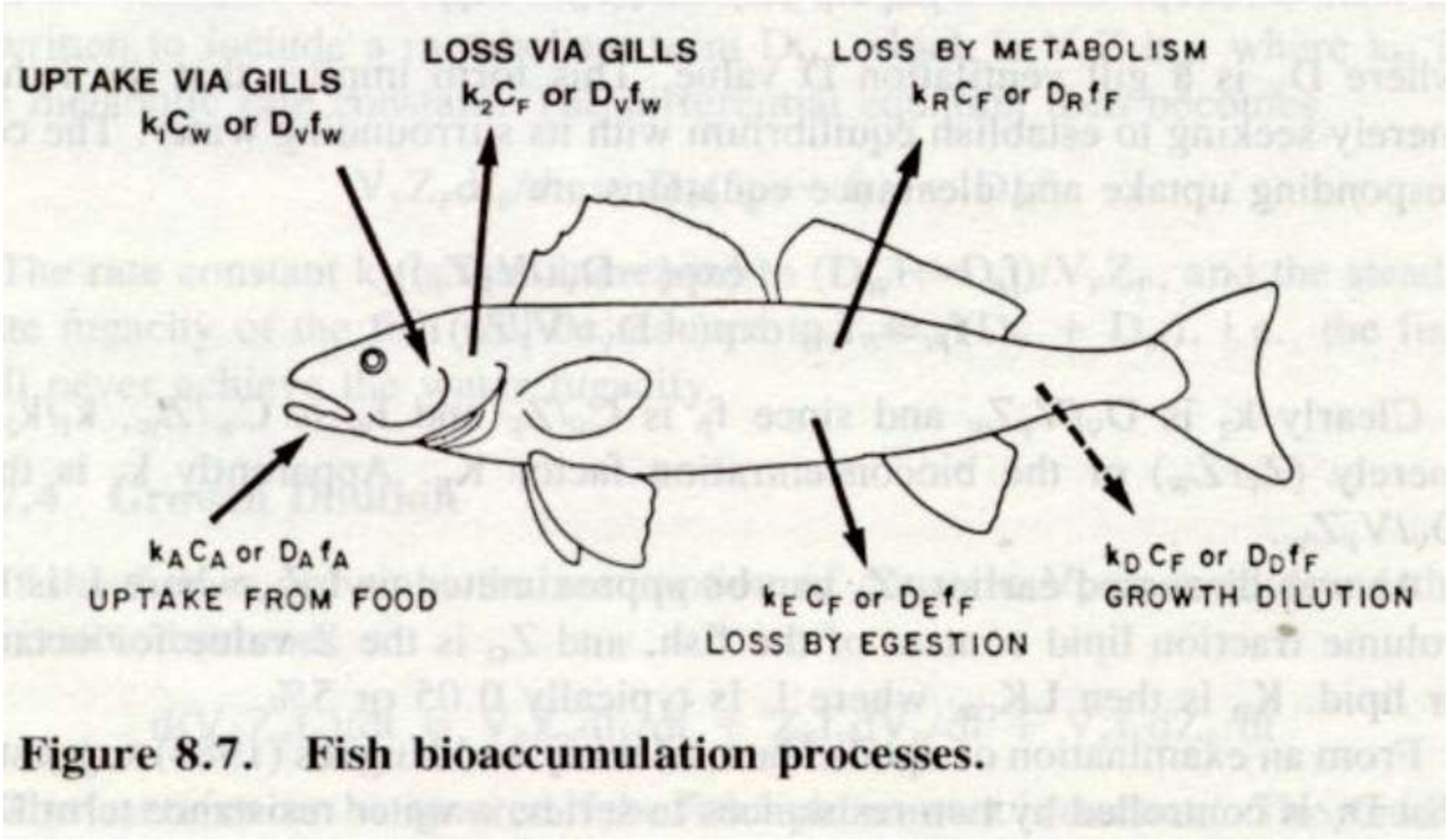


Figure 8.7. Fish bioaccumulation processes.

•The higher the ratio, the more severe the bioconcentration.

•A high BCF can lead to health problems such as genetic mutations passed on to offsprings

In fish populations increasing numbers of fish born with ambiguous genitalia have been identified in waterways contaminated with pharmaceuticals.

Effects of Bioaccumulation on Humans

Filipino cuisine

Japanese cuisine

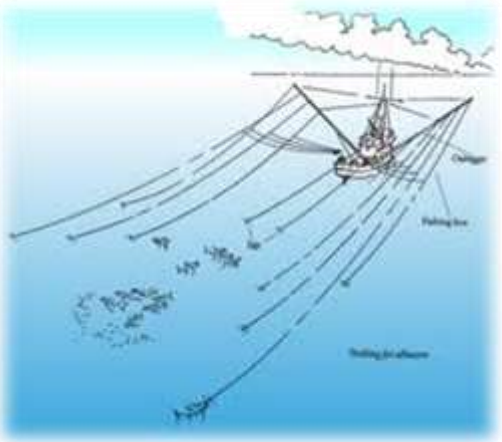
Bengali cuisine

Pros

- Protein
- Omega 3 fatty acid
- Vitamin B
- Relatively low in fat
- Good for the heart and bones

Cons

- Mercury
- Fishing methods
- Farming methods



Mercury levels in fish across West Bengal

•Alarming levels of toxic mercury were found in 264 samples of popular fish (like Rohu, Bhola, Tangra, Aar, Bhetki and other fish varieties)collected across West Bengal .[organisations :Toxics Link and DISHA on 2012]

•The trend is applicable across the country

•While 52 cases had mercury concentrates in excess of the Prevention of Food Adulteration (PFA) Act standards of 0.5 ppm

• 129 of the fish showed methyl mercury levels (a metabolized and more poisonous form of mercury) exceeding the 0.25 ppm PFA stipulations.

Causes

- coal firing
- mining
- thermal plants
- industrial effluents directly discharged into water bodies
- municipal waste water streams.

High level of mercury causes:

- neurotoxicity and impairs motor skills
- stunts psychological development and growth
- can cause serious mental disorders over a gradual period of time

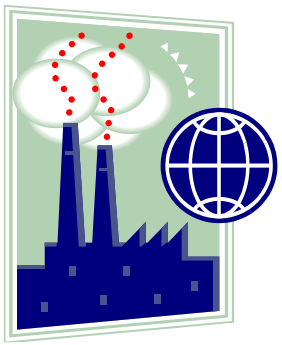
Biodiversity Research Institute in Maine ,August 2013
estimated that 83% of fish worldwide have unsafe mercury levels

Over 50% of Asian population have more than the 5ug/ml mercury level in blood

Cause for global concern because:

•Most Seafood is imported and exported

•Pollution is World-wide problem, requires cooperation of various nations. E.g. pollution of the ocean and seas



The Gelfond Fund for Mercury Research & Outreach

Fish with the Highest Levels of Mercury

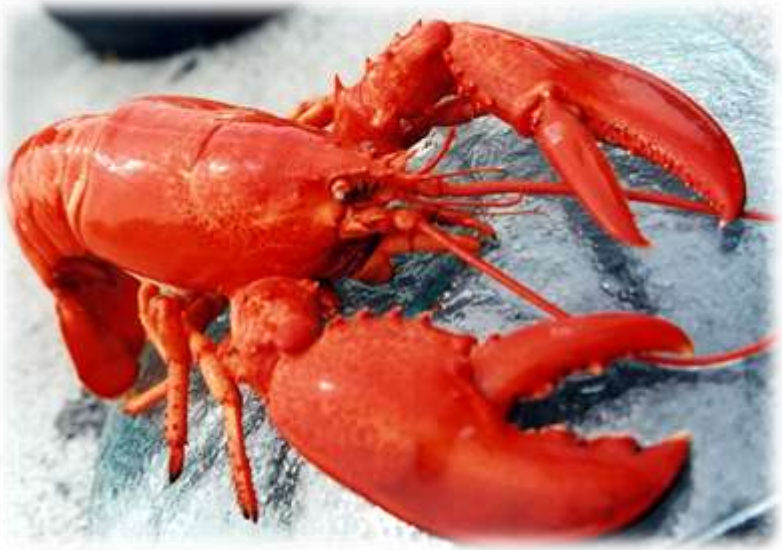
King Mackerel
Swordfish
Tilefish
Shark

Swordfish

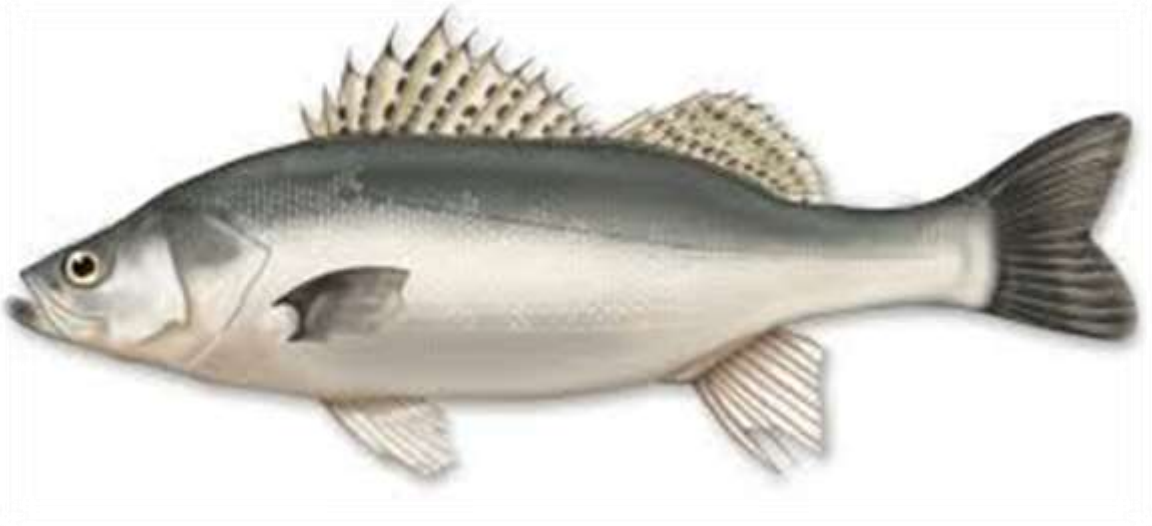
Shark

Fish and Seafood with Mid-Range Mercury Levels

Tuna
Orange Roughy
Marlin
Grouper
Spanish Mackerel
Chilean Seabass
Bluefish
Lobster
Weakfish (sea trout)
Halibut
Sablefish
Striped Bass or Rockfish



Lobster

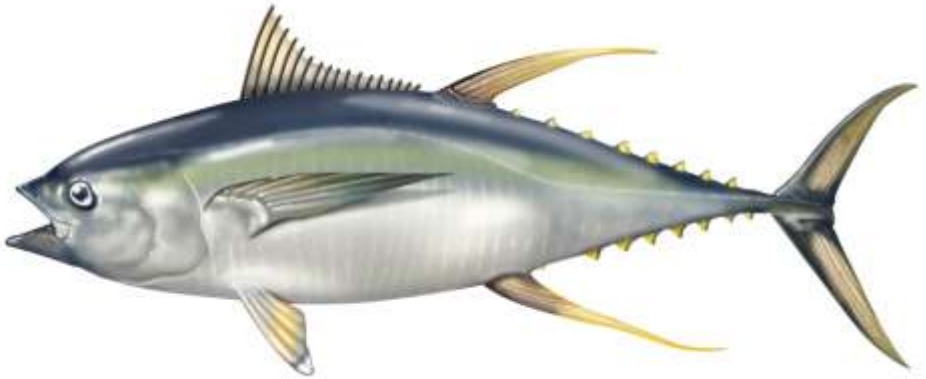


tuna

Fish and Seafood with Low Mercury Levels

Snapper
Monkfish
Carp
Freshwater perch
skate
skipjack
Spiny lobster
Jacksmelt
Boston or Chub Mackerel
Croaker
Trout
Squid
Whitefish
American shad
Crab
Scallop

Crab



monkfish

Squid

carp

Fish and Seafood with Very Low Mercury Levels

- Catfish
- Mullet
- Flounder, fluke, plaice, sand dabs
- Herring
- Anchovies
- Pollock
- Crayfish
- Haddock
- Sardine
- Hake
- Salmon
- Oyster
- Tilapia

Anchovies

crayfish

salmon

Thank you