Exposures to Mercury: Valuable Lessons for Human Health and the Environment

Friday, 8 August 2008, 12:00-14:00
Room 3, International Environment House 1

Mercury (with the chemical symbol of Hg) is a naturally occurring element found in air, water, and soil. It is distributed throughout the environment by both natural and anthropogenic (human) processes. The three primary forms include elemental, inorganic, and organic mercury, with methylmercury being the most important.

Mercury is a toxic, persistent pollutant that biomagnifies through food webs. People are exposed to methylmercury mainly through their diet, especially through the consumption of freshwater and marine fish and consumption of other animals that consume fish (such as marine mammals). People may also be exposed to elemental or inorganic mercury through inhalation of ambient air during occupational activities; and from dental amalgams. Occupational exposures can occur where mercury or mercury compounds are produced, used in processes, or incorporated in products.

UNEP together with WHO is launching a guidance document entitled "Identifying Populations at Risk from Mercury Exposure". The document is intended to assist countries concerned about the potential national impacts of mercury pollution to identify specific populations or subpopulations that may be at risk. It aims to provide guidance on estimating exposures to mercury through biomonitoring as well as exposures to methylmercury using data on dietary fish intake. It gives an overview of mercury toxicity, exposure pathways, health and environmental impacts, as well as available reference levels. This document is being issued as a joint UNEP/WHO document in cooperation with the FAO. You are cordially invited to listen to an overview of the guidance document.

12:00 Sandwiches/ Video presentation on "Minamata Disease"

12:30 Welcome and introduction
- UNEP Chemicals, Division of Technology, Industry and Economics (DTIE)

Mercury sources of exposure, impact on the environment and health
- UNEP Chemicals, DTIE

Risk management of methylmercury in fish
- Health Security and Environment, WHO

Current Activities of the UNEP Mercury Programme
- UNEP Chemicals, DTIE

13:45 Open forum

14:00 Closing
- UNEP Chemicals, DTIE

11-13 chemin des Anémones, CH - 1219 Châtelaine, Geneva, Switzerland
Tel.: [41-22] 917-8326 Fax: [41-22] 797-3464 Web site: www.environmenthouse.ch

Mercury:
What we need to know…

Desiree M. Narvaez
Programme Officer
Mercury and other metals programme
Chemicals Branch, DTIE
UNEP

Mercury (Hg) is a heavy metal

Species:

- ✓ Metallic or elemental : Hg^{o}
- ✓ Ionic or Inorganic : Hg^{+} and Hg^{2+}
- ✓ Organic Hg when combined with C

  Notably methylmercury : $MeHg^{+}$ or CH_3Hg^{+}

  Ethylmercury, Phenylmercury

Source: UNIDO

Natural mercury releases

- Mercury is an element, neither created or destroyed
- Average 0.05 mg/kg in earth's crust
- Gradual release from crust to atmosphere
- Volcanoes
- Weathering of rock
- Under sea vents

Anthropogenic releases

- **Releases from mobilisation of mercury impurities**:
  Coal-fired power, Cement production,
  non-ferrous metals mining

- **Releases from intentional extraction and use of mercury**: primary Hg mining,
  chlor alkali, small scale gold mining,
  manufacturing of products

- **Releases from Waste Treatment**:
  such as incineration/
  waste disposal sites, landfill

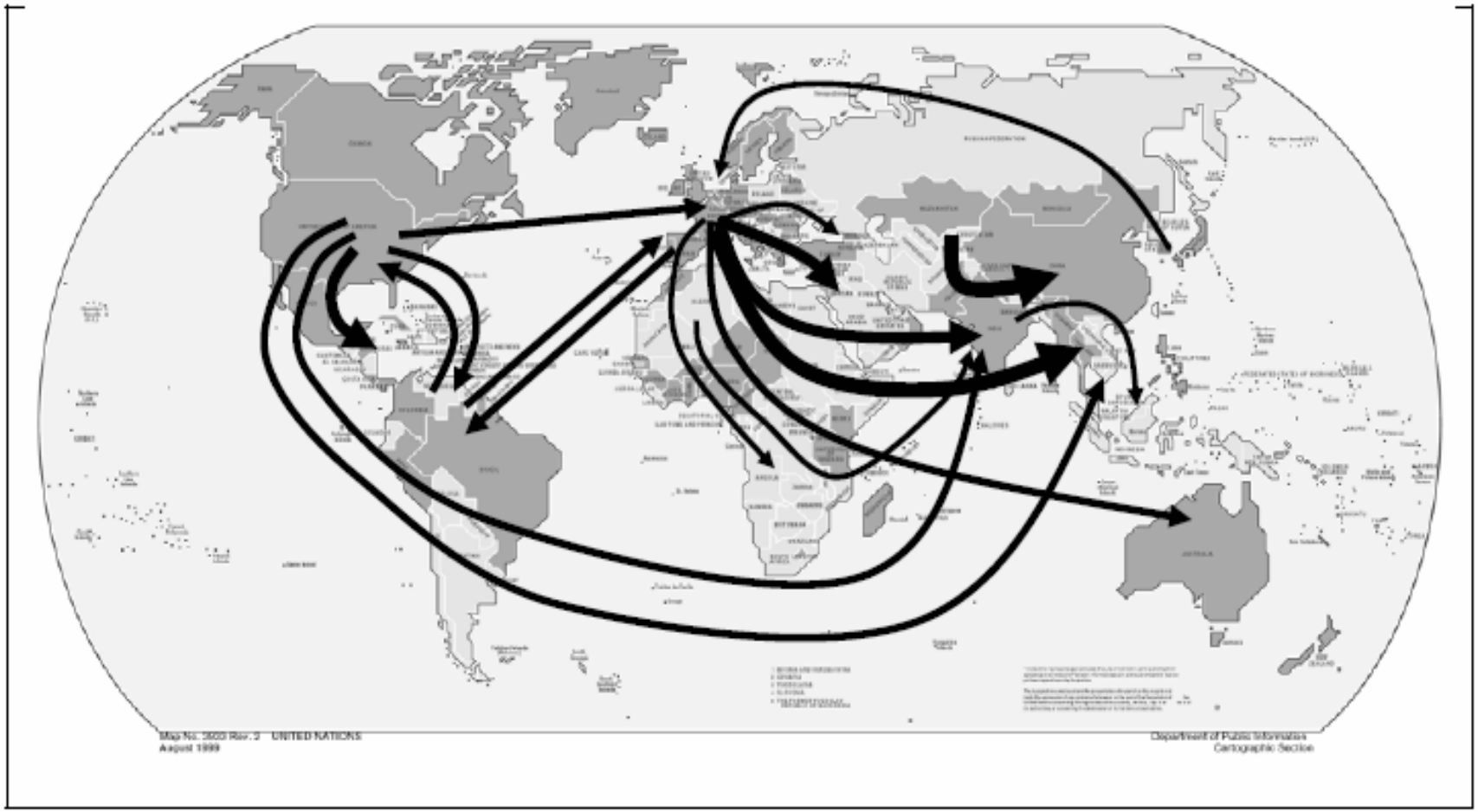
Sources of Global Mercury Supply

Sources of mercury supply (2005)	Mercury supply (metric tonnes)
Primary mercury mining	1350-1600
By-product mercury	450-600
Recycled mercury from chlor-alkali wastes[a)]	90-140
Recycled mercury - other[b)]	450-520
Mercury from chlor-alkali cells (decommissioning)[c)]	600-800
Stocks[d)]	0-200
Total	**3000-3800**

Source: Maxson, "Mercury flows and safe storage of surplus mercury" for the Environment Directorate, European Commission, August 2006 (with data ranges). See: http://ec.europa.eu/environment/chemicals/mercury/pdf/hg_flows_safe_storage.pdf

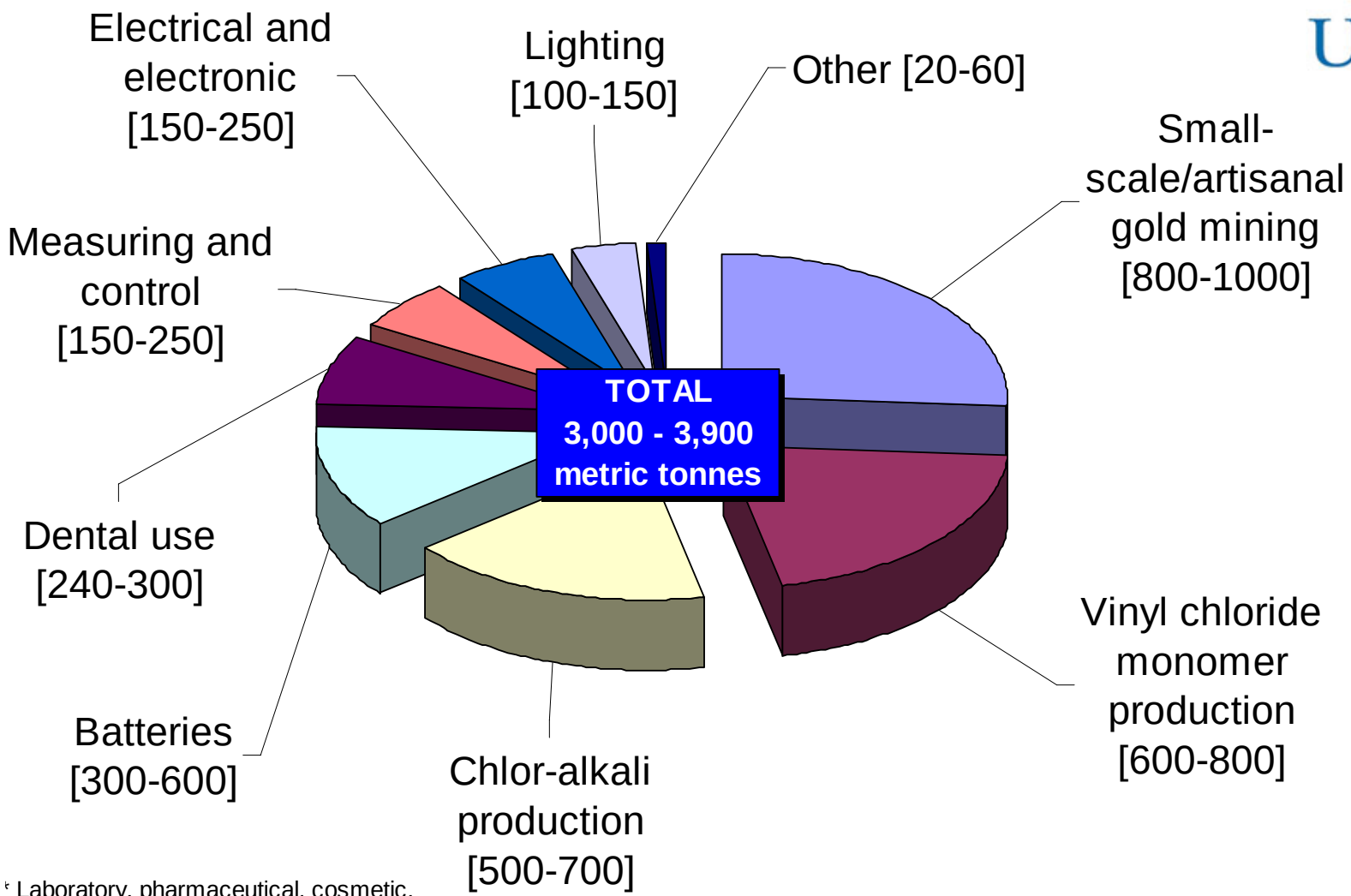
Mercury Trade 2004

Figure 4 Commodity mercury shipments among world regions, 2004



From: UNEP Chemicals. Summary of Supply, Trade and Demand Information on Mercury. Nov 2006

Mercury continues to be used…

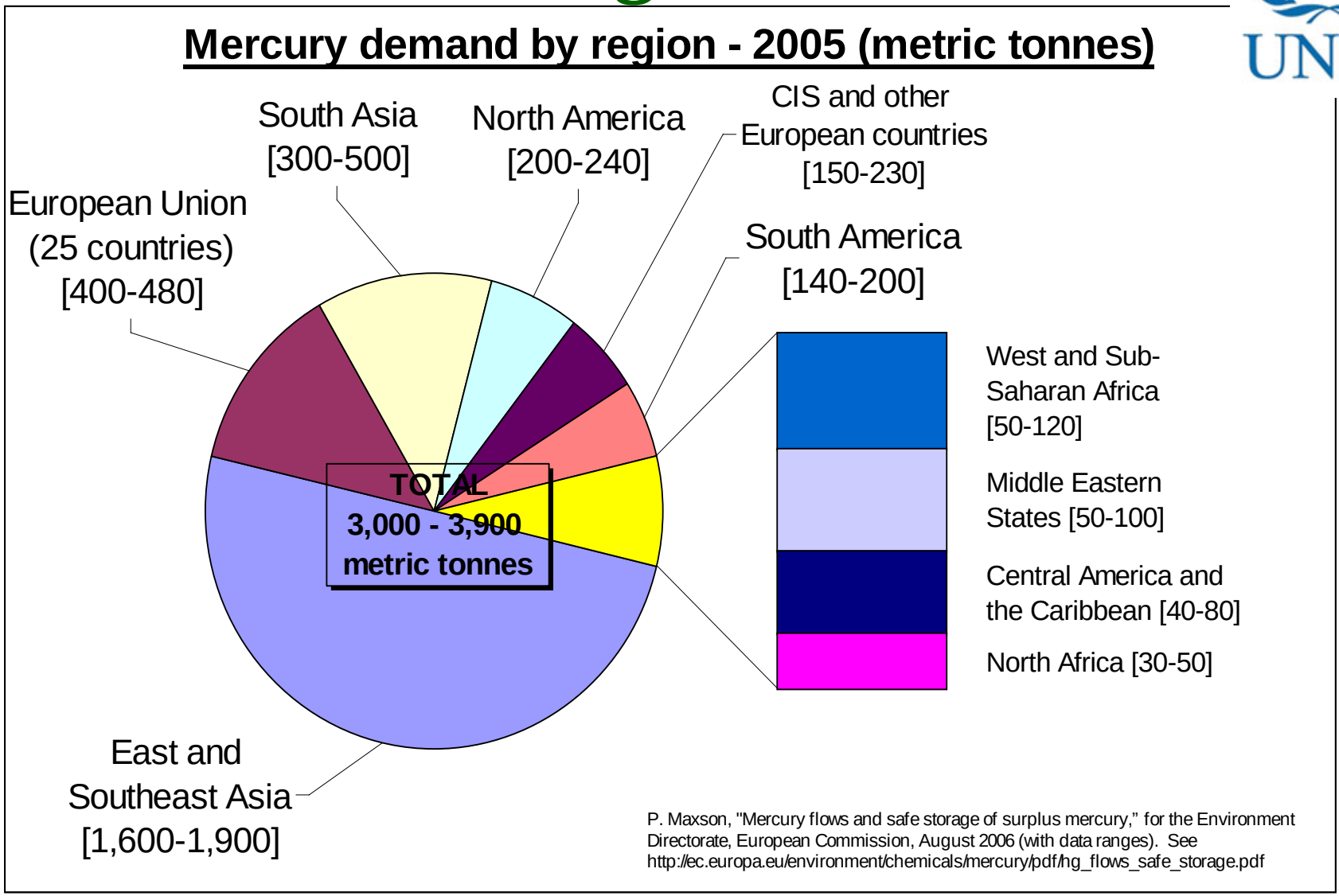


[c] Laboratory, pharmaceutical, cosmetic, cultural/traditional uses, etc.

October 2006

Source : UNEP Chemicals. Summary of Supply, Trade and Demand Information on Mercury. Nov 2006

… and there is a global demand.



Source; UNEP Supply, Trade and Demand Information on Mercury. Nov 2006

Uses of mercury

As a metal :

- ✓ **Extraction of gold/silver(ASM)**
- ✓ **Catalyst for chlor-alkali production**
- ✓ **Manometers for measuring and controlling pressure**
- ✓ **Thermometers**
- ✓ **Electrical and electronic switches**
- ✓ **Backlight of computers**
- ✓ **Fluorescent lamps**
- ✓ **Dental amalgam fillings**

Uses of mercury

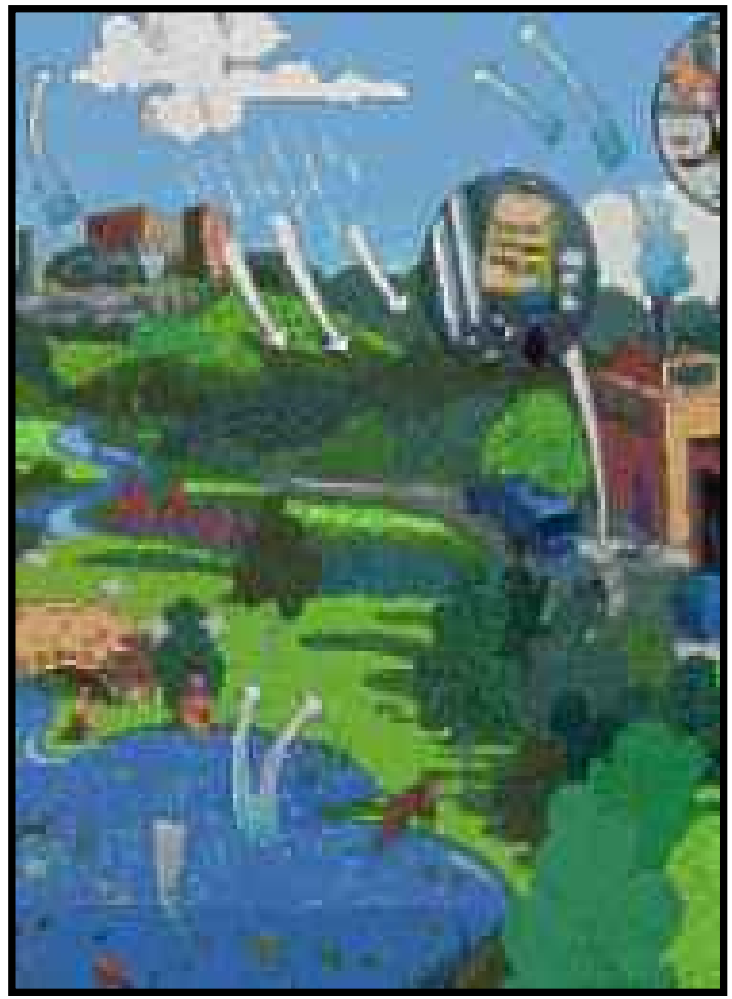
<u>As a chemical compound</u> (among others):

- ✓ **Batteries**
- ✓ **Biocides in paper industry, pains and on seed grain**
- ✓ **Antiseptics in pharmaceuticals**
- ✓ **Laboratory analyses reactants**
- ✓ **Catalyst**
- ✓ **Pigment and dyes**
- ✓ **Detergents**
- ✓ **Explosives**

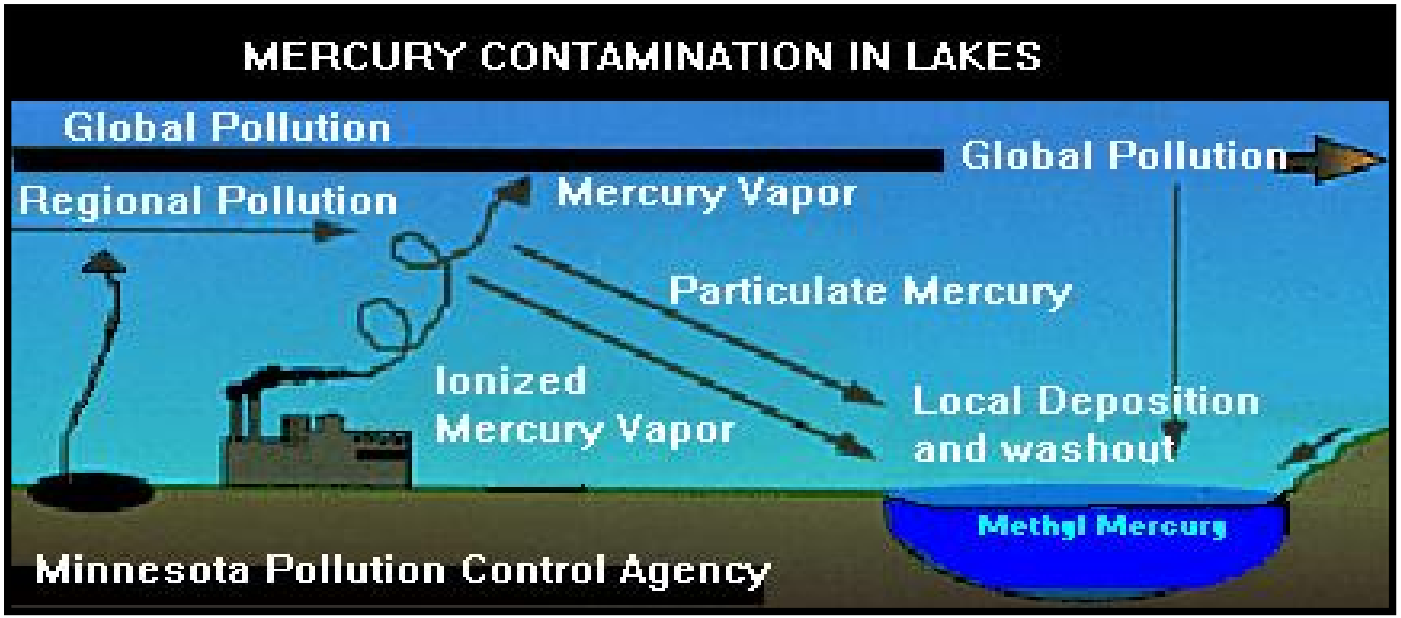
Global Cycle

- Hg moves through environmental media (air, sediment, water, soil)- undergoes complex transformation

- Atmosphere: Hg vapor circulates up to one year- dispersed and transported thousands of miles from source; oxidized in the atmosphere to water soluble ionic mercury returned to earth in precipitation



Transport of Mercury



- Ultimately enters water bodies and deposits either close to source or long distance from source

EPA

- Chemical and physical forms determine their behavior in the environment and pattern of deposition

❖ Divalent Hg- water soluble and relatively reactive and likely to deposit within a short distance

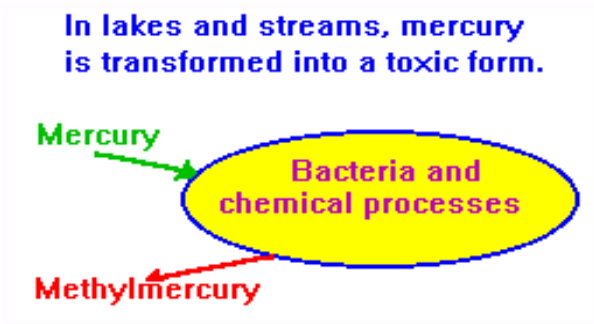
❖ Elemental Hg-tends to disperse long distance and may not deposit until it has traveled thousands of kilometers

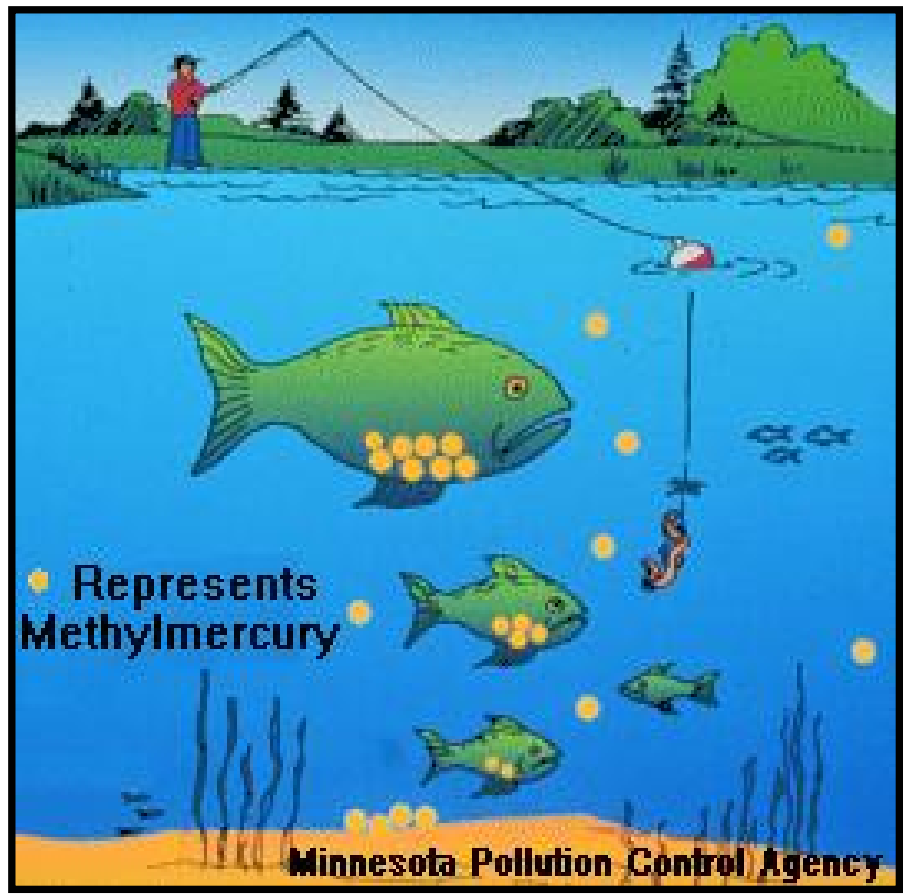
Fate of Mercury

Metabolic conversion, bioaccumulation biomagnification through "food-chain"

- Hg in sediments converts into methylmercury (MeHg)
- MeHg enters the aquatic food chain: fish (marine freshwater),

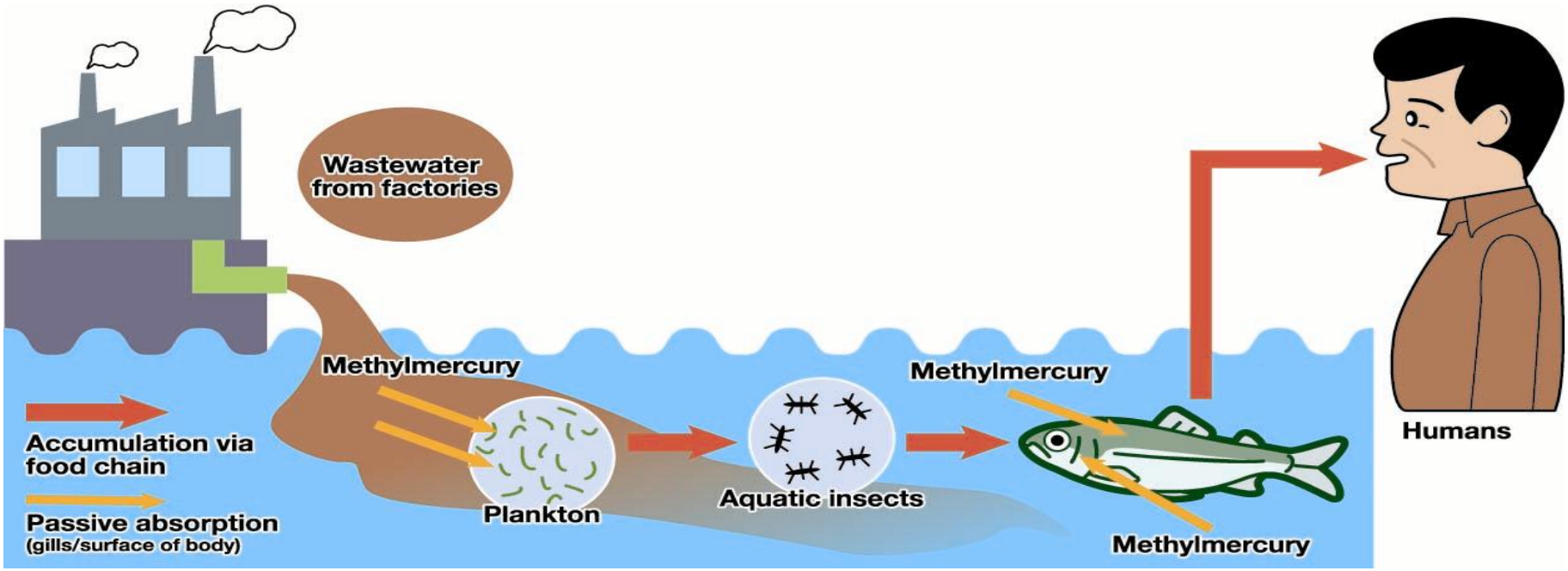
  marine mammals
- MeHg uptake by humans through fish consumption





EPA

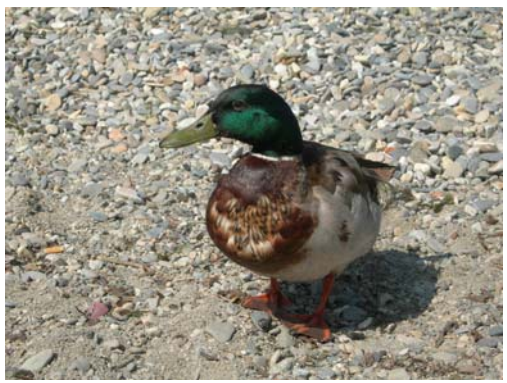
MethylMercury

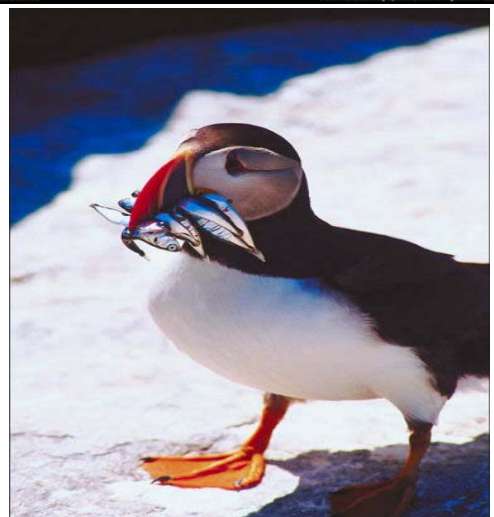


Organic (Methylmercury)- ingestion (95% absorbed in GIT) of freshwater and marine fish
-bound in protein tissue, not in fatty deposits
-trimming and skinning of contaminated fish do not reduce Hg

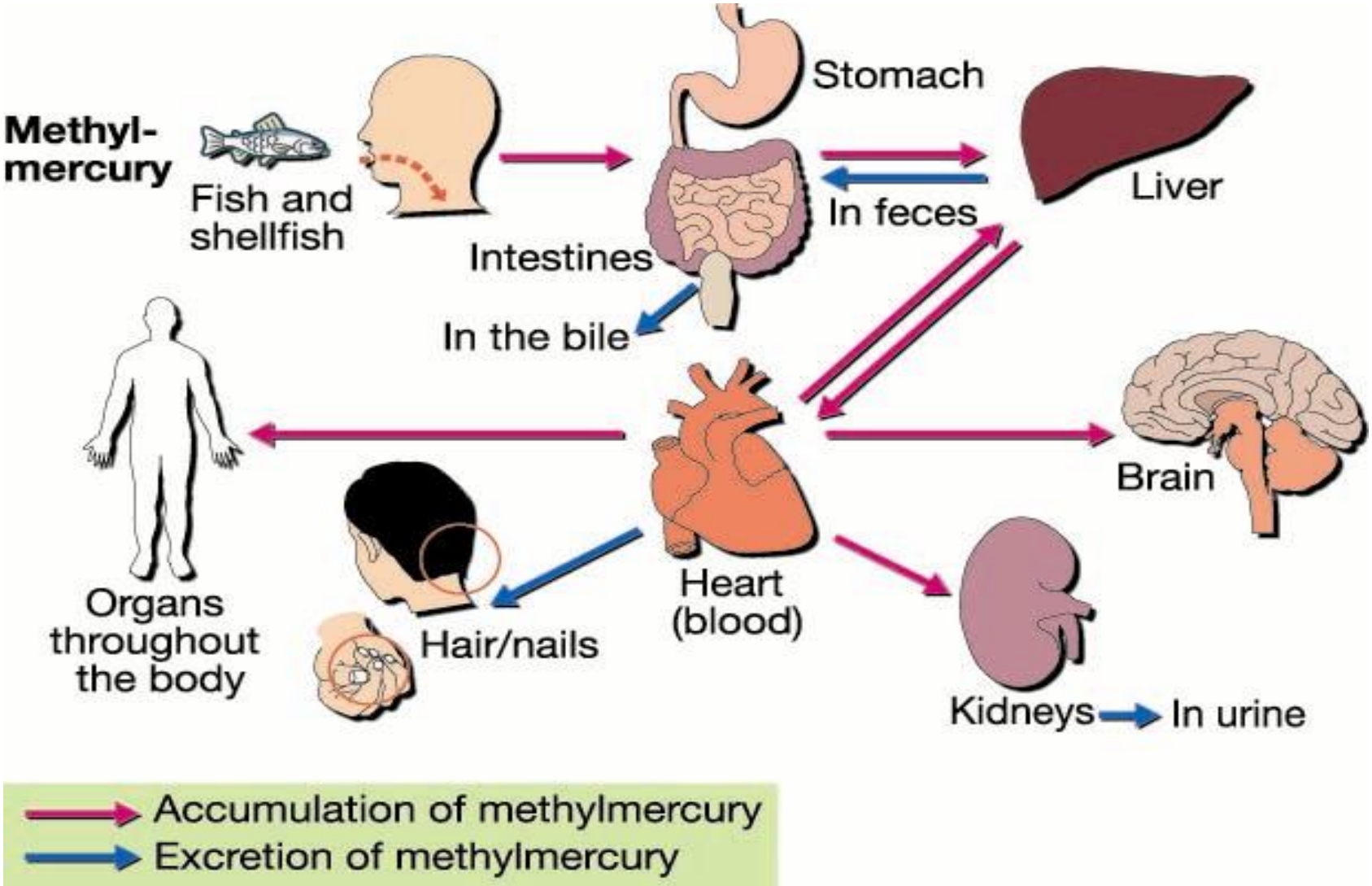
Effects on the Environment and the Ecosystem

- Causes neurological and reproductive effects, particularly in birds and predatory mammals
- High levels seen in seals, whales, polar bears





Exposure Pathway and Effects on Humans



Mercury Species	Sources	Routes of exposure	Elimination	Toxicity
Elemental (metallic)	•**ASM** •**Chlor alkali** •**Non ferrous mining** •**Waste incineration** •**Amalgams** •**Manufacturing of medical devices** •**Folk remedies** •**Cosmetics/soaps**	**Inhalation** **Dermal**	**Urine and faeces**	**CNS** **Kidney** **Lungs** **Skin (Acrodynia in children)**
Inorganic (mercuric chloride)	•**Manufacturing and breakage of Lamps, Batteries** •**Disinfectants** •**Cosmetics/soaps** •**Folk medicine**	**Inhalation** **Ingestion** **Dermal**	**Urine**	**CNS** **Kidney** **GI tract** **Skin (Acrodynia in children)**
Organic (methyl; ethyl)	•**Fish** •**Fungicides** •**Preservatives (vaccines)**	**Ingestion** **Parenteral** **Transplacental; inhalation**	**Faeces**	**CNS** **Cardiovascular**

Mercury: Toxic Effects

- **Neurotoxicity: CNS main target (endpoint in exposure to organic and elemental Hg)**
- **Nephrotoxicity: kidney (endpoint in exposure to inorganic Hg)**
- **Teratogenicity: MeHg is a teratogen (Minamata disease)**
- **CVS: elevated risk of heart attack, hypertension (?)**
- **Carcinogenicity: MeHg is a possible human carcinogen (Group 2B: IARC)**
- **Mutagenesis: Hg seems not to be mutagen**
- **Reproduction: no clear evidence of effect**
- **Immunotoxicity: under scientific discussion**

Mercury: Acrodynia

Uncommon syndrome "Pink disease":

- Pain in the extremities
- Pinkish discoloration and desquamation
- Hypertension
- Sweating
- Insomnia, irritability, apathy

Considered as idiosyncratic reaction.

Schwarz

Muhlendahl

Source: WHO Children’s Environmental Health

Factors affecting Occurrence and Severity of Health Effects

- Chemical form
- Dose
- Age
- Duration
- Route of exposure
- Dietary patterns of fish and seafood consumption

Susceptible Population

- More sensitive- fetus, newborn, children

  Mothers, pregnant women, women of reproductive age

- Exposed to high levels of Hg-subsistence fishers, recreational anglers, regular eaters of fish, shellfish, muscles and organs from marine mammals

- Individuals with diseases of the liver, kidney, nervous system, lungs

- Individuals with dental amalgams

- Workers with high occupational exposure

- Users of products (soaps, creams, traditional/cultural)

Exposure Assessment: Biomonitoring

- Hair-chronic exposure to methylHg, direct relationship with blood
- Blood
- Cord blood or tissue
- Urine
- Nails
- Human milk

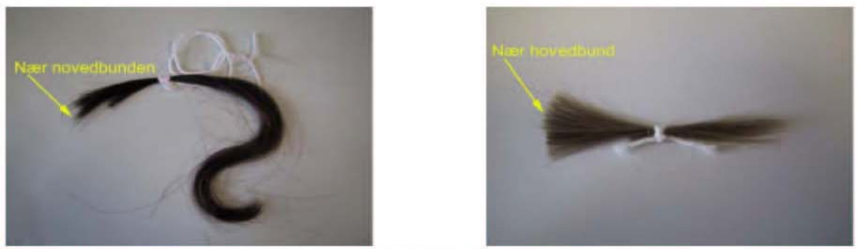
.1µg/kg/day intake of methylHg=
1 µg/g hair=5-6 µg/li in cord blood=4-5 µg/li blood

Health Assessment: Collection of Hair Samples

Instructions for hair sampling for mercury analysis

A small lock of hair (thickness about a match) from the back of the neck is tied together with a cotton string. The knot is tied about 1 cm from the scalp.

The lock is cut as close to the scalp as possible and placed is a marked paper envelope (not plastic due to problems with static electricity). The hair sample below to the right is ideal, because the hair strands are aligned, and proximal end of the hair is easily identified (the yellow arrow).



The envelopes with hair samples can be stored at room temperature.

Please label the envelope with the following information:

- Project name or number
- Subject name and/or code
- Date of sampling
- Sampling number (if appropriate)

Trace Elements Laboratory
University of Southern Denmark/ Odense University Hospital
April, 2005

Reference Levels for Methylmercury

Country/Organization	Reference Level (µg MeHg/kg bw/week)	Year adopted
Canada[5]	1.4 [6 7]	1997
Japan[8]	2.0	2005
Netherlands[9]	0.7	2000
United States[10]	0.7 [7]	2001
JECFA[11]	1.6	2003

[5] Bureau of Chemical Safety

[6] For pregnant women, women of childbearing age and young children. The reference level for the general population of 3.3 µg MeHg/kg bw was established in 1972.

[7] Originally expressed in terms of µg MeHg/kg bw/day

[8] Food Safety Commission

[9] National Institute for Public Health and the Environment

[10] US Environmental Protection Agency

[11] Joint FAO/WHO Expert Committee on Food Additives

Maximum allowable Hg in Fish to be sold in the market

- Codex Alimentarius: .5 mg methylHg in non predatory fish;

  1 mg methylHg in predatory fish
- USFDA: set an action level of 1 mg methylHg in finfish and shellfish
- EC: allows .5 mg Hg/kg

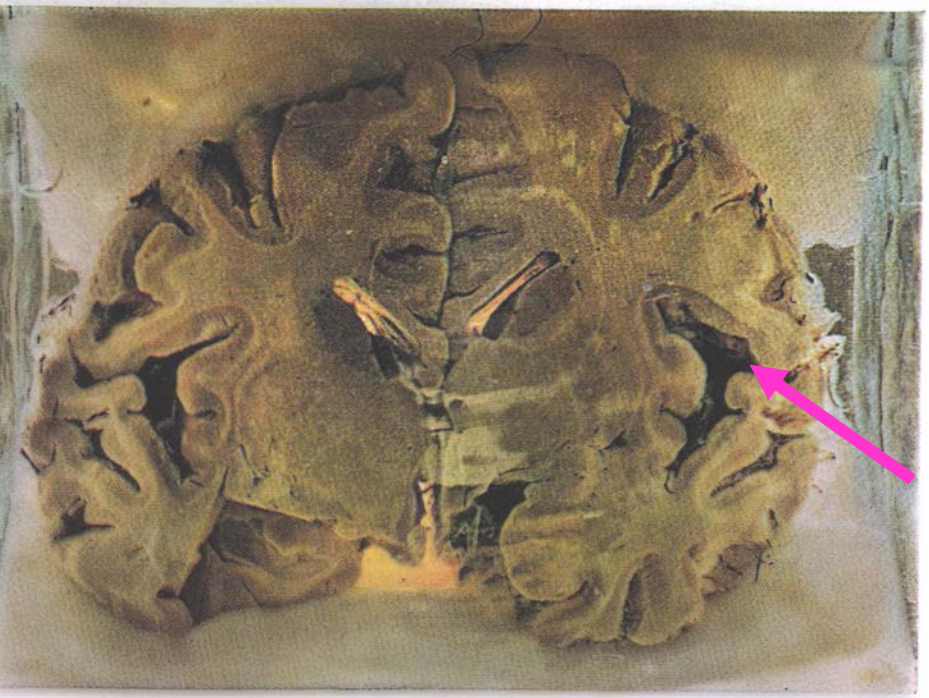
  in fish products
- Japan: .3 mg methylHg/kg

  in fish

Source: FAO

The worst:
Empty head/
Vacant mind

Healthy brain



Brain from a person with Minamata disease.

An empty space in a shrinking brain due to necros/small neuron

Lars.Hylander@hyd.UU.SE

Guidance for Identifying Populations at Risk from Mercury Exposure June 2008

Available at…

http://www.chem.unep.ch/mercury/Populationsatrisk.htm

http://www.chem.unep.ch/mercury/

Risk Management of Mercury in Fish

Dr Gerald G. Moy
Food Safety and Zoonoses Department
Cluster on Health Security and Environment
World Health Organization
Geneva, Switzerland

World Health Organization

- Established in 1948
- Currently 192 Member States
- Headquarters and 6 Regional Offices

- Provides guidance in the field of health
- Strengthens national health programmes
- Develops and transfers appropriate health technology, information and standards

WHO and Food Safety

WHO Constitution

Develop, establish and promote international standards with respect to food (1948)

Milestones

Toxic hazards of pesticides (1953)

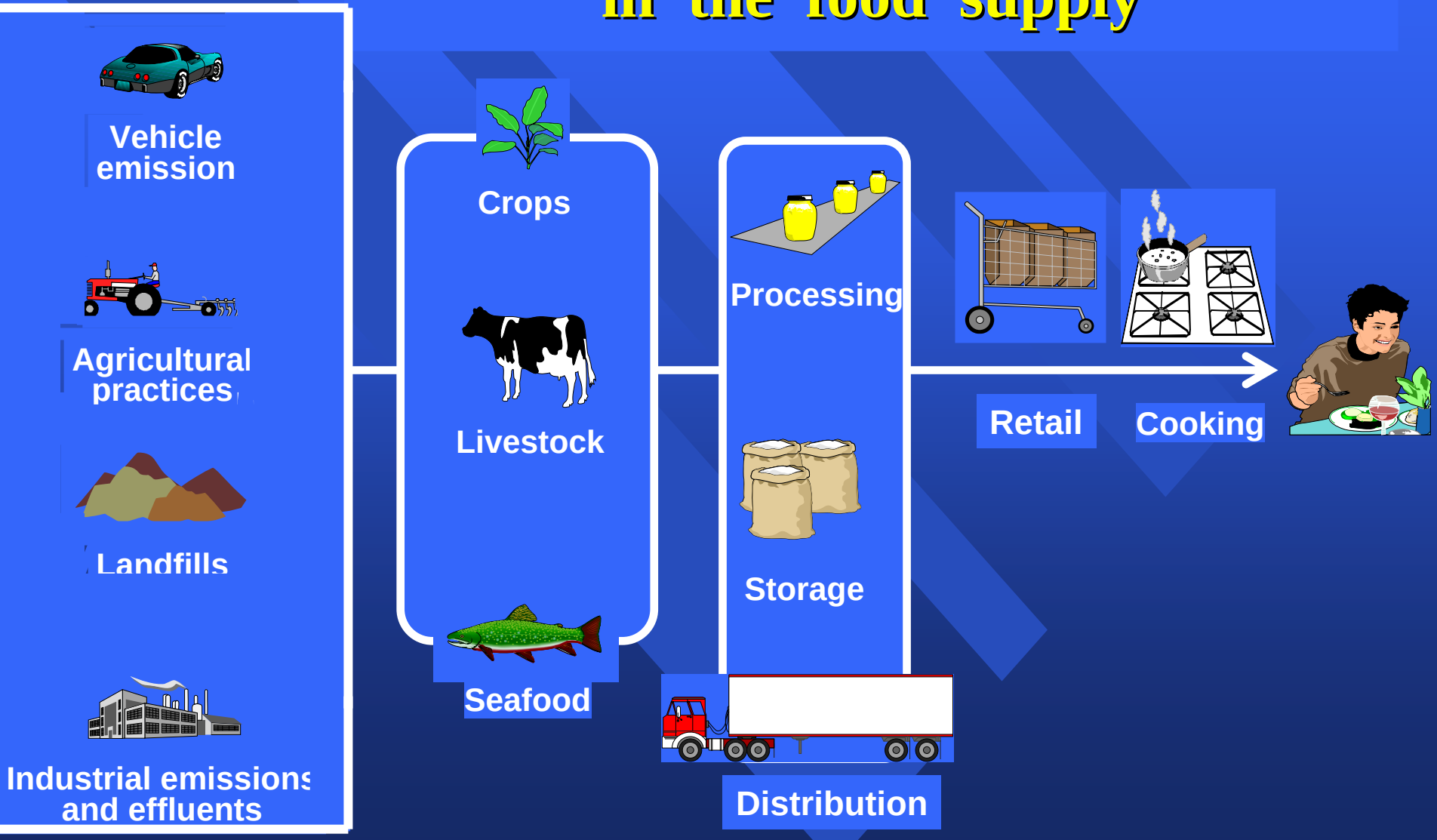
Codex Alimentarius Commission (1963)

WHO Food Safety Programme est. (1978)

Food safety in environmental health and nutrition (UNCED and ICN, both1992)

WTO SPS Agreement (1995)

Where chemical hazards arise in the food supply



Risk Analysis Paradigm

- Risk assessment
- Risk management
- Risk communication

Risk Assessment

- Hazard Identification
- Hazard Characterisation
- Exposure Assessment
- Risk Characterisation

Risk Management

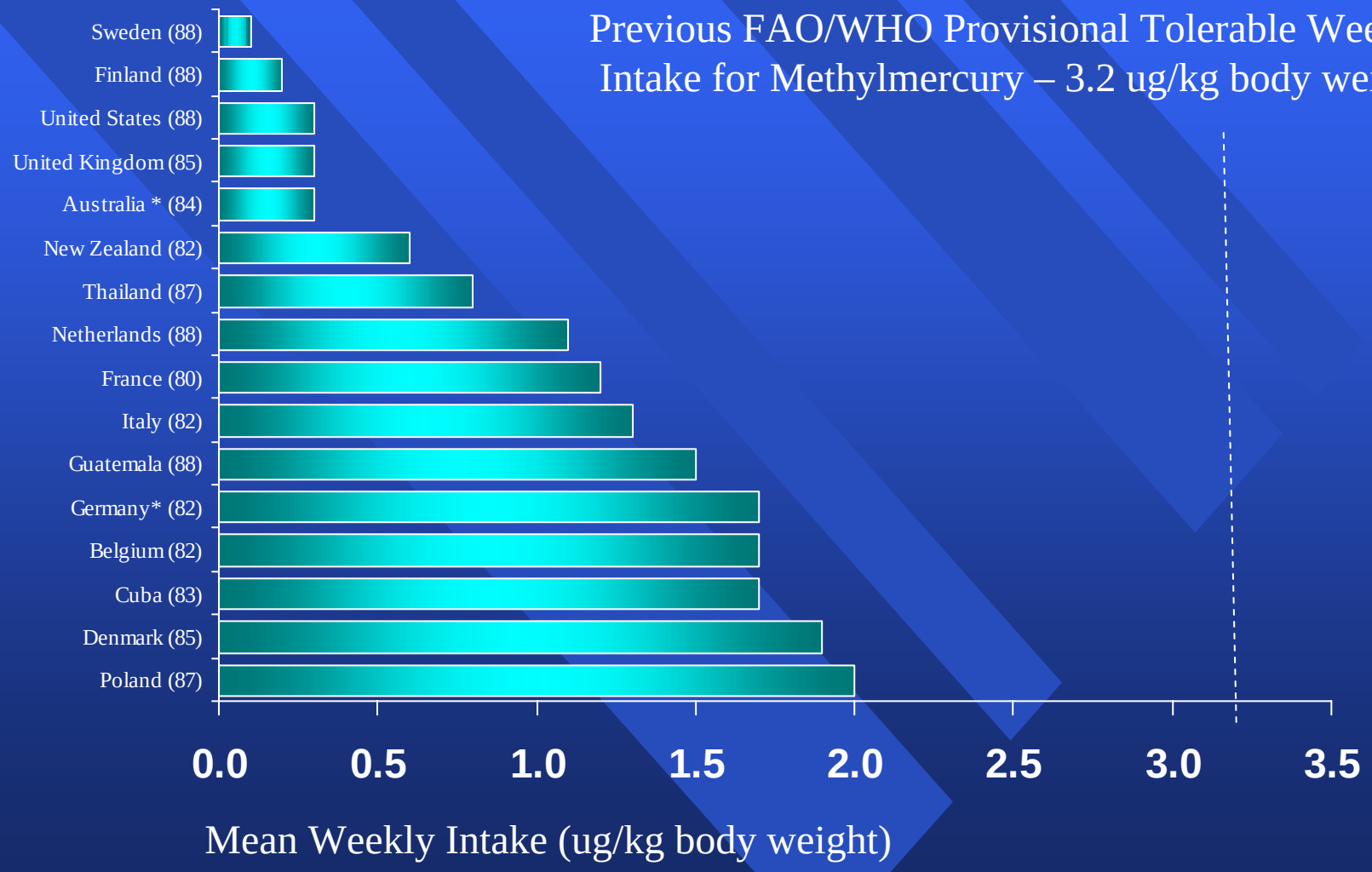
- Risk Evaluation
- Management Option Assessment
- Implementation of Selected Option
- Monitoring and Review


Risk Communication
Risk Characterization
Risk Evaluation
Option Assessment
Hazard Characterization
Exposure Assessment
Risk Management
Option Implementation
Risk Assessment
Monitoring and Review
Hazard Identification
Consumers, Industry and
Other Interest Parties

Risk Assessment and Management at International Level

- Joint FAO/WHO Expert Committee on Food Additives (JECFA)
- Codex Alimentarius Commission

Dietary Intake of Mercury by Adults



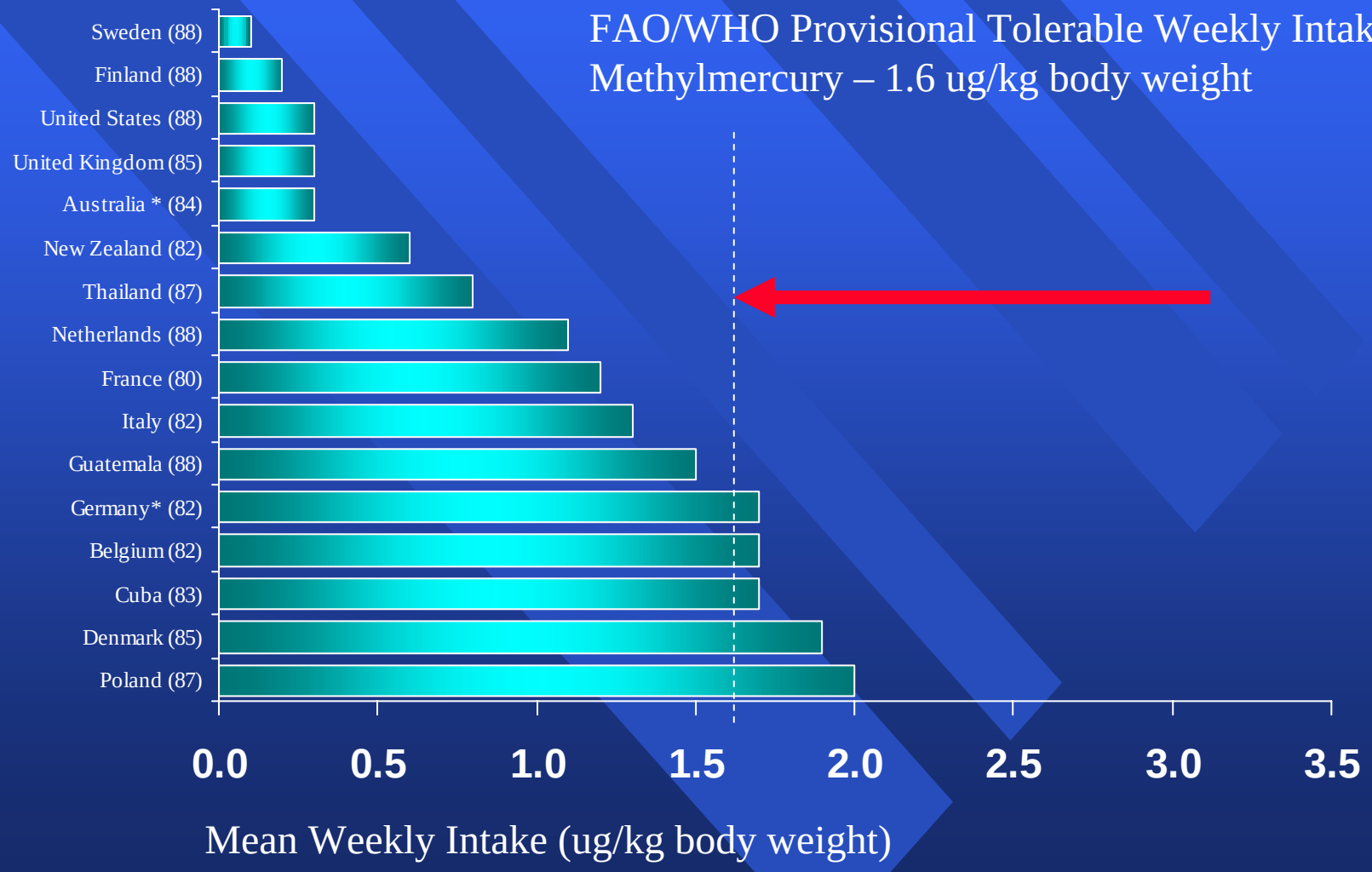
*Median Weekly Intake

Codex Alimentarius Commission

- Guideline Levels for Methylmercury
  - 0.5 mg/kg for non-predatory fish
  - 1.0 mg/kg for predatory fish

Dietary Intake of Mercury by Adults

FAO/WHO Provisional Tolerable Weekly Intakes
Methylmercury – 1.6 ug/kg body weight



*Median Weekly Intake

Need for Guidance for Risk Managers

- Focus on fetus
- Consider benefits of fish consumption
- Refine exposure assessment of main target group, i.e. women of childbearing age
- Use tiered approach to promote cost-effectives
- Include consideration of uncertainty

Risk Manager's Guide to Methylmercury in Fish

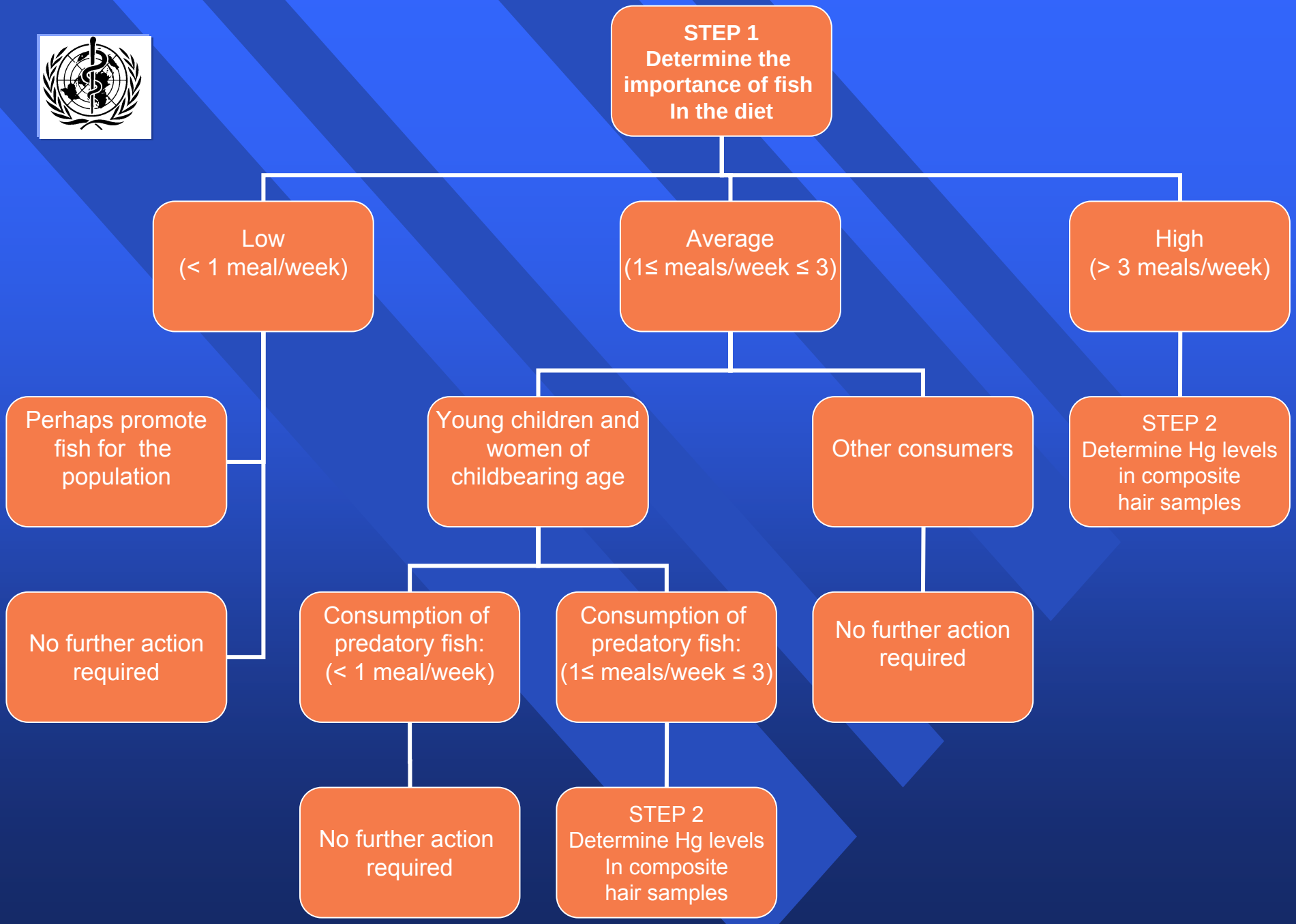
Hazard Identification

Risk Assessment

STEP 1
Determine the importance
of fish in the diet

Reference Levels for Methylmercury

Country or authority	Level in ug/kg bw/week	Year of adoption
Canada	1.4	1997
Japan	2.0	2005
Netherlands	0.7	2000
United States	0.7	2001
JECFA	1.6	2003


STEP 1
Determine the importance of fish In the diet
Low
(< 1 meal/week)
Average
(1≤ meals/week ≤ 3)
High
(> 3 meals/week)
Perhaps promote fish for the population
No further action required
Young children and women of childbearing age
Other consumers
STEP 2
Determine Hg levels in composite hair samples
Consumption of predatory fish:
(< 1 meal/week)
Consumption of predatory fish:
(1≤ meals/week ≤ 3)
No further action required
No further action required
STEP 2
Determine Hg levels In composite hair samples

STEP 2
Determine Hg levels in composite hair samples

Hg in composite hair samples << 2 µg/g

No further action required

Hg in composite hair samples ≥ 2 µg/g

STEP 3
Determine Hg levels in individual hair samples

STEP 3
Determine Hg levels in individual hair samples

Distribution of Hg levels mainly < 2 µg/g, with few individuals over 2 µg/g

No further action required

Distribution of Hg levels mainly < 2 µg/g, but some individuals over 2 µg/g

Risk management judgement

Distribution of Hg levels mainly ≥ 2 µg/g

STEP 4
Refine exposure database

STEP 4
Refine exposure database

Determine fish intake by species, amount and frequency

Determine total Hg in species of fish consumed

Determine consumer body mass

STEP 5
Calculate Hg exposure

STEP 5
Calculate Hg exposure

MeHg intake
< 1.6 µg/kg bw/week*
< 3.2 µg/kg bw/week**

No further action required

MeHg intake
≥ 1.6 µg/kg bw/week*
≥ 3.2 µg/kg bw/week**

STEP 6
Determination of MeHg in composite fish samples

STEP 7
Calculation of MeHg exposure from fish

* Valid for women of childbearing age and young children
** Valid for other adults

STEP 7
Calculation of MeHg exposure from fish

MeHg intake:
< 1.6 µg/kg bw/week*
< 3.2 µg/kg bw/week**

No further action required

MeHg intake:
≥ 1.6 µg/kg bw/week*
≥ 3.2 µg/kg bw/week**

Implement public education

Implement regulatory measures

* Valid for women of childbearing age and young children
** Valid for other adults

Consider regulatory measures to:

- Prohibit sale of fish not in compliance with guideline levels
- Restrict fishing in water where fish are known to be high in Hg
- Implement environmental measures to reduce emissions

Consider public education by promoting:

- Consumption of non-predatory fish species
- Consumption of fish species of smaller size
- Reduction of fish intake among high consumers

Acknowledgements

Dr Edenise Garcia

Ms Melissa Legrand

Ms Jennifer Murcott

MERCURY : A Global Approach

UNEP's mercury initiative

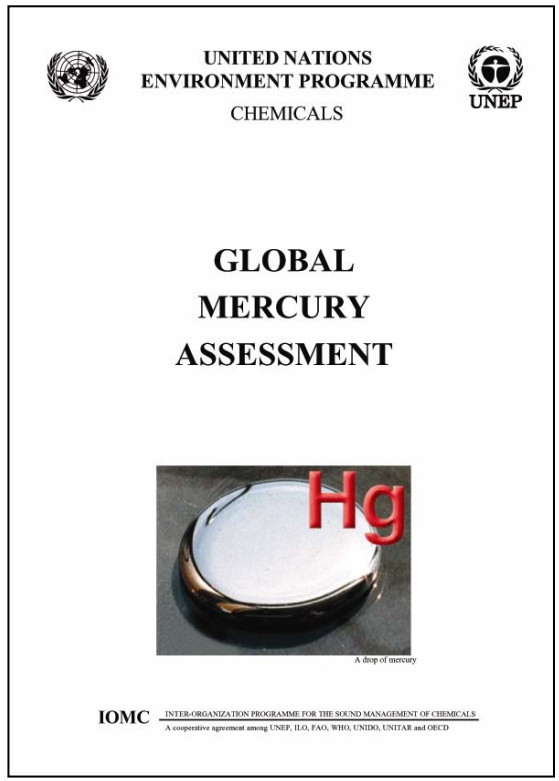
Sheila Logan
Coordinator
Mercury and other metals programme

Overview of Presentation

- Overview and Context of the UNEP Mercury Programme
- Political Process
- UNEP Global Mercury Partnership
- Air Emissions Report

The problem with mercury – the global assessment

- Initiated by UNEP GC in 2001;
- Concerns that national/regional actions were not sufficient


UNITED NATIONS
ENVIRONMENT PROGRAMME
CHEMICALS

UNEP

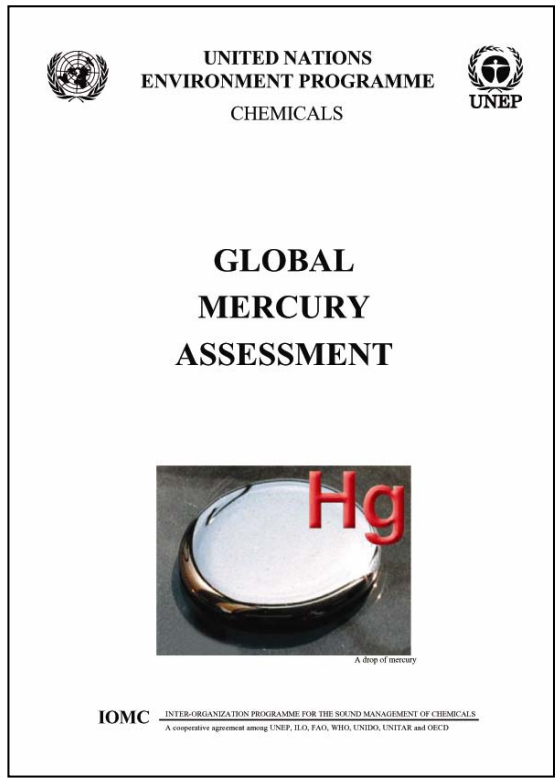
GLOBAL
MERCURY
ASSESSMENT

A drop of mercury

IOMC INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD

Key Findings of the Global Mercury Assessment …

- Hg is persistent and cycles globally – emissions in any continent can contribute to deposition in others thus an international issue
- Due to long-range transport, even nations with minimal Hg releases, and other areas remote from industrial activity, may be adversely affected.
- sufficient evidence of significant global adverse impacts from mercury to warrant further international action.



Mandates for Mercury Work

- 2001: global assessment of mercury
- 2003: national, regional and global actions, to be initiated ASAP
- 2005: call for partnerships between Governments, IGOs, NGOs and private sector to reduce risks from mercury
- 2007: Recognition that efforts were inadequate

Mandates for Mercury Work

- 2007: UNEP's Governing Council :
  - Concluded that further long-term international action is required; and
  - Decided to review the options of enhanced voluntary measures and new or existing legally binding instruments
  - strengthened the role of partnerships

Overarching objective for the UNEP mercury programme

- To protect human health and the global environment from the release of mercury and its compounds by minimizing and, where feasible, ultimately eliminating global, anthropogenic mercury releases to air, water and land.

UNEP Mercury Programme focused in three main areas

1. Open ended working group process
   - POLITICAL
2. Mercury partnership programme
   - PLATFORM FOR ACTIONS
3. Development of reports
   - BASIS FOR DECISION-MAKING

1. Open Ended Working Group

- Established in 2007 to review and assess options for enhanced voluntary measures and new or existing international legal instruments.
- Final meeting from 6-10 October 2008, Nairobi.

- Possible final recommendations to address mercury include:
  - Utilization of relevant elements of existing instruments (both legally binding and voluntary)
  - Drafting new protocols or procedures for inclusion in existing instruments
  - Negotiation of a “stand-alone” agreement (could be legally binding and/or voluntary).

2. UNEP Global Mercury Partnership

- UNEP was mandated to strengthen to the Partnership programme through:
  - Developing an overarching framework for the UNEP Global Mercury Partnership (developed and to be presented to the Governing Council in February 2009).
  - Development of business plans, identify partnership objectives for individual partnership areas.
  - Strengthening actions.

What is the role of a partner…?

- Supports the overall goal of protecting human health and the global environment from the release of mercury and its compounds by minimizing and, where feasible, ultimately eliminating global, anthropogenic mercury releases to air, water and land

- Commits to contribute resources or expertise towards the development and implementation of partnership activities

- Networks with other organizations/agencies/ individuals

Mercury partnership activities currently underway

- artisanal/small-scale gold mining;
- coal combustion;
- chlor-alkali sector;
- reduction in products
  - batteries, dental amalgams, measuring and control (largely medical sector), electric and electronic switches, flourescent lamps, cosmetics; and
- air transport and fate research.
- waste combustion

New partnership areas proposed by Governing Council Decision

- vinyl chloride monomer production
- non-ferrous metals mining
- cement production
- supply and storage

Artisanal & Small Scale Gold Mining

UNEP

- UNIDO has developed ground level expertise in this area:
  - wrapping up a pilot project in 6 countries (Brazil, Lao PDR, Indonesia, Sudan, Tanzania and Zimbabwe)
  - looking to broaden and build on the pilot project;
  - Currently fundraising and organising Phase II of the project
- UNEP is organising regional projects within the partnership with SAICM QSP in Asia and Latin America

Coal fired power & heat production

- **Current Priority actions**
- Encourage use of BAT/BEP to reduce or eliminate mercury releases into the environment.
- Assist countries in evaluating environmental impacts of coal combustion and evaluating the opportunities to achieve multi-pollutant emission reductions.
- Support the development and/or improvement of mercury emission inventories to evaluate both mercury emissions and the effectiveness of emission reduction approaches.
- Increase the awareness of mercury as a pollutant of concern through increased outreach efforts and collaboration with complementary programmes (such as at UNFCC level).

Chlor-alkali production

On-going and Planned Activities

- Arctic Council Action Plan (ACAP) has been working closely with Russia's Volgograd Caustic:
  - UNEP working with ACAP to see if pilot project can be used to demonstrate more broadly planning and changeover process
- World Chlorine Council working to catalogue facilities using mercury-cell technology and collecting information on use and emissions from its facilities;
- UNEP surveying existing chlor-alkali plants to update use and release information

Mercury in products

- Mercury in products awareness workshops
- Health care sector- hospital projects in Mexico, China, Argentina, South Africa
- Schools project- Philippines
- Waste management guidelines;
- Arctic Council Action Plan (ACAP) mercury project ‘Collection, storage and treatment of mercury containing waste in Russia Demonstration Project’;
- Linkages within DTIE Sustainable Consumption & Production Branch.

Air Transport and Fate Research

UNEP

On-going and Planned Activities

- Italy is planning a monitoring project in China.
- An overall plan indicating contributions of various countries is being developed by Italy.
- The partnership is making a contribution to the updated emissions study requested by GC 24/3
- Work on inventories in Asia and Latin America will contribute information to this partnership

Waste partnership

- Led by Japan
- Business plan developed
- A ‘waste’ project building on previous inventory work is proposed as an activity under this partnership
  - Working in partnership with the secretariat of the Basel Convention

3. Reports, guidelines and guidance

- UNEP has developed a number of reports over the last three years to provide information and guide country activities
  - Guidance for Identifying Populations at Risk from Mercury Exposure (launched today!)
  - Toolkit for identification and quantification of mercury releases
  - Guide for reducing major uses and releases of mercury
  - Summary of Supply, Trade and Demand information on mercury

UNEP is developing an air emissions data report

- Based on best available data;
- Where possible includes an analysis by country region and sector, including consideration of driving trends and applicable regulatory mechanisms.
- Large improvements, new methodologies, improved estimations, however still large uncertainties!

Scenarios included

- Scenario developed for 2020:
  - The Status Quo
    - Based on expected increase in economic activity, but with current patterns and uses of Hg andno change in emissions control
  - The Extended Emissions Control
    - implementation of emissions control measures practiced or committed to in Europe extended globally
  - The Maximum Feasible Technological Reduction
    - Assume implementation of all possible measures to reduce mercury emissions

Report availability

- Currently out for review
- Draft report will be made available to second meeting of OEWG in October
- Final report will be tabled at GC 25, 16 – 20 February 2009

Looking ahead in 2008…

1. Second meeting of the OEWG
   - 6-10 October 2008
   - Will present options and any consensus recommendations to the Council at its twenty-fifth regular session;

2. Partnership:
   - Activities to reduce uses and releases of mercury ongoing (ASM, waste, storage, products)

3. Air emissions report will be published late 2008

Further information can be found at:

http://www.chem.unep.ch/mercury/

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