Asia-Pacific
Economic Cooperation

2015/SOM3/CD/WKSP/012

Regulation of Metals in Aquatic Systems

Submitted by: OECD

APEC
PHILIPPINES
2015

Workshop on Metals Risk Assessment
Cebu, Philippines
28-29 August 2015

Regulation of Metals in Aquatic Systems

Joop de Knecht

Environment Health & Safety Division,
OECD

Overview

- U.S. EPA (and U.S. States) regulatory approach as illustrative example (from K. Gallagher, U.S. EPA, 2014)
- Australia/New Zealand: Similar approach
- European Union: Similar approach
- Possible approaches for APEC Economies for regulating metals

2

U.S. EPA (and U.S. States) Regulatory Approach

3

U.S. Law: Clean Water Act

- **Objective:** "restore and maintain the chemical, physical and biological integrity of the Nation's waters" (Clean Water Act 101(a))
- **Interim goal:** "water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation (Clean Water Act 101(a)(2))
- **Implementation by States, Territories, and authorized Tribes**

4

Framework for Clean Water Act Standards

Set Standards

Technology-Based Standards
- Minimum national standards for industrial and municipal discharges (ELGs & BPJ)

Water Quality-Based Standards
- EPA develops recommended **Water Quality Criteria**
- Used by states in setting water quality standards

Implement Programs

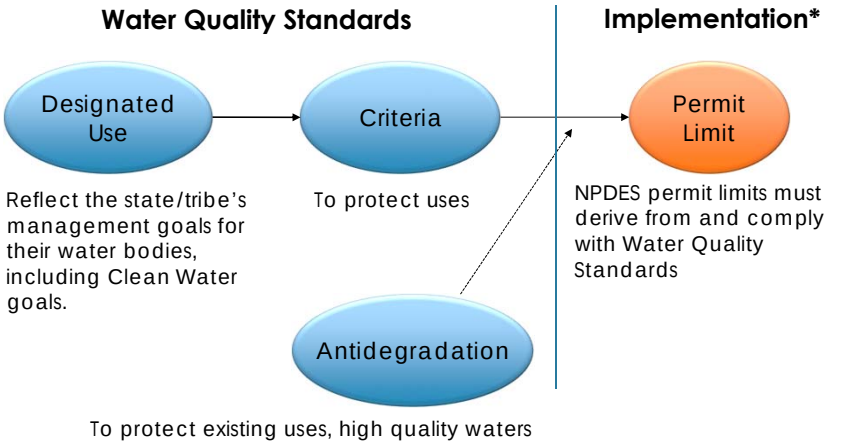
- **State Water Quality Standards**
- **Surface Water Assessment and Listing**
- **TMDLs***
- **Nonpoint Source Program**
- **Trading**
- **NPDES# Permits**

* "Total Maximum Daily Load" limits

National Pollutant Discharge Elimination System

5

Water Quality Standards Schematic



* NPDES is just one example of implementation

6

Examples of Designated Uses

- **Protection and propagation of fish, shellfish, and wildlife**
- **Recreation in and on the water**
- Public water supply
- Agriculture
- Navigation
- Other uses

Photo courtesy of USGS

7

Water Quality Criteria

- A scientifically determined numeric value (e.g., concentration, duration, and frequency) or narrative statement developed to be protective of aquatic life.
  - **Example numeric:** "To protect Aquatic Life, Chemical X shall not exceed ***y micrograms per liter*** as a ***one hour average*** more than ***once every three years***."
  - **Example narrative:** "To protect all Designated Uses, there shall be no toxic materials in toxic amounts.
- **Represent a level of water quality that supports a particular use**
- **EPA Publishes Water Quality Criteria recommendations under Section 304(a) of the Clean Water Act (also known as "EPA's 304(a) criteria recommendations")**

8

Minimum Dataset for Freshwater Criteria Derivation

SALMONID

SECOND FISH FAMILY

CHORDATA

PLANKTONIC CRUSTACEAN

BENTHIC CRUSTACEAN

INSECT

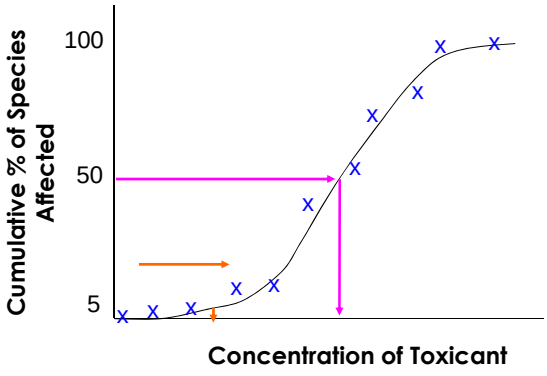
ROTIFERA, ANNELIDA, MOLLUSCA

OTHER INSECT OR MOLLUSCA

9

Species Sensitivity Distribution (SSD) Methods

- **In these methods the cumulative frequency of the sensitivity of species is plotted against the chemical concentration at which each species begins to experience toxicity**

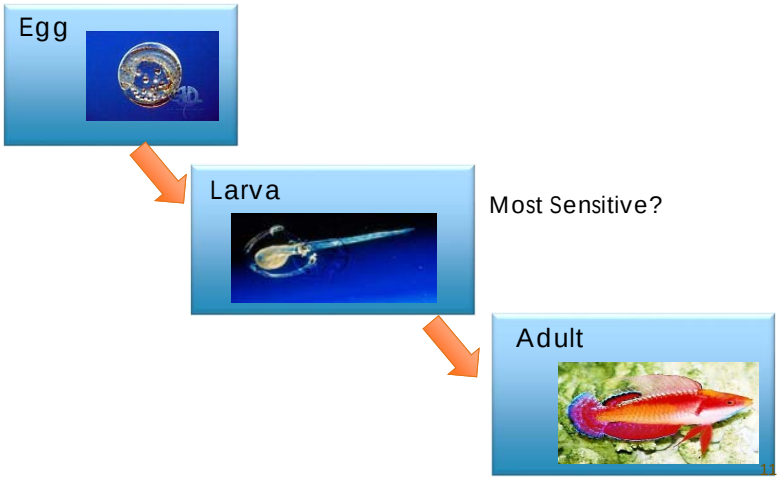


A distribution is fitted to the data and then the concentration that corresponds to allowing only a certain percentage of species to be affected is calculated e.g. HC50 (pink) and HC5 (orange)

10

Data Requirements

Data from the most sensitive life stage



11

Toxicity Test Data

- **Data sources and endpoints**

  Data are pulled from ecological toxicity database (ECOTOX, epa.gov/ecotox), and screened for applicability and quality. This is constantly updated, on a chemical-specific basis, from literature. A data search is also performed from a number of current sources, to be certain that data are current and accounted for.

  - **Acute:** 48-hour or 96-hour toxicity test, or longer (e.g., OECD)
    - Measured as LC50, EC50
    - Lethal concentration/effects concentration of 50% tested organisms
  - **Chronic:** 7-day or longer toxicity test
    - Measured as NOEC, EC10
    - Effects on mortality, growth, reproduction of tested organisms

12

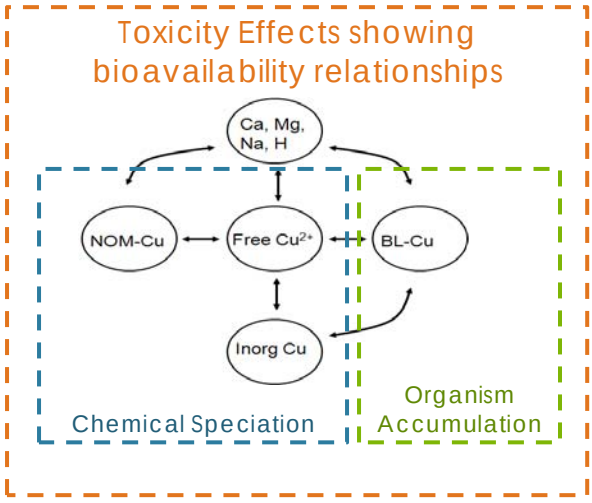
Water Quality Criteria Requirements (40 CFR 131.11)

- **States should adopt numeric Criteria based on:**
  - **Tier 1:** EPA's 304(a) National Criteria recommendations
  - **Tier 2:** 304(a) recommendations modified to reflect site-specific conditions:
    - Recalculation option: Criteria (SSD) based on local species sensitivity
    - Water effect ratio: Biovailability modified by toxicity testing in local water
    - For metals—Biotic Ligand Model: Biovailability predicted for local water chemistry
  - **Tier 3:** Other scientifically defensible methods
- **States should adopt narrative Criteria:**
  - Where numeric Criteria cannot be established
  - Or to supplement numeric Criteria

13

Marine BLM Conceptual Model and Data Needs

- **Input data**
  - pH
  - Dissolved organic carbon (DOC)
  - Salinity
  - Temperature



14

Freshwater Copper BLM: Current Status at EPA

- **Acute and Chronic Criteria for freshwater copper based on the Biotic Ligand Model (BLM) issued in 2007:**
  - Chronic, now based on Acute/Chronic Ratio, because of inadequate chronic data before 2007
  - EPA's national (BLM-based) copper criteria – adopted or considered by 34 U.S. States for their State Standards, thus far

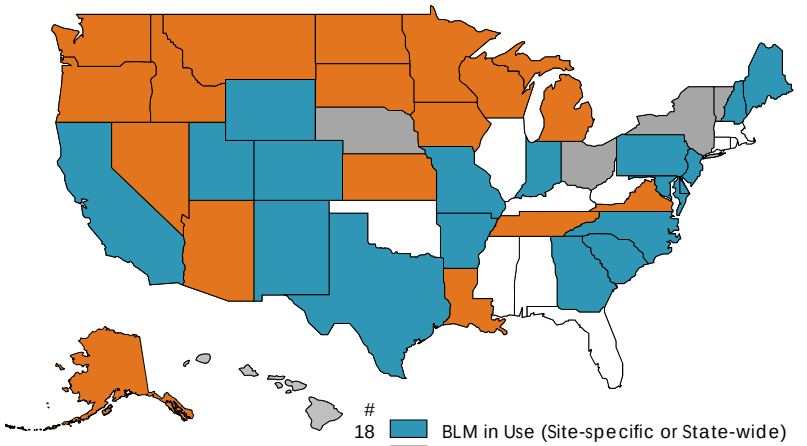
15

Freshwater Copper BLM: Current Status at EPA *(continued)*

- **U.S. EPA is updating the freshwater copper Biotic Ligand Model:**
  - Adding new toxicity data
  - Adding full chronic data/Species sensitivity distribution in lieu of A/C
  - Updated BLM will have ability to calculate a fixed monitoring benchmark (FMB) to adjust acute and chronic criteria for frequency and duration of exposure
  - New FMB BLM version – functionally equivalent to BLM version currently distributed by U.S. EPA
  - Expect to release an updated draft Cu BLM in 2015
- **EPA is developing BLM-based copper criteria for saltwater systems**

16

Copper BLM: Current States' Adoption



* Northern Mariana Islands also "state-wide"

17

U.S. Saltwater Criteria: BLM-based Update

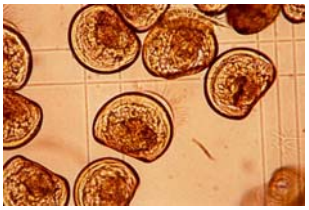
- **Literature including those included in the 1995* marine Criteria document, as well as new data published through April 2012 were screened for inclusion in this document**
- **Data were screened using standard EPA acceptability criteria**
- **Revision includes toxicity information for 553 saltwater toxicity tests using 83 species in 70 genera**
- **1995 document included 33 species in 26 genera**
- **Data were normalized to consistent chemistry conditions using the BLM**

*U.S. Environmental Protection Agency, Glen Thursby, and David J. Hansen. 1995. Ambient Water Quality Criteria - Saltwater Copper Addendum (Draft). EPA 440-5-80-036.

18

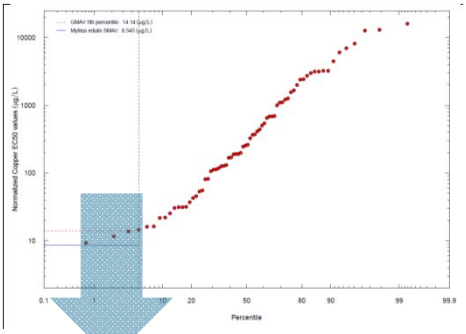
Sensitive Marine Invertebrates Used for BLM Development and Testing






19

Species Sensitivity Distribution Draft Update (HDR | Hydroqual 2012)

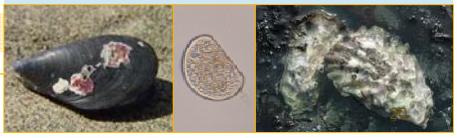


Sensitivity Rank	Species	SMAV (µg/L)
4	Eastern oyster, *Crassostrea virginica*	12.31
3	Summer flounder, *Paralichthys dentatus*	11.68
2	Mediterranean mussel, *Mytilus galloprovincialis*	10.11
1	Blue mussel, *Mytilus edulis*	8.54

Source: HydroQual 2012. Draft Update of Aquatic Life Ambient Saltwater Quality Criteria for Copper. Prepared for the U.S. Environmental Protection Agency.

- Updates and corrects 1995 dataset to include **67 genera (2.5X)** in SSD.
- **Incorporates Biotic Ligand Model** for Cu in saltwater
- Chronic[1]: 7.07 µg/L dissolved Cu **8.52 µg/L tot recov Cu**
- Acute[1]: 7.07 µg/L dissolved Cu **8.52 µg/L tot recov Cu**

[1]Normalized to DOC of test water
EPA diss/tot conversion: 0.83
FAV: 13.40 µg/L dissolved Cu
Mussel GMAV: 8.54 µg/L dissolved Cu
GMAV/1.2 = 7.07 µg/L dissolved Cu
Updated FACR = 1.2, based on mussel tests



20

Summary and Conclusions

- An update to the U.S. EPA saltwater criteria for copper that incorporates the BLM has been developed and is in review by U.S. EPA
- The BLM WQC uses DOC, pH, salinity to determine a protective criterion that considers local variation
- The BLM sets criteria that are protective of the most sensitive life stage of the most sensitive organism (*Mytilus* sp.)
- The saltwater BLM provides an easy to use tool that can develop protective marine values for copper using DOC, pH, and salinity

21

Australia-New Zealand Water Quality Guidelines

CSIRO Land and Water, Sydney, Australia

22

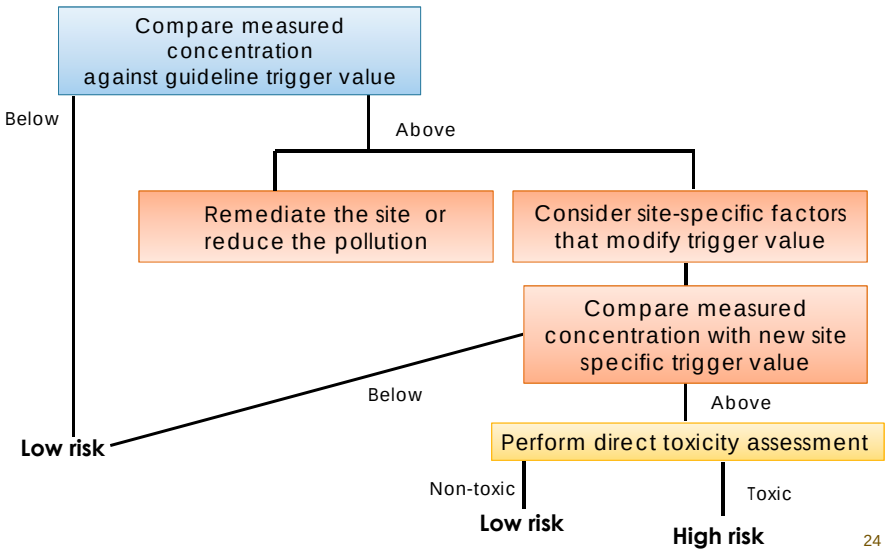
Levels of Protection

- **High conservation/ecological value systems**
  - No detectable change in biological diversity – PC99 (HC1)
- **Slightly-moderately disturbed systems**
  - Where guidelines will mostly be applied. Less stringent but maintain biological diversity – PC95 (HC5)
- **Highly disturbed systems**
  - Degraded and, while having ecological or conservation value, not restorable in short term – PC90 or PC80

...but the philosophy is one of continual improvement

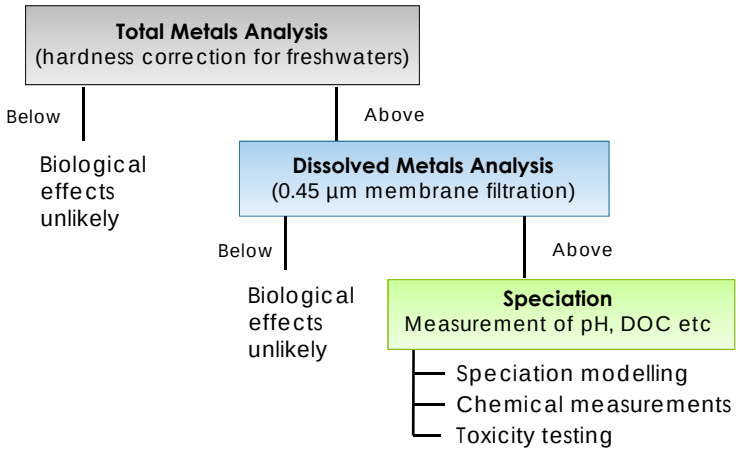
23

Aus WQGs Encourage Site-Specific Assessment



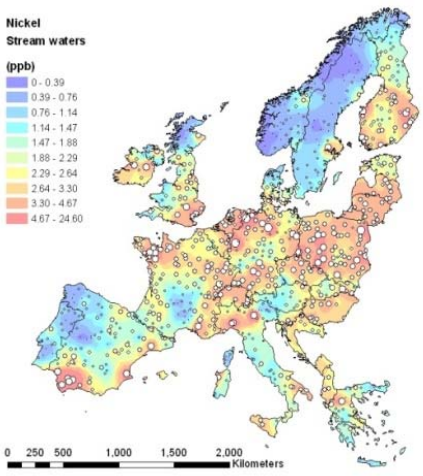
24

Australia: Tiered Decision Tree for Metals in Waters



25

Status of metal Environmental Quality Standards in the EU Water Framework Directive



26

EU Water Framework Directive (WFD, 2000/60/EC)

- **Goal—Ensure that European surface waters exhibit:**
  - Good ecological quality
  - Good chemical quality
- **Ecological quality**
  - 5 categories based on observed vs. expected community structure: bad, poor, moderate, good, high
  - Expert judgment involved

27

EU Water Framework Directive (WFD, 2000/60/EC) *(continued)*

- **Chemical quality**
  - Determined by comparison of ambient concentrations with Environmental Quality Standards (EQS)
    - If ambient concentrations > EQS, "failure to meet good quality"
    - Derogation (€ sent to Brussels)
  - EQSs established for Priority Hazardous Substances (PHS) and Priority Substances (PS)

28

Metals with EQSs under the WFD

- European Commission: Submitted proposal on January 31,st. 2012

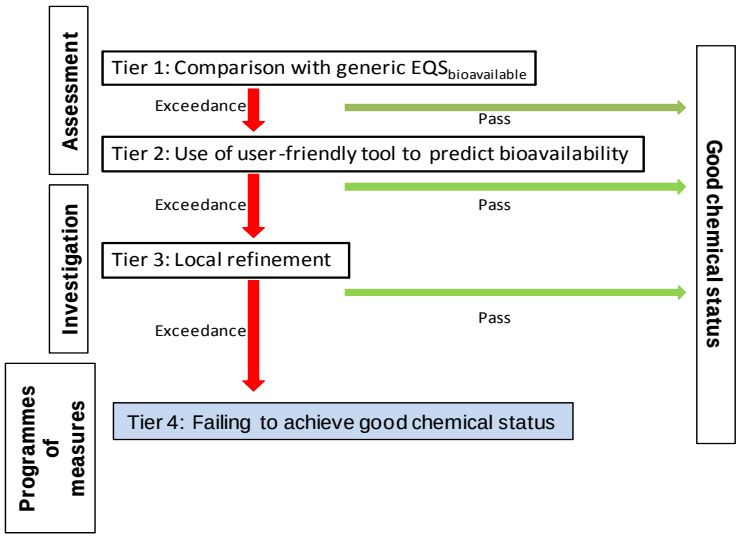
Metal	Classification[1]	Proposed EQS[2]
Cd	PHS	• 0.08 – 0.25 µg L^{-1} (Hardness-based)
Hg	PHS	• 0.07 µg L^{-1} (Dissolved) • 20 µg Hg/mg fish tissue (Tissue-based)
Ni	PS	• 4 $\mu g_{bioavailable}$/L (BLM-based)
Pb	PS	• 1.2 $\mu g_{bioavailable}$/L (DOC-based)
TBT	PHS	• 0.00002 µg /L (Dissolved)

[1] Classification:
PHS = Priority Hazardous Substance
PS = Priority Substance
[2] Scope: Freshwater, annual average based compliance

- Specific Pollutants: Some EU Member States (e.g., the UK, France) have developed bioavailability-based standards for metals, outside of their WFD obligations

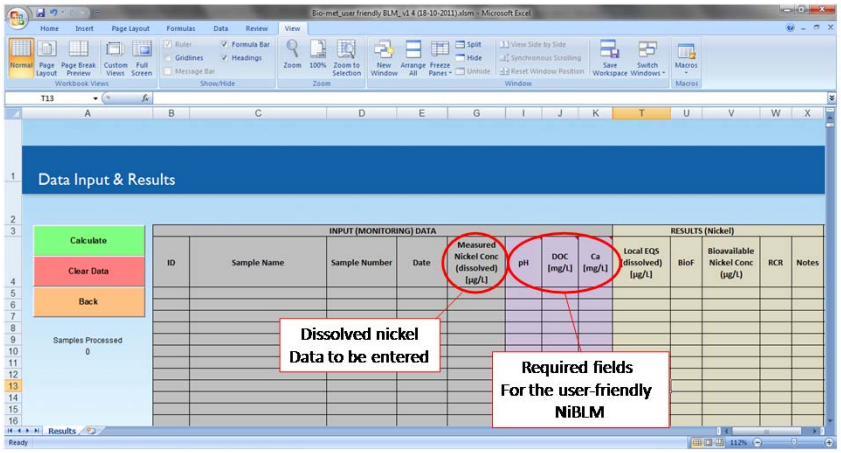
29

Incorporation of Bioavailability-Based Metal EQS into Compliance-Checking Programs: Tiered Approach and User-Friendly BLM



30

bio-met Bioavailability Tool



- Supported by NiPERA, Intl. Zinc Assoc., Intl. Copper Assoc.
- Developed by WCA Env. (UK) and Arche (Belgium)
- Available at www.bio-met.net

31

Possible Approaches to Setting Standards for Subtropical Asian Regions…

- **Examine the acute and chronic SSDs from U.S., Europe, possibly other countries (Australia, Brazil, …) for each chemical**
- **Identify sensitive taxonomic groups (e.g., cladocera, for Copper)**
- **Test local species of this/these taxonomic groups for both acute and chronic toxicity; confirm local species sensitivity to the chemical (i.e., near the 5th percentile of sensitivity)**

32

Possible Approaches to Setting Standards for Subtropical Asian Regions… *(continued)*

- **Supplement the foreign SSD(s) with the new local data**
- **For metals, if the local species is sensitive at/near the 5th percentile of the SSD, use that species to calibrate a BLM, and make the BLM available to Government Permit Writers to set local Standards near each discharger**

33

Possible Approaches to Setting Standards for Subtropical Asian Regions: Local Policy Decisions

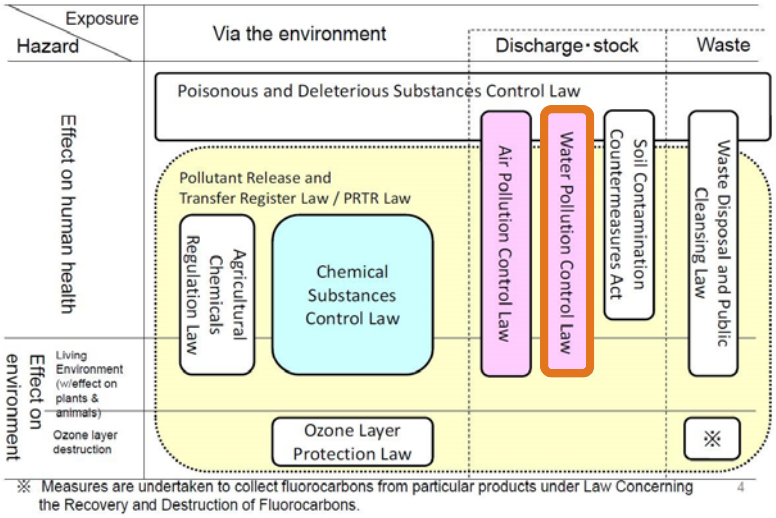
- **Decide on level, and spatial extent, of protection needed:**
  - Whole river/water body? → set standards based on chronic toxicity, or
  - Acute standard for a short distance downstream of discharge point (Mixing Zone), then chronic standard further downstream
- **Decide on schedule for implementation:**
  - Protection immediately, or after "compliance period" ?
  - Chronic-based standard NOW, or
  - Acute-based standard, with discharge permits given extended "compliance period" to meet chronic-based standard

34

Regulation of Metals in Aquatic Systems: Japan

35

Overview on Chemical Regulations in Japan



36

Chemical Regulations related to Environmental Risks of Metals in Japan

1. **Chemical Substances Control Law (CSCL)** REACH, TSCA
   - Pre-marketing regulation and the control of the existing chemicals.
2. **Environmental Quality Standards (EQS)** WFD
   - EQS for water for the protection of aquatic life Effluent Standards for Point Sources (End-of-Pipe)[Water Pollution Control Law]
3. **Initial Environmental Risk Assessment of Chemicals by Ministry of Environment**
   - Selection of candidate chemicals for detailed assessment

37

EQS of Zinc in Japan

- **Environmental Quality Standard (EQS) of zinc for the protection of aquatic life was established in 2003**
  - The first EQS for the protection of aquatic life in Japan
  - The EQS values are 0.03 mg/L for freshwaters, 0.02 or 0.01 mg/L for seawaters
- **Cu, Ni and Cd are among the candidates for setting EQS**

38

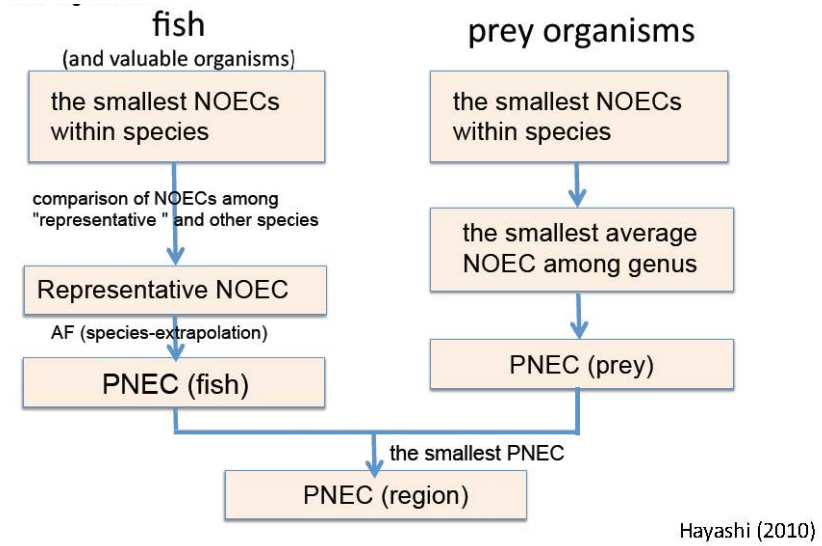
EQS of Zinc in Japan

- **The basis of the EQSs for the protection of aquatic life in Japan**
  - The most sensitive toxic value (e.g., NOEC) from a chronic exposure study on a native Japanese species or the related species
  - For zinc, the freshwater EQS was determined based on a chronic toxicity data of a mayfly *Epeorus latifolium* (Ephemeroptera). NOECgrowth = 0.03 mg/L
- **EQSs in Japan are strongly linked to National Effluent Standards**

39

The Framework for Deriving EQS: Summary

Aquatic lives are identified as "valuable" (edible or having amenity value) aquatic lives or their "food" organisms



Hayashi (2010)

Metal-specific Approaches are Not Currently Applied to Regulatory Risk Assessment of Metals in Japan

- **No bioavailability and BLM concept**
  - In CSCL
  - In EQS
  - In initial EPA
- **In FY2013, Working group on environmental risk assessment of metals for Initial ERA have discussed the current scientific and regulatory issues regarding the BLM application**

41

Challenges Ahead (From the WG and personal view)

- **Monitoring or database for BLM input parameters (e.g., pH, DOC, Ca, Mg)**
- **Domain of applicability of BLM in environment (e.g., low hardness) and species in Japan**
- **Understanding the issues on metal specificities among stakeholders**
- **Development of standardized methods or technical guidance**

42