Centro de Humedales Río Cruces

Universidad Austral de Chile
Conocimiento y Naturaleza

Contamination and pollution of water in Chile:

implications for water quality management in a country with extreme climatic differences.

CHILE-CHINA WORKSHOP
ON WATER RECOURSES MANAGEMENT IN CHINA AND CHILE

Santiago, June 27th, 2018

www.cehum.org

Intro. Chemical Pollution

- Volatilization.
- Transport (Water Cycle).
- Bio-accumulation.
- Bio-magnification.
- Maternal Transference.
- Mixes (Synergy).
- Degradation (Metabolites).

Bio magnificación

$3 \text{ X } 10^6$

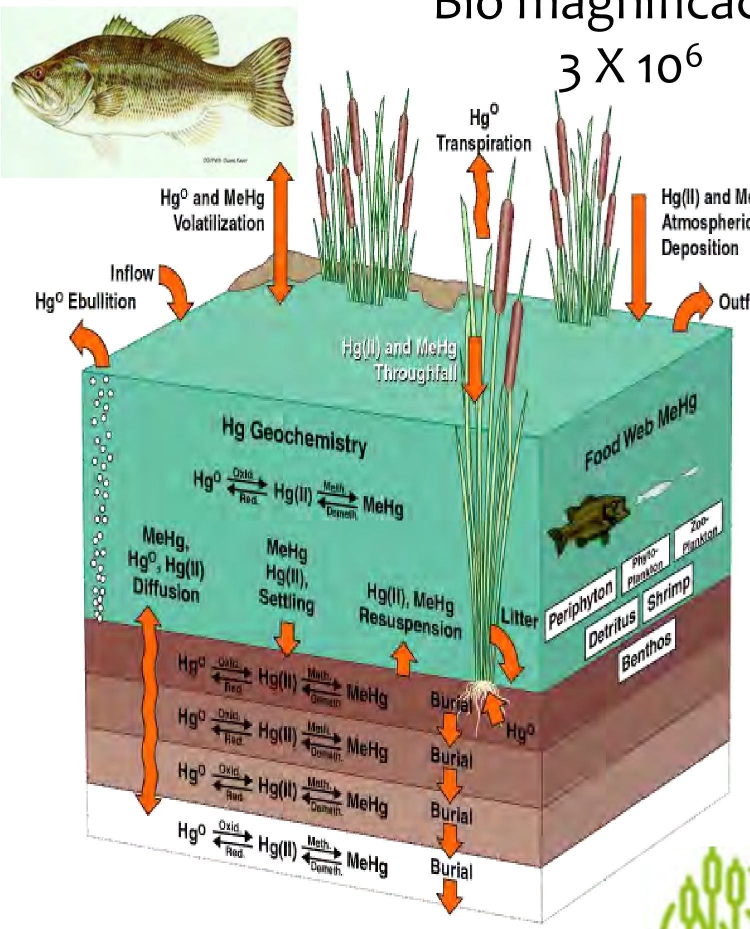


Figure 1. Conceptual model of Hg cycle in Everglades Hg Model

Important distinctions

"The known known, the known unknown and the unknown unknown"

Contamination≠ Pollution

Poor water quality = Less water availability

Effects on Organism Populations

Tipo de Compuesto	Mecanismo	Organismo	Referencias
Anti-incrustantes (tributiryl, TBT)	Esterilización y cambio de sexo	Gastrópodos	Oehlmann et al. 1996
Anti-conceptivos (Etinil estradiol)	Esterilización y cambio de sexo	Peces	Kidd et al, 2007
Pesticidas (DDT)	Adelgazamiento cáscara del huevo	Aves Rapaces	Porter and Wiemeyer 1969; Vos et al. 2000
Pesticidas (DDT), Herbicides, POPs	Varios efectos en reproducción (Disrupción endocrina, reducido tamaño peniano, transferencia maternal)	Reptiles	Guillette Jr et al. 1999, Willemsen and Hailey 2001, van de Merwe et al. 2010

Rodríguez-Jorquera et al, 2016. IEAM. DOI 10.1002/ieam.1839

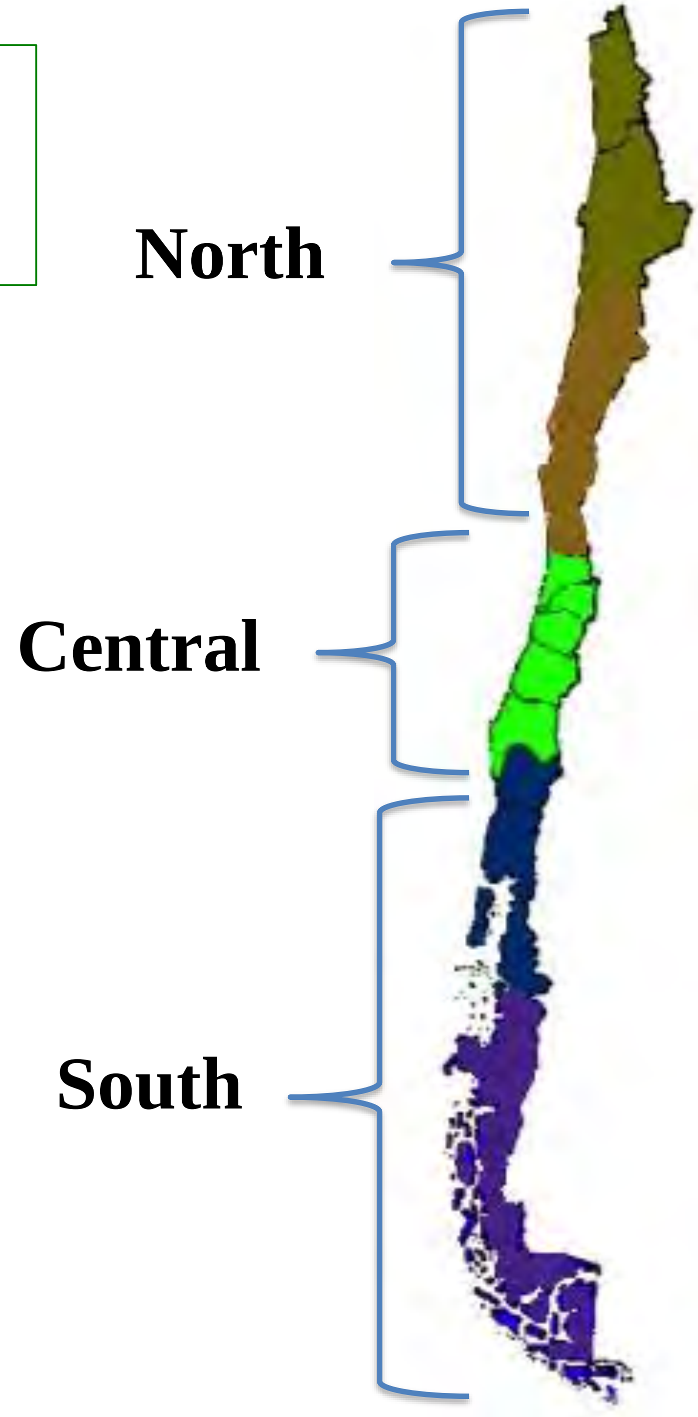
Effects on Organism Populations

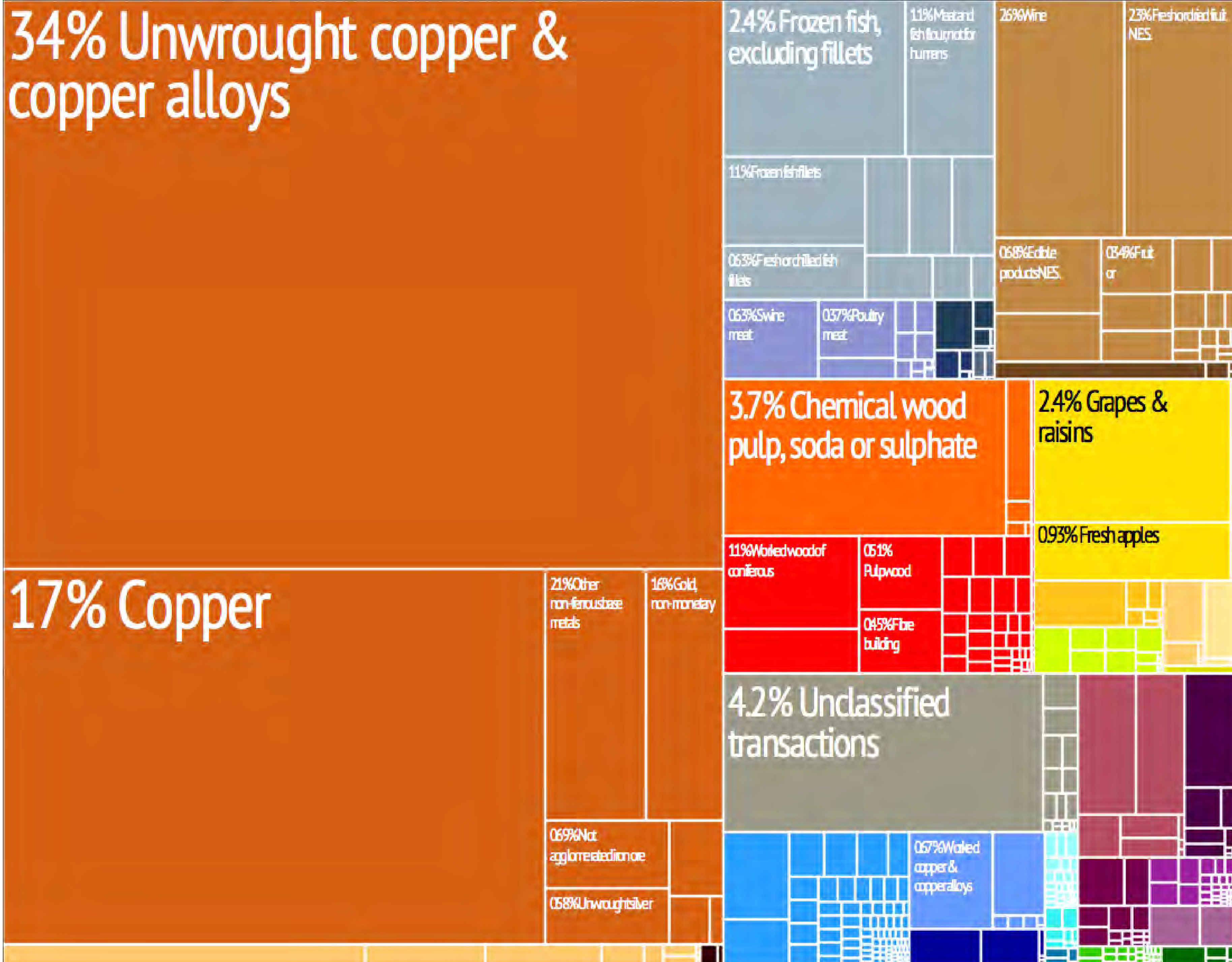
Tipo de Compuesto	Mecanismo	Especies	Referencias
Nitrógeno, Fósforo, Pesticidas.	Varios efectos en reproducción (Disrupción endocrina), deformaciones	Anfibios	Blaustein and Kiesecker 2002
Aguas servidas (Mezclas), Mercurio, residuos de papeleras.	Disminución de fertilidad y eclosión de huevos	Vertebrados ovíparos	Wolfe et al. 1998, Henny et al. 2002, Karasov et al. 2005, Tyor et al. 2012; Vasseur and Cossu-Leguille 2006
Nitrógeno, metales trazas	Varios	Macrófitas	Lepp 2012, Clark et al. 2013
Pesticidas		Bacteria	Imfeld and Vuilleumier 2012; Chakraborty and Bhadury 2015

Rodríguez-Jorquera et al, 2016. IEAM. DOI 10.1002/ieam.1839

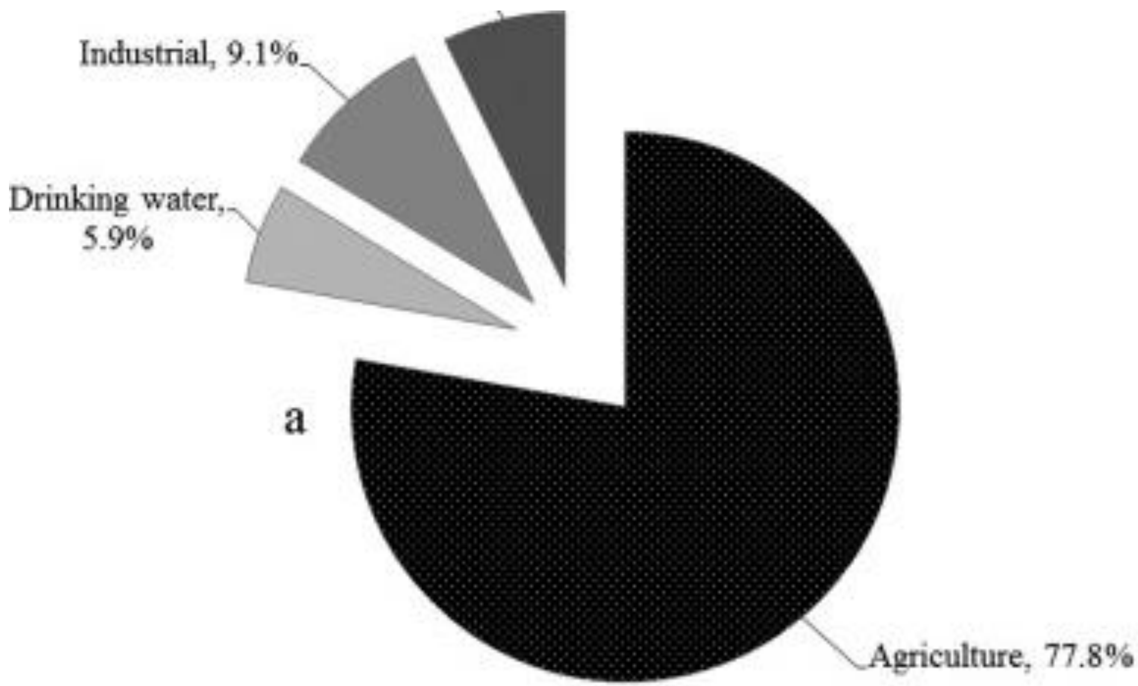
Macrozones

Climatic and water availability are major drivers on sources and water quality issues in Chile

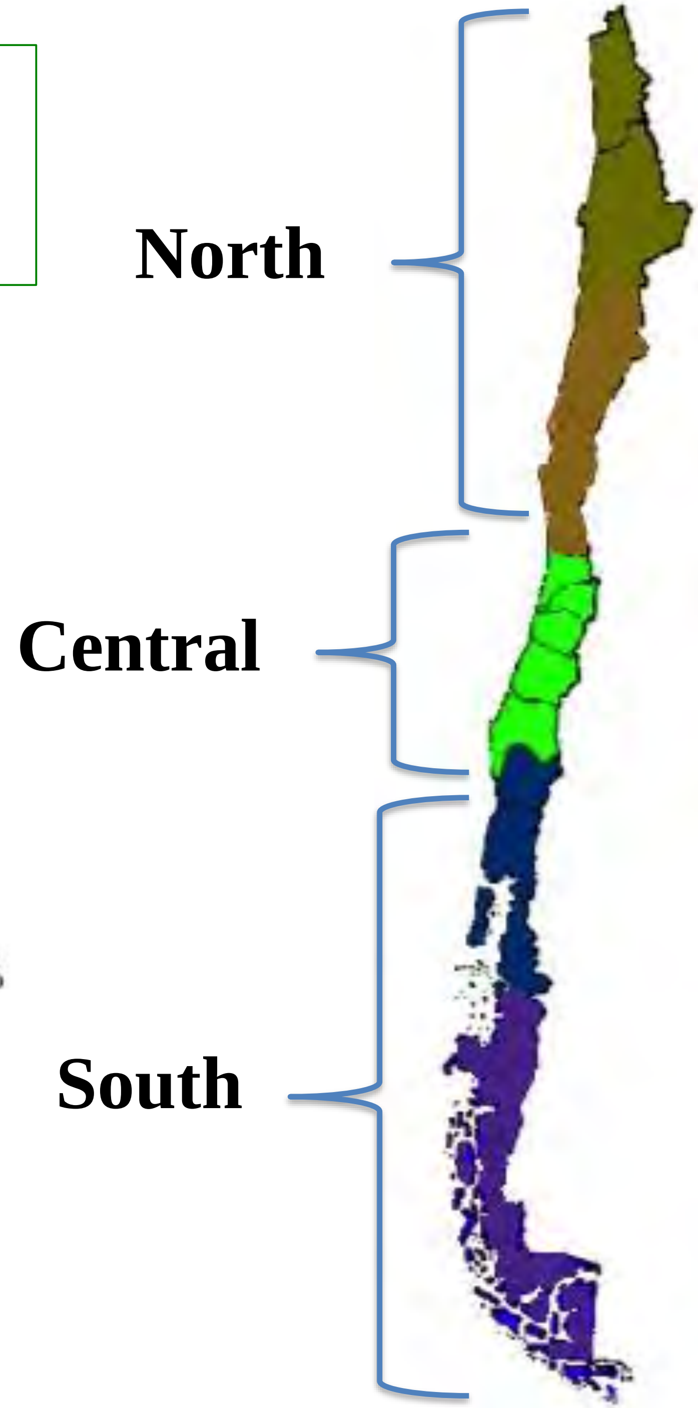



34% Unwrought copper & copper alloys
17% Copper
2.1% Other non-ferrous base metals
1.6% Gold, non-monetary
0.69% Not agglomerated iron ore
0.58% Unwrought silver
2.4% Frozen fish, excluding fillets
1.1% Meat and fish flour, not for humans
1.1% Frozen fish fillets
0.63% Fresh or chilled fish fillets
0.63% Swine meat
0.37% Poultry meat
2.6% Wine
2.3% Fresh or dried fruit NES
0.68% Edible products NES
0.34% Fruit or
3.7% Chemical wood pulp, soda or sulphate
1.1% Worked wood of coniferous
0.51% Pulpwood
0.45% Fibre building
2.4% Grapes & raisins
0.93% Fresh apples
4.2% Unclassified transactions
0.67% Worked copper & copper alloys

Water Use



Modified from Valdes-Pineda et al, 2014



Nutrients, pesticides and agrochemicals

AGRICULTURE

Agriculture Contaminants Sources

- **Non-point source** contamination = key aspects (Ribbe et al., 2008).
- North macrozone = soil and groundwater salinization due to **low rainfall, high evaporation and evotranspiration** (Donoso et al., 1999)
- Central Chile macrozone = **Nutrients** (fertilizers) and agrochemical N diffuse pollution especially for **groundwater contamination** with nitrates (Donoso et al., 1999).
- South macrozone, increased nitrate and phosphorus contamination of the lakes contributing to eutrophica processes (Steffen, 1993). Pollution subsidized by dilu processes.


199
RP60
RP23
205
203
Valdivia
206
234
Los Ríos
La Unión
Osorno
215
231
237
5
23
RP77
San Carlos de Bariloche
258
225
US Dept of State Geographer
© 2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
40
Google Earth
Puerto Montt

Others

Urban Development

- Water quality issues in Central Chile (where most urban development is located), mainly downstream to urban areas due to **treated wastewater discharge during summer** (Debels et al., 2005)

- In the 90’ Industrial and domestic waste waters in Chile were **discharged without previous treatment into rivers and other inland waters which are used to irrigate agricultural lands**.

- Antibiotic resistance

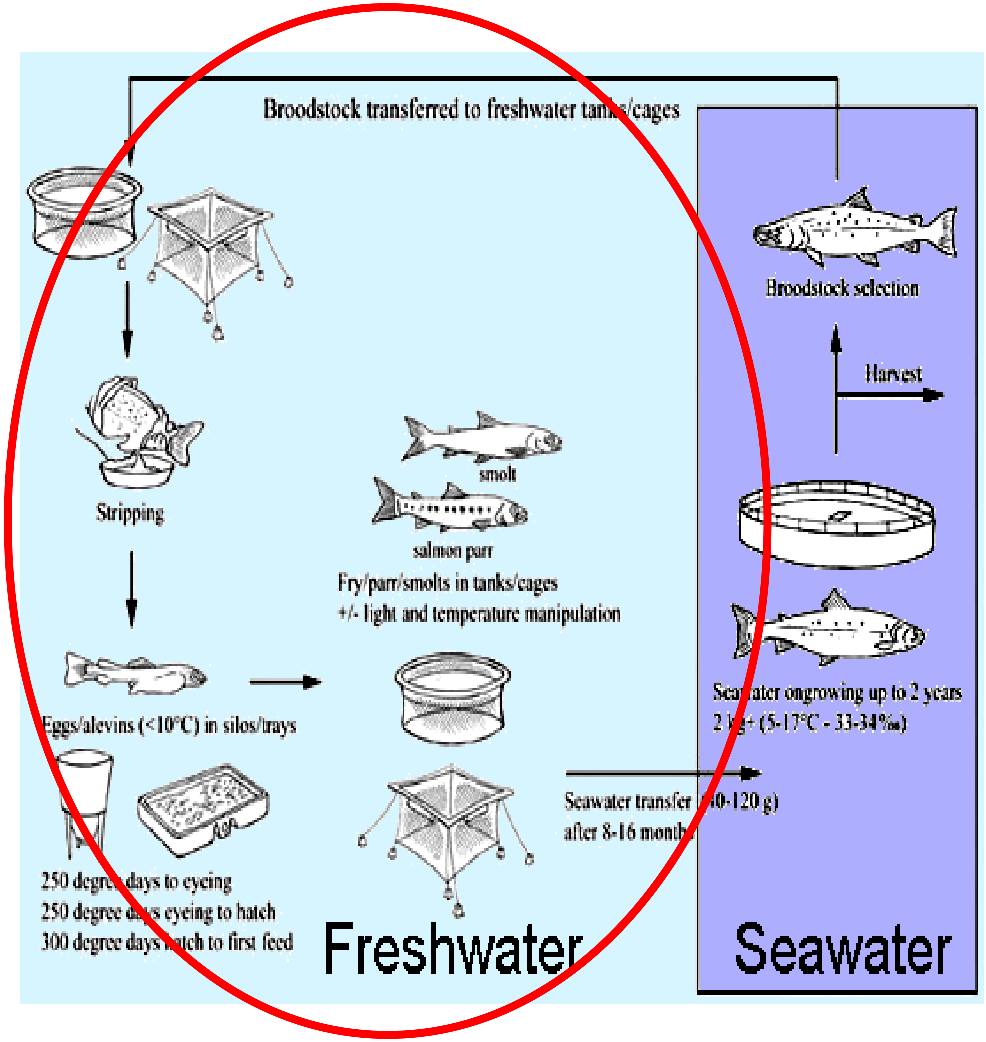
Salmonids and Fisheries

AQUACULTURE

Universidad Austral
de Chile

Ciclos de producción de salmónidos

Two stepts production cycle



Source: http://www.thefishsite.com/articles/731/production-methods-for-coho-salmon

Main Contaminants: DOM
C, P, N

PRODUCCIÓN ANUAL
≈ 950.000 TON (2014) ≅

P: ~ 12 .500.000 personas
N: ~ 11.500.000 personas
C: ~ 8.500.000 personas

Descarga Diaria

(1.8 gP/d*p)
(11 gN/d*p)
(45 gC/d*p)

P, N, C (Disolved , Particulated)

Copper mining, the salary of Chile

MINING

Mining as Contamination Source

- **Dumpings and Tailings** from copper mine affected marine coastal ecosystems (Chañaral Bay 1938–1974- unknown quantities of chemicals (Cu, As, Cd) (Castilla and Nealler, 1978; Castilla, 1983).
- High **copper** content found in **most of the rivers** (Central Chile). Source : copper mining wastewaters.(Eduardo Schalscha and Ines Ahumada, 1998)
- High percentages of **sulfate and heavy metals found in fog**, (nitrate, As, and Se) source: anthropogenic activities such as power plants, mining, and steel industry (Sträter et al., 2010).
- The **storing and transport of mineral** concentrates genera open acting on exposed material (Eisler 2003; Huertas et 2012).


MAS DE 350 MILLONES DE TONELADAS
DE DESECHOS MINEROS

"Next" Mining: a Source of Contamination (?)

- **Potential impacts of lithium mining** on the "lithium triangle" including the impact on salt flats (high altitude wetlands called Salares) located in Atacama Region (Gutiérrez et al., 2018).

- **Risk from rare metals** used in new technological devises. Metals such as tantalum, gallium, germanium, indium, niobium, tellurium and thallium are considered technology-critical elements but no information is known about their extraction environmental effects (Espejo et al., 2018a, 2018b).

Including pulp a paper mill

FORESTRY

Pulp Mills

- Studies explored **effects of pulp mill on fish**.
- EROD, inhibition of acetylcholinesterase activity, **significant endocrine–disrupting effect** (reproductive level) increments in gonad somatic index and plasma vitellogenin levels (Orrego et al., n.d.)
- Male fish showed **intersex** characteristics Tertiary treated PPME from Eucalyptus production have stronger estrogenic effects on juvenile fish (Chiang et al., 2015)
- **Chlorine free processes has reduced drastically the impact on biota** with minor effects on Daphnia (Chamorro et al., 2016)
- River Cruces (C.A. Nature Sanctuary) influential **Eco-Social conflict**


CARABINEROS
DE CHILE

Áreas Protegidas en Latinoamérica: Protegidas de la Contaminación Química?

Integrated Environmental Assessment and Management — Volume 9999, Number 9999—pp. 1–10

Latin American Protected Areas: Protected from Chemical Pollution?

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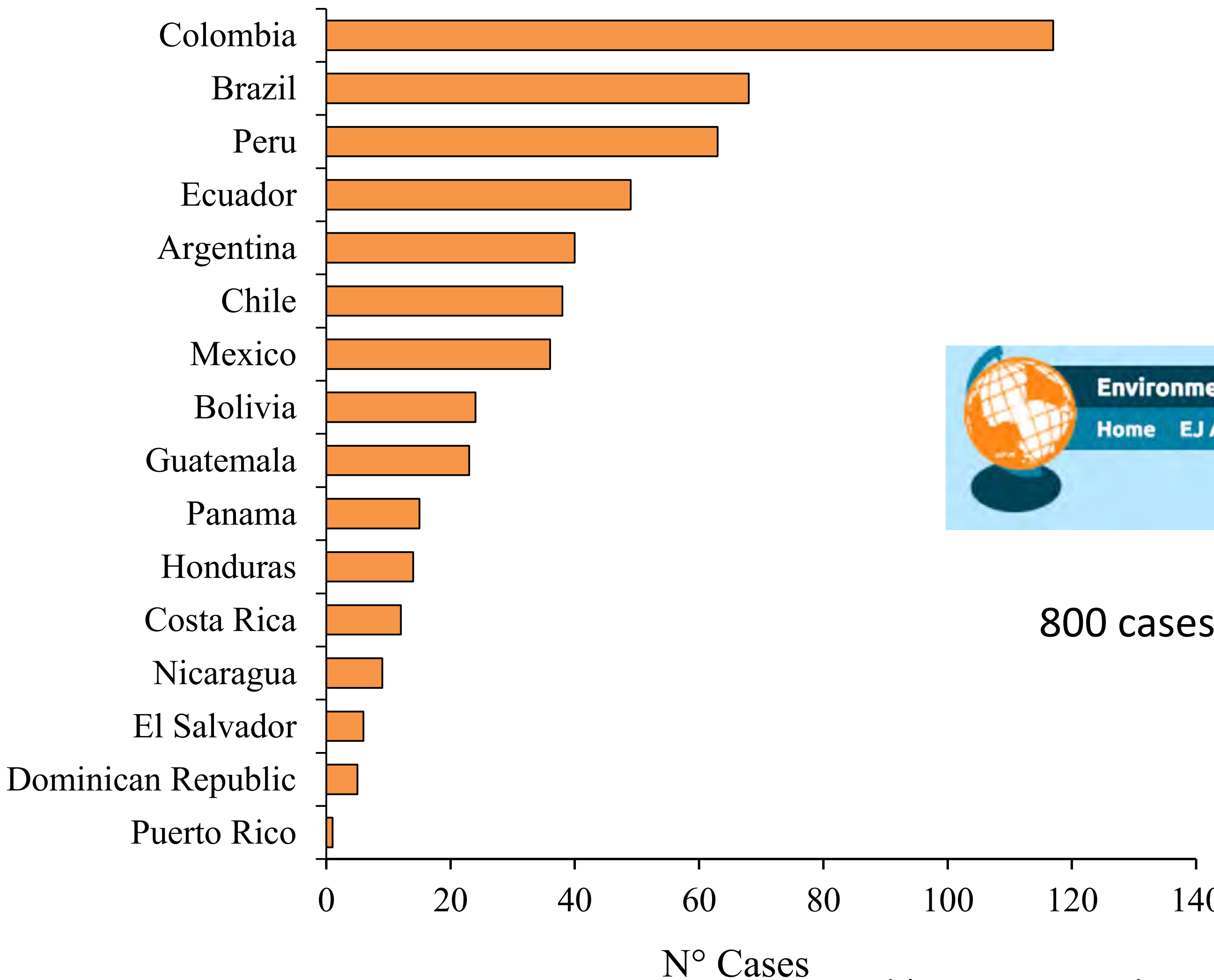
(Submitted 23 March 2016; Returned for Revision 6 May 2016; Accepted 26 July 2016)

Health & Ec

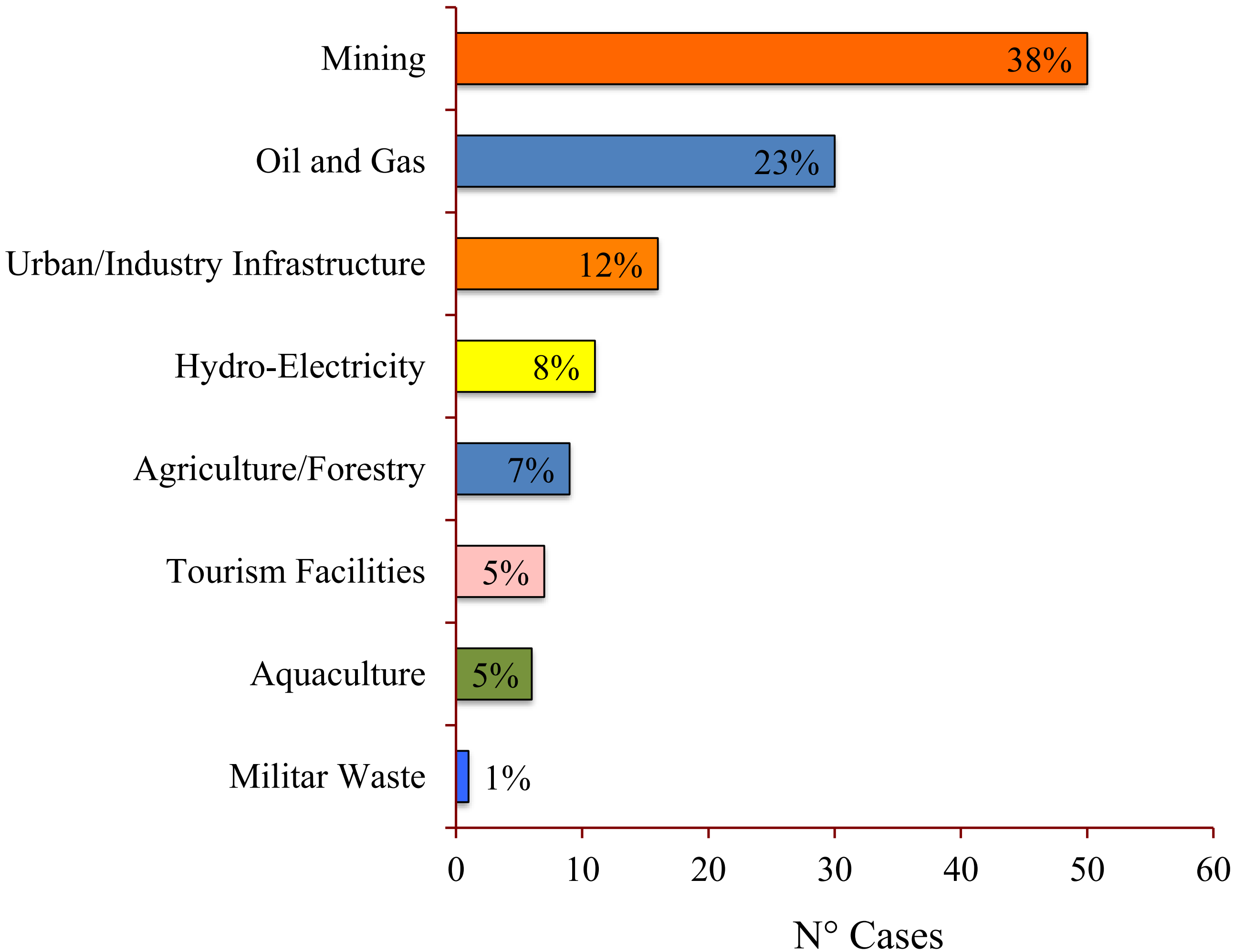
Total Number of Environmental de Conflictsin Latin-america.



800 cases reviewed

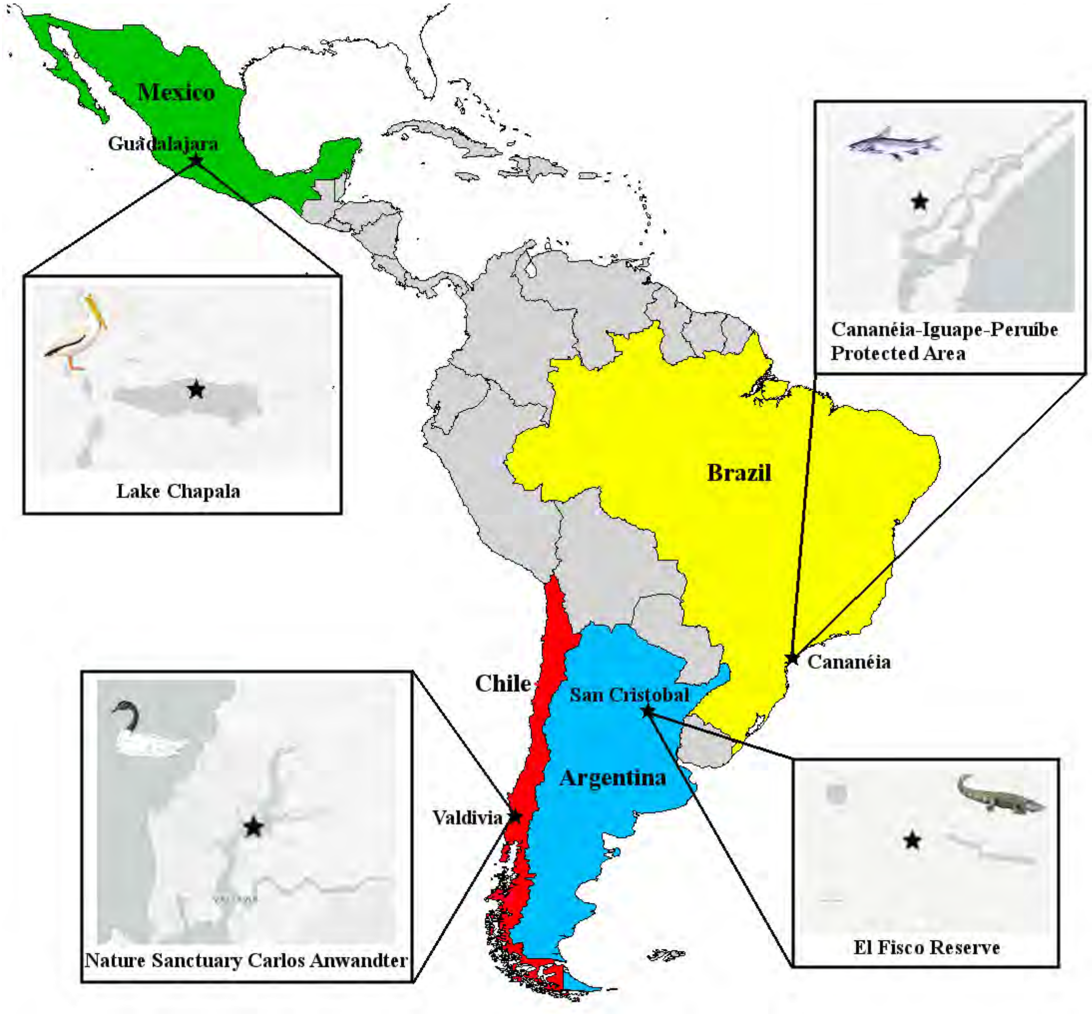
Rodríguez-Jorquera et al, 2016. IEAM. DOI 10.1002/ieam.1839

Types of Chem. Pollution Inside PA



Rodríguez-Jorquera et al, 2016. IEAM. DOI 10.1002/ieam.1839

Case Studies

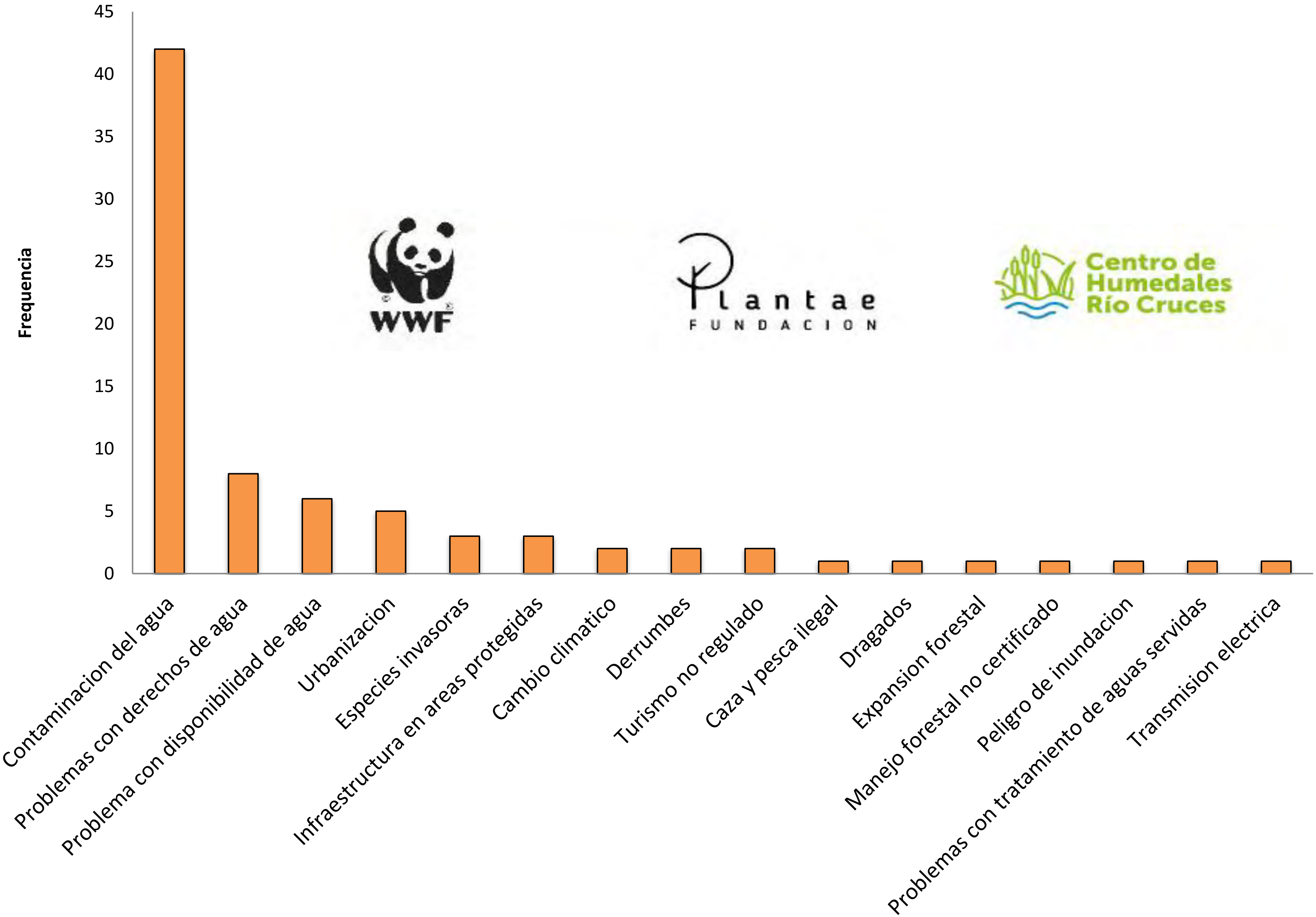


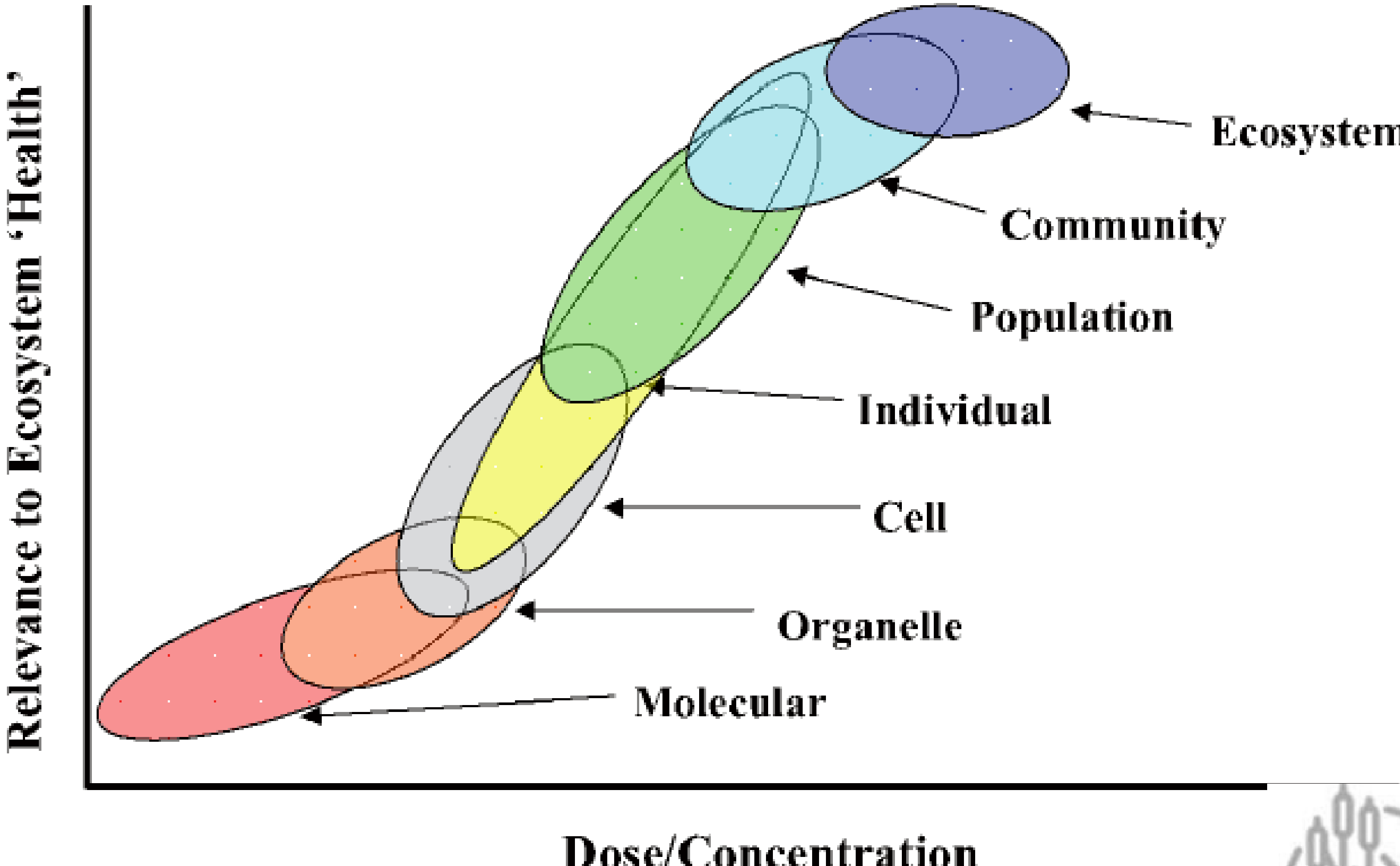
Rodríguez-Jorquera et al, 2016. IEAM. DOI 10.1002/ieam.1839

Impact on ecosystems

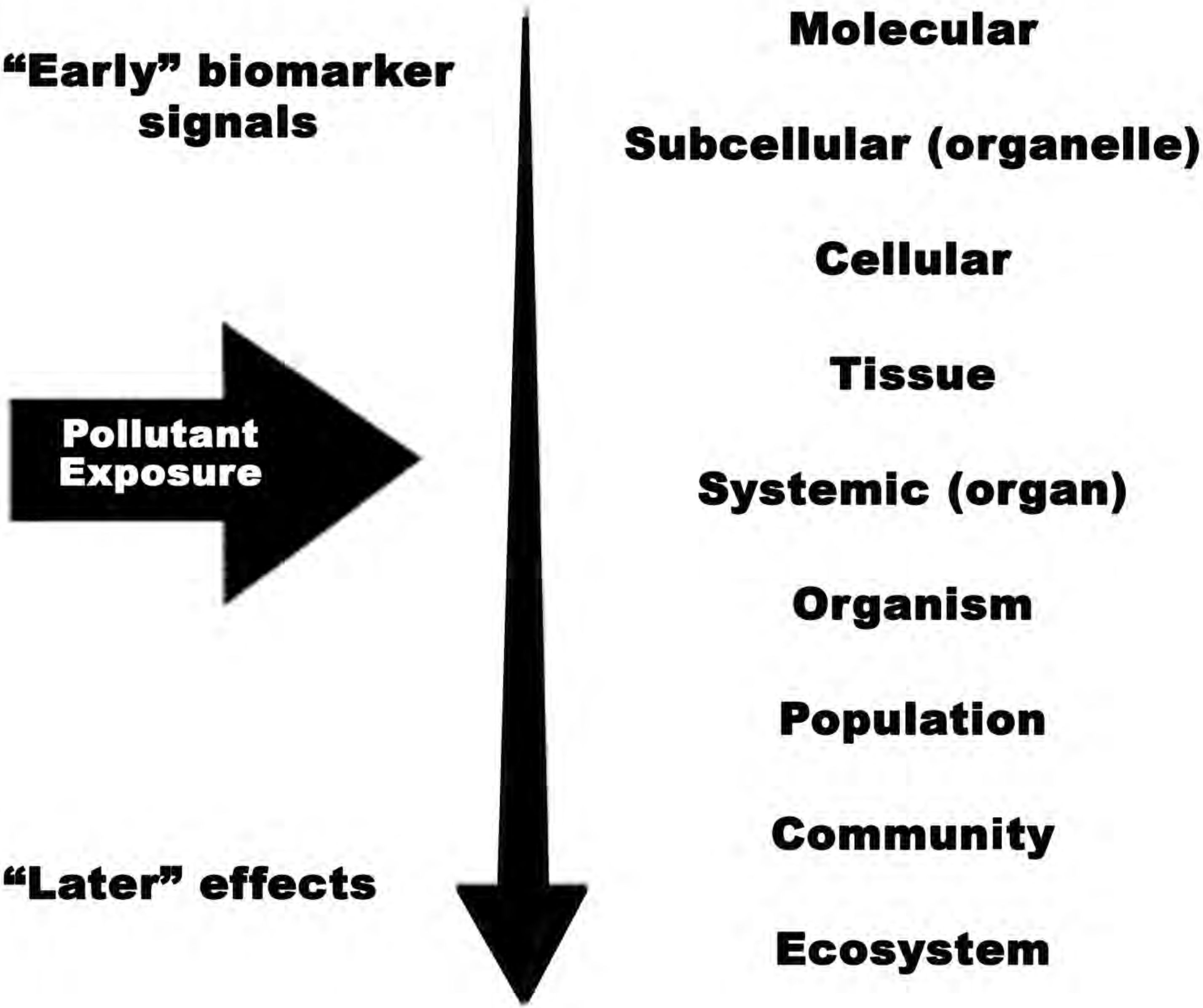
- An **index of economic welfare** includes pollution of water but **no the impact on wetlands** (Castañeda, 1999).
- Discussion regarding **the impacts of chemical pollution on PAs** biodiversity has been virtually **absent from the scientific literature** (Rodriguez-Jorquera et al. 2015, 2016).
- **Coastal wetlands more vulnerable** (Rodriguez-Jorquera et al. 2016).
- **Pollution was the most commonly reported factor of change** affecting the ecological character of these wetlands (Frazier, 1999)

Threats ID during Water Dialogue

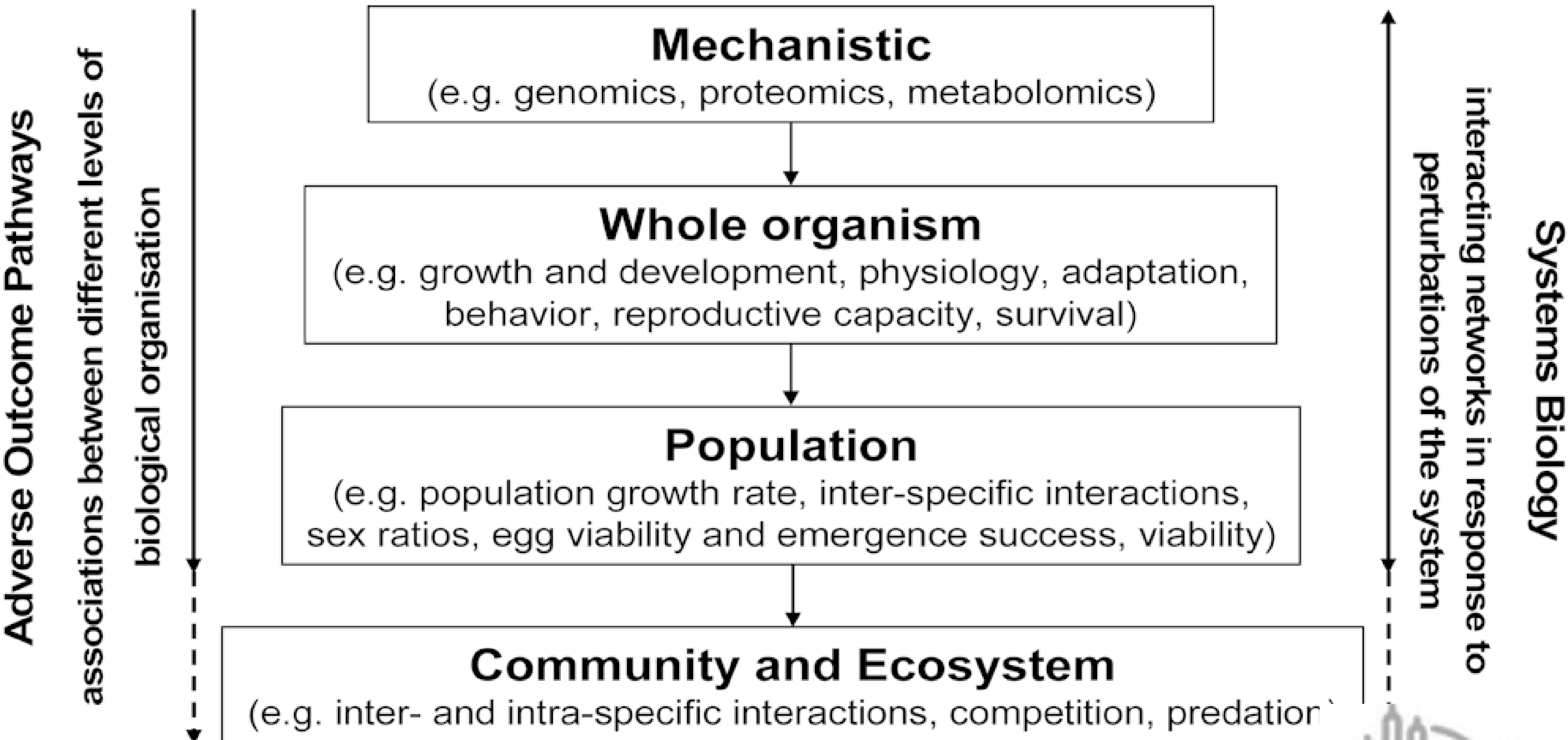




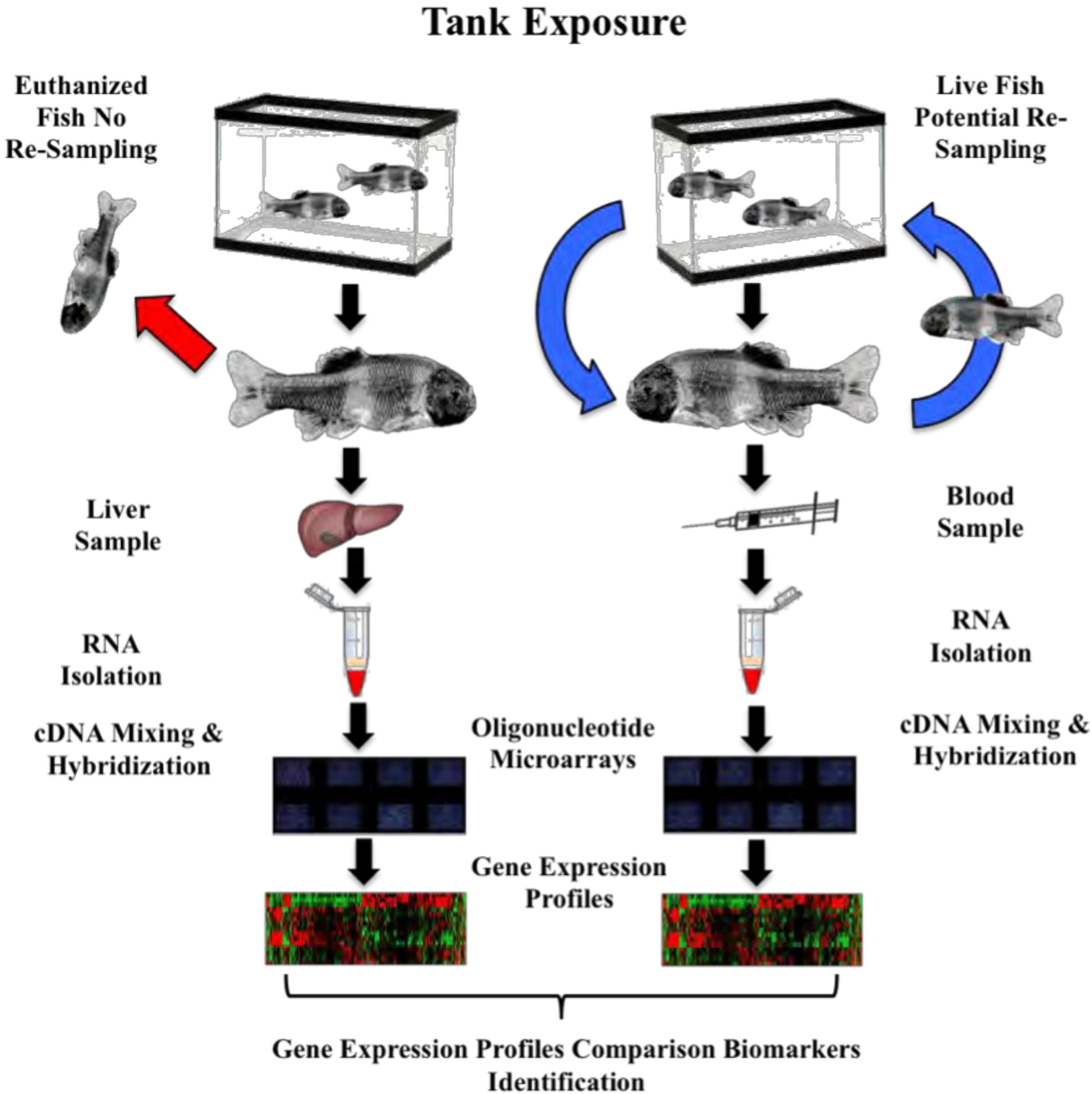
Transitional Waters Bulletin 3(3):32-90 · January 2009
DOI: 10.1285/i1825229Xv3n3p32



"Early" biomarker signals
Pollutant Exposure
"Later" effects
Molecular
Subcellular (organelle)
Cellular
Tissue
Systemic (organ)
Organism
Population
Community
Ecosystem



Sensors 2012, 12(9), 12741-12771; doi:10.3390/s120912741


Tank Exposure
Euthanized Fish No Re-Sampling
Live Fish Potential Re-Sampling
Liver Sample
Blood Sample
RNA Isolation
RNA Isolation
cDNA Mixing & Hybridization
Oligonucleotide Microarrays
cDNA Mixing & Hybridization
Gene Expression Profiles
Gene Expression Profiles Comparison Biomarkers Identification

Challenges and Opportunities

- Generate a critical numbers of eco toxicologists / environmental toxicologists in Chile.
- Propose *ad hoc* solutions to the economic realities of Latin American countries. Equipment cost can be 3 times higher compared to USA.
- Address using the precautionary principle and anticipate “new types” of pollution (i.e. lithium mining).
- Promote paradigm changes related to pollution / pollution and the environment (sub lethal effects, low dose effects).

Challenges and Opportunities

Towards Sustainable Environmental Quality: Priority Research Questions for Latin America.

Furley et al, 2017.

Critical Review sent to IEAM Journal

How effective are protected areas including terrestrial (e.g., parks, wildlife corridors), freshwater and marine habitats to safeguard biodiversity from the impact of environmental pollutants?

Research Needs

- Improve on the **determination of the effects** of contaminants in ecosystems components (biota, services) –Ecotoxicology labs; OMICs, Monitoring.

- Use of new technology as massive sequencing (OMICs) and advance analytical chemistry (**more instruments**!!!).

- Anticipate the future impact of nutrients (**eutrophication**) in the South macrozone.

Research Needs

- **Research on the impact of antibiotics** from aquaculture and meet industry (Resistance).
- **Develop model species** for pollution impact determination.
- Impact of "**next mining**" on vulnerable ecosystems.

Challenges

- Improve **regulations and regulatory coordination** among institutions.
- Improve **communication between government and academia**.
- Improve **mining residues allocation and transport** including tailings location to avoid spills after catastrophic rain events.
- **Better urban planning conserving natural wetlands** and/or using **green infrastructure** to reduce water pollution transport to coastal areas
- Include **explicit pollution control monitoring on Protected Areas.**

The Proposed “Model”

ID Main Contaminant **Sources**

Determine Contaminants **Transport /fate**

Determine ideal bio-indicator Species **(Most Sensitive? Key? Endangered?)**

Determine Main Effects on selected Species

Use Available Data **Desktop Work Sampling**

Use Available Technology in Analytical Chemistry and efficient sampling method

Reviews/Laboratory work/ field work **Propose considering cost and extent of use**

Propose powerful but feasible method **OMICs? Field ECOTOX?**

Propose **Mitigation** Actions /Chemical Impact Awareness/ Laws and Regulation (Governance)

Natural and/or constructed wetland to reduce water pollution

GREEN INFRASTRUCTURE


Aguas Grises de la Cocina, el Lavabo, u otra Fuente
Humedal Construido para Tratamiento de Aguas Grises
La estructura del humedal debe ser impermeable.
100cm
55-75cm
Vegetación común
Río
Filtro de malla fina
Gradiente de 0.5%
Filtro de malla fina
Drenaje

Contaminant Reduction

The results have shown that the constructed wetlands have been able to eliminate contaminants in the effluents of cellulose:

Organic matter, Biological Oxygen Demand in five days (**BOD5**)

Chemical Oxygen Demand (**COD**) from 50 to 90% ;

Total Suspended Solids (**TSS**), greater than 50%;

Nutrients (nitrogen and total phosphorus) between 20 and 60%; and

AOX, chlorophenols over 80% (Rani et al., 2011; Vymazal et al., 2014; Choudhary et al., 2015).

Metals:

Aluminum (> 80%),

Cadmium (> 75%),

Zinc (65%)

Lead (25%) (Vymazal, 2005, Kumar et al., 2017).

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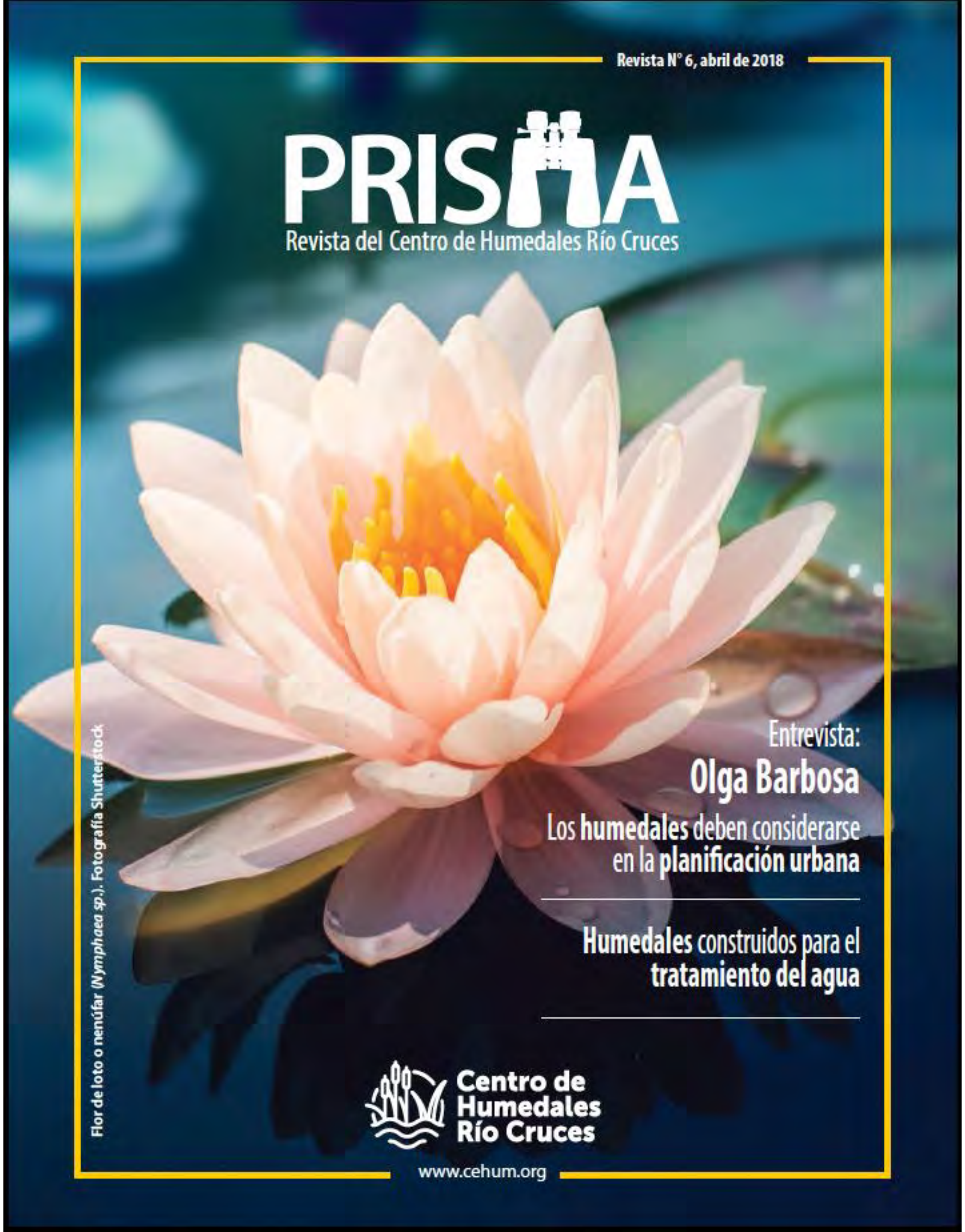
PRISMA
Revista del Centro de Humedales Río Cruces



Flor de loto o nenúfar *(Nymphaea sp.)*. Fotografía Shutterstock

Entrevista:
Olga Barbosa
Los **humedales** deben considerarse en la **planificación urbana**

Humedales construidos para el **tratamiento del agua**

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