The use of avoidance by organisms as an ecotoxicological response: How to measure it and what can it tell us about contamination?

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Group: Ecotoxicology, Ecophysiology and Biodiversity of Aquatic Systems

What are we talking about?

www.multicecotox.csic.es

Se puede ver el video en el enlace arriba

ECOTOXICOLOGY

ECOLOGY + TOXICOLOGY = ECOTOXICOLOGY

The word **ecotoxicology** was proposed in 1969 by René Truhaut

The science of the effects of the contaminants on ecosystems

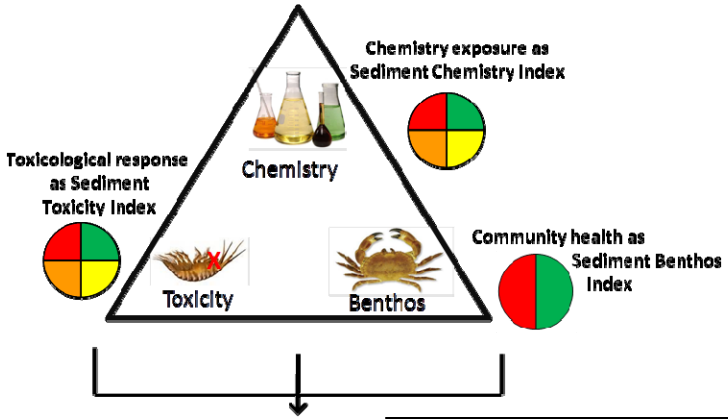
TOXICOLOGY: effects of the chemicals on one species

(ej.: experiments with animals → human health)

ECOTOXICOLOGY: biological effects of chemicals on “ecosystems”

ECOTOXICOLOGY – improving the ERAs (toxicity)

One line of evidence to environmental risk assessment (ERA)



Sediment Quality Triad Index Category	Sediment Quality Triad Index Score
Unimpacted	>81-100
Likely unimpacted	>57-81
Possibly impacted	>35-57
Likely impacted	>5-35
Clearly impacted	0-5
Inconclusive	

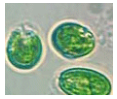
Department of Ecology
State of Washington

ERA-sloot_risk

- Methods should be **practical, easy and cost-effective**: standardization for legal use (government and industries)

Experimental evolution – practicality vs. relevance

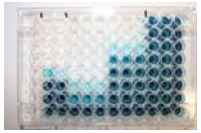
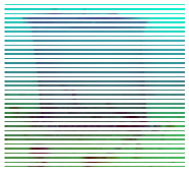
Test organisms



Species from temperate regions → **The most sensitive species** → Tropical Ecotoxicology → Key species

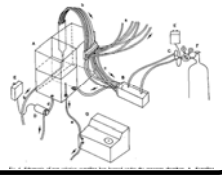
Types of assays



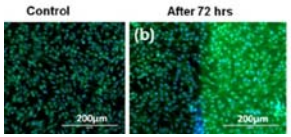

Types of exposure

Static → Renew of the medium → Flow through assays

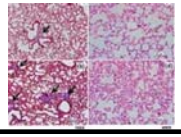


Types of responses/endpoints

Mortality

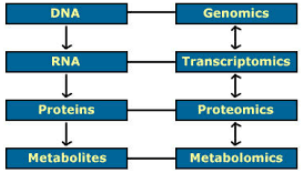



Physiological endpoints



Biomarkers

Genomics

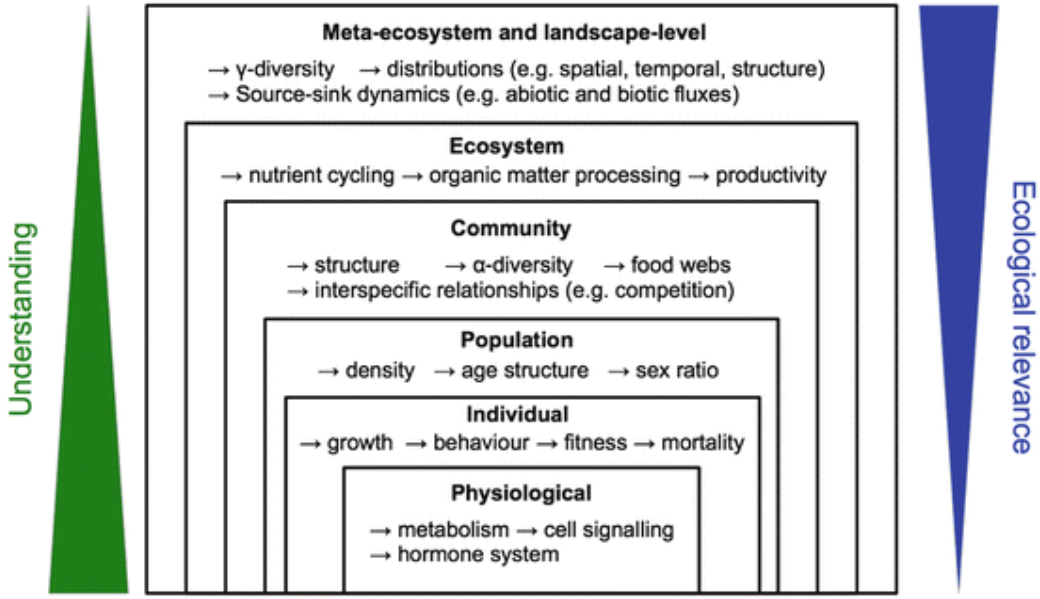


Toxicologists vs. Ecologists

a) Toxicologists interested in the environment.

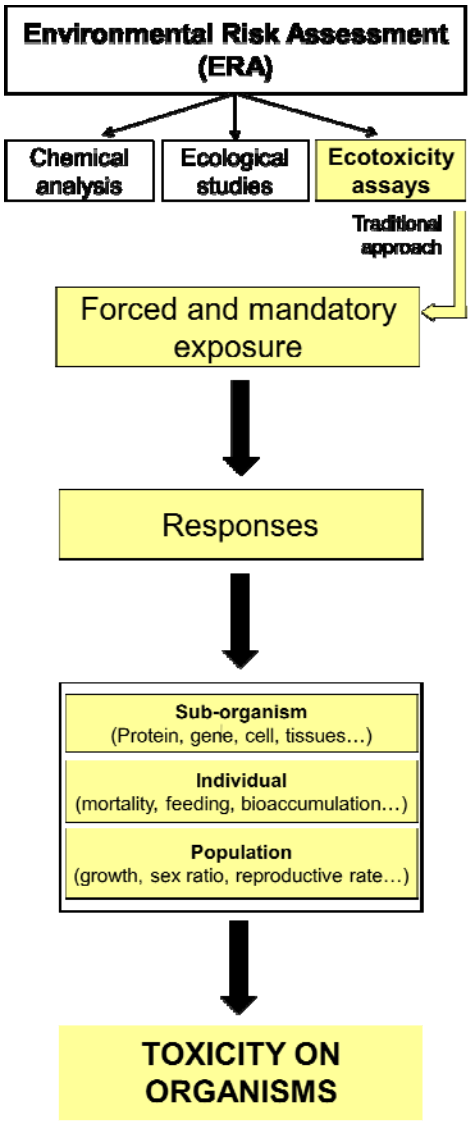
b) Ecologists interested in contamination.

Van Straalen, 2003.



Schäfer and Bundschuh, 2018.

FORCED EXPOSURE – mandatory exposure in a chemically heterogeneous scenario



Imagine the following scenario:

1. Some organisms can swim

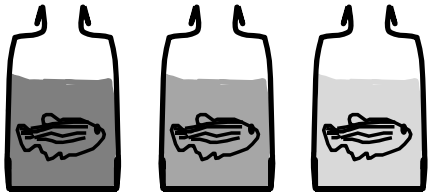
1. The contamination is not homogeneously distributed

Why should the exposure to contaminants be considered mandatory?

HOW TO FACE THE CONTAMINATION?

Option A: Fight

✓ Physiological processes are triggered to maintain the homeostasis



Forced and mandatory exposure

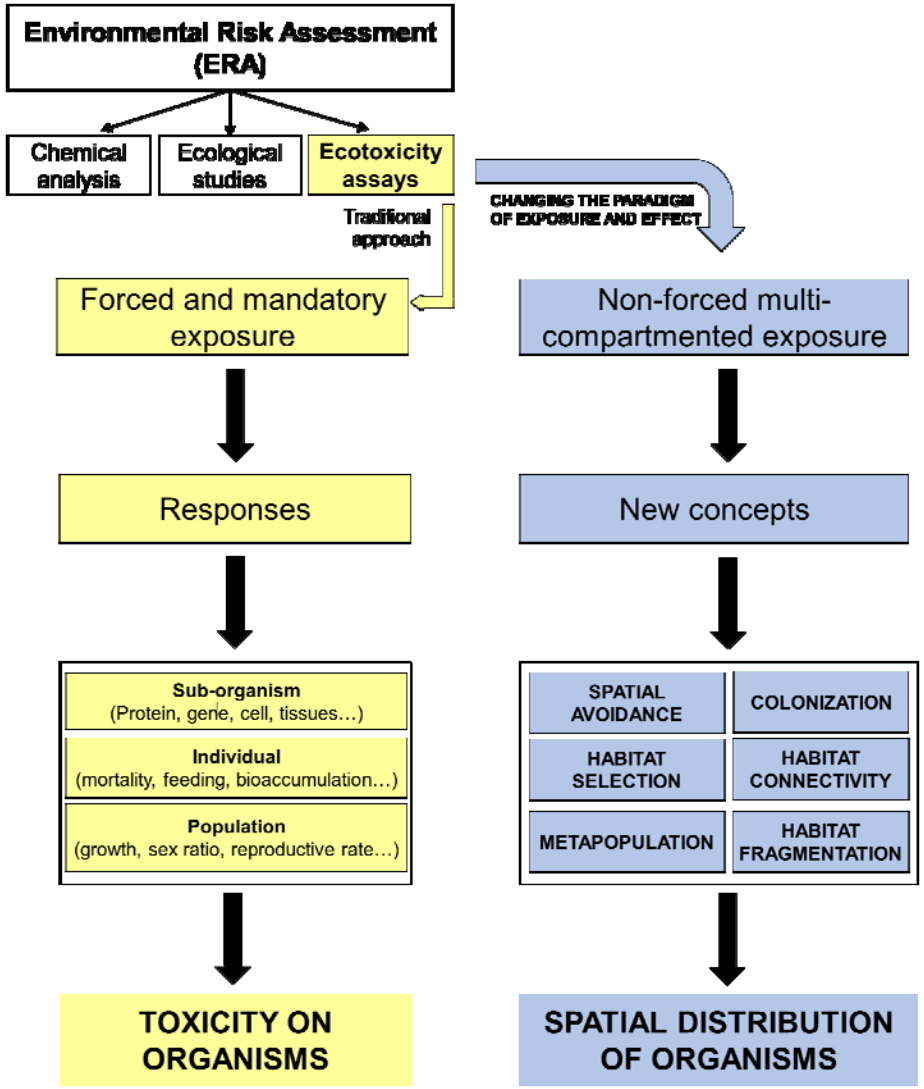
Option B: Flight

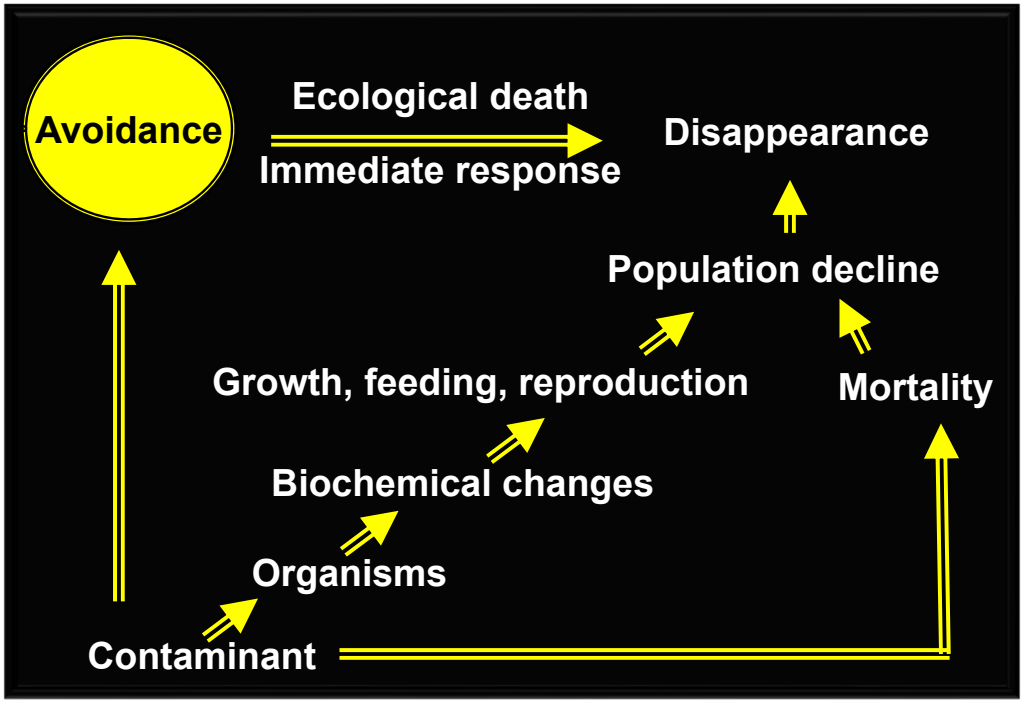
✓ **Perspective form individuals** (traditional ecotoxicology): no suffering

✓ **Ecological perspective:**

?

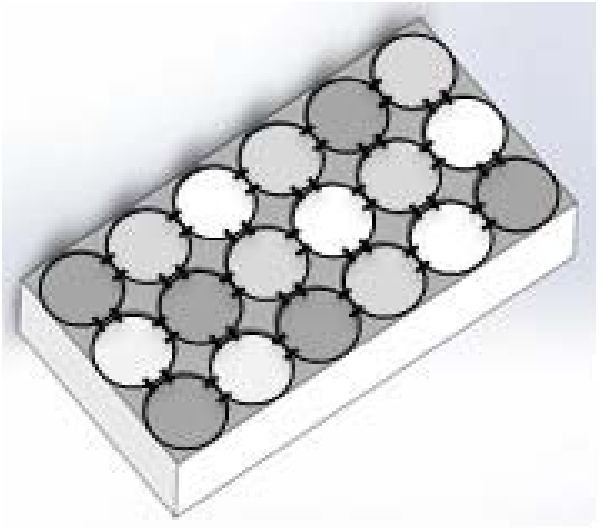
A COMPLEMENTARY TOOL BASED ON DISPLACEMENT





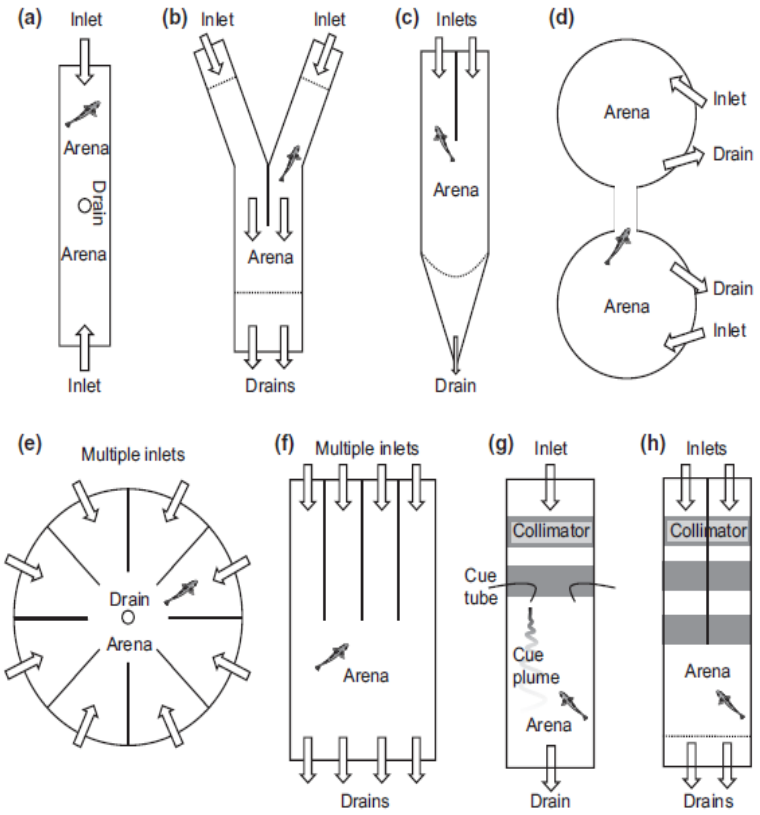
SHIFTING THE APPROACH

Are organisms able to escape from contaminants thus not suffering toxic effects?



What is the role of contamination on organisms habitat selection processes?

WHAT IS KNOWN?

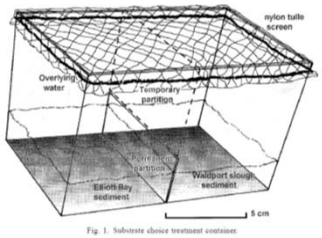


Methods in Ecology and Evolution
Methods in Ecology and Evolution 2017, 8, 379–390 doi: 10.1111/2041-210X.12668

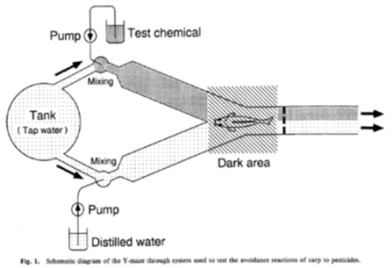
REVIEW

Two-current choice flumes for testing avoidance and preference in aquatic animals

Fredrik Jutfelt[1,2]*, Josefin Sundin[3], Graham D. Raby[4], Anna-Sara Krång[2,5] and Timothy D. Clark[6]



Kravitz et al. 1999



Ishida and Kobayashi, 1995

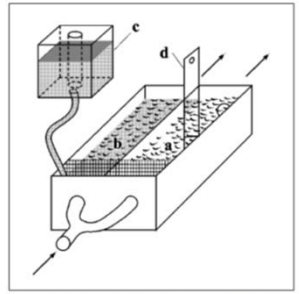
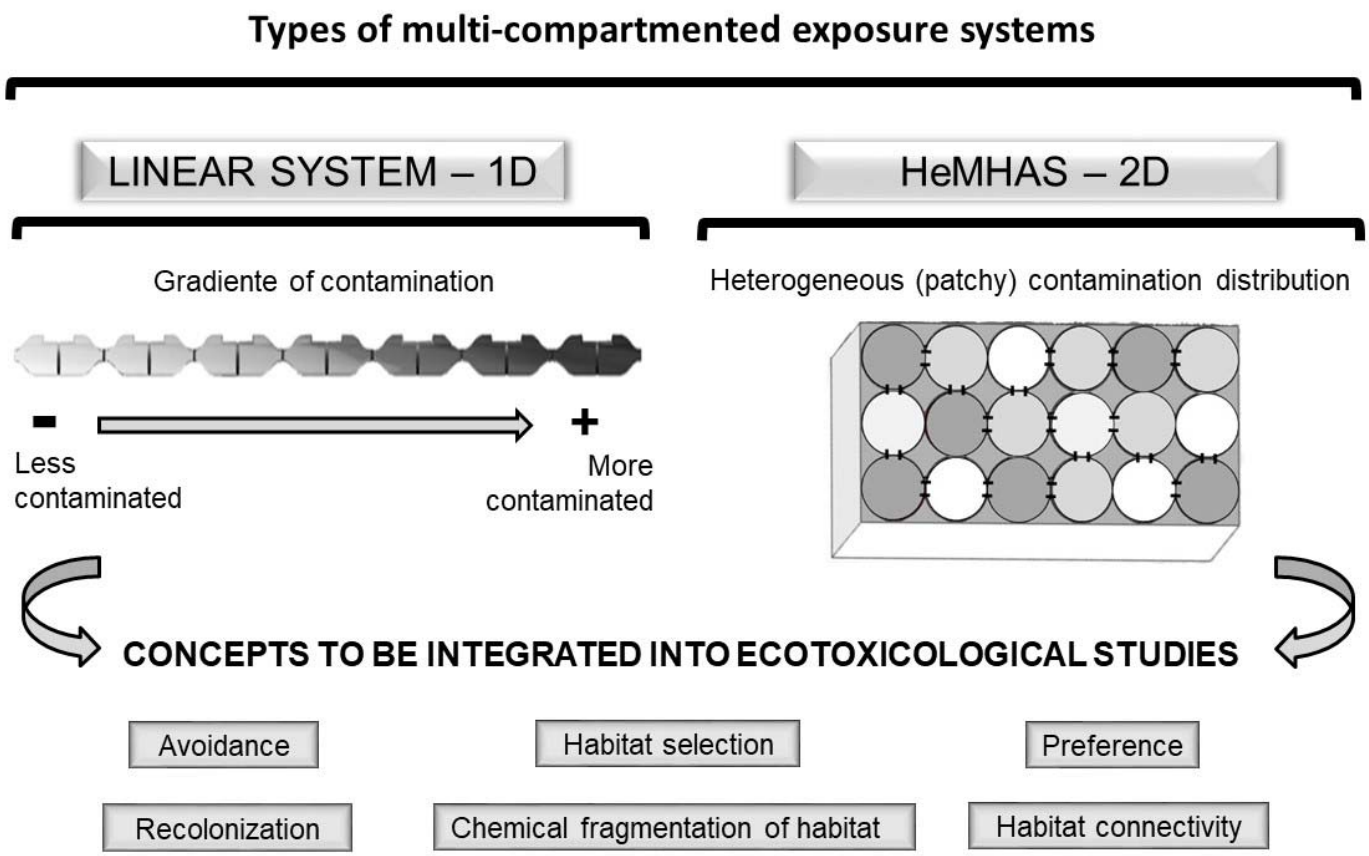


Figure 1. Gradient chamber: a – pure water zone; b – polluted water zone; c – toxicant supply tank; d – slipping bolt

Svecevičius et al. 1999

- ✓ Simulating less realistic contamination scenarios
- ✓ They can not calculate estimate ACx values (avoidance concentration)

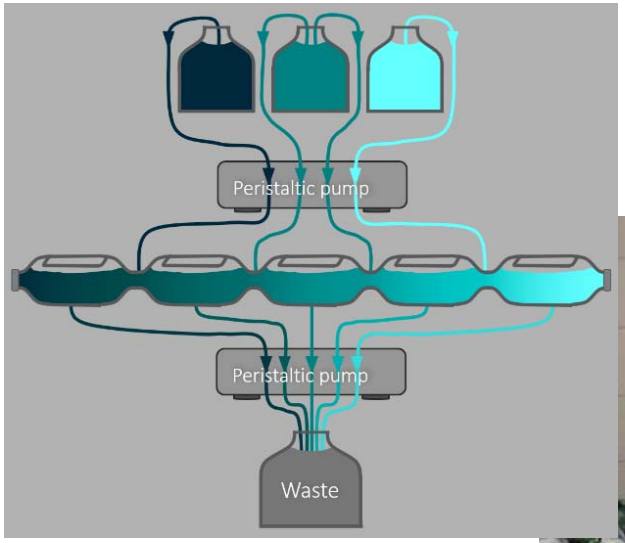
WHAT IS PROPOSED?



METHODOLOGICAL CHANGES

CONCEPTUAL CHANGES

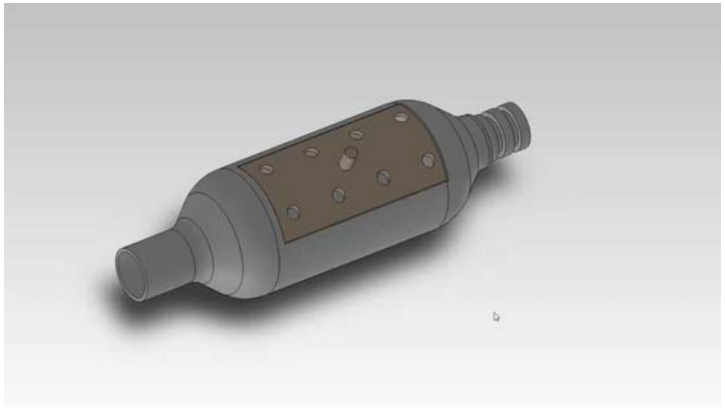
THE MULTI-COMPARTMENTED, NON-FORCED EXPOSURE SYSTEMS



Lopes et al., 2004
Moreira-Santos et al., 2008
Rosa et al., 2008

- ✓ To simulate more realistic contamination scenarios.
- ✓ To estimate ACs values.

THE COMPARTMENT (PREPARING A NEW SYSTEM)



Se puede ver el video en este enlace:

http://www.multicecotox.csic.es/index.php/results/13-preparing-a-linear-multi-compartmented-system

THE DISPLACEMENT OF THE ORGANISMS

Se puede ver el video en este enlace:

http://www.multicecotox.csic.es/index.php/missions

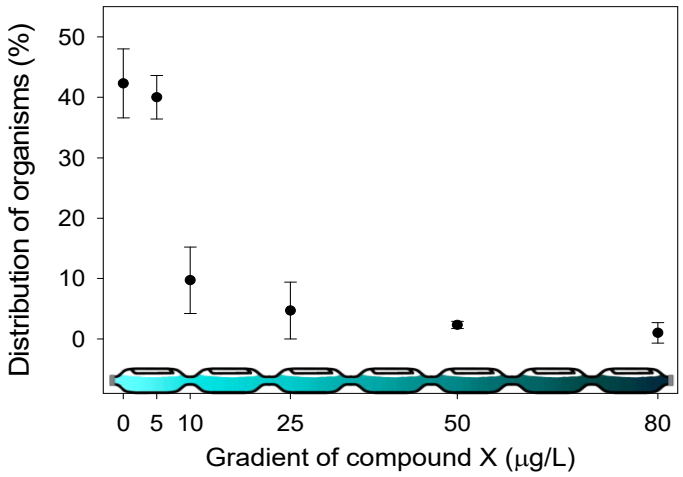
HeMHAS – HETEROGENEOUS MULTI-HABITAT ASSAY SYSTEM

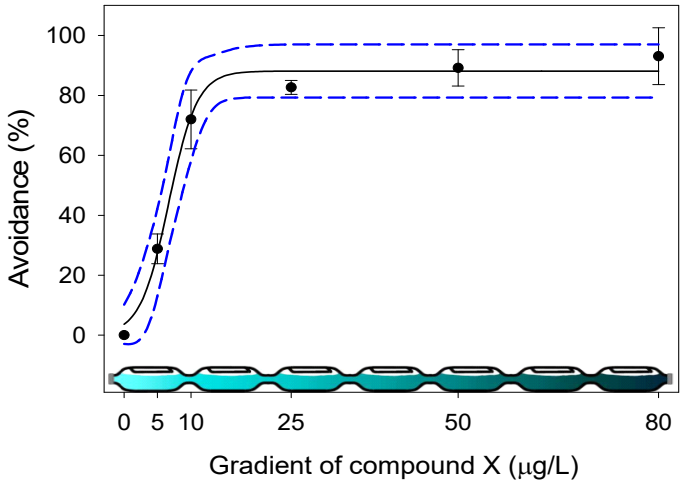
Se puede ver el video en este enlace:

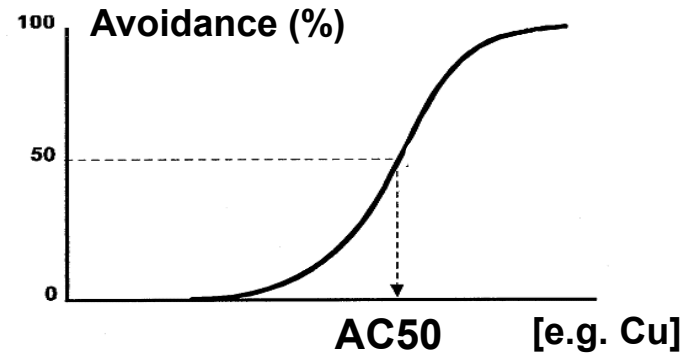
http://www.icman.csic.es/es/un-nuevo-sistema-de-experimentacion-para-evaluar-como-los-contaminantes-condicionan-la-distribucion-espacial-de-los-organismos/

CONCENTRATION-RESPONSE RELATIONSHIP

The contamination-driven organisms' distribution and the avoidance response







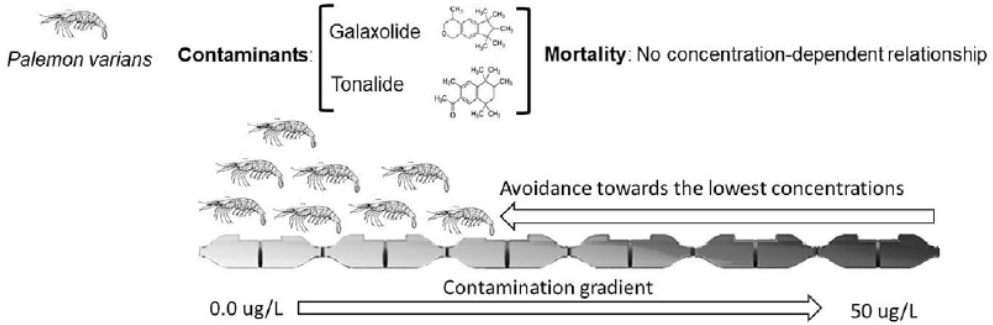
It is similar to the calculation of the LCx/Ecx; therefore, it is possible:

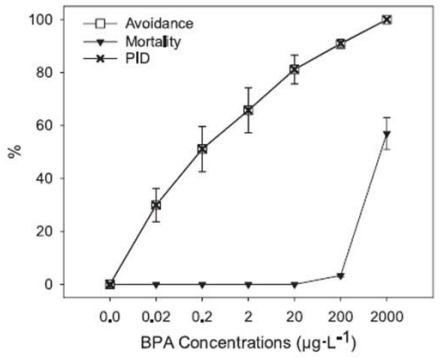
- ✓ To compare sensitivities
- ✓ To integrate with other endpoints (some avoid, some suffer toxicity)

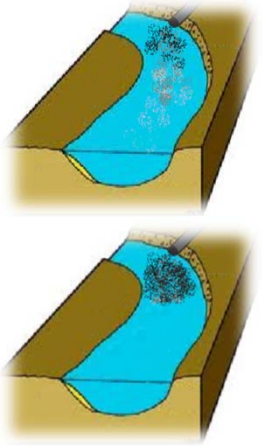
MORE “ECO” INTO ECOTOXICOLOGY

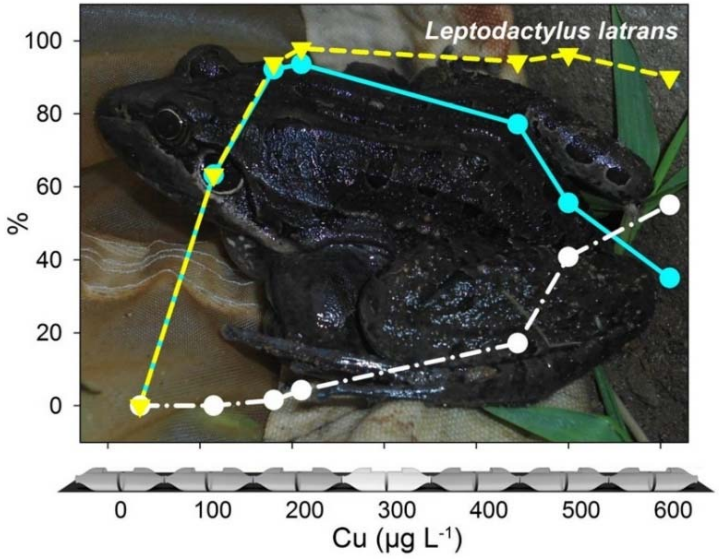
Is the contamination the determinant factor for the spatial distribution of the organisms?

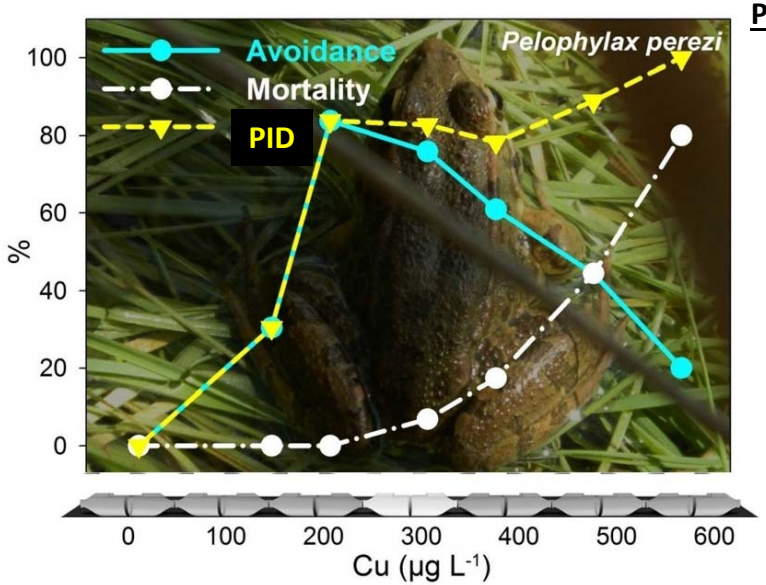
REPELLENCY











Population Immediate Decline

- *Huida*
- *Mortalidad*
- *PID*

REPELLENCY AND LOSS OF MOTILITY

Test organism

Palaemon varians

Chemicals

Sunscreens
(A, B and C)

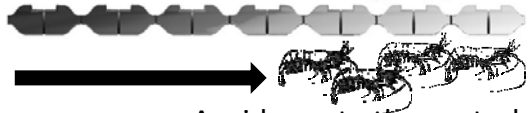
Spiking methods

Homogenization

Direct
immersion

Exposure system and endpoints

Non forced
exposure



Avoidance to the control

Forced exposure

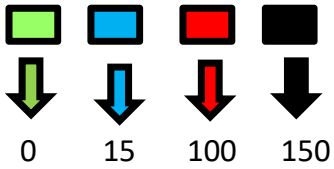
Some loss of motility and mortality

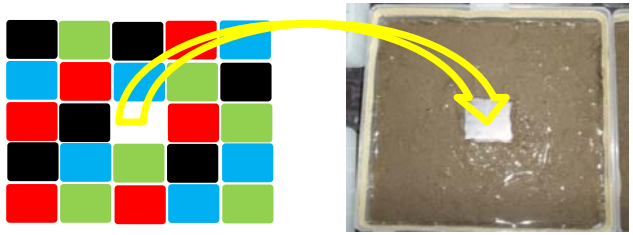
REPELLENCY (*IN SEDIMENT*)

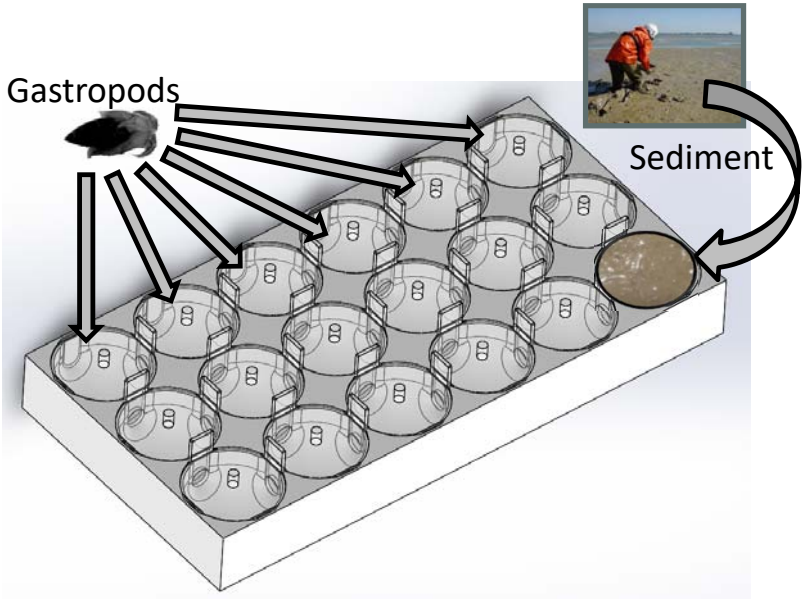
Peringia ulvae

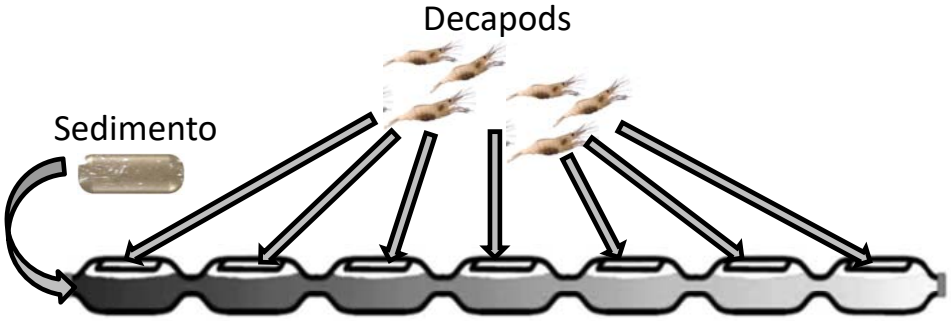
100%	60%	30%	0%
100%	100%	100%	100%
0%	0%	0%	0%

Cd (mg/kg):









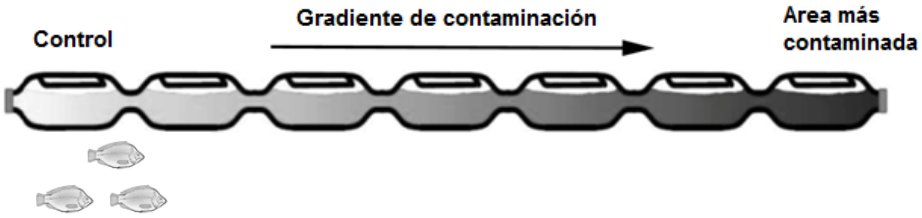
(RE)COLONISATION

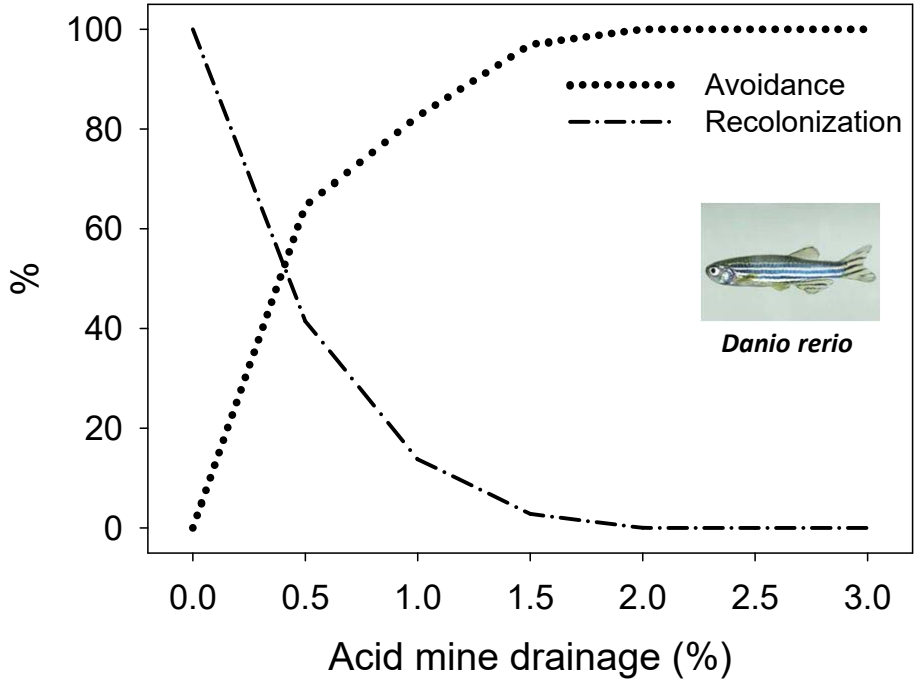
¿ $AC_x = RC_{100-x}$?

AC: Avoidance concentration

RC: Recolonisation concentration

$AC_x = RC_{100-x}$





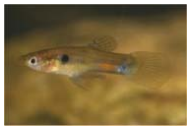
3 Rs (Replacement, Reduction, Refinement)

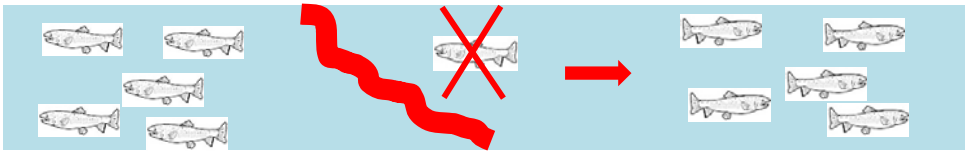
- Less fish to be used in experimentation
- To reduce the suffering

HABITAT FRAGMENTATION (CHEMICAL BARRIER)

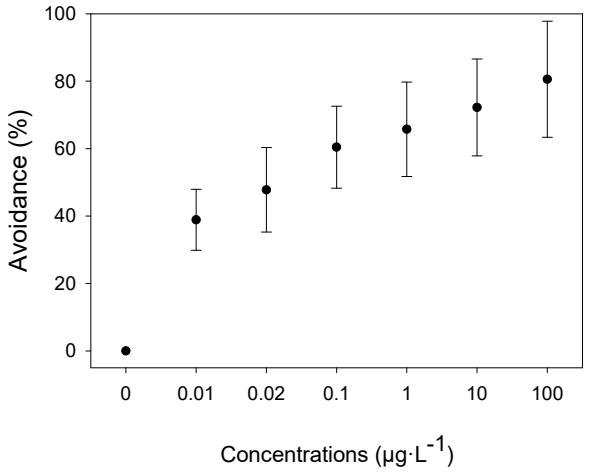
Populations are isolated

Poecilia reticulata



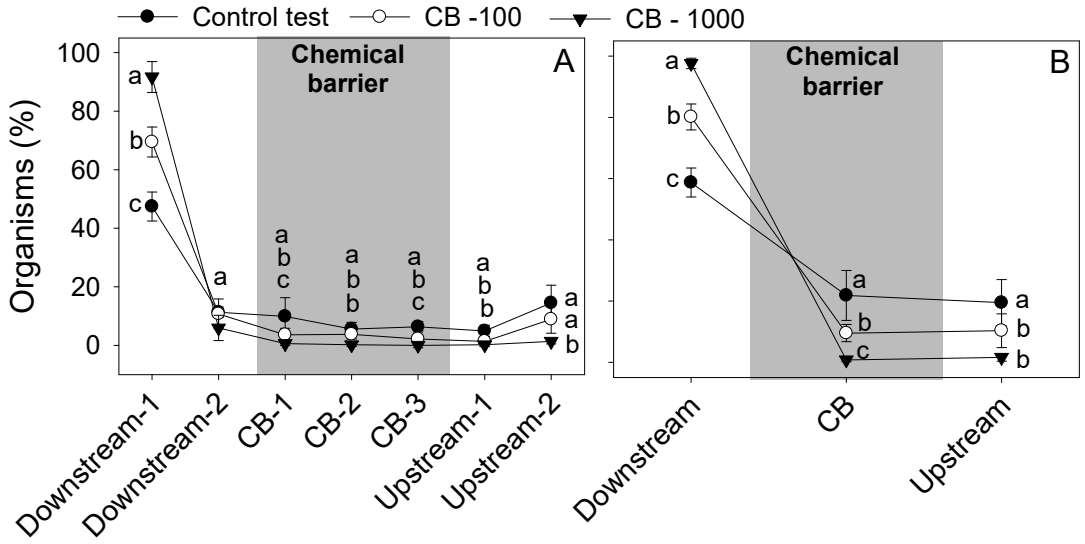


Atrazine: pesticide banned in European Union, but used in many countries

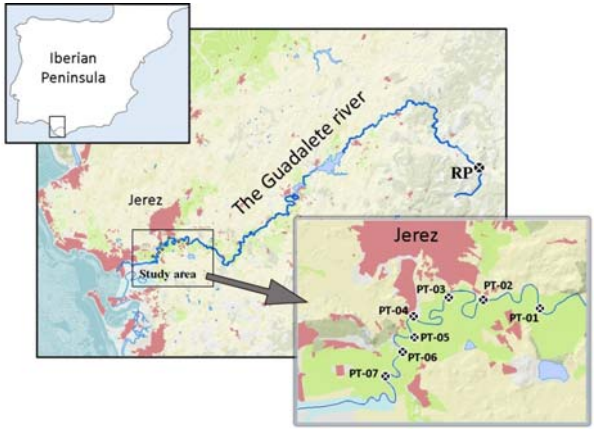


Defining the threshold of chemicals for the populations' connectivity:

HABITAT FRAGMENTATION CONCENTRATION (HFCx)

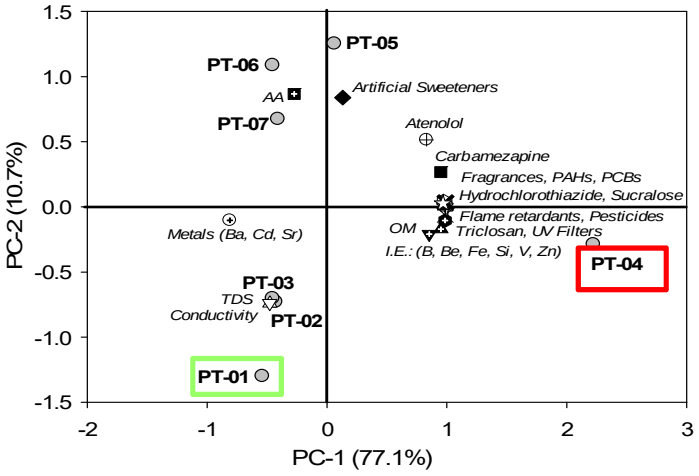


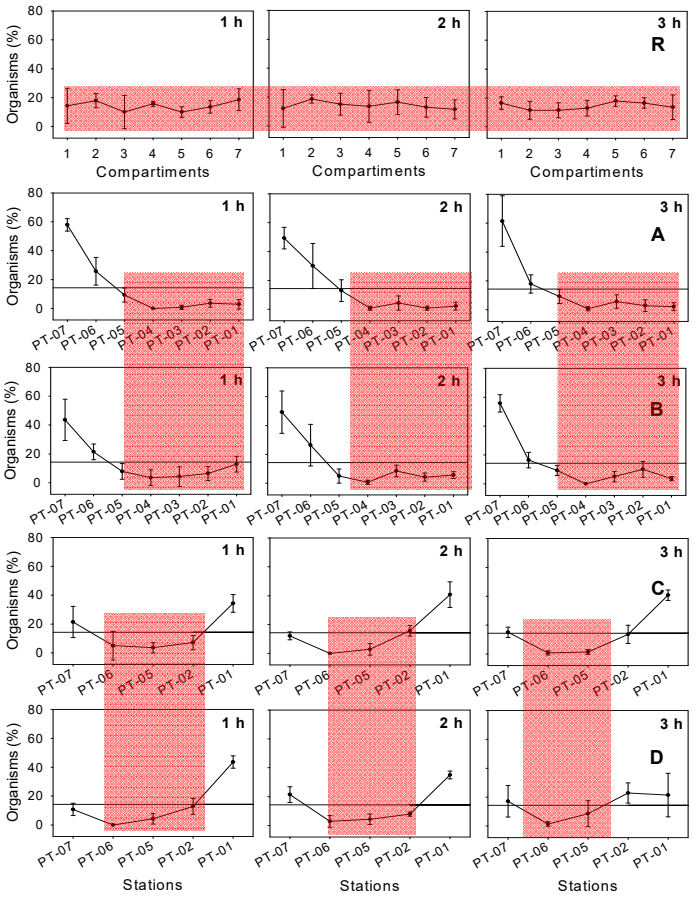
HABITAT FRAGMENTATION (CHEMICAL BARRIER)



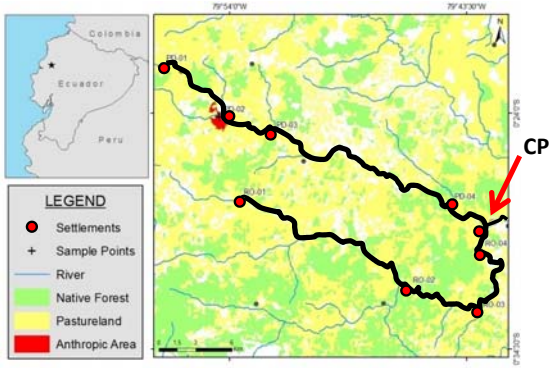
Atyaephyra desmaresti

120 parámetros (19 grupos de contaminantes)

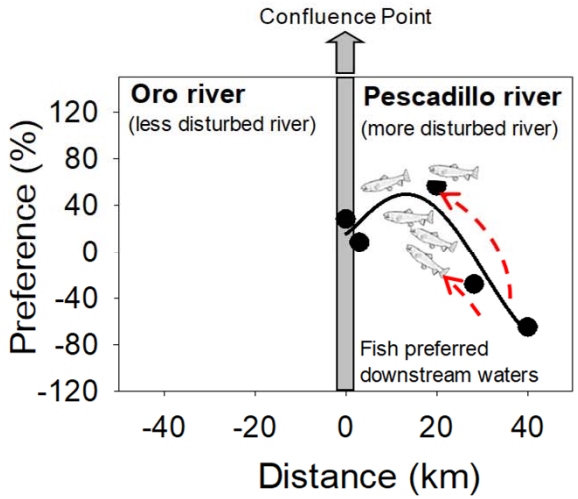


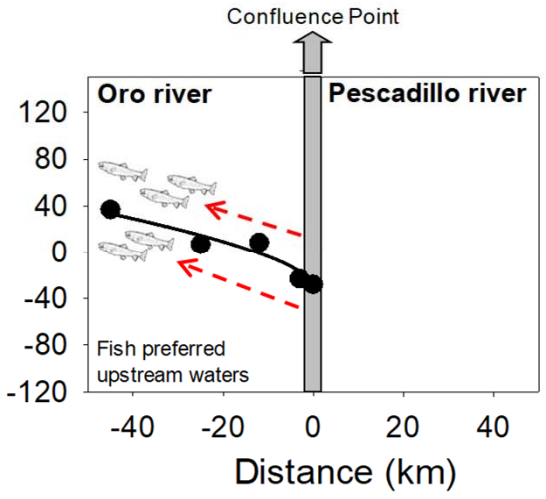


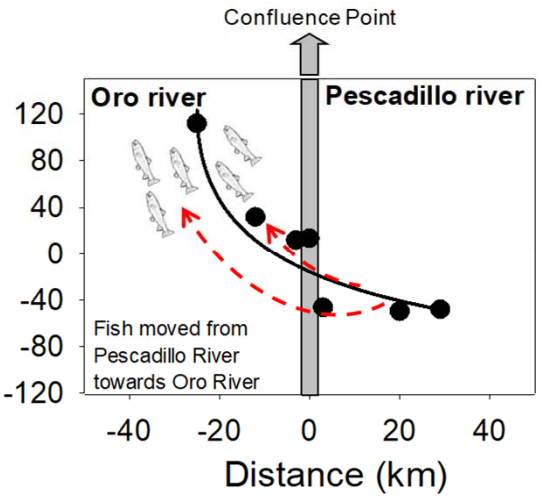
HABITAT CONNECTIVITY (*Landscape Ecotoxicology)*



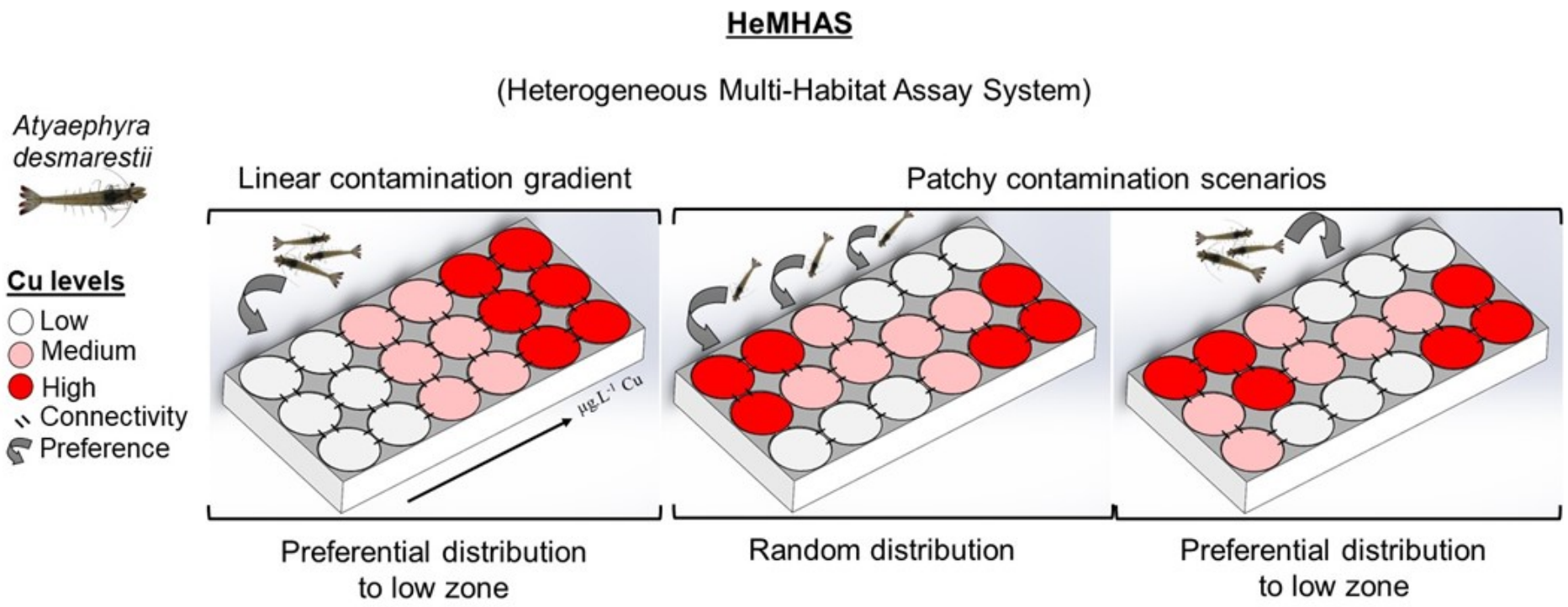
Danio rerio





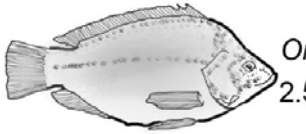


METAPOPULATION (*Meta-ecosystem)*



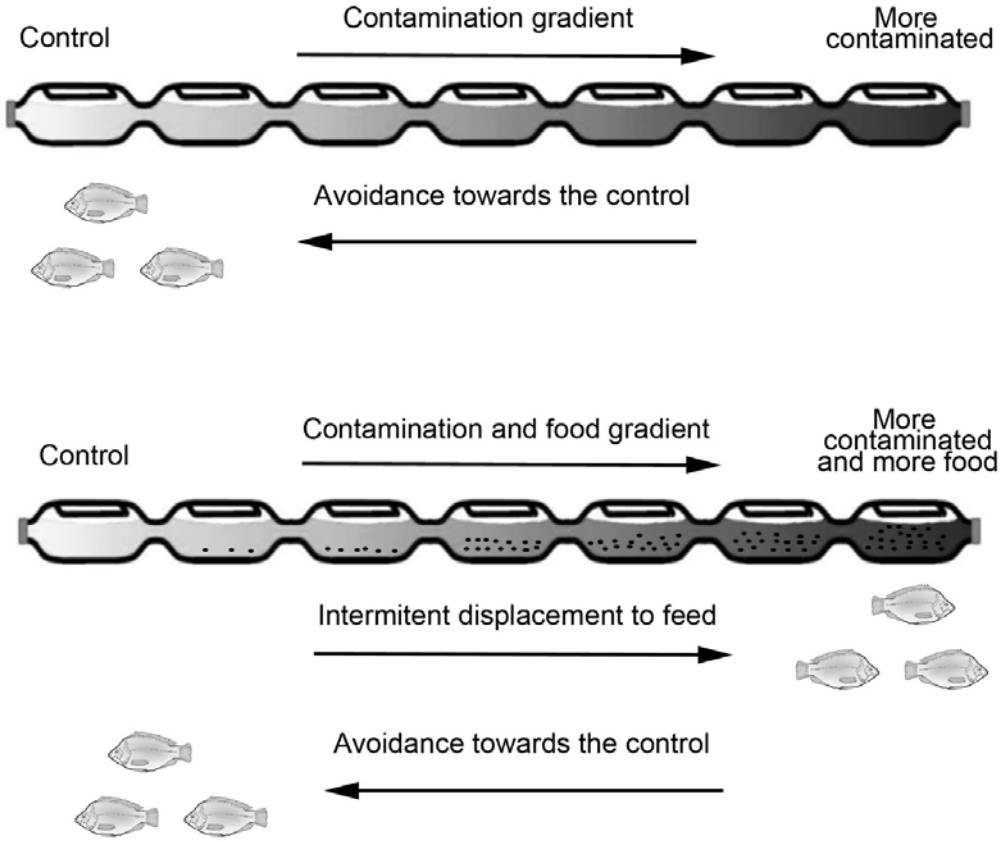
Less or uncontaminated zones might represent less stressful areas to protect populations against continuous contamination exposure.

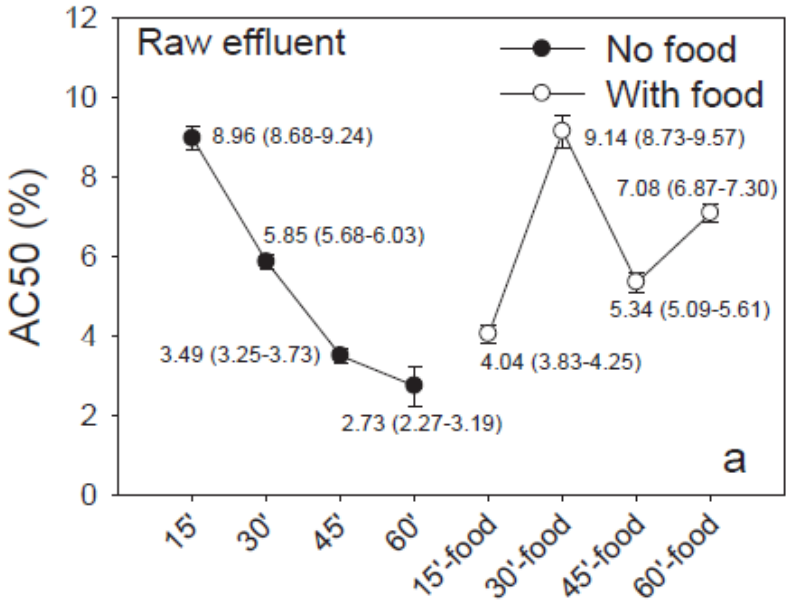
HABITAT SELECTION (FOOD)



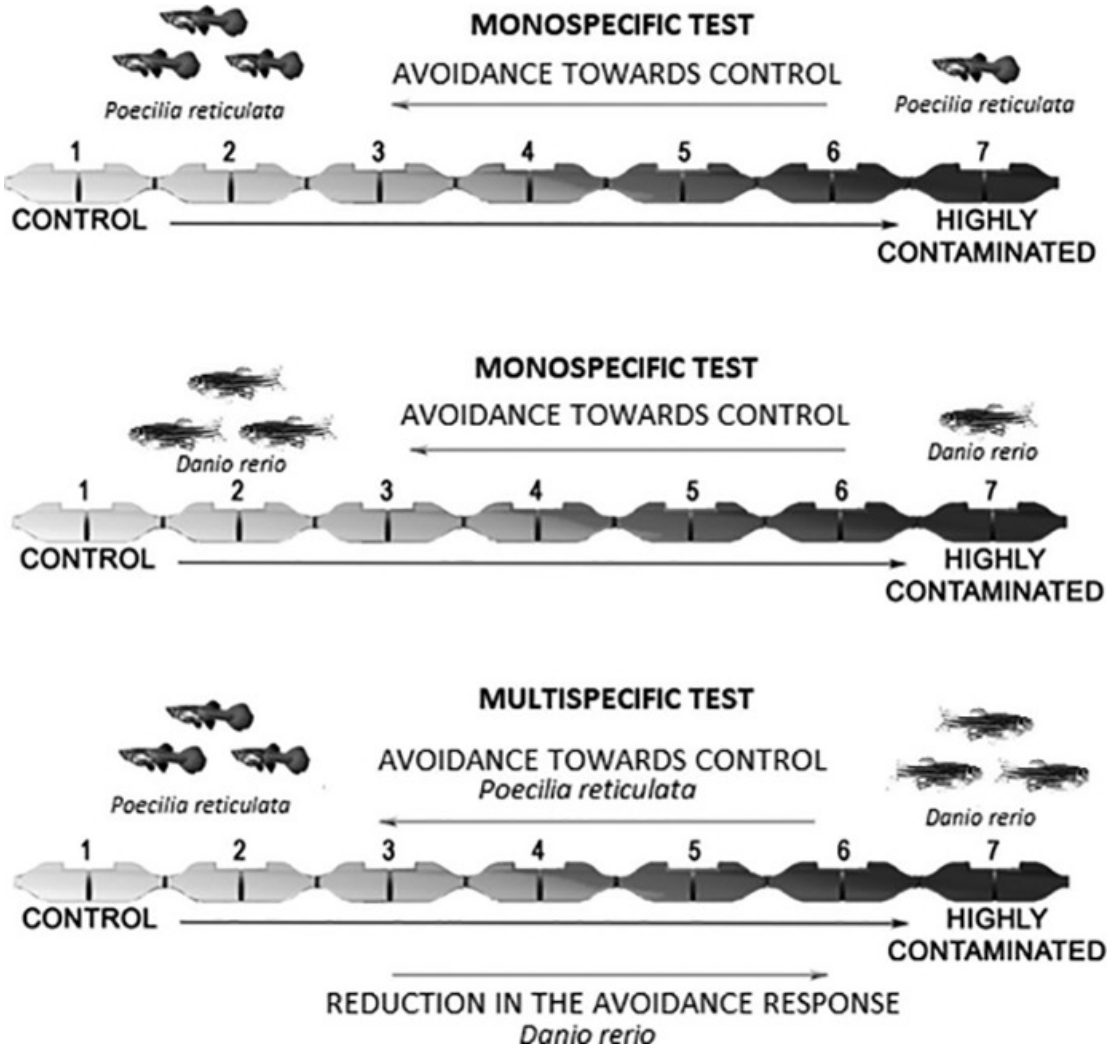
Oreochromis sp.
2.5 - 3 cm length

AVOIDANCE ASSAYS
NON-FORCED EXPOSURE





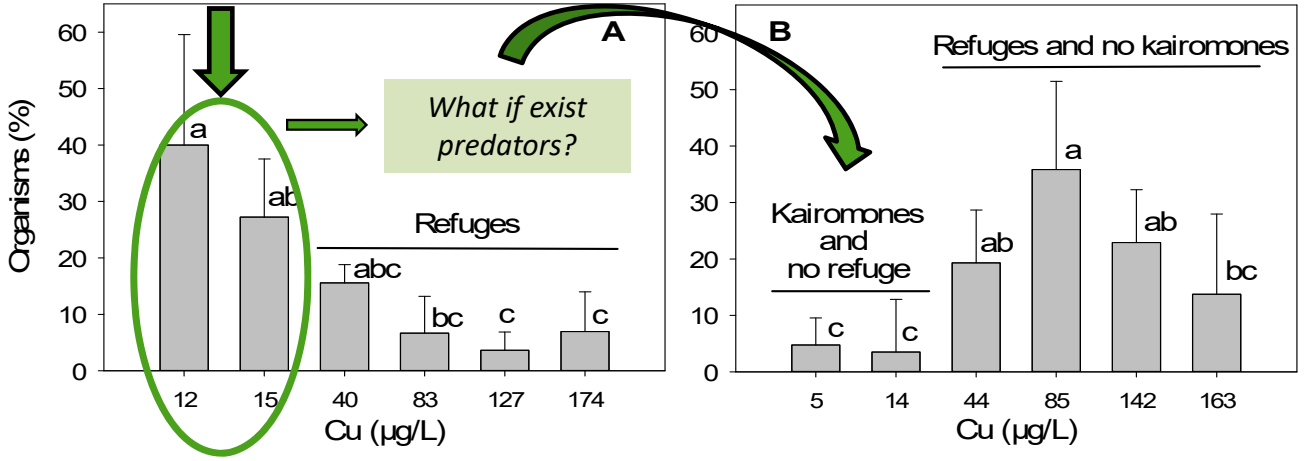
HABITAT SELECTION (POSSIBLE COMPETITION)

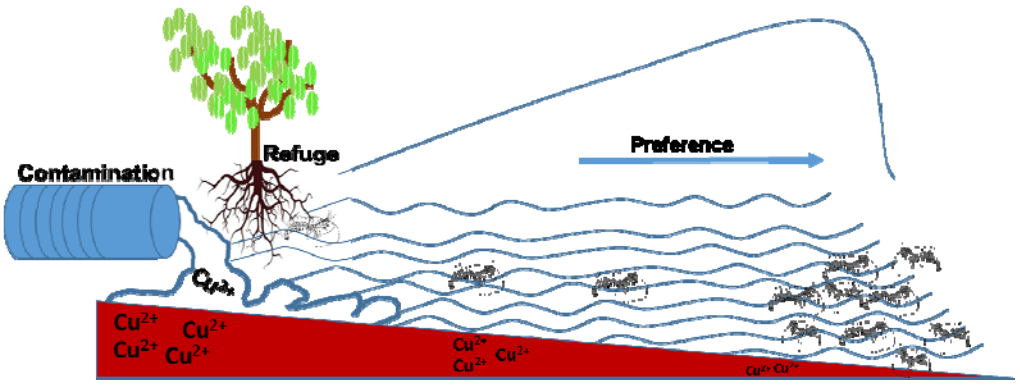


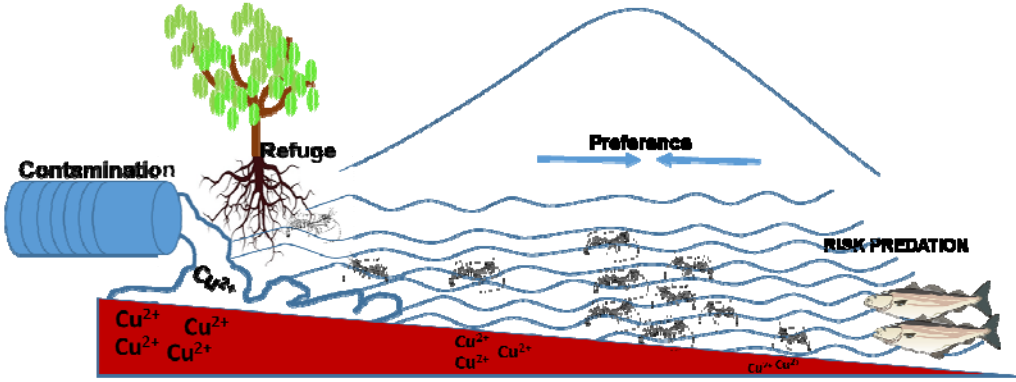
HABITAT SELECTION (*CONTAMINATION, SHELTER AND PREDATION)*

(cost-benefits-based habitat selection hypothesis)

Atyaephyra desmaresti







NEW CHALLENGES

What are the new challenges of the multi-compartmented exposure approach?

THE RELEVANCE OF THE SPATIAL SCALE

Avoidance is spaceless but NOT timeless

(spacelessness hypothesis)

3.0 m

30.0 m

- **3.0 m**

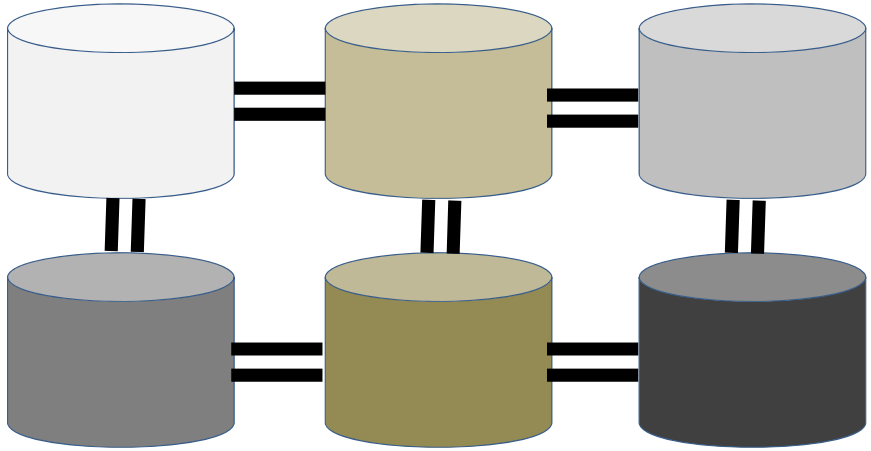
vs.

- **30 m**

[…]

MESOCOSMS AND *IN SITU* ASSAYS

IFAPA
Instituto de Investigación y Formación Agraria y Pesquera



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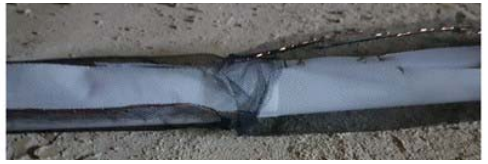
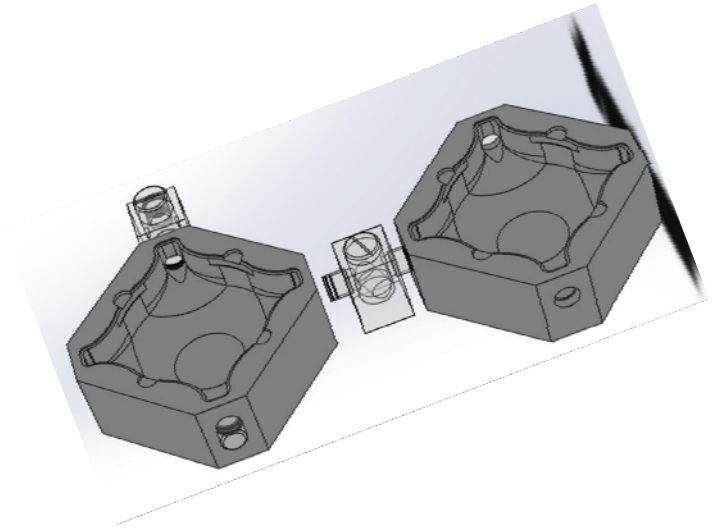


NEW EXPERIMENTAL SYSTEM



WHERE ARE WE GOING TO?

REGULATORY TOXICOLOGY AND PHARMACOLOGY 8, 226–238 (1988)

Putting the Eco in Ecotoxicology[1]

JOHN CAIRNS, JR.

University Center for Environmental and Hazardous Materials Studies and Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

PERGAMON

Marine Pollution Bulletin 44 (2002) 7–15

MARINE POLLUTION BULLETIN

www.elsevier.com/locate/marpolbul

Viewpoint

Integrating toxicology and ecology: putting the "eco" into ecotoxicology

Peter M. Chapman*

EVS Environment Consultants, 195 Pemberton Avenue, North Vancouver, BC Canada V7P 2R4

PERGAMON

Marine Pollution Bulletin 44 (2002) 279–285

MARINE POLLUTION BULLETIN

www.elsevier.com/locate/marpolbul

New concepts in ecological risk assessment: where do we go from here?

Keith R. Solomon *, Paul Sibley

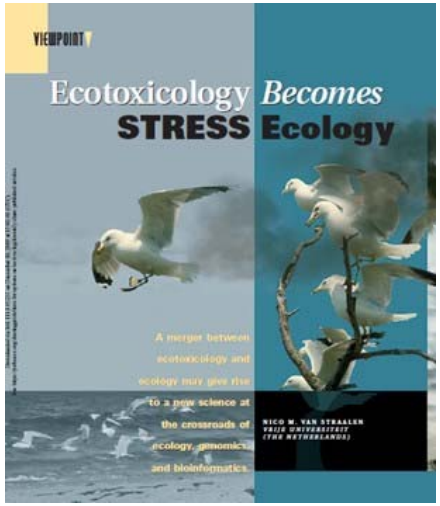
Department of Environmental Biology, Centre for Toxicology, University of Guelph, Guelph, ON, Canada N1G 2W1

Human and Ecological Risk Assessment: An International Journal

ISSN: 1080-7039 (Print) 1549-7860 (Online) Journal homepage: http://www.tandfonline.com/loi/bher20

Landscape Ecotoxicology and Assessment of Risk at Multiple Scales

Alan R. Johnson



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The Science of the Total Environment 317 (2003) 207–233

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Review

Indirect effects of contaminants in aquatic ecosystems

John W. Fleeger[a,*], Kevin R. Carman[a], Roger M. Nisbet[b]

Science of the Total Environment 408 (2010) 3871–3879

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

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Review

Ecological vulnerability in risk assessment – A review and perspectives

H.J. De Lange [a,*], S. Sala [b], M. Vighi [b], J.H. Faber [a]

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[b] *Department of Environmental Sciences, University of Milano Bicocca, Piazza della Scienza, 1, 20126 Milano, Italy*

Environ. Sci. Technol. 2008, 42, 9999–9004

ENVIRONMENTAL Science & technology Viewpoint

Ecological Risk Assessment: From Book-Keeping to Chemical Stress Ecology

PAUL J. VAN DEN BRINK

Alterra & Aquatic Ecology and Water Quality Management, Wageningen University, The Netherlands

underpinning ERA, should permit itself to grow out of its "single-species" shell because it should focus on the protection of populations and communities in the field (1, 2). The discrepancy between the question posed in ERA and the answer provided by single-species tests is concealed by the use of assessment factors (1).

This historical background explains why only a very limited amount of ecological theory has become integrated into the field of ecotoxicology and ERA. As a result, science-based, ecosystem-level risk assessment methodologies have hardly been developed. To counteract this ecological defi-ciency in ERA, frameworks have been proposed to integrate

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ENVIRONMENTAL POLLUTION

Environmental Pollution 138 (2005) 420–424

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Commentary

Island biogeography and landscape structure: Integrating ecological concepts in a landscape perspective of anthropogenic impacts in temporary wetlands

David G. Angeler [a,*], Miguel Alvarez-Cobelas [b]

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Review

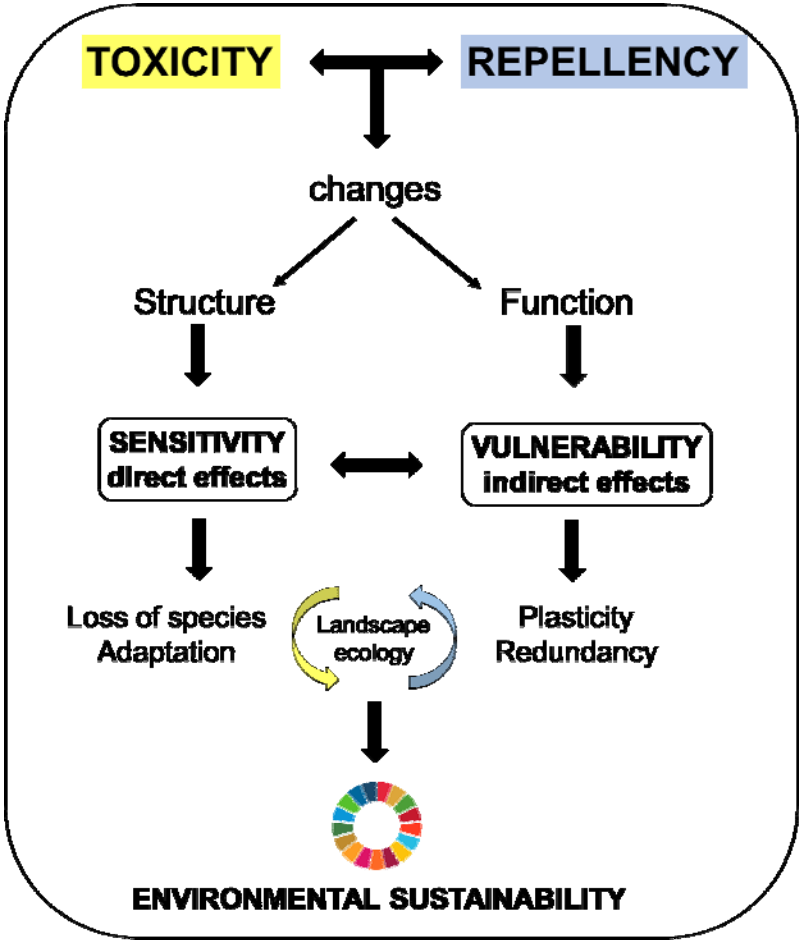
TIME AND SPACE ISSUES IN ECOTOXICOLOGY: POPULATION MODELS, LANDSCAPE PATTERN ANALYSIS, AND LONG-RANGE ENVIRONMENTAL CHEMISTRY

JORGE ARES*

National Patagonic Center, CONICET, P.O. Box 76, 9120 Madryn, Argentina

STRESS ECOLOGY

A more ecological vision to the ecotoxicological studies



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04/05/2020