



**SOCIETY OF ENVIRONMENTAL  
TOXICOLOGY AND CHEMISTRY**

Environmental Quality Through Science®  
[www.setac.org](http://www.setac.org)



**Global  
Horizon  
Scanning™**



# TOWARDS SUSTAINABLE ENVIRONMENTAL QUALITY:

## PRIORITY RESEARCH NEEDS FOR EUROPE

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# PROGRAMME



- 08:30 Introduction to the programme and questions on vulnerability, propagation of effects, multiple stressors and effect modelling (**Paul van den Brink**)
- 09:00 Research needs for high-throughput assessment of individual contaminants and their mixtures, both historical and emerging, and sustainable molecular design and alternatives analysis of chemical products (**Bryan Brooks**)
- 09:20 Prioritisation and detection of existing and emerging environmental contaminants (**Alistair Boxall**)
- 09:40 Predicting stressor effects on ecosystems and their services in a changing world: implications for risk communication, risk management and restoration (**Lorraine Maltby**)
- 10:00 Discussion on way forward
- 10:15 End





# WHY GLOBAL HORIZON SCANNING?

- Numerous global challenges and opportunities exist to achieve more sustainable environmental quality
- Environmental science has responded to many issues, but has not undertaken a prospective activity to identify strategic research needs
- The Global Horizon Scanning Project aims to identify important environmental quality research needs
- Results of this project contribute to the mission of SETAC to achieve Environmental Quality Through Science®



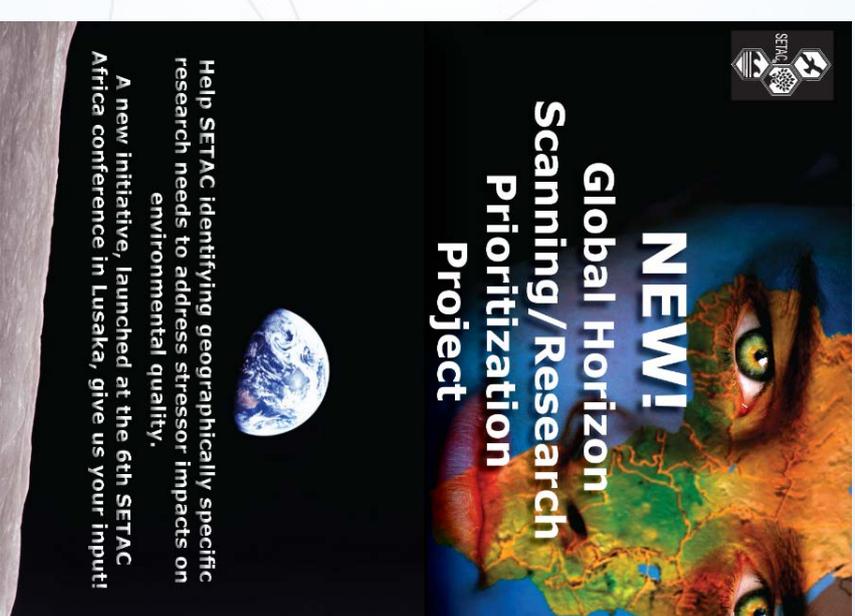


# EUROPE HORIZON SCANNING PROJECT



Solicited research questions  
from SETAC Europe members in  
2014 – 2015

- 183 questions submitted
- 107 valid, unique questions
- 90 selected for workshop





# What was an 'ideal' question?

- Address important gaps in knowledge
  - Produce a step change in understanding or practice
- Be answerable through a realistic research design
  - Cover a spatial and temporal scale that could realistically be addressed e.g. over 5 years with ~ €10 million
- Have a factual answer that does not depend on value judgments



# THE EUROPE HSP WORKSHOP



Structuring the Input  
from Europe and  
the Middle East

6-7 May 2015  
Barcelona, Spain



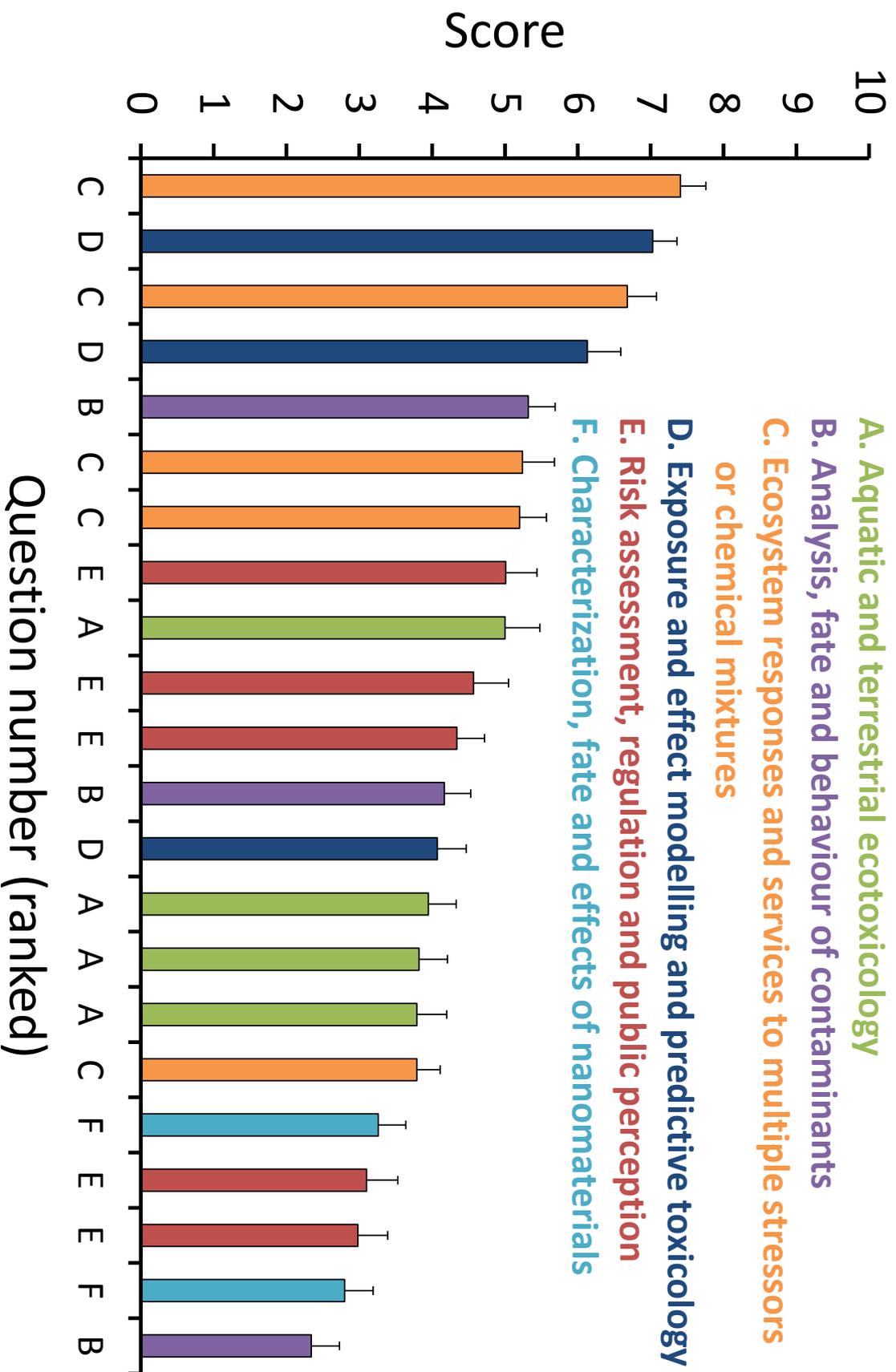
## 22 PRIORITY QUESTIONS ...



- A. Aquatic and terrestrial ecotoxicology (4)
- B. Analysis, fate and behaviour of contaminants (3)
- C. Ecosystem responses and services under multiple stressors and chemical mixtures (5)
- D. Exposure and effect modelling and predictive toxicology (3)
- E. Risk assessment, regulation and public perception (5)
- F. Characterization, fate and effects of nanomaterials (2)

... ranked by SETAC Europe members





Question number (ranked)

# 5 MOST HIGHLY RANKED QUESTIONS



1. How can interactions among different stress factors (chemical, physical, biological) operating at different levels of biological organization be accounted for in environmental risk assessment?
2. How do we improve risk assessment of environmental stressors to be more predictive across increasing environmental complexity and spatiotemporal scales?
3. How can we define, distinguish, and quantify the effects of multiple stressors on ecosystems?
4. How can we develop mechanistic modelling of toxicokinetic and toxicodynamic data to comparatively extrapolate adverse effects across species, life stages, and different levels of biological organization, from genetic processes to the ecosystem scale?
5. How can we combine existing and develop innovative techniques to better characterize the use, emissions, fate and exposure (of humans and ecosystems) of/to chemicals at different spatial and temporal scales?





# VULNERABILITY, PROPAGATION OF EFFECTS, MULTIPLE STRESSORS AND EFFECT MODELLING (QUESTIONS 1, 2, 8, 9, 14, 15)

- Aquatic and terrestrial ecotoxicology
- Ecosystem responses and services under multiple stressors and chemical mixtures
- Exposure and effect modelling and predictive toxicology





# AQUATIC AND TERRESTRIAL ECOTOXICOLOGY

- How can a framework be developed and implemented that integrates evolutionary and ecological knowledge in order to quantify and predict vulnerability of populations and communities to stressors?
- How do sublethal effects alter individual fitness and propagate to the population and community level?





# ... FRAMEWORK ... TO QUANTIFY AND PREDICT VULNERABILITY ... TO STRESSORS?

- Using morphological, physiological and ecological traits and phylogeny
- Interface between species' traits, phylogeny and sensitivity has only been studied fragmentally
- A common definition of sensitivity is lacking
- Vulnerability concept (sensitivity, exposure, recoverability, structure and length of the food web, etc.)
- Assess the regulatory relevance of microevolutionary responses





# HOW DO SUBLETHAL EFFECTS ... PROPAGATE TO THE POPULATION AND COMMUNITY LEVEL?

- The sublethal effects assessed in standard toxicity experiments are mobility, reproduction, development and growth,
- Use of biomarkers and other assays that study physiological responses → development of adverse outcome pathways → link to regulatory and ecologically relevant endpoints!
- Some are included in individual, population and community level mechanistic effect models
- Higher tier: individual based TKTD models → population model
  - GUTS: General Unified Threshold model for Survival
  - DEBtox: dynamic energy budget models





# ECOSYSTEM RESPONSES AND SERVICES UNDER MULTIPLE STRESSORS AND CHEMICAL MIXTURES

- How can we define, distinguish, and quantify the effects of multiple stressors on ecosystems?
- How can interactions among different stress factors (chemical, physical, biological) operating at different levels of biological organization be accounted for in environmental risk assessment?



# HOW CAN WE DEFINE, DISTINGUISH, AND

## QUANTIFY THE EFFECTS OF MULTIPLE STRESSORS ...?



- Multiple stressors are reality
- Synergistic effects found in 28 – 36% of the cases (2 reviews)
- Need to perform studies with more than 2 stressors
- Current understanding is extremely limited → hampering risk assessment and management strategies
- Big (large-scale geospatial) data, high-throughput genomic sequencing techniques, traits data bases needed
- combination of comprehensive field studies (covering a wide range of stressor interactions), laboratory toxicity tests and mesocosm studies



# HOW CAN INTERACTIONS AMONG ... STRESS FACTORS ... BE ACCOUNTED FOR IN ... RISK ASSESSMENT?



- ERAs primarily focus on single or a limited number of stressors in a few model species, over limited spatial scales
- Prospective or retrospective ERAs may fail to protect the 'real' ecosystems
- integrated assessment of toxic and non-toxic stressors including cultural and ecological protection goals
- Greater integration among different scientific disciplines
- Application of new and emerging tools (e.g. ecological modelling) and incorporation of ecosystem services endpoints





# EXPOSURE AND EFFECT MODELLING AND PREDICTIVE TOXICOLOGY

- How can we develop more ecologically relevant *in silico* methodology for fate, biotransformation and effect parameter estimation including chemical properties, species traits and environmental variability?
- How can we develop mechanistic modelling of toxicokinetic and toxicodynamic data to comparatively extrapolate adverse effects across species, life stages, and different levels of biological organization, from genetic processes to the ecosystem scale?



# ... DEVELOP MORE ECOLOGICALLY RELEVANT ... METHODOLOGY FOR FATE, ... AND EFFECT



## PARAMETER ESTIMATION ...

- Improving the ecological realism of exposure prediction
- Ecotoxicologically relevant concentration (ERC)
- TKTD model for linking exposure with effects
- Now uses exposure scenarios representing European landscapes that are biologically meaningless
- Environmental scenarios → exposure and ecological scenarios
- Framework to predict effects from the receptor to the landscape level using traits-based approaches



# ... MODELLING OF TKTD ... TO ... EXTRAPOLATE ... ACROSS ... LEVELS OF BIOLOGICAL ORGANIZATION



- TKTD models predict the development of the toxic effects from the molecular level to the life-history traits of the individual
- AOPs offer a powerful approach to collect, organize and generalize toxicity-related information → more focus on ecology and species interactions up to ecosystem services
- AOP framework can inform the selection of targets, processes and conditions to be considered in model development and generation of experimental data
- AOP integrate expert knowledge on different aspects of toxicity, promoting community-wide interdisciplinary research



