Australian Government
Department of the Environment and Energy
Supervising Scientist

Bringing water quality benchmark derivation approaches into the 21st century

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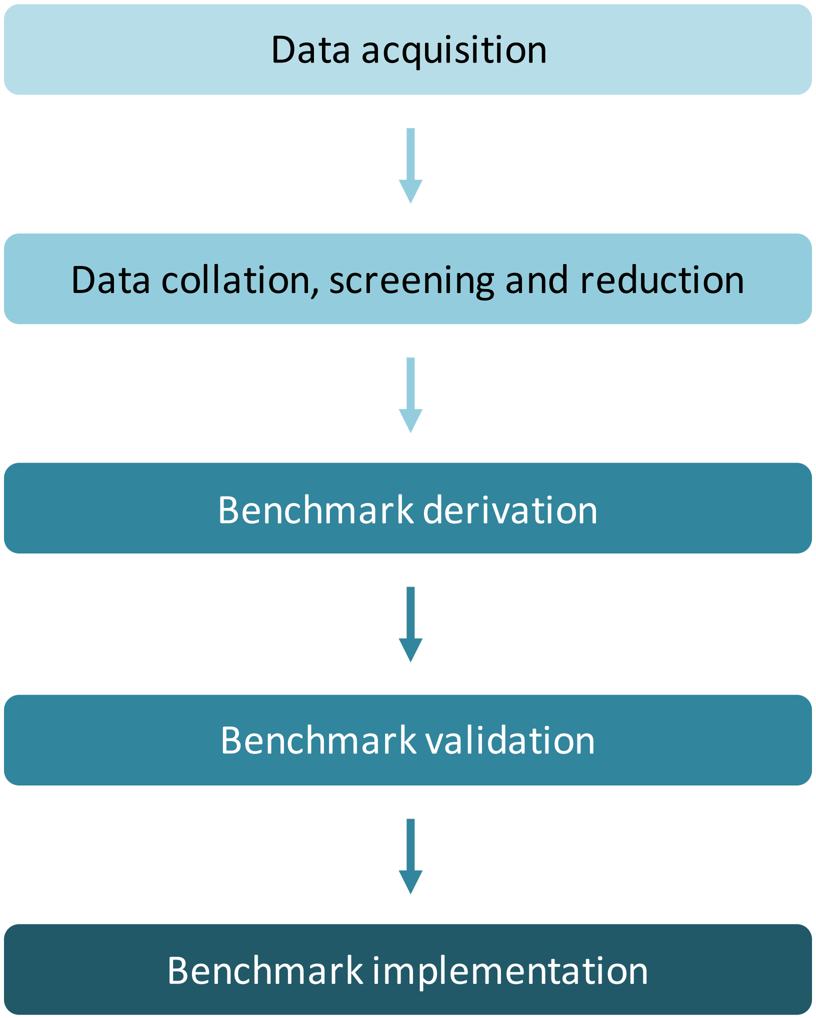
Outline

1. Water quality benchmarks – general process and its challenges
2. Species sensitivity distributions revisited – brief history, general process and challenges
3. Efforts to improve derivation methods
4. Adoption
5. Conclusions & what to do next?

1. Water quality benchmarks

General process



1. Water quality benchmarks

General process

Data acquisition

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Data collation, screening and reduction

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Benchmark derivation

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Benchmark validation

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Benchmark implementation

Challenges

- Experimental design
- Toxicity estimates (e.g. NOEC v ECx v NEC)
- Ecologically relevant data

- Definitions/classifications (e.g. acute, chronic toxicity)
- Quality assessment systems
- Subjectivity

- Lack of data
- Assumptions
- Uncertainty
- Assessment factors

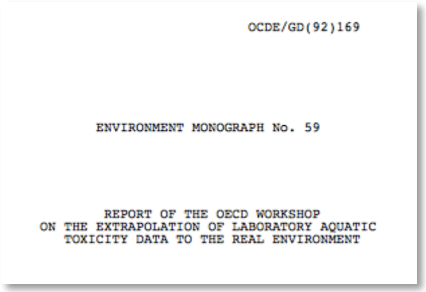
- Lack of data

- Criteria/standards v guidelines
- Inadequate monitoring data
- Practitioner inexperience

2. Species sensitivity distributions revisited

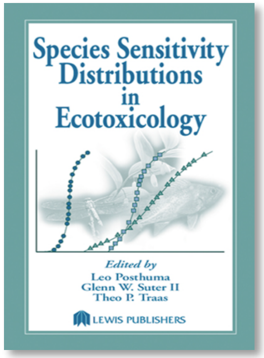
Brief history

- Used in U.S. and Europe to derive WQBs (and for ERA) since the 1980s
- Multi-jurisdictional workshop in early 1990s consolidated the concept (OECD 1992)
- Adopted by others through the 1990s/early 2000s
- Comprehensively reviewed in 2002 (Posthuma et al. 2002), to:
  - "…suggest paths forward, to suggest solutions for the most relevant criticisms voiced in the past, and to break inertia in the evolution of the SSD concept itself."
- EU updated its method for EQS derivation in 2011
- State of the science reviewed again in 2014 (ECETOC 2014; Belanger et al. 2016)
- Aust/NZ derivation method revised 2017
- US EPA method currently under revision


OCDE/GD(92)169

ENVIRONMENT MONOGRAPH No. 59

REPORT OF THE OECD WORKSHOP
ON THE EXTRAPOLATION OF LABORATORY AQUATIC
TOXICITY DATA TO THE REAL ENVIRONMENT


Species Sensitivity Distributions in Ecotoxicology

Edited by
Leo Posthuma
Glenn W. Suter II
Theo P. Traas

LEWIS PUBLISHERS


ecetoc

…stimating toxicity thresholds for
…quatic ecological communities
from sensitivity distributions
…-13 February 2014, Amsterdam

Workshop Report No. 28

EUROPEAN CENTRE FOR ECOTOXICOLOGY AND TOXICOLOGY OF CHEMICALS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664 Received: 18 February 2016 | Returned for Revision: 24 May 2016 | Accepted: 5 August 2016

Health & Ecological Risk Assessment

Future Needs and Recommendations in the Development of Species Sensitivity Distributions: Estimating Toxicity Thresholds for Aquatic Ecological Communities and Assessing Impacts of Chemical Exposures

Scott Belanger,*† Mace Barron,‡ Peter Craig,§ Scott Dyer,† Malyka Galay-Burgos,|| Mick Hamer,# Stuart Marshall,†† Leo Posthuma,‡‡§§ Sandy Raimondo,‡ and Paul Whitehouse||||

2. Species sensitivity distributions revisited

General process

Data acquisition, collation, screening and reduction

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Construction of cumulative distribution function (SSD) using final dataset

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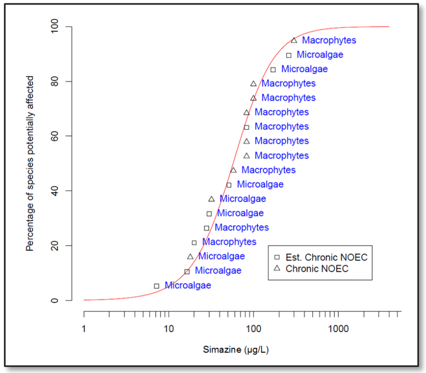
Interpolation/extrapolation of a WQB (HC_p, PC_x)



Has proven a useful, practical and intuitive tool for WQB derivation

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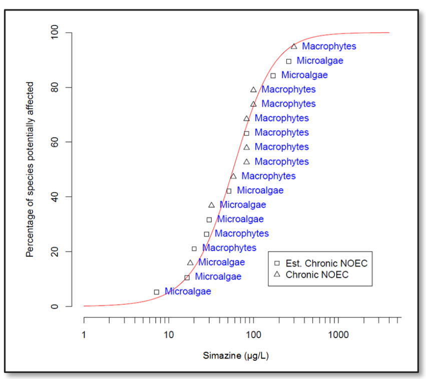


Has proven a useful, practical and intuitive tool for WQB derivation

Traditional SSD-related challenges

- Sample size
- Distribution assumptions
- Bi/multi-modality
- Other routes of exposure
- Species representativeness
- Randomness of species selection
- Contaminant interactions
- Ecosystem interactions
- Protectiveness of the WQB

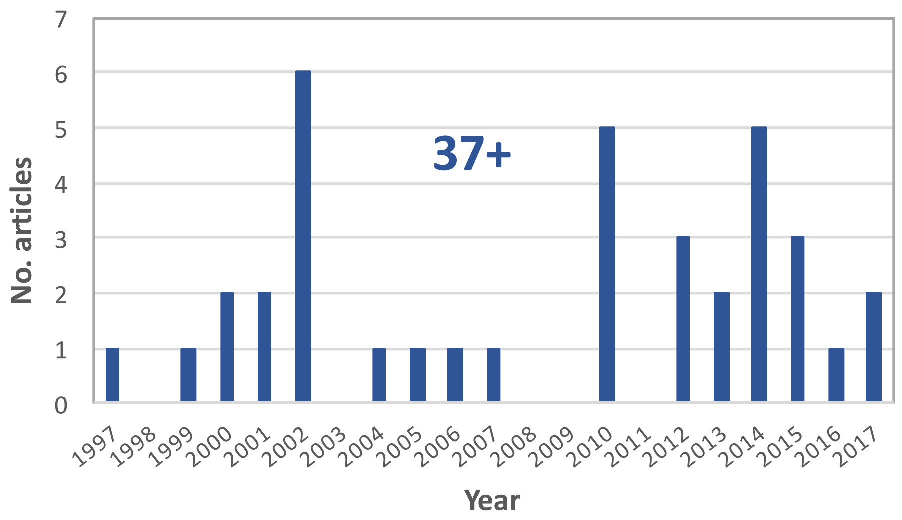
A mix of problems related to:

(i) SSDs themselves (statistical);
(ii) how we push SSDs; and
(iii) how we use SSD outputs

3. Efforts to improve derivation methods

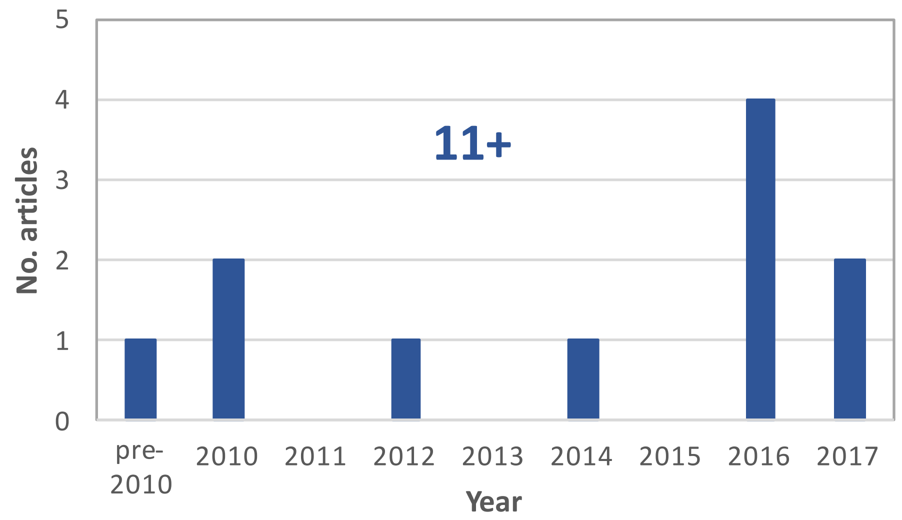
Overview

- Articles proposing improvements or alternatives to SSD-based methods for WQB derivation



- Published methods from other fields that may have potential for WQB derivation

(mostly field-based)



3. Efforts to improve derivation methods

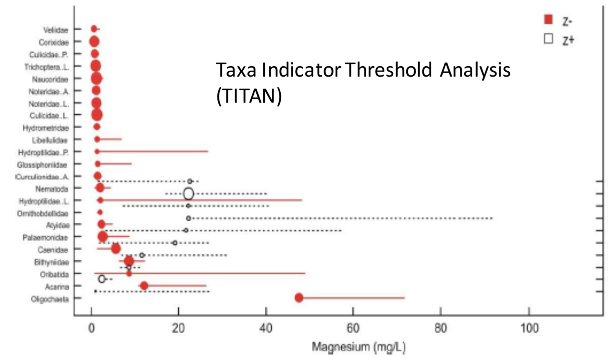
SSD-based methods – examples

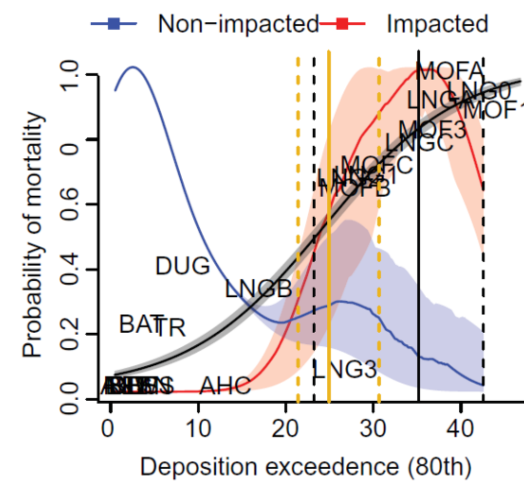
- Bootstrapping methods
  - Do not assume any distributional form
  - Problematic for small datasets
- Bayesian methods
  - Overcome several limitations of conventional (frequentist) SSDs
  - Inclusion of empirical or expert information prior to the analysis (prior distributions) to inform the analysis
- Other aspects
  - Correcting for species selection bias
  - Propagating uncertainty from toxicity data through to the WQB (using all the conc-response data in the models, not just the toxicity estimate)
  - Modelling bimodal datasets
  - Critical body burden SSDs
  - Augmented SSDs (interspecies correlation estimation)
- For metals – BLMs and, more recently, MLRs (e.g. USEPA 2007, USEPA 2017)
- Field-based / community SSDs (e.g. USEPA 2016)

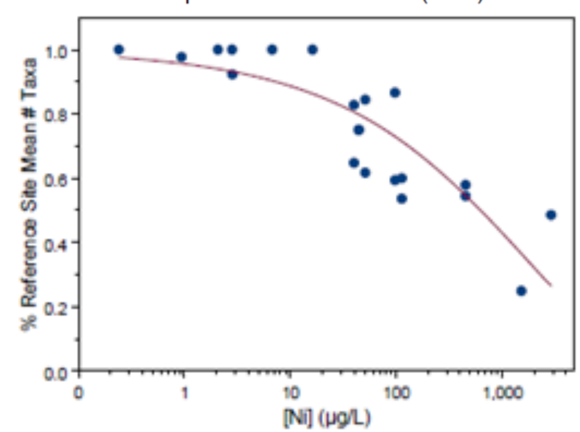
3. Efforts to improve derivation methods

Non-SSD methods – examples

- Most still not fully demonstrated
  - TITAN (Baker & King 2010)
  - Gradient forests (Ellis et al. 2012)
  - NCAP (Millar et al. 2005)
  - Probablistic dose-response thresholds (Fisher et al. 2017)
  - Species distribution modelling (Ochoa Ochoa et al. 2017)
  - Direct ECx calculation of the assemblage/ecosystem response (e.g. Hydrobiology 2016)
  - Drawing on the field of Decision Theory
- *Note* – Many are field-based approaches



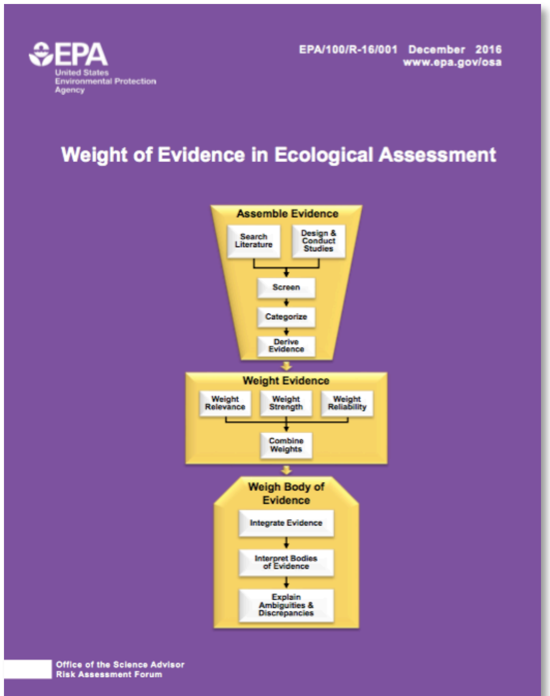




3. Efforts to improve derivation methods

Weight of evidence

USEPA (2016), Suter et al. (2017)



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Health & Ecological Risk Assessment

A Weight of Evidence Framework for Environmental Assessments: Inferring Quantities

Glenn Suter,† Susan Cormier,† and Mace Barron‡*
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‡US Environmental Protection Agency, Office of Research and Development, National Health and Environmental, Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Florida

Buchwalter et al. (2017)

Modernizing Water Quality Criteria in the United States: A Need to Expand the Definition of Acceptable Data

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Aust & NZ governments (2018)

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Guideline values
- Deriving guideline values
- Reference-site data
- Laboratory-effects data
- Field-effects data
- Using multiple lines of evidence
- Cultural and spiritual values
- Default guideline values
- EDIT LINKS

Deriving guideline values for water quality

To derive a guideline value requires the collection of data or information on an indicator for a water body, then use of these data to determine concentrations that will protect a particular community value.

Here we describe methods for guideline value derivation related to the protection of aquatic ecosystems — relevant to both default guideline values (DGVs) and site-specific guideline values — and other community values.

Aquatic ecosystem guideline values

Guideline values for aquatic ecosystems can be derived using:

- reference-site data
- laboratory-effects data
- field-effects data
- multiple lines of evidence based on two or more of these d...

These derivation methods are relevant to indicators for all lines of evidence that may require guideline values, namely chemical and physical lines of evidence (physical and chemical stressors, toxicants) and ecosystem receptor lines of evidence (bioaccumulation, biodiversity, toxicity).

For guideline values derived from field and laboratory-effects data, the ecological or biological effects of the stressors are used to define guideline values below which ecologically meaningful changes do not occur.

Referential guideline values define a measurable level of change from a natural reference condition that, although the ecological consequences are unknown, is considered unlikely to result in adverse effects.

For toxicants in waters and sediments, the preferred approaches to deriving guideline values are usually through the use of field and/or laboratory biological-effects (toxicity) data. But this will be dictated by other factors, including the significance or risk of the stressor and the level of protection being assigned to the waterway. For example:

- a stressor assessed to be of low risk to a waterway may not require a guideline value based on field-effects data
- a stressor assessed to be of high risk to a waterway may require a guideline value based on a multiple lines-of-evidence approach using both field and laboratory-effects data
- for waterways of high conservation/ecological value — where any change in water quality from natural background concentrations might be unacceptable — a conservative reference-site approach to deriving guideline values might be preferable.

For physical and chemical (PC) stressors, our preferred approach to derive guideline values is to use local field and/or laboratory-effects data. But these are

4. Adoption

- Little adoption of improved/new methods in >20 years
- Two most recent WQB derivation revisions:
  - ***Aust/NZ (2017)*** – recognised potentially improved approaches to basic SSDs, but lacked resources to explore them
  - ***US EPA (in progress)*** – will expedite provision of tools to assist criterion derivation, esp. for small datasets, but unlikely to make fundamental changes to SSD/HC_{05} approach
- Possible reasons for lack of adoption:
  - Proposed approaches considered too complex and unfamiliar for routine uptake
  - Lack of systematic comparisons between existing and proposed methods
  - Lack of an effective synthesis of the case – research outcomes remaining largely out of sight of the decision makers
  - Requirement for consistency with other regulatory programs, with different revision timeframes
  - Regulatory/government inertia
- Can we learn from successful adoption examples (e.g. BLMs)?

"…Approaches that are seriously considered for routine use should be practical and acceptable for risk managers." (Suter 2002, in Posthuma et al. 2002)

5. Conclusions & what to do next?

- There is undeniable benefit in improving SSD approaches, and expanding the range of acceptable tools for WQB derivation beyond existing SSD approaches
- No shortage of discussion in this area, but not much formal adoption as yet

- Better understand why change has not been effected to date
- Understand the improvement(s) within the full WQB 'life cycle' (not just SSDs!) that will yield the greatest benefits to environmental protection
- A continued collaborative approach, with a long-term strategic view towards best practice guidance (*sensu* ECETOC 2014 recommendation)
- BUT, we need to first decide what is *current* best practice