

Estimation of Effect Factors for application to marine eutrophication in LCIA

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Estimation of Effect Factors for application to marine eutrophication in LCIA



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Marine eutrophication

Ecosystem response to an excessive input of nutrients promoting an increase of primary production

Also from emissions of organic matter (e.g. river transport, sewage discharge)

Results in excessive oxygen depletion and impacts on biota, ecosystem and (socio)economy







Characterisation modelling

LCIA -> Characterisation Factors (CF) to translate emissions to potential impacts

CF = FF * XF * EF

Factors:

Fate (FF): how much N available ?

Exposure (**XF**): how N originates O₂ depletion ?

Effect (EF): benchmarks the impacts of oxygen depletion on biota

Damage dimension: species affected/ disappeared (i.e. loss of biodiversity)



Species sensitivity to hypoxia

The dataset:

Thresholds of hypoxia for marine biodiversity Raquel Vaquer-Sunyer* and Carlos M. Duarte 15452-15457 | PNAS | October 7, 2008 | vol. 105 | no. 40

- Data of sublethal threshold concentration (mgO_2/L) for <u>71</u> marine species
- <u>58</u> relevant species: only benthic, demersal and benthopelagic
- Fish (12), crustaceans (13), molluscs (7), echinoderms (7), annelids (7), cnidarians (11), plants (1)

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Endpoints tested

Sub-lethal responses:

- Behavioural level (e.g. avoidance strategies)
- Physiological level (e.g. limiting growth, activity and respiration rates)
- (NOT) Ecological level

 (e.g. altering structure, function, and services of benthic communities)

Sensitivity to dissolved oxygen levels = LOEL, Lowest Observed Effect Level

How to extrapolate individual species sensitivity to ecosystem's?





Species distribution

Geographical distribution of the 58 species:

- 'World Register of Marine Species' (WoRMS) (www.marinespecies.org)
- 'The Species 2000 & ITIS Catalogue of Life' (www.catalogueoflife.org)
- 'Fishbase' (www.fishbase.org)
- 'FAO FishFinder' (www.fao.org/fishery/fishfinder)

Grouped into 5 climate zones:

Polar, subpolar, temperate, subtropical, and tropical

Sample size and lack of representativeness prevented classification at finer spatial resolutions





Species Sensitivity Distribution (SSD)

Potentially Affected Fraction of species (PAF) vs. levels of dissolved oxygen (DO)

SSD uses a probabilistic model to deliver the sensitivity of the community to an environmental stressor through a statistical distribution function of the sensitivities of individual species Posthuma et al. (2002)

Methodology and assumption used in LCIA for the sensitivity extrapolation

Estimate $HC50_{LOEL}$, i.e. the concentration of DO affecting 50% of the species above their LOEL





Effect Factor (EF)

The EF expresses the change of effect (Δ PAF) due to a variation of the stressor intensity (depletion of DO, i.e. Δ [O₂])

 $\mathbf{EF} = \frac{\Delta \mathbf{PAF}}{\Delta[\mathbf{O}_2]} = \frac{\mathbf{0.5}}{\mathbf{HC50}_{\mathbf{LOEL}}}$

HC50_{LOEL} can be obtained with SSD curves

by $PNAF = \frac{1}{1 + e^{-(logHC50_{LOEL} - \alpha)/\beta}}$

or calculating the geometric mean of the LOEL data, $HC50_{LOEL} = 10^{avg(logLOEL)}$ [PAF·m³/kgO₂]

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Preliminary results (I)



SSD curve of sensitivity to hypoxia (LOEL)

Estimation of e.g. the global default $HC50_{LOEL}=1.453 \text{ mgO}_2/L (n=58)$

PNAF, Potentially Not Affected Fraction of species





Preliminary results (II)

SSD curves for 5 climate zones and global default





Preliminary results (III)

EF estimation for 5 climate zones and global default

	Climate zone Polar Subpolar	<i>n taxa</i> 13	mgO ₂ /L	lower Cl			
	Polar Subpolar	13			PAF·m /kgO ₂	upper Cl	
	Subpolar	10	1.57	215.18	318.90	416.34	
	Supportai	38	1.52	237.51	329.88	434.47	
	Temperate	47	1.44	249.72	347.07	452.15	
	Subtropical	41	1.73	191.01	289.48	416.32	
_	Tropical	19	1.75	229.18	285.93	347.16	
_	Global	58	1.45	267.76	344.10	421.23	
EF [PAF·m ³ /kgO ₂]	500 450 350 300 250 200 150 50 0 Polar	Subp	olar Temp Cli	perate Subtrop	Tical Tropical	upper 95% EF Iower 95%	<mark>6 CI</mark> 6 CI

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Discussion (I)

Why such low spatial differentiation?

Species per climate zone range from 13 (polar) to 47 (temperate) – too few?

Species overlap:

- 100% Polar also found in Subpolar
- 72% Subpolar found in Temperate ⁹ -25%

Test

• 72% Temperate found in Subtropical -44%

Overlap = high contribution from sensitive species

Spatial resolution at climate zone level – is it too low?

Is there actually a natural differentiation of sensitivity? (water Temp, metabolism, solubility)





Discussion (II)

Issues with data representativeness?

Test-related errors – experimental methods, endpoints classification or identification

Biased selection for 'preferred' species or taxonomic groups:

- Easier to rear/maintain
- Show visible (easy) endpoints
- Commercial value
- Locally available

Geographical representativeness and species coverage

e.g. Mediterranean Sea (18/170) – LOEL for only 11% of potentially occurring species (IUCN db)





Preliminary conclusions

Method based on SSD and sensitivity to oxygen depletion was proposed

Applicable in LCIA as an EF for the marine eutrophication indicator

Contribute to a CF expressing the damage to ecosystem quality

The global default EF can be used for any region

Low spatial differentiation obtained mainly due to a short dataset and some concerns about representativeness

To increase resolution -> expand the dataset





Thank you all for your attention



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