MONITOOL PROJECT

DGT as a Tool to be Included in the Weight of Evidence (WOE) Approaches for Ecological Risk Assessment (ERA) in Marine Environments

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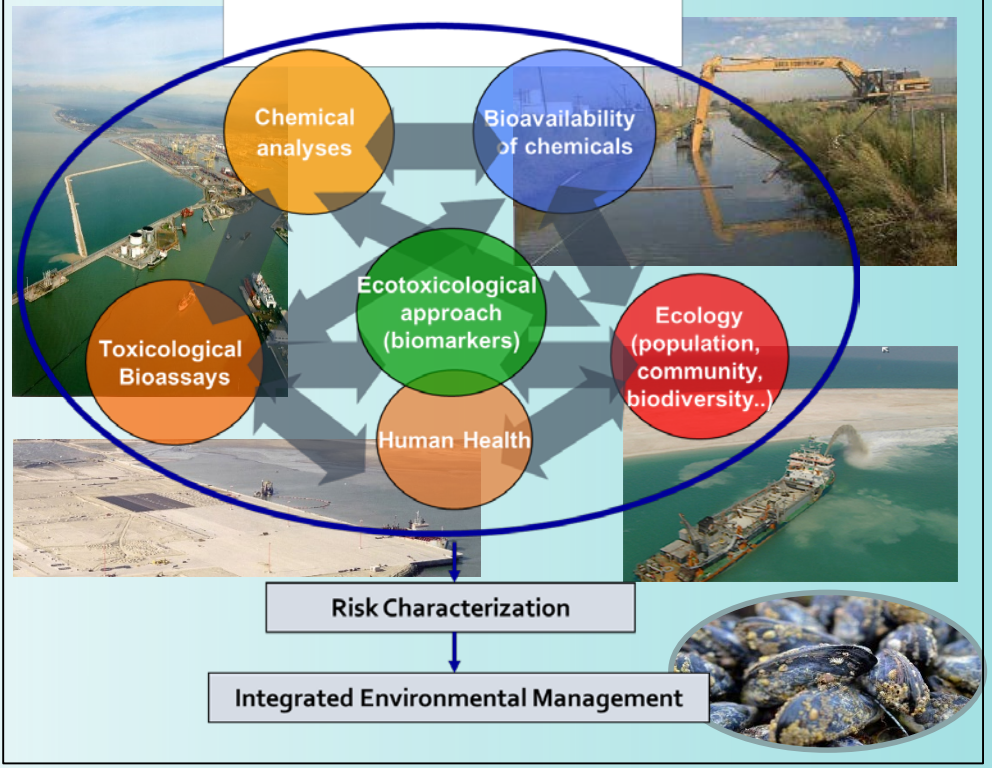
Weight Of Evidence (WOE) approaches for risk assessment in the marine environment: definition of weighted criteria for elaboration of individual Lines Of Evidence (LOEs)

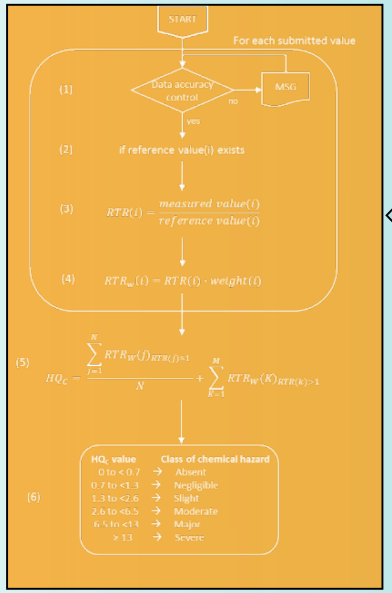
INTEGRATED MODELS FOR RISK ASSESSMENT

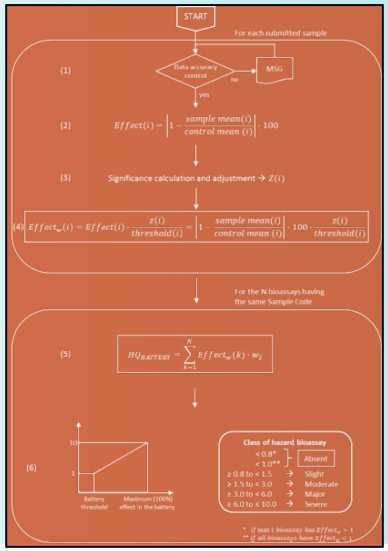


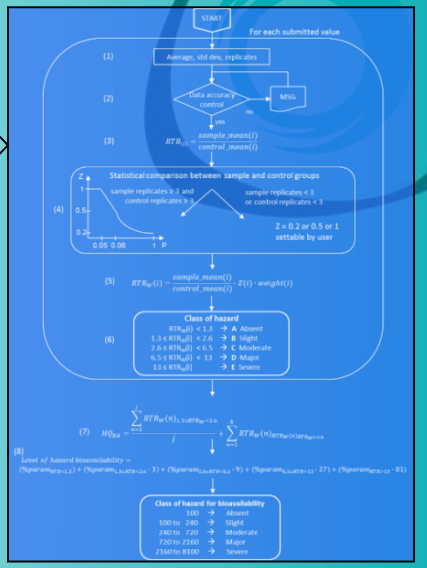
CRITICAL ISSUES IN RISK ASSESSMENT

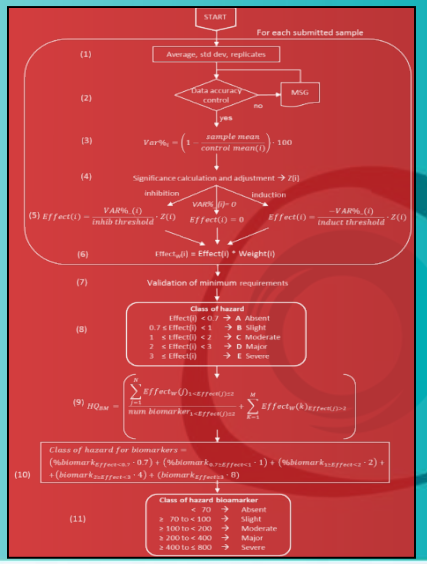
- **Interpretation and significance of complex datasets of heterogeneous results**
- **Qualitative and quantitative evaluations: indices and scales development**
- **Integration of different typologies of data**
- **Synthetic risk characterization/communication**

Quantitative risk assessment model based on Weight of Evidence (WOE) approach









LOE 1 Chemical analyses

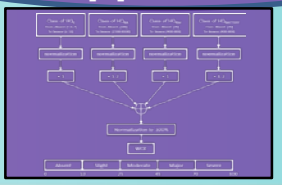
LOE 2 Bioavailability

LOE 5 Benthic communities

LOE 4 Bioassays

LOE 3 Biomarkers

Integrated Risk Index using WOE approach



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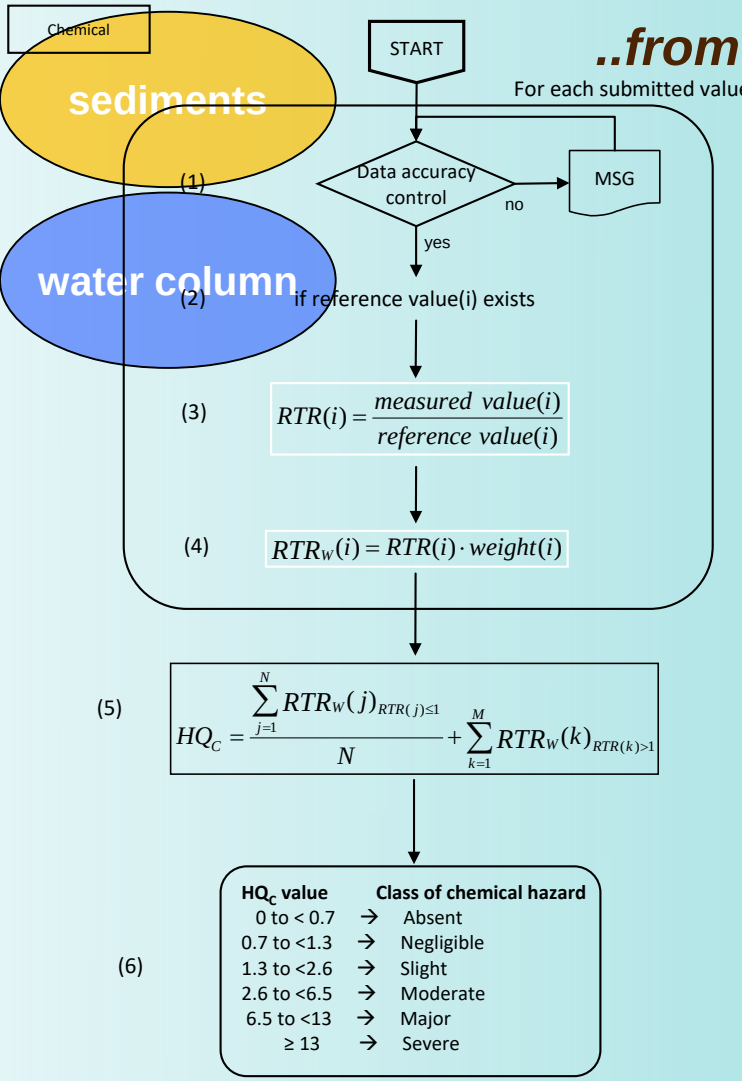
Elaboration of chemical characterization in abiotic matrices

..from pass-to-fail approach to weighted criteria



-Calculation for each parameter concentration of the Ratio To Reference, RTR

-Correction for typology of pollutants (i.e. hazardous or priority), RTR*p*

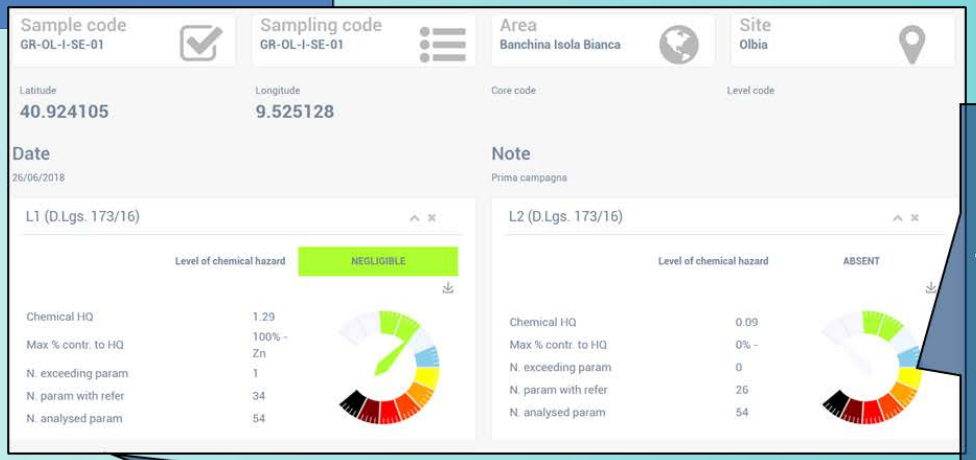
- Cumulative HQ differently weights for parameters with RTR<1 and those with RTR>1

- Classification of HQ in 1 of 5 classes of hazard (absent-negligible, slight, moderate, major, severe)

	Longitude	Area	Site	Date	Sampling code	Core code	Level code	Sample code	As	Ba	Be	Cd	C
2	8,922483	Genova	Diga foranea imboccatura levante	13/12/2018	GR-GE-I-SE-01			GR-GE-I-SE-01	8,78078			0,74035	
3	8,919	Genova	Porto antico	13/12/2018	GR-GE-I-SE-02			GR-GE-I-SE-02	5,6098			0,34246	
4	8,875117	Genova	Foce Polcevera	13/12/2018	GR-GE-I-SE-03			GR-GE-I-SE-03	10,4238			0,46893	
5	8,933853	Genova	Diga foranea imboccatura levante	16/05/2019	GR-GE-II-SE-01			GR-GE-II-SE-01	8,03118			0,43679	
6	8,921642	Genova	Porto antico	16/05/2019	GR-GE-II-SE-02			GR-GE-II-SE-02	13,9585			0,40952	
7	8,874175	Genova	Foce Polcevera	16/05/2019	GR-GE-II-SE-03			GR-GE-II-SE-03	5,45135			0,37115	
8	9,849547	La Spezia	Molo Fornelli	20/11/2017	MF1			MF1					
9	9,849579	La Spezia	Molo Fornelli	20/11/2017	MF2			MF2					
10	9,849583	La Spezia	Molo Fornelli	20/11/2017	MF3			MF3					
11	9,849546	La Spezia	Molo Fornelli	20/11/2017	MF4			MF4					
12	9,84578	La Spezia	Tra Molo garibaldi e Molo Fornelli	14/05/2019	GR-SP-II-SE-01			GR-SP-II-SE-01	23,7409			0,084	

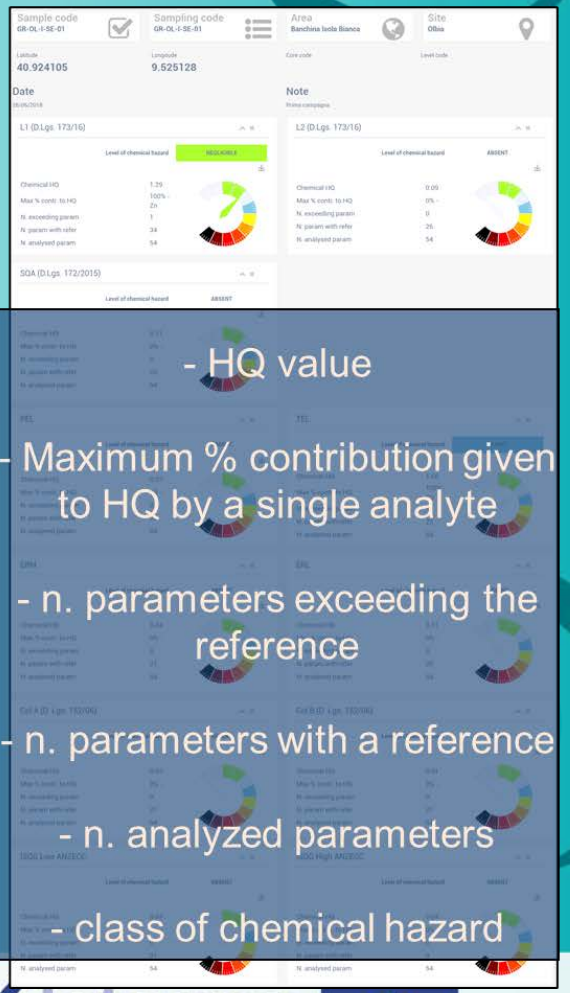
REFERENCE VALUES (Marine sediments)
L1 (DM 173/2016)
L2 (DM 173/2016)
ERL (Effect Range Low) (Long et al., 1995)
ERM (Effect Range Median) (Long et al., 1995)
TEL (Threshold Effect Level) (Mac Donald, 1994, Long et al. (1995)
PEL (Probable Effect Level) (Mac Donald, 1994, Long et al. (1995)
SQA (D. Lgs 172/2015),
SL/SQHV (ANZECC, 2009)
Column A, (Allegato 5, parte IV, Titolo V, D. Lgvo 152/2006)
Column B ("…")

EASY TO UPDATE WITH OTHER REFERENCES



NORMATIVES AND SEDIMENT QUALITY GUIDELINES

EASY TO UPDATE WITH OTHER REFERENCES



- HQ value
- Maximum % contribution given to HQ by a single analyte
- n. parameters exceeding the reference
- n. parameters with a reference
- n. analyzed parameters
- class of chemical hazard

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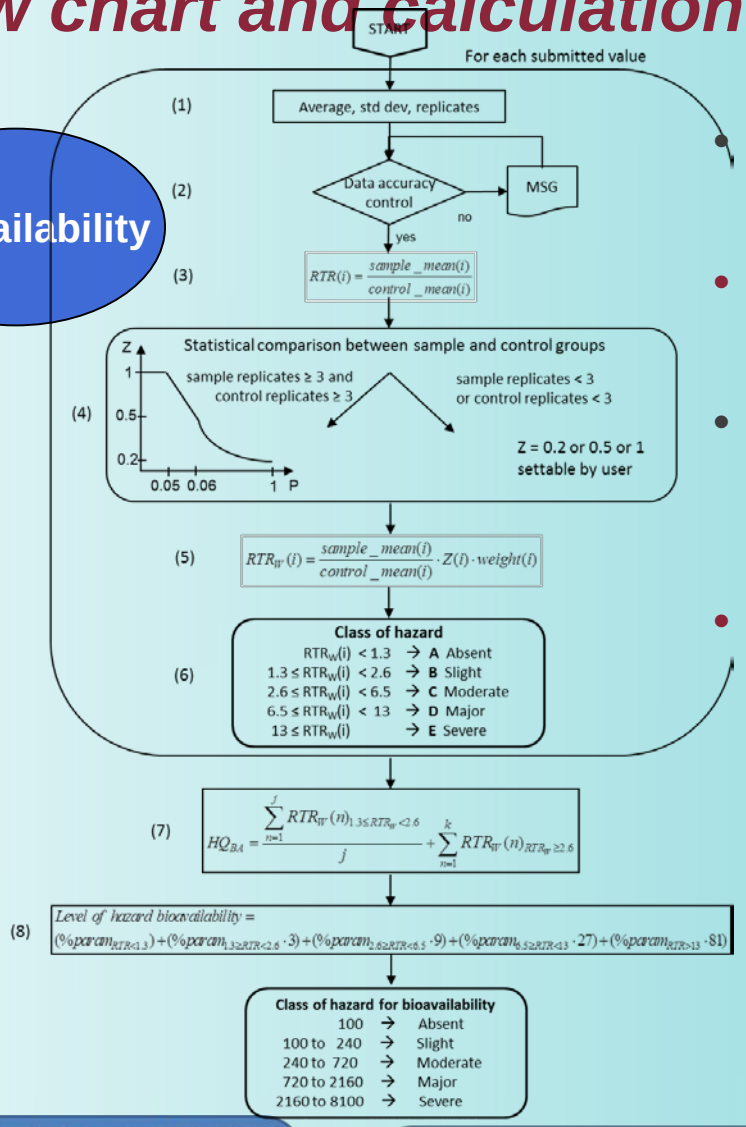
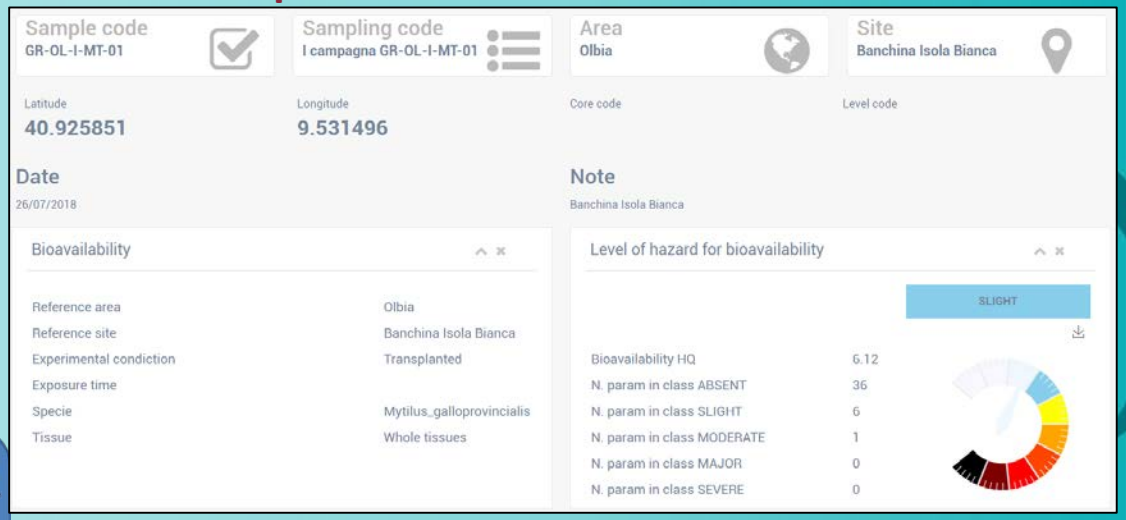
Flow chart and calculation of bioavailability HQ

Bioavailability



- Calculation for each analyte of <u>increased concentration</u>, corrected for <u>weight</u> and <u>statistical significance</u> (RTRw)
- Assignment of each parameter to 1 of 5 classes of effect (absent, slight, moderate, major, severe)
- The cumulative HQ <u>differently weights</u> these parameters according to the entity of variation (is not an average)
- Level of cumulative HQ is summarized by the % distribution of parameters in the classes of effect



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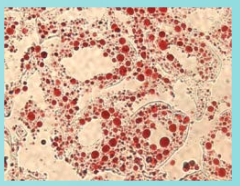
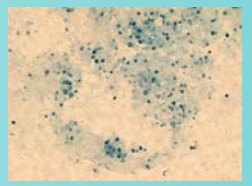
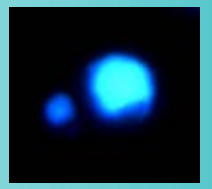
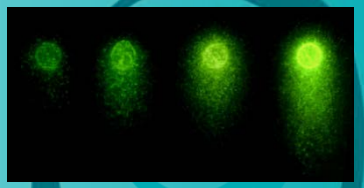
Flow chart and calculation of biomarkers HQ

Biomarkers

START

For each submitted sample

(1) Average, std dev, replicates

(2) Data accuracy control → no: MSG; yes

(3) $$VAR\%\_(i) = \left(1 - \frac{sample\ mean(i)}{control\ mean(i)}\right) \cdot 100$$

(4) Significance calculation and adjustment → Z(i)

(5) inhibition: $$Effect(i) = \frac{VAR\%\_(i)}{inhib\ threshold} \cdot Z(i)$$ | $VAR\%\_(i) = 0$: $Effect(i) = 0$ | induction: $$Effect(i) = \frac{-VAR\%\_(i)}{induct\ threshold} \cdot Z(i)$$

(6) $Effect_w(i) = Effect(i) * Weight(i)$

(7) Validation of minimum requirements

(8) **Class of hazard**

Effect(i)	< 1	→	A Absent
1 ≤ Effect(i)	< 1.5	→	B Slight
1.5 ≤ Effect(i)	< 2.5	→	C Moderate
2.5 ≤ Effect(i)	< 4	→	D Major
4 ≤ Effect(i)		→	E Severe

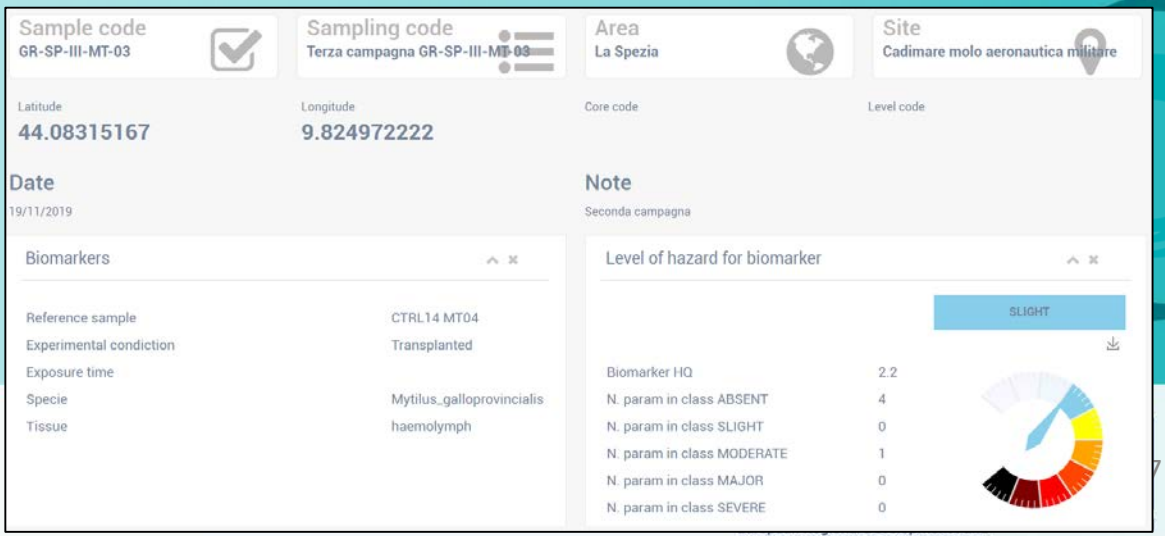
(9) $$HQ_{BM} = \left(\frac{\sum_{j=1}^{N} Effect_w(j)_{1.5<Effect(j)\leq 2.5}}{num\ biomarker_{1.5<Effect(j)\leq 2.5}} + \sum_{k=1}^{M} Effect_w(k)_{Effect(j)>2.5} \right)$$

(10) Class of hazard for biomarkers =
$(\%biomark_{Effect<1} \cdot 1) + (\%biomark_{1\geq Effect<1.5} \cdot 1.5) + (\%biomark_{1.5\geq Effect<2.5} \cdot 2.5)$
$+(\%biomark_{2.5\geq Effect<4} \cdot 4) + (\%biomark_{Effect\geq 4} \cdot 6)$

(11) **Class of hazard bioamarker**

< 100	→	Absent
≥ 100 to < 150	→	Slight
≥ 150 to < 250	→	Moderate
≥ 250 to < 400	→	Major
≥ 400 to ≤ 600	→	Severe

- For each biomarker, the variation is compared to Threshold, corrected for statistical significance and importance of biomarker (weight)
- Assignment of each biomarker response to 1 of 5 classes of effect
- Calculation and classification of cumulative HQ in a level of hazard according to % distribution of biomarkers in the 5 classes



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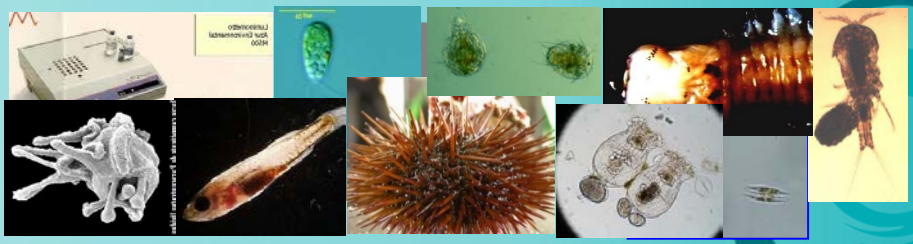
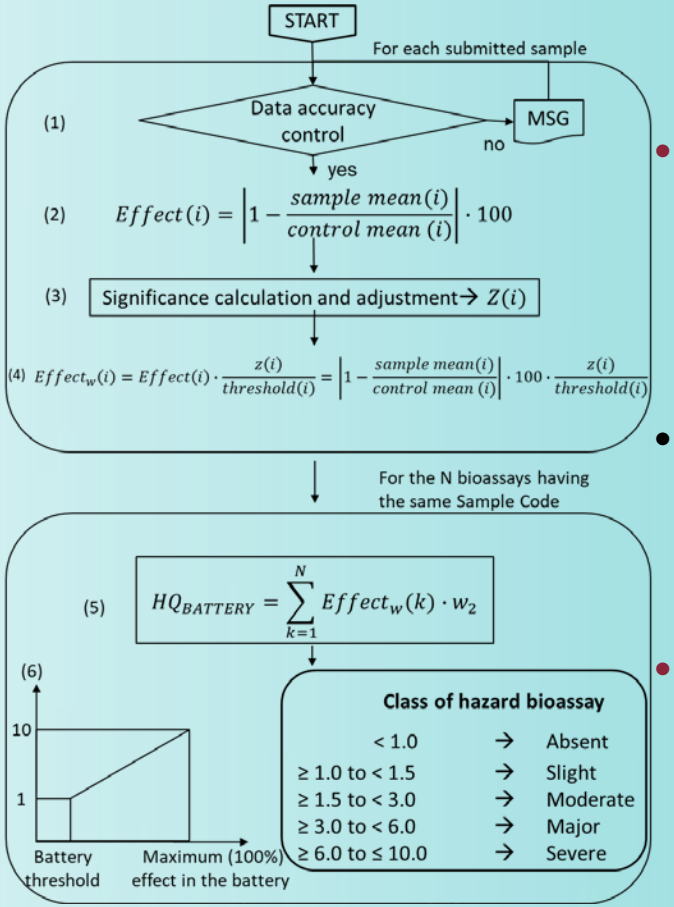
Flow chart and calculation of bioassays HQ



LOE 5 Bioassays



- Species
- Matrix
- Endpoint
- Experimental conditions

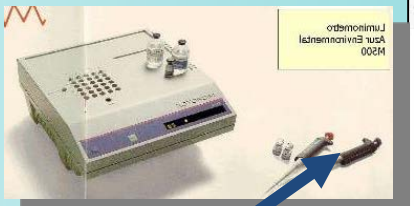
- **Each bioassay has a <u>Weight</u> depending on the biological endpoint, and a <u>Threshold</u> based on tested matrix, time of exposure, hormesis**
- **Variation of each bioassay is compared to its Threshold, corrected for the <u>statistical significance</u> and the <u>weight</u> of the assay**
- **A <u>cumulative HQ</u> for the battery is calculated by the summation of each effect vs the threshold of the battery**

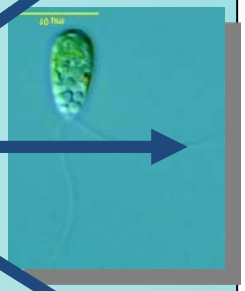
Output Module bioassays

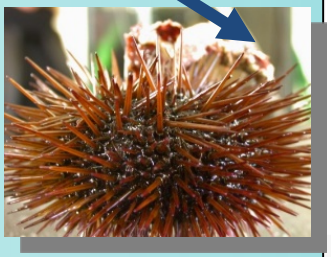
Bioassays

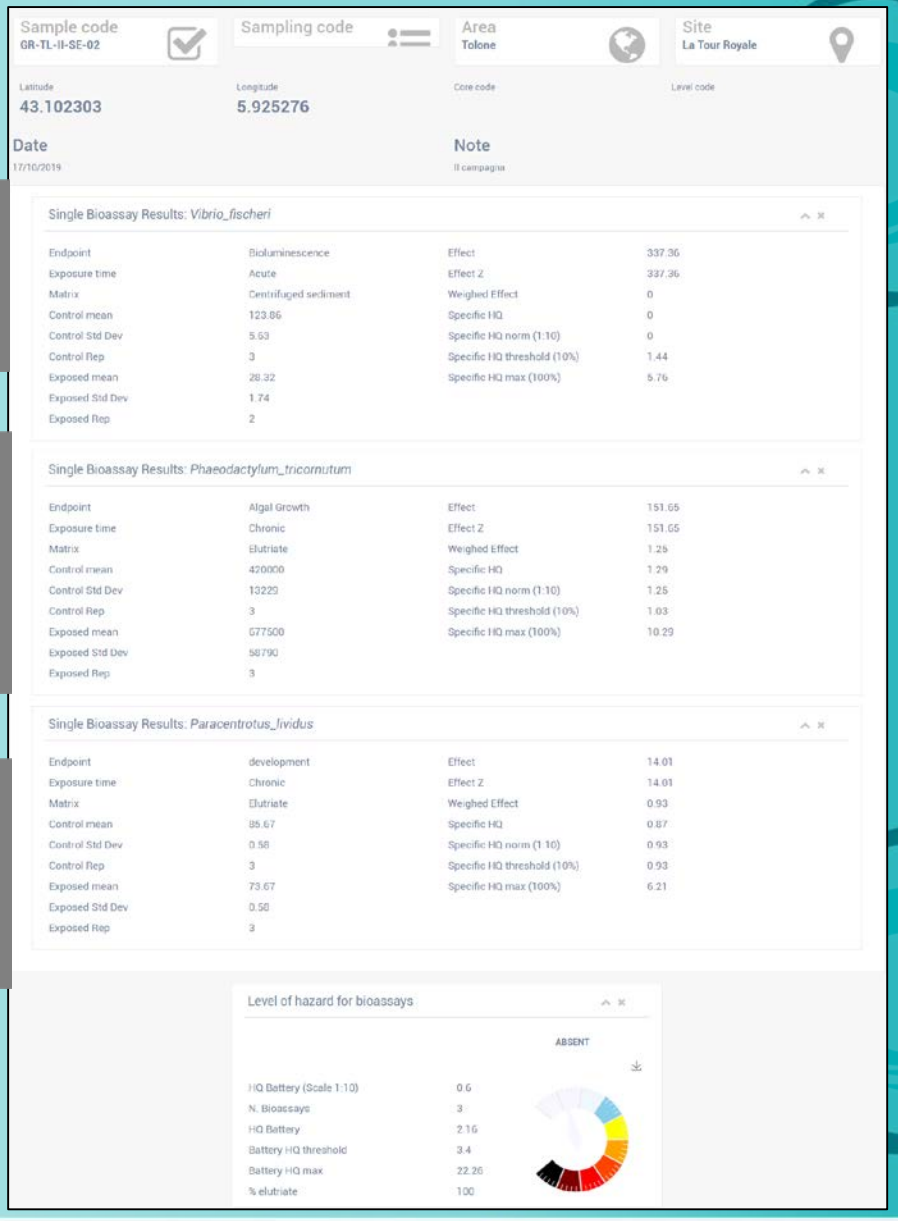
Single Bioassay Results

Level of hazard for bioassays



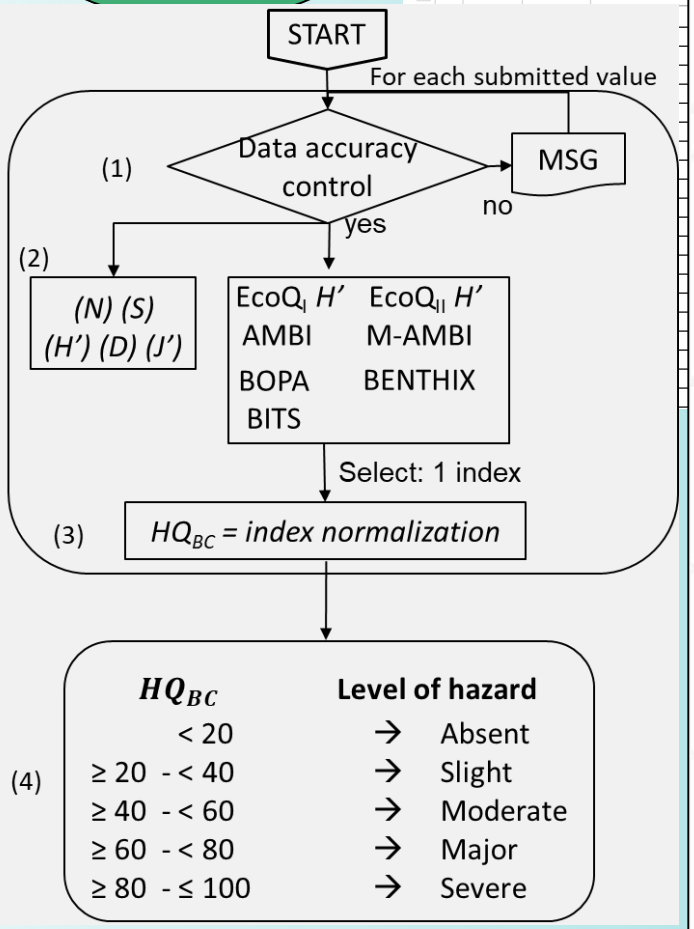


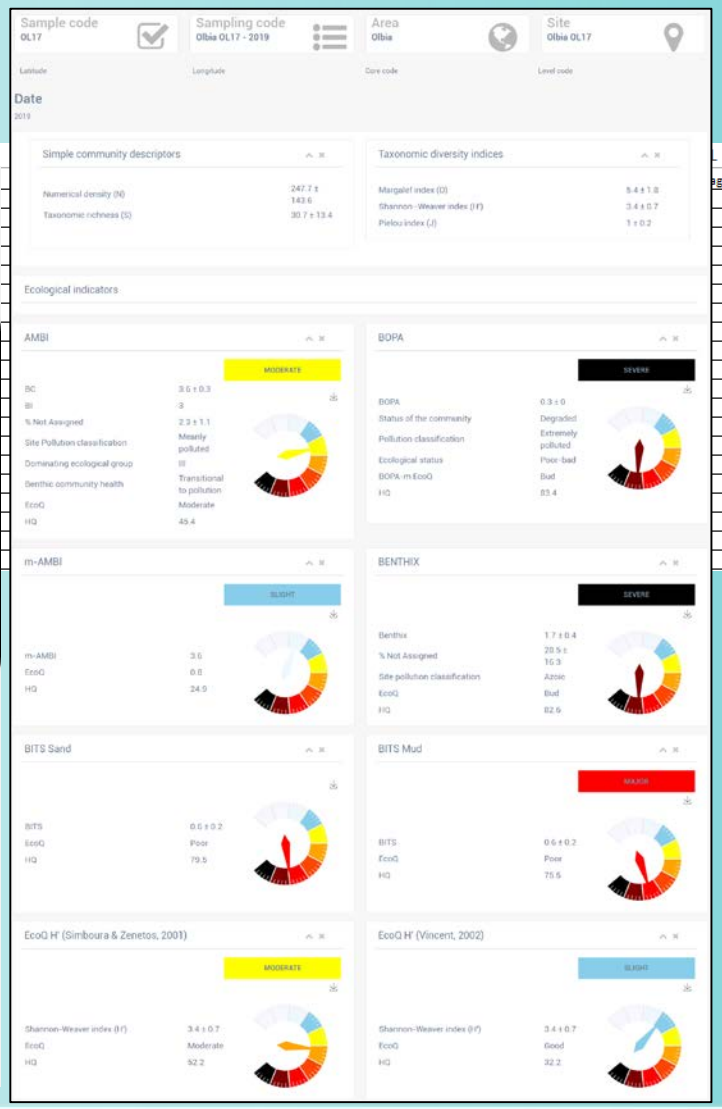




Example of elaboration and data output

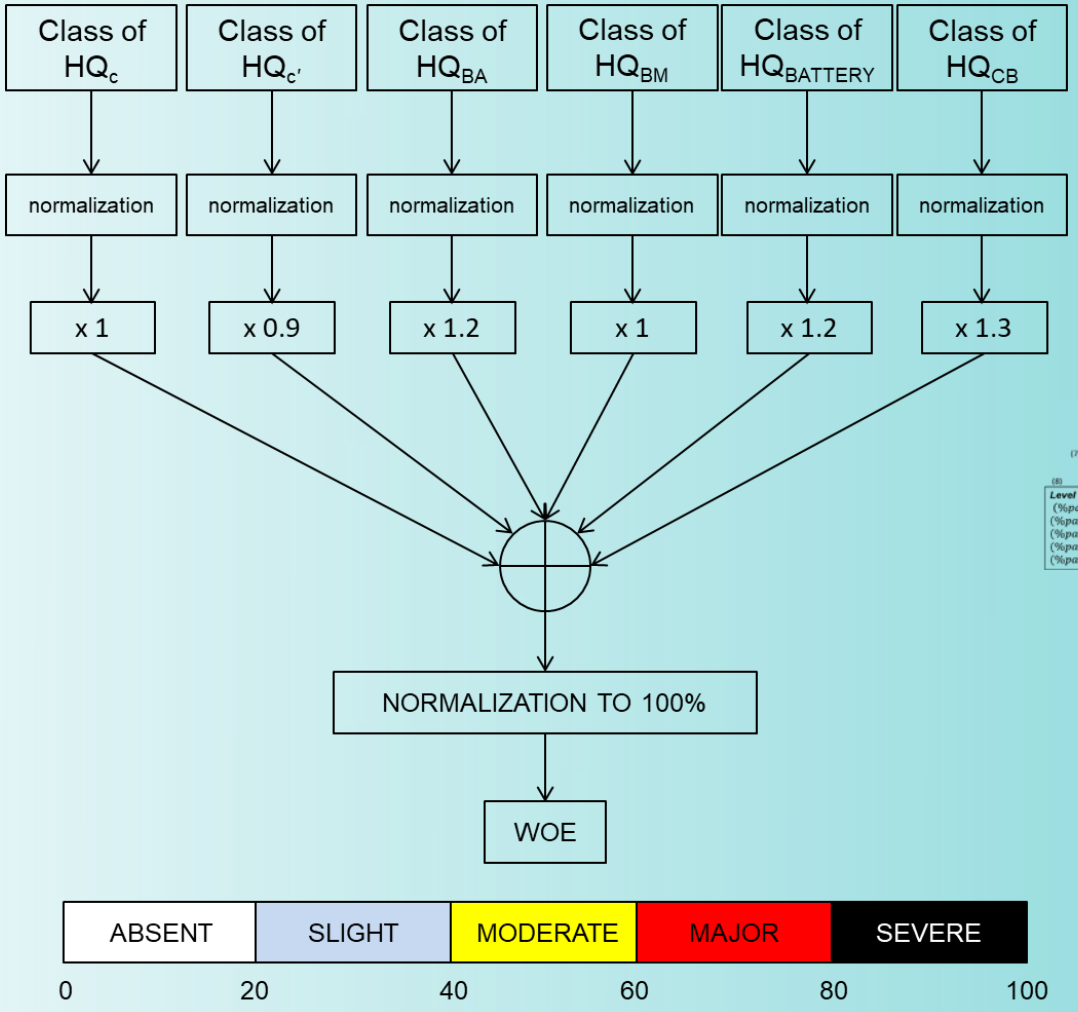
Benthic communities

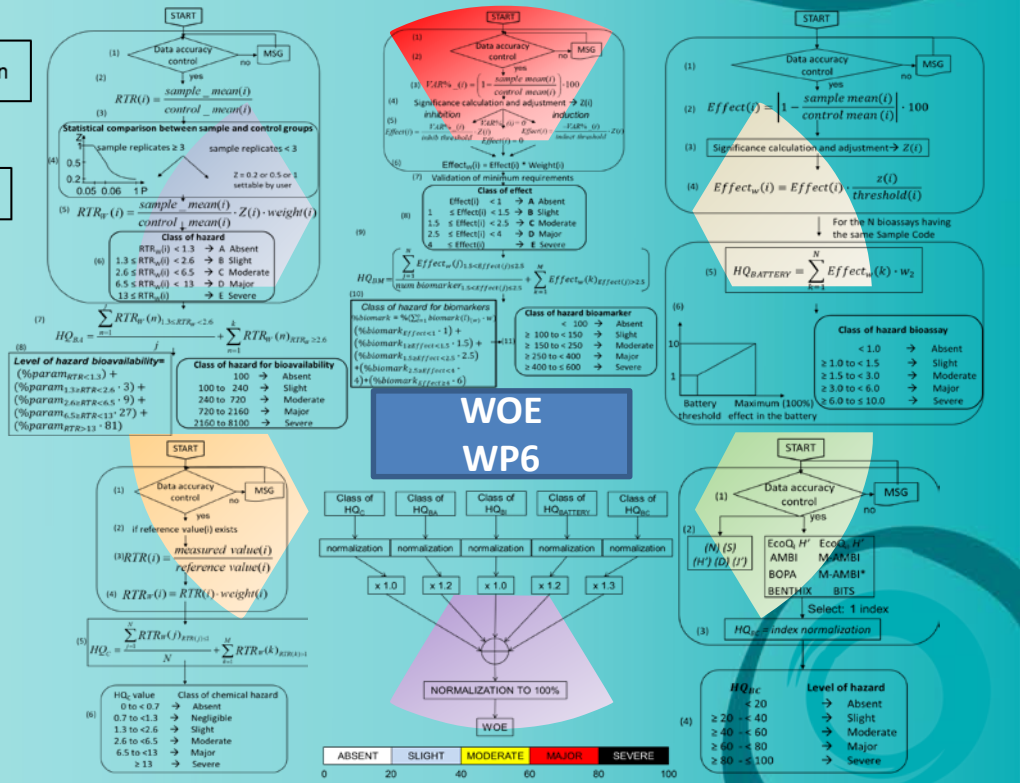




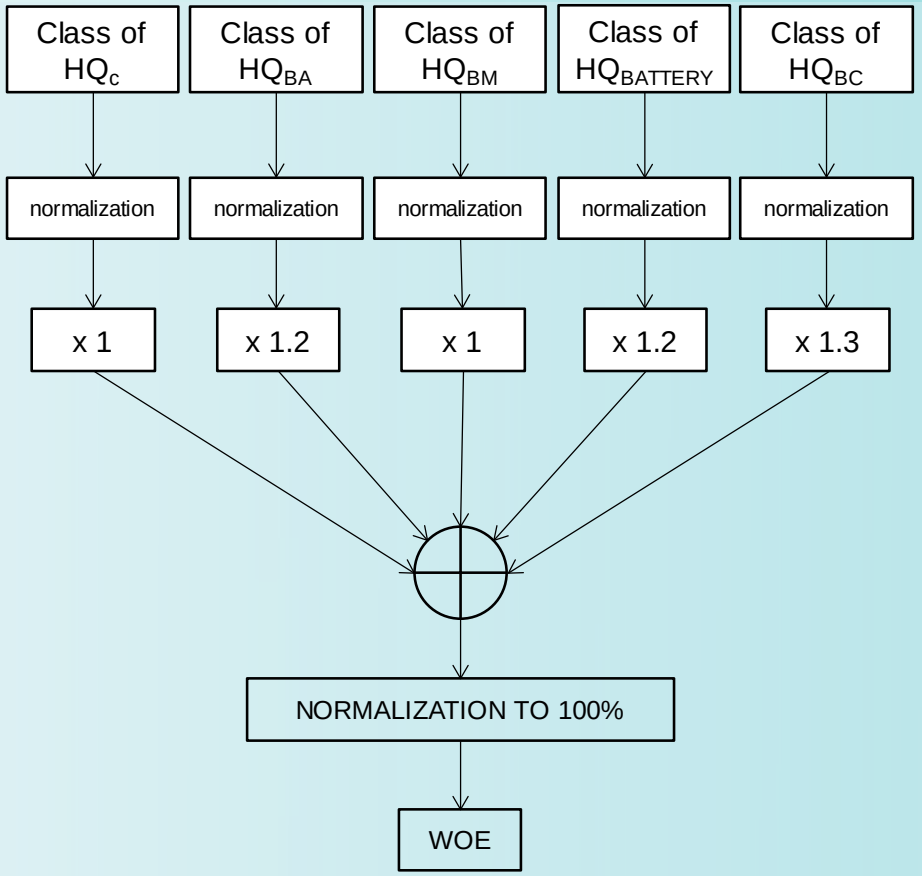
	M	N	O	P	Q	R
	Phylum	Class	Genus	Species	Family	abb
	Anellida	Polichaeta		Ampharete acutifrons	Ampharetidae	17,2
	Anellida	Polichaeta		Aricidea albatrossae	Paraonidae	17,2
	Anellida	Polichaeta		Cirratulus sp.	Cirratulidae	17,2
	Anellida	Polichaeta		Glycera sp.	Glyceridae	17,2
	Anellida	Polichaeta		Hesionidae	Hesionidae	17,2
	Anellida	Polichaeta		Levinsenia sp.	Paraonidae	120,7
	Anellida	Polichaeta		Marphysa bellii	Eunicidae	17,2
	Anellida	Polichaeta		Notomastus latericeus	Capitellidae	17,2
	Anellida	Polichaeta		Orbinia sp.	Orbiniidae	51,7
	Anellida	Polichaeta		Paralacydonia paradoxa	Paralacydoniidae	17,2
	Antropoda	Crustacea	Ostracoda	Ostracoda		17,2
	Antropoda	Crustacea	Tainadacea	Leptochelia savignyi	Leptocheliidae	17,2
	Echinodermata	Holoturidea		Myriotrochus sp.	Myriotrochidae	17,2
	Mollusca	Bivalvia		Parvicardium minimum	Cardiidae	17,2
	Mollusca			Dosinia lupinus	Veneridae	17,2
	Mollusca			Loripes lacteus	Lucinidae	34,5
	Mollusca			Mysella bidentata	Montacutidae	17,2
	Mollusca			Kellia suborbicularis	Kelliidae	17,2
	Nematoda			Nematoda		137,9
	Prialupida			Priapulus sp.	Priapulidae	34,5

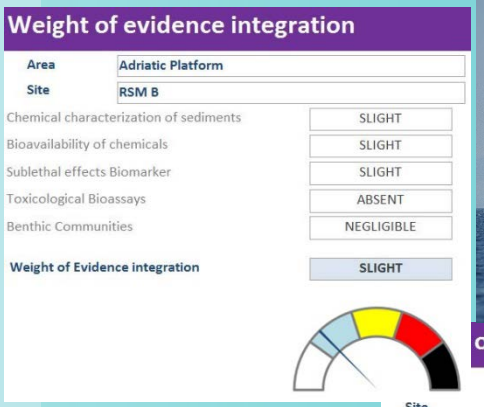
Integration of various LOEs into WOE and class of Risk

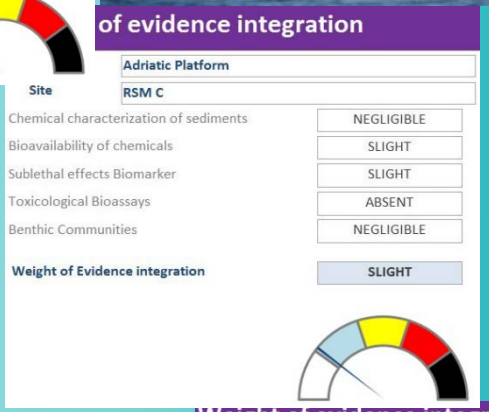


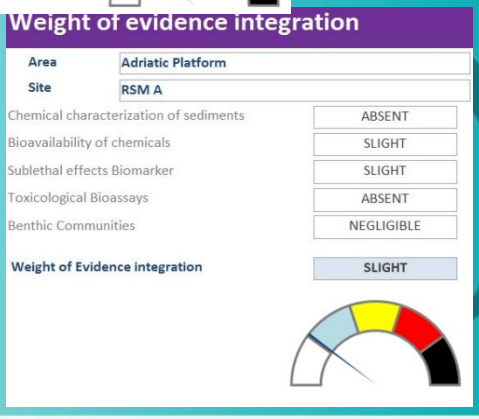


WOE for monitoring complex scenarios









Almost 7.000 analyses to interpret….and summarize!

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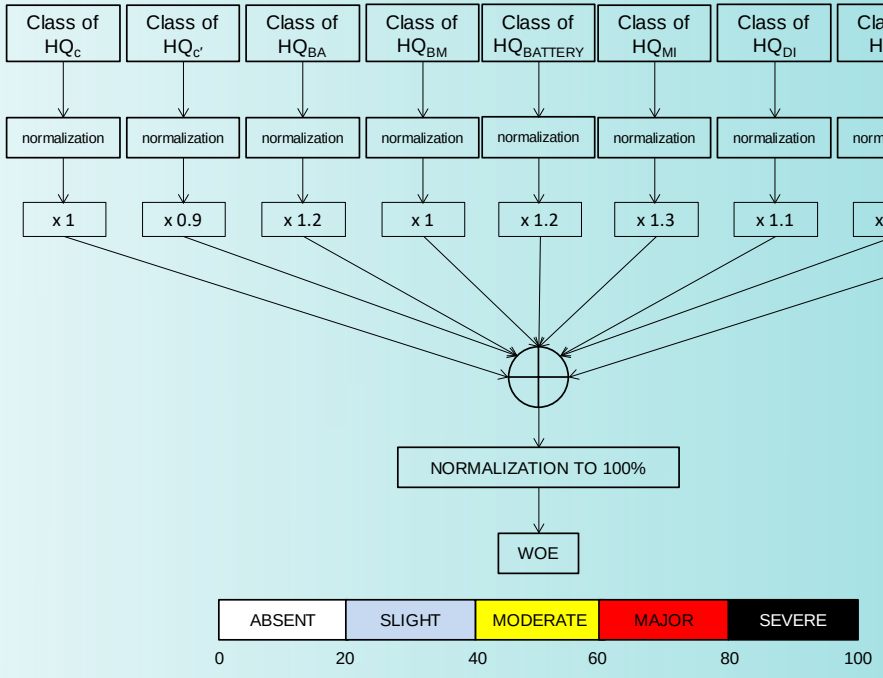
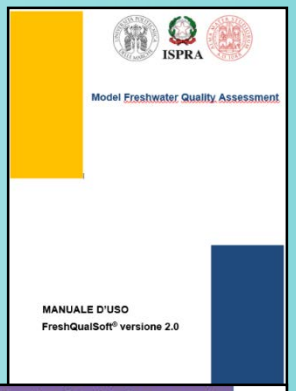
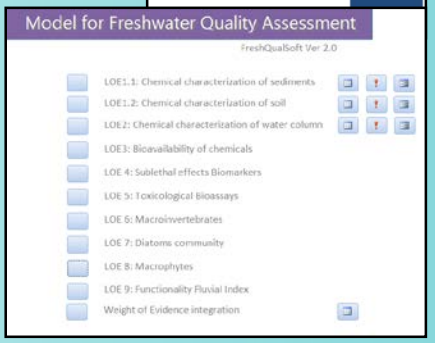
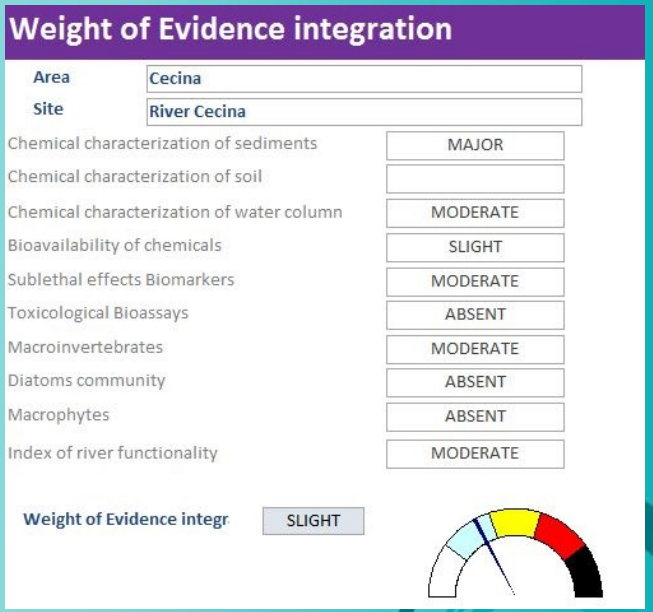
Validation of Weight of Evidence (WOE) model for freshwater environments









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frontiers in Marine Science

ORIGINAL RESEARCH
published: 15 November 2019
doi: 10.3389/fmars.2019.00688

Mussel Caging and the Weight of Evidence Approach in the Assessment of Chemical Contamination in Coastal Waters of Finland (Baltic Sea)

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TABLE 3 | Elaborations with levels of hazard assigned to the different LOEs and the final WOE.

Site	Chemical characterization	Bioavailability	Biomarkers	Benthic communities	Near-bottom oxygen	Eutrophication	Weight of Evidence integration
Kotka	HQ: 0.284 Absent -	HQ: 63.417 Major BaP–DBahA–BkF; PER	HQ: 4.229 Moderate CAT-GST	HQ: 67.174 Major	Absent	Major	MODERATE
Porvoo	HQ: 0.311 Absent -	HQ: 63.030 Major ANT–FLU; PER	HQ: 4.642 Moderate GST-LPO-CAT; GR	HQ: 46.078 Moderate	Slight	Major	MODERATE
Helsinki	HQ: 2.271 Slight 100% Zn	HQ: 14.842 Slight -;-	HQ: 2.517 Moderate -; GST	HQ: 31.326 Slight	Absent	Major	SLIGHT
Hanko	HQ: 0.28 Absent -	HQ: 29.925 Moderate -; 1-MetNAPH	HQ: 2.714 Moderate GR-GST; -	HQ: 46.377 Moderate	Absent	Moderate	SLIGHT
Parainen	HQ: 1.7 Slight 100% Zn	HQ: 59.329 Major BbF–BaP; PER	HQ: 2.008 Slight LPO;-	HQ: 48.291 Moderate	Absent	Major	MODERATE
Naantali	HQ: 2.829 Moderate 100% Zn	HQ: 80.710 Major FLU; PER–OSn	HQ: 2.402 Moderate GST-CAT; -	HQ: 49.020 Moderate	Absent	Major	MODERATE
Uusikaupunki	HQ: 1.566 Slight 100% Zn	HQ: 1.985 Slight -;-	HQ:2.42 Moderate CAT-GST; -	HQ: 9.520 Absent	Slight	Moderate	SLIGHT
Rauma	HQ: 6.18 Moderate 81.5% Zn	HQ: 64.589 Major -; PER–BaP	HQ: 2.125 Slight CAT; -	HQ: 33.676 Slight	Absent	Moderate	MODERATE
Pori	HQ: 0.293 Absent -	HQ: 0 Absent -;-	HQ: 0 Absent -;-	HQ: 50.986 Moderate	Absent	Slight	SLIGHT
Vaasa	HQ: 2.199 Slight 100% Zn	HQ: 4.296 Slight -;-	HQ: 1.0 Slight -;-	HQ: 59.938 Moderate	Absent	Slight	SLIGHT

Hazard Quotient (HQ) is provided for chemical characterization of seawater (showing the percentage of the parameter contributing most to the HQ), bioavailability (parameters showing major or severe effects), biomarkers (parameters showing moderate or major effects), and benthic communities

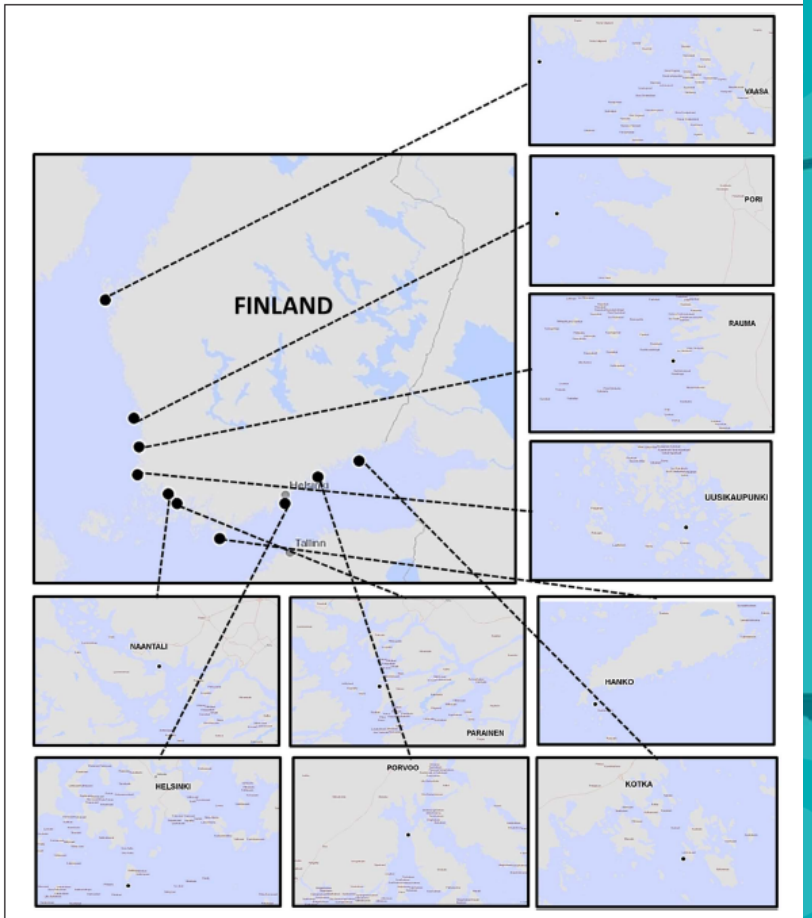

FIGURE 1 | Study sites along the coast of Finland. The black dot in each site map represent the exact site of the mussel cage.

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