



Interreg
Atlantic Area
European Regional Development Fund



MONITOOL PROJECT

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

Francesco Regoli (Università Politecnica
delle Marche)



David Pellegrini (ISPRA Livorno)



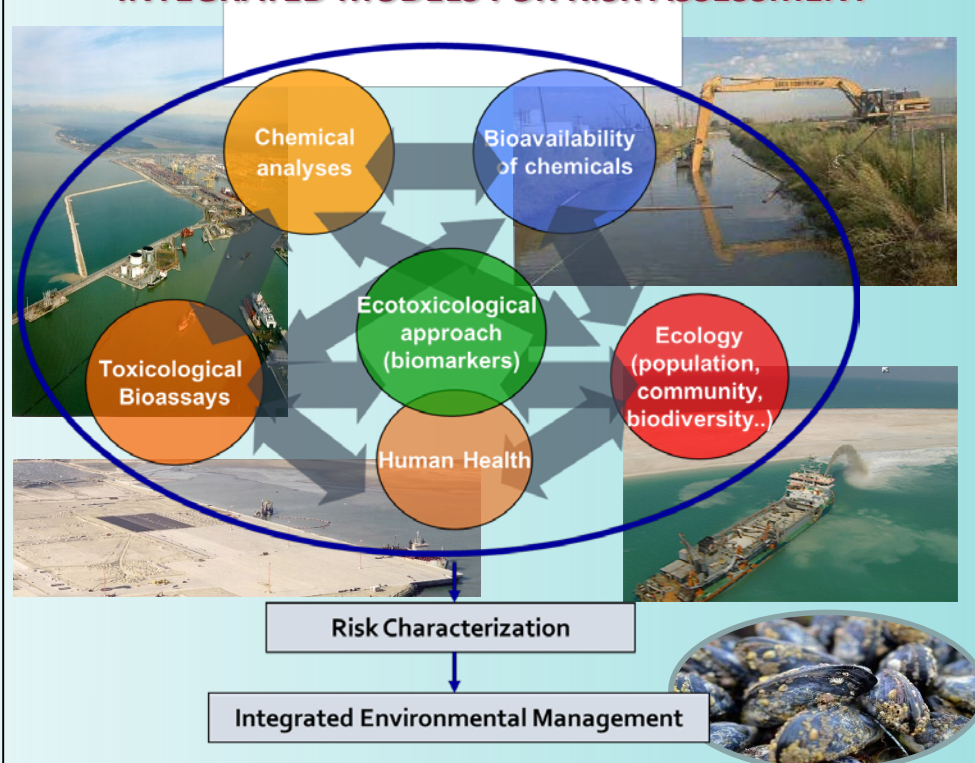
ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale



MONITOOL
new tools for water quality monitoring

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

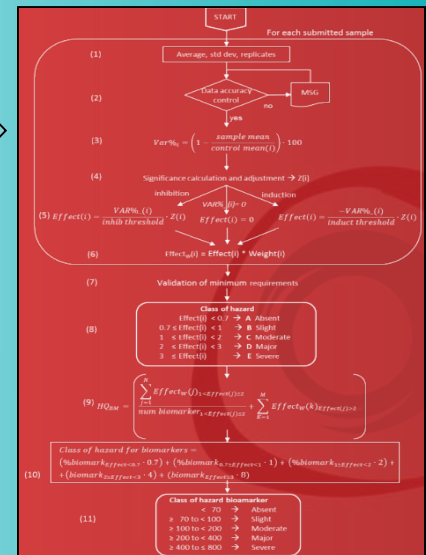
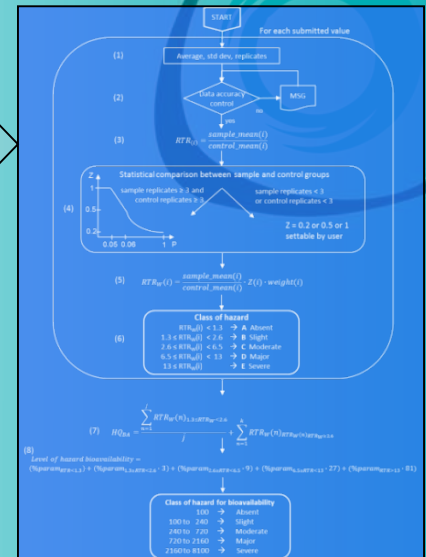
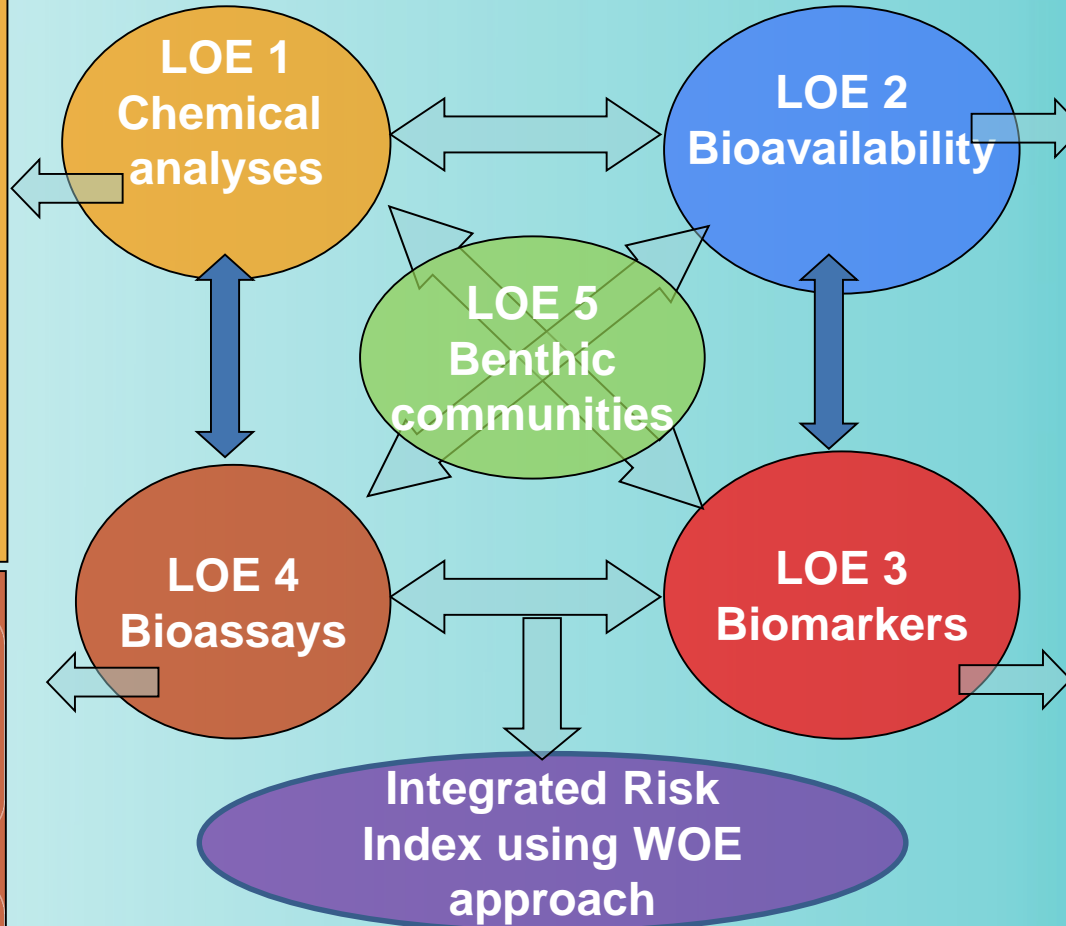
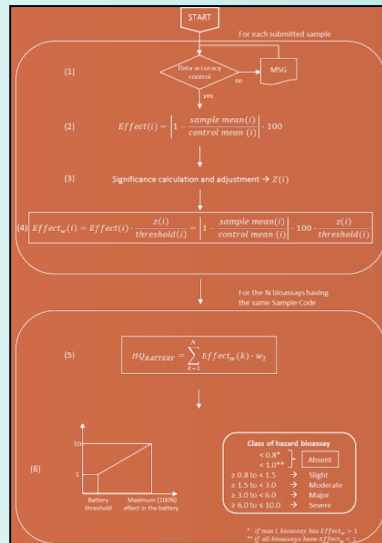
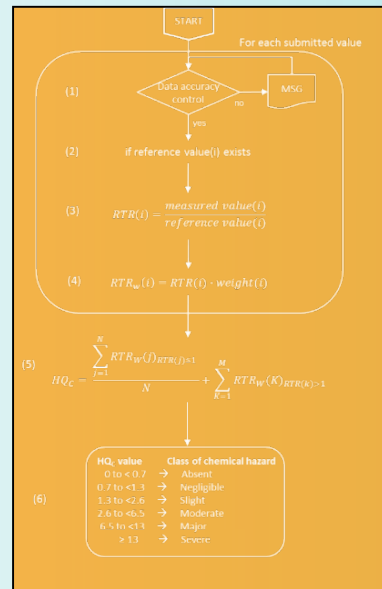
INTEGRATED MODELS FOR RISK ASSESSMENT



CRITICAL ISSUES IN RISK ASSESSMENT

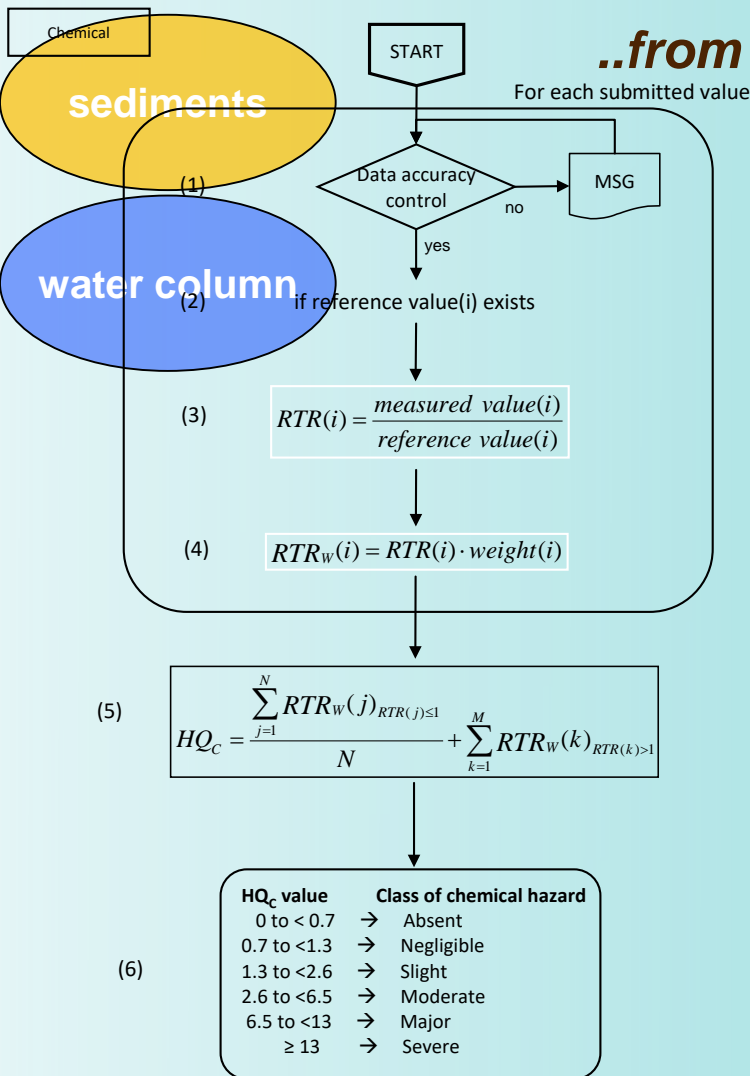
- Interpretation and significance of complex datasets of heterogeneous results
- Qualitative and quantitative evaluations: indices and scales development
- Integration of different typologies of data
- Synthetic risk characterization/communication

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



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
1	8.922483	Genova	Diga foranea imboccatura levante	13/12/2018	GR-GE-I-SE-01			GR-GE-I-SE-01	8.78078			0.74035	
2	8.919	Genova	Porto antico	13/12/2018	GR-GE-I-SE-02			GR-GE-I-SE-02	5.6096			0.34246	
3	8.875117	Genova	Foce Polcevera	13/12/2018	GR-GE-I-SE-03			GR-GE-I-SE-03	10.4238			0.46893	
4	8.933853	Genova	Diga foranea imboccatura levante	16/05/2019	GR-GE-II-SE-01			GR-GE-II-SE-01	8.03118			0.43679	
5	8.921642	Genova	Porto antico	16/05/2019	GR-GE-II-SE-02			GR-GE-II-SE-02	13.9585			0.40952	
6	8.874175	Genova	Foce Polcevera	16/05/2019	GR-GE-II-SE-03			GR-GE-II-SE-03	5.45135			0.37115	
7	9.849547	La Spezia	Molo Fornelli	20/11/2017	MF1			MF1					
8	9.849579	La Spezia	Molo Fornelli	20/11/2017	MF2			MF2					
9	9.849583	La Spezia	Molo Fornelli	20/11/2017	MF3			MF3					
10	9.849546	La Spezia	Molo Fornelli	20/11/2017	MF4			MF4					
11	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	
12													

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**

Sample code

GR-OL-I-SE-01

Sampling code

GR-OL-I-SE-01

Area

Banchina Isola Bianca

Site

Olbia

Latitude

40.924105

Longitude

9.525128

Core code

Level code

Date

26/06/2018

Note

Prima campagna

L1 (D.Lgs. 173/16)

Level of chemical hazard

NEGOTIABLE

Chemical HQ

1.29

Max % contr. to HQ

100% - Zn

N. exceeding param

1

N. param with refer

34

N. analysed param

54

L2 (D.Lgs. 173/16)

Level of chemical hazard

ABSENT

Chemical HQ

0.09

Max % contr. to HQ

0% -

N. exceeding param

0

N. param with refer

26

N. analysed param

54

**NORMATIVES AND SEDIMENT QUALITY GUIDELINES
EASY TO UPDATE WITH OTHER REFERENCES**

Sample code

GR-OL-I-SE-01

Sampling code

GR-OL-I-SE-01

Area

Banchina Isola Bianca

Site

Olbia

Latitude

40.924105

Longitude

9.525128

Core code

Level code

Date

26/06/2018

Note

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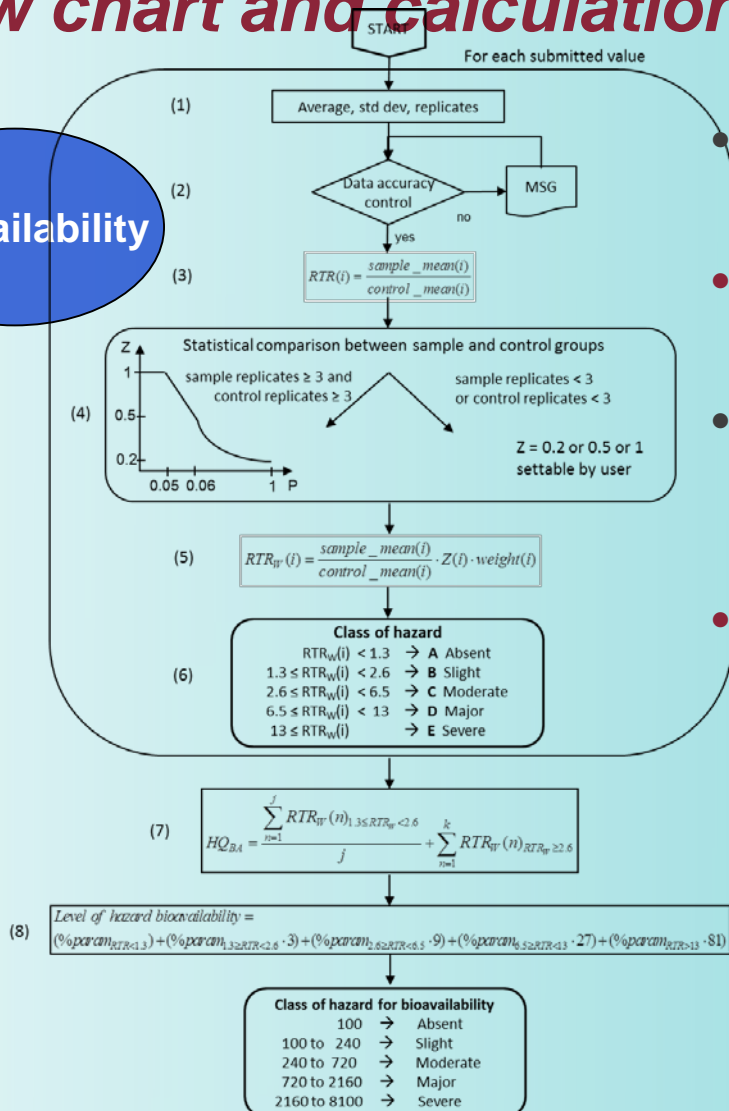
54

Level of chemical hazard

ABSENT

Flow chart and calculation of bioavailability HQ

Bioavailability



Calculation for each analyte of increased concentration, corrected for weight and statistical significance (RTRw)

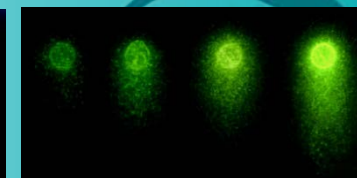
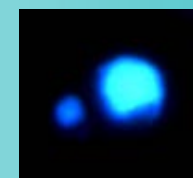
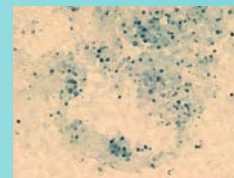
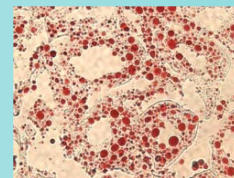
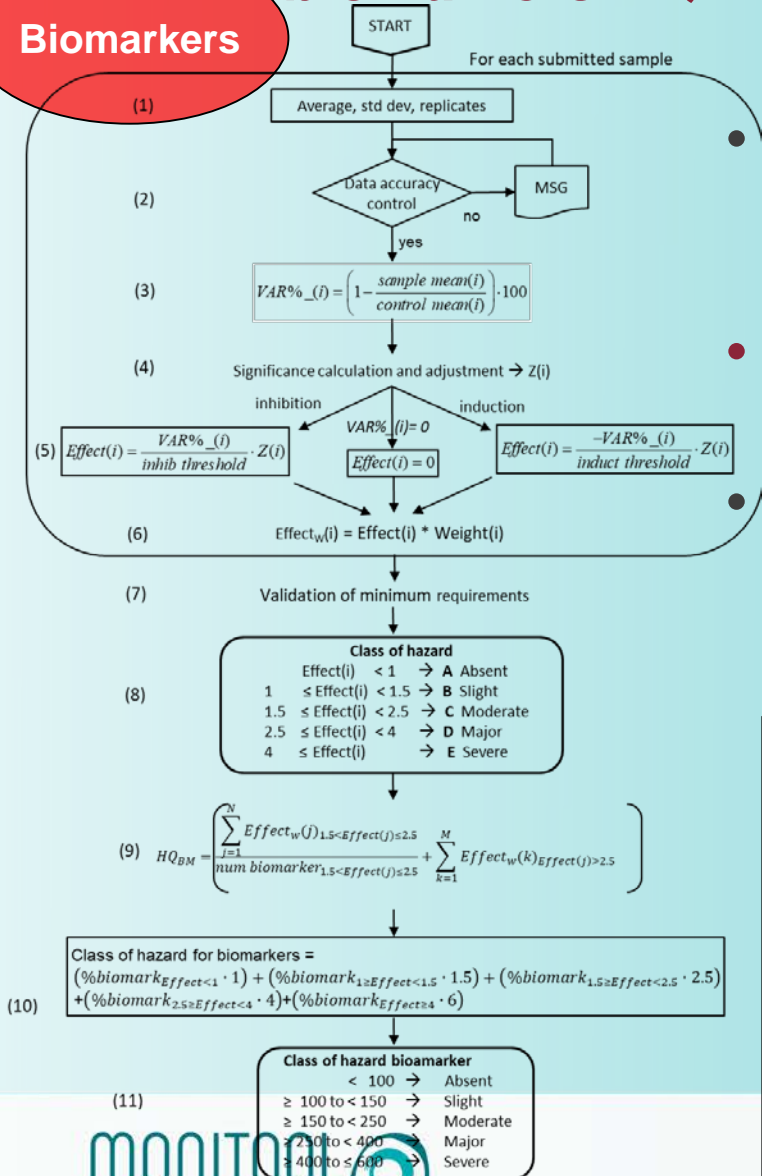
- Assignment of each parameter to 1 of 5 classes of effect (absent, slight, moderate, major, severe)
- The cumulative HQ differently weights these parameters according to the entity of variation (is not an average)
- Level of cumulative HQ is summarized by the % distribution of parameters in the classes of effect

Sample code GR-OL-I-MT-01	<input checked="" type="checkbox"/>	Sampling code I campagna GR-OL-I-MT-01	Area Olbia	Site Banchina Isola Bianca
Latitude 40.925851	Longitude 9.531496	Core code	Level code	
Date 26/07/2018	Note Banchina Isola Bianca			
Bioavailability				
Reference area	Olbia			
Reference site	Banchina Isola Bianca			
Experimental condition	Transplanted			
Exposure time				
Specie	Mytilus galloprovincialis			
Tissue	Whole tissues			
Level of hazard for bioavailability				
SLIGHT				
Bioavailability HQ	6.12			
N. param in class ABSENT	36			
N. param in class SLIGHT	6			
N. param in class MODERATE	1			
N. param in class MAJOR	0			
N. param in class SEVERE	0			



Flow chart and calculation of biomarkers HQ

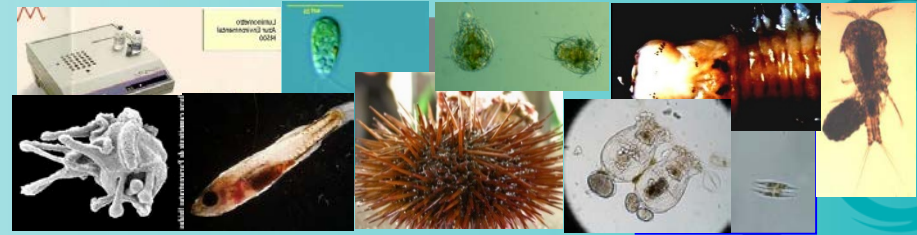
Biomarkers



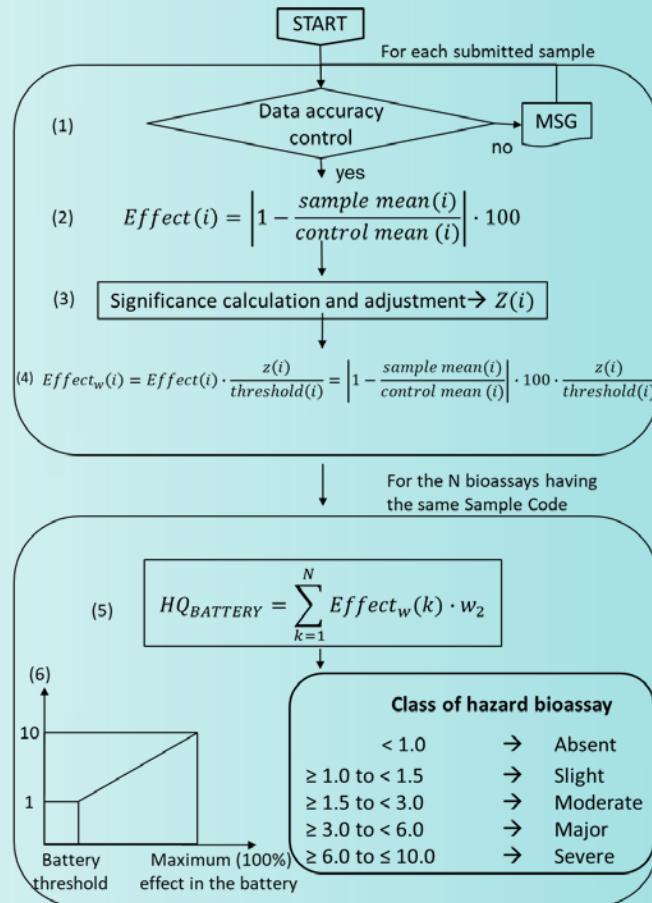
- For each biomarker, the variation is compared to Threshold, corrected for statistical significance and importance of biomarker (weight)
- Assignment of each biomarker response to 1 of 5 classes of effect
- Calculation and classification of cumulative HQ in a level of hazard according to % distribution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

Sample code GR-SP-III-MT-03	<input checked="" type="checkbox"/>	Sampling code Terza campagna GR-SP-III-MT-03	Area La Spezia	Site Cadimare molo aeronautica militare
Latitude 44.08315167	Longitude 9.824972222	Core code	Level code	
Date 19/11/2019				
Note Seconda campagna				
Biomarkers				
Reference sample	CTRL14 MT04			
Experimental condition	Transplanted			
Exposure time				
Specie	Mytilus galloprovincialis			
Tissue	haemolymph			
Level of hazard for biomarker				
Slight				
Biomarker HQ N. param in class ABSENT N. param in class SLIGHT N. param in class MODERATE N. param in class MAJOR N. param in class SEVERE	2.2 4 0 1 0 0			

Flow chart and calculation of bioassays HQ



LOE 5 Bioassays



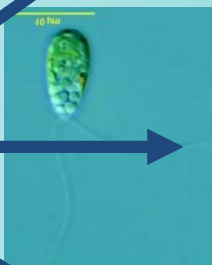
- Each bioassay has a Weight depending on the biological endpoint, and a Threshold based on tested matrix, time of exposure, hormesis
- Variation of each bioassay is compared to its Threshold, corrected for the statistical significance and the weight of the assay
- A cumulative HQ for the battery is 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



Sample code GR-TL-II-SE-02	<input checked="" type="checkbox"/>	Sampling code	Area Tolone	Site La Tour Royale
Latitude 43.102303		Longitude 5.925276	Core code	Level code
Date 17/10/2019		Note II campagne		

Single Bioassay Results: <i>Vibrio_fischeri</i>			
Endpoint	Bioluminescence	Effect	337.36
Exposure time	Acute	Effect Z	337.36
Matrix	Centrifuged sediment	Weighted Effect	0
Control mean	123.86	Specific HQ	0
Control Std Dev	5.63	Specific HQ norm (1:10)	0
Control Rep	3	Specific HQ threshold (10%)	1.44
Exposed mean	28.32	Specific HQ max (100%)	5.76
Exposed Std Dev	1.74		
Exposed Rep	2		

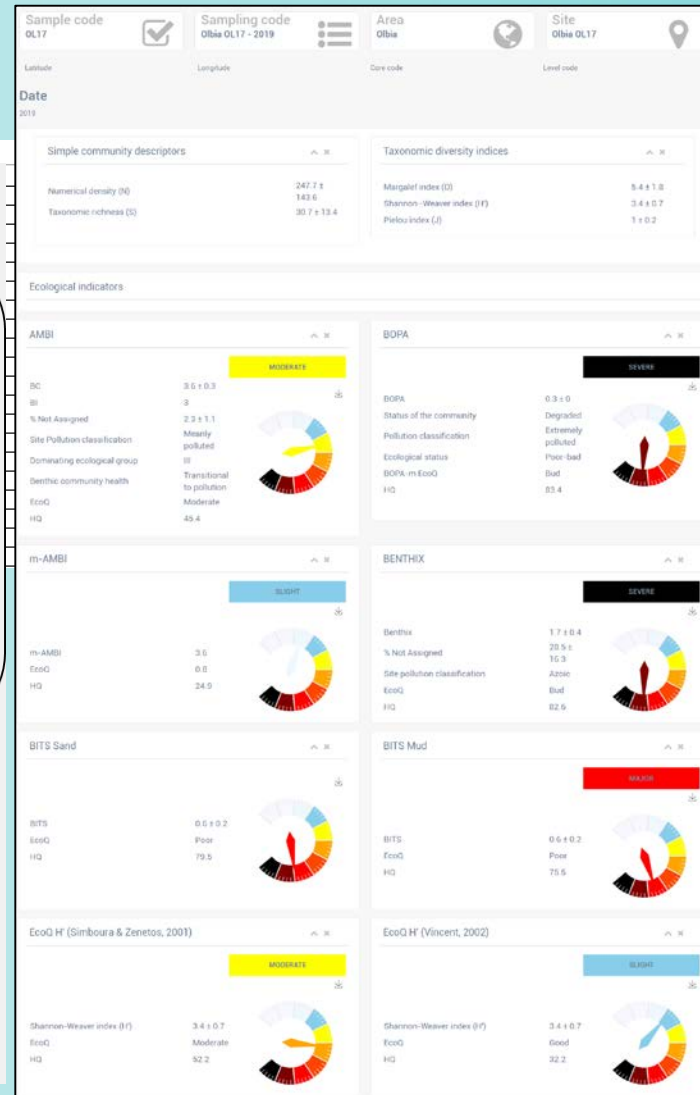
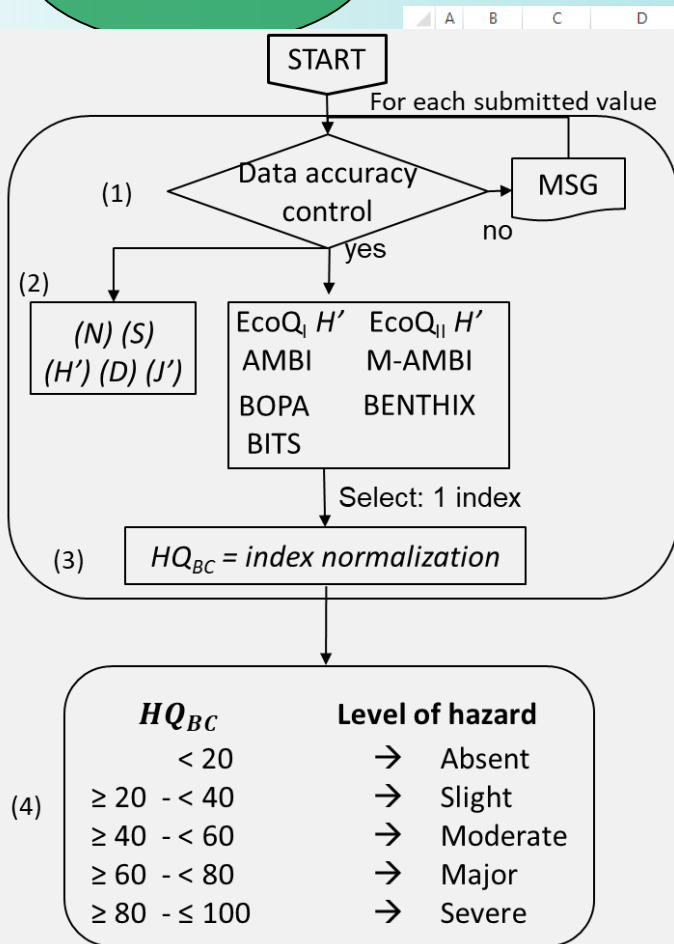
Single Bioassay Results: <i>Phaeodactylum_tricornutum</i>			
Endpoint	Algal Growth	Effect	151.65
Exposure time	Chronic	Effect Z	151.65
Matrix	Elutriate	Weighted Effect	1.25
Control mean	420000	Specific HQ	1.29
Control Std Dev	13229	Specific HQ norm (1:10)	1.25
Control Rep	3	Specific HQ threshold (10%)	1.03
Exposed mean	677500	Specific HQ max (100%)	10.29
Exposed Std Dev	58790		
Exposed Rep	3		

Single Bioassay Results: <i>Paracentrotus_lividus</i>			
Endpoint	development	Effect	14.01
Exposure time	Chronic	Effect Z	14.01
Matrix	Elutriate	Weighted Effect	0.93
Control mean	85.67	Specific HQ	0.87
Control Std Dev	0.58	Specific HQ norm (1:10)	0.93
Control Rep	3	Specific HQ threshold (10%)	0.93
Exposed mean	73.67	Specific HQ max (100%)	6.21
Exposed Std Dev	0.50		
Exposed Rep	3		

Level of hazard for bioassays	
HQ Battery (Scale 1:10)	0.6
N. Bioassays	3
HQ Battery	2.16
Battery HQ threshold	3.4
Battery HQ max	22.26
% elutriate	100

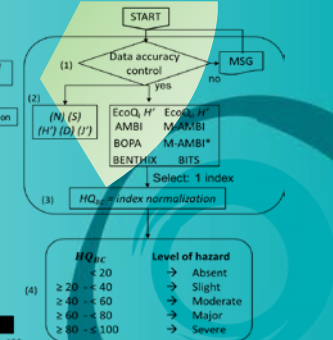
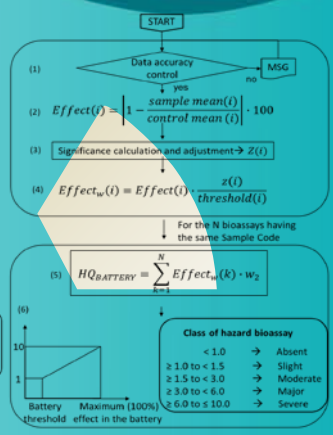
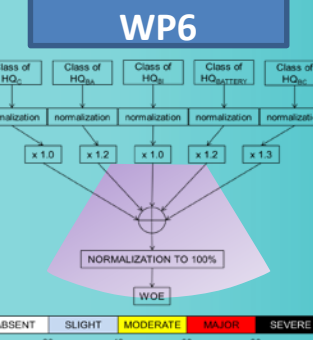
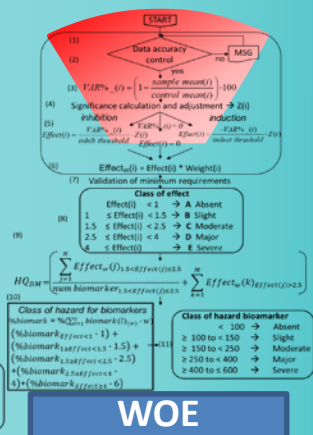
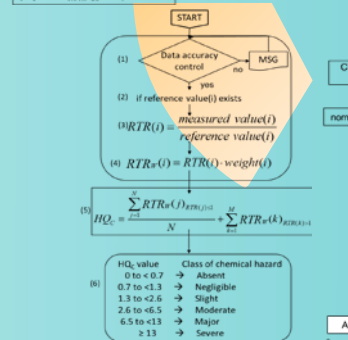
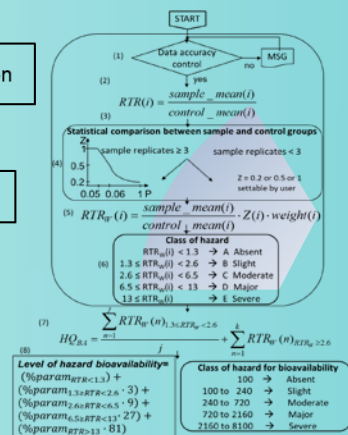
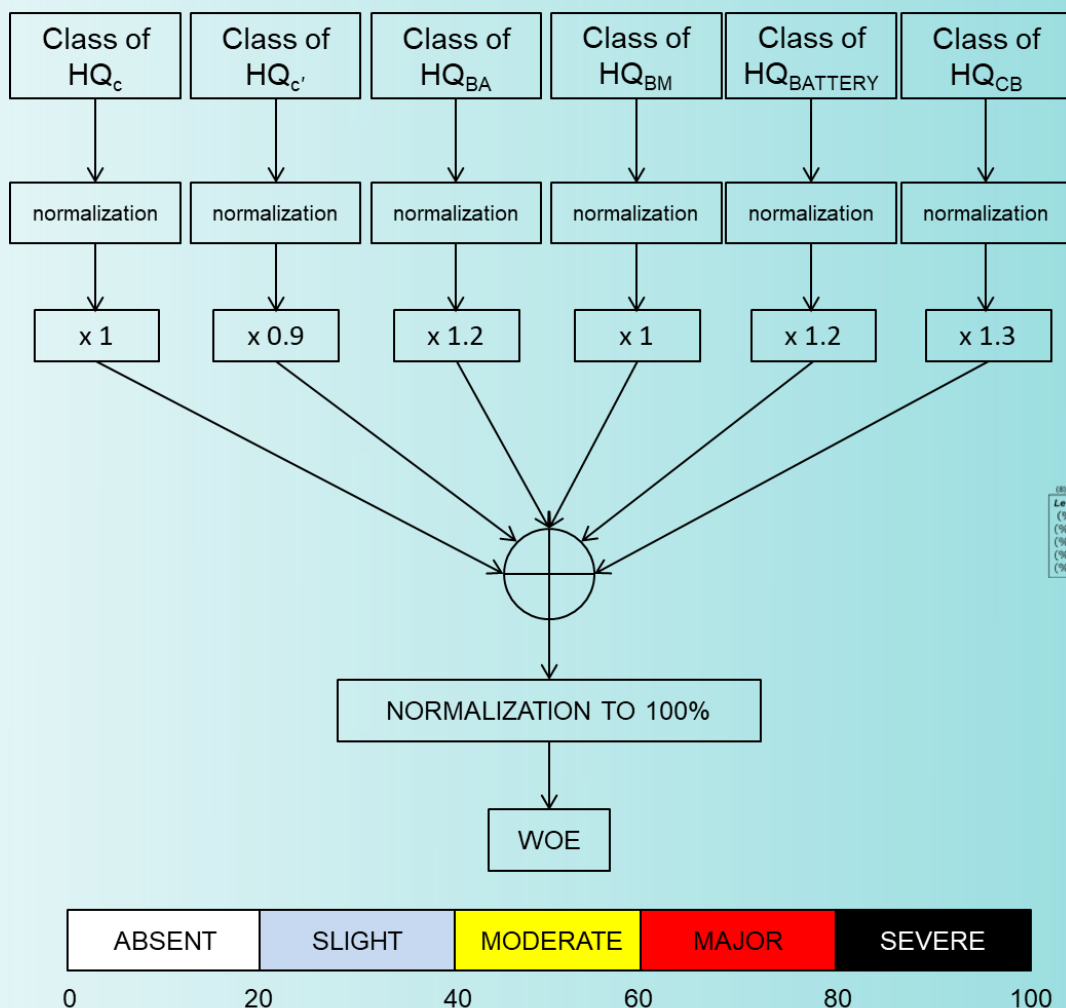
Example of elaboration and data output

Benthic communities

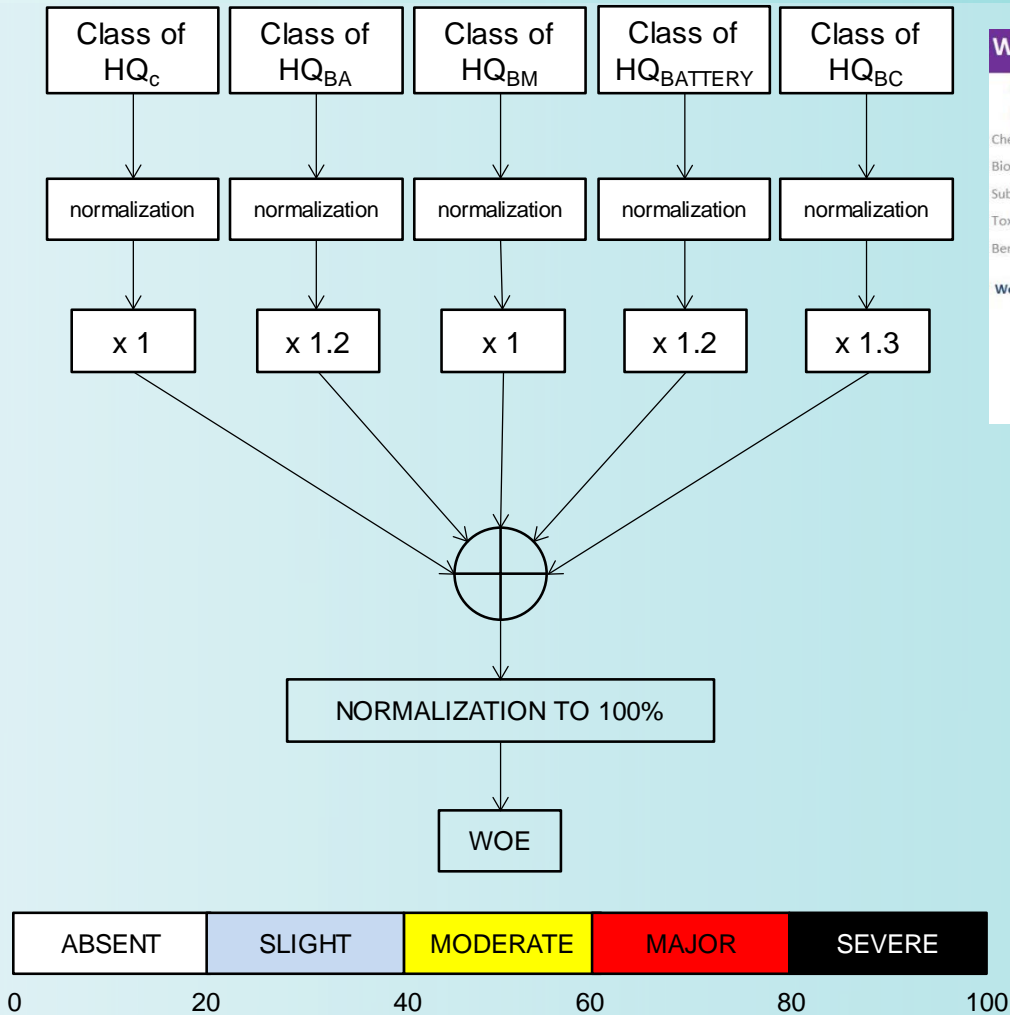


	M	N	O	P	Q	R
Phylum	Class	Genus	Species	Family	abb	
Anellida	Polichaeta		Ampharete acutifrons	Ampharetidae		17,2
Anellida	Polichaeta		Aricidea albatrossae	Paraonidae		17,2
Anellida	Polichaeta		Cirratulus sp.	Cirratulidae		17,2
Anellida	Polichaeta		Glycera sp.	Glyceridae		17,2
Anellida	Polichaeta		Hesionidae	Hesionidae		17,2
Anellida	Polichaeta		Levinsonia sp.	Paraonidae		120,7
Anellida	Polichaeta		Marphysa bellii	Eunicidae		17,2
Anellida	Polichaeta		Notomastus latericeus	Capitellidae		17,2
Anellida	Polichaeta		Orbinia sp.	Orbinidae		51,7
Anellida	Polichaeta		Paralacydonia paradoxa	Paralacydoniidae		17,2
Antropoda	Crustacea	Ostracoda	Ostracoda			17,2
Antropoda	Crustacea	Tainadacea	Leptochelia savignyi	Leptocheliidae		17,2
Echinodermata	Holothuridea		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			Myssella bidentata	Montacutidae		17,2
Mollusca			Kellia suborbicularis	Kelliidae		17,2
Nematoda			Nematoda			137,9
Priapulida			Priapulid sp.	Priapulidae		34,5

Integration of various LOEs into WOE and class of Risk



WOE for monitoring complex scenarios



Weight of evidence integration

Area: Adriatic Platform
Site: RSM B

Chemical characterization of sediments: SLIGHT
Bioavailability of chemicals: SLIGHT
Sublethal effects Biomarker: SLIGHT
Toxicological Bioassays: ABSENT
Benthic Communities: NEGLIGIBLE

Weight of Evidence integration: SLIGHT



Weight of evidence integration

Area: Adriatic Platform
Site: RSM C

Chemical characterization of sediments: NEGLIGIBLE
Bioavailability of chemicals: SLIGHT
Sublethal effects Biomarker: SLIGHT
Toxicological Bioassays: ABSENT
Benthic Communities: NEGLIGIBLE

Weight of Evidence integration: SLIGHT

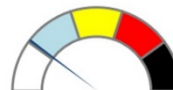


Weight of evidence integration

Area: Adriatic Platform
Site: RSM A

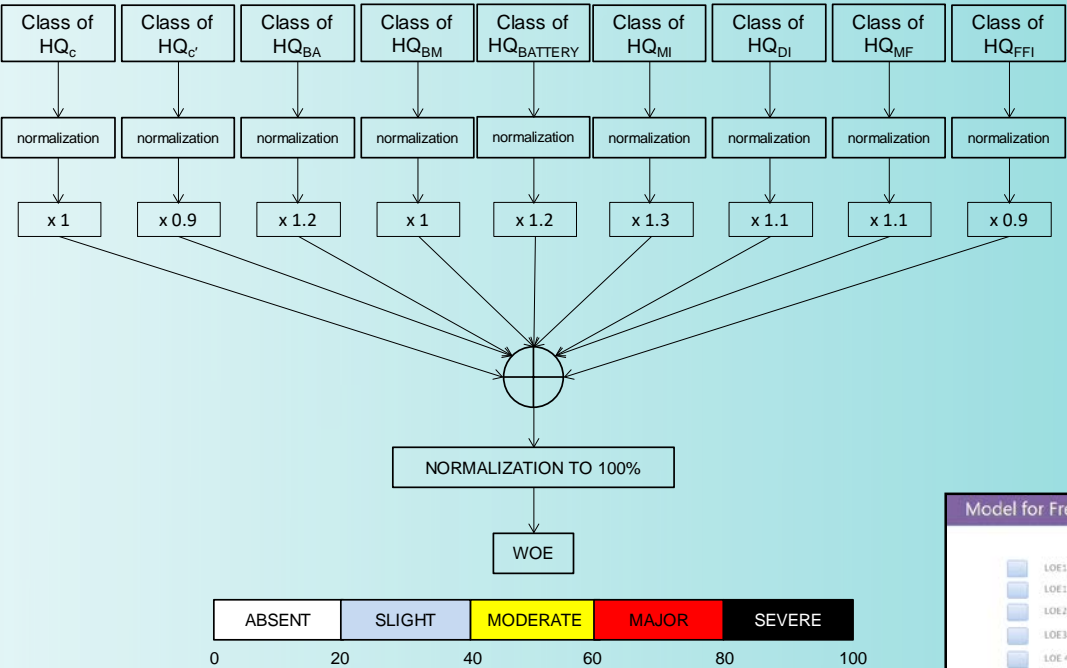
Chemical characterization of sediments: ABSENT
Bioavailability of chemicals: SLIGHT
Sublethal effects Biomarker: SLIGHT
Toxicological Bioassays: ABSENT
Benthic Communities: NEGLIGIBLE

Weight of Evidence integration: SLIGHT



Almost 7.000 analyses to interpret....and summarize!

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



Model Freshwater Quality Assessment

MANUALE D'USO
FreshQualSoft® versione 2.0

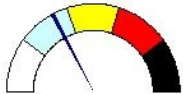
Model for Freshwater Quality Assessment
FreshQualSoft Ver 2.0

- LOE1.1: Chemical characterization of sediments
- LOE1.2: Chemical characterization of soil
- LOE2: Chemical characterization of water column
- LOE3: Bioavailability of chemicals
- LOE 4: Sublethal effects Biomarkers
- LOE 5: Toxicological Bioassays
- LOE 6: Macroinvertebrates
- LOE 7: Diatoms community
- LOE 8: Macrophytes
- LOE 9: Functionality Fluxial Index
- Weight of Evidence integration

Weight of Evidence integration

Area	Cecina
Site	River Cecina
Chemical characterization of sediments	MAJOR
Chemical characterization of soil	
Chemical characterization of water column	MODERATE
Bioavailability of chemicals	SLIGHT
Sublethal effects Biomarkers	MODERATE
Toxicological Bioassays	ABSENT
Macroinvertebrates	MODERATE
Diatoms community	ABSENT
Macrophytes	ABSENT
Index of river functionality	MODERATE

Weight of Evidence integr SLIGHT





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

Kari K. Lehtonen^{1*}, Giuseppe d'Errico², Samuli Korpinen¹, Francesco Regoli², Heidi Ahkola³, Tanja Kinnunen¹ and Anu Lastumäki¹

Lehtonen et al.

Contamination and the WOE Approach in the Baltic Sea

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-DBaH- 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-MeLNAPH	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.

Lehtonen et al.

Contamination and the WOE Approach in the Baltic Sea

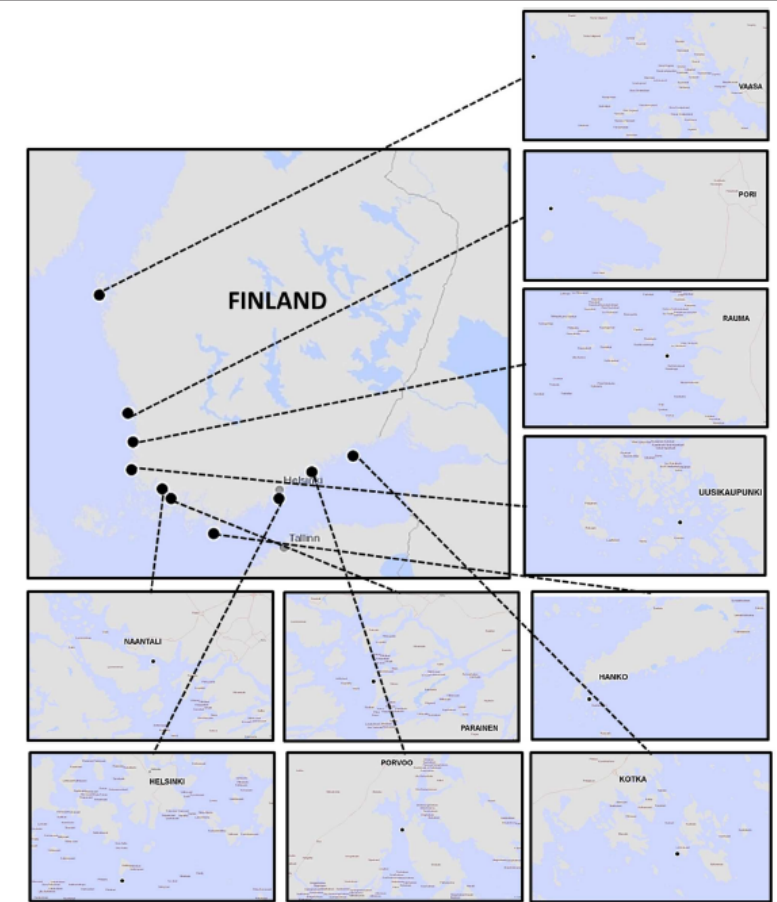


FIGURE 1 | Study sites along the coast of Finland. The black dot in each site map represent the exact site of the mussel cage.