

# A multidisciplinary approach for the evaluation of contaminant effects in marine organisms: from biomarkers to food safety

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Natural and anthropogenic heavy metal sources

Highly persistent, toxic and bioaccumulate in living tissues through the food chain

Enter the human food chain through consumption of contaminated seafood

Trophic magnification

Humans



Fish



Mollusc



Zooplankton



Bacteria



Increase in concentration



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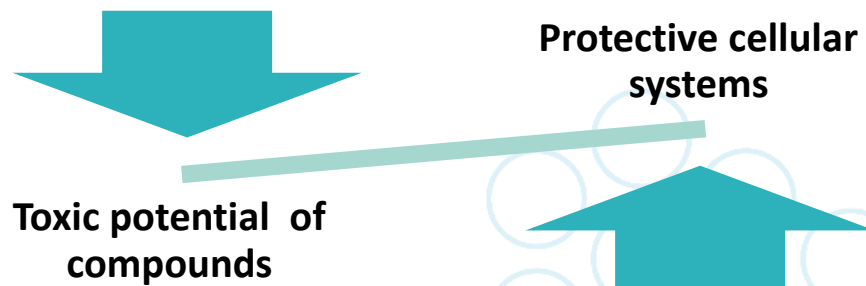
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## Heavy metals bioaccumulation

- The rate of contaminant elimination depends on chemical properties, exposure levels, the species involved and the specific organs or tissues affected

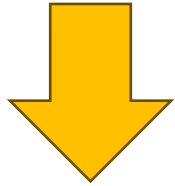


## Chemical-organism interactions

- The toxicity of contaminants is influenced by the metabolic processes they undergo and the mechanisms by which they exert their biological effects

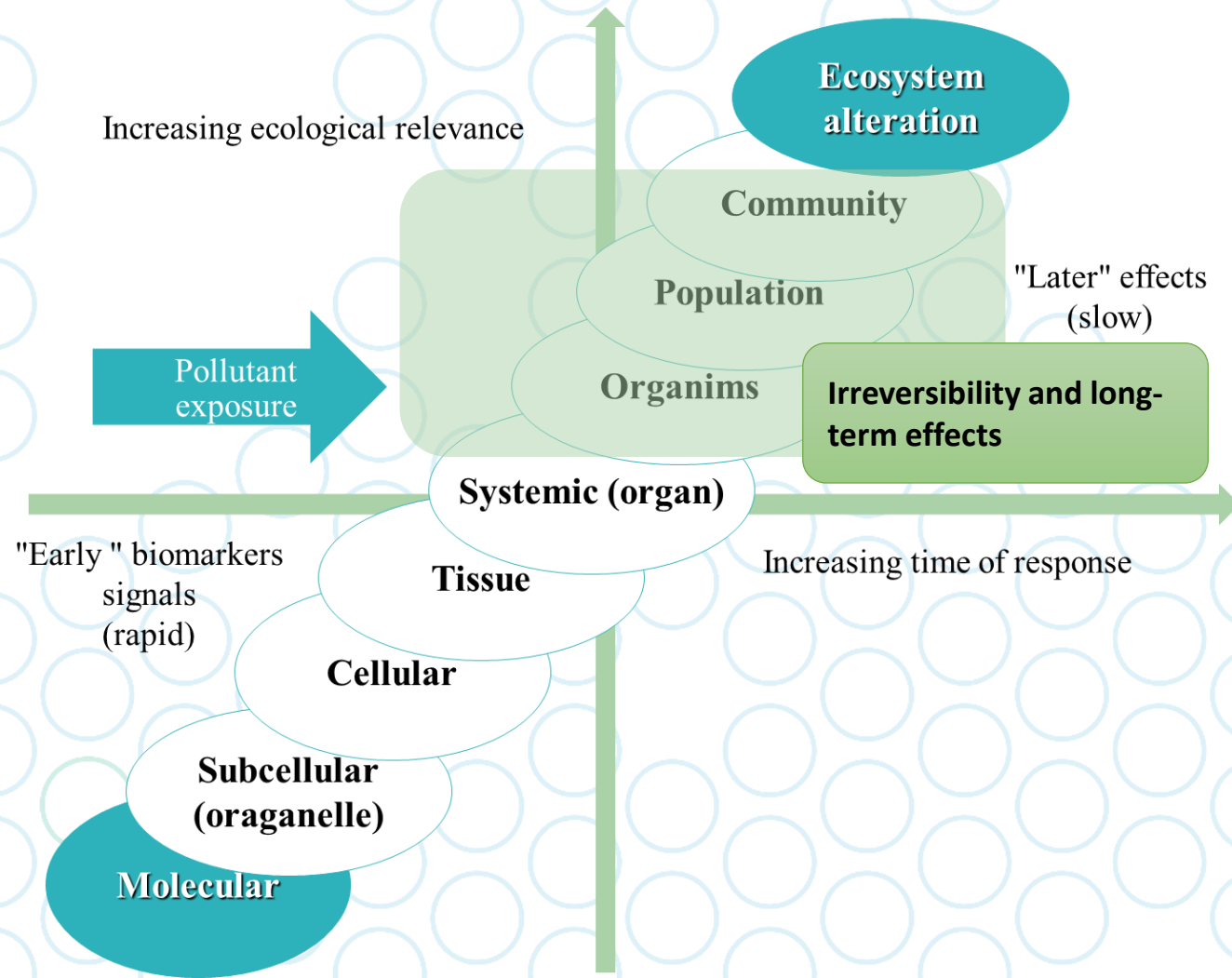


# Role of biomarkers in the assessment of aquatic ecosystem health



Biomarkers are sensitive tools for environmental monitoring and to identify toxicity and hazard levels of environmental stressors

Biomarkers detect stress responses at the cellular and molecular level, before the effects are observed at higher levels of biological organization



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Chemical contaminants



ROS

Antioxidants

Oxidative stress

Antioxidant proteins (SOD, CAT, GST)



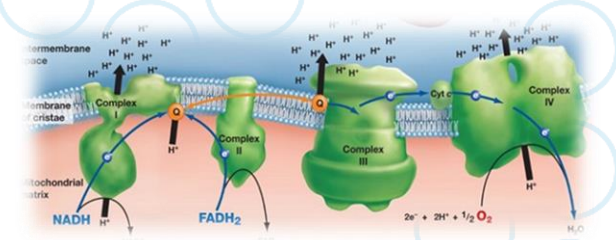
Cellular damage (DNA, proteins, lipids)

Signal transduction pathways

Transcription factors

Gene expression

Disrupt signalling pathways:  
Cell cycle, apoptosis, energy balance, cellular metabolism



Radicals		Non-radicals	
Superoxide $\text{O}_2^-$		Hydrogen peroxide $\text{H}_2\text{O}_2$	
Hydroxyl radical $\text{OH}$		Ozone $\text{O}_3$	
Alkoxy, e.g. methoxy group $\text{RO}\cdot$		Hypochlorous acid $\text{HOCl}$	



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Oxidation of polyunsaturated Fatty Acids (PUFAs)

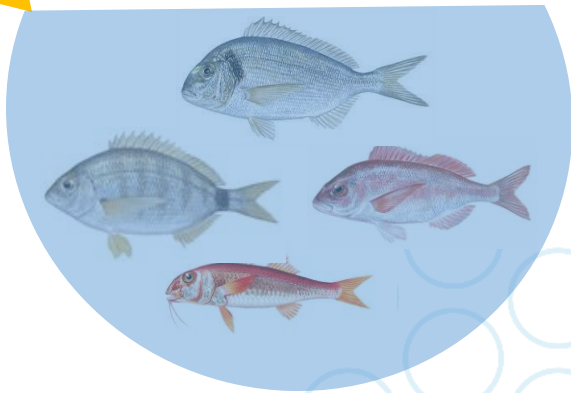


Lipid peroxidation leads to malondialdehyde (MDA) production which is a main oxidation product of peroxidised polyunsaturated fatty acid



PUFA and MDA, as oxidative stress biomarkers

ROS



PUFAs, including omega-3 play a key role on health and function of marine organisms at all trophic levels

PUFA can be considered as ecosystem health and stress biomarkers for the high sensitivity of lipid to stressors and environmental changes



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Sub-lethal doses of polybrominated diphenyl ethers affect some biomarkers involved in energy balance and cell cycle, via oxidative stress in the marine fish cell line SAF-1

Cristobal Espinosa Ruiz<sup>a</sup>, Simona Manuguerra<sup>a</sup>, Alberto Cuesta<sup>b</sup>, Maria Angeles Esteban<sup>b</sup>, Andrea Santulli<sup>a,c</sup>, Concetta M. Messina<sup>a,\*</sup>



Carbamazepine, cadmium chloride and polybrominated diphenyl ether-47, synergistically modulate the expression of antioxidants and cell cycle biomarkers, in the marine fish cell line SAF-1

Cristobal Espinosa Ruiz<sup>a</sup>, Simona Manuguerra<sup>a</sup>, Eleonora Curcuraci<sup>a</sup>, Andrea Santulli<sup>a,b</sup>, Concetta M. Messina<sup>a,\*</sup>



Article  
**Sub-lethal Doses of Polybrominated Diphenyl Ethers, in Vitro, Promote Oxidative Stress and Modulate Molecular Markers Related to Cell Cycle, Antioxidant Balance and Cellular Energy Management**

Simona Manuguerra<sup>1,\*</sup>, Cristóbal Espinosa Ruiz<sup>1,†</sup>, Andrea Santulli<sup>1,2</sup> and Concetta Maria Messina<sup>1,\*</sup>



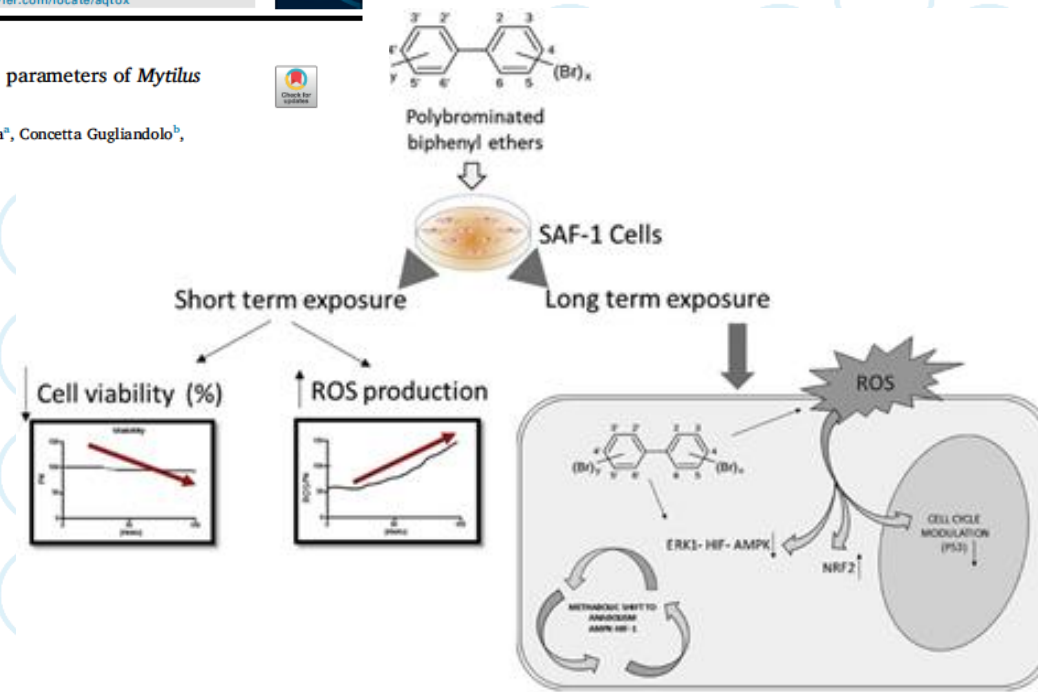
Article  
**Oxidative Stress, Induced by Sub-Lethal Doses of BDE 209, Promotes Energy Management and Cell Cycle Modulation in the Marine Fish Cell Line SAF-1**

Cristobal Espinosa Ruiz<sup>1</sup>, Simona Manuguerra<sup>1</sup>, Alberto Cuesta<sup>2</sup>, Andrea Santulli<sup>1,3</sup> and Concetta M. Messina<sup>1,4</sup>



Effects of BDE-47 exposure on immune-related parameters of *Mytilus galloprovincialis*

Cristobal Espinosa Ruiz<sup>a</sup>, Maria Morghese<sup>a</sup>, Giuseppe Renda<sup>a</sup>, Concetta Gugliandolo<sup>b</sup>, M.A. Esteban<sup>c</sup>, Andrea Santulli<sup>a,c</sup>, Concetta M. Messina<sup>a,\*</sup>



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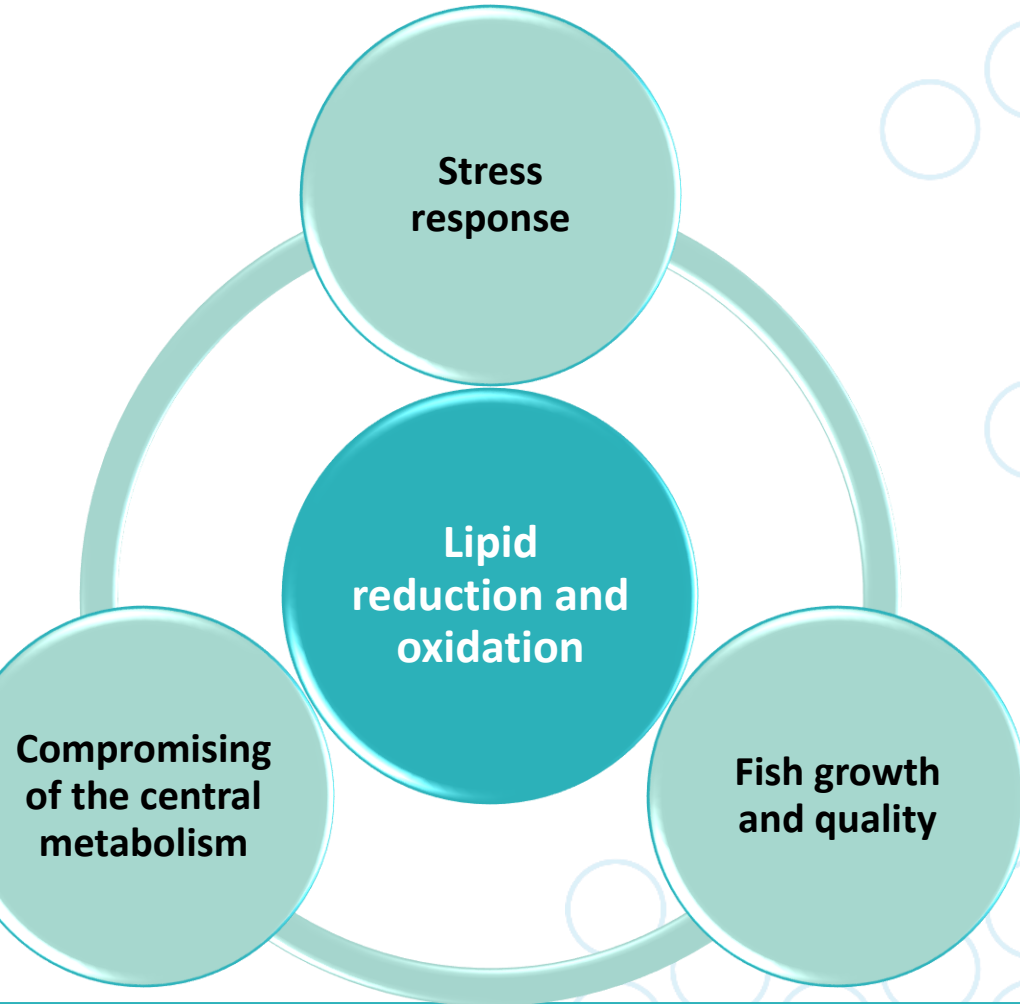


# A multidisciplinary approach to understand the mechanisms of bioaccumulation and biomagnification of contaminants



The effects of bioaccumulation on chemical composition and quality of fish products can be assessed by molecular and biochemical analysis related to lipid metabolism and its relationship with ROS

- Evaluation of fatty acid profile alterations and lipid peroxidative damage
- Use of selected biomarkers
- Early Warning System



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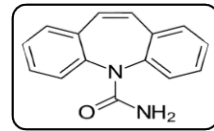
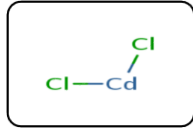
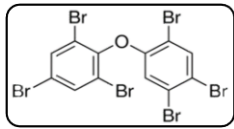
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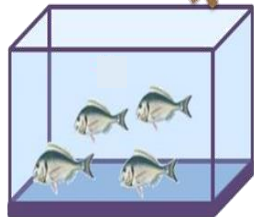
Contaminant-induced oxidative stress underlies biochemical, molecular and fatty acid profile changes, in gilthead seabream (*Sparus aurata* L.)

Concetta Maria Messina<sup>a,\*</sup>, Simona Manuguerra<sup>a,1</sup>, Rosaria Arena<sup>a,1</sup>, Cristobal Espinosa-Ruiz<sup>a,b</sup>, Eleonora Curcuraci<sup>a</sup>, María Angeles Esteban<sup>b</sup>, Andrea Santulli<sup>a,c</sup>

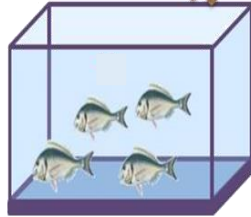
PBDE-47    Cadmium chloride    Carbamazepine



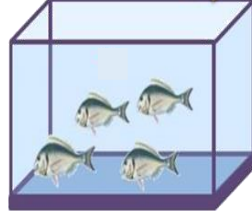
Control Diet  
n=6 x2



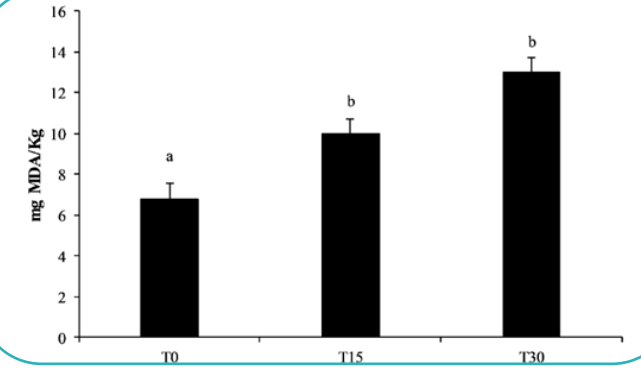
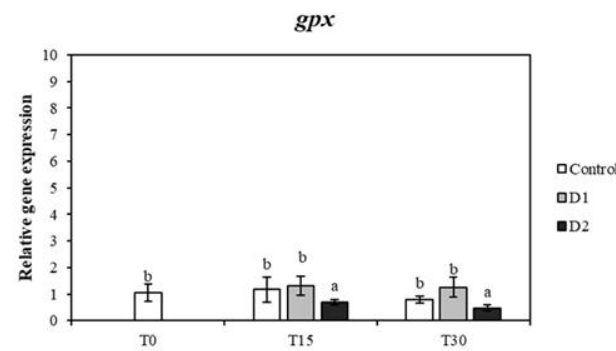
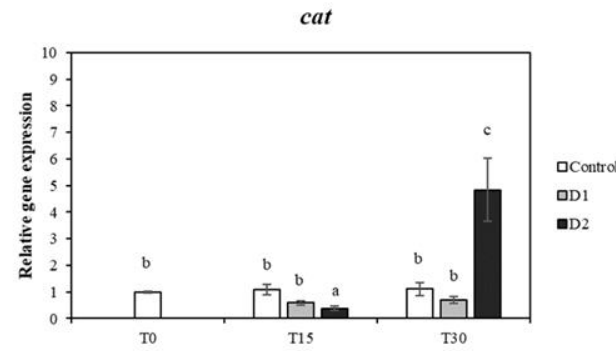
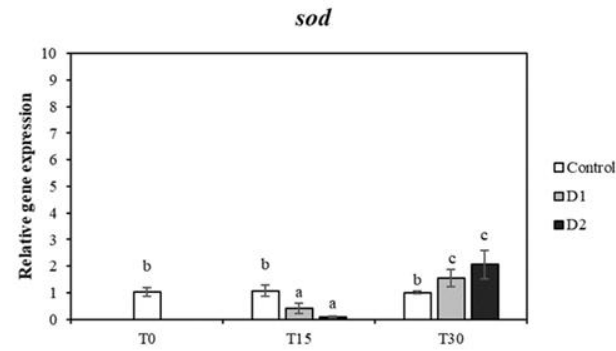
Mixture dose 1  
n=6 x2



Mixture dose 2  
n=6 x2



- **Molecular markers involved in ROS scavenging** (sod, cat and gpx) by gene expression analysis
- **Markers of quality:** lipid peroxidation, fatty acids profile and malondyaldeide (MDA) level



Chemical contaminants altered the oxidative balance, affected the antioxidant defense system, fatty acid content and increased lipid peroxidation levels

Molecular and biochemical markers adopted, could be used to monitor the health of aquatic organisms in the marine environment

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## Multidisciplinary Approach

Integration bioavailability and bioaccumulation data with molecular and cellular assessments, provides a comprehensive framework for marine health assessment

## Utilizing Biomarkers

The development and application of biomarkers can provide early warning indicators of environmental stress in marine organisms

## Promoting One Health approach

Relationship among environmental, animal and human health to ensure environmental sustainability, ecological integrity and food safety for the future



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