Integrated biomarker analysis in cod (*Gadus morhua*) from dumpsites of chemical munitions in the Baltic Sea

Lang, T.[1], Straumer, K.[1], Lastumäki, A.[2], Turja, R.[2], Ahvo, A.[2], Brenner, M.[3], Lehtonen, K.K. [2]

[1] Thünen-Institute of Fisheries Ecology (TI-FI)

[2] Finnish Environment Institute (SYKE)

[3] Alfred Wegener Institute of Polar and Marine Research (AWI)

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Fig. 1: Baltic cod (*Gadus morhua*)

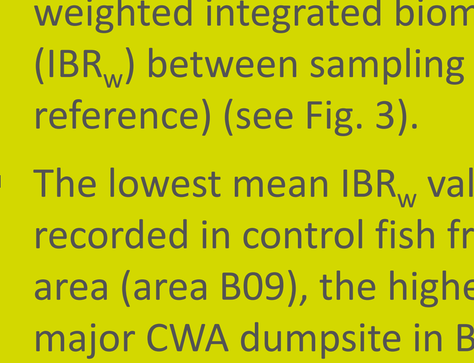
In the framework of the CHEMSEA project (2011-2013), Baltic cod (*Gadus morhua*) from CWA dumpsites located in the Bornholm Basin, Gotland Deep and Gdansk Deep as well as from a munitions-free reference site outside the Gdansk Bay (Fig. 2) were studied for spatial patterns in biomarker responses.

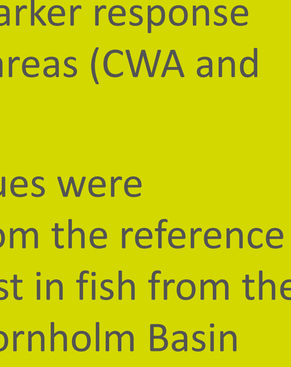
A battery of established biomarkers was analysed, reflecting exposure, early or chronic contaminant effects. These included enzymatic (acetylcholinesterase, glutathione S-transferase, glutathione reductase, catalase), cell and tissue (lysosomal membrane stability, lipofuscin accumulation, apoptosis, liver histopathology) as well as fitness and health biomarkers (condition index, gross diseases and parasites) (Tab. 1).

For the integrated analysis of biomarker data obtained, a modified version of the Integrated Biomarker Response (IBR) approach (*Beliaeff & Burgeot 2002*[1]) was applied, introducing weighting factors for each biomarker as an additional new component, emphasizing the significance of the response/effect for the host.

Key messages:

- The Integrated Biomarker Index (IBR) combines different biomarkers to single values, which can be used to describe the toxically-induced stress level of populations in different areas, such as CWA dumpsites.
- In the present study, the original approach (Beliaeff & Burgeot 2002[1]) was modified in that weighting factors were introduced that convert the significance of biomarker responses recorded into numeric values (Tab. 1).
- There were marked spatial differences in weighted integrated biomarker response (IBR_w) between sampling areas (CWA and reference) (see Fig. 3).
- The lowest mean IBR_w values were recorded in control fish from the reference area (area B09), the highest in fish from the major CWA dumpsite in Bornholm Basin (area B13).
- The IBR_w approach is regarded as an appropriate tool for integrated assessment related to biological effect of hazardous substances originating from dumped munitions.





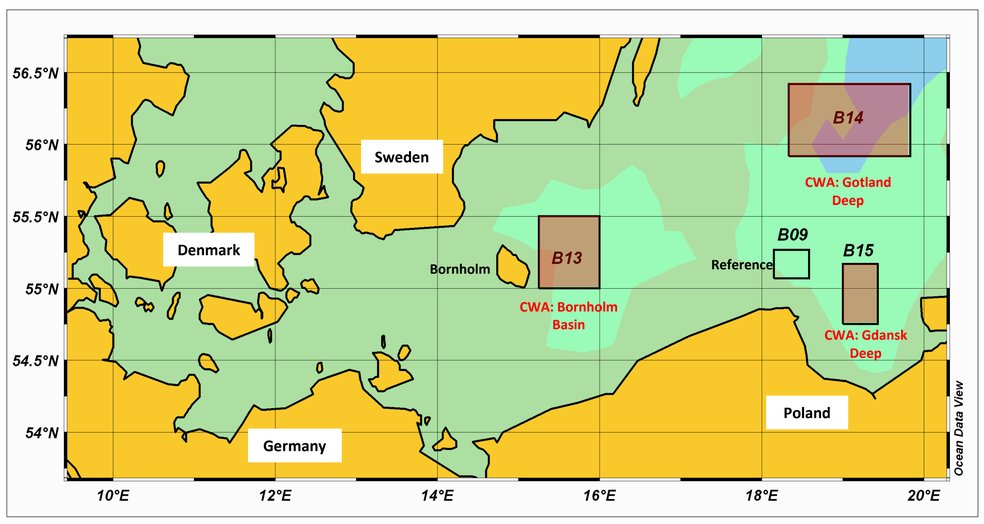


Fig. 2: Sampling areas in the Baltic Sea for the analysis of biomarkers in cod (*G. morhua*) *(B13, B14, B14: dumpsites of chemical munitions/ warfare agents, B09: reference area)*

Biomarker Category	Biomarker	Weighting Factor	Tissue
Fitness	Fulton's condition factor	1.5	Whole fish
Disease/Pathology	Fish Disease Index (FDI)	2.4	Whole fish
	Lysosomal membrane stability	1.5	Head kidney
	Lipofuscin accumulation	1.2	Head kidney
Oxidative Stress	Glutathione S-transferase	1.0	Liver
	Glutathione reductase	1.0	Liver
	Catalase	1.0	Liver
Neurotoxicity	Acetylcholinesterase inhibition	1.5	Muscle
Carcinogenicity	Histopathology/Tumours	2.4	Liver

Tab. 1: Biomarkers measured in cod (*G. morhua*) from CWA dumpsites in the Baltic Sea during the CHEMSEA project used for calculation of the weighted Integrated Biomarker Response (IBR_w)

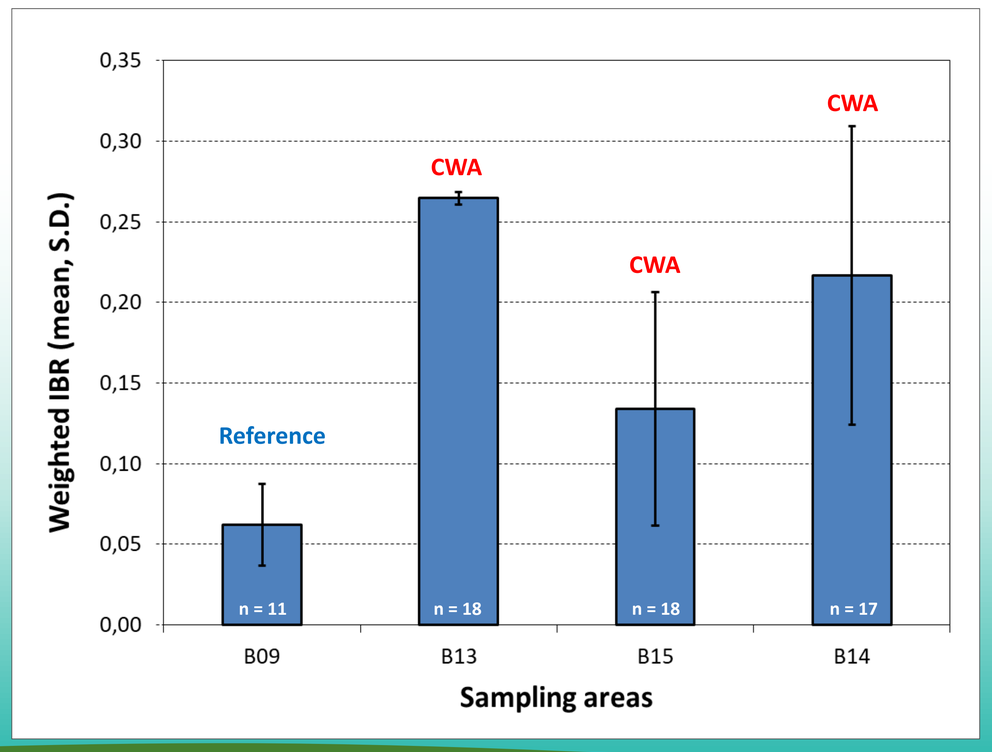


Fig. 3: Weighted Integrated Biomarker Response (IBR_w) in cod (*G. morhua*) from CWA dumpsites in the Baltic Sea (data CHEMSEA project) (High values indicate biological effects of contaminants.)

[1] Beliaeff, B., Burgeot, T. (2002). Integrated biomarker response (IBR): a useful graphical tool for ecological risk assessment. Environmental Toxicology and Chemistry 21, 1316–1322