ZooNotes 259: 1-4 (2025)
www.zoonotes.bio.uni-plovdiv.bg
ISSN 1313-9916

DOI: 10.69085/zn20250259

Cetaceans - Can they be indicators of the state of the Black Sea environment?

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Abstract. Anthropogenic pollution affects marine ecosystems worldwide, including the Black Sea. Heavy metals accumulation in animal tissues is crucial for monitoring ecosystem health. As top predators, cetaceans can serve as indicators of marine conditions. This study examines five heavy metals (Pb, Cd, Zn, Cu, Ni) in tissues of two Black Sea cetaceans and three fish species, constituting the their diet. Zinc showed the highest concentration in all studied samples. The Biomagnification factor (BMF) results indicate biomagnification in the cetaceans samples for the elements Cd and Zn.

Key words: cetaceans, heavy metals, Black Sea.

Introduction

Heavy metals pollution in marine environments is a significant risk, as contaminants accumulate in food chains and may indicate ecosystem contamination (Yan *et al.* 2020). Bioaccumulation and biomagnification primarily threaten top predators like cetaceans (Garcia-Cegarra *et al.* 2020). While metal accumulation has been studied in Black Sea mollusks and algae, data on cetaceans as bioindicators are limited (Das *et al.* 2004; Evtimova *et al.* 2019).

The Black Sea is home to three cetacean species: Black Sea Common Dolphin (*Delphinus delphis ponticus* Barabasch-Nikiforov, 1935), Black Sea Bottlenose Dolphin (*Tursiops truncatus ponticus* Barabash-Nikiforov, 1940), and Black Sea Harbor Porpoise (*Phocoena phocoena relicta* Abel, 1905). This study investigates the presence and accumulation of five heavy metals - lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu), and nickel (Ni) in bones of *Delphinus delphis* and *Phocoena phocoena*. Heavy metals are also investigate in a few fish species, included in the cetaceans diet - Mediterranean horse mackerel (*Trachurus mediterraneus*), Atlantic bonito (*Sarda sarda*) and bluefish (*Pomatomus saltatrix*).

Material and Methods

This study was conducted in autumn 2022 along the Bulgarian Black Sea coast. Fish samples were collected from two locations: Cape Kaliakra in the north and Tsarevo in the south, using commercial fishing gear. The line transect method was used to sample cetaceans along selected coastal sections. Three fish species were collected: *T. mediterraneus, S. sarda,* and *P. saltatrix*, along with four cetacean bone samples - two from *Ph. phocoena* and two from *D. delphis* in the northern area. Fish samples were dissected for muscles, bones and gills, while only bones samples were prepared from cetaceans. All samples were processed by air-drying, grinding, and mixing with concentrated acids. Heavy metal content was measured using an ISP "OPTIMA 7000" Perkin-Elmer in the Atomic Absorption Spectrophotometry Laboratory.

Received: 10.02.2025, Accepted: 25.03.2025, Published: 26.03.2025
Университетско издателство "Паисий Хилендарски"
Plovdiv University Press "Paisii Hilendarski"

The results are present as concentrations of heavy metals mg/kg dry weight. To assess the degree of biomagnification within the food web, we applied the biomagnification factor (BMF), defined as: BMF = CB/CD, where CB represents the chemical concentration in the organism, and CD denotes the concentration in its diet (Gobas & Morrison 2000). Values > 1 indicate magnification.

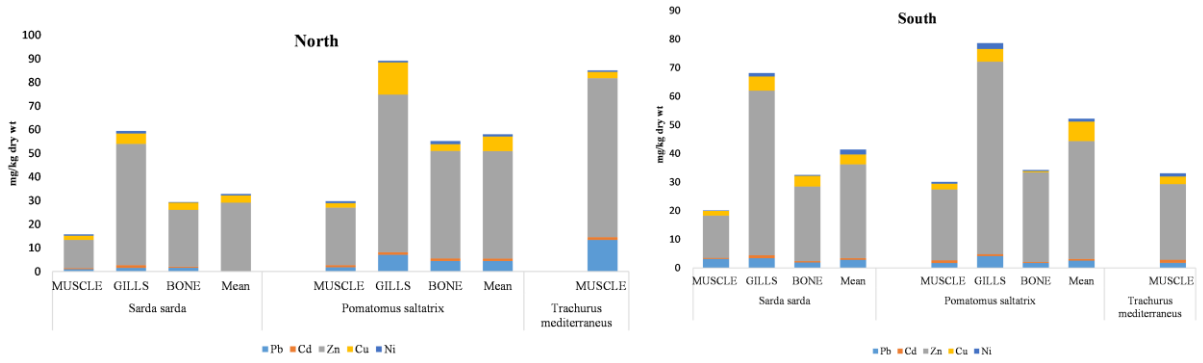
Results and Discussion

A total of 18 samples (n=18) were analyzed - 4 cetacean bone samples (n=4) and 14 fish samples (muscles, gills, and bones). Two *Ph. phocoena* and two *D. delphis* were found only in the northern region. All five analyzed metals were detected in the cetacean samples. *Ph. phocoena* showed the highest levels of Zn and Cd, while *D. delphis* had the highest Zn and Pb concentrations (Table 1). The distribution of metals in cetaceans followed this pattern: Zn > Cd > Pb > Cu > Ni. The average metal concentrations in *Ph. phocoena* from the Black Sea were lower than those measured in 2019 (Evtimova *et al.* 2019), especially for Pb (2.41 mg/kg vs. 13.8 mg/kg) and Zn (55.43 mg/kg vs. 294.8 mg/kg).

Table 1. Concentration of heavy metals in cetacean samples (mg/kg dw). Mean and SD.

Cetacean	**Pb**	**Cd**	**Zn**	**Cu**	**Ni**
Phocoena phocoena	2.65	8.20	87.40	3.73	0.71
Phocoena phocoena	1.22	0.68	10.22	0.04	0.02
Delphinus delphis	5.50	1.59	117.79	4.88	0.13
Delphinus delphis	0.293	0.272	6.331	0.23	0.072
Mean	**2.41**	**2.69**	**55.43**	**2.15**	**0.26**
SD	2.27	3.72	55.87	2.13	0.28

The study shows that Pb and Cu concentrations are significantly higher in fish from the northern Black Sea coast compared to the south (Fig. 1). This difference is likely due to more intensive agricultural activity in the north (Ministry of Agriculture Food and Forestry 2020), as well as variations in anthropogenic pressure, hydrography, and proximity to large rivers. The highest concentrations of all examined elements were found in *P. saltatrix*, indicating species-specific accumulation of heavy metals. The highest concentrations of heavy metals were found in the gills of all species, likely due to their direct exposure to the marine environment, facilitating pollutant absorption. The order of element concentration in fish tissues is: Zn > Cu > Pb > Ni > Cd.



A **B**

Fig. 1. Concentrations of heavy metals (mg/kg dry weight) in different tissues of fish along the **A**- northern and **B** - southern Bulgarian Black Sea.

The Biomagnification Factor (BMF) results show biomagnification of Cd and Zn in all cetacean samples. Among the species, *Ph. phocoena* have high BMF for Cd, while *D. delphis* exhibited a high BMF for Pb and Zn (Fig. 2).

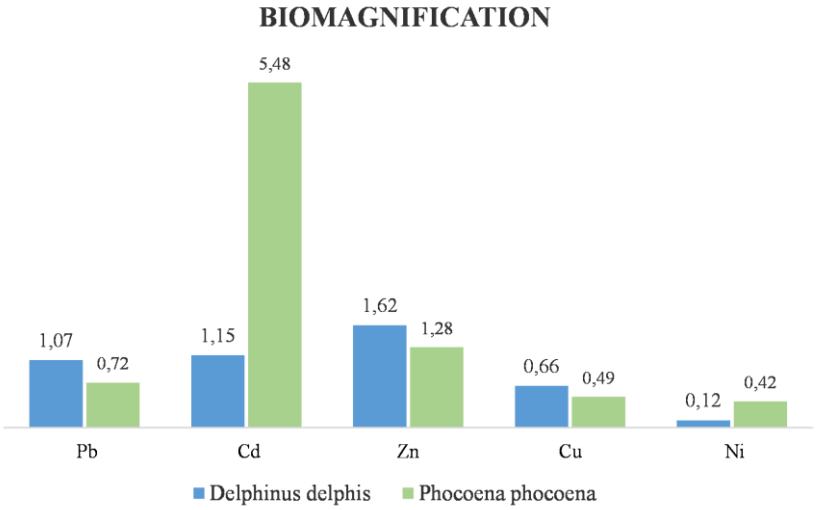


Fig. 2. Biomagnification Factor (BMF) by cetacean species. Values **>1** indicate biomagnification.

Conclusions

Among the heavy metals, the highest average concentration was observed for Zn in all studied samples (cetaceans and fish). Zinc (Zn) and copper (Cu) mainly accumulate in fish, and their concentration is highest in the gills. Biomagnification data in food chains are available for Cd and Zn. For more definitive conclusions, additional data and samples are needed. However, the results suggest that cetaceans accumulate elements through the food chain in the Black Sea, serving as valuable bioindicators of its ecological state.

Acknowledgments. This study was carried out under the National Scientific Program "Young scientists and post-doctoral students - 2". The results were presented at an International Cetacean Forum with the assistance and support of Sofia University Marking Momentum for Innovation and Technological Transfer (SUMMIT).

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