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Monitoring plastic and Hg pollution impacts on two commercial species from the North Evoikos Gulf

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Abstract This study examines the presence of microplastics (MPs) and mercury (Hg) concentrations in 230 *Boop boops L.,* and 203 *Nephrops norvegicus L.,* sampled from the North Evoikos during the years 2021, 2022 and 2024. Microplastics were detected in 56.1% of *B. boops*, with a mean abundance of 1.74 MPs/individual, and in 79.3% of *N. norvegicus*, with a mean of 3.72 MPs/ individual. Polymer composition analysis revealed species-specific differences in the dominant MP types. Mercury concentrations remained within the permissible limits established by European regulatory standards, with mean levels of 0.32 mg/kg *w.w.* in *N. norvegicus* and 0.05 mg/kg *w.w.* in *B. boops* indicating no immediate risk to human health (THQ <1).

Keywords: *Pollution, Microplastics, Hg, Biomarkers, Mediterranean Sea*

1. Introduction

The North Evoikos Gulf is a semi-enclosed Gulf in the Aegean Sea, particularly vulnerable to marine pollution due to its proximity to anthropogenic and industrial activities. This area contributes significantly to the accumulation of various pollutants, notably heavy metals and microplastics (MPs) [1]. Various marine species are included in international and European monitoring programs for the Mediterranean and the Atlantic ecosystems, providing essential insights into their ecological status [2]. *Boops boops* (bogue) and *Nephrops norvegicus* (Norway lobster) are species of particular interest due to their wide distribution, ecological relevance, and commercial importance for monitoring marine litter ingestion (descriptor D10C3) and assessing good environmental status in European waters, in the frame of the Marine Strategy Framework Directive (MSFD) [3]. Mercury (Hg), a toxic heavy metal, is known to bioaccumulate through marine food webs, representing a substantial risk to both marine organisms and human health through seafood consumption [4]. The primary aim of this study is to assess the presence and concentrations of MPs and Hg in *B. boops* and *N. Norvegicus*, utilizing them as bioindicator species, for the pelagic and benthic ecosystems correspondingly.

2. Materials and Methods

Sample collection was conducted during the years 2021, 2022 and 2024. Biometric parameters were recorded, including total length (mm), body weight (mg), and sex. The gastrointestinal tracts were examined for the presence of MPs following the MEDSEALITTER protocol [5]. Polymer composition of recovered MPs was determined using Fourier-transform infrared spectroscopy (FT-IR; Cary 630 FTIR). Mercury concentrations, in pooled muscle tissue samples stratified by sex and size, were quantified by Cold Vapor Atomic Absorption Spectrometry (CVAAS). To assess dietary exposure and potential health risk the Estimated Daily Intake (EDI) and Target Hazard Quotient (THQ) were calculated using standard US EPA formulas (2011) [4]. Blank controls were included throughout the analytical workflow while contamination control protocols were rigorously applied. Non-parametric tests and regression analyses were used to assess differences and relationships among variables. Statistical significance was established at α=0.05.

3. Results

Boops boops: A total of 232 plastic items were identified, comprising 225 microplastics with mean length 1.47±1.09 mm and 7 macroplastics with mean length 7.88±2.19 mm. MPs were detected in 56.1% of individuals, with a mean abundance of 0.98 ± 1.20 items/individual (**Table 1**). Fibers were the dominant shape (83.1%), primarily black in color (67.8%). FTIR analysis identified polyethylene (PE) (36%) and polypropylene (PP) (21%) as the main polymers (**Figure 1**). Mean Hg concentration in muscle tissues as well as EDI and THQ values are shown in **Table 1**.

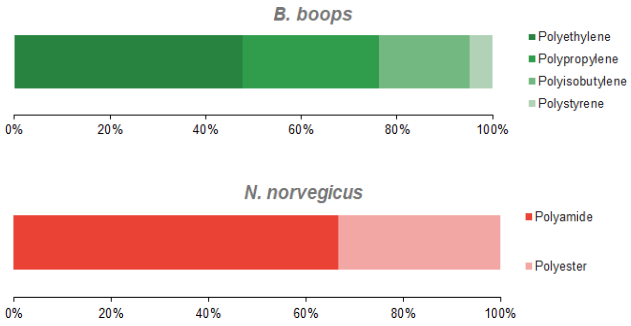
Nephrops norvegicus: A total of 756 plastic items were recorded, including 563 microplastics and 191 macroplastics. MPs were detected in 79.3% of individuals, with a mean abundance of 2.77 ± 4.07 items/individual (**Table 1**). Mean MP length was 2.05 ± 1.17 mm, while the mean of macroplastics was 9.02 ± 5.14 mm. Fibers dominated (90.9%), most frequently white (24.7%). FTIR analysis showed

polyamide (PA) (62.5%) and polyester (PET) (31.2%) as predominant polymers (**Figure 1**). Mean Hg concentration was 0.32 ±0.11 mg/kg *w.w.*, with significant differences among the size-classes (ANOVA, $p<0.05$). EDI and THQ values are shown in **Table 1**.

Table 1. Data for the MPs and Hg impact on *B. boops* and *N. norvegicus* from the North Evoikos Gulf.

	B. boops	***N. norvegicus***
Number of individuals	230	203
Total Length *mean±SD*	188.3±33.0	121.5±19.4
MPs Occurrence (%)	56.1%	79.3%
MPs items	225	563
MPs items range/ind^{-1}	0-6	0-35
MPs/ind^{-1} *mean±SD*	0.98±1.20	2.77±4.07
Hg (mg/kg) *w.w. mean±SD*	0.05±0.03	0.32±0.11
EDI (µg/70 kg bw/d)	0.039	0.017
THQ	0.385	0.166

Figure 1. Polymer types in *B. boops* and *N. norvegicus* from the North Evoikos Gulf.



Procedural blanks showed no evidence of MP contamination. No significant correlations ($p>0.05$) were found between Hg concentration and MP abundance in the studied species.

4. Discussion

The species *B. boops* (semi-pelagic) and *N. norvegicus* (benthic) although originating from the same region exhibited significant differences in the occurrence, abundance, and chemical composition of ingested microplastics. The comparatively lower levels of plastic items found in *B. boops* are consistent with its pelagic feeding habits and reduced contact with sediment. On the other hand, the polymer type differences could be attributed to the different polymer types found in their marine environment. High-density polymers tend to sink and build up in the sediment whereas, low-density polymers are bound to float onto the surface or can be maintained in the water column as suspension [6].

MPs abundance in *B. boops* was consistent with levels reported in previous studies from various areas of the Mediterranean Sea, except for higher levels noted in Lazio, Italy [7]. Besides, *N. norvegicus* exhibited lower MPs abundance compared to other Mediterranean areas, including the northern coast of Barcelona and Sardinia [3] probably because of the relatively reduced tourist and industry activities in the North Evoikos Gulf.

Mercury concentrations were lower than those reported in the Adriatic Sea for both species [8,9], remained within the permissible limits established by European regulatory standards. Moreover, Hg levels remained below established safety thresholds for human consumption, indicating no immediate health risk. Our findings corroborate the previous assessment of the Ecological and Integrative Environmental Status of the North Evoikos Gulf as moderate [1] and highlight the need for biomonitoring to track regional pollution trends and support effective pollution management.

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