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Can the Fulton and hepatosomatic indexes be good indicators of charity of the baltic fish according to microplastics pollution?

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Abstract: Pollution with MPs and health condition of herring and by-catch species like cod, flounder, sprat, long-spined bullhead, and lumpfish from the Baltic Sea were assessed. Fish were characterized by varying biometric features and condition indexes (i.e. the Fulton factor (K) and the hepatosomatic index (HSI)). MPs items were identified in all species, with the highest contribution in lumpfish (78.9%) and the lowest in sprats (21.4%). The number of items per fish ranged from 1 to 12, averaging 3.14, with MPs observed in the gills (46%), liver (16%), and digestive tract (38%). Multidimensional analysis showed a relationship between fish pollution with MPs and health condition indexes. It revealed that the shoals of Baltic herrings could be assessed based on condition indexes according to fishing zones and, in general confirms, that there is a link between pollution of MPs and fish health condition. The analysis showed that Baltic herring less contaminated with MPs were characterized by a higher K value, indicating better health in comparison to individuals more contaminated with MPs. Proposed methodology can be considered as important tool in monitoring of ecological risks for fish exposed to MPs pollution and other environmental stressors.

Keywords: plastic pollution, health condition factors, the Baltic Sea, multidimensional PCA, biometric features

1. Introduction

The use of physiological indicators to monitor the effects of anthropogenic impacts on aquatic fauna and flora becomes a common and desired practice (Madliger et al., 2018). Physiological indicators serve as acting in warning of a decline in health, alerting to issues before they negatively impact symptoms on reproduction, survival, as well as population dynamics. One of the most commonly used physiological indicators is Fulton's condition factor (K factor). It measures the energy reserves and general health status of fish. A high value suggests that the examined fish is well-nourished and in good physical condition, while a low value usually indicates feeding problems, environmental stress, or health issues.

Another physiological indicator is the hepatosomatic (HSI) index. HSI reflects the mobilization or accumulation of lipids in the liver. It is used to assess the liver condition and hence the physiological state of fish, their ability to accumulate energy, and the impact of various environmental and dietary factors on their organism (Bruslé and Anadon, 1996).

Since MPs items and associated xenobiotics pose a toxicological threat to fish health, the aims of this study were: (i) assessment of the well-being of species by evaluation and comparison of fish condition parameters based on the K and HSI indexes, as well as the ratios of gill mass (GILSI) and digestive tract mass (GITI) to total body mass, (ii) exploration the relationships between biometric features and condition parameters, considering the fishing season and fishing zones for baltic herring assessment by the use of application of multivariate analysis.

2. Materials and methods

2.1. Fish species

The study included 6 marine fish species (baltic herring, baltic cod, flounder, long-spined bullhead, lumpfish, and sprat). Fish were acquired by a commercial fishing vessel, according to cooperation with a fish processing plant, within area 27 FAO Major Fishing Areas for Statistical Purposes, sub-area IIID (fishing grounds: 103, 105, 108, 129, 135).

2.2. Microplastics determination

Once fish thawing at room temperature was accomplished, the total body length (centimeters, TL) and total body mass (grams, TW) of each species were determined. The organs (digestive tract, liver, and gills) were dissected and weighed separately using a digital analytical scale with an accuracy of ± 0.0001 g (Ohaus PX225D, Parsippany, NJ, USA). The prepared organs were placed in dry glass beakers. Samples of fish organs were digested using 10 % potassium hydroxide to isolate MPs. A detailed description of the extraction procedure is described in already published references (Piskuła and Astel, 2023, 2024).

2.3. *Health condition indexes*

Fish condition status was assessed by Fulton's condition factor (K), hepatosomatic index (HSI), the ratio of gill masses to the total body mass of fish (GILSI), and the ratio of digestive tract masses to the total body mass of fish (GITI), using following formulas:

$K = (\text{total fish weight (g)} \bullet 100) / (\text{total fish length (cm)}^3)$
HSI = liver weight (g) / total fish weight (g)
GILSI = gills weight (g) / total fish weight (g)
GITI = digestive tract weight (g) / total fish weight (g)

3. Results and discussion

The relationship between MPs abundance and Baltic herrings' charity indexes was evaluated by the use of PCA. Two principal components (PC1 – 1.87, PC2 – 1.08) were obtained, accounting for 59.12 % of the total variance. The PC1 explaining 37.27 % of the total variance, was contributed by HSI, GILSI, GITI, and MPs, while the PC2 explaining 21.85% of the total variance, was contributed by the K factor and MPs (Figure 1). Within PC1 HSI, GILSI and GITI exhibited mutual directly proportional correlation (factor loadings in the range -0.67 - -0.74 of the same sign), however, they were indirectly correlated with MPs (0.56), that also significantly contributed to PC1. PC1 could be accepted as a component presenting the negative impact of MPs on the development of major organs since decreasing index values corresponded to an increase in MPs abundance. Similarly, as in PC1, the K factor and MPs contribution in PC2 were characterized by opposite signs suggesting the negative impact of MPs abundance on the charity of fish expressed by the K factor.

Since the higher the factor score the higher the impact (in terms of the value of the given variable contributed to the factor) of the factor, generally better charity indexes corresponding to lower abundance of MPs were confirmed.

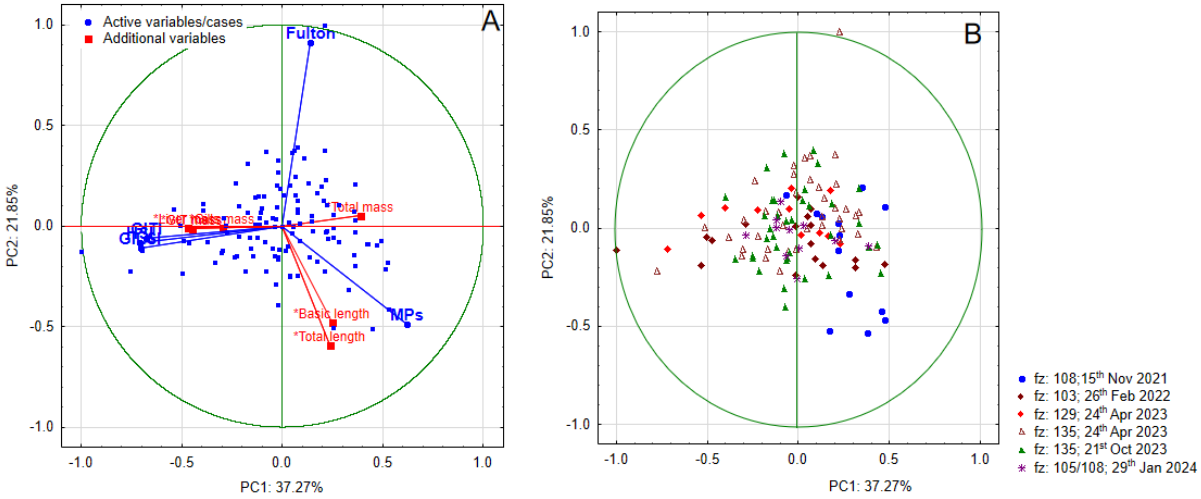

Figure 1. Biblot of PC1 and PC2 loadings and scores with active variables and cases and additional variables (Fig. 1A), and principal component scores according to fishing zones (fz) and fishing date (Fig. 1B), respectively computed for baltic hearing data set.

4. Conclusion

Multidimensional analysis successfully revealed that the shoals of Baltic herrings could be assessed based on condition indexes according to fishing zones and, in general, confirms, that there is a link between pollution of MPs and fish health condition. The analysis showed that Baltic herring less contaminated with MPs were characterized by a higher K value, indicating better health in comparison to individuals more contaminated with MPs, which is consistent with other studies. The fish health condition factors and proposed indexes can be considered as important monitoring of ecological risks for fish exposed to MPs pollution and other environmental stressors.

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