

Development, harmonizing and application of innovative methodologies for the study of the presence and effects of marine litter on organisms in Mediterranean marine protected areas within the Plastic Busters MPAs project

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Abstract

The irreversibility and global ubiquity of marine litter pollution and plastic, in particular, make this material a potential planetary boundary threat. Despite the growing attention from the scientific community and the increasing number of peer-reviewed papers, the occurrence and distribution of plastic litter in the Mediterranean Marine Protected Areas (MPAs) and its impacts and effects on marine wildlife remain still poorly investigated. Within the Plastic Busters MPAs project, this PhD thesis provided a comprehensive assessment of marine litter pollution in the sea surface waters and beaches of the Pelagos Sanctuary and the Tuscan Archipelago National Park and the potential physical and chemical impacts related to plastic ingestion on several Mediterranean bioindicators. The experimental designs planned *ad-hoc* for the selected study areas (Chapter 3), harmonised and implemented the current methods for sampling marine litter in the different environments and defined a new simultaneous multilevel approach reflecting the strong pressure that marine litter, and in particular plastics, exert on organisms inhabiting the protected areas. A total of 273 monitoring transects of floating macrolitter, 141 manta trawl and 14 beaches were sampled and monitored evaluating the occurrence, abundances and composition of marine litter according to the characterization protocols implementing the Marine Strategy Framework Directive (MSFD) (Chapter 4). Particular attention was applied to investigate the potential influences of environmental and anthropic variables affecting litter distribution and to identify potential hotspot accumulation areas representing a major hazard for marine organisms. Several species were collected, starting from invertebrates to cetaceans, to evaluate the frequency of ingestion and confirm/validate their potential role as marine litter bioindicators (Chapter 5). For the first time, an exhaustive analysis of phthalate acid ester (PAEs) presence was assessed on different organisms and biological tissues through the GC-MS analysis (Chapter 5). Strong litter inputs were identified to originate from the mainland and accumulate in coastal waters within about 10-15 nautical miles. Harbours and riverine outfalls may contribute significantly to plastic pollution representing the main sources of inputs as well as areas with warmer waters and weak oceanographic features that could facilitate the accumulation of litter. The high concentrations of plastics floating on the sea surface (399 items/km² for macrolitter and 259,490 items/km² for MPs) and stranded on beaches (up to 1,033 ± 915 items/100m) indicate a potentially threatening trend of particle accumulation that may pose a serious risk to organisms living in the Pelagos Sanctuary. The twofold monitoring approach, simultaneously investigating plastic and MP ingestion in several species and concentrations of plasticizers has allowed gaining information on the direct link between synthetic particle ingestion and its additive substances release. Microplastic ingestion was assessed for the first time in the Mediterranean Sea in *Velevella velevella* organisms (0.71 items/ind.), filter-feeding organisms such as the *Mobula mobular* (23 items/ind.) and *Balaenoptera physalus* (35 items/ind.), as well as in poorly investigated species i.e. seabirds, lanternfishes and odontocete cetaceans. Phthalate acid ester loads (mainly DIBP, DBP and DEHP compounds) and their pattern of accumulation were evaluated in several species and different biological tissues respectively, according to their feeding behaviour, long life span and spatial distribution. Finally, the spatial risk assessment (Chapter 6) indicated the Gulf of La Spezia and the National Park of the Tuscan Archipelago as the most affected by the accumulation of plastic waste and at higher risk of exposure to organisms as well as the Genova Canyon and the seamount area. The results obtained here provide further indications for dealing with plastic pollution in MPAs and could facilitate future recommendations for the management and use of the marine and coastal environment of these protected areas.