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EDITORIAL
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Editorial: From Pole to Pole: Contamination of Marine Ecosystems in a Changing World

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Editorial on the Research Topic

From Pole to Pole: Contamination of Marine Ecosystems in a Changing World

Polar Regions have gained increasing interest during the recent years for many aspects: they are the last frontiers of adventure tourism and an increasing number of ship cruises reach the most accessible areas of the Arctic and Antarctic, e.g. Greenland, Svalbard, Antarctic Peninsula islands, Ross Sea coasts. In the Arctic, there is an alarming growing interest for fishing, mining, and oil prospections for commercial exploitation, despite extreme weather and geographical conditions; climate change is affecting both Polar Regions more seriously and rapidly respect to other regions of our planet, resulting in a change in the structure and functioning of the ecosystems, moving of indigenous people from their coastal native villages due to the collapse of the permafrost and melting of the pack ice, and stronger meteorological events. The global changes affect also the contaminant transport, distribution and bioaccumulation that are all linked to interactions between environment, organisms and the physical-chemical properties of pollutants.

Pollutants can be natural (e.g. oil and derivate, rare earth and trace elements), synthetic (xenobiotics, e.g. persistent organic pollutants, plastics), or their by-products. There is an increasing volume of scientific literature addressing pollutant levels and impacts in Polar Regions, although a large gap still exists on the knowledge of how climate change (extreme events or single parameter alterations), may interact with pollutant transport, distribution and fate.

Topic updates scientific literature on the contamination of Polar Regions in a changing world, aiming to provide a unifying framework into which polar ecology can be integrated and focusses on the conservation of both ecosystems and biodiversity. The articles published in this collection present research on contaminant levels, their environmental distribution and biological effects in Polar Regions. Below there is a brief summary of the main aims of articles published in this collection.

Among persistent organic pollutants (POPs), both legacy and emerging POPs were investigated in Weddell, Ross and crabeater seals (Khairy et al.), killer whales (Khairy et al.; Panti et al.), and seabirds (Alfaro Garcia et al.). Arsenic and metals were investigated in soil (Trevizani et al.). Besides chemicals, micro- and nano-plastics were studied both in field studies (in surface soils and intertidal sediments (Perfetti-Bolaño et al.), and in a laboratory simulation approach focussing on the embryonic development of Antarctic krill after a combined exposure to nanoplastic and ocean

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acidification conditions (Rowlands et al.). The effects and/or exposure of contaminants in biota were also investigated through biological markers in marine mammals (Khairy et al.; Panti et al.).

The bioaccumulation of contaminants in Antarctic top predators was investigated in three articles. Per- and polyfluoroalkyl substances are found in Antarctic wildlife, with high levels in top predator like the South Polar skua. In this paper (Alfaro Garcia et al.), the authors hypothesized that available prey during the breeding period contribute to the contamination in this species. To test this, the authors compared increasing levels of 22 per- and polyfluoroalkyl substances in skuas and their main prey from two breeding sites in West and East Antarctica; studied preys included Antarctic petrel stomach content, eggs, chicks, and adults, and Adélie penguin chicks.

Two articles reported interesting results on contaminant bioaccumulation and biomarkers of exposure in Type C killer whales from Terra Nova Bay, Ross Sea, and from the Amundsen and Ross Seas. Killer whales from Terra Nova Bay were studied to evaluate the toxicological hazard of this species. Legacy and emerging pollutants together with the protein expression of cytochrome P450, the mRNA level variations of the peroxisome proliferator-activated receptors α and γ, Oestrogen Receptor α, Aryl Hydrocarbon receptor, and Cyp1a were assessed. The mRNA levels of five target genes did not statistically correlate with POP levels (Panti et al.).

The other article reported the bioaccumulation and food web dynamics of POPs as a function of species, age and sex in killer whales and Weddell, Ross and crabeater seals. In this study, POP concentrations significantly correlated with gene transcription of nuclear receptors involved in detoxification of contaminants and immune relevant cell mediators in the crabeater seals, indicating possible immunotoxic and deleterious effects (Khairy et al.).

The issue of research station impacts in Polar Regions is discussed in a couple of studies conducted at King George Island on metals and arsenic (Trevizani et al.) and on microplastics (Perfetti-Bolaño et al.). The levels of metals and arsenic were determined in soils collected from 2012 to 2018 at one of these stations after an accidental fire occurred in 2012, and at control sites. This study also represents an update overview of the environmental impacts around the research station (Trevizani et al.). The occurrence of microplastics has been investigated in the Fildes Peninsula, King George Island, containing six permanent Antarctic stations. Surface soils (Frei Antarctic station - Fildes Bay transect) and intertidal sediments (from Fildes Bay and Ardley Island, Antarctic Specially Protected Area No. 150) has been considered in this study first reporting the presence of microplastics in Antarctic soils. In addition, the finding of fibres in Ardley Island sediment indicates that microplastic contamination has reached protected areas (Perfetti-Bolaño et al.).

Plastics, have been studied in laboratory adopting a multi-stressor standpoint (Rowlands et al.). The authors determined the behaviour of aminated polystyrene nanoplastic in Antarctic seawater samples, in terms of dispersion and stability. Single and combined effects of nanoplastic and ocean acidification were explored on the embryonic development of Antarctic krill (*Euphausia superba*) collected in the northern Scotia Sea. This study provided quantifiable evidence that the combined stressors of nanoplastic and ocean acidification hinder the embryonic development of Antarctic krill and the same developmental impact was not manifested when addressing the stressors in separately.

It is interesting to note that the possible correlation between one or more climate parameters and contaminant presence is not reported in any of these articles, as proposed originally in the Research Topic. At the same time, no articles dealt with this correlation in the Arctic ecosystems. To understand the emerging issues of contaminant behaviour in face of climate changes in Polar Regions, climate parameters should be recorded when studying contamination and possible correlations, in the context of a systematic monitoring under standardized methods.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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