Summary

Mercury (Hg) is one of the most hazardous trace metals, and one of the most toxic elements, causing a range of harmful health effects, especially in the case of long-term exposure. Nevertheless, it is still widely used in various industries, significantly contributing to environmental pollution (Jahanbakht et al., 2002; Gochfeld, 2003). In response to global mercury-related threats, the Minamata Convention was adopted, aiming to reduce emissions and the use of this metal, as well as to protect human health and ecosystems (UNEP, 2024). However, despite these efforts, mercury is still being released into the environment as a by-product of processing materials that contain it (e.g., fossil fuel combustion or metallurgy). Moreover, mercury that was emitted into the environment in the past continues to circulate due to re-emission processes, making its complete elimination impossible. One of the most toxic forms of this metal is methylmercury (MeHg), which easily undergoes biomagnification and bioaccumulation in the food chain. The impact of mercury on marine organisms includes damage to the nervous system, which can lead to behavioral, coordination, and orientation disorders. In aquatic organisms, mercury can affect mobility, food acquisition, and predator avoidance, reducing their chances of survival. Moreover, mercury can disrupt reproductive processes, leading to a decrease in offspring numbers and fertility issues in many species (Crump & Trudeau, 2009).

Although mercury naturally occurs in the hydrosphere, lithosphere, and atmosphere (at low concentrations), its form and behavior vary significantly depending on the environment (Gworek & Rateńska, 2009). Human activity since the Industrial Revolution has led to a significant redistribution of mercury in the environment, transferring it from natural reservoirs (e.g., the lithosphere) to more active and biologically available forms in the atmosphere, water, and organisms, thereby increasing the concentration of more mobile and bioavailable forms of this metal. Mercury from both natural and anthropogenic sources is primarily emitted into the atmosphere. In the air, the dominant form of Hg is elemental mercury (Hg^0), which accounts for over 95% of total atmospheric mercury (Gustin & Jaffe, 2010; Korejwo et al., 2020). This stable, volatile, and poorly soluble form has a long atmospheric residence time—ranging from six months to a year—allowing it to be transported over long distances, making Hg a transboundary pollutant. Consequently, mercury is frequently detected in remote regions such as the Arctic and Antarctic (Schroeder & Munthe, 1998; Selin et al., 2007). In the atmosphere, Hg^0 can oxidize to Hg^{2+} (Gworek & Rateńska, 2009), a key process in the biogeochemical cycle of mercury, as approximately 5% of atmospheric mercury exists in the form of Hg^{2+}. In polar regions, a unique phenomenon known as the Atmospheric Mercury Depletion Event (AMDE) has been observed. This occurs mainly in spring when Hg^0 oxidizes to Hg^{2+} and is subsequently deposited on land and the ocean surface. In polar regions, this phenomenon contributes to the deposition of approximately 100 tons of mercury per year. Some of the deposited mercury is re-emitted into the atmosphere, while some is incorporated into the food chain (Angot et al., 2016).

Mercury in polar regions originates from a combination of local sources, such as research stations and other human activities, as well as global atmospheric transport and natural processes, including volcanic activity and rock weathering (Cossa et al., 2011; Mason et al., 2012; Gionfriddo et al., 2016; Obrist et al., 2018). Climate change may significantly affect the mercury cycle in these areas (AMAP, 2021; Chiang et al., 2021). In the Arctic and Antarctic, ocean warming may accelerate the remineralization of organic matter, potentially increasing methylmercury production in the sea. In polar areas, microbial activity is the primary driver of MeHg production. This process may be intensified by ongoing environmental changes.

The total concentration of mercury is not a sufficient indicator for assessing its behavior in the environment. Inorganic mercury compounds are poorly absorbed by the gastrointestinal tract (<10%), whereas organic forms of mercury, such as methylmercury, are almost completely absorbed (95–100%) (WHO, 1990; 1991). Methylmercury undergoes biomagnification in marine food chains, leading to a gradual increase in its concentration in organisms at higher trophic levels—from plankton to fish and ultimately to top predators such as seabirds, marine mammals, and humans. The accumulation of mercury in polar marine ecosystems is of particular concern, as these systems are highly sensitive to mercury pollution. Even low environmental concentrations can negatively affect organisms, especially apex predators at the top of the food chain (King & Riddle, 2001).

Due to its toxicity, mercury is extensively studied in both the abiotic environment and marine organisms. In recent years, numerous studies have examined mercury cycle in polar regions (e.g., Andersson et al., 2008; Agather et al., 2019; Seco et al., 2021; Jonsson et al., 2022; Bank et al., 2023; Cusset et al., 2023; Dastoor et al., 2022; Yurkowski et al., 2023; Galloway et al., 2024; Yang et al., 2024). However, they still provide only a partial picture of this phenomenon, focusing primarily on the total concentration of mercury, whereas it is the form of the metal that determines its bioavailability. Also, the incorporation of mercury into the marine food chain is less frequently addressed (e.g., Hilgendag et al., 2022; Asiedu et al., 2023b; Carrasco et al., 2024), despite the fact that organisms at the base of the trophic chain are crucial for understanding mercury transformation processes in next trophic levels. Plankton, due to its substantial biomass and ability to efficiently absorb mercury from surrounding water, plays a key role in introducing this element into the aquatic food web. As both a primary producer and a fundamental consumer, it represents the first and most important reservoir of mercury in the food chain (Harding et al., 2018; Saniewska, 2019; Jędruch et al., 2024). Plankton is significant because it responds rapidly to environmental changes, including variations in mercury concentrations in the water column, making it a potential bioindicator (Kehrig, 2011; Asiedu, 2023a). Despite its ecological importance, polar plankton—except for krill—has been poorly studied regarding total mercury concentrations, and data on specific mercury forms are even more limited (Morel et al., 1998; Bargagli, 2008). Similarly, research on mercury in benthic organisms in polar regions is scarce and mostly focuses on total mercury (Ali et al., 1997; Guns et al., 1999; Fox et al., 2017). This represents a significant knowledge gap, as it is estimated that over 90% of the 4,000 species inhabiting the Arctic live on the seafloor (arcodiv.org). Benthos, similarly to plankton, plays a crucial role in the incorporation of mercury into the trophic web.

Considering the current state of knowledge, the following research hypotheses have been formulated:

I. Melting glaciers represent an additional source of mercury in polar ecosystems, contributing to elevated mercury concentrations in marine organisms. (**publication 1, publication 3**)
II. The origin of organic matter plays a key role in the bioavailability of mercury associated with it in polar regions. (**publication 1, publication 3**)
III. Organisms occupying the lowest trophic levels play a key roles in the transfer of mercury within the polar food web, and interspecies differences in mercury accumulation levels are primarily driven by variations in behavior and diet. (**publication 2, publication 3**)

The main objective of this doctoral dissertation was to expand the knowledge on the incorporation of mercury into polar ecosystems, including its distribution in organisms at the lowest trophic levels, as well as to determine the influence of environmental factors on mercury concentrations in these organisms and the biomagnification of mercury within the polar food web. Considering that the form of mercury determines its bioavailability, particular emphasis in this study was placed on identifying the specific forms of mercury present in the analyzed samples. Accordingly, the following research objectives were formulated:

I. Identification of mercury concentrations and forms in polar ecosystems (water, sediments, suspended particulated matter, and organisms).
II. Determination of factors influencing the concentration and form of mercury in organisms at the lowest trophic levels of the polar food chain.
III. Identification of factors influencing the incorporation and transfer of mercury at the base of the polar food web.

The achievement of these objectives enabled a more comprehensive understanding of the biogeochemical cycle of mercury in polar regions and allowed for the verification of the research hypotheses.

The research material included samples of seawater, suspended particulate matter, and microplankton from Antarctic, collected in 2018 (**publication 1**) from Admiralty Bay, the largest bay on King George Island, which is recognized as one of the most contaminated areas in maritime Antarctic due to significant human activity and the presence of numerous research stations (**Fig.1A**) (Bargagli et al., 1998, 2007; Santos et al., 2007). The study also included zooplankton samples (*Euphausia superba, Thysanoessa macrura, Themisto gaudichaudii*) from the Western Antarctic Peninsula, collected in 2018 (**Fig.1B**) (**publication 2**). Investigated species are key organisms in the Antarctic food web (Murphy et al., 2007). They are a significant dietary component of various marine organisms like fish, penguins, whales (Panasiuk et al., 2020; McCormack et al., 2021; Wawrzynek-Borejko et al., 2022). The collected material included also surface sediments and benthic organisms from the Arctic (macrophytobentos: *Laminaria digitata*, brittle stars: *Ophiopholis aculeata*, starfish: *Henricia* sp., Sea urchins: *Strongylocentrotus droebachiensis*, and gastropods: *Boccinum glaciale*), collected in 2018 (**publication 3**) from Isfjorden, the second longest fjord in the Svalbard archipelago (**Fig.1C**).

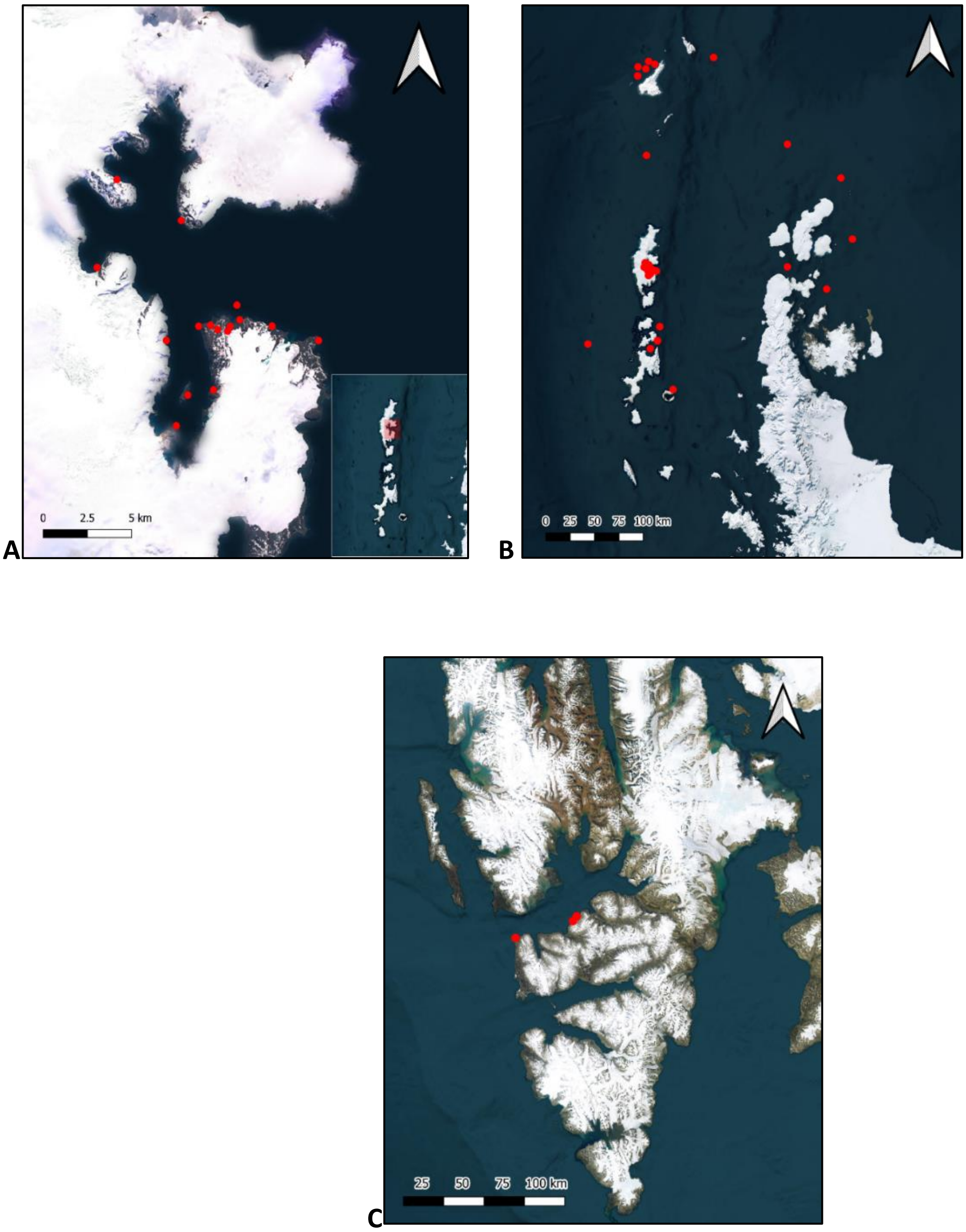

Figure 1 Localization of research stations during expeditions in 2018 in **A** Admiralty Bay, Antarctica (publication 1); **B** west part of Antarctic Peninsula (publication 2); **C** Spitsbergen, Isfjorden, Svalbard Archipelago (publication 3)

Solid samples (suspended particulate matter, sediment, organisms) were analyzed using the **following methods**:

I. Analysis of total mercury concentration (THg) by thermodesorption at 750°C coupled with atomic absorption spectrometry using a DMA-80 analyze (Milestone) (publication 1; publication 2; publication 3).

II. Analysis of labile and stable mercury fraction concentrations (**Table 1**) by a five-step thermodesorption technique in the range from 175°C to 750°C combined with atomic absorption spectrometry (TD-AAS) using a DMA-80 analyzer (Milestone) (developed by

Saniewska & Bełdowska (2017) and modified by Jędruch et al. (2018) and Wilman et al., (2023)) (**publication 1; publication 2; publication 3**).

III. Analysis of methylmercury concentrations by using gas chromatography coupled with atomic fluorescence spectrometry (GC-AFS) on the automated MERX-M methylmercury system (Brooks Rand) (**publication 1; publication 2; publication 3**).

IV. Analyses of organic carbon (C_{ORG}) and total nitrogen (N_{TOT}) concentrations, as well as stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) using a Flash EA 1112 Series Elemental Analyzer coupled with a Delta V Advantage Isotopic Ratio Mass Spectrometer (IRMS) (Thermo Electron Corp.), following the procedure outlined by Koziorowska et al. (2016) (**publication 2; publication 3**), and in some of the samples, according to the method described by Madej et al. (2022), using the HS20–22 Continuous Flow Isotope Ratio Mass Spectrometer (IRMS) (Sercon Limited), coupled with the SL elemental analyzer (Sercon Limited) (**publication 1**).

V. Analysis of basic parameters of the sediment: humidity by freeze-drying to constant weight, organic matter contents based on loss on ignition at 550°C in a muffle furnace (**publication 3**).

Water samples were analyzed using the **following methods**:

I. The analyses of total mercury concentration were performed according to the 1631 method (US EPA, 2002) analyzed via cold vapor atomic fluorescence spectroscopy (CV-AFS) on a Tekran 2600 analyzer (Tekarn Industries Corporation) (**publication 1**).

II. The analyses of the concentration of methylmercury were carried out on an automated methylmercury system MERX-M (Brooks Rand) according to Method 1630 via the atomic fluorescence spectrometry (CV-AFS) method after separation on a chromatography column (GC) (**publication 1**).

Table 1 Mercury fractions released during the thermodesorption method (**publication1; publication 2; publication 3**). (After Kwasigroch et al., 2023).

FRACTION	GROUPS	Hg Compounds	Properties
Hg_{F1}	mercury halides	$HgCl_2$, $HgBr_2$, HgI_2	mercury compounds loosely bound to the matrix surface (adsorbed)
Hg_{F2}	mercury bound to organic matter, as well as other Hg compounds with ligands	$Hg(SCN)_2$, $(CH_3COO)_2Hg$, $Hg(NO_3)_2 \cdot H_2O$, $Hg(ClO_4)_2 \cdot xH_2O$ and MeHg	mercury compounds strongly bound to the matrix (absorbed)
Hg_{F3}	mercury sulfide	HgS	stable fraction, practically not bioavailable
Hg_{F4}	mercury sulfate and mercury oxide	HgO, $HgSO_4$	partially labile mercury compounds
Hg_{F5}	mineral bound mercury	residual fraction	non-specific mercury compounds that are residues from the thermodesorption process

The obtained results allowed to attain the objectives of this dissertation and to verify the research hypotheses. The first research objective, which was **the identification of mercury concentrations and forms in polar ecosystems**, was addressed in **publications 1, 2, and 3**. Mercury concentrations and forms were analyzed at the lowest trophic levels of the pelagic food web—ranging from seawater and suspended matter, through microplankton (**publication 1**) and zooplankton (**publication 2**), to the benthic organisms (**publication 3**). **The dominant form of total mercury in water was dissolved mercury, which is more bioavailable to marine organisms than mercury bound to glacier-origin suspended particles (publication 1;** hypothesis II was partially confirmed). The average total mercury concentration in water samples from creeks, which may reflect runoff from melting glaciers and snow, was 2.5 times higher than in seawater from Admiralty Bay, suggesting that **melting glaciers and snow should be considered additional sources of mercury in the coastal zone of polar regions** (**publication 1;** hypothesis I was partially confirmed). In suspended particulate matter (SPM), the predominant form of mercury was the Hg_{F2} fraction, representing mercury in organic compounds, including methylmercury. The concentration of suspended particulate matter in water from Admiralty Bay decreased with distance from the glacier, which clearly indicates that glaciers were also a significant source of SPM in seawater (**publication 1**). This suspended matter settles near glaciers, which probably was affecting the life of benthic organisms. SPM also plays a key role as a carrier of mercury, particularly in semi-enclosed water systems with high surface runoff, such as Admiralty Bay. In these environments, SPM is significant for the transport and distribution of mercury in water column because the particles can adsorb, absorb, and retain the element, allowing it to move within aquatic systems (Saniewska et al., 2014; 2022). **Microplankton, dominated by diatoms, accumulated mercury more slowly than SPM** (**publication 1**). This suggests that, in addition to mineral suspended matter, the SPM most likely contained nanoplankton (bacteria and cyanobacteria), which stimulated mercury accumulation in the SPM. However, this aspect requires further investigation. **Mercury concentrations in plankton increased with rising mercury levels in water and in SPM, which may suggest a marine origin of the mercury** (**publication 1;** hypothesis I was partially confirmed).

The proportion of methylmercury in total mercury varied depending on the environmental component: it was 1.1% in water, 0.7% in SPM, and 2.4% in microplankton. These results confirm the influence of MeHg production processes in the environment on obtained results. The concentration of methylmercury in water increased with distance from the glacier, suggesting that **methylmercury production in the sea has a greater influence on the concentration of this mercury form at the base of the pelagic food web than melting glaciers and snow** (**publication 1;** hypothesis I was partially disproven). The concentration of methylmercury in SPM also increased with distance from glaciers, indicating that ***in situ* production in the water column was a significant source of this form of mercury in suspended matter, on the other hand, the glacier-generated suspended matter primarily contains the inorganic form of this metal** (**publication 1;** hypothesis II was partially confirmed). A decrease in methylmercury concentration was observed with an increase in microplankton biomass, which confirms that biological dilution of MeHg may have occurred during the intensive growth of organisms.

The median concentration of total mercury in microplankton from Admiralty Bay was 2.5 times higher than the median THg in krill (*Euphausia superba)* from the Antarctic Peninsula (**publication 2**). However, the total mercury concentration in microplankton was comparable to levels recorded in predatory *Themisto gaudichaudii*. Both species (*Euphausia superba* and *Themisto gaudichaudii*) are part of the macrozooplankton and represent the next trophic level in the pelagic food web compared to microplankton, which is dominated by diatoms. Krill exhibited moderate mercury concentrations, which varied depending on age and diet (**publication 2**). In both groups of organisms, the labile forms of mercury, which are potentially bioavailable, predominated. Additionally, **volcanic activity observed in the studied area influenced the proportion of the stable fraction containing HgS in krill** (**publication 2**). This increased the proportion of this fraction, especially in juvenile organisms feeding on algae from sea ice, which during melting can release land-derived particles previously deposited on its surface (hypothesis II was partially confirmed). This confirms the land-based origin of this fraction (Cichecka et al., 2024). In all the studied krill species, the dominant fractions were the labile fractions (Hg_{F1} and Hg_{F2}), with the average contribution of the fraction ranging from 21% in *T. gaudichaudii* to 48% in *E. superba*. Meanwhile, the contribution of the Hg_{F2} fraction averaged from 44% in *E. superba* to 78% in *T. gaudichaudii*. The highest proportion of the Hg_{F2} fraction was observed in the predatory species *T. gaudichaudii*, which may indicate biomagnification of this mercury fraction in the food web. In krill, the contribution of methylmercury in the Hg_{F2} fraction was 31%. **This suggests that not only MeHg, but also other mercury compounds, undergo biomagnification in the marine food web.**

To investigate the entry of mercury into the benthic system, the focus was placed on the most abundant organisms, such as microphytobenthos, echinoderms (starfish, sea urchins, brittle stars), and mollusca (gastropods), as well as on surface sediments, which serve as the environmental background (**publication 3**). **Changes in the total mercury concentration in sediments were dependent on local sources of this metal** (hypothesis II was partially confirmed). The highest concentration of total mercury, five times higher than at the reference (marine) station, was found at station located directly next to seabird colonies and near the remains of Russian coal mine, which likely served as significant secondary sources of mercury in the area (**publication 3**). In contrast, at the station closest to the glacier, the mercury concentration in sediments was lower than at other stations, despite the high content of organic matter (**publication 3**). This suggests that, **although the glacier contributed to the increased organic matter content in the sediments, its impact on mercury levels in the sediments was much smaller compared to the influence of seabird colonies or the remains of the mine** (**publication 3**; hypothesis I was disproven; hypothesis II was partially confirmed). For the studied marine organisms, zoobenthos, the highest total mercury concentration was measured in starfish. The dominant form of mercury was the labile fraction Hg_{F2}, which is potentially bioaccumulative and can be transferred to higher trophic levels (Jędruch et al., 2018). It was observed that the labile fraction of Hg_{F2} increased with trophic level. This occurs because methylmercury is present in this fraction along with other substances. **Based on the results, it is likely that not only methylmercury underwent biomagnification, but also other forms of mercury contained within this fraction.**

Another goal of the study was t**o determine the factors influencing the concentration and form of mercury in organisms from the lowest trophic levels of the polar food web**, which was discussed in **publications 1, 2, and 3**. Literature data suggest that differences in mercury concentration and form between species may result from their diet and size. However, in the case of microplankton — which, alongside suspended matter (likely enriched in nanoplankton), was responsible for the effective incorporation of mercury into the marine food web — the concentration in plankton was 40,000 times higher than in seawater (40×10^3) (**publication 1**). **The source and form of the metal in the environment were significant factors influencing the mercury fractions**. The labile fraction, Hg_{F1}, showed a negative correlation with the concentration of dissolved mercury in seawater and a positive correlation with mercury bound to the SPM. This suggests that this form of mercury was adsorbed on the surface of the microplankton (**publication 1**). Increased microplankton biomass, which provides a larger sorption surface area, increased the proportion of Hg_{F1} in the microplankton, indicating that mercury adsorbs on the available surfaces of plankton (Morel et al., 1998). Additionally, this fraction showed a negative correlation with $\delta^{15}N$, suggesting that **atmospheric sources of nitrogen - isotopically lighter than of marine origin** (Jiskra et al., 2019), **likely transport halogenated (nonorganic) forms of mercury to the sea** (**publication 1**).

At the next level of the pelagic food chain, zooplankton, **factors such as diet, age, and size had a significant impact on mercury concentration and form** (**publication 2**; hypothesis III was partially confirmed). The highest Hg concentrations were found in the species *Themisto gaudichaudii*, which is predatory and thus exposed to higher doses of the metal absorbed with the food. *Euphausia superba* accumulated more metal than the smaller *Thysanoessa macrura* (**publication 2**). In addition to diet, **developmental stage also influenced mercury concentrations in krill**. Juvenile individuals exhibited higher concentrations of mercury and methylmercury compared to adults, which can be attributed to their intense feeding and differences in toxin elimination mechanisms (Coelho et al., 2008; Jędruch et al., 2019; Seco et al., 2019) (**publication 2**). Adult organisms may transfer mercury to their eggs as part of detoxification processes, which may contribute to higher mercury concentrations observed in the youngest stages. This is confirmed by the lower mercury concentration found in the most mature stages of krill (**publication 2**). Furthermore, **dilution with increasing body mass may also contribute to lower mercury concentrations in adult individuals** (hypothesis III was confirmed). Nevertheless, this aspect requires further investigation.

In the benthic food web, the highest mercury concentration was observed in starfish, despite not being at the highest trophic level. This was influenced by their behavior. Starfish are omnivorous, and therefore, they are exposed to higher mercury concentrations accumulated from food compared to other studied benthic organisms. Additionally, **lifespan had a significant impact on the results**. Although gastropods represent the highest trophic level in all studied organisms, their shorter lifespan (about one year) limits their ability to accumulate mercury to the same extent as long-lived starfish, which can live for several decades (Fraussen & Terryn, 2019) (hypothesis III was partially confirmed).

The aim of the study was also to **identify the factors influencing the incorporation and transfer of mercury at the base of the polar marine food web**, as discussed in **publications 1, 2, and 3**. One of the key factors determining mercury incorporation by marine organisms at the initial levels of the food chain was its chemical form. Methylmercury and labile forms of mercury, primarily Hg_{F1} and Hg_{F2}, were more bioavailable to organisms than stable forms of mercury (Bełdowska et al., 2018; Jędruch et al., 2018). **Mercury fractions such as Hg_{F1} can adsorb to the surface of microplankton**, emphasizing the importance of planktonic biomass and available surface area in mercury accumulation processes (hypothesis III was partially confirmed). The bioconcentration factor (BCF) of methylmercury in suspended particulate matter was ten times higher than the average BCF for microplankton (**publication 1**). This is most likely due to the fact that nanoplankton organisms (which can include also bacteria) present in SPM can more effectively methylate Hg than microplankton (Monperrus et al., 2007). A similar trend was observed for total mercury. **In zooplankton, the highest mercury concentration was measured in predatory organisms, suggesting biomagnification of Hg in pelagic food web** (**publication 2**). Methylmercury represented an average of 16% of the total mercury in zooplankton organisms. **The proportion of MeHg decreased with the age of the organisms, suggesting effective demethylation or elimination mechanisms for this form of mercury** (**publication 2**). **An additional factor influencing the decreased proportion of MeHg with age could have been the dilution of concentration with the increase in organism biomass.**

An important factor influencing mercury transfer in the marine food web were the transformations of Hg occurring within the organism (**publication 3**; hypothesis III was partially confirmed). In benthic organisms, the results indicated that starfish were the most contaminated with mercury, with total mercury concentrations at least 10 times higher than in other studied organisms (**publication 3**). However, starfish effectively dealt with the presence of mercury by transporting it to hard tissues. **Starfish and sea urchins showed the highest efficiency in transferring mercury to hard tissues, with starfish transporting about 50% of the total mercury to these tissues** (**publication 3**). In contrast, gastropods were less efficient in detoxifying their bodies from mercury, transferring only about 10% of the THg to the hard tissues, with toxic methylmercury being the dominant form of mercury in their shells. This difference is significant for predatory organisms and Hg transfer to higher levels of the benthic food web, as whether the organisms consume only soft tissues, or the entire organism influences mercury accumulation in the food chain. These observations suggest that **specific biological traits of benthic organisms, such as diet, lifestyle, and detoxification mechanisms, play a key role in mercury accumulation and transfer within polar ecosystems** (**publication 3;** hypothesis III was partially confirmed). Additionally, the presence of labile mercury (including MeHg) in organisms highlights the potential risk of mercury biomagnification at higher trophic levels.

The results obtained in this study allowed for the formulation of the following **conclusions**:

- Mercury in seawater occurred primarily in the dissolved form, making it more bioavailable to marine organisms. Methylmercury accounted for only 1.1% of the total mercury present in the water (**hypothesis II** was verified);
- Melting glaciers and snow, bird colonies, and coal mine served as additional sources of mercury in the coastal zones of polar regions. However, mercury released from these sources differed in bioavailability. Mercury leached from soil next to bird colonies and coal mine quickly settled in sediments, making them a local source of the metal in the benthic food web. No evidence was found that mercury from melting glaciers was effectively incorporated into the pelagic or benthic cycles. This was also confirmed by plankton studies. The concentration of total mercury and methylmercury in plankton increased with rising mercury levels in the water and SPM, which may suggest a marine origin of the mercury (**hypothesis I** was negatively verified);
- The dominant form of mercury in the studied organisms was the labile form (Hg_{F2}), which is potentially bioaccumulative and may be transferred to higher trophic levels. In addition to methylmercury, other mercury compounds incorporated into the tissues of organisms can also undergo biomagnification. This is confirmed by the percentage of MeHg in the Hg_{F2} fraction, which increased with trophic level—from 0.8% in suspended particles to 31% in predatory zooplankton and 58% in zoobenthos (gastropods). This indicates biomagnification of this mercury fraction in both the pelagic and benthic food webs (**hypothesis III** was verified);
- The processes of mercury accumulation and transfer in the food web of polar ecosystems are complex and depend on the specific biological characteristics of the organisms, such as diet, size, lifespan, and detoxification mechanisms (**hypotheses III** was verified);
- A key factor influencing the concentration and form of mercury in benthic organisms was the efficiency of mercury elimination from the organism. Starfish and sea urchins were more effective at transferring mercury to hard tissues than gastropods, which affected further biomagnification in the benthic food web (**hypothesis III** was verified).