Summary

Due to its high toxicity and high mobility in the environment, mercury (Hg) is one of the most hazardous elements that is naturally present in the environment (Kabata-Pendias and Pendias, 1999; UNEP, 2019). Even in low concentrations, it poses a serious threat to living organisms. Mercury causes irreversible damage to the brain and nervous system, as well as cardiovascular system. It also interferes with vital biochemical processes, and exhibits hepatotoxic, embryotoxic, and mutagenic properties (Ariza and Williams, 1999; Choi et al., 2017; Branco et al., 2021). Mercury shows bioaccumulation and biomagnification abilities, which means that organisms at the top of the food chain, including predatory fish, birds, and mammals, but also humans, are particularly sensitive to its harmful effects (Lavoie et al., 2013). Mercury also affects organisms in the lower trophic levels, disrupting their physiology, food intake, digestion, reproduction, and development (Weis, 2014).

One of the most significant sources of mercury pollution in Europe and worldwide is burning of fossil fuels, such as hard coal, lignite, peat, and wood, both in industrial and domestic conditions (EEA, 2019; KOBIZE, 2019). Seas and oceans are the most vulnerable to mercury pollution, which is mainly introduced with rivers and atmospheric deposition (HELCOM, 2021). The Baltic Sea, as a semi-enclosed basin with limited water exchange, a densely populated and heavily human-transformed catchment area, and a large freshwater input, is particularly prone to the inflow and accumulation of pollutants (Reusch et al., 2018; Reckermann et al., 2022). The most important sources of mercury in the Baltic Sea area are coal and metal ore mines, steel and metallurgical industries, paper and saw mills (HELCOM, 2021), but also underwater ammunition dumpsites and shipwrecks (Bełdowski et al., 2019; Zaborska et al., 2019; Jędruch et al., 2023). Mercury enters the Baltic Sea in suspended form, i.e., bound to mineral or organic particles dispersed in water (Saniewska et al., 2014a, b). The main source of these particles is land, especially rivers, coastal erosion (Bełdowska et al., 2016), direct run-off from urban areas (Saniewska et al., 2014a) or groundwater inflow (Szymczycha et al., 2013). In the case of riverine water, mercury associated with suspended particulate matter can account for up to 80% of the total pool of this element (Saniewska et al., 2014b).

Mercury is not biodegradable and the half-life of its compounds in the environment is very long (Gworek et al., 2020). Combined with the slow water retention of the Baltic Sea (Osvath et al., 2001), this means that once introduced, mercury remains in the basin for a long time, moving between living and non-living components of the ecosystem. Although marine bottom sediments are considered as a storage of mercury, it is only temporary one (Tolonen et al., 1988; Zaferani and Biester, 2021). Indeed, in the Baltic Sea, it is estimated that more than half of the mercury can be remobilized and reintroduced into the water column.

(Bełdowski et al., 2009). Remobilization of mercury from sediments is affected by a number of biotic and abiotic processes occurring in the near-bottom zone, such as bioturbation, resuspension, diffusion (Tolonen et al., 1988). Marine sediments play a key role, both as a habitat and a food source for organisms: meio- and benthic macrofauna (Snelgrove, 1997; Jankowska et al., 2015) Due to their ability to accumulate contaminants, including mercury, bottom sediments are an important secondary source of this element in the marine environment, including marine trophic web (Jędruch et al., 2019; Zaborska et al., 2019).

The bioavailability of mercury and its ability to accumulate in organisms depends on its chemical form. The form of mercury is also of key importance in terms of its toxicity (Coulibaly et al., 2016; Duan et al., 2020; Graca et al., 2022). Mercury can enter the body by adsorption onto its surface or penetrate cell membranes by passive or active transport (Pickhardt and Fisher, 2007; Harding et al., 2018). Organic mercury compounds, such as methylmercury (MeHg), easily cross biological membranes and require a long time to be eliminated from tissues. It is due to their strong affinity for lipids and ability to form complexes with sulfhydryl groups (Lawson and Mason, 1998; Lin et al., 2015; Mishra et al., 2017). Methylmercury and other organomercury compounds also undergo effective biomagnification in organisms that constitute successive links in the food chain (Mason et al., 1996; Konieczka et al., 2020). However, organic mercury is not the only form of this element that can accumulate in the tissues (Jędruch et al., 2018; Graca et al., 2022; Korejwo et al., 2022). The chemical form of mercury also affects its transport between components of the ecosystem. In the case of abiotic elements, such as suspended particulate matter or bottom sediments, organic mercury represents a small percentage of total mercury (Siedlewicz et al., 2020; Graca et al., 2022; Saniewska et al., 2022). Under favorable environmental conditions, inorganic forms of mercury can undergo methylation, i.e., conversion to the most hazardous mercury-organic compounds (Sunderland et al., 2004). Taking into account the pool of mercury accumulated over hundreds of years in the sediments of the Baltic Sea (Leipe et al., 2013; Jędruch et al., 2023), identification of the contribution of potentially bioavailable forms of the element is crucial in assessing the health risks to organisms inhabiting the seabed and water column, as well as to humans utilizing marine resources.

The core focus of this dissertation was to fill a cognitive gap in the research on the mobility and bioavailability of mercury deposited in bottom sediments, which represent a key component of the biogeochemical cycle of this element in the marine environment. Therefore, the following **research objectives** were formulated:

i. Estimation of the contribution of coastal erosion to the inflow of labile and stable forms of mercury into the marine environment, using the example of the Gulf of Gdańsk;

ii. Determination of the concentrations of total mercury and its labile and stable forms in suspended particulate matter, depending on its origin;

iii.   Assessment of the horizontal and vertical variability of labile and stable forms of mercury concentrations in Baltic Sea sediments;

iv.   Identification of factors shaping the bioavailability and mobility of mercury in Baltic Sea sediments.

Their implementation allowed for a more complete understanding of geochemical transformations of mercury occurring in bottom sediments, as well as a better ability to evaluate the remobilization potential of mercury and estimate the associated environmental risks, including toxicological ones.

Considering the current state of knowledge, the **hypotheses** were formulated as follows:

i.   Sedimentary material from eroded coastal areas is an important source of labile mercury to the marine environment, with mercury in the form of halides being the dominant form in the suspended particulate matter regardless of its origin;

ii.   The implementation of restrictions on the use and release of mercury into the environment has resulted in a decrease in the concentration of the element in surface sediments of the Baltic Sea. However, regions with high mercury concentrations still exist, posing a potential threat to the ecosystem;

iii.   A significant contribution of mercury accumulated in Baltic Sea sediments is labile and can be reintroduced into the water column and marine food web. The bioavailability and mobility of mercury in sediments are associated, among other factors, with the concentration and type of chemical forms of iron.

The research material consisted of **terrestrial sediments** from coastal areas exposed to erosion, collected in 2011-2013 (**publication 1**) and 2016-2017 (**publication 2**) from the slopes of four active cliffs (Dubrawski and Zawadzka-Kahlau, 2006) located on the western shore of the Gulf of Gdańsk (**Fig. 1**). The study also utilized **suspended particulate matter** from surface layer of the water column and near-bottom water, which were collected during cruises conducted in the years 2011-2013 (**publication 1**) and 2016-2017 (**publication 3**) aboard the research vessel RV Oceania of the Institute of Oceanology, Polish Academy of Sciences. The samples were collected from twenty-one research stations situated in the coastal zone and open waters of the Baltic Sea (**Fig. 1**).

Material also included samples of marine **surface sediments** collected from the research vessel RV Oceania in 2016-2017 at 95 locations in the Baltic Sea (**publication 2**; **publication 3**) and **sediment cores** collected from the hydrographic ship of the Polish Navy ORP Heweliusz in 2017 at four points located in the Gulf of Gdańsk (**publication 4**) (**Fig. 2**).
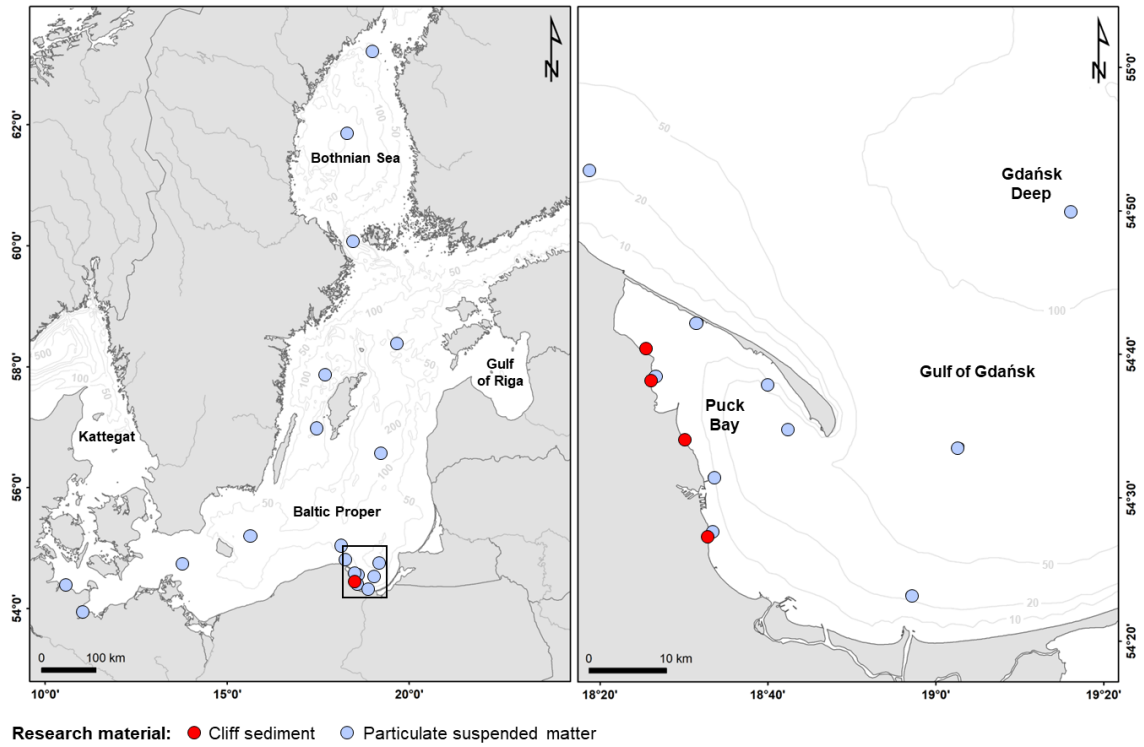
Research material: ● Cliff sediment ● Particulate suspended matter

Figure 1 Location of cliff sediment (**publication 1**; **publication 2**) and suspended particulate matter sampling sites in the Baltic Sea (**publication 1**; **publication 3**) during 2011-2013 and 2016-2017

Research material: ● Surface sediment ● Sediment core
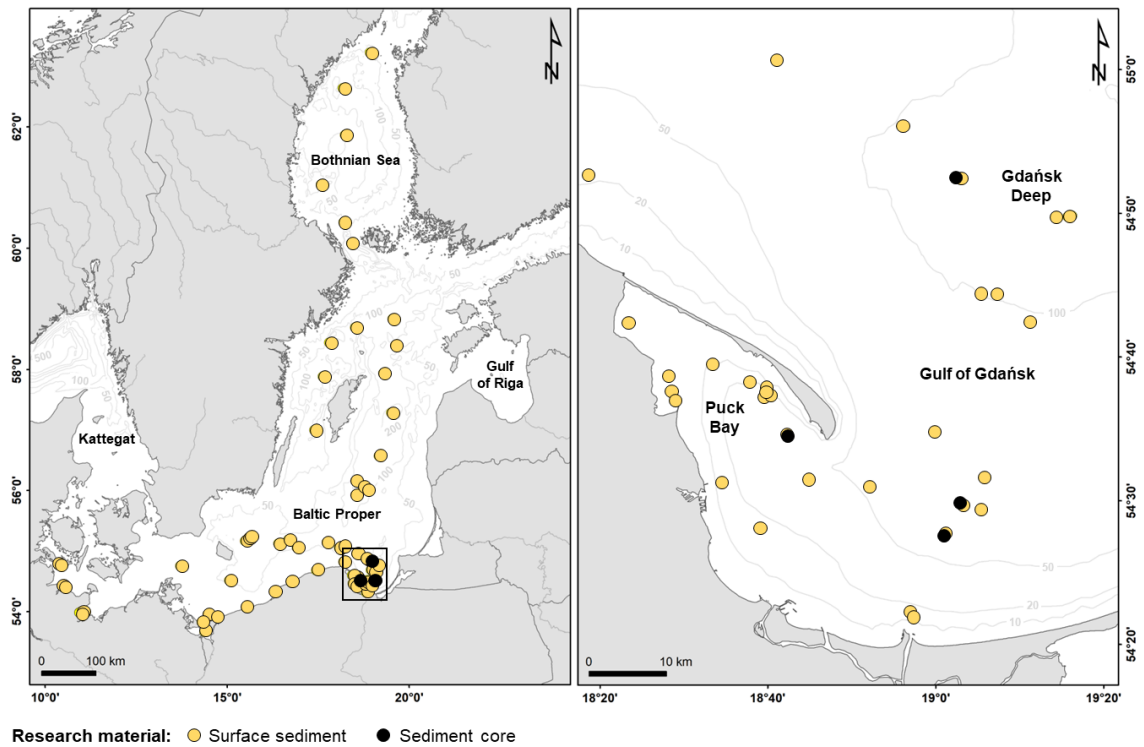
Figure 2 Location of sampling sites for marine surface sediment samples (**publication 2**; **publication 3**) sediment cores in the Baltic Sea (**publication 4**) in years 2016-2017

Sampling of marine sediments was accompanied by measurements of basic environmental parameters at the water-sediment interface: temperature, salinity, pH and reduction-oxidation potential.

Suspended particulate matter and marine sediment samples were analyzed using the **following analytical methods**:

i.   Analysis of total mercury concentration (Hg_{TOT}) using thermodesorption at 750°C coupled with atomic absorption spectrometry (TD-AAS) using an AMA-254 analyzer (Altec) (**publication 1**),

ii. Analysis of organic carbon (C_{ORG}) and total nitrogen (N_{TOT}) concentrations and the ratio of stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) by an elemental analysis technique coupled with isotope array mass spectrometry (EA-IRMS) on a FLASH 2000 analyzer coupled to a Delta V Plus spectrometer (Thermo Scientific) (**publication 1**),

iii. Analysis of total mercury concentration (Hg_{TOT}) by thermodesorption at 750°C coupled with atomic absorption spectrometry using a DMA-80 analyze (Milestone) (**publication 2**; **publication 3**; **publication 4**),

iv. The analysis of labile and stable mercury fractions concentration (**Table 1**) by a five-step thermodesorption technique in the range from 150°C to 750°C developed by Saniewska and Bełdowska (2017) and modified by Bełdowska et al. (2018) combined with atomic absorption spectrometry (TD-AAS) using a DMA-80 analyzer (Milestone) (**publication 2**; **publication 3**; **publication 4**),

v.   Analysis of total iron concentration (Fe_{TOT}) by atomic absorption spectroscopy with flame atomization (FAAS) using an AAnalyst 300 analyzer (Perkin Elmer) after prior mineralization in an Ethos One microwave mineralizer (Milestone) (**publication 4**),

vi. Analysis of iron forms (**Table 2**) by the sequential extraction method described by Zhabina and Volkov (1978) and Poulton and Canfield (2005) using a Cadas 200 UV/VIS spectrometer (HACH LANGE DR6000) (**publication 4**),

vii. Analysis of basic parameters of the sediment: humidity by drying to constant weight at 60°C, loss on ignition at 550°C in a muffle furnace (SNOL), and the granulometric composition of the sediment by sieve analysis using an Analysette 3 screen (Fritsch) (**publication 2**; **publication 3**; **publication 4**).

Table 1 Mercury fractions released during the thermodesorption method (**publication 2**; **publication 3**; **publication 4**) and their physicochemical properties (Zhong and Wang, 2006; Park and Zheng, 2012; Dziok et al., 2017; O'Connor et al., 2019; Graca et al., 2022)

Name	Temperature	Dominant forms of mercury	Physical and chemical properties
Hg_{ADS1}	175°C	Mercury halides ($HgCl_2$, $HgBr_2$, HgI_2, $Hg(CN)_2$)	Water-soluble labile mercury compounds, loosely bound to the matrix surface (adsorption), exhibiting low bioavailability
Hg_{abs}	225°C	Mercury bound to humic substances and organic ligands (($CH_3COO)_2Hg$, $Hg(NO_3)_2 \cdot H_2O$, $Hg(SCN)_2$, $Hg(ClO_4)_2 \cdot xH_2O$), methylmercury (MeHg)	Mercury compounds insoluble in water, soluble in organic solvents, bound to organic matter (absorption), with high bioavailability, especially in the case of MeHg
HgS	325°C	Mercury sulfide (HgS)	Stable, insoluble in water, hardly soluble in concentrated acids, practically not bioavailable
Hg_{ADS2}	475°C	Mercury sulphate and oxide ($HgSO_4$, HgO)	Partially labile mercury compounds, insoluble in water, showing low bioavailability
Hg_{RES}	750°C	Residual mercury	Non-specific mercury compounds that are residues from the thermodesorption process, mercury in minerals (e.g., pyrite), practically not bioavailable

The **obtained results** allowed to achieve the objectives of this dissertation. The first objective of this study, which was to **estimate the contribution of coastal erosion to the inflow of labile and stable forms of mercury into the marine environment, using the example of the Gulf of Gdańsk**, was addressed in **publication 1** and **publication 2**. On the basis of the obtained results, it was found that the destruction of the coastal zone, caused by the interaction of natural and anthropogenic external factors such as storms, other weather phenomena, and engineering works on the cliff slope, significantly affects the concentration of total mercury in suspended particulate matter in the coastal waters of the studied area. The conducted research has shown that these processes can impact an increase in the concentration of total mercury in suspended matter, potentially increasing it up to threefold compared to the typical concentrations of this element in marine suspended matter during the entire study period (**publication 2**). Isotopic analysis has confirmed the terrestrial origin of the suspended matter collected in the coastal zone of the cliff during its intensified erosion (**publication 1**). The concentration of total mercury in the cliff sediments did not exceed the geochemical background level of this element in the Baltic Sea (Leipe et al., 2013), however, it was several times higher than values measured in the surface sediments of the coastal zone of the Gulf of Gdańsk (**publication 1**; Jędruch et al., 2019; Jędruch and Bełdowska, 2020).

Table 2 Iron forms determined by chemical sequential extraction (**publikacja 4**) and their physicochemical properties (Poulton and Canfield, 2005; Manecki and Muszyński, 2008; Górska and Piech, 2018; Linsy et al., 2023)

Name	Extrahent	Dominant forms of iron	Physical and chemical properties
Fe$_S$	Acid chromium chloride solution (hot extraction)	Iron in the form of sulfides, including iron disulfide (FeS$_2$), e.g. pyrite and marcasite; iron monosulfides (FeS), e.g., pyrrhotite and mackinawite	Stable compounds under anaerobic conditions that cause iron accumulation in sediment
Fe$_R$	Hydroxylamine hydrochloride*; Sodium dithionite**; Ammonium oxalate***	Reactive forms of iron, including: amorphous iron hydroxides (FeO(OH)), e.g., ferrihydrite, lepidocrocite (Fe$_{OX1}$)*; Iron oxide hydroxides (FeO, Fe$_2$O$_3$, Fe(OH)$_X$), e.g., goethite, hematite, akaganeite (Fe$_{OX2}$)**; Mixed iron oxides (FeO· Fe$_2$O$_3$), e.g., magnetite (Fe$_{MAG}$)***	Compounds with strong sorption properties towards metals, unstable under reducing conditions, readily react with hydrogen sulfide to form sulfides. Their reactivity decreases in the following order: Fe$_{OX1}$, Fe$_{OX2}$, Fe$_{MAG}$
Fe$_{CARB}$	Sodium acetate	Iron carbonate (FeCO$_3$), e.g., siderite, ankerite	Authigenic minerals formed in reducing sediments containing high concentrations of dissolved inorganic carbon and iron, forming concretions with other iron minerals, such as pyrite and marcasite
Fe$_{PRS}$	Concentrated hydrochloric acid	Iron in clay minerals, including weakly reactive aluminosilicates, e.g., biotite, vermiculite, illite, smectite	Weathering products of rocks on land and diagenesis in marine sediments, the main component of clay sediments, exhibit good sorption properties towards cations, anions, and organic compounds
Fe$_{UN}$	The difference between total iron and the sum of other forms	Non-reactive iron, including iron silicates, e.g., augite	Stable forms of iron that do not react with hydrogen sulfide

Despite the relatively low concentration of mercury in the cliff sediment, the estimated load of this element introduced into the Gulf of Gdańsk through coastal erosion amounted to over 15 kg of mercury per year (**publication 2**). This value is comparable to the load introduced into the basin with wet atmospheric deposition, but exceeds the load of mercury with dry atmospheric deposition and its inflow with small rivers such as Reda, Zagórska Struga, Płutnica, Gizdepka, as well as groundwater discharge (Szymczycha et al., 2013; Bełdowska et al., 2016; Saniewska, 2019; Bełdowska et al., 2022). This is significant as labile forms of mercury accounted on average for more than half (64%) of the total mercury accumulated in cliff sediments (**publication 2**). This means that approximately 10 kg of potentially bioavailable mercury is introduced into the marine environment with eroded sediment annually. This is approximately twice the amount of bioavailable mercury deposited in the water body through atmospheric aerosols (Bełdowska et al., 2016; Korejwo et al., 2020). The

contribution of coastal erosion to the mercury budget in the Gulf of Gdańsk may increase by up to 50% (**publication 2)** in the coming years, as a result of the projected intensification of coastal erosion processes (Różyński and Lin, 2021). Crucially, labile mercury accumulated in cliff sediments enters the water body mainly during extreme hydrometeorological events, which occur several times per year, posing a relatively high stress on organisms inhabiting the marine coastal zone (**publication 1**; Bełdowska et al., 2016).

Another aim of the study was to **determine the concentrations of total mercury and its labile and stable forms in suspended particulate matter, depending on its origin**. **Publication 1** and **publication 3** were dedicated to the accomplishment of this objective. The study showed that mercury concentrations in suspended particulate matter in surface waters of the coastal zone of the Gulf of Gdańsk were about 30%-50% higher compared to concentrations measured in the suspended particulate matter in areas located further from the shore (**publication 1**). This relation suggests that proximity to the shoreline is a key factor influencing mercury concentrations in suspended particulate matter. Analyses of stable isotopes of carbon and nitrogen have shown that, in addition to riverine material, coastal erosion is an important source of allochthonous mercury suspended in the coastal zone of the Gulf of Gdansk. Thus, the concentration of mercury bound to suspended particulate matter in the studied basin increased during periods of spring thaws, flooding, or the so-called 'backwater' phenomenon (**publication 1**). Among the autochthonous sources of suspended mercury in the waters of the Gulf of Gdańsk, a significant importance was attributed to phytoplankton blooms, especially cyanobacteria and diatoms. The highest concentrations of suspended mercury were measured at the Gdynia-Oksywie site, an area under strong anthropogenic pressure, located close to the port, shipyard, and wastewater treatment plant. Also noteworthy are the results obtained south of the Hel Peninsula tip, at Jurata, where the bottom water layer showed increased mercury concentrations in suspended matter, which may be due to resuspension of bottom sediments (Bełdowski et al., 2009). The isotopic composition of the suspended particulate matter in this area suggests the inflow of matter from the open sea, which is confirmed by the patterns of bottom currents in this region (Bradtke et al., 2005; Matciak et al., 2011). The lowest levels of mercury concentration were measured in the suspended particulate matter from western part of the Gotland Basin, which is likely due to the distance from the coast and consequently limited inflow of the element into the Baltic Sea from land (**publication 3**). In the case of deep-water areas such as the Landsort Deep, Gdańsk Deep, and Bornholm Deep, the inflow of mercury associated with suspended particulate matter into the bottom waters was limited by the pycnocline, which hindered vertical mixing of the water masses. The predominant forms of mercury in suspended matter in Baltic waters were labile mercury compounds, mainly mercury halides, loosely bound to the matrix surface (Hg_{ADS1}) and compounds built in organic matter (Hg_{ABS}) (**Table 1**). The proportion of the Hg_{ADS1} fraction in suspended particulate

matter was higher in the open sea compared to the coastal zone (**publication 3**). This is not only related to the lower proportion of organic matter in the suspended particles sampled in areas distant from the coast compared to the coastal zone (**publication 1**), but also to the increasing importance of atmospheric deposition of mercury, including mercury halides, in the offshore zone (Bełdowska et al., 2018; Korejwo et al., 2020).

The aim of the thesis was also to **assess the horizontal and vertical variability of labile and stable forms of mercury concentrations in Baltic Sea sediment**, which was described in **publication 3** and **publication 4**. Based on the conducted research, it was found that the spatial variation in mercury concentration in surface sediments of the Baltic Sea depended on the study area. The highest concentrations of mercury were observed in the Kiel Bay, which is an area under strong anthropogenic pressure due to the presence of a port and a shipyard (**publication 3**). The sediments in the Mecklenburg Bay also showed elevated levels of mercury, which can be attributed to historical disposal of industrial and military waste (Leipe et al., 2013; Bełdowski et al., 2019). In the Arkona Basin, mercury concentrations were about ten times higher compared to the geochemical background level determined for this region by Leipe et al. (2013). One of the main factors influencing this is the Odra River, which is a significant source of pollution in this area (Pempkowiak et al., 2005). Locally elevated mercury concentrations were also found in the sediments of the Bornholm Basin, which is likely a consequence of military activities, including the dumping of chemical and conventional ammunition in this area during World War II (Bełdowski et al., 2019; Siedlewicz et al., 2020). During that time, mercury was commonly used, among others, as an initiating explosive material. Mercury was also present in the fuel that powered or was transported in sunken ships (Gosnell et al., 2020; Hac and Sarna, 2021). Despite spatial variation in total mercury concentrations in Baltic Sea sediments, the dominant form of the element in the surface sediment layer in all studied regions was potentially bioavailable mercury bound to the organic matter. This suggests that surface sediments can act as a secondary source of mercury for marine organisms, especially benthic species closely associated with the seabed (Jędruch et al., 2019). Importantly, Baltic Sea sediments exhibited a relatively high proportion of labile forms of mercury, accounting for approximately 70% of the total mercury pool accumulated in the sediments (**publication 3**). This implies that Baltic Sea sediments serve as a temporary reservoir for mercury, which will eventually re-enter the biogeochemical cycle. The estimated percentage of labile mercury in total mercury in Baltic Sea sediments is also significantly higher compared to previous calculations presented in the study by Bełdowski et al. (2009), which ranged from 20 to 50%. A decrease in total mercury concentration with increasing sediment depth was observed in the investigated sediment profiles (**publication 4**). The exception was the layer between 10 and 20 cm core depth, where elevated concentrations of mercury were found compared to the other layers. These results are consistent with previous studies conducted in the Baltic Sea

region, indicating a similar increase in levels of the element at this depth (Bełdowski and Pempkowiak, 2003; Leipe et al., 2013). The estimated age of this sediment layer indicates that it was deposited during the period between World War II and the 1980s when the European economy experienced rapid development, and the use of mercury in various industries, agriculture, medicine, and everyday life significantly increased (EEA, 2018). In the surface layers of the sediment cores, mercury bound to organic matter was dominant, while in deeper layers, an increase in the contribution of stable mercury sulfide (**Table 1**) was observed. Mercury sulfide was formed under reducing conditions, often in the presence of hydrogen sulfide (**publication 4**).

The studies conducted as part of this research aimed to **investigate the factors shaping the bioavailability and mobility of mercury in Baltic Sea sediments**, which were the focus of **publication 2**, **publication 3** and **publication 4**. In this study, the term 'bioavailability' is used to refer to the fractions of mercury that can be captured and adsorbed or absorbed by organisms in intracellular or extracellular processes (Jędruch et al., 2018; Graca et al., 2022). One of the main factors influencing the bioavailability of mercury was the content of organic matter in the sediments. Its high level had a direct impact not only on the total mercury concentration in the investigated sediments but also on the content of mercury in organic compounds (**publication 2**, **publication 3**, **publication 4**). The sediment type, particularly the content of fractions with a grain size less than 0.063 mm, also had a significant influence on the bioavailability of mercury. Fine-grained sediments exhibited significantly higher concentrations of total mercury and a greater proportion of labile mercury fractions compared to sandy sediments (**publication 3**, **publication 4**). It has also been shown that the improvement of oxygen conditions in the near-bottom water layer, resulting from the inflows from the North Sea, can lead to the oxidation of stable forms of mercury in the sediments. This can result in enhanced remobilization of mercury into the water column and an increase in the bioavailable pool of the element in the marine environment (**publication 3**). It was also found that increase in pH of bottom and pore waters could lead to a lower proportion of mercury bound to organic matter in surface sediments (**publication 4**). In deeper sediment layers and under hypoxic conditions, a decrease in mercury mobility has been observed. This revealed by a decrease in concentration of labile forms and the dominance of stable mercury sulfide. There was no direct impact of total iron concentration on the lability of mercury. However, the analysis of individual iron forms indicated a positive correlation between the presence of reactive iron and the proportion of labile mercury forms (**Table 2**). Additionally, a relationship was observed between the share of mercury halides and the fraction of iron associated with clay minerals, including low-reactivity iron silicates. An increase in the proportion of clay minerals in the sediment led to an increase in the specific surface area of the sediment, accompanied by increased adsorption of mercury halides loosely bound to the surface of the sediment grains (**publication 4**).

Based on the results of the research conducted in this study, the following **conclusions** were formulated:

i.   Sedimentary material from eroded coastal areas was identified as a significant source of labile mercury to the marine environment, including organisms living in the coastal zone (**publication 2**);

ii.   The origin and concentration of mercury in the suspended particulate matter in the waters of the Gulf of Gdańsk varied depending on the location, and was influenced by factors such as surface runoff, primary production, environmental dynamics, and the origin of organic matter. The dominant form of mercury in the suspended particulate matter at all investigated stations were mercury halides (**publication 1**, **publication 3**);

iii.   Labile forms of mercury, including mercury halides, oxides, sulfates, and organic compounds, constituted a significant portion (on average 67%) of the total mercury content in the Baltic Sea sediments. This percentage is higher than previous estimates, indicating the potential remobilization of mercury from sediments (**publication 3**);

iv.   The inflows from the North Sea, which improve oxygen conditions in the near-bottom zone of the Baltic Sea, may contribute to the oxidation of stable forms of mercury in the sediments, transforming them into potentially labile and bioavailable forms. This process can influence the increase of mercury concentration in the water column as well as in the marine food web (**publication 3**);

v.   Despite significant reduction in anthropogenic mercury emissions to the Baltic Sea in recent decades, there are still areas with high concentrations of mercury in surface sediments. This indicates persistent mercury contamination in these areas and highlights the importance of sediments as potential sources of bioavailable mercury, especially in the western regions of the Baltic Sea such as the Belt Sea and Arkona Basin, where mercury concentrations in sediments are the highest (**publication 3**);

vi.   The presence of reactive iron in the sediments of the Gdansk Basin influenced the increase in the proportion of labile forms of mercury, particularly mercury halides and mercury associated with humic substances and organic ligands. Although high content of reactive iron in sediments is typically associated with shallow areas near river mouths, this form can also occur in the clay and colloidal fractions of sediments in accumulation regions (**publication 4**);

viii.   The lack of a distinct relationship between total mercury and total iron concentrations may indicate an anthropogenic origin of mercury in the study area (**publication 4**).