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First record of *Moerisia* cf. *inkermanica* Paltschikowa-Ostroumowa, 1925 (Hydrozoa, Moerisiidae) in the Gulf of Gdańsk (southern Baltic Sea)

Michał Olenycz*, Marcin Kalarus

Abstract
The hydromedusa *Moerisia* cf. *inkermanica* Paltschikowa-Ostroumowa, 1925, native to the Pontocaspian region, was recorded for the first time in the Gulf of Gdańsk, in the waters of the Port of Gdańsk. In August 2024, 78 specimens (2–12 mm) were collected at three research stations. This observation constitutes the second Baltic record of the species and the first in the southern Baltic Sea. While ballast water discharge is the most likely vector for the introduction of the species, the ban on untreated ballast water discharge, which came into effect in 2020, suggests an emerging local population that warrants further investigation.

Keywords
Hydromedusae; Non-native species; Species introduction; Ballast water

Gdynia Maritime University, Roberta de Plelo 20, 80–548, Gdańsk, Poland
***Correspondence**: molenycz@im.umg.edu.pl (M. Olenycz)

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1. Introduction

Since the 19th century, over 120 non-native species have been recorded in the Baltic Sea, of which approximately 80 have established stable populations (HELCOM, 2013; AquaNIS, 2025). Most of these non-native species have appeared in the last 50 years, coinciding with the rapid expansion of international shipping in the region. Maritime transport – particularly the uptake and discharge of ballast water – is considered the primary anthropogenic vector for the introduction of marine organisms (Leppäkoski et al., 2002). Ballast water taken up by ships during cargo unloading may contain adult organisms, eggs, and larvae. The discharge of this water at the next port, during cargo loading, may release these organisms into new environments where, if conditions are favorable, they may establish viable populations (HELCOM, 2014).

An illustrative case in the Gulf of Gdańsk is the round goby (*Neogobius melanostomus* (Pallas, 1814)), native to the Pontocaspian region. First recorded in the Baltic Sea in the early 1990s, it rapidly colonized bays and coastal inlets and is now one of the most abundant fish species (GDEP, 2018a). Another notable invader in the southern Baltic, likely introduced via ballast water, is the Harris mud crab (*Rhithropanopeus harrisii* (Gould, 1841)), native to the northwestern Atlantic (GDEP, 2018b).

Another example of a non-native species is the ctenophore *Mnemiopsis leidyi*. During October and November 2007, large numbers of *M. leidyi* – previously unrecorded in the region – were documented in the Gulf of Gdańsk (Janas and Zgrundo, 2007). Its presence was not limited solely to the Gulf of Gdańsk, as it was common throughout much of the Baltic Sea in late 2007 (Haslob et al., 2007). In Polish waters, it was subsequently recorded twice in the Pomeranian Bay (western part of Polish marine areas) (GDEP, 2018c). The appearance of *M. leidyi* in the Gulf of Gdańsk was most likely not a result of ballast water discharge, but rather the transport of specimens from western regions by sea currents. This is suggested by their large numbers and their widespread distribution in the southern Baltic Sea.

The native gelatinous fauna of the southern Baltic currently comprises two scyphozoan jellyfish, *Aurelia aurita* (Linnaeus, 1758) and *Cyanea capillata* (Linnaeus, 1758), as well as the ctenophore *Mertensia ovum* (Fabricius, 1780). Genetic analyses by Lehtiniemi et al. (2013) indicate that earlier records of *Pleurobrachia pileus* (O. F. Müller, 1776) in the Baltic were likely misidentifications of the morphologically similar *M. ovum*, which is now known to inhabit nearly the entire sea. No other free-living cnidarians occur in the southern Baltic, as the eastward decline in salinity acts as a natural barrier limiting their expansion beyond the western part of the sea.

Moerisia cf. *inkermanica* Paltschikowa-Ostroumowa, 1925 was first recorded in 2024 in the southern Gulf of Gdańsk, representing the first newly documented cnidarian in this region – and more broadly in the southern Baltic Sea – since the appearance of *Mnemiopsis leidyi* in 2007.

M. cf. *inkermanica* had previously been recorded in the Baltic Sea as a one-off occurrence in the summer of 2018 in Vitter Bodden and Greifswalder Bodden (Rügen, Germany) (McKenzie et al., 2022). This species originates from the Pontocaspian region and is native to the Black Sea (Saraber, 1962; Schuchert, 2010). It is characterized by a high tolerance to a wide range of environmental conditions, primarily salinity, temperature, and oxygen concentration, and most often occurs in coastal brackish waters (Schuchert, 2010; Restaino et al., 2018). Over the past several decades, its presence has been recorded in various coastal regions around the world, although these were, typically, one-off occurrences – at Grote Sluis of the North Sea Canal (Netherlands) (Saraber, 1962); Faisqueira River, Antonina Bay (Brazil) (Nogueira and de Oliveira, 2006); Barnegat Bay, New Jersey (USA) (Restaino et al., 2018); and in the ballast waters of oil tankers operating in the Gulf of Mexico (USA) (Ahuatzin-Hernández et al., 2024). This indicates that, despite its easy introduction, this species has low invasive potential and a limited capacity to develop self-sustaining populations in the water bodies where it has been introduced. Studies conducted in 2005 in the area of Gulf of Mexico have shown that medusae of *M.* cf. *inkermanica* can be transported in the ballast waters of ships, which indicates – and is consistent with other evidence – that ballast water is the primary vector of introduction for this species (Ahuatzin-Hernández et al., 2024).

This study documents the first occurrence of *M.* cf. *inkermanica* in the southern Baltic Sea based on specimens collected during monitoring of marine non-indigenous species in the Port of Gdańsk. This unexpected finding prompted further investigation. Accordingly, we provide morphological evidence supporting the species' taxonomic identification and explore plausible scenarios regarding its origin and potential establishment in the region. Al-

Figure 1. Location of sampling stations in the area of the Port of Gdańsk, where medusae of *Moerisia* cf. *inkermanica* Paltschikowa-Ostroumowa, 1925 were found.

though we did not formulate formal hypotheses a priori, we evaluated whether the observed hydromedusae represent an isolated introduction event or the emergence of a self-sustaining local population.

2. Material and methods

2.1 Sampling and identification

The presence of *M.* cf. *inkermanica* in the Gulf of Gdańsk was recorded in August 2024, during a non-indigenous species monitoring program conducted in the waters of the Port of Gdańsk, which was aimed at detecting alien species of microorganisms, plankton, benthos, and fouling organisms.

The Port of Gdańsk lies in the southern Gulf of Gdańsk, a semi-enclosed basin strongly influenced by freshwater inflow from the Vistula River. Water temperature ranges from below 0°C in winter to over 20°C in summer (Kruk-Dowgiałło and Szaniawska 2008). Mean surface salinity is approximately 7.0 PSU, with seasonal lows near 5.5 PSU in spring (high river discharge) and highs around 8.0 PSU in summer (peak evaporation) (Janecki et al., 2021).

The medusae of *M.* cf. *inkermanica* were detected during a plankton sampling carried out in May and August 2024 at three stations within the port's administrative boundaries (Figure 1). Stations W1 and W3 were located in the port channel – the upper section of the Dead Vistula (Martwa Wisła) – while station Z4 lay in the area open to the Gulf of Gdańsk. Stations W3 and Z4 were positioned near the cargo handling areas: for coal, LPG, and containers (station Z4); and for barley and malt (station W3). Station W1 was located in the port channel, away from cargo handling zones.

At each station, a plankton sample was collected by performing a single vertical haul (from the bottom to the water surface) using a 100 µm mesh size WP2 net, followed by an additional haul with a 300 µm net. WP2 nets were equipped with flowmeters to measure the volume of water filtered during sampling. The collected samples were preserved in formalin solution (final concentration 4%) and subsequently subjected to microscopic examination.

The medusae present in the samples were separated and photographed, with particular attention paid to their diagnostic morphological features. The taxonomic identification followed Schuchert (2010) as well as photographic documentation of the distinctive taxonomic features (e.g. number of tentacles, gonads position, nematocysts position, perradial lobes shape, manubrium shape and size) provided by Nogueira and de Oliveira (2006) and Ahuatzin-Hernández et al. (2024).

The monitoring also included the study of fouling organisms, which could also lead to the identification of *M. c*f. *inkermanica* polyps. For this purpose, square PVC plates were placed underwater near the sampling stations at depths of 1, 3, and 7 m. The plates remained submerged for 5 months (early April – early September 2024). After retrieval, they were frozen at –20°C and subsequently analysed morphologically under a microscope.

3. Results and discussion

Table 1 provides data on the number of specimens found at each station and information on environmental conditions, including water salinity, temperature, and oxygen levels during sampling. While medusae of *M.* cf. *inkermanica* were found at each station and in each haul, the highest abundance of specimens was recorded at station W1.

For comparison, in May, salinity levels at stations Z4, W1, and W3 were lower than in August, measuring 6.3, 6.2, and 4.7 PSU, respectively. As typical for the spring season, seawater temperatures were also lower – 12.0, 11.8, and 13.3°C – while dissolved oxygen concentrations were higher: 9.9, 10.2, and 9.7 mg dm^{-3}, respectively.

Stations W1 and W3 exhibited significantly lower salinity in May compared with station Z4 and with the overall values recorded in August. These stations were located in the upper section of the Dead Vistula, which in May was still under the influence of seasonally elevated discharge from the Vistula River driven by typical spring precipitation across its basin. By August, salinity levels at W1 and W3 closely matched those measured at station Z4.

No polyps of *M.* cf. *inkermanica*, other hydrozoans, or gelatinous plankton were found on the plates retrieved in September from any of the stations.

Table 1. Number of specimens and abundance of *Moerisia* cf. *inkermanica* Paltschikowa-Ostroumowa, 1925 and environmental conditions during sampling in August 2024.

Sampling station	Depth [m]	Number of *M.* cf. *inkermanica* specimens caught		Calculated abundance of *M.* cf. *inkermanica* [ind. m^{-3}]		Max depth [m]	Mean water salinity	Mean water temperature [°C]	Mean water oxygen concentration [mg dm^{-3}]
		100 µm	300 µm	100 µm	300 µm				
Z4	11.5	4	11	0.8	2.3	11.4	6.8	21.7	8.2
W1	10.9	27	24	5.8	5.5	11.9	6.8	21.7	8.6
W3	6.5	9	3	3.0	1.1	11.5	6.7	21.4	6.9

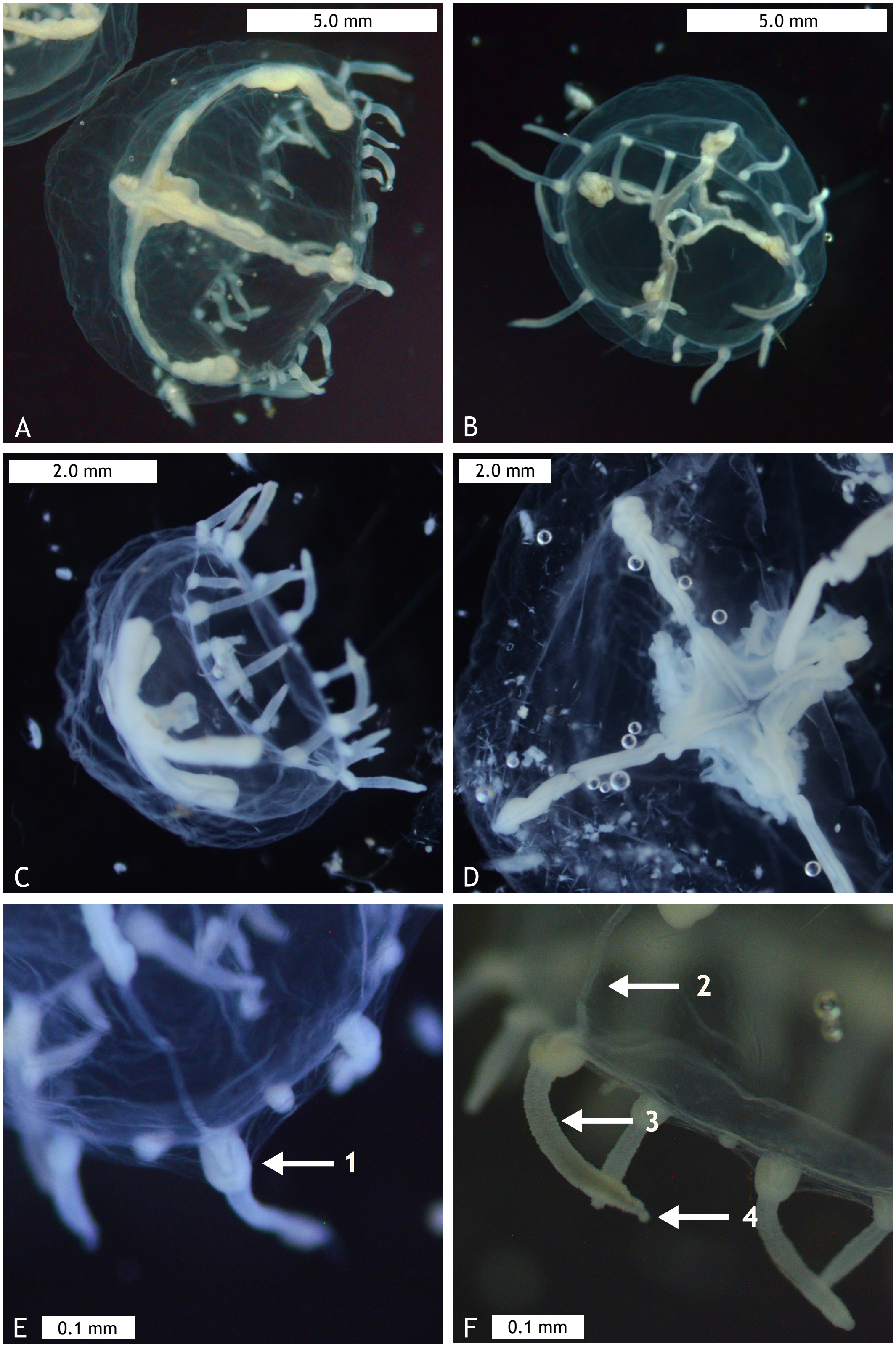

Figure 2. Specimens of *Moerisia* cf. *inkermanica* Paltschikowa-Ostroumowa, 1925 observed during the plankton sampling conducted in August 2024 in the Gulf of Gdańsk. A–B) Aboral and oral view of mature specimens; C) Side view of juvenile specimen – not fully developed perradial lobes; D) Aboral view of basal plate of manubrium; E) Oval clasping tentacle bulb (1); F) Visible radial canal (2), moniliform tentacle (3) with a terminal nematocyst knob visible at the tentacle margin (4), tentacles at different development stages visible at umbrella margin.

3.1 Morphological description

The diameter of the umbrella of collected individuals was always slightly greater than the height. The smallest individual had a diameter of 2.0 mm, and the largest 12.0 mm (mean 5.69 mm ± 2.27) and 1.7 mm and 10.2 mm height, respectively (mean 4.84 mm ± 1.93). It should be noted that the size of the measured specimens may have been affected by fixation in formaldehyde, which can cause slight shrinkage. A thick layer of mesoglea was visible. The manubrium, ending with a narrow oral aperture, was elongated (not exceeding half the length of the subumbrellar cavity) (Figure 2A–D). In some individuals, a poorly developed fold divided into four parts was visible around the oral aperture. The small base of the manubrium was square-shaped. From the base of the manubrium, four open, straight perradial canals extended without any branching or diverticula. In the proximal part, the groove of the canal was wider and narrowed toward the edge of the umbrella. Swollen perradial lobes were present along the edges of the radial canals. Pale yellow gonads were visible on the manubrium and the perradial lobes. In the largest individuals, the perradial lobes extended almost to the edge of the umbrella, with a pendent sac-like, distal part (Figure 2A). Long perradial lobes with gonads and a quadrate manubrium are characteristics of the family Moerisiidae. The edge of the umbrella was simple and unnotched. The marginal canal connected to the radial canals was visible along its boundary (Figure 2E–F). Thin vellum covered up to 1/4 of the subumbrellar cavity. The number of moniliform tentacles along the umbrella's margin ranged from 6 to 28 (14–16 in most specimens). A single tentacle per bulb is another characteristic morphological feature of the family Moerisiidae. The lowest number of tentacles was observed in the smallest individuals (umbrella diameters of 2–4 mm). Tentacles in various stages of development were visible in some specimens. The tentacles were covered with nematocysts arranged in densely packed rings. The distal end of well-developed tentacles bore a terminal knob (Figure 2F). No tentacles were present on the manubrium.

3.2 Remarks

In the samples collected in May, no medusae of *M.* cf. *inkermanica* were detected; however, in August, they were present at each station.

Interestingly, the largest *M.* cf. *inkermanica* medusae captured in these studies were larger than those reported by Schuchert (2010) – who described a maximum diameter of 6.5 mm, typically 4–6 mm – and larger than the measurements taken on individuals obtained from tankers in the Gulf of Mexico – max 6.5 mm (Ahuatzin-Hernández et al., 2024) and from Antonina Bay, Brazil – max 5 mm (Nogueira and de Oliveira, 2006).

Morphological analysis did not reveal the presence of ocelli in the analysed specimens, which are a diagnostic character at the family level (Schuchert, 2010). The absence of ocelli is attributed to the deterioration of the specimens caused by the age of the samples and the fixation method.

3.3 Possible introduction routes

A single sampling event does not allow for determining whether the observed *M.* cf. *inkermanica* medusae derive from an established population in the southern part of the Gulf of Gdańsk. Nevertheless, two factors suggest that a population is likely to be present. First, since 2020, the Baltic Sea has been subject to provisions of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (the BWM Convention), as implemented under national law, which prohibits the discharge of untreated ballast water by ships arriving from outside the Baltic Sea. It is therefore very unlikely that the presence of *M.* cf. *inkermanica* medusae in 2024 is the result of ballast water discharges that occurred within a short period before sampling. However, it is possible that this species was introduced before the implementation of the BWM Convention (i.e., before 2020) and subsequently developed a sustained population in the port area over the following years. The species could have remained undetected during that time, as no zooplankton monitoring is conducted in the Port of Gdańsk or, more generally, in this part of the Gulf of Gdańsk. Due to their small body size, hydromedusae are very difficult to detect visually in the water column, even when occurring in surface waters.

Alternatively, *M.* cf. *inkermanica* medusae may have been transported from other regions of the Baltic Sea by marine currents. Wind drives circulation in the Baltic Sea, while air pressure and density gradients contribute to secondary flow patterns (Myrberg and Lehmann, 2013). Prevailing southwestern winds typically create counterclockwise circulation in the Baltic (Liblik et al., 2022). Along the Polish coast, this wind-driven surface current moves eastward toward the Hel Peninsula before veering south into the Gulf of Gdańsk (Jasińska and Massel, 2003).

A similar mechanism explained the 2007 mass occurrence of *Mnemiopsis leidyi* when strong currents carried specimens from western Baltic populations into the Gulf of Gdańsk (Lehmann and Javidpour, 2010). This mechanism is probably not responsible for the appearance of *M.* cf. *inkermanica*, as it has not been recorded in the Baltic since 2018 in any zooplankton monitoring programme. In the absence of a known donor population, current-mediated transport alone cannot account for the sudden appearance of these hydromedusae in 2024. Continuous monitoring and targeted surveys are needed to rule out alternative introduction pathways.

Can we then consider the occurrence of *M.* cf. *inkermanica* in the southern Gulf of Gdańsk as an indicator of a developing population? If so, why were they not present in the samples collected in May 2024?

The explanation for this situation may lie in the life cycle of *M.* cf. *inkermanica*. We may hypothesize that no medusae of *M.* cf. *inkermanica* were observed in mid-May because the samples were collected at a time when medusae were absent in the water, as the release of medusae from polyps had not yet begun. For example, the strobilation process of *A. aurita* polyps – a common scyphozoan in the Baltic Sea – is triggered by water temperature shift in the spring (Jensen et al., 2023). *A. aurita* medusae appear in the Gulf of Gdańsk in June and occur commonly until the end of November (Olenycz, 2015; Brulińska et al., 2016). By analogy, no medusae of *M.* cf. *inkermanica* were found in May because the samples were collected at a time when medusae were absent, as the process of medusae release from the polyps had not yet begun. That may be a far-reaching assumption and needs more data to validate, as *A. aurita* and *M.* cf. *inkermanica* belong to different Medusozoa classes and can exhibit significant differences in their life cycle and ecological roles. However, studies done in Upper San Francisco Estuary (U.S.A) show that occurrence of *Moerisia* sp. medusae is strongly correlated with seasonal changes of water temperature (Wintzer et al., 2011). The authors of the cited studies found that medusae of *Moerisia* sp. were present in Upper San Francisco Estuary only in summer months – from June to September, when water temperature exceeded 17°C, with highest abundances in August and September when water temperature was the highest. Water temperature was positively related to abundance of medusae – largest biomass was found in August and September, when water temperature reached its highest values. On a theoretical assumption that *M.* cf. *inkermanica* developed a stable population in the southern part of the Gulf of Gdańsk, the absence of its medusae in May can be explained by unfavourable water temperature conditions (11.8–13.3°C). Rising temperatures in the following months initiated the process of polyps budding, which led to medusae presence in the water in August.

Despite the inclusion of fouling organisms in the monitoring of non-indigenous species in the Port of Gdańsk, no *M.* cf. *inkermanica* polyps were detected. This is most likely due to the methodology employed, which was based on the inspection of settlement plates placed at selected locations within the port waters. Even though the surface area of the plates provided a suitable substrate for the development of polyp colonies, the timing of the study may not have been optimal for this species. The surveys of fouling organisms on the settlement plates were carried out from early April to early September – on the assumption that polyp recruitment occurs in other months, settlement would therefore have taken place before or after this period. Under these circumstances, it was not possible for the inspections to reveal the presence of *M.* cf. *inkermanica* polyps on the plates.

Another possible explanation for the presence of the *M.* cf. *inkermanica* medusae in the southern part of the Gulf of Gdańsk may be their production from polyps colonizing the hulls of ships arriving at the Port of Gdańsk from regions where *M.* cf. *inkermanica* occurs natively. Such an explanation was proposed by Sarber (1962) for medusae of *M.* cf. *inkermanica* found in Dutch waters. The polyps are considerably more tolerant to environmental variability and can survive across a broader range of temperature (0–30°C) and salinity (0.5–4%) than medusae, whose recruitment occurs under narrowly defined conditions (Schuchert, 2010). It is therefore possible that polyps of *M.* cf. *inkermanica* growing on a ship's hull reached the Gulf of Gdańsk during a period favourable for medusae production. In August, the Gulf's waters reach their maximum temperatures, which favours the onset of medusa production (ibidem). If subsequent iterations of the Port of Gdańsk's non-native species monitoring program do not detect medusae of *M.* cf. *inkermanica*, their appearance in 2024 – as a result of polyps inhabiting ship hulls – would be the most plausible explanation.

4. Conclusion

The above considerations do not provide a definitive answer as to whether the *M.* cf. *inkermanica medusae* observed in August are part of a developing population of this hydrozoan in the southern Gulf of Gdańsk. However, they do not rule out that possibility; therefore, further targeted studies are needed to confirm this possibility.

Monitoring studies have revealed the presence of a new Hydrozoa species in the Gulf of Gdańsk. Future iterations of non-indigenous species monitoring in the Port of Gdańsk should be adjusted to enable a thorough investigation of the occurrence and population dynamics of *M.* cf. *inkermanica medusae*. Particularly important is the identification of polyp presence, which requires spatial and temporal expansion of fouling organisms monitoring.

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Conflict of interest

None declared.

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