

Recognition of the vibriosis risk in Polish coastal waters of the Baltic Sea and public engagement in its mitigation

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Abstract: The surface water temperature in the Baltic Sea has been growing as a consequence of broader changes of the Earth's climate, which contributes to the proliferation of natural bacterioplankton and new types of bacteria, such as *Vibrio vulnificus*, in the region. This pathogenic bacterium finds optimal conditions for growth primarily in warm brackish waters. Places particularly vulnerable to these bacteria include shallow Baltic coastal waters where the proliferation of *Vibrio* strains increases in summer. The growing temperature of coastal waters boost this phenomenon, posing a serious threat to human health and the coastal Baltic tourism.

The BaltVib project implemented by marine microbiologists investigates the impact of the so-called “system engineers”, e.g. mussels, macroalgae, and seagrass, on the diversity and abundance of vibriosis. The research should help to develop strategies to mitigate the problem of excessive populations of vibriosis through nature-based solutions.

In addition to environmental and health issues, public awareness of the phenomena and future threats are equally important and these are also addressed in the project. The article presents results of a survey conducted on the Polish coast involving 140 respondents interviewed concerning their awareness of the increasing population of pathogenic vibriosis. The survey helped to diagnose how local residents perceive the threat to human health posed by *Vibrio vulnificus* now and in the future, as well as possible impacts these bacteria might have on economic use of the coastal waters. The survey also investigated the level of acceptance for various methods used to mitigate negative environmental changes.

Keywords: bacterioplankton, Baltic Sea coast, climate change, mitigation measures, Natural based Solutions, Polish case, public awareness, *Vibrio vulnificus*

INTRODUCTION

Climate change and progressing eutrophication of the Baltic Sea contribute to changes in salinity, oxygenation and water temperature. Over the next 100 years, the average water temperature is expected to increase by 2–4°C (e.g. Kabel *et al.*, 2012), and the water salinity is expected to become even lower because of the increased precipitation and river discharges (e.g. Meier, 2006). These changes are expected to impact both the community composition and the ecosystem functions at all trophic levels in the Baltic Sea. As a result, they are likely to lead to the abundance of potentially pathogenic *Vibrio* bacteria.

Vibrio bacteria are present in all marine ecosystems and they are found in coastal, estuarine, brackish and fresh waters, as well as in sediments, often in association with higher organisms. The genus *Vibrio* contains approximately 130 described species and dozens of these have been demonstrated to cause infections in humans, fish or mussels (e.g. Sakar *et al.*, 1985; Baker-Austin *et al.*, 2017). *V. cholerae*, *V. vulnificus*, *V. parahaemolyticus*, and *V. alginolyticus* are four most important pathogenic *Vibrio* species (Baker-Austin *et al.*, 2017). These organisms are common pathogens in marine and estuarine waters, sediments and plankton and they can cause infections in humans, usually through the consumption of raw seafood or direct contact with marine or brackish waters (Amato 2022, CDC, no date).

It is expected that an increase in water temperature in the Baltic Sea will lead to an increase in the population density of *Vibrio* species, especially of the pathogenic kind (Hartnell *et al.*, 2018). Given that the coast of the Baltic Sea is used intensively as a tourist destination, special attention should be paid to *V. vulnificus*, which not only can cause skin infections but also lead to sepsis in human bodies. Although only a small number of infections are associated with *V. vulnificus*, infections caused by these bacteria could be, indeed, dangerous for humans as this species contributes to one of the highest mortality rates of any bacterial pathogen. To illustrate the scale of the potential problem, data from the Center for Disease Control (CDC) in the United States come useful (Newton *et al.*, 2010). According to these data, about 80,000 cases of vibriosis occur in the United States every year, while about 500 of these infections require hospitalization and about 100 cases lead to death (CDC, no date).

The unmonitored increase in the potentially pathogenic *Vibrio* bacteria can have a negative influence on local communities and economies around the Baltic Sea, especially through hampering the tourism industries in coastal regions. The impact on tourism may not necessarily stem from the actual number of infections, as these are rare, but rather from the threatening narratives¹ that arise around individual cases and are widely disseminated by social and traditional media. Such narratives may cause unnecessary panic among people visiting seaside resorts and beaches. Examples of the above have been seen in the Polish media. Although the Polish media had mainly reported cases from the German coast – as there was only one incident in Poland unrelated to the sea used for recreation – some concerns are present among local authorities and stakeholders involved in the coast-oriented business, and especially within the tourism industry.

The main goals of this study include: (i) assessment and evaluation of the levels of *Vibrio*-related concerns and, (ii) assessment of the awareness among relevant stakeholders on the *Vibrio*-related threat(s). Our study also explores ‘if’ and ‘how’ environmental concerns – risen predominantly by the environmental scientists in relation to the increase of the *Vibrio* bacteria – are reflected or perceived by stakeholders along the Polish coast. Finally, we also investigate what managerial and economic responses to the *Vibrio* problem are expected or are acceptable by the majority of stakeholders representing the tourism sector.

STUDY MATERIALS AND METHODS

The study uses a quantitative approach, i.e. the on-line survey, in order to investigate opinions and levels of knowledge on the potentially pathogenic *Vibrio* bacteria among local stakeholders along the Polish coast of the Baltic Sea. The survey was addressed to stakeholders representing the tourism sector from two

¹ Such exaggerated narratives are common and are present in all press articles concerning *Vibrio* bacteria we have evaluated under the BaltVib project. It should, however, be noted that the media analysis was not by any means comprehensive. It rather served the purpose of getting a general overview on how the issue of *Vibrio* has been presented and discussed outside the scientific community.

distinctive regions on the Polish coast, i.e. (i) Szczecin Lagoon and the Pomeranian Bay in the Zachodniopomorskie Voivodship, and (ii) Gulf of Gdańsk in the Pomorskie Voivodship. In addition, the design of the survey allowed to differentiate between stakeholders who were familiar (or knowledgeable) with the *Vibrio* occurrence and *Vibrio*-related threats prior to their participation in the study and those who were not.

The two geographical regions were selected based on the occurrence of *Vibrio* by the ECDC Geoportal (Fig. 1) run by the European Centre for Disease Prevention and Control (ECDC).

All together 140 responses were collected from the stakeholders representing the tourism industry. Fishery Local Action Groups (FLAGs) were asked to disseminate information about the survey among potential participants who were expected to have relatively little knowledge about the *Vibrio* bacteria but could demonstrate relatively high vulnerability to the effects of the increasing number of the pathogenic *Vibrio*. We specifically focused on representatives of the tourism sector, i.e. owners of local businesses, in order to assess how *Vibrio* is perceived by local communities whose social and economic well-being depends on marine resources. The on-line survey (see “Supplementary material” for details) consisted of 30² mainly close-ended questions related to the two overarching themes, i.e. (i) *Vibrio* bacteria, and (ii) nature-based solutions (NbS) that could be used to address *Vibrio*-related problems. For the respondents, who declared no knowledge on the pathogenic *Vibrio* bacteria and NbS, short explanations were provided. Such an approach allowed to explore views based on information provided³ instead of evaluating first-hand experiences.

The development of the on-line survey was preceded by information collected during a dedicated workshop and semi-structured interviews with representatives of institutions responsible for the environmental protection, management of the sea, and public health. Not only were these experts expected to be more interested in the results of the BaltVib project, i.e., facilitating practical implementation of solutions developed within the project, but they could provide information on how the *Vibrio* threat was perceived and managed at the national level. The results of these two lines of research were the basis for the awareness study among representatives of the tourism sector. Hence, these results are shortly summarized below.

The interactive workshop consisted of short discussion sessions which were designed to gather more qualitative insights into the perception of the *Vibrio* bacteria as a possible environmental and public health threat. The major findings indicate that the current growth of pathogenic *V. vulnificus* populations is not yet perceived as a public (health) problem. Together with other *Vibrio spp.*, these bacteria are rarely monitored without distinc-

² Not all respondents were expected to reply to all questions. Some of the questions were omitted based on replies provided by an individual respondent. The survey did not directly assess the perception of the media narratives and emphasised environmental angle of the study reflecting the original setting of the BaltVib project itself.

³ At least to some extent, such a format allowed to evaluate how information shapes public opinion regarding *Vibrio*. In other words, it was possible to get some insight into which stakeholders (those with pre-existing knowledge or without it) demonstrate a higher level of concern towards the pathogenic *Vibrio*.

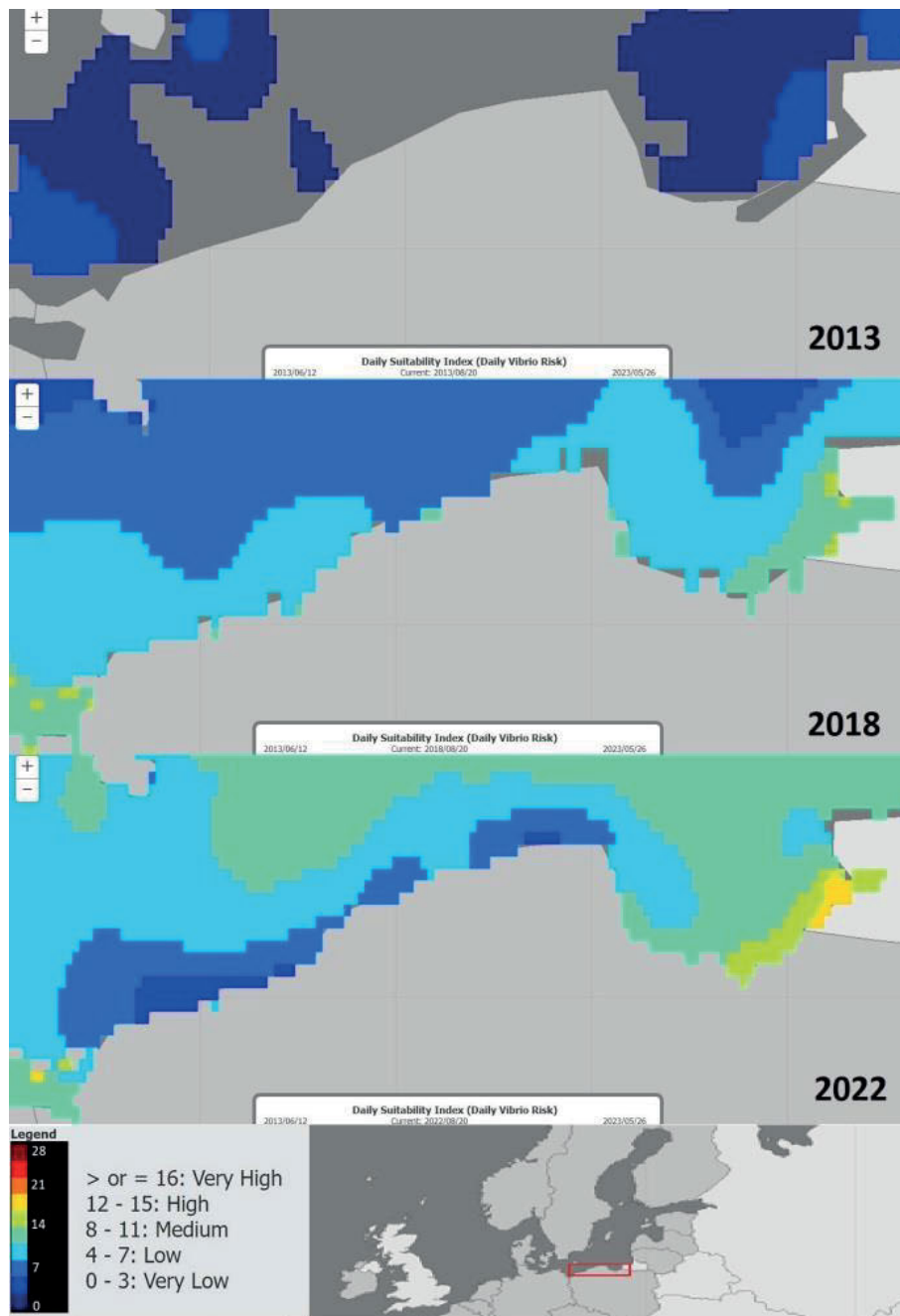


Fig. 1. Spatial distribution of *Vibrio* spp. on the Polish coast of the Baltic Sea on August 20th 2013, 2018 and 2022 demonstrating the increase of *Vibrio* density during the last ten years; source: ECDC Geportal

tion of particular species. The results of semi-structured interviews confirm these from the workshop. Regional authorities follow governmental guidelines concerning *Vibrio* monitoring, and the monitoring program will only get expanded if deemed necessary in the future. A small number of laboratories with the capacity to determine *Vibrio* species is pointed out as a major problem to expand surveillance of the pathogens in question. Although the bacteria are not deemed to be a pressing problem, a concise information for the public and health care professionals was developed (Wołkiewicz, 2019), describing new risk factors for *V. vulnificus* infections in immunocompromised individuals, as well as some mitigation measures were proposed. This suggested

that the problem could become more severe in the future and some preparations to address it are already needed.

Finally, there are two major limitations concerning the study. Firstly, there was a relatively low recognition of the problem (i.e. both related to the *Vibrio* bacteria and the NbS) among our respondents. Secondly, an uneven distribution of the respondents among geographical regions makes the comparison difficult and, therefore, any generalizations should be made with caution. Not surprisingly, the region with a higher number of responses was more affected by the problem in the past and was characterized by the higher level of awareness concerning the *Vibrio* problem.

RESULTS AND DISCUSSION

We have collected 140 responses from both geographical regions. Eighty-five replies were received from respondents representing the Zachodniopomorskie Voivodeship (61%) and fifty-five (39%) from the Pomorskie Voivodeship (Fig. 2). Fifty-four percent of all respondents in both regions were familiar with the problem of the *Vibrio* bacteria, while this number was significantly higher in Zachodniopomorskie (79%) when compared with Pomorskie (15%). This may stem from the fact that the first case of *V. Vulnificus* infection in Poland was diagnosed in the Zachodniopomorskie Voivodeship, but we also suggest that the proximity to the German border, where more cases occurred and were diagnosed, might have played certain role in spreading the information.

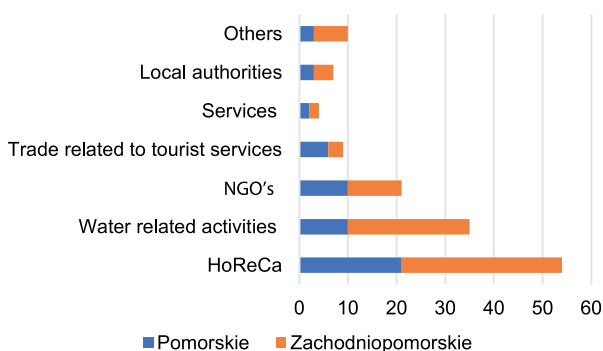


Fig. 2. Sectors represented by respondents by region; source: own study

We need to determine the origin of the knowledge about *Vibrio*. The majority of respondents (Fig. 3)⁴ pointed to social media and the broadly defined “Internet” (61 indications; 48%) as their major information sources. New media were followed by the

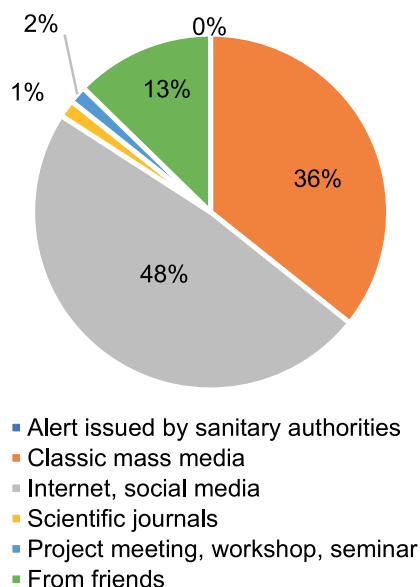


Fig. 3. Sources of information about *Vibrio* bacteria; source: own study

⁴ The question about the source of information about *Vibrio* resulted in several responses. Individual indications were analysed, so the number of responses is larger than the number of survey participants.

traditional mass-media (45 indications; 36%), and hearsay, i.e. information heard during conversations with friends or colleagues (16 indications; 13%). Only two replies specified information obtained from other sources, including scientific publications or seminars (4%). Alerts issued by relevant authorities were not selected even once. In our opinion, these results are in line with the concerns expressed by the representatives of the managing institutions that there is lack of adequate monitoring and diagnostics to identify *Vibrio* as the cause of the infection. Hence, no alarms were (and can be) issued and there would be no justification for them.

The occurrence of the *Vibrio* bacteria in the Polish coastal waters was indicated as a serious threat by half of the respondents. Among these respondents, who had previously had at least some knowledge about *Vibrio* (Fig. 4a), 35% assessed the threat as important. No stakeholders in this group considered the threat as very important. The respondents who had only received information about *Vibrio* during the survey expressed much higher concerns (Fig. 4b), i.e. 56% of them considered *Vibrio* as important and to further 11% it was even more significant. The differences between these groups were remarkable, which can be interpreted as an impulsive reaction to learning about the threat among those, who were not previously confronted with information about *Vibrio*.

Fifty-seven percent of our respondents predicted that the problem of the excessive growth of *Vibrio* bacteria will become more significant in the future, while 3% saw no such possibility. Forty percent did not have a clear opinion on the issue. The tourism (32%) and health care (16%) sectors were considered to be the most vulnerable to the presence of these bacteria in the Polish coastal waters. On the other hand, there was a relatively high number of respondents, who claimed that there was no threat to any sector. Such a position was expressed by 32% of the respondents with no prior knowledge on *Vibrio* while this number was significantly higher (58%) among those, who declared at least some knowledge before completing the survey (Fig. 5).

Now, let us discuss specific implications of the increase in the *Vibrio* bacteria in the coastal waters from July to September for the local tourism sector. Our respondents were predominantly concerned about the possible outflow of tourists from the region and an increase of costs associated with proper preparation of the recreational infrastructure. They also expressed concerns about stagnation and a decrease of tourist activity during the season (Fig. 6). Indeed, respondents with declared prior knowledge about *Vibrio* were more likely to suggest their own solutions, such as the need for additional investment in infrastructure or appropriate information on available methods to reduce the threat.

Regardless of their prior knowledge of *Vibrio*, our respondents suggested that the *Vibrio*-related problem should be addressed by relevant state authorities (Fig. 7). In their opinion, it should be done predominantly by supporting research. Science and scientists should develop and test methods that could be later used to mitigate bacteria growth and related risks. Support for research was favoured by 92% of respondents. Only 2% indicated that they could accept closure of the whole or part of the coastal area for tourists, and 6% suggested that no actions were needed as natural resilience of ecosystems should be enough to mitigate the threat.

The second part of the survey aimed to assess the perception of the nature based solutions (NbS) that could be used to mitigate

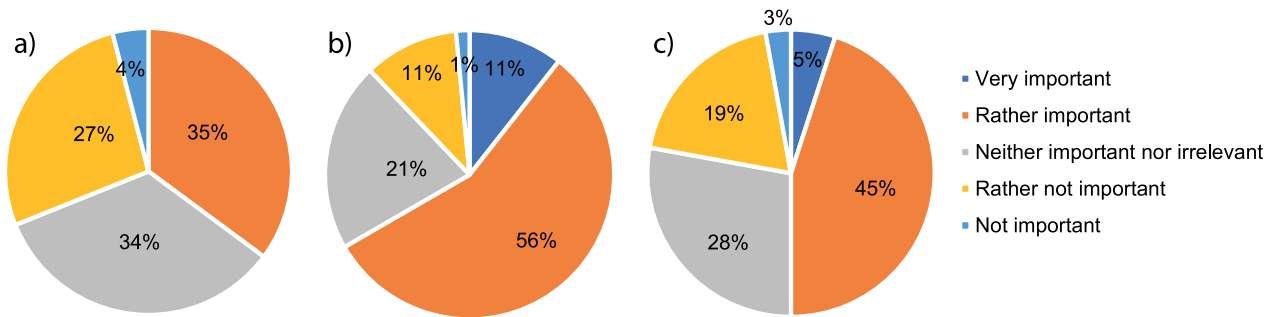


Fig. 4. Indication of the importance of the threat of *Vibrio* abundance among respondents in three groups: a) familiar, b) not familiar, c) together; source: own study

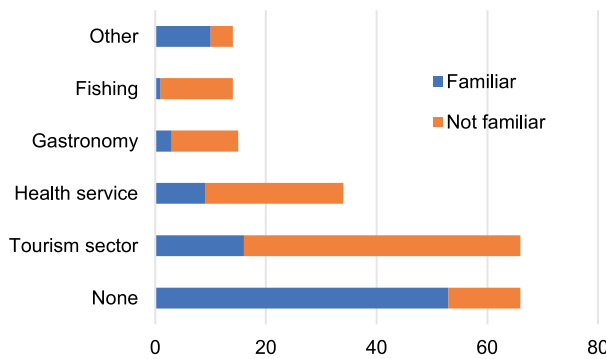


Fig. 5. Indications of sector affected by *Vibrio* growing abundance; source: own study

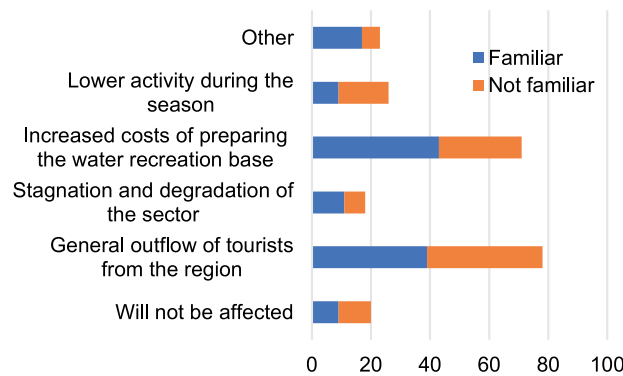


Fig. 6. Predicted results of future increase in *Vibrio* by groups of respondents; source: own study

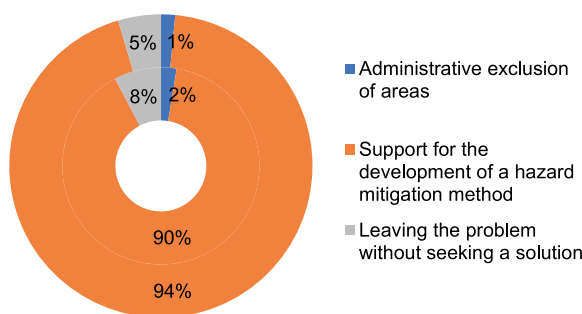


Fig. 7. Action taken as a response to pathogenic *Vibrio* increase; source: own study

the excessive growth of the pathogenic *Vibrio* bacteria population. These NbS relate to the presence of mussels, seagrass and macroalgae (that are called system engineers) in the coastal zone and their expected positive impact on the diversity and abundance of the *Vibrio vulnificus* bacteria. The use of system engineers, e.g. through the underwater islands of seagrasses and mussels, might, however, cause some restrictions in the use of coastal waters.

The section below discusses opinions respondents had about system engineers and interference with the use of coastal waters for tourism and business. The respondents were generally sceptical about the possible negative influence (Fig. 8). About half of replies (58% of those with prior knowledge and 47% of those without it) suggested that such solutions would not affect tourism. Thirteen percent of the respondents considered it to be an effective marketing tool to promote the cleanliness of the sea waters in the region. Nineteen percent of respondents in both groups suggested that the introduction of systems promoting the increase in seagrass, algae and mussels would be negatively perceived by people enjoying sea bathing, while 6% and 11% saw the presence of such factors as a psychological barrier to using the sea and the coast. Two percent of respondents with some prior knowledge and 3% without it believed that the creation of artificial structures may limit marine space available for leisure due to safety regulations.

Similar results were obtained, when the respondents assessed the impact of the system engineers specifically on bathing with or in close proximity to seagrass, mussels or macroalgae (Fig. 9). The majority of respondents in both groups (i.e. these with and without prior knowledge about *Vibrio*) suggested that the system engineers are natural part of the marine environment and people should simply get used to them. On the other hand, 35% of responses indicated that the presence of seagrass and algae may be perceived as a barrier for many users. Only a small number of our respondents (3% of those with prior knowledge and 6% without it) claimed that NbS would negatively affect the use of the bathing sites and tourism in general because “people usually don’t want to bath with seagrass or mussels on the bottom”.

Twelve percent of “other” responses pointed out the need for adequate information about the marine environment and the role of such agents prevailed.

As the majority of our respondents originated from the tourism sector, it was perhaps not surprising that 42% (39% with some prior knowledge and 45% without it) were against introducing any new limitations in use (Fig. 10). In their opinion, tourism was already rather limited and there were already quite

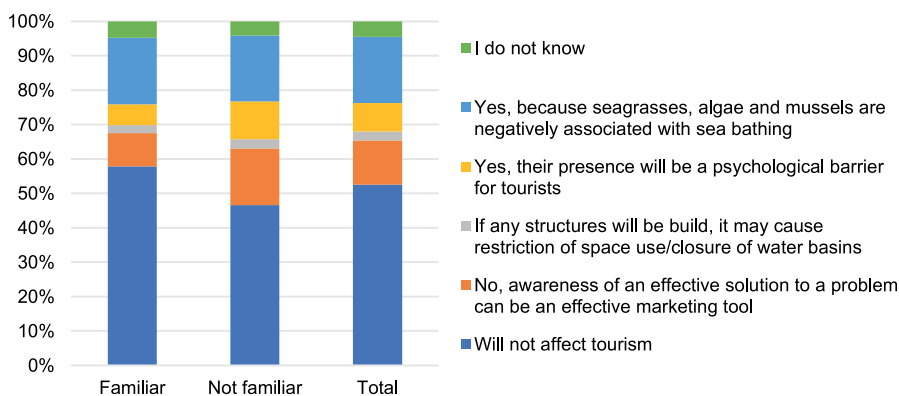


Fig. 8. Acceptance to nature-based solutions and close to natural solutions in groups of respondents; source: own study

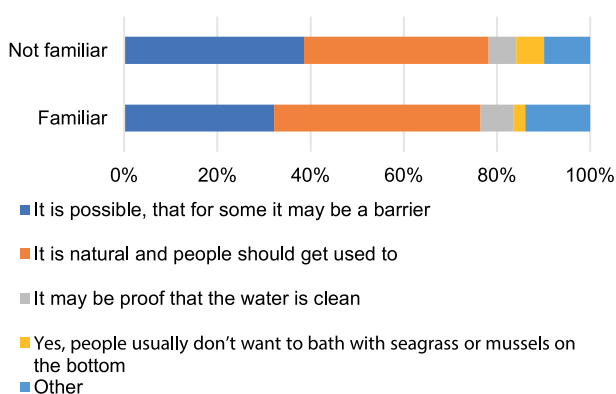


Fig. 9. Awareness of the system agents' presence; source: own study

many areas that were not available for any further development. Despite that, 41% (45 and 37% respectively) indicated that they could understand the need for new restrictions, even if they actually supported the opinion that tourism development was already overregulated. They still believed that environmental protection should be prioritised, because it is the long-term foundation of sustainable development. Finally, 12% of our respondents suggested that they would expect scientific justification of any new restrictions before any actions were undertaken, and appropriate procedures and information about such actions should be disseminated. Only if these conditions were fulfilled, they would accept further limitations.

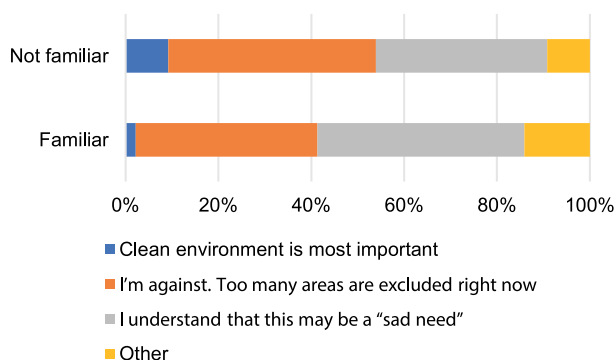


Fig. 10. Acceptance of nature-based solutions and close to natural solutions in groups of respondents.

CONCLUSIONS

The general overview of the stakeholders' opinions about the *Vibrio* bacteria presented a relatively unclear picture. On the one hand, a relatively large number of respondents declared that they were familiar with the *Vibrio*-related problems, while on the other, their knowledge was relatively small. Stakeholders who knew more about *Vibrio* seemed to consider it less of a problem than those who only learnt about it from the information provided through our study. Thus, their opinions were relatively closer to that of an expert with more in-depth knowledge. It also seems that although the stakeholders did express concerns about information provided to tourists, with even more concern about the form in which information was disseminated, i.e. threatening narratives, they were not influenced by that information directly. They were rather concerned about decisions tourists could make in the future, and the potential outflow of tourists from the region when adverse conditions continue to appear.

Since information seems to play a major role in assessing the significance of the *Vibrio* threat at individual and personal levels, it is obvious that developing a proper communication strategy is, indeed, currently needed to address the issue at hand. We suggest that the *Vibrio* bacteria should not be discussed separately as one of many environmental threats, but rather information should be delivered from the perspective of public and individual health. In the context of media narratives and concerns of local communities, it is insufficient to address the *Vibrio* bacteria only from the point of view of the marine environment and nature based solutions. Therefore, mixed expertise should be included in the communication about *Vibrio*. The expertise of medical microbiologists and medical doctors is very much needed. Since *Vibrio*-related health issues could (and in fact should) be solved at the personal level, perhaps information provided should emphasize the safety of the Baltic Sea marine environment (in *Vibrio* context) and individual vulnerability to potential infection. Such information should be complemented with guidelines on how to behave to avoid infection and use the sea in a safe way. Guidelines targeted at individuals using the sea need to be complemented by relevant changes in the health care system, i.e. an easy access to a proper medical diagnosis in case of an infection and easily available laboratory tests to identify *Vibrio* infections.

We also suggest that more research is needed on how to inform the general public, mainly tourists, about *Vibrio*-related

health issues in order to raise awareness and do not spread unnecessary panic. As a benchmark, we suggest to evaluate and follow information provided by the American Center of Disease Control and Prevention (CDC), which provides scientific information about statistics, prevention measures, and symptoms recognition.

SUPPLEMENTARY MATERIAL

Supplementary material to this article can be found online at https://www.jwld.pl/files/Supplementary_material_Rakowski.pdf.

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