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Contribution to the Research on Marine Environment Pollution from Nautical Tourism Vessels

Abstract

Nautical tourism has experienced significant growth, particularly in the last thirty years. Alongside its many socioeconomic impacts, there are also negative effects on the marine environment and, consequently, on humans. The increase in the number of nautical tourism vessels can lead to high concentrations of bacteria and other organisms that harm the ecosystem. The implementation of international conventions aims to protect human life and the marine environment, but this is still not enough. The adoption of specific conventions exclusively focused on nautical tourism could reduce the ecological risks resulting from various human activities at sea and along the coast. The authors provide an overview and analysis of legal regulations while explaining the importance of improving the regulation of issues related to pollution in the marine environment from nautical tourism vessels. An analysis of ecological risks of pollution in the marine environment from nautical tourism vessels has been conducted and preventive measures are proposed. The contribution of this study lies in the analytical review of legal literature and ecological risks, as well as proposing measures that can contribute to the long-term reduction of pollution in the marine environment from nautical tourism vessels.

Keywords: nautical tourism, nautical tourism vessels, ecological risk, marine environmental pollution

1. Introduction

The environment of nautical tourism consists of the sea, land and air. The indented coastline with sheltered bays, a pleasant climate with moderate winds and cultural attractions are prerequisites for the development of nautical tourism. The need to preserve the marine environment increases with the increase in the number and length of vessels and the construction of new marinas. The first forms of nautical tourism developed in the 16th century in the northern countries of Europe. Regattas and various types of rowing represent the beginnings of nautical tourism, and with the growing interest in recreational sailing, the first sailing clubs were founded. Before there were specialised harbours, nautical tourism vessels docked in the existing city harbours. The word 'marina' was first used in New York in 1928.

The problem of pollution of the marine environment by nautical tourism vessels arose when the vessels began to be used for longer stays at sea, so black water had to be disposed of. The sea as a vast expanse thus became a place where wastewater and solid waste were dumped. In addition, the part of the ship's hull that is submerged below the sea surface can be colonised by various organisms over time. When they accumulate in this way, they change the surface, making it rough and uneven. This can lead to higher fuel consumption, but also to an increased release of harmful gases. The harmony of nature is already disturbed by the passage of vessels and pollution can hardly be stopped, but there are ways to reduce it. Pollution is the direct or indirect introduction of hazardous substances into the marine environment by humans. The consequences of pollution can be catastrophic for marine organisms, but also for the entire marine ecosystem. It also jeopardises human health, disrupts maritime activities, destroys the quality of seawater and ultimately reduces the attractiveness of coasts and coastal areas.

A risk is a predicted or expected damage that occurs due to hazards, losses or threats. In an endeavour to identify all foreseeable risks, risk assessment consists of a detailed evaluation of all actual and potential hazards. The analysis of the most likely and the most unfavourable outcome of the event can also be used to determine the risk. The environmental risks in nautical tourism relate to the sea and coastline polluted by nautical tourism vessels. The concentration of nautical tourism vessels in an area is high and therefore poses a risk of harmful events. Although negative environmental impacts of nautical tourism vessels are usually not visible to the naked eye, they are certainly present and disrupt the harmony of an ecosystem.

2. Legal sources

As the international framework aims to harmonise maritime law, the adoption of international conventions is the most appropriate way to achieve this. The first convention concluded in 1973 to protect the marine environment was the International Convention for the Prevention of Oil Pollution of the Seas. The Protocol of 1978

renamed it to the International Convention for the Prevention of Pollution from Ships, which it still bears today. The contracting parties agreed to adopt universally applicable rules covering not only oil pollution of the marine environment. The Parties also recognised that the intentional, negligent or accidental discharge of oil and other harmful substances by ships is one of the main sources of pollution [19].

The MARPOL Convention applies to ships depending on the type of cargo they carry, their deadweight and the number of passengers. According to the Convention, a 'ship' is a vessel of any type operating in the marine environment and includes hydrofoils, hovercraft, submarines, floating objects and fixed or floating rigs [2]. However, the Convention does not apply to ships carrying less than 12 persons, to ships sailing in national waters, and not engaged in international maritime transport, to yachts carrying less than 12 persons and to boats by virtue of their capacity and the number of persons carried.

In addition to ships, yachts and small boats are also involved in shipping and pollution of the marine environment. The biggest problem with pollution from small vessels is faecal water. Smaller vessels are built in such a way that they have no collection tanks for black wastewater. They have toilets with direct discharge by manual or electric pumps [6]. Vessels equipped with wastewater retention tanks, discharge black water into the marine environment at a distance of less than 12 nautical miles, as there are no black water collection facilities on land. The Convention stipulates that untreated faecal water may not be discharged at a distance of less than 12 NM from the coast.

Yachts carrying more than 12 persons are subject to the MARPOL Convention (Annex IV) but are not subject to an inspection to ensure that the certificates and equipment comply with the Convention. The equipment prescribed in MARPOL Annex IV is required for the initial inspection and periodic inspections by the flag state. Based on the Regulations on Boats and Yachts (NN 13/2020) [9], all vessels for personal needs, that have sanitary facility must undergo regular inspections every five years. The 1982 Paris Memorandum does not provide for yachts to be subject to port state control inspection, so it is questionable whether this equipment is in proper and working order and whether, how and to what extent it is being used [7]. MARPOL is not the only convention dealing with pollution prevention and protection of the marine environment, but none of the others address the issue with such precision. According to the Ordinance on the terms and methods of maintaining order in ports and other parts of the internal sea waters and the territorial sea of the Republic of Croatia (NN 72/21) [10] all county port authorities must adopt a Plan for the reception and handling of ship-generated waste.

As a country of the European Union, the Republic of Croatia is a signatory to all conventions on the protection and preservation of the marine environment. The MARPOL Convention is a comprehensive document on the protection of the marine environment. By adopting Directives, the EU can increase the effectiveness of conventions. The following directives have been adopted to prevent marine pollution from ships:

- Directive 2000/59/EC of the European Parliament (27 November 2000)
- Directive 2099/2002/EC of the European Parliament and of the Council (5 November 2002)
- Directive 2002/84/EC of the European Parliament (5 November 2002)
- Directive 2005/35/EC of the European Parliament and of the Council (7 September 2005)
- Directive 2007/1/EC of the European Parliament and of the Council (17 September 2009)

The directives clearly prescribe the role of ships in protecting the marine environment, be it in the handling of faecal waters or other types of ship-generated waste, as well as introduce fines for infringements.

States may adopt and apply specific provisions in their national legislation that relate to vessels exempted from the MARPOL Convention. However, as nautical tourism is developing rapidly and the number of nautical tourism vessels is increasing year by year, the adoption of international conventions would largely prevent the pollution of the marine environment. The introduction of competent authorities to monitor the implementation of international conventions at national level would have a positive impact.

In 2001, the International Maritime Organisation (IMO) adopted the International Convention on the Control of Harmful Antifouling Coatings on Ships [2]. The main features of the Convention are general obligations aimed at reducing or eliminating harmful effects on the marine environment and human health. It prohibits and/or restricts the use of harmful substances in antifouling coatings, listed in the Annex to the Convention. Annex 1 of the Convention lists the prohibited coatings and the corresponding control measures. The Parties to the Convention are obliged to cooperate in the implementation of the provisions of the Convention in order to promote the continuous development of an environmentally safe and effective antifouling system. Yachts, boats and sailboats are not subject to strict controls in the marinas they enter, so the possibility of using coatings containing harmful substances is greater.

In 2012, the European Parliament and the Council adopted the Regulation 528/2012 concerning the making available on the market and use of biocidal products [1] with the aim of improving the functioning of the internal market by harmonising the rules on the making available on the market and use of biocidal products, while ensuring a high level of protection of human and animal health and the environment [1]. With Regulation (EC) No 782/2003 of 14 April 2003 on the prohibition of organotin compounds on ships, the European Union has prohibited the entry into ports of ships with a coating based on the TBT compound, and with Regulation 528/2012, biocidal products may not be placed on the market or used if they do not comply with the provisions of this Regulation.

3. Analysis of environmental risks in nautical tourism

Environmental risk is an indicator of the certainty of loss, damage to health or property, i.e. environmental damage due to exposure to a particular environmental hazard [6]. In order to make decisions regarding the environment, it is necessary to predict the relationships between environmental pressures and environmental impacts. There are two elements that determine the content of environmental risk, namely the environmental hazard itself and the exposure to it. Exposure to environmental hazards includes the link between the source of the damage and the environment it affects [15]. Nautical tourism is exposed to various forms of hazards and threats, and for risk management it is necessary to monitor certain subsystem processes. Marinas, together with vessels, are hotspots of exposure to coastal hazards – a concentration of assets with high economic value, densely packed behind concrete breakwaters [3].

The ecological dangers of nautical tourism are the result of inadequately defined laws at international and national level. It is often claimed that nautical tourism is a newer branch of tourism and has grown exponentially over the last 30 years. The rapid growth, which has not been accompanied by regulations, has led to subsequent efforts to correct the shortcomings of human activities. It is necessary to prevent any and all disposal of waste into the sea [4]. The negative impacts of nautical tourism vessels on the sea and the coast include exhaust gases, the discharge of wastewater, the fouling of the ship's hull and the increase of urban waste and plastic pollution in the sea.

The danger of pollution lies in the faecal waters that are discharged without control into the marine environment by nautical tourism vessels. The reason for this is the small number of reception facilities in marinas, urban harbours and uninhabited bays, as well as insufficiently strict regulations whose implementation is not monitored. Vessels that are subject to the conventions are equipped with devices for collecting and retaining black water. The growing number of nautical tourism vessels has increased the pollution of the marine environment with faecal water. This wastewater contains disease-causing organisms or pathogens originating from the interstitial tract of mammals, including humans [13].

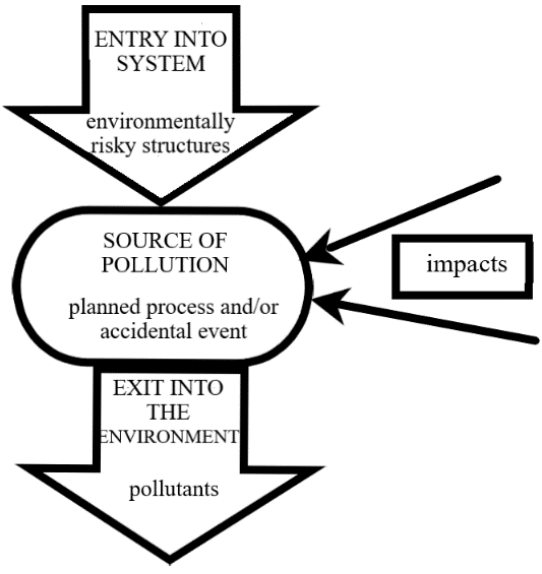

Figure 1. Environmental risk of faecal water (made by author).

In nautical tourism, ecologically risky structures can be faecal matter in the faecal tank (source of pollution). The source of pollution is influenced by the inadequate number of reception facilities in marinas and urban harbours, resulting in faeces entering the marine environment. Faeces from an ecologically risky structure become environmental pollutants.

When tests are carried out to determine the quality of the sea, microorganisms that are indicators of bacteriological pollution are sought. Most commonly, these are total coliforms, faecal coliforms and faecal streptococci, which are an integral part of the intestinal flora but pose a risk if they get outside the digestive tract. Toilet water contains harmful bacteria, viruses and intestinal parasites, and if it enters the marine environment untreated, it can lead to bacterial and viral contamination of fish and shellfish [16], which in turn can affect human health. Organic products from faeces, when processed and somewhat decomposed by bacteria, lead to an increase in nitrogen levels in the sea and thus to eutrophication.

According to the Regulation on Sea Bathing Water Quality (O.G. 73/2008) and the EU Directive concerning the management of bathing water quality (2006/7/EC), intestinal enterococci and Escherichia coli are microbiological indicators of the state of the sea. The Republic of Croatia is a popular tourist destination, which is why sea quality tests are carried out at more than 1,000 locations along the coast. When testing the quality of the sea, it is necessary to avoid places where city sewage flows. The standards for the assessment of sea quality after each test are listed in the table.

Table 1. Standards for evaluating the quality of the sea after every test [17].

Indicator	Quality of sea		
	excellent	good	satisfactory
intestinal enterococci (CFU*/100 ml)	< 60	61 – 100	101 – 200
Escherichia Coli (CFU/100 ml)	< 100	101 – 200	201 – 300

**CFU – no of visible colonies*

According to the Ministry of Economy and Sustainable Development and the Institute of Oceanography and Fisheries, the final assessment of the sea quality for bathing in the 2024 is excellent, which is further illustrated in Table 2 and Figure 2. Forty-two samples do not refer to the marine coastal area and they are excluded from the table and graph.

Table 2. Final evaluation of the quality of the sea for bathing for the 2024 [11].

No of samples: 1010			
Excellent	Good	Sufficient	Poor
986	12	1	11
97.62%	1.19%	0.10%	1.09%

Figure 2. Graphic display of the final evaluation of the quality of the sea for bathing for the 2024 [11].

The above data relates to the areas where bathers are present. But what about the quality of the sea in marinas and harbours? Koboević (2015 and 2022) cites the results of random sampling of the Dubrovnik water area in places where cruise ships, ro-ro passenger ships, smaller passenger ships, fishing boats, mega yachts, yachts and small boats are moored. The study clearly shows that the number of faecal coliform bacteria is 0 in the area where ships are moored with facilities for collecting and treating (purification) faecal water, while the number of bacteria increases in places where vessels are moored or anchored without facilities. It can therefore be concluded that the implementation of the regulations contributes significantly to the protection of the marine and coastal environment.

An example of a country that is not a signatory to MARPOL Annex IV and has its own national regulations is the United States of America. In its national regulations, the USA has prohibited the discharge of untreated black water more than 3 nautical miles from the coast. Some waters in the USA are designated as "no discharge zones", in which the discharge of treated and untreated wastewater is prohibited. Failure to comply with federal laws will result in penalties at the federal level and possibly at the state level. All boats with a toilet bowl must be equipped with a US Coast Guard certified MSD (Marine Sanitation Device). There are three models of the device, either just a tank that collects faecal water or devices that treat faecal water.

Recognising the seriousness of this problem, the Republic of Croatia has also taken positive steps towards better protection of the sea from pollution by smaller vessels in the territorial sea and adopted a new regulation in 2020, the Ordinance on Boats and Yachts. Among other provisions, the Ordinance also prescribes environmental standards that vessels must fulfil, such as exhaust gas and noise emissions. The Ordinance also regulates the prevention of marine pollution from oils, sanitary wastewater, the bilge system, waste and requirements for antifouling coatings. This Ordinance prohibits boats and yachts to discharge oil or oily mixtures, bilge water, or sanitary wastewater into the sea. Boats and yachts that have a toilet with direct discharge into the sea must be equipped with a collection tank for collecting sanitary wastewater and a connection or other means for connecting to port reception facilities. Furthermore, it is not permitted under this Ordinance to discharge waste into the sea. The term 'garbage' includes all types of waste (unused, unnecessary or superfluous materials) related to food, living and work, plastic, cargo residues, cooking oil, fishing gear and animal carcasses (except fresh fish and its remains) that are generated during the normal use of the boat and that must be removed continuously or periodically. All boats, regardless of their purpose and sailing area, must have a container for waste disposal. This Ordinance also prohibits the use of antifouling coatings on the underwater part of the hull that contain organic tin compounds (tributyltin – TBT) on all boats [9].

Another negative impact of nautical tourism vessels on the marine environment is antifouling coatings. Over time, various organisms can colonise the part of the hull that is submerged below the sea surface. As they accumulate, these organisms change the surface of the hull, making it rough and uneven. This can lead to higher

fuel consumption, but also to increased emissions of harmful gases. Ship fouling is a way of transferring organisms from one area to another. The organisms survive all the conditions that await them during navigation (water current, temperature, salinity). In order to survive in the new conditions, they become more aggressive and thus jeopardise the ecosystem of the area concerned. The purpose of the antifouling coating is to protect the underwater parts of the hull from fouling and to maintain the smoothness of the plating [5]. Hull antifouling coatings can be categorised as biocidal or non-biocidal (foul release).

Various means have been used throughout history to prevent fouling of the hull. Until the 18th century, more natural agents were used for coatings, while more modern and effective agents were developed in the 19th and 20th centuries. Coatings based on tributyltin (tributyltin – TBT) showed long-term effectiveness and low production costs. TBT is a broad-spectrum biocide that effectively prevents the fouling of ship hulls. Several studies have shown that TBT compounds have negative effects on aquatic life. The use of antifouling coatings containing TBT compounds has been phased out and banned in many countries due to their high toxicity not only to fouling species but also to non-target species in the environment [14]. The release of chemicals from anti-fouling coatings into the environment also harms non-fouling organisms, allowing them to dissolve in seawater and be carried by currents to other areas. In addition, some of the chemicals can separate from the surface and sink to the seabed contaminating it. In 1982, France banned the use of TBT compounds in antifouling paints for vessels less than 25 meters in length, and later the IMO also banned their use on large ships.

Following the ban on TBT compounds, copper was increasingly used alongside zinc. Although the biocide was effective, it was short-lived as the vessels had to be cleaned frequently. Copper is an essential element in nature with normal concentrations between 0.5 and 3μgL^{-1} of seawater. When it is released from vessels and deposited in marine sediment, copper concentrations rise above the limit that marine organisms can tolerate, with levels reaching up to 21 μgL^{-1}. According to studies by Neira, Levin, Mendoza & Zirino [12], copper concentrations in sediment in areas with vessels are significantly higher than concentrations in areas without ships. As a result, biodiversity is greater in the area where copper concentration is lower.

It has been proven that TBT compounds and copper cause great harm in the marine environment, especially in confined waters. Most marinas are closed basins with a large number of vessels in which the seawater is not exchanged. The current is very weak, so that hazardous substances can accumulate on the bottom due to the impossibility of mixing the water columns. In the past, efficiency and price played an important role in the selection of antifouling agents. Today, where extreme attention is paid to ecological impact, they are chosen because they have as little negative impact on the entire ecosystem as possible.

In order to protect the environment, and thus also human health, people began to look at organisms in nature that prevent the formation of fouling on their surface. In nature, organisms have developed complex nanostructures on their surface that do

not allow other organisms to attach to them. The ability of the surface to repel water (hydrophobicity) hinders the adhesion of organisms. When passing through the water, only those organisms that have managed to attach themselves can be cleaned. The shark's skin is covered with micrometre-sized placoid scales with tiny teeth that create water turbulence on the animal's surface as it swims, making it difficult for organisms to attach [18].

4. Measures to reduce pollution of the marine environment from vessels

The islands of the Republic of Croatia are valuable reservoirs of biodiversity and typical habitats of certain biocenoses, as Koljatić [8] emphasised, and if they are not protected and the ecosystem is not cared for, biodiversity will be affected. It is very important to improve awareness of the values of the sea, both among the local population and among tourists – boaters and sailors.

Faecal waters can seriously pollute the marine environment, especially in coastal areas. Bays where tourists – boaters and sailors – anchor and discharge untreated faeces pose a major risk. Each country should introduce stricter measures in its national legislation or measures for vessels that are exempt from the conventions. In view of the fact that the world is striving to standardise maritime law, the proposed measure is standardisation in the area of nautical tourism. In this way, the adopted rules would be implemented by all participants in nautical tourism, as is the case in shipping. In addition, a service should be set up exclusively to monitor participants in nautical tourism. Marinas should be more strongly obliged to equip their coastal infrastructure with wastewater collection facilities, and certificates should be issued for the amount of faecal water discharged. Training of nautical tourism staff would raise awareness of the importance of the marine environment and its protection.

To protect the submerged part of the hull from fouling, it must be coated with an antifouling coating. Coatings contain biocides that have a negative impact on flora and fauna. In marinas, this is expressed in larger quantities, as there is a large concentration of vessels in one place. They are located in naturally sheltered water areas where the current is very weak and there is no exchange of seawater. As a result, many toxic substances are deposited on the seabed, jeopardising biodiversity. The proposed measure is to tighten controls on the use of antifouling coatings on vessels moored in marinas. When assessing the impact on the environment, it is necessary to consider the direction of sea water current, which would enable a natural, highly effective purification of the sea.

5. Conclusion

Environmental risks cannot be completely eliminated, but they can be controlled through conventions. The passage of vessels through the marine environment disturbs the harmony of the marine system. In order to better protect the marine environment, the International Maritime Organisation adopted international agreements – conventions which have been ratified by member states and incorporated into national legislation. The reduction of pollution from ships, which is actually only minor compared to other polluters of the marine environment, has been achieved through strict regulations and inspections.

Nautical tourism is constantly developing, and the number of vessels is increasing. At the same time, there are no standardised rules, such as conventions, to control the vessels involved in nautical tourism. Boats and yachts belonging to recreational vessels and vessels for longer stays at sea are not subject to strict rules and are not inspected.

National regulations prohibit any activity that harms the environment. One of the measures to protect the marine environment starts primarily on land and refers to the installation of a sufficient number of reception facilities for sanitary wastewater, oily water, plastic, garbage and municipal waste in marinas, berths and wharves. It is also important to establish continuous monitoring to effectively control the implementation of laws and regulations. The control of antifouling paints on ships moored in marinas for longer periods would reduce the use of paints containing toxic substances.

As it is well known, we have borrowed the environment from future generations, so there is no excuse for irresponsible behaviour. The protection of the marine environment in the context of nautical tourism must be raised to the international level through conventions and other legal acts.

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