http://dx.doi.org/10.18623/rvd.v17i39.1803

THE ENVIRONMENTAL IMPACTS OF THE "MARITIME AUTONOMOUS SURFACE SHIPS" (MASS)

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ABSTRACT

Autonomous ships are already a reality. They are on the agenda of international law and international society in general. In a short time, it will also be a reality in all the world's oceans. Thus, international organizations, States and international society need to be prepared for these autonomous ships. They will bring new challenges to the law of the sea and international maritime transport. One of these challenges is just what are the environmental impacts that these "Maritime Autonomous Surface Ships" (MASS) will bring with them. That is, what are the consequences for the marine environment of these autonomous ships? This is precisely the objective of this article: to understand the environmental impacts of MASS and what are the new challenges that humanity will have to face the imminent advent of these ships. In this sense, it will be demonstrated what the advantages and disadvantages of these vessels for the environment are and, in particular, what care the world needs to take to protect and preserve the marine environment due to the advent of these new technologies.

Keywords: autonomous ships; Law of the Sea; marine environment.

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OS IMPACTOS AMBIENTAIS DOS "MARITIME AUTONOMOUS SURFACE SHIPS" (MASS)

RESUMO

Os meios autônomos já são uma realidade a ser considerada pelo direito e pela sociedade internacional. Em pouco tempo serão também uma realidade em todos os oceanos no mundo. Diante disso, é de extrema importância que os organismos internacionais, os Estados e a sociedade internacional esteja preparada para estes navios autônomos, que trazem novos desafios ao transporte marítimo internacional e ao direito do mar como um todo. Um destes desafios é justamente quais serão os impactos ambientais que estes "Maritime Autonomous Surface Ships" (MASS) trarão consigo. Isto é, quais as consequências para o meio ambiente marinho destes meios autônomos? É justamente este o objetivo do presente artigo, entender os impactos ambientais dos MASS e quais os novos desafios que a humanidade terá que enfrentar com o eminente advento destes navios. Neste sentido, ficará demonstrado quais as vantagens e desvantagens destas embarcações para o meio ambiente e, em especial, quais os cuidados o conjunto da sociedade internacional precisa ter para proteger e preservar o meio marinho com estas novas tecnologias.

Palavras-chave: *Direito do Mar; meio ambiente marinho; meios autônomos.*

INTRODUCTION

As a result of modern technological developments of our time, autonomous and remotely controlled vessels are becoming a reality, bringing with them essential challenges for international society (LIU, 2018, p. 490). Kongsberg Gruppen, in collaboration with Yara, is producing the world's first fully electric, autonomous, zero-emissions container ship (called "YARA Birkeland"). The ship will operate along the coast of Norway[2].

With the rapid development of artificial intelligence (AI), unmanned ships can lower the cost of maritime transport. Also, they can bring other benefits such as preventing loss of life at sea. However, for autonomous marine systems, route planning and predicting obstacles to avoid collisions are new and relevant topics to consider.

The transition to this new era of unmanned ships challenges not only technological development. Autonomous ships will have to find their place in international law. Currently, treaties and other law of the sea documents require the presence of a crew on board. Thus, the international debate on unmanned ships has come under analysis by the International Maritime Organization (IMO). This organization, as responsible for regulating all international shipping, could not refrain from analyzing and creating legal rules to regulate the navigation of these new ships[3]. The starting point was the decision taken by IMO to include the issue of Maritime Autonomous Surface Ships (MASS) on its agenda. This occurred through the Maritime Safety Committee (MSC) at its 98th Session, from 7 to 16 June 2017. It was decided to perform a scoping exercise to determine how safe, secure and environmentally sound operation of MASS may be introduced in IMO instruments. The MSC recognized that the IMO should take a proactive role in examining and regulating the introduction of commercially operated vessels in an autonomous mode (operating without crew).

These autonomous ships have some notable advantages. As Pedrozo (2019, p. 211) observes: "because they reduce risk to human life, unmanned systems are becoming the preferred alternative for dull, dirty or dangerous missions". Besides, unmanned ships can remain at sea for more extended periods than ships with crews. They can also expand operating areas, fill capacity gaps and, most importantly, reduce shipping costs. Can

2 See https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/. Accessed on 08/02/2020.

3 For a more in-depth discussion of MASS regulation see Chircop, Roberts and Prior (2019, p. 18-32).

all these benefits be beneficial for shipowners; however, the same goes for society in general?

Currently, the impact that the technological innovation of autonomous ships will have on navigation is still uncertain. Rensburg (2018, p. 2-3). Especially concerning the protection of the marine environment and the possible damage or advantages that MASS can cause are not yet entirely understood. Therefore, the objective of this article is to analyze the environmental impacts on the marine environment resulting from the use of these autonomous ships. For this, the research methodological techniques employed in this paper include bibliographic and documental revision.

1 AUTONOMOUS SHIPS AND THE LEVEL OF CONTROL DEFINITIONS

It is not the purpose of this article to delve into the conceptual legal discussion of Maritime Autonomous Surface Ships. However, for a better understanding and examination of the environmental impacts of the use of MASS, understand what are really "autonomous ships" and, in particular, their classification regarding the level of control. Only in this way will it be possible to assess the probable advantages and disadvantages of these autonomous ships, since the level of autonomy – and the crew onboard – influences these environmental impacts.

First, it is important to highlight the role of the International Maritime Organization (IMO) in the regulation of MASS. On the issue of MASS regulation, says Ringbom (2019. p. 24):

> Should the IMO decide to broaden the current limited regulatory scoping exercise, a series of issues that go beyond the current provisions in existing conventions will have to addressed. […] While regulation of automation is by no means a new topic for the organization, the available precedents are not analogous to the issues raised by the development of MASS and are thus of limited assistance and guidance for the organization. The novelty of the subject represents an argument in favor of developing a new instrument to specifically address the various aspects of highly automated and autonomous Ships.

Thus, in 2017 at the 98th Session of the MSC, the IMO defined the degrees of autonomy identified for the scoping exercise[4]:

4 Available at http://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx. Accessed on 08/02/2020.

- **Degree one – ship with automated processes and decision support:** seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
- **Degree two – remotely controlled ship with seafarers on board:** the ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.
- **Degree three – remotely controlled ship without seafarers on board:** the ship is controlled and operated from another location. There are no seafarers on board.
- **Degree four – fully autonomous ship:** the operating system of the ship is able to make decisions and determine actions by itself.

On the other hand, the European Union, through a working group of the European Defense Agency, entitled Safety and Regulations for European Unmanned Maritime Systems (SARUMS)[5], has drawn up a table with six levels of control applicable to vessels. Brazil recently adopted a Provisional Regulation for Autonomous Vessel Operation, published in the DOU on 02/21/2020 in which it follows the European model:

- **Level 0 – manned:** MASS is controlled by operators aboard
- **Level 1 – operated:** under operated control all cognitive functionality is within the human operator. The operator has direct contact with the MASS over e.g., continuous radio (R/C) and/or cable (e.g., tethered UUVs and ROVs). The operator makes all decisions, directs and controls all vehicle and mission functions.
- **Level 2 – directed:** under directed control some degree of reasoning and ability to respond is implemented into the MASS. It may sense the environment, report its state and suggest one or several actions. It may also suggest possible actions to the operator, such as e.g. prompting the operator for information or decisions. However, the authority to make decisions is with the operator. The MASS will act only if commanded and/or permitted to do so.
- **Level 3 – delegated:** the MASS is now authorised to execute some functions. It may sense environment, report its state and define actions and report its intention. The operator has the option to object to (veto) intentions declared by the MASS during a certain time, after which

5 In 2015 SARUMS published what it called "Best practice guide for UMS handling, operations, design and regulations".

the MASS will act. The initiative emanates from the MASS and decision-making is shared between the operator and the MASS.

- **Level 4 – monitored:** the MASS will sense environment and report its state. The MASS defines actions, decides, acts and reports its action. The operator may monitor the events.
- **Level 5 – autonomous:** the MASS will sense environment, define possible actions, decide and act. The Unmanned Vessel is afforded a maximum degree of independence and self-determination within the context of the system capabilities and limitations. Autonomous functions are invoked by the on-board systems at occasions decided by the same, without notifying any external units or operators.

It is observed that only from level 3 there is a real autonomy in the ships. At levels 0, 1 and 2, the human operator still controls the ship. Only at levels 3, 4 and 5 is the ship controlled by an onboard program. Furthermore, it is just after level 3 that the vessel is unmanned. These factors are essential for the analysis of the environmental impacts of autonomous ships since the level of control and the absence of crew on board influences the environmental advantages and disadvantages of these autonomous vessels.

2 THE ENVIRONMENTAL IMPACTS OF MASS

2.1 The advantages of MASS for the environment

The advantages of using autonomous ships, concerning the protection and preservation of the marine environment, are concentrated in two main areas: the reduction of pollution by vessels; and the reduction of human error.

2.1.1 Reduction of pollution by vessels

The first advantage, from the environmental point of view, of the MASS is the reduction of pollution by ships. This is primarily due to the absence of crew on board. This absence means that, for example, no garbage or sewage is produced inside the ship. Thus, with these autonomous ships, pollution by dumping materials at sea is eliminated. That is, with no crew on board, there is no need to talk about pollution by dumping debris in the marine environment.

Pollution by dumping, which represents approximately 10% of the pollution of the marine environment (SANDS; PEEL, 2012), is a significant visible source of pollution, which causes sensitive damage to the environment. Still, it is a pollution that, in general, imposes risks of damage to the marine environment to many States, to the benefit of a small number of industrialized States and with larger naval fleets. In other words, the more developed countries (via land source) and with larger fleets (by sea) tend to dump into the sea more significant amounts of materials, often toxic, that pollute the marine environment in general and cause damage to coastal areas of other states (TANAKA, 2015).

Regarding the dumping of debris at sea by ships, a significant advantage of autonomous ships is the elimination of the introduction of plastics into the oceans. Even though the introduction of these polymers by ships corresponds to 20% of the total plastics introduced into the maritime environment (the other 80% are by land) (ZANELLA, 2019), MASS eliminate a significant amount of this pollutant. This becomes more significant as plastic pollution is one of the principal marine environmental problems today. It is a material dumped in vast quantities and with the potential to degrade the marine environment significantly. As Lavender *et al*. (2010, p. 1185): “Plastics are a major contaminant in the world’s oceans”.

Another type of marine pollution that can decrease with MASS is noise pollution. Vessels are potentially causing noise pollution, which in recent years has become a real concern for international organizations. On this topic, the statement of Primo, Barreto and Mont’Alverne (2018, p. 279) is illustrative:

> The harmful effects of the emission of anthropogenic noises in the oceans, once ignored, today occupy a prominent role among the concerns of international society. The theme was even a topic of debate at the Conference of the Oceans, a global event aimed at promoting sustainable development in the context of the seas and oceans, held under the auspices of the UN, in June 2017, in New York.[6]

These autonomous ships, which are necessarily more modern, tend to emit lower levels of noise pollution, which contributes to reducing the stress that international maritime navigation causes in the marine environment.

Second, the reduction of pollution by vessels is related to the advancement of the technologies used. These more modern vessels tend to use less energy and emit fewer pollutants. This is not just an advantage for autonomous ships. All the most modern ships, even with crew on board,

6 Translated by the author.

can have this environmental advantage over older vessels. However, due to all the technology necessarily employed by autonomous ships, they tend to pollute the environment less as far as it is concerned. For example, the emission of gases and oil in the marine environment tends to be lower in these ships compared to older ones. In this sense, Li and Fung (2019, p. 335): "Using battery as its means of propulsion, it is believed that the unmanned vessel should be free from any emission and reduce air pollution to the environment". The vessel as mentioned earlier "YARA Birkeland", for example, will be electric. That is, it had not emitted atmospheric polluting gases resulting from the burning of fossil fuel. Besides, it will not introduce oil, which occurs naturally with other fuel-powered vessels.

This lower energy consumption – or more sustainable consumption – with the reduction or even elimination – in the case of electric ships – of the use of fossil fuels is particularly significant concerning oil pollution and atmospheric pollution from ships. On the issue of atmospheric pollution, Miola *et al*. (2010, p. 12): "Furthermore, emissions from ships are transported in the atmosphere over several hundreds of kilometers, and thus can contribute to air quality problems on land even if they are emitted at sea".

Regarding oil pollution, it is important to note that this pollution from ships occurs in two main ways: first, as a result of maritime accidents that cause the spillage of large amounts of oil into the sea; and secondly, through operational discharges of the waste generated by the vessels, which involve the insertion of pollutants in smaller, but cumulatively significant quantities (ZANELLA, 2019, p. 329). Although oil tanker accidents are a more visible and dramatic cause of marine pollution, they account for less than 10% of all oil spilt at sea. The greatest threat still comes from deliberate discharges, such as tank cleaning operations (ROBERTS, 2007, p. 47-48). In this sense, a more sustainable ship, which consumes less fossil or even electric fuel, decreases or eliminates the introduction of oil into the sea relative to normal ship operations.

Regarding atmospheric pollution, it should be noted that this type of pollution has, in the past decades, undoubtedly become an environmental problem to be tackled (ZANELLA, 2018, p. 302). The continued growth of international maritime navigation has naturally led to a proportional increase in air pollution from vessels worldwide. There are several substances inserted in the air by burning the ships' fuel, and the emission can have local and global impacts. As pollutants such as sulfur oxide (SOx); Nitrogen oxide (NOx) and Particulate Material (PM) impact on the quality of the local (or regional) air, greenhouse gases (for example, Carbon Dioxide – CO2) have a global climate impact. In this sense, MASS tend to reduce the emission of polluting gases considerably, since they are necessarily modern and some will be powered by electricity (LI; FUNG, 2019, p. 335). On this issue, Villa Caro (2018, p. 402):

> Energy efficiency in propulsion: improving it through the use of more efficient engines, hybrid systems (LNG / electric) and more innovative solutions. More efficient energy technologies must be developed since ship propulsion and power generation have to be areas of technological development in the coming years. In which future engines of alternative fuels, propulsion energy-saving devices, energy sources, renewable hybrid power generation, and emission reduction technologies are explored. These challenges will pose environmental and commercial challenges”[7].

Thus, it is evident that the MASS will bring advantages to international maritime navigation. The reduction of environmental pollution by ships is a significant advantage that these ships will have over crewed vessels. This is due to two main reasons: on the one hand, with no crew on board, there will be a considerable decrease in pollution from ships since there will be no production of waste or sewage on board; on the other hand, these ships will necessarily be more modern than the current ones. So the pollution caused by the regular operation of the ships – as it happens today, with the introduction of oil and atmospheric pollution, for example – tends to decrease considerably.

2.1.2 Reduction of human error

Maritime navigation is undoubtedly a risky activity, and maritime disasters occurred due to the complex environment of the ship’s operation. Although maritime transport has a relatively low mortality and injury rate (PORTELA, 2005), the consequences of an accident can be vast. The repercussions of oil pollution, for example, can reverberate for many years and affect companies, people and States.

In this sense, a second group of advantages of autonomous ships, concerning the protection and preservation of the marine environment, is the reduction of human error. As summarized by Hogg and Ghosh (2016, p. 206): “Those who embrace the technology advocate economic, safety and environmental benefits. For example, reduced number of mariners at sea brings wage savings and reduced risk of human errors that can lead to environmental disasters”.

7 Translated by the author.

It is estimated that more than 80% of ship accidents occur due to human error (PORTELA, 2005, p. 4). These errors can happen due to several factors, such as a decrease in performance (due to fatigue, stress, health problems), insufficient technical and cognitive abilities, precarious interpersonal skills (communication difficulties, difficulties in mastering a situation, language), organizational aspects (safety training, team management, safety culture).

With the automation of ships, the trend is a reduction in accidents at sea, which often cause severe pollution with spills of oil and other substances. As human factors are the primary source of risk of accidents at sea, it seems interesting to develop technology that will make it possible to resolve these errors. Thus, logically, the autonomy of a ship results in the reduction of human error[8].

On the other hand, vessels monitored on land will require reliable communication systems between the unmanned ship and the controller on land. Communication systems are critical to the safety and protection of the environment and will have a high cost. Efficient and safe operation will require specialized systems, all with redundant operations. Also, onshore operators must be highly trained not to make mistakes and cause damage to the marine environment.

For autonomous ships controlled entirely by the on-board computer and its artificial intelligence, it is necessary to have a highly reliable and error-free system. That is, many tests will have to be carried out so that a ship at the last level of control (level 5: autonomous) can operate with total safety and reduce the number of accidents at sea. In other words, there is no point in changing human error as a cause of maritime accidents to the error of on-board computers that control autonomous ships. The risks of human error are eliminated, but the unmanned ships will face new challenges for successfully safe operation. On the issue, say Hogg and Ghosh (2016, p. 207):

> It is proclaimed that the incidence of human error will be significantly decreased on the unmanned merchant ship; however, the onboard technology requires calibration and maintenance by humans and the vessel requires constant monitoring from a shore control room where operators will be interpreting, absorbing and acting on information sent from the ship.

8 For a deeper understanding of the consequences of human error in maritime accidents see Chauvin (2011) and Lardjaneb *et al*. (2013).

To avoid accidents, MASS need to know the environment in which they navigate. That is, they need to understand the scenario around them and on their route, the adversities of the environment, identify obstacles and other objects to avoid collisions that can cause severe damage to the marine environment. Wang *et al*. (2019) makes an interesting discussion in the article "Path Planning of Maritime Autonomous Surface Ships in Unknown Environment with Reinforcement Learning", about the autonomous ship's learning modes and its artificial intelligence to avoid any accident.

2.2 The disadvantages of MASS for the environment

Despite the interesting advantages of autonomous ships for the protection and preservation of the environment, there are some disadvantages, some concerns and challenges that international society needs to take into account in relation to MASS. In particular, there are three main groups of disadvantages: the first related to the slow capacity to respond to accidents at sea, since there is no crew for any contingency and control of the facts; the second related to the restriction of transportation of some goods; and the third concerns cyber attacks that can cause accidents and damage to the environment.

2.2.1 Response to accidents at sea

The absence of crew on board is an advantage from an environmental point of view. When analyzing that the human factor is responsible for most accidents at sea, as previously seen, unmanned ships eliminate human error as the cause of accidents. However, this absence of crew onboard can become a disadvantage at the moment when an accident occurs with risk of damage to the marine environment. This is because, with a trained crew on board, the capacity of response is much higher than on unmanned vessels (CHONG, 2018, p. 39).

The maritime emergency includes collision, capsizing, shipwreck, fire, oil pollution, engine room problems, among others. On crewed ships, the response to these emergencies is carried out by the crew. This onboard crew can control the situation and prevent the damage from increasing. On unmanned ships, the extent of the result of non-navigational accidents (for example, fire) can be much higher. This is due, logically, to the lack of staff to assess and perform damage control. On the matter, Wróbela, Montewka and Kujala (2017, p. 164):

> The results show on one hand that the damage assessment and control is likely to be one of the biggest difficulties in achieving unmanned vessels' safety. Separating humans from all the dangers associated with working at sea will be opposed by a disturbing thought that there will be nobody on the scene of the accident to counteract the damage immediately. Preventing accidents from occurring appears therefore to be a better idea than counteracting its consequences. Actions aiming at reducing the occurrence of accidents must be implemented at early stages of system's design and combined with well-prepared operational procedures.

In the event of an accident involving an oil spill, for example, it will be the crewmembers that will make the contingency of the pollution. At least until aid arrives from the land. Without people on board, the ship is unable to respond. It is necessary to wait for rescue teams to arrive on the scene to try to contain any pollution, which may be too late. In other words, a crew on board is more likely to control and contain possible damage to the environment than an autonomous ship. For example, in the case of fire on board, the lack of a crew to contain the fire can be catastrophic. To resolve this issue highlights (EC, 2015, p. 15):

> The endurance of the ship on long voyages as well as the impossibility to do corrective work on the ship during the voyage requires systems that have low maintenance requirements. This can be achieved by minimizing number of and complexity of ship systems that cannot be operated reliably without continuous maintenance.

In short, the lack of crew in the MASS will be a challenge, especially to gather information, assess the situation and decide what type of assistance is needed. The lack of crew on board can result in an inaccurate assessment of the emergency. That is, the people on the ship can contain the problem or inform the authorities on shore what exactly is happening. Without this crew on board, a small problem (as in the case of a fire that can be easily controlled) can become catastrophic. Also, it is more difficult to understand what exactly is happening on the ship to send specialized teams to resolve the issue.

2.2.2 Restriction of goods transport

This second topic is also related to the lack of crew on board. Not all goods will be suitable for autonomous transport by sea. Unmanned vessels must carry stable cargo, which does not require maintenance or monitoring during the voyage, and not dangerous cargo. Unstable, flammable and explosive products, such as gas, chemicals and oil, are unlikely to be considered suitable for transport by MASS. In the same sense, says the European Commission (EC, 2015, p. 20): “There may be limits to what cargo an unmanned ship can carry. If the cargo cannot safely be handled without regular human inspection or intervention, it cannot be carried on an unmanned ship without new types of automation”.

These products need to be monitored carefully. As described in the International Maritime Dangerous Goods Code (IMDG) (IMO, 2014) in the event of an emergency, immediate crew intervention on board is essential to contain and manage any potential hazards that may arise. It is unlikely that any insurance company will cover the responsibility for transporting dangerous cargo by MASS.

2.2.3 Cyber-attacks

Trust in technology is essential for autonomous ships to become a reality. The continuous development of technology is fundamental for the international society to have confidence and to be able to regulate the navigation of these ships (FASTVOLD, 2018, p. 54). As previously mentioned, the effectiveness of the communication and artificial intelligence systems of these new ships will be crucial for the protection and preservation of the marine environment.

However, there is always a risk that these MASS will suffer some cyber-attack and cause environmental pollution. In the opinion of Hogg and Ghosh (2016, p. 211): “There is also the inherent possibility of extortion by cyber-attack on an unmanned ship. If critical systems are infiltrated, the vessel may lose its ability to navigate, resulting in a collision causing casualties or pollution and environmental damage”. These attacks can occur for several reasons, such as piracy or terrorism. In these cases, there is always a risk of damage to the marine environment, since the possibility of an accident – voluntary or not – increases considerably. In other words, if critical systems are infiltrated, the vessel may, for example, lose the ability to navigate, resulting in a collision with environmental damage.

It is worth noting that the IMO produced an Interim Guidelines on Maritime Cyber Risk Management through MSC.1 / Circ.1526, 2016. This is because, according to the Guidelines, “cybertechnologies have become essential to the operation and management of numerous systems critical to the safety and security of shipping and protection of the marine environment" (IMO, 2016).

For IMO, risk management is essential for safe shipping operations. Traditionally, risk management has focused on operations in the physical domain, but a greater reliance on digitization, integration, automation and network-based systems has created an increasing need for cyber risk management in the shipping industry (IMO, 2016).

Even before producing a document with the scope to regulate autonomous ships, the cyber issue was already a topic of concern for the International Maritime Organization. This is because even merchant ships with crew on board can suffer cyber-attacks. Several electronic components can be the object of cyberattacks, such as communication systems, bridges, cargo handling and management, propulsion and machinery management, among others. However, with manned ships, controlled onboard by a captain, the risks of cyber attacks, as well as the risks resulting from a possible attack, are considerably less than on autonomous ships. Logically, in MASS systems have a leading role in navigation, which makes an attack potentially much more dangerous for the safety of the ship and the environment. The IMO itself states that "Ships with limited cyber-related systems may find a simple application of these Guidelines to be sufficient; however, ships with complex cyber-related systems may require a greater level of care and should seek additional resources through reputable industry and Government partners" (IMO, 2016).

CONCLUSION

The design and research of unmanned ships are developing at an unprecedented rate. In general, these autonomous vessels have the potential to improve maritime safety and environmental protection, balancing the commercial interests and sustainable growth of the maritime industry.

When analyzing the impacts of autonomous ships on the protection and preservation of the environment, it appears that there are many more pros than cons. That is, in general, the trend is that the environmental impacts of MASS are positive. This, necessarily, is linked to the technological development that guarantees an effective, safe navigation of these ships.

The introduction of unmanned ships should be done with the utmost caution and will require extensive testing. Before the long-term effects can be proven, the technology must be validated as being adequately safe for the environment. This will require repeated proof that human operators can handle a critical situation on the ground. In the case of genuinely autonomous vessels (level 5), there must be sufficient evidence that they are truly safe and fully capable of operating autonomously.

Removing the crew from a vessel can mean a considerable decrease in cases of marine accidents. On the other hand, this situation immediately leads us to the disturbing thought that there will be no one at the scene of the events to control events promptly. Thus, preventing accidents from occurring, therefore, appears to be a better idea than neutralizing their consequences.

The development of a system of intelligent algorithms to avoid collisions, combining multiple vessel situations and dynamic weather conditions is still being developed for unmanned merchant ships. Although technical, operational and legislative concepts are at the forefront of development, there is still much work to prove that autonomous ships are not a risk to themselves, their cargo, the environment or other ships.

Finally, improving navigation safety, eliminating human errors and reducing pollution – such as atmospheric emissions – can make transport safer and more sustainable. However, as the technology is still in development, it is too early for a final assessment.

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Article received on: 03/17/2020.
Article accepted on: 11/23/2020.

How to cite this article (ABNT):

ZANELLA, T. V. The environmental impacts of the "Maritime Autonomous Surface Ships" (MASS). *Veredas do Direito*, Belo Horizonte, v. 17, n. 39, p. 367-384, sep./dec. 2020. Available from: http://www.domhelder.edu.br/revista/index.php/veredas/article/view/1754. Access on: Month day, year.