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Process management of waste generated on ships

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ABSTRACT

This work is not intended to be a theoretical study on management by processes and continuous improvement, but rather its implementation, as an analysis methodology, to the specific case of waste management, on board ships, for subsequent delivery in the ports. However, there will be a description of what is process management and continuous improvement and some of the associated tools for its implementation, highlighting, from the wide range existing, those that can be adjusted to our needs at the time of apply this methodology. Subsequently, a study of the existing literature is made, regarding its use in the maritime field and finally the application to the specific case of waste management on board is developed, which will allow us to analyze how waste management is carried out on board, identify problems or aspects for improvement and make proposals for improvement. The lack of space and the difficulties for the segregation of waste on board ships are shown as the main obstacles to proper waste management.

1. Introduction.

The term manage is accompanied by expressions such as: do, conclude, carry out. Thus, for example, if we talk about environmental management, it is recognized as a diagnostic and planning instrument for solving environmental problems (Brennan & Owende, 2010) (Foley et al., 2011) , which can manifest itself, for example, through the promotion of actions such as reuse or recycling.

Quality management, for its part, implies planning, implementation of programs and / or control of results (Durán, 1992). In business terms, it can be defined as the administration of resources to achieve the proposed objectives (Mora-Pisco et al., 2016).

On the other hand, the word process comes from the Latin processus and means advance, march, development. This fact of going forward, or of the successive phases, implies that at the end of the process some products, results, services can be obtained, different from the elements present at the beginning of said process. It is therefore a transformative action, as described in the numerous texts collected by Sánchez & Blanco, (2014), which indicate the presence of inputs and outputs such as the beginning and the end.

From these definitions, some of the factors necessary to develop a process can be recognized.

- The input elements, which may be, in turn, the outputs of a previous process. It should be borne in mind that we may or may not have control over the input elements, so that, as if it were a control system of an automatism, some authors define them as manageable variables or disturbances (Mantovani & Ferrarini, 2015) (Taha et al., 2014).

Within the inputs, we can find different typologies, among them are:

- Human media, who does it? Operators or workers are human resources and will always act as input, both in manufacturing and in services, however, the client or beneficiary is not always an input. A hospital patient will be in his healing process, but a customer of an ice cream parlour, for example, will

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never be an input in himself, only his request about the product he intends to purchase.

- Material resources, such as: available spaces, machinery, computer systems ...

- The economic resources allocated for the execution of the process (Adame, Marco Antonio et al., 2010).

- The activities, which are each of the actions that are carried out to complete the process and the procedures that are the method of execution. What is done and how it is done (López Lemos, Paloma, 2015). The sequential character should answer the question of when is it done? Both for each of the activities within the process, as well as for the process itself within an integrated management system. Highlighting the condition of horizontality, "alternative vision to the traditional one characterized by hierarchical organizational structures" (Saltos et al., 2016).

- The results or outputs, which may have the character of controlled or uncontrolled output. "Outputs as results of value for the client provided by the process and outputs generated by the process as a consequence of the transformation of the inputs" (Cuenca et al., 2008). Citizen as client, user or beneficiary. Within the consideration of client, the concept of internal clients is established, when the output, result or exit, becomes the input of another process (R. Martínez, 2016).

1.1. Process management.

Process management is a technique developed since the late eighties, last decade, whose objective is the improvement and innovation of organizations. Both its content and its definition have generated a debate among scientists, which, in turn, has been a source for studies that seek common points and discordant points in terms of models and definitions. Thus, for example (Palmberg, 2009) recognizes that there are two major movements "the management of processes for the improvement of unique processes and the management of processes for the administration of systems." On the other hand, there are the authors who recognize management by processes as technological tools (Reijers, 2006) (Van der Aalst, 2004) compared to those who establish that technology is at most a "peripheral aspect of Management" (Hammer, 2015).

1.2. Continuous improvement.

Each of these activities that are part of a process, are they carried out correctly? Do they produce the desired effects? Can they be improved? We could answer all these questions by establishing a continuous improvement plan, defining this as "The planned, organized and systematic process of continuous and incremental change" (Garcia-Sabater & Marin-Garcia, 2009).

In broad terms, it can be said that the implementation of these systems can have as objectives: customers, production systems and costs, to face the competition, employees and / or suppliers, through the improvement in the efficiency of each and every one of the processes and sub-processes executed (Proaño Villlavicencio et al., 2017) (Singh & Singh, 2015). For this, the Deming cycle or PDCA cycle (Plan, Do, Check, Act), is one of the basic models to carry it out, when it comes to non-complex problems (Deming, 1994). Quality standards, such as, for For example, ISO 14001, related to environmental management systems, includes the PDCA cycle as the basis for their implementation.

- Plan: The first of the phases of the cycle includes actions such as: Define, Measure, Analyze ... All of them will materialize, creating the appropriate teams to identify the problem and determine its causes. Designing the action plans and establishing the objectives and the choice of methods to carry out the improvement.

- Do: It consists of implementing changes, collecting data, measuring progress and documenting the result, in order to compare the efficiency before and after.

- Check: This phase includes the analysis of the data, the recording of the lessons learned and the comparison between the objectives set and the results obtained to determine if they are adequate.

- Act: Once the changes produce the desired improvements, they are introduced in a standardized way.

1.2.1. Tools.

There are numerous application tools for continuous improvement processes. The former was based on Ishikawa's principles and his seven basic statistical tools. The Japanese professor wanted all employees to have basic knowledge of statistics (López, 2016) and to become "little scientists" (Galgano, 1995). Subsequently, other tools oriented to planning and quality management have been added (Camisón et al., 2006).

These seven tools are briefly described below:

- Data collection sheet: It is a document in which the information of a certain process is recorded.

- Histogram: Representation, by means of a bar graph, of the information.

- Cause-effect diagram, Ishikawa diagram or thorn diagram: It is a graphic representation used to identify the causes that cause a specific problem.

- Pareto Diagram: It consists of a graphic representation of the causes of problems and is based on the Pareto principle (80/20 rule), which recognizes that 80% of problems originate from 20% of the causes.

- Correlation or dispersion diagram: It is a graphic representation used to identify the relationship between cause and effect.

- Stratification: It consists of the creation of homogeneous groups of data to analyze or interpret a certain phenomenon.

- Control chart: Graphic tool used to measure the variability of a process.

To the description of these basic tools, the flowchart is added, as it is one of those used to carry out this study.

In many cases, several of the tools are used together, although the groupings of tools have different nuances, according to the authors, in all cases we are talking about the same tools.

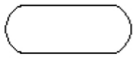
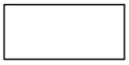
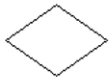
1.2.1.1. Flowchart.

It is a graphic representation in which, through the use of different conventional symbols, it is intended to show the sequence of steps that a certain process has (Pérez Fernández de Velasco, 2004).

Since it is a representation formed by a succession of graphic symbols, it is essential to know the meaning of each one of them. There are many standardization bodies that have designed their own symbology and although in many cases, certain symbols are similar, the meaning of each one for the chosen system must be clear, since there are none commonly accepted and, therefore, it is It is essential to define what symbology is used in each case.

For this study, the symbol system designed by the American National Standards Institute (ANSI) is used, since it is very intuitive and offers a sufficient range of symbols for the needs of the diagrams to be represented.

Table 1: Symbols for the elaboration of flowcharts.

Symbol	Use
	Indicates the beginning and end of the diagram.
	Represents a step in the process.
	Represents any type of document that is generated, used, or extracted from the procedure.
	It represents a decision, a point at which several alternatives are possible.
	Represents the connectors. Indicates the order in which operations are carried out

Source: ANSI Symbols.

In the previous table, only the symbols used for the design of the flowcharts elaborated for this work were represented.

2. State of the Art.

The management and continuous improvement of processes, aims to generate value. At the business level this implies growth and, in many cases, the very survival of the company. With its origin in the manufacture of products, management by processes and continuous improvement, it is used today in many and varied fields.

Thus, for example, apart from the industrial sectors where process management originates, we can speak of process management and applied continuous improvement, among others:

In the small and medium-sized business sector, for *service management* (Rubio & Burgos, 2017), (Xu et al., 2014) to the health sector (Haddad et al., 2016) (Nunes et al., 2016) (Chagnon, 1992) (Tsuru et al., 2009) (Shah et al., 2013)

In the field of university education (Plaza et al., 2013) (Ortiz et al., 2014), (Jiménez et al., 2015) and in higher education (Saulnier, 2013) (Palmer, 2013).

To the management of sports facilities (Aguilera & Morales, 2011). To livestock farms (Souza & Molento, 2015). *Implementation in the mining industry* (Botín & Vergara, 2015) or in the field of material resistance (Eckert, 2016)

In the maritime field, the number of applied studies is scarce. The main studies on the subject are briefly described below. Management by processes has been applied in the navy in order to improve global operation, with the definition, design and implementation of the so-called fundamental processes (Romero & Rodriguez, 2006), and with the adoption of the processes in the units to float as a method to systematize its tasks (Estevan, 2013), in these works flowcharts and process maps were used as main tools, as well as process files to describe the input and output of each of the processes. In the shipbuilding sector, process management is considered as an alternative to the usual project management methodology (Porras, 2016).

To establish a comparison between different Indian ports in container traffic (Thill & Venkitasubramanian, 2015), based on graphic information systems and data mining methods, they develop a decision tree model. On the other hand, (Popovic & Orlandic, 2017) propose the development of a comprehensive management model from the point of view of quality, environmental protection, safety and security, and its practical application in a Croatian port using management tools such as SWOT analysis or Porter's value chain together with other tools associated with the management and improvement of processes themselves, based on different philosophies, such as Lean Management and / or the Toyota Production System.

Among the referenced articles, it was found that the approaches of most of them cannot be considered within the comprehensive methodological framework of process management, although both (Islam et al., 2013) in their reengineering work of the port container truck transport process, such as Meng & al., (2009) with their study to improve port efficiency, approximate this methodology, through the use of tools such as flow charts.

It is also verified that the publications on management by processes in the maritime field are poorly developed and that, basically, they focus on port management, especially in container traffic, there is no scientific literature on the processes carried out on board of merchant ships, despite the fact that quality standards, such as ISO, have been in place for a long time by crews.

3. Methodology and Data.

3.1. Application to waste management on board.

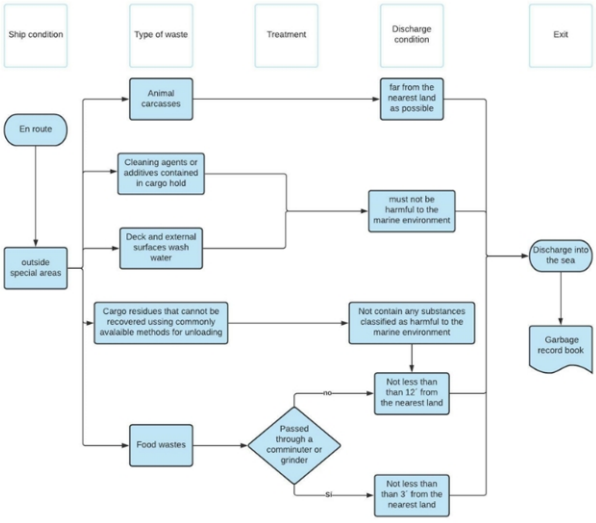
To apply process management and continuous improvement in the management of waste on board a ship, flowcharts have been developed based on the rules of Annex V of the MARPOL Convention in which the controls or conditions for unloading to the sea of waste are established. Thus, all the waste that cannot complete this described flow must be kept on board for later unloading at an authorized port facility.

3.2. Control of garbage discharge.

The discharge of garbage into the sea is included in regulations 4, 5 and 6 of Annex V of the Convention. The condition for such discharges is determined by the vessel's navigation area, the nature of the garbage itself, whether or not they should receive prior treatment before unloading, which determines, in

some cases, the discharge distance and whether they are harmful or not for the marine environment.

Figure 1: Flowchart of solid waste discharge into the sea. Rule 4.

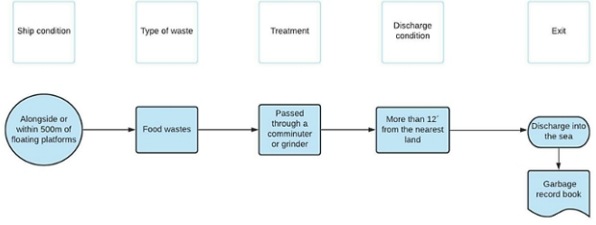


Source: MARPOL. Authors.

With all this, five differentiated blocks were identified to elaborate the flowcharts corresponding to each rule:

- Ship condition.
- Type of waste.
- Treatment.
- Discharge condition.
- Exit.

Figure 2: Flowchart of solid waste discharge into the sea. Rule 5.



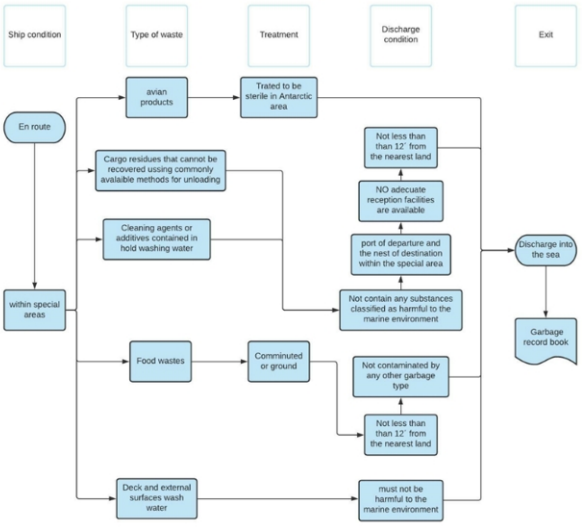
Source: MARPOL. Authors.

3.3. On-board management of stored waste.

Continuous improvement, regarding the management of garbage on board, could follow a scheme such as the one represented in the Figure 5, in which the results obtained by the actions carried out by the shipping company and by the ship, through the management plans determine the results, which are susceptible to improvement, as long as they deviate from the established objectives.

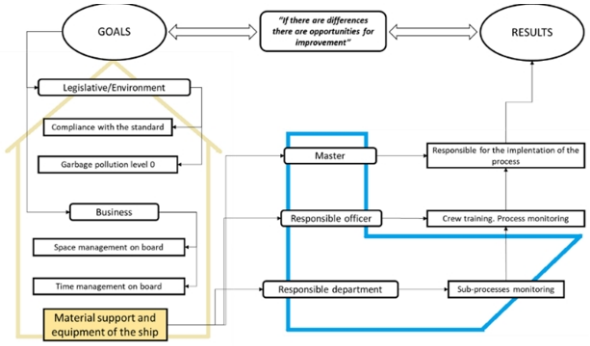
Once the determining elements for the discharge into the sea of the different wastes have been analyzed, we analyze the on-board management of the waste that must be stored for later delivery to a reception facility in port.

Figure 3: Flowchart of solid waste discharge into the sea. Rule 6.



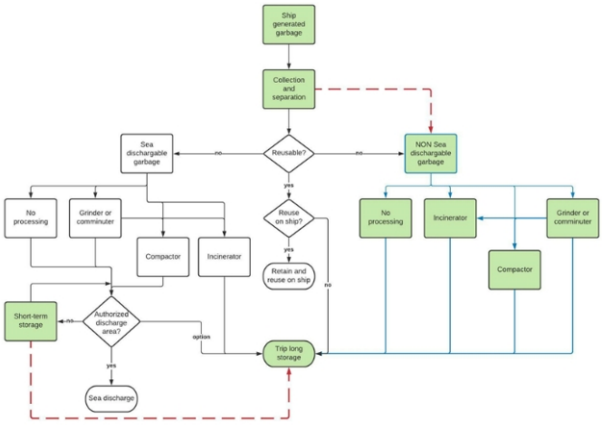
Source: MARPOL. Authors.

Figure 4: Continuous improvement of garbage management on board.



Source: Authors.

Figure 5: Options for handling and disposal of garbage on board.



Source: Resolution MEPC.295(71).

3.4. Types of solid waste and levels of segregation.

The waste management process begins from a previously completed process, which is the reception of materials and supplies likely to become garbage. Hence the recommendations of the International Maritime Organization itself, to "consider, together with ship suppliers, the acquisition of products based on the garbage they are going to produce." In the process of waste management, the ship's crew goes from assuming the role of internal client, to that of supplier:

"Compliance with Annex V of the MARPOL Convention requires the participation of personnel and the use of equipment and procedures for the collection, classification, treatment, storage, recycling, reuse and discharge of garbage" (Resolution MEPC. 295 (71)). The standard itself also states that these procedures will depend on issues such as: *The type and size of the vessel, the area of operation, the shipboard treatment equipment, the storage space, number of crew or passengers, duration. of voyage, and/or regulations and reception facilities at ports of call.*

The Figure 5 shows the flowchart corresponding to the general garbage management plan presented by said resolution.

Those options for garbage that cannot be discharged into the sea have been marked in color (those reflected in the original scheme of the Resolution, as susceptible to short-term storage are also considered) since, for management purposes, they are garbage that cannot be discharged into the sea.

Regarding collection and separation issues, we must comply with the regulatory specifications, garbage record book, previous delivery forms and, to a lesser extent, delivery receipts, since these will be the documents that record the end of the process. The current specifications of the Garbage Record Book and the prior notification form establish the following levels of segregation:

Table 2: Levels of segregation of solid waste.

Segregation level
Plastics
Food waste
Household waste
Cooking oil
Incinerator ashes
Operational waste
Animal carcasses
Fishing arts
Electronic waste
Cargo residues (NOT harmful to the environment)
Cargo residues (harmful to the environment)

Source: MEPC.1/Circ 834/Rev.1.

Some of these "levels" may continue to contradict the idea of separation recommended in the latest resolutions:

Both in the prior notification forms and in the waste delivery receipt templates, for example, the total amount in m3 of household waste that originates in accommodation spaces must be indicated, where they are included, among others, paper products, rags, glass, metals, china, bottles. All of them indicated as capable of being separated.

Table 3: The recommended garbage types that should be separated.

Recommended separation	
1 Non-recyclable plastics and plastics mixed with non-plastic garbage	
2 Rags	
3 Recyclable material:	
	1 cooking oil
	2 glass
	3 aluminium cans
	4 paper, cardboard, corrugated boar
	5 wood
	6 metal
	7 plastics
4 E-waste generated on board	
5 Garbage that might present a hazard to the ship or crew	

Source: Resolution MEPC 295(71).

The current formats of the cited documentation do not recognize the need to break down or describe in detail the nature of said garbage, which does not promote their segregation. In the same way it happens with all those epigraphs that include very different substances in a single concept, as is the case of operational waste.

In Resolution MEPC.295(71), described in table 3, you can see the recommendation of the separation of plastic into different categories, non-recyclables, mixed with non-plastic garbage and recyclables, however, the documentation of delivery only contemplates a generic, plastic heading. On the other hand, food waste is not included, while it does appear in the prior notification form.

3.5. Perception of crews.

In addition to the regulatory review, for the preparation of this work, we have had the MARPOL waste delivery receipts in the port of Santander corresponding to the years 2012 to 2016. Despite the fact that the model used for these delivery receipts has changed, the database created, helps us to identify the interpretation that the crews make of the different types of waste, depending on the epigraph in which they are recorded.

To check the opinion of the crews on the treatment of waste on board (management) and its delivery to the port, a survey was used that was sent to the crew (deck officers and engines). In many cases, these are those responsible for the management system implemented by their companies, but the perception of other crew members not directly linked to the supervision of said systems is also collected. In the sample, there are different types of ships, with crews ranging from 7 people in small freighters to 56 in some mixed RO-RO-Passage ship, which make trips that can last from a few hours to 10 days or even several months. when it is a question of a trawler, or as the particular case, of a surveyed crew member, who responded from a shipyard where he was with his ship.

Table 4: Management issues.

Where?	Who?	Responsable?	Collection area	Storage area
Decks and holds	Boatswain and deck sailor	Boatswain and deck sailor	Storeroom	
Crew accommodations	Crew	Boatswain and deck sailor	Crew accommodations	
Navigation bridge	Deck officer	Boatswain and deck sailor	Bridge deck	Coincident with collection area
Kitchen	Cook	Cook	Kitchen	
Officier accommodations	Deck officer	Steward	Officier accommodations	
Engine room	Engine crew	Greasers	Engine room	

Source: Garbage management plans of the Maritime Company. Authors.

The survey consists of several blocks of questions. Block two deals with the main obstacles that prevent the correct functioning of the system. It is composed of ten closed questions for whose answers the Likert scale was used, with ratings ranging from 1 for those considered less important to 5 for those with greater importance.

We must, therefore, look for the answers to certain questions: Where is waste generated? Who generates it? Who is responsible for its collection? What is its collection place? storage? What is the level of segregation achieved on the ship? Does the same ship always generate the same type of waste?

4. Results.

According to the garbage management plans already approved by the shipping companies, some of the answers that are offered are:

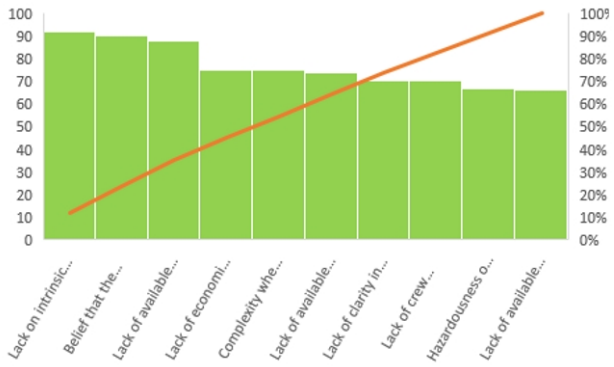
In addition to this, the possibility of installing other types of containers to favor the recycling of some waste is recognized, such as, among others: glass, metal, paper and cardboard, which implies the need to characterize each waste generated by board, which responds to each of these questions raised above, which will allow an adequate level of segregation of the waste to be reached for its delivery to the reception facilities in port.

It has been possible to verify how the epigraphs called cargo waste, ship products and others (in which the waste must be described), contain the same type of waste, in many cases. This implies that, either, residues are recorded in headings that do not correspond to them or that the same type of waste may be included in different headings, which makes the system ineffective.

On the other hand, due to the fact that the particular regulations of the ports may establish different levels of segregation, waste typologies have been recognized that, for certain ports, do not conform to the categories included in the MARPOL service, which makes it even more difficult the work of the crews.

The Pareto diagram indicates the perception of the crews, in terms of the obstacles they face when managing waste on board ships.

Figure 6: Crews' perception of obstacles.

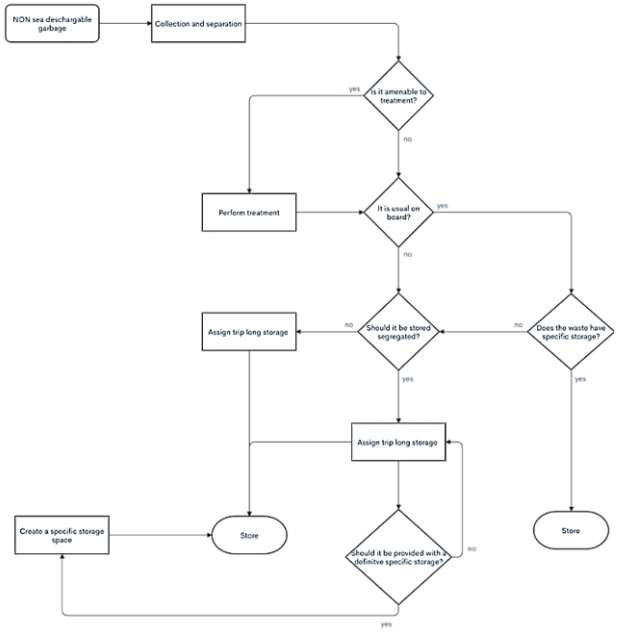


Source: Authors.

The lack on intrinsic motivation of the crews, the belief that the system is not useful and the lack of space on board, are the three main obstacles recognized by the surveyed crews.

It seems necessary, therefore, to define a *"vessel experience factor"* in terms of the different types of waste generated, so that, on the one hand, the need for different segregations can be recognized according to the particular circumstances of each ship and, on the other, the changes can be adapted in case of "new waste" not common on board. For which an alternative flowchart to the one proposed by the standard is made.

Figure 7: Proposed vessel experience factor flow chart.



Source: Authors.

5. Conclusions.

This work shows the difficulty in characterizing the waste, which in many cases does not facilitate the work of the crews when managing the collection, segregation and storage of these.

The prior notification forms offer a type of segregation, the guidelines for the implementation of Annex V offer another possibility and the crews, depending on the different types of waste generated on each ship, adapt, making sometimes erroneous interpretations of how certain wastes generated on board should be classified.

All this generates distrust, in terms of the effectiveness of the system and therefore in the motivation to implement the management plans, on the part of the crews.

The solution proposed for the management of waste that cannot be discharged into the sea, which must be delivered to a port reception facility, involves a characterization of each waste generated on board, which will make it possible to achieve an adequate level of segregation and at the same time define a "*vessel experience factor*" in terms of the different typologies, so that the changes that may occur in each ship can be adapted.

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