



The MARPOL Convention in scientific literature. Bibliographic review

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ABSTRACT

The objective of this work is to carry out a bibliographic review, in the field of the International Convention for the Prevention of Pollution from Ships. To do this, all the article-type publications that appear in the Web of Science and Scopus databases until 2017 have been searched using the keyword MARPOL. Subsequently, the abstracts of all the articles are grouped together and a record for each of these references. With the data obtained, analyzes are carried out, both quantitative and qualitative. All this in order to obtain a global vision of the way in which the scientific literature deals with maritime environmental problems. The work shows the direct relationship between the entry into force of the different Annexes and the increase in scientific production and that the most numerous works are those that deal with legal and prevention aspects.

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1. Introduction

The evolution of maritime transport, with the use of ever-larger ships and the increase in accidents that caused catastrophic consequences, especially during the 1970s (Hooke, 1997), forced International Organizations to consider the need to regulate the prevention of spills by ships and as a result of this arises the MARPOL Convention (IMO, 2017), as the legal basis on which all the regulations for these issues are based.

The Convention appears to be a “living” text, which has been subjected to profound modifications, necessary to adapt to the new requirements regarding discharges and maritime pollution.

The entry into force of the different Annexes and their adaptation to European regulations and national regulations, consti-

tute the main basis on which the scientific literature published on this Convention is based.

Table 1: Entry into force of the MARPOL Convention in the Spanish legal system.

Event	Date	Reference
<i>MARPOL 1973</i>		
<i>Protocol 1978</i>	1984-10-06	
<i>Annex I</i>	1984-10-06	(BOE 249, 1984)
<i>Annex II</i>	1984-10-06	
<i>Annex V</i>	1991-04-21	(BOE 56, 1991)
<i>Annex III</i>	1992-07-01	(BOE 125, 1992)
<i>Annex IV</i>	2003-09-27	
<i>Protocol 1997</i>	2005-05-19	(BOE 251, 2004)
<i>Annex VI</i>	2005-05-19	
<i>Annex IV (Revised)</i>	2005-08-01	(BOE 153, 2005)

Source: B.O.E. Authors.

2. Materials and methods.

To prepare this review of the state of the art on prevention and management of marine pollution by residues, all the article-

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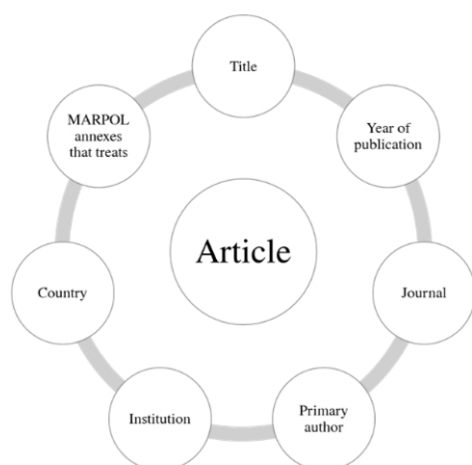
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Figure 1: Data collected from each record.



Source: Authors.

type publications that appear in the Web of Science and Scopus databases up to the year have been searched using the keyword MARPOL. 2017 included. Subsequently, a single database is created by putting the records together. Finally, the summaries of all the articles are grouped and a record is created with each of these references, where the data of each of them are collected, as shown in Figure 1.

Before continuing with the rest of the analysis, the articles that are found duplicates are checked for appearing in the two databases.

Table 2: Keywords to define the Annexes of the MARPOL Convention.

Annex	Title	Keyword
I	Regulations for the Prevention of Pollution by Oil	Oil
II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk	Noxious Liquid Substances
IV	Prevention of Pollution by Sewage from Ships	Sewage
V	Prevention of Pollution by Garbage from Ships	Garbage
VI	Prevention of Air Pollution from Ships	Emissions

Source: MARPOL Convention. Authors.

In addition to this, in some cases, neither the article nor the abstract of the records is available, so these references can only be used for some of the parts of the study.

These data will allow us to prepare a quantitative and qualitative analysis (Sánchez & Blanco, 2016) of the publications,

collected in the two aforementioned databases, on the Agreement and its Annexes I, II, IV, V and VI.

From now on, the keywords listed in Table 2 will be used to refer to some aspect of the corresponding Annex.

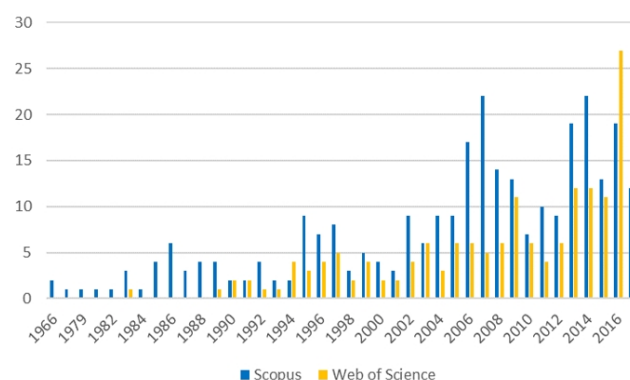
On the other hand, for each of the articles, the typologies, themes and contents are defined. Definitions that are only intended to be valid within the present work. This will allow us to carry out a qualitative analysis. It includes, first, a study of the topics and contents treated for the different Annexes and later an analysis of the applied typologies and a relationship between these three defined variables. All this in order to obtain a global vision of the way in which scientific literature deals with maritime environmental problems.

3. Results.

3.1. Quantitative analysis.

Regarding the temporal evolution of the number of publications, although in 2016 and 2017 the number of publications collected in Web of Science is higher, with 27 in 2016 and 18 in 2017 compared to 19 in 2016 and 12 in 2017 of Scopus, as shown in Figures 2 and 3; the Scopus database is the one with the highest number of total publications, 292 compared to Web of Science with 177.

Figure 2: Number of publications per year in each database.

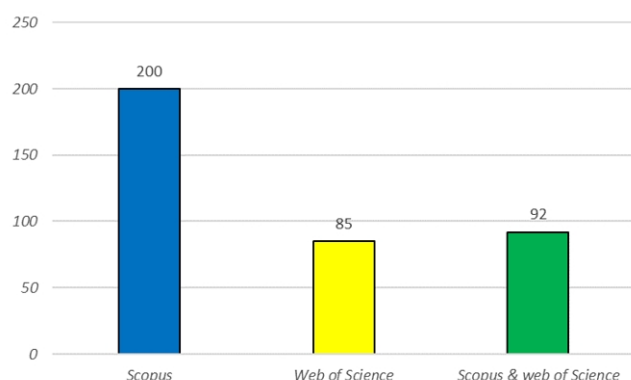


Source: Web of Science & Scopus. Authors.

The figure shows us that, except for the sharp decline in 2011, in the Web of Science database, it is between 2005 and 2016 where the scientific production with the aforementioned guidelines, remained at the highest values. Scopus data indicate that, except for the sharp decline in 2010, it is between 2004 and 2016 where the scientific production with the aforementioned guidelines, remained at the highest values. As of 2016, Web of Science records more publications than Scopus.

After performing all the aforementioned filters, the total number of articles under analysis is 377, distributed as shown in Figure 3.

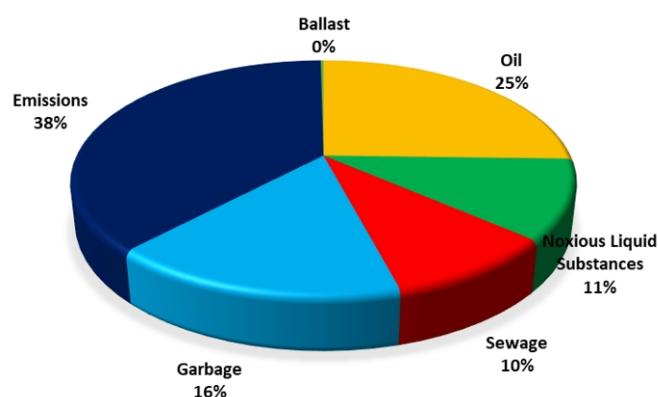
Figure 3: Number of publications in each database.



Source: Web of Science & Scopus. Authors.

The number of publications on each of the different MARPOL Annexes is analyzed. There are articles whose subject matter focuses on a single Annex to the Convention and others that deal with several at the same time. Each different named Annex is independently registered for computational purposes. An article dealing with ballast water has also been included: “Ballast system design for flow-through exchange of ballast water” (Armstrong et al., 1997) because it mentions what could constitute a new MARPOL Annex, although obviously the percentage with respect to the total published on other annexes is negligible. Some ballast water management guidelines and the development of ballast water management plans MEPC.127(53), MEPC.161(56) and MEPC.206(62) are already in force, for the exchange of ballast water. ballast MEPC.149(55), for sampling MEPC.173(58), etc...

Figure 4: Percentage of articles published in each Annex.



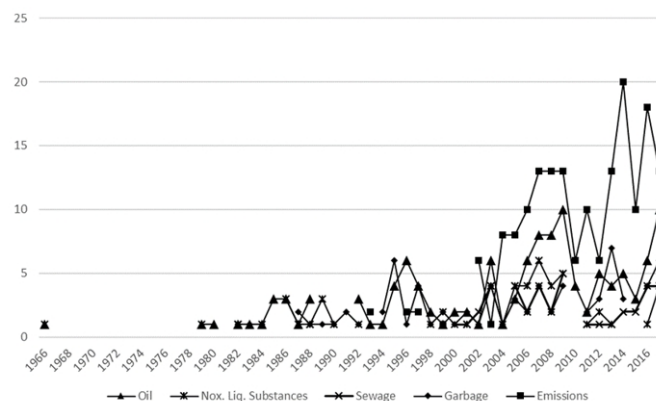
Source: Web of Science & Scopus. Authors.

It can be seen that the publications on Emissions and Oil are the most numerous. Being curiously, the first Annex to come into force, Hydrocarbons, and the last, Emissions. Against these data, it is worth highlighting Dirty Waters, in force since September 27, 2003 and which is the least treated by scientific production.

In addition to the percentage values of publications, the number of annual publications of each Annex was analyzed. It

can be seen in figure 5 how in oil and noxious liquid substances they are the ones that have been published for the longest time, as it cannot be otherwise, since they are the ones that have been in effect for the longest time.

Figure 5: Annual publications by Annex.



Source: Authors.

In any case, it is the Oil that have a higher production and that is maintained over a longer time. The maximum values for scientific production of Oil between 2005 and 2010 and between 2011 and 2016 coincide with the entry into force of a large part of the amendments to this Annex I.

Regarding Noxious liquid Substances, the figure shows us that it had little significance in the 90s, despite the fact that a large part of the amendments to this annex are from that time. The registered maximums coincide with the 2007 amendments. There have been no registered publications since 2013 despite the modifications that include the new resolutions to which this Annex has been submitted.

The articles related to Sewage are, as was reflected, those with the lowest number of publications. As indicated in the figure, it reaches a relative maximum of production at the time of its entry into force, in 2003. The revisions of this Annex and its date of entry into force take place between August 2005 and January 2017.

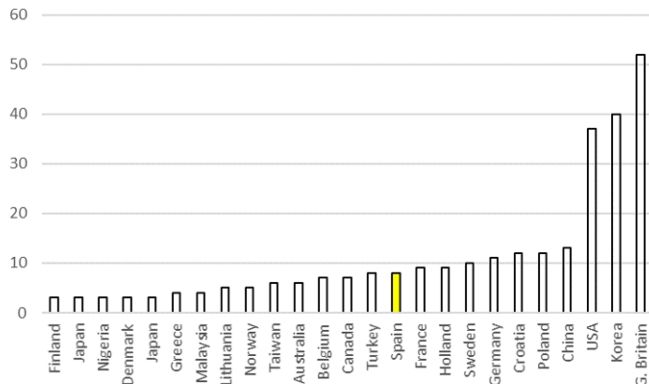
As regards work on garbage, the peak of scientific production occurred in 1995, the year after the first series of reviews. In the years 2006–2007, after the amendments, there are relative maximums of publications whose subject is garbage. The last relative production peaks take place in 2013, coinciding with the revisions. The last revision of this annex is from January 2017.

The articles on Emissions begin their production from the year 1993, Although it was adopted by the International Conference of the parties to the MARPOL Convention in September 1997, it did not enter into force until May 19, 2005, the year in which it is experienced. an increase in scientific production related to this annex. The figure shows that this annex accounts for a good part of the texts published in recent years. The latest series of revisions to this annex begins in 2011.

After having analyzed the time and subject evolution of the publications, a geographical analysis was then carried out.

Thus, the number of publications per country is shown in Figure 6. The country assigned to each record is the one corresponding to the affiliation of the first author of each publication.

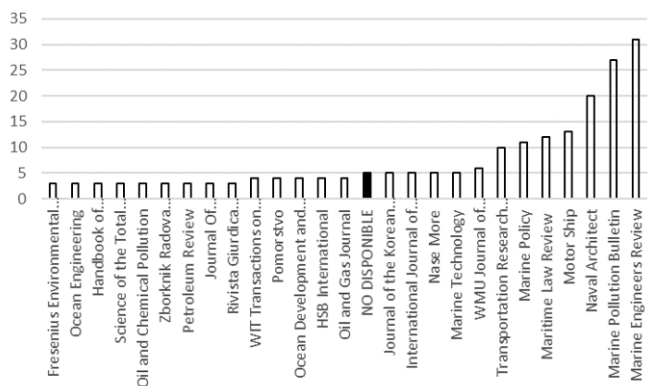
Figure 6: Publications by country.



Source: Web of Science & Scopus. Authors.

Great Britain, Korea and the United States stand out for the number of publications. Eight registries with Spanish affiliation are present.

Figure 7: Publications by journals with a minimum of three articles.



Source: Web of Science & Scopus. Authors.

Another quantitative data to be analyzed was the origin of the publications, that is, the journals where these articles appear. For simplicity of graphic representation, only those publications that have a minimum of three registered articles have been collected, as shown in figure 7. The publications on engineering, contamination and legal aspects stand out.

To complete the quantitative analysis, a study of the articles published in relation to the authors is carried out, considering only the first author and the institution to which he belongs. To simplify the representation, only those records with a minimum of two publications are considered and, in addition, all those reflected as anonymous, or for which the affiliation is not available in the respective databases, are discarded.

Table 3: Most prolific authors and affiliation.

Author	Institution	Total
Schinas, O. D.	Hamburg School of Business Administration, Maritime Business School	3
Lee, H.-Ch.	Chonnam National University	2
Pavlakis, P. J.	Institute of Oceanography, National Centre for Marine Research, Athens	2
Listewnik, J.	Akademia Morska w Szczecinie, Inst. of Ship Propuls. Plant Oper., Szczecin	2
Vermeire, M.	Chevron Global Marine Prod, Oslo	2
Tinsley, D.	Fermi National Accelerator Laboratory, Batavia	2
Speares, S.	Freelance Maritime Journalist	2
Mobilik, J. M.	Malaysia Marine Department (Sarawak Region)	2
Mazzin, J. M.	Ministère de l'Environnement, DEPPR, Service de l'Eau	2
Fu, S.	Natl Engn Res Ctr Water Transport Safety, Wuhan	2
Carpenter, A.	Organisational Sustainability, Ltd., Cardiff	2
Lindstad, H. E.	Sintef Ocean AS MARINTEK, Trondheim	2
Tanaka, Y.	Univ Copenhagen	2
Camarda, G.	Univ degli Studi di Palermo	2
Panasiuk, I.	Univ Klaipeda, Dept of Ship Engineering	2
Lin, C.	Univ Ocean National Taiwan, Department of Marine Engineering	2
Lin, B.	Univ Ocean National Taiwan, Department of Merchant Marine, Keelung	2
Geng, P.	Univ Shanghai Maritime, Merchant Marine College	2
Worham, J.	Univ Wales coll Cardiff, Dept maritime studies & int transport	2
Hurford, N.	Warren Spring Laboratory, Stevenage	2
Draffin, N.	Worshipful Company of Fuellers	2

Source: Web of Science & Scopus. Authors.

The author with the highest number of publications is Doctor Orestis D. Schinas of Greek nationality. His articles are registered with German nationality since he is a member of the “Hamburg School of Business Administration. Maritime Business School” so as indicated above, it is the nationality of the institution to which the author belongs, which is shown in the study. His three works deal with socio-economic issues and focus on Annex VI of the Convention.

Methodological framework for estimating the impact on the cost of some of the environmental measurements and specifically on the increase in operating expenses of maritime vessels, due to the limits of sulfur emissions (Schinas & Stefanakos, 2012).

Employing a financial model to help comply with regulations on sulfur emissions (Schinas & Stefanakos, 2014).

Proposal for a methodology to evaluate the commercial incentives required to promote LNG as a marine fuel (Schinas & Butler, 2016).

3.2. Qualitative analysis.

For the preparation of the qualitative analysis, the themes and contents are previously defined so that they can be subsequently related to the different annexes of the Agreement. Each theme and content are unique for each article.

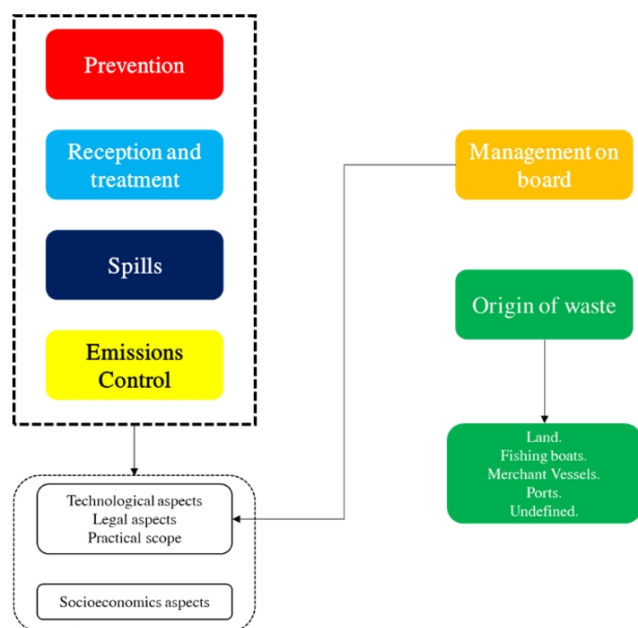
Subsequently, the typologies of each publication are described according to the treatment that the article gives to the question studied in it.

To establish the themes, a first analysis was made by reviewing all the articles and it was found that some of them dealt with issues specific to the annex to which they refer, such as: Emissions Control. - Own theme of the articles related to Annex VI.

Spill. - Own theme of the articles related to Annex I.

And others that, to a greater or lesser extent, appear in the different Annexes, such as:

Figure 8: Themes and contents.



Source: Authors.

Prevention. - It fits perfectly to two of the meanings of the dictionary of the RAE. "Preparation and provision that is made in advance to avoid a risk or execute something". "Provision of maintenance or something else that serves a purpose"

Management on Board. - They are those works that deal with how the implementation and compliance of certain Annexes affects the routine and work on board ships.

Reception and treatment. - The Convention determines the role to be played by ships, the administration and the ports. How they act to conform to the Annex is included in this classification.

Origin of Waste. - A good part of the scientific literature on this matter focuses on determining the origin of the waste, in order to be able to determine and tackle problems from the source.

In addition to defining themes, content has been defined. With two different classifications since the issue of origin of waste showed other alternatives

Figure 8. shows the general scheme that has been followed to classify the articles.

To define the Contents of each of the Topics, key words or expressions have been searched that serve as a link between the different articles in such a way that they show homogeneity:

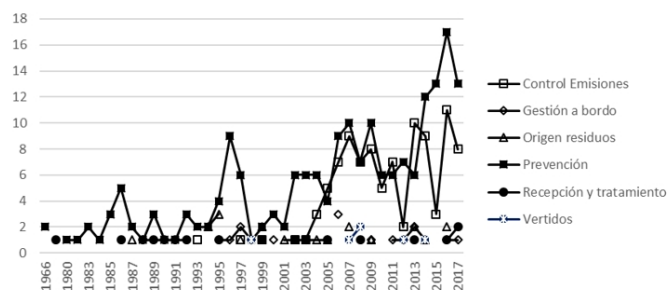
For the articles dealing with the origin of waste and its different contents, the subdivision was more evident. Being classified as of indefinite origin, those works that study the waste and the consequences that they cause, but do not enter into value or do not provide the data of the origin of said waste, such as those that deal with the contamination of fauna by plastics, for chemical residues, etc.

3.2.1. Themes.

The relationship between the themes and their evolution over time and of these with each of the annexes of the MARPOL Convention was studied.

Figure 9 shows us that both issues of prevention and control of emissions are the ones that are most discussed throughout the period analyzed. Although the latter have a much shorter route, the data reflects that there is more and more dedication to the study and observation of greenhouse gas emissions into the atmosphere.

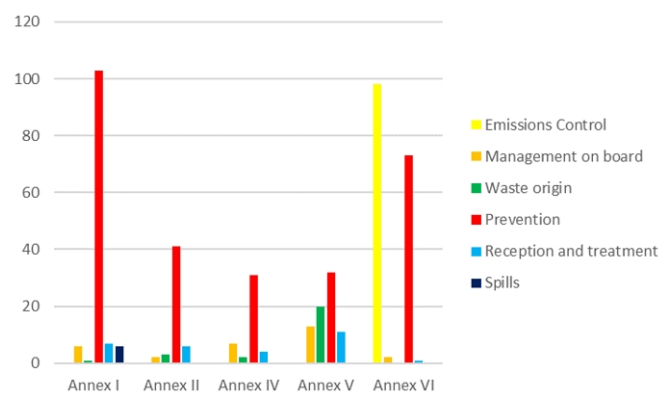
Figure 9: Themes over time.



Source: Web of Science & Scopus. Authors.

The relationship between themes covered in each of the different Annexes is represented in figure 10.

Figure 10: Themes that appear in the different Annexes.



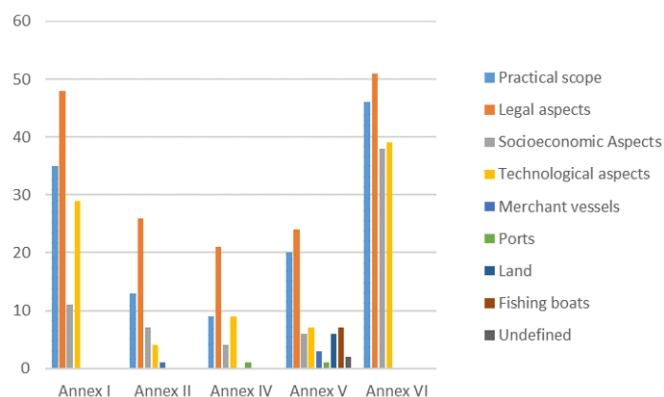
Source: Web of Science & Scopus. Authors.

The theme most covered by each of the Annexes is prevention, except in the corresponding Annex VI where it is Emissions control, which presents more than half of the publications. The waste origin should be highlighted in the Annex dedicated to Garbage, which shows the great interest of the scientific literature for the identification of the waste collected on the coasts.

3.2.2. Contents.

The Contents related to each annex of the Agreement are analyzed and the results are shown in Figure 11. The Contents defined as Legal aspects are the most used in each and every one of the Annexes.

Figure 11: Contents that appear in the different Annexes.



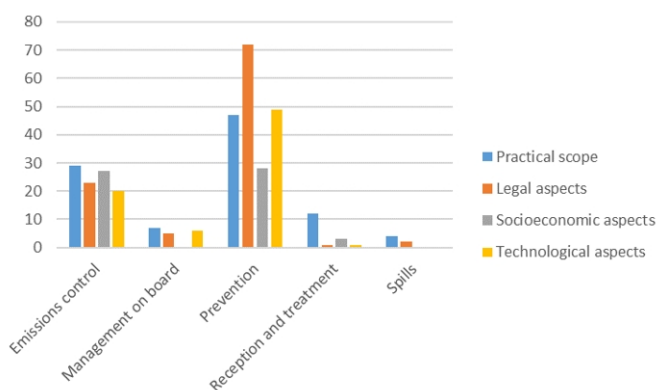
Source: Web of Science & Scopus. Authors.

Only the Annex referring to Garbage presents all the Contents defined in this study. It highlights the importance given to Socioeconomic aspects in Annex VI.

Themes and Contents that are common have been listed in figure 12.

The result shown indicates that except in prevention, where legal aspects predominate, most of the literature on the MARPOL agreement has its greatest content in the practical sphere, that is: Models, tools, plans, systems, protocols...

Figure 12: Themes and Contents.



Source: Web of Science & Scopus. Authors.

On board management, there are no texts on socio-economic aspects and it can be observed that most of the publications are practical and technological aspects, that is, development and evolution of “tools” for the implementation and compliance with the Annexes.

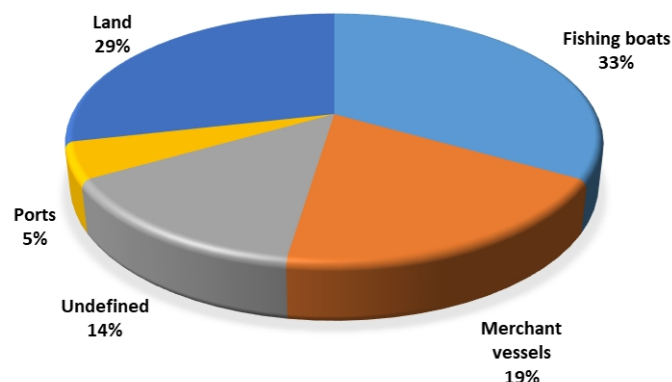
In the texts that refer to the reception and treatment of waste, it can be observed that most of them present contents of a practical scope, that is, availability of stations for the reception and management of said waste and socioeconomic aspects that determine the costs / benefits of having such facilities.

The representation of the Theme on the Origin of Waste and the different contents is shown in figure 13.

It can be seen that 14% of the total publications deal with

waste without defining its origin and that most of the waste referred to originates from fishing boats 33%, basically gear and fishing gear and origin 29% land, such as, for example, household waste on the beaches.

Figure 13: Origin of waste.



Source: Web of Science & Scopus. Authors.

3.2.3. Tipologies.

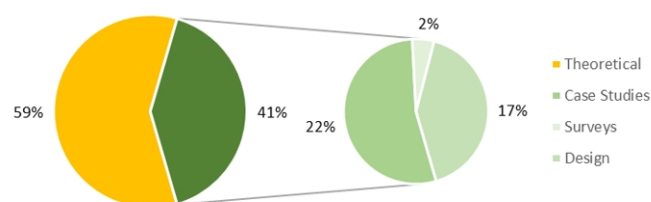
To establish this analysis on the registered publications, both in Scopus and in Web of Science, a classification has been established according to their typologies, for each of the articles. Said typologies are defined by the treatment that the article gives to the question studied in it. Thus, for example, there are several articles that deal with the requirements of Annex VI for the use of new fuels and that, however, present different typologies.

A first classification responds to, if it is about theoretical studies such as: The effects of the new international regulations from a political, technological, economic and / or legislative perspective. Comparative law studies. Reviews of the degree of implementation of the Convention in certain countries ...

The second describes the empirical type of work, the latter being able to have the structure of:

- Surveys, as an indicator of the degree of implementation of the different annexes or the degree of satisfaction on the part of the users;
- Design work, where technological projects are described to implement and comply with the specifications of the different Annexes, the tools developed, the new constructions...;
- Or, Case studies, defined as the scientific method and the knowledge acquired based on careful observation and measurement of the objective reality that exists “out there” (Creswell, 2009). In which different systems are compared to obtain the same purpose, studies are carried out through sampling, follow-up and monitoring of contaminants are carried out...

Figure 14: Typologies.

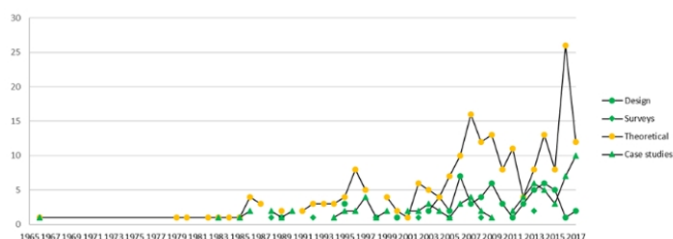


Source: Web of Science & Scopus. Authors.

In view of this figure, it can be said that Theoretical studies predominate over the empirical ones and that within the latter, the Case Study is the most prolific methodology.

Another noteworthy data is the one that figure 15 offers us, where it can be observed that the Theoretical type works are maintained over time and the Study cases begin in the middle of the 90s and are maintained today.

Figure 15: Typologies over time.



Source: Web of Science & Scopus. Authors.

The works with Design Typology has their validity in the first decade of the XXI century coinciding with the maximum production of articles related to Emissions and, finally, the Survey works that have a sporadic nature.

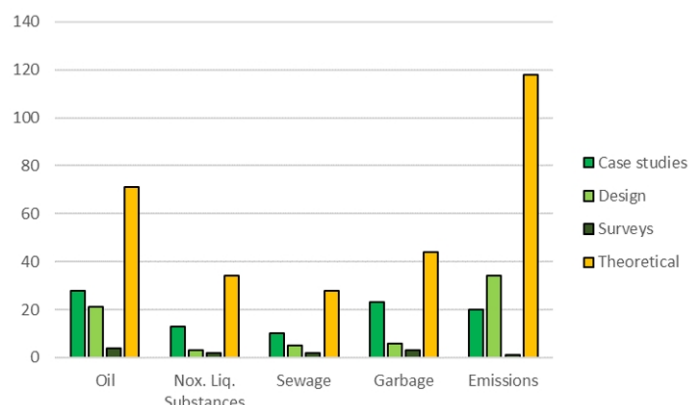
To define the relationship between the different Typologies and the MARPOL Annexes treated, figure 16 is represented so that we can obtain the publications that each Typology dedicates to each Annex, the vision of the Typologies used in the field or fields to be studied and what that they represent in the global.

It can be seen that in all cases the Theoretical studies are those with the greatest scientific production. Surveys are only of notable value in articles referring to Noxious liquid substances and Oil. Despite the data previously reflected that indicated that the Designs are most valid at the time related to the highest production in Emissions, this Typology represents a scarce 1.7% of the total published in relation to this Annex.

Conclusions.

Scientific production based on the MARPOL Convention has not been very prolific during these years, showing production peaks every time, a new Annex came into force.

Figure 16: Typologies-MARPOL Annexes.



Source: Web of Science & Scopus. Authors.

In recent years, concern about environmental issues and air pollution has increased.

Both prevention and emission control issues are the most discussed throughout the period analyzed.

The works related to legal aspects are the most used in each and every one of the Annexes.

Most of the studies have an eminently theoretical profile.

This work has shown the different themes, contents and typologies of the scientific literature related to the MARPOL Convention.

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