Risk assessment approximation to the introduction of species in Colombian Seaports, through ballast water

Aproximación a la evaluación de riesgo de introducción de especies en puertos colombianos, a través del agua de lastre

DOI: 10.26640/22159045.424 **Reception date:** 2016-02-05 **/ Acceptance date:** 2016-05-10

Juan Pablo López Morales*, Estefania Palacio Cardoso & Mary Luz Cañón Páez*****

López Morales, J., Palacio Cardoso, E. & Cañón Páez, M. (2016). *Risk assessment approximation to introduction of species in Colombian Seaports, through ballast water.* Bol. Cient. CIOH (34):13-26. ISSN 0120-0542 and ISSN online 2215-9045 DOI: 10.26640/22159045.424

Abstract

Colombia has eight ports receiving ships of international maritime traffic, whose impacts on ecosystems, infrastructure and health, can be caused by the discharge of ballast water from different places globally. The International Maritime Organization since more than two decades has established guidelines to counteract the problem of biological pollution in coastal areas generated by the ballast water vector, between these guidelines have been established several models to assess the introduction risk of species into new areas, which consider for example: arrival frequency *(C1)*, ballast water volumes discharged in seaport *(C2)*, the environmental similarity, between source port and receiving port *(C3)*, and introduced species in the study areas *(C4)*, with two risk reduction factors: Tanks size *(R1)*, and the days of permanence of water in tanks *(R2)*. From this methodology and the ballast water management formats submitted to the Maritime Authority in compliance to the resolution 477/2012[1] during 2014, the risk level was established to eight Colombian ports. Puerto Bolívar, Coveñas and Santa Marta were identified as the main importers ports of ballast water in the country with 10041 444 m^3 (34.64 %); 9552 509.26 m^3 (32.95 %) and 7846 182.632 m^3 (27.07 %). On the other hand was identified that Tumaco y Santa Marta, although not represent high discharges of ballast water, generate high risks by environmental similarity between these and the ballast water source.

KEYWORDS: Ballast Water, Risk Assessment, Bioinvasion, Colombian Port.

Resumen

Colombia cuenta con ocho puertos que reciben buques de tráfico marítimo internacional cuyos impactos en los ecosistemas, infraestructura y salud, pueden ocasionarse por las descargas de agua de lastre procedentes de diferentes lugares a nivel global. La Organización Marítima Internacional desde hace más de dos décadas ha establecido lineamientos para contrarrestar el problema de la contaminación biológica en las áreas costeras generada por el vector agua de lastre; entre estos lineamientos se han establecido varios modelos para evaluar el riesgo de introducción de especies en nuevas áreas, los cuales consideran por ejemplo: la frecuencia de arribo (C1), los volúmenes de agua de lastre descargados en puerto (C2); la similitud ambiental entre el puerto de origen con el puerto de descarga (C3) y las especies introducidas en las áreas de estudio (C4), con dos factores de reducción del riesgo: tamaño del tanque (R1) y los días de permanencia del agua en los tanques (R2). A partir de esta metodología y los formatos de gestión de agua de lastre remitidos a la Autoridad Marítima en cumplimiento a la Resolución 477/2012[1], durante 2014 se estableció el nivel de riesgo de introducción de especies en ocho puertos de Colombia. Puerto Bolívar, Coveñas y Santa Marta se identificaron como los principales puertos importadores de agua de lastre en el país con 10041 444 m^3 (34.64 %); 9552 509.26 m^3 (32.95 %) y 7846 182.632 m^3 (27.07 %). Por otro lado, se identificó que aunque Tumaco y Santa Marta, no representan altas descargas de agua de lastre, generan altos riesgos por la similitud ambiental entre estos y el origen del agua de lastre.

PALABRAS CLAVES: *agua de lastre, evaluación de riesgo, bioinvasión, puertos colombianos.*

* General Maritime Directorate. Integral Maritime and Port Security Area. E-mail: jlopezm@dimar.mil.co

** General Maritime Directorate. Integral Maritime and Port Security Area. E-mail: epalacio@dimar.mil.co

*** General Maritime Directorate. Integral Maritime and Port Security Area. E-mail: mcanonpaez@dimar.mil.co

1. Resolution issued by the maritime authority, by which the measures and the control procedure are adopted and established to verify the management of Ballast Water and sediments on board national and foreign naval vessels and artifacts in Colombian jurisdictional waters.

Introduction

Maritime transport brings about commercial and social development worldwide in an efficient way; however, it entails pollution problems related to the danger of the substances that can be transported, as well as the emissions produced constantly into the atmosphere. But in recent years another problem has been identified in relation to the introduction of species through ballast water[2], which has generated alterations in the normal cycle of ecosystems in various parts of the world, reduction in the number of individuals of the native populations and therefore an effect on local fishing (Gollasch, Cabrini, Perkovic, Bosnjak & Virgilio, 2007).

Several studies carried out in different parts of the world have shown that ballast water from ships is the main facilitator of transfers of aquatic organisms including human pathogens through natural barriers or limits (Leal Flórez, 2011).

The objective of this research was to evaluate the risk of the introduction of marine species in the main Colombian ports, identified as importers or receivers of ballast water; to establish control measures and management of this problem and avoid new bio invasions, based on the risk assessment methodology endorsed by the International Maritime Organization (hereafter, OMI).

The evaluation of risk as a logical process serves to determine the probability and consequences of specific phenomena; in this case, events such as the introduction, establishment or spread of harmful aquatic organisms and pathogens (MEPC, 2007). In general, a risk analysis intends to operate at different levels: the environmental adequacy and the approach of biogeographic species are methods used (in a global context) when donor and recipient ports are located in different bioregions; in the case that the donor and receiver ports are within the same bioregion, it is assumed that the environmental conditions are similar, therefore a species-specific risk analysis approach is necessary (Matej, Gollasch & Leppakoski, 2013). When this analysis is done rigorously and systematically, risk assessment can be a valuable tool for decision making; the risk levels of all the origins of the arriving ships can be meticulously prioritized to ensure measures to prevent the invasion of non-native species (Liu, Chang & Chou, 2014).

This type of evaluation has been carried out in some pilot countries; one of these countries was Brazil (in the port of Sepetiba), for which it was found as a novelty that 20% of the ports identified with ballast water discharge are located in the same country; It was also found that the ports that represented the greatest risk came from southern Europe and the Brazilian ports themselves (Clarke, *et al.,* 2004). In the case of Odessa (Ukraine) located in the Black Sea, it was identified that the origin of the ballast water comes from its great majority of ports located in this same sea, and the ports with high risk for Odessa are located in eastern Russia and in Japan (Alexandrov, *et al.,* 2013).

In Colombia, this evaluation is based on the information reported in the ballast water notification format annexed to Resolution DIMAR *477 / 2012.*

Study area

Ballast water is loaded and unloaded at the ports located in the Caribbean and Colombian Pacific, for which the risk assessment was applied to 8 maritime ports of Colombia (Figure 1):

Tumaco, Buenaventura, Barranquilla, Santa Marta, Cartagena, Turbo, Coveñas and Puerto Bolivar, since the discharge activity only occurs in these, which makes them vulnerable to marine bio invasion. Ports such as Cartagena and Buenaventura, which have high maritime traffic, are characterized by the import and export of goods, identifying that they mostly receive container-type vessels. While in ports such as Puerto Bolívar, Coveñas and Santa Marta, solid

2 Ballast water: Water, with the materials in suspension that it may contain, loaded aboard a ship or naval device to control the list, depth, stability and structural efforts (General Maritime Directorate, 2012).

or liquid bulk cargoes are exported, which is why they receive larger ships of the bulk and oil type.

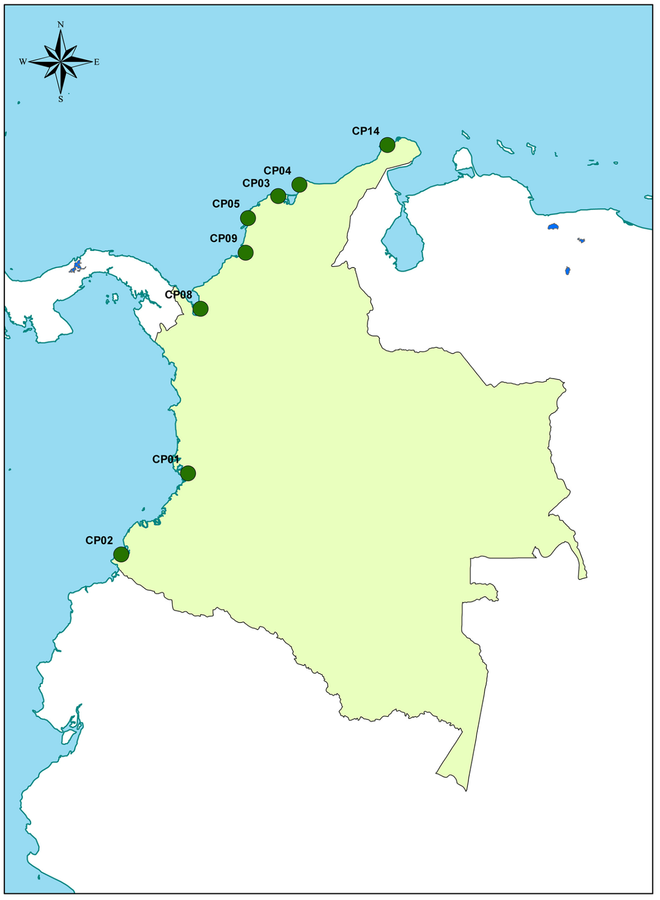

Figure 1. Location of the analyzed ports in the colombian coast.

The Colombian Caribbean is subdivided into two provinces (oceanic and coastal), with the presence in turn of three coastal regions contained within the coastal province, whose dynamics are affected by contributions from continental waters (Magdalena Region and Gulf of Darién Region) and by ascents of water masses (Guajira-Paraná outcrop region) (Cañón Páez, 2010). In the case of the Colombian Pacific Basin, it is divided into two regions: the coastal one that extends from the border and maritime delimitations with Panama and Ecuador along the entire continental coast, including the islands located by the continental shelf; and the oceanic region, which extends from the outer limit of the coastal region to the outer limits of the Colombian jurisdictional waters, being an open watershed, unlike the Caribbean basin (Arboleda & Jiménez, 1988).

Methodology

To calculate the introduction risk, the integral risk model established by the IMO Ballast Water Program was considered, which establishes that from the information provided in the ballast water register formats of the ships that arrived at the Colombian maritime ports, the risk is calculated based on four aspects (Table 1) $CRG=(C1+(C2*R1)+C3+(C4*R2))/4$[3] where:

3. Global Risk Equation CRG: is the combined measure of four coefficients, and two reduction factors, expressed as a proportion or total percentage of the risk posed by all ports of origin of ballast water.(Clarke *et al.,* 2004).

Table 1. Coefficients for calculating the Global Risk Equation CRG.

Coefficient	Definition
C1	Relative frequency of the number of ballast tanks coming from a certain port in relation to the total of discharged tanks.
C2	Proportion of the volume of ballast water of a given port of origin, in relation to the total volume discharged.
C3	Multi variate analysis of Euclidean distance coefficient, performed in parallel, where environmental similarity values were generated between the receiving port and each ballast water donor port.
C4	Provides a measure of the risk presented by each donor port due to the number of risk species present in the port's bioregion.

(Clarke *et al.,* 2004)

Based on the information provided by the annex to *Resolution 477 / 2012*, the volumes discharged of ballast, the on-board management carried out, and the basic data of the ships arriving at Colombian ports, were identified.

With this information 3 risk coefficients were established; the coefficient *C4*, referring to the invasive potential of the species, was not taken into account for this calculation, due to the lack of information for both Colombian ports and for many of the donor ports.

Additionally, a risk reduction factor was applied, according to the intervals recommended by the integral risk model proposed by the IMO (Table 2):

Table 2. Intervals for the reduction factor R1.

Volume (m^3)	<10	100-500	500-1000	>1000
R1: Related to the size of the ballast water tank	0,4	0,6	0,8	1

(Clarke *et al.,* 2004)

With the database of the Ministry of Transport of Turkey that contemplates 28 environmental variables, it was possible for the case C3 to establish estimates (Table 3) and the environmental similarity between the ballast water receiving port and the origin of the ballast water discharged. This variables were standardized considering the model *(Z= X-μ/∂)*,calculating the correlation between the variables through the Pearson model. So the similarity was determined in a range between *-1* a *+1* in the evaluated ports.

Finally, with the information of the three calculated coefficients, the risk value was obtained for each port of origin without integrating the equation in accordance with the international guideline; the representation of these coefficients was graphed with proportionality conventions to highlight the level of risk per port.

Summary

During 2014, 3345 formats were analyzed with a total of 28982 472.85 m^3 of ballast water discharged. Buenaventura reported the lowest discharge (77107.86 m^3), representing, according to C2, a lower probability of introducing species with respect to other Colombian ports; while in Puerto Bolívar the highest discharge was recorded (10041 444 m^3), followed by Coveñas with 9552 509.26 m^3, these two ports representing 67.61 % of the total ballast water discharged in the country (Figure 2).

Table 3. Variables obtained from the database of the Ministry of Transport of Turkey for the calculation of environmental similarity *(C3)*. Adapted from (Clarke, *et al.,* 2004).

Environmental variables used for the calculation of C3	
1. Port Type	15. Total rainfall in the 6 driest months (mm)
2. Average water temperature in the warmest time (ºC)	16. Number of months with 75 % of total rainfall
3. Maximum water temperature in the warmest time (ºC)	17. Distance from BW downloads to nearby ecosystems such as:
4. Average water temperature in the coldest time (ºC	18. Mouth of the nearest river
5. Minimum water temperature in the coldest time (ºC)	19. High tides
6. Average air temperature during the hottest day (ºC)	20. Sandy beaches
7. Maximum air temperature during the warmer season (ºC)	21. Rocky beaches
8. Average air temperature at night during the coldest time (ºC)	22. Low tides
9. Minimum air temperature at night during the coldest time (ºC)	23. Mangroves
10. Average salinity in the wettest period (g / L)	24. Cliffs
11. Minimum salinity in the wettest period (g / L)	25. Mud ecosystems
12. Average salinity in the driest period (g / L)	26. Seagrass meadows
13. Maximum salinity in the driest period (g / L)	27. Coral reefs
14. Total rainfall in the 6 driest months (mm)	28. Rocky reefs

Adapted from (Clarke *et al.,* 2004)

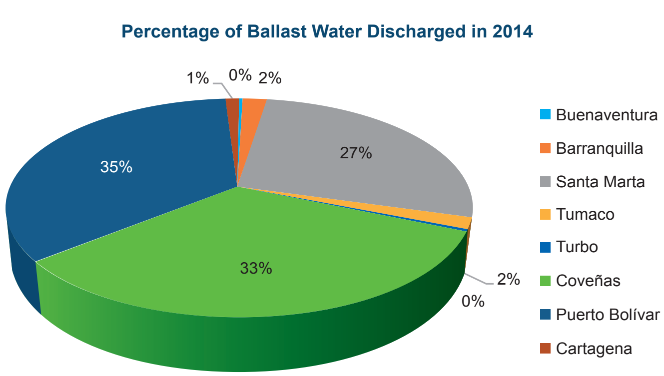

Figure 2. Total ballast water volumes for each maritime port of Colombia in 2014.

According to coefficient *C1* (arrival frequency) for the different ports analyzed, it was found that the total ballast water tanks discharged in the country (10962), 35 % performed this operation in Puerto Bolívar; 24 % in Santa Marta and 23 % in Coveñas, maintaining consistency with the previous coefficient, these three ports being the ones with the highest volumes of discharge.

The highest values in environmental similarity, were for Puerto Bolivar showing a value of 0.93 with Lázaro Cárdenas/México, followed by Buenaventura which presented a value of 0.92 similarity with Tumaco/Colombia. The least similar result was presented for Turbo, where 0.3 was the value calculated for the closest C3 coefficient within the origins recorded for this port.

By arrival frequency from the same origin *(C1)* in Buenaventura, it was identified that Guayaquil/Ecuador (19.58 %), Callao/Peru (18.52 %), Tumaco/Colombia (16.93) and Balboa/Panama (11.11) represent the highest frequencies; the highest volume of water discharged *(C2),* came from Callao/Peru (34.4 %) and Guayaquil/Ecuador (19.88 %). While the highest environmental similarity *(C3)* of Buenaventura occurred with Tumaco/Col (0.928) and Guayaquil/Ecuador (0.768) (Figure 3).

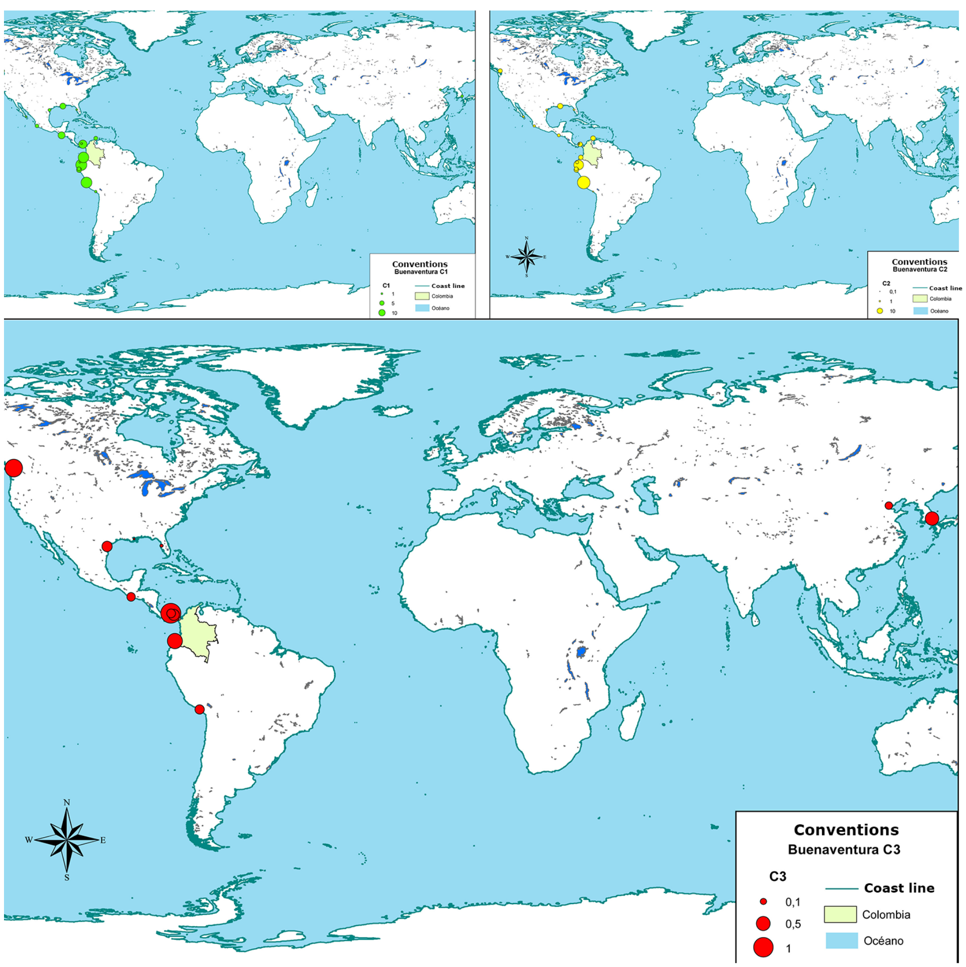

Figure 3. World map with the ports of origin according to variable C1, C2 and C3 for Buenaventura port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

Regarding Tumaco, the highest arrival frequency was Long Beach/USA (19.29 %), followed by Acajutla/El Salvador and Barranquilla/ Colombia, both with (6.07 %). For *C2*, Long Beach/ USA was the source of most water discharged (19.67 %), followed by San José/Guatemala (5.82 %). Regarding the environmental similarity *(C3)*, Cherry Point/USA (0.998) y Taboguilla/Panamá (0.995), were more similar (Figure 4).

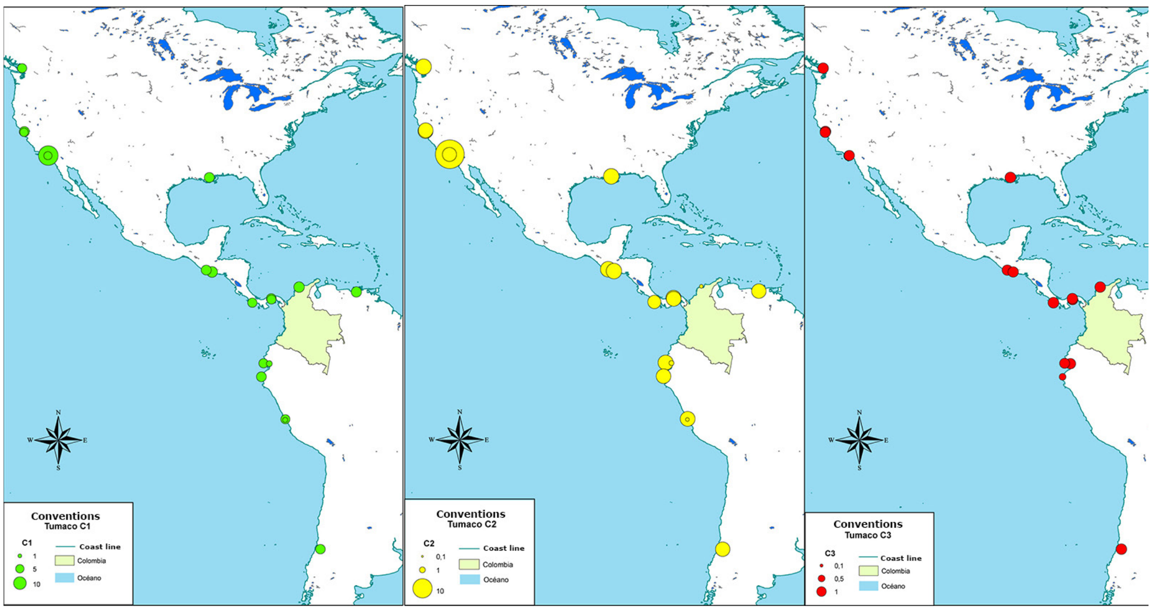

Figure 4. World map with the location of the ports according to the coefficients *C1*, *C2* and *C3* for Tumaco port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

In Barranquilla, the highest frequency of arrival *(C1)* was from Chiriquí Grande/Panama (24.61 %), and the origin of the water discharged *(C2)* was also from this port (37.59 %); the other ports were constituted as small ballast water donors. In terms of environmental similarity *(C3)*, Chiriquí Grande/Panamá (0.891) and Oranjestad/ Aruba (0.708) (Figure 5), were the most similar with Barranquilla.

In Cartagena, the highest arrival frequency *(C1)* was from Fuuik Baai/Curacao, Crabs Bay/ Antigua & Barbuda and from Bahía from the Minas/Panamá; while the origins of discharged water *(C2)* came from Chiriqui Grande/Panamá (16.56 %) and Houston/USA (13.72 %). Cartagena is very similar environmentally *(C3)* with Kingston/Jamaica (0.889), and Santa Marta/Colombia (0.812) (Figure 6).

In Santa Marta, the highest frequency of arrival *(C1)* was Rotterdam/Holland (9.14 %) and Mobile/USA (3.75 %); while the largest volume of water discharged *(C2)* came from Rotterdam/Netherlands (15.26 %) and Amsterdam/Netherland (6.31 %). This port is very similar according to *(C3)* with Ashkelon/ Israel (0.784) and Lázaro Cárdenas/México (0.775). (Figure 7).

In Turbo, the highest arrival frequency *(C1)* was from Portsmouth/United Kingdom (70.83 %), and Antwerp/Belgium (13.02 %), the other ports did not exceed 3 %. The largest volume of water discharged *(C2)* was also from these two ports Portsmouth/ United Kingdom (72.64 %) and Antwerp/Belgium (16.11 %). Turbo showed similarity *(C3)* with Marín/Spain (0.6014), while with Portsmouth/ United Kingdom it was low (0.3755) (Figure 8).

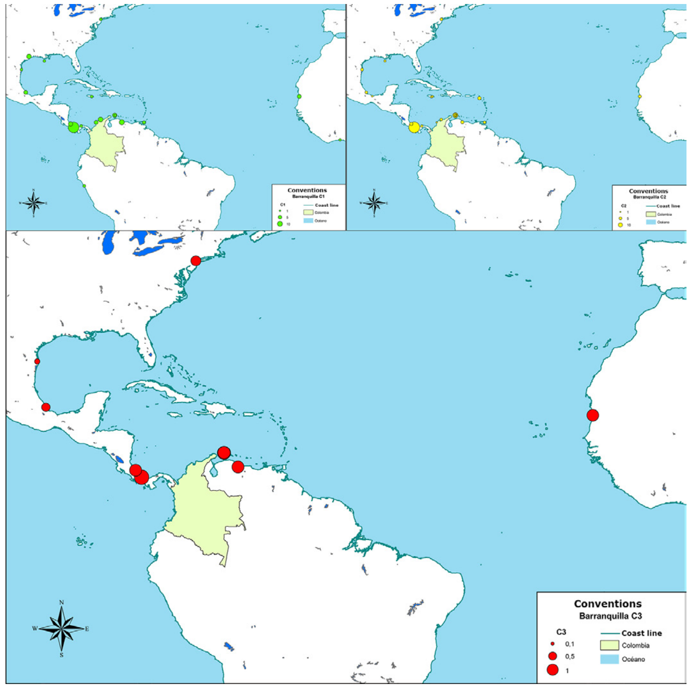

Figure 5. World map with the ports of origin according to the coefficients *C1*, *C2* and *C3* for Barranquilla port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

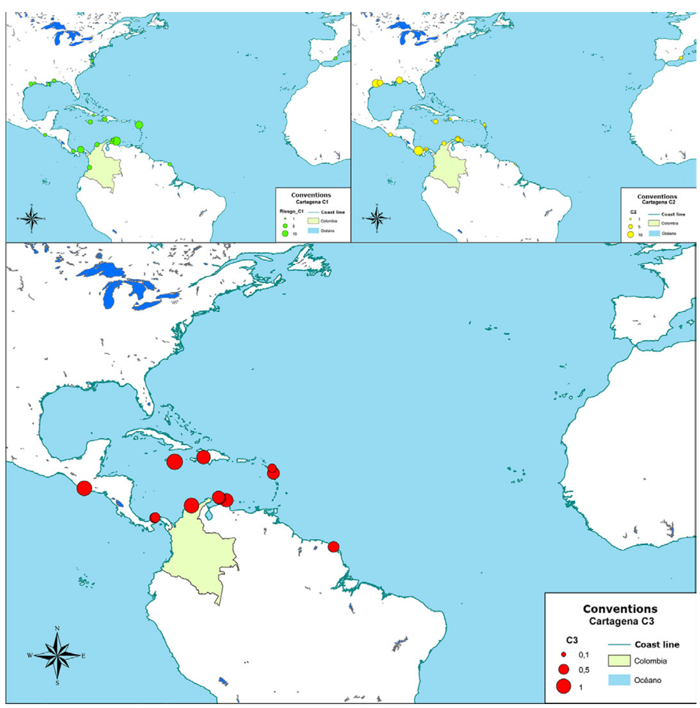

Figure 6. World map with the ports of origin according to the coefficients *C1*, *C2* and *C3* for Cartagena port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

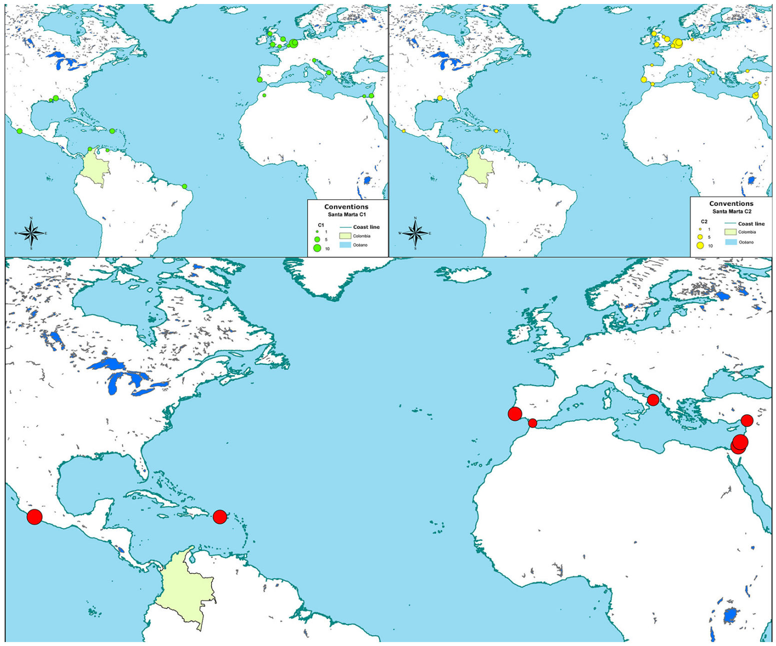

Figure 7. World map with the ports of origin according to the coefficients *C1*, *C2* and *C3* for Santa Marta port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

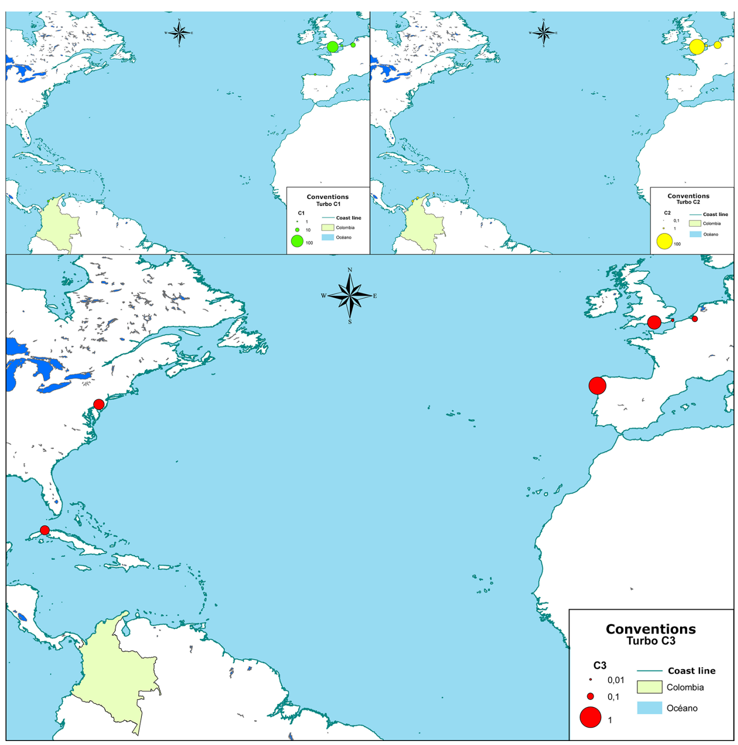

Figure 8. World map with the ports of origin according to the coefficients C1, C2, and C3 for the Turbo port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

For Coveñas the highest frequency (C1) occurred with Chiriqui Grande/Panama (11.05 %) and Houston/USA (9.03 %). The largest volume downloaded (C2) was from Chiriquí Grande/Panama (12.09 %), Loop/USA (10.94 %) and Houston/USA (8.11 %); the other ports did not exceed 5 %. This port was similar (C3) with St Charles/USA (0.858) and Aruba/Aruba (0.848). (Figure 9).

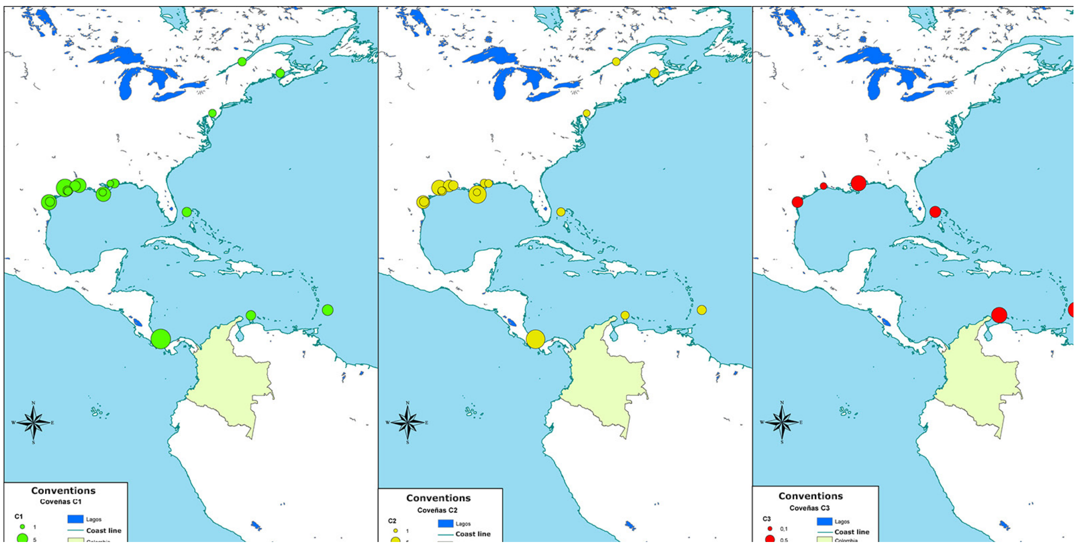

Figure 9. World map with the ports of origin according to C1, C2 and C3 for Coveñas port. Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

On the other hand, in Puerto Bolívar, the highest provenance *(C1)* and volume discharged *(C2)* was from Rotterdam/Netherland and Immingham/United Kingdom. As for the other ports, wide differences were observed, where most did not exceed 3 % in either of two coefficients. Puerto Bolívar was very similar *(C3)* with Lazaro Cárdenas/Mexico (0.937), and Ashkelon/Israel (0.813) (Figure 10).

Discussion

The ports of Santa Marta, Coveñas and Puerto Bolívar accounted for 94.67 % of the total ballast water discharged in Colombia in 2014, which is closely related to the type of operation that takes place there, which is oriented to the export of oil and coal. For this reason, the ships that arrive at these ports export solid or liquid cargoes in bulk, which involves transporting ballast water for navigation safety. A different case is identified for Buenaventura, where the vast majority of ships arrive with goods in containers, so the volumes of ballast water discharged are very small or nonexistent. This means that the ships are loaded with ballast water to be able to return or continue to their next destination, where Buenaventura could represent risks for other ports in the world as a donor port.

According to the results for the port of Buenaventura, it was observed that of the 21 ballast water sources identified, the port of Guayaquil (Ecuador) reflected a high risk value in the three coefficients. The above suggests carrying out an analysis of the geographical location and the ecosystems present around the ports. Buenaventura and Guayaquil are in the same bioregion, which probably means few differences in species (Gollasch and others, 2007) and really, a lower risk than the global risk equation indicates. However, the risk transfer of pathogens can constitute a high value and the necessary measures should be taken when epidemics or blooms occur. Otherwise, in the case of El Callao (Peru), which represented the greatest risk in terms of frequency *(C1)* and

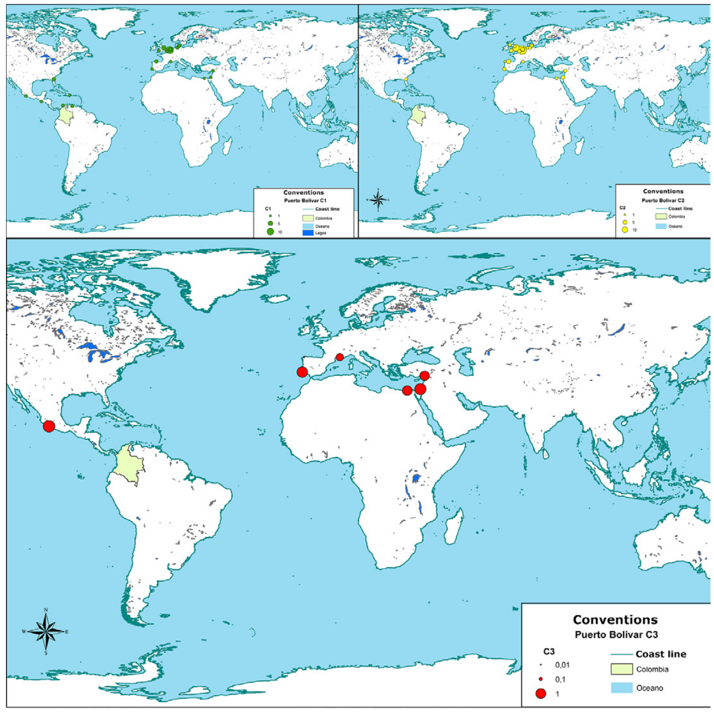

Figure 10. World map with the ports of origin according to the coefficients C1, C2 and C3 for Puerto Bolívar Top left: Green circles: Arrival frequency, Top right: Yellow circles: Discharged volumes, Below: Red circles: Environmental similarity.

volume discharged *(C2),* but in environmental similarity presented a negative value; due to the high frequency of discharges, the risk may lie in the invasive potential of the species that inhabit that ecosystem (Gollasch *et al.,* 2007).

In the case of Tumaco, *C3* continues to show high similarity with the ports of the region; however, the origin of the largest amount of water discharged corresponds to a port of different environmental characteristics, such as Long Beach (USA), which showed the highest values in *C1* and *C2*. So taking into account the values obtained for each of the coefficients calculated for the 19 origins, the risk levels of these are between medium and low, with special attention to the Long Beach donor port due to the abrupt change of bioregion (Atlantic- Pacific), meaning it is necessary to increase control by the Maritime Authority over the ships of high frequency from the same origin (Liu and others 2014).

In Barranquilla 44 sources of ballast water were found where the greatest risk was represented by the port of Chiriqui Grande (Panama) with the highest values of frequency *(C1)* and volume of discharge *(C2)*; for the coefficient *C3* it obtained a positive value but less than 0.5 with a low similarity value, which can be explained by the location of the ports in the same bio-region (Daza Suárez, 2004). The influence of some oceanographic characteristics such as currents that transit this zone where the dynamics are affected by the Panama Colombia gyre, and this generates a small sub-region (Cañón Páez, López Osorio, & Arregoces Silva, 2010), implying certain changes in the ecosystem with respect to the other ports. The values in C1 and *C2* are very low in relation to those of Chiriqui Grande, with which the level of risk is low; for the coefficient *C3*, only Oranjestad (Aruba) and Puerto Limón (Costa Rica) obtained significant similarity values but due to their low frequencies and discharge volumes, the risk is reduced to low; however, it should be considered that even small amounts of potential organisms present in a ballast water discharge could result in a successful transfer of species and have negative consequences (Gollasch *et al.,* 2007).

In the case of Cartagena, the control should be increased on ships from North America, because of their high ballast water discharges; due to environmental similarity, attention should be paid to the ships originating from Puerto Quetzal (Guatemala), which despite having low discharges, is located in a different bioregion from Cartagena and its similarity is high, generating an average risk, like Bahia de las Minas (Panama), because it is in a different dynamic region (Cañón Páez *et al.,* 2010).

The similarity model does not give certainty to define the level of risk for Santa Marta, and although the ports of greater frequency and discharge are far away in terms of characteristics of environmental similarity, it is necessary to increase control over ships from Europe (Netherland) and Asia (Israel). The ports of these countries are in the Baltic and Mediterranean Sea, for it is estimated that in these marine ecosystems there are 89 and 480 reported invasive species respectively (Loebmann, Mai & Lee, 2010), which may increase the potential for invasion by ballast water imported from these ports. In this case, it would be pertinent to evaluate the risk from the perspective of the coefficient *C4*.

For Coveñas, the similarity with Panama is evident, they are even in areas located in the same biogeographical region, and for this reason it is inferred that an approximation of species introduced in the ports of origin of the ballast water, will allow a better evaluation for this port regarding the ports of greater frequency and volume of unloaded ballast (Gollasch *et al.,* 2007).

The similarity of Puerto Bolivar with the port of Israel is striking, for this reason the control level over ships coming from this port should be increased and, as in the other ports, the *C4* model would allow this analysis to be better addressed, more so when the introduction of the *Charybdis hellerii* (Milne, 1687) has been reported for Puerto Bolívar.

With the results obtained for the ports analyzed, it could be inferred that is not a model that allows the risk to be adequately evaluated, since the most similar ports are located in the same region, in this sense it is necessary to propose another model with a more approximate view of risk, as is the case of the coefficient *C4* (by species introduced in the ports of origin of ballast water) (Gollasch *et al.,* 2007). In addition, variables must be considered that have to do with the population dynamics of the various species with potential for invasion, such as growth, reproduction and mortality (Loebmann *et al.,* 2010).

Given the results for the ports analyzed, and the ecological importance of these in terms of biodiversity and other aspects, the risk assessment applied determined that the ports with the highest risk were Santa Marta and Coveñas, so implementing these risk models in these ports is vital importance, in order to minimize the likelihood of bio invasion. Marine ecosystems are particularly vulnerable to invasions from alien species and the dispersion of these occurs more easily than in terrestrial environments (Loebmann *et al.,* 2010).

Conclusions

Although the coefficients *C1*, *C2* and *C3* were considered individually for the determination of the risk level for the donor ports, it is evident that the coefficient related to the environmental similarity *C3* is decisive for the risk evaluation, but in ports located in the same bioregion, it is not as effective.

One of the problems in Colombia and worldwide has to do with obtaining the information for the calculation of the coefficient *C4*, which provides a measure of the risk presented by each donor port due to the number of risk species present in the bioregion of the port. In order to calculate it, it is necessary that the states keep up-to-date taxonomic inventories of the flora and fauna present in their coastal marine areas, in order to establish which type of species pose the greatest risk when introduced into other ecosystems.

This type of risk level studies are necessary to support and give focus to the control and management of ballast water and sediments of ships in the country, since they provide clear and quantifiable values, which allow us to draw specific objectives, and point to the root of the problem, in this case the biological contamination that this vector entails.

It was possible to identify that the greatest risk comes from international traffic vessels flying the flag of other countries, and it is the Coastal State and the Governing State of the Port that make it possible to guarantee these ships comply with the regulations, and the prevention functions. In addition, they may impose sanctions on ships that do not comply with the specifications of the Convention, for which they have tools such as inspection, where certification compliance is verified and samples taken from ballast tanks and pipes.

Due to some ports have very high maritime traffic, in cases such as Cartagena and Buenaventura, it is too expensive and logistically very difficult to inspect all the ships; here the risk assessment becomes a useful tool to prioritize the ships that require inspection; in this way the inspections will focus mainly on ships whose ballast originates from an area considered of high risk to the receiving port.

Bibliography

Alexandrov, B., Bashtannyy, R., Clarke, C., Hayes, T., Hilliard, R., Polglaze, J., . . . Raaymakers, S. (2003). *Ballast Water Risk Assessment, Port of Odessa, Ukraine: October 2003: Final Report.* Organización Marítima Internacional. Londres: Globallast Monograph Series No. 10, 56-64.

Arboleda, E. & Jiménez, S. (Noviembre de 1988). Distribución y abundancia de larvas y huevos de peces durante el crucero pacífico XII Erfen X. *Boletín Científico CCCP*(2), 33-49.

Cañón Páez, M. (2010). Regionalización dinámica del Gran Caribe basada en productos espectro radiométricos satelitales. *Art. en preparación*. 3-5.

Cañón Páez, M. L., Lopéz Osorio, R. & Arregoces Silva, L. J. (2010). *Informe Valoración rápida. Componente técnico para la gestión del Agua de Lastre en Colombia.* (D. G. Marítima, & CIOH, Edits.) Colombia. 35-37.

Clarke, C., Hilliard , R., Junqueira , A. d., Neto, A. d., Polglaze, J. & Raaymakers , S. (2004). *Ballas Water Risk Assesment, Port of Sepetiba, Federal Republic of Brazil, December 2003: Final Report.* International Maritime Organization. Globallast Monograph Series. No.14. IMO London. 52-59.

Daza Suárez, A. (2004). Regionalización del Pacífico colombiano a partir de imágenes de color del océano. 90. (U. J. Marina, Recopilador) Bogotá, Colombia, 35-61.

Dirección General Marítima. (6 de Septiembre de 2012). Resolución 477. *Por la cual se adoptan y establecen las medidas y el procedimiento de control para verificar la*, 2. Bogotá, Colombia. 2-3.

Gollasch, D. M., Cabrini, S., Perkovic, M., Bosnjak, D. & Virgilio, D. (2007). Results from the first ballast water sampling study in the Mediterranean Sea-the Port of Koper study. *Mar Pollution Bulletin*, 377-390.

Leal Flórez, J. (2011). Impactos socioeconómicos de las Especies no Nativas en Ambientes Costeros. En Invemar, Ministerio de Ambiente y Desarrollo Sostenible, A. Gracia, J. Mora, D. Gil Aguadelo, & V. Puentes (Edits.), *Guía de las Especies Introducidas Marinas y Costeras de Colombia* (págs. 20-27). Colombia.

Liu, T.-K., Chang, C.-H. & Chou, M.-L. (2014). Management strategies to prevent the introduction of non-indigenous aquatic species in response to the Ballast Water Convention in Taiwan. *Marine Policy*, 187-195.

Loebmann, D., Mai, A. C. & Lee, J. T. (Septiembre de 2010). The invasion of five alien species in the Delta do Parnaíba Enviromental Protection Area, Northeastern Brazil. *International Journal of Tropical Biology and Conservation, 58*, 909-923.

Matej, D., Gollasch, S. & Leppakoski, E. (2013). Risk assessment for exemptions from ballast water management – The. *Marine Pollution Bulletin*, 205-217.

MEPC. (13 de Julio de 2007). Resolución MEPC.162 (56). *Directrices para la Evaluación de Riesgos* *a efectos de la Regla A-4 del Convenio sobre la gestión del Agua de Lastre (BWM) (D7)*, 2-12.

Milne, E. (1687). Charybdis Hellerrii. En J. Medellin, A. Gracia. & D. Gil, *Guía de las Especies Introducidas Marinas y Costeras de Colombia* (págs. 73-77). Colombia: Invemar, Ministerio de Ambiente y Desarrollo Sostenible.