Project	AtlantOS – 633211
Deliverable number	8.7
Deliverable title	Oil spill hazard bulletin
Description	**Dissemination Method:** Web **Product weblink:** https://glamor.sincem.unibo.it The MSFD, the new Directive on Safety of offshore oil and gas operations (2013) and the European Maritime Safety Agency require robust tools for oil spill hazard mapping, from accidental to operational. In this activity WP7 and Marine Core Service products were coupled to Medslik-II oil spill model **in order to produce, on request, an Oil Spill Hazard Bulletin** based upon the hazard mapping data generated earlier in the project. This report contains background information and some examples of oil spill hazard bulletins for target Atlantic areas. The web-GIS Portal GLAMOR developed for Task 8.4 "Oil spill hazard mapping and disaster risk reduction best practices" is used to create the information content in the requested bulletins. Please note: bulletins are only produced on a request basis.
Work Package number	8
Work Package title	Societal benefits from observing/information systems
Lead beneficiary	UNIBO
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Comments	[in case the deliverable is late please explain why]

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Last updated: 16 April 2018

Stakeholder engagement <u>relating to this task</u>*

WHO are your most important stakeholders?	☐ Private company If yes, is it an SME ☐ or a large company ☐? ☐ National governmental body ☑ International organization ☐ NGO ☐ others Please give the name(s) of the stakeholder(s): IMO, ITOPF, EMSA
WHERE is/are the company(ies) or organization(s) from?	☑ Your own country ☑ Another country in the EU ☐ Another country outside the EU Please name the country(ies): UK,
Is this deliverable a success story? If yes, why? **If not, why?**	☑ Yes, because it is the first time that the actual oil spill hazard due to maritime traffic is mapped in the Atlantic scale. ☐ No, because …..
Will this deliverable be used? **If yes, who will use it?** **If not, why will it not be used?**	☑ Yes. The deliverable will be used as a guide for our web-GIS and we expect that future bulletins will support oil spill hazard assessments and regulations. ☐ No, because …..

NOTE: This information is being collected for the following purposes:

1. To make a list of all companies/organizations with which AtlantOS partners have had contact. This is important to demonstrate the extent of industry and public-sector collaboration in the obs community. Please note that we will only publish one aggregated list of companies and not mention specific partnerships.
2. To better report success stories from the AtlantOS community on how observing delivers concrete value to society.

*For ideas about relations with stakeholders you are invited to consult <u>D10.5</u> Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation.

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Introduction

The oil spill hazard (OSH) bulletin is a short document aimed to provide answers to key relevant questions related to oil spill risk & emergency management.

Key questions managers are likely to ask include:

- If an oil spill occurs at a known release point, can the service provided here produce the most likely pathway the oil slick will follow?
- How likely is it that the shoreline (name provided by oil spill risk & emergency manager) will be impacted by an offshore oil spill? and How much oil should we expect to reach our coastline of interest?

The probabilistic answers given by the OSH Bulletin are generated on the GLAMOR web-portal (https://glamor.sincem.unibo.it). The information created and stored in GLAMOR originates from a large ensemble oil spill simulation experiment. Details on how this was done are available on the GLAMOR website. We recommend that users of this service begin by watching the GLAMOR video tutorial.

This report presents the basic structure of an Oil Spill Hazard bulletin. The OSH data products are created using the facilities provided on the GLAMOR website. It is on the GLAMOR web portal that users interact to compile useful information related to potential oil spill hazards for all Atlantic ocean coastal areas. The OSH Bulletin generation is a user-interactive process, where the end-user is expected to select the area of interest and, if necessary, add textual descriptions to retrieved information. In the following section (OSH bulletin structure), we explain the proposed structure of the bulletin and how it can be used. Since examples are informative we have provided two finished product OSH bulletin examples. One for the Canary Islands and the other for NE Brazil in (Annexes I and II.

OSH bulletin structure

The structure of the oil spill hazard bulletin is simple and should answer key hazard management questions. The document is divided into the five sections listed below. The reasoning behind each section is to help the user with their oil spill hazard risk assessment task.

1. On the "area of interest"

Here, we describe the study area and the objectives of the OSH bulletin. It may be of special interest to bulletin readers (the final end-users) to know more about local bathymetry, coastline characteristics, e.g. presence of mangroves, rocky shore, maritime traffic in the surrounding areas and coastal uses (e.g. tourism, fisheries). This type of information is inputted into the bulletin by the user. The risk scenario list is also selective and the GLAMOR user producing a bulletin for their region will decide what to include since requirements can vary from region to region and by user type.

2. Climatological surface circulation

The GLAMOR portal will soon include an option to visualise the average Atlantic surface currents and the standard deviation of velocity amplitude (i.e. variability). Combining velocity plots available on the GLAMOR portal with available literature, an overall description of a focus area flow field is presented. Ocean currents that play a pivotal role in potential oil spill slick movement are considered to modulate the oil spill hazard risk. When describing local circulation patterns, an effort is made to identify areas with characteristics of strong average flow or high variability because this has a direct impact on oil slick trajectories and on the oil spill hazard/risk. Furthermore, regions with high variability give an idea of the trajectory uncertainties. For further clarification on the modulation of oil slick trajectories by ocean current characteristics (i.e. properties - attributes or variables) we discuss two example hypothetical cases in Annex I and II.

3. Oil release points and most likely oil trajectories

The Atlantic coastline is very complex with peninsulas, large rivers and archipelagos. The distribution of release points (RPs) along the coastline is done in GLAMOR, in an automatic manner. Note: the proposed grid may not fully fulfil all end-user requirements. The OSH bulletin includes a map of all the RPs surrounding the selected area of interest and he RP maps are retrieved from the GLAMOR website.

In this section of OSH bulletin, we address the question
"*In case of an oil spill at a certain release point, where would the slick most likely go?"*

Based on the oil spill ensemble experiment outputs, the "most likely" slick path can be inferred from the cumulative trajectory plots available in the GLAMOR portal for each RP area of interest. As shown in Annexes I and II, there are situations where the large variability in the flow fields make it unfeasible to establish a "most likely" trajectory.

The example OSH bulletins shown in Annex I and II highlight that the number of release points can potentially be very large. Depicting a clear pattern through observing the cumulative trajectory plots for each RP is a challenging task. In case of emergency, the strategy should be to find the likely trajectories from the closest RP provided by GLAMOR. If the average currents are strong in the area of interest, then results from the GLAMOR database could be very useful to help shape first responses to an oil spill hazard. In the case of delayed mode applications, such as accidental oil spill management planning activities, a reasonable strategic approach is advised e.g. focus on RPs along dense maritime traffic routes; focus on beaches that are more likely to be impacted by offshore oil spills based on local knowledge of-ocean current conditions.

Release points located in areas of strong current variability, as previously mentioned, can generate cumulative trajectories with "quasi-random" directions thus informing the user of the large uncertainty in the hazard maps. In the bulletin examples (Annexes I and II), the cumulative trajectory plots for four RPs in each of the focus areas are displayed with some examples of very uncertain simulated oil slick trajectories and other examples of areas where strong mean flow conditions transport the spill in ocean currents that exhibit the same direction of flow throughout the whole year.

4. On the statistical distribution of beached oil concentrations

In this section of OSH bulletin, we address the questions
How likely is it that the shoreline (name provided by oil spill risk & emergency manager) will be impacted by an offshore oil spill?
and
How much oil should we expect to reach our coastline of interest?

The oil concentrations found at the end of each ensemble simulation for coastal segments encompassed by the state/country of interest are presented in GLAMOR by a histogram well fitted by a Weibull distribution. The histogram readily provides information on some key parameters related to the coastal oil spill hazard, such as:

- the number of beaching events that could potentially take place in the target area
- a range of oil spill concentrations
- Distribution of oil beaching events for a range of different oil concentrations.

The GLAMOR web portal also provides information on the estimated Weibull average concentration and its uncertainties. Examples on how to interpret the concentration histograms are given in Annexes I and II.

The histogram analysis is very informative when with the focus is on a low number of states/countries. However, the results can easily grow in complexity if the OSH bulletin encompasses several states/countries. In such cases, the usage of the Weibull moments (average and standard deviation) in addition to the total number of events observed can be very helpful to detect spatial distribution of oil beaching events and their respective magnitudes in the area of interest. A practical example Is provided in Annex II.

5. The beached oil hazard index

Histograms contain all the information necessary to evaluate an oil spill hazard for a single country/state are very useful. However, if the user is interested in comparing the oil spill hazard between different states/countries our advice is to initially focus on a single indicator (i.e. oil spill hazard index) which takes into consideration both the frequency and the magnitude of the beaching events. The oil spill hazard index, H, is currently calculated as follows:

$$H = \frac{1}{N_t} \sum_{i=M\_C_{min}}^{M\_C_{max}} N_i$$

where M_C_{min} and M_C_{max} are the bins corresponding to the minimum and maximum concentrations of interest, N_i is the number of beaching events in each bin and N_t is the total number of events. There are plans to enhance the hazard index in the future when more spill scenarios will be available. The feedback loop through stakeholder engagement activities to discover the end-user needs will determine any new additions.

In the last section of the OSH Bulletin, computed oil spill hazard index for the states/countries in the study area is provided to support local oil hazard management. For those interested in comparing the hazard levels obtained in the target study area with other areas in the Atlantic, a hazard rank is included to the bulletin.

Note:
The GLAMOR web portal is continuously evolving with new oil spill simulations for the hazard mapping added as required. Some of the functionalities presented in this report (i.e. average surface circulation maps, maritime traffic density maps and possibility to input text to the website) are still to be implemented.

Annex I The Canary islands case

ATLANTOS OIL SPILL HAZARD BULLETIN

CANARY ISLANDS, SPAIN

The bulletin users are invited to visit our website (https://glamor.sincem.unibo.it) to know more about the methodology and vocabulary used.

FOREWORD

The bulletin was designed to support the national and international policy makers and practitioners of oil spill emergency management. Its structure is simple: first, we depict the overall surface circulation in the area of interest (i.e. Canary Islands), which will give the environmental sea condition awareness from the advanced analysis system of Copernicus Marine Environment Monitoring Service. Finally, we describe the oil spill hazard at the coasts as represented by a number of release points near the coasts simulating potential oil spills from maritime traffic routes.

ON THE CANARY ISLANDS

Currently, about 2,100,000 people live in the Canary Archipelago, located off the African coast (Figure 1) and with strong connections to the sea mainly by the tourism industry. The archipelago is exposed to heavy maritime traffic (Figure 2), which might represent a threat to the coasts.

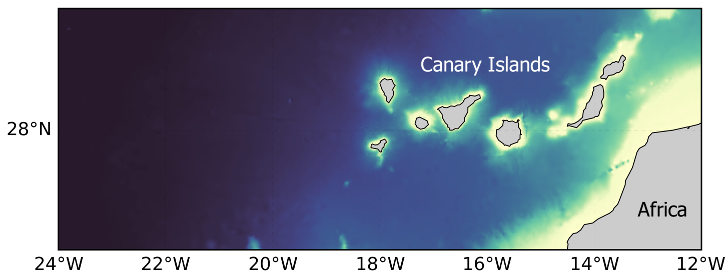


Figure 1 Canary archipelago and bathymetry of surrounding areas

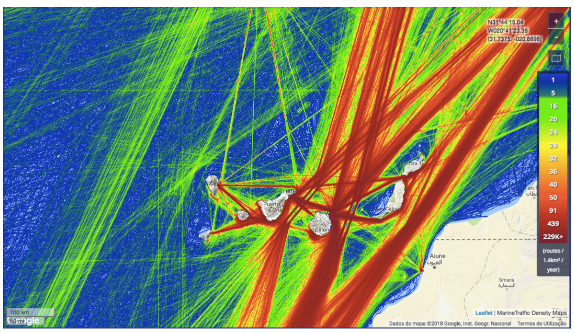


Figure 2 Maritime traffic density for the year of 2017. Extracted from www.marinetraffic.com

LOCAL OCEAN CIRCULATION

The ocean surface circulation in the Canary Islands and surroundings is influenced by the eastern part of the North Atlantic Subtropical Gyre, characterized by a relatively weak and broad southwestward flow (the Canary current). The Canary current is found close to the African shoreline and to the southern shores of the islands flowing southwestwards. The presence of the Canary archipelago locally alters the flow around the islands.

The average surface currents (vectors) and their variability (background color) for the year of 2013 are shown in Figure 3. As expected, the Canary current is composed of several branches along the eastern side of the archipelago and the African coasts. The flow field is intensified along the south-eastern shores of all the islands except for the most north-western island, La Palma, where a northern intensification is found. The variability is also stronger where currents have largest amplitude.

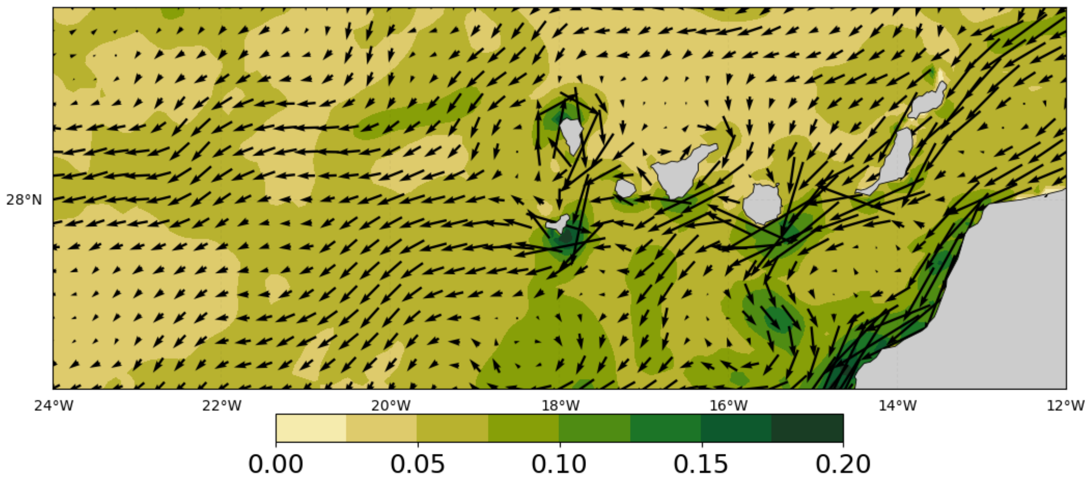


Figure 3 Average surface currents (vectors) and standard deviation (background color) for the year of 2013 (in m/s). Based on daily velocity fields from CMEMS global ocean analyses (http://marine.copernicus.eu/).

LOCAL RELEASE POINTS AND MOST LIKELY OIL TRAJECTORIES

The oil spill release points (RPs) surrounding the Canary archipelago are shown in Figure 4, covering marine areas situated between 30 and 130 km from the closest shoreline with a 0.25º spatial distance between them. Comparing Figures 2 and 4, the proposed release grid covers most of the heavily trafficked maritime corridors in this region.

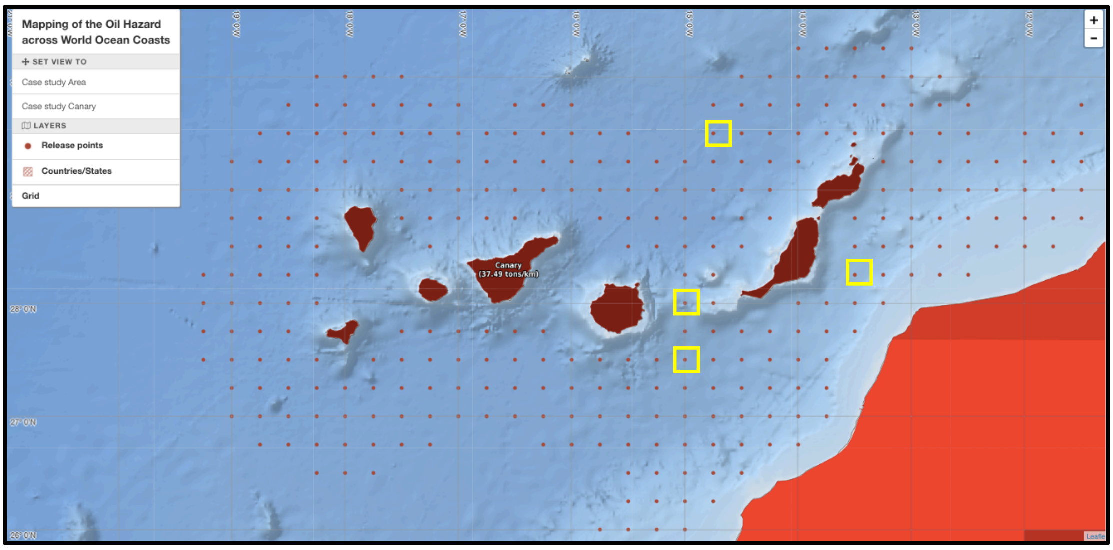


Figure 4 Release points in the Canary Islands area (red dots). Four RPs, highlighted with yellow boxes, were selected to analyze the slick trajectories originated there. Figure extracted from the GLAMOR website.

Four release points were selected in trafficked areas surrounding the Canary Islands (marked in yellow on Figure 4). The "most likely" oil fates, *i.e.* cumulative trajectories for the year 2013 and for spills originated at the selected points are presented in Figure 5.

In Figure 5a, the effects of the Canary current on the simulated spill trajectories originated off the western portion of the

archipelago are clear. The strong average current on the south-western side of the islands resulted in southwesterly-oriented cumulative trajectories suggesting that, for a spill taking place in the year of 2013 and in this area, the slick is likely to flow southwestwards with limited impacts on the archipelago.

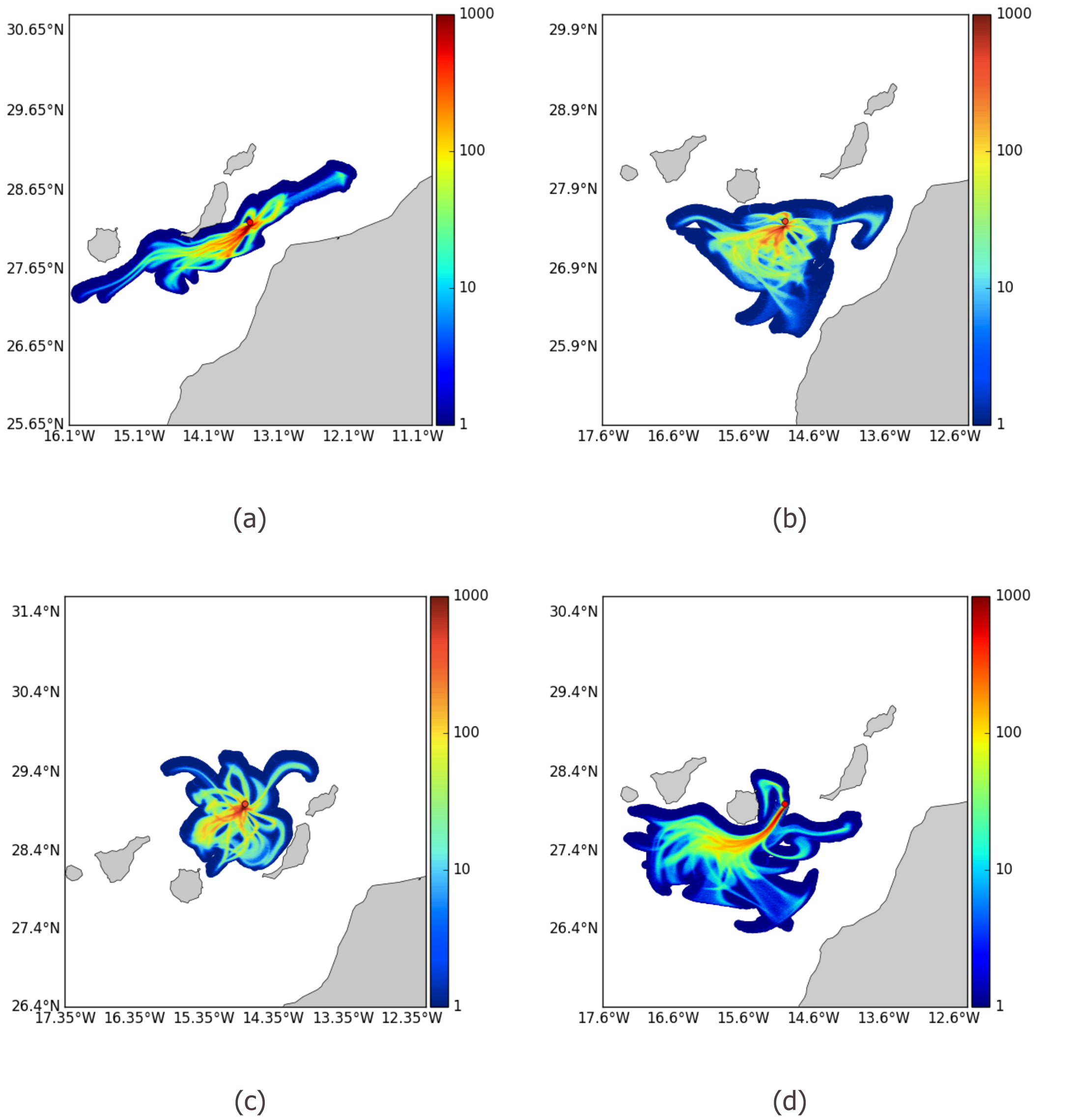


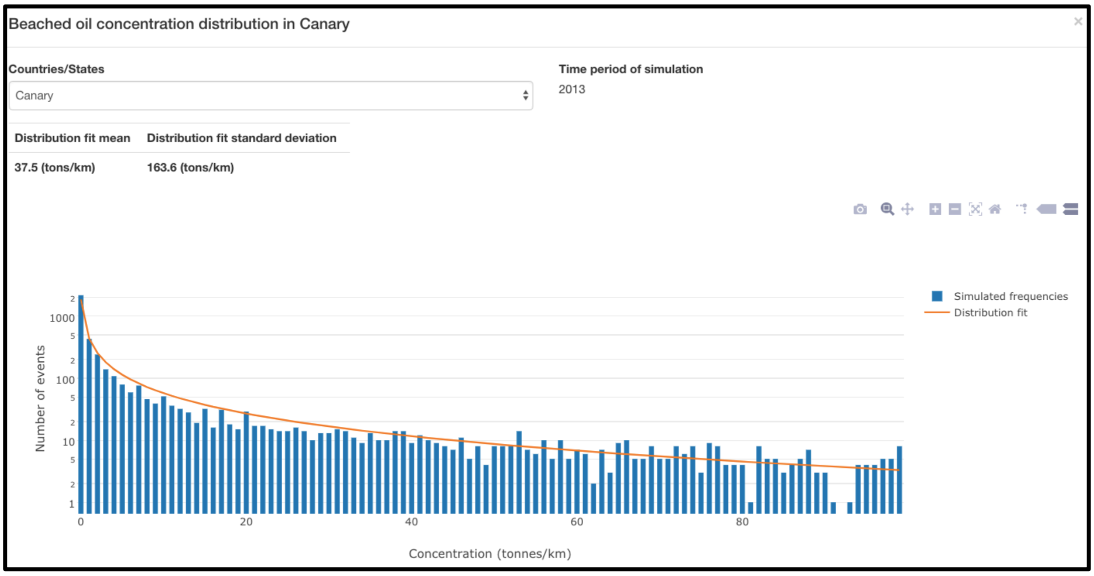
Figure 5 Cumulative trajectories for the year of 2013 for the four release points in Fig. 4. Colors represent the cumulative frequency (in number of oil observations). The spill origin is marked with a red circle in each picture.

The cases in which the RPs are situated in areas of larger standard deviations are shown in Figures 5b and 5c. The large ocean variability resulted in "quasi-random" trajectories. Our final example (Figure 5d) shows a case where the oil spill release takes place in an area of well-defined SW flow constrained between to islands transiting into a highly turbulent area downstream the archipelago. The initial slick paths have a clear SouthWestward direction becoming heavily dispersed south of the island. It is difficult to infer the potential impact of the oil on the coasts only looking at the oil slick trajectories and we have to use model concentrations at the coasts to quantify the oil spill hazard.

STATISTICAL DISTRIBUTION OF BEACHED OIL CONCENTRATIONS

Figure 6 shows the histogram of the beached oil concentrations obtained for all the 2013 release points around the Canary Islands. The histogram is fitted with a Weibull distribution (orange line) and the Weibull mean and standard deviation are also presented. In total, over 4000 beaching events took place in the Canary Islands involving concentrations of up to 100 tons of oil per shoreline kilometer. This information is open and free for any end-user at our portal.

We could interpret our histogram as follows: *"in case of an oil spill accident off the Canary archipelago, the potential slick is likely to reach the coastline (about 4,000 events), most likely involving lower oil concentrations (below the 20 tons/km) but with a significant probability of higher magnitude events (close to 100 tons/km)."*



OIL SPILL HAZARD INDEX

The oil spill hazard index, H, is currently calculated as follows:

$$H = \frac{1}{N_t} \sum_{i=M\_C_{min}}^{M\_C_{max}} N_i$$

where M_C_{min} and M_C_{max} are the bins corresponding to the minimum and maximum concentrations of interest, N_i is the number of beaching events in each bin and N_t is the total number of events.

The H index allows to compare different coastal areas and rank the hazard from oil spills. The list, although still incomplete, shows how the Canary Islands is a place where the oil spill hazard is relatively high (Table 1):

Country/State	Mean concentration (tons/km)	standard deviation (tons/km)	number of events	oil spill hazard index
Guinea	197.091	889.479	369	0.705
Madeira	136.633	666.215	1020	0.658
Guinea-Bissau	62.615	245.748	570	0.625
Cape_Verde	30.693	119.897	13336	0.596
Canary_islands	37.491	163.633	4839	0.556
Portugal	33.845	168.122	577	0.53
Spain	25.75	108.496	2365	0.52
Bahia	16.863	66.028	4737	0.517
Mauritania	24.376	109.024	2709	0.495
Rio_Grande_do_Norte	14.265	54.309	3881	0.495
Sierra_Leone	17.043	70.774	1549	0.485
Gabon	17.612	76.116	1625	0.46
Uruguay	35.412	189.957	1823	0.455
Nigeria	10.264	41.572	634	0.44
South_Africa	8.197	32.165	3287	0.423
Angola	10.872	46.938	1201	0.419
Paraiba	9.195	36.83	2738	0.416
Ivory_Coast	11.496	50.508	2061	0.415
Liberia	11.583	48.339	1314	0.413
Senegal	16.527	79.297	1304	0.411
Pernambuco	11.397	49.63	4191	0.407
Cameroon	19.31	102.098	2533	0.395
Marocco	17.078	102.245	281	0.352
Alagoas	6.182	26.613	2302	0.349
Sergipe	3.214	11.711	514	0.339
Sao_Paulo	9.219	41.669	1838	0.337
Gana	4.042	17.183	1397	0.273
Benin	6.938	39.641	122	0.262
Santa_Catarina	0.988	2.526	560	0.238
Namibia	2.411	10.163	60	0.233
Western_Sahara	1.225	4.301	944	0.19
Congo_and_Belize	0.918	3.943	137	0.131
Guinea-Equatorial	1.391	6.053	84	0.107
Rio_Grande_do_Sul	0.168	0.492	193	0.067
Parana	0.097	0.127	28	0.036
Espirito_Santo	0.182	0.204	2	0
Rio_de_Janeiro	0	0	0	0

ACKNOWLEDGEMENTS

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Annex II Brazil coasts case

ATLANTOS OIL SPILL HAZARD BULLETIN

NORTHEAST BRAZIL

Bulletin users are advised to visit our website (https://glamor.sincem.unibo.it) to find out more about the methodology and vocabulary used.

FOREWORD

This bulletin is designed to support national and international policy makers and practitioners of oil spill emergency management. The bulletin structure is simple. First, we depict the overall surface circulation in the area of interest (i.e. Northeast Brazil), based on the global Copernicus Marine Environment Monitoring Service ocean forecast. Second, we describe the oil spill hazard for the coast of interest using a set number of release points near the coast to represent potential oil spills along well known maritime traffic routes.

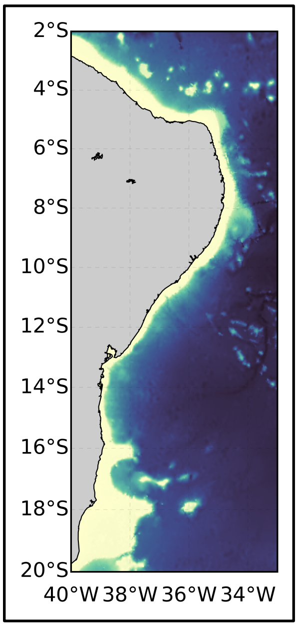

Figure 1 Brazilian NE coastline and bathymetry

THE BRAZILAN NORTHEAST COAST

The focus area encompasses six Brazilian states (Bahia, Alagoas, Sergipe, Paraiba, Pernambuco and Rio Grande do Norte), over 2000 km of coastline (Figure 1) and along routes of heavily trafficked waters (Figure 2). From an oceanographic perspective, the coastal area of NW Brazilian is characterised by two opposing western boundary ocean currents: the Brazil current and North Brazil current.

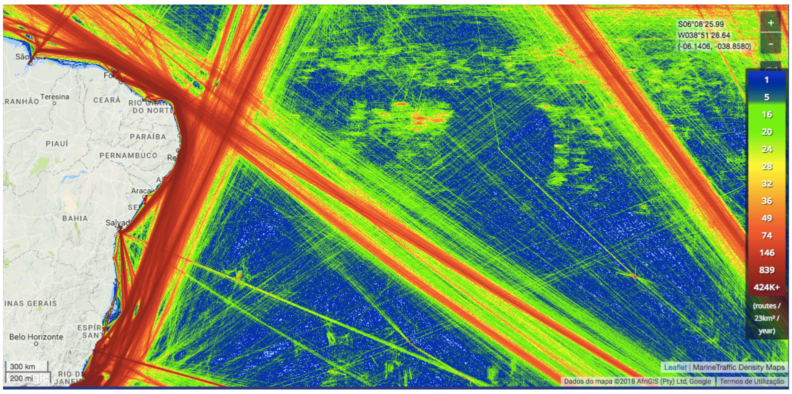

Figure 2 Density of Maritime traffic in 2017.
Extracted from www.marinetraffic.com

LOCAL OCEAN CIRCULATION

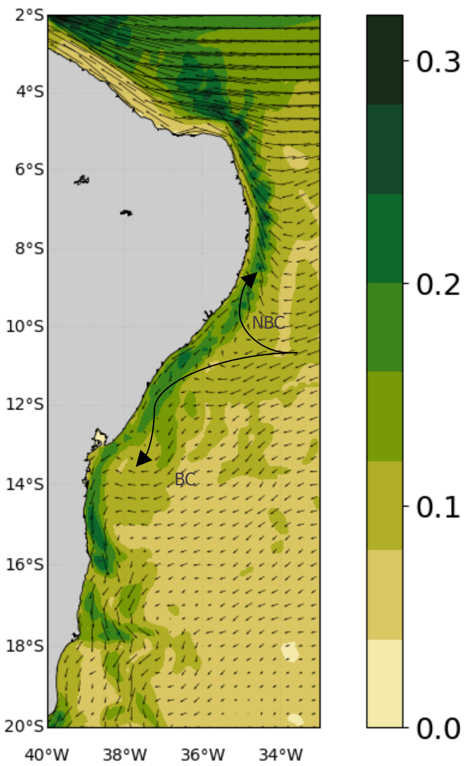

Figure 3 Average surface currents (vectors) and standard deviation (background color) in 2013 (m/s), based on daily velocity fields from CMEMS global ocean analyses (http://marine.copernicus.eu/).

Figure 3 presents the 2013 annual average surface circulation and its variability off NW Brazil (source: global CMEMS ocean currents). The map shows the Southern Equatorial Current (SEC), a westward flowing open ocean current that splits at ~ 10ºS into two main branches when approaching the continental margins off Brazil. A relatively weak southern branch, called the Brazil Current (BC), flows S-SW along the continental slope. Recent studies suggest that the BC is an "eddy-dominated" system between latitudes 10º S and 20º S.

The North Brazil Current (NBC) is the northern branch of the SEC. The NBC flows northward, following the offshore isobaths almost parallel to the Brazilian coastline. The NBC is a strong and stable western boundary current with intense eddy formation.

The continental shelf narrows off NW Brazil. Here, the western boundary current significantly influences the coastal circulation patterns and, thus, oil slick trajectory simulations in the area.

LOCAL RELEASE POINTS AND MOST LIKELY OIL TRAJECTORIES

Oil spill release points (RPs) off the coastal area in northern Brazilian are shown in Figure 4. The marine areas covered by the RPs are situated 30 to 130 km offshore. The spatial resolution of the release grid is 0.25° (~28 km for this region). The release grid covers most of the coastal maritime corridors active in the area.

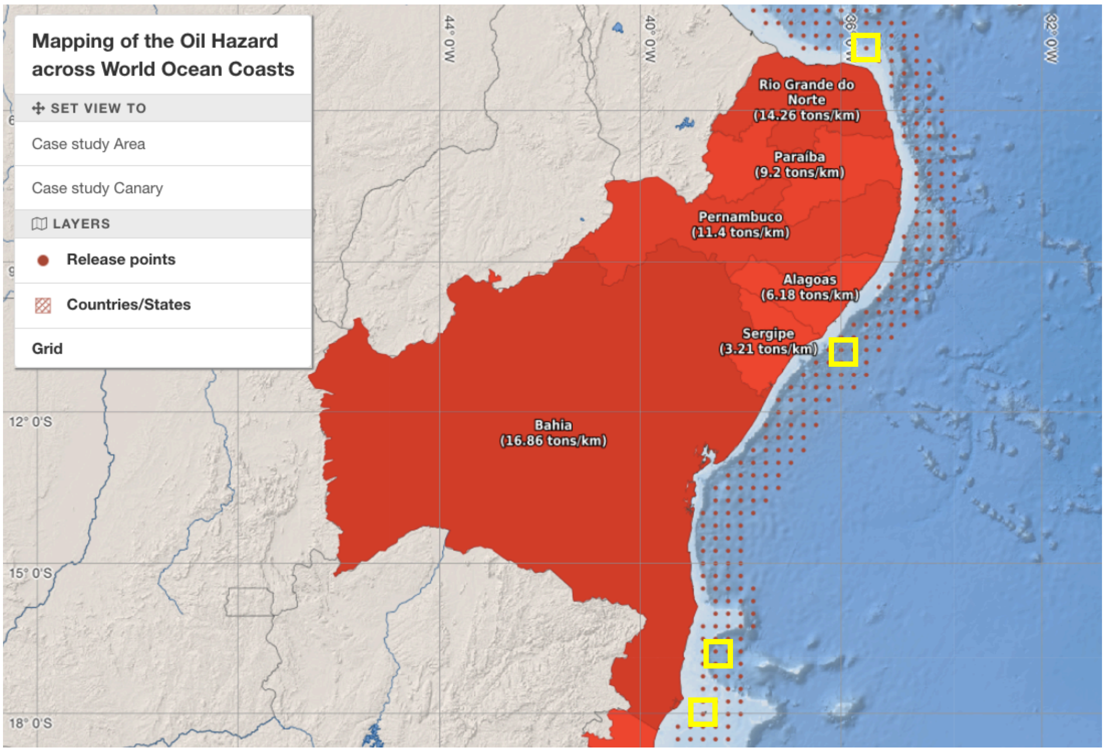

Figure 4 Release points in the northern Brazilian coastal area (red dots). Four RPs, highlighted with yellow boxes, were selected to analyze the slick trajectories originated there. Figure extracted from the GLAMOR website.

Four RPs are used to illustrate the effects of different flow fields on the oil slick trajectories and, consequently, on the coastal oil spill hazard (see Figure 4 for the release point locations). The cumulative trajectory plots for each release point are presented in Figure 5.

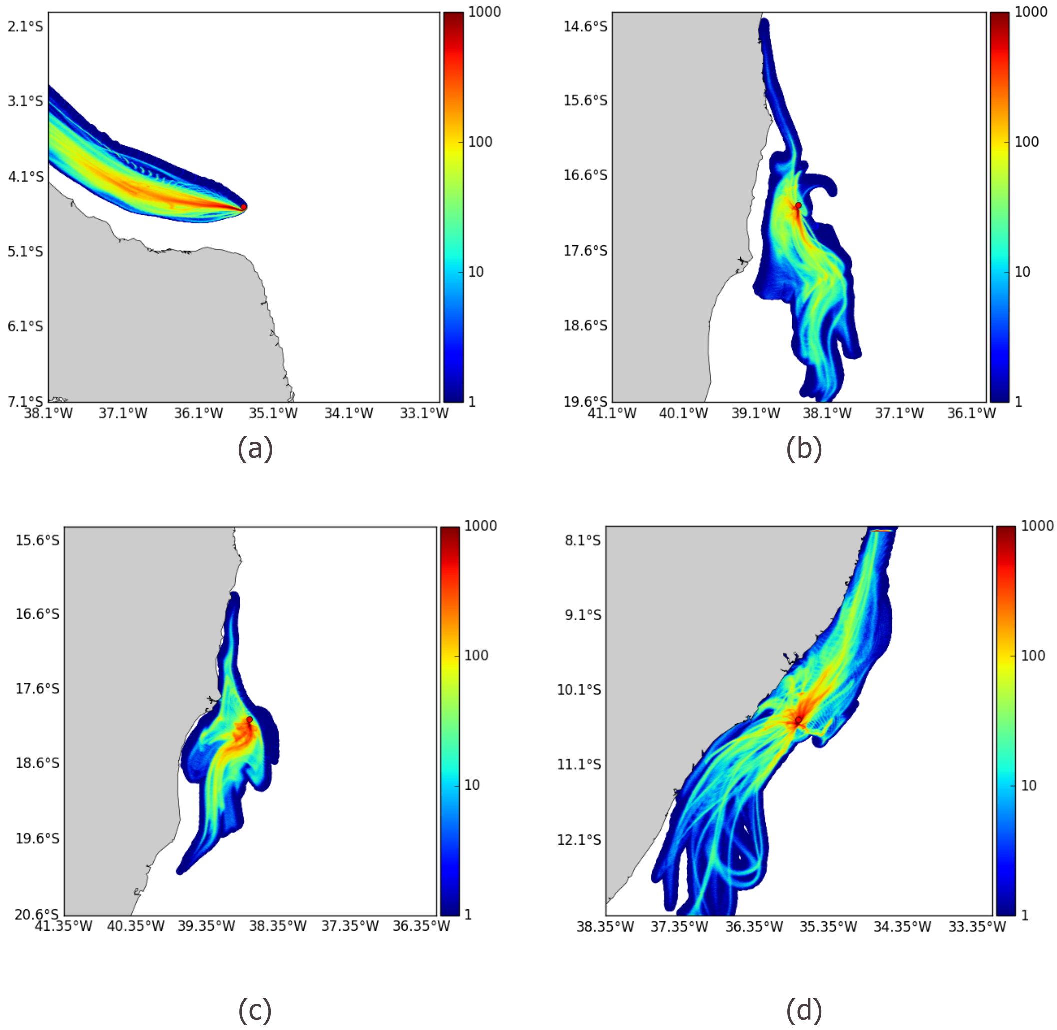

Figure 5 Cumulative oil spill trajectories for four release points off the Brazilian NE coast. Release points are marked by a red circle. Colours represent the number of oil observations at the grid point in the ensemble experiment.

The first RP (Figure 5a) of interest is located in the northern portion of the domain, an area influenced by the North Brazil Current. The simulated oil slick trajectories are shown in Figure

5a. The ensemble output indicates that if an oil spill occurred in this RP area, surface oil would most likely be transported in northwestward direction with the North Brazil Current. The possibility of oil slicks reaching the shores close to an accident in the area is low.

Figure 5 (b) shows another example. This time the simulated oil spill is situated close to the shelf break off the Bahia coast, to the south of the ocean region where the SEC splits. This region is known for intense eddy formation. Most of the slick trajectories simulated here showed a meandering southward pattern and eddy-like streams of the oil slicks. There is also a northward-oriented single trajectory, which demonstrates the importance of natural current variability events in the definition of the oil spill hazard.

The case presented in Figure 5c highlights that even a few kilometres difference in the RP location can lead to divergent oil slick simulated pathways. The RPs of Figures 5b and 5c are separated by only 25 km. The RP in Figure 5b is located outside the continental shelf and therefore exposed to transport influences of the Brazil Current (S-SW flows). The RP in Figure 5c is situated on the continental shelf. This slight change in position onto the shelf led to greater trajectory spread of the simulated oil slick and, thus, a higher likelihood that oil will reach the coastline should an oil spill occur in this area.

The final case, Figure 5d, shows the impressive uncertainty regarding the "most likely" pathway for a potential oil spill at 10ºS, where the Southern Equatorial Current separates. The oil slick trajectories are evenly separated in their northern and southern paths and do not allow us to describe a preferred path.

ON THE STATISTICAL DISTRIBUTION OF BEACHED OIL CONCENTRATIONS

Beached oil concentration histograms for the six States of the northern Brazilian coastal area are shown in Figure 6.

Starting with a visual comparison of the histograms, we can conclude that:

- most beaching events are related to the States of Bahia, Rio Grande do Norte and Pernambuco
- Sergipe shows the minimum number of events
- the maximum oil concentrations observed in all states are similar except for Sergipe

Comparison of the beached oil distribution Weibull average values among States, shown in Table 1, confirm that the most probable (average) beached oil concentration is largest for Bahia, Rio Grande do Norte and Pernambuco States and lowest for the State of Sergipe.

Table 1 Summary of the Weibull moments for the concentration of oil beached on the northern Brazilian coastal area.

State	Mean (tons/km)	Standard deviation (tons/km)
Bahia	16.9	66
Pernambuco	11.4	49.6
Sergipe	3.2	11.7
Alagoas	6.2	26.6
Paraiba	9.2	36.8
Rio Grande do Norte	14.3	54.3

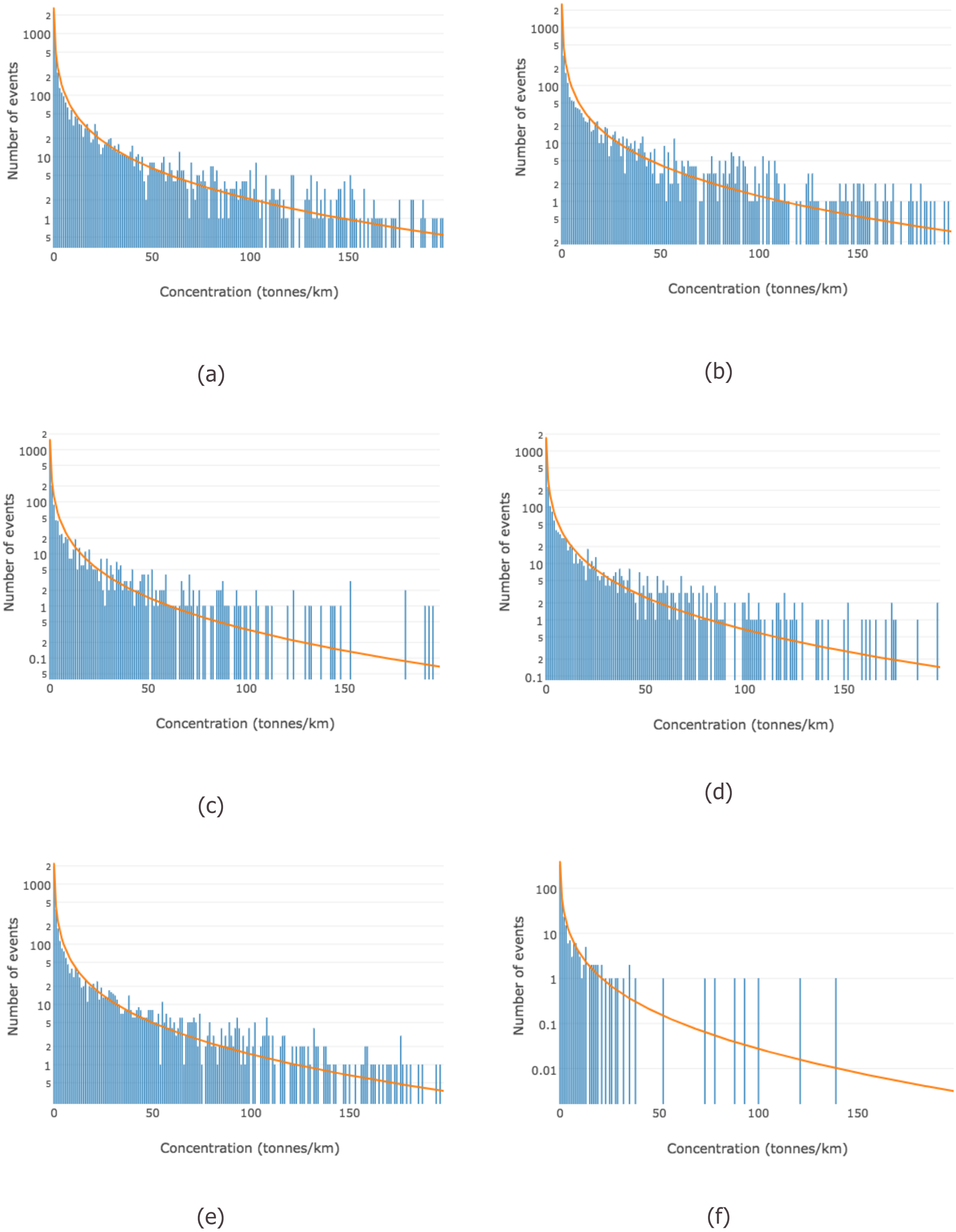

Figure 6 Beached oil concentration histograms (blue bars) and Weibull fit (red line) for the States of (a) Bahia, (b) Pernambuco, (c) Alagoas, (d) Paraiba, (e) Rio Grande do Norte and (f) Sergipe.

OIL SPILL HAZARD INDEX

An oil spill hazard index, H, has been defined and is calculated as follows:

$$H = \frac{1}{N_t} \sum_{i=M\_C_{min}}^{M\_C_{max}} N_i$$

where M_C_{min} and M_C_{max} are the bins corresponding to the minimum and maximum concentrations of interest, N_i is the number of beaching events in each bin and N_t is the total number of events.

For the sake of illustration, we calculated two different H indices: the first with a minimum concentration of 0.2 tons/km (called *H* index) and the second with a minimum concentration of 50 tons/km (called "high concentrations" H; see Table 2). For the specific NW Brazilian coastal case, the *H* index ranking showed Bahia and Rio Grande do Norte as the most exposed states in the area. Paraiba and Pernambuco switched positions, showing that beaching events in the latter tended to involve higher concentrations than those occurred in the former.

Country/State	Mean concentration	standard deviation	number of events	H index	High-concentration H index
Guinea	197.091	889.479	369	0.705	0.314
Madeira	136.633	666.215	1020	0.658	0.268
Guinea-Bissau	62.615	245.748	570	0.625	0.254
Cape_Verde	30.693	119.897	13336	0.596	0.137
Canary_islands	37.491	163.633	4839	0.556	0.165
Portugal	33.845	168.122	577	0.53	0.123
Spain	25.75	108.496	2365	0.52	0.129
Bahia	**16.863**	**66.028**	**4737**	**0.517**	**0.094**
Mauritania	24.376	109.024	2709	0.495	0.129
Rio_Grande_do_Norte	**14.265**	**54.309**	**3881**	**0.495**	**0.086**
Sierra_Leone	17.043	70.774	1549	0.485	0.102
Gabon	17.612	76.116	1625	0.46	0.105

Uruguay	35.412	189.957	1823	0.455	0.140
Nigeria	10.264	41.572	634	0.44	0.068
South_Africa	8.197	32.165	3287	0.423	0.053
Angola	10.872	46.938	1201	0.419	0.072
Paraiba	**9.195**	**36.83**	**2738**	**0.416**	**0.063**
Ivory_Coast	11.496	50.508	2061	0.415	0.068
Liberia	11.583	48.339	1314	0.413	0.078
Senegal	16.527	79.297	1304	0.411	0.107
Pernambuco	**11.397**	**49.63**	**4191**	**0.407**	**0.075**
Cameroon	19.31	102.098	2533	0.395	0.117
Marocco	17.078	102.245	281	0.352	0.093
Alagoas	**6.182**	**26.613**	**2302**	**0.349**	**0.046**
Sergipe	**3.214**	**11.711**	**514**	**0.339**	**0.021**
Sao_Paulo	9.219	41.669	1838	0.337	0.072
Gana	4.042	17.183	1397	0.273	0.037
Benin	6.938	39.641	122	0.262	0.057
Santa_Catarina	0.988	2.526	560	0.238	0.005
Namibia	2.411	10.163	60	0.233	0.017
Western_Sahara	1.225	4.301	944	0.19	0.013
Congo_and_Belize	0.918	3.943	137	0.131	0.015
Guinea-Equatorial	1.391	6.053	84	0.107	0.024
Rio_Grande_do_Sul	0.168	0.492	193	0.067	0
Parana	0.097	0.127	28	0.036	0
Espirito_Santo	0.182	0.204	2	0	0
Rio_de_Janeiro	0	0	0	0	0

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