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ASSIGNATION OF RESOURCES FOR SEA RESCUE. AN APPLICATION TO THE BASQUE COUNTRY

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ABSTRACT

The problem of the location of sea rescue resources generates certain controversies which are generally revived after accidents which have had a great social impact. The aim of the present paper is to formulate a methodology based on gravity models allowing sea rescue resources to be assigned. To this end, a study has been made of the problems of accident assessment, of ports and airports and their relation with the above and of zonification. Finally, an empirical application of this methodology to the Basque Country has been made.

KEYWORDS

1. INTRODUCTION

The concept of sea rescue has varied considerably over the last two decades. The boom in communications, the advances in the field of navigation, the use of elements of aerial intervention, the increase in sea traffic and especially in sports crafts has substantially modified traditional sea rescue models.

But what is sea rescue? Much was said over the course of the last century about the meaning of this term and its repercussions and its legal comparisons with aid. For some specialists in marine law, these are similar concepts. For others, in contrast, the difference is quite clear. Without going into the legal smallprint, and adhering to the dictionary of the Spanish Academy, 'sea rescue' is defined as 'action and effect of saving' and 'aid' as 'help, succour, assistance'. However, on examining the matter further, our dictionary would seem to make it clear that these are two distinct concepts. Taking all of this into consideration, and looking at the matter more from a technical than a legal viewpoint, sea rescue may be defined as the external action aimed at rescuing persons, crafts or objects in immediate and irreversible danger should no intervention be made. Aid means help to anyone in a difficult situation. The aid given to persons or to a craft does not always mean that without that aid, the person or craft could not have got out of that difficult situation. Finally, 'sea rescue' also has a legal acceptance when a great ecological or economic tragedy is avoided by such action.

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Nowadays, rescue organisations are costly and complex and are no longer locally based, but rather are of an interregional or even global nature. Much time has passed now since May 5th 1879, when, probably precipitated by the great gales of the spring of the previous year which left the Cantabrian coast with heavy human and material losses, the Project was drawn up in the Ateneo of San Sebastian for what would later become the Humanitarian Society for Sea Rescue of Guipúzcoa, the predecessor of the Spanish Society of Sea Rescue of 1880. Not to mention the English, pioneers in everything related to safety at sea, who took us forward by a century, as well as several other European countries at the forefront in this age.

Our country, thanks to the International Convention on Search and Rescue of 1979, has fulfilled its commitments efficiently since over a decade ago, through the development of the National Sea Rescue Plan and Fight aginst Pollution Plan and by creating a geographical network of Rescue Centres to which can be added specialist units such as tow-boats, speedboats and helicopters and agreements and contracts are made with several organisms for an effective coordination of the resources. And thus, almost overnight, we are now on a par with the most advanced countries in the world in matters of coastal protection.

In this paper, we interpret accidents at sea to be any event which affects a craft, implying grave danger to the craft itself, the persons or the load. This may be due to human error, materials or bad weather and may cause damage involving the loss of the craft, faults in the hull, human loss, etc. These are classified in categories such as sinking, collision, fire, explosion, etc.

In Spain, from 1992 to 1999 there were 3,006 accidents involving 3,235 crafts, meaning that there is an average of just over one accident per day (1.3). Our country, because of its strategic position, is a crossroads for several important sea routes, such as those of The Straits of Gibraltar and the North-West peninsular. This means that Andalucía and Galicia are the most significant and conflictive regions from the point of view of marine safety. Although the accident figures are clearly the most important, the rescue services also undertake other activities, such as various incidents related with navigation (accidents at work, activation of radio buoys, medical evacuations, etc). The number of these incidents is almost twice that of accidents: 674 in 1992, 812 in 1993 and 1,116, 929 and 1085 in the years 1994, 1995 and 1996, respectively. This is without taking into account other services not related with crafts which are very numerous, such as the removal of floating objects dangerous for navigation, service of supervision of oil slicks, recovery of bodies of victims of fatal accidents, etc.

Let us, however, continue with accidents. Table 1 shows the pattern of accidents in the Basque Country, the object of our study: 122 accidents with 127 crafts affected. It is not an area in which accidents are particularly frequent: it is not a crossroads for any major routes and the sea traffic can be considered to be around average.

Total number of accidents occurring 1992-99 in the SAR zone under Spanish liability:

Table 1

Year	Total	Merc.	Other	Fish.	Tug.	SD.	Yacht	Fail.	Disap	Inj.	Resc.
1992	328	61	29	138	3	1	96	47	117	70	1268
1993	486	68	20	159	2	1	236	65	53	35	1301
1994	457	89	17	177	3	0	171	27	48	53	831
1995	435	71	34	143	6	0	181	34	27	31	660
1996	507	76	11	190	5	0	225	44	48	27	666
1997	506	56	16	183	4	0	247	49	83	36	868
1998	516	59	22	163	2	0	270	50	89	24	684
	3235	480	149	1153	25	2	1426	316	465	276	6278

Table 2 – Basque Country

	Total	Merc.	Fish.	Yacht	Tug	Oth-ers	SD	Fail.	Disap.	Inj.	Resc.
1992	3	1	1	1	0	0	0	0	0	1	11
1993	19	7	6	4	1	1	0	3	2	1	27
1994	17	4	7	4	0	2	0	1	0	3	27
1995	17	1	11	3	0	2	0	2	0	0	37
1996	20	3	12	5	0	0	0	0	0	1	21
1997	22	1	10	10	0	1	0	1	3	8	43
1998	29	1	12	16	0	0	0	0	0	1	17
Total	127	18	59	43	1	6	0	7	5	15	183

Tables 1 and 2 above show the statistics to be used for the present work.

Regarding the data shown in these tables, we shall now outline some aspects relating to the generation of the information contained therein. When an accident occurs, the authorities in charge send all of the reports corresponding to that accident to the Government Board for Maritime Affairs. The gravity of the accident can be deduced from the number of documents or reports. The functionaries of the Government Board draw up the official statistics from the data sent, using numerous variables such as the region where the accident took place, the name of the craft, day and time, age of craft, nationality, GRT, type of craft, type of accident, cause, damage, persons affected, contamination and mediums used. We have added to this information other aspects related to the geographical location of the accident, the metereological conditions of the moment, etc., which we considered essential for the present work.

2. METHODOLOGY: AN APPROACH TO GRAVITY MODELS

2.1. GENERAL APPROACH

In order to build our model, we have taken as a reference the works of Hansen (1959), Catenese and Steiss (1968) and Quade Boucher (1968). In keeping with these, the proposed model aims to redistribute or locate the rescue resources efficiently.

The assessment of a location is to be undertaken taking into account the gravity or weight of the accidents,number, distance and capacity or appropriacy of the place of evacuation, be this a port or an airport. On weighing things up, it must be borne in mind that the gravity of an event will have preference over other aspects, always considering that any accident must be attended to immediately. This is the typical pattern of a gravity model.

As regards the appropriacy factor, a gravity model has to consider the available installations, medical care and technical aspects. This work studies each of the mediums (launch, tow-boat, helicopter) separately. This approach is logical since the locations of each of these do not necessarily coincide. An accident may require the presence of one, two or more than two of the above resources.

In view of this approach, it can be observed that the model may be applied accident by accident, and the expression relating the variables to consider is:

$$Coef = f \sum_{i=1}^{i=n} \frac{P_i}{d_i}$$

Coef is a coefficient which measures the value of a rescue medium located at a specific point.
f is the factor of appropriacy for the location in question.
n is the number of accidents in the data base located within the radius of action of the rescue means under study.
P_i is the weight of each of the accidents.
d_i is the distance between the location and the accident.

However, the clarity of the calculations is greater if, as shall be seen below, the waters under study are divided into zones.

The accidents have been divided into four groups, assigning to each of them an evaluation to establish a hierarchical number of 5, 3, 2 and 1 points, respectively for most serious, serious, moderate and slight. In the terms of the gravity models, we are assigning 'weight' to the accidents. The accident classification procedure is a decisive factor.

The distribution of the accidents in groups has been made according to the following procedure: first, the records corresponding to the accident in question are selected from the data base. The data appearing in the data base obtained directly from the Government Board or in the files are evaluated: place of accident, type of accident, consequences for the craft, number of injured persons, deaths or disappearances, number of persons on board, type of craft, age, tonnage, time of day, month of year to calibrate the temperature of the water, state of the weather and the sea. The situation of the accidents on the Nautical Map will serve as a perfect complement to the above: whether the wind or the sea were or not favourable, whether the place where the accident occurs is sandy or rocky, whether the beach is flat, etc. Thus, the accidents were grouped in logical categories valid for any type of study.

The classification is:

Very serious accidents: When there have been deaths or disappearances, or the rescue of various injured or uninjured persons in such a way that if no external action had been taken the result would heve been death for these persons. In these accidents, there is total loss or serious damage to the craft or substantial contamination. Apart from the above questions, very serious accidents are characterised by the difficulty of the rescue operation since, generally, the external agents (weather, season, time) act as negative factors.

Serious accidents: When there are deaths, disappearances, injured or rescued parties. It is different from the above in that if no external help had been provided, the risk of death for the crew would, in many cases, have been evident, but the external agents did not act exclusively against the resolution of the problem. Typical accidents in this category are stranding and the subsequent loss of the craft, water entering the craft, heeling and persons falling into the water with little or no possibility of recovery, as well as quite substantial contamination.

Moderate: When the accident may constitute a certain danger for the crew. These produce damage to the craft and the external elements do not act against the resolution of the problem.

Slight: When the accident does not constitute a serious risk to the crew. They are accidnets with little personal or material damage. Their common denominator is mechanical or human failure which give rise to towing or to small collisions and stranding. It is the classical accident of estuaries and their surroundings with non-damaging external elements.

2.2. PROCEDURE FOR THE ASSIGNATION OF SEA RESCUE RESOURCES

In order to study which medium should go out in aid of the damaged craft, the following is available:

1. Information provided by the data base (gravity of accident, type of craft, type of accident, weather conditions, time and season) distance, winds, currents, etc.

2. Operability and functionality of each of the rescue mediums.

With the results of the analysis described in the above paragraphs, the logic fields are filled in the form: 'require medium X'. Making use of these fields, an automatic selection can be made of the accidents in which each of the rescue mediums are to be used.

New fields or rows will be added to the data base: need for helicopters, tow-boat, launch or other elements, etc. The operative process for sending a medium to the zone will be similar to that used for the assignation of categories and bearing in mind the following considerations:

Rescue Helicopters:

Essential elements in current rescue systems. Autonomy of the best types: maximum radius of action, 150 miles; maximum capcacity, 25 personas; highest speed, 120-130 miles/hour. These can act in almost all situations.

It has been verified that these perform very fast. According to the files of the Government Board, after an average of 11 minutes after receiving the order to leave, they are taking off from the airport. They are used in all cases of immediate rescue and whenever there is a possibility of sinking or imminent danger. They are also used for pursuits and tracking or to provide any information necessary to the services in charge.

Rescue tow-boats:

These can act in all weather conditions, with a great radius of action, great capacity for taking on shipwrecked persons, as landing grounds for helicopters, can carry the leaders of a rescue operation, tow, have fireproof systems, bailing and the means to fight contamination. Their drawbacks are their relative slowness, draught and lack of manoeuvrability in some cases. Normal radius of action: 100 miles.

Rescue launches:

Great speed, reach 30-35 knots in good weather, serve for the open sea or offshore. They are not operative in rouge seas and their autonomy is 400 miles. Whenever aid is to be given to a small craft with some damage, or it is to be pulled out of a stranded situation, or tossed or any other attention and for rescuing persons, this medium is selected. Radius of action: 50 miles.

We shall describe the assessment of locations, the problem of zonification, the formulation of the model and its application.

a) Evaluation of locations

Any rescue medium, such as a launch, can be located at a specific point near a place where accidents proliferate. Thus, the port in question will be will be a clear candidate for locating a rescue medium when a gravity model is applied. However, this port may have certain conditions which prevent the launch from taking to sea in bad weather, which will reduce its possibilities. In fact, this model evaluates the capacity of the locations and develops from this evaluation 'indicators of appropriacy'.

The 'indicators of appropriacy' are numerical assignations ranking from 1 to 0. An optimal port has an assignation of 1, a good one up to 0.8, and so on, decreasing when considered regular, bad or very bad. The assignation of a factor of appropriacy to each of the locations is performed in accordance with the following considerations:

Access: access to the port from the sea is evaluated; whether it is possible to continue operating in storms or to what proportion its docks are closed and with what seas; capacity for medical care; infrastructure of the port itself; capacity for making repairs; fuel supply system; cranes, etc; innovative elements: new docks with more room for sports crafts, etc.

There will be one factor for the launches and another for the two-boats. Airports are all valued equally, since all of the airports selected are close to hospital infrastructures and dispose of the necessary technical means.

b) The problem of zonification and formulation of the model

The gravity model could be applied accident by accident as stated previously. However, this approach involves the calculation of the distance between each accident and the different locations. These calculations can be simplified if the water zones under study are divided. Also, the specific case that may arise when an accident affects a marine medium in its own base is eliminated.

The accidents that occur in each of the zones are grouped into one 'superaccident'. The weight of this is obtained by adding up that of the respective accidents. The situation of 'superaccident' is obtained from the mathematical average of the latitudes and longitudes corresponding to the accidents arising in the zone in question

The greatest problem with zonification is to determine the size of the zones. Zones which are too small lead to unnecessary calculations, while those which are too big induce all accidents to be treated equally, though these clearly require different operating procedures.

The size of the zone depends on the rescue medium. The zone must be a sea region whose size means that the conditions of access to any of its points are quite similar. In other words, the size of the zone must be small in comparison with the radius of action of the rescue medium, so that the criteria followed has been to use zones whose size guarantees that access can be made to any of its points practically homogenously. Thus the coast of the Cantabrian Sea and Galicia has been divided in zones, 207 for the two-boats and 34 for the helicopters.

Once the accidents have been distributed in zones, the calculation is made of the 'superaccident' corresponding to each of them. This 'superaccident' represents the zone in question and is determined by a situation (latitude and longitude) and a weight.

Once the sample is zonified, we select those 'superaccidents' which take place in the radius of action of the rescue medium found in the location under study. The coefficient which evaluates the location is obtained with the expression mentioned above with slight variations:

$$Coef = f \sum_{i=1}^{i=n} \frac{P_i}{d_i}$$

Coef is a coefficient which measures the value of a rescue medium situated in a specific location.

f is the factor of appropriacy for the location in question.
n is the number of zones situated within the radius of action of the rescue medium whose base is the location under study.
P_i is the weight of the 'superaccident' which represents the zone.
d_i is the distance between the location evaluated and the 'superaccident'.

Below the method followed is explained using an example.

The figure below shows a series of accidents in a specific zone and the distance between these and three ports located in the surrounding area.

The coefficient of each port in relation to zone A will be the result of dividing the total of the weights in zone A (PA=22, the largest circle in the schema) by the distance in miles from the centre (average distance of all of the accidents in the zone) to each port. This for the port on the left of the schema, 22 will be divided by 40 giving 0.55. This number will have to be multiplied by the appropriacy of the port (access by sea and land, infrastructure, hospital care, geographical situation, etc.). An ideal port has a maximum value of 1. Assume that the port represented has 0.6. Then, the coefficient of that port in relation to zone A will be: 0.55*0.6= 0.33. A similar operation is performed for all ports within less than 50 miles for the launches, 100 for the tow-boats and 150 for the helicopters.

The port on the right in relation to zone A will have the best coefficient for two reasons: firstly because it is the closest (24 miles) and because it has better performance characteristics than the others (the corresponding circle is the biggest). In other words:

It can be observed from the schema that the power of attraction between the accidents occuring in zone A (represented by PA) and P´ is greater than that between the same and d. The formula which measures the attraction between P´ and zone A is:

$$CoefP'_A = \frac{P_A}{d_A} = \frac{\sum P_{accA}}{d_A}$$

in which *dA* is the average distance to all of the accidents of the zone. As stated above, in gravity models the distance factor is elevated or not to one power depending on the experimental comparison. In this case, it is not elevated although, if this were done, the results would not change substantially.

In our paper, we will use the function of distance rather than that of weather as this would vary for each accident for any small variation in metereological conditions.

The formula will now be developed considering mainly four zones: A, B, C, D:

$$CoefP' = CoefP'_A + CoefP'_B + CoefP'_C + CoefP'_D$$

It can also be stated that:

$$CoefP' = \sum_{zona=1}^{4} \frac{P_{zona}}{d_{zona}}$$

Considering the capacity of the port,

$$Coef\ P' = \left(\frac{P_A}{d_{A,X}} + \frac{P_B}{d_{B,X}} + \frac{P_C}{d_{C,X}} + \frac{P_D}{d_{C,X}} \right) * Idoneidad_{puerto}\ P'$$

When the number of zones is greater, the final coefficient (Coeff puertox) will take into account the n zones and the formula will be:

$$Coeff_{puerto\ X} = \left(\sum_{zona=1}^{n} \frac{P_{zona}}{d_{zona,\ puerto\ X}} \right) * Idoneidad_{puerto\ X}$$

c) Application of model and interpretation of results.

The coefficient is a numerical value which establishes a hierarchy of port or airport in relation to the accidents. This depends on their number, gravity, the distance at which they occur and the appropriacy of the port or the airport. For the calculation of the coefficients of the helicopters, tow-boats and launches, the gravity model formula outlined above has been used and we have used the data base for this. It goes without saying that through the study of the coefficients over several stages, the evolution of accidents in a zone can be studied.

Although the coefficients lead us to the almost total resolution of the location of the mediums, it must be borne in mind that there are other aspects that allow us to situate these mediums appropriately along the coastline.

The work equlibrium centres are those points on the coast which establish the distances to be covered by each rescue medium and their mission is to share out the work appropriately, taking into account the capacity of each medium. And what are these distances? For the Basque-Cantabrian coast with its geographical characteristics, metereological conditions and volume of traffic, the ideal distance, bearing in mind the opinions of several experts and their studies (captains, pilots and owners of launches, tow-boats and helicopters) as well as those that exist in other countries such as France and England, these will be:

For rescue launches, the maximum radius of action should not exceed 25 miles (50 miles between them) 50 for tow-boats (100 maximum distance between them) and 75 (150) as the crow flies for helicopters.

3. APPLICATION TO THE BASQUE COUNTRY

3.1. RESCUE LAUNCHES IN THE BASQUE COUNTRY

The zone studied takes in the area from the border with France to the eastern limit of Cantabria.

Accidents requiring launches in the Basque Country 1992-1999: 82. Total weight: 164. average: 2.0. Four were very serious, 18 serious, 30 moderate, and 30 slight. In the proximities of Pasajes there were 25 (with a weight of 49), around Orio 11 (with a weight of 11), in the area of Deva 14 (with 26), Elanchove 10 (with 15), Bakio 5 (with 17) and Bilbao 23 (with 46).

Zonification: the coast under study is divided into 17 zones (207 for all of the North-Galicia) of around 10*10 miles and a northern boundary whcih coincides with that of the area of responsibility of the Spanish SAR

The launches assist preferably fishing boats and sports crafts rescuing persons in places not too far from the coast. They also act as a complement to helicopters or tow-boats in very serious cases.

Evaluation of accidents and locations: this is done according to the criteria described above, that is with 5 for serious accidents, 3 for serious ones, 2 moderate and 1 slight, and for locations, those shown in the table below in the column 'appropriacy of port'.

Ports studied: the main ports of the whole area: Fuenterrabía, Pasajes, San Sebastián, Guetaria, Lequeitio, Bermeo y Bilbao.

For the calculation of the distances from the ports to the 'superaccident' (orthodromic distance) a correction by outputs has been performed, whenever these existed.

The coefficients obtained for the Basque coast are:

Basque Country	Initial Coef.	Appropriacy of port	Final Coef.	Weight	Total Distance	Average Distance	Between L= 1° 45,0W and [illegible]	Betweee L=2° 27,2W y 3° 09,1W
Fuenterrabía	**10,86**	0,75	**8,15**	164	2483	30,3	14,6	
Pasajes	**27,37**	0,82	**22,41**	164	2111	25,7	**10,3**	
San Sebastián	**14,64**	0,82	**12,05**	164	2039	24,9	10,7	
Guetaria	**10,72**	0,75	**8,05**	164	1810	22,1	12,9	
Lequeitio	**14,29**	0,75	**10,72**	164	1653	20,2	20,4	19,9
Bermeo	**11,56**	0,82	**9,48**	164	1842	22,5		13,9
Bilbao	**29,11**	0,92	**26,78**	164	2546	31,1		**11,9**

If a single launch had to be positioned in The Basque Country to attend to such a great area of coast, the most suitable point would be at Longitude = 2º 25.0 W which coincides with the area around Ondárroa. But it has already been pointed out that a single launch in the Basque Country is insufficient since, from the nearest port which is Lekeitio, it would have to travel an average of 20.9 miles, a figure which is too high for a single launch. It is necessary to determine which ports are best placed to cover all of the coast with average distances of less than 15 miles. In the same table, it can be clearly observed which ports do this: Bilbao and Pasajes, which have the highest coefficients and the shortest distances.

For a correct distribution of work, one will cover from the French border to the area around Ondárroa and the other from there to the border with Cantabria.

As an example of other northern ports, the corrected coefficients and average distances to all the accidents in the area are for Cantabria: Castro 13.28 and 17.46; Santoña 9.57 and 21.00; Santander 34.85 and 13.8; Suances 5.63 and 20.6 and San Vicente 4.67 and 34.4.

3.2 INTERZONAL ANALYSIS OF LAUNCHES IN THE BASQUE COUNTRY

The maximum radius of action is 50 miles which means that the Basque ports take coefficients for accidents occurring in Cantabrian waters and Cantabrian ports take them for the bordering communities. Operating with the data base and spreadsheets gives the results shown in the table below. It can be observed that Lekeitio, Bermeo and Bilbao have higher coefficients while the other ports maintain their previous values since their bases are more than 50 miles away.

Basque Country	Coefficient	Appropri-acy of Port	Total Dis-tance	Average Distance
Fuenterrabía	10,01	0,75	Farther	
Pasajes	27,24	0,82	656,4	**13,4**
San Sebast.	14,61	0,82	631,4	12,9
Guetaria	11,15	0,75	656,6	13,4
Lequeitio	15,44	0,75	Farther	
Bermeo	14,52	0,82	942,5	18,8
Arminza			689,1	13,8
Bilbao	33,15	0,92	654,5	**13,1**

It has always been maintained that the oragnisation of rescue operations needs to be global, so that once the launches are located in the Basque Country, bearing in mind that the Community of Cantabria is to the east, and analysing the situation there, it becomes clear that the launch at Bilbao could cover part of this Community without any inconvenience for Bilbao. The launch at Santander would also benefit from this as it would not have to cover such great distances. If this were the case, the launch at Pasajes would have to cover 5.5 miles to the west, so that it would cover from the French border to the Cape of Santa Catalina in Lequeitio. This study shows the places where accidents proliferate. The launch at Bilbao will have responsibility for almost 11 miles more to the west, clearly reducing the load on the launch at Santander. The Bilbao launch will establish this point to the east and Mount Buciero in Santoña to the west. Thus, the launches in the Basque Country will be located thus:

One launch in Pasajes which will cover from the French border to Longitude = 2º 30,5 W; that is to the Cape of Santa Catalina in Lequeitio. Number of accidents in the last 7 years: 49. Two very serious, 11 serious, 13 moderate and 23 slight. Weight: 92. Average 1.88. 29 occurred in the open sea. Distance to cover between capes: 36 miles.

One launch in Bilbao which will cover from the cape of Santa Catalina to the mount of Santoña, that is from Longitude = 2º 30,5 W to Longitude = 3º 27,2 W. Thus the 17 accidents occurred in the waters of eastern Cantabria would be attended to by the Bilbao launch, since the distance is shorter. Total accidents in 7 years: 50. Very serious 3, serious 12, moderate 19 and slight 16. Weight: 105. Average: 2.1. 29 took place in the open sea.

Distance to the nearest launch: 55 miles. Distance between capes: 42. A Red Cross launch may be located at an intermediate point.

Thus, the Santander launch, should it not have the assisatnace of the Bilbao launch, would have to cover from the border with Vizcaya to Tina Mayor. As the Bilbao launch covers up to Buciero, the reduction would be of 20% of the accidents in Cantabria requiring a launch. It would thus attend to 68 accidents with an average distance of 10.8 instead of the 13.8 in the case of acting without this coordination.

3.3. AUTONOMOUS AND INTERREGIONAL ANALYSIS OF HELICOPTERS IN THE BASQUE COUNTRY

Maximum radius of action of helicopters: all of the Basque Country. Zones in the Basque Country: 6. Airports evaluated, all the existing ones: Fuenterrabía, Bilbao and Vitoria.

Evaluation of the locations: all of the airports have been assigned the same evaluation (factor of appropriacy: 1).

Zonification: the coast under study is divided into 6 zones, bordered by the coastline in the longitudinal direction. In the part which goes from east to west, each zone has an extension of 20 miles and a Northern border which coincides with the zone of responsibility of the Spanish SAR, although 3 accidents are evaluated whcih, though they took place in areas under French responsibilty, are normally assisted by the Spanish rescue service.

Accidents occurring 1992-99 requiring helicopter: 44. Putting the above method into practice and taking as reference the data base and the columns of latitudes and longitudes gives:

From the French border to the border with Cantabria. Number of crafts suffering accidnets: 44. Total weight: 122. Very serious: 5. serious: 21. moderate: 16. slight: 2. Average per accident: 2.77, including moderate and serious.

Coefficient for Fuenterrabía: 6.678. Total distance of all accidents requiring helicopter in The Basque Country: 1,486.3 miles. Average distance: 33.7 miles.

Bilbao coefficient: 6.672. Total distance of all accidents requiring helicopter in the Basque country: 1,398.8. Average distance: 31.8 miles.

Ídem Vitoria: 2.543. Total distance: 2,165.7. Average Distance: 49.2 miles.

Conclusion: if the aerial mediums of the Basque Country acted autonomously and only one single helicopter were to be located, the coefficients of Fuenterrabía and Bilbao are almost identical. This means that the accidents which take place to the east are, on average, slightly more serious than those of the western zone. Thus, the location selected must be Bilbao. In short, the gravity of the accidents is widely distributed all along the Basque coast. Logically, Vitoria is badly situated on all counts.

Now, from which part of the coast could a more efficient service be made? The place whose weight is equivalent for both the east and the west corresponds to a point on the coast at Longitude = 2º 22,3 W, which is at Punta Alcolea, near the port of Motrico. This point is obtained from the data base by interpolation of longitudes until the weights are equal, since The Basque Country extends approximately on a parallel. If the rescue operations were not coordinated between communities, this would be the ideal place to locate a helicopter. Distance from the point mentioned to all accidents: 1,131 miles; average distance: 25. 7 miles.

But maintaining that accidnets must be attended to on an interregional or international level and bearing in mind that the maximum radius of action from the bases of Fuenterrabía, Bilbao and the other airports of the north will be 150 miles, the situation is as follows.

Coefficient for Fuenterrabía (its radius of action would be up to Tazones): 8.2029. Coefficient for Bilbao (up to Vidio): 9.0075.

Table summarising use of Basque airports.

Airport (1)	Weight (2)	Coefficient (3)	All D. (4)	E-Bars (5)	Lim. Bars (6)	Limit Ribadeo (7)	Distance (8)
Fuenterrabía	247	8,2029	91313	18903	128,6	12905	104,9
Bilbao	334	9,0075	75484	14095	95,9	9209	74,8
Santander	356	9,2447	64613	11956	81,4	8004	65,1

Column 3 shows the coefficients, and Column 4 gives the total distance from all accidents requiring helicopter assistance occurring in the north, including Galicia, for all bases. Columns 5 and 6 show the distances from the French border to Estaca de Bares and distances to Cantabrian airports. Coumn 7 gives distances with respect to the border at Ribadeo and 8 gives average distances with this border.

3.4. TOW-BOATS IN THE BASQUE COUNTRY: AUTONOMOUS AND INTERREGIONAL ANALYSIS

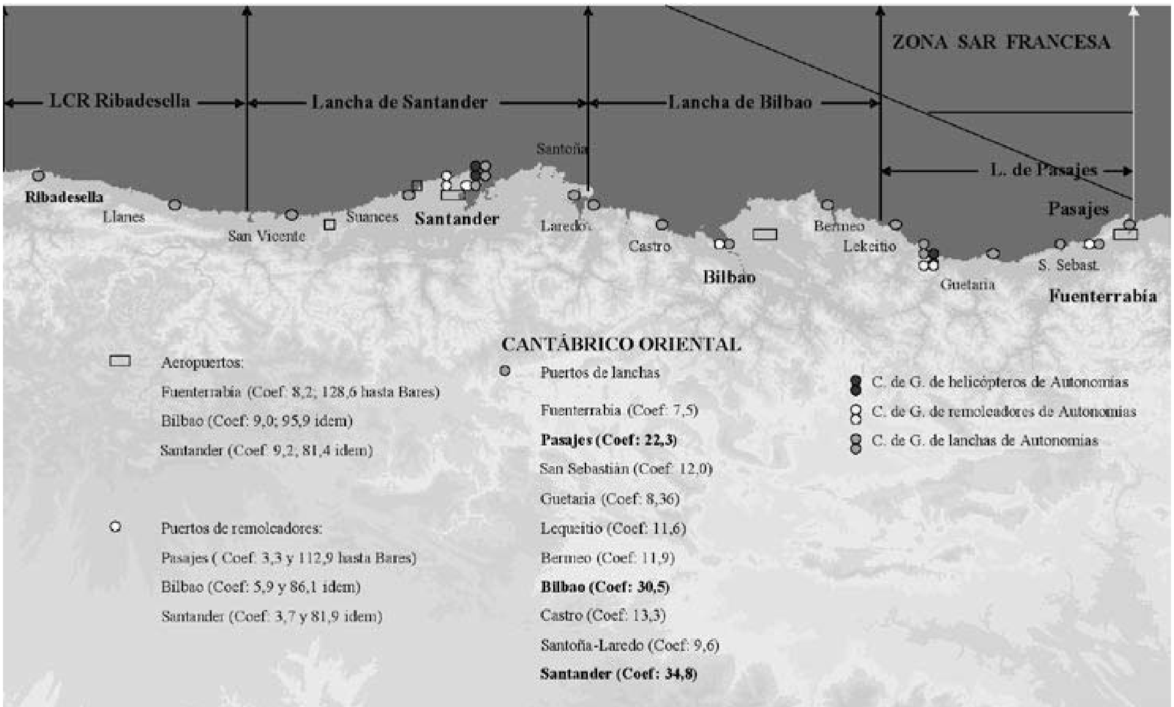
Radius of action of tow-boats: 100 miles. Ports studied: Bilbao and Pasajes, since they fulfil the basic conditions for accommodating this type of crafts. The main services of the tow-boats are: assistance, preferably for freight crafts and fishing boats in cases of collision, strandings or failures of materials or mechanics, towing or fighting contamination and fire. They are not characterised by a high level of assistance for persons. All of the other parameters are based on the aspects considered above.

Borders: from the French border to the border with Cantabria. Number of accidents requirng tow-boats: 38. Total weight: 78. Average: 2.05.

Coefficient for Pasajes for accidents in the Basque Country requiring tow-boats: 3.51 for 0.82 appropriacy of port: 2.88. Total distance to Pasajes for all accidents: 1338.7. average distance: 35.2. Coefficient for Bilbao: 4.01 for 0.96: 3.84. Total distance: 1295.5. average distance: 34.1. The most suitable port would be Bilbao, although the presence of a smaller tow-boat is desirable in Pasajes for the rescue service, since this is a zone of moderate risk.

For all of the Basque Country, the location closest to all acidents would be at Longitude = 2° 23,5 W. Centre of gravity between Motrico and Ondárroa.

Finally, and with a radius of action of 100 miles, the following table shows the coefficients for the two main Basque ports and for Santander.



CONCLUSIONS

1. The launches in the Basque Country should be located in Pasajes and in Bilbao with a smaller one in an intermediate port. The Bilbao launch will attend to 20% of the services of eastern Cantabria.

2. In the Basque Country, with an interregional analysis, there should be a helicopter located in Bilbao with similar characteristics to the Galician 'pesca' in order to improve the coverage of eastern Cantabria (for the year 2004 there is the following prediction of work: accidents-year Basque Country and Cantabria requiring helicopter: 16, incidents on crafts 32, incidentes not on crafts 64). There would thus be a good coverage provided for the ferries which arrive in Bilbao and Santander with up to 3,000 passengers per trip and for the fishing fleet. All of this without considering the foreseeable increase in accidents, since governments have undertaken measures to increase the number of moorings for sports crafts. Their coverage would be at sea but could also cover specific cases on land. The paper also summarises the location of the maritime and aerial mediums all along the northern Spanish coast

3. The two Basque ports with freight traffic should dispose of the service of a two-boat. The policy of providing private tow-boats in important ports by the authorities in charge of the rescue service is a good one.

4. Coefficients are given throughout this work of other places on the northern Spanish coast serving to establish comparisons with those obtained for the Basque Country.

5. The variation in the coefficients is valid for establishing the evolution of accidents.

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APENDICE: ASIGNACIÓN DE RECURSOS PARA EL SALVAMENTO MARÍTIMO. UNA APLICACIÓN AL PAÍS VASCO

RESUMEN

La problemática en la ubicación de los medios de salvamento marítimo genera algunas controversias que suelen reavivarse con posterioridad a los accidentes que ocasionan gran impacto social. El objetivo del presente trabajo es formular una metodología -que permite asignar recursos a los salvamentos marítimos- basada en los modelos de gravedad. Con tal finalidad, hemos procedido a abordar la problemática de la valoración de los accidentes, de los puertos y aeropuertos y su interrelación con los anteriores, y de la zonificación. Finalmente, se ha realizado una aplicación empírica de dicha metodología al País Vasco.

PALABRAS CLAVES

1. INTRODUCCIÓN

El salvamento marítimo se puede definir como la acción externa dirigida a sacar a personas, a buques o a cosas de un peligro inmediato e irreversible si no se ayuda. Últimamente también tiene la consideración legal de salvamento cuando con una acción se evita una gran tragedia ecológica o económica.

Nuestro país, en virtud del Convenio Internacional sobre Búsqueda y Salvamento de 1979, da una respuesta eficaz a sus compromisos internacionales desde hace más de una década mediante el desarrollo de los Planes Nacionales de Salvamento Marítimo y Lucha contra la Contaminación al crearse una red geográfica de Centros de Salvamento a los que se agregan unidades especializadas como remolcadores, lanchas rápidas y helicópteros y se firman acuerdos y convenios con diversos organismos para la adecuada coordinación de los medios.

Un accidente marítimo es todo suceso que afecta al buque en su materialidad suponiendo un grave peligro para el mismo, las personas o la carga. Puede deberse a fallos humanos, materiales o al mal tiempo y puede causar un daño que suponga la pérdida del buque, averías en el casco, pérdidas humanas, etc. Se clasifican en categorías: hundimiento, colisión, incendio-explosión, etc.

En España desde iniciado el año 1992 hasta 1999 sucedieron 3.006 accidentes con 3.235 buques implicados, es decir, significa que hay una media de poco más de un accidente diario (1,3). Nuestro país por su situación estratégica es zona de confluencias de las grandes rutas marítimas como son la Zona del Estrecho de Gibraltar y el Noroeste peninsular.

En el País Vasco, objeto de nuestro estudio, sucedieron según se refleja en la tabla 1, 122 accidentes con 127 barcos afectados. No es una zona en la cual los accidentes proliferen de manera especial: no está dentro de confluencias de grandes rutas y el movimiento marítimo de la zona puede considerarse de tipo medio.

Tabla 1 País Vasco.

	Total	Merc.	Pesq.	Yates	Reml.	Otros	SD	Fall.	Desp.	Her.	Resc.
1992	3	1	1	1	0	0	0	0	0	1	11
1993	19	7	6	4	1	1	0	3	2	1	27
1994	17	4	7	4	0	2	0	1	0	3	27
1995	17	1	11	3	0	2	0	2	0	0	37
1996	20	3	12	5	0	0	0	0	0	1	21
1997	22	1	10	10	0	1	0	1	3	8	43
1998	29	1	12	16	0	0	0	0	0	1	17
Total	127	18	59	43	1	6	0	7	5	15	183

Cuando ocurre un accidente son enviados a la Dirección General de la Marina Mercante por las autoridades competentes, todos los informes correspondientes a ese accidente. Del número de documentos o informes se puede deducir la importancia o gravedad del mismo. Con los datos enviados, el personal funcionario de la Dirección General elabora estadísticas utilizando diversas variables como la región donde se ha producido el siniestro, nombre del buque, edad, día y hora, nacionalidad, TRB, tipo de buque, tipo de accidente, causa, daños materiales, personas afectadas, contaminaciones y medios utilizados. A dicha información hemos añadido otros aspectos relativos a situación geográfica del accidente, condiciones meteorológicas del momento, etc, que hemos considerado indispensables para la realización del presente trabajo.

2. METODOLOGÍA

Para construir nuestro modelo matemático hemos tomado como referencia los trabajos sobre modelos de gravedad de Hansen (1959). De acuerdo con los mismos, el modelo que proponemos pretende redistribuir o ubicar los medios de salvamento de forma eficiente. La evaluación de una ubicación se ha de efectuar teniendo en cuenta, por un lado, los accidentes: gravedad o peso de los mismos, número, y distancia a los posibles puertos o aeropuertos receptores de medios específicos de salvamento y por otro lado la capacidad o idoneidad de estos puertos o aeropuertos como accesos desde la mar, capacidad hospitalaria, accesos terrestres, infraestructura del puerto, etc.

Los accidentes los hemos dividido en cuatro grupos, asignándole a cada uno de ellos una valoración para establecer una jerarquía numérica de 5, 3, 2 y 1 puntos, respectivamente para los muy graves, los graves, los moderados y los leves. En términos de los modelos de gravedad, estamos asignando "peso" a los accidentes. El procedimiento de clasificación de los accidentes es un factor determinante.

Accidentes muy graves: Cuando ha habido fallecidos o desaparecidos, o rescate de diversas personas heridas o ilesas, de tal manera que si no se hubiese actuado externamente, el resultado habría sido de muerte para ellas. En estos accidentes hubo pérdida total o se produjo gran daño al buque o una muy importante contaminación.

Accidentes graves: Se denominan así cuando hay algún muerto o desaparecido, heridos o rescatados y daños importantes.

Moderados: Se han seleccionado como moderados aquellos accidentes que pueden constituir un cierto peligro para los tripulantes. Producen daños moderados al buque.

Leves: No constituyen un peligro razonable para los tripulantes. Son accidentes con pocos daños personales o materiales.

En el procedimiento de asignación de los medios (lanchas de salvamento, remolcadores y helicópteros principalmente) se ha tenido en cuenta la autonomía de los mismos, cabida, velocidad, calados, maniobrabilidad, medios técnicos y operatividad en diversas situaciones meteorológicas.

Para la elaboración del presente trabajo se ha dividido la zona de responsabilidad marítima asignada por los organismos internacionales en áreas geográficas de aproximadamente 10 por 10 millas. En el País Vasco se han establecido 17 áreas o zonas para el estudio de las lanchas de salvamento y 8 para remolcadores y helicópteros. Teniendo en cuenta todos los factores mencionados se ha elaborado una fórmula basada en los modelos de gravedad que establece la interrelación entre los accidentes y los puertos o aeropuertos de las inmediaciones que nos proporcionan unos coeficientes de acuerdo a la fórmula siguiente y apoyados en la base de datos de la que se ha hecho mención:

$$Coeff_{\text{puerto } X} = \left(\sum_{zona=1}^{n} \frac{P_{zona}}{d_{zona,\ puerto\ X}} \right) * Idoneidad_{\text{puerto } X}$$

El coeficiente es un valor numérico que establece una jerarquía de puerto o aeropuerto con relación a los accidentes. Depende del número de ellos, de su gravedad, de la distancia a la que se producen y de la idoneidad del puerto o aeropuerto. Por descontado que mediante el estudio de coeficientes entre diversas etapas se puede estudiar la evolución de los accidentes.

Si bien los coeficientes nos resuelven la resolución de las ubicaciones de medios, debemos tener en cuenta otros aspectos que nos permitirán situar dichos medios de manera adecuada a lo largo de la costa.

Los centros de equilibrio de trabajo son aquellos puntos de la costa que establecen las distancias que debe cubrir cada medio de salvamento y tienen como misión repartir el trabajo de manera adecuada, teniendo en cuenta la capacidad de cada medio. Y ¿cuáles son esas distancias? Para la costa vasco-cántabra con sus características geográficas, condiciones meteorológicas y volumen de tráfico las distancias serán: para lanchas de salvamento el radio máximo de actuación no debe sobrepasar las 25 millas, de 50 para remolcadores y 75 para helicópteros en línea recta.

En el presente trabajo se analizan los coeficientes en el País Vasco referentes a lanchas remolcadores y helicópteros que nos han de servir de guía para la correcta ubicación de los medios desde los aspectos autónomo e interregional.

CONCLUSIONES

6. Las lanchas en el País Vasco han de situarse en Pasajes y en Bilbao con una menor en un puerto intermedio. La de Bilbao asistirá el 20% de los servicios de Cantabria oriental.

7. En el País Vasco y visto interregionalmente debería haber un helicóptero que se situaría en Bilbao con características parecidas a los "Pesca gallegos" para que la cobertura aérea del Cantábrico oriental fuese mejor. Su cobertura sería la marítima pero podría cubrir casos muy específicos en tierra.

8. Los dos puertos vascos con tráfico mercante deben contar con servicio de remolcador de salvamento. La política de habilitar remolcadores privados en puertos importantes por parte de los responsables marítimos para el servicio de salvamento es acertada.

9. La variación de los coeficientes es válida para establecer la evolución de los accidentes.