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Lifeguard assistance at Spanish Mediterranean beaches: Jellyfish prevail and proposals for improving risk management

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ABSTRACT

Although beaches can be hazardous environments, few studies have identified injuries in broad coastal areas. We performed a retrospective descriptive study of injuries and other services provided by lifeguards during 2012 along the Spanish Mediterranean beaches. The trend in jellyfish stings was also examined for the period 2008-2012 using a standardised *Sting Index*.

Obtaining data relied on voluntary cooperation of local authorities, resulting in data provided from 183 cities out of 234 present in the study area and 760 beach lifeguard stations (LGS) out of about 1200. Lifeguard stations provided an average of 89 days of service per year, from late June to the beginning of September. A total of 176,021 injuries were reported, of which *jellyfish stings* were the main need for assistance with 59.7% (n=116,887) of the injuries and 257.0/LGS, followed by *wounds* (14.4%, 50.9/LGS), and *sunburn* (3.3%, 15.8/LGS). Apart from attending injuries, beach lifeguard services provided 21,174 other services such as *help to disabled people* (57.9/LGS), *blood pressure measurements* (12.7/LGS), *rescues at sea* (6.5/LGS), *lost* *children* (5.7/LGS), and *transfers to the hospital* (4.6/LGS). Official reported fatalities for all the beaches in 2012 were 24.

We proposed a *Sting Index* (*SI*) to allow comparisons of the incidence of stings between years and/or localities by standardising jellyfish stings by the total of all injuries. Historical data were consistent enough to calculate *SI* between 2010 and 2012 and showed an oscillating pattern without a clear trend (2008: 2.4, 2009: 1.3, 2010: 2.4, 2011: 2.0, 2012: 2.6). Estimation of total number of *jellyfish stings* for all the beaches present in the area would reach 184,558 for 2012.

There were very few fatalities in comparison with other coastal regions, probably due to the combination of a calm sea, a low number of high dangerous situations, and a high percentage of lifeguarded beaches during the bathing season. Nevertheless, although Spanish Mediterranean beaches could be described as low risk, we propose measures to facilitate a precautionary management to prevent injuries based on a real-time beach assistance database of injuries to identify high-incidence assistance categories.

Keywords: Beach lifeguard, public health, jellyfish stings, coastal risks.

INTRODUCTION

Tourist beaches can be hazardous environments, where beachgoers are exposed to different risks when swimming, snorkelling, playing sports, walking, sunbathing or relaxing. Characteristics of risks depend on substrate type, such as sand, pebbles or rocky shore, the presence of cliffs, variable weather conditions including winds, rip currents, and surf intensity (Abraldes and Perez-Gomez, 2009; Heggie, 2013), as well as presence of harmful organisms such as spiny fish, sea urchins, and jellyfish (Taylor et al., 2002; Walsh et al., 2011). In addition, people usually do not know about hazardous animals or risky behaviours and may have not good swimming skills. Furthermore, sunbathing without proper protection could be a cause of fainting, heatstroke or sunburn (de Vries and Coebergh, 2004), even among lifeguards (Hiemstra et al., 2012).

Beaches are one of the most important tourist resources in Spain, therefore all main bathing beaches along the Spanish Mediterranean are served during the bathing season (at least July and August) by lifeguard stations, which depend on municipalities. Unfortunately, in the Spanish Mediterranean, there is no comprehensive database compiling data on injuries attended by beach lifeguard stations and no official data are published. Grey literature such as news or web reports from municipalities or subcontracted companies such as Red Cross or private companies only offer gross numbers of beach injuries and assistances, usually coping with a few lifeguard stations. We have not found any other published study in the Mediterranean that analysed beach lifeguard assistances on a broad spatial scale.

There are some papers about beach injuries and lifeguard services in other seas. For example, on a beach in New Zealand, stings (including jellyfish) accounted for 16% of all injuries, laceration/abrasion represented 47%, bruising 12%, feeling unwell 5%, and sunburn was only 0.1% of all injuries (Moran and Webber, 2014). In Victoria (Australia), a study analysed injuries caused by marine animals, which were mainly due to fish (40%), stingrays (22%), and jellyfish (20%) (Taylor et al., 2002).

Jellyfish stings are a common hazard in bathing waters around the world. The most dangerous jellyfish species are distributed mainly in tropical and subtropical waters. For example, in Australia, *Chinorex fleckeri* (Fenner, 1998; O'Reilly et al., 2001) and irukandji box jellyfish (Gershwin, 2006a; Gershwin et al., 2013), and *Physalia* sp. (Tibballs, 2006)are responsible for many serious effects on patients' health. Other species such as *Chiropsalmus* sp. may cause severe symptoms but no deaths have been reported (Bailey et al., 2005). For Australian waters, irukandji jellyfish are responsible for one fatality each 3-4 years, similar to shark attacks (Fenner and Williamson, 1996; Williamson et al., 1996), although the actual death toll is likely to be higher (Gershwin et al., 2013).

In the Mediterranean Sea, jellyfish species are not as dangerous as in tropical waters, but there are relatively high densities of jellyfish of different species with low to medium toxicity (Bordehore et al., 2015; Mariottini and Pane, 2010; Mariottini et al., 2008). However, the highly toxic *Physalia physalis* appears occasionally, being responsible in 2010 for the first known fatality caused by a jellyfish sting on the Mediterranean island of Sardinia (Boero, 2013).

Some studies have been published on the epidemiology of jellyfish stings, for example, for the Salento Peninsula, southern Italy (De Donno et al., 2014, 2009) and for the

Central and Eastern Mediterranean (Mariottini et al., 2008). Purcell et al. (2007) listed some papers reporting stinging episodes for the Mediterranean, totalling more than 61,000 people stung by *Pelagia noctiluca*.

While major incidents such as drowning generally have been well reported in the scientific literature (Morgan et al., 2008), relatively little is known about the nature and extent of less serious injuries incurred at beaches (Moran and Webber, 2014). Despite the numerous beach lifeguard stations, large public budget and the tens of thousands of people assisted, we found no previous quantitative studies about lifeguard assistances in the Mediterranean on a broad spatial scale. The aim of this study was to analyse the nature of injuries from lifeguard-recorded data for the Spanish Mediterranean beaches for 2012 and to study any trend in jellyfish stings from the earliest summer available until 2012 using a *Sting Index*. We also propose measures to facilitate a precautionary management and reduce injuries based on a real-time beach assistance database of injuries to identify high incidence assistance categories.

MATERIAL AND METHODS

The study was a retrospective, descriptive analysis of data obtained from local first-aid beach services in the Spanish Mediterranean, including the Balearic Islands. The northern and southern limits were the borders with France and Portugal, respectively, and totalled 3864 km (INE, 2014), although beaches accessible to visitors totalled 1270 km (MAGRAMA, 2016) (Figure 1).

Figure 1. Study area along the Spanish Mediterranean coast (dashed line).

Data acquisition

Under the current Spanish legal framework, first-aid services at beaches depend on cities according to article 115.d of the Coast Law 22/1988 (López, 2003). It is mandatory for municipalities to provide a lifeguard service at their beaches, at least during the bathing season and for the most relevant beaches. There is no national, regional, or local database gathering beach lifeguard data. To request them, we first telephoned the responsible department of each coastal city in September 2012. Subsequently, we emailed the person in charge at each city council, attaching a message from the project partners and an official letter of support from the responsible national administration, the Directorate General for Coast and Sea Sustainability of the Ministry of Agriculture, Food and Environment (MAGRAMA). The cities that did not respond in about a month were emailed and telephoned again; we continued such data requests until December 2013.

Responses were classified in four categories according their quality as follows: *good data* that contained information about jellyfish stings separated from the other marine animal stings and adequate information about the other main injury categories; *incomplete data* due to a lack of proper jellyfish sting data; *incomplete data* due to a partial or total lack of categories other than jellyfish; *no data*.

Jellyfish stings trend in the studied area

We also explored the temporal trend in jellyfish stings, but there was a handicap comparing years or areas due to the different numbers of beaches providing data each year. For that reason and because no data on the number of beachgoers were available, we standardised the numbers of stings by a number we believed to be proportional to the number of beachgoers, specifically, the sum of injuries other than jellyfish stings and other marine animal stings (drowning symptoms, cardiopulmonary resuscitation, seizures and respiratory failure, total musculoskeletal injuries, eye problems, inner ear problems, total sun-related problems, allergies, dizziness, pain, and general ill feeling, see Table 1). Then we calculated a *Sting Index* by dividing the total number of jellyfish stings by the sum of those density-dependent injuries.

RESULTS

For 2012, we obtained data from 183 cities, which had 760 lifeguard stations from the existing 234 municipalities and about 1200 lifeguard stations in the study area. Of these 183 cities, 72 provided *good data*, 44 provided *incomplete data* lacking proper jellyfish sting data, and 68 cities provided *incomplete data* lacking assistance categories other than jellyfish. The remaining 51 cities did not answer our inquiries. In Appendix I, a Google Earth file (.kmz) shows the spatial distribution and quality of data available and the number of lifeguard stations in each municipality. In Appendix II, a Google Earth file (.kmz) shows the 72 municipalities that provided *good data* for 2012.

Service duration

We received information about the duration of lifeguard services from 61 cities. Service days were between 62 and 74 for 22% of cities, from 75 to 99 for 60%, up to 100 for

12%, and more than 100 days for 4%. The minimum number of service days was 62, corresponding to the months of July and August, and the maximum number of service days were 170 and 130 for two cites and one city with 365. The days of service per year averaged 89. For those cities with less than 100 days per year, the start of the service season varied between 1 May (4%), 1 June (13%), 15 June (39%), 30 June and 1 July (44%). The end of the service was 31 August (10%), 1 September (12%), 15 September (65%), and 30 September (13%).

Assistances by category

The number of categories into which lifeguard services were grouped showed great variation among cities. Table 1 shows the numbers of cities and lifeguard stations using each category in their reports, as well as the total number of assistances within each category and the mean number of assistances per lifeguard station.

A total of 176,021 injuries were reported from 760 lifeguard stations, corresponding to 183 cities. In the group of sea life-related injuries, *jellyfish stings* was the most numerous injury with an average of 257.0/LGS, totalling 116,887 records, of which 94,453 were reported as *jellyfish stings* (193.9/LGS) and 22,434 were reported as *other marine animal stings* (63.0/LGS). This last category was actually a euphemistic way to refer to *jellyfish stings*, as disclosed by the majority of the consulted lifeguard services that used this undefined category, although it is plausible that a small percentage of stings could be attributed to an unknown stinger.

In the medical emergency group, *drowning symptoms* averaged 0.5/LGS, *cardiopulmonary resuscitation* 0.2/LGS, and *seizures and respiratory failure* 0.3/LGS. The musculoskeletal group of injures averaged 50.9/LGS for *wounds*, 4.5/LGS for *bruises*, 1.9 for *luxation*, and 1.1/LGS for *bone fractures*. Injuries related to *insects* averaged 10.0/LGS, *eye problems* 4.5/LGS, and *inner ear problems* 2.1/LGS. Sun related conditions ranged from 15.8/LGS for *sunburn* to 2.4/LGS for *fainting and heat exhaustion*. The incidences of *allergies* reached 10.6/LGS, *dizziness, pain, general ill feeling* 2.7/LGS, and *other causes* 28.5/LGS.

Activities carried out by lifeguards other than from injuries accounted for 21,174, with *help to disabled people* being the main reason for assistance (57.9/LGS), followed by *blood pressure measurement* (12.7/LGS), *rescues at sea* (6.5/LGS), *lost children* (5.7/LGS), and *transfers to the hospital* (4.6/LGS).

	Total injuries		**Cities with this category**		**Lifeguard Stations**		**Injuries /Life Guard Station**	
	176,021	**%**	**N**	**%**	**N**	**%**	**N/LGS**	**%/LGS**
Jellyfish	94,453	53.7	78	42.6	487	64.1	193.9	47.0
Other marine animal sting[1]	22,434	12.7	46	25.1	356	46.8	63.0	15.3
Sea urchin spine	1,197	0.7	27	14.8	235	30.9	5.1	1.2
Weever fish and related	1,980	1.1	18	9.8	136	17.9	14.6	3.5
Total sea life-related injures	**120,064**	**68.2**					**Σ276.6**	**67.0**
Drowning symptoms	194	0.1	59	32.2	370	48.7	0.5	0.1
Cardiopulmonary resuscitation	18	0.01	12	6.6	100[5]	13.2	0.2[5]	0.04
Seizures and respiratory failure	32	0.02	11	6.0	114[5]	15.0	0.3[5]	0.1
Deaths[3]	7 (24)	0.004	6	3.3	1200[6]	100[6]	0.02[6]	0.005
Total medical emergency[2]	**251**	**0.2**					**Σ 1.0**	**0.2**
Wounds	25,329	14.4	81	44.3	498	65.5	50.9	12.3
Luxation	478	0.3	33	10.0	246	32.4	1.9	0.5
Bruise	2,142	1.2	77	42.1	484	63.7	4.5	1.1
Bone fracture	252	0.1	40	21.9	225	29.6	1.1	0.3
Total musculoskeletal[2]	**28,201**	**16.0**					**Σ 58.4**	**14.1**
Insects (terrestrial)	2,913	1.7	41	22.4	290	38.2	10.0	2.4
Eye problems[2]	682	0.4	24	13.1	151	19.9	4.5	1.1
Inner ear problems[2]	66	0.04	6	3.3	32[5]	4.2	2.1[5]	0.5
Fainting and heat exhaustion/stroke	739	0.4	56	30.6	309	40.7	2.4	0.6
Heat stroke[4]	13	0.01	18	9.8	61[5]	8.0	0.2[5]	0.1
Sunburn	5,810	3.3	65	35.5	368	48.4	15.8	3.8
Total sun-related[2]	**6,562**	**3.7**					**Σ 18.4**	**4.5**
Allergies[2]	3,927	2.2	39	21.3	370	48.7	10.6	2.6
Dizziness, pain, general ill feeling[2]	432	0.2	22	12.0	163	21.4	2.7	0.6
Other causes	12,923	7.3	65	35.5	453	59.6	28.5	6.9
		100.0					**Σ 412.8**	**100.0**

	Total activities		**Cities with this category**		**Lifeguard Stations**		**Activities/Life Guard Station**	
	21,174	**%**	**N**	**%**	**N**	**%**	**N/LGS**	**%/LGS**
Help to the disabled people	14,353	68.3	44	24.0	248	32.6	57.9	65.1
Blood pressure measurement	481	2.3	8	4.4	38[5]	5.0	12.7[5]	14.2
Rescues at sea	2,670	12.7	70	38.3	410	53.9	6.5	7.3
Lost children	1,755	8.3	41	22.4	308	40.5	5.7	6.4
Transfer to the hospital	1,440	6.8	55	30.1	312	41.1	4.6	5.2
Other consultations	324	1.5	31	16.9	216	28.4	1.5	1.7
		100.0					**Σ88.9**	**100.0**

Table 1. Assistances from 760 lifeguard stations (LGS) corresponding to 183 cities from the Spanish Mediterranean in 2012. Data are separated by *Injuries* and other *Activities*. **1**: actually jellyfish stings, some municipalities used this euphemistic term to refer to jellyfish stings. **2**: denominator in the *Sting Index* (except *deaths*), categories considered proportional to the total numbers of beachgoers. **3:** 7 deaths were reported by lifeguard stations; however, 24 was the official number in 2012. **4**: this classification

should be taken cautiously because lifeguard medical information could not diagnose this severe condition adequately. [5]: means for these categories should be taken cautiously because few lifeguard stations used them. [6]: mean calculated from the total number of fatalities using official data (24) and all the LGS present in the studied area.

Jellyfish stings over time

We could gather good data (complete records of *jellyfish stings* and non-sting assistances) from a subset of municipalities for the period 2008 to 2012 (Table 2). Although we obtained data from some municipalities for the previous period 2005-2009, we could not use them to calculate the *SI* because few cities contributed data (<5). The *Sting Index* oscillated between 1.3 and 3.2 in the period 2008 to 2012, showing fluctuations with no overall trend (Fig. 2 and Table 2).

Table 2. Jellyfish sting injuries, non-sting injuries, numbers of contributing cities and *Sting Index* for years 2008 to 2012.

Year	**2008**	**2009**	**2010**	**2011**	**2012**
Jellyfish stings	13,378	18,085	50,753	55,679	89,245
Non-Stings	5,532	13,803	21,231	27,646	34,619
Sting Index	***2.4***	***1.3***	***2.4***	***2.0***	***2.6***
Number of cities	18	29	44	50	72

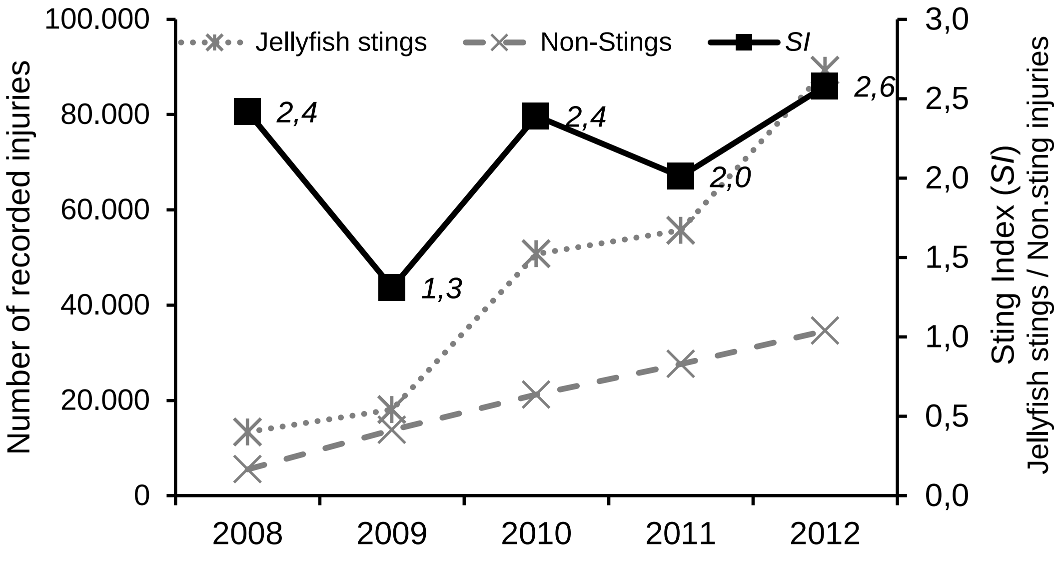

Figure 2. Changes by year in the numbers of recorded cases of *Jellyfish* S*tings*, non-sting assistances and the *Sting Index* (calculated by dividing *Jellyfish Stings* by non-sting assistances). Non-sting assistances were considered those proportional to beachgoers: *total medical emergency*, *total musculoskeletal*, *eye and inner ear problems*, *total sun related*, *allergies*, and *dizziness* (see Table 1).

For year 2012, we calculated the *SI* for the 72 municipalities with good data, which averaged 2.6 (Table 3). Most cities (51.4%) had a low *SI* (<2.6), 31.9% had an intermediate *SI* (2.6-10), and 16.7% had a very high *SI* (>10).

Table 3. *Sting Index* calculated for 72 municipalities with good data for year 2012. Mean *SI* for 2012 was 2.6.

Sting Index	$SI \leq 1$	$1 < SI \leq 2.6$	$2.6 < SI \leq 5$	$5 < SI \leq 10$	$10 < SI \leq 15$	$15 < SI \leq 20$	$SI > 20$
	26.4%	25.0%	12.5%	19.4%	9.7%	1.4%	5.6%

DISCUSSION

Jellyfish

Jellyfish stings were the most numerous injury (mean of 257.0/LGS, 62.3% of injuries/LGS), with almost five times the number of the second category (*wounds* 50.9/LGS, 12.3% of injuries/LGS). Summing the *sea-related injuries*, they reached 276.6/LGS, 67.0% of injuries/LGS. These percentages were slightly smaller than those recorded in other Mediterranean beaches. For example, in Malta a total of 3149 injuries were recorded at 6 beaches and *jellyfish stings* accounted for 349.2/LGS and 67% of beach injuries and *other stings*, 76.7/LGS at 15% in 2012 (A. Deidun pers. comm.).

Jellyfish stings accounted for 116,887 stings at 760 LGS of about 1200 present in the studied area. If we extrapolate to all of the LGS, *jellyfish stings* would reach 184,558 for the entire Spanish Mediterranean coast. A previous estimate of stings for the Spanish Mediterranean coast was much below ours (Boero, 2013). In other seas, published numbers were lower; for example, in a New Zealand beach for the period 2007-2012, jellyfish stings (n=1376) accounted 16% of all injuries (Moran and Webber, 2014) and other beach marine-life injuries accounted only for 20.5% (Taylor et al., 2002). In Australia, more than 10,000 jellyfish stings occurred annually (Fenner and Williamson, 1996), with only one fatality every 3 to 4 years due to Irukandji species, which are reported to sting about 60 people each year (Gershwin et al., 2013).

The actual incidence of jellyfish stings is likely to be higher than we reported here for several reasons. First, not all the people stung go to the lifeguard station at the beach. Second, a percentage of beaches with lower public use are not covered by first-aid services. Finally, some of the affected people go directly to a medical centre or hospital, mainly when systemic effects arise. Although this study did not obtain sting data from hospitals and medical centres, we learned that there is no specific category of assistance for jellyfish stings at health centres; therefore, we suggest creating a specific category including species identification, if known. For example, code X26 in the Catalonia Health Services included injuries by jellyfish, anemones, coral, sea urchins, and holothurians, so it is not possible to target jellyfish stings or their associated symptoms.

According to our calculations using the *Sting Index*, the incidence of jellyfish stings oscillated between 1.3 and 3.2 for years 2008 to 2012 (Figure 2, Table 2). This result should be interpreted cautiously because the sting numbers were not standardised against the actual numbers of beachgoers, but against the sum of non-sting injuries. Nevertheless, we believe the *Sting Index* provides a semi-quantitative approach to assess the temporal dynamics of jellyfish stings and jellyfish populations, assuming that the stings reflect jellyfish abundance. There was a wide range of the *SI* for single municipalities (Table 3), indicating that those with a high sting incidence should be monitored in order to determine whether there are large populations of jellyfish, the causes, and possible solutions.

The overall *SI* for the study area showed oscillations without any clear pattern, thus not confirming the studies in the Mediterranean that reported an increase in jellyfish abundance (Boero, 2013; Brotz and Pauly, 2012). Nonetheless, we detected some municipalities with a clear positive trend in *SI* in 2010-2012 that could show a local increase in jellyfish populations. In the future, if a comprehensive and mandatory system of recording assistances is implemented so all the 1200 LGS provide data, the *SI* would gain accuracy as a proxy for jellyfish abundance.

Jellyfish in bathing areas constitute a public health concern because of the negative effects on human health such as toxicity or allergies (Burnett, 2001; Fenner, 1998; Mariottini and Pane, 2010). The stings of Mediterranean jellyfish have been described as “modest” for human health, but some species can generate serious effects in cases of hypersensitivity (reviewed in Mariottini and Pane, 2010). As an example, in the Mediterranean, some unusual cases of severe and systemic effects were reported associated with *Physalia physalis* (in Mariottini and Pane, 2010), the cubozoan *Carybdea marsupialis* (in Bordehore et al., 2015), *Pelagia noctiluca* (in Mariottini et al., 2008), and the lessepsian jellyfish *Rhopilema nomadica* (in Silfen et al., 2003; Uri et al., 2005). Thus, although the risk is not great in terms of severe events or fatalities, stings constitute a health hazard that should be minimized using a preventive approach from lifeguard managers. Study of the causes of high-sting-incidence areas and how to address them should be promoted. Surprisingly, although jellyfish stings were the main source of injuries at beaches, some lifeguard services used *other marine animal sting* to record actual jellyfish stings, as if trying to conceal those injuries. Although *jellyfish stings* have high relevance at beaches as reported here, they were not even mentioned in a list of eleven beach concerns in Catalonia (NE Spanish coast) (Ariza et al., 2012), probably due to a lack of public knowledge of the actual numbers of each type of injury.

Sting mitigation effort

The number of people stung could be significantly reduced by adopting preventive measures coordinated by managers and used by swimmers, as done in other places such as Australia with great success (Gershwin, 2006b; Gershwin et al., 2010). Efforts should focus on raising awareness about the most dangerous species in the area, how to behave when swimming and swarms of jellyfish are seen. Information at the beach should be provided about the presence of jellyfish, for example using jellyfish-warning flags, in combination with the standard colour code for denoting sea roughness (green/yellow/red flags), in order to warn swimmers and minimize contact. We found some lifeguard services that already inform swimmers about jellyfish presence using the jellyfish-warning flags and even temporarily close the beach when the risk of stinging was high and the species present was of medium to high toxicity (mainly *P. noctiluca*); however, at others, no preventive measure was taken in order to warn swimmers.

Furthermore, stung people should be informed at lifeguard points to visit a doctor if symptoms other than skin irritation appear. Those cases would benefit from clinical monitoring of health effects and proper treatment and also would allow epidemiologic studies, which now are under-represented in the literature (Cegolon et al., 2013). Systemic health effects can appear after being stung, depending on species toxicity and patient sensitivity, as with a patient that required treatment for systemic effects from a *Carybdea marsupials* sting, a Mediterranean box jellyfish (Bordehore et al., 2015) that was previously considered not to be dangerous (Kokelj et al., 1992; Peca et al., 1997). It is remarkable that up to a 4% of Mediterranean jellyfish stings could led to symptoms other than skin irritation (De Donno et al., 2009) and even acute allergic reactions that require medical attention (Karatzanis et al., 2009).

Correct identification of the jellyfish species by first-aid services at the beach is also necessary in order to associate the symptoms with the jellyfish species and determine the correct treatment. For example, ammonia, which is used to deactivate cnidocysts of scyphozoans, has the opposite effect on cubozoan cnidocysts, on which vinegar should be used instead (Cegolon et al., 2013). Species identification would also facilitate further analysis of the abundance and temporal trends of each species. In addition to victim's age and gender, the body area stung should be recorded, as already is done by some beach managers (Taylor et al., 2002) to evaluate the effectiveness of protective clothing.

Prediction based on observations of adults (e.g. routine monitoring of jellyfish abundance by lifeguards) would be useful for identifying days or areas with high jellyfish densities (Gershwin et al., 2010). Finally, a sting risk audit at a beach scale, comparing the *Sting Index* over time and among beaches at a regional scale would detect hot spots or rising trends that would indicate study and mitigation efforts in those areas, which could have negative economic and social impacts as quantified for the E Mediterranean (Ghermandi et al., 2015).

Other categories

The numbers of the remaining categories should be taken cautiously when used by few LGS (Table 1), as for example for *weever fish, cardiopulmonary resuscitation, seizures* *and respiratory failure, inner ear problems, eye problems or heat stroke*, that were used by less than 20% of LGS studied. *Wounds* was the main cause of injury after jellyfish, with 50.9/LGS; however, 12.3%, is low when compared with other seas with more swell and rip currents where *wounds* can be the main cause of assistance (e.g. Hawaii, Harada et al., 2011). *Sunburn*, although accounting for only 3.3% of assistances, should be taken seriously, especially in children, because of the direct relationship with melanoma (Cust et al., 2011). *Sunburn* can be easily prevented by avoiding exposure at midday hours, using high sun-protection-factor creams, hats, and clothes. Water biological quality, which could be correlated with *eye* and *inner ear problems*, accounted only for 1.1% and 0.5% of assistances/LGS, respectively, reflecting a good water quality due to an effective sewage treatment under the European environment policy (EEA, 2014). It is remarkable that the category of *Other causes* totalled 12,923 (6.9%/LGS), a relatively high number for unspecified services that could reflect a misclassification of injuries. Thus, efforts should be made to improve the reporting of activities using standardized categories.

Of activities other than injuries, *rescues at sea* totalled 2670 and averaged 6.5/LGS, which is a low number compared with other studies at beaches with bigger surf and rip currents. For example, Oahu island in Hawaii averaged 1140 rescues per year, approximately 9.2 rescues per 10,000 bathers (Harada et al., 2011).

Lifeguard services at the beaches that provided data reported only 7 deaths in summer 2012; however, official published data from the Spanish Ministry of Health registered 24 deaths for all beaches in 2012 for the same area. Nevertheless, the Spanish beaches seem to be safer than others in the Mediterranean and some other seas. In Israel for example, Hartmann (2006) reported 8.1 deaths per million inhabitants, higher than for the Spanish Mediterranean coasts, which would yield about 0.4 deaths per million using the coastal population (23.7 million) plus foreign tourists (38.3 million) for the studied regions (Catalonia, Valencian Community, Balearic Islands, Murcia Region and Andalucia) for 2012 (INE, 2014). In other seas, drownings in Brazil, which mainly were attributed to rip currents, were quantified at about 7500 per year and defined as catastrophic (Klein et al., 2003).

Among activities that lifeguards carried out, *help to disabled* people was the main reason for assistance (57.9/LGS), showing a high effort in services for the handicapped at Spanish beaches.

Lost children (5.7/LGS) seems to be a common problem at beaches related to a lack of appropriate close supervision from parents or caregivers, together with overconfidence in the child's skills in orientation or swimming (Moran, 2009). This could cause an increase of dangerous situations, especially those at sea such as drowning. Thus, it is important to remind adults to adequately supervise children.

Counting beachgoers

Studies on the prevalence of injuries at beaches should take into account the number of people at the beach to facilitate quantitative calculations (e.g. injuries/1,000 beachgoers). For example, Harada et al. (2011) used the estimate of beachgoers made by the lifeguards three times a day to give a ratio of 9.2 rescues per 10,000 bathers, a rate that increased by 29% over a 5-year period. That kind of analysis would not be possible without the actual numbers of beachgoers. Beachgoers were not counted in the Spanish beaches, so we lacked any direct data about the numbers of beachgoers in our study area. To circumvent that handicap for a quantitative approach to management, we proposed a *Sting Index* to standardise the number of jellyfish stings; nevertheless an optimal management scenario would require the actual number of beachgoers. We propose that lifeguard services should estimate the numbers of beachgoers, establishing a consistent methodology for all the Spanish beaches. The method should be designed with the stakeholders' consensus and take into account previous papers that show the importance of methodology in obtaining accurate data (Dwight et al., 2007; King and McGregor, 2012). Thereafter, developing recommendations for effective management would be straightforward, for example, comparing the prevalence of certain injuries, health problems or lifeguard services among beaches and within a beach among years.

Study limitations and recommendations for data acquisition

Our study had some limitations due to its retrospective approach, as have other studies based on this methodology (Forrester, 2006; Yoshimoto and Yanagihara, 2002). The primary limitation was the source of the data, although we got a good collaboration

(78% of municipalities and 63% of LGS), not all the lifeguard services used the same categories (Table 1). Specifically, the *other causes* category, with more than 12,000 cases, would hide classifiable injuries and misclassification of jellyfish stings in the category of *other marine animal stings*. Although the main categories of attendance were present in most lifeguard services, we consider that a standardisation of the list of lifeguard categories is necessary to permit a more robust analysis. A joint effort should be required by lifeguard services and the responsible administrations (local, regional, and national) to standardize reporting files and thus facilitate beach risk monitoring. Other limitations of the study were due to the fact that not all the injured people go to a lifeguard station or go directly to a hospital or health centre. To our knowledge, injured beachgoers in a lifeguarded beach look for first aid at the beach and then, if necessary, go to a health centre on their own or are transferred by lifeguard ambulance to hospital, as reflected in the category *Transfer to the hospital* with 1,440 services (Table 1). Moreover, although not all the beaches have first aid services, all of the most-frequented beaches within each municipality along the Spanish Mediterranean are lifeguarded at least from mid-June to mid-September, covering most of the bathing season.

The lack of a central or regional archive with beach lifeguard assistance data makes the task of obtaining them from each city time consuming and laborious. Cities that did not answer our requests (50 out of 234) stated that no historical data were available for various reasons: changes in the company in charge of the lifeguard service, lost records, no knowledge of where those data were, no one responsible for archiving or analysing those data, or no interest in participating in the project.

As an action of the LIFE Cubomed project (www.cubomed.eu) and with the support of the Ministry responsible for the environment, we are developing a participatory process among all stakeholders to define the categories of activities and injuries that should be used and other useful data for beach risk management, such as counting beachgoers (Harada et al., 2011). More information is recommended to denote the presence of jellyfish and their identification and to gather personal data for sting patients (e.g. gender, age, etc.) and the main characteristics of their injuries (limb, severity scale, etc.).

To solve limitations of data compatibility and facilitate data gathering by municipalities and their analysis, we are designing an online database for real-time collection of all information generated at the lifeguard stations. This monitoring would offer a powerful tool for beach managers to minimise risks, such as instantaneously and automatically activating warnings when, for example, jellyfish are present or stings exceed a threshold. Analysis of assistance data on a daily basis would provide public managers with a valuable tool to identify priorities in order to reduce injuries and other incidents occurring at beaches.

In conclusion, this study shows the high number of lifeguarded beaches in the Spanish Mediterranean, with approximately 1,200 LGS, reflecting that safety is a priority for local authorities. Beach tourism represents an important percentage of the economic activity in Spain, where tourism accounts for nearly 11% of the gross domestic product. Nevertheless, reducing risks at beaches not only needs a good lifeguard service and budget, but also reliable data to allow a continuous improvement of the service. To our knowledge, no other large scale study of this kind has ever been done for Mediterranean beaches. Our data showed that Spanish Mediterranean beaches are safe with very low fatalities compared to other beaches in the world. But going further to implement a precautionary management, injury quantification and analysis would improve definition of safety priorities and attain an even higher visitor safety.

APPENDIX I

A Google Earth .kmz file can be downloaded in Appendix I where all the coastal cities are marked, showing data quality for 2012 with the following key: Good data; Incomplete data due to a lack of proper jellyfish sting data; Incomplete data due to a partial or total lack of categories other than jellyfish; No data at all. Next to locality, in brackets, we show the years for which data were available and the number of lifeguard stations within each municipality.

APPENDIX II

A Google Earth .kmz file can be downloaded in Appendix II. It shows the 72 municipalities used for calculations of *Sting Index* in Table 3.

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