

Analysis of the vulnerability of tourism and leisure to jellyfish swarms on the eastern Costa del Sol. A multiscale and multi-temporal perspective

Análisis de la vulnerabilidad del turismo y el ocio ante enjambres de medusas en la Costa del Sol oriental. Una perspectiva multiescalar y multitemporal

Francisco José Cantarero-Prados

fjcantarero@uma.es  0000-0002-4811-8724

Ana de la Fuente-Roselló

anadelafuente@uma.es  0000-0003-4337-9439

Sergio Jesús Reyes-Corredera

sergioreyes@uma.es  0000-0002-2760-6489

*Departamento de Geografía. Universidad de Málaga.
Campus de Teatinos s/n. 29071 Málaga, España*

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ABSTRACT

A methodological essay is presented to assess vulnerability of beaches' human activity caused by jellyfish blooms arrivals. The pilot study area are the beaches of Torre del Mar and Caleta de Vélez (Velez-Málaga, Spain). The methodology proposes various criteria to assess the vulnerability of the tourism sector at various levels of scale, both in spatial and temporal dimensions. There are three spatial levels: scale of detail (the beach itself), socioeconomic influence area and municipal scale. On the other hand, the short and long-term consequences are estimated at a temporary level. Fundamentally, user surveys, interviews with economic actors in the area and analysis of statistical records are used. In general, it is observed that part of the economic activity related to the beaches improves in the short term with the presence of jellyfish while in the long term it suffers.

RESUMEN

Se expone una metodología que permite determinar la vulnerabilidad de la actividad humana en las playas causada por la llegada de medusas. La zona piloto de análisis se corresponde con el área costera de Vélez Málaga (Málaga), en las playas de Torre del Mar y Caleta de Vélez. La metodología propone diversos criterios para evaluar la vulnerabilidad del sector turístico a diferentes niveles de escala, tanto en la dimensión espacial como en la temporal. A nivel espacial se plantean tres: escala de detalle (la propia playa), área de influencia socioeconómica y escala municipal. Por su parte, a nivel temporal se estiman las consecuencias a corto y largo plazo. En su realización, se utilizan fundamentalmente encuestas a usuarios, entrevistas a actores económicos de la zona y análisis de registros estadísticos. A nivel general se observa que parte de la actividad económica relacionada con la playa mejora en el corto plazo con la presencia de medusas mientras que a largo plazo ésta se resiente.



1. INTRODUCTION

Jellyfish swarms have been reaching a good part of the coast of southern Spain for decades (Prieto & Navarro, 2013; Red de Información Ambiental de Andalucía (REDIAM), 2018; De la Fuente et al., 2021). Although strandings year frequency are not regular, touristic and leisure activity in those beaches are sometimes quite affected (Rubio & Gutiérrez, 2020). There was a pick in the summer of 2018, so quite part of beaches on the coast of the provinces of Malaga and Granada were affected. This fact has led to fear on the part of the local authorities and the tourist sector in this part of the southern Spanish coast. Moved by this concern, this work presents a methodology to measure vulnerability tourism and leisure in beaches that can be applied to Spanish beaches at several scales.

Jellyfish are gelatinous marine organisms of the zoological group Cnidaria (Boero, 2013). They generally have 8 months average lifespan (Spring et al., 2000), initially as polyps attached to the substrate and later developing into jellyfish. Their proliferation is not regular, sometimes generating “blooms” (Mills, 2001; Boero, 2013). *Pelagia Noctiluca* is the species that mainly experiences this type of phenomenon in the western Mediterranean (Canepa et al., 2014). As plankton, jellyfish are driven by marine currents (Mills, 2001, Doyle et al., 2007), sometimes reaching the coasts pushed by winds and tides (Gutierrez-Estrada et al., 2021). In general, most of the scientific literature on jellyfish in previous years has focused on biological aspects on their proliferation (Boero, 2013; Canepa et al., 2014; Goy et al., 1988; Prieto et al., 2015; Sabatés et al. 2010) or biophysical aspects, like the drifting of these blooms to the coasts (Bellido et al., 2020). However, there is a growing interest in research on the social and economic consequences of jellyfish strandings in recent years.

The main objective of this work is to design a methodology to assess the consequences of the arrival of jellyfish on tourist beaches at different scales. As jellyfish are seen as a threat, analysis has adopted the wellknown Disaster Risk Management schema, based on the *Ecuación General del Riesgo, made up of three factors: Hazard, Exposure and Vulnerability* (Olcina, 2002), so the focus here is the assessment on the vulnerability of the tourist and leisure activity in two pilot beaches. For this reason, the following specific objectives are presented:

- To subdivide the study area into five level of analysis: 3 spatial and 2 temporal.
- To characterise the degree of vulnerability of the considered pilot areas to jellyfish strandings. Indicators has been designed to do it.
- Apply the indicator-based methodology on the pilot beaches, displaying a survey and using some other standard data from official statistical offices.

The eleven thematic objectives approved by Regulation (EU) No. 1303/2013 has been adopted in the General Plan for Sustainable Tourism in Andalusia, Horizon 2020 (Junta de Andalucía, 2020). One of them is “Promote adaptation to climate change and risk prevention and management”. For this reason, the results derived from the application of the proposed methodology could be used to diagnosis and management measures for the jellyfish problem at a local or regional level

2. STATE OF ART

Tourism spaces managed within the framework of sustainability began to consider safety as a relevant element in their management about a decade ago (Global Sustainable Tourism Council (GSTC), 2013; Herrera & Rodríguez, 2016). This concern has now led to risks and safety occupying specific chapters in tourism planning (Instituto Hondureño de Turismo (IHT), 2011; Secretaría de Turismo de México, 2020; Junta de Andalucía, 2020, among others).

In coastal tourist areas, the new paradigm of the Sustainable Blue Economy (European Commission, 2021) is beginning to spread, which in the development of tourism in coastal regions must be linked to disaster risk control and hence in regions such as Andalusia, scientific production oriented towards risk control in coastal tourist areas is growing. Among others, in this region there are works that address issues such as the vulnerability of the tourism sector in coastal areas (Vallejo, 2020), sea level rise (Ojeda et al., 2011),



management of the COVID pandemic on beaches (Prieto & Díaz, 2021; Vallejo, 2020), problems related to undertow currents on beaches (González, 2020), among others. Also in this region, there is recent work on the impact of jellyfish on tourist activity. Rubio and Gutiérrez (2020) deal with the impact on the tourism sector, counting sightings and collecting information on the level of concern of potential beach users. De la Fuente et al. (2021), carry out an exhaustive study on the occurrence of jellyfish using data from the Infomedusa app (Aula del Mar, 2021). These data have also been processed by Gutierrez et al. (2021) with artificial intelligence to create a predictive model of jellyfish arrival.

Jellyfish phenology and their propagation cycles are one of the most studied elements in regions around the world (Lee et al., 2021; Cillari et al., 2022; Ottmann et al., 2021; Luskow et al., 2021; Yamaguchi et al., 2021 among others). Despite the perception of increased sightings, the global datasets used by Condon et al. (2013) do not allow him to claim that there is an increase in the recurrence of jellyfish swarms. It could be thought that global change and its consequences could be the cause, but several investigations have not been able to establish an absolutely direct relationship (Purcell, 2005, Purcell et al., 2007; Møller et al., 2010). Bellido et al. (2020) in some cases relate the appearance of jellyfish to the NAO (North Atlantic Oscillation) and the AO (Arctic Oscillation), however, despite this research and many others (Boero, 2013; Sabatés et al., 2010; Canepa et al. 2014; Prieto et al., 2015; among others) there is currently not enough capacity to predict with total certainty the degree of proliferation of jellyfish months or a year in advance. When these predictions are made, they are at a macro scale (Marchessaux et al., 2021) or only on blooming probability (Fernández-Alias et al., 2021). If they are at the local scale, they are usually valid for only 1 or 2 days (Gutierrez et al., 2021).

Regarding to the impact of jellyfish on humans, there are numerous papers that address the consequences of jellyfish stings (Bordehore et al., 2016; Killi & Mariottini, 2018, Chongyang et al. 2021, among others). In the social sciences, the impact of jellyfish on human activities is the subject of numerous investigations in fisheries (Conley & Sutherland, 2015; Tomlinson et al. 2018) and tourism. Specifically in the Mediterranean, tourism impacts have been studied in several regions such as the Gulf of Lions (Kontogianni & Emmanouilides, 2014), Catalonia (Nunes et al. 2015, Tomlinson et al. 2018) or Israel (Ghermandi et al. 2015), Morocco (Mghili et al., 2022). In addition, some other researches note jellyfish as an incipient fishery resource (Brotz et al., 2021).

3. MATERIAL AND METHODS

The pilot study area is located in the municipality of Vélez Málaga (Málaga), on the beaches of Torre del Mar and Caleta de Vélez (figure 1).

Both beaches are located in the Bight of Vélez-Málaga (Alboran Sea), very close to the contact zone of the Western and Eastern Alboran oceanic gyres (Bellido et al, 2020). These beaches receive a large number of users, both locals and tourists. The municipality has 1,332 hotel beds, 1,703 tourist apartments, and 5,647 housing for tourism purposes (Ministry of Tourism, Regeneration, Justice and Local Administration, 2022). summer 2018 was highly impacting due to jellyfish strandings. 94 sightings were registered in both beaches through the Infomedusa App (Aula del Mar, 2013).

The methodology to evaluate the vulnerability of the tourism sector to the recurrence of jellyfish on the beach that has been taken as an area of study will be developed at different levels of both temporal and spatial scale. On the one hand, the spatial dimension will consider the study of vulnerability at three scales:

- **Beach:** scale of detail. Consisting of the beach itself and the adjacent promenade.
- **Area of influence:** It extends from the beach to the nearby dependent tourist facilities, so it is its closest area of influence. Its delimitation is inspired by the basic criteria of Berry's (1971) *theory of market centers and the retail distribution of Berry*, which consider a variable extension to the central places based on criteria such as the density of establishments. therefore it is a "commercial" area of influence, that in this specific study area only reaches 3 streets parallel to the promenade where most hotels are located. Anyway, in other cases, its delimitation does not have a fixed extension but variable, that depends on elements such as the beach's own relevance power of attraction.
- **Municipal:** That of the municipality or supra-municipal area to which the beach belongs.



Figure 1. Location of the study area. Source: Own elaboration based on the World Ocean Reference included in ArcGIS by ESRI.

At a **temporal** level, two dimensions will be identified:

- **Short-term:** consider the possible immediate impact of the arrival of a jellyfish swarm.
- **Long-term:** to address future impacts in a hypothetical scenario of more frequent jellyfish blooms.

Concerning the different dimensions of vulnerability, the socio-economic dimension is mainly evaluated, which is addressed through interviews with local entrepreneurs and surveys of beach users.

The methodology, which is explained in detail below, has been applied to two of the beaches that form part of the Beach Guide produced by the Ministry of Agriculture and Fisheries, Food and Environment (MAPA-MA, 2019), specifically the so-called “Torre del Mar” and “Caleta de Vélez”, both located on the eastern Costa del Sol, in the municipality of Vélez Málaga (Málaga).

Given the two dimensions of analysis (temporal and spatial) and the scales considered within each of them, this methodological proposal will therefore potentially consider the following six combinations of spatial-temporal context to address the research:

- a) Short term detail (beach) analysis, i.e. what can happen on the beach on a day when jellyfishes appear.
- b) Analysis in the short-term area of influence, like the previous one, this part of the analysis focuses on knowing the consequences in the area of influence of the beach if jellyfish arrive at the adjacent beach on a specific day.

The area of influence is understood to be the space immediately adjacent to the beach under study. In urban areas, it usually corresponds to the neighborhood between the seafront and the road artery with greater range that runs parallel to it. In many cities, large roads usually delimit the neighborhoods. On the Costa del Sol, the national road 340 serves as a clear delimiter of what in this methodology are called “areas of influence”, which in this case are the neighborhoods between this road and the seafront. In the case of the periurban areas, or diffuse urbanization, this area corresponds to the urbanized area near the sandy area, which, if it is continuous, can be delimited by using again the road of greater range parallel to the coast. Finally, what we are trying to do is to zone the area that almost all the beaches have in their vicinity in which economic activities of services and hospitality are located, and which have a certain



relationship with the leisure or tourist experience sought in the nearby sandy area. These activities are typically: hotel and restaurant business, and other complementary activities.

- c) Analysis of the consequences at a municipal level in the short term, i.e. what repercussions the punctual arrival of jellyfish on a specific day may have at a municipal level. A priori, the treatment of the problem in this space-time context is the one that gives less play. The appearance of a swarm of jellyfish on a specific day in summer will probably mean more expenditure on municipal assistance services on the beaches or, most certainly, more water consumption in the showers installed for the use of bathers. However, in the overall context of municipal management, it can be considered, that these expenses or consequences are diffused in the overall amount of expenditure on services that a municipality may have over the course of a day. For this reason, despite considering this spatial-temporal context conceptually, the methodology of this work will not develop it.
- d) Analysis of the long-term consequences on the beach (spatial scale of detail). In this case, the main objective is to know the possible modifications in the future use of the beach in a hypothetical scenario of continuous summers of recurrent appearance of jellyfish on the beach under study.
- e) Analysis of the long-term consequences in the area of influence of the beach. In a similar way to the previous one, the analysis in this space-time context is oriented to estimate the possible changes in the frequentation and use of the existing economic activities in this part near the beach in the same scenario of recurrent visits of the jellyfish to this part of coast.
- f) Analysis of the long-term consequences in the municipality. The impact at this municipal level will focus on evaluating the vulnerability of the economic structure in the municipality and the purchasing power of its residents to move to alternative bathing areas located in other municipalities or, at least, in areas other than their nearest beach.

In analysing these six spatio-temporal contexts, two types of sources have been used. On the one hand, official economic statistics offered by official statistics institutes (in the case of Andalucía, the Andalusian Institute of Statistics and Cartography) and on the other hand, surveys and interviews performed through fieldwork. These sources have been used depending on the context, for the beach, its area of influence or both (table 1).

Table 1. Types of sources used according to the spatial-temporal context to be analyzed.

	Beach	Area of influence	Municipality
Short Term	a) Usage level: user surveys Economic activity: interviews with employers (hotel, restaurant, etc.)	b) Economic activity: interviews with employers (hotel, restaurant, etc.)	c) -
Long Term	d) User surveys	e) User surveys	f) Official statistics on economic activity

Source: Own elaboration.

The different methodological procedures for dealing with the analysis in these different spatial-temporal contexts are developed below. They have been structured in two large blocks according to the time scale (first in the short term and then in the long term):

3.1. Analysis of possible short-term consequences

The short-term analysis considers the immediate consequences of jellyfish emergence on a specific day, analysing their repercussions at the beach level on the one hand and at the level of their area of influence on the other hand¹.

¹ The sources for this part of the study are varied and are set out in Appendix I.



3.1.1. Short-term beach-scale analysis

The way to approach the study in this spatial-temporal context is based on the typical structure of studies aimed at reducing vulnerability against natural risk. Firstly, the exposure of both users and economic activities located in the vicinity of the beach is assessed, and secondly, the vulnerability of both.

- a) Total exposure. Through this, a first double Inventory of economic activities related to the beach located on the area or on the sea front (restaurants, bars, pedal boats, hammocks, street vendors, etc.) is made.
- b) Net exposure. These are the users who are directly affected by the presence of jellyfish on the beach, as they come to the beach with the intention of bathing, thus ignoring those users who come to the beach with other intentions.
- c) User Vulnerability. The level of affectation or level of vulnerability of the users has been segmented into three different components:
 - I. Degree of discomfort or dissatisfaction. The affliction suffered by users is firstly due to the dissatisfaction caused by having their access to the seawater limited by the presence of jellyfish. This component is used to measure this dissatisfaction.
 - II. Protection elements. As one of the pieces of the vulnerability, the analysis of the elements that provide protection to the beach user is also undertaken. Within this component, aspects such as the following are considered, among others:
 - Preventive information to allow users to manage their decisions
 - Elements to mitigate the physical consequences of jellyfish stings.
 - Physical protection as strategies for blocking or collecting jellyfish before they reach the shore.
 - Physical protection as strategies for blocking or collecting jellyfish before they reach the shore.
 - Existence of action protocols on the beach to assist those affected or to manage the arrival of swarms.
 - III. Alternatives to the bath. This component considers if beach users can resort to some alternative to the bath (own or friend swimming pools, etc.) in the same day in which the arrival of jellyfish to the beach happens.
- d) Vulnerability of economic activity. Finally, there is also a section that assesses the possible economic impact on activities located in the sandy area (picnic areas, hammocks, pedal boat rentals, etc.)

As can be observed (table 1), most of the sources used are own and have been obtained through fieldwork.²

3.1.2. Analysis in the influence area in short-term

The analysis is mainly aimed at businesses close to the beach that could be particularly affected, with the aim of finding out if there are any differences in their activity as a result. Semi-structured interviews were carried out with the employees of the establishments mentioned.

The main hypothesis is that the discomfort of the arrival of jellyfish on the beach can displace some of the users to hotels (especially with swimming pools) and to bars and restaurants. In addition, pharmacies, which are suppliers of sting mitigation products, may potentially experience higher sales volumes.

In short, it is a question of sounding out the area around the beaches to find out if there is any kind of modification in the economic activity when jellyfish appear on the nearby beach.

3.2. Long-term impact analysis

This analysis is based on a hypothetical scenario of increased jellyfish occurrence in different summer seasons. The hypothesis is that there is a possible impact on beach-related economic activity.

² In order to carry out this study, the methodology provides a questionnaire which is shown in Appendix II.



Making forecasts for scenarios that are temporarily far from the present moment requires an effort of interpretation that implies the recognition that these estimations, the farther in time, must be effectively understood as forecasts subject to margins of error inherent in dynamic systems that oscillate continuously.

Furthermore, to the complexity involved in forecasting long-term scenarios is added the difficulty of refining the analysis to spatially reduced areas such as a beach or its area of influence. This is due, per se, to the dynamism of the vast amount of spatial-temporal factors intertwined in the economic, social or environmental reality of the territories; even more so if the analysis is carried out focusing it on an activity, such as tourism, that is controlled by internal but also external factors, which are also subject to an intrinsic dynamism at different scales.

For all the above reasons, this analysis mainly considers internal factors and is specifically focused on specific aspects.

Likewise, for the above reasons, this long-term analysis first addresses the more general spatial scale of the proposals, the municipal one, so that, depending on the results of the latter, the resolution can be increased until the analysis reaches the reduced study area of the beach section that is the object of this study.

3.2.1. Analysis of long-term consequences in the municipality

The focus given to this analysis assumes a decline in tourism activity, which may lead to a drop in local income. In this scenario, an assessment of the municipality's vulnerability from a socio-economic point of view is proposed.

The approach to the repercussions at this municipal level is done through two general indicators: one of approach and another of concretion.

The *indicator of approach* is the fraction of the municipal economy (percentage) that depends on tourism. The sources used for its estimation are the Sistema de Información Multiterritorial de Andalucía (SIMA), specifically the data collected from the business sector and the labor market.

The *concretion indicator* is specifically the fraction (percentage) of the municipal economy that depends on sun and beach tourism activity. It is necessary to consider this second indicator in those large municipalities where tourist activity is not only linked to the coastal tourism sector.

In the hypothesis considered of a scenario of decreasing income from tourism, the repercussions go beyond the economic ones at the municipal level. The loss of employment or the drop in income will have a strong impact on people directly linked to the sun and beach sector. It can be considered that, beyond the economic aspect, the direct impact on these workers can relegate them to situations of social vulnerability. For this reason, an indicator of social vulnerability is proposed, which consists of the percentage of the active population employed in the sun and beach tourism sector. In this case, the data for the calculation of this indicator can be obtained through SIMA.

3.2.2. Analysis of the long term consequences on the beach and its area of influence

In assessing the social and economic consequences that is the subject of this work, we have chosen to assess the possible behavior of the beach user through the collection of information through surveys, in order to know what their behaviour would be in case of a recurrent arrival of jellyfish in the next summers.

The motivations for going to the beach have been divided into the following groups, depending on where the visitor comes from:

1. **Local population.** Generally, the main factor in the selection of this beach is the proximity or easy access.
2. **Summer visitors** who choose the municipality or region of study as a place to spend their holidays. These in turn have been divided into nationals and foreigners.
3. **Occasional tourists.** Occasional visitors are those who change destinations regularly. These in turn have also been divided into nationals and foreigners.



The aim of the survey is to find out whether the current visitors to the beach under study would stop visiting it and whether their only criteria are jellyfish, or this is combined with others. Based on this differentiation, various versions of the questionnaire are proposed depending on the type of user (table 2).

Table 2. Version of the questionnaire depending on the type of user.

Type of user	Question/Reactive	Answer options
Local population	Would you be willing to change to another beach if the situation is repeated this summer and in the following ones?	Yes/No
Non locals	Is this your first season with us?	Yes/No
	Would you consider repeating your holidays in this area in future holiday periods?	
Summer visitors	Would you change your holiday location in case this beach is now experiencing recurrent arrivals of jellyfish?	Yes/No
	In case of changing the place of summer holiday (if the answer to the previous question is "yes"): Wouldn't other kinds of things make up for it?	Prices Weather Environment Security Complementary offer Others
	In case the interviewee shows a preference to remain in the area in later years (if the answer to the previous question is 'no'): What factors keep you from changing your choice?	Jellyfish are not a problem for me Quality of life The prices I own a property in the area Others...
Occasional tourists	Order from highest to lowest the motivation of your visit to our area	Sun and beach Culture Nature Gastronomy Others

Source: Own elaboration.

The results of this question can be of relevant interest because in case of a hypothetical recurrence of jellyfish the image of the sun and beach can be deteriorated.

Finally, a concluding question is asked as to whether jellyfish are a critical constraint or simply an eventuality, according to their answers, in the previous question, the respondents are asked to classify different topics that may attract them to the tourist destination. However, as our main objective is to know if jellyfish are a negative factor in the decision to travel to the Costa del Sol, the question asked is the following:

Would you have chosen our region/municipality for your trip if you had read any news related to jellyfish in the Mediterranean in the media?

3.3. Methodology application

The uncut data obtained has been collected in the field using the Google Forms application for this purpose. The information collected was then processed through the Microsoft Excel spreadsheet.



Fifty surveys have been carried out with beach users and seven interviews with service providers. Those establishments, which are better valued by the users, have been selected through TripAdvisor or other gastronomic reference webs.

The surveys and interviews have been carried out over three days in different locations on the beaches under study and their influence area. They were performed between 12:00 and 16:30. Table 3 shows the specific details of their timing.

Table 3. Dates, times and numbers of users surveyed.

Survey day	Estimated time	No. of users surveyed
26th May	12:00	20
June 2nd	16:30	30
June 8th	12:00	10 (+ 7 hotel establishments)

Source: Own elaboration.

4. RESULTS

The results obtained are set out below summarized in table 4, which reflects the analysis at all the scales considered in the study. In addition, the same figure shows the long-term analysis at all levels of spatial approach. In both cases, given the volume of information obtained, the main findings are discussed, organizing their description in the same structure of factors and indicators proposed in the methodological section.

4.1. Short-term consequences

Exposure

Concerning the total exposure, the number of visitors exposed has been estimated on the basis of the study carried out by Navarro Jurado et al. (2009) which estimates a total of 8 m² of beach area occupied per user. For the beaches of this municipality, which covers an area of 8,672.29 m², measured on aerial orthophotography (Plan Nacional de Ortofotografía Aérea, 2016), the result of the total exposure is 1,084.04 users.

In the inventory process of the potentially exposed economic activities, several types have been classified, such as restaurants, bars, pedal boat rental businesses, hammocks, street vendors, shops, hotels and tourist homes, as well as activities derived from the yacht club and the sports courts established in the study area. There is no hotel accommodation on the beach of Torre del Mar, although there is in its area of influence. There are, however, two restaurants and fifteen beach bars. On the beach of Caleta de Vélez, as on the beach of Torre del Mar, there is no accommodation, although it does have a restaurant and three beach bars. Likewise, the beaches of the municipality of Vélez Málaga analysed have sports courts and a sailing club, as well as services such as showers, a lifeguard post, children's playgrounds and information points, which serve as support elements for the leisure activities that take place on the beach.

The beaches analysed, belonging to the Axarquía region, in the Eastern Costa del Sol, are located at the head of the region, being beaches that receive much more users than the rest of the eastern sector of the Costa del Sol (Instituto de Estadística y Cartografía de Andalucía (IECA), 2020). This area bases its economy on the service sector combined with highly profitable agriculture.



Table 4. Short-term and long-term consequence analysis.

Analysis of possible short-term consequences			
Detailed analysis (on the beach itself) in the short term (in the temporal immediacy)			
Exposition	Exposition total	1,084 users Restaurants and bars Pedal boats and hammocks Peddlers Shops Hotels (4) and tourist homes Nautical and sports activities	
	Exposition net	87% users bathe 68% users bathe unless the water is cold	
Vulnerability	User	Degree of discomfort experienced	Assessment of experience 35% very high nuisance due to dirt in the water. 27% annoying very high due to sand dirt (25% high) 16% bad weather 16% seawater temperature 6% beach over-occupation
		Degree of discomfort experienced	Willingness to stay in case of the appearance of jellyfish 52% of users -17% high discomfort -31% very high annoyance
	Protective elements	Preventive information (knowledge of the “Infomedusa” application)	62% are unaware of Infomedusa
		Use of anti-jellyfish protection	64% are unaware or do not use protection 53% indicate that they would apply vinegar and lemon.
	Mitigation elements: what to do in case of a jellyfish sting	30% know how to act	
Alternatives to the bathroom	15% would seek an alternative to stay on the beach 25% would stay on the beach 20% would go to another beach 40% would go to a pool		
Economic activity	It has not suffered alterations		
Analysis in the area of influence in the short term			
It has not suffered alterations with the presence of jellyfish			
Long-term consequence analysis			
Analysis of long-term consequences in the municipality			
High vulnerability: 24.7% of companies and 71.6% of registered contracts are linked to the tourism sector			
Estimation of possible consequences on the beach and area of influence in the long term			
27,3% vacationers would not return 72,7% vacationers would repeat their vacations vacationers would stay for: - The weather (28%) - Prices of restaurants and establishments (28%) - Complementary offer (21%) - The environment (17%) - Security (6%). Main factors of visit of occasional tourists: - Beach (72%) - Festival Weekend Beach (72%)			

Source: Own elaboration.



Analysing the net exposure (figure 2), 87% of users state that they went to the beach for leisure and bathing enjoyment. Of the total number of users, 68% stated that they usually go swimming, except when there is a particularly low water temperature. These results indicate a considerably high net exposure, as many users consider themselves to be particularly exposed.

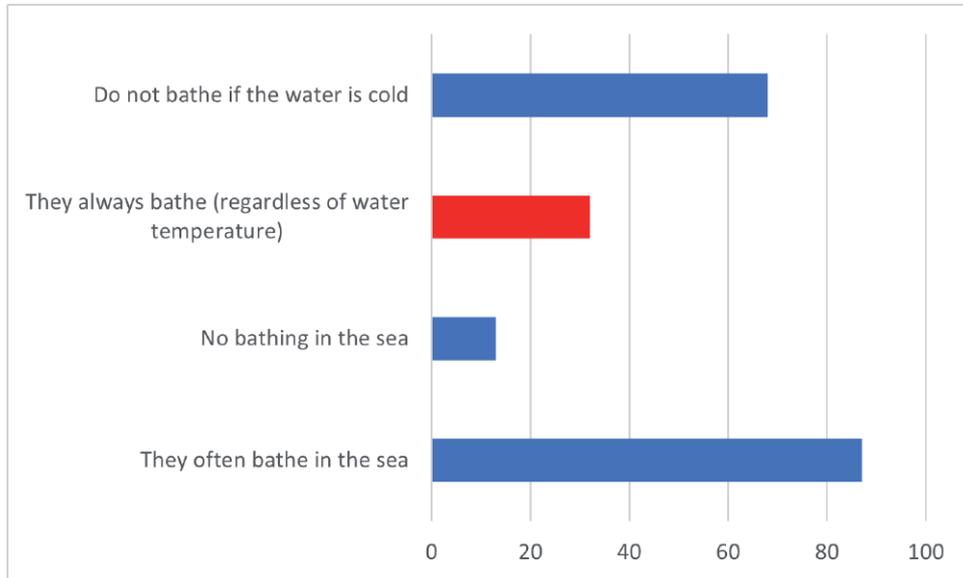


Figure 2. Exposure. Source: Own elaboration.

User vulnerability

Beaches whose users are more sensitive to the jellyfish problem, less aware of it, and have no alternatives have been considered more vulnerable. Discussions about user vulnerability, in relation to the degree discomfort experienced, in which the aim is to characterise the dependence on bathing when going to the beach in the presence of adverse elements that make it impossible, among others jellyfish. Therefore, on the one hand, the assessment of the state of the beach has been analysed, and on the other hand, the valuation of the state of the beach has been analysed and on the other hand the valuation with respect to the presence of annoying elements such as the presence of jellyfish. Concerning the evaluation of beach state, most of the users (62%) consider the dirtiness of both the water and the sand as negative elements that affect their experience, the rest include more negative phenomena such as bad weather, water temperature or overcrowding on the beach.

On the other hand, 52% of the users are willing to stay on the beach although of the presence of jellyfish in the water, while a high percentage of them indicate that the degree of annoyance is high (17%) or very high (31%) (figure 3).

Connecting this question with the result of net exposure, if there is a significant percentage of users who go to the beach with bathing as their main motivation and bathing always takes place, regardless of water temperature, these areas can be considered particularly exposed. The results indicate that users are highly dependent on the state and temperature of the water, so vulnerability is considerably high on this indicator.

Analysing the preventive measures taken by the users, the vast majority (80%) are unaware of mobile applications, such as InfoMedusa, which evaluate the presence or not of jellyfish on the beach. In similar proportions, there are users who do not use any protective or mitigating element against jellyfish stings and those who do not know how to act in such a situation, which implies a high degree of vulnerability in this indicator.



Also at user level, the possible alternatives to bathing in case of elements that make bathing difficult have been analyzed. Of the total number of respondents, most of them would go to a swimming pool, although 25% would stay on the beach in case of disturbing elements and 20% would look for an alternative beach. A small percentage said they would stay on the beach with the alternatives it offers (15%). This means that more than half of the users would abandon the beach (figure 4).

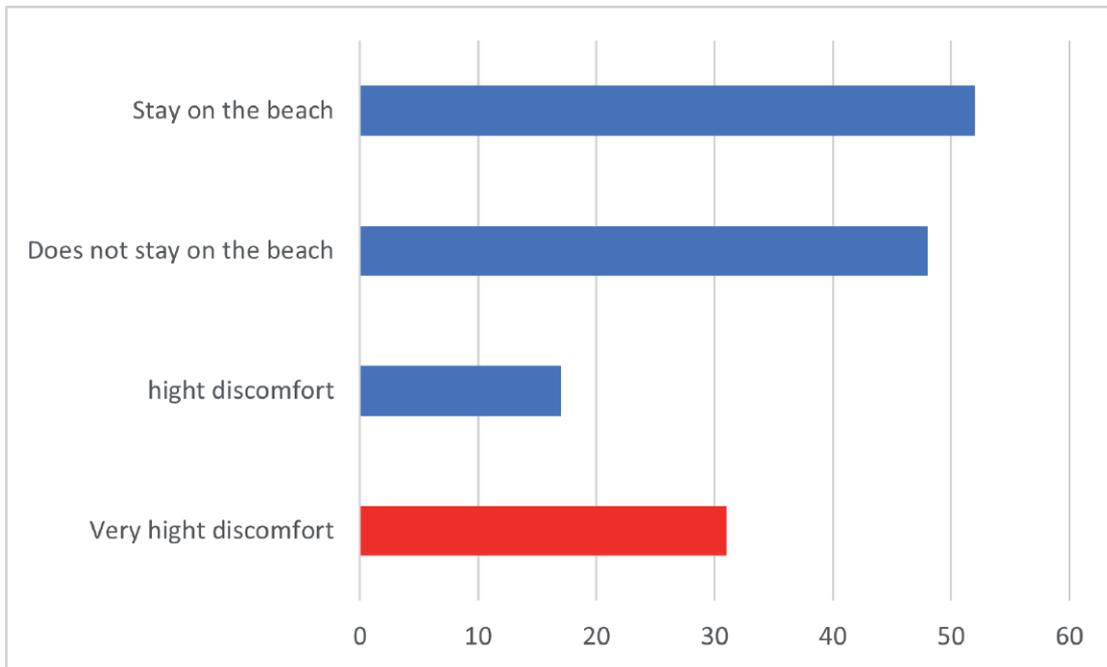


Figure 3. Degree of discomfort experienced. Source: Own elaboration.

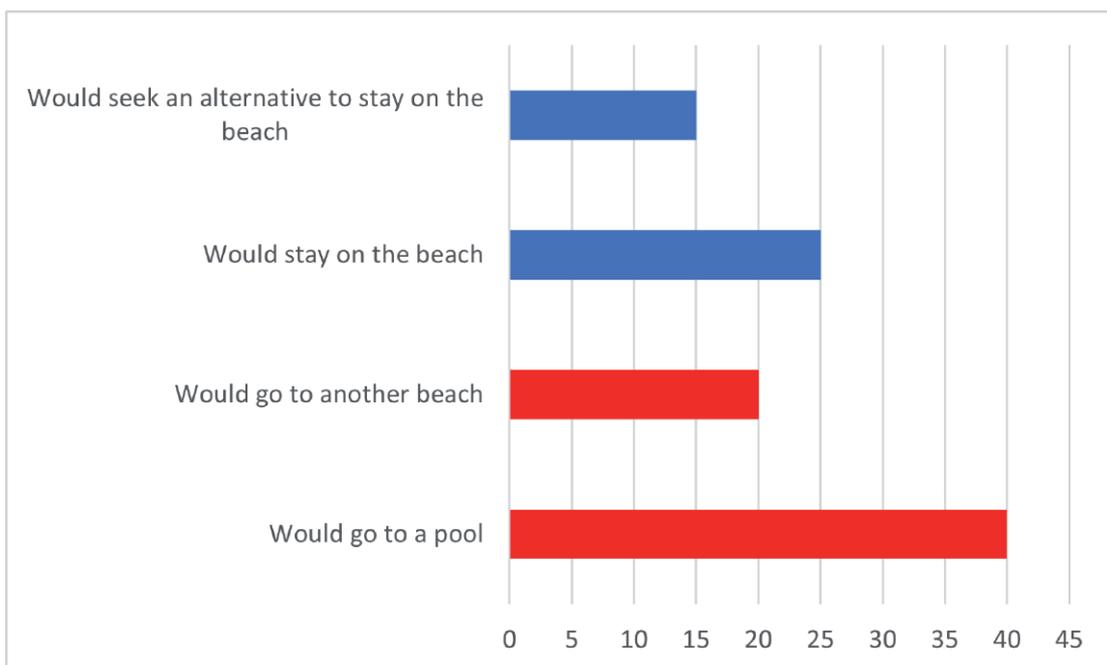


Figure 4. Alternatives to the bathroom. Source: Own elaboration.



Vulnerability of economic activity

After the analysis of the economic vulnerability, carried out through interviews with the suppliers of tourist goods and services on the beachfront, it is concluded that the economic activity at this scale has not been altered by the presence of jellyfish on the beach, with no cancellations of reservations due to this reason. With respect to the hotel establishments, most of them determine that they have not suffered cancellations due to the appearance of jellyfish on the beaches, although there is a greater use of the hotel facilities (swimming pool and restaurant) on the days when jellyfish appear.

4.2. Long-term impact analysis

In the analysis of the long-term consequences for the municipality, by consulting the source data available in the Multiterritorial Information System of Andalusia (SIMA), a high vulnerability of the municipal economy is perceived since 24.7% of the companies in the municipality are directly or indirectly linked to the tourism sector (Accommodation, recreational activities, employment agencies, construction, real estate, travel agencies...). In addition, taking into account the official data on contracts registered by the State Public Employment Service (SEPE) and the Andalusian Employment Service (SAE), it appears that 71.6% belong, directly or indirectly, to tourism, with 61% belonging to the service sector and 10.6% to the construction sector.

Regarding the long-term consequences for the beach's socioeconomic influence area, it is important to emphasize that 23,7% of vacationers would choose not to continue going to this stretch of beaches. Despite this, 72,7% would repeat their holidays in this segment of the coast. Of this total, 28% of holidaymakers say that they would stay in the area because of the climate and the prices of restaurants and establishments. The complementary offer (e.g. the water park) is an incentive for 21% of those surveyed. Other positive elements are the town's environment (17%) and safety (6%). On the other hand, occasional tourists indicate that the main factors for which they visit the area are the sun and beach (72%) and the Weekend Beach Festival (72%) (table 4).

In conclusion, the results show a high vulnerability of the beach, especially in the short term, mainly due to a high net exposure, composed by users significantly affected by the consequences of a hypothetical case of impossibility to bath. Moreover, preventive measures, such as the use of mobile applications or jellyfish protection devices, are not very popular among users, most of whom do not know how to act in case of jellyfish presence or stings. Even so, the consequences are not so negative in the long term, since it is estimated that most of the respondents would return to this stretch of coast for holidays.

As for the area of influence, it is not affected in the short term, although it is highly vulnerable due to the high number of workers and businesses related to the tourism sector.

5. DISCUSSION

Regarding the general structure of the analysis, despite the apparent complexity of spatial-temporal, it is necessary to compartmentalize the analysis because the consequences of the arrival of jellyfish on the beach can be opposed depending on the moment in which they are measured. On the economic side, it is clear that the arrival of jellyfish on the beach may generate profits at first (bathers can look for bars, restaurants, nearby hotels with swimming pools as an alternative, pharmacies to relieve themselves, etc.), but the impact changes into negative on the long-term, like states Nunes et al. 2015, Tomlinson et al. 2018 to Catalonia or Mghili et al. 2022 in the case of Morocco.

The results of this study point to a high level of discomfort from jellyfish. In this sense, they coincide with other previous works that addressed similar issues in Costa del Sol. Navarro et al. (2008) probed this same beach for dirt and obtained similar results of rejection. Rubio Gómez and Gutiérrez Hernández, 2020 also obtained similar results on the Costa del Sol, in this case specifically on jellyfish.

It is necessary to divide the analysis into factors, sub-factors and components in the space-time context "a" (Appendix I), Otherwise It could not be possible to detect in which concrete topics the use of the beach is



more vulnerable. However, it is possible to organize them, assign weights to them and generate complex indicators of both exposure and vulnerability for every beach. This would help to standardize the results between some beaches and others in order to prioritize when it comes to management. That was done by Ojeda et al. (2011) to assess coastal vulnerability to sea level rise, but the main objective on this work is to show the complexity of jellyfish impact on beaches. Next work could accomplish synthetic indexes to jellyfish phenomenon.

In addition, it is possible to continue to develop more derivative products than this methodology suggests. For example, more could be done with some of the information gathered in the field, such as that used to develop indicator element 3.1.1 of the analysis in the space-time context "a" (Appendix I). Its results could be used to recalculate the volume of users on a beach in case of sudden jellyfish arrivals. In that case, it will be necessary to dedicate a specific work to the sampling strategy. Since this first approach has been a methodological test, in order to carry out this study in a more exhaustive way, it is necessary to establish specifically the size of the samples. To implement the above, it is first necessary to know the universe of the study, which in this case is the visitors to the beach. That is where the problem resides. Research work would be necessary to be able to discern the "unique users". Brand new researches about beach carrying capacity (Yepes 2000, 2002, 2007 and 2020) could be observed in order to improve this task.

Method complexity or perfection can also be extended to long-term results. For example, in the approach of the consequences at municipal level, more sophisticated indicators of economic-social structure could be used to group the different coastal municipalities using Cluster-type statistical analysis, in the way that Thiel Ellul (2014) puts it into practice for the coastal municipalities of Andalucía. It would be worthwhile to distinguish between municipalities with many hotels and others with a higher proportion of secondary residences.

Regarding the resources to carry out this work, it would be worthwhile to implement new technologies in field data collection with big data analysis techniques or through mobile applications, such as the already existing Infomedusa (Aula del Mar, 2013). This application could be used to ask its users some of the questions proposed in this study and thus collect the information directly from the database of its administrators. Moreover, results about jellyfish hazard in Costa del Sol supplied by De la Fuente et al (2021) and Rubio and Gutiérrez (2020) may serve as a complement in order to perform the *ecuación general del riesgo* on the southern Mediterranean coast.

6. CONCLUSIONS

Due to the increasingly frequent presence of jellyfish shoals on the Mediterranean coasts and to the unquestionable importance of the good condition of the beaches for the economy of the coastal areas, it has been considered positive, in the analysis of the problem in question, to evaluate the consequences and implications on the users of the beaches, as well as in their area of influence, in which the coastal tourist activity is developed. A methodology has been provided in the article that allows to know the point of view of the users of the beaches, as well as of the businesses that depend on the tourist sector in the coastal areas in the face of a negative event such as the appearance of jellyfish. For this purpose, a pilot study area has been used as a sample in the beaches of Torre del Mar and Caleta de Vélez, in the municipality of Vélez Málaga (Málaga), understood as an excellent example of tourist dependence on sun and beach and therefore optimal for applying its vulnerability to events of massive appearances of jellyfish.

When analysing the results, it is concluded that there is a notable vulnerability of the tourist in the study areas due to the phenomenon of jellyfish swarms, being affected the users of the beaches, as well as the economic activities linked to the tourism of sun and beach (catering and accommodation industry). Tourists and visitor's perception expose the resistance to this spatial phenomenon in short periods, being intolerable in cases where it extends to the medium and long term, assuming a decrease in local tourism and, therefore, a decrease in the diversity of the local economy.

However, most users are unwilling to leave this destination in the long term as they prefer to remain in the study area despite the problem since, in most cases, they are local residents and, failing that, they may choose to move to other beaches if effective measures are not taken to alleviate the effects of the swarms on users.



In conclusion, the phenomenon of jellyfish swarms tends to show a certain repetition in time and space conditioned by the predicted climatic contextual situation. Therefore, these spaces are exposed and vulnerable both on a social and economic level to the cycles observed which could alter the situation of the human environment in the Mediterranean framework. The existence of alternatives to the Costa del Sol destination in other geographical area of the world may have an impact and decrease on economic activities, which may result in the displacement of visitors and tourists to other geographical points that preserve the traditional characteristics of the tourist culture of this inland sea.

Knowing the vulnerability of the territory is fundamental for the application of measures to mitigate the problem and avoid the loss of visitors during periods of special affection. The application of the proposed methodology in other study areas would permit to compare results from different areas and it would also allow to obtain comparable maps of vulnerability in several study areas.

Responsible reporting and conflict of interest

The authors declare that there is no conflict of interest in relation to the publication of this article. The writing of the introduction, methodology, results and discussion has been carried out by the first two authors and the last one. The database of the methodological section was prepared by the third author.

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APPENDIX I

Structure of the study of the risk due to affectation of jellyfish and sources used for it. Analysis in the spatial-temporal context “a” (consequences on a spatial scale of detail on the beach) in the short term (on the day the jellyfish arrive). Source: Own elaboration

Factor	Subfactor	Type	Component	Indicator	Source	Representation	Note
Exposure	Potential exposure	physical/personal	—	1.1. Number of visitors per day (average)	Public statistical sources (mainly municipal) · Field work	Monthly chart, hourly daily in high season)	Serves as a preview of the volume of daily visits if no daily data exists, other time intervals can be used (monthly or yearly)
		physical/personal	—	1.2. Origin of beach users	Public statistical sources (mainly municipal) · Field work	Annual chart	Serves to give previous information of the type of users of the beach
		economic	—	1.3. Inventory of economic activities related to the beach (restaurants, bars, pedal boats, hammocks, street vendors, etc.)	Google maps · Field work	GIS format map with associated ddbb	The question is whether users go mainly for bathing or have a different main motivation
	Net exposure	physical/personal	—	2.1. Main reason(s) for going to the beach	Surveys (field work)	Distribution charts of responses	People who do not indicate, “taking a bath” as a reason will not be exposed.
		physical/personal	—	2.2. Personal predisposition takes a sea bathing in 100% of the occasions that one goes to the beach	Surveys (field work)	Distribution charts of responses	The greater the number of users with a decided and unequivocal intention to bathe, the greater the exposure
	Vulnerability	User vulnerability	behavioural/personal	Degree of discomfort (dissatisfaction) caused by jellyfish	3.1.1. Willingness of users to stay on the beach in case of the appearance of jellyfish on the same day	Surveys (field work)	Distribution charts of responses
3.1.2. Level of discomfort that jellyfish generate in the user (1: very low - 5: very high)					Surveys (field work)	Distribution charts of responses	It may be interesting to compare the responses given by locals versus tourists
3.1.3. Gradation of the most common beach disturbances (to put in context)					Surveys (field work)	Distribution charts of responses	In this way, dissatisfaction with the presence of jellyfish can be compared to other frequent discomforts They are compared with each other (or graduated from 1 to 5) discomforts such as the following: dirt from the water, dirt from the sand, the environment, overcrowding, jellyfish, and bad weather. An alternative is to apply pair-wise comparison techniques



Factor	Subfactor	Type	Component	Indicator	Source	Representation	Note
Vulnerability	User vulnerability	behavioural/personal	Degree of discomfort (dissatisfaction) caused by jellyfish	3.1.1. Willingness of users to stay on the beach in case of the appearance of jellyfish on the same day	Surveys (field work)	Distribution charts of responses	In contrast to the previous one, this question only addresses discomfort related to bathing in the sea
				3.1.5. Evaluation of the experience in case of not being able to take a sea bath due to causes that prevent bathing (dirt, jellyfish, swell, low water temperature, etc.)	Surveys (field work)	Distribution charts of responses	—
			Protective elements	3.2.1. Knowledge (yes or no) of the existence of the Infomedusa application for mobile phones	Surveys (field work)	Distribution charts of responses	—
				3.2.2. Infomedusa application is installed on the user's mobile phone (yes or no)	Surveys (field work)	Distribution charts of responses	—
Vulnerability	User vulnerability	behavioural/personal	Protective elements	3.2.3. Basic Notions of what to do in case of a jellyfish sting	Surveys (field work)	Distribution charts of responses	The user who gives an affirmative answer is asked what the procedure to be followed is.
				3.2.4. Use of protective measures such as creams, etc.	Surveys (field work)	Distribution charts of responses	—
		Institutional		3.2.5. Existence of action protocols to inform users about the existence of jellyfish in the water	Interview with the competent administration	—	—
				3.2.6. Existence of action protocols in the event of the appearance of a swarm of jellyfish to prevent their arrival in the bathing areas (nets, jellyfish removal boats, etc.)	Interview with the competent administration	—	—



Factor	Subfactor	Type	Component	Indicator	Source	Representation	Note
	User vulnerability	Socio-economic	Alternatives to bath	3.3.1. Possibility of access to take a bath through showers installed on the beaches	Field work• Beaches Guide (MAPAMA, 2019)	-Showers per 1000 m2	—
				3.3.2. Possibility of access to take a bath in aquatic facilities or dwellings with a swimming pool to which users have access	Interview with the competent administration	Distribution charts of responses	—
	Vulnerability of goods and activities	Economic	-	4.1 Existence of differences in the level of activity/incomes	Interviews with tourist goods and services suppliers on the beach (field work)	Distribution charts of responses	In this case the activity may be even higher than on days without jellyfish, so it could be said that technically this part of the study may find vulnerabilities, if the expression “negative” is accepted



APPENDIX II

Field questionnaire applied to collect information on different aspects of vulnerability of users to the presence of jellyfish on the beach in the context of space and time “a” (on the beach in the short term). Source: Own elaboration.

Indicator	Question/Reactive	Answer options
2.1. Main reason(s) for going to the beach	Choose the reason or reasons why you come to the beach	<ul style="list-style-type: none"> - For aesthetics (to get a tan) - I don't spend and it's fun - Because I spend time with my family - By medical prescription - Practicing sport - To take a bath - Other (please specify)
2.2. Personal predisposition to go into the water on 100% of the occasions you go to the beach	Do you take a bath in seawater every time you come to the beach?	<ul style="list-style-type: none"> - Not if the water is too cold - - Almost always - Always
3.1.1. Willingness of the user to stay on the beach in case of an appearance of jellyfish on the same day	If you come to the beach one day and there are jellyfish... Do you stay at the beach or do you go back to your house?	<ul style="list-style-type: none"> - Yes - No In case you stay why? If you leave: why?
3.1.2. Level of discomfort that jellyfish generate in the user (1: very low - 5: very high)	Do jellyfish bother you? Answer by considering that 1 is “not bothering me enough” and 5 is “bothering me too much”	<ul style="list-style-type: none"> - 1 “I'm not bothered much” - 2 - 3 - 4 - 5 “they bother me too much”
3.1.3. Gradation of the most common beach disturbances to put into context. In this way, dissatisfaction with the presence of jellyfish can be compared to other frequent discomforts	With 1 being very little and 5 being a lot, Evaluate to what degree you are bothered by the following eventualities that may be encountered on the beach:	<p>Uncomfortable eventualities to be assessed:</p> <ul style="list-style-type: none"> - Dirt in the water - Dirt from the sand - The environment (yelling, children running and throwing sand, loose dogs, people playing ball who do not respect, etc.) - Over-occupation (many towels or umbrellas together) - Jellyfish - Bad weather
3.1.4. Gradation of elements that generate most discomfort when deciding to take a bath	What elements keep you from getting in the water? With 1 being “a little limiting” and 5 being “too limiting”, how much does it condition you?	<ul style="list-style-type: none"> - The earthy - Dirt - The water temperature - Jellyfish - The number of people - Other (please specify)
3.1.5. Assessment of experience in the event of not being able to take a bath in seawater due to causes that constrain bathing (dirt, jellyfish, waves, low water temperature, etc.)	If one day you go to the beach and cannot swim for one of the above reasons... How would you rate your experience from 1 to 3?	<ol style="list-style-type: none"> 1. Very bad because I always want to swim in the sea 2. Bad because it forces me to cool down in another way (showers bar, being under the umbrella all the time...) 3. I do not care because I do not mind. It is no bother to go to the shower, bar, I am not hot...



Indicator	Question/Reactive	Answer options
3.2.1. Knowledge (yes or no) of the existence of the Infomedusa application for mobile phones	Do you know the Infomedusa application?	<ul style="list-style-type: none"> - Yes - No
3.2.2. The Infomedusa application is installed on the user's mobile phone (yes or no)	Do you have Infomedusa installed in your mobile phone?	<ul style="list-style-type: none"> - Yes - No
3.2.3. Basic notions of how to act in case of jellyfish stings	Do you know how to act when a jellyfish stings you?	<ul style="list-style-type: none"> - Yes - No <p>The user who gives an affirmative answer is asked what the procedure is. (free answer; later they are grouped)</p>
3.2.4. Use of protective measures such as creams, etc.	Do you use any jellyfish protection? (cream, etc.)	<ul style="list-style-type: none"> - Yes - No <p>If the answer is yes, the user is asked about his or her protection technique or strategy (free answer; later they are grouped)</p>
3.3.2. Possibility of take a bath in aquatic facilities or homes with a swimming pool to which users have access	Do you have any alternative to bathing in case it is impossible to get into the water on this beach (e.g. red flag)?	<ul style="list-style-type: none"> - Go to another beach - Go to my poo - Go somewhere with a pool that I have access to (a friend, neighbour, etc.) - Go to a paying pool (public/private) - Going to a water park - Go to a nearby river/pools - Go to a reservoir with a swimming area - To stay and resign - Other alternatives
<p>Along with all the previous questions, the following are also asked of all respondents:</p> <p>a. What is your usual place of residence? (to detect who are locals or tourists)</p> <p>b. Where does the beach come from today? (private home or hotel)</p> <p>c. By what means of transport have you reached the beach?</p>		
4.1. Existence of differences in the level of activity/income from tourist activities in the beach area	Do you notice any difference in your economic activity on a day when jellyfish appear on the beach?	Free answer