applied sciences

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Impact of Tourist Behavior on the Discharge of Sunscreen Contamination in Aquatic Parks, Sinkholes, and Beaches of the Mexican Caribbean

Diego Armando Casas-Beltrán [1,*], Karelys Febles-Moreno [2], Emely Hernandez-Yac [3], Courtney Maloof Gallaher [3], Jesús Alvarado-Flores [1,*], Rosa María Leal-Bautista [1] and Melissa Lenczewski [4]

[1] Centro de Investigación Científica de Yucatán A.C., Unidad de Ciencias del Agua, Cancún CP 77524, Mexico; rleal@cicy.mx
[2] Pontificia Universidad Católica de Puerto Rico, Ponce, PR 00717, USA; kfeblesmoreno@pucpr.edu
[3] Department of Geographic and Atmospheric Sciences, Northern Illinois University, DeKalb, IL 60115, USA; ehernandezyac@ucmerced.edu (E.H.-Y.); cgallaher@niu.edu (C.M.G.)
[4] Department of Geology and Environmental Geosciences, Northern Illinois University, Dekalb, IL 60115, USA; lenczewski@niu.edu
* Correspondence: dr.diegocasas.asesor@gmail.com (D.A.C.-B.); jesus.alvarado@cicy.mx (J.A.-F.); Tel.: +52-(998)-211-3008 (ext. 122) (J.A.-F.)

Abstract: The Mexican Caribbean is part of the Mesoamerican Barrier Reef System, considered the second largest reef system globally. This system, as well as inland aquatic ecosystems, are at risk of contamination due to the intensive use of sunscreen by the tourists who visit the Riviera Maya each year. At present, the regulation and management of sunscreens are inconsistent, with most policies and legislation focused on the protected marine areas with little current focus on inland aquatic ecosystems. An estimated 229.76 tons of sunscreen are used annually, with residues putting the health of the marine and freshwater aquatic ecosystems and residents at risk. Groundwater is used recreationally (e.g., tourists swimming in sinkholes or cenotes) and as household drinking water. To understand the environmental impacts of sunscreen use and the management implications, a mixed-methods study was carried out, combining survey and interview data on how tourists use sunscreen and their perceptions of discharge of sunscreens into the water, with analysis of regional, national and international policies and legislation. Our findings of touristic behaviors, gaps in current legislation, and the pollution implications of different sunscreen types provide useful information for future decision-making and the creation of stronger environmental regulations.

Keywords: sunscreen pollution; social perceptions; water contamination; environmental assessments

Citation: Casas-Beltrán, D.A.; Febles-Moreno, K.; Hernandez-Yac, E.; Gallaher, C.M.; Alvarado-Flores, J.; Leal-Bautista, R.M.; Lenczewski, M. Impact of Tourist Behavior on the Discharge of Sunscreen Contamination in Aquatic Parks, Sinkholes, and Beaches of the Mexican Caribbean. *Appl. Sci.* **2021**, *11*, 6882. https://doi.org/10.3390/app11156882

Received: 13 May 2021
Accepted: 14 July 2021
Published: 27 July 2021

1. Introduction

The intensive use of sunscreen in aquatic tourism has increased annually around the world, particularly in coastal areas where tourists apply sunscreen to mitigate the harmful effects sun exposure. Although protective against the risks of skin damage, the widespread application of sunscreen poses a risk for aquatic ecosystems; when people partake in aquatic activities, a percentage of sunscreen applied to their skin is discharged into the water. Aquatic tourism, including tourism at water parks, public beaches, natural and artificial water systems, and hydrological reserves, has increased the presence of chemical contaminants in the surface and groundwater systems. Chemical compounds deriving from sunscreen have been identified in the coastal zone mainly where coral reefs are located, in bodies of water with recreational activities, and water treatment plants. The substances contained in sunscreen are highly dangerous if they continue to reach aquatic systems because they have endocrine and carcinogenic effects, and even with high doses of exposure, their lethality has been demonstrated in indicator organisms. Therefore,

sunscreen pollution in ecosystems is directly related to anthropogenic activities, especially in coastal tourist destinations.

In this sense, the discharge of sunscreen in aquatic and marine ecosystems is a serious environmental problem for the state of Quintana Roo and the Caribbean coast of the Yucatán peninsula of Mexico. Every year, more than 15 million tourists visit the Riviera Maya, which is the 120 km tourist corridor located between the cities of Cancun and Tulum on the Caribbean coast of the state of Quintana Roo. Another 1.5 million residents live in the state of Quintana Roo [1]. Sunscreen is used intensively by tourists and residents, yet legislation of these products is scarce and ambiguous in the state of Quintana Roo [2]. Casas-Beltran et al. [3] found that more than 313 tons of sunscreen were released in the region over the last 12 years, and Leal-Bautista et al. [4] confirmed the presence of organic contamination in the groundwater flows of Quintana Roo, which indicates the transport of pollutants from inland groundwater to the Caribbean coast. According to Sánchez-Quiles et al. [5], 10% of the world's population lives in coastal areas, which are used for anthropogenic, industrial, and commercial activities. In addition, tourist activities in coastal areas are considered important for the country because they considerably economically benefit society. Therefore, and according to the estimates of Casas-Beltran et al. [1], the pollution due to sunscreen use, directly and indirectly, is immense; its discharge is related to the increase in tourism. Notably, 89% of tourists engage in aquatic activities, which increases the potential for discharging chemicals into the water in coastal areas. Sunscreen is a mixture of organic and inorganic substances, e.g., glycerin, vitamins, silicone, benzotriazole derivatives, and nylon-derived compounds, which were devised to protect the skin from solar radiation. This mixture depends on the formulation and regulations of the final composition of each ingredient, that is, each ingredient does not exceed more than 40% of the total composition, and some are even less than 10% of the total mixture [6]. Most of the estimation of sunscreen discharge has been performed in the coastal areas of the world, and mainly on coral reefs. It is estimated that more than 10,000 tons per year are discharged on the reefs. The component most likely to be present in the water, because it is fundamental for mixtures of sunscreens, is oxybenzone; however, nanoparticles such as TiO_2 and ZnO are equally highly dangerous [5]. Contamination by sunscreen components is difficult to quantify and estimate in water, but concentrations of even 1 mg/L were already reported in the ocean [7]. The Yucatán Peninsula, in the state of Quintana Roo, is underlain by karst geology. The hydrogeological characteristics of karst systems lead to high infiltration and permeability, which facilitate the rapid transport of pollutants in underground flows, ultimately affecting coastal reefs [8]. Sunscreens directly enter these fresh and marine aquatic ecosystems as residues that are washed off tourists' skin, or indirectly when they are washed off during bathing and enter the water sanitation system [9,10]. Tourists are often encouraged to choose ecologically friendly or biodegradable sunscreen options, but even those are not without risk. In addition, parks, protected natural areas, and cenotes invite visitors to not use sunscreens or use environmentally friendly sunscreens. If visitors enter the water, they must wash their bodies before doing so, with showers that are located near recreational sites.

However, Hernandez-Pedraza, et al. [11] reported that both non-biodegradable sunscreens and some sunscreens labeled as biodegradable are toxic to the aquatic species of Quintana Roo. Given the potential ecological risk, combined with the lack of clear regulations, we investigated the social perceptions of sunscreen contamination by residents and tourists, examined environmental legislation on the use and application of sunscreen, and estimated the total annual discharge of sunscreen particularly in sinkholes, aquatic parks, and beaches in the three principal touristic states. From this, we then constructed recommendations for the better management of sunscreen for the aquatic ecosystems of the Mexican Caribbean.

2. Materials and Methods

2.1. Study Area

In this study, we present unpublished data from two prior research studies. The first study, described by Casas-Beltran et al. [12], was carried out in the Riviera Maya, México. The study focused globally on the 120 km tourist corridor that is located along the Caribbean Sea on the Yucatan Peninsula, known as the Riviera Maya, and that extends from the city of Cancun to the town of Tulum. The Riviera Maya receives 87% of all tourists to México. In addition, along the entire coastal zone of the Mexican Caribbean, reported for the state of Quintana Roo are six protection areas of flora and fauna (381,184 ha), seven national parks (26,845 ha), four biosphere reserves (853,423 ha), and a sanctuary (10 ha), all under the federal competence. Moreover, under state oversight, there are four parks (1191 ha), three reserves (309,190 ha), and three areas subject to ecological conservation (2480 ha). In total, there are 28 protected natural areas in Quintana Roo and more than 50% are aquatic ecosystems according to the National Institute of Statistics and Geography of Mexico (data obtained from https://www.inegi.org.mx/, accessed on 10 May 2021). They are interconnected between the sea and the karst aquifer. Data for this study were collected over two weeks in July 2019 and consisted of surveys of visitors (tourists and locals) to beaches, downtown areas, and sinkholes regarding visitors' perceptions of water quality and the use of sunscreen (n = 253).

2.2. Surveys

The interview procedure was carried out according to Casas-Beltran et al. [12]. Survey questions focused on (a) basic sociodemographic questions (age, sex, level of studies, place of origin, etc.); (b) level of environmental concern (level of knowledge of the impact on the aquatic environment of biodegradable and non-biodegradable sunscreen); (c) frequency of sunscreen application at different sites (sites that were visited and sunscreen was applied, such as beaches, sinkholes, water parks, etc.); (d) choices regarding sunscreen (non-biodegradable or biodegradable). Data from the surveys were analyzed using SPSS version 26 (IBM, Armonk, NY, USA). The number of surveys (n = 253) could be regarded as a limitation; however, this is a significant effort for an exploratory study in a region where studies on the impact on sunscreen are scarce given the tourist destination being the most important in Latin America and the Caribbean.

2.3. Environmental Legislation

Additionally, we drew on our prior analysis of laws and policies relevant to sinkhole environmental regulation based on the regulatory framework of sunscreens application and control. We included municipal laws and policies that govern karst groundwater systems in Campeche, Yucatán, and Quintana Roo [12]. Twenty-seven documents of the environmental legislation were reviewed to determine if they describe the integral management of the contamination produced by sunscreen or if they allow it to be used (sunscreens) within the protected natural area.

2.4. Discharge Estimation of Sunscreens

Finally, we estimated the quantities of sunscreen potentially discharged to sinkholes, aquatic parks, and beaches. With the data obtained from the surveys, we adjusted important values in the calculations of the discharge of sunscreen, a formula that was published by Casas-Beltran et al. [3]. The values that were adjusted in the formula were the following: (a) the percentage of tourists using sunscreen (TBS; represents the percentage of tourists using sunscreen); (b) the number of times a tourist applied sunblock (TVEC, the number of times that sunblock is applied by a tourist in a day including six hours of water activities); and (c) the percentage of tourists who entered an aquatic system to engage in water activities (TAQ, equal to the percentage of tourists who enter an aquatic system), including aquatic recreational parks, sinkholes, caverns, and beaches.

Next, we followed the methodology proposed in Casas-Beltran et al. [1] to calculate the number of tons of sunscreen or sunscreen components released in the water annually.

$$TDS = \{[(TTyear * TAQ) * (TBS)] * [(TGdays) * (TVEC) * [Tdays]\} * 0.25$$

where total discharge of sunscreen (TDS) is the total contamination by sunscreen. It is also possible to calculate the total discharge for each ingredient of a sunscreen mixture, using the same formula proposed by Casas-Beltran et al. [1]. In the formula, this TDS value is multiplied by 0.25, which corresponds to the 25% sunscreen applied by one person that spreads into the water only if the person who applied the sunscreen enters the water [1]. In the above equation, TTyear is the total number of tourists per year (by state or municipally) as reported by the portal of the national tourism statistical and geographical information system of México (DATATUR, website: www.datatur.sectur.gob.mx, accessed on 10 March 2020). TAQ is the percentage of tourists who enter an aquatic system to engage in water activities, visit recreational parks that include water activities, and visit sinkholes and caverns. TBS represents the percentage of tourists using sunscreen, which, according to Rodríguez-Fuentes et al. [13], is 83.7%. Tdays is the average total number of days of a tourist's stay. TGdays represents the amount of sunscreen that a tourist applies per day based on the amount in grams used by one person in a day as reported by Poiger et al. [14] and the dose recommended by the American Academy of Dermatology [14]. Thus, TGdays = 1263 mg + (3000 mg/2), which is equal to 2131.5 mg or 2.1315 g. TVEC is the number of times that sunblock is applied by a tourist in a day including six hours of water activities. If one application occurs every two hours, then the TVEC is equal to three. In the sum, the calculated values indicate the number of tons of sunscreen or components of sunscreen in the water annually.

3. Results

The discharge of sunscreen in aquatic systems is dependent on several factors, including the total number of tourists in a region, and regulations imposed by tourism sites and by environmental legislation governing the usage of sunscreens. The estimated total discharge of sunscreen (TDS) in Quintana Roo is high. In 2019, we estimate that between 231 and 313 tons of sunscreen were discharged into fresh and marine aquatic ecosystems. We found that the largest quantities of sunscreen were discharged at beaches, followed by sinkholes, and finally inland aquatic parks (Figure 1).

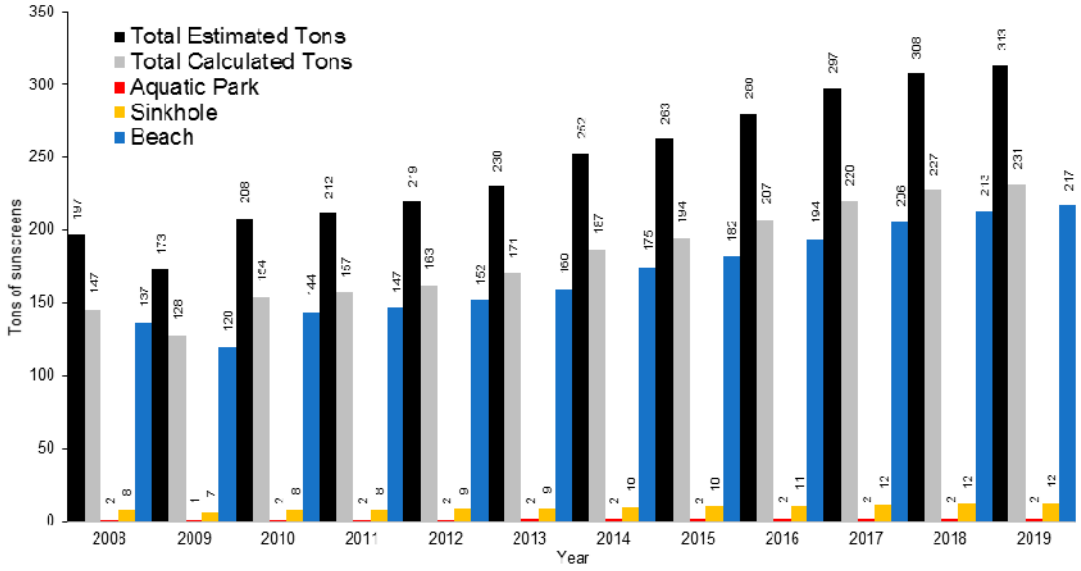

Figure 1. Estimated total sunscreen discharge by Casas-Beltran [1] and the present study for the last 12 years of tourist activity in the state of Quintana Roo, México. To determine total calculated tons (TCT), we used field-generated survey data to adjust the total estimated tons. TCT is broken down by study area: aquatic parks, sinkholes, and beaches.

In addition, our analysis of estimated discharge over the last 12 years demonstrated an increase in sunscreen discharge at beaches, water parks, and cenotes (Figure 1). The largest discharges of sunscreen occurred in the tourist destinations of Cancun and the Riviera Maya, where we estimated that more than 500 tons of sunscreen were discharged in the last 12 years. Isla Mujeres and Chetumal are the municipalities with the least total estimated discharge of sunscreens. However, the rate of increase over the last 12 years varied by municipality. The estimated total sunscreen discharge at Isla Mujeres quintupled, from 2 tons in 2007 to more than 10 tons in 2019. Cancun and the Riviera Maya doubled their estimated total discharge over the past 12 years. Chetumal, as a tourist destination, increased from a discharge of five tons in 2007 to less than nine tons in 2019. Annual sunscreen discharge in Cozumel doubled over the last 12 years (Figure 2).

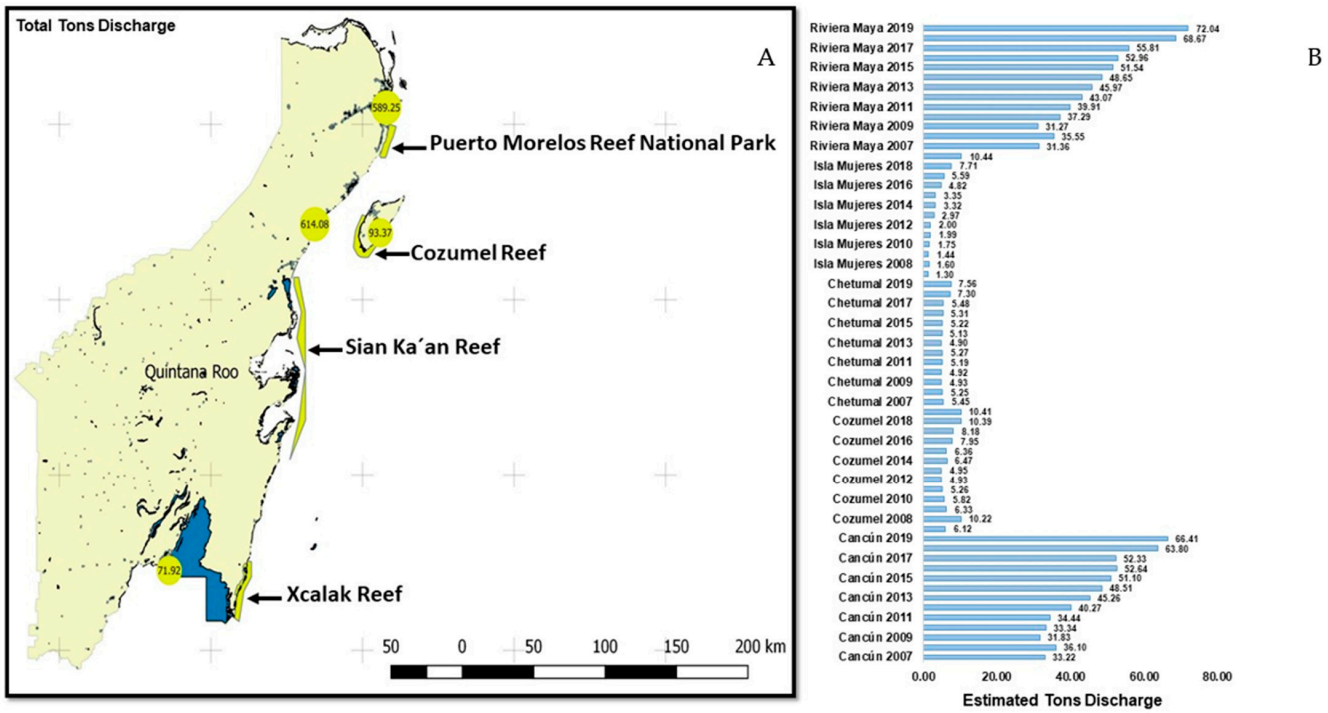

Figure 2. Estimation of the total discharge of sunscreen (TDS) in the five main tourist destinations of Quintana Roo, México, over the last 12 years. (**A**) Total discharge of sunscreen in four important reef areas of Quintana Roo, México. (**B**) Total discharge of sunscreen from 2007 to 2019 in the five principal tourism states of Quintana Roo.

Based on the results of our survey of visitors to the region, we found that approximately 29% of visitors apply sunscreen when visiting a beach, and they apply it on average 4.5 times per day. Sinkholes and water parks often require visitors to not apply sunscreen, which is reflected in our findings that only 2% of visitors to water parks applied sunscreen and they applied it an average of 1.5 times during their visit. Similarly, only 4% of visitors reported that they apply sunscreen when they visit a sinkhole, again applying an average of 1.5 times a day. Understanding what this means in terms of total sunscreen discharged to the region is challenging because the exact number of visitors per year to different locations is unknown as there are no public data available on total visitors.

The discharge calculated in the present work was adjusted with the TBS, TVEC, and TAQ values, which depend on the behavior of the tourist. This behavior can be modified by environmental legislation. Our results of the analysis of environmental legislation are described below.

There are currently no regulations regarding the use of sunscreen at beaches in the Riviera Maya, and only limited regulations elsewhere. Additionally, visitors differ in their understanding of the potential environmental harm caused by different types of sunscreen.

From our survey of visitors to the region, we found that 78% of people understood that conventional sunscreen can cause pollution, and 58% said biodegradable sunscreen can also be a pollutant. Despite this, the vast majority chose to use conventional sunscreens (not biodegradable), while 10% mentioned using biodegradable or ecological sunscreens.

In the state of Quintana Roo, the use of sunscreen in sinkholes is only regulated in two of the eleven municipalities (Solidaridad and Tulum, Table 1), which still allow the use of biodegradable sunscreens.

Table 1. Analysis of the regulation of the use of sunscreen in protected aquatic systems of the Yucatan Peninsula. FFPA: Flora and Fauna Protection Area; BR: Biosphere Reserve; NP: National Park; S: Sanctuary; BIO, biodegradable sunscreen; NONBIO, non-biodegradable sunscreen.

Category	Name	Decree Date	Year Publication of the Management	With Management Program	With Regulation of Sunscreens	Allows NONBIO	Allows BIO
FFPA	Yum Balam	1994	2018	YES	YES	NO	YES
FFPA	Isla Cozumel	2012	2016	YES	YES	NO	YES
NP	Arrecife de Puerto Morelos	1998	2000	YES	NOT		
NP	Arrecifes de Cozumel	1996	1998	YES	YES	NO	YES
NP	Arrecifes de Xcalak	2000	2004	YES	YES	NO	YES
NP	Costa Occ. de I Mujeres, Pta Cancun y Pta Nizuc	1996	2016	YES	YES	NO	YES
NP	Isla Contoy	1998	2015	YES	YES	NO	YES
NP	Tulum	1981	-	NO			
BR	Arrecifes de Sian Ka'an	1986	2014	YES	YES	NO	YES
BR	Banco Chinchorro	1996	2000	YES	YES	NO	YES
BR	Sian Ka'an	1986	2014	YES	YES	NO	YES
S	Playa de la Isla Contoy	1986	-	NO			
BR	Tiburón Ballena	2009	2015	YES	YES	NO	YES
FFPA	Bala'an Ka'ax	2005	2007	YES	NO		
FFPA	Uaymil	1994	2014	YES	YES	NO	YES
FFPA	Manglares de Nichupte	2008	2014	YES	NO		
BR	Reserva de la Biósfera Caribe Mexicano	2016	2018	YES	NO		

In the state of Yucatán, biodegradable sunscreens are permitted in sinkholes throughout the state, except in the state capital, Mérida, where no sunscreen is permitted inside the sinkholes. Finally, in the state of Campeche, there is currently no legislation that regulates or protects the quality of the water in the sinkholes (Table 2).

Table 2. Laws and regulations on state and municipal regulations of the Yucatan peninsula, about the use of sunscreen.

Laws and Regulations	Regulates Tourisms	Encourages the Conservation of Aquatic Systems	Allows Sunscreens	Type NONBIO	Type BIO
Ley de protección al medio ambiente del Estado de Yucatán, 2010 [14]	Yes	Yes	Yes	No	Yes
Reglamento de cenotes, cuevas y pozos comunitarios del municipio de Mérida, 2012 [15]	Yes	Yes	Yes	No	No
Reglamento de la Ley de Protección al Medio Ambiente del Estado de Yucatán en Materia de Cenotes, Cuevas y Grutas, 2014 [16]	Yes	Yes	Yes	No	Yes
Decreto número 117—Se establece el área natural protegida denominada reserva estatal geohidrológica del Anillo de Cenotes, 2013 [17]	No	Yes	No		
Ley del equilibrio ecológico y la protección al ambiente del estado de Quintana Roo, 2001 [18]	No	Yes	No		
Ley de Asentamientos Humanos, Ordenamiento Territorial y Desarrollo Urbano del Estado de Quintana Roo, 2018 [19]	No	Yes	No		
Reglamento de actividades en cenotes, cavernas y grutas del municipio de Solidaridad, Quintana Roo, 2017 [20]	Yes	Yes	Yes	No	Yes
Reglamento de actividades en cenotes, cavernas y grutas del municipio de Tulum, Quintana Roo, 2015 [21]	Yes	Yes	Yes	No	No
Reglamento de Ecología y Gestión Ambiental del Municipio de Benito Juárez, Quintana Roo, 2015 [22]	Yes	Yes	No		
Ley General del Equilibrio Ecológico y la Protección al Ambiente, 1994 [23]	Yes	Yes	No		

4. Discussion

More than 15 million tourists visited the Riviera Maya in 2019. Although only 8 million visited in 2020 due to the COVID-19 pandemic, tourism is expected to increase in 2021 and beyond. In areas visited by large numbers of tourists, the total discharge of sunscreen (TDS) can be high [24], even if the percentage of tourists applying sunscreen is low. For example, although proportionally fewer people apply sunscreen when visiting aquatic parks, some popular water parks receive large numbers of tourists (millions/year) and thus experience a high total discharge of sunscreen. Qualitative interviews revealed that many tourists felt a false sense of safety in the use of biodegradable sunscreen, while others found the meaning of the various terminologies used on sunscreen labels confusing, such as ecological, natural, organic, or biodegradable. All of these terms appeal to the commonly ingrained idea that "everything natural is good" [25]. However, this is not entirely true. There is little regulation of ecofriendly products, and thus the label may refer to many different things, such as the process of manufacturing the product (e.g., a reduction in greenhouse gas emissions) or the sources of the ingredients used, that may not be based on the impact of these products on aquatic and marine environments [25]. Even the term "biodegradable" is used generally to mean that a product will decompose in nature but does not specifically consider the impact on aquatic and marine environments [25].

The term "organic" is regulated by the European Union and the United States Department of Agriculture (USDA) to mean that at least 95% of the product's ingredients are produced using organic farming methods (i.e., free of synthetic fertilizers and pesticides), but has no direct bearing on the impact of this product on the natural environment [26].

Without clear guidance on what types of sunscreen products minimize risk to aquatic ecosystems, or which ingredients should be omitted from sunscreen products entirely, it is nearly impossible for tourists to make ecologically responsible decisions. However, at present, the regulation of marine areas and coral reefs is inadequate. Of the 17 local protected marine areas, 2 of them do not have management programs and thus no regulation on the use of sunscreen. Of the 15 remaining protected marine areas, only 11 regulate the use of sunscreen. Therefore, only 65% of the protected marine areas in the Mexican Caribbean have specific regulations concerning the use of sunscreens. In those protected marine areas that do regulate the use of sunscreen, tourists are only permitted to use biodegradable formulations, many of which still cause some harm to aquatic ecosystems. Even more alarmingly, the four protected marine areas that lack legislation regulating sunscreen use are the ones visited by the highest numbers of visitors annually. Thus, there is a significant need for stricter regulation of sunscreen use in all protected marine areas in the Mexican Caribbean.

The discharge of sunscreen is difficult to estimate; for example, quantitative data were reported from UV filters in seawater ($n = 11$) as an average concentration of 561 ± 941 ng/L; whereas in swimming pools, it was reported ($n = 5$), on average, as 201 ± 334 ng/L from UV filters [5]. In addition, contamination with even 1 mg sunscreen/L was already reported in the ocean [7]. For this reason, we used estimation as a tool to determine the contamination by sunscreen, considering the behavior of tourists and the number of tourists who visit a specific area, using a practical method to understand and identify the sites with high pollution. A recent study examining the toxicity of non-biodegradable and biodegradable sunscreen products on four zooplankton species from the region found that while non-biodegradable sunscreens pose high risks to aquatic life, even the biodegradable sunscreens still pose a moderate risk to these species [11]. We identified weak legislation, especially given the reports of the adverse effects of sunscreen on aquatic ecosystems and the tons of sunscreen that potentially discharge into the water. From an international point of view, efforts have been made to prohibit their use as strict measures; however, based on our data, these actions should be individualized based on discharge estimates, identifying areas of high contamination and high-tourism seasons. The use of non-toxic sunscreen should be encouraged and analyzed, as performed by Hernandez-Pedraza et al. [11].

We also know that the strategies that help to modify or strengthen legislation and encourage appropriate use of sunscreen by tourists will significantly help the discharge of chemical substances into the water, thus reducing the amount applied, and encourage better choices regarding behavior or the type of sunscreen. The estimation of the discharge of sunscreen is a unique tool for society, governments, and academics because the formula can be used in a particular region, for example, water park, hotel zone, or public beach, to determine the potential contamination caused by tourists who visit these sites to engage in aquatic activities.

Sunscreen discharge from tourists also occurs at inland sinkholes. Although sinkholes represent only 15% of the sites visited by tourists, these have been increasing in popularity as tourists seek alternatives to beaches that are increasingly polluted by massive quantities of seaweed [12]. Increasing sinkhole tourism has been economically beneficial for local communities, but poses risks to these fragile freshwater as they are not well-protected by environmental regulations. Sinkhole owners may discourage tourists from applying sunscreen, or require them to shower before swimming in sinkholes, but legal protections of these aquatic ecosystems are scarce. Our data estimating the discharge of sunscreen to water parks, beaches, and cenotes suggest other additional pollution problems such as enrichment, resulting in eutrophication of water, due to the discharge of other substances for personal use, such as personal products, antibiotics, and others; and compounds in creams, deodorants, and detergents. Due to the increase in the population and the increase in tourism. The contamination by sunscreen and other substances for personal use poses a challenge for society, governments, and academics because everyone must participate in the usage, regulations, and protection of the environment. It is important to continue regularly estimating the discharge of sunscreen into aquatic systems as an indicator of environmental pollution associated with tourism. In the Riviera Maya, local policies prohibit the use of conventional sunscreens in marine parks, and visitors to cenotes are required to shower prior to entering cenotes. However, our results show that most visitors are still using conventional sunscreens at beaches, cenotes, and coral reefs despite knowing about their potential to contaminate the water. Much of this appears to stem from confusion about environmentally friendly types of sunscreen, and the lack of alternative sun protection options. Most visitors reported being willing to adopt environmentally friendly behaviors, but are in a position of having to balance personal health in terms of sun protection with concerns about the environment and a lack of options, especially as biodegradable sunscreens can be toxic to marine life. To better promote the protection of aquatic ecosystems in the Riviera Maya, more rigorous laws or policing are required that incentivize sunscreen manufacturers to provide more ecologically friendly choices to consumers. An example of this is Hawaii's Gold Standard law, passed in 2018, where they prohibited every sunscreen containing oxybenzone and octinoxate, which are destroying coral reefs.

5. Conclusions

The Mesoamerican Reef System, as well as the inland water bodies in the Mexican Caribbean, are at risk of contamination due to the intensive use of sunscreen [13] due to the 229.76 tons of sunscreen applied by the 17 million tourists who visit them entering local aquatic ecosystems over the last 12 years [3,13]. We found that three tourist areas showed the largest increase in total sunscreen discharge over the 12-year period from 2007 to 2019: Cancun, Isla Mujeres, and the Riviera Maya. The three areas should be a priority for studying the adverse effects of the direct or indirect discharge of sunscreen, as well as increased management efforts. Stricter regulation of sunscreen in both protected marine areas and inland water bodies is essential to the future health of these aquatic ecosystems; without specific regulations, the health of these aquatic ecosystems will be dependent on the responsibility of individual tourists to make environmentally friendly choices. In the absence of strong regulations, improved labeling practices would provide clearer information to tourists clarity regarding environmentally safer choices when purchasing

sunscreen. Finally, visitors to the region need to be better educated about the impacts of sunscreen on the marine and aquatic environment caused by sunscreens, since 90% of those surveyed continue to use conventional sunscreens, and in the case of those using biodegradable products, more than 40% were unaware that these products may still cause harm. Because the Mesoamerican Reef System is increasingly fragile due to the combined threats of climate change and pollution, it is imperative that the regulation and use of sunscreen products be improved to protect the future health of the reef as well as the health of inland freshwater ecosystems [27].

Author Contributions: All authors contributed in a variety of ways. Conceptualization, D.A.C.-B., C.M.G., J.A.-F., R.M.L.-B. and M.L.; Data curation, K.F.-M. and E.H.-Y.; Formal analysis, D.A.C.-B. and J.A.-F.; Investigation, D.A.C.-B., K.F.-M., E.H.-Y., C.M.G. and J.A.-F.; Methodology, D.A.C.-B.; Project administration, R.M.L.-B. and M.L.; Resources, R.M.L.-B. and M.L.; Writing—original draft, D.A.C.-B. and J.A.-F.; Writing—review & editing, C.M.G., R.M.L.-B. and M.L.. All authors contributed to the writing and review of this manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research was conducted using support from NSF award EHR-1560045. Project #2944, Cathedra's CONACYT, also funded this work.

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Northern Illinois University (#HS19-004, approved 3/6/2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We would like to express our sincere thanks to the participants that participated in this research project: persons from the Sinkhole Route of Puerto Morelos, Quintana Roo, México.

Conflicts of Interest: The authors declare no conflict of interest.

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