

# How important are artificial reefs to the tourism industry? A review of the literature

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## Abstract

The main objective of the present study is to review the published scientific literature related to recreational or tourist activities and artificial reefs (AR). The paper covers different geographical contexts and determines the relevance of AR tourism. The content analysis methodology is in two parts: a protocol for reviewing the literature containing the words “artificial reef(s)” and “tourism” published in four different science portals, and a systematic review of the study objectives in the eligible literature. The results highlight the evolution of and trends in scientific production in the field of AR tourism from 1991 to 2020. While the number of AR papers generally has been increasing in the last decade, there are still few papers covering AR tourism. The results show which countries produce more literature related to AR tourism, the analytical methods used, the focus, the impact factor of the top ten countries, the areas/categories of knowledge covered, and the main tourism journals where papers are published. This literature analysis intends to make a connection between artificial reefs and potential interest aroused in the tourism industry.

**Keywords:** diving tourism, recreational, reef tourism, sport fishing, surf tourism, stakeholders.

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## 1. Introduction

Based on an empirical assumption verified centuries ago that sunken structures allowed marine organisms to aggregate, the idea of establishing artificial reefs began to spread (Chou, 1997). Presently, it is commonly accepted that artificial reefs (AR) can generate substrate for living organisms (Vivier *et al.*, 2021). The three-dimensionality of AR makes it possible to attract or aggregate marine species in empty sites that are sandy or hollow (Smith *et al.*, 2017).

In the last 50 years, AR have been widespread all over the world, not only in saltwater, but also in freshwater (Creque *et al.*, 2006). They have essentially served various purposes, including the protection of marine species, particularly the macroalgae fields (kelp) (Tsiamis *et al.*, 2020); the improvement of fisheries (Watanuki & Gonzales, 2006); and tourism-related activities such as leisure/recreational diving (Brock, 1994), sport angling (Baine, 2001), surfing (Black & Mead, 2009; Lopes & Bicudo, 2017), or other educational and conservational aspects (Dalton, 2006).

Diving tourism is highly sought after in some countries, namely in tropical countries with clear waters and natural reefs (including corals) (Seaman, 2000). However, many of these natural reef sites are under great pressure. Thus, it has been decided to deploy AR to somehow assume a role identical to that of natural reefs and alleviate the anthropogenic pressure on them (Kirkbride-Smith *et al.*, 2013; Oliveira *et al.*, 2015; Polak & Shashar, 2012; Stolk *et al.*, 2005). In certain places, artificial coral reefs are made to mimic natural ones (Perkol-Finkel *et al.*, 2006).

In 2020, the COVID-19 pandemic influenced tourism demand globally, including AR tourism (Fotiadis *et al.*, 2021). The scientific literature produced on AR portrays this (China *et al.*, 2021).

The main objective of this paper is to analyse the scientific production on tourism related to AR by performing a search on four search engines (Ingenta Connect, Google Scholar, ScienceDirect, and ScELO) from 1991 to 2020. The search aims to ascertain the number of articles published that are related to the key terms/words related to “artificial reefs” and “tourism”, namely “diving”, “sport fishing”, “surfing”, and “other related activities”. The main authors are identified and the countries in which scientific literature is produced in each of the reef tourism activities. The most used analysis methods are identified. The occurrence of the most frequent words in the article titles is determined. The average impact factor of the top ten countries producing AR scientific literature is evaluated through a combined analysis of indicators. The main subject areas/categories of research where the papers are published are also identified. Finally, the paper offers an overview of the category of tourism, leisure and hospitality management and the main journals indexed in this category.

The present study will thus describe the development of research in AR and tourism by identifying the literature produced on the interconnection of these two themes. This study is intended as an important reference for researchers undertaking future research on this subject. In this study, after introducing the reef theme, the literature on AR and its potential connection with tourism is reviewed. In the following section, the research method is described to find published literature linking the two themes. In the fourth section, the results are presented in accordance with the methodology. Afterwards, the results are discussed. The final part of the study contains conclusions, limitations and suggestions for future research.

## 2. Literature review

Conceptually, AR can be submerged not only for environmental but also for socioeconomic purposes. One objective with a more human utility aspect is to deploy AR for diving or angling and thus expand

the recreational and tourist offer (economic activities). Here a question arises: how important are artificial reefs to the tourism industry? In this sense, it is important to carry out a literature review to investigate what has been published.

The scientific literature on AR is quite extensive (Baine, 2001). However, tourism-related reef literature on artificial structures remained quite scarce until 2020 (e.g. Schaffer & Lawley, 2008). Only recently has some literature been published on this specific topic (e.g. Isdianto *et al.*, 2022; Özgül & Lök, 2022). Tourism on AR is essentially linked to scuba diving (Oh *et al.*, 2008; Saayman & Saayman, 2018). The most sought-after areas for diving are in warmer water zones, which are in tropical areas (Stolk *et al.*, 2007). There is also some connection between AR and sport fishing (Keller *et al.*, 2016). In areas closer to the coast, AR are sometimes developed to create waves to be used in surfing (Fletcher *et al.*, 2011). AR can also have other purposes related to tourism in terms of conservation and education (Edney & Spennemann, 2015).

The United States, particularly the southernmost states, has the largest number of AR tourism-related activities (Hindsley *et al.*, 2023; Seaman & Jensen, 2000), while the link between AR and tourism in South America is less evident. In South America, Brazil leads activities with AR (Hackradt *et al.*, 2011), followed by other countries such as Colombia where several socioeconomic studies have been carried out (Castro, 2001). In the Pacific, the Philippines use AR for tourism purposes, as do neighbouring countries in Southeast Asia such as Indonesia, Thailand and Malaysia (Olewiler *et al.*, 2016). Research is carried out in West Africa—namely in Kenya, but it is focused more on habitat restoration than on the duality of AR and tourism (Crabbe & McClanahan, 2006; Knoester *et al.*, 2023). In the Middle East, in Israel and Egypt, there are many activities related to AR tourism (Stolk *et al.*, 2007). In Europe, in the Mediterranean basin, countries such as France, Italy, Spain and Greece have also developed some AR tourist activities (du Plessis & Saayman, 2017; Westerberg *et al.*, 2013). In the North-East Atlantic strip—for example, in the south of England, Portugal and Cape Verde—reefs with tourist usufruct have also been established (Fabi *et al.*, 2011; Oliveira *et al.*, 2015).

In terms of scuba diving, it is in the United States that the largest projects are made to serve diving tourism, essentially on sunken ships in Florida and California (Pendleton, 2004). There is an aspect also occasionally used for tourist purposes, which is rigs-to-reefs, where obsolete structures used in the production of oil and natural gas are transformed into AR (Smyth *et al.*, 2015). There are also several AR in Australia, where they try to mitigate the harmful effects of mass diving tourism somewhat (Edney & Spennemann, 2015). In Israel and Egypt, dives are also carried out on AR essentially made from corals located in the Gulf of Aqaba and in the Red Sea area (Hilmi *et al.*, 2018). In Europe, the waters are not so clear, and dives are made in areas of sunken ships and concrete blocks (Lee *et al.*, 2018). In Indonesia, the Philippines and Malaysia, reef dives are performed in areas presenting submerged sculptures, a little like some other tropical destinations (Dunning, 2018).

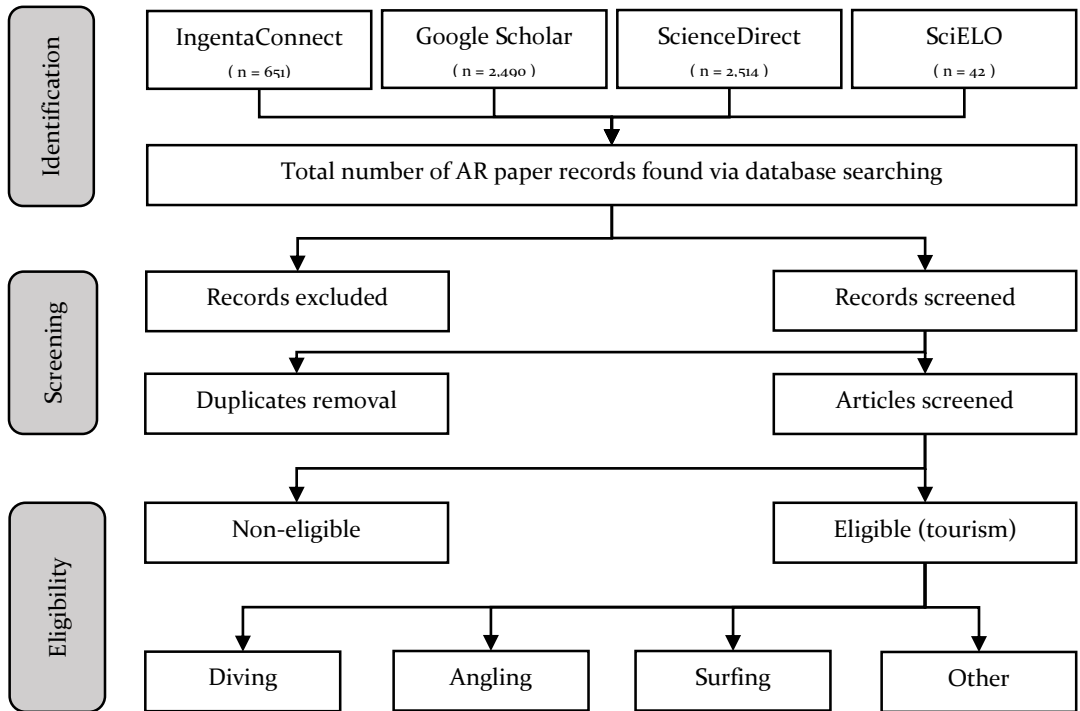
### 3. Methodology

In this article, a bibliometric analysis is used to study articles that cover the themes of both AR and tourism. For the bibliometric analysis, the databases and the keywords for the search were chosen. In addition, the main authors and the places where the studies were carried out were determined. A chronological analysis is also carried out and any increase or decrease in interest in the research topic is verified.

It should be noted that the present study was restricted to publications in English. This is a limitation of the analysis in the present literature review: it means that the scientific work produced in AR and tourism is underrepresented.

### 3.1 Protocol for literature review

In this bibliometric analysis, the sampling protocol is carried out in three phases: identification, screening, and eligibility of articles to carry out the literature analysis (Figure 1).



**Figure 1.** Flowchart of the three-stage bibliometric analysis approach. Source: Author’s own elaboration.

For identification, four scientific databases were chosen (Ingenta Connect, Google Scholar, ScienceDirect, SciELO). In total, 5,697 documents were identified. As not all these documents are relevant to the scientific study, the screening only selected articles that derived from publication in an indexed scientific journal, or related articles such as peer-reviewed book chapters. Grey literature was excluded — e.g. doctoral and master's theses, as well as abstracts published in conference proceedings.

Regarding the eligibility of articles or book chapters, all those whose theme was within the subject of AR but was not related to tourism were excluded. Therefore, all those articles relating to biological, physical, chemical, engineering, oceanography and other issues were excluded.

### 3.2 Bibliometric analysis

For the literature assessment, it was decided to carry out an investigation of the literature through bibliometric analysis (e.g. Ellegaard & Wallin, 2015). An adaptation was made to the AR tourism case, involving nine main steps.

The first step was to take note of the year of publication of the articles. It is important to note that the experimental part of the articles’ research usually does not correspond to the publication date.

The second step was to find what was the purpose of AR and their relationship with tourism: diving, sport fishing, surfing or other related activities. Only articles focusing on at least one of these human

activities in some detail were considered. Articles referring to other less explicit activities were not considered.

The third step was to know the scale and coverage of each reef study—that is, whether the coverage was only local, covered a region, or had a national, continental or even global scope.

The fourth step was to know the location of the reef—that is, in what country and place each AR under analysis was located. The country and institution of the first author of each article were also identified. The reef location did not always coincide with the nationality of the first author.

In the fifth step involved understanding the analytical method used to gather the data for each article. Methods used are not always singular and can be combined. The generalist approaches used to classify the studies were based on the following analytical methods: analytic hierarchy process (AHP; Saaty, 2003), case study (Yin, 2014), cost-benefit analysis (CBA; Atkinson & Mourato, 2008), interview (Fontana & Frei, 2005), multi-criteria analysis (MCA; Munda *et al.*, 1994), qualitative research (Yin, 2015), literature review (Rowe, 2014), stakeholder analysis (Brugha & Varvasovszky, 2000), and surveys in social research (de Vaus & de Vaus, 2013).

The sixth step was to verify the focus of each article. To this end, the titles of each of the 112 articles were analysed and an analysis was performed in NVivo™ to determine the frequency of words in a qualitative analysis in a word cloud.

In the seventh step, it was important to know the impact factor of the articles on AR in the ten main countries of origin of the first author. In this sense, the *h*-index and ranking in the Scimago Journal & Country Rank (SJR; SCImago, n.d.) were analysed.

The eighth step involved identifying the main scientific areas/categories of the articles found and grouping them. This separation allowed relationships to be established between the different areas of knowledge related to AR tourism.

Finally, the ninth step aimed to identify where the articles found in AR tourism were published with specific reference to the category of tourism, leisure and hospitality management. It was also important to list other characteristics of the articles (i.e. authors, publication date, article title).

**Table 1.** *Literature analysis for AR articles related to tourism.*

Step	Description
1	Reference year
2	Purpose of tourism: diving, angling, surfing, other
3	Scale of study's coverage: local, regional, national, continental, or global
4	AR location (country/place) and country of the institution of first author
5	Analytical method (sampling)
6	General focus (word frequency criteria - word cloud)
7	Impact factor for the papers published (top-10 countries)
8	Subject categories of research
9	Papers in the category of "Tourism, leisure and hospitality management"

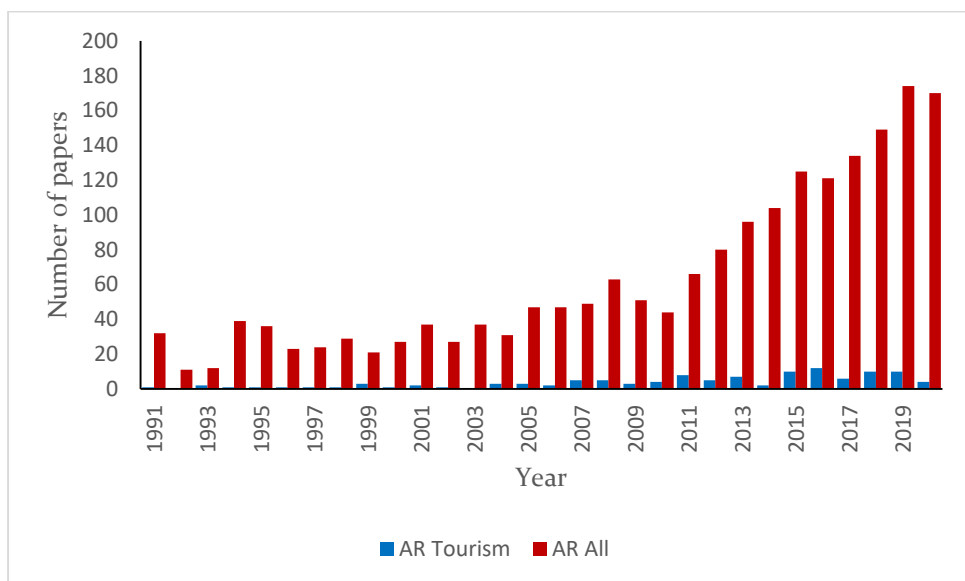
Source: Adapted from Lima *et al.* (2019).

## 4. Results

### 4.1 Number of publications per year (1991-2020)

In the last 30 years, the number of articles in reef literature covering all subjects is considerable (Figure 2). Between 1991 and 2000, the production of reef literature covering all subjects reached an average of about 25 articles per year. From 2001 to 2010, the average rose to around 43 articles per year. From 2011 to 2020, the trend grew: the number of publications has practically tripled in absolute numbers with an average of about 122 articles per year.

Articles related to tourism in AR are still relatively scarce compared to the total number of articles on these structures. In the present study, the author identified 112 relevant articles. The average for the decade from 1991 to 2000 was 1.2 articles per year. Between 2001 and 2010, the average more than doubled to around 2.8 articles per year. From 2011 to 2020, the average almost tripled to 7.4 articles per year.



**Figure 2.** Time-series of papers published on AR since 1991 to 2020 ( $n_{All} = 1,906$  and  $n_{Tourism} = 112$ ).

### 4.2 Study type and scale by continent and activity

Regarding coverage by continents, most studies on AR tourism were carried out in America, followed by Europe (Table 2). The largest number of articles found had a national or regional scope. Of the 112 articles selected, 45 were national studies and 38 regional studies.

Most articles are related to diving (58), while the smallest number of articles found is related to surfing (3). There are a few articles related to sport fishing (8) and a larger number of articles related to other tourism issues such as education and conservation, or not well defined (43).

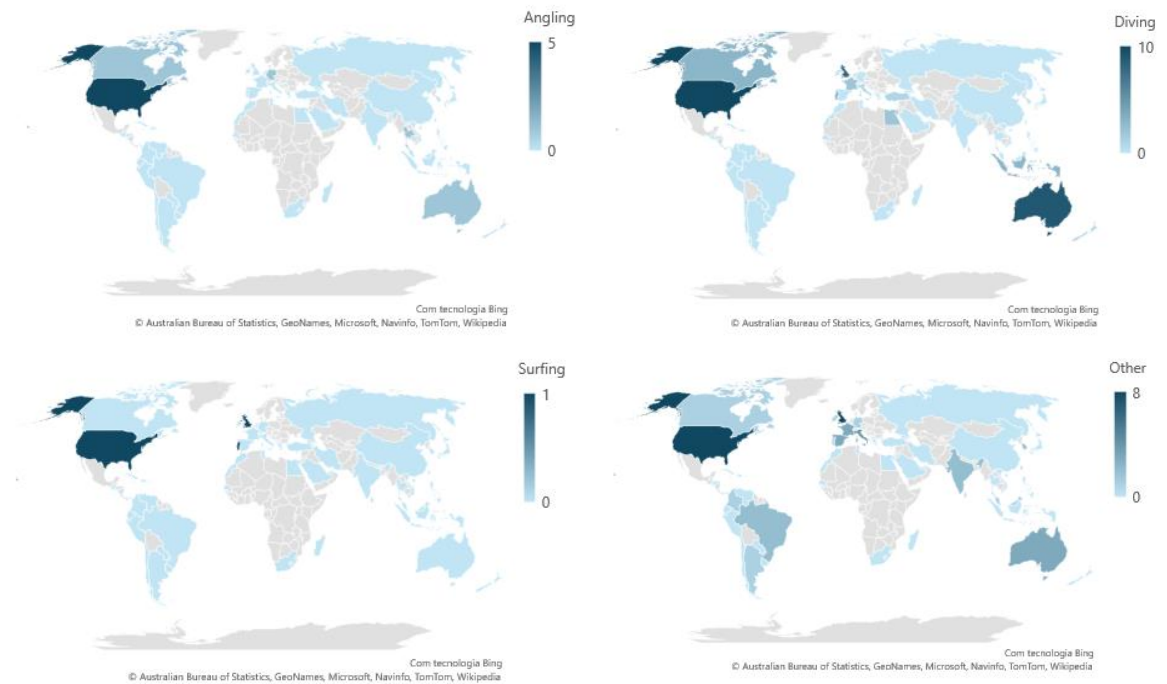
As for the materials used for AR, the articles published refer to a wide variety; it is also dependent on the type of activity considered. For example, AR with the purpose of surfing use geo-textiles in their manufacture. There are some articles that mention several types of AR simultaneously, while others stick to a single type of AR, such as the use of obsolete ships that are sunk to be used for diving.

**Table 2.** Results from the literature analysis of tourism activities related to AR Abbreviations refer to diving (D), angling (A), surfing (S) and other activities (O).

Continent	Africa (n=6)				America (n=35)				Asia (n = 24)				Europe (n=28)				Oceania (n=19)									
Activity type	D	A	S	O	D	A	S	O	D	A	S	O	D	A	S	O	D	A	S	O						
<b>Scale of study</b>																										
Local (n=6)					1				1					1				1				2				
Regional (n=38)	4				7	4	1	2	7					1	2			1	5				4			
National (n=45)	1				7	1			3	5					9	2	1	1	5	6	2				3	
Continental (n=5)									1													4				
Global (n=16)	1				3				5					1	3			2	1				1			
<b>Total</b>	<b>6</b>				<b>18</b>	<b>5</b>	<b>1</b>	<b>11</b>	<b>13</b>					<b>11</b>	<b>8</b>	<b>1</b>	<b>2</b>	<b>17</b>	<b>13</b>	<b>2</b>				<b>4</b>		

4.3 Country of affiliation of first author by tourism activity

The US is the most representative country for all reef tourism activities (Figure 3). In scuba diving, alongside the United States, Australia is one of the largest scientific producers on the subject. The United States also produced more scientific literature related to AR for sport fishing. Literature is scarce regarding AR and surfing: only three articles were found, relating to the United States, the United Kingdom, and Portugal.



**Figure 3.** Density world map of AR tourism.

Note: Figure 3 is split up into four images as follows: angling (top left), diving (top right), surfing (bottom left), and other activities (bottom right) according to the number of papers found in the literature search.

Source: Author’s own elaboration based on Ingenta Connect, Google Scholar, ScienceDirect, and SciELO.

#### 4.4 Analytical methods by type of reef tourism

As far as analytical methods in tourism-related AR studies are concerned, most review other articles, use surveys, or employ other combined methods of analysis (Table 3). To interpret this table better, it is important to explain that the left column includes AHP, CBA, and MCA. In addition, N refers to all papers, D to diving, A to angling, S to surfing and O to other. There are also some articles that make use of stakeholder analysis and qualitative descriptive methods. Studies using a simple method such as interviews, a case study and CBA are less common.

**Table 3.** Analytical methods used for AR tourism studies ( $n = 112$ ).

Method	N	D	A	S	O	Authors
AHP	3	3				Ramos <i>et al.</i> (2006); Dey & Ramcharan (2008); Hidayah <i>et al.</i> (2016)
Case-study	2		1		1	Dafforn <i>et al.</i> (2015); Boucquey (2017)
CBA	1	1				Choi <i>et al.</i> (2016)
Interview	5	2		1	2	Fitzsimmons (2008); Fletcher <i>et al.</i> (2011); Hillmer-Pegram (2014); Hogarth & Wójcik (2016); Hooper <i>et al.</i> (2015)
MCA	2	1			1	Harik <i>et al.</i> (2017); Reguero <i>et al.</i> (2018)
Other	27	13		2	12	Gangai & Ramachandran (2010) ; Garrod (2007) ; Genzano <i>et al.</i> (2011) ; Harris (1995); Jensen (2002); Kheawwongjan & Kim (2012); Kim <i>et al.</i> (2016) ; Merchant (2018); Ng <i>et al.</i> (2013) ; Rico <i>et al.</i> (2019) ; Rinkevich (2015) ; Rybaczuk (2001) ; Santos <i>et al.</i> (2013) ; Siciliano <i>et al.</i> (2016) ; Simón <i>et al.</i> (2004) ; Slotkin <i>et al.</i> (2009) ; Suckale <i>et al.</i> (2018) ; Talberg <i>et al.</i> (2018) ; van Treeck & Schuhmacher (1999a) ; van Treeck & Schuhmacher (1999b); Verkoeyen & Nepal (2019); Wessel <i>et al.</i> (2018) ; Whelchel <i>et al.</i> (2018) ; Wilhelmsson <i>et al.</i> (1998); Yoon <i>et al.</i> (2016); Zanuttigh (2011); Zhang <i>et al.</i> (2016)
Qualitative descriptive	9	5	1	3		Ariadi <i>et al.</i> (2018); As-Syakur & Wiyanto (2016); Bideci & Cater (2019); Castanhari <i>et al.</i> (2012); Causon & Gill (2018); Creque <i>et al.</i> , (2006); De Brauwer <i>et al.</i> (2018); Dimmock & Musa (2013); Saharuddin <i>et al.</i> (2012)
Review	27	10	2		15	Ammar (2009); Bolding (2004); Bonanno & Orlando-Bonaca (2019); Brock (1994); Choi (2019); Edney & Spennemann (2015); Fabi <i>et al.</i> (2011); Fernandez (1996); Flaherty & Karnjanakesorn (1993); Foldvary & Hammer (2016); Francour <i>et al.</i> (2001); Genç <i>et al.</i> (2017); Guerra <i>et al.</i> (2015); Hardiman & Burgin (2010); Koseoglu <i>et al.</i> (2016) ; Ocke & Ikeda (2013); Pears & Williams (2005); Pendleton (2004); Pendleton (2005); Pereira <i>et al.</i> (2018); Relini <i>et al.</i> (2007); Seaman & Depper (2019); Smyth <i>et al.</i> (2015); Sreekanth <i>et al.</i> (2019) ; Stolk <i>et al.</i> (2007) ; Sutton & Bushnell (2007); Valentine (2011)
Stakeholder analysis	10	6	2	2		Angelelli & Saffache (2010); Anisimov <i>et al.</i> (2020); Bar-On, (1993); Eggen (1997); Enemark (2000); Evans <i>et al.</i> (2019); Fidelman <i>et al.</i> (2019); Hattam <i>et al.</i> (2020); Momtaz & Gladstone (2008); Read <i>et al.</i> (2011)
Survey	26	17	2	7		Belhassen <i>et al.</i> (2017) ; Börger <i>et al.</i> (2015) ; Chen <i>et al.</i> (2015) ; Ditton & Baker (1999) ; Holland (1991) ; Jakšić <i>et al.</i> (2013) ; Kemperman (2021) ; Kirkbride-Smith <i>et al.</i> (2013) ; Kirkbride-Smith <i>et al.</i> (2016) ; Klain <i>et al.</i> (2020) ; Lewin <i>et al.</i> (2020) ; Minelli <i>et al.</i> (2021) ; Morgan & Huth



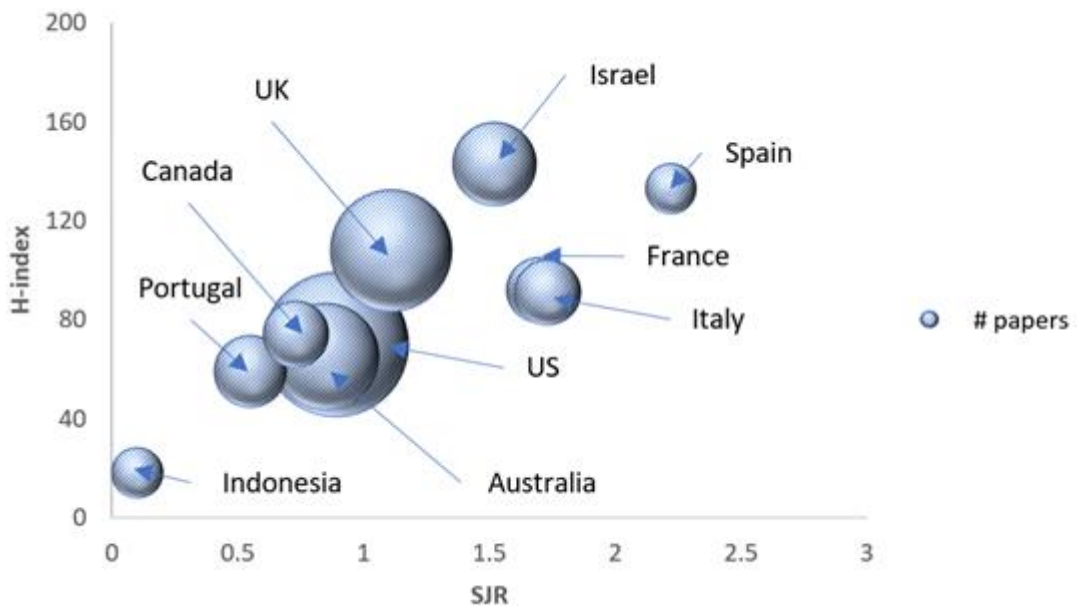


#### 4.6 Impact factor of papers related to reef tourism

A higher impact factor suggests that that country's research is being published and cited in influential journals, which can improve the reputation of the country's research output on the topics under review. A higher impact factor is associated with higher quality research and prestige among peers. Therefore, a country's ability to publish in journals with higher impact factors is reflected in the quality of its production in that specific area.

However, there are constraints associated with relying on impact factors to assess a country's research production on a specific topic. For example, most of the highest impact journals are published in English, thus not contributing to research in developing countries regardless of the quality of their research. Furthermore, impact factors only measure the impact of journal citations and do not provide information about the broader social impact of a study or its relevance to local contexts.

The ten countries that have produced the most scientific literature related to AR and tourism are shown in Figure 5. Two metrics were used: the bibliometric parameter *h*-index and the ranking in the SJR. For this analysis, the country of origin with which the first author of each article was affiliated was verified. The United States is the country where the most scientific articles were found, followed by the United Kingdom and Australia. The country with the highest SJR indicator was Spain, followed by Italy and France with similar values in both the SJR and the *h*-index. The last place in the top ten in these indexes was Indonesia. The country with the highest *h*-index indicator was Israel.

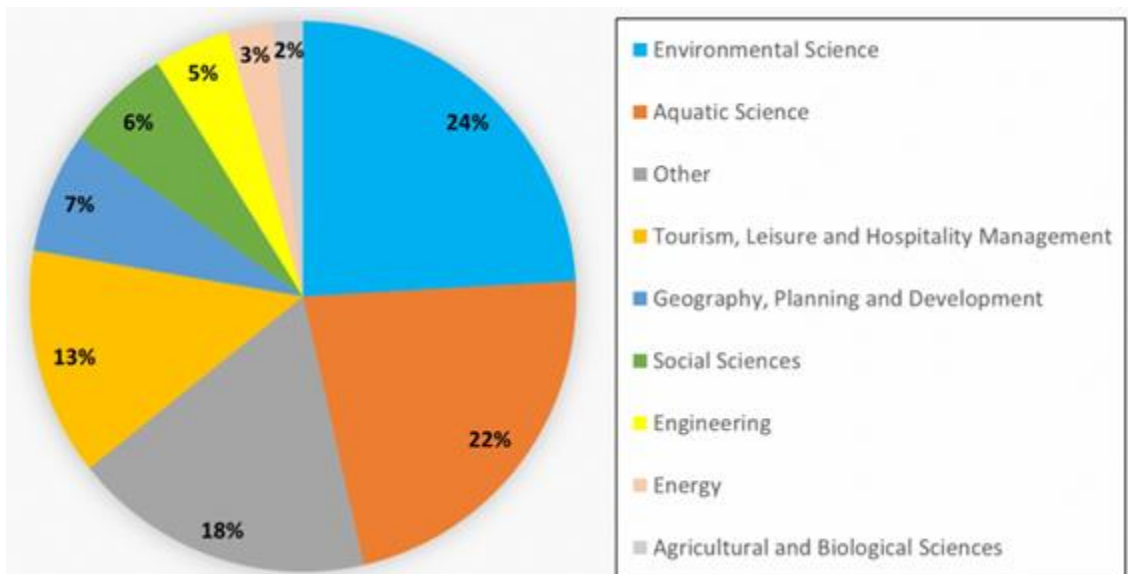


**Figure 5.** Impact factor of AR tourism related papers (top ten countries).

#### 4.7 Subject categories of research for papers in AR tourism

From 1991 to 2020, research in AR tourism covered more than 20 categories. Figure 6 shows the eight main categories of journals indexed in the SJR. "Other" is not considered a category per se, since it refers to the exception of papers found essentially in books or journals with another type of indexing than in the SJR. "Other" also included categories where only one article was found (including multidisciplinary ones). The most prominent categories are environmental science (24%) and aquatic science (22%). The category of tourism, leisure and hospitality management yielded the third highest number of articles.

It should be noted that the social sciences category comprised several disciplines, including economics, sociology, anthropology and communication.



**Figure 6.** Subject categories of research for papers in AR tourism.

Source: Adapted from SCImago, (n.d.).

#### 4.8 AR tourism papers in the category of Tourism, Leisure and Hospitality Management

Of the 15 papers published in journals in the category of tourism, leisure and hospitality management and referring to AR activities, eight are conceptual applications and the rest related to applied cases (Table 4). From the conceptual papers, the underlying theories are related to economic evaluation methods applied to tourism studies, reuse of obsolete ships and their conversion to AR, carrying capacity, or sustainability aspects related to coastal infrastructures where AR are included. The journal *Tourism Management* published the largest proportion of articles (4 out of 15). In the remaining seven journals, only a couple of articles were published in four of them, while the remaining three journals published only one.

### 5. Discussion

In the period under analysis (1991–2020), the first twenty years saw relative consistency in terms of scientific production related to AR in general with very few articles related to AR and tourism. However, in the last decade there has been an increase in scientific production related to AR: there has been a steady rise in the number of articles published dealing with tourism related to this type of structure. Several factors may have contributed to the increase in the number of published articles about AR and tourism in the last decade compared to previous years.

*Growing interest and awareness.* Over the past decade, there has been growing interest and awareness among researchers, policymakers and stakeholders of the potential benefits of AR for tourism. As a result, there has been an increase in research activity in this area.

**Table 4.** Papers referring to AR tourism on the category of tourism, leisure and hospitality management” (*n<sub>TLHM</sub>* = 15).

Authors	Title	Year	Journal	Categorization
Bar-On	Coast cities, tourism and environment.	1993	Tourism Management	Conceptual application
Fitzsimmons	Why dive? And why here? a study of recreational diver enjoyment at a Fijian eco-tourist resort.	2008	Tourism in Marine Environments	Applied case
Flaherty & Kar-njanakesorn	Commercial and subsistence fisheries conflicts in the Gulf of Thailand: the case of squid trap fishers.	1993	Applied Geography	Applied case
Hillmer-Pegram	Understanding the resilience of dive tourism to complex change.	2014	Tourism Geographies	Conceptual application
Jakšić <i>et al.</i>	Impacts of artificial reefs and diving tourism.	2013	Turizam	Conceptual application
Kemperman	A review of research into discrete choice experiments in tourism: Launching the Annals of Tourism Research Curated Collection on Discrete Choice Experiments in Tourism.	2021	Annals of Tourism Research	Conceptual application
Koseoglu <i>et al.</i>	Bibliometric studies in tourism.	2016	Annals of Tourism Research	Conceptual application
Ng <i>et al.</i>	Seeking harmony in coastal development for small islands: exploring multifunctional artificial reefs for São Miguel Island, the Azores.	2013	Applied Geography	Applied case
Rico <i>et al.</i>	Carbon footprint of tourism in Barcelona.	2019	Tourism Management	Applied case
Seaman & Depper	Visiting scuttled ships: An examination of the important elements of the wreck diving experience.	2019	Tourism in Marine Environments	Conceptual application
Shani <i>et al.</i>	Artificial reefs and mass marine ecotourism.	2012	Tourism Geographies	Conceptual application
Simón <i>et al.</i>	Carrying capacity in the tourism industry: a case study of Hengistbury Head.	2004	Tourism Management	Applied case
Stolk <i>et al.</i>	Perceptions of artificial reefs as scuba diving resources: a study of Australian recreational scuba divers.	2005	Annals of Leisure Research	Applied case
Stolk <i>et al.</i>	Artificial reefs as recreational scuba diving resources: a critical review of research.	2007	Journal of Sustainable Tourism	Conceptual application
Westerberg <i>et al.</i>	The case for offshore wind farms, artificial reefs and sustainable tourism in the French Mediterranean.	2013	Tourism Management	Applied case

*Expansion of artificial reef projects.* In recent years, new projects have provided researchers with more opportunities to study the impacts of AR on tourism and related socioeconomic factors.

*Technological advances.* Underwater survey techniques, remote sensing technologies and data analysis tool, have made it easier and less expensive for researchers to study AR and their effects on tourism. These technological advances may have contributed to the increase in science production in this area.

*Recognition of economic importance.* The economic importance of tourism, particularly in coastal areas where AR are frequently established, has been recognised in recent years. Various stakeholders are interested in understanding how AR can attract tourists, improve recreational opportunities and contribute to local economies, thereby increasing research into this thematic duality.

*Environmental concerns and conservation efforts.* AR are often deployed to aid marine conservation and habitat restoration. With increasing concern about the health of marine ecosystems and sustainable management practices, there has been growing interest in studying the impacts of AR, including their role in supporting tourism.

It is essentially on the American continent that more scientific articles related to reef tourism are produced. The selection of publications related to AR tourism showed that the activity of diving is well developed, as this is the area in which more articles are published (Bideci & Cater, 2019). These articles focus on low latitudes and tropical countries with relatively warm waters which are more favourable to the practice of this tourist activity. This trend is constant for all continents except Europe, where more articles related to other aspects of tourism prevail (e.g. education or conservation).

Most of the published studies have national or regional coverage. They demonstrate the existence of reef programmes in large countries such as the United States and Australia, where this type of AR programme exists in certain states. In the case of Europe, there are AR with diverse objectives (Fabi *et al.*, 2011). There are relatively few articles on tourism and AR on the African continent, and it is not surprising that all of them are related to non-extractive practices concerning marine resources such as diving. In Asia, there is more literature related to reef tourism and diving at a regional level and other types of reef tourism activity on a national scale. This fact may indicate the encouragement of sea tourism businesses and education and other practices related to the protection and sustainability of marine resources (e.g. Bottema & Bush, 2012).

Articles covering the widest range of AR topics can be found in large countries and territories. However, in the case of studies related to AR tourism, fewer countries have published articles. More articles related to diving can be found in North America and Oceania, where the United States and Australia lead the number of articles published. In sport fishing, the United States also tops the list of countries with the highest number of titles published. Published articles related to surfing on AR are relatively scarce. The countries with the most publications focusing on other issues related to tourism are America and Europe (Jensen, 2002).

For the theme of AR tourism, the chosen analysis methods are essentially qualitative and generally involve a review, survey, or other unspecified or more general method. More specific methods, which generally presuppose less flexibility or greater difficulty in their application—as is the case of MCA and the AHP—are much scarcer in the reef literature related to tourism. As AR usually involve several actors (users and non-users), analytical methods that allow a more flexible approach, such as stakeholder analysis, appear more frequently in the AR articles linked to tourism. There are also some published articles involving stakeholder analysis methods, as they are the most applied in social sciences.

For AR tourism, the most common focuses are on the management of reefs, coral, and recreational activities in general. In AR tourism typologies, diving is a very recurrent word. The same is not true for sport fishing or surfing. This finding may suggest that in terms of tourism, there is more demand for diving than for other activities. By the same token, the prevalence of AR for diving exceeds other suggested uses.

There are countries that have many publications involving AR associated with tourist activities, such as the United States, the United Kingdom and Australia. However, Israel has the highest *h*-index related to papers published on AR tourism. Spain, in turn, has the most relevant SJR (SCImago, n.d.).

Based on the SJR, it can be said that, of the analysed papers, the largest proportion of the literature is in the area of environmental science, not specifying a particular category (SCImago, n.d.). Regarding the area of agricultural and biological sciences, most of the literature belongs to the category of aquatic science; additionally, there is some literature without a specific category. In the area of business, management and accounting, it is the category of tourism, leisure and hospitality management” that particularly stands out, all publications falling into this category. In the area of social sciences, the category of geography, planning and development has the most articles, being the sum of the rest.

Of the 15 articles found in the tourism, leisure and hospitality management category, nine are published in journals in the top ten. The top journal is also the one with the highest number of AR tourism articles in this category—i.e. *Tourism Management*, with four articles. Three other articles on AR tourism are in the upper quartiles of this category.

## 6. Conclusions, limitations and future research

A review of the literature suggests that AR play a role of some significance in the tourism industry, particularly in coastal areas. From the literature review, the following points can be highlighted.

- Attraction for divers: AR often serve as popular diving and snorkelling spots, attracting tourists in underwater exploration and marine biodiversity. Studies have shown that AR can increase the recreational value of coastal destinations and contribute to diversification of the tourist offer.
- Economic benefits: AR enhance economic benefits for local communities and tour operators related to tourism, including diving charters, equipment rental, accommodation, meals and other services, thus contributing to stimulating employment and generating income.
- Improved recreational opportunities: By providing habitat for diverse marine life and creating underwater landscapes, AR contribute to improved recreational opportunities for tourists. This can lead to increased visitor satisfaction and repeat visits to coastal destinations.
- Promoting sustainable tourism: AR have the potential to promote sustainable tourism practices by reducing pressure on natural ecosystems. They can serve as alternative diving sites, thus dispersing visitor use and minimising impacts on sensitive marine environments.
- Educational and interpretive value: AR provide educational and interpretive opportunities for tourists interested in learning about marine ecology, conservation and underwater ecosystems. Interpretive programmes and guided tours can enhance visitor experiences and promote habitat conservation.
- Cultural tourism: In addition to their ecological significance, some AR are designed to incorporate cultural and historical elements, such as shipwrecks. These places can attract tourists interested in exploring maritime history.

Overall, the literature suggests that AR play a multifaceted role in the tourism industry, contributing to economic development, ecological conservation, recreational opportunities and cultural enrichment in coastal communities. However, it is important to highlight that the potential success of AR tourism

initiatives requires effective planning, management and stakeholder engagement to ensure sustainable outcomes for both the environment and local communities. Some large countries are the liveliest in AR tourism. There are, however, some exceptions where relatively small countries produce a comparatively large amount of literature related to AR, such as Israel and Portugal.

### 6.2 Limitations

It was found in the published literature that in places where AR were deployed with a main purpose other than leisure or tourism, little interest is generally triggered in the tourist sector to make use of these structures (usually modular). The reason may be that modular structures are not appealing.

As this study only considered for analysis scientific literature on AR tourism with articles published in English (or at least with an abstract in that language), one of the limitations found in this review is the shortage of scientific literature combining the two themes (tourism and AR). There are many literature review studies on AR in relation to various topics, but, to the best of the author's knowledge, the present study is the first systematic review covering published scientific research on AR and tourism from 1991 to 2020.

### 6.3 Future research

The results of this review allow future lines of inquiry in AR tourism. Future research including both themes should be expanded and include languages other than English.

Some specific aspects of AR tourism that could benefit from further research, along with potential gaps or emerging trends for researchers to focus on, are visitor experience and satisfaction, community engagement and stakeholder perspectives, ecotourism activities and sustainable practices, economic impacts and cost-benefit analysis, promotion strategies, monitoring and management, and climate change adaptation.

By addressing these specific aspects and gaps in the literature, researchers can contribute to a better understanding of AR tourism and provide valuable insights for policymakers, practitioners and local communities involved in the planning and management of coastal tourism destinations.

Theoretical contributions in these areas can be useful for academia by advancing knowledge and understanding of AR tourism from an interdisciplinary perspective, providing conceptual frameworks for future research, and informing practical interventions and policy recommendations for sustainable tourism development (Bortone, 2015; Lima *et al.*, 2019). By integrating theoretical insights with empirical evidence and case studies, scholars can contribute to the academic discourse on AR tourism and address pressing issues related to environmental conservation, community development and tourism sustainability (Ramos, 2022).

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