

ARE WE MISSING THE BIGGER PICTURE? AN ANALYSIS OF HOW SCIENCE CAN CONTRIBUTE TO AN ECOSYSTEM-BASED APPROACH FOR BEACH MANAGEMENT ON THE SÃO PAULO MACROMETROPOLIS¹

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Introduction

Preventing, scaling or mitigating the impacts of human activities on the coastal zone (CZ), defined as the land-sea interface, is a challenge due to its intrinsic complexity (CICIN-SAIN; KNECHT, 1998; WILLIAMS; MICALLEF, 2009; HALPERN; LESTER; MCLEOD, 2010; BARRAGÁN, 2016), the diverse impacts it is subjected to, and their synergistic and cumulative interactions (HALPERN; LESTER; MCLEOD, 2010). Among the ecosystems that are included in the CZ, sandy beaches are the gateway to the sea and the environment most used by human populations (SCHLACHER et al., 2007). Beaches provide essential goods and services, which can be grouped into three main functions:

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shoreline protection; maintenance of marine life and biodiversity; and meeting the needs of human populations for recreational activities (DEFEO et al., 2009; WILLIAMS; MICALLEF, 2009; SARDÁ et al., 2015). Beaches are also relevant due to their role in the human-ocean interaction and in the promotion of ocean literacy (SANTORO et al., 2017) or “maritime mindset”, i.e., “the individual or collective conviction or belief of the importance of the sea” (CENTRO DE EXCELÊNCIA PARA O MAR BRASILEIRO, 2012), which is important to create awareness of citizens for more coherent attitudes towards the sustainable use of the marine environment .

Considering their physical characteristics, beaches are defined as sedimentary deposits, predominantly sandy fractions, formed by the action of waves and/or tides (MCLACHLAN; DEFEO, 2017). However, for beach management, it is also important to consider the biological and social processes that operate in the beach environment and its surroundings. Thus, beaches should be regarded as social-ecological systems, i.e., integrated systems between people and nature with reciprocal and interdependent feedback (BERKES; FOLKE, 1988). In this regard, beach management can be understood as the management of human activities which directly or indirectly affect this environment, seeking to repair or mitigate deleterious and negative effects (WILLIAMS; MICALLEF, 2009) that occur both on beaches and in the marine and terrestrial areas they are connected to and affected by.

To understand and manage beaches as social-ecological systems, it is necessary to recognize that the distinction between their social and ecological components is arbitrary. It is also necessary to acknowledge the importance of nature to human populations as well as the influence that social and political dimensions exert on the natural environment. Social-ecological systems are often exposed to crises (BERKES; FOLKES, 1988), be they natural events such as storms, droughts or pests; or social, such as political and financial crises. All these factors should be considered in an integrated way and at different temporal and spatial scales in beach management (MCLACHLAN et al., 2013), a challenge that is yet to be overcome.

Historically, beach management has focused on the maintenance of sand volume and beach width, protection of local infrastructure and of its recreational function (ARIZA; JIMÉNEZ; SARDÁ, 2008; WILLIAMS; MICALLEF, 2009). Thus, beach management targeted at maintaining or restoring the physical and geomorphological characteristics of beaches related to erosion and flood prevention (JAMES, 2000; SCHILLACH, et al., 2008; WILLIAMS, MICALLEF, 2009), or their touristic functions, i.e., seeking to provide comfort, bathing and a beautiful scenery to beach users (ARIZA; JIMÉNEZ; SARDÁ, 2008). International literature reports several beach management initiatives related to beach certifications and awards, user perception, and indexes that estimate the quality of the beach, especially for tourism (WILLIAMS, MICALLEF, 2009; BOTERO et al., 2015; LUCREZI, SAAYMAN, VAN DER MERWE, 2015). These initiatives, which address specific and usually limited beach characteristics, have resulted in management models that disregard the particularities of beach ecosystems and their social-ecological complexity (ARIZA; JIMÉNEZ; SARDÁ, 2008). Consequently, they fail to maintain important functions and services of beaches which may compromise other relevant

functions within a few years.

Based on this understanding of sandy beaches as a social-ecological system, it is necessary to develop new management and governance models that promote more integrative, interdisciplinary, holistic and participatory approaches (CICIN-SAIN; KNECHT, 1998; ROSENBERG; MCLEOD, 2005; ARKEMA; ABRAMSON; DEWSBURY, 2006; MCLEOD; LESLIE, 2009; CURTIN; PRELLEZO, 2010). In this regard, ecosystem-based management (EBM) presents an interdisciplinary approach that incorporates ecological, social and governance principles to maintain the long-term capacity of an ecosystem to deliver multiple benefits (MCLEOD; LESLIE, 2009; CURTIN; PRELLEZO, 2010; LONG; CHARLES; STEPHENSON, 2015).

EBM emerges as a way to promote the integrated management of living and non-living resources, considering ecosystems as a planning unit and focusing on maintaining the processes, functions, and interactions which are essential for the provision of ecosystem services and human well-being (ARKEMA; ABRAMSON; DEWSBURY, 2006; LONG; CHARLES; STEPHENSON, 2015). Thus, it seeks to broaden social involvement and to consider diverse sources of impact and their effects on ecosystem functioning (CURTIN; PRELLEZO, 2010). Although much more discussed in the scientific community than applied in policymaking (ARKEMA; ABRAMSON; DEWSBURY, 2006), EBM arises as an alternative to traditional coastal management models, aiming to facilitate the process of integrating information and promoting a less sectorized approach to coastal management (UNITED NATIONS ENVIRONMENT PROGRAMME, 2011; ASMUS et al., 2018).

Among the EBM principles, fifteen have been recurrently cited in the scientific literature (LONG; CHARLES; STEPHENSON, 2015): (1) ecosystem connections; (2) appropriate spatial and temporal scales; (3) adaptive management; (4) use of scientific knowledge; (5) stakeholder involvement; (6) integrated management; (7) sustainability; (8) accounting for dynamic nature of ecosystems; (9) maintenance of ecological integrity and biodiversity; (10) recognizing coupled social-ecological systems; (11) decisions must reflect societal choices; (12) need for distinct management boundaries; (13) interdisciplinarity; (14) appropriate monitoring; (15) acknowledging uncertainty.

In addition to being considered a principle itself, the use of scientific knowledge is directly related to the principles of interdisciplinarity, appropriate monitoring and recognition of uncertainty, which illustrates its importance in supporting the EBM process (ARKEMA; ABRAMSON; DEWSBURY, 2006; LESLIE; MCLEOD, 2007). Nevertheless, scientific knowledge is often not considered for decision-making processes due to the lack of integration between academia and the actors involved in management (ARKEMA; ABRAMSON; DEWSBURY, 2006; MCNIE, 2007; NURSEY-BRAY et al., 2014). In this context, the compilation and critical analysis of scientific information relevant to beach management is fundamental to acknowledge what has been produced by science and what are the knowledge gaps to support EBM implementation (ARKEMA; ABRAMSON; DEWSBURY, 2006; LESLIE; MCLEOD, 2007; CURTIN; PRELLEZO, 2010).

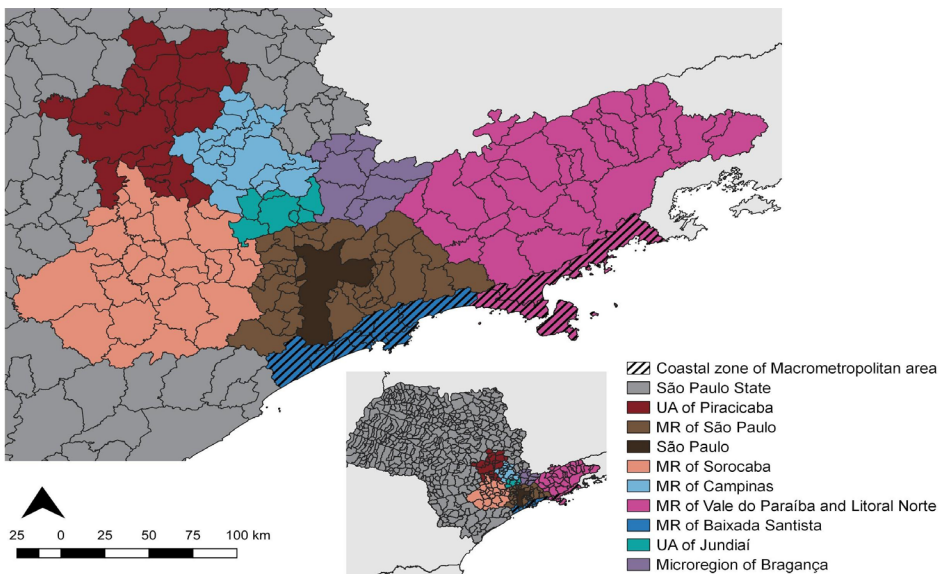
This work aims to present an overview of the Brazilian scientific production related to beach management, especially of research in the São Paulo Macrometropolis (MMP, from the Portuguese term *Macrometrópolis Paulista*), one of the largest urban agglomerations in the Southern Hemisphere. Specifically, this work aims 1) to identify the scientific

production related to beach management in Brazil, focusing on the MMP; 2) analyze whether existing information can support ecosystem-based beach management; 3) highlight which studies should be prioritized so that more integrated and holistic management can be achieved. In this sense, the focus on the MMP becomes relevant because it presents the opportunity to look at a new territorial approach of relevance for beach management in an integrated manner, considering the coast and beaches as part of a larger area, interconnected through socioeconomic and environmental flows and interdependencies.

The Coastal Zone of the São Paulo Macrometropolis

The MMP includes the Metropolitan Regions of São Paulo, Baixada Santista, Campinas e Sorocaba, and of the Paraíba Valley and Northern Coast; the Jundiaí and Piracicaba Urban Agglomerations; and the Bragantina Regional Unit (Figure 1). This territory covers an area of 53.4 thousand km², equivalent to 21.5% of the State of São Paulo, including 174 municipalities, 50% of the urbanized area of the whole state, and a population of more than 33 million inhabitants (EMPRESA PAULISTA DE PLANEJAMENTO METROPOLITANO, 2018).

Figure 1 – The São Paulo Macrometropolis, its metropolitan regions (MR) and urban agglomerations (UA), highlighting the coastal zone.



Source: GONÇALVES et al., 2019; author Guilherme Leria (Macroamb/FAPESP);

The coast of the MMP is of territorial and socioeconomic relevance and includes the metropolitan region of Baixada Santista (MRBS) and the Northern Coast of the State of São Paulo (NCSP), counting cerca three hundred beaches⁷. The MRBS, created in

7. Number based in the list of beaches provided in the websites of each municipality.

1996, is composed of nine municipalities: Bertioxa, Cubatão, Guarujá, Itanhaém, Mongaguá, Peruíbe, Praia Grande, Santos, and São Vicente. This region is recognized by the diversity of functions of its municipalities, as the industrial complex of Cubatão and the Port of Santos, the largest port complex in Latin America. Additionally, the MRBS plays prominent roles at the state level for industry and tourism, and further important roles at the regional level, especially those related to wholesale and retail trades, healthcare, education, transport, financial and international trade operations (EMPRESA PAULISTA DE PLANEJAMENTO METROPOLITANO, 2018). This region is the home for 1,831,884 people which are increasing in a average annual rate (FUNDAÇÃO SEADE, 2020).

The Northern Coast of São Paulo (NCSP), included in the Metropolitan Region of the Paraíba Valley and Northern Coast created in 2012, comprises four municipalities: Ubatuba, Caraguatatuba, Ilhabela and São Sebastião. Currently, the NCSP has 325,627 inhabitants and shows a high annual population average rate growth (1.58%) (FUNDAÇÃO SEADE, 2020) which surpasses the state rate (0.80%), the rate of the metropolitan area to which it belongs (0.97%), and the rate for the RMBS. This growth, coupled with a non-sustainable tourism practices and inefficient urban planning, has a major consequence on the aggravation of local problems such as low sanitation rates, absence of an appropriate place for solid waste disposal, occupation of hillsides, floods, pollution, erosion and coastal degradation, and reduction of fish stocks (GONÇALVES et al., 2018). These problems are recurrent in all NCSP cities and managed in an uncoordinated manner by the public authorities (SANTOS; TURRA, 2017). In regards to the industrial activities of the NCSP, the highlights are the oil and gas industry, the project to expand the Port of São Sebastião, and the consequent adaptation of all regional road logistics, including the expansion of the traffic capacity of the SP-099 Highway (TEIXEIRA, 2013).

The MMP has a unique dynamic (GONÇALVES et al., 2018) due to the city-coast connection resultant from flows of people, goods, services, and residues, and interactions between the coastal region and the main metropolitan regions of MMP - São Paulo and Campinas, which concentrate more than 21 million and 3 million inhabitants, respectively (EMPRESA PAULISTA DE PLANEJAMENTO METROPOLITANO, 2019a, b), and the presence of the port complexes and the oil and gas industry. This developing economy will bring major changes and reinforce the need to better integrate the coastal region with the metropolis (LENCIONI, 2015), building a more integrated and systemic vision.

Given the complexity, flows and multi-scalar nature of this area (BRENNER, 2018), it requires transversal and articulated policies, involving different social actors, levels of government (NEGREIROS; SANTOS; MIRANDA, 2015), and new governance arrangements that may promote the EBM in a multi and/or trans-scalar approach, considering the socioeconomic connections and interdependencies. The challenge lies in proposing institutions, management and governance systems that cope with these connections, recognizing and analyzing the metropolization of space and its respective flows to govern the territory by promoting sustainable development (VEIGA, 2010). In this context, beach management demands an equally systemic approach, acknowledging the need for appropriate knowledge to face these challenges and to support the application of EBM.

METHODS

Here, we present a review of scientific literature (as defined by RANDOLPH, 2009) related to beach management in Brazil, focusing on the São Paulo Macrometropolis. We considered peer-reviewed articles published on-line up to 2018. To provide an overview of the Brazilian scientific production related to the theme, searches were conducted with the search terms “manag*” or “conserv*” combined with “beach” and “Brazil” in the SCOPUS® database. The results from this preliminary search were manually refined by reading article abstracts, which allowed for the identification of articles which, despite meeting search criteria, were not related to the scope of this manuscript; coded (as described by PLUMMER; ARMITAGE, 2007); and classified according to their relation to beach management (Table 1, Line 2).

In a second abstract reading process, which also served to refine the codes, studies identified as directly related to beach management (BM) were classified according to spatial scale, location, focus, and type of information provided (Table 1). These studies were also analyzed considering their authors, year and type of publication (original article, review article, proceedings or short communications). Additionally, we searched for the terms “ecosystem-based management”, “ecosystem service”, “ecosystem approach” and “govern*” in the titles, abstracts, and keywords of the articles classified as BM.

For the overview on publications related to the São Paulo Macrometropolis, a complementary search was made replacing the keyword “Brazil” by “São Paulo”, in the SCOPUS® and Web of Science® databases. The results of this search went through the same process of abstract reading and codification as the previous one and the articles which reported studies in the MMP and were classified as BM and coastal management (CM) were downloaded, read in full and classified according to Table 1. At this stage, we sought to identify the same general patterns of scientific production related to the beach management in the MMP, as well as how this information may favor the ecosystem-based management implementation.

Table 1 – Classes and classification criteria applied for the classification of scientific production related to beach management considering the national scientific literature and with focus on the São Paulo Macrometropolis (MMP)

	Class	Classification criteria
Relation to beach management - national scientific production and scientific production in the MMP	BM - Beach Management	Manuscripts that consider the beach as an ecosystemic unit and report information related to its management.
	BioM - Biodiversity Management	Manuscripts that are limited to discussing beach biodiversity (e.g., species that have been identified in the ecosystem), but do not consider the ecosystem as a whole. May bring subsidies for beach management.
	CM - Coastal Management	Manuscripts that discuss general coastal management issues, without focusing on any specific ecosystem, or in systems other than the beach. May bring subsidies for beach management.
	WM - Waste Management	Manuscripts that discuss beach waste/pollutants and problems related to them, but are not focused on the beach ecosystem as a whole. May bring subsidies for beach management.
	Others	Other studies that may bring subsidies for beach management. Including manuscripts on themes such as environmental education, traditional knowledge, fishing management, among others.
Scale	Local	Manuscript reports information for one beach
	Municipal	Manuscript reports information for different beaches, in the same municipality.
	Regional	Manuscript reports information for different beaches in different municipalities/states.
	National	Manuscript reports information for the whole Brazilian coast.
	Undetermined	It was not possible to determine the research scale.
Research area	Brazilian state where the research was conducted *national scale or beach(es) where the study was conducted at the MMP Scale ¹ .	
Research focus	List of themes that are the focus of the manuscripts.	
Type of information provided	Management case study	Manuscript presents a case study for beach management.
	Management support	Manuscript does not present a case study for beach management, but provides information that can subsidize management processes.

Source: Table made by authors

RESULTS

National scientific production

The search performed on the SCOPUS® database yielded 312 references that met the specified requirements. After the first step of reading and coding of these references, 9 were discarded for not having a direct relationship with the objectives of the review and the remaining were classified according to Table 1. Of these, 97 were classified as

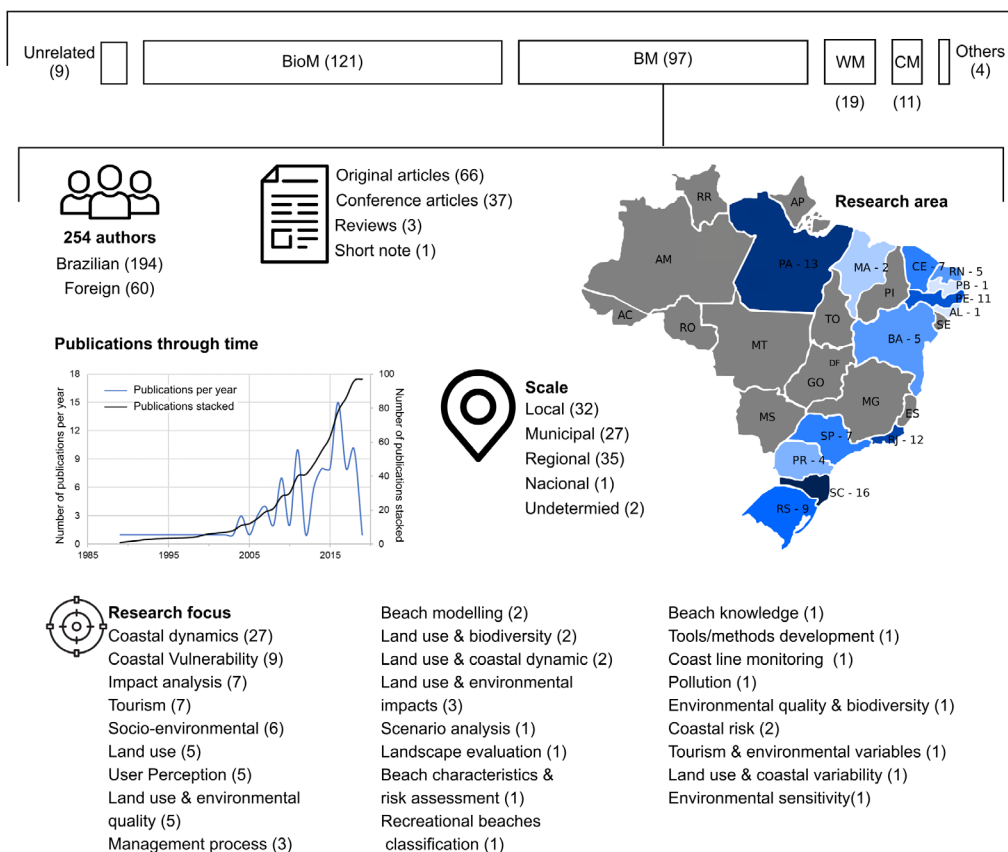
BM and were re-read for the classification according to scale, location, the focus of study, and the type of information provided.

Among the references classified as BM, 254 authors were identified in a national and international collaboration network. An analysis of the number of publications over time indicates that there has been a recent increase, with 15 being the maximum number of publications in the same year, 2016. Regarding the type of publication, most were original articles (68 %) that include regional studies (36.1%) (i.e., that reached more than one beach in different municipalities or states), with a majority of studies carried out in different municipalities of the same state. We also identified many local studies (33%) (i.e., carried out on just one beach). The states with the largest number of studies were Pará, Pernambuco, Rio de Janeiro, and Santa Catarina, the one with the highest records (16). No BM studies were identified on the states of Amapá, Piauí, Alagoas and Espírito Santo.

Regarding the focus of the articles, 28 themes or combinations of themes were identified. The predominant theme was coastal dynamics (27 studies), related to sedimentation/coastal erosion, sediment transport, beach morphodynamics, wave pattern, and circulation. Also noteworthy is the number of studies related to land use (such as urbanization or recreational use) and damage caused by land use patterns (totaling 17 studies); as well as the studies related to coastal vulnerability (10 studies). Regarding the type of information, only five case studies on coastal management were identified, and most of the studies (N=97 studies, or 94.8%) were classified as studies that can provide management although not directly, instead only cite the importance of the study as a source of information for management practices. Figure 2 provides an overview of national publications identified as BM.

Figure 2 – National overview of the Brazilian scientific production related to beach management (BM) and number of articles classified as relating to waste management (WM) and coastal management (CM). On the map, blue colors indicate the Brazilian states where the studies considered for this characterization were performed.

SCOPUS search (312)



Source: Figure made by the authors based on the literature review. (Icons from: www.flaticon.com)

As for the identification of the terms “ecosystem-based management”, “ecosystem service”, “ecosystem approach” and “governance”, only the term “ecosystem services” was identified in two articles (in both titles and one of the abstracts), whereas the other terms have not been identified in any of the articles.

Scientific production in the São Paulo Macrometropolis

The search performed in the SCOPUS® and Web of Science® databases resulted in 43 articles that presented the search terms. After the first abstract reading and coding step, 11 (25.58%) were discarded for not being related to the review objectives. The

remaining 32 articles (72%) were classified according to their relationship with beach management, and the seven (16%) classified as BM and the nine (20%) as CM were read in full. After the reading, eight references were discarded because their contents were not directly related to BM or CM. The eight references considered for final analysis are presented in Table 2.

Table 2 – References related to beach management (BM) and coastal management (CM) selected after the process of reading the abstracts and full texts

Reference	Author's Institution	Relationship with beach management	Focus of the study
MAGINI; HARARI; ABESSA (2007)	UFC; IOUSP; UNESP	CM	Coastal dynamics; Coastal vulnerability
SARTOR et al., (2007)	FNMA; MonteSerrat; FNMA; MonteSerrat, UNESP	CM	Development of tool/method;
GOUVEIA-SOUZA (2009)	IG	CM	Development of tool/method; Coastal risk
MELLO et al. (2013)	ESALQ/USP; UFSCAR; UNESP; UFSCAR	CM	Use and occupation
SOUSA; SIEGLE; TESSLER (2011)	IOUSP; IOUSP; IOUSP	BeM	Use and occupation; Coastal risk
SOUSA; SIEGLE; TESSLER (2013)	IOUSP; IOUSP; IOUSP	BeM	Coastal vulnerability; Development of tool/method
TURRA et al. (2016)	IOUSP; IOUSP; IOUSP; UniModulo; UniModulo	BeM	Use and occupation & biodiversity
DE ANDRADE; SOUSA; SIEGLE, (2019)	IOUSP; UNILAB; IOUSP	BeM	Coastal vulnerability; Development of tool/method

Source: Elaborated by the authors based on the literature review.

UFC: Universidade Federal do Ceará. UNESP: Universidade do Estado de São Paulo. IOUSP: Instituto Oceanográfico do Universidade de São Paulo. FNMA: Fundação Nacional de Meio Ambiente. MonteSerrat: faculdade Monte Serrat. IG: Instituto Geológico. ESALQ/USP: Escola Superior de Agricultura "Luiz de Queiroz" da Universidade de São Paulo. UFSCAR: Universidade Federal de São Carlos. Unimodulo: Centro Universitário Módulo.

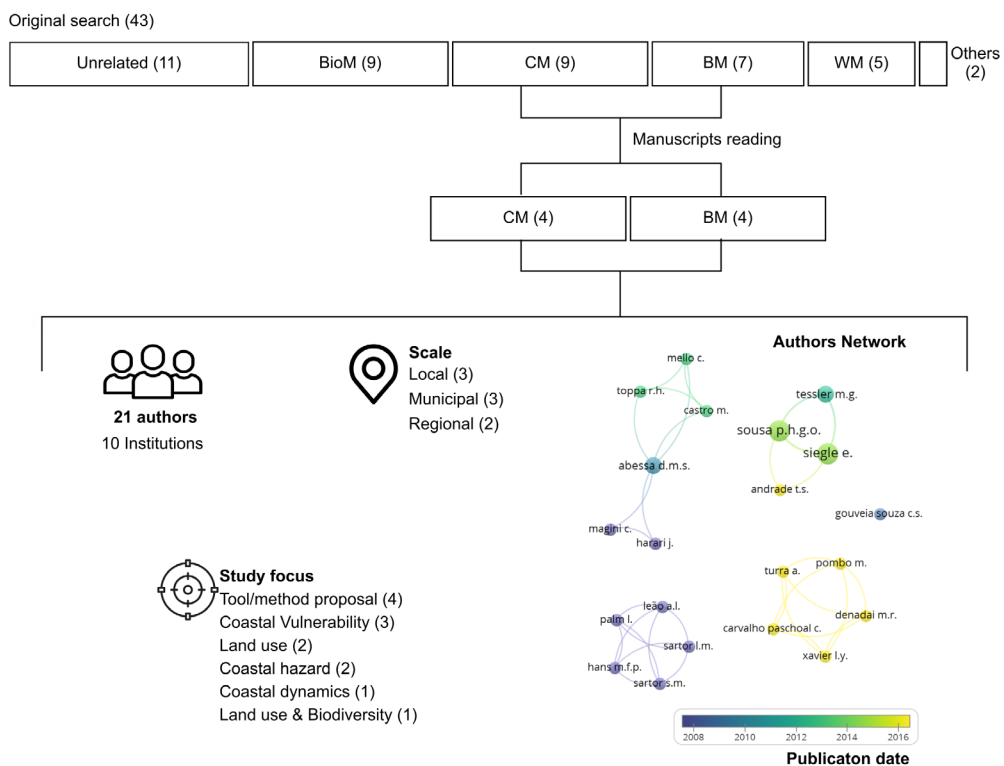
The eight articles read in full represented the works of 21 authors, organized in four different collaboration groups without connection to each other, and one isolated author. The authors with the most publications (SOUSA, P.H.O., and SIEGLE, E., with three publications each) are within the same research group. All publications are recent articles published between 2007 and 2018⁸, three with local, three with municipal and two with regional scope. Among them, the work of Gouveia-Souza (2009), draws greater

8. The article from De Andrade,; SOUSA and Siegle (2019) was available online in December 2018

attention for mapping the risk of flooding for the entire NCSP. In the studies that specified the beaches studied, 12 different beaches were identified.

Regarding the scope, the articles cover six themes or a combination of different themes. The predominant theme was the development tool/methods (SARTOR et al., 2007; GOUVEIA-SOUZA, 2009; SOUSA; SIEGLE; TESSLER, 2013; DE ANDRADE; SOUSA; SIEGLE, 2019), usually related to coastal vulnerability mapping, which was the second most recurrent theme (MAGINI ; HARARI; ABESSA, 2007; SOUSA; SIEGLE; TESSLER, 2013; ANDRADE; SOUSA; SIEGLE, 2019). Figure 3 presents an overview of publications identified as BM and CM carried out on the coast of the MMP.

Figure 3 – Overview of the scientific production related to beach management in the coastal area of the São Paulo Macrometropolis.



Source: Figure made by the authors based on the literature review. (Icons from: www.flaticons.com)

None of the eight publications discussed beach management directly, but they all support beach management either by providing information for decision-making processes or, in most cases, methodological development. Four of them make concrete proposals on how to use the information provided: Magini, Harari and Abessa (2007) recommend a greater integration of public policies for the municipality of São Vicente, indicating the main policies to be considered; Mello et al. (2013) indicate the need for maintenance

actions for some of the Santos municipality channels, and Turra et al. (2016) propose measures for the management of the harvesting activity of the bivalve *Tivela mactroides*. The latter study quotes EBM directly and seeks to include its principles in the recommended management proposals. Sartor et al. (2007) propose the use of maps as a tool to support EBM and demonstrate what types of information can be obtained, but do not define what they consider EBM.

Although not directly, some studies point services and benefits provided by the coastal zone and beaches such as coastal protection (SOUSA; SIEGLE; TESSLER, 2011, 2013; DE ANDRADE; SOUSA; SIEGLE, 2019); support of the caçara culture (TURRA et al., 2016; DE ANDRADE; SOUSA; SIEGLE, 2019); maintenance of fishing stocks (DE ANDRADE; SOUSA; SIEGLE, 2019); use for tourism and recreation activities (SARTOR et al., 2007; SOUSA; SIEGLE; TESSLER, 2011; MELLO et al., 2013; TURRA et al., 2016; ANDRADE; SOUSA; SIEGLE, 2019); support for the transportation of goods (SOUSA; SIEGLE; TESSLER, 2011); and food supply (TURRA et al., 2016).

The studies also enabled the identification of pressures and impacts that affect the coastal zone, and the beaches in particular: the coastal use and occupation (MAGINI; HARARI; ABESSA, 2007; SARTOR et al., 2007; GOUVEIA-SOUZA, 2009; MELLO et al., 2013; DE ANDRADE; SOUSA; SIEGLE, 2019); coastal erosion (SOUSA; SIEGLE; TESSLER, 2011, 2013; DE ANDRADE; SOUSA; SIEGLE, 2019); floods (GOUVEIA-SOUZA, 2009; DE ANDRADE; SOUSA; SIEGLE, 2019); impairment of coastal water quality (SARTOR et al., 2007; TURRA et al., 2016); and overexploitation of resources (TURRA et al., 2016). Such impacts are generally related to climate change, which may increase their magnitude and frequency of occurrence (MAGINI; HARARI; ABESSA, 2007; SOUSA; SIEGLE; TESSLER, 2011, 2013; ANDRADE; SOUSA; SIEGLE, 2019). The few studies that relate the impacts described for the various flows occurring on the macrometropolitan scale, cite the impact of tourism activities (MELLO et al., 2013; DE ANDRADE; SOUSA; SIEGLE, 2019) and impacts related to territorial planning and policies that affect the development of coastal territory (SOUSA; SIEGLE; TESSLER, 2011; MELLO et al., 2013; DE ANDRADE; SOUSA; SIEGLE, 2019), as in the case of the growth of the municipality of São Vicente, resulting from public policies to encourage MRBS industrial development (MELLO et al., 2013).

Discussion

In order to be effective, beach management must be based in sound scientific findings (NEL et al., 2014). Additionally, in order to face current environmental problems, the science needed for management should be interdisciplinary, holistic, aligned with management needs and available to managers and society (ARKEMA; ABRAMSON; DEWSBURY, 2006; LESLIE; MCLEOD, 2007; MCNIE, 2007), as required for EBM implementation.

Brazilian coastline extends for more than 9000 km between latitudes 4°N and 34°S. Part of this extension is occupied by more than 2000 beaches (MINISTÉRIO DO MEIO AMBIENTE, 2015), which are of great importance to the national economy. Brazil is

among the countries where field-based beach publications is higher (NEL et al., 2014). Nevertheless, few scientific publications have some relation to the management of this ecosystem and are diffuse and recent - although there have been studies focused in biodiversity of beach environment for more than four decades (AMARAL et al., 2016). Brazil has 17 states with coastal areas, of which 13 are represented in the references identified in the broader search. Despite this, the number of studies by state is low (less than five for most states). For the MMP region, the numbers are also low, and most studies are focused on proposing new tools or methods for coastal zone mapping and classification.

The low number of publications indicates that investment in beach management research needs to be increased, both to generate basic information and, mainly, to discuss management processes and their improvement. On his broader literature review, Nel et al. (2014) showed that beach science is historically underrepresented in publications, and, among existing articles, the ones discuss management processes account for a very small parcel. For Brazil, most studies classified as BM may subsidize management, but it was not possible to identify direct recommendations for the application of the results in the abstracts, only indication that they could contribute to the process. The same pattern emerged in the full reading of MMP-related publications, with few studies providing direct proposals for the use of information produced in management, or discussing the topic as to contribute to its improvement.

Considering the relationship of these studies with EBM, among the references for the Brazilian coast, only two studies (SOUZA FILHO et al., 2014; AMARAL et al., 2016) mentioned the topic of ecosystem services and none explicitly addressed EBM in their abstract, title or keywords. For the MMP, there were studies found that explicitly address EBM, but in general, scientific production does not promote the application of its key principles (as defined by LONG; CHARLES; STEPHENSON, 2015). The literature on EBM is growing worldwide (LONG; CHARLES; STEPHENSON, 2015) and is also being incorporated by studies on beaches (SARDÁ et al. 2015), however Brazilian publications do not yet reflect this trend.

Although most studies provide valuable information for management practices, scientific research is still predominantly reductionist, disciplinary and lack an ecosystemic and multi-scalar approach compatible with management needs (ARKEMA; ABRAMSON; DEWSBURY, 2006; CASH et al., 2006; MCNIE, 2007). As an example, they do not discuss the influences of socioeconomic flows and/or direct and indirect impacts from the MMP on the beach system. Tourism from metropolitan areas of the capital to the coast, commuting and daily trips between Santos and São Paulo (CUNHA et al., 2013) and trade and services relations between the coastal region and the metropolis of São Paulo are examples of how the coastal zone connects to other MMP regions to meet social and economic needs, a context that is disregarded by the scientific production. The macrometropolitan area makes beach management more complex, and highlights the importance of the connections between the coast and the other metropolitan regions (GONÇALVES et al., 2019), indicating that an approach which considers solely coastal ecosystems or beaches, as a unit, is not sufficient once these are subject to pressures that go beyond their political and geographical limits.

Another topic underexploited by the studies is the connection of the beach ecosystem with adjacent natural ecosystems, such as other coastal ecosystems, ocean areas or watersheds, known sources of nutrients and pollutants. The characterization of the connectivity of other ecosystems with the beaches is fundamental for their maintenance (COCCOSSIS, 2004; BARBIER et al., 2011). Connection with other ecosystems is capable of significantly altering local conditions that affect biodiversity on beaches, changing variables such as salinity, and contributing to the input of debris, one of the bases of the food chain (LOZOYA; DEFEO, 2006; SCHLACHER; CONNOLLY, 2009), consequently affecting the provision of beach ecosystem services. The lack of this recognition undermines the promotion of integrated management practices and the maintenance of ecosystem integrity, as supported by EBM principles.

The lack of interdisciplinarity and integration is reflected in management practice, for example, in the Action Plan for São Paulo Macrometropolis (EMPLASA, 2014), formulated in a sectoral approach. Although not considered for this review, beach management can benefit, even indirectly, from research related to topics such as biodiversity and waste, which appear in the initial searches of our study. This resides in the role of beaches as habitat or site of reproduction, growth or a stepping stone for migration species (LASIAK, 1986; HUBBARD; DUGAN, 2003), but also as a final destination for waste generated by human activities (as solid waste) (DEFEO et al., 2009). The relevance of this information for management proposals reinforces the need and the challenge of sectoral integration and interdisciplinarity.

Another aspect to be considered is the low number of studies which provide explicit management recommendation based on their findings. As important as the quality of the information, its utility is dependent on how it is made available to managers (NURSEY-BRAY et al. 2014). Improving availability goes from fostering knowledge exchange processes to promoting the co-production of knowledge (XAVIER; JACOBI; TURRA, 2018). Choosing what path to go is case-dependent (MCNIE, 2007) and demands understanding of the management process itself. Thus, there is a need for studies that analyze the effectiveness of ongoing management practices and methods on the Brazilian coast. Overall, considering the national and the MMP scientific production, the main shortcoming is management-focused studies that discuss guidelines for making management more integrated, interdisciplinary and participatory. There is also the absence of papers discussing the challenge of the new institutional and governance arrangements needed for the sustainability of the coastal zone and its beaches.

Final remarks

This paper evaluates the publications related to beach management in Brazil and, in detail, of the São Paulo Macrometropolis territory. The review provides an overview of how beach management has been addressed in the national scenario and the MMP, and contributes to the deepening of the knowledge of the subject, thus making it possible to advance the research and academic agenda on beach management in Brazil.

The low number of articles that discuss this issue demonstrates that beach management research is at an embryonic stage. It is imperative to promote studies that focus

on this coastal ecosystem, especially with a focus on interdisciplinarity and analysis of integrated and adaptive management processes. The small investment in the development of adequate beach management strategies, associated with the impacts derived from the ill-planned exploitation of its resources (AMARAL et al., 2016) or its marine and terrestrial surroundings (SANTOS; TURRA, 2017), undermine the health of these ecosystems and their ability to provide multiple benefits.

Promoting interdisciplinarity and a more holistic understanding of socio-ecological systems are fundamental steps for the promotion of EBM, but not the only challenges that need to be faced. As a recommendation for future research in the study of beach management, it is necessary, in addition to deepening interdisciplinary production and the integration of different areas of knowledge, to focus on efforts to make the information produced accessible to decision makers and to identify factors and characteristics that may lead to the promotion of a more democratic and participative management.

Increasing the production of knowledge for more effective beach management and promotion of EBM is a worldwide challenge (NEL et al., 2014). In this sense, the United Nations Decade of Oceanic Science for Sustainable Development (2021-2030) (UNESCO, 2019) represents a great opportunity to mobilize scientists to focus on beaches and the production of knowledge that is interdisciplinary, relevant, applicable, aligned with global and focused initiatives. promoting the sustainability of both this coastal environment and the oceans as a whole.

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ARE WE MISSING THE BIGGER PICTURE? AN ANALYSIS OF HOW SCIENCE CAN CONTRIBUTE TO AN ECOSYSTEM-BASED APPROACH FOR BEACH MANAGEMENT ON THE SÃO PAULO MACROMETROPOLIS

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ARE WE MISSING THE BIGGER PICTURE? AN ANALYSIS OF HOW SCIENCE CAN CONTRIBUTE TO AN ECOSYSTEM-BASED APPROACH FOR BEACH MANAGEMENT ON THE SÃO PAULO MACROMETROPOLIS

Abstract: The complexity of human-environment interactions in coastal areas represent management challenges, especially in the beach environment, important for its ecosystem services and contribution to human well-being. To overcome these challenges, ecosystem-based management proposes a more holistic and integrated approach, with a great contribution from scientific knowledge. We present here a review of Brazilian scientific production related to beach management, focusing on the Macrometrópole Paulista. The review showed that research on beach management is in an embryonic stage, being focused on biophysical information and without presenting indications for the application of the knowledge generated in decision-making processes. We conclude that it is imperative to invest in studies with an interdisciplinary, integrated and applied approach in order to promote the ecosystem approach. This is a worldwide challenge, and has been tackled by international initiatives such as the promotion of the United Nations Decade of Ocean Science for Sustainable Development.

Keywords: ecosystem-based management; science-policy interface; coastal management; Brazil

ESTAMOS OLHANDO PARA O LADO CERTO? ANÁLISE DA CONTRIBUIÇÃO DA CIÊNCIA PARA UMA ABORDAGEM BASEADA EM ECOSSISTEMAS PARA O GERENCIAMENTO DE PRAIAS NA MACROMETRÓPOLE PAULISTA

Resumo: A complexidade das interações homem-ambiente em zonas costeiras são desafios à gestão, especialmente no ambiente praias, importante por seus serviços ecossistêmicos e contribuição ao bem-estar humano. Para superar tais desafios, a gestão baseada em ecossistemas propõem uma abordagem mais holística e integrada, com grande contribuição do conhecimento científico. Apresentamos aqui uma revisão da produção científica brasileira relacionada à gestão de praias, com foco na Macrometrópole Paulista. A revisão mostrou que as pesquisas sobre gestão de praias estão em estágio embrionário, sendo focadas em informações biofísicas e sem apresentar indicações para a aplicação do conhecimento gerado em processos de tomada de decisão. Concluímos que é imperativo investir em estudos com uma abordagem interdisciplinar, integrada e aplicada a fim de promover a abordagem ecossistêmica. Tal desafio é mundial, e vem sendo combatido por iniciativas internacionais como a que institui a Década das Nações Unidas da Ciência Oceânica para o Desenvolvimento Sustentável.

Palavras-chave: gestão baseada em ecossistema; interface ciência-gestão; gestão costeira; Brasil

¿NOS ESTAMOS PERDIENDO LA IMAGEN MÁS GRANDE? ANÁLISIS DE LA CONTRIBUCIÓN DE LA CIENCIA A UN ENFOQUE BASADO EN EL ECOSISTEMA PARA EL MANEJO DE PLAYAS EN LA MACROMETRÓPOLIS DE SÃO PAULO

Resumen: Las interacciones complejas hombre-medio ambiente en las zonas costeras son desafíos de gestión, especialmente para la playa, importante por sus servicios ecossistémicos y contribución al bienestar humano. Para superar-los, la gestión basada en el ecosistema propone un enfoque más holístico e integrado, con una gran contribución del conocimiento científico. Presentamos aquí una revisión de la producción científica brasileña relacionada con la gestión de playas, centrada en la Macrometrópole Paulista. La revisión mostró que la investigación sobre el manejo de playas se encuentra en una etapa embrionaria, centrada en información biofísica y sin presentar indicaciones para la aplicación del conocimiento generado en procesos de toma de decisiones. Concluimos que es imperativo invertir en estudios con un enfoque interdisciplinario, integrado y aplicado para promover el enfoque por ecossistemas. Este desafío es mundial y ha sido abordado por iniciativas internacionales como la Década de las Naciones Unidas de la Ciencia del Océano para el Desarrollo Sostenible.

Palabras-clave: manejo basado en ecossistemas, interfaz ciencia-política, manejo costero; Brasil