



# Social and Ecological Elements for a Perspective Approach to Citizen Science on the Beach

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Sandy beaches are ecotonal environments connecting land and sea, hosting exclusive resident organisms and key life stages of (often charismatic) fauna. Humans also visit sandy beaches where tourism, in particular, moves billions of people every year. However, instead of representing a connection to nature, the attitude toward visiting the beach is biased concerning its recreational use. Such “sun, sea, and sand” target and its display seem to be deeply rooted in social systems. How could scientists engage the newest generations and facilitate an exit from this loop, fostering care (including participative beach science), and ultimately sustainable sandy beach use? To tackle this question, we applied the concept of social–ecological systems to the Littoral Active Zone (LAZ). The LAZ is a unit sustaining beach functionalities, though it includes relevant features making a beach attractive to the public. Out of the analysis of the system LAZ in its social and ecological templates, we extracted elements suitable to the planning of citizen science programs. The perspective of leverage points was integrated to the needs identified in the analysis, through reconnecting–restructuring–rethinking the components of the system. Two cross-cutting approaches were marked as important to social and ecological designs and break through the dominant perception of beaches as mere piles of sand: the physical dimension (LAZ) of the beach as a unit, and the use of communication through social media, suitable to both monitoring and scientific data collection, and to data communication and hedonistic display of a day on the beach.

**Keywords:** beaches, social ecological systems, leverage points, attractiveness, Littoral Active, Littoral Active Zone, recreation, leisure

## INTRODUCTION

Sandy beaches are ecotonal environments, meaning they connect the land and sea and provide a range of ecosystem services—from nutrient cycling to shoreline protection, to uniquely adapted biodiversity (McLachlan and Defeo, 2017). The perception of those diverse ecosystem services, however, often remains unseen due to the focus on the cultural ecosystem service of recreation. Such bias led to a short-term vision in beach management at the expense of the sustainability of their use and maintenance of the processes they host (Butler, 1980 for the life cycle of a touristic area; Fanini et al., 2020a for natural risks enhanced by human overuse). Calls for attention to the system “beach” by sandy beach ecologists remained unattended (Defeo et al., 2009; Dugan et al., 2010),

in spite of the paramount economic relevance depending on the availability of an ecologically healthy beach. Sandy beach ecologists hypothesized that the perception of beaches as mere piles of sand and the scarce appeal of resident beach fauna (semiterrestrial crustaceans, insects, and worms) was at the base of such lack of attention, hampering any grassroots movements toward the conservation of beaches—even in case of endemic fauna (Harris et al., 2014). The periodic occurrence of charismatic megafauna seems to be the only triggering factor of actions (Maguire et al., 2011). However, actions not supported by a systemic view risk to remain limited in vision and short-termed, such as protecting the nests of sea turtles rather than protecting the nesting habitat as a whole.

Beaches are extremely attractive to people worldwide. On social media, hashtags related to the beach raise huge attention, e.g., on Instagram (hereafter used as the main example due to its strong association of images, short text, and hashtags), #beach reaches 265M posts, with #sandybeach 612K, and #shinglebeach 10K, but also when using other languages, #praia is 29.6M and #playa 27.4M—data retrieved March 31, 2021). The vast majority of the posts is related to recreation and business and reflects the general perception and attitude toward the “sun, sea, and sand” model. Especially on social media, there is an added element, i.e., to show as a trophy: the own presence on a desirable beach (Baldacchino, 2010). Yet, when studying what makes a beach attractive, features intrinsically interconnect attractiveness to geomorphology and ecology (e.g., Anfuso et al., 2018). We do, therefore, believe that making such a connection explicit will unleash huge potential for engaging users. Special attention goes to social media-active generations, because of the visual impact and attention that the features of a healthy beach can raise. In this viewpoint, we intended to extract key variables from the sandy beach research study and make them pillars for citizen science actions, viable for societal mainstreaming through media.

## PERSPECTIVES

### Sandy Beaches as Systems

To delimit the social–ecological system, a first step is to identify it physically. The concept of Littoral Active Zone (LAZ), i.e., the dimension across land and sea where dynamic exchanges of energy and material occur (Tinley, 1985), was first proposed as a budgetary approach to estimate the amount of sand available on the littoral. Such clear functional dimensionality allowed the extension of the concept to the processes encompassed within and finally its inclusion in a social–ecological perspective (Defeo et al., 2020). Most importantly, the use of the LAZ concept allows the identification of a specific system boundary, expected to react as a whole to environmental drivers and threats, hence a suitable unit for actions of research and management (Fanini et al., 2020b). Our perspective relates to the extraction of features from sandy beach research studies, which are as follows: (1) common to both ecological and social templates of the LAZ, (2) relevant to a long-term vision, and (3) easy to share *via* images and short text—as these are most common actions related to information mainstream *via* social media.

Given those characteristics, we proposed them as operational tools for conservation support to beaches and monitored by citizen scientists, with specific attention to generations Y and Z as both users and drivers of change.

We applied the conceptual framework of social–ecological systems (Berkes and Folke, 1998) to the LAZ (Figure 1), allocating within the template elements suggested in literature reviews and meta-analyses related to ecological paradigms, the attractiveness of a beach, and suitability and potential for conservation.

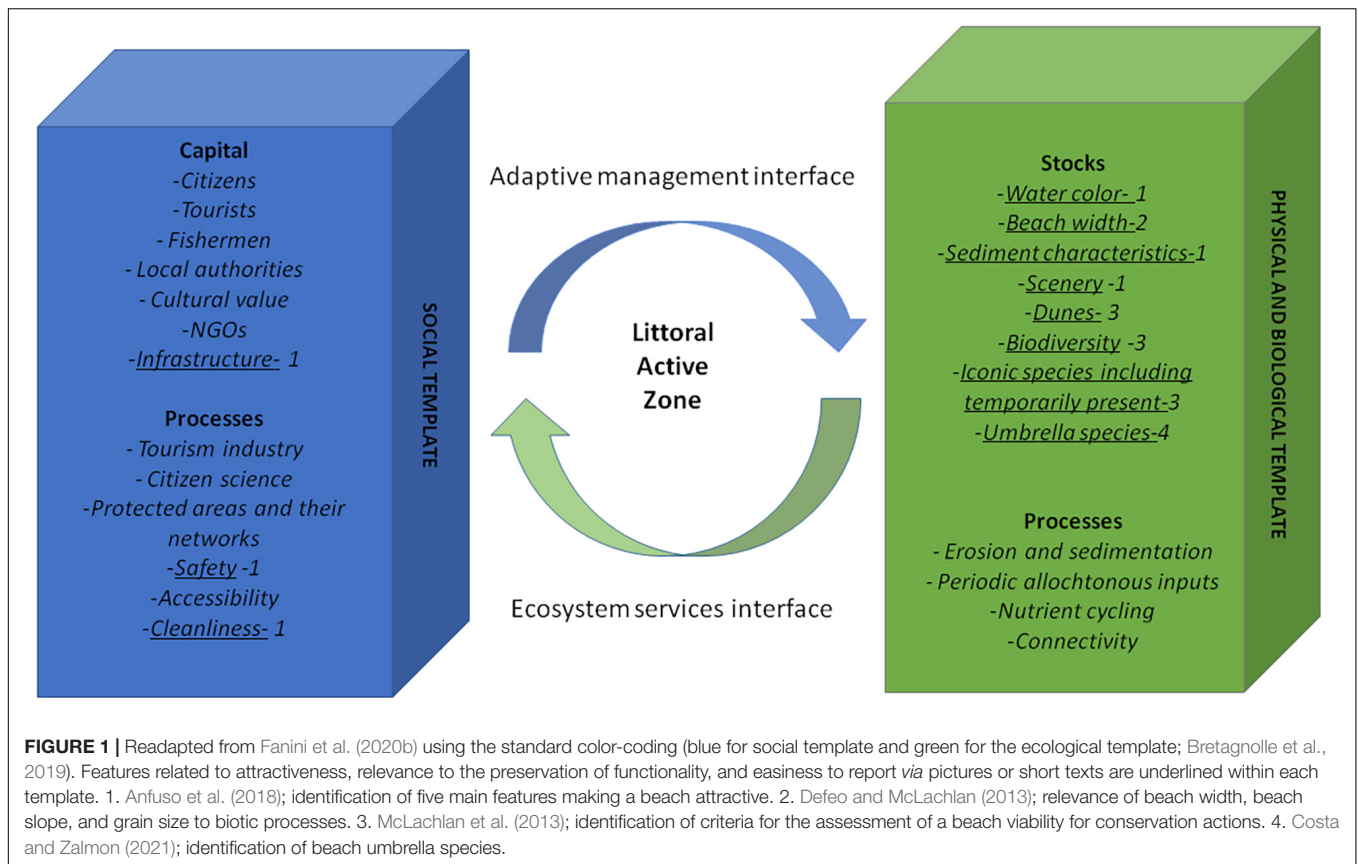
Key features of the LAZ system relate to the ecological mesoscale, which is of particular importance for the macrofaunal diversity, though they connect ecological and social templates, being the very background for the attractiveness of a beach. For instance, the variable “beach width,” a key for habitat availability, biodiversity, and populations traits (Barboza and Defeo, 2015), also represents the available space for recreation and matches the concept of “beach” by the lay public. Variables such as water and sand color (Mestanza-Ramón et al., 2020) are rooted in the “beach imaginary” and partly overlap with the “sun, sea, and sand” model. They are featured in social media profusely and represent desirable beaches, though they are connected to dynamics such as erosion, contamination, integration of infrastructures, accessibility, and safety.

Following this conceptual organization, it clearly results that most elements suitable for connecting beach users to the beach as a system through citizen science actions belong to the LAZ physical and biological stocks. Research studies in beach ecology can provide a sound background on stocks and also standard methods to measure and quantify them. For instance, the attitudes of beachgoers also involve items from the social template. In this aspect, users seem ready to consider both templates—perhaps even a step ahead of scientists. Also, beach users can easily connect to other components of the system, in visualizing related information and returning benefits to scientists, citizens, and to sustain governance as an ultimate goal.

### Beach Citizen Science Projects

Recent reviews of marine citizen science projects pointed out the fact that the beach is an easy and cost-effective location for citizen science actions (García-Soto et al., 2021). Projects span from species-specific focus, usually tackling the habitat where iconic species nest (birds and turtles), live (insects and ghost crabs), or spawn (fish), but also in fewer cases and in a country-specific fashion, dealing with broader scales, biodiversity, and geomorphology (e.g., on wrack-associated fauna and shoreline erosion, respectively) (Earp and Liconti, 2020). The common background to most projects remains the LAZ, with the single beach as a unit, and the focus on physical and biological stocks. In these contexts, the inclusion of sensitive features from the social template would start building links across science and society, given that the very same unit is not only where ecological processes occur but also the area experienced by beachgoers and the unit under management by local authorities.

Regarding the tools available, the attention toward mobile apps and platforms is clearly raising, driving toward a “socio-technical approach,” as summarized by Sturm et al. (2017),



allowing to keep the connection between citizen science principles (see 10 principles of the European Citizen Science Association<sup>1</sup>), the social background of participants and the rapidly growing range of technological tools. Finally, the success of citizen science projects will still rely on the strength of the message and its social–ecological impact. We believed that social media, where the beach has a widespread presence already, would represent a source of paramount relevance to mine into. Emerging approaches such as netnography (Kozinets, 2019), browsing for qualitative inter-connections within social media, would greatly support advances in this sense. Queries related to images, toponyms, and co-occurrence of hashtags would relate physical and biological beach stocks and ideally highlight their cultural value and attitudes of users. New tools available would sustain the restructuring of meanings of system elements, breaking through old perceptions and attitudes.

## Stories From Beached Plastics, the Blue Flag, and Tourism-Oriented Platforms

Beached plastic litter as a subject of citizen science actions is worth a mention. The reaction to a littered beach is rooted on the perception of the litter as an offense (Tudor and Williams, 2003) and has a huge potential to engage and build on people active citizenship (Battisti et al., 2020). Cleanup actions are related to conservation, though can support citizen science, contribute

to the research study of litter pollution on beaches and their management at different scales (Chen et al., 2020; Urbina et al., 2021). The great support of people toward cleanup movements comes from their relationship with the environment by itself and not from an awareness of preserving biodiversity. However, this indirectly benefits the entire beach ecosystem, being a great option for the purpose of conservation and maintenance of a harmonious relationship between beach users and beach nature. It also relates to LAZ features such as beach cleanliness and safety. Most widespread protocols, e.g., OSPAR (2010) and WIOMSA (Barnardo and Ribbink, 2020), are in place and offer visual manuals, as well as platform and apps support (e.g., the Marine LitterWatch app). Pictures of cleanup results are often shown on social media, especially in association with different campaigns (and huge differences, e.g., #2minutebeachclean, 152K posts on Instagram; #marinelitterwatch counts less than 100 posts—data retrieved on April 4, 2021). They are often disconnected from the beach where they proceed from. The connection of these actions to the beach as a living system (Kiessling et al., 2017) would allow going beyond the approach to beaches as “resting places” for plastic litter. The achievement of a systemic view could be improved by adding information requests, whether in pictures or short texts, from basic features from the physical and biological stock (Figure 1).

Initiatives to promote beach quality such as the Blue Flag (BF) are not based on citizen actions; however, the BF implementation highlighted attitudes connected to the

<sup>1</sup><https://ecsa.citizen-science.net/documents/#tenprinciples>

promotion of a good environmental quality beach under both ecological (i.e., cleanliness of sand and water) and social (i.e., accessibility and safety) aspects. In most cases, it is progressively perceived as a touristic label (McKenna et al., 2011; Peña-Alonso et al., 2017). It is an important signal of the attention that beach features can raise and shows a promising background for the reconnection of beach users to the beach system, but it needs to be integrated by relevant literacy (a process that has to start from researchers providing literacy points). Actions specific for the association of the BF with other elements of the LAZ, such as a hashtag, strongly associated with conservation would help to inter-link components and counterbalance the current attitude to recreation as a sole driver.

An example of an interactive case, commercial and not associated with quality labels, is the platform: [www.cretanbeaches.com](http://www.cretanbeaches.com). The identification of attractive stocks (i.e., water color, size and color of the substrate, infrastructure, accessibility, and frequentation) was applied to a local (the island of Crete) level. The site quickly became a reference for both locals and foreigners, with millions of visualizations (AR, Cretanbeaches CEO, personal communication, data from 2019). The information related to single beach proceeds from the feedback of visitors *via* multiple entries, though the dataset is lively and constantly reviewed by “peer beachgoers”—which explains the success of the website.

These experiences are powerful indicators of the potential for citizens to take on a major role when comes to provide, share, and use information about beaches in an integrated fashion [also including biotic aspects, such as the presence of threatened, endemic and/or charismatic species, and threats (e.g., fishing, vehicle traffic, and sewage disposal)]. The need to assess and follow up the process of change in a social–ecological system can be fulfilled by an approach *via* leverage points.

## Leverage Points

One perspective for the comprehensive assessment based on social–ecological system thinking is the perspective of leverage points (Meadows, 1999; Fischer and Riechers, 2019). Leverage points are “places to intervene in a system” (Meadows, 1999) and are based on a hierarchical structure, from shallow (e.g., changes in parameters such as the amount of plastic at the beach or feedbacks in touristic platforms) to deep (Abson et al., 2017). Deeper leverage points are found in a system which is defined by the structure of information flows; they relate to the rules of the system and the power to add, change, or self-organize the system structure. This includes a change of mindset or paradigm shift (Meadows, 1999). Changing the system intent would hence influence its structure, rules, delays, and parameters (Abson et al., 2017; Meadows, 1999). In the case of beaches, shallow leverage points such as beach cleanups are important, especially when they are linked to deeper transformation through education and behavior change. However, the perspective of leverage points can aid to focus on the transformative potential of specific interventions, so to include actions that lead to sustainability in the long term (Riechers et al., 2021). Deep leverage points to foster a sustainability transformation relate

to *reconnecting* people to nature, *restructuring* institutions, and *rethinking* how knowledge is created and used to achieve sustainability (Abson et al., 2017).

The reconnection of beach users to the beach environment beyond its recreational and temporary use will go through the recognition of the tie between beach attractiveness and preservation of its stocks, which will, in turn, keep the system functionality. The huge socioeconomic relevance of the role of beachgoers and the immediate mainstream that they might have *via* the sharing of their feedback online (e.g., Google guides), or *via* social media, can be a powerful driver for management and governance adaptation. At the same time, the basic information useful to science can be provided by such a continuous and widespread monitoring.

Restructuring of mindsets and attitudes supporting governance is the main challenge for ecologists *in primis* and relates to their ability to not only provide knowledge but also to mainstream it in a long-term vision (e.g., Otto and Pensini, 2017). The use of LAZ as social–ecological system is a frame into which novel approaches such as imaging, hashtag research study, and social-media-related actions can be integrated and harmonized, and information often embedded in academia (without enough reach) can be made explicit and usable instead. The process of restructuring does not have to be disruptive, yet old tools can be loaded with new meaning. This would span from very practical tools (e.g., the recommendation to refer to existing icons for visual communication, Sturm et al., 2017) to broaden existing perspectives (e.g., the increase in ecological insights required to shift from considering charismatic species to umbrella species, including habitat requirements, taxon congruency, and ecological interactions beyond charisma, Costa and Zalmon, 2021).

Rethinking how knowledge is created will necessarily go through the involvement of the social template, where citizen science can be used as a tool for informing the public, especially regarding the novel communication potential held by generations Y and Z. Rethinking how sandy beaches are perceived but also what academic knowledge means will challenge presumptions, expectations, and perceptions. And especially in the case of younger generations, the stakes are high and could lead to a powerful intervention to foster a rethinking of knowledge and a reconnection to the complexity of the ecosystem that is the sandy beach.

## CONCLUSION

Sandy beaches hold a high potential for citizen science and citizen monitoring actions, and scientists should challenge to include the emerging set of tools for engaging young generations and sustain their shift in attitudes with a vision. The loading with the new meaning of old models would boost social and ecological governance support of such relevant environments.

We intended to conclude with a few general recommendations, to start the process of making our perspective operational.



- In line with the ECSA principles, “citizen scientists may, if they wish, participate in multiple stages of the scientific process.” Following this key point, the design of actions shall include the selection of features of high interest for beachgoers, as well as the participative establishment of icons, hashtags mentioning stocks, processes, and capital. Rules for visual outcomes on social media should also be set as part of the planning of actions.
- Existing actions could add simple measurements related to the LAZ, such as beach width (using steps as a proxy of meters) or pictures of the substrate. Furthermore, beached wrack could be co-measured along with anthropogenic litter in the occasion of cleaning campaigns, with the option of developing other specific targets related to the interaction of templates (e.g., insects entrapped in bottles, Romiti et al., 2021).
- The planning in space and time of citizen science actions should consider LAZ features across templates. Information provided by citizens will return patterns across social and ecological scales, e.g., geomorphological, ecological, and managerial as well as cultural. Yet, because of its connection with the youngest generations, this information will be projected into the future. Regarding the approach to human impacts on beaches, the adaptation of the concept of gravity center (e.g., Peng et al., 2017), related to the vicinity of the LAZ to a possible impact on

stock and capital, would greatly support both science and governance. Timing of citizen science actions could finally integrate socially relevant phenomena, e.g., touristic season and cultural festivals.

## AUTHOR CONTRIBUTIONS

LF, MR, LC, and IZ discussed the topic and co-wrote the manuscript. LF provided drafts as background for discussion and led the redaction of the final document. All authors contributed to the article and approved the submitted version.

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