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# The role of scientists in providing formal and informal information for the definition of guidelines, regulations or management plans for sandy beaches

Felicita SCAPINI * & Lucia FANINI

*University of Florence, Department of Evolutionary Biology, Via Romana 17, 50125 Firenze, Italy*

**Abstract.** Sandy beaches are becoming subject to increasing attention of policy makers and planners. The importance of beaches as environments of economic relevance is generally recognized as well as the threats to their existence self, deriving from the increasing urbanization, on one hand and negative consequences of climate change both inland in the oceans, on the other hand. Policy makers of higher international levels have developed guidelines and regulations aiming at mitigating the negative effects of anthropogenic and natural pressures to the marine environments, including beaches. The question stays open about setting priorities when the implemented actions are conflicting. Coastal areas are managed locally under conflicting pressures of economic development and negative impacts to beach ecosystems, such as beach erosion, coastal waters pollution, etc. The inputs of a sound scientific research are necessary and asked for by managers at both levels, the international and the local one. In the framework of the three Euro-Mediterranean research projects, MECO, MEDCORE and WADI, we were witness to conflicts for the management of coastal resources among various stakeholders, often insurmountable without compromises. In order to avoid irreparable harms to the ecosystems, scientists should develop methods of clearly communicating the relevant results of scientific research to stakeholders, without unnecessary and often erroneous generalizations or simplification of the real world. The goal of this paper is to derive some lessons from case-studies, present formal and informal actions undertaken to encourage communication among stakeholders and raise awareness about such important and fragile ecotonal systems. The role of scientists in communicating the good information is discussed.

**Key words**: Sandy beaches, coastal zone management, conflicts, indicators, beach ecosystems.

**Résumé.** ***Rôle des scientifiques dans la communication d'informations formelles et informelles en vue de la formulation de lignes directrices, réglementation et plans d'aménagement des plages sableuses*.** Les plages sableuses bénéficient de plus en plus de l'attention des aménageurs et des politiciens, soit pour leur importance économique soit pour les risques auxquels ces environnements côtiers sont exposés, dont les principaux sont l'érosion et l'urbanisation croissante. Au niveau international, les politiciens développent lignes directrices et règles dans le but d'atténuer les effets négatifs dus aux changements climatiques et aux pressions anthropogéniques qui menacent les plages. Le problème principal qui reste posé est la prise de décision sur les priorités en cas de conflits entre différentes actions envisagées. D'autre part, les environnements côtiers sont souvent aménagés au niveau local suite à des conflits entre un développement économique et son impact sur les écosystèmes des plages, comme l'érosion, la pollution, etc. Les résultats de la recherche scientifique deviennent alors nécessaires et sont de plus en plus demandés par les aménageurs à tous les niveaux (local, national et international). Dans le cadre de trois projets euro-méditerranéens de recherche, MECO, MEDCORE et WADI, plusieurs conflits ont été observés entre les différentes parties prenantes suite à l'aménagement des ressources côtières, qui aboutissent souvent à des compromis qui présentent cependant des risques pour les écosystèmes. Seule une communication claire entre les chercheurs scientifiques et les parties prenantes, sans généralisation ni simplification excessives et non nécessaires par rapport aux problèmes réels, peut contribuer à développer une meilleure stratégie d'action, qui tient compte du développement économique et de l'intégrité des écosystèmes. Dans cet article, les auteurs présentent les enseignements tirés à partir d'observations effectuées sur les sites d'étude autour de la Méditerranée accompagnés de leurs commentaires, en vu d'encourager une meilleure communication entre les parties prenantes et améliorer la connaissance sur les fragiles systèmes des plages. L'importance de la communication scientifique en vu d'un aménagement durable des systèmes côtiers est discutée.

**Mots clés** : Plages sableuses, aménagement des zones côtières, conflits, indicateurs, écosystèmes des plages.

## SANDY BEACH MANAGEMENT: CONFLICTS AT MULTIPLE LEVELS

Sandy beaches have been traditionally almost neglected by marine biologists for their apparently poor diversity and ecosystems whose processes are mainly driven by physical factors (McLachlan & Brown 2006). However, beaches represent the most important links between sea and land environments around the world and their ecological relevance as ecotones has been recognized (Defeo *et al.* 2009). In the last two centuries, however, following the discovery of coastal areas for human health, recreation and, more recently, mass tourism, sandy beaches are becoming object of increasing attention by policy makers and planners (Scapini 2002). The importance of beaches as environments of economic relevance has increased and management plans have been developed for these areas in most countries, particularly around the Mediterranean (Swarbrooke & Horner 2007). Such sudden discovery of the economic relevance of sandy beaches had no correspondence in the development of clear ecological paradigms on what a "natural sandy

* Corresponding author
E-mail address: scapini@unifi.it

beach" is and management actions have been often undertaken independently from the scientific progresses. The ecology of sandy beaches has now to deal with anthropogenic landscapes and mostly degraded systems. Moreover, processes towards the uptake of new scientific information are extremely slow (about a human generation, i.e. 20-25 years), while environmental management has a faster dynamics (five years is usually the time span of a political mandate). Confusion and lack of clear scientific concepts may invalidate most of the actions undertaken to face the risks that threaten the existence self of sandy beaches or erode this resource in terms of availability and quality.

Policy makers at all levels are becoming aware of the risks that threaten these valuable environments and are developing guidelines and regulations aiming at mitigating the negative effects of both anthropogenic and natural pressures on sandy beaches. Researchers are asked for sound scientific inputs, but these may be too complex to deal with and therefore may not be taken into account in a current management plan. On the contrary, simple instructions (e.g., "protect this particular beach sector where turtles are nesting") may understate the importance of beach ecosystems and ecosystems' services, and be inefficient in the long term (Martin-Cantarino 2010).

On one hand, sandy beaches are threatened by increasing urbanization and, on the other hand, by the negative consequences of climate change acting as pressures both inland and in the oceans. At the same time, there is still a lack of understanding of the dynamics of sandy beach ecosystems, representing ecotones between land and sea with peculiar processes. The consequence is often a reductive approach (although applied globally) of a complex problem, limiting the approach to few compartments, namely those that are better understood and appear most relevant, e.g. the exploitable surface of the beach. This creates fractures, usually widening through time due to the lack of communication among compartments (Van Koningsveld *et al.* 2003) or even harshening when conflicts for natural resources already exist (Scapini & Ciampi 2010). A reductive approach may cause a polarization between an economical exploitation of natural resources and their conservation, and escalate the conflicts in the long term. In such framework, often science is unfortunately considered one compartment and not an integration tool. However, scientists are independent from sandy beach resources (thus they are not stakeholders in the current meaning) but could add an external perspective, also validated by a worldwide dialogue. As a rule, scientific results are subject to the process of scientific information production and falsification.

At Mediterranean level the Barcelona Convention, or better the process of Barcelona, has promoted actions in such framework. The MSSD "Mediterranean Strategy for Sustainable Development", adopted by the Contracting Parties to the Barcelona Convention in 2005, covers seven priority fields of action (water resources; energy management and addressing impacts of climate change; transport; tourism; urban development; agriculture and management of the sea; coastal areas and marine resources) to ensure a sustainable development in the region. Coastal areas are central in this Convention. The challenge of developing the economies around the Mediterranean Sea is clearly the driving force. The question stays open about setting priorities when the actions implemented are conflicting among each other.

Despite their international relevance, coastal areas are managed locally under the conflicting pressures of economic development and negative impacts on sandy beaches and related systems, such as beach erosion, coastal waters pollutions, biodiversity erosion, etc. Moreover, measures are taken locally and sectorally, which may impact other areas and ecosystems. In such complex and interconnected environments, however, mitigation actions that are efficient against a negative effect (e.g., beach stabilization against coastal erosion) may impact nearby areas (e.g., through deviation of long-shore currents, or drawing of sand for beach nourishment from marine fragile environments, etc.). At this level, the main challenge is how to comply with the international directives without losing opportunities of local socioeconomic development with attention to environmental quality preservation. Some international directives are apparently non profitable locally. An example is the regulation against constructions within a given distance from the shoreline, recently proposed within the Barcelona framework and signed by most Mediterranean countries. The result has been that too many exceptions to the general regulation are driven by local contexts. Also, the establishment of protected areas and ecological corridors are often contrasted locally with the outcome of a fragmentation of the protected areas self (Innamorati, *pers. comm.*) regarding the marine protected areas in Tuscany, Italy). Another example is the choice of the location of the ports, either for commercial, fishing or leisure activities, which is regulated at higher levels, but may have impacts on the local level.

So, this kind of top-down approach raises challenges mainly for local people and their life quality, especially in the case of strict and multiple links between local economies and environmental resources. Cultural diversity can also be impacted by an erosion of or change in use of the ecological resources (Canestrini 2004), with a consequent re-assessment of cultural values and usually a loss of cultural diversity, as this latter feature is likely to be shaped by local environmental characteristics (Löfgren 2002). Also in this respect, conflicts may arise between local and central policies.

The need of integration when approaching a complex environment was already established (see Conrad & Cassar 2007 and citations therein). An integration of scientific information and local perspectives (as seen for local Agenda 21) is needed as input for effective environmental management, while integrated outputs are needed as well.

When planning actions with stakeholder participation, it was recognized that the statement of priorities is helpful in correctly addressing the problems and consequently avoid dispersion and lack of efficiency (Van Koningsveld *et al.* 2005). However, the scale of problems faced was again found to have an effect on information production and communication efficiency. An increasing discrepancy between information production and information demand was found related to the length of the projects undertaken (Van Koningsveld *et al.* 2003). This is consistent to both the inertia, i.e. an emerging characteristics of human ecology (Marten 2001), and to the fact that actions are addressed to a dynamic system, namely to the linking functions between variables and not to the state variables self.

Ideally, environmental protection should be a priority at all decision levels, for the benefit of the future generations in the long term as well as hedonic aims (related to leisure activities) in the short term (Agenda 21). But this is rarely the case. As a rule in environmental management, economic considerations override all other concerns and are acting with faster dynamics than ecological ones. Money can be spent in view of a gain, i.e. for the benefit it may bring in the short or medium term, not just for the sake of a vague concept of environment (Ciampi 2010). For this reason, attempts have been made to valuate environmental goods, including biodiversity, and such evaluation has been adapted to beach-dune systems (Sala *et al.* 2008; Table I).

Tourism is peculiar phenomenon acting with seasonal dynamics on sandy beaches. It is a powerful driving force and is often proposed by international organizations and NGOs as a tool to alleviate poverty and preserve the environment at the time (World Tourism Organisation 2002). However, when the sectoral approach is followed, as for the risk mitigation mentioned above, the same threat of "problem displacement" becomes consistent and also worsened by the seasonality typical of seaside tourism (Baum & Lundtorp 2001).

Another kind of action often undertaken in terms of "sandy beach preservation" is the "emergency", e.g., the protection against severe erosion of the shoreline. In most of the cases, the cause of the phenomenon is neglected and efforts are devoted merely to mitigate the negative effects (see Fanini *et al.* 2009, for the case of Arno River mouth, Italy). However, the object of interest is not the beach, but the backing environment (e.g. the wetland area and its biodiversity, Fanini *et al.* 2009, or constructions, even if built on the dune and therefore being the indirect cause of the erosion, Nordstrom & Jackson, 2003, for the eastern coasts of U.S.A.). Protection or mitigation actions are therefore fitted to environments different than the beach, although carried out on the beach self and directly impacting on its ecosystems.

Conflicts in management may arise at all levels, but are likely to explode at local level, due to different ideological backgrounds, often related to extreme positions, e.g. "environmentalists" and "econo-micists" that set contrasting priorities and, being extreme, do never come to a compromise (Ciampi 2010). It is easy to show that both types of solutions, as proposed in the framework of similar conflicts, will cause disasters both to the environment and economy in the medium and long term.

In an holistic perspective, links have been identified between different components of the sandy beach environments, comprising natural systems, management systems, socio-cultural systems and the links within (Platt 1994). But we are still far from an overall understanding (James 2000). In a scenario with science at service to the society, scientists are asked to fill the gaps, making efforts to overcome the mere consideration of "sectors". But the information raised in this perspective has then to be spread to the society in a suitable way. As for the study of complex systems that need integration, also the information delivery must be tuned to the audience. And each priority setup must have a corresponding target of audience.

**Integration: the inputs**

The need of integration in knowledge building and knowledge use for common welfare is well recognized and sandy beaches are not an exception. However, integration is sensitive to different contexts and different times. Issues to be faced when dealing for integration are shown in Table II. The elements to be integrated are on different levels and their relationships are generally more complicated than simple additions (i.e. we must keep in mind that integration is not the summation of elements, but their interactions must be taken into account as well as the emerging features of the systems).

The inputs of a sound scientific research are necessary in view of a sustainable management. Managers and policy makers at various levels, the international, national and local ones, ask for scientific inputs. In the complex reality, the international and local perspective may be contrasting, as the former tends to simplify reality (e.g., providing simple instructions such as "sandy beaches need one hundred meters of width to be sustainable, irrespective of the characteristics of the ecosystems") and the latter may prioritize particular relationships (e.g., the needs of a small group of people vs. other groups, or the protection of one particular flag species over others). However, as Beck (1998) pointed out, only local stakeholders know the real relationships between elements of the systems and apply a regulation in a sustainable way for a particular context. Environmental management is made and maintained locally and indicators of sustainability should therefore be chosen and estimated locally. An analysis of stakeholders' perception was proposed to involve the stakeholders' perspective since an early planning phase, to avoid their consideration at last decision-making stages only (e.g., "do you agree with this plan or not?") (Pereira da Silva 2003). Also, the valuation of perception may supply an useful background for those, e.g. policy-makers, who are looking for public consensus.

Interdisciplinary integration needs the development of a common framework and testable hypotheses. Useful paradigms on sandy beach ecology have been developed firstly taking into account the abiotic component as main drivers of sandy beaches types by Short (1996). Such paradigm was then successfully tested on a wide geographical range and integrated with biotic components (Defeo & McLachlan 2005).

The integration of the human component started from the analysis of human impacts on the ecosystems (McLachlan & Brown 2006) and is finally moving towards the integration of sociocultural heritage into a social-ecological system. Also, some inputs from economic science have been provided to improve the integrated management of sandy beaches, i.e. the valuation of ecosystem services applied to sandy shores, and the economic promotion through eco-labels of touristic beaches. However, the evaluation of their effectiveness on people (both managers and consumers) behavior can be made only on the medium and long term. The lack of knowledge about the links connecting sectors could be a hazard, affecting both the tools mentioned above.

**Integration: the outputs**

At overall level, there is a need of understanding the processes of scientific information production. The awareness of how the information is provided, the idea of a sound test behind any information supplied and its possibility to be replicated over a range of contexts, should represent a background for the use of tools coming from the research (Wals 2009) and their application to sandy beach environments. Also, the feeling of openness of the scientific information to a dialogue with the society should be up taken at all societal levels, and multiple scales. Multiple tools to reach these conditions can be highlighted, among them:

*Education*. For its own nature, it has a long-term effect, but it has the potential of providing a background of societal openness to integration and fostering a dialogue between science and society. Beyond the education to the scientific approach, the uptake is relevant of updated information in school programs and information flow to the families; the first is slow and the second is characterized by uncertainness. Schoolchildren are not only the future citizens, but also represent a link between the institutions (schools) and the families (Vaughan *et al.* 2003).

*Information and popularization*. A crucial aspect in this trend relates to how scientific issues are presented to the general public by the media (Stanica & Thomas *in press*). The media have a relevant and increasing role in the formation of individual environmental perception (Fanini & Fahd 2009). The concept of environment is often presented by the media as external to the real life, thus disconnected from the domestic context (to which the beach pertains in the case of local stakeholders). This may contribute to maintain a sectoralization of the information. Storytelling is a popularization tool suitable to deal with the wide diffusion of scientific information, as it allows for the inclusion of qualitative data into a context's description (Zellmer *et al.* 2006). This is particularly needed in the case of dynamic contexts, such as sandy beaches and the dynamics acting on them. Also quantitative information is included in storytelling, emphasizing relevant topics with the use of numbers. Artworks generally integrate this information, by attracting the attention (as art moves the affective domain) and eventually adding relevant data in a synoptic way of communication. The wide use of posters in conferences may confirm the above said. In the past, famous artworks by nineteenth century's artists contributed to bring the idea of "nature", "landscape" and "biodiversity" to the cultural domain of the wide public. An example are the masterpieces of Henri Rousseau, known for his representations of tropical forests and their biodiversity (Fig. 1). As a matter of fact, Rousseau never traveled abroad and took models from the botanical garden in Paris, but histories about his journey to Mexico with the French expeditionary forces were spread to the public and associated to his paintings. In this case, storytelling gave an increased credibility to visual representations. The latter were correct as they came from the botanical garden, but were not linked to the affective domain that was supplied by the "exotic" framework of the storytelling and the artwork.

Table I: Ecosystem goods and services provided by beach-dune systems. In bold, those services of higher relative magnitude with respect to other marine habitats. In brackets, those goods and services that sandy beaches apparently do not provide (adapted from Sala *et al.* 2008).

| *Goods and services* |
|---|
| Food, Fiber, Timber, Fuel, (Medicines) |
| Biodiversity, Biological regulation |
| Freshwater storage and retention |
| (Biochemical), Nutrient cycling and fertility |
| Hydrological |
| Atmospheric and climate regulation |
| Waste processing |
| **Flood/storm protection, Erosion control** |
| **Cultural amenity, Recreational, Aesthetics** |

Table II: The issues of integration

| | |
|---|---|
| • Issue of scales | – different elements have different scales<br>– beaches are open systems |
| • Issue of integration | – of elements of the system<br>– of disciplines<br>– of scientists, managers and decision makers<br>– of local, national and international levels |
| • Issue of communication | – to whom?<br>– what?<br>– how? |

*Indicators.* These are suitable management tools to deal with complexity (Lenz & Peters 2006). For tourism, there are many quality indicators (and a consequent suite of quality labels for sandy beaches), but there is a risk of

choosing indicators related to some sectors only, unable to indicate more than a single phenomenon. A set of indicators may therefore be more appropriate, including social dependence on ecosystems (Scapini 2002, Petrosillo *et al.* 2006). Indicators deal with the real state of the system, while the ideal state only exists in the minds of stakeholders; actions are taken by managers to reduce the difference between the real case and the ideal one (Fig. 2).

At overall level, a system level that includes both ecological, socio-cultural and economic components and the relationships thereof can be used as integrated information for a sustainable management of the environment. In this light, biodiversity starts to be considered as linked to the ability of the system to change rather than a quantitative list of species (UNEP 2009). For sandy beaches, measures can be undertaken to mitigate the instability due to peculiar phenomena such as the seasonality of tourism (Jang 2004) for the benefits of the whole system, not eroding some compartments in favor of some others.

**A real-case example**

In the framework of the three Mediterranean research projects, MECO[1] (1998-2001), MEDCORE[2] (2002-2005) and WADI[3] (2006-2009), we were witness to conflicts among various stakeholders over coastal resources, often insurmountable without compromises. In the case of conflicting views, scientists are generally asked to help mangers, e.g., providing tools to set priorities, showing the trends of changes, developing predictive models, to find sound solutions of the conflicts and consequently provide tools to decision makers and environmental planners to take the best compromise in the conflicts. Each of these inputs are subject to the risk of simplifying the real world The three projects mentioned above ultimately aimed at solving problems and conflicts among different elements of the systems (MECO), coastal areas and inland (MEDCORE) and different stakeholders (WADI). In this respect, sandy beaches are arenas (place or scene of activities or conflicts), where contrasting interests are evident and pressures are acting at different time and space scales.

One case-study that was followed throughout the three projects above was the Zouara beach in Tunisia (Bouslama *et al.* 2011 - this volume). This beach-dune system is located in the north-western Tunisian coast, subject to the strong natural dynamics of winds and waves. The beach ecosystems are still pristine, while the dune fields have been regulated by forestation. During the MECO project the international teams of researchers provided a set of sound geographic, ecological and socioeconomic data to the national agency for the management of the littoral zone. So the management plan of the area included this scientific information, aiming at enhancing the value of the natural goods. Eco-tourism activities were proposed in the area that would respect the fragile elements of the beach-dune ecosystem (Scapini 2002). At the same time, it was realized that a "light" eco-tourism would not be sustainable in a developing economy searching for economic gains in the short term. As a matter of fact, the national tourism agency has proposed a mass tourism's development of the area, an airport was constructed nearby and the construction of international hotels on the consolidated dune fields was planned. So a dispute has arisen between the two agencies, depending from the Ministry of the Environment and the Ministry of Tourism, as the agency for the littoral zone has denied the permission for the construction of resorts on the consolidated dune fields, according to their mandate of coastal conservation.

Independently of the outcome of this dispute over the management of the area, the Zouara beach has started to retreat in a dramatic way. The direct cause of the shoreline regression was the construction of a dam up the river mouth and the consequent blocking of sediments flow to the sea. The dam was needed to supply the nearby cities and agriculture lands of fresh water. Ultimately, a compartment external to the area (the watershed) has severely impacted the beach-dune system (UNESCO-IHP 2009). This case-study clearly shows the need of an integrated management, as well as the difficulty of setting priorities by different stakeholders. Ecologists expert of sandy beaches should come together with economists and planners to find the best compromise to manage this valuable area. However, the choice of the best management plan will in any case depend on policy makers on the national level.

In the same area, we carried out actions of environmental education with local schoolchildren (i.e. the citizens of tomorrow). Throughout these activities we identified specific gaps in the perception of the sandy beach environments (Fanini *et al.* 2007). While some information was clear for the children, such as the damages due to garbage dumping on the beach, the origin of sand dunes was absolutely mysterious for them. These results were probably due to different information flows. The information about a correct behavior for the preservation of environmental goods is available on the mass media and many initiatives are periodically organized to this aim. Instead, a basic knowledge about sandy beach environments still has to be up taken in the school programs, following a different and much slower process of information flow. The results of actions to raise awareness can therefore be differential, depending on the topic and on the media used to talk about it.

[1] MECO: "Bases for the Integrated Sustainable Management of Mediterranean Sensitive Coastal Ecosystems", IC18-CT98-0270, 4th Framework programme of the European Commission

[2] MEDCORE: "From river catchment areas to the sea: a comparative and integrated approach to the ecology of Mediterranean coastal zones for sustainable management", ICA3-CT2002-10003, 5th Framework programme of the European Commission;

[3] WADI: "Sustainable management of Mediterranean coastal fresh and transitional water bodies: a socioeconomic and environmental analysis of changes and trends to enhance and sustain stakeholders benefits", INCO-CT2005-015226, 6th Framework programme of the European Commission.

Figure 1: Henri Rousseau, “Exotic landscape”, 1910. The artwork *ante litteram* illustrates the concept of “biodiversity”.

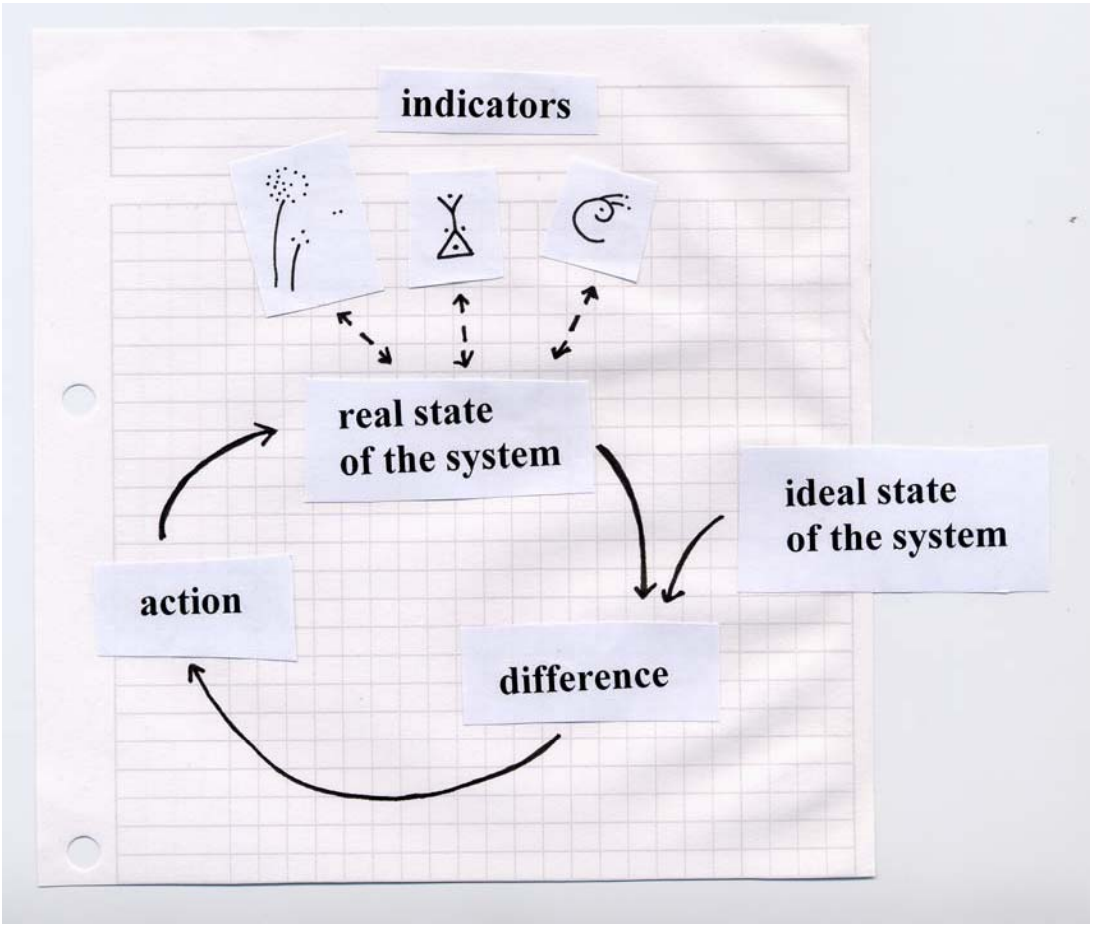


Figure 2: The role of indicators in a dynamic system, managed on the basis of the differences between the real state and the ideal one: indicators are suitable to give proxies of the real state of the system (and not of the ideal one, neither of the actions undertaken), as they are system’s components.

## DISCUSSION: COMMUNICATION ISSUES

The process of knowledge building about sandy shores started from the information about physical and ecological components, but gaps still exist between the knowledge of geomorphologic and ecological characteristics, the effects of human use and of political choices, despite the efforts carried out to fill such gaps (McLachlan & Brown 2006). However, the consideration of sandy beaches as integrated management units is likely to be the best approach to maximize efficiency and minimize conflicts in the definition of guidelines, regulations or management plans. In this perspective, scientists are asked to deal with complex systems and make complexity affordable to a wide range of stakeholders, not only managers, but also inhabitants (strictly linked to the ecosystem) and children (the citizens of tomorrow).

Throughout this process of communication among scientists and stakeholders, the role of Science is not to predict the future nor to simplify a complex reality, but to try to understand it throughout a continuous dialectic process. Are scientists prepared to analyze complexity? There is trade-off between the need of quantification and modeling and the analysis of complex systems. Often ecologists start the analysis of an ecosystem from a complex conceptual model, but can not go beyond because they lack of mathematical tools. Also when suitable mathematical tools are available, the results would be too complicated for communication to lay-men. Scientists should honestly say this to stakeholders and develop methods of clearly communicating the results of scientific research, without unnecessary and often erroneous generalizations or simplification of the real world. These may just help decision making or environmental planning at small spatial and temporal scales, but it may be risky in the long term and on wider spatial scales.

Also science should avoid extreme paradigms, which are easy to communicate, but are generally unbalanced towards the conservation of particular species or the earning of money (Ciampi 2010). New paradigms should be developed in ecology, with focus on dynamics and processes, rather than on quantitative issues (Graham & Dayton 2002).

It is important that scientists develop shared outputs that can be supported as a group (Defeo *et al.* 2009). Moreover, biased approaches should be avoided, both eco-centric and anthropocentric. Possible sources of bias are: 1) neglecting or considering merely negative the human use of the beaches and/or looking for pristine areas only as study-sites; alternatively, 2) over-emphasizing money flow, e.g., in the ecosystem goods and services approach in the economic valuation of ecosystems (Table I). For example, production of goods (e.g. crop) is not applicable on beaches and this may lower their value or emphasize hedonic services. A parallel can be drawn with forestry science that must take into account both the health of the forest as an ecosystem and the exploitation of wood (Piussi, *pers. comm*.).

Social ecological systems can thus be considered integrated management units. The patchiness of beach ecosystems may be taken into account by coastal managers in integration with the patchiness of human use. In temperate climates, the seasonality of anthropogenic pressures deriving from the seasonality of activities linked to tourism, may suggest some management options. In the case of seasonality, both the social and ecological components depict cyclical frameworks. The average values, often used to model systems, are not good indicators. The integration outputs mentioned above should be resistant to time differences, such as cyclic variations. Thus, the time (cyclic) components should be included in the communication and integrated with the spatial ones, which are generally mapped out.

The challenge for sandy beach researchers is to create research paradigms including the use of these economically important environments, but not neglecting the fragile beach-dune and intertidal ecosystems.

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