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# Proposal for an Integral Quality Index for Urban and Urbanized Beaches

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**Abstract** A composite index, based on function analysis and including thirteen sub-indices, was developed to assess the overall quality of urban and urbanized beaches in the Mediterranean area. The aggregation of components and sub-indices was based on two questionnaires completed by beach users and experts. Applying the new Beach Quality Index (BQI) demonstrated that the quality of beaches could be improved. In general, the strongest aspects of the beaches assessed were those related to short-term user demand, and the weakest were those related to the consequences of human pressure on the area, in particular, erosion problems. The composite index is intended to be used together with Environmental Management Beach Systems (EMBs) as a hierarchical management scorecard and in monitoring programs. This new tool could also make planning more proactive by synthesizing the state of the most important beach processes.

**Keywords** Beach management · Integral quality · Indicators · Function analysis · Multi-criteria analysis

## Introduction

Tourism has shown a sharp increase in recent decades in many coastal areas of the world, such as the north-western Mediterranean (Sardá and Fluviá 1999). This has led to increased pressure on the main tourist asset of those areas, beaches, and threatens their use as economic, recreational, natural and aesthetic resources. These tendencies have important consequences for beach management, which is now primarily concerned with satisfying user expectations (Ariza and others 2008a). In Spain, for example, in terms of Function Analyses (De Groot and others 2002; Micallef and Williams 2003), effort of managers has focused mainly on the recreational function, and the natural and protective functions of beaches have been considered secondary (Ariza and others 2008b).

Beaches are systems that are subject to integrated and non-integrated processes. In Spain there is no specific beach policy, but the recent development of a sustainable coastal plan (Plan Director para el Desarrollo Sostenible de la Costa 2005) may be a first step for modifying current beach management practices. Some major shortcomings have been detected in the traditional legal and administrative framework used for beach management. Responsibilities, economic and personnel resources, local characteristics, local processes and stakeholder profiles have not been defined (Ariza 2007). As a consequence, beach management is essentially reactive rather than proactive (James 2000). Responding to problems is limited by the absence of medium/long-term planning. Some of the main persisting problems faced by local beach managers include the loss of sediment [which currently affects many European coastlines

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(Eurosion 2004)], beach cleaning [human pressure causes litter to accumulate during the summer season (Ariza and others 2008c)] and emergency situations (beach closures are common in the north-western Mediterranean (Ariza and others 2008a]).

There is a need to apply more proactive beach management practices and new tools that take into account the physical, natural, and socio-economic characteristics of beaches. A new initiative to apply formal Environmental Management Systems for Beaches (EMSBs) was recently launched in Spain (Ariza and others 2008b). EMSBs has three main goals: commitment to environmental policy, commitment to the compliance with legal and other applicable regulations, and continuous improvement. If these goals are achieved, it is possible to create a management organization that establishes, achieves, and renews environmental goals by means of a (Plan-Do-Check-Act) PDCA approach (Deming 1986). In this framework it is necessary to develop and include monitoring tools for all important beach processes in order to ensure sustainability (Elefsiniotis and Wareham 2005).

Currently, quality issues rather than managerial systems are driving beach management. Quality is measured by means of performance standards and performance rating systems, which are reviewed in literature (Williams and Morgan 1995; Cagilaba and Rennie 2005; Ariza and others 2008b). They focus mainly on water quality monitoring, following the standards established in the EC Bathing Water Directive 76/160/EEC (CEC 1976). Although these standards could be used partially instead of EMSBs, as they set specific requirements that are also included in EMSB goals, in most cases the quality measurements do not allow variations to be quantified or changes in some beach processes to be detected (Sardá 2001), which is very crucial for improving the integrated management of coastal areas (Pickaver and others 2004).

Current performance assessment measurements may be included in EMSBs, but Ariza and others (2008b) have demonstrated that none of these covers all of the management requirements that should be taken into consideration for north-western Mediterranean beaches. In some cases, performance assessment measurements are complementary. They may be used inside EMSBs for assuring overall quality of beaches, but including them may lead to inefficient management effort and organizational problems. It seems more suitable to use a single management tool that synthesizes all the criteria needed, allowing beach processes to be monitored separately and integral quality to be quantified periodically.

The main aim of this article is to develop a new Beach Quality Index (BQI) that can be used within EMSBs as a guidence and control system, with the final goal of guaranteeing beach quality. Due to the different functions of beach environments, it is very important to create a new tool based on function analysis that allows one to present complex information in a clear and simple manner, and capture relevant beach aspects. It may be very useful to solve problems detected in Mediterranean beaches: erosion/sediment management, lack of a unified management organization and beach closures. BQI may also help to detect legal problems, achieve steady improvement or reduce/prevent environmental impacts. The index was designed to help manage the beaches along the north-eastern Mediterranean coast of Spain, and was applied to six beaches in this area as an example. However, it can be adapted to other environments by readjusting the coefficients.

## The Beach Quality Index

### General Approach

As they are complex systems, beach environments carry out different and independent functions according to the characteristics of their processes. These functions were therefore included in the BQI. The integral quality of beaches can be ensured by assessing and controlling three of them: the Recreational Function, the Natural Function, and the Protective Function. In relation to these, three components were created: the Recreational Function Index (RFI), the Natural Function Index (NFI) and the Protective Function Index (PFI) (Ariza and others 2008b). For each component, a set of sub-indices was also defined to allow the services evaluated in each function to be correctly monitored. The structure of the BQI, including components and sub-indices, establishes groups of related items, the absence of which has traditionally been a flaw of performance and rating systems (Micallef and Williams 2004).

All beaches cannot be managed in the same way, and quality must be a function of the kind of beach under consideration. Therefore, we classified the beaches in the study area into two different types: urban beaches or urbanized beaches. Each of these has its particular weighting scores, which regulate the importance of the components and sub-indices. Urban beaches were considered to be those located in the main town center (urbanization in those areas is highly dense, and main land use type is urban). Urbanized beaches were those located in residential areas on the outskirts of a town (urbanization exists but is not as intense as in urban beaches and there is a balance of urbanized and natural land use types) (Ariza and others 2008a). There are also differences in the characteristics of the natural community (more developed in urbanized beaches), the problems caused by storms (urban beaches are usually more exposed) and profile of users

(users have different priorities), means of transportation (an important percentage of users go on foot to urban beaches) and patterns of usage (stays in urban beaches are shorter) (See Roca and Villares 2008; Sardá and Fluvià 1999). Natural beaches have not been considered in this study.

The frequency and season of measurement for each sub-index are defined and explained below. In some cases measures were taken weekly (microbiological water quality, environmental quality, and activities) and in others every three years (quality of surrounding areas), but most of them fall between these two extremes.

Main Components

The three components were designed to aggregate sub-indices that aggregate individual indicators. The individual indicators were extracted from several published documents that contain expert opinions on beach quality assessment (Breton and others 1996; Morgan and others 1996; Leatherman 1997; Morgan 1999a, b; Nelson and others 2000; Buceta 2000; Brown and McLachlan 2002; Yepes 2002; Yepes and Cardona 2000; Jiménez and others 2002; Diputació de Barcelona 2003a, b; Diputació de Barcelona 2005a, b; Universidad de Cantabria 2002; Valdemoro 2005) and on beach management issues in the studied area. To allow the BQI to be used inside EMSBs, nine individual sub-indices were considered for constructing the RFI, three for constructing the NFI, and only one for calculating the PFI. Each component makes a contribution to the final BQI, so they can be used separately to define specific programs, goals and objectives within the EMSB (see Table 1):

*Aggregation and Weighting*

Literature on aggregation methods was revised (Nardo and others 2005). All additive aggregation, geometric aggregation and non-compensatory multi-criteria analysis methods were considered. The linear combination (the most widespread summation of weighted and normalized data), see below, as well as a multi-criteria method were chosen as aggregation methods into the BQI. Other additive methods (calculation of the ranking of different sub-indices or the number of indicators above or below a give benchmark) were considered, but they were discarded due to the fact that absolute and interval level information were lost in the process. Geometric aggregation was also discarded because the method did not allow integral assessment to be made when individual sub-indices had 0 values. The combination of both chosen methods allows assessing marginal contributions when using lineal aggregation without losing absolute information and at the same time avoiding the problem of compensability.

Global beach quality has been established as an addition of different partial qualities, with different importance regulated by weighting. For that reason, the choice of the coefficients of each of the components and sub-indices was extremely important.

Three coefficients (p) were selected for components and 11 for sub-indices (t and u), see formulas below. The coefficients for the components adjust the importance of the three analyzed functions in the analyzed beach typologies: urban and urbanized. The t and u coefficients adjust the importance of the sub-indices for each component. The sum of all coefficients is equal to 1.

The final construction of the BQI, for the first aggregation method used (linear aggregation), is shown below, including each component, sub-index and the partial scores from 0 (worst situation) to 1 (best situation).

$$\mathrm{BQI} = p_1(\mathrm{RFI}) + p_2(\mathrm{NFI}) + p_3(\mathrm{PFI})$$
$$\mathrm{RFI} = \alpha\big[t_1(\mathrm{IC}) + t_2(\mathrm{IEQ}) + t_3(\mathrm{ISerF}) + t_4(\mathrm{IAct}) + t_5(\mathrm{IAcPar}) + t_6(\mathrm{IComf}) + t_7(\mathrm{IS}) + t_8(\mathrm{IBS})\big]$$
$$\mathrm{NFI} = u_1(\mathrm{IN}) + u_2(\mathrm{IWSP}) + u_3(\mathrm{IPQ})$$
$$\mathrm{PFI} = \mathrm{IPP}$$

The weighting procedure was very important for assuring the validity and representativeness of the index. Two approaches were used. In the first one, the responses of 16 experts were obtained from a questionnaire. Experts were chosen for their knowledge and experience in the beaches of the area, as well as their involvement in the different aspects of beach quality (Table 2). In the second approach, the weightings of the sub-indices of the recreational function were based on beach user questionnaires distributed at the beaches in the study area. We obtained 113 valid questionnaires from users of urbanized beaches and 131 from urban beaches. The questionnaires assessed the variables covered by the index (Roca and Villares 2008). Average responses from experts were used as coefficients for all the three components and those sub-indices that needed technical knowledge to evaluate their importance (u and IBS). The results of the user questionnaires were used for establishing coefficients of the sub-indices related to user recreation (crowding, environmental quality, services and facilities, activities, access and parking, comfort and quality of surrounding area). The user questionnaire results were also used for checking parameters included in the BQI by experts. The T-test for dependent samples was used for establishing the weights of the sub-indices in the Recreation Function Index. This method has been used previously to construct other composite indicators (Nardo and others 2005).

The information compiled by the BQI must also be presented disaggregated by components and/or sub-indices. The final results can be considered as a potential

**Table 1** Structure of the Beach Quality Index

| Comp | Partial indices | Des | Imp | S/R | FM | HA | OR-SC |
|---|---|---|---|---|---|---|---|
| RFI Monitors processes related to the recreational experience of users | α: Microbiological Water Quality | Provides criteria for evaluating *Coliforms* and *Streptococcus* | Detection of organic pollution (mandatory) | EC Dir 1976/160/EC | W | Y | Ufc/100 ml (100–20,000) |
| | IC: Beach Crowding | Measure of quality of use considering optimum and crowdedness thresholds | Detection of overuse (very common in tourist beaches) | MOP 1970 PAP 1997 | S | Y | $m^2$/user (0–16) |
| | IEQ: Environmental Quality | Integrated measure of the aesthetic and hygienic environmental quality | Monitors aesthetic and hygienic environmental quality (very important for users) | Catalan Water Agency | W | Y | Qualitative scale 1–5 |
| | ISerF: Services and Facilities | Evaluation of 11 components. Differences for urban and urbanized beaches | Monitor adequate provision of services and facilities (very important in tourist beaches) | Yepes 2002 | S | Y | m and presence (distance between facilities; existence of facilities) |
| | IAct: Activities | Evaluates annoying and other types of undesirable behaviour | Detection bothering activities (very important in tourist beaches) | – | W | Y | Presence (existence of activities) |
| | IAcPar: Access and parking | Measure of accessibility to surrounding areas, signposting, access to the beach and parking and transportation | Assessment of accessibility (very important according to questionnaires) | Shores Act 22/88 Yepes 2002 | S | Y | m, presence and quality (distance; existence; state) |
| | IComf: Comfort Quality | Evaluation of aspects of the beach structure and climatic conditions that affect users' experience: 8 factors | Monitor comfort (very important according to questionnaires) | Buceta 2000 | S/W | Y/N | m, degrees, quality, cm, degrees Celsius and % (distance: slope intensity, height; temperature; weather conditions) |
| | IS: Surrounding Area Quality | Evaluates landscape and aesthetic quality | Monitor increasingly degraded coastal landscape | – | 3 years | Y | % (artificial land use surface) |
| | IBS: Beach Safety | Integrated measure of the safety and rescue services | Provides a measure of safety conditions (very important according to questionnaire of beach experts) | Beach Safety Plan of Barcelona | S | Y | Presence (existence of safety elements) |
| NFI Monitors processes related to beach bio-physical condition | IN: Natural Conditions | Assess quality of the natural systems in the wind-controlled upper part of the beach (vegetation representation, surface coefficient and development of the habitat) | Monitor quality of the typical natural community very degraded in many beaches | – | 2 years | Y | % and quality scale (number of species; vegetated surface; dune system development) |
| | IWSP: Water–Sand Pollution | Monitors effects of pollution events on different natural communities | Monitor frequent pollution events | – | S | Y | Number of events (pollution episodes) |
| | IPQ: Physical Quality | Represents the effect of human changes on the physical properties of beaches (grain size, surface and wave regime) | Monitor changes in physical quality by human activities | – | S | Y | % (affected surface) |
| PFI Monitors gains and losses of sediments in relation to protection of coastal facilities | IPP: Protection | Represents the importance of beaches in protecting coastal features in the study area | Monitor vulnerability of coastal facilities (very important due to frequent severe damage in many coastal areas) | Larson and Krauss 1989 | S | Y | % (length of beach protected) |

*Comp* Components, *Des* Description, *Imp* Importance, *S/R* Source/Reference; *FM* Frequency of Measurement (Weekly, Seasonally, Yearly), *HA* Human Activity (Yes, No), *OR-SC* Original scale of measurement

**Table 2** P-coefficients, t-coefficients and u-coefficients obtained after consulting 16 coastal management experts as well as beach users through questionnaires

| | Urban beaches | | Urbanized beaches | |
|---|---|---|---|---|
| | Average value | SD | Average value | SD |
| p-coefficients | | | | |
| Recreational function (RFI) | p1A = 0.600 | 0.140 | p1B = 0.400 | 0.120 |
| Natural function (NFI) | p2A = 0.100 | 0.080 | p2B = 0.300 | 0.110 |
| Protective function (PFI) | p3A = 0.300 | 0.130 | p3B = 0.300 | 0.140 |
| t-coefficients | | | | |
| Crowding (IC) | t1 = 0.080 | 0.020 | t1 = 0.12 | 0.029 |
| Environmental Quality (IEQ) | t2 = 0.220 | 0.034 | t2 = 0.20 | 0.029 |
| Services and Facilities (ISerF) | t3 = 0.080 | 0.002 | t3 = 0.06 | 0.020 |
| Activities (IAcT) | t4 = 0.120 | 0.033 | t4 = 0.12 | 0.029 |
| Access and Parking (IAcPar) | t5 = 0.080 | 0.003 | t5 = 0.08 | 0.002 |
| Comfort (IComf) | t6 = 0.120 | 0.032 | t6 = 0.12 | 0.029 |
| Quality of Surrounding Area (IS) | t7 = 0.120 | 0.027 | t7 = 0.12 | 0.027 |
| Beach Safety (IBS) | t8 = 0.180 | 0.110 | t8 = 0.18 | 0.100 |
| u-coefficients | | | | |
| Natural Conditions (IN) | u1 = 0.150 | 0.140 | u1 = 0.200 | 0.090 |
| Water–Sand Pollution (IWSP) | u2 = 0.500 | 0.210 | u2 = 0.500 | 0.190 |
| Physical Quality (IPQ) | u3 = 0.350 | 0.140 | u3 = 0.300 | 0.160 |

management scorecard that can be used to analyze the information from individual components as separate blocks.

## Partial Indices

The Microbiological Water Quality index ($\alpha$) provides criteria for evaluating the established requirements of the EC Directive 1976/160/EC (CEC 1976) on the quality of bathing waters, recently repealed by 2006/7/EC (European Parliament and the Council 2006). As the latest directive has not yet been transposed to Spanish legislation, for the purposes of this article we consider the principles included in Directive 1976/160/EC, which were incorporated into the Catalan legislation by the Catalan Water Agency (ACA). The values in Table 3 will have to be modified when the new requirements established in Directive 2006/7/EC come into force. The index varied between 0 and 1 depending on the total or partial fulfillment of the proposed limits of these directives. In situations in which the mandatory values were not obtained, the assigned score was 0. The least favorable of the three established values was used in the index. In our study case, the final results were obtained by calculating weekly averages during the entire season.

Scores based on water quality measurements are not distinctive of the quality of the beaches in many areas of the north-western Mediterranean. Sewage treatment and regulation of discharges mean that the requirements established in 76/160/EC are generally not violated. Water quality fails to fulfill the established regulations at only a very few beaches. For this reason, in the Beach Quality Index (BQI), water quality is considered an eliminative factor (it functions as a coefficient that may neutralize all other scores, but fulfilling it does not contribute to the final score). This sub-index is regulated legally and for this reason its assessment is clearly defined and carried out by the regional administration.

**Table 3** Microbiological water quality assessment

| | TC | FC | FS | $\alpha$ value |
|---|---|---|---|---|
| Very good | $\leq$500 | $\leq$100 | $\leq$100 | 1 |
| Good | $\leq$2.000 | $\leq$500 | $\leq$500 | 0.8 |
| Moderate | $\leq$10.000 | $\leq$2.000 | $\leq$2.000 | 0.5 |
| Deficient | $\leq$100.000 | $\leq$20.000 | $\leq$20.000 | 0 |
| Bad | >100.000 | >20.000 | >20.000 | 0 |

The table is based on the requirements outlined in Directive 76/160/EC and the classification criteria established by the Catalan Water Agency (ACA). Values are expressed in ufc/100 ml

*TC* Total Coliforms, *FC* Faecal Coliforms, *FS Faecal Streptococcus*

The Beach Crowding Index (IC) considers beach use patterns. Increases in tourist use and possible overcrowding problems were considered to be important factors for assessing the recreational function of beach environments (Ariza and others 2008b). We considered two threshold values for crowdedness based on crowding measures defined in the literature (MOP 1970; PAP 1997): 4 $m^2$/user and 8 $m^2$/user for urban and urbanized beaches,

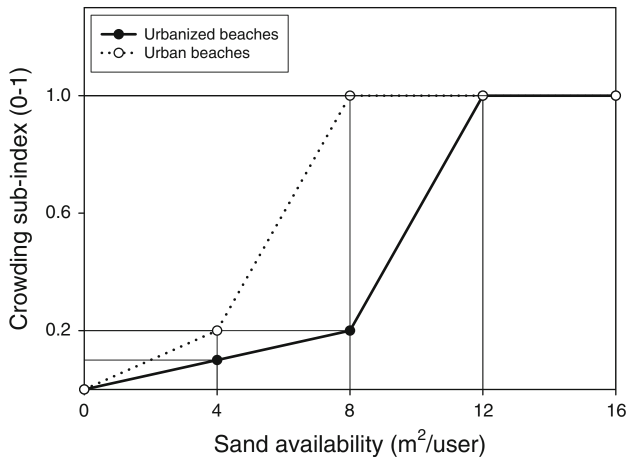



**Fig. 1** Values of the crowding sub-index. Standards of crowding and optimal values are defined for the two types of beaches assessed

respectively. We also defined optimal situations in which sand availability is greater than 8 $m^2$/user for urban beaches and 12 $m^2$/user for urbanized beaches. We defined a crowding score of 0.2 (based on a Delphi approach among experts), to indicate the point at which overcrowding occurs (scores lower than this value indicate excessive use of the beach). A score of 1 indicates optimal conditions (Fig. 1). In our study case, in order to calculate the sub-index we used the highest beach use values obtained during the bathing season (May–September). This sub-index has to be calculated every year.

The Environmental Quality Index (IEQ) provides an integrated measure of the aesthetic and hygienic environmental quality of beaches, which is very important for beach users (Morgan and others 1996; Leatherman 1997). In Catalonia, the Agència Catalana de l'Aigua (the public organization with responsibilities in water and beach issues in the autonomic community) is currently carrying out visual assessment programs of water and sand quality that rate the conditions of a beach between 1 (bad) and 5 (excellent). The water quality parameters analyzed are color, transparency, solid human waste, plant waste, marine plant waste, foam, tar, odor, oil, and the presence of jellyfish. The sand quality parameters analyzed are beach user waste, human waste, plant waste, marine plant waste, tar and the presence of jellyfish. In our study, we averaged the global quality values obtained in these monitoring programs for water and sand quality during the bathing season and normalized the values to a range between 0 and 1. The ACA carried out visual assessments of the beaches twice a week during the bathing season, so we were also able to obtain this information at weekly intervals. The presence of a rainwater outfall on the beach incurred a penalization of 0.20 points in the final score and each beach closure due to pollution during the assessed bathing season

**Table 4** Importance of the items considered in the services and facilities sub-index for the two beach types

| Services/facilities | Urban beaches | Urbanized beaches |
|---|---|---|
| Beach guarding | Basic | Important |
| Showers and feet washers | Basic | Basic |
| Umbrellas and hammocks | Important | Important |
| Bins | Basic | Basic |
| Facilities for children | Important | No |
| Restaurant/bars and kiosks | Basic | Important |
| Facilities for handicapped people | Basic | Important |
| Telephone | Important | Important |
| Information | Basic | Important |
| Sanitary facilities | Basic | Basic |
| Sports facilities | Important | No |

All basic services should be present in both urban and urbanized beaches (if not, the score is 0)

incurred a penalization of 0.25 points (also based on a Delphi approach).

The indicators, the metrics, and the importance of the items included in the Services and Facilities Index (ISerF) were determined from standards available in the Shores Law 22/88, in quality requirements previously established for Spanish beaches (Yepes 2002) and the results of the beach user questionnaires. We decided upon 11 indicators to be assessed in this partial index (Tables 4, 5). After checking available studies and results from user questionnaires, the group of experts decided that the ISerF items should not be considered equally important in the two beach types and were classified as basic, important and not considered for urban and urbanized beaches. The importance assigned to the items defined their score. This index must be assessed at the beginning of each bathing season.

The Activities Index (IAcT) was developed to include the detected presence of annoying and other types of undesirable behavior. Sports outside specific areas, the presence of pets, fishing during bathing hours, and sailing activities in bathing areas were considered to have a negative impact on the enjoyment of most beach users (these activities are prohibited in the study area, although, according to local managers, present in some beaches of the catalan coast). As these activities were thought to be detrimental to beach quality, each activity detected reduced the final score by 0.2 points from an initial score of 1 (based on the results of a Delphi approach). In our study, this sub-index was measured once a week during the bathing season.

The Access and Parking Index (IAcPar) provides a measure of the accessibility to the beaches and is an important factor for users in their choice of beach (according also to responses to beach user questionnaires). It consists of three indicators: access to the beach

**Table 5** Expert criteria for scoring the items considered for the services and facilities sub-index

| | Good | Regular | Bad |
|---|---|---|---|
| Beach guarding | Permanent | Punctual | Nonexistent |
| Showers and feet washers | Showers/feet washers separated <150 m | Showers/feet washers separated between 150 and 250 m | Showers/feet washers separated ≥250 m |
| Umbrellas and hammocks | Maximum occupied surface <30% of beach surface | Maximum occupied surface between 30% and 50% of beach surface | Maximum occupied surface >50% of beach surface |
| Bins | Bins separated <50 m (with support and hermetic closing) Segregated waste disposal on the beach | Bins separated by between 50 m and 100 m | Bins separated >100 m |
| Facilities for children | Existing | Nonexistent | |
| Restaurant/bars and kiosks | Seasonal facilities in the DPMT separated by at least by 200 m. They should be well maintained and with minimal impacts | Seasonal facilities in the DPMT | Permanent facilities in the DPMT or no facilities |
| Facilities for handicapped people | At least 1 accessible point | Adapted accesses | No adapted accesses or accessible points |
| Telephone | No further than 150 m from any point of the beach | Between 150–300 m from any point of the beach | Further than 300 m from any point of the beach |
| Information | Existing | Non existent | |
| Sanitary facilities | Facilities separated by a maximum of 300 m | Facilities separated by between 300 and 500 m | Facilities separated by more than 500 m |
| Sports facilities | Existing | Non existent | |

For basic services, the regular score is 0.056 for urban beaches and 0.075 for the urbanized ones. The good score is 0.073 for urban beaches and 0.064 for the urbanized ones. For Important services, possible scores are 0.025 for the regular category and 0.050 for the good one

surroundings and signposting (IAcces), access to the beach itself (IAcState), and the availability of parking and other available transport means (ITrans). This sub-index is measured at the beginning of the summer season and the score lasts for the whole season. The score (14 points as a maximum score) is calculated based on expert judgment criteria shown in Table 6 (obtained from the Shores Act 22/88 and Yepes 2002). The final value was then normalized to a range between 0 and 1.

The Comfort Index (IComf) includes the aspects of the beach structure and climatic conditions that affect users' recreational experience. Based on surveys carried out at different beaches (Morgan and others 1996; Buceta 2000), eight comfort indicators were included in this sub-index (Table 7). The water temperature measure and the percentage of sunny days were averaged from weekly measurements during the bathing season. In order to score the comfort indicators, the criteria considered were modified from those created for the CEDEX Index (Buceta 2000) after beach properties and user opinions about the beaches' geomorphologic characteristics had been analyzed. The presence of abrasive material (shell material and rough sediments that bother user when getting into the water) has been included in the IComf because it may be an important problem. This sub-index (8 points as a maximum score) is calculated at the beginning of the bathing season for morphological characteristics or whenever any of the parameters are known to have changed, and weekly for climatic factors. The final value was also normalized to a range between 0 and 1.

The Quality of Surrounding Area Index (IS) was designed as the average of two different indicators: the landscape indicator (IL) and the aesthetic indicator (IA) (Table 8). The landscape indicator consists of three different indicators of equal weight: the percentage of impervious surface in the hinterland (a band of 500 m around the beach, based on the area of influence defined in the Shores Act 22/88), the percentage of coastal defense works against beach length, and the percentage of the water table enclosed by harbor and/or marina developments in a band of 200 m offshore from the emerged beach (defined by a Delphi approach).

The aesthetic indicator (IS) was scored by calculating the percentage of the impervious land use in the viewshed of the beach (the viewshed is the portion of a surface that is visible from a given point on or above it) (Table 8). Photographs taken from the beaches were used for the analysis. Both indicators should be calculated every three years. The total mean percentage was normalized to a range between 0 and 1. Importance of landscape for beach users was also reflected in the beach user questionnaires.

**Table 6** Expert criteria for scoring the items considered for the access and parking sub-index

| Beach surroundings (IAcces) | Good | Regular | Bad |
| --- | --- | --- | --- |
| Accessibility | Well asphalted (2 points) | Asphalted with irregularities (1 point) | Not asphalted (0 points) |
| Signposting | Signposting further than 200 m (2 points) | Signposting within 200 m (1 point) | No Signposting (0 points) |
| **Accesses (IAcState)** | **Good** | **Regular** | **Bad** |
| Distance between parking and beach | <200 m (1 points) | Between 200 and 300 m (0.5 points) | ≥300 m (0 points) |
| Distance between pedestrian accesses | <50 m (1 points) | Between 50 and 100 m (0.5 points) | ≥100 m (0 points) |
| State of accesses | Easy and safe (1 points) | Safe but not easy (0.5 points) | Not safe, not easy (0 points) |
| Distance between traffic accesses | <500 m (1 points) | | ≥500 m (0 points) |
| | <100 m (urban beaches) | | ≥100 m (urban beaches) |
| Distance between footbridges | In urbanized beaches at main accesses (1 points) | | In urbanized beaches not at main accesses (0 points) |
| **Transportation (ITrans)** | **Good** | | **Bad** |
| Parking | Existing (4 points) | | Nonexistent (0 points) |
| Transportation | | | |
| Public transportation | Existing (0.5 points) | | Nonexistent (0 points) |
| Parking for bicycles | Existing (0.5 points) | | Nonexistent (0 points) |

Distance less than 200 m between parking and beach was considered good based on literature revised. Beach users prefer short distances and scenery is not really affected by parking proximity

**Table 7** Expert criteria for scoring the items considered in comfort sub-index

| Beach factors | Good | Moderate | Bad |
| --- | --- | --- | --- |
| Width | 20–35 m | 15–20 m or 35–50 m | <15 m and ≥50 m |
| Slope of dry area | 0–4° | 4–6° | Above 6° |
| Slope of wet area | 1–5° | 0–1° or 5–8° | Above 8° |
| Obstacles | No obstacles | Obstacles present in less than 15% of the shoreline | Obstacles present in more than 15% of the shoreline |
| Step | Step <10 cm | Between 10 and 20 cm | Step ≥20 cm |
| Abrasive material | Without or disperse abrasive material | Significant accumulation that does not obstruct entering and exiting the water along 75% of the shoreline | Accumulations that obstruct entering and exiting the water in more than 25% of the shoreline |
| Water temperature | 23–27° | 21–23° or 27–29° | <21° or ≥29° |
| % of sunny days | From 0 (no sunny days) to 1 (all days are sunny) | | |

Each of the eight items scores 1 point (good), 0.5 (moderate) or 0 (bad)

The Beach Safety Index (IBS) provides an integrated measure of the safety and rescue services provided at a particular beach. Both urban and urbanized beaches were considered to have identical requirements for this particular sub-index. The Spanish regulation establishes responsibilities for local authorities but it does not define the mandatory standards in terms of personnel and facilities that should be provided. In the present sub-index, we followed the requirements established in the Beach Safety Plan of Barcelona (Diputació de Barcelona 2003a). Twelve indicators were reviewed and selected as evaluation criteria: facilities, transport material, communication material, rescue material, sanitary material, emergency warning, buoying, signposting of dangerous areas and activities, risk assessment of each beach, preventive plan, accident indicators and absence of wave regime risk. The final score (normalized to the interval between 0 and 1) was achieved by adding the number of fulfilled criteria and dividing this number by the total number of criteria. The sub-index should be measured every year at the beginning of the bathing season. Beach Safety has also been included in beach management tools designed for other coastal areas (Leatherman 1997; Morgan 1999a).

The Natural Conditions Index (IN) was designed to assess the quality of the natural systems present in the

**Table 8** Criteria used for assessing the quality of surroundings area sub-index

| Aspect | Measurement | |
|---|---|---|
| *Landscape index (IL)* | | |
| Impervious space (Is) | Impervious Area/500 m Buffer Area | |
| Beach coastal defence works | Beach coastal defence works/Beach total length | |
| Surface of port in the maritime hinterland (Ispm) | Surface of water table closed by harbour developments/ total surface in a 200 m buffer in the maritime area | |
| *Aesthetic index (IA)* | | |
| Impervious land use in the view shed basin (Ia) | <5% Impervious | 0 |
| | 5–20% impervious | 0.33 |
| | 20–60% impervious | 0.66 |
| | >60% impervious | 1 |

wind-controlled upper part of the beach (Brown and McLachlan 2002). It consists of three different indicators: the vegetation representation coefficient (Cr), the surface coefficient (Cs) and the development of the habitat coefficient (Cd). The representation coefficient provides the percentage of beach plant species found on a particular beach with respect to a catalogue of 30 characteristic species that can be found in the local area. The surface coefficient measures the total vegetated area with respect to the area behind the storm drift line, which is the wind-controlled part of the beach. Finally, the habitat coefficient provides a measure of the state of the dune belt based on expert visual evaluation in four categories:

1. Beaches cleaned with heavy mechanical devices: no development or very low development.
2. Beaches with vegetated sand alongside promenades, other artificial structures or rocks at the edge of the beach.
3. Beaches with patches of incipient dunes.
4. Beaches with a dune belt.

This sub-index is initially calculated as IN = log [Cr*Cs*Cd] and the score is then scaled from 0 (IN = 0) to 1 (IN = 4.6 is the maximum possible value). The index has been designed to detect small changes occurring in urban and urbanized beaches that occur in the North-Western Mediterranean coast. The goal of the sub-index is to reflect poor quality of highly used beaches, and this method is a way to penalize very low scores. It has to be measured every 2 years.

The Water–Sand Pollution Index (IWSP) was included to monitor pollution events that can often cause beach closures in the area (Ariza and others 2008a). Pollution events were considered when a particular beach had to be closed completely or when bathing had to be prohibited due to a particular pollution episode during the bathing season. A quarter of a point was subtracted from an initial score of 1 for each total or partial closure (also as a result of the Delphi approach). This sub-index should be modified as soon as ecological indicators for assessing water masses required in the Water Framework Directive 2000/60/EC (European Parliament and the Council 2001) are ready to be used. The IWSP has to be measured every year at the end of the season.

The Physical Quality Index (IPQ) represents the effect of human changes on the physical properties of beaches. Some of these changes have a strong influence on the ecological community of the beach (McLachlan 1996). The sub-index was designed to quantify changes in grain size (Igr), beach area (Ibs) and wave regime (Iwr) as a result of human activity during the last 10 years. Nourishment (supplying sediments of different characteristics from the original type) and engineering works (stopping the pass of sediments and water flow) are the main reasons for those changes. The sub-index does not consider whether natural conditions (i.e. grain size) are good or bad for beach users. Changes of those conditions are the negative quality aspect. For that reason, the sub-index records variations from the original condition of the beach. The observed alteration is described as moderate or severe for the three selected indicators; it is considered moderate when it affects less than 30% of the beach area and severe in all other cases. A score of 0 was awarded in the case of severe alterations, 0.5 for moderate alterations and 1 for cases in which no alterations were observed (those values were defined by the group of experts). The final sub-index calculated as an average value of these three indicators can be calculated at the beginning of the bathing season or whenever there is human activity that potentially affects physical quality.

The Protection Index (IPP), which represents the importance of beaches in protecting coastal features in the study area, has been defined in previous studies (Valdemoro and Jiménez 2006). In the BQI structure the Protection Index consists of a single sub-index that measures a beach's capacity to dissipate wave energy and prevent damage to promenades and maritime facilities. The indicators included are: (i) the effective beach width (EBW), which is the distance between existing infrastructures and the shoreline; (ii) the storm reach (SR), which is the beach width potentially eroded by a storm of a given return period; and (iii) the minimum beach width (MBW), which is the minimum width an operative beach is required to have for protection purposes (i.e. for beach infrastructures to be protected from storm impacts). This index must be defined by managers and based on scientific knowledge. In this study, the SR was estimated for the study area as 13 m (for the effect of a storm with a return period of 10 years, and using the Sbeach model (Larson and Krauss 1989) and the MBW was set at 13 m. This sub-index should be measured every year at the end of the season.

$$IPP1 = EBW/(SR + MBW)$$
$$IPP = L(IPP1 > 1)/Ltotal$$

where IPP1 Partial Protection index (for a particular point of the beach); IPP Partial Protection index (for the whole beach); L(IPP1 > 1) The total beach length in which the value of IPP1 is 1 or higher; *Ltotal* Total length of the beach

## Application of the BQI to Beaches in the Selva Marítima Area of the Costa Brava (North-Western Mediterranean)

### BQI Assessment Area

The BQI was applied to six beaches on the Catalan coast in north-eastern Spain (Fig. 2): Malgrat Nord in the Maresme coastal region, and S'Abanell Nord, Treumal-Sta. Cristina, Lloret Centre, Canyelles, and Tossa-Mar Menuda in the La Selva coastal region. The area is characterized by abrupt forms and the coastline has an irregular profile (small pocket beaches and cliffs are abundant). Tourism and construction are the main socioeconomic activities in the area. The landscape has been transformed during the last 50 years and the surface area has increased remarkably (Martí 2005). These beaches are composed of sediments from nearby mountains. There is no longitudinal transport of sediments between beaches in the area, as the headlands act as barriers that block the passage of sediments. Wave patterns affecting the area mainly follow an E-SSW direction. Storms coming in from the east and south occur during the year and frequently cause damage to facilities in the back beach area (Ajuntament de Lloret de Mar 2002).

By performing a GIS and cluster analysis (using Primer 5 software package) of the main land use types (urban, urbanized and natural) in the coastal hinterland (500 m-wide strip), we were able to group the beaches into two general categories: urban and urbanized (the main features and views of the selected beaches are shown in Table 9 and Fig. 2). The classification of beaches determines the weighting of components and sub-indices.

The sub-indices were measured during the summer seasons of 2005 (beach crowding and environmental quality) and 2006 (the remaining sub-indices). There were no substantial changes in the most important beach factors

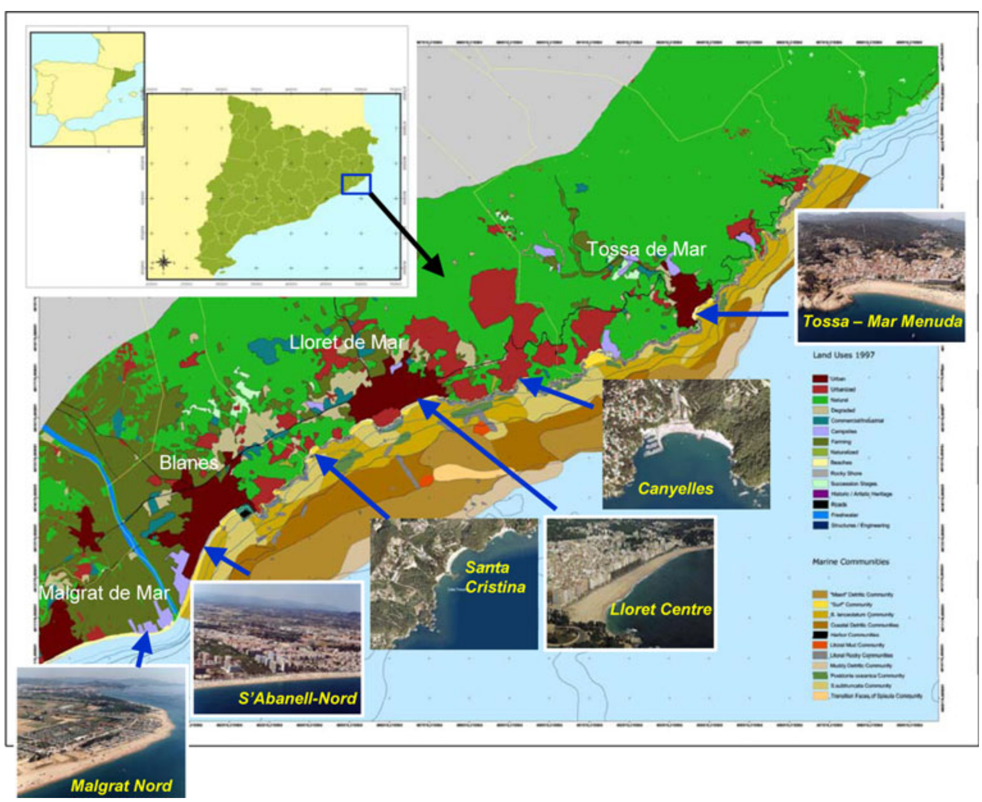



**Fig. 2** Beaches assessed by the Beach Quality Index

**Table 9** The main characteristics of the beaches where the Beach Quality Index was applied and results of the components and the BQI obtained for them

| Beach | | Type | Exposure | Length | Width | RFI | NFI | PFI | Global score |
|---|---|---|---|---|---|---|---|---|---|
| Platja Malgrat Nord | Mal | Urbanized | High | 2500 | 63.5 | 0.53 | 0.80 | 0.50 | 0.60 |
| Platja S'Abanell Nord | S'Ab | Urban | High | 1500 | 35 | 0.73 | 0.92 | 0.48 | 0.67 |
| Platja Treumal-Sta. Cristina | T-SC | Urbanized | Moderate | 446 | 31–40 | 0.63 | 0.91 | 1 | 0.82 |
| Platja de Lloret Centre | LLo | Urban | High | 1300 | 49 | 0.68 | 0.87 | 0.61 | 0.68 |
| Platja de Canyelles | Cany | Urbanized | Moderate | 400 | 35 | 0.60 | 0.88 | 0.83 | 0.75 |
| Platja Tossa-Mar Menuda | T-MM | Urban | High | 530 | 70–30 | 0.69 | 0.91 | 1 | 0.81 |

during the period between the two measurements at any of the studied beaches, so it can be reasonably assumed that the conditions were essentially the same for all beaches.

## Components, BQI Results and Discussion

The results show that three sub-indices have very high quality levels at all the studied beaches (microbiological water quality, water–sand pollution and physical quality). Water quality, according to standards defined in Directive 1976/160/EC, is very good at all studied beaches due to sewage treatment processes applied in the last few decades (unpublished data). This situation is very common on Spanish beaches, especially those used for recreation (Fig. 3). The Water–Sand pollution sub-index score was also high. Only Malgrat Nord beach was closed due to water quality problems during the summer of 2006. No pollution episodes were recorded at any of the other beaches during this period. In the case of the Physical quality, no changes in grain size or shape, wave regime or beach area due to human activity were detected at the six studied beaches.

Although the previous sub-indices showed similarities, some differences were found in the scores of the other indices, and also in some of the sub-indices included in the Recreational Function Index (crowding, activities, quality of surrounding area, and beach safety) (Fig. 3). Daily beach use at the peak of the summer season was high for both urban and urbanized beaches (Roca and others 2008). The only beaches at which crowding was not observed were the larger ones of Malgrat Nord and S'Abanell Nord. Few disturbing activities (presence of pets and recreational fishing) were detected for the studied beaches, and the lowest scores were recorded at Malgrat Nord and Canyelles. Other differences were found in the Quality of Surrounding Area score. S'Abanell Nord and Lloret Centre beaches showed the greatest transformation of the surrounding area. The highest aesthetic quality was recorded for the urbanized beaches of Sta. Cristina and Canyelles, although no beaches obtained a very high score (Fig. 3). Although some safety services are available at the studied beaches, they do not meet the general safety standards established for beaches in the Barcelona area. The lowest level of services was recorded at Malgrat Nord.

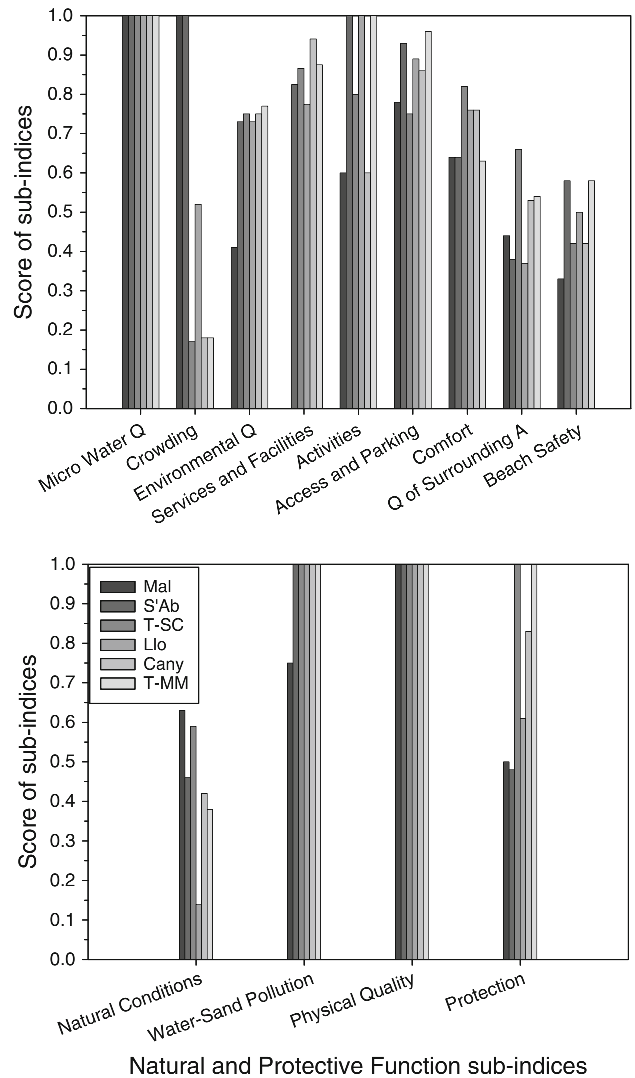



**Fig. 3** Results of the sub-indices obtained for the analyzed beaches of la Selva (Malgrat Nord, S'Abanell Nord, Treumal-Sta. Cristina, Lloret Centre, Canyelles and Tossa-Mar Menuda)

The Natural Conditions is the sub-index of the Natural Function Index with the most different scores, although none of the beaches obtained a high score. Results were higher for the urbanized beaches than for the urban ones. The highest scores were obtained at Malgrat Nord and Treumal-Sta. Cristina (0.63 and 0.59). The highest score for urban beaches was recorded at S'Abanell Nord (0.46) and the lowest score was recorded at Lloret Centre (0.14).

Variations were also found in the Protection sub-index used for assessing the Protective Function Index. The lowest score for the protection sub-index was recorded at S'Abanell Nord. Low scores are associated with exposure to wave energy. The highest scores were obtained at Canyelles, Sta. Cristina and Gran de Tossa-Mar Menuda, which are more sheltered beaches.

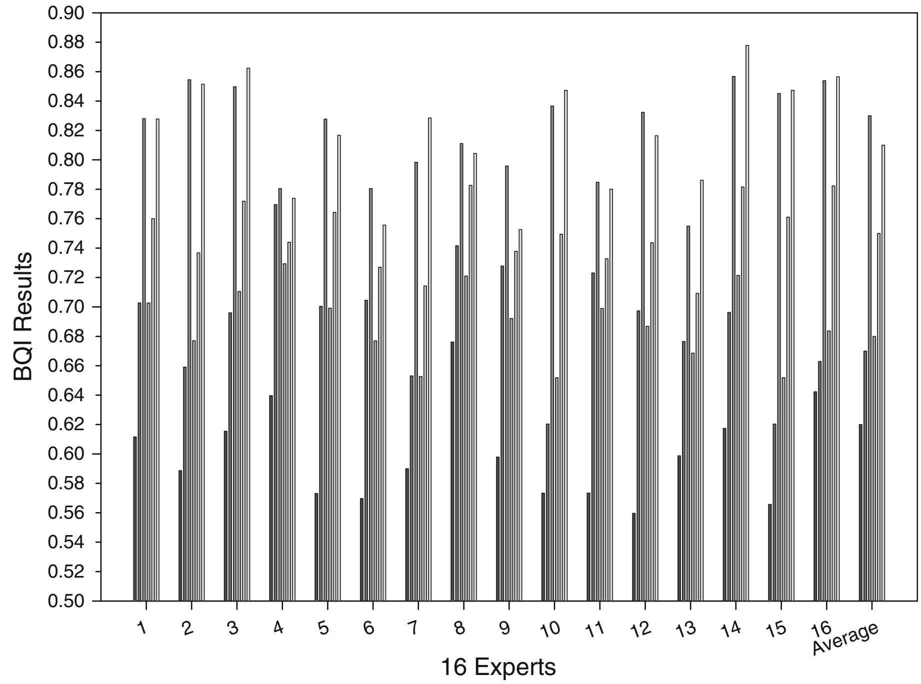
All obtained values could be used to determine future beach quality improvement plans, and efforts should focus on all of the weaknesses detected (scores are low in key sub-indices). In order to prevent the emergence of irreversible processes, it is important to adopt measures such as controlling beach use, transforming the surrounding areas and monitoring the evolution of the natural community. Beach safety and the protection sub-index should be treated as priorities in order to guarantee a pleasant leisure experience for users and protect facilities against potential damage caused by wave energy. Therefore, plans should be developed that include coordinated participation of different stakeholders with responsibilities for these processes. Beach management planning could also be included in the local Agenda 21 of the municipalities. The sub-index scores may help to make the management process more socially transparent (Barragán 2003). Most variables included in the BQI may be clearly managed. However, some items considered in the comfort index cannot (water temperature or percentage of sunny days). Those are aspects important for the comfort of users and for recreation. Although managers cannot establish measures to modify them, we think that they should be included in the BQI.

To apply effective management practices, scale issues should be clearly defined when the BQI is used (Micallef and Williams 2002). It is important to understand the possible evolution of beach quality during both the bathing season and other periods of the year if the BQI is to be integrated into EMSBs. Beach management should be carried out throughout the year, although goals and priorities vary according to the season (Valdemoro and Jiménez 2006). Some of the sub-indices considered in this study may remain constant during the bathing season (services and facilities, access and parking, quality of surrounding area, beach safety, natural conditions and physical quality) while others may vary (microbiological water quality, crowding, environmental quality, activities, comfort, water–sand pollution, and protection). During the season, variability in the components and BQI score is produced by the second group of sub-indices. For those that may change during bathing season, frequency of measurement has been adapted (such as width, slope and pollution events). It should be detailed for each sub-index in the protocol of operational control of EMSBs (Lamprecht 1997). The protocol should also define events that would require exceptional measurements of the indices. In some cases, sub-indices are very sensitive to environmental changes. In the case of the Protection sub-index, for example, S'Abanell Nord beach obtained a score of 0.48 in 2006. In 2007, the capacity to protect the beach was greatly reduced and the score, if it had been measured, would have been very differed.

We aggregated the results of the different sub-indices into two types of composite indicators: function indicators and the overall BQI score (Table 9). The lowest score for the recreational function component was recorded for the Malgrat Nord beach. The scores for the urbanized beaches were lower than those for the urban beaches. The scores for the Natural Function Index were very high for all studied beaches, although the results for the natural conditions sub-index were low or moderate. This is mainly due to the values obtained for water–sand pollution and physical quality, which were very high for all beaches. The lowest score was again recorded at Malgrat Nord, due to a pollution episode during the summer of 2006. The scores for the protective function index depend on the degree of exposure. This is very high at Sta. Cristina, Canyelles and Gran de Tossa-Mar Menuda and moderate at Malgrat Nord, S'Abanell Nord and Lloret Centre. The BQI scores were either good or very good for all of the studied beaches: the lowest score was recorded at Malgrat Nord, the results for S'Abanell Nord and Lloret Centre were similar, and the highest scores were recorded at Treumal-Sta. Cristina and Gran de Tossa-Mar Menuda, followed by Canyelles. It has been detected an important association between beach length and BQI. The lower the length, the higher the BQI. This association has also been found for the three components (Recreational, Natural and Protection). Many sub-indices included in the Recreational Function Index also obtained lower scores in longer beaches. This fact probably has to do with the difficulty of providing services and facilities for the whole area when beaches are extensive, as well as the stronger effect of wave regime on more open beaches (those longer). The latter reason also provides an explanation for the results found for the Protection Function Index. Natural communities and landscape are also more degraded in longer beaches due to the fact that they have traditionally suffered a stronger pressure from human activities.

The effect of the variability of the weighting process on the final score of the index was also analyzed (Saisana and others 2005). BQI scores were calculated using the

**Fig. 4** BQI scores of the six beaches calculated using the weights assigned by the 16 consulted experts




different weights assigned by every expert and the mean value was compared to them (Fig. 4). Standard deviation for the six beaches were: ±0.03 for Malgrat Nord, ±0.04 for S'Abanell Nord, ±0.03 for Treumal-Sta. Cristina, ±0.02 for Lloret, ±0.02 for Canyelles and ±0.04 for Tossa-Mar Menuda. Moderate standard deviation values in weights (Table 2) led to moderate variability in the BQI results for the different experts consulted (Fig. 4).

Robustness studies of the composite indicators have identified certain weaknesses in construction processes (Munda and Nardo 2003). The two most important problems are preferential independence and compensability. As a result, we used a second aggregation method (non-compensatory multi-criteria approach) (OECD 2008) to produce three different rankings of the studied beaches. The urban and urbanized beaches were ordered separately according to the quality levels measured. The ranking of the urbanized beaches from the highest quality to the lowest includes Sta. Cristina, Canyelles, and Malgrat Nord. The ranking of the urban beaches includes Tossa/MarMenuda, Lloret Centre and S'Abanell Nord. We also produced a third ranking which included all beaches. The ranking included Tossa-Mar Menuda, Sta. Cristina, Lloret Centre, Canyelles, Malgrat Nord and S'Abanell Nord. The rankings were compared with the final results obtained using the linear aggregation all of the scores for the sub-indices. The results were the same for both methods in the first two analyses, but some differences were observed in the results for the final method. The ranking obtained using the scores of the quantified sub-indices included Sta. Cristina, Tossa-Mar Menuda, Canyelles, Lloret Centre, S'Abanell Nord and Malgrat Nord.

In relation to the aggregation of the scores of the components and sub-indices, some considerations must be taken into account. When the BQI is applied to benchmark beaches, the sub-indices must be used carefully and without global aggregation. The linear aggregated values of the different Beach Quality Index components should be used for guidance purposes only and should always be considered together with the disaggregated analysis and ranking analysis. Moreover, aggregated values should be used with further research on the assessment of the relationship among sub-indices and the measurement of a single construct (Marull and others 2004; Saisana and Tarantola 2002). The sample of beaches considered in our study was small. Interpretation of results (particularly linear aggregated) and application of measures of management should be done with precaution, and always considering the latest available studies.

We did not incorporate managerial aspects in the BQI. These are the main requirements of EMSBs (compliance with existing legislation, specific emergency plans, proactive planning and the allocation of resources and responsibilities) and must be assumed by beach management organizations, independently of the monitoring function provided by the BQI (although legal requirements are included in the BQI through derived quality criteria). If BQI is not used inside EMSBs, some managerial aspects or proactive planning may not be implemented. However, if EMSBs are used without the BQI or another equivalent beach management tool, it becomes more difficult to detect legal problems, achieve steady improvement or reduce/prevent environmental impacts. BQI sub-indices allow complex information to be presented clearly and simply (Jiménez and Van Koningsveld 2002). Using the BQI may help to solve problems detected in the study area, which include erosion/sediment management, lack of a unified management organization and beach closures (Ariza and others 2008a).

For example, according to the EMSB scheme (Ariza and others 2008b), at the Sta Cristina-Treumal beach, the environmental policy should consider reducing beach use, controlling annoying activities, and guaranteeing good accessibility and safety services. Commitment to preserving the current quality of the surrounding area and natural conditions should also be included. The significant environmental aspects may be defined based on the lowest scores obtained, the importance assigned by experts/users and the need to maintain the quality of the beach's landscape and natural conditions. As well as considering the defined significant environmental aspects, the program could also analyze ecosystem services and define the economic balance of the beach. Other periodic aspects that could be improved are cleaning services to prevent the accumulation of litter, controlling the entire beach area that has facilities, and installing parking areas for bicycles and litterbins with hermetic seals. The operational control procedure should also include a detailed protocol for measuring partial indices.

Using the BQI inside EMSB managerial schemes should ensure ongoing improvement in beach quality practices. The BQI could be used to clearly identify environmental aspects that need to be improved or to monitor existing management programs. Of the beaches evaluated in this study, only Lloret Centre has taken a step towards carrying out EMSBs: it uses the "Q for Quality" system and is currently being audited to obtain the ISO 14001 and EMAS certifications. EMSBs could allow permanent planning to be developed, as was established for Spain in the revoked Shores Law of 1969 (Yepes 2002), rather than the seasonal beach management practices that are currently in use.

Finally, the adaptation of the BQI for the measurement of beach quality of other coastal areas would require some adjustments. In the US for example, the microbiological water quality index should be based on requirements established in the Beaches Environmental Assessment and Coastal Health Act of 2000 (Congress of the United States of America 2000), instead of those of the 76/160/EC. Access and parking index, due to legal requirements that allow beaches to be private properties, should value more intensively adequate disposition of public accesses. In beach with very well developed dune systems, the natural conditions index should be adapted by removing the log function out of the sub-index. Other sub-indices, such as services and facilities, beach safety and water–sand pollution index should be modified taking into account technical and legal requirements of established for specific sites. In other coastal areas, where no alternative criteria for assessing BQI indices have been defined, the use of criteria described in this article is recommended.

## Conclusions

The BQI is a new beach management tool intended to be used with Environmental Management Systems for Beaches (EMSBs), as a hierarchical management scorecard and in monitoring procedures. By including beach functions in the index, it has been possible to use the BQI to identify and achieve more specific goals. Function analysis may allow different factors of beach quality to be quantified at the same time or in different periods of the year (management objectives are not the same in winter as they are in spring or summer). The structure of the BQI makes it easier to detect strong and weak areas than when other established beach management tools are used. This has been a problem with the beach management tools used traditionally (Micallef and Williams 2004).

By applying the BQI to the study area, we demonstrated that the quality of urban and urbanized beaches on the Costa Brava was good for certain criteria and bad for others. In general, the main strengths of the studied beaches were related to satisfying short-term user requirements (water quality, environmental quality, services and facilities, activities, comfort, and the absence of water/sand pollution). The only exception was beach safety, which is demanded by users, but insufficient resources are available to ensure it on the studied beaches. In contrast, the weaknesses identified were associated with areas affected by strong human pressure (beach crowding and the protection of coastal facilities at some beaches, quality of surrounding areas, and natural conditions). Human pressure in the area is strong and affects other aspects of beaches such as aesthetic quality.

This new tool will allow local managers to monitor and control important beach processes and will help them in the decision taking processes. The use of the sub-indices will also be important in order to achieve more transparent practices of management and learn and adapt to the very changing beach environments.

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