Journal of Coastal Conservation 9: 35-42, 2003

Towards a common Mediterranean framework for beach nourishment projects

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Abstract. Integrated Coastal Zone Management as a strategy for achieving conservation and sustainable multiple use of the coastal zone includes various types of management initiatives. Due to natural phenomena such as tides and winds and to social and economic activities, coastal areas undergo transformation. Coastal erosion and the disappearance of beaches as a result of wrong planning decisions and lack of effective legislation are among the most damaging effects and to reverse them requires application of a series of engineering techniques. Beach nourishment projects as a way towards shore protection and utilization through recreational purposes in the Spanish and Italian coasts are noteworthy in this respect.

In beach nourishment projects, the roles of various entities, both public and private, should be clearly indicated and in the evaluation and execution stage a series of questions should be answered for the successful completion of any nourishment project. Past projects in the Mediterranean and experiences from recent Italian projects in Anzio and Nettuno confirm this. For example, dredging of the entrance channel of the port of Anzio enabled middle-sized ferryboats once again to enter the port (which had not been possible before). This will in turn increase the tourism potential of the town. Nourishment of two beaches at these sites prevented further erosion and provided more area for recreational purposes. Expected economic contribution of beach nourishments to the regional authority was estimated for Nettuno and Anzio; the resulting theoretical payback period was found to be 3 yr for the former and 15 yr for the latter.

Keywords: Beach nourishment; Coastal erosion; Coastal tourism; Economic analysis; Erosion control; ICZM.

Abbreviation: ICZM = Integrated Coastal Zone Management; TSHD = Traling Suction Hopper Dredger.

Introduction

Beaches are scarce resources stretching between the coast and the land. However, 95% of the world beaches are eroding (Pranzini & Rossi 1995) due to human activities and moving dynamics. Beside wave and wind actions, the main reasons for erosion include construction of hotels, second homes and other similar structures on beaches and dunes, dam and harbour constructions causing cut-off natural transport of sediments to the sea, river bed quarrying and river diversion for land reclamation which reduce the river sediment input, marina developments which split up beach morphology while changing sediment transport systems and re-activating the movement of the sea and fishing ports that increase the deposition of the finest sediments in partly enclosed areas.

Especially tourist facilities such as hotels and apartment complexes which were constructed on European dunes, beaches and cliffs from the 1960s to the 1980s caused large-scale beach and dune erosions. This is not only an ecological problem confronting coasts but also an economic one. Governments and especially their regional bodies have been forced to redress coastal erosion and flooding risks through large-scale beach nourishment projects, construction of dykes and even construction of hard coastal defence structures to create beaches that did not previously exist. Moreover, erosion of beaches and thus loss of recreational areas has led many countries to adopt or revise their coastal laws and regulations (Anon. 1999).

For Mediterranean destinations, beaches are one of the most valuable natural resources and basic supports of local and national economies. Beside for sunbathing and swimming sporting activities such as sailing and surfing also attract visitors to the beach.

Beach management

As stated by Williams & Davies (1995): "Effective beach management is a considered response to a specific interaction of cultural influences with the physical environment with the objective of developing a sustainable landscape resource". Beach managers must be able to identify:

- Range and causes of problems leading to poor resort quality;
- Detect the strengths and opportunities unique to their own resort;
- Devise comprehensive, practical and fundable action programmes;
- Encourage third parties to cooperate in bringing about improved environmental standards and a long-term quality investment for the benefit of end users and investors.

If management of beaches is considered in two ways, one being the utilization through recreational purposes and the other being shore protection and defence, the latter is probably the more urgent. Management programs for the protection of the shore begin when problems are perceived by the beach front community including residents, seasonal visitors, local government bodies etc. Damage or flooding to private or public facilities, loss of tax revenues and decrease in land prices, and the loss of recreational beach through natural or man-made effects are the main problems identified (Anon. 1995).

Considering the effects of shoreline changes and also changes caused by man-made structures, three broad management strategies are available (Anon. 1995):

- Construction of a structure – a groin or a sea wall – in order to limit the continuing damage or threat of damage which is considered as a hard measure;
- Initiation of a periodic nourishment program which is a soft measure, and providing the desired level of protection sometimes in conjunction with taking hard measures;
- Abandonment or moving of buildings/other facilities from affected environment to prevent further erosion / damage.

Several techniques are used for protecting shore (and so sandy beaches):

- Hard measures (these were in effect until the 1980s);
- Groins constructed with stone material;
- Breakwaters (submerged/merged/offshore breakwaters);
- Sea walls;
- Soft measures (after the 1980s with the failure of many hard structures and the increasing environmental concerns);
- Beach nourishment;
- Semi-soft measures;
- Submerged barriers;
  rubble mound barriers
  sand sac barriers
- Merged sand barriers.

The choice of management strategy and subsequent technical solutions depend on:

- The level of damage/erosion faced, the quality of design reference data and professional knowledge available in the coastal area concerned;
- Abilities (financial, management, etc.) of local government bodies to handle and proceed with the necessary steps that should be taken before/during/ after the management program (Anon. 1995);
- Willingness of local government bodies to take into consideration economic and environmental issues and the ability to match these issues with an appropriate dissemination of information to political and information channels to allow for sufficient support and feedback from the feasibility stage.

While beach nourishment has been the preferred tool for coastal hazard management over the past decades, future beach nourishment applications are expected to increase for the creation and maintenance of recreational areas. "It is therefore prudent for coastal managers to begin to consider minimum criteria for consistent evaluation of nourishment projects and to coastal engineers to provide them agreed (and eventually standardized) tools to obtain the quantitative information for such evaluation. However there is a complex challenge that will require effectual coordination of science and policy" (Ruol et al. 1997).

In northern Europe, beach nourishment has been practised since 1985. There are also examples from Spain, Portugal and Italy from the last decade. Being a flexible option as compared to 'solid' ones, beach nourishment is better suited to the natural dynamic character of sandy coasts.

Beach nourishment: Spanish and Italian cases

For a particular location the appropriate option for overcoming erosion – restoration/re-establishment/ abandonment – depends mainly on engineering and economic analyses. "Both initial costs and continuing costs differ for the three options, and opportunities to share these costs vary with the federal and state governments. Moreover each option has different long-term impacts on the community, region and on the nation" (Anon. 1995). For instance, in Spain the recovery of damaged coastal areas and re-establishment of beaches along the 8000 km of littoral have been aimed at the provision of environmental space and as a natural defence and hence contribution to the economic revitalization. Besides, many stretches of the shore have been rehabilitated through construction of esplanades, coastal parks etc.

The works carried out by the State Coast Office of Spain allowed the recovery of damaged coastal areas and extended the area of beaches. "Between 1983-1992, a total of 7.7 million square meters beach were created on the Spanish coasts" (Anon. 1993). However a series of initiatives was also carried out in Italy for the protection of the littoral Adriatic coast. Beside hard measures, beach nourishment projects (or both methods) were also employed in order to control coastal erosion and increase recreational possibilities. Such projects were carried out mainly along the coasts of Lazio, Abruzzo, Emilia Romagna and the Veneto Region and on the islands of Sicilia and Sardinia. Beach nourishment in Ostia (Lazio) and Capo d'Orlando (Sicily), beach nourishment with angular gravel at Cala Gonone (Sardinia), submerged barrier installation and beach nourishment in Riccione (see also Preti et al. 1997; Ruol et al. 1997; Pacini et al. 1997) and also along the Venice lagoon island facing the Adriatic sea can be mentioned. The progress of erosion in Regione Lazio at North of Capo d'Anzio and at Nettuno beaches has recently been reversed by placing a soft defence wall of dredged sand from the sand barrier blocking the Port of Anzio.

In Italy the beachfront area is state property and is given in concession only when public authorities consider the areas suitable for beach establishment development. Traditionally, these concessions have been obtained by public bidding towards municipal or regional entities. Therefore beach management for tourism purposes and economical return is fully related to private initiatives or organizational approaches by semi-public associations (navy, airforce, military, AGIP, post office, beach clubs etc.), and hotels and resort developers. The extreme fragmentation of reference data and highly subjective criteria on profitability makes it almost impossible to decide future return.

Considering beach nourishment for tourism purposes and economical return, a physical carrying capacity approach can be utilized to predict expected economic contribution. Physical capacity of the nourished beach could be calculated by dividing the size of the effective beach area by a standard of ca. 12 m^2 beach area per person. This figure varies mainly according to the characteristics of the beach area and the locality and recommended areas per person vary from 5 to 25 m^2 (Pearce 1989; Ryan 1991; Anon. 1984) .

By assuming the variables of a rental price of a set of deck chairs and umbrellas, expected number of visitors in a season and occupancy rates during the week and weekend, operation costs and profits, and regional tax that might be paid to the regional/local authority, then net profit to the beach operator could be estimated. Moreover, considering tax payment to regional/local authorities and total cost of the nourishment, the estimated pay-back period for beach nourishment and profit to the authority could be calculated. However it should always be borne in mind that ecological, social and economic attributes of a coastal system deserve attention as well.

Recent experiences in the Mediterranean

Excavation of the entrance channel of the Port of Anzio and nourishment of the beach at the north of Cape Anzio and the beach at the west coast of Nettuno using the dredged sandy material define the details of this project. Detailed contract documents defining in detail the sand quality conditions, the appropriate dredging and pumping ashore techniques and a precise program inclusive of coastal monitoring and sediment investigation activities were prepared by the client 'Regionale Lazio'. The project now comprises ca. 480000 m^3 of beaches and was executed by the self-discharging trailer hopper suction dredger DRAVO Costa Blanca between March and September 2001.

In Anzio, due to bad planning and design of the port entrance, currents and waves caused the accumulation of sand close to the port entrance over the years. This made it impossible even for middle-size ferryboats to enter the port (which used to be possible in the past). Besides, due to coastal erosion, the beaches within 6 miles sailing distance were recedingyear by year. Therefore an initiative was started in 2000 by the Lazio Region to solve these problems through excavating the entrance of the port and nourishment of beaches in Anzio and Nettuno.

During the dredging of the entrance channel of the port and distribution of sand on two main beaches, a total of 480000 m^3 sand was excavated from the sea bottom down to a depth of 6 - 7 m. A total of 80000 m^3 sand was discharged over a length of 900 m on the Nettuno beach and 400000 m^3 to the Anzio beach. The total costs of this artificial nourishment was 585000 Euro for Nettuno and 3305000 Euro for Anzio whilst the port entrance was made accessible at minimum costs.

Current results of the project and expected contributions provided positive outputs. Dredging of the entrance channel of Anzio Port made it possible to for middle-size ferryboats to enter the port starting from mid-June. This will in turn increase the tourism potential in the town. The nourishment of two beaches provided more recreational space for beach users. Considering the physical carrying capacity approach mentioned above, total revenues in a season was estimated as 6.943.980.000 Italian Lire for Nettuno and 6.995.610.000 Italian Lire for Anzio. Finally, the expected economic contribution of the beach nourishments to the regional authority was calculated as 416.638.800 ITL for Nettuno and 419.736.600 ITL for Anzio, while the estimated pay-back period was found to be 3 yr for the former and 15 yr for the latter (Unal 2001).

Evaluation and execution principles for future beach nourishment projects

It is not always clear which public institutions have management competence for matters related to beaches and coastal offshore zones. Shore-based public or private entities can easily get on a collision course with public entities dealing with planning of marine activities. The reason is often the historical difference in approach or the highly diverse technical competence of such entities. It is important that key decision-makers become aware that only an integrated solution will withstand the many criteria of evaluation. Parties may have their individual perceptions of the technical and organizational issues, but should be professional and accept priorities of other parties as a valid part of the evaluation of the projects. In view of the unfamiliarity of public entities with the variety of the elements involved with beach nourishment projects it is worthwhile to break down the specialized knowledge into more familiar subareas thereby indicating which specialists or key organizations will usually be involved.

Where?

Where coastal regions are in retreat because of erosion, beach nourishment becomes an appropriate solution when presence of sand along the coastline forms part of the natural environment. Beach profiles are part of a dynamic systems initiated by continuous wave, tidal and current movements. Defining potential projects is highly dependent on the ability to forecast whether adapting or restoring a coastline will be tolerated and become stable under the influence of such a dynamic system. Therefore besides the availability of sand for renourishment there is an absolute need of high-quality information on sea-state conditions preferably already used for research on the causes of coastal erosion. The first basic design data are wave climate, hydrographic and geotechnical information (see also the decision model mentioned below). The above-mentioned basic requirements reduce the potential areas for immediate projects considerably and should lead to a definition of basic data requirements for research programs possibly by integrating these requirements with standard sea and coastal research.

Key players capable of providing required data include universities, marine research centres and private marine engineering and sediment investigating companies which can be referred to the 'Science Group' (SCG).

Why?

The usefulness of beach-nourishment is supported by two main reasons, the intervention for prevention of coastal erosion and secondly the restoration of tourism potential. Although one can obtain similar results by other technical methods it has to be said that beach nourishment by marine sand can be achieved within short periods with immediate redelivery of the site to tourist operators. Furthermore, the technique allows for flexibility by providing the opportunity during construction for interacting with the natural reshaping taking place by the action of waves and currents. If marine areas can provide variable grain sizes, it is possible to place coarser sand at strategic locations while using visually better appreciated sand in the top layers of the beach.

Key players in a position to quantify the importance of coastal protection and/or benefits to tourism economy: public entities in possession of historic data on shore erosion on the one hand and national institutes for tourism, chambers of commerce, associations of the regional tourism industry and beach establishment operators on the other. This group which is often in a position to obtain the consensus for project financing can be referred to as the 'Public/Political Group' (PPG).

Which type?

It is essential to determine which type of man-made beach can resist the above-mentioned dynamic processes of waves, currents and littoral sediment transport. Those beaches can only be established by engineers specialized in hydraulics and coastal engineering with the possibility of executing studies and calculations using mathematical models. National research centres or universities often have a role of continuous reference for such engineers and contribute to building up reference information on previously executed projects. Knowledge of sediments behaviour in the dynamic process requires the back-up of field data preferably verified over a longer period of time and within the vicinity of a future beach nourishment. Eventually the dosage and shaping of sand has to be expressed in theoretical beach profiles during construction and presumed stable profiles after reworking of the sand by waves and currents. Some specialists prefer the insertion of beach nourishment within perpendicular and/or submerged parallel breakwaters, whilst others are convinced of the need for an abundance of sand with the possibility of selective re-supply for maintenance of the beach. This group of specialists can be referred to as the 'Design Group' (DG).

Which offshore areas?

Which offshore areas are suitable to become a marine borrow areas can be scientifically determined based on wave climate and sea-bottom contours. Generally speaking for the Mediterranean, based on such criteria one should go below the 15 m depth contour. However, penetration of sunlight and therefore the occurrence of active underwater flora and fauna, indicates that in many areas intervention on the sea-bottom can be harmful to the marine benthos.

Environmental assessment studies compromising sea-bottom conditions, water quality and underwater flora and fauna usually have been executed at regional or national scale and in particular the charts indicating the presence of *Posidonia* areas can be useful at an early stage to short-list potential borrow areas. The restrictions may vary therefore and strongly depend on the conditions for undisturbed underwater fauna and the natural presence of turbidity, for instance in the vicinity of river outlets. One may find potential marine borrow areas at 25 - 30 m depth (for example in the Adriatic Sea near Venice), whilst around Sardinia it is preferred to go to the 40 m contour in order to avoid disturbing *Posidonia* areas. In Spain where sand has previously been dredged in the 15 - 40 m depth range, environmental considerations now indicate the 40 - 80 m depth range as interest areas. However, the increasing depth of dredging is associated with an increase in costs.

Fishing grounds can become an issue when the habitats of particular species are affected by strong changes in the sea bottom, but in practice it has been seen that marine areas can also become fresh-food grounds attracting higher concentrations of fish. The Ministry of Environment usually works with specialized sea research institutes; however approval criteria for new marine borrow areas have still not been standardized. The group dedicated to these issues can be referred to as the 'Environment Protection Group' (EPG).

Quality concern

The quality issue is the most important aspect of any beach nourishment project. The sand is the single item, which can make or break the project's feasibility. Geotechnical data are thus essential from the early stages of any study. Nautical charts give limited information about sea-bottom conditions in relation to anchoring of vessels. Geophysical studies have seldom been initiated with the intention to evaluate marine areas for sand dredging. Standard seismic investigations are done to evaluate the geophysical state of the very deep and thick layers of the seabed, while nourishment projects require very detailed information on the first 2 - 10 m of sea bottom. As a consequence it is unavoidable that clients have to invest in considerable sediment investigations prior to being able to decide on the feasibility of proposed projects. The investigation can be divided into three stages:

- Desk and literature study in order to choose potential areas;
- Seismic investigations together with taking surface samples for calibration;
- Vibrocore campaign for obtaining 6-m probes, defining unsuitable overburden layers (silt, clay etc.); laboratory analysis and report on the nature and thickness of each layer.

Exact vessel positioning and hydrographic information greatly improve the research results. Through laboratory work it is possible to ascertain the compatibility of sand with the beach requirements from a geophysical and geochemical point of view. The involved parties can be seen as the 'Control Group' (CG).

Which quantity, equipment and costs

After many studies one has to decide how to 'do it'. The level of accuracy, efficiency and organizational capacity required to allow a defined project to follow the strict parameters defined by the above-mentioned groups is often surprising. It is also complicated to explain to the non-executing groups how much influence all special requirements have once a figure for quantity of sand for beach nourishment has been indicated. Beach-nourishments may require from 150600 m^3 of sand per linear meter of beach and typical construction velocity can vary from 20000 m^3 to 400000 m^3 of sand per week, which can be expressed in horizontal progress as approximately 35 to 2500 linear m of beach per week. Obviously there are many a 'what if' and 'what not to do' that need to be considered and it is only after a detailed technical and economical study that one can establish a cost for each m^3 of sand after selecting the right equipment with consequent 'construction speed'.

Few people outside the dredging sector realize that each piece of dredging equipment with a capability to reach more than 25 m depth, to transport sand in open sea conditions and to build for pumping sand ashore over more than 3000 meter of pipeline distance may need to be mobilized from locations within 1500-8000 miles sailing range. Further, the vessels also demand installation of auxiliary equipment such as floating, submerged and shore pipelines. Therefore minimum sediment quantities are needed in order to distribute such costs over the project and to achieve sustainable cost-price levels (when compared for instance with the price for minor quantities of shore delivered sand). In order to give broad guidelines one can list the key

Table 1. Key characteristics for self discharging trailing suction hopper dredgers (Dravo S.A. – Italy; van der Salm, J.1999)

Transport capacity	Dredging depth	Economical distance to marine borrow area	Loaded operation depth	Class type	Indicative production range (1000 m^3/week)	Typical economical project quantity
750 - 2500 m^3	26 - 35 m	6 - 12 miles	5 - 8 m	Small	40.000 m^3+	300000 m^3
2500 - 5000 m^3	30 - 45 m	10 - 20 miles	7 - 10 m	Medium	100.000 m^3+	750000 m^3
4500 - 8000 m^3	40 - 60 m	15 - 20 miles	9 - 11 m	Big	200.000 m^3+	1500000 m^3
8000 - 18000 m^3	50 - 110 m	20 - 50 miles	11 - 14 m	Jumbo	500.000 m^3+	3000000 m^3

characteristics for self-discharging trailing suction hopper dredgers as follows:

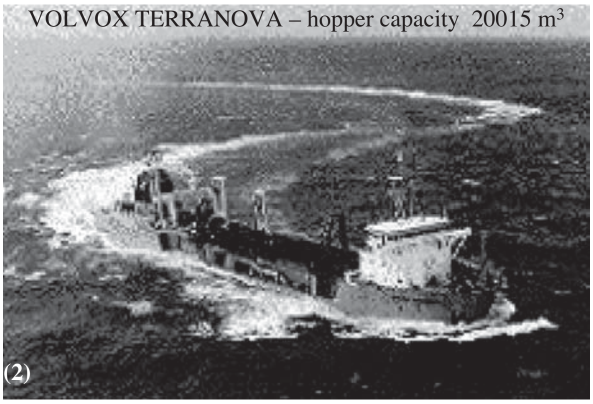
The Trailing Suction Hopper Dredger (TSHD) is a type of equipment (Figs. 1 and 2) which is mainly owned by a group of six specialized dredging contractors (with head offices in The Netherlands and Belgium) who conduct project activities on a worldwide scale. The fleet of ca. 50 vessels and their markets are highly mobile, although the majority of these vessels are usually engaged in infrastructure projects in the Far East.

Specialized engineering staff are able to combine historic and recent vessel data together with engineering theory. With such knowledge they can effectively forecast operational requirements for a marine borrow area project to make the most economic vessel choice. Overall, such specialists have to take into account the following major cost elements:

- Fixed operating costs: vessel depreciation, interest charges, maintenance costs;
- Fuel, lubricants and consumables costs;
- Crew costs inclusive of social charges and taxes and general support (varying for each country);
- Auxiliary equipment like floating, submerged and shore pipelines; together with an auxiliary tugboat and hydrographic survey equipment;
- Geotechnical investigation and possible removal costs of non-suitable surface materials (overburden); demining operation for marine borrow area (when prescribed by the client);
- Mobilization costs;
- Site organization costs, general overheads, financial costs and surcharge for profit and risk.

Each project configuration and total sand supply quantity will indicate a favourite class of the TSHD vessel and a working methodology with subsequent definition of auxiliary equipment. The execution phase is generally the project phase where typically 60-80% of the total project value is spent, and an early recognition of budget costs may therefore assist a client to define an economical target project quantity and budget level.

The above 'know how' is typically available within the specialized dredging sector and one can refer to this sector as the 'Execution / Creating Group' (EXG).



Figs. 1 & 2. Trailing suction hopper dredgers.

How to plan and finance the project

The allocation of finances only makes sense when the foregoing decision groups have defined a plan with a detailed scope and execution methodology. It is counter-productive for a defined project when the execution is stretched over time and split up into phases for budgetary planning reasons. A linear m of beach does not resemble a linear m of road construction and the reduction of projected sand quantities to considerably lower levels of m^3/linear m may have also near to '0' as result.

Instead, clients should be aware that it may be better to wait until some of the most technically and economically advanced TSHD equipment comes within reach of the project and then take quick steps to put the project out to tender.The financing traditionally depends on the budget allocation under national and regional coastal defence or tourism schemes. It is sometimes possible to obtain European Community financial assistance when the areas concerned belong to priority assistance areas. Finances rely heavily on the professionality and ability of the financial specialist to search for resources and to combine multi-sectorial information on forecasted return on investment or spin off return when the projects enter into a justification process. In future it should be possible to charge levies to direct users to obtain royalties or regional tax returns in order to have additional project financing for beach nourishment without relying only on general budgets. This group can be referred to as 'the Funding and Planning Group (FPG)'.

Integrated Coastal Zone Management

Implementing a project within the natural environment speaks to the imagination of every single group indicated above and requires Integrated Coastal Zone Management (ICZM) to guarantee construction of widely accepted projects. People will seldom refrain from having their say on whether the beach nourishment is an appropriate solution. Utilising construction materials readily available within nature is not justified without studies and environmental assessments. Interdisciplinary action and balanced management policies will permit the combination of safety and economical interests with concerns about causing permanent damage to the environment.

The rules for key players in planning and urbanization projects on-shore are better defined and new projects are often dealt with in a standardized manner. On the contrary working in coastal zones requires dealing with a diversity of organizations with more or less defined competence and decision power in relevant matters. As a result there is a stronger need to guide a beach nourishment project through its various phases than there is with on-shore projects.

Specialists with the capability to maintain the 'helicopter view' of the project in progress must have the will to make the impossible become possible, whilst dealing with reasonable and unreasonable obstacles during the various stages of a beach nourishment project. Expertise and reference experience are sometimes only available on a national or international scale implying that ICZM specialists will have to integrate the individual group work into a common project solution. This group can be referred to as the 'Consultants and Strategy Group (CSG)'.

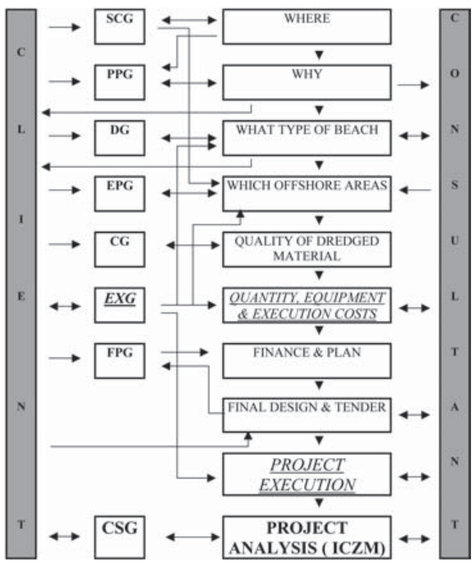
In general the decision-making needed for any progress in the project from the initial idea for a beach nourishment to the actual execution is more complex in the Mediterranean compared to elsewhere as in, for instance, northern Europe or the Far East for a number of reasons:

- Lead-time for study and elaboration of design data is still long due to unfamiliarity of public administrations with beach nourishment projects and their environmental evaluation.
- Limited sea-bottom data are available during the preliminary stage; thus it takes more time to assess the possibility of starting development of a marine sand borrow area.
- Presence of specialized TSHD vessels is erratic compared to the northern Europe and Far East markets due to the large volume projects in these areas, which therefore receive more attention by the dredging companies.

Mainly for the above reasons it is necessary that all interested parties face these extra obstacles in project development by stimulating exchange of information between the various groups. Early involvement of the 'Executing Group' fosters project development due to utilization of their vast experience in such projects.

The above-mentioned evaluation and execution principles provides a decision organization model that can be applied to any beach nourishment project in the Mediterranean (Fig. 3).

From the initial stages of the project to the completion, the Client, the Consultant, the Project Execution Group and the Consultants and Strategy Group are the



SCG = Science Group **PPG** = Public/political Group
DG = Design Group **EPG** = Environmental ProtectionGroup
CG = Control Group **EXG** = Execution/creating Group
FPG = Funding and Planning Group
CSG = Consultants and Strategy Group

Fig. 3. Decision organisation model that can be applied to beach nourishments in the Mediterranean.

key decision makers and there are mutual interactions among them. The type of beach desired, quantity of dredged material, equipment necessary for the preparation of the site, dredging and nourishment works, execution costs, final design of the project and tender as well as project execution, and project analysis are the main considerations that should be discussed in detail by the above-mentioned decision-makers.

However, for the successful completion of the project, the client is responsible for providing the necessary information to the other parties who then will be responsible for the provision of the required data (Science Group), for quantifying the importance of the beach nourishment project to the tourism economy and to the society who are directly or indirectly affected by (Public/Political Group), and for establishing a suitable and erosion-resistant beach type and profile (Design Group).

Conclusion

Where coastal areas are in retreat because of natural and anthropogenic factors, effective management strategies are needed to rehabilitate them. Erosion control through beach nourishment projects is a coastal zone management tool that not only protects the coast from the effects of wave and wind action but also provide recreational possibilities. However evaluation and execution of such projects can only be effective through:

- Key decision makers who are fully aware of the problems and their possible solutions; willingness to take into consideration both economic and environmental issues; awareness that not only an integrated approach will satisfy the many criteria of evaluation.
- Parties that are professional and accept the priorities of other parties as a valid part of the project evaluation.
- Definition of potential projects by forecasting the tolerance of the coastline to restoration and stabilization.
- High-quality information/data, and quantification of the importance of coastal protection and/or benefits to local tourism economy, and to regional tourism, e.g. in the Mediterranean.
- Detailed technical and economical study in order to achieve accuracy, efficiency and high level management during project execution.
- Professional attitude and ability of the financial specialist to search for resources and combine the multi-sectoral information on forecasted return on investment or spin-off return.

References

Anon. (World Tourism Organisation) 1984. Tourist carrying capacity. In: *UNEP Industry and Environment* 7 (1), pp. 30-36.

Anon. 1993. *Recovering the coast*. State Coast Office, Madrid, ES.

Anon. (National Research Council) 1995. *Beach nourishment and protection*. http://books.nap.edu/books/0309052904/html

Anon. 1999. *Tourism and recreation*. http://www.coastalguide.org/code/tourism.html

Dravo S.A. & van der Salm, J. 1999. *Meetings between sea and shore with beach nourishment on Spanish coasts*. Proceedings of the Seminar on Coastal Engineering, November 1999. University of Monserrato (Cagliari), IT.

Pacini, M., Pranzini, E. & Sirito, G. 1997. Beach nourishment with angular gravel at Cala Gonone (Eastern Sardinia), Italy. In: Özhan, E. (ed.) *Proceedings of the Third International Conference on the Mediterranean Coastal Environment MEDCOAST 97*, November 1997, Qawra, Malta, pp. 1043-1058. METU, Ankara, TR.

Pearce, D. 1989. *Tourist development*. 2nd. ed. Longman, Harlow, UK.

Pranzini, E. & Rossi, L. 1995. A new Bruun-rule-based model: An application to the Tuscany Coast, Italy. In: Özhan, E. (ed.) *Proceedings of the Second International Conference on the Mediterranean Coastal Environment MEDCOAST 95*, October 1995, Tarragona, Spain, pp. 1145-1159. METU, Ankara, TR.

Preti, M., Lamberti, A. & Martinelli, L. 1997. Analysis of a sand sac submerged barrier: Case of a beach in Riccione. In: Özhan, E. (ed.) *Proceedings of the Third International Conference on the Mediterranean Coastal Environment MEDCOAST 97*, November 1997, Qawra, Malta, pp. 1059-1072. METU, Ankara, TR.

Ruol, P., Capobianco, M. & Tondello, M. 1997. Physical model tests in the framework of beach nourishment performance evaluation. In: Özhan, E. (ed.) *Proceedings of the Third International Conference on the Mediterranean Coastal Environment MEDCOAST 97*, November 1997, Qawra, Malta, pp. 1073-1088. METU, Ankara, TR.

Ryan, C. 1991. *Recreational tourism: A social science perspective*. Routledge, London, UK.

Unal, O. 2001. *Beach regeneration projects as a way towards integrated coastal zone management: The cases of Anzio and Nettuno (Lazio Region), Italy*. Unpubl. Research Report, Amelia, IT.

Williams, A.T. & Davies, P. 1995. *Beach management guidelines: Dimensional analysis*. Paper presented in the MEDCOAST 95 Institute, The Med-Campus Certificate Program on Coastal Zone Management in the Mediterranean. Ankara, Marmaris, Cappadocia, TR.

Received 24 June 2002;
Revision received 3 April 2003;
Accepted 3 April 2003.
Co-ordinating Editors: M. Cassar & E. van der Maarel.