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# Application of coastal cells for the multi-level study of Hormozgan coastline at Northern Persian Gulf and Oman Sea

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ABSTRACT

Coastal cells are considered as an appropriate framework in studying coastal processes and shoreline evolution as the basis for both engineering objectives and shoreline management plans. In this article a summary of the identification of cells and sub-cells as part of a multi-level coastal study of Hormozgan coastline and Qeshm Island is presented. The application of this concept for the study area encounters a number of restrictions and requires specific considerations, which stem from complex feature of the coastline and lack of reliable data regarding the available sediment sources and limited evidences for the processes in the past. The scientific value of this study is in its potential application for the lengthy and mostly undeveloped coastline of the Persian Gulf and Oman Sea with the similar characteristics and in association with the objectives of integrated coastal zone management regarding coastal sediment processes.



## 1. Introduction

Evaluating the coastline evolution along with the impacts of human intervention on the coastal environment and neighboring territories are of most importance in the Integrated Coastal Zone Management (ICZM). Understanding coastal geomorphology is fundamental to the success of coastal management. Improving our understanding of coastal system in terms of its past evolution and present processes that govern the coastline change while affecting the coastal geomorphology is significant for the Shoreline Management Plans (SMPs). The concept of sediment budget balance in littoral cell (coastal sediment cell), here is recently considered as a powerful tool in developing a systematic planning zone for the management of coastal processes (French, 1997; Kamphuis, 2000; Pontee and Parsons, 2010). This concept facilitates managerial decision making at regional scale rather than traditional fragmental approach in the past based on administrative boundaries, when and where the approach was prone to long term malfunction and possible side effects on neighboring territories.

A coastal (littoral) sediment cell is defined as a district, relatively self-confined coastal region that contains a complete cycle of sedimentation, including sources (input), transport paths (process), and sinks (output). The cell boundaries delineate the geographical area within which the budget of sediment is balanced (Inman, 2003). In a broader definition the boundaries can be defined by identifying the discontinuities in the rate or direction of sediment transport (Van Rijn, 2010). Within a large sediment cell, a number of smaller sub-cells can often be identified; where these sub-cells are not fully independent of up drift or down drift where sediment may pass the boundaries in exceptional circumstances. Boundaries of littoral cells are either barriers to alongshore sediment pass (natural e.g. headlands, or artificial e.g. long breakwaters) or sediment sinks such as estuaries (Cooper et al., 2001; Davidson-Arnott, 2010). By identifying the cell and sub-cell boundaries, a coastline is compartmentalized into a number of more or less independent units. Any development or activity or change in driving forces which affect the supply or movement of sediment, may influence the processes in the same cell or sub-cell but will have no or minor effect on beaches in other cells (Lees, 2010). Through this definition, if more sediment is transported into a sediment cell than out of it, shoreline accretion occurs and in the reverse processes, erosion occurs. Balancing the inflow and outflow of sediment for a given littoral cell is therefore important for maintaining the beaches stability (Boateng et al., 2012).

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Since the introduction of the coastal cell concept and its initial application in Southern California Coastline (Bowen and Inman, 1966), many coastal regional sediment management plans have adopted and implemented it worldwide (Anfuso et al., 2011; Best and Griggs, 2012; Cappucci et al., 2009; Collen et al., 2009; Cooper et al., 2001; Nair et al., 2011; Rao et al., 2009 etc.). An excellent example is the coastal sediment budget analysis of entire California coastline where the current situation and possible consequences of coastal remedial works are analyzed in series of littoral cells (Patsch and Griggs, 2006). Zviely et al., 2007 studied the volume of sand deposited at Haifa bay about 600 km away from the source of Nile delta within one of the greatest littoral cell of Nile along the southeastern Mediterranean coast. Montreuil and Bullard (2012) studied the coastline position change within a single sediment cell of eastern England over 150 years where the geomorphology includes cliffs, beaches and salt marshes. The coastal sediment cells are now widely applied in many countries for coastal management planning, where cell boundaries may define the planning units (Cooper and Pontee, 2006).

Despite the value of the coastal sediment budget, it is still difficult to establish the concept in practical manner everywhere. The biggest problem here is that all key components within the budget, including sources need to be identified, understood and quantified if the overall budget is to be considered reliable (Boateng et al., 2012). Due to lack of data, the contributions from individual sources are often evaluated based on unverified assumptions or extrapolations, which result in inaccurate predictions (Best and Griggs, 2012).

The other difficulty in application of the littoral cell concept in some cases is the accurate identification of the boundaries. At the trailing-edge and marginal coasts, which is the case for the entire Northern coastline of the Persian Gulf and Oman Sea, the coastline features are rather complex and the natural barriers of short headlands only partially interrupt the sediment path. The other common boundaries such as spits and sand banks have limited stability. This in turn yields to an ambiguity in selecting the cell boundaries which is a key issue in this concept (Patsch and Griggs, 2008).

Moreover, the coastal cell is rather a beach process unit, suitable for sediment management strategies at regional scale. The application of the coastal cells as coastal management units to acquire different objectives of coastal management is disputable (Cooper and Pontee, 2006; Hansom et al., 2004). It is argued that when and where the concern is something other than sedimentation/accretion and coastline evolution, one alternative for littoral cell could be adoption of a process defined management unit (PDMU) approach. PDMU is introduces as a locally driven issue identification approach whereby the management units are identified based on the relevant local processes relevant to the issue at hand. Hansom et al. (2004) applied the PDMU approach for Scotland coastline, where the conservation of the national heritage was the matter.

This article provides a summary of the identification of cells and sub-cells as part of above multi-level study on coastal processes and shoreline evolution for Hormozgan and Qeshm Island at the Northern Persian Gulf and Oman Sea. The outline of this article is: the overview of multi-level study on coastal processes and shoreline evolution at Hormozgan coastline is described. Next, the general feature of the study area is introduced. Then, the problems that exist in identification of the appropriate cells and sub-cells that would suit the characteristics of the coastline in association with the eventual objectives of the study are then discussed. By adopting the concept, the coastal cells that identified for the coastline of Hormozgan and Qeshm Island are briefly described. Since this study is one of the first conducted on study the sedimentation of the Northern Persian Gulf and Oman Sea at the regional scale, the attempt is also made to illuminate the general feature of the coastline in order to emphasis on the common difficulties that one may face for studying such a complex, highly diversified and mostly under-developed coastline.

## 2. Multi-level study on coastal processes and shoreline evolution at Hormozgan coastline

Comprehensive multidisciplinary project of data gathering and modeling met-ocean parameters and coastal processes at Hormozgan coastline and Qeshm Island, at the Northern Persian Gulf was introduced by Iranian Port and Maritime Organization, PMO (FDA, 2012). The study area covers approximately 750 km of the northern coastline of Persian Gulf and Oman Sea including the strategic strait of Hormoz as well as 261 km coasts of Qeshm Island. The south of Hormozgan province, extended in the middle part of southern coasts of Iran, as shown in Fig. 1, has accommodated several large fishery and commercial ports including, Shahid Rajae the largest and the most strategic in the country. The project was planned to provide the baseline information for development of the Shoreline Management Plan (SMP) and ultimately feed the national strategic project of ICZM for entire coastline of Iran (Pak and Farajzadeh, 2007; Dibajnia et al., 2012).

The study on sediment transport and prediction of shoreline evolution for entire coastline is constituent section of this study. The overall objective is to obtain the most fundamental information required to understand and model the coastal system behavior so that a predictive capability could be accomplished. Furthermore, evaluation of existing and possible future problems due to human interventions regarding sedimentation/erosion and proposed solution at and around some specified sites (hotspots) along the coastline were also required. Based on this findings, the regional sediment management (RSM) approaches in response to coastal erosion/accretion problems can be introduced.

Therefore, the study inherently included combination of regional and local scales of coastal processes (Larson et al., 2002). In the regional scale, the wide-scale influences of natural processes in various geomorphic features are addressed. The local scale refers to the scale, where the coastal processes are typically considered in engineering design. Here, the objective is to predict the coastal processes interaction in terms of erosion or sedimentation and the function of coastal facilities. To manage these two classes of study, three levels are introduced for the study in order to organize the available and required inputs, applicable predictive tools, anticipated outcomes and interconnections between the two in a rational manner (Shanehsazzadeh and Parsa, 2013). The coverage, study procedure and applications of each levels of the study are depicted in Fig. 2. Each level of the study can best be understood in the context of its correlation with the other levels. In other words, in this procedure, the outputs of each level provide the basic information for the more precise study at the higher level and by contrast, the detailed study at higher levels provide the indicators for coastal processes in a wider stretch of the coastline.

In order to provide a practical and rational framework for the multi-level study of Hormozgan and Qeshm Island coastline, the coastal (sediment) cells are applied to discretize the coastline based on beach processes. The primary outcomes of the study for each cell (or sub-cell) then include:

- Improving the understanding of the coastal processes within the coastal cell or sub-cell.
- A sound prediction of the likely future evolution of the coast and identification of possible properties or coastal facilities affected by coastal changes.