Journal of Oceanography and Marine Research

Alcantara-Carrio et al., Oceanography 2014, 2:3
DOI: 10.4172/2332-2632.1000e108

Editorial Open Access

Geomorphological Coastal Classifications after Natural Processes and Human Disturbance

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Classifications after Natural Processes

In geomorphological studies, a wide range of coastal classifications based on natural processes are available. These classifications results from very different approaches but are not necessarily incompatible. Used criteria basically include the tectonic [1] and hydrodynamic controls, as well as the sedimentological response.

Hydrodynamics control includes classifications after wave parameters [2,3], spring tidal range [2,4] and a combination of both [4-6]. A major advance in this type of classifications was the inclusion of the term megatidal, previously applied in ecological studies [7,8] and later adopted in coastal geomorphology. Thus, Levoy et al. [9] defined as megatidal the coast with tidal ranges higher than 8 m, while other authors [10,11] agree to locate the limit of megatidal coasts at 6 m. Therefore, the following four types of coasts, differentiated after its tidal range, should be considered as standards for future researches: microtidal (0-2 m), mesotidal (2-4 m), macrotidal (4-6 m), and megatidal (>6 m). A ternary classification, considering river, wave, and tide influence supported a very useful analysis of siliciclastic sedimentary coasts [12-14]. The combination of tectonic and hydrodynamic controls led to the proposition of coastal morphogenetic classifications [15,16], which are probably the most widely used classification schemes.

Grain size [17] and sediment composition are also very useful to classify and describe the coastal sedimentary environments. Thus, three different types of coastal environments are defined after their dominant mineralogical composition: siliciclastic, carbonate and evaporitic sedimentary coasts, main sediment sources relating to continental inputs, biogenic supply from the marine ecosystems, or evaporitic coastal processes, respectively. Therefore, mineralogy allows identifying the source and sinking areas of the coastal system [18]. Microfossil content in sediments is also useful to classify the coastal environments [19,20]. More accurate coastal classifications of sediment provenance can be obtained combining grain size, mineralogy and microfossil content analyses [21]. On the other hand, coastal classification based on availability or shortage of sediments, can be also obtained by combination of grain size and mineralogical features [22], as well as from analysis of the thickness of the sedimentary deposit [23].

Coastal Classification after Human-Disturbance

Kelletat [24] introduced for the first time the term manmade coasts. However, due to the complexity and diversity of human activities, a coastal geomorphological classification based on the extent of human disturbance has not been yet achieved. In order to cover this lack, we propose the definition of three main types of coasts according to the nature and extension of human disturbance: Natural indirectly-modified coasts, Rural or intermediate coasts, and Human-developed coasts.

The term Natural indirectly-modified coasts refers to natural coastal zones without a significant human presence, but influenced by the global change, i.e. pollution, sea-level rise and consequent coastal erosional trends, and/or by human-induced loss of biodiversity, among other indirect anthropic impacts. Its geomorphological evolution is still mainly controlled by natural processes, but human impacts are also noticeable in minor proportions. Unfortunately, we must assume that currently all natural coasts are subject to human influences.

The class Rural or intermediate coasts applies where the human presence is low, typically associated to traditional practices, mainly agriculture and fishing activities. Land occupation in these areas is low or very low, with an alongshore population density lower than 10%. Therefore, the natural geomorphological processes are still dominant, but localized areas with noticeable human impacts can be easily identified.

Human-developed coasts are those characterized by strong alterations of the natural processes, and natural landscapes are replaced by cultural landscapes (Nordstrom, 2000). This class of coasts includes Semi-urban coasts, Urban coasts, Manmade coasts, and Harbors. Semi-urban coasts are characterized by an intermediate alongshore density occupation, about 10-25%. They are typically occupied and developed by modern populations, with a higher number of socio-economical activities and therefore, numerous direct impacts and substantial morphological modifications. For more human impacted coast, the term Urban coasts refers to those coasts occupied by cities, villages and settlements, with its shorelines covered in big proportion by walls, breakwaters, artificial reefs, promenades and other manmade constructions. Manmade or artificial coasts, *sensu stricto*, show strong modifications of its pre-existing natural morphology, or even events of total destruction and reconstruction, for instance in the artificial islands. Finally, harbors are another type of human developed coast, particularized because they are basically concrete coasts. Morphology of harbors results not only from engineering activities, but also from human adaptation to natural conditions. Thus, similarly to the subaerial morphological types of river deltas [25], they can be classified after the fluvial, wave and tidal hydrodynamic control (Figure 1). Fluvial dominated harbors locate on river channels, relatively close to the mouth. Tide dominated harbors are typical of macrotidal and

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Received August 26, 2014; **Accepted** September 03, 2014; **Published** September 10, 2014

Citation: Alcantara-Carrio J, Fontán Bouzas A, Albarracin S, Correa ID, Montoya Montes I, et al. (2014) Geomorphological Coastal Classifications after Natural Processes and Human Disturbance. Oceanography 2: e108. doi:10.4172/2332-2632.1000e108

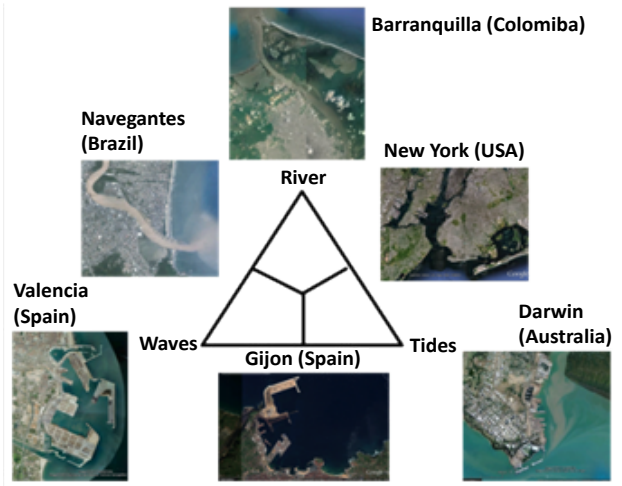

Figure 1: Harbors' classification after their morphology and coastal hydrodynamics (aerial photographs from Google Earth).

megatidal estuaries, free of storm waves influence. Wave dominated harbors locate on open microtidal coasts without fluvial influence. Intermediate cases can also be defined, always with a logical relationship between the morphology and hydrodynamics.

Hard structures and beach nourishment are designed to protect intermediate and human-developed coasts from shore erosion, being isolated in the first case and very frequent in the second one. In contrast, alternative adaptation strategies like relocation and retreat are typically assumed in rural and low developed coast [26].

Conclusions

From a geomorphological point of view, the coast is a relatively narrow fringe whose morphology and evolution depend of numerous interactions between hydrodynamic, continental, atmospheric, tectonic, geochemical and biological processes, last one including the human disturbance.

After human disturbance, three kinds of coasts can be defined: Natural indirectly-modified coasts, Rural or intermediate coasts, and Human-developed coasts. Human developed coasts can be further subdivided in Semi-urban coasts, Urban coasts, Man-made coasts, and Harbors. The integration of previous tectonic, hydrodynamic, morphogenetic and sedimentary coastal classifications after natural processes, with this classification allows a holistic description of coastal geomorphology. Therefore, it should be useful to normalize the description of the study areas in coastal geomorphological researches, and consequently to facilitate comparisons among them.

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