

Appendix V-A. Conceptualization of natural processes influencing the coastal morphology. Adapted from Prothero and Schwab (2013), Masselink et. al. (2011), Bird (2008), Pranzini (2008) and Morton and Pieper (1977)

Generic definition of Process: Set of successive phases of a complex phenomenon or event. **Bold letters refer to human transformations.**

Category	Process	Description	Causes (origin)	Conditioning *
<u>Geological</u>	Subsidence by sediment compaction	Sinking of terrains due to the progressive deposition of sediments in a sedimentary basin. This influences relative sea level	Weight of the sediments deposited in a progressive manner (sedimentation gradients)	<ul style="list-style-type: none"> - Tectonic activity inducing liquefaction - Environments with high sediment loads (e.g. deltas) - Extraction of fluids from underground reservoir - Deforestation (increasing sediment load) - Dredging
	Vertical movements associated to diapirism	Vertical movements of the Earth surface, where the acting force is the density difference of the deposited materials. This influences relative sea level	+ Density difference of deposits induces the intrusion of more deformable, mobile and ductile material through overlying and denser rocks or materials (e.g. mud or salt diapirism) + CO ₂ and CH ₄ accumulation from organic matter trapped in denser sediment layers + Clay dehydration	<ul style="list-style-type: none"> - Environments with current or former high sediment loads (e.g. deltas and pro-deltas) - Presence of structural controls (faults, fractures) where diapirism seek a way out - Tectonic activity inducing violent diapiric intrusions (lateral compression) - Drillings (shallow or deep) inducing violent mud ejection
	Earth movements by neo-tectonics	Sinking, uplifting, tilting or crust displacements along structural controls in the coastal zone and surroundings, influencing relative sea level. Abrupt movements of this kind in underwater locations can trigger tsunamis	+ Movement of tectonic blocks (e.g. earthquake) + Variations in volume and heat within magmatic chambers (volcanism) + Isostatic balance and rebound	<ul style="list-style-type: none"> - Drillings (crust perforation) - Fluid injection or extraction on the underground
	Physical weathering by structural controls	Mechanic disintegration of rocks into clasts due to wave pressure associated to the presence and configuration of structural controls (e.g. faults, fractures and stratigraphic sequences)	+ Water pressure by the impact of waves + Dilation forces of salt crystal formation and wetting/drying cycles within structural controls	<ul style="list-style-type: none"> - Capillarity and cracks on rocks (Fracture density) - Type of substrate (e.g. sedimentary rocks) - Differentiated wave energy - Exposure to wave attack - Drillings (crust perforation)

	Littoral mass movements	<p>Emerged and submerged falls, slides and flows of substrate, associated to rocks lithology and structural stability.</p> <p>Examples of these processes are cliff toppling, in the emerged coast, and submarine sand slides in the submerged coast, which can also trigger tsunamis</p>	<p>+ Deep-seated failures, unconsolidated material or well jointed rocks that configure the detachment of blocks from cliffs</p> <p>+ Slides of loose sediments by gravity forces.</p>	<ul style="list-style-type: none"> - Wave energy - Weathered degree of rocks - Natural runoff channels - Turbidity currents from high load of sediments - Deforestation on the basin (increasing sediment load) - Deforestation in situ (reducing bio erosion on hard substrates) - Drains caved for built structures on hard substrates - River mouth channeling
	Erosion in the drainage basin (sediment inputs)	Sediment generation (continuous or intermittent) to the littoral system from disperse continental sources during the erosion of the Earth crust.	Detachment and mobilization of loose particles from the weathering of substrates in the watershed	<ul style="list-style-type: none"> - Lithology - Relief configuration (steepness) - Amount of rain - Deforestation
	Sediment sinking by geomorphologic configuration	Leaking of sediments from the littoral systems, associated to the presence of geomorphological features like submarine canyons in the submerged coast or tidal inlets in the emerged coast	<p>+ Submerged projection of drainage, associated to the relief configuration in glacial periods</p> <p>+ Carved channels in littoral substrates by tidal currents that carry along sediments</p>	<ul style="list-style-type: none"> - Sea bottom dredging - Artificial inlets for navigation (jetties) - Artificial inlets for controlling the sea communication with coastal lagoons
	Water table changes	Rise or decrease of water table levels, associated with the underground hydric balance in a watershed. The reduction of freshwater supplies can lead to soil salinization	Consumption or recharge of underground freshwater along permeable substrate and aquifers	<ul style="list-style-type: none"> - Extraction of fluids from underground reservoir -
Geochemical	Chemical formation of sediments	Generation of sediments in situ, along the littoral system, due to the chemical composition and reactions of sea water and substrates	Precipitation and formation of minerals from dissolved ions carried in solution to the depositional site in the littoral	<ul style="list-style-type: none"> - Water temperature - Ion content in water - Pollution: unusual concentration of compounds, elements or energy in the natural matrix
	Chemical weathering	Disintegration of rocks into dissolved constituents by simple solution, hydration, hydrolysis or oxidation.	Interaction of the mineral in the rock with different chemical elements and compounds (e.g. H ₂ O, O ₂ , OH ⁻ ...)	<ul style="list-style-type: none"> - Mineral composition of rocks - Fractures of rocks - Pollution: unusual concentration of compounds, elements or energy in the natural matrix

Climatic	Eustatic sea level changes	Changes in the water volume of oceans and seas due to trends in global climate	+ Melting and formation of ice caps and glaciers + Thermal expansion of the water	- Isostatic adjustments (balance and rebound) - Emerged and submerged relief configuration
	Semi-periodic sea level changes	Anomalous variations of sea level due to phenomena like ENOS, NAO...	Thermic expansion of water and changes on atmospheric pressure during the increase of sea surface temperature	- Emerged and submerged relief configuration - Local weather patterns (e.g. westerlies)
	Extreme meteorological events	Intensification of hydrodynamic processes during storms and their different intensities due to an abnormal rise in sea level	Strong onshore wind and abrupt atmospheric pressure reduction that take place at variable time periods and frequencies over a year	- Fetch length - Wind speed and direction - Low pressure systems migration
	Drainage in the basin by weather events	Input of sediment to the littoral system due to the transport and deposition of eroded sediments from the watershed	Precipitation pulses that conduct sediments along the watershed by runoff	- Lithology - Relief configuration - Deforestation - Dams - Streams disruption (e.g. levees) - Groundwater extraction - Quarrying
Hydrodynamic	Littoral erosion	Removal of sediments from one location or substrate due to impact and shear forces during the movement of water	Blow of waves or erosion and abrasion by tidal and wave currents	- Micro tidal range - Energetic wave conditions - Material resistance of rocky substrates - Exposure to wave and refraction patterns - Tsunami's intensifying effects on shore - Structures on the shore and nearshore
	Littoral sediment transport	Conduction of sediments within the littoral area in longitudinal and transversal directions due to the movement of sea water	+ Nearshore currents (longshore, onshore and rips), controlled by the way waves approach to the shore + intertidal flows during daily elevation and depletion of sea level	- Tidal and wave regimes - Exposure to wave and refraction patterns - Tsunami's intensifying effects on shore - Structures on the shore and nearshore
	Littoral deposition	Localized accumulation of sediments, associated to diffraction phenomena or longshore transport energy reduction	Dissipation of the energy from wave or tidal currents due mostly to the presence of obstacles on the beach	- Sediments' grain size - Exposure to wave and refraction patterns - Structures on the shore and nearshore

<u>Eolic</u>	Wave generation by wind	Sea wave induced by winds are eventually transmitted into coastal zones	Speed and direction of the wind triggers the generation of waves, depending on the duration of the blow and the distance over which the wind blows on the water surface (fetch)	- Exposed configuration of the coast
	Sediment transport and deposition by wind	Conduction and redistribution of loose sediments along and cross shore by wind action	Wind current and the dissipation of its energy by obstacle on the emerged beach and backshore	- Sediments' grain size - Screen effect from buildings in the seafront (wind current concentration) - Reduced energy from the obstacles of human facilities in the seafront - Physic occupation of deposition centers
<u>Biogenic</u>	Biogenic sediment production	Sediment production by secretion and transformation of mineral (e.g. Carbonates) and disintegration of rocks into clasts. Contribution of plants and animals in the physical and chemical weathering of littoral substrates	+ Biological function of marine flora and fauna, which generate particle that precipitate into sediments + Chemical reactions induced by products of metabolism + rock fragmentation by the action of grazing and boring organisms	- Carbonated environments - Degrees of terrigenous contributions - Alkaline water - Controlled concentration of natural and human induced compounds - pollution
	Sediment fixation	Emerged and submerged capture of sediments by the presence of organisms	Mainly plants trap and stabilize loose sediments in deposition centers. E.g. Dune vegetation, Mangrove, Marine Phanerogam (seagrass-posidonia-etc), algae.	- Water turbidity - Controlled concentration of natural and human induced compounds – pollution - Tourist activities (transit on dunes)

* **Bold letters refer to human transformations**

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