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Effect of outlet hydrodynamics on the formation of river channel morphology

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The existence of salinity gradients between fresh water and salt water at river outlets has been known and documented. The recognition of a halocline in such aquatic environments has helped to better understand the nature of mixing between saline and fresh waters; the presence of halocline dividing waters of contrasting salinity, suspended sediment concentration and thermal characteristics have been explored in the past two decades. However, the effect of the interface between rivers and saline waters in saline or semi-closed seas and their inland intrusion has not been studied hitherto with respect to its effect on nearshore stream channel morphology and consequent formation of bed topography.

The evolution of the studied fluvial system takes place in the the hyperarid Dead Sea environment, Israel, constrained by a very short time scale system response to very abrupt (1 m/yr) base level lowering taking place while channel water discharge remains relatively constant. These conditions lead to formation and development of channels in a cohesive-lacustrine depositional environment. High resolution 3-D velocity measurements, salinity distribution, suspended sediment concentration and channel bed topography survey reveal that a hypersaline Dead Sea water prism intrudes in the form of a wedge-shaped salty bottom layer several metres into the brackish stream channel, generating a wide parabolic cross-section. The magnitude of intrusion is responsible for the rate of channel widening at the nearshore area and for initiation of primary bed topography – a longitudinal trough - of the evolving proto-channel. The sea effect on initial topography seems to have a relatively long-term consequence developing to a more pronounced bed element during further phases of channel development due to the effect of bed topography on flow structure.

The role of the salt water interface on the rate of erosion or sedimentation in the channel outlet is not fully understood. However, 3-D velocity and suspended sediment distribution along the cross-section suggests complex dynamics resulting in ca 20% sediment exchange along the channel bed in the shore-adjacent zone. This implies downstream transport of sediment in the upper layer, while sea penetration into the channel results in landward transport of sediment and its resuspension.