



Mid- to late-Holocene environmental evolution of the Loire estuary as observed from sedimentary and microfaunal characteristics

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We used sedimentological and foraminiferal characteristics of four sedimentary cores, supported by paleogeographical and historical data, to reconstruct the depositional history of the inner Loire estuary (Near Saint-Nazaire, France) and the response of benthic foraminifera to the mid- to late-Holocene marine flooding of the incised valley. These were further used to evaluate the consequent changes in estuarine morphological and hydro-sedimentary patterns during this time period. Our results described significant changes in hydro-sedimentary dynamics over the past ~ 6 kyrs BP. At our location, these changes expressed the combined influence of marine (e.g., tide, storm waves) and fluvial dynamics (e.g., floods), which are linked, on a broader scale, to sea-level variations and the regional climate regime. Three main periods stand out: (1) from ~ 6.0 to ~ 2.5 kyrs BP, when the sea-level rise slowed down, a large brackish bay extended over and around the study area. The fine-grained tidal rhythmites recorded north of the Bilho bank (the main tidal bar located in our study area) indicated a calm depositional environment, protected from the main riverine influence. The presence of thick flood deposits from ~ 5.4 to ~ 4.0 kyrs BP near the Bilho bank indicates further the dominance of humid conditions. (2) From ~ 2.5 kyrs BP to ~ 1850 CE (pre-industrial state), sea-level stabilized at its present value, and the pre-existing bay was progressively infilled. North of the Bilho bank, near a major mudflat (Méan), the generally homogenous sedimentation composed of silty muds rich in organic matter indicated a sheltered environment; the main water flow channel being located south of the Bilho bank. Within this overall homogenous sedimentation, foraminiferal assemblages described rather accurately the progressive infilling of the valley (indicated by a decrease in the proportions of outer estuarine species), accompanied with the channelization of the main entering marine currents (tide, storm waves) (indicated by an increase in the proportions of transported species from the adjacent upper continental shelf), and finally the buildup of the Méan mudflat and the stabilization of the environment to its present day configuration (indicated by the dominance of autochthonous inner estuarine species). (3) Since 1850 CE, the human impact progressively modified the general landscape of our study area with the construction of the Saint-Nazaire shipyard, the digging of the northern navigation channel and the polderization of the northern Bay. The southern channel was progressively abandoned by the main water flow in favor of the newly dug northern channel, causing the southern migration of the Bilho sandbank and the progressive filling of the southern channel.

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