ID: W1983643333

TITLE: Large-scale dam removal on the Elwha River, Washington, USA: Source-to-sink sediment budget and synthesis

AUTHOR: ['Jonathan A. Warrick', 'Jennifer A. Bountry', 'Amy East', 'Christopher S. Magirl', 'Timothy J. Randle', 'Guy Gelfenbaum', 'Andrew Ritchie', 'George R. Pess', 'Vivian Leung', 'Jeffrey J. Duda']

ABSTRACT:

Understanding landscape responses to sediment supply changes constitutes a fundamental part of many problems in geomorphology, but opportunities to study such processes at field scales are rare. The phased removal of two large dams on the Elwha River, Washington, exposed 21 ± 3 million m3, or ~ 30 million tonnes (t), of sediment that had been deposited in the two former reservoirs, allowing a comprehensive investigation of watershed and coastal responses to a substantial increase in sediment supply. Here we provide a source-to-sink sediment budget of this sediment release during the first two years of the project (September 2011?September 2013) and synthesize the geomorphic changes that occurred to downstream fluvial and coastal landforms. Owing to the phased removal of each dam, the release of sediment to the river was a function of the amount of dam structure removed, the progradation of reservoir delta sediments, exposure of more cohesive lakebed sediment, and the hydrologic conditions of the river. The greatest downstream geomorphic effects were observed after water bodies of both reservoirs were fully drained and fine (silt and clay) and coarse (sand and gravel) sediments were spilling past the former dam sites. After both dams were spilling fine and coarse sediments, river suspended-sediment concentrations were commonly several thousand mg/L with ~ 50% sand during moderate and high river flow. At the same time, a sand and gravel sediment wave dispersed down the river channel, filling channel pools and floodplain channels, aggrading much of the river channel by ~ 1 m, reducing river channel sediment grain sizes by ~ 16-fold, and depositing ~ 2.2 million m3 of sand and gravel on the seafloor offshore of the river mouth. The total sediment budget during the first two years revealed that the vast majority (~ 90%) of the sediment released from the former reservoirs to the river passed through the fluvial system and was discharged to the coastal waters, where slightly less than half of the sediment was deposited in the river-mouth delta. Although most of the measured fluvial and coastal deposition was sand-sized and coarser (> 0.063 mm), significant mud deposition was observed in and around the mainstem river channel and on the seafloor. Woody debris, ranging from millimeter-size particles to old-growth trees and stumps, was also introduced to fluvial and coastal landforms during the dam removals. At the end of our two-year study, Elwha Dam was completely removed, Glines Canyon Dam had been 75% removed (full removal was completed 2014), and ~ 65% of the combined reservoir sediment masses?including ~ 8 Mt of fine-grained and ~ 12 Mt of coarse-grained sediment?remained within the former reservoirs. Reservoir sediment will continue to be released to the Elwha River following our two-year study owing to a ~ 16 m base level drop during the final removal of Glines Canyon Dam and to erosion from floods with larger magnitudes than occurred during our study. Comparisons with a geomorphic synthesis of small dam removals suggest that the rate of sediment erosion as a percent of storage was greater in the Elwha River during the first two years of the project than in the other systems. Comparisons with other Pacific Northwest dam removals suggest that these steep, high-energy rivers have enough stream power to export volumes of sediment deposited over several decades in only months to a few years. These results should assist with predicting and characterizing landscape responses to future dam removals and other perturbations to fluvial and coastal sediment budgets.

SOURCE: Geomorphology

PDF URL: None

CITED BY COUNT: 131

PUBLICATION YEAR: 2015

TYPE: article

CONCEPTS: ['Sedimentary budget', 'Hydrology (agriculture)', 'Sediment', 'Geology', 'Dam removal', 'Fluvial', 'Sink (geography)', 'Sediment transport', 'Progradation', 'Channel (broadcasting)', 'Floodplain', 'Silt', 'Tributary', 'River delta', 'Environmental science', 'Geomorphology', 'Delta', 'Geotechnical engineering', 'Sedimentary depositional environment', 'Cartography', 'Geography', 'Ecology', 'Engineering', 'Structural basin', 'Aerospace engineering', 'Electrical engineering', 'Biology']