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The 2014 water release into the arid Colorado River delta and associated water losses by evaporation

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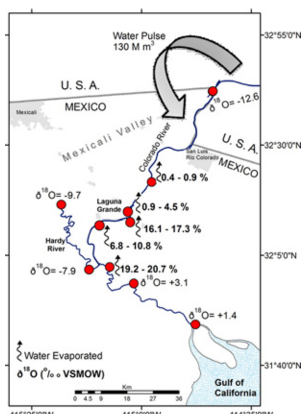
HIGHLIGHTS

- Isotope ratios of oxygen and hydrogen quantify water lost through evaporation.
- Evaporation losses between 16.1 and 17.3% during the 2014 Colorado River
- Larger water volumes are required to influence the estuary ecosystem.

GRAPHICAL ABSTRACT



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ABSTRACT

For the first time in history, water was intentionally released for environmental purposes into the final, otherwise dry, 160-km stretch of the Colorado River basin, south of the Mexican border. Between March and May 2014 three pulses of water with a total volume of 132×10^6 m^3 were released to assess the restoration potential of endemic flora along its course and to reach its estuary. The latter had not received a sustained input of fresh water and nutrients from its main fluvial source for over 50 years because of numerous upstream dam constructions. During this pulse flow large amounts of water were lost and negligible amounts reached the ocean. While some of these water losses can be attributed to plant uptake and infiltration, we were able to quantify evaporation losses between 16.1 to 17.3% of the original water mass % within the first 80 km after the Morels Dam with water stable isotope data. Our results showed no evidence for freshwater reaching the upper Colorado River estuary and it is assumed that the pulse flow had only negligible influences on the coastal ecosystem. Future water releases that aim on ecological restoration need to become more frequent and should have larger volumes if more significant effects are to be established on the area.

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1. Introduction

The Colorado River (CR, Fig. 1), on its final 160-km stretch to the ocean downriver of the Morelos Dam, is a river run dry. For over 50 years, water management strategies for flood regulation, the supply of irrigation and municipal water, and the generation of hydroelectricity have resulted in numerous upstream dam constructions such as the Hoover and Glenn Canyon Dams in the USA. These developments have stopped this once mighty river from flowing into the Gulf of California, except for rare flood events. The latest of these occurred in the year 2000 (IBWC, 2014). While the ecological consequences on land are evident from the desertification of practically all of the original wetlands, the effects on the coastal marine ecosystems are not yet fully understood (Orozco-Durán et al., 2015). High nutrient concentrations still sustain significant primary productivity and fisheries in the upper Gulf of California, despite the lack of continuous input from the CR.

In spring 2014, a programmed pulse flow of 132 × 10^6 m^3 was released through the USA-Mexico international border over an eight-week period. This amount represented less than 1% of the average historical annual flows of the CR before the construction of large dams (Witze, 2014). The aim of this large-scale ecological experiment was to assess the response of the ecosystem to renewed humid conditions, such as the germination of cottonwoods and willow trees. It also intended to trigger the partial restoration of riparian habitats. On 15 May 2014, two weeks before the pulse ended, the river finally reached the ocean via a 5 m wide man-made pilot channel (Nelson et al., 2013; Postel, 2014; Orozco-Durán et al., 2015). This structure was built in 2012 to allow river discharge into the estuary but it also enables entry of marine waters into the lower riverbed during high spring tides (Site C7 or Channel B in Fig. 1).

The pulse flow events were divided into three separate stages of water release at different locations along the riverbed in the Mexicali Valley (Fig. 1):

(a) 102 × 10^6 m^3 starting on 23 March 2014 through the Morelos Dam at the Northern International Border (NIB).
(b) 21 × 10^6 m^3 starting on 21 April 2014 at the Southern International Border (SIB), 37 km downriver of the Morelos Dam.
(c) 9 × 10^6 m^3 starting on 3 May 2014 via the Reforma Channel, 79 km downriver of the Morelos Dam.

2. Methods

2.1. Field sampling

During the pulse water event, samples were collected on four different dates as the water moved along the dry CR riverbed (20 March, 14 April, and 14 and 30 May 2014; Fig. 1 and Appendix 1). Water samples were collected in high-density polyethylene bottles (HDPE) and kept tightly sealed until analysis. Specific conductivity and temperature were analysed on site with an YSI 6600 sensor (YSI Inc., Yellow Springs, OH, USA).

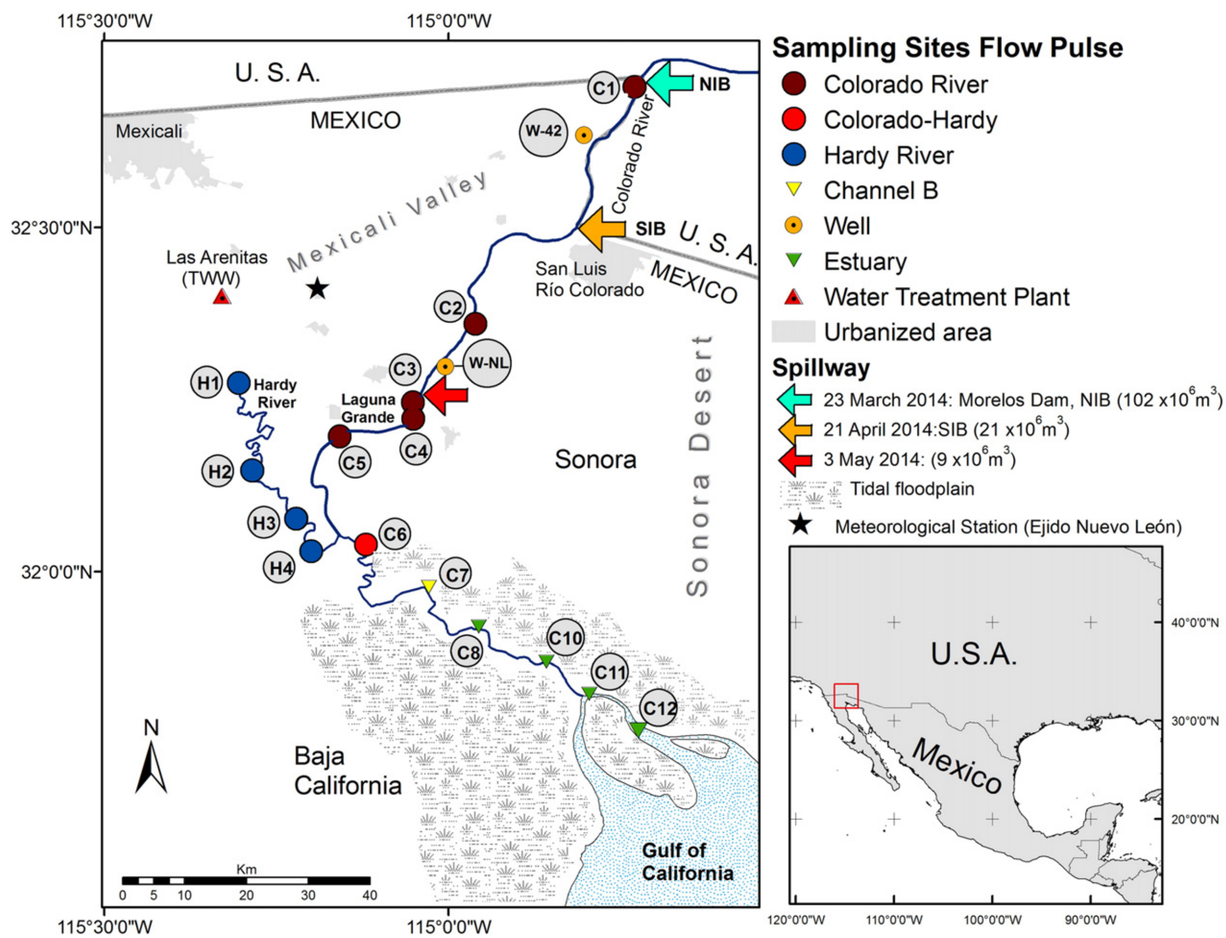

Fig. 1. Pulse flow-sampling sites along the CR and estuary: arrows show the water-release sites. Stable isotope and electrical conductivity data are given in the Appendix 1. NIB—Northern International Border (Morelos Dam); SIB—Southern International Border.