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Hydrologic indicators of hot spots and hot moments of mercury methylation along river corridors

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The biogeochemical cycling of metals and other contaminants river-floodplain corridors is controlled by microbial activity is often affected by dynamic redox conditions. Riverine flooding thus has the potential to affect speciation of redox-sensitive metals such as mercury (Hg). Therefore, flow history over a period of decades potentially holds information on past production of bioavailable Hg. We investigate this process within a Northern California river system that has a legacy of industrial-scale 19th century hydraulic gold mining. In the first known application of this methodology, we combine hydraulic modeling, measurements of Hg species in sediment and biota, and first-order calculations to assess the role of river floodplains in producing monomethylmercury (MMHg), which accumulates in local and migratory biota. We identify areas that represent 'hot spots' (frequently inundated areas of floodplains) and 'hot moments' (floodplain areas inundated for consecutive long periods). We show that the probability of MMHg production in each sector of the river system is dependent on the spatial patterns of overbank flow and drainage, which affect its long-term redox history. MMHg bioaccumulation within the aquatic food web may pose a major risk to humans and waterfowl that eat migratory salmonids, which are being encouraged to come up these rivers to spawn, and there appears to be no end to MMHg production under a regime of increasingly common large floods with extended duration. These findings identify river floodplains as periodic, temporary, yet important, loci of biogeochemical transformation in which contaminants may undergo change during limited periods of the historical hydrologic record. We suggest that inundation is the primary driver of MMHg production in river corridors and that the entire flow history must be analyzed in terms of magnitude and frequency of inundation in order to accurately assess biogeochemical risks, rather than merely highlighting the largest floods.