Technical Comment on Sabo et al. "Designing river flows to improve food security futures in the Lower Mekong Basin"

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Abstract: Sabo et al. (1) use sophisticated analyses of flow and fishery data from the Lower Mekong Basin to design a "good" flow regime and claim that, if implemented by proposed dams, it would improve the fishery yield by a factor of 3.7. However, the flow regime is not implementable in practice, and, if it were, it would devastate the fishery.

In a methodological tour de force, Sabo et al. (1) relate components of the flow regime of the Mekong River, quantified as stage at Stung Treng, to the catch in the important Dai fishery on the Tonle Sap River. They use these empirical relationships to design a "good" flow regime, proposed as an "ecological objective function" for the operation of controversial planned dams on the Mekong River, and project that this flow regime would increase the yield of the Dai fishery by a factor of 3.7. However, simple hydrological considerations show that the "good" regime could not be implemented, and if it were, it would devastate the Dia fishery.

Stung Treng is several hundred kilometers upstream from the Tonle Sap-Mekong confluence. The Tonle Sap connects the Mekong to a large natural lake and adjacent floodplains that support large populations of many fishes (2). Water flows up the Tonle Sap to the Great Lake during high flows in the Mekong, and down the Tonle Sap to the Mekong during low flows. The Great Lake also receives ~40% of its water from tributaries and rainfall (2). Thus, although flow at Stung Treng certainly affects conditions in the Great Lake, the connection is not tight (Figure 1).

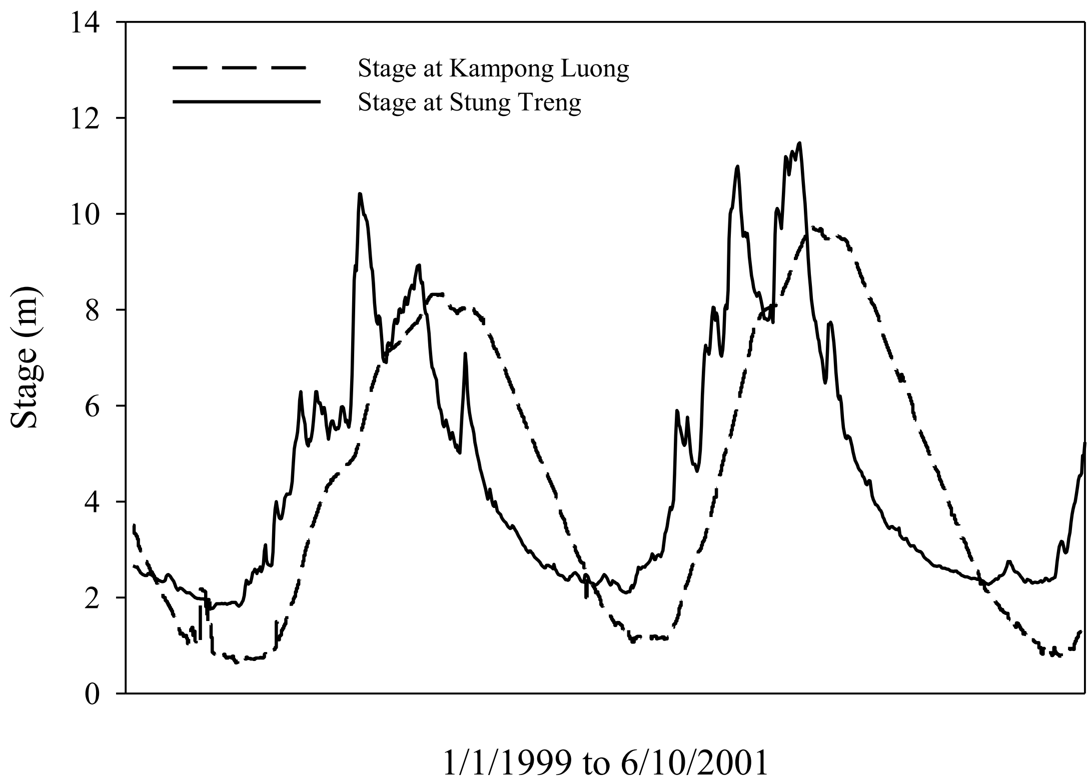

Figure 1. Stage of the Mekong River at Stung Treng (solid line) and the Great Lake at Kampong Luong (dashed line), for two flood cycles. The flood pulse in the Great Lake lags that at Stung Treng, and variation is suppressed. Data from Sameng Preap, Mekong River Commission.

Sabo et al. depict the historical flow regime, plus a “good” and a “bad” regime, as plots of stage over time in their Figure 4. The plot of the “good” regime is a roughly rectangular wave, with a long period of low-flow connected to a shorter period of high flow by brief transitions ~15 days long. The transitions are more gradual in the “bad” regime. Sabo et al. do not clearly specify where their “good” regime should apply, but their research article summary states “… we used estimated hydrologic drivers of the historical bag net, or “Dai,” fishery on the Tonle Sap River—the largest commercial fishery in the Mekong—to design better fisheries futures by comparing designed flows to current and pre-dam (natural-flow) regimes.” This implies that they intend their “good” flow regime for the Tonle Sap River, although they may also intend the regime to apply elsewhere in the Lower Mekong Baisn (LMB) as well.

Consider trying to implement this “good” flow regime in the LMB, using releases from the most downstream planned dam, over 100 km upstream from the Tonle Sap-Mekong confluence at Sambor. During the low flow period, releases would be small, and presumably the floodplain downstream from the dam would be dry; during the high flow period, releases would be large, and the floodplain would be inundated. At the end of the high flow period, releases from the dam would be cut to create the desired decrease in stage. Simple calculations show that even if releases were cut to zero, the Great Lake would not drain in 15 days through the existing Tone Sap channel. The volume of the Great Lake varies annually by over 60 km^3 of water (2). Draining this volume in 15 days would require a constant discharge greater than 40,000 m^3s^{-1}, about 4 times higher than the high flows reported in (2), and about equal to current peak flows in the Mekong. The opposite would have to happen at the end of the dry season.

The situation is not much better in the Mekong downstream from the dam. As soon as releases were cut, water would flow laterally off the floodplain and into the channel, reducing the rate of decrease in stage (and discharge) in the channel farther downstream. The opposite would happen at the end of the low flow season, prolonging the transition from dry to wet conditions. Thus, the rectangular wave would degrade to something more like the "bad" flow regime.

The Dai fishery uses what are essentially anchored trawls, mouths facing upstream, that depend on current to function. The nets target fishes migrating out of the Great Lake to the Mekong River with the falling limb of the hydrograph as the Great Lake drains over 5+ months (2). If somehow the "good" flow regime could be implemented, shortening the falling limb of the hydrograph to ~ 15 days would truncate the period when the nets might be used by a factor of about 11. And, until the channel enlarged in response to the higher flows, the flow would probably be too swift to fish with the fine mesh nets needed to catch the small fish that make up the bulk of the Dai fishery catch (2), even if it were possible to anchor the nets.

Sabo et al. "… hypothesized that high fisheries yields are driven by measurable attributes of hydrologic variability, and that these relationships can be used to design and implement future flow regimes that improve fisheries yield through control of impending hydropower operations" (article summary). Sabo et al. have found statistical associations between several attributes of variability in stage at Stung Treng and the Dai fishery catch, but how many of these are real "hydrologic drivers" of the catch remains an open question. Intuitively, variation in stage in the Great Lake seems more likely to influence the catch in nets targeting fishes migrating out of the lake than variation in stage in the Mekong River hundreds of kilometers upstream.

Despite the sophistication of the methods used to develop empirical relationships, predictions based on them depend on the assumption that all else will remain more or less equal, which clearly will not be true if the proposed dams are built and the hydrograph is radically altered. Complex computer-based analyses can be marvelously powerful tools, but they should be used carefully, and it is always necessary to think clearly about the results.

References:

1. J. L. Sabo *et al*., Designing river flows to improve food security futures in the Lower Mekong Basin. Science 358, eaao1053 (2017). DOI: 10.1126/science.aao1053

2. A. S. Halls et al., "The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia," MRC Technical Paper No. 32 (Mekong River Commission, Phnom Penh, Cambodia, 2013).