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Comment on "Designing river flows to improve food security futures in the Lower Mekong Basin"

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Sabo *et al.* (Research Articles, 8 December 2017, p. 1270) used statistical relationships between flow and catch in a major Lower Mekong Basin fishery to propose a flow regime that they claim would increase catch, if implemented by proposed dams. However, their catch data were not adjusted for known variation in monitoring effort, invalidating their analysis.

The Mekong River supports fisheries that are important to more than a million people (*1*) and these fisheries are threatened by the rapid development of large dams for hydropower (*2*). Sabo *et al.* (*3*) used statistical relations between flow in the Mekong River and catch in an important fishery on the Tonle Sap River, Cambodia, to design a flow regime for the Mekong that could be generated by coordinated flow releases from future and existing dams (*4*). Sabo *et al.* projected that their proposed flow regime would increase yield from the fishery by a factor of 3.7, providing additional justification for large dams on the river. We separately objected to this study on different grounds (*5*, *6*) and later discovered that it used catch data that differ from the data reported by another study of the fishery using the same database (*1*) (Fig. 1). We diagnose the problem below, after describing the context.

The Tonle Sap River connects the Mekong River to the Great Lake, which occupies a geological depression in Cambodia (*1*, *7*). The Southeast Asian monsoon drives strong seasonal variation in flow. Water flows from the Mekong to the Great Lake and surrounding flood plains in the high-flow season and drains back to the Mekong during the low-flow season. Many fishes rear in the Great Lake and adjacent floodplains, and many of these migrate to the Mekong as the lake drains.

The fishery consists of 64 stationary trawls (Dais) in 14 rows of one to seven nets that target these migrating fishes, including 28 "common" species, as detailed in (*1*). Catch varies strongly by lunar phase, month, and location, and is monitored by a complex stratified sampling program that concentrates sampling effort to times and locations where catch is high. Results are stored in an Access database maintained by the Mekong River Commission. The data for 1995–1996 to 2008–2009 show that each Dai made a few to more than 100 hauls per day. When a Dai was monitored, the weight of 1 to 10 hauls was measured if catch was small and estimated if catch was large, and the average of these can be multiplied by the reported number of hauls for the day to estimate total catch for the Dai for that day, which ranged from a few to ~200,000 kg. Species composition and size distributions were also recorded for the haul or a subsample, depending on the size of the haul, so that catch can be estimated from the total weight of the haul or by summing over species. These estimates may differ somewhat because of sampling uncertainty in the estimates of weight by species, or because of different assumptions about the data in different Access database queries (*1*).

Sabo *et al.* (*3*) analyzed total catch per unit effort (CPUE) for the 64 Dais, summed over the rows, giving 14 values for each year. However, their data do not show the strong downstream depletion as fish pass the nets reported by (*1*). To check their data, we first worked with data for row 13, which has only one Dai. We found that we could closely approximate their data simply by summing the estimated catch for the Dai for days when the Dai was sampled (Fig. 2), which varied from 1 to 15. For example, for 1996–1997, catch was estimated for only four hauls on 17 January, with estimated weights of 500, 65, 500, and 400 kg (mean = 366.25 kg). The Dai operator reported 48 hauls on that day, and 366.25 times 48 gives 17,580 kg for the day, which corresponds closely to 17,025 kg mistakenly given for the entire season in table S3 of (*3*). Matches are not exact because our reconstructed data are based on total weight of the sample hauls, whereas the data of (*3*) were compiled from estimates of the catch by species.

More technically, Sabo *et al.* claim to have fitted their model to data they described as "total CPUE." CPUE is commonly used as an index of fish abundance, assuming that catch is proportional to abundance after accounting for fishing effort. However, the index Sabo *et al.* apparently used does not include a term for effort. Rather, it is simply the sum of the estimated daily catch of Dais that were sampled by the monitoring program:

$$Catch_{r,y} = \sum_{m}\sum_{d}\sum_{i}^{n} C_{i,r,d,m,y} \quad (1)$$

where $Catch_{r,y}$ is the catch sampled by the monitoring program from row r during year y, and $C_{i,r,d,m,y}$ is the estimated catch of Dai i, from row r, on day d, during month m and year y. We reconstructed $Catch_{r,y}$ for 1996–1997 to 2007–2008 to confirm that Eq. 1 was indeed the estimator for "total CPUE" used by Sabo *et al.* For the set of 167 data points, 56% of our reconstructed data are within 1% of their table S3 data, 76% are within 2%, and 95% are within 11 to 13% of the table S3 data. Again, we used estimates of total weight, instead of weight per species, which accounts for some of the differences; differences in the queries used and errors in one dataset or the other (such as the problem for Dai 13A for 2006–2007 described in the caption for Fig. 2) probably account for the rest.

If sampling had been consistent, then using only the samples might not matter, because the data were normalized as part of the statistical analysis in (*3*) (J. Sabo, personal communication, 30 July 2018). However, sampling effort varied considerably over the study period; Dais were sampled 174 times in 1996–1997 and 314 to 452 times from 1997–1998 to 2008–2009 [annex table 25 of (*1*)]. Thus, the Sabo *et al.* data reflect sampling effort as well as catch. The net result is the differences in catch shown in Fig. 1, which must affect the relationships between "total CPUE" and flow variables claimed by Sabo *et al.* Consequently, what their results mean, if anything, is unclear, and they should not be relied upon, especially for assessments of the effects of building new dams.

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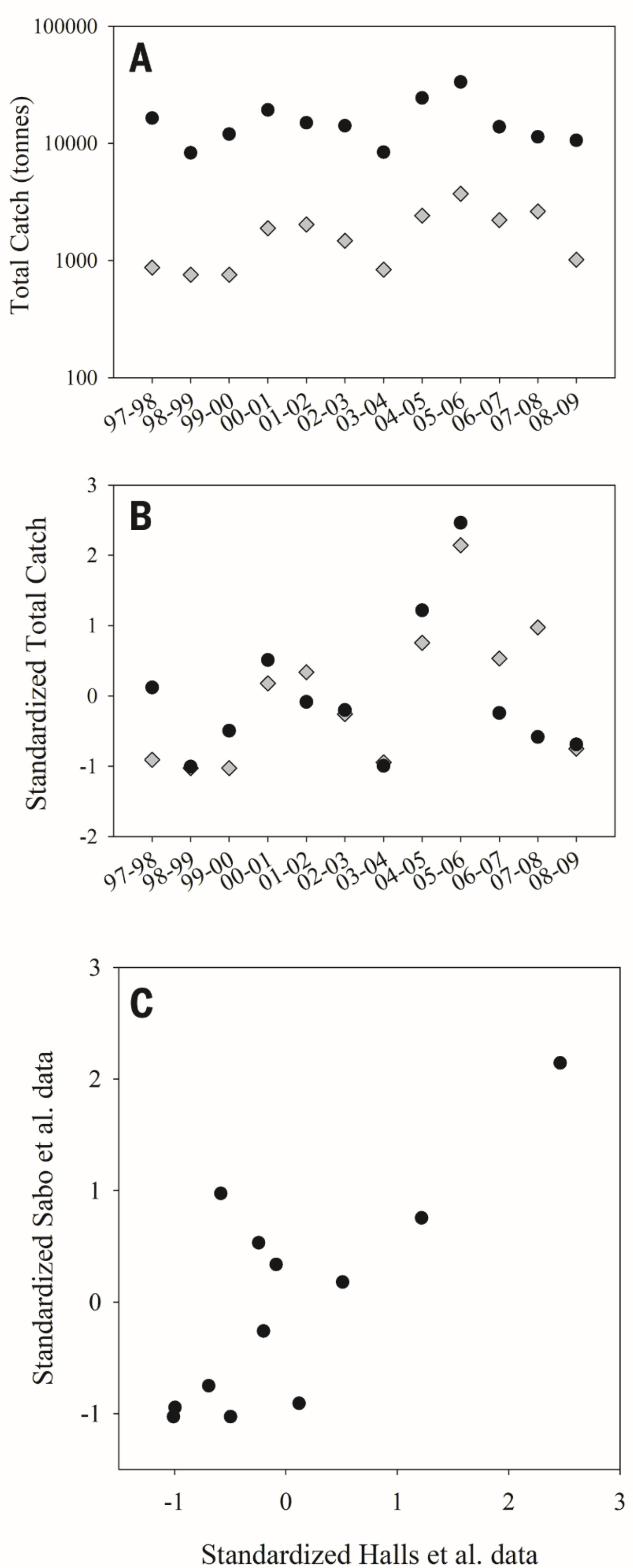

Fig. 1. Comparison of data from Halls *et al.* (2013) and Sabo *et al.* (2017). (A) Total annual catch in tonnes (note log scale) emphasizes the difference in magnitude between the two sets of estimates. (B) Standardized annual catch (units are standard deviations, zero = the mean) emphasizes the difference in temporal patterns. The Pearson correlation between the two datasets is 0.77. In (A) and (B), the Halls *et al*. data are shown as black circles, the Sabo *et al*. data as gray diamonds. (C) Standardized Sabo *et al*. (2017) data plotted over standardized Halls *et al*. (2013) data emphasize the range in the Sabo *et al*. data when values in the Halls *et al*. data were near or below the mean. [Panel A reproduced with permission from John Wiley & Sons]

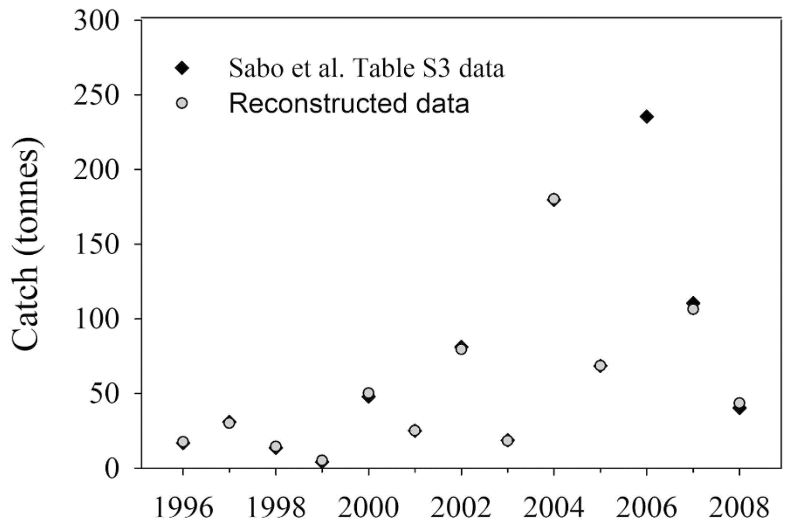

Fig. 2. Total annual catch estimates for row 13 from table S3 of Sabo *et al.* (2017) and reconstructed estimates consisting of the sum of the estimated daily catch for days when samples were taken. Following the convention in (*3*), the seasons are labeled by the year of the first part of the season (e.g., 1996 for 1996–1997). The matches are not exact for reasons explained in the text. No estimate was reconstructed for 2006–2007 because of an obvious error in the monitoring date for a period of large catch (conflicting numbers of hauls for the same day). We also reconstructed the entire dataset with an SQL query of the original Access database, which would not catch such errors.

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