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Fish dieoff at Brazil's Sinop Dam: Reply to A.A. Agostinho

Philip M. Fearnside[1]

[1.] National Institute for Research in Amazonia (INPA), Manaus, Amazonas, Brazil.

My text "Brazil's Sinop Dam flouts environmental legislation," published by *Mongabay* (Fearnside, 2019a) and also available on the ResearchGate website, attracted an attack by Angelo Antonio Agostinho, who posted a text on ResearchGate entitled "Comment: About the Mr Fearnside commentary in Mongabay (death of fish in dams)" (Agostinho, 2019a). The Portuguese-language version of my article (Fearnside, 2019b) attracted a briefer attack from Agostinho (2019b), to which I also replied (Fearnside, 2019c). Agostinho's ResearchGate comment presents a series of arguments (and insinuations) that he believes invalidate my article. As explained below, my conclusions are based on oxygen measurements in the water leaving the reservoir, and, unless these measurements are erroneous, my conclusions stand.

The law requiring clearing of forest in reservoirs is as stated in my article, including the loophole for leaving trees in a reservoir when needed for the "protection" of fish. The law does not establish criteria defining what is needed for fish or how this is determined, thus allowing, in practice, the determination to be made based on an "expert opinion" (EO) ("*parecer*" in Portuguese), such as the one Angelo Antônio Agostinho coauthored as a consultant for the dam project.

Agostinho's comment states that he suggested that the criterion for leaving dead trees in a reservoir for the benefit of fish should be a simulation model of water quality indicating that oxygen levels would be at least 4 mg/liter, and implies that as much forest as possible should be left standing within the bounds set by the oxygen-level requirement. This does not appear in either the consultant reports on fish or on the water-quality modeling (CES, 2016), but it does help clear up the mystery of the 4 mg/liter oxygen value being used for the decision on "vegetation suppression," since no known laws or other regulations allow a decision on leaving forest uncleared to be justified on the basis of a water-quality model, fish being the only acceptable justification. As noted in my article, the underlying assumption of the model is that the more forest is left standing in the reservoir the lower the oxygen level in the water will be. This makes Agostinho's argument that there is no connection between the two strange. The leaves and other soft biomass are the source of the connection since the wood decomposes very slowly (as Agostinho correctly points out).

Agostinho takes great exception to my "absurd" mention of Brazil's Balbina Dam, which he considers inherently irrelevant to Sinop. Balbina is widely viewed as one of the world's worst environmental disasters from a hydroelectric dam, and Brazil's hydropower industry and government authorities routinely dismiss it because the dam was built during the country's military dictatorship and before the current environmental licensing system was implanted. However, many aspects of Balbina are highly relevant to current dam projects, including the effect of leaving dead trees in a reservoir. What is probably the world's largest "graveyard" of dead trees did not prevent the fish stocks from crashing.

Agostinho cites studies showing that some Amazonian fish species have physiological and behavioral adaptations allowing them to survive in water with low oxygen levels. Unfortunately, Amazonian fish die *en masse* when oxygen is almost zero, as in the measurements that were taken in the water leaving the reservoir at the time of the fish dieoff. Mass fish mortality, such as that accompanying the 2005 drought (Figure 1), is testimony to the fact that Amazonian fish are not immune to anoxia.

Figure 1 -- Fish mortality accompanying the 2005 drought (Photo: Greenpeace).

The critical question is the validity of the oxygen measurements in the water leaving the reservoir, shown in the photographs of the screen of the measuring devise included in my article. The measurements were made just below the spillway on 6 February 2019 by Politec (Official Expertise and Technical Identification [*Perícia Oficial e Identificação Técnica*]), an official government agency charged with this kind of assessment. The fish mortality began on 4 February; according to local reports collected at the site by Nelson Faustinho on 7 February, the hydropower company closed the spillway completely, leading the flow to fall to a very low level below the dam and precipitating the beginning the dieoff; the dam then opened the spillway and the mortality worsened (N. Flaustino, personal communication). Note that very low flow levels can lead to anoxia, as in the case of rivers impacted by the 2005 drought (Figure 1). Agostinho points to measurements that a consulting firm hired by the hydropower company made at other locations indicating higher oxygen levels. Agostinho implies that the Politec measurements that I referred to might be invalidated if there were additional information on the time of day and the depths at which the measurements were made. Unfortunately, even if made at midnight at the bottom of the river (where oxygen would be lowest), the measurements would in no way be invalidated. It is a basic principle of science that whenever a theory does not agree with actual observations, it is the theory that is wrong. In this case it is the model submitted by the hydropower company on which the Mato Grosso State Secretariat of Environment (SEMA) based its license for the Sinop Dam that is wrong.

A second fish dieoff that occurred in June 2019 (Figure 2), this time in the main reservoir, reinforces the lack of reality of the model used in the licensing, which claimed that the reservoir would not stratify. The most likely cause of the present mortality is that anoxic water from the bottom of the reservoir reached the surface in an overturning event, such as those that can occur during a cold snap.

Figure 2 -- Fish mortality in the main body of the Sinop reservoir in June 2019 (SBT programa comunidade [television program]).

The hypothesis that the February 2019 fish dieoff was caused by lacerations, excoriations and other physical injuries to the fish seems unlikely for the large number of dead fish that appeared below the dam (Figure 3). The examples cited by Agostinho of physical injuries at other dams involve fish being cut while passing through the turbines, but in the Sinop case the turbines had not yet been turned on. Very obvious external wounds are not apparent on the dead fish (Figure 4).

Figure 3 – Burial of dead fish with quicklime during the February 2019 fish dieoff below the Sinop Dam.

Figure 4 – Dead fish in the February 2019 fish dieoff below the Sinop Dam

The fact that the Sinop power company is attempting to escape from fines totaling R$50 million (~US$13 million) (Curvo, 2019) points to a strong motive to search for explanations of the mortality other than the impact of the dam. The company commissioned autopsies on some of the dead fish. It would have been better if these had been done by agencies that are more removed from those with a financial interest in the conclusions. SEMA, which licensed the dam and is a defendant in the ongoing court case, also has a strong motive to find alternative explanations for the dieoff.

Agostinho implies that the conclusions of consulting firms are trustworthy because the firms are concerned about their reputations. This line of argument is remarkable since, from the viewpoint of a consulting firm, the reputation that is most relevant is the perception by potential contractors (such as a hydropower companies) that the consultant reports will bolster the companies' financial interests. If a consulting firm is known for pointing out disastrous consequences of the activities of the companies that hire it, that firm will be unlikely to attract future contracts.

Agostinho's implication that the conclusions of consultant reports are independent of what their patrons want to hear is, to say the least, unconvincing. The pattern is the opposite not only in Brazil but throughout the world. A relevant and well-documented case in point is the Nam Theun 2 (NT2) Dam in Laos (Shoemaker & Robichaud, 2018). Among the ironies of this case is the dam project being allowed to leave the forest standing in the reservoir on the basis of misleading claims by the same French hydropower company (Electricité de France, or EDF) that owns a controlling interest in the Sinop Dam (Fearnside, 2019d). The dams in the Mekong River basin in Southeast Asia, including Nam Theun 2, are notorious for their rapid destruction of the world's richest riverine fishery, along with the human societies that depend on this resource.

Agostinho objects to mention of the Brumadinho mine-tailings dam disaster. However, this case is relevant both as an example of the weakness of state-level environmental licensing and because it brought attention to the largely invisible role of consultants when those who had produced expert opinions attesting to the dam's safety were jailed.

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