

Interactive comment on “Commercial traceability of *Arapaima* spp. fisheries in the Amazon Basin: can biogeochemical tags be useful?” by L. A. Pereira et al.

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Anonymous Referee #2 Comments (1) comments from Referees, I have reviewed this ms and find it to deserve publication after a few revisions are made. The ms tests the general idea that biochemical tags can be used to identify the origin of harvested individuals of arapaima in various regions of the Amazon, and this can be used to improve the management of this economically important but overexploited fish. While the authors have done an apparent good job in analyzing data, I feel like the true contribution of this ms is not reflected in the text.

The introduction generally sets out the research question clearly, but there are impor-

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tant issues that were not considered and would help sharpen it and increase the value of this research. For instance, about 3/4 of the introduction is devoted to describe the use of biochemical tags to trace the origin of fish worldwide, and the Amazon is introduced only after that. When the subject of the Amazon is introduced, a key idea that is missing here is spatial heterogeneity in the chemistry of river waters. That heterogeneity is what allows the authors to test the main hypothesis yet it is not described here, not even briefly. The hypothesis only makes sense IF there is spatial heterogeneity in chemistry, so this needs to be established in the introduction (and could be expanded in methods).

(2) author's response, (3) author's changes in manuscript. We thank the referee for this important comment. We have included a better description of the existing contrasts in Sr isotopic composition among the different sub-basins of the Amazon, to provide a clear background for the reader (page 2 lines 27-29)

(1) comments from Referees, Also, the study focuses on arapaima and its conservation. But while a lot of space in the introduction is devoted to reviewing the use of chemical markers for sustainable fisheries management in general terms (paragraphs 1-3), there is almost no mention of details about the conservation measures that currently are bringing arapaima back from overexploitation. Given the paper focuses on arapaima, that seems to need attention. In particular, some 500 fishing communities in the State of Amazonas in Brazil (alone, and more now in Pará State) are setting fishing quotas and selling their “sustainable” fish to the market while fulfilling strict government limits. Each individual fish harvested under this management system receives a unique, government-issued, identifying a tag that buyers can use to know where the fish came from, where and when it was harvested. But many such tags are illegally re-used to allow the “legal” sale of unsustainably harvested fish. This presents a major management problem for arapaima that the study in question can help solve because its results can potentially be used to ‘trace’ back the origin of the fish and hence determine if the origin of the fish matches the tag. This study should link its results to such

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major ongoing management initiative for arapaima.

(2) author's response, (3) author's changes in manuscript. We thank the referee for this important comment and for the details. We have addressed this issue in the introduction section of the revised manuscript as it constitutes an important justification of the study (page 3 lines 8-16). Since 1989 Arapaima stocks are recovering, indicating that the adaptive management of Arapaima fisheries has been a success and may hopefully become a positive example of synergetic social and political actions in the region. However, as stated by the referee the situation is not completely controlled and we hope the development of such tools of commercial traceability would help to improve further the situation.

(1) comments from Referees, Finally, the hypothesis of the study only makes sense IF arapaima is not highly migratory and move between and among river systems with different water chemistries. As such, known data on the general migratory behavior of arapaima should be determined 'before' the hypothesis for the hypothesis to make sense. When this is done, typical habitat and food sources (some of which are presented in methods), should also be presented here, to provide context for the hypothesis. To implement such changes, I suggest shortening the first 3 paragraphs and expanding the remainder of the introduction. (2) author's response, (3) author's changes in manuscript. We agree with the reviewer comments and suggestion about the introduction. We have revised it and included a description of arapaima habitat and trophic relations page 3 lines 17-27).

(1) comments from Referees, Fig 1 needs to be edited so the font is readable at half-page width size; currently, the most important information cannot be read for having font too small. A lot of space on the sides is used to show regions of no interest. The fig could be "zoomed in" to the area of interest. As for the analysis, there is a major mismatch in geographical precision of the otolith data. The fish otoliths were collected from fishermen residing in sites (Table 1). Each of the 'sites' mentioned, such as Itacoatiara, Manaus, or Mamirauá reserves are, in fact, enormous regions,

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each of which encompasses several different habitats, each of which can have varied water chemistries. For instance, the Mamirauá Reserve is flooded by some five or more major river tributaries and includes surrounding areas influenced by blackwater ria lakes. This variability in regional water chemistry is not matched by the literature data used for each "site" It also constitutes a limitation of the analytical approach undertaken. More detail on fish capture location will be introduced Could this lack of specificity in the otolith origin data help explain part of the unexplained variance in the analyses? I would seem so. As such, the "match" between the otolith and water chemistry data should be presented and discussed in methods, as well as in the discussion. It does not invalidate the analysis but it adds more nuance and probably helps explain its results.

(2) author's response, (3) author's changes in manuscript. We have improved Fig. 1 by zooming and increasing the fonts. We have also emphasized the lack of precise information about fish capture location, which is part of the fragility of the actual system of traceability (page 5, lines 1-7). We agree that this issue, which may be related to the unexplained variance of the analysis, and have added another row in Table. 1 about the specimen origin. This topic was further addressed in the discussion sections.

(1) comments from Referees, Discussion: Line 10: are there movement studies showing arapaima do not migrate long distances? If so, this is the place to cite them (again, after introducing them in the intro)

(2) author's response, (3) author's changes in manuscript. We have cited previous studies about arapaima migration (page 14, lines 9-10).

(1) comments from Referees, Lines 12-14: this is where a well-developed discussion of the potential for lack of geographical specificity in the otolith data to influence the results could go.

(2) author's response, (3) author's changes in manuscript. We have stated that the lack of precise information of fish origin have limited the approach and are one of the main

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causes of incongruity in the analysis (page 15, lines 14; page 18 line 20-22)

(1) comments from Referees, In general, the text of the discussion is sound. But I find it to be too long and unclear at times, so I suggest condensing it and revising it for clarity. What is really missing is linking the results to their application, following the idea suggested above.

(2) author's response, (3) author's changes in manuscript. We have revised the text in order to make it clearer.

(1) comments from Referees, *Spp* is not italicized Line 25: use 'developed' instead of 'satisfying'

(2) author's response, (3) author's changes in manuscript. We have made the changes suggested by the reviewer. The authors strongly valued all the suggestions made that are important contributions to improve the quality of the work.

Interactive comment on Biogeosciences Discuss., <https://doi.org/10.5194/bg-2018-471>, 2018.