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The best catch data that can possibly be? Rejoinder to Ye et al. "FAO's statistic data and sustainability of fisheries and aquaculture"

Daniel Pauly*, Dirk Zeller

Sea Around Us, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver V6T1Z4, Canada

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ABSTRACT

Here we reply to a commentary by Ye et al. (Mar. Policy 2017; Ye et al.) on our article (Pauly and Zeller, 2017 [2]) commenting on FAO's interpretation of current fisheries trends in SOFIA 2016 (The State of World Fisheries and Aquaculture). We show how arguments such as FAO's catch statistics being "the best they can possibly be", and other manifestations of FAO's difficulties in constructively engaging with comments compromises FAO's stated goal to engage with academia and civil society. This is particularly serious in an age where the value of an open scientific discourse is increasingly under threat, as is the food security of many poor countries in which fish supplied by domestic fisheries constitutes a strong component of local diets.

1. Introduction

We agree with many points in the response of Ye, Barange [1] to our recent comments [2] on FAO's 2016 edition of SOFIA [3]. Firstly, we would like to unambiguously re-emphasize here our long-standing position that FAO does an exemplary job of the difficult task of annually assembling, harmonizing and archiving global reported landings statistics provided to FAO by member countries and other sources, especially given the mandate constraints under which FAO operates, and given the often poor responses FAO receives from member countries on their annual data requests [4]. Secondly, as we also point out in Pauly and Zeller [5], FAO ought to be provided with more resources to "…*more intensively assist member countries in submitting better and more comprehensive fishery statistics*…".

2. Comments

Particularly, we agree with Ye, Barange [1] that whatever corrections third parties (e.g., university-based research groups such as the *Sea Around Us*) may suggest for the global fisheries catch data curated by the FAO, these corrections need to, ultimately, come from member countries that submit annually revised catch time series. This is contrary to the assertion by Ye, Barange [1] that we "… *criticized FAO for not using* [our] *catch reconstruction*…". We never once argued that FAO should use our data (we have been fully aware for a very long time that FAO is not permitted to do so under their data mandate), but rather suggested in Pauly and Zeller [2] that FAO could have used SOFIA 2016 to simply acknowledge the existence of the catch reconstructions covering all countries in the world. Given the wide-spread popularity of SOFIA 2016, as indicated by Ye, Barange [1], this simple step would have contributed directly to FAO's stated goal "…*that FAO recognizes the potential value of catch reconstructions. Such exercises may … help identify fisheries' sub-sectors that are not well covered in national data collection systems (e.g. recreational catches), and help countries revise their submissions*". Furthermore, FAO could use the information and knowledge derived from the individual country catch reconstructions to encourage and work with countries to (a) improve their historic catch data back to 1950 (retroactive time-series corrections, which is at the core of catch reconstructions) that are required to eliminate the occurrence of what we may call 'presentist bias'[1] in official reported landings datasets [2, Mozambique is a prime but not unique example of this 7], as well as (b) improve data collection systems going forward (which is at the core of the highly welcome and extremely beneficial ongoing FAO engagements with countries for statistical data system improvements). Note that both are required to improve global data sets to allow reliable and comprehensive global fisheries trend analyses such as emphasized in FAO's SOFIA. As we have said repeatedly, the *Sea Around Us* welcomes any engagement with countries that wish to

* Corresponding author.
E-mail address: d.pauly@oceans.ubc.ca (D. Pauly).

[1] We coin the term 'presentist bias' (over-emphasizing '*the present*' vis-à-vis '*the past*') to describe the bias introduced by generally improving quality of data collection systems over time (i.e., in more recent years compared to earlier decades), by accounting for an increasing share of actual catches without making retroactive corrections and adjustments to the under- or non-reporting of such catches in earlier years, leading to inconsistent historic baselines and the illusion of increasing catches ([5] Pauly D, Zeller D. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nature Communications. 2016;7:10244 [6], Zeller D, Harper S, Zylich K, Pauly D. Synthesis of under-reported small-scale fisheries catch in Pacific-island waters. Coral Reefs. 2015;34:25-39.)

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consider or review reconstructions in the context of their national data improvements.

Furthermore, while Ye, Barange [1] suggest that the catch reconstruction methodology has attracted criticism [8,9], they fail to acknowledge that these criticisms have been debunked [10,11]. Note that we do not argue that the data emanating from reconstructions are error free or may not contain mistakes (see below), rather the specific criticisms that have, so far, been levied in the scientific literature at some of the basic principles and details of the methodology and approach have been shown to be incorrect.

We fully recognize, as does FAO, the value of countries revising their catch estimates based on comments and studies by third parties, as, e.g., China did in the years following comments on the over-reporting of their domestic marine catches [[12], i.e., a study commissioned and funded by FAO] and as Myanmar seems in the process of doing, perhaps partly based on the comments in Booth and Pauly [13]. Thus, we are pleased that "*FAO recognizes the potential value of [such] reconstruction*". In fact, when we wrote that FAO pretends "*that catch reconstructions don't exist*", it was mainly because the absence of any brief statement of the former sort in SOFIA surprised us.

All this is to say that, in principle, it should be easy for academics and other scientists to help FAO in its crucial mission to provide the world with solid information on the state and trend of fisheries and aquaculture. However, unfortunately it is not, as illustrated by the fact that after assuring us that FAO "*will continue to work closely with member states, IGOs, NGOs, academia and civil society*", they also assert that their "*datasets are the best they can possibly be*" [1].

We obviously cannot speak for member states, IGOs and other partners of FAO, but we are academic scientists, and as such we reject such absolutist statements from authority. Rather, because we know from direct experience how many countries assemble the fisheries catch data they forward to FAO, we know that these data are generally uncertain estimates of often poorly known or even unknown quantities [see [14] for a satirical account on data reporting to FAO by someone who knew the process in great detail from extensive first hand experience]. That the 'official' data should therefore have error bars (i.e., are uncertain) is obvious, but this is never mentioned or acknowledged by governments, nor implemented by country-level agencies or by FAO. On the other hand, much is made by Ye, Barange [1] of the error bars around reconstructed catches, about which more below.

In fact, country catch reports, besides being catch *estimates*, can be viewed as hypotheses about the fisheries from which they emanated. Therefore, like all scientific hypotheses, they: 1) must be refutable in principle (hence no appeal to the authority, e.g., government sources, can make them immune to refutation); and 2) can never be verified (from *veritas* = "truth"), but can only be corroborated, i.e., they are accepted, but can still be falsified later [see e.g., [15]]. And this is, in fact, what happens in reality. Thus, Ye, Barange [1], who informed us that the FAO datasets "*are the best they can possibly be*" also informed us that their data will soon be corrected for the fact that the "*catch*" data from Myanmar, which increased even in the year that cyclone Nargis destroyed the bulk of its fishing fleet [13], were not catch data at all, but the goals of annual or other plans. We suggest, as well, that the FAO data be corrected (via working with national or other relevant authorities), e.g., for the catch from the Gaza Strip being reported as catch from Israel in the years that Israel occupied Gaza [16,17], and for the changed catch baseline of the island of Cyprus, which after the Turkish invasion of 1974 became split with nearly half the country's fisheries data no longer reported [18]. Further corrections could be undertaken, e.g., with the countries of Mozambique for years prior to 2000 [7,19,20], and Tanzania about data for Zanzibar missing for years prior to 2000 [7,21,22]. The list of such data improvements is as along as the list of countries in the world…. Hence the utility of the national catch reconstructions for providing insights and impetus for improvements.

We could here cite dozens of other instances where the FAO datasets

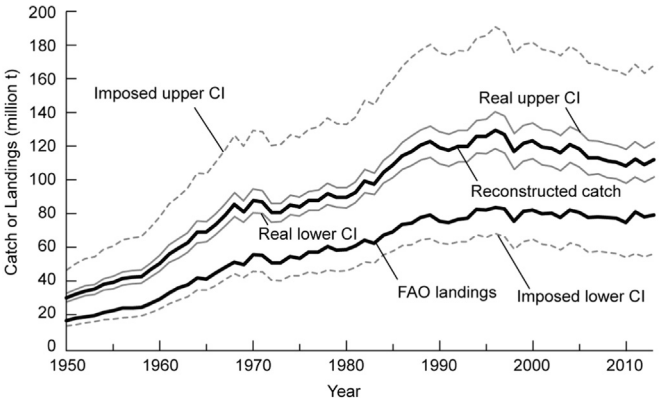

Fig. 1. Global marine fisheries catch as reported by the FAO based on the submission of its member countries (without confidence intervals and excluding plants, corals, sponges, reptiles and marine mammals), and as based on the sum of the national catch reconstructions performed or inspired by the *Sea Around Us* [5]. The confidence intervals for the latter time series (updated to cover 1950–2013), as estimated by combining for each year, using the Monte Carlo method, the uncertainty associated with each sector in each national reconstruction into an overall 95% confidence interval [grey 'Real CI'; see also Figure 14.1 in [25]]. The dashed lines ('Imposed CI'), finally, show the meaningless intervals that are obtained when applying the average relative uncertainty of the national reconstructions to the global catch. That procedure was imposed on us by an anonymous reviewer and an editor of *Nature Communications* (see text), and we regret having acceded to their demands, which ignores a key tenet of parametric statistics, i.e., the Central Limit Theorem.

are not the best that they could possibly be, but this would be counterproductive, especially because the *Sea Around Us* data set also includes errors, which are unavoidable (whenever pointed out to us, we strive to correct these as rapidly as possible based on best available supporting data).

Instead, the point here is that cooperation with academia implies admitting that errors can occur everywhere, and that working only with or through "member countries" does not preclude errors creeping into a database. Moreover, the *Sea Around Us* explicitly relies on FAO data as the starting point for reconstructions. Thus, it does benefit from all the validation procedures that Ye, Barange [1] describe, and we appreciate their dedication and effort. All the *Sea Around Us* really does is add data for "*fisheries subsectors that are not well covered in national collection systems (e.g., recreational catches)*" which should and can help countries revise their data submissions. We welcome such collaboration opportunities. As a matter of fact, such catch reconstruction-driven corrections and updates are already underway, e.g., in The Bahamas and in parts of West Africa, with the full knowledge of, and hopefully country-level support of FAO. So, why object to the conclusions and suggestions our work and the associated data generate? Why can't we get along? After all, both parties want the same thing: to ensure the world has access to better and better global datasets for each country.

3. Four technical points

We conclude our response to Ye, Barange [1] by addressing 4 technical questions which will hopefully resolve some residual misunderstandings:

1. The catch reconstructions performed over the last 15 years by *Sea Around Us* staff or by our collaborators throughout the world were as independent of each other as we could possibly make them. Thus, except for the fact that each reconstruction had to cover the same time period (1950–2010, updated since), the same sectors (Industrial, Artisanal, Subsistence and Recreational), and include discards whenever they occurred, each set of authors was encouraged to use local/national data and information, notably to infer ratios used to compare various estimates (e.g., retained vs. discarded catch; or reported versus unreported artisanal catches).

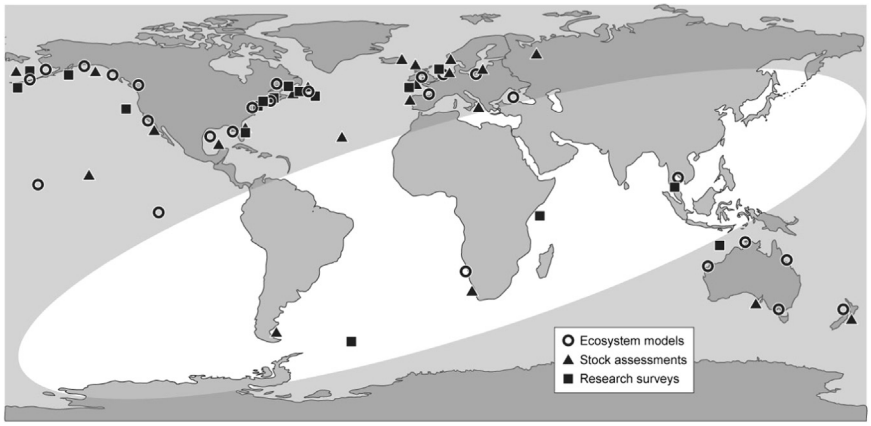

Fig. 2. A modified version of Fig. 1B in Worm, Hilborn [31] showing that 59 case studies from developed countries in North America, Europe and Oceania, against 7 from Asia, Africa and South America (i.e., continents with immense fisheries) were used to infer that fisheries stocks "globally" were in relatively good shape. A subsequent study [36], in which Asia, Africa and South America were far more adequately represented, correctly reported a globally declining trend of exploited biomass, which, if not reversed, will lead to the collapse also projected by Worm, Barbier [30]. This demonstrates clearly that global studies on the status of fisheries must be based on proper representation of the world fisheries, and not be based on an arbitrary, and likely biased set of cases studies from richer and likely well managed countries.

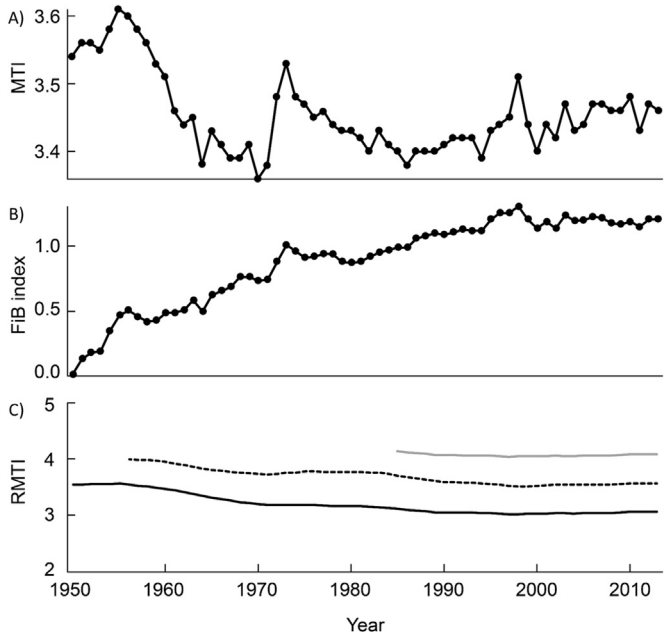

Fig. 3. Showing that "fishing down marine food webs" occurs on a global basis, in combination with a globally declining catch, which is contrary to the optimistic expectations as suggested in Ye, Barange [1]. A: Marine Trophic Index (MTI) of global fisheries, i.e., unmodified, catch weighted mean trophic level trend of the world marine catch; B: Trend of the FiB index, suggesting [as shown in [37]] a spatial expansion of operations of the world's fishing fleets [38]; C: Application to the data in A of the routine of Kleisner, Mansour [39], enabling the separation of fishing down occurring inshore (lower trend line) from its occurrence further offshore (upper trend lines).

Additionally, to prevent any "top down" advice (even subconsciously) biasing country-level results, we did not combine the reconstructed country-level catches to examine global-level catch trends before all national catch reconstructions were completed. Thus, any regularity between the global reconstructed catch and the global (FAO) reported landings is an *emergent* property, not evidence of "guiding" parameters. Figure 3 in Ye, barange [1] is therefore irrelevant to any argument that may be made about individual reconstructions: some differed widely over time from official data [e.g., Mozambique, [7,20,23]], while some were very close, for example, the Japanese Main Islands [24]].

Overall, once combined, the reconstructions generate what appears to be regular ratios between unreported and reported catches. This is similar to any independent measure of related quantities in nature, which usually approximate known distributions (Gaussian, as required by the Central Limit Theorem, or exceptionally log-normal, Zipf, etc.), without such distributions having been used to generate the underlying dataset.

2. This brings us to the wide "confidence intervals" in Figure 1 of Ye, Barange [1], redrawn from Figure 1 in Pauly and Zeller [5]. These "confidence intervals" are not the rigorous confidence intervals we originally submitted to *Nature Communications*. The confidence intervals in our original submission were estimated by a rigorous application of the Monte Carlo method and were much narrower [see 'Real CI' in present Figure 1, and also Figure 14.1 in 25].

   The reason for this is that if you add, for every year, over 200 estimates of independently derived confidence scores, the confidence interval of the sum will be much narrower than the confidence intervals of the independent estimates, for the simple reason that it is improbable that they were all under- or over-estimated [i.e., the Central Limit Theorem comes into play, [26–28]].

   Our original submission had a reviewer who, for reasons unknown to us, did not agree with the Central Limit Theorem, and an editor at *Nature Communications* who agreed with the reviewer. They insisted we use, instead of what we believed was the correct statistical procedure, the mean (relative) upper and lower confidence bounds of the individual reconstructions, which indeed are huge (see 'Imposed CI' in Fig. 1), and included the sum of the landings reported to FAO, thus unfortunately leading Ye, Barange [1] to the mistaken conclusion that our estimates were so uncertain as to invalidate any inference.

   Even worse, we went along with the reviewer's erroneous request, eager to see our paper published, and anticipated that the readers would ignore these absurd confidence intervals. Most readers appear to have done that, but some have not, which helped them ignore our conclusions. We now realize that we should not have accepted what amounts to the probably unethical and statistically erroneous imposition of a misleading graph component as the price for being published in *Nature Communications*. The upshot is that the current Figure 1 [and Figure 14.1 in [25]] more appropriately (and statistically correct) presents the range of uncertainty around the global summary estimate of reconstructed data ('Real CI', Fig. 1).
3. Our third technical point deals with the issue raised by Ye, Barange [1] that "*overfishing of top predators could reduce natural predation, increase fishable biomass of prey species at lower trophic levels, and subsequent total landings. This has indeed been demonstrated by Szuwalski, Burgess [29], consistent with the fishing down the food web theory* [.....]. *Based on FAO's analysis of assessed commercial stocks,*

the share of fish stocks within biological sustainable levels decreased from 90% in 1974 to 68.6% in 2013".

Perhaps we should not worry about the decline of the share of sustainably exploited stocks suggested by the numbers above, since, assuming linearity and all else being equal, sustainably fished stocks will cease to exist in 125 years, much later than the 2048 date suggested in a much and unjustifiably vilified paper [30]. Indeed, Worm, Barbier [30] which pointed at worrisome trends, was not at all refuted by a subsequent analysis [31] as suggested by Ye, Barange [1], as Worm, Hilborn [31] omitted the bulk of the world's fisheries (see Fig. 2), and hence should not have included the word "global" in its title or interpretation.[2]

As for fishing down leading to increased catches, we should not count on this as a generally useable principle for fisheries policy or management going forward, because the world catch is decreasing (Fig. 1), while the mean trophic level of catches is also on a long-term decreasing trend (Fig. 3).

With regards to the apparent increase in total landings reported from China, readers should also be informed of (a) the potential confounding of locally caught (i.e., within the FAO statistical areas that encompass Chinese waters) versus distant-water fleet catches that might be spatially misreported [32,33]; and (b) the nature of the local landings increasingly consisting of a jellyfish/zooplankton/small fish sludge [see photo in [34], and Figure 1 in [35]], which Ye, Barange [1] do not mention. Such catches are fit only as feed to farmed fish, not as food for humans. This brings us to our last technical point.

4. Inserting a step (i.e., farmed fish fed by wild caught fish/fishmeal) between fisheries catch and human consumption largely negates the gains from increasing catches, a point completely overlooked in the reference that Ye, Barange [1] cite. Thus, we maintain our concern that aquaculture is not the panacea that many think or hope it is, at least as far as the faming of carnivorous fish is concerned. Finally, while FAO's SOFIA indeed presents fishmeal data separately from catches for direct human consumption in Table 1 of FAO [3], its high level summary Figure 1 in SOFIA [3] (which is what attracted global media attention) does not seem to exclude fish catches destined for fishmeal when combining wild capture fisheries catches with aquaculture production.

4. Conclusion

Overall, we regret that Ye, Barange [1] did not really engage constructively with the main points in Pauly and Zeller [2], and rather chose to suggest that we engaged in "*mixing up statistical metrics and using simple normative explanations to interpret complex data sets*", which is a complicated way of saying "trust us, because we know", which in science (as in politics) is a questionable position to take. We repeat here our long-standing offer to collaborate with FAO and any country that wishes to use data or information gained through catch reconstructions in order to improve their national (and ultimately FAO) datasets.

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[2] One of us (DZ) was a co-author of the paper in question, but his objections to the claim that the analysis was "global" in scope was overruled.

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