



# The ‘presentist bias’ in time-series data: Implications for fisheries science and policy



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## A B S T R A C T

The bias in catch time series data that occurs when improvements in fisheries catch reporting systems (e.g., consideration of a previously unmonitored fishery, or region) lead to an increase in current catches without the corresponding past catches being corrected retroactively, here called ‘presentist bias’ is described, and two examples, pertaining to Mozambique and Tanzania are given. This bias has the effect of generating catch time series at the aggregate that appear ‘stable’ or increasing when in fact catches are declining over time, with potentially serious consequences for the assessment of the status of national fisheries, or in interpreting the global landings data disseminated by the FAO. The presentist bias can be compensated for by retroactive national data corrections as done, e.g., through catch reconstructions.

## 1. Introduction

Like many other scientific, economic and policy endeavours, fisheries science uses time-series data as part of investigations and analyses, and derives both scientific conclusions and policy recommendations from such data. What if the gradual improvements of the data collection systems underlying these data, covering more fisheries over time generated increases of reported catches, without retroactive corrections of earlier data? One can infer that this would lead to a time-series bias, which would affect inferences on catch trends. This type of bias is defined and labelled here as ‘presentist bias’, and its occurrence in the reported fisheries catch data of several countries is illustrated. This bias is inadvertently built-in the history, development and evolution of national and global data collection systems, but is generally overlooked or ignored.

### 1.1. Fisheries data

One of the most basic and fundamental types of fisheries data are time-series of the catches taken by national fisheries [1,2]. These data are collected or estimated by nearly all countries in the world, usually by their fisheries departments or national statistics agencies, and are used for national fisheries assessments, and management and policy purposes [3]. Here, we define such data as ‘official data’ or ‘officially reported data’, in contrast to ‘reconstructed data’. Furthermore, we define the term ‘statistics’ more broadly than many governmental or

inter-governmental organizations, e.g., the OECD defines ‘statistical data’ as “data from a survey or administrative source used to produce statistics” (<https://stats.oecd.org/glossary/detail.asp?ID=2543>). We define ‘statistics’ (as in ‘catch statistics’) as equivalent to the term ‘data’ in the more broadly accepted scientific manner, namely as “the practice or science of collecting, analysing and interpreting numerical data in large quantities”. We also define ‘catch’ as the sum of both ‘landed catch’ (i.e., landings) and ‘discarded catch’ (i.e., discards) [4]. In line with standard data practice of the Food and Agriculture Organization (FAO) of the United Nations, we treat ‘catch’ as being ‘wet-weight’ or ‘whole weight’ catch, i.e., not processed or product weight [4].

These official data are also requested, assembled and harmonized annually by the FAO which disseminates them to the global community. These national and (in aggregated form) global official, reported datasets are essentially time-series of fisheries catches (actually they are landings data, as discards are explicitly excluded from consideration, see [5]) by fishing country, year and taxon, and the globally assembled data are presented by FAO on behalf of the countries by a small number of very large statistical areas (19 marine areas covering all ocean basins, plus 7 terrestrial areas; [www.fao.org/3/a-az126e.pdf](http://www.fao.org/3/a-az126e.pdf)). While some of these areas have some data by subareas, this spatially more detailed coverage is often incomplete.

Important in the present context is that the global data assembled and reported by FAO on behalf of countries are analyzed every two years by staff of the FAO for presentation as part of their widely distributed “*State of World Fisheries and Aquaculture*” report (SOFIA, most

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recent issue, [6]), which is timed to coincide with the biennial meeting of the “Committee on Fisheries” (COFI). This committee is the only UN-level, inter-governmental forum where international fisheries issues can be examined and discussed, often leading to important recommendations or even global agreements [7,8].

Thus, SOFIA and the underlying FAO data (reported by FAO on behalf of member countries) form a key information tool that influences national, regional and international fisheries policy developments, as well as informing global funding decisions by the international community, development aid agencies and international NGOs. It thus behoves the international scientific and policy community to be aware if the underlying data may have consistent problems associated with them, especially if any such problem leads to a fundamental bias that impacts catch trends, which [9], a FAO Fishery Statistician rightly sees as key in the interpretation of the data.

## 1.2. Catch reconstructions

Catch reconstructions have become an important component of the *Sea Around Us* research initiative. The earliest reconstructions were commissioned by the US Western Pacific Regional Fishery Management Council [10–13] and were intended to account for obviously missing catch data, such as fisheries sectors that were largely or completely omitted from official data collection/reporting systems (e.g., subsistence fishing, [14]). Later reconstructions, which eventually covered all maritime countries in the world, and their overseas territories, also emphasized recreational fisheries [15], assumed or demonstrated illegal fishing [16,17] and discarded catches [5]. The outcome of this decade-long endeavour by a team of over 300 collaborating scientists from around the world was not only a likely more *accurate* volume of catch (i.e., closer to the unknown true catch volumes), but more importantly a different *trend* in global catches than suggested by officially reported statistics [18,19].

A large and growing number of peer-reviewed reconstruction studies are being published in the scientific literature ([3,14,15,20–24], all listed at [www.seaaroundus.org/articles](http://www.seaaroundus.org/articles)), contributing to and resulting in increased use of reconstructed data, e.g., by the Ocean Health Index [25,26] and the Environmental Performance Index [27], both examined and monitored closely by many countries; by UN affiliated organizations and groups such as the Biodiversity Indicators Partnership ([www.bipindicators.net](http://www.bipindicators.net)) as part of indicator requests of the Convention on Biological Diversity (CBD) and other biodiversity-related conventions, for the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), for reporting on the UN Sustainable Development Goals, and for use by national and regional governments; as well as by other global studies, e.g., on human nutrition [28,29]. Some criticism has been levied at the globally reconstructed catch data of the *Sea Around Us*. These criticisms were either directed at details of individual reconstructions [30,31], or took issue with novel approaches to aid in estimation [32,33]. All these criticisms were examined, and either addressed or refuted [34,35]. Also, some worried about the perceived ‘uncertainty’ associated with estimates of unreported data, despite officially reported statistics (all without their uncertainty ever being assessed or reported) also largely consisting of ‘estimates’ [36–38].

Thus, much focus was aimed at the methods and details used to address the fundamental under-reporting in official statistics of most countries, rather than the underreporting itself, or the potential impact of improvements in data collection systems over time on time-series catch data. With few exceptions [37,39,40], this under-reporting by official data is the result of most countries unfortunately not having the financial or technical resources to monitor and report on all their fisheries (e.g., large subsistence sectors on Pacific islands, [14]), or making deliberate choices to not report to FAO on certain fisheries components (e.g., the domestically well monitored but internationally unreported recreational catches in the USA, [41]). Obviously, this leads

to differences between officially reported and reconstructed data (which incorporate official reported data); indeed, this was, jointly with the decision to include clearly-labelled discards in all reconstructed catch data [5], the main reason for reconstructing fisheries catches in the first place.

## 2. ‘Presentist bias’

Interestingly, these various critiques missed the data bias which should be considered a major point of concern about officially reported catch time-series. What is now termed ‘presentist bias’ is an inadvertent by-product of the often intense and laudable efforts of most countries, often commendably aided and supported by FAO, to improve their national data collection systems over time. Essentially, a ‘presentist bias’ occurs when an improvement in an official catch reporting system (e.g., consideration of a previously unmonitored fishery, sector, fleet, gear or region) leads to an increase in reported catches for more recent time periods without the corresponding past (unmonitored) catches being corrected for retroactively. The presentist bias thus over-emphasizes ‘the present’ vis-à-vis ‘the past’, and it generates an often subtle, but consistent bias over time, due to the commendable efforts of countries to improve the quality of their data collection systems over time. It needs to be emphasized that this is inadvertent and not deliberate.

The statistical reporting systems of countries are subjected to presentist bias when improvements account for a growing share of actual catches, e.g., by adding new or improving existing data collection efforts for previously non-sampled or unmonitored fisheries sectors or components. Crucially in the present context, however, countries do these improvements for data going forward in time without making retroactive corrections for the previous under-reporting (or non-reporting) of such catches in earlier years and decades. It should be acknowledged that FAO has previously indicated this point [9], and does seem to encourage countries to do retroactive corrections. However, such corrections, if they are made, rarely go far enough back in time, mainly due to perceived data ‘quality’ or ‘reliability’ concerns. In cases where retroactive corrections are comprehensive back in time, obviously the reported data no longer contain a presentist bias, and the present argument becomes moot. However, most corrections do not go back far enough to remove this bias, as will be illustrated by the example of Tanzania below. This can then lead to inconsistent historic baselines and the illusion of stable or even increasing catch trends when none occur, even in the face of actual declines [19,36,37].

The existence of such unintentional, but structurally deeply embedded data omissions over time was first pointed out on page 3 of [19] as a “*gradually increasing incorporation of artisanal and other small-scale catches in the officially reported data presented by FAO on behalf of countries ...*”, but was first clearly emphasized in [36]. Below is an illustration of this presentist bias through examples.

The purpose here is not to point fingers, as the existence of this bias is an inadvertent by-product of important improvement efforts for data collection systems, which in themselves are a worthy and important cause. Rather, the point is to draw attention to this issue, and encourage countries to retroactively correct for the entirety of this bias, which can be easily achieved via in-depth corrections of past data, e.g., through data reconstructions. Retroactive data corrections are commonly practised with many national datasets, and accepted and supported by FAO if they come from national reporting agencies [6,38]. The *Sea Around Us* is also willing to engage with countries that wish to address this data bias, or other missing data issues, and improve their historical national catch data [36], something that is already happening in some countries that are open to the concept and concerns of time-series data [15]. It needs to be clearly re-emphasized here (as was done previously elsewhere; e.g., [4]) that reconstructions always contain data estimates, with accompanying uncertainty that at times can be higher than the uncertainty around official reported catch data (official reported

statistics also consist of estimates, with their own unacknowledged uncertainty; [36,37]). If not done carefully, catch data reconstructions may introduce potentially different sets of biases (although we are currently not aware of any), and thus are always open to corrections, changes and improvements, if better information becomes available.

### 3. Examples of ‘presentist bias’

#### 3.1. Mozambique

Mozambique is one of the poorest countries in the world, and, following independence from colonial Portugal in 1975, suffered through many years of civil war (1977–1992). While the economic development is currently accelerating, much of the economy and livelihoods remain firmly based on agriculture and fisheries, much of it on a small-scale subsistence or artisanal basis [42–44]. For earlier time periods, the small-scale sector was essentially absent from reported data, as focus was solely on the limited industrial and semi-industrial fisheries, assumed to have been reported to FAO by the colonial administration on behalf of Mozambique. Thus, historical reported data substantially underestimated actual catches in Mozambique for a long time [45].

Continued absence of small-scale data was also encouraged by the apparent lack of interest in such data by FAO staff for a long time (Rudy van der Elst, ORI, pers. comm., in [46]). Starting in the early 2000s, however, Mozambique made concerted efforts (supported by international NGOs, notably WWF) to create a data sampling and reporting scheme for estimating small-scale catches [47,48], resulting in substantially higher catches appearing almost overnight in official reported data.

For example, the 2004 officially reported data provided an 800% increase in small-scale catches compared to the previous year, clearly the result of the improvements in the data sampling and reporting systems, and not actual changes in fisheries catches from one year to the next (Fig. 1A). A catch reconstruction for Mozambique was undertaken a decade ago [46] which examined and addressed this historical data issue (Fig. 1B), and was published in the peer-reviewed literature shortly thereafter [42]. This was followed by further data corrections and refinements through collaborative studies that involved staff from the National Fisheries Institute (Instituto Nacional de Investigação Pesqueira) of Mozambique [43,44]. This body of work clearly documented that historically, total catches in Mozambique peaked in the 1980s (largely due to the effects of civil war driven coastal migration leading to massive increases in coastal fishing pressure and subsequent overfishing), and declined strongly thereafter (Fig. 1C). Surprisingly, to this day FAO does not seem to have used this well-documented knowledge to actively work with Mozambique on comprehensively correcting historical data prior to the 2000s. Currently, official data as reported by FAO on behalf of Mozambique (as of FAO data release 2015) have not been corrected in any form for this clear case of the presentist bias for years prior to the early 2000s, resulting in unrealistic and erroneous reported data for pre-2000 periods. This makes FAO statistics for Mozambique unsuitable for time-series trend analysis (Fig. 1A versus 1C).

#### 3.2. Tanzania

Tanzania essentially consists of two regions, the mainland (historically ‘Tanganyika’) and the island group around and including Zanzibar. While both shared the same colonial history over the last 100+ years (first German, then British), they gained independence separately in 1961 and 1963, but merged into one country, the United Republic of Tanzania in 1964. However, the historical separation into two regions seems to continue to haunt fisheries management and national (and by extension international) fisheries data systems, as clearly documented by the Tanzanian catch reconstruction [42,49,50]. While Tanzanian fisheries are dominated by the extensive freshwater fisheries

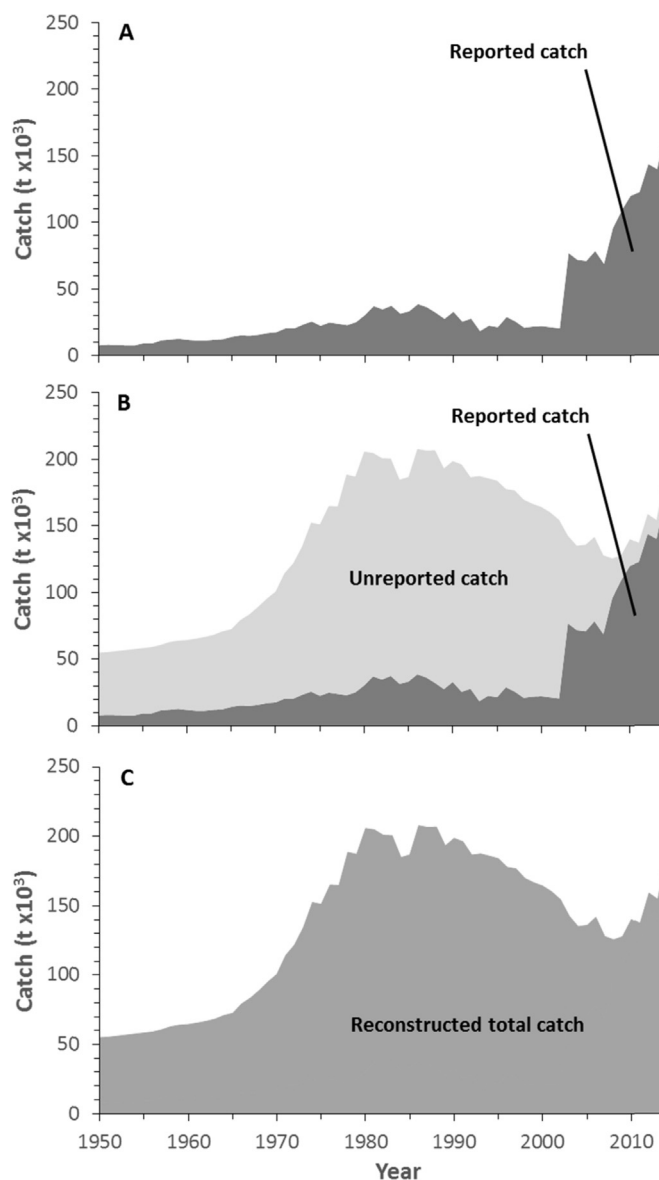
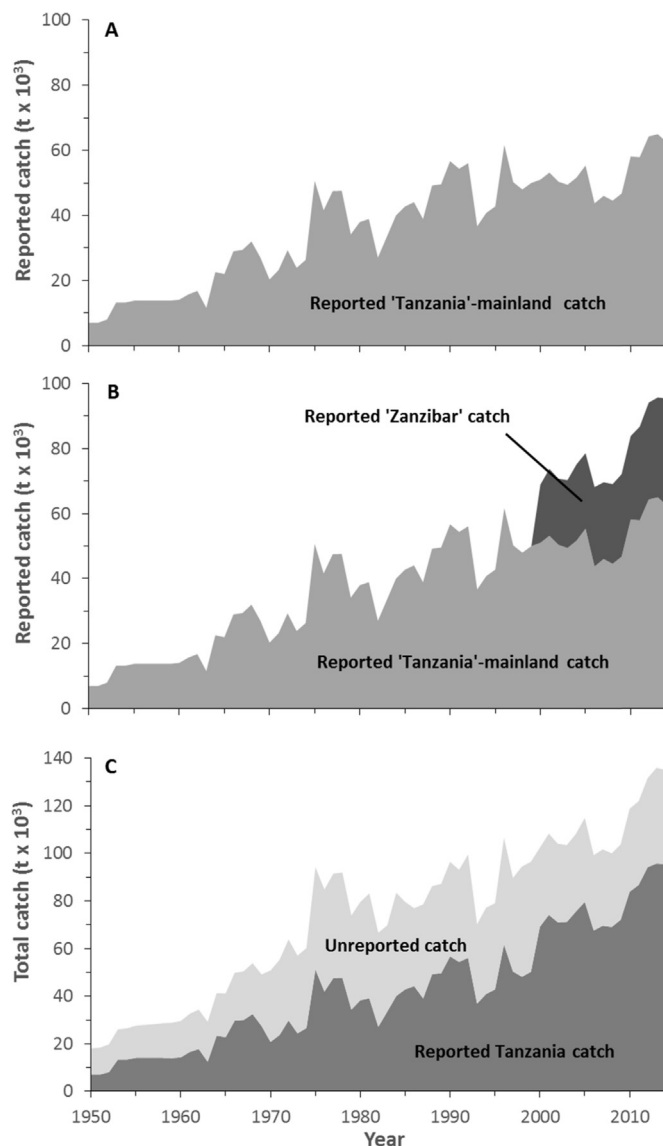


Fig. 1. Marine fisheries catches for Mozambique, (A) Official data as reported by FAO on behalf of Mozambique, clearly showing the sudden and rapid increase in reported catch starting in 2004 as a result of improvements in the national data collection system; (B) Addition of the estimates of unreported catches with emphasis on addressing the presentist bias generated by the improvements in the data collection system in the early 2000s; and (C) Total reconstructed catch, combining reported and unreported catch estimates, and thus providing a more accurate and comprehensive time-series trend in the domestic fisheries.

in Lake Victoria, marine fisheries also developed, both industrial-scale fisheries (e.g., for shrimp), as well as subsistence and small-scale commercial fisheries (i.e., artisanal) that have been feeding coastal and island communities for centuries.

As in many developing countries, the official catch data collection and reporting system in Tanzania experienced substantial challenges, including missing data for the colonial periods [51] as well as incomplete data for more recent time periods [52,53]. The detailed examination during the original catch reconstruction conducted in the mid-2000 [50] revealed for the first time that catch data for Zanzibar were entirely missing from the data reported by FAO on behalf of Tanzania (Fig. 2A). This was thought to be due to the political history of Tanzania, as both mainland and Zanzibar islands each have separate and essentially autonomous institutional and legal structures for managing and accounting for fisheries, and thus have separate systems



**Fig. 2.** Fisheries catches for the United Republic of Tanzania, (A) Official reported data for the United Republic of Tanzania as per data reported by FAO on behalf of the United Republic of Tanzania, consisting only of mainland Tanzania data. This was the default data reported by FAO for Tanzania until 2009; (B) Official reported data as per data reported by FAO on behalf of the United Republic of Tanzania starting in 2009, consisting of two separate entries, one for ‘Tanzania’ and the second for ‘Zanzibar’, which is only included back to 2000, thus creating a presentist bias; and (C) Reconstructed catches consisting of the combined ‘Tanzania’ and ‘Zanzibar’ reported data plus estimated unreported catches, thereby addressing the presentist bias.

of data collecting and reporting. In essence, it seems that Zanzibar’s data were either never forwarded to national authorities on the mainland, or were never included in national data reports requested by FAO on an annual basis. Interestingly, within two years (as of August 2009) of the release of the reconstructed data ([50], including personally informing FAO staff of the findings), FAO started reporting Zanzibar’s official data [42]. However, only data from the year 2000 onwards were presented by FAO, and furthermore as a separate ‘country’ entity, i.e., not as part of Tanzania, but as ‘Zanzibar’ (Fig. 2B).

Thus, consideration and use of official reported data by any party not familiar with this labelling quirk would result in erroneous conclusions for ‘Tanzania’ (Fig. 2B). Furthermore, even with consideration of FAO-reported Zanzibar data, the data still illustrate a case of presentist bias due to the omission of catches from Zanzibar fisheries prior to 2000 (Fig. 2B). As such, the combined officially reported data for

Tanzania (mainland) and Zanzibar present an image of a considerable and sudden increase in marine catches in the early 2000s, rather than the more gradual growth in catches as determined through the reconstruction (Fig. 2C). Hence, even if this case of presentist bias does not lead to a distinct change in time-series trend (as is the case for Mozambique above), the existence of the presentist bias can lead to subtle misinterpretation of data and hence erroneous conclusions.

Several other examples of the existence of the presentist bias in official reported data could be presented here [54–58]. However, the above two cases will hopefully suffice to demonstrate the principles and potential consequences of not addressing this time-series data bias.

Some may argue that anyone using fisheries data would (or should) know about these time-series limitations, or that this bias occurs only in a few countries, or that this bias is usually small and can be neglected. However, firstly, international datasets such as those assembled by FAO on behalf of the global community are widely utilized by what may be called ‘non-country’ and ‘non-specialist’ users (e.g., international NGOs, charitable foundations, marine scientists etc.) who generally will not know about the specifics of individual country data or may use multiple country datasets; secondly, these official data are being used by FAO in SOFIA [6], a widely used and appreciated document that provides trend information on global fisheries, which contain this time-series bias and are thus misleading [36,37]; and thirdly, ‘small’ or ‘minor’ issues have the potential to cause rather large and important effects once aggregated in a global total, as is indeed clearly and unambiguously the case for the trend in global fisheries catches [18,19].

#### 4. Conclusions

A commonly heard comment among many fisheries scientists is that more recent data which are used for assessments are *better*, therefore there is no need to bother with correcting data for periods often many decades ago. However, as has now been demonstrated globally [19], as well as regionally [14] and locally [42], not accounting for the presentist bias over an entire reported data history (i.e., back to 1950 in the case of data reported by FAO on behalf of countries) almost invariably leads to misinterpretation of fisheries trends. This was unfortunately demonstrated for global catch data in the most recent SOFIA [6], which claimed stability in global fisheries catches, but did not account for the trend-altering impact of the presentist bias on global time series trends as was pointed out by [36,37]. Not addressing this bias can contribute to erroneous and shifting baselines [59].

Formal stock assessments often try and use data in addition to catch data, and it is worth noting that:

Firstly, fishing effort data and independent survey data are often used in formal stock assessments when they are available and deemed suitable. However, what the reader needs to consider is that such data are often even more incomplete than catch data, both in what they include and time coverage. Many countries do not have any or very limited effort data for anything other than some major fleets or gear types, thus their use introduces a new set of potential bias if used without detailed (e.g., reconstructed) corrections of the effort data. Fisheries independent surveys of sufficient detail and quality to assist stock assessments are also very rare outside of developed countries and are often financially beyond the resources of most developing countries. Thus, for many places in the world, unfortunately catch data is all they have in sufficient detail to be somewhat representative of total fisheries. There are so-called data-poor methods for assessment [60] that allow what can be called first-order assessments to be undertaken, but they too require at the very least comprehensive time series of catches, with good taxonomic resolution.

Secondly, statistical correction methods do exist to help work around issues of presentist bias in stock assessments, and are (hopefully) being used, despite being analytically challenging. More importantly, however, using such methods requires awareness, knowledge and acknowledgement of the existence of the presentist bias in each



case in the first place.... which is a major problem as most assessment staff have no idea if it exists, in what parts of the data it exists, or what its impact may be. In essence, without conducting the equivalent of 'reconstruction-type' investigations into historical data gaps to determine where such a presentist bias exists in each case, the assessment staff would not know where and when to apply the stock assessment correction methods.

Therefore, for official, national catch statistics to more accurately reflect historical patterns and trends in fisheries catches, any existing presentist bias needs correcting as best as possible for the entire time period of comprehensive international statistics, i.e., back to 1950. Ultimately, the onus is on countries themselves, who need to address this core data issue.

The first step is obviously to recognize and acknowledge the existence of this bias, and the substantial influence it can have on time-series data. It needs emphasizing that the presentist bias is generally an inadvertent and incidental by-product of the well-intentioned and worthwhile efforts by countries to improve their data systems over time. Thus, there is no deliberate malice by countries in creating this data problem.

Following recognition, the second step is to obviously do something about it. The only way to accomplish this is to retroactively fill the data gaps created by this bias through best estimates of these 'missing' catches, ideally using the now established and extensively documented catch reconstruction approach ([4,12,61], see also the detailed technical reconstruction reports for each country at [www.seaaroundus.org](http://www.seaaroundus.org)).

Finally, once these time-series data corrections have been implemented in national data systems, countries need to formally request from FAO that it undertake retroactive data corrections and data replacements of existing FAO data in the FAO's databases, for the entire time period back to 1950. Unless countries officially request such changes, FAO is unlikely to undertake them, given the constraints of their mandate. Fortunately, this only needs to be done once, as future iteration of FAO data will reflect past data corrections requested by member countries.

The *Sea Around Us* teams at the University of British Columbia and the University of Western Australia are always willing and interested in working with countries that wish to address these and similar data issues and thereby improve their official national data baselines. Such corrections can rapidly lead to improvements in the comprehensiveness of historical national data that can influence national policy discussions around fisheries. These corrections can definitely also lead to enhancements and refinements in regional and global data sets as presented by the statistics collated and reported annually by FAO on behalf of countries, which in turn will result in improved and more accurate assessments via instruments such as SOFIA.

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## References

- [1] D. Pauly, Does catch reflect abundance? Yes, it is a crucial signal, *Nature* 494 (2013) 303–306.
- [2] D. Pauly, On the importance of fisheries catches, with a rationale for their reconstruction, in: D. Pauly, D. Zeller (Eds.), *Global Atlas of Marine Fisheries: A critical appraisal of catches and ecosystem impacts*, Island Press, Washington, DC, 2016, pp. 1–11.
- [3] D. Zeller, P. Rossing, S. Harper, L. Persson, S. Booth, D. Pauly, The baltic sea: estimates of total fisheries removals 1950–2007, *Fish. Res.* 108 (2011) 356–363.
- [4] D. Zeller, M.L.D. Palomares, A. Tavakolie, M. Ang, D. Belhabib, W.W.L. Cheung, et al., Still catching attention: sea around us reconstructed global catch data, their spatial expression and public accessibility, *Mar. Policy* 70 (2016) 145–152.
- [5] D. Zeller, T. Cashion, M.L.D. Palomares, D. Pauly, Global marine fisheries discards: a synthesis of reconstructed data, *Fish. Res.* 19 (2018) 30–39.
- [6] FAO, *The State of World Fisheries and Aquaculture 2016 (SOFIA): Contributing to Food Security and Nutrition for All*, Food and Agriculture Organization, Rome, 2016, p. 200.
- [7] D. Pauly, T. Charles, Counting on small-scale fisheries, *Science* 347 (2015) 242–243.
- [8] FAO, *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*, Food and Agriculture Organization of the United Nations, Rome, 2015 (p. xii + 18).
- [9] L. Garibaldi, The FAO global capture production database: a six-decade effort to catch the trend, *Mar. Policy* 36 (2012) 760–768.
- [10] D. Zeller, S. Booth, D. Pauly, Reconstruction of coral reef- and bottom-fisheries catches for U.S. flag island areas in the Western Pacific, 1950 to 2002, Report to the Western Pacific Regional Fishery Management Council, Honolulu, 2005, p. 110.
- [11] D. Zeller, S. Booth, D. Pauly, Fisheries contribution to the gross domestic product: underestimating small-scale fisheries in the Pacific, *Mar. Resour. Econ.* 21 (2006) 355–374.
- [12] D. Zeller, S. Booth, G. Davis, D. Pauly, Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years, *Fish. Bull.* 105 (2007) 266–277.
- [13] D. Zeller, S. Booth, P. Craig, D. Pauly, Reconstruction of coral reef fisheries catches in American Samoa, 1950–2002, *Coral Reefs* 25 (2006) 144–152.
- [14] D. Zeller, S. Harper, K. Zyllich, D. Pauly, Synthesis of under-reported small-scale fisheries catch in Pacific-island waters, *Coral Reefs* 34 (2015) 25–39.
- [15] N.S. Smith, D. Zeller, Unreported catch and tourist demand on local fisheries of small island states: the case of the Bahamas 1950–2010, *Fish. Bull.* 114 (2016) 117–131.
- [16] D. Belhabib, D. Hellebrandt da Silva, E.H. Allison, D. Zeller, D. Pauly, Filling a blank on the map: 60 years of fisheries in Equatorial Guinea, *Fish. Manag. Ecol.* 23 (2016) 119–132.
- [17] D. Belhabib, A. Mendy, Y. Subah, N.T. Broh, A.S. Jueseah, N. Nipey, et al., Fisheries catch under-reporting in The Gambia, Liberia and Namibia, and the three large marine ecosystems which they represent, *Environ. Dev.* 17 (2016) 157–174.
- [18] D. Pauly, D. Zeller, *Global Atlas Of Marine Fisheries: A Critical Appraisal Of Catches And Ecosystem Impacts*, Island Press, Washington, D.C, 2016 (p. xvii + 486).
- [19] D. Pauly, D. Zeller, Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining, *Nat. Commun.* 7 (2016) 10244.
- [20] K. Seto, D. Belhabib, J. Mamie, D. Copeland, J. Michael Vakily, H. Seilert, et al., War, fish, and foreign fleets: the marine fisheries catches of Sierra Leone 1950–2015, *Mar. Policy* 83 (2017) 153–163.
- [21] M. Khalfallah, K. Zyllich, D. Zeller, D. Pauly, Reconstruction of domestic marine fisheries catches for Oman (1950–2015), *Front. Mar. Sci.* 3 (2016) 152.
- [22] D. Zeller, S. Booth, E. Pakhomov, W. Swartz, D. Pauly, Arctic fisheries catches in Russia, USA and Canada: baselines for neglected ecosystems, *Polar Biol.* 34 (2011) 955–973.
- [23] M. Léopold, G. David, J. Raubani, J. Kaltavara, L. Hood, D. Zeller, The reconstruction of total marine fisheries catches for the New Hebrides and the Republic of Vanuatu, 1950–2014, *Front. Mar. Sci.* 4 (2017) 1–11.
- [24] T. Cashion, S. Glaser, L. Persson, P.M. Roberts, D. Zeller, Fisheries in Somali waters: reconstruction of domestic and foreign catches for 1950–2015, *Mar. Policy* 87 (2018) 275–283.
- [25] B.S. Halpern, S.D. Gaines, K. Kleisner, C. Longo, D. Pauly, A.A. Rosenberg, et al., Halpern et al. reply to "Is the ocean food provision index biased?", *Nature* 495 (2013) E7.
- [26] B.S. Halpern, C. Longo, D. Hardy, K.L. McLeod, J.F. Samhoury, S.K. Katona, et al., An index to assess the health and benefits of the global ocean, *Nature* 488 (2012) 615–622.
- [27] A. Hsu, *Environmental Performance Index, 2016* Yale University, New Haven, CT, 2016, p. 123 (Available: [www.epi.yale.edu](http://www.epi.yale.edu)).
- [28] C.D. Golden, E. Allison, W.W.L. Cheung, M. Dey, B. Halpern, D.J. McCauley, et al., Nutrition: fall in fish catch threatens human health, *Nature* 534 (2016) 317–320.
- [29] C.D. Golden, O.L. Chen, W.W.L. Cheung, M. Dey, B. Halpern, D.J. McCauley, et al., Reply to Belton et al.: are farmed fish just for wealthy markets? *Nature* 538 (2016) 171.
- [30] D. Belhabib, V. Koutob, A. Sall, V. Lam, D. Pauly, Fisheries catch misreporting and its implications: the case of Senegal, *Fish. Res.* 151 (2014) 1–11.
- [31] C. Chaboud, M. Fall, J. Ferraris, A. Fontana, A. Fonteneau, F. Laloë, et al., Comment on "Fisheries catch misreporting and its implications: the case of Senegal", *Fish. Res.* 164 (2015) 322–324.
- [32] D. Al-Abdulrazzak, D. Pauly, Managing fisheries from space: Google Earth improves estimates of distant fish catches, *ICES J. Mar. Sci.* 71 (2014) 450–455.
- [33] L. Garibaldi, J. Gee, S. Tsuji, P. Mannini, D. Currie, Comment on: "Managing fisheries from space: Google Earth improves estimates of distant fish catches" by Al-Abdulrazzak and Pauly, *ICES J. Mar. Sci.* 71 (2014) 1921–1926.
- [34] D. Belhabib, V. Koutob, A. Sall, V.W.Y. Lam, D. Zeller, D. Pauly, Counting pirogues and missing the boat: reply to Chaboud et al.'s comment on Belhabib et al. "Fisheries catch misreporting and its implications: the case of Senegal", *Fish. Res.* 164 (2015) 325–328.
- [35] D. Al-Abdulrazzak, D. Pauly, Ground-truthing the ground-truth: reply to Garibaldi et al.'s comment on "Managing fisheries from space: Google Earth improves estimates of distant fish catches", *ICES J. Mar. Sci.* 71 (2014) 1927–1931.
- [36] D. Pauly, D. Zeller, The best catch data that can possibly be? Rejoinder to Ye et al. "FAO's statistic data and sustainability of fisheries and aquaculture", *Mar. Policy* 81 (2017) 406–410.
- [37] D. Pauly, D. Zeller, Comments on FAOs state of world fisheries and aquaculture

- (SOFIA 2016), Mar. Policy 77 (2017) 176–181.
- [38] Y. Ye, M. Barange, M. Beveridge, L. Garibaldi, N. Gutierrez, A. Anganuzzi, et al., FAO's statistic data and sustainability of fisheries and aquaculture: comments on Pauly and Zeller (2017), Mar. Policy 81 (2017) 401–405 (in press).
- [39] D. Pauly, F. Le Manach, Tentative Adjustments of China's Marine Fisheries Catches (1950–2010), Fisheries Centre Working Paper #2015-28, University of British Columbia, Vancouver, 2015, p. 16.
- [40] R. Watson, D. Pauly, Systematic distortions in world fisheries catch trends, Nature 414 (2001) 534–536.
- [41] A. McCrea-Strub, Reconstruction of Total Catch by U.S. Fisheries in the Atlantic and Gulf of Mexico: 1950–2010, Fisheries Centre Working Paper #2015-79, University of British Columbia, Vancouver, 2015, p. 46.
- [42] J.L. Jacquet, H. Fox, H. Motta, A. Ngusaru, D. Zeller, Few data but many fish: marine small-scale fisheries catches for Mozambique and Tanzania, Afr. J. Mar. Sci. 32 (2010) 197–206.
- [43] B. Doherty, M.M. McBride, A.J. Brito, F. Le Manach, L. Sousa, I. Chauca, et al., Marine fisheries in Mozambique: catches updated to 2010 and taxonomic disaggregation, in: F. Le Manach, D. Pauly (Eds.), Fisheries Catch Reconstructions in the Western Indian Ocean, 1950–2010. University of British Columbia, Vancouver, 2015, pp. 67–81 (Fisheries Centre Research Reports 23(2)).
- [44] M.M. McBride, B. Doherty, A.J. Brito, F. Le Manach, L. Sousa, I. Chauca, et al., Taxonomic Disaggregation and Update to 2010 for Marine Fisheries Catches in Mozambique, Fisheries Centre Working Papers 2013-02, University of British Columbia, Vancouver, 2013, p. 26.
- [45] P. Charlier, Development of a Data Collection System for the Small Scale Fisheries in Mozambique, Food and Agriculture Organization (FAO), Rome, 1994, p. 68 (Report prepared for the project MOZ/93/002).
- [46] J.L. Jacquet, D. Zeller, National conflict and fisheries: reconstructing marine fisheries catches for Mozambique, in: D. Zeller, D. Pauly (Eds.), Reconstruction of Marine Fisheries Catches for Key Countries and Regions (1950–2005), University of British Columbia, Vancouver, 2007, pp. 35–47 (Fisheries Centre Research Reports 15(2)).
- [47] IIP, Relatório Annual. Maputo (Mozambique), Instituto Nacional de Investigação Pesqueira (IIP), Maputo, Mozambique, 2003, p. 60.
- [48] IIP, Relatório Annual. Maputo (Mozambique), Instituto Nacional de Investigação Pesqueira (IIP), Maputo, Mozambique, 2004, p. 56.
- [49] E. Bultel, B. Doherty, A. Herman, F. Le Manach, D. Zeller, An update of the reconstructed marine fisheries catches of Tanzania with taxonomic breakdown, in: F. Le Manach, D. Pauly (Eds.), Fisheries Catch Reconstructions in the Western Indian Ocean, 1950–2010. University of British Columbia, Vancouver, 2015, pp. 151–161 (Fisheries Centre Research Reports 23(2)).
- [50] J.L. Jacquet, D. Zeller, Putting the 'United' in the United Republic of Tanzania: reconstructing marine fisheries catches, in: D. Zeller, D. Pauly (Eds.), Reconstruction of Marine Fisheries Catches for Key Countries and Regions (1950–2005), University of British Columbia Fisheries Centre, Vancouver, 2007, pp. 49–60 (Fisheries Centre Research Reports 15(2)).
- [51] Anon, Donors Conference on International Assistance for Development of the Fisheries Sector. Dar Es Salaam, Tanzania: in: Proceedings of the FAO/Government National Seminar on Policy and Planning, University of Dar Es Salaam, 1988.
- [52] M. Guard, A. Mmochi, C. Horrill, Tanzania, in: C. Sheppard (Ed.), Seas of the Millennium, an Environmental Evaluation. Pergamon Press, Amsterdam, 2000, pp. 83–98.
- [53] H. Mongi Review of the marine fisheries sub-sector for Tanzania mainland, in: J.D. Ardill, M.J. Sanders (Ed.), Proceedings of the Seminar to Identify Priorities for Fisheries Management and Development in the Southwest Indian Ocean, Albion, Maritius, Rome: FAO Fisheries Report 457, 3–5 September 1991, pp. 153–171.
- [54] F. Le Manach, D. Dura, A. Pere, J.J. Riutort, P. Lejeune, M.C. Santoni, et al., Preliminary estimate of total marine fisheries catches in Corsica, France (1950–2008), in: S. Harper, D. Zeller (Eds.), Fisheries Catch Reconstructions: Islands, Part II, University of British Columbia, Vancouver, 2011, pp. 3–14 (Fisheries Centre Research Reports 19(4)).
- [55] F. Le Manach, D. Pauly, Update of the Fisheries Catch Reconstruction of Corsica (France), 1950–2010, Fisheries Centre Working Paper #2015-33, University of British Columbia, Vancouver, 2015, p. 5.
- [56] K. Zyllich, S. Harper, N. Winkler, D. Zeller, Reconstruction of marine fisheries catches for Niue (1950–2010), in: S. Harper, K. Zyllich, L. Boonzaier, F. Le Manach, D. Pauly, D. Zeller (Eds.), Fisheries Catch Reconstructions: Islands, Part III, University of British Columbia, Vancouver (Canada), 2012, pp. 77–86 (Fisheries Centre Research Reports 20(5)).
- [57] K. Zyllich, S. Harper, D. Zeller, Reconstruction of fisheries catches for Tokelau (1950–2009) (Fisheries19(4)), in: S. Harper, D. Zeller (Eds.), Fisheries Catch Reconstructions: Islands, Part II, University of British Columbia, Vancouver, 2011, pp. 107–117 (Fisheries Centre Research Reports 19(4)).
- [58] S. Harper, L. Frotté, S. Booth, D. Zeller, Reconstruction of marine fisheries catches for Wallis and Futuna Islands (1950–2007), in: D. Zeller, S. Harper (Eds.), Fisheries Catch Reconstructions: Islands, Part I, University of British Columbia, Vancouver, 2009, pp. 99–104 (Fisheries Centre Research Reports 17(5)).
- [59] D. Pauly, Anecdotes and the shifting baseline syndrome of fisheries, Trends Ecol. Evol. 10 (1995) 430.
- [60] S. Martell, R. Froese, A simple method for estimating MSY from catch and resilience, Fish Fish. 14 (2013) 504–514.
- [61] D. Zeller, D. Pauly, Marine fisheries catch reconstruction: definitions, sources, methods and challenges, in: D. Pauly, D. Zeller (Eds.), Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts. Island Press, Washington, DC, 2016, pp. 12–33.