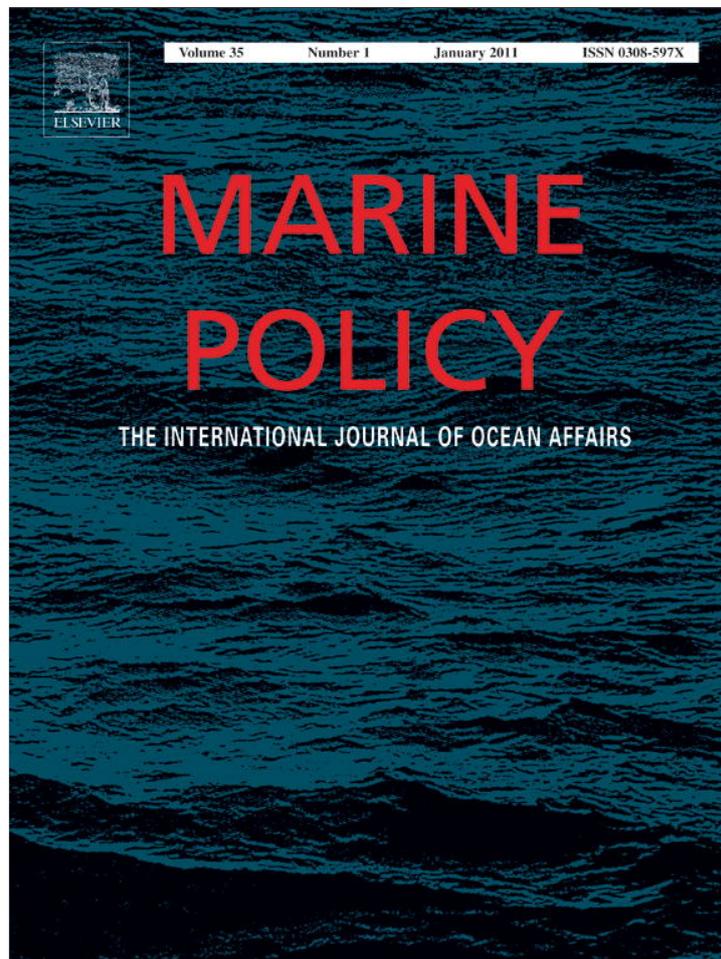


Provided for non-commercial research and education use.
Not for reproduction, distribution or commercial use.



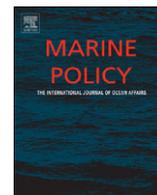
(This is a sample cover image for this issue. The actual cover is not yet available at this time.)

This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

<http://www.elsevier.com/copyright>



Comments on FAO's State of Fisheries and Aquaculture, or 'SOFIA 2010'

Daniel Pauly^{a,*}, Rainer Froese^b

^a Sea Around Us Project, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, Canada V6T 1Z4

^b IFM-GEOMAR, Düsternbrooker Weg 20, 24105 Kiel, Germany

ARTICLE INFO

Article history:

Received 9 September 2011

Received in revised form

28 October 2011

Accepted 28 October 2011

Keywords:

Fisheries catch

Statistics underreporting

Overfishing

Fishing down

ABSTRACT

Comments are provided on a few sections of the FAO's 2010 edition of the bi-annual 'State of the World's Fisheries and Aquaculture' (SOFIA), i.e., its characterization of the present as a period of 'stability', the peculiar role of China's fisheries statistics, the under-reporting of much of the small-scale fisheries catch from developing countries as a key aspect of the deteriorating quality of statistical data submitted to the FAO by member countries, and some other minor topics (but not aquaculture). Overall, this SOFIA report, like its predecessors, provides an excellent starting point for debates about the status of global fisheries, rather than settling them, and a few vignettes are presented, which illustrate this. Moreover, this debate should be broader, e.g., involve more university- and civil society-based researchers, to provide the wide variety of views and analyses required to strengthen FAO in its laudable mission of providing dependable information on the state of global fisheries.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

While the Food and Agriculture Organization of the United Nations (FAO) has issued its authoritative 'State of the World's Fisheries and Aquaculture' (SOFIA) reports since 1995, it is only since 1996 that it has become biennial. Here, comments are provided on 'SOFIA 2010' [1], which, while incorporating some information from 2009 and early 2010, largely consists of an analysis of fishery catch and aquaculture production data submitted to FAO by member countries up to 2008. No comments are given on aquaculture; moreover, the remarks that are given do not cover the entire report, either. Rather, they concentrate on issues that the authors have also worked on, here treated in form of five vignettes. The text then concludes with an overarching discussion.

However, before this begins with what may be perceived as critical comments, an important fact must be stated, summarized in the title of the first vignette.

1.1. FAO's work in global fisheries is positive, irreplaceable and must be strengthened

There are, for important agricultural commodities (wheat, rice, maize, etc.), numerous global databases and research groups throughout the world with familiarity and expertise on the global

production and trade of these commodities. One result is that, for example the effects of a drought in one part of the world can be evaluated and debated by various independent groups, and their implications for other regions outlined to policy makers.

Despite of the globalized nature of the world fisheries and trade in seafood products [2], FAO not only created the only database of this sort on the world's fisheries, but FAO staff have been to date, with some exceptions,¹ the only experts who analyzed this extremely valuable database, which started in 1947, and led in 1950 to the first annual 'Yearbook of Catch and Landing Statistics' [3].

This has led, on one hand, to FAO staff acquiring a broad vision of fisheries throughout the world, which contrasts favorably with the more parochial views of fisheries scientists working for national research bodies, as the great majority does. On the other hand, it has also led to a certain defensiveness in the face of attempts by others to interpret the 'FAO data', as manifested, e.g., in reactions following the publications of independent analyses by Pauly et al. [4] and Watson and Pauly [5]—although neither of these analyses were critical of FAO or its staff [6].

Thus, it must be reiterated here that the views below are not a critique of FAO, or of its staff or work. They are, rather, comments that may be helpful to others in critically interpret this work, and

¹ One of these few exceptions is the Sea Around Us project (<http://www.seaaroundus.org/>), which attempts to reconstruct the 'real' catches of all maritime countries of the world (see [34–40,43–45]); however, many of these reconstructions use previous FAO data as starting point.

* Corresponding author. Tel.: +1 604 822 1201.

E-mail address: d.pauly@fisheries.ubc.ca (D. Pauly).

to break with the pattern wherein the world community accepts successive SOFIAs as ‘the’ status of fisheries in the world, rather than a view of it (albeit a well-informed one).

1.2. A word rarely used to describe catch trends: stability

After noting that ‘since the mid-1990s and throughout the 2000s, several studies have predicted the rapid decline of marine fisheries worldwide’ and strangely citing Hilborn [7] to back this up, i.e., an

author who believes these predictions have no basis in fact [8], FAO [1] writes: ‘paradoxically, a glance at the global capture statistics collated by FAO [...] prompt a word that has very rarely been used to describe catch trends: stability’. This is later reiterated, i.e., ‘[a]s already stated, 2005–2008 global marine production was practically stable although individual fishing areas showed distinct catch trends’ [1].

It is true that the world marine catch may charitably be viewed as stagnating (Fig. 1A), and less charitably as slowly declining, particularly if the catch data reported by China are

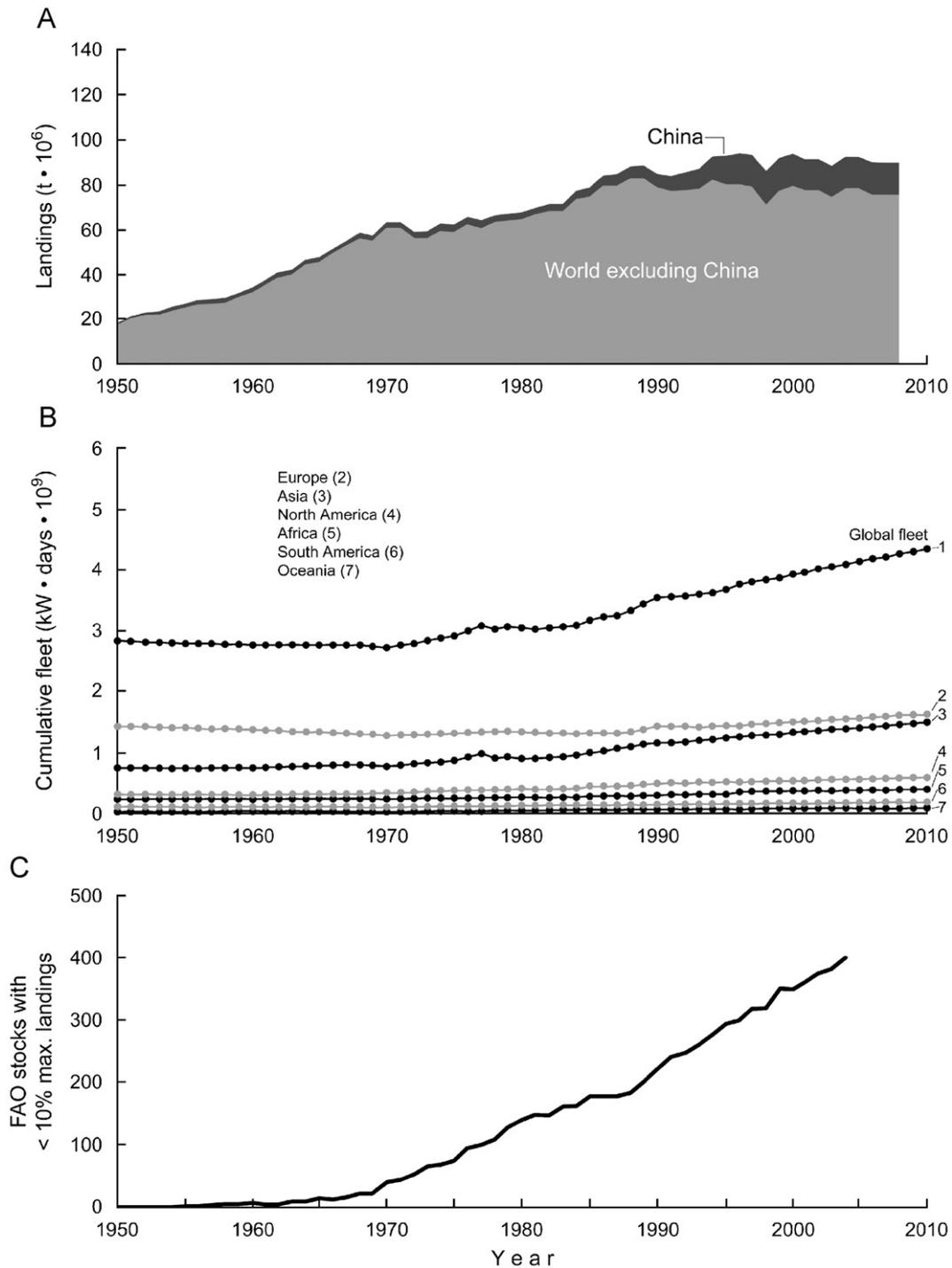


Fig. 1. Major trends in world fisheries catch. (A) World capture fisheries catch, with and without China (adapted from Fig. 3 in [1]); note marked declining trend in the latter; (B) trend in fishing capacity, roughly corresponding to fishing effort (adapted from Fig. 1 in [42]); (C) number of fish stocks monitored by FAO, and yielding less than 10% of their historic maximum catches, i.e., mostly stocks, which have crashed (see text).

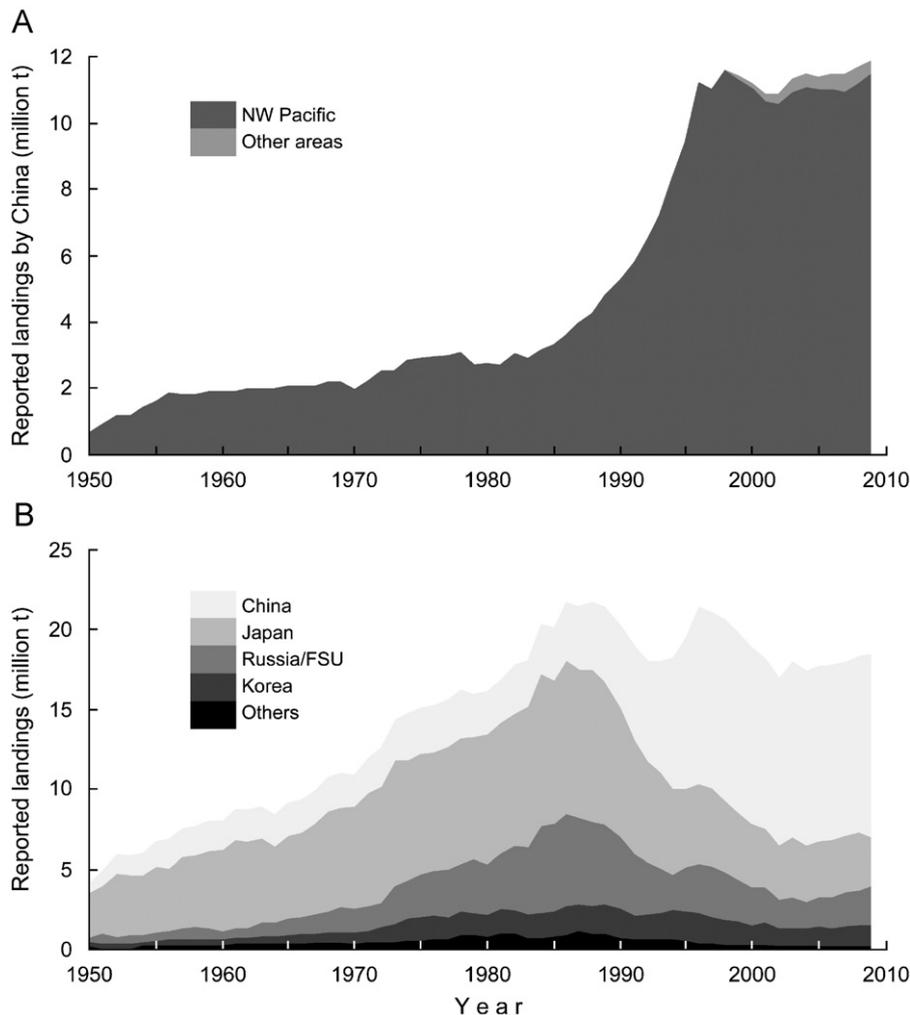


Fig. 2. Marine fisheries catch in Northeast Asia. (A) reported Chinese catches, featuring the small (13%) correction to the decreed flat catches since 1998, which followed on a non-credible increase from the mid-1980s to 1998 (see text). (B) Catches of the 4 major fishing countries (+ 'others'), illustrating the radically different trajectories for China and the other countries.

excluded from the evaluation, as they must (see below). However, stagnating, or even declining, catches in the face of rapidly expanding fishing effort (Fig. 1B) are not indicative of 'stability'. Rather they are indicative of a strong biomass decline [9,10], especially since second-order effects, such as hyperdepletion and hyperstability [11], will not operate at global/decadal scales. This also applies if some reduction in catch occurred via deliberate quota reductions, as a result of management, because in the relatively few fisheries that are managed by harvest management rules, smaller quotas are instituted – given active lobbying by the fishing industry – only when the biomass they exploit has strongly declined [12,13]. Also, there are enough independent studies confirming that continuous biomass declines are the rule throughout the world—especially for large high trophic level fishes (see e.g., [14]), notwithstanding the rebuilding of a few stocks in the US [8,15].

To back such claims, one needs only examine the number of FAO 'stocks' (species by statistical area which contributed at least 10 t to the time series) which produced less than 10% of their previous maximum catches (Fig. 1C). Given the controversy [14,16] following a previous extrapolation of these data by Worm et al. [17], it is easy to resist the temptation to fit (and extrapolate) a function to the curve, but it is quite obvious that many stocks will fall below the 10% threshold before 2048 if

current trends continue. Note that the estimate of 37% depleted stocks in 2009 in Fig. 1C is higher than the 32% of overexploited, depleted or recovering stocks estimated by SOFIA [18] for 2008, because FAO's estimate is based on a subset of commercially important and presumably more resilient stocks.

1.3. The major importance of China in the global context

Although, it might have been known to some FAO staff (see [6], pp. 75–82), the massive catch over-reporting by China documented in Watson and Pauly [19] was not previously known to the majority of fisheries scientists at the dawn of the 21st century. This was implicitly acknowledged by FAO ([20], p. 3), when they stated that '*there are increasing indications that capture fishery and aquaculture production statistics for China may be too high as suggested by several academic studies,² and that this problem has become more pronounced since the early 1990s. Because of its production statistics, China is usually discussed separately from the rest of the world, as in the previous edition of this document.*³

² The 'several academic studies' not being cited, one can only wonder what they were, if not [19], and [5], which prepared the ground.

³ There is no evidence that, in earlier SOFIAs, the catch of China was treated separately from that of the rest of the world, as done since SOFIA 2002 [20].

However, the problem continues ten years hence, even after China retroactively corrected the data it submitted to FAO. Thus, '[w]hile revisions varied according to species, area and sector, the overall result was a downward correction by 13.5%. FAO subsequently estimated revisions for its historical statistics for China for 1997–2005'. But the point here is that China does not know how much its fisheries catch, which appears to be similar for other key production statistics [21,22].

This is best illustrated by Fig. 2A (adapted from [1]), which documents the rapid increase of its catches up to 1998, which was so in-credible that China's central government decreed that the catch should forthwith cease to increase [23], whereupon it ceased to increase, or rather the statistics were adjusted accordingly. For contrast, Fig. 2B compares the Chinese catch trend to radically different catch trends of three of China's neighbors in the Northwest Pacific, i.e., Russia, South Korea and Japan.

The recent adjustment by China by 13.5% of the *decreed* total catch is not solving the problem. What FAO should do instead is suggest to the Chinese government that it should, with FAO's help, establish a decent stratified statistical survey of its fishing ports and other landing places and ceases to submit unrealistic values, which only mislead the Chinese authorities as well as the world community. FAO assisted the government of India with such a sampling scheme in the 1950s, and it has produced excellent catch statistics until the scheme was partly dismantled in the 1990s [24].

1.4. Assemblage overfishing

Assemblage overfishing is an apparently new term for a phenomenon better known as 'fishing down marine [or aquatic] food webs', possibly derived from Lambert [25], who wrote '*of a phenomenon known as 'fishing down' a fish assemblage* [4,26].'

'Fishing down' is the process wherein fisheries either target the large fish in an ecosystem, and thus reduce their abundance relative to that of smaller fish, or target all fish sizes, and thus the abundance of larger and longer lived fishes decline relative to the abundance of smaller, shorter-lived fishes and invertebrates, due to the difference in fishing mortality their populations can tolerate [27]. In both cases, the change in species composition can usually be detected through declining trends in the (size-related) mean trophic levels of the catches from the ecosystem in question, and has been shown to occur in a wide range of freshwater and marine settings, once masking factor are accounted for [28,29].

In FAO ([1], p. 85), it stated, correspondingly: '*In 1940, the total catch from the Tonlé Sap of 125,000 t consisted mainly of large and medium-sized fish; while in the 1995–96 catch of 235,000 t contained hardly any large fish and was dominated by small fish.*' (see Fig. 3A).

However, SOFIA 2010 uses the term 'assemblage overfishing' to describe this phenomenon, as if to avoid mentioning a paper still viewed as inconvenient, and which described, based on FAO

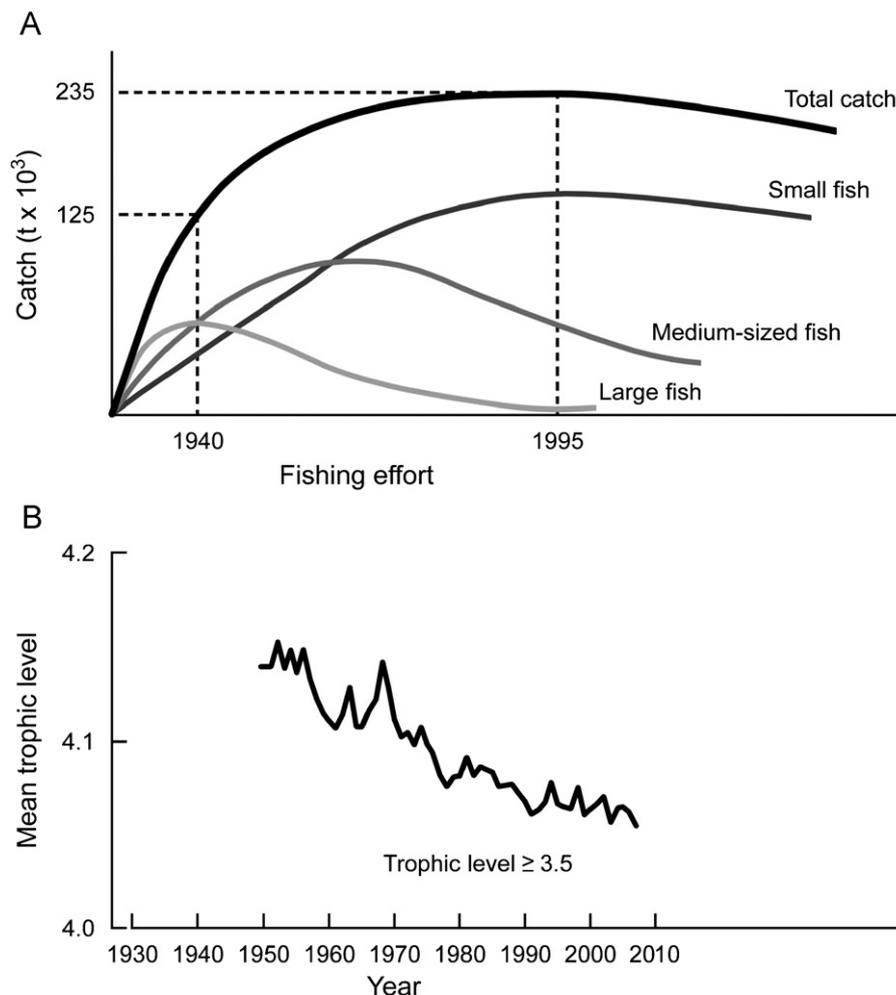


Fig. 3. 'Fishing down' as a ubiquitous phenomenon. (A) It occurs in exemplary fashion in the Tonlé Sap, Cambodia, and is labeled as such in local publications, but is referred to as "assemblage overfishing" in FAO ([1]; adapted from their Fig. 46). (B) It also occurs (as an unexplained phenomenon) in Fig. 2 [30], a paper supposed to show that the fishing down does not exist.

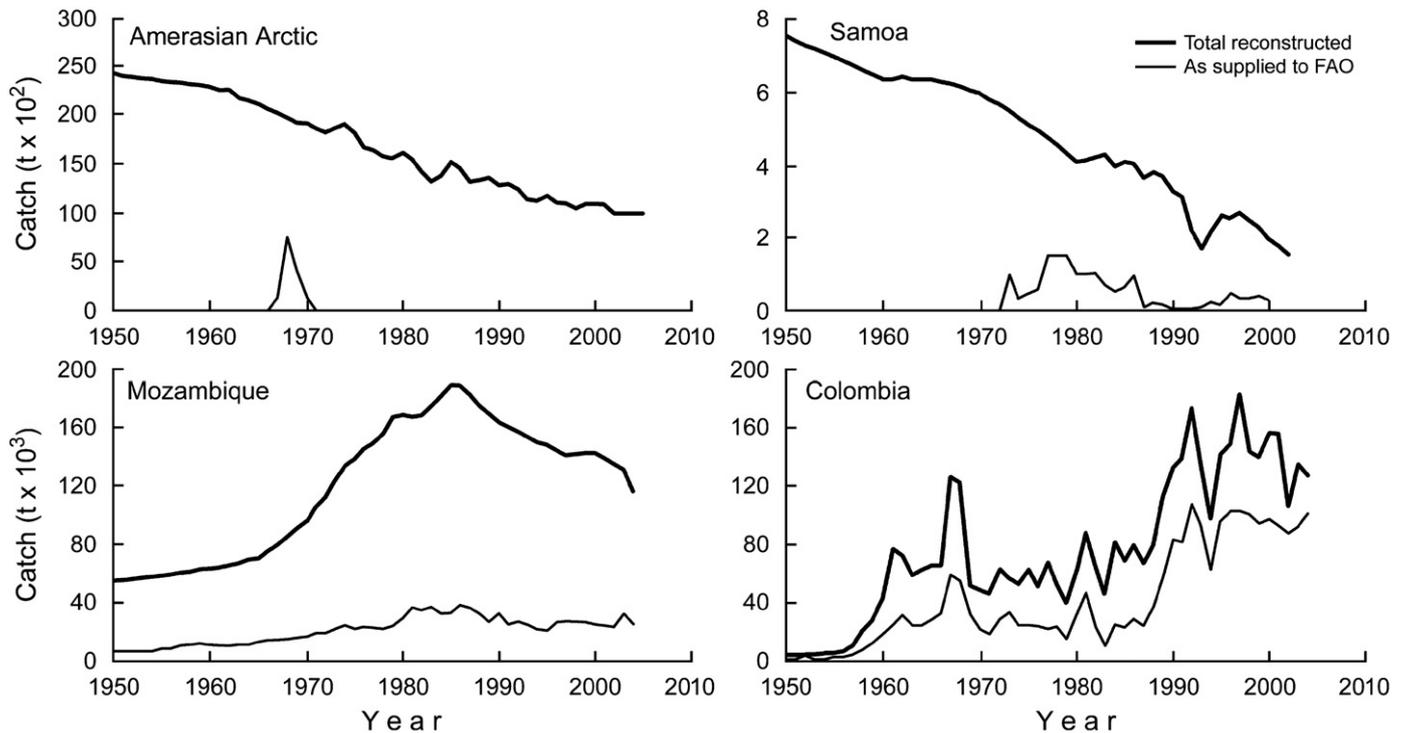


Fig. 4. Estimates of the marine catch for 4 countries or ecosystems, with thick black lines representing 'reconstructed' catch (i.e., estimates of actual catches) and the thin lines representing official catches (mostly the industrial catch) reported by the countries in question to FAO. Upper left: Amerasian Arctic, i.e., Northern Siberia (Russia), Arctic Alaska (USA) and Arctic Canada; based on [40]; upper right: Samoa (USA), based on [43]; lower left: Mozambique, based on [44]; lower right: Colombia, based on [45].

data, the ubiquitous occurrence of 'fishing down' ([4]; see also Fig. 3B).

There are colleagues who assert that this phenomenon does not even occur [8,30]. But FAO staff know better, given the wide scope of their experience, and in their comments on the paper, which first reported on the phenomenon [31], they stated 'We do not disagree that a general decline in mean trophic level of marine landings is likely to have occurred in many regions,' concentrating instead their critical comments on the potential sources of bias, which may affect one's view of the ubiquity and intensity of the phenomenon.

By renaming 'assemblage overfishing' a process, which colleagues with local expertise previously identified as 'fishing down' [25,32], the FAO headquarter staff who drafted SOFIA 2010 disconnected themselves from the lively community – in university and government laboratories worldwide – which has documented the widespread nature of this phenomenon and is engaged in a debate on how to overcome its perniciousness.

1.5. A worsening of the quality of capture fisheries statistics

Given the unique nature of the FAO catch data, it is extremely important that they are reliable. However, many of the FAO member countries submit data, which are of declining quality. Thus, FAO writes that '[a]s for other activities depending on public funding, it is possible that some schemes to collect national fishery data were cut or reduced owing to the global economic crisis. However, national administrations should consider as a priority maintaining data collection systems that, despite reduced budgets, would continue to enable reliable trend studies on national and international fishery production' [1].

One additional aspect of this quality problem is that the provision of these data to FAO is largely viewed as a chore in the ministries (often Ministries of Trade, or Agriculture) that are charged with filling the required FAO forms (see [33], for a slightly dated, but still funny account). However, another reason (and one about which

FAO can also do something), is that its staff do not consider involving non-government entities (environmental NGOs, universities, etc.) in the process of acquiring and/or analyzing these data [6].

Fig. 4 illustrates both the extent of the catch statistics reliability problem that FAO faces, and one approach to retroactively estimate total withdrawals from marine ecosystems, as required for ecosystem-based management. Also note, with regard to collaboration with non-government entities, that at least another U.N. technical organization – UNESCO – has a long tradition of working with non-governmental scientists and NGOs, to the benefit of all participating.

Such cooperation would also help to overcome the strange situation that SOFIA does not comment, while discussing data quality and what to do about it, on the fact that the *Sea Around Us* project [34] published, early enough for consideration in [1], 'catch reconstructions' (i.e., attempts at estimating time series of annual actual catch since 1950) for over 50 countries and territories (see e.g., [35–38]; see Fig. 3A–D), with most of these studies demonstrating that these countries and territories massively underreport their catches to the FAO.⁴

2. Discussion

In a section of their contribution titled 'FAO and the Government', the authors of [41] wrote that '[t]he FAO is responsible for

⁴ Several such papers here have been published since 2009, notably [39], which established that all countries bordering the Baltic Sea under-estimated their catch therein by about 35%, and [40], which demonstrated that FAO Area 18, comprising the northern Siberian coast, the northern coast of Alaska, and the Canadian Arctic featured near zero catches in the FAO database, although extensive, if declining small-scale fisheries occur in the area, but whose catch is not reported on by Russia, the US and Canada.

the collation of national statistics for assessing the status of fisheries, both inland and marine, at the national, regional and international scale. The organization relies on member countries to compile and submit national fisheries statistics. For information-poor countries [...], where statistical sampling have never been carried out at the national level, highly subjective assumptions are made about the status of fishery resources; [...] alternative data, often collected by foreign projects, subsequently met opposition or private derision from government counterparts as a result. The submission of often obviously wrong figures is a combination of a perceived obligation to FAO and reluctance to admit to the nature of the information collected [...]. Since these figures are published by FAO, the [...] government then reiterates and amends them. The result has been an increase in production [...], again based not on sampling but on perceptions'.

It appears that the mixture of catch over-reporting by a few countries, and serious under-reporting by most others, notably developing countries, which presently characterize FAO's global fisheries statistics, also mask a fundamental trend in world fisheries, i.e., the increasing appropriation of global fisheries resources by a few developed countries [2], and by China. If it holds, this hypothesis would have great consequences for food security, especially in developing countries. However, this hypothesis cannot be evaluated at present: the state of the only global database of fish catches in the world, FAO's Fishstat is just too unreliable, as illustrated by Fig. 4.

Given the present financial difficulties of public sector research, even when very applied (such as fisheries science), there is an urgent need for cooperation between institutions, e.g., U.N. technical organization and civil society, as represented by universities and non-government organizations. SOFIA 2010 illustrates this need particularly well. Hopefully, its next incarnation will reflect more of an engagement with the non-government institutions, even when, as is the case here, their comments are critical.

The message that comes out most clearly from SOFIA 2010 is the concern that the world fisheries are on dangerous course. This sober assessment is very different from the insouciance with which others [e.g., [8]] evaluate global fisheries.

There are, on the other hand, colleagues in universities and civil society who share FAO's concerns, and who could help document the cause for these concerns, and collaborate on identifying potential solutions. We hope that this will result in increased collaboration and overall, in more of the wisdom implied by SOPHIA.

Acknowledgments

Daniel Pauly acknowledges the support from the *Sea Around Us* project, a scientific collaboration between the University of British Columbia and the Pew Environment Group. The paper also benefited from numerous discussions with D. Zeller and other colleagues. Rainer Froese acknowledges support by the Future Ocean Excellence Cluster 80, funded by the German Research Foundation on behalf of the German Federal State and State Governments.

References

- [1] FAO. The state of the world fisheries and aquaculture. Rome: Food and Agriculture Organization of the United Nations; 2010.
- [2] Swartz W, Sumaila U, Watson R, Pauly D. Sourcing seafood from three major markets: the EU, Japan and the USA. *Mar Policy* 2010;34:1366–73.
- [3] FAO. Yearbook of catch and landing statistics. Rome: Food and Agriculture Organization of the United Nations; 1950.
- [4] Pauly D, Christensen V, Dalsgaard J, Froese R, Torres FC. Fishing down marine food webs. *Science* 1998;279:860–3.
- [5] Watson R, Pang L, Pauly D. The marine fisheries of China: development and reported catches. Fisheries Centre Research Report. Vancouver, B.C.: University of British Columbia; 2001 [p. 50].
- [6] Pauly D. Five easy pieces: how fishing impacts marine ecosystems. Washington, D.C.: Island Press; 2010.
- [7] Hilborn R. Reinterpreting the state of fisheries and their management. *Ecosystems* 2007;10:1362–9.
- [8] Hilborn R. Apocalypse forestalled: why all the world's fisheries aren't collapsing. *Sci Chronicles (Nat Conservancy)* 2010;5–9.
- [9] Beverton RJH, Holt SJ. On the dynamics of exploited fish populations. Fisheries investigations, Series 2. London: H.M. Stationary Office; 1957.
- [10] Ricker WE. Computation and interpretation of biological statistics of fish populations. *Bull Fish Res Board Can* 1975;191:382.
- [11] Hilborn R, Walters C. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. London: Chapman & Hall; 1992.
- [12] Ludwig D, Hilborn R, Walters C. Uncertainty, resource exploitation, and conservation: lessons from history. *Science* 1993;260:17–8.
- [13] Duffy JE. The future of marine fish resources. *AIBS Action BioSci* 2009.
- [14] Froese R, Proelß A. Rebuilding fish stocks no later than 2015: will Europe meet the deadline? *Fish Fish* 2010;11:194–292.
- [15] Worm B, Hilborn R, Baum JK, Branch TA, Collie JS, Costello C, et al. Rebuilding global fisheries. *Science* 2009;325:578–85.
- [16] Branch TA. Not all fisheries will be collapsed in 2048. *Mar Policy* 2008;32:38–9.
- [17] Worm B, Barbier EB, Beaumont N, Duffy JE, Folke C, Halpern BS, et al. Impacts of biodiversity loss on ocean ecosystem services. *Science* 2006;314:787–90.
- [18] FAO. The state of world fisheries and aquaculture. Rome Food and Agriculture Organization of the United Nations; 2008 [p. 176].
- [19] Watson R, Pauly D. Systematic distortions in world fisheries catch trends. *Nature* 2001;414:534–6.
- [20] FAO. The state of the world fisheries and aquaculture. Rome: Food and Agriculture Organization of the United Nations; 2002.
- [21] Thurow L. A Chinese century? Maybe it's the next one. *The New York Times* New York: New York Times Company; 2007.
- [22] Bason A. Chinese data 'man-made': leaked cable shows now vice premier calling local data unreliable. *The Wall Street Journal*. New York City: Dow Jones and Company; 2010.
- [23] Pang L, Pauly D. Part 1 Chinese marine capture fisheries from 1950 to the late 1990s: the hopes, the plans and the data. In: Watson R, Pang L, Pauly D, editors. The marine fisheries of China: development and reported catches Fisheries Centre Research Report. Vancouver, B.C.: University of British Columbia; 2001.
- [24] Bhathal B, Pauly D. 'Fishing down marine food webs' and spatial expansion of coastal fisheries in India, 1950–2000. *Fish Res* 2008;91:26–34.
- [25] Lambert D. The Tonlé Sap lake as a productive ecosystem. *Int J Water Resour Dev* 2006;22:481–95.
- [26] Welcomme RL. Principles and approaches for river fisheries management. In: Cowx I, editor. Management and ecology of river fisheries. Oxford: Blackwell; 2000.
- [27] Pinsky ML, Jensen OP, Ricard D, Palumbi SR. Unexpected patterns of fisheries collapse in the world's oceans. *PNAS (Proc Nat Acad Sci USA)* 2011.
- [28] Pauly D. Five easy pieces: how fishing impacts marine ecosystems. Washington, D.C.: Island Press; 2010.
- [29] Pauly D. Focusing one's microscope. *Sci Chronicles (Nat Conservancy)* 2011;4–7.
- [30] Branch TA, Watson R, Fulton EA, Jennings S, McGilliard CR, Pablico GT, et al. The trophic fingerprint of marine fisheries. *Nature* 2010;468:431–5.
- [31] Caddy JF, Csrke J, Garcia SM, Grainger RJ. How pervasive is "Fishing Down Marine Food Webs?" *Science* 1998;282:1383a.
- [32] Van Zalinge N. Data requirements for fisheries management in the Tonlé Sap. New approaches for the improvement of inland capture fishery statistics in the Mekong Basin—ad-hoc expert consultation. Charoen Sri Grand Royal Hotel Udonthani, Thailand: RAP Publication; 2003 [p. 68–75].
- [33] Mariott SP. Notes on the completion of the FAO form Fishstat NS1 (National Summary). *Fishbyte (ICLARM)* 1984;2:7–8.
- [34] Pauly D. The Sea Around Us Project: documenting and communicating global fisheries impacts on marine ecosystems. *AMBIO: J Hum Environ* 2007;34:290–5.
- [35] Zeller D, Booth S, Davis G, Pauly D. Re-estimation of small-scale for U.S. flag-associated islands in the western Pacific: the last 50 years. *Fish Bull* 2007;105:266–77.
- [36] Zeller D, Pauly D. Reconstruction of marine fisheries catches for key countries and regions (1950–2005). Fisheries Centre Research Reports. Vancouver, B.C.: University of British Columbia; 2007.
- [37] Zeller D, Harper S. Fisheries catch reconstructions: islands, part I. Fisheries Centre Research Report. Vancouver, B.C.: University of British Columbia; 2009.
- [38] Harper S, Zeller D. Fisheries catch reconstruction: islands, part II. Fisheries Centre Research Reports. Vancouver, B.C.: University of British Columbia; 2011 [p. 143].
- [39] Zeller D, Rossing P, Harper S, Persson L, Booth S, Pauly D. The Baltic Sea: estimates of total fisheries removals 1950–2007. *Fish Res* 2011;108:356–63.
- [40] Zeller D, Booth S, Pakhomov E, Swartz W, Pauly D. Arctic fisheries catches in Russia, USA and Canada: baselines for neglected ecosystems. *Polar Biol* 2011.
- [41] Bush SR, Hirsh P. Framing fishery decline. *Aquat Resour, Cult Dev* 2005;1:79–90.

- [42] Anticamara JA, Watson R, Gelchu A, Pauly D. Global fishing effort (1950–2010): trends, gaps, and implications. *Fish Res* 2011;107:131–6.
- [43] Zeller D, Booth S, Craig P, Pauly D. Reconstruction of coral reef fisheries catches in American Samoa 1950–2002. *Coral Reefs* 2006;25:144–52.
- [44] Jacquet J, Fox H, Motta H, Ngusaru A, Zeller D. Few data but many fish: marine small-scale fisheries catches for Mozambique. *Afr J Mar Sci* 2010;32:197–206.
- [45] Wielgus J, Zeller D, Caicedo-Herrera D, Sumaila UR. Estimation of fisheries removals and primary economic impact of the small-scale and industrial marine fisheries in Colombia. *Mar Policy* 2010;34:506–13.