

Chapter 12

The Making of a Global Marine Fisheries Catch Database for Policy Development

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12.1 INTRODUCTION

The world oceans are beleaguered by three major stressors: (i) global warming and the attendant deoxygenation and acidification; (ii) pollution by plastics; and (iii) the industrial-scale extraction of their larger organisms, also known as “fishing.” Items (i) and (ii) are dealt with here only as they relate to fishing, which for the last few centuries has been (Roberts, 2007) and still is the main driver of global change in marine ecosystems, and which also reduces their resilience and responses to the other two stressors.

Fishing impacts the oceans directly by generating a catch (i.e., by extracting and killing animals via a variety of fishing gears), which can be landed ashore (landings) and marketed, or is thrown overboard (discards), or which remains underwater (“ghost fishing” by lost and abandoned fishing gear, and “underwater mortality” of catch that escapes the deployed fishing gear).

Indirect effects of fishing include genetic modifications of the fished species via natural selection pressures imposed by fishing (Fraser, 2013; Mee, Otto, & Pauly, 2017; Palkovacs, 2011), and habitat modifications, notably by active bottom-contact gears such as trawlers (Chuenpagdee, Morgan, Maxwell, Norse, & Pauly, 2003; Hermesen, Collie, & Valentine, 2003; Trush & Dayton, 2002; Watling & Norse, 1998), and loss or abandonment of fishing gear. Gear abandonment, jointly with our propensity to mindlessly throw away plastic bags and other nonbiodegradable items, has created new, plastic-dominated ecosystems (e.g., “Plastisphere,” Zettler, Mincer, & Amaral-Zettler, 2013) in the ocean (Gross, 2015; Law, 2017; Sherman & van Sebille, 2016; Item (ii) above). This is also clearly illustrated by the population explosion of sea striders (*Halobates sericeus*), which is, to our knowledge, the only multicellular organism known to benefit from floating plastics (Goldstein, Rosenberg, & Cheng, 2012).

Fisheries catch that is landed (i.e., landings) is used either for direct human consumption, as animal feed for industrial feed stock production (Cashion, Le Manach, Zeller, & Pauly, 2017), or is lost to spoilage (Opara, Al-Jufaili, & Rahman, 2007). In addition, industrial fishing (i.e., large-scale fishing) is responsible for much of the world’s discarded catch (Zeller, Cashion, Palomares, & Pauly, 2018) and for the majority of landings not used for direct human consumption (Cashion et al., 2017). Furthermore, industrial, large-scale fisheries are also responsible for much of the environmental impacts alluded to above.

Policies to tackle the fisheries issues listed here on a global or regional basis need to be developed. The key to formulating such policies in the first place are estimates of the scope of the problem at hand and their distribution and intensity in space and time (Pauly, 2016b; Pauly & Zeller, 2016a; Zeller et al., 2016; Zeller & Pauly, 2016).

12.2 THE FAO GLOBAL CATCH (LANDINGS) DATABASE

The Food and Agriculture Organization of the United Nations (FAO) has created and maintains a global database of fisheries “catches” based on annual voluntary data submissions by member countries. In principle, the FAO database should provide key numbers for dealing with these fisheries and related equity and food security issues. Unfortunately, despite the optimistic title in Garibaldi (2012), the FAO “catch” database does not. Thus,

1. the FAO fisheries statistics refer to landings only, that is, discarded fish is explicitly excluded (Pauly & Zeller, 2017a,b), not to mention fish killed by ghost fishing (e.g., Bullimore, Newman, Kaiser, Gilbert, & Lock, 2001; Poon, 2005);
2. much of the catch of small-scale commercial (artisanal) fisheries is not included (Pauly & Zeller, 2016a);

3. the catch of subsistence fishers is largely omitted from the statistics of almost all countries that have such fisheries (Zeller, Harper, Zylich, & Pauly, 2015);
4. catches made by Aboriginal fishers throughout most of the world are also largely missing in the statistics submitted by member countries (Cisneros-Montemayor, Pauly, Weatherdon, & Ota, 2016; Zeller, Booth, Pakhomov, Swartz, & Pauly, 2011);
5. recreational catches are (despite being requested by FAO) generally not included in marine capture statistics reported by countries to FAO (Smith & Zeller, 2016; Pauly & Zeller, 2016a), although exceptions exist (e.g., Finland, Zeller et al., 2011). This may be in contrast to freshwater fisheries (i.e., inland catch statistics), where some regions, for example, Europe, do seem to include recreational catch data (Bartley, De Graaf, Valbo-Jørgensen, & Marmulla, 2015); and
6. geographically, the landings data are reported and presented by 19 very large FAO statistical areas (e.g., ranging from Bangladesh to the Antarctic Convergence in the Indian Ocean), whose sizes preclude ecosystem-based fisheries evaluations and whose nonconsideration of “fisheries-political” boundaries (i.e., Exclusive Economic Zones) ignores management and policy relevance for extractive resource control and responsibility.

These deficiencies, with the possible exception of Item (1), are not FAO’s fault; rather, they are due to the data its member countries annually supply to FAO (see also Pauly & Zeller, 2017a, 2017b). In fact, the point here is not to blame anyone for these deficiencies, which are largely founded in the historic developments of global and national data collections systems after WWII (Ward, 2004). These developments focused almost exclusively on market-development and cash-economy principles, rather than the ecosystem and sustainability considerations that are emphasized in many national and especially global policy environments these days (Griggs et al., 2013). These guiding principles for data reporting seem to have not changed much in national and international data systems, and thus partially explain the predominance of commercial and especially industrial and export-oriented catch data in official data records. Most countries have difficulties monitoring their nonindustrial fisheries, which are widely dispersed and rural based, and often outside the reach of government enumerators (see also Zeller et al., 2015). Instead, we describe here the creation of a global database that builds on that created and maintained by FAO, but addresses the deficiencies in (1)–(5).

12.3 THE SEA AROUND US CATCH DATABASE

The development of the *Sea Around Us* global catch database, which took much of the 2000s and early 2010s to complete, was undertaken by the staff of the *Sea Around Us*, a research initiative at the University of British Columbia that aims to research, document, and communicate the effects of fishing on the marine ecosystems of the world, and to propose mitigating solutions (Pauly, 2007). This ambitious project could only be achieved with the assistance of a large global network of local fisheries scientists who provided key insights, knowledge, and data sets, and who completed national reports that followed a basic standard that was set by the authors of this contribution (Zeller & Pauly, 2016; Pauly, 2016b). These standards were as follows:

1. the period covered must be 1950–2010 (recently updated to 2014);
2. the fisheries covered must include both large-scale (i.e., industrial) and small-scale sectors, the latter consisting of artisanal, subsistence, and recreational sectors;
3. for every existing fishery, a catch estimate must be available or derived, including separately identified discards if discarding occurs;
4. illegal and other traditionally unreported fisheries must also have a (conservative) catch estimate;
5. ideally, no more than about 10% of the total domestic catch should consist of “miscellaneous fish” or other similarly uninformative categories (i.e., the catch must be taxonomically disaggregated); and
6. to ensure that the catch time series estimates are as independent from each other as possible, items (1)–(5) should preferably be based on data and information from the country in question, that is, not based on ratios or numbers from other countries or regional or global studies.

We call the processes involved in standards (1)–(6) and the results from it “catch reconstructions” (Zeller, Booth, Davis, & Pauly, 2007; Zeller et al., 2016; Zeller & Pauly, 2016). Catch reconstructions (a seven-step technical process, Fig. 12.1; Zeller et al., 2016) may be seen as impossible to perform for some countries or territories for which “there are no data,” as the phrase goes (Zeller & Pauly, 2016). However, we could demonstrate to those of our collaborators who initially believed that *dictum* that, in fact, for almost any country in the world (even for seemingly impossible cases such as North Korea, Shon, Harper, & Zeller, 2014), there is a substantial amount of data and information on the fisheries and related sectors, in libraries, archives, and on the Internet. One simply has to be willing to also look outside of conventional fisheries catch data sources.

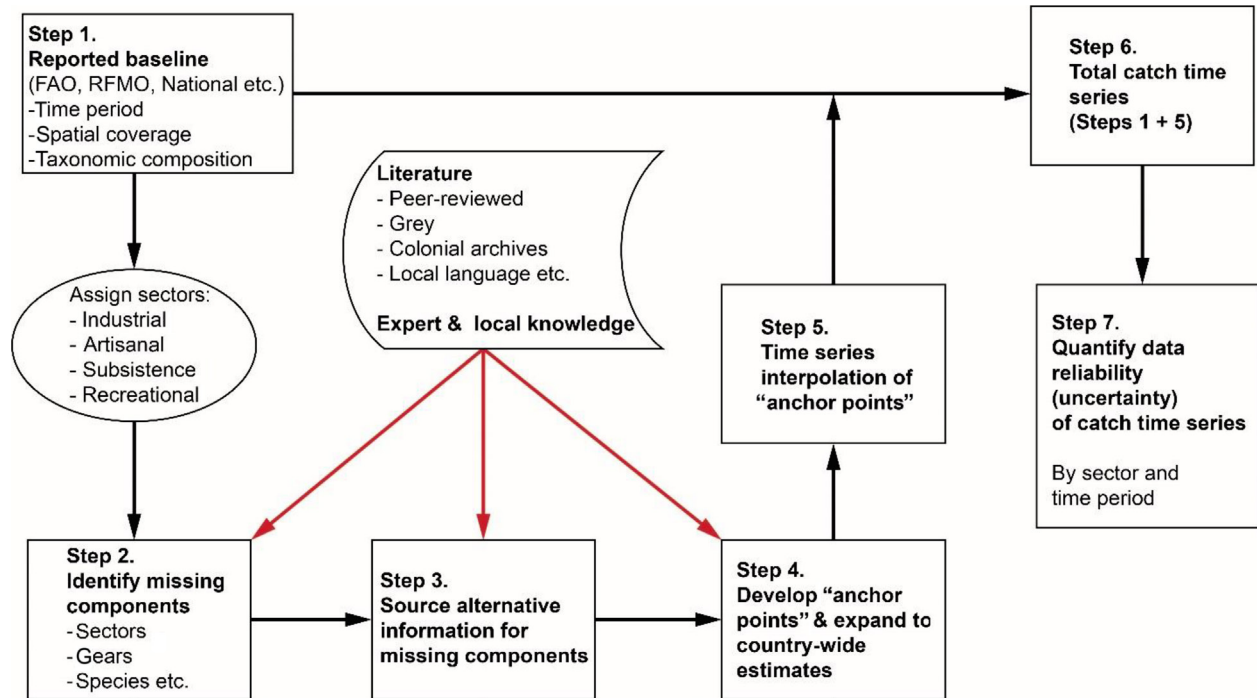


FIG. 12.1 Flowchart illustrating the seven-step catch reconstruction approach for marine fisheries data as first described in Zeller et al. (2007) after original implementation in Zeller, Booth, Craig, and Pauly (2006) and further refined and detailed in Zeller et al. (2016). Graph modified from Zeller, D., Palomares, M. L. D., Tavakolie, A., Ang, M., Belhabib, D., Cheung, W. W. L., et al. (2016). *Still catching attention: Sea Around Us reconstructed global catch data, their spatial expression and public accessibility*. Marine Policy, 70, 145–152.

The reason for this is that fishing is a social activity and, as such, will always impact the other sectors of the economy and society of a country or territory within which the fishery is embedded (Pauly, 1998a, 2016b). Thus, one can use indirect sources (i.e., nonfishery sources) to help infer the scale of nonreported catches. For example, household surveys to infer noncommercial fish consumption in small island states (Zeller et al., 2006, 2007, 2015), or newspaper articles about illegal vessels being apprehended to infer the presence of foreign fleets (e.g., Pauly et al., 2014).

The reconstruction work itself was accomplished over a period of nearly 15 years. However, the six “standards” above were formulated first in the context of a consultancy for the US Western Pacific Regional Fishery Management Council (Zeller, Booth, & Pauly, 2005), which led to reconstructions for Hawai’i and US flag territories in the Pacific (Zeller et al., 2006, 2007; Zeller, Darcy, Booth, Lowe, & Martell, 2008).

Other special reconstruction projects were conducted, for example, Arctic Alaska for the Lenfest Foundation (Booth & Zeller, 2008; Zeller, Booth, et al., 2011); Baltic Sea countries for the *Baltic 2020 Foundation* (Zeller, Rossing, et al., 2011), several East Africa countries for WWF (Jacquet, Fox, Motta, Ngusaru, & Zeller, 2010; Jacquet & Zeller, 2007a, 2007b), Pakistan for the FAO Regional Office (Hornby, Moazzam, Zylich, & Zeller, 2014), or countries surrounding the Bay of Bengal for the *Bay of Bengal Large Marine Ecosystem (BOBLME) Project* supported by the FAO (Harper, O’Meara, Booth, Zeller, & Pauly, 2011; Kleisner & Pauly, 2011). However, the bulk of the reconstructions was (a) those performed by staff of the *Sea Around Us* (e.g., Bultel, Gascuel, Le Manach, Pauly, & Zylich, 2015; Bultel, Le Manach, Ulman, & Pauly, 2015; Divovich, Belhabib, Zeller, & Pauly, 2015; Divovich et al., 2015; Harper & Zeller, 2011; Harper et al., 2012; Sobolevskaya & Divovich, 2015; Zeller & Harper, 2009, and many more, all accessible at www.seaaroundus.org) and MSc and PhD students of the first author (e.g., Al-Abdulrazzak & Pauly, 2013; Al-Abdulrazzak, Zeller, Belhabib, Tesfamichael, & Pauly, 2015; Bhathal & Pauly, 2008; Schiller, Alava, Grove, Reck, & Pauly, 2015; Tesfamichael & Pauly, 2016), with almost all of these activities generously supported by The Pew Charitable Trusts and (b) those performed by numerous colleagues around the world who could be convinced of the value of a reconstruction for their country and of contributing to a global project (e.g., Inés Lorenzo, Defeo, Roshan Moniri, & Zylich, 2015; Mendoza, 2015; Moutopoulos, Tsikliras, & Stergiou, 2015; Villasante et al., 2015).

This part of the work was extremely rewarding, if at times challenging, as it involved colleagues collaborating across seemingly insurmountable borders, for example, the reconstructions for Israel and the Gaza Strip, whose catches had been misassigned in the years during which the Gaza Strip was occupied by Israel (Abudaya, Harper, Ulman, & Zeller, 2013;

Edelist et al., 2013), or the reconstruction for the island of Cyprus, whose official catch had not included North Cyprus since the 1974 invasion by Turkey (Ulman et al., 2013, 2015). Another problem was that of the opacity of dictatorial regimes, surmounted, for example, by Belhabib, Hellebrandt da Silva, Allison, Zeller, and Pauly (2016) for Equatorial Guinea, or North Korea, when a Korean speaking staff of the *Sea Around Us* discovered that the South Korean government has a special department devoted to shadowing the North Korean economy, including its fisheries (Shon et al., 2014). This last example also illustrates the still important role of languages other than English in assembling global data sets (Zeller et al., 2016, including supplementary materials; Zeller & Pauly, 2016), a fact that is neglected by many US- and UK-based research groups.

Also important is that the colleagues in (b) were not offered and did not receive monetary incentives. Indeed, if this global project had been performed via consultants (as many global reviews are, for example, by the World Bank, the FAO, or the OECD), it would have been so costly as to be impossible to fund. Rather, it was conducted as a scientific activity whose rewards were expressed in the currency of science, that is, recognition through publications. This is the reason why each reconstruction for a country or territory was published first as a *Fisheries Centre Working Paper* (e.g., Gibson, Froese, Ueberschaer, Zylich, & Zeller, 2015; Harper, Frotté, Booth, Veitch, & Zeller, 2015; Jeanel, Ramdeen, Zylich, & Zeller, 2015; Miller & Zeller, 2013; Persson, Lindop, Harper, Zylich, & Zeller, 2014) or a chapter in a *Fisheries Centre Research Reports* (e.g., Doherty, Herfaut, Le Manach, Harper, & Zeller, 2015; Greer, Harper, Zeller, & Pauly, 2012; Lingard et al., 2012; Luckhurst, Booth, & Zeller, 2003; Ramdeen, Zylich, & Zeller, 2014) or other reports (Booth, Zeller, & Pauly, 2008; Carreras, 2014; Harper, O'Meara, Booth, Zeller, & Pauly, 2011). Thereafter, in updated and improved form, they can be published in the primary literature (e.g., Abudaya et al., 2013; Edelist et al., 2013; Greer, Harper, Zeller, & Pauly, 2014; Jacquet et al., 2010; Piroddi et al., 2015; Zeller et al., 2015). Indeed, of the over 200 individual reconstructions covering 273 EEZs, over 100 EEZ reconstructions for over 80 countries (i.e., nearly 40%) are, as of this writing (March, 2017), published in peer-reviewed journals. This makes the catch data they contain and the website that presents them in an interactive form (see www.seaaroundus.org) a formidable source of information on marine fisheries (Pauly, 2016a).

12.4 OUTPUT FROM THE SEA AROUND US GLOBAL CATCH DATABASE

This global catch database, which we make freely available to all users (Zeller et al., 2016), is the amalgamation of many individual reconstructions (see Fig. 12.2 for some examples for countries often overlooked). This database permits examination and data analyses of global fisheries in an ecosystem setting by all interested parties, and thus is a step toward moving fisheries policy from the more “exclusive” resource policy framework many fisheries have operated under in the past toward a more “inclusive” public policy environment (Zeller & Pauly, 2004). Based on this database, we published an article in January 2016 whose title gives its main results: “*Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining*” (Pauly & Zeller, 2016a). Thus, by summing the catches from the over 200 reconstructions for 273 EEZ pieces, plus a global “large pelagic” catch data set, we found that the world’s marine catch over the last 60+ years was about 50% higher than officially reported. Importantly, we also demonstrated that this catch has been declining since 1996—which is also the time when FAO’s reported marine landings begin to decline, although at a lower rate than reconstructed catches (Fig. 12.3). The reaction to these results is worth discussing in some detail, as it illustrates how different audiences respond to scientific results that have substantial policy implications.

12.5 RESPONSES TO FINDINGS FROM THE SEA AROUND US GLOBAL CATCH DATA

There were a large number of newspaper articles (e.g., *The Washington Post*: Why we have been hugely underestimating the overfishing of the oceans¹; *The Guardian*: We knew fish catches were high. But it's much worse than we thought²; *Le Monde*: La surpêche et le déclin des ressources ont été largement sous-estimés³), which triggered numerous emails sent by lay persons to the authors. In retrospect, we think that it was not so much the decline of the catch which attracted attention (although this is a sign of overfishing when combined with increasing fishing effort, of which we did not speak, however). Rather, it was because reporting higher catches than officially reported was perceived as an indication of overfishing, which it is not.

1. https://www.washingtonpost.com/news/energy-environment/wp/2016/01/19/why-weve-been-hugely-underestimating-the-overfishing-of-the-oceans/?utm_term=.5b195e88d1c5.

2. <https://www.theguardian.com/commentisfree/2016/jan/21/fish-stocks-low-worse-official-figures>

3. http://www.lemonde.fr/biodiversite/article/2016/01/19/le-declin-de-la-peche-a-ete-largement-sous-estime_4849986_1652692.html

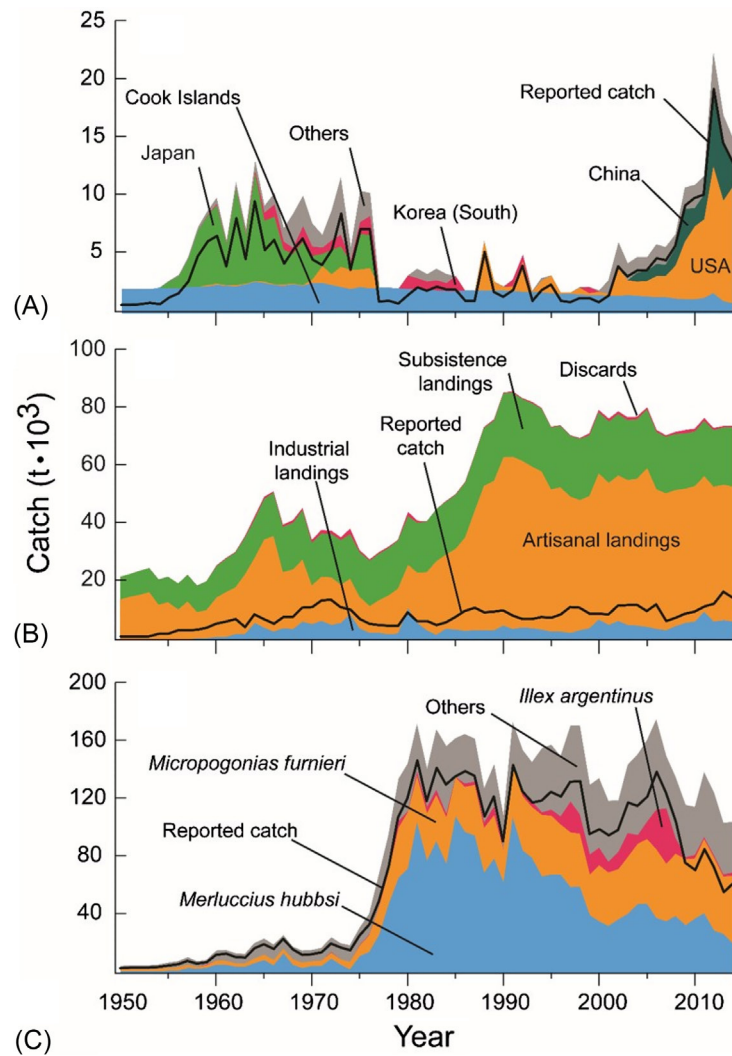


FIG. 12.2 Examples of the domestic and foreign catches taken in the Exclusive Economic Zones (EEZ) of (A) the Cook Islands in the Pacific, shown by fishing country; (B) Benin in West Africa, shown by fishing sector plus discards; and (C) Uruguay in South America, shown by major species. The data represent the reconstructed data for each country, plus the foreign catches as allocated to each EEZ using the *Sea Around Us* global catch allocation procedure described in Zeller et al. (2016). Overlaid over each graph as a line graph (black) are the data deemed reported by each country involved in each EEZ fishery. Data for all countries in the world (data available by various geographies) are freely available for downloading at www.seaaroundus.org.

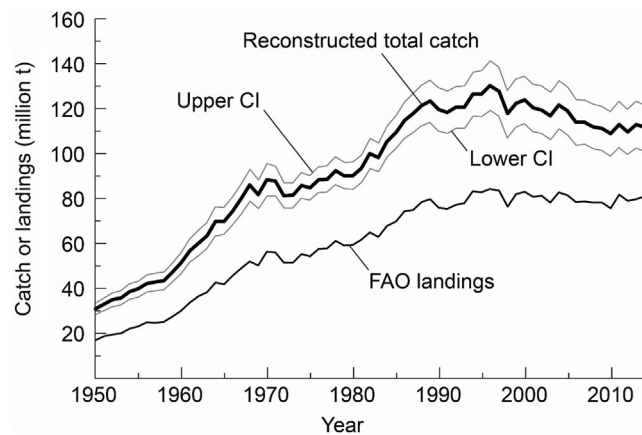


FIG. 12.3 Global marine fisheries catch (1950–2014) as reported by the FAO based on the submission of its member countries (without confidence intervals and excluding plants, corals, sponges, reptiles, and marine mammals) and as based on the sum of the national catch reconstructions performed or inspired by the *Sea Around Us* (Pauly & Zeller, 2016a, 2016b). The confidence intervals for the latter time series (gray lines), 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 (Pauly & Zeller, 2016c, 2017b).

The reception by the scientific community was overall positive, as assessed by the speed at which our article began to accumulate citations in the scientific literature (see Article Metrics at www.nature.com/articles/ncomms10244/metrics, and over 90 citations within the first year of publication, see Google Scholar). Obviously, there were the perennial critics of everything we do, but they do not carry as much influence as before, notably since their strong links to the fishing industry have been uncovered.

However, the most baffling response was that of FAO, which instead of recognizing the new database as what it is—namely, a complement to their laudable efforts of reporting on the world’s fisheries within the constraints of the UN system, and with the countries subjected to their own personnel and budget constraints—seemed to perceive the *Sea Around Us* database and the ensuing interpretation of these data (e.g., [Pauly & Zeller, 2017a](#)) as a direct challenge to FAO’s position as provider of global fisheries data ([Ye et al., 2017](#)). Thus, besides numerous points we never disputed and fully agree upon, FAO states in [Ye et al. \(2017\)](#), for example, “[FAO] datasets are the best they can possibly be,” and *Sea Around Us* uses “some magical method” to estimate unreported catches. Such absolutist and “imaginary” terminology from an organization that is supposed to be a global leader in fisheries data and facilitator of global fisheries policy is disconcerting.

Our rejoinder ([Pauly & Zeller, 2017b](#)) to the commentary by FAO attempts to correct this impression and apparent misunderstanding. We assume that this situation will improve with time and as more and more researchers work with the *Sea Around Us* database, learn about it, and, in the process, provide feedback which will improve it. This is how FishBase, the online encyclopedia on fishes (www.fishbase.org) which, incidentally, is used to verify the taxonomy in the *Sea Around Us* database, has now become the trusted reference it is.

Ultimately, however, it is the countries themselves, driven by their national fisheries data specialists and national fisheries departments, that must recognize the implications of the holes in their national data and initiate the process to comprehensively fill these. In this, FAO ([Ye et al., 2017](#)) and the *Sea Around Us* ([Pauly & Zeller, 2017a, 2017b](#)) are in complete agreement. Also important in this context is the crucial requirement for retroactive corrections to national data back to 1950 to ensure that historic catch baselines are comprehensive and avoid the currently existing “presentist bias” ([Zeller & Pauly, 2018](#)).⁴ It is such baselines, together with ancillary data such as fishing effort trends over time, that allow comprehensive examinations of fisheries trends over time, which need to inform future policies. In order for such actions to be taken on by the generally understaffed and underresourced national fisheries and statistical departments, we call upon the NGO community, as a key stakeholder representing the interest of the general public and especially of future generations, to take on the task of using information and knowledge gleaned from catch reconstructions as impetus to move countries toward more comprehensive accounting of all fisheries catches (including retroactive corrections) and the resultant policy implications ([Pauly & Zeller, 2016a, 2016c](#)).

In the following, to assist user feedback that will lead to improvements of the *Sea Around Us* data, we summarize some of the content of the *Sea Around Us* database and website, as described in more detail in [Zeller et al. \(2016\)](#).

12.6 CATCH TIME SERIES

The *Sea Around Us* database provides catch data for the Exclusive Economic Zones (or part thereof) of all maritime countries of the world and their overseas territories, a total of 273 individual entities, and for the high seas (i.e., Areas Beyond National Jurisdiction, ABNJ) by large ocean areas.

These annual catch data, currently covering the years 1950 to 2014, have been allocated to 180,000 half-degree longitude/latitude cells ([Zeller et al., 2016](#)), enabling catches to be regrouped into a variety of other geographies. Thus, our website also allows these data to be presented by 66 Large Marine Ecosystems ([Pauly et al., 2008](#)), by the 19 FAO marine statistical areas or by areas covered by Regional Fisheries Organizations (RFMOs, [Cullis-Suzuki & Pauly, 2010](#)). Other geographies are under consideration, such as marine ecoregions ([Spalding et al., 2007](#)) or climate zones ([Pauly, 1998b](#)), and we welcome further suggestions for geographies with global reach that may be of interest.

The catch data time series are visualized geographically on our website by several data types (the downloadable data contain all data types and parameters in full hierarchical combination):

- (1) Taxonomically disaggregated; 10 taxa is the default, but they are also viewable with a resolution of 5, 15, and 20 items (any more would make the web visuals unwieldy). The downloadable data include, however, the full taxonomic diversity, that is, often hundreds of taxa per EEZ;

4. The term “presentist bias” (overemphasizing “the present” vis-à-vis “the past”) describes the bias introduced by the 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 nonreporting of such catches in earlier years. This effect contributes to inconsistent historic baselines.

- (2) By fishing country, that is, which country was deemed to catch how much in the given EEZ. Foreign catches have higher uncertainty than the reconstructed domestic catches (Zeller et al., 2016). Furthermore, for years prior to a given EEZ's year of declaration (legal establishment), the waters are deemed high seas waters with unrestricted open access;
- (3) By "catch type," that is, whether the catch is landed or discarded. This accounts for the discards that the FAO database does not include;
- (4) By reporting status, that is, whether the country and/or the FAO report that specific catch component, or not. The catch difference (usually a positive quantity) is due to the reconstruction; and, most importantly
- (5) Catch by fisheries sector, that is, differentiating between two commercial sectors, industrial (large-scale) and artisanal (small-scale) commercial fishing, and two noncommercial small-scale sectors, subsistence and recreational fishing.

This degree of detail, particularly items (1) and (5), is we think, what will make the database most useful to scholars studying fisheries systems, and to NGO staff working to change their mode of operation or governance.

We have plans to add to this several new data types, notably

- (1) catch by their end use, that is, either for direct human consumption or for other uses such as fishmeal or as direct feed (Cashion et al., 2017);
- (2) catch by fishing gear types, enabling the identification of the fraction of the world's maritime catch originating from trawlers, which are highly unselective and destructive of sea floor habitats; and
- (3) catch by lost gear, that is, ghost fishing, which can be sizeable (Bullimore et al., 2001; Poon, 2005) but which has, to our knowledge, never been estimated on a global basis, and whose catches are currently not included in the *Sea Around Us* data.

Note that all catches can not only be expressed in tonnes (metric tons) as the default but also as landed value in 2010 US dollars, using ex-vessel prices first derived by Sumaila, Marsden, Watson, and Pauly (2007) and updated by Swartz, Sumaila, and Watson (2013).

12.7 CATCH-BASED INDICATORS

A number of indicators on the status of fisheries and/or the ecosystems in which they are embedded can be derived from catch data alone (e.g., Froese, Zeller, Kleisner, & Pauly, 2012; Kleisner, Mansour, & Pauly, 2014; Kleisner, Zeller, Froese, & Pauly, 2013; Pauly, 2016b). The following indicators are automatically computed and presented from the catch data in the *Sea Around Us* database and are recomputed every time these data are updated and/or corrected:

- Stock-status plots, which show the trends over time in the fraction of stocks (see Fig. 12.4A for an example), and the fraction of the catch originating from stocks (Fig. 12.4B) of a given stock status (or fisheries development category), as inferred from the trend of their catch time series (Froese et al., 2012, 2013; Kleisner et al., 2013).
- Multinational footprint, which is based on a concept first presented by Pauly and Christensen (1995), presents time series of the fraction of the primary production of a given geographic entity (e.g., EEZ) that is appropriated by the biomass of fish represented in the catch of the fleets of different countries fishing in the given geographic entity (e.g., EEZ; Fig. 12.5).
- The Marine Trophic Index (MTI, the mean trophic level of the catch; Pauly, Christensen, Dalsgaard, Froese, & Torres, 1998) and two related indicators (Fig. 12.6).
 - the FiB index roughly quantifies the spatial expansion of the fisheries in the geographic entity in question (Bhathal & Pauly, 2008). The FiB index should always be cointerpreted in conjunction with the MTI; and
 - the RMTI (R=regional) consists of time series of the mean trophic level of catches in roughly parallel segments of a coastline, from inshore to offshore (Kleisner et al., 2014). The RMTI essentially combines the concepts of the MTI and FiB indices into one indicator, thus easing the interpretation of changes in trophic level in the catch (MTI) combined with spatial expansion (FiB).

The website also offers, for EEZs and other geographies, access to biodiversity information for fishes (i.e., finfishes) provided by FishBase (www.fishbase.org) and for no-fish marine life provided by SeaLifeBase (www.sealifebase.org). This can include all taxa in a given area, or only the pelagic or reef taxa, or the threatened taxa as derived from the IUCN Red List.

Finally, the website provides access to other relevant databases, for example, to EcoBase (Colléter et al., 2013, 2015), which contains the overwhelming bulk of the Ecopath and Ecosim models of marine ecosystems published to date, and to a database on estuaries (Alder, 2003). Furthermore, our website also provides access to information pertaining to the

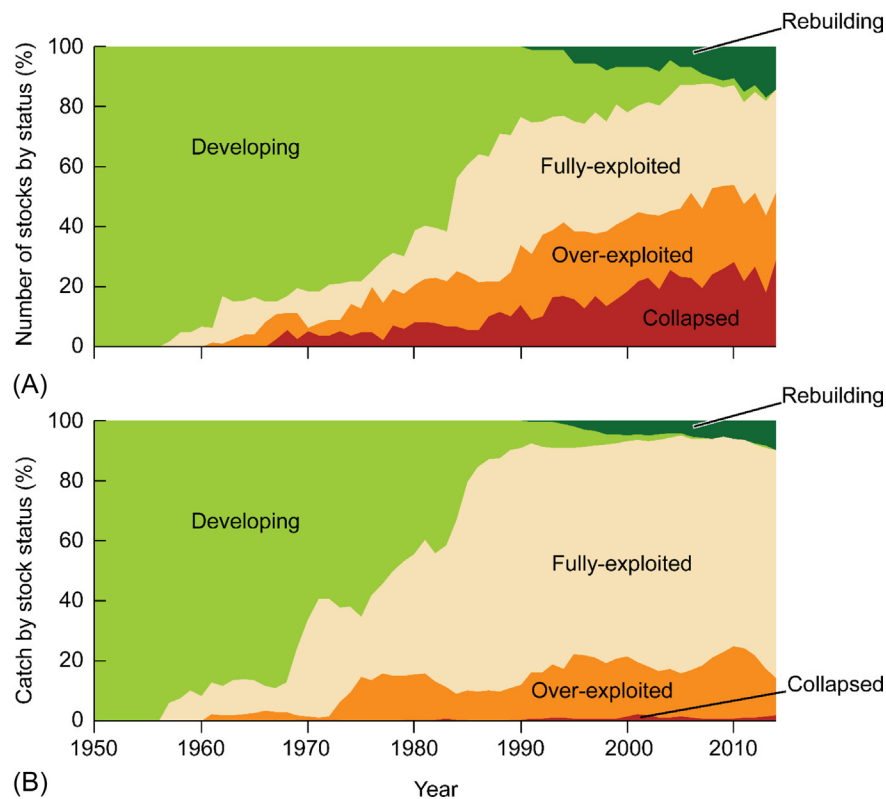


FIG. 12.4 Stock-status plots for the EEZ of Liberia in West Africa, showing the general trend over time in (A) the fraction of stocks; and (B) the fraction of the catch tonnage originating from stocks of a given stock-status or fisheries development category, as inferred from the trend of their catch time series (Froese et al., 2012; Froese, Zeller, Kleisner, & Pauly, 2013; Kleisner et al., 2013). This illustrates that even without availability of detailed and expensive fisheries independent survey data or access to technical stock assessment expertise, basic first-order stock-status evaluations can be undertaken with catch data only. Note that the directionality of the trend of the separation lines between status categories is important in stock-status plots, not the actual percentage values in a given year (Pauly & Zeller, 2017a, 2017b).

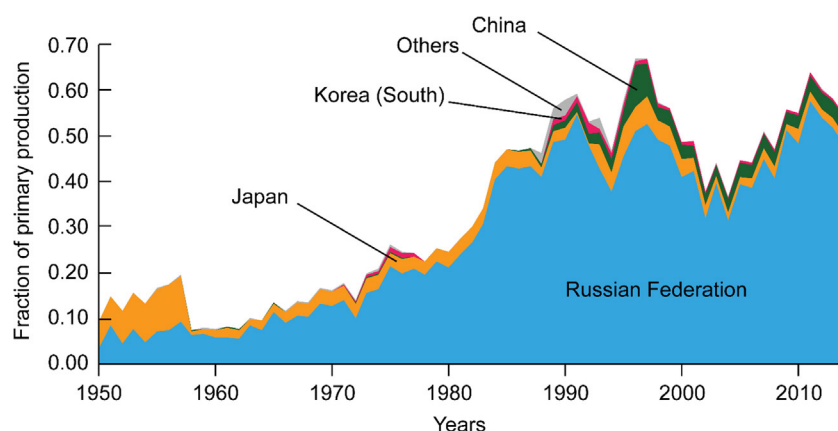


FIG. 12.5 Multinational footprint based on the original concept of Pauly and Christensen (1995), and here representing the Far East Russian EEZ waters. Multinational footprints present time series of the fraction of the primary production of a given geographic entity (here, EEZ) that is appropriated by the biomass of fish represented in the catch of the fleets of different countries fishing in the given geographic entity.

economics of fisheries (e.g., the subsidies provided by governments; Sumaila, Lam, Le Manach, Swartz, & Pauly, 2016) and their governance (e.g., country profiles, treaties, and conventions that countries adhere to, fishing access agreements, and so on). The variety of data available at the *Sea Around Us* facilitates the examination of key issues affecting strategic policy considerations in fisheries, such as the comparison between large- and small-scale fisheries sectors (Fig. 12.7), which should lead informed society to a sectoral shift away from industrial and toward small-scale fisheries in the name of sustainability, livelihoods, and food- and nutritional security (Pauly & Zeller, 2016c).

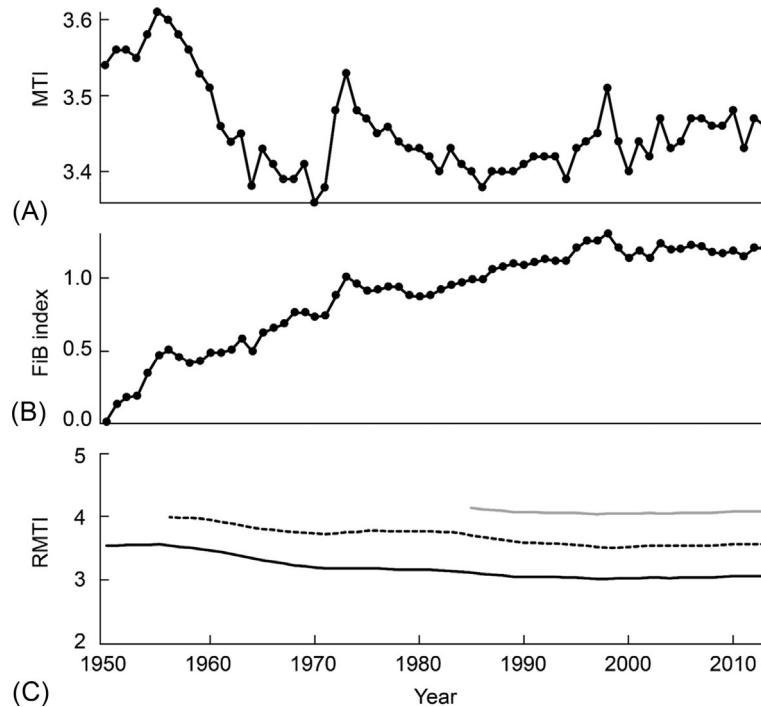


FIG. 12.6 Marine Trophic Index related indicators showing that “fishing down marine food webs” occurs on a global basis, in combination with a globally declining catch (see Fig. 12.3; and also Pauly & Zeller, 2016a). (A) Marine Trophic Index (MTI) of global fisheries, that is, unmodified, catch weighted mean trophic level trend of the world marine catch; (B) trend of the FiB index, suggesting (as shown in Bhathal & Pauly, 2008) a spatial expansion of operations of the world’s fishing fleets (Swartz, Sala, Tracey, Watson, & Pauly, 2010); (C) application to the data in A of the routine of Kleisner et al. (2014), enabling the separation of fishing down occurring inshore (lower trend line) from its occurrence further offshore (upper trend lines). *Graph adapted from Pauly, D., & Zeller, D. (2017b). The best catch data that can possibly be? Rejoinder to Ye et al. “FAO’s statistic data and sustainability of fisheries and aquaculture”. Marine Policy 81, 406–410.*

12.8 FUTURE DEVELOPMENTS

In addition to regularly updating and improving the underlying catch database, the *Sea Around Us* is anticipating further developments. Among other items, we wish to update and incorporate/deep-link a currently separate yet detailed global database on marine reserves, which was originally developed at the *Sea Around Us* as mpaglobal.org (Wood, 2007), and has since been reincorporated into the UNEP-IUCN-WCMC World Database on Protected Areas (WDPA) at ProtectedPlanet.net. Further, we are planning to geographically integrate the details on the mean temperature of fisheries catches (Cheung, Watson, & Pauly, 2013) and integrate data sets on the evolution of fishing power by the national fleets of the world (i.e., updating the earlier work of Anticamara, Watson, Gelchu, & Pauly, 2011).

In the longer term, we would also like to address a persistent, if misplaced criticism that catch data do not inform on the status of stocks as well as traditional stock assessments. While we recognize the high utility of such traditional stock assessments, often their extreme cost (many approaches require very expensive fisheries-independent data such as research vessel surveys) and technical complexities requiring dedicated and expensive technical skill sets make them nearly irrelevant for most of the nondeveloped countries in the world. Thus, we would like to address this misperception on a global scale by considering one of the most useful stock assessment approaches for data-poor stocks, the Catch-MSY method of Martell and Froese (2013), which requires only catch data, resilience of the respective species, and simple assumptions about relative stock sizes to derive estimates of MSY. Our long-term partnership with and deep integration of the FishBase and SeaLifeBase biodiversity databases will enhance our ability to implement the Catch-MSY method for the majority of the species stocks for all countries around the world. This has the potential of turning into an invaluable tool for use in fisheries management and policy, especially for developing countries constrained by limited financial and technical resources. Where relevant and compatible, such analyses would include comparisons with traditional stock assessment results as provided, for example, by the Ram Myers Legacy stock assessment database developed by Ricard, Minto, Jensen, and Baum (2012).

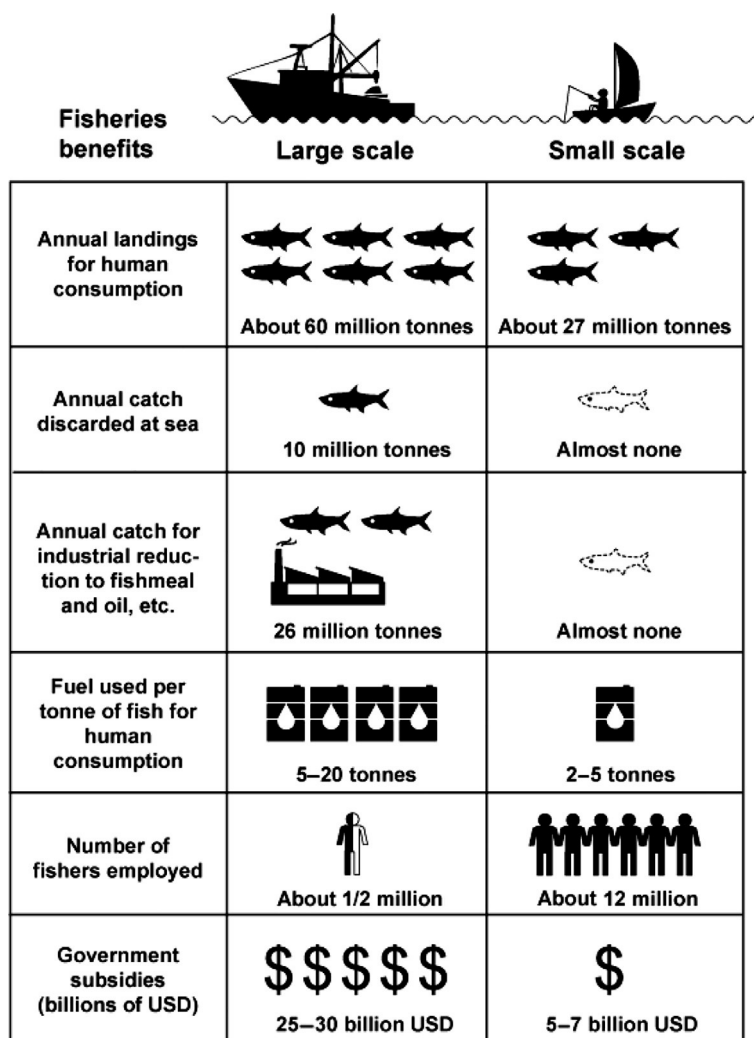


FIG. 12.7 Comparing large- and small-scale fisheries during the period 2000–2010 through an updated Thompson graph (Thompson, 1988), which contrasts the performance of large-scale (industrial) and small-scale (artisanal and subsistence) fisheries on key criteria. The definitions of large-scale (industrial, often mislabeled “commercial”) and small-scale (often mislabeled “traditional”) are those prevailing in each maritime country, yet they do not differ much (Chuenpagdee & Pauly, 2008). The tonnage of fish reduced to fishmeal were based on Cashion et al. (2017), while the fuel consumption figures (Tyedmers, Watson, & Pauly, 2005) were scaled up from nominal reported landings, the number of fishers employed (Teh & Sumaila, 2013) and the subsidies (Sumaila et al., 2010, 2016) were split into large- and small-scale sectors (Jacquet & Pauly, 2008). Graph adapted from Pauly, D., & Zeller, D. (2016c) *Towards a comprehensive estimate of global marine fisheries catches*. In: D. Pauly & D. Zeller (Eds.), *Global atlas of marine fisheries: A critical appraisal of catches and ecosystem impacts* (pp. 171–181). Washington, DC: Island Press.

These steps will further enhance the utility of the *Sea Around Us* database and make it an indispensable tool for the study of global fisheries and their impact on marine ecosystems.

12.9 CONCLUSION

Overall, we look forward to engaging with colleagues on correcting and updating the catch database and our website and expanding its reach. We firmly believe that the data and the website will fill a gap in the various global marine data sets that are available, for example, for studying the impact of global warming on the oceans, for which we have comprehensive global data (Cheung et al., 2010, 2013; Cheung, Watson, & Pauly, 2013), and which are being continuously improved upon. However, the biggest advantage of the *Sea Around Us* data content and variety is the underlying philosophy and core principles of the *Sea Around Us*: Truly global coverage, and the integration of conservative estimates for the deeply engrained but problematic “no data” syndrome (Zeller et al., 2016; Zeller & Pauly, 2016).

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