Global Fisheries Catches and their Reconstruction

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Fisheries can be defined as the interaction of fish (incl. aquatic invertebrates), at a certain location, with fishing gear, deployed by fishers, and resulting in catches.

Catches thus help defining fisheries, whether they are made by super trawlers in Alaska, ‘pirogues’ in West Africa, or a runabout in Australia.
While catches are important, *Nature* asked a misleading question:

**Does catch reflect abundance?**

Researchers are divided over the wisdom of using estimates of the amount of fish hauled in each year to assess the health of fisheries.

**POINT**
Yes, it is a crucial signal

*The only data available for most fisheries are the weight of fish caught each year,* insists Daniel Pauly.

**COUNTERPOINT**
No, it is misleading

*The major database on all the fisheries of the world is the FAO Yearbook, Fishery and Aquaculture Statistics. This collates the amount (in weight) of haddock, bream, cod and more than 1,000 other species hauled in each year by fishermen, whether from commercial trawlers or canoes, using estimates sent in by officials from individual countries. For the past few years, researchers have been conducting analyses.*
As posed by *Nature*, this question is misleading because even if the answer were negative, we still require catch data when working on fisheries, because:

1. The size of a fishery, relevant to assessing whether it warrants devoting resources to its study and management;
2. The gross value of a fishery (when landings are multiplied with ex-vessel prices), as required for negotiations about bilateral fisheries access agreement;
3. The magnitude of the environmental impacts of fisheries (especially when combined with the catch rate of various habitat impacting gear); and
4. The extent of criminal and/or fraudulent activities in the case of illegal catches, etc.
Indeed, one could argue that we don’t know a fishery when we don’t know its catch – since it is conducted, after all, to produce a catch.

Which is where accurate statistics come in...

When working on the fisheries of their country, fisheries scientists, staff of environmental NGO’s and other parties, usually work with their own, and/or national data, and there are few problems of accuracy. The US NOAA data are a case in point.

When working on foreign countries, most actors use FAO statistics, which are based on annual submissions by their member countries.
The FAO statistics are misleading.

Fifteen years ago, we still thought that they were roughly correct, i.e., that their errors are more or less randomly distributed (except for the famous case of China).

We were wrong: the FAO data (with a few exceptions) are strongly biased downward because the countries do not see it fit to report on all of their fisheries, especially on their small-scale fisheries, which turn out to be one of the major sources of IUU catches (i.e., unreported catches).
But how can we know what FAO and/or its member countries don’t seem to know? (Or more accurately: don’t bother with.)

This is where catch reconstruction comes in, which are based on two pillars:

1) Fishing is a social activity, which therefore throws a ‘shadow’ on the economy and the society that it is embedded in. Thus, in literate societies, it is not possible to operate a fishery which will leave no written trace on other sectors of the economy and/or on society at large; and

2) Almost any reasonable estimate, even a guess based on this societal ‘shadow’ in (1) will be a better than the precise estimate of zero that is implied when, absent detailed statistics, a bureaucrat simply ignores a fishery.

‘Catch reconstruction’

Catch reconstructions are estimates of all withdrawals from the ecosystem:

- Complement data reported by countries to FAO with best estimates of unreported catches;
- Time: back to 1950 (to be able to compare present with earlier system state);
- Fishing sectors: industrial, artisanal, subsistence, and recreational;
- Landed catch & discards (because the fish don’t care who killed them).

Our definitions

- **Industrial sector**: relatively large motorized vessels, requiring large sums for construction, maintenance and operation, either domestically, in the waters of other countries and/or the high seas, and landing a catch that is overwhelmingly sold commercially;

- **Artisanal sector**: small-scale (hand lines, gillnets etc.) and fixed gears (weirs, traps, etc.) whose catch is predominantly sold commercially (notwithstanding a small fraction of this catch being consumed or given away by the crew);

- **Subsistence sector**: fisheries whose primary driver is for consumption by one's family, rather than engage in commerce. Often these are conducted by women and children. Also the fraction of the catch of mainly artisanal boats that is given away to the crews’ families or the local community;

- **Recreational sector**: fisheries conducted mainly for pleasure, although a fraction of the catch may end up being sold or consumed by the recreational fishers and their families and friends.

Also: **Catch = Landings + Discards**

Reconstruction approach

Conceptual representation of the stepwise catch reconstruction approach as developed by the Sea Around Us.

Step 1. Reported baseline (FAO, ICES, National etc.)
- time period
- spatial coverage

Step 2. Identify missing components
- sector
- gears
- species etc.

Step 3. Source alternative information for missing components

Step 4. Develop ‘anchor points’ & expand to country-wide estimates

Step 5. Time series interpolation of ‘anchor points’

Step 6. Complete total catch time series (Steps 1 + 5)

Step 7. Quantify uncertainty of catch time series
By sector and time period

Literature
- Peer-reviewed
- Grey
- Colonial archives
- Local language etc.

Assign sectors:
- Industrial
- Artisanal
- Subsistence
- Recreational

Expert & local knowledge

Reconstruction: Jigsaw puzzle

Edges & corners = reported catch data

Reconstructed data = reported + unreported

Quantify reliability: ‘Score’ quality of time series data

‘Scores’ for evaluating the quality of time series of reconstructed catches, with their approximate confidence intervals (IPCC criteria from Figure 1 of Mastrandrea et al. 2010); the percent intervals are adapted from various sources (available on request)

<table>
<thead>
<tr>
<th>Score</th>
<th>Reliability</th>
<th>+/- (%)</th>
<th>Corresponding IPCC criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Very high</td>
<td>10</td>
<td>High agreement &amp; robust evidence</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>20</td>
<td>High agreement &amp; medium evidence or medium agreement &amp; robust evidence</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>30</td>
<td>High agreement &amp; limited evidence or medium agreement &amp; medium evidence or low agreement &amp; robust evidence.</td>
</tr>
<tr>
<td>1</td>
<td>Very low</td>
<td>50</td>
<td>Low agreement &amp; low evidence</td>
</tr>
</tbody>
</table>

Mastrandrea et al. (2010) note that “confidence increase” (and hence confidence intervals are reduced) “when there are multiple, consistent independent lines of high-quality evidence”.

Pauly and Zeller (2016) Nature Communications 7: 10244
The reconstructions are done by Exclusive Economic Zones (EEZs; except for industrially-caught tuna). Extent and delimitation of countries’ EEZs, as declared by individual countries, or as defined by the Sea Around Us are based on the fundamental principles outlined in UNCLOS (i.e., 200 nautical miles or mid-line rules), and the FAO statistical areas by which global catch statistics are reported. Note that for several FAO areas, some data exist by sub-areas as provided through regional organizations.

Pauly and Zeller (2016) Nature Communications 7: 10244
Data status:

- Over 200 individual reconstructions for 273 individual EEZ pieces;
- Global industrial large pelagic dataset (RFMO);
- Over 100 of theses are now published in the scientific literature;
- By year (1950-2013, 2014 update in progress)
- By taxon (> 2,500)
- By sector (industrial, artisanal, subsistence, recreational)
- By ‘catch type’ (landed catch, discarded catch)
- By ‘reporting status’ (reported, unreported)

Spatial data allocation
Spatial allocation

- **Input data**
  - Catch Data Layer 1, 2, 3
  - Fishing Access Agreement
  - Biological Taxon Distributions
  - GIS Data \( \frac{1}{2} \) Degree Cells

  **Flowchart**
  - Perform consistency tests
  - All tests passed?
    - Yes: Integrate into the main database
    - No: Send the log file to data experts, reiterate the process with the corrected input data
  - Compute spatial allocation results [Where all the input data coalesce]

**References**
- Pauly and Zeller (2016) Nature Communications 7: 10244
Spatial allocation to 180,000 half degree cells

Pauly and Zeller (2016) Nature Communications 7: 10244
We present fisheries and fisheries-related data at spatial scales that have ecological and policy relevance, such as by Exclusive Economic Zones, High Seas, or Large Marine Ecosystems.
The Bahamas

Catch (t)

Year

FAO

The Bahamas

![Graph showing fish catch over the years in the Bahamas, with categories for Large-scale, Artisanal, Subsistence, Recreational, and FAO. The graph includes data from 1950 to 2010.]

Pacific Islands

Summary of 25 island entities

Summary of 25 island entities

Pacific Islands

2.5 x

Data supplied to FAO
Discards
Recreational
Industrial
Subsistence
Artisanal

Arctic waters (FAO 18)

Area from which Russia, the USA and Canada report zero or near zero catch

Zeller et al. (Polar Biology, 2011)
Global catches

ARTICLE
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Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining

Daniel Pauly¹ & Dirk Zeller¹

Pauly and Zeller (2016) Nature Communications 7:10244
Comparing reported and reconstructed catches by FAO areas....

When added up, the country catch reconstructions confirm that the world catch has been declining for the last 2 decades. Important is also that the trend is more marked than in the officially reported catch.

The story with ‘our’ confidence intervals, or how we abandoned our principles and now must pay for it…
Then there is another red herring...

Fig.3 Relationship between “reported” and “unreported” catch in Pauly and Zeller [3]. Linear regressions provided for the 1950-1995 and 1996-2013 periods.

...says FAO
Reconstructed catches for all countries in the world, plus High Seas, by large-scale (industrial) and small-scale sectors (artisanal, subsistence, recreational); discards are presented separately.
What the future will bring:

- We will continue to improve the contents and usefulness of our revamped website (www.seaaroundus.org), which presents all the reconstructed data (and from which they can be downloaded);

- We will work with our network of colleagues throughout the world to update and correct the reconstructed catch time series time;

- We will add new global data sets to the website (e.g., on fishing effort), for joint analyses with the catch time series;

- We (in Vancouver) will work with the newly established unit in Perth, at UWA, the Sea Around Us – Indian Ocean (see Drs. Jessica Meeuwig and Dirk Zeller for details).

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• Thanks to all members of the Sea Around Us, past and present...

... sorry, we ran out of pictures....

and thanks to many other colleagues

visit us at www.seaaroundus.org

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