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The FAO global capture production database: A six-decade effort to catch the trend

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ABSTRACT

With data series extending for 60 years, including catch data for almost 1850 species items, and reflecting geo-political, historical and natural events, the FAO capture database provides a service to the community interested in fishery information. Over 600 articles from refereed journals cited the database in the last 15 years. Species included grew significantly in the last decade and an analysis of annual reporting showed more timely data submissions, although the number of non-reporting countries remained stable throughout the years. An evaluation of data quality found over half developing countries reporting inadequately but also one-fourth of reports by developed countries were not satisfactory. This article also provides meta information on historical developments, data sources and coverage, and advice on what should be kept in mind when using the database for trend studies.

1. Introduction

The FAO global capture database is largely used (see citation analysis in Section 5.3) to analyze global, regional and national catch trends by country, fishing area and species. However, this article written in the occasion of six decades of data available in the database does not add a further trend study but intends to cover most meta information aspects that may be of interest to the database users. It also aims at increased transparency on the procedures followed by FAO in gathering and compiling the data submitted by national correspondents, the use and relevance of other data sources, and the production of estimates for not reported data. Statistics on countries' annual submissions are also revealed.

2. A bit of history

The function of collecting, analyzing and disseminating data and information relating to 'agriculture' – including fisheries – is embedded in Article 1 of the Food and Agriculture Organization of the United Nations (FAO) Constitution, and has been performed since the establishment of the organization, which dates back to 1945. The first issue of the FAO Yearbook of Fisheries Statistics [1] was published in Washington, D.C., USA. It included 1930–1946 officially reported or published data by a limited number of countries on trade and landings and also some scattered information on craft and gear. Until 1964, 15 issues of the Yearbook were published covering production, fishing craft and trade for an increasing number of countries in three slightly different formats (see 'List of yearbook of fishery statistics' [2]). Since the third issue the Yearbook was published in Rome, Italy, where the FAO headquarters had moved in 1951.

Starting with volume 16 published in 1964 [3], "Catches and landings" and "Fishery commodities" were fully separated in two different yearbooks. Major changes and improvements were introduced in the compilation of global catch statistics. The first rough versions of the FAO fishing areas and the "International Standard Statistical Classification of Aquatic Animals and Plants" (ISSCAAP) were refined. Before the publication of volume 16, it was issued a revision [4] of the 1937–1938 and 1947–1961 landings by species according to the new standards and readers were urged to report to FAO their comments.

Two major improvements occurred in the mid-1990s. Firstly, to commemorate FAO's 50th anniversary in 1995, a computerized set of fishery production statistics going back to 1950 was published [5]. Until then, the computer database only contained time series starting in 1970. To extend the series backwards, it was necessary to apportion data by fishing areas for all 1950–1969 data and estimates catches for those years in which figures were not available. Much use was made of library material, such as reports of regional fishery organizations, national publications and project documents. For some countries, data were obtained directly from national sources. Differently from the standard

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procedure, for the newly compiled 1950–1969 data it was decided to round to the nearest 10 or 100 all figures not directly submitted by countries or derived from regional bodies (i.e. mostly tuna data), and do not mark them with the 'F' symbol for estimated figures.

Secondly, starting with the publication of 1996 data [6], the Yearbook included only the production from capture fisheries with the exclusion of aquaculture production and its title was changed accordingly from "Catches and landings" to "Capture production". The 1984–1997 aquaculture data had been published yearly as "FAO Fisheries Circular No. 815" but in 2000 the first FAO Aquaculture production yearbook was issued [7]. Backward revision of the two data series was completed in 2003, when fully separated capture and aquaculture datasets for the 1950–2001 period were made available through the FISHSTAT+ software.

Finally, in 2008 the three Fishery Statistics Yearbooks on "Capture production", "Aquaculture production", and "Fishery Commodities" have no longer been published in hard copy but only on a CD-ROM enclosed in a booklet [8] including summary tables for all databases. Since the following edition [9] were also added overviews, charts and a section on "Food Balance Sheets".

To coordinate fishery statistical programs of regional and inter-governmental organizations, in 1960 the FAO Conference established the "Continuing Working Party on Fishery Statistics in the North Atlantic Area" (CWP). In 1995, the CWP changed its title to "Coordinating Working Party on Fishery Statistics" due to its new global coverage. The CWP has played a key role in establishing and harmonizing concepts, techniques, classifications and standards for the collection, processing and dissemination of fishery statistics [10]. Nowadays, 19 regional and global organizations[1] participate in the mechanism meeting approximately every two years.

3. General information on data collected and their compilation

3.1. Data sources

Catch data and other fishery statistics are generally submitted to FAO by national correspondents in the appropriate ministry or institution. At about May every year, FAO sends to correspondents paper and electronic versions of standard questionnaires and encourages reporting through them. However, to facilitate data submission, any format in which the national statistics are stored is accepted by FAO. The deadline to return data to FAO is the 31st August. As soon after this date, FAO starts to send out reminders and contact those countries which have not yet submitted their data. The FAO capture database is usually closed at about the end of February and at the beginning of March the updated database is made available on the web.[2]

Statistics made available by national authorities are complemented or replaced if better data of other origins are available. The CWP at its 18th Session [11] recommended members to regard as the most reliable data those held by the Regional Fishery Body (RFB) with assessment responsibility for a given stock, which are supposed to be the 'best scientific estimate'. Following this recommendation, FAO often replaces the data received from national offices with those validated by RFBs, e.g. the catch statistics for tuna and shark species compiled by IATTC[3] (2009 data taken for 12 countries), ICCAT[4] (28), IOTC[5] (23) and WCPFC[6] (14). For non-tuna catch statistics, data compiled by CCAMLR[7] for the Antarctic areas are fully incorporated in the FAO database, as well as data on whales by IWC.[8] In recent years, collaboration in the fishery statistics field has been developed with SEAFO[9] and SPRFMO[10] (see in Sections 3.2.2 and 3.3 respectively), two organizations with a mandate for high seas areas.

Foreign catches reported in bulletins produced by Northwest African countries (e.g. Guinea-Bissau and Mauritania) are checked against data submitted to FAO by Distant Waters Fishing Nations (DWFNs) operating in the area, and catches identified as unreported by DWFNs are entered in the FAO database. Another source of information is the Falkland Islands Fisheries Department, which provides FAO with annual catch data by country and species for their Interim and Outer Conservation and Management Zones. The inclusion of data from additional sources, along with other specific information by country, is reported in the section "Notes on individual countries or areas" of the FAO capture production yearbook.

3.2. Data coverage

The FAO capture database contains marine and inland catch data by three variables: country, FAO fishing area and species item. Capture production is measured in tonnes for all species items, except aquatic mammals and crocodiles, which are measured by number of animals.

Countries' submissions should record nominal catches, i.e. weight of the whole and live animal. If the catch has been processed, a conversion factor to calculate the live weight should be applied by the reporting country. However, in some regions (e.g. Central America and the Caribbean, South Pacific Islands, etc.) catches of several important commercial species (e.g. shrimps, lobsters, crabs, conchs, sea cucumbers, sharks, etc.) are often reported as processed weight and only rarely FAO is informed whether a conversion factor has been already applied or not, causing uncertainty and biasing the trend analysis at the regional level, e.g. for important and overexploited species such as the queen conch (*Strombus gigas*).

Catch statistics should be collected for all industrial, artisanal and subsistence fisheries, excluding aquaculture practices. Data on discarded catches are not included in the FAO database as it covers only retained catches. Following a recommendation of the 16th Session of the CWP [12], data reported to FAO should also include recreational catches. Unfortunately, only a limited number of countries collect this information and submit it to FAO, and only a few inform about the inclusion/exclusion of recreational catches. At present, data on recreational catches are included in the database almost only for catches of inland water species by some European countries, as the FAO-EIFAAC[11] questionnaire to collect data in that area and environment is tailored to report recreational catches in a specific column.

[1] http://www.fao.org/fishery/cwp/en

[2] At this time, the FAO capture production database can be accessed through three electronic means:

- the FISHSTAT+software downloadable at: http://www.fao.org/fishery/statistics/software/fishstat/en
- embedded in the new FISHSTATJ software at: http://www.fao.org/fishery/statistics/software/fishstatj/en
- through the online query panel at: http://www.fao.org/fishery/topic/16140/en

[3] Inter-American Tropical Tuna Commission (IATTC).

[4] International Commission for the Conservation of Atlantic Tunas (ICCAT).

[5] Indian Ocean Tuna Commission (IOTC).

[6] Western and Central Pacific Fisheries Commission (WCPFC).

[7] Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

[8] International Whaling Commission (IWC).

[9] South East Atlantic Fisheries Organization (SEAFO).

[10] South Pacific Regional Fisheries Management Organisation (SPRFMO).

[11] European Inland Fisheries and Aquaculture Advisory Commission (EIFAAC).

3.2.1. Countries

In 1954, the United Nations Statistical Commission decided that catches should be assigned to the country of the flag flown by the fishing vessel. As reconstructed by Edeson [13], this basic concept was agreed by all member agencies of the CWP at its 9th Session [14], defined more precisely at the 10th Session [15], and further refined at the 18th Session [11] seeking to strengthen even more the role of the flag State and endeavoring to eliminate some uncertainties about joint ventures and charters. In this latest formulation adopted by the CWP and that is still in place, it was also reaffirmed that "…*the flag State is responsible for the provision of the relevant data*".

Despite this standard rule having been applied and agreed by all fishery organizations for many years, officers from regions where DWFNs have been fishing extensively (e.g. Northwest Africa and South Pacific) often pointed out that catch statistics in international databases should not be recorded by flag of the vessel but by the Exclusive Economic Zone (EEZ). Such a change would have a serious adverse effect on the continuity of the catch data series. In addition, if catches were reported by EEZ irrespective of the flag, there may be a serious risk of double counting and it would be necessary that all coastal countries collect a complete record of catches by DWFNs in their EEZ even if not landed in their country, which seems rather unrealistic. However, it would be highly desirable to have data by flag separated for catches taken inside and outside EEZs and moves in this direction are underway (see Section 3.2.2).

FAO aims to achieve a complete global coverage of capture fishery production. The FAO capture production database [16] holds data for the 191 FAO's Member Nations, two Associate Members (i.e. Faroe Islands and Tokelau), three other nations (i.e. Brunei Darussalam, Liechtenstein and Singapore) which are member of the United Nations (UN) but not of FAO, four countries that no longer exist, the "Other nei"[12] item, and for 39 territories, dependencies or provinces of sovereign states. Given the peculiarities of catch statistics is very important to have separate data for territories which in many cases are quite distant from the main part of the country and their capture production may be different in many aspects, in particular for species composition. As a total, the database includes 240 "countries or areas" (as defined in the UN terminology, although in the fishery field the term 'areas' may be mixed up with 'fishing area').

A recent notable addition to the list of territories, dependencies or provinces present in the database is that of the Zanzibar Island. FAO was aware for many years that capture production reported by the United Republic of Tanzania did not include catches from the semi-autonomous Zanzibar Island and made several attempts to obtain their fishery data either from the Tanzanian authorities or Zanzibar itself. In October 2008, at last FAO received the 2000–2007 catch data from the Department of Fisheries and Marine Resources in Zanzibar, which since that has become a regular data provider, and these data were included in the following annual release (February 2009). Unfortunately, this improvement was not noted in papers [17,18] that came afterwards and which still remarked that Zanzibar's catch data were missing in the FAO database.

Geo-political and historical events since 1990 are reflected in the database and can be classified into three major groups: (a) dissolution of a country with the emergence of successor countries; (b) a part of a country seceded and became a new state; and (c) two countries merged in a new state. Belonging to the first group are Czechoslovakia's separation into two countries (January 1993), the breakdown of the USSR (December 1991) into 15 new Republics, and Yugoslavia SFR that dissolved into five independent states (1991–1992) but one of which (Serbia–Montenegro) split into two further countries in 2006. The presence or absence of annual catch data for all the former and new countries matches the years of the events with the only exception of an 'historical false' for data related to the ex-USSR new Republics. In fact, in mid-1990s FAO requested a consultant working at the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) to compile catch statistics separated by the 15 new Republics also for four years (1988–1991) before the USSR dissolution.

New independent states that seceded from a country which continues to exist include Eritrea (1993) from Ethiopia, Namibia (1966 and 1990[13]) from South Africa, and Timor-Leste (1999) from Indonesia. Finally, for the group of countries in which two formerly distinct nations reunified in a new one (e.g. Germany, Viet Nam and Yemen), the historical catch data series previously separated have been merged.

3.2.2. FAO fishing areas

In the present configuration, there are 26 "FAO Major Fishing Areas for statistical purposes" consisting of 7 major inland fishing areas, covering the inland waters of the continents, and 19 major marine fishing areas encompassing the waters of the Atlantic, Indian, Pacific and Southern Oceans with their adjacent seas (Fig. 1). However, since the first map appeared in the FAO Yearbook published in 1957 [19], fishing areas have been subject to several changes.

The numeric two-digit code was used for the first time in the 1970 Yearbook [20]. The first digit was assigned in accordance with a former classification by "Marine Regions" (e.g. North Atlantic, South Atlantic, etc.). In the second digit, certain positions were left vacant (e.g. between 21 and 27) as it was considered the possibility to allocate available numbers if additional fishing areas would need to be created in the future. The main considerations taken into account in establishing the fishing areas [21] were: (a) boundaries of existing international conventions and regional commissions and already established 'statistical areas'; (b) generally recognized boundaries of geographical, ecological, oceanographic and faunal zones; (c) natural configurations of bordering coastline, island groups, etc. and (d) latitudes and longitudes which coincide with the proposed boundaries for 'divisions'.

The latest changes of FAO fishing areas' boundaries were in 1999 between areas 51 and 57 (as a consequence Sri Lanka moved from the Western to the Eastern Indian Ocean area) and in 2001 between areas 57 and 71 in the Australian–Indonesian region to match the border between the IOTC and WCPFC areas of competence. At its 22nd Session [22], the CWP reconfirmed the conditions to be met before changing boundaries between major fishing areas: (a) no country should object the proposed change; (b) no Regional Fishery Body (RFB) should object the change and effort should be made to reconcile boundaries between RFBs jurisdictions and those of the FAO Major Fishing Areas; and (c) countries involved in the proposed change should be able to provide to FAO revision of historical capture statistics according to new boundary. Other proposals to modify the boundary between areas 47 and 51 to match the ICCAT-IOTC border, the northern boundary between areas 57 and 71, and the southern

[12] Under "Other nei" are gathered catches by unidentified countries as reported by RFBs, national bulletins and other sources.

[13] In 1966, the United Nations General Assembly (UNGA) terminated South Africa's mandate over Namibia and placed the territory under the direct responsibility of the United Nations but in practice it remained under South African administration. At last, the country obtained full independence in March 1990. In the FAO database, there are some catch data under Namibia starting 1966 but quantities significantly increased since 1990.

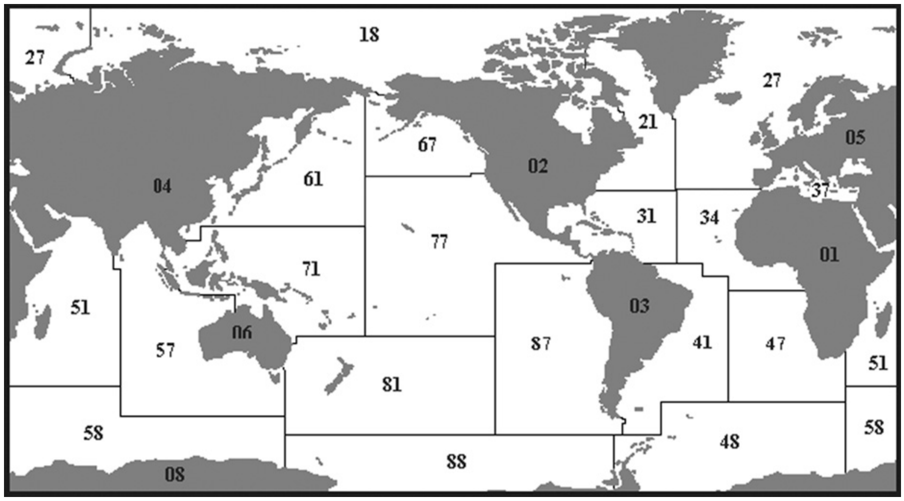

Fig. 1. Map of the FAO Major Fishing Areas.

boundary between 57 and 81 are pending until these requirements are met.

The FAO Major Fishing Areas are often considered too large and coarse to correspond to stocks and allow detailed analysis of catch trends [23]. However, many major fishing areas are further subdivided into statistical subareas and divisions [24]. For several areas in which FAO and non-FAO regional fishery commissions are in place, catch data[14] are also available by 'statistical divisions', providing a finer geographical resolution.

FAO is receiving increasing requests to incorporate more detailed catch location in the database, in particular to distinguish EEZ catches from catches in the high seas. A first step was undertaken for the Southeast Atlantic fishing area. Statistical divisions for this area have been revised in agreement between FAO and SEAFO, which Convention covers the high seas in the Southeast Atlantic, with the aim of obtaining separate data between catches taken inside and outside EEZs of coastal states [25]. A similar proposal [26] to modify statistical divisions in the Eastern Central Atlantic was also submitted to the CECAF.[15]

Definition of inland waters varies among countries and in some cases there is uncertainty in classifying a water bodies as marine or inland waters and hence assigning the catch to the relevant fishing area. Salinity cannot be always used to define boundaries because in some areas it fluctuates with tides and season and there are also inland water bodies which are highly saline (e.g. Caspian Sea). On the other hand, aquatic animals which are considered as freshwater species can tolerate changes in salinity and can be caught in maritime regions which have low salinities (e.g. Baltic Sea) due to river outflows. Therefore, the CWP agreed [27,28] that is up to the national authorities to decide on the boundaries between marine and inland areas as appropriate to their specific situations and to report catch statistics accordingly.

The grid classification of global marine waters into the FAO Major Fishing Areas is not only used for statistical purposes but also legislation makes reference to it. For example, a Regulation [29] issued in 2001 by the European Commission prescribes that fishery products may be offered for retail sale only on condition that a number of requirements regarding consumer information are met. One of the requirements is that the region where the product has been caught is clearly indicated by the FAO fishing area. This has brought about that most fish shops in Europe are displaying a map of the FAO fishing areas to allow customers to locate the area of origin for products on display.

3.2.3. Species items

The third variable for which catch data are available in the database is the statistical category called 'species item'. This term is used to identify the statistical taxonomic unit, which can correspond to species, genus, family or to higher taxonomic levels. Species items included in the FAO capture database reached a total of 1844 in 2009 data. Since 1996 data, from which the database included only catch statistics excluding aquaculture production, the number of species items has been growing at an average annual rate of 4.6% and totaled an overall increase of 78.2% (see Fig. 2). This improvement is mainly due to more detailed reports by countries, which are requested to add in the questionnaire other species if available in their statistics, but also to the establishment of new mechanisms such as the "ASFIS List of Species for Fishery Statistics Purposes" [30] to facilitate reporting of new species by national correspondents and their inclusion in the database.

In its 2011 release[16], the ASFIS List includes 11,562 species items and provides codes (ISSCAAP group, taxonomic and 3-alpha), taxonomic information (scientific name, author(s), family and higher classification), and the availability of fishery production statistics in the FAO databases. In addition, about 75% of the records had an English name, 41% a French name and 37% a Spanish name. The present ISSCAAP codification is organized into 9 divisions that are further split into 50 groups on the basis of their taxonomic, ecological and economic characteristics and follows a revision proposed by FAO and endorsed by CWP at its 19th Session [31]. The taxonomic code is used for a more detailed classification of the species items and for sorting them out within each ISSCAAP group. The 3-alpha identifier is a unique code made of three letters that is widely used for the exchange of data with national correspondents and among fishery agencies, and also adopted for use in fishing logbooks (e.g. in the European Union).

[14] Catch databases for Eastern Central Atlantic-CECAF, Mediterranean and the Black Sea-GFCM, Gulf-RECOFI, and Southeast Atlantic-SEAFO are downloadable at the web addresses provided in footnote 2. Databases by other RFBs (e.g. CCAMLR, ICES and NAFO) can be downloaded from the web site of the respective organization.

[15] Fishery Committee for the Eastern Central Atlantic (CECAF).

[16] Downloadable at: http://www.fao.org/fishery/collection/asfis/en

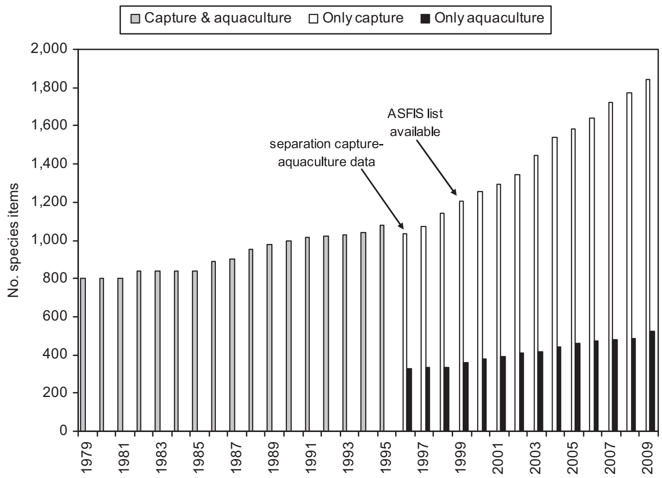

Fig. 2. Improvement of species breakdown in the FAO capture and aquaculture databases.

FAO strives to improve the species breakdown in its databases although this may create disruption in the data series and bias trend studies. However, is often probable that catches for newly reported species were earlier included under not identified (e.g. 'Marine fishes nei') or higher taxonomic level (e.g. genus, family, etc.) items, or even under another species, consequently decreasing the quantities reported onward for the more highly aggregated items. There are also cases in which countries have been reporting catch statistics with a good species breakdown for some years, thanks to specific projects or temporary availability of funds but, when the data collection activities ceased or became unsustainable, the information submitted was drastically reduced. Variations in the quality and level of species breakdown throughout the years make very difficult to use the information in the database as an indicator of increasing or decreasing biodiversity in reported catches, as improvements in data reporting cannot be distinguished from real changes in catch composition.

3.3. Estimates, revisions and discrepancies between different sources

As soon as the annual deadline to submit data expires, FAO contacts the national correspondents of those countries that have not yet reported their fishery statistics. If after several reminders a country still does not return data FAO estimates the missing data and marks them in the database with an 'F'. All data reported by countries are carefully checked and, when the figures are questionable, the national correspondent is consulted for clarifications. Unfortunately, sometimes such requests remain unanswered and FAO has to take decisions whether including or not in the database data that seems unreliable. There are countries which in some years are able to report only data for a component of the fishery sector (e.g. industrial or artisanal) but FAO has to add up estimates for the missing catches because data on total fish supply by each country are needed to calculate the apparent consumption of fish and fishery products in the Food Balance Sheets [2].

There are no predefined rules concerning how to produce the FAO estimates. In general, data from the previous year are either repeated or rounded to the nearest 10 or 100 to hint that they have not been officially submitted. When the total catch is available but species breakdown was not provided for a given year, catches by species are estimated proportionally to figures reported for previous years. In these cases, the 'F' is removed from the country's totals in the relevant tables of the FAO capture production yearbook. The attribution or removal of the 'F' to totals is very accurate for recent years but may not be always consistent for older years.

Data reported for the latest year are considered as provisional and may be subject to revision the following year. In addition, FAO revises catch data for backward years as new data provided by national correspondents, RFBs or other sources become available. Among the most significant data revisions occurred in the last twenty years, two concerned China's statistics.

In the mid-1990s it was realized that the inland and marine mollusc production reported by China was in meat weight and it had to be raised to live weight equivalents by using a conversion factor. This revision was implemented in 1996 data and backward [32], increasing Chinese and global total capture and aquaculture production. It also added concern about possible overestimation of catches reported by China that was increasing in those years, prompting FAO to conduct studies and workshops in collaboration with the Chinese authorities. Furthermore, data for China and the rest of the world were considered separately in the 1998 issue of the FAO's "The State of World Fisheries and Aquaculture" [32]. An estimation of magnitude of overreported catches was later made by Watson and Pauly [33].

Eventually, China decided to reduce its 2006 capture production statistics by about 14% following the outcome of the Second National Agriculture Census conducted in 2007, which also contained for the first time questions on the fishery sector. Given the substantial share on global production of Chinese fishery production, this revision decreased the 2006 global production by about 2% for capture production and 8% for aquaculture production [34,35]. Estimates of China's statistics for the 1997–2005 period were subsequently produced by FAO and accepted by the Chinese authorities.

Other kinds of revisions include new extensive data series that become available for one or more species. For example, clarifications requested by FAO about inland water catches reported by Turkey for 2007 resulted in increased disaggregation by species including catch data back to 1969 for *Chalcalburnus tarichi*, a cyprinid fish endemic to the Lake Van in Turkey that is reported in the IUCN Red List [36] as declining due to illegal fishing and habitat degradation. When revised data for a given species are available only for scattered years, missing figures are calculated by linear interpolation.

In many countries, different sets of catch statistics are maintained by the official institution in charge to oversee the fishery sector production – usually the Ministry or Department of Fisheries in the Agriculture Ministry but in some cases also the national institute of statistics – and the research institute monitoring the stock status. Besides being a duplication of costs and efforts, sometimes the compilation of different catch data causes conflicts and confusion at the national level and in international fora. This is particularly relevant to RFBs, to which data for stock assessment purposes are usually reported by the research institute to the scientific committee but official catch production, which should also comply with the quota assigned to the country, is very often submitted by another institution.

As mentioned in Section 3.1, in several cases FAO derives complementary data or replaces those received from the national correspondents with information disseminated by RFBs. In addition to regularly checking the data made available by RFBs, FAO has held discrepancy exercises with RFBs (most recent: SPC[17] [37] and ICCAT [38–39]; exercises with Eurostat/ICES[18] and NAFO[19]

[17] Secretariat of the Pacific Community (SPC).
[18] International Council for the Exploration of the Sea (ICES).
[19] Northwest Atlantic Fisheries Organization (NAFO).

have not been published) covering also historical data to realign as much as possible data in the FAO and RFBs databases. Collaboration recently established with SPRFMO allowed the recovery of almost 900,000 t that had not been reported to FAO over the 2003–2009 period, including 650,000 t of jack mackerel caught by vessels flagged by Vanuatu [40].

4. Statistics on countries' annual reporting

Although in the Article XI of the FAO Constitution is clearly stated that all member countries should communicate regularly statistics and other technical information available to the government to allow FAO compiling and disseminating data on global trends, not all countries submit their annual fishery statistics to FAO. Failing to report is mainly due to the fact that for several countries is difficult to collect reliable catch statistics in a continuous manner, as it is a costly activity that needs skilled personnel and in many cases production points (i.e. landing sites) cover a large geographical area and are dispersed. However, there are also cases in which data have been collected but trivial problems in communication (e.g. turnover of the responsible officer, etc.) hamper the transmission of information to FAO.

FAO has been recording modalities of submission and evaluating the catch data received for the last ten statistical inquiries (2000–2009 data). The introduction of electronic questionnaires since the 1999 inquiry certainly contributed to the improvement of more timely reporting as the average number of submissions within the deadline increased from 51 in 2000–2003 to 72 in 2007–2009 (Fig. 3). Despite FAO's efforts, unfortunately the number of non-reporting countries has remained stable, although countries or territories that never submitted catch data during the decade are not many but more than half of the countries did not report at least once.

The quality of fishery data is known to be very uneven among countries. Besides data on timing of submission, also information on species breakdown and an evaluation of data consistency have been recorded since the 2000 inquiry. Rank values from 4 to 1 were assigned to all countries for the three indicators, which were then combined in a 'General evaluation' index of country's submission for each year. The 'General evaluation' score obtained by each country for 2009 has been plotted in a matrix against the 'Per capita supply' of fishery products [2], which was considered as a valid indicator of the importance of fisheries in each country as unfortunately data on fishery contribution to national GDP are not consistently available for all countries.

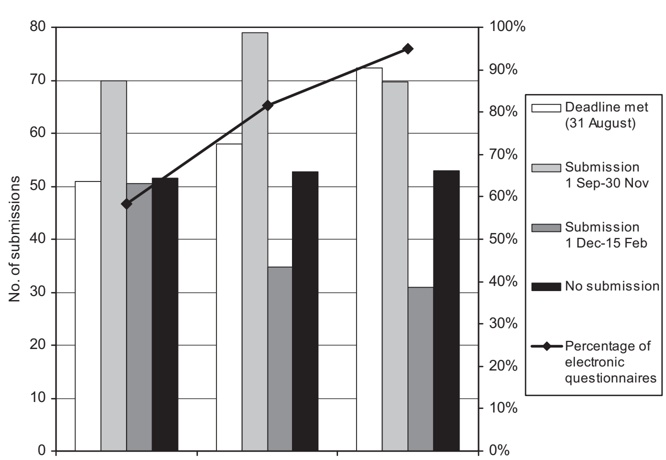

Fig. 3. Average number of submissions by countries and percentage of reporting by electronic questionnaires.

Table 1
Countries or territories with no adequate 2009 catch data submission.

	No. countries	No adequate submission	Percentage (%)
Developed	54	13	24.1
Developing	164	100	61.0
Africa	54	33	61.1
America, North	37	18	48.6
America, South	14	5	35.7
Asia	51	31	60.8
Europe	39	8	20.5
Oceania	23	18	78.3
Total	218	113	51.8

Data submitted or non-reported were considered inadequate in relation to the relative importance of capture fishery for over half of the countries. As expected, this percentage was greater for developing countries but also about one-fourth of reports by developed countries were not satisfactory. Countries that should improve their data collection and reporting systems are mainly found in Africa, Asia and among the island states in Oceania and the Caribbean (Table 1).

5. Studies based on data in the FAO capture database

5.1. What should be kept in mind when using the database for trend studies

The quality of the statistics included in the FAO capture databases is mostly dependent upon the accuracy and reliability of the data collected and provided by countries. When analyzing aggregated or global trends, the number of countries, the size of FAO fishing areas and the extended species coverage included in the database often play a buffer effect. Despite significant annual variations by country, fishing area and species, recent global total catch trend has been quite stable in the last four years (2006–2009) for which statistics are available at the time of writing, ranging between 88.9 and 90.1 million tonnes. On the other hand, in some cases disaggregated data series may be biased or disrupted due to a range of reasons:

- *erroneous reporting*: magnitudes of reported catches may be erroneous due to shortcomings in the data collection system, wrong procedures applied in raising sample data,[20] or for political reasons, e.g. countries with a centrally planned economy which report continuously growing catches to match targets set in yearly or multi-year national plans;
- *changes in the national data collection system*: improvements in national data collection and reporting systems are always welcomed but, unless historical data are corrected, in most cases provoke disruption in the total amount of national total catch and, if species breakdown is also improved, of species items trends[21];

[20] For example, according to G. de Graaf (pers. comm.), floodplain fisheries in Bangladesh is covered by sampling rural households for their annual catch. Total catches are then raised to whole population applying the percentage of rural households engaged in fishing as derived from a frame survey executed in 1983. As it is very improbable that the share of people involved in fisheries remained constant against a population growth of over 60% in the last 25 years, total catch trend has resulted to be linked to the population increase.

[21] See, for example, case of Ghanaian clupeoid catches examined by Longhurst [41].

- *changes in the species items reported over the years*: national offices reporting catch data mostly by the 3-alpha identifier often switch among codes for the species, its genus or family, thus disrupting data series of individual species;
- *incomplete identification*: some catches of a species included under a genus item, a higher taxonomic category or even as 'Marine fishes nei (not elsewhere included)', causing underestimation of real catches for the individual species.

As already noted in Section 3.2.1, trends in the data series also reflect political and natural events that greatly impacted the fishery sector in a country. For example, striking decreases of capture production in the 1960s for the Democratic Republic of the Congo and in 1996 for Burundi and Rwanda were due to political crises and civil wars, while the drop of Spanish catches in the Southeast Atlantic was a consequence of the Namibian independence. Hurricane Katrina struck the US Gulf Coast at the end of August 2005 and, although the Western Central Atlantic fishing area covers the US coast from North Carolina to the Mexican border, total catches by the United States in that year decreased by almost 20% in comparison to the previous year. Serious catch reductions are also expected as a consequence of the April 2010 oil spill in the Gulf of Mexico and the March 2011 tsunami in Japan.

Unexpectedly, other natural disasters, like the December 2004 tsunami that affected many important Asian fishing countries and the cyclone Nargis that in May 2008 caused the worst natural disaster in the recorded history of Myanmar, did not result in significant catch decreases as it would have been expected due to the magnitude of the devastations. FAO requested clarifications to the most involved countries. Indonesia replied that damages in Banda Aceh due to the tsunami were compensated by increased catches in other regions. Myanmar claimed that the cyclone Nargis had been destructive only in one out of three main fishing grounds and that, despite serious losses in fishing boats and gears, the fish populations greatly benefited from the stop to fishing operations in the three months after the cyclone.

Inland waters and shark catch statistics subsets included in the FAO database have been often critically scrutinized in recent years. Despite that total global inland water catch exceeded 10 million tonnes since 2008 and increased by 20% between 2004 and 2009, it is still the opinion [42,43] that it may be underestimated. However, recent global totals have been seriously influenced by great catch increases reported by some major Asian inland waters fishing countries which do not seem fully reliable [35,44].

Many environmentalist groups are devoting efforts to raise awareness on the status of shark stocks and campaign within international organizations [45]. In this context, the need to improve the quality of shark catch data collected by countries and reported to FAO is often raised. However, shark is the marine species group with the highest increase in number of species items in the FAO database during the last 15 years. Improvements and problems in interpretation of shark catch data were illustrated by the FAO fishery statistics group to a recent workshop on the shark status [46].

When capture and aquaculture data are extracted from the FAO databases, it should be kept in mind that, in order to obtain totals by country, continent and other aggregates as presented in FAO publications, some species groups have to be excluded. Besides those species groups which are given in numbers (i.e. whales, seals and crocodiles) and those grouped under 'Miscellaneous aquatic animal products' (i.e. pearls, corals and sponges), aquatic plants are also usually excluded. However, given their relevance in the aquaculture sector and use as human food in various regions, some studies include also aquatic plants in the aquaculture production greatly increasing the total obtained.

5.2. Studies by FAO

Every two years, recent trends of global capture production are analyzed in the FAO Department of Fisheries and Aquaculture's flagship publication "The State of World Fisheries and Aquaculture", also widely known as SOFIA [35]. For those fishing areas where no stock assessment information is available, data included in the database are also used to provide some hint on the stock status for the "Review of the State of World Marine Fishery Resources" [47] prepared by the FAO Marine and Inland Fisheries Service.

An FAO study by Garibaldi and Caddy [48] attempted to quantify geographical stocks that could be considered as depleted on the basis of catch statistics for a 33-year period examined by a multiple criteria method. About 10% of the species items analyzed matched the selection criteria, that is the same proportion of stocks classified as depleted by FAO in the stock status report available at that time [49], even though differences were found among the species identified. Recently, a more elaborated comparison [50] between data in the FAO capture database and the latest stock status classification [35] obtained similar figures, with a range between 7% and 13% of all global stocks classified as collapsed.

The database also provided information for the Grainger and Garcia [51] study, which developed a methodology to analyze the major phases (i.e. undeveloped, developing, mature and senescent phases) of fishery developments on the basis of capture data. The same approach has been later applied to analyze development phases at the national (Cuba [52]) and regional levels (Eastern Central Atlantic [53]).

According to their biological characteristics, the "oceanic" species for which statistics are available in the FAO database were identified and further subdivided into "epipelagic" and "deep-water" [54]. This species classification was used to quantify high seas catches and their trends [34,49,55,56], although coincidence between catches in the high seas and those beyond the continental shelf is coarse in some areas. It is interesting to note that the number of species items classified as deep-water more than doubled between the 1999 and 2006 releases of the database, probably reflecting mostly a greater global attention to monitoring deep-water fishing rather than increased fishing activities.

5.3. Citation analysis for the FAO capture database

Citation analyses performed for FishBase [57] and the FAO Code of Conduct for Responsible Fisheries [58] reported that both had been cited more than 500 times, enrolling them to the restricted group of highly-cited items. In fact, it was estimated that among the 20 million items published between 1900 and 2005 that have been cited at least once, only about 21,400 were cited more than 500 times representing 0.11% of the total [59]. Similar research conducted for the FAO capture database found out that also this item should be added to the exclusive club.

The FAO capture database is cited in an array of different manners and the bibliographic database *Scopus*[22] was searched using 15 word combinations referring to 'FAO capture database', 'FAO Yearbook of Fishery Statistics', 'Fishstat software', etc. After removing duplicates and citations referring to the FAO

[22] Elsevier's SciVerse Scopus bibliographic database ⟨http://www.scopus.com/home.url⟩ accessed 13–17 June 2011.

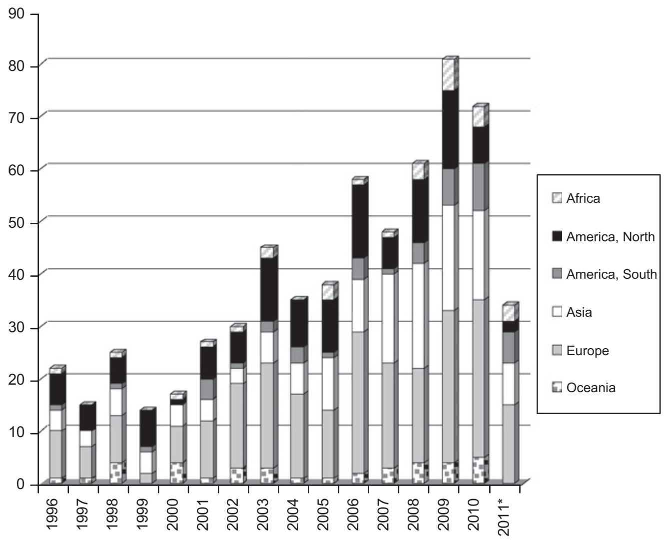

Fig. 4. Number of citations for the FAO capture production database by continent (*data for 2011 are only up to mid-June).

aquaculture or fishery trade databases, it resulted that a total of 622 articles from refereed journals cited the FAO capture database between 1996 and mid-June 2011. However, the number of scientific papers that have been analyzing data extracted from the FAO capture database is higher, as it was noted that several articles either largely based on data from the database (e.g. [50,60–62]) or discussing its content (e.g. [17,18,63]) did not cite it in the references section.

Analysis of citations showed that a peak was reached in 2009 and that a 40% average of the articles are by authors affiliated to European institutions followed by Asian and North American authors (Fig. 4). The number of citations in 2010 plus those already available for 2011 exceeded that for 2009 in all continents with the exception of North America. This may be due to the increasing use by North American fishery scientists of data compiled by the *Sea Around Us* project rather than those from the FAO capture database. The *Sea Around Us* database was established in the mid-2000s and complements data from the FAO capture database with other sources [64] estimating and adjusting data on the basis of spatial models [62]. However, the *Sea Around Us* database seems to no longer be regularly updated.[23]

6. Conclusions

As demonstrated by the citation analysis, the service provided by the FAO global capture database to the community interested in fishery information during the last 60 years is relevant but the need for reliable data in the fishery sector is felt now more than ever. Once the continuous catch increase reported by China for many years has been settled and revised (see Section 3.3), figures for total global catches have been rather steady in the last four years (2006–2009) and also estimation and forecast for some important species in 2010–2011 are rather positive [65]. Recent scientific articles [66–68] reported successes in rebuilding or maintaining at sustainable levels stocks of several species and in this context it is very important that data from the FAO capture database provide reliable indications on global and regional trends.

To this end, national data collection systems have to be improved in those countries where they are weak, not operating regularly, or even not present at all. Efforts should be also made at the national level to avoid inconsistencies between data compiled by different institutions and to avoid reporting of catches linked to national plans rather than actual data. Lastly, FAO should cooperate continuously with national institutions to reduce as much as possible the still high percentage of non-reporting countries.

[23] Accessed in mid-June 2011, the *Sea Around Us* databases 〈http://www.seaaroundus.org/data/〉 included data up to 2006 whereas the FAO database at the end of February 2011 was updated to 2009 data.

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