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Data for Fish Stock Assessment Obtained from the CMSY Algorithm for all Global FAO Datasets

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Abstract: Assessing the state of fish stocks requires the determination of descriptors. They correspond to the absolute and relative (to the carrying capacity of the habitat) fish biomasses in the ecosystem, and the absolute and relative (to the intrinsic growth rate of the population) fishing mortality resulting from catches. This allows, among other things, to compare the catch with the maximum sustainability yield. Some fish stocks are well described and monitored, but for many data-limited stocks, catch time series are remaining the only source of data. Recently, an algorithm (CMSY) has been proposed, allowing an estimation of stock assessment variables from catch and resilience. In this paper, we provide stock reference points for all global fisheries reported by Food and Agriculture Organization (FAO) major fishing area for almost 5000 fish stocks. These data come from the CMSY algorithm for 42% of the stock (75% of the global reported fish catch) and are estimated by aggregated values for the remaining 58%.

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1. Summary

Data are mainly presented through a table listing for the 4993 species-area associations, the main characteristics of the Food and Agriculture Organization (FAO) database (common name, scientific name, FAO area ID, current catch) and the assessed stock descriptors (the fishing mortality F, the fishing mortality at the maximum sustainability yield F_{MSY}, the ratio FF_{MSY}, the biomass B, the biomass at the maximum sustainability yield B_{MSY}, and the ratio BB_{MSY}, all with corresponding confidence intervals).

The accuracy of the assessments is qualitatively determined through a classification which addresses the potential bias on the results and quantitatively by the confidence intervals of stock parameters. Classes are defined according to the available data (time series duration, missing data...) and the necessary assumptions (for non-fish species and multi-species datasets).

For 2917 stocks, the available data do not allow the use of the CMSY algorithm [1]. These results of too many blank years in the time series, too short data time series, too many species aggregated in the dataset, or non-convergence of the algorithm. For these entries, F, F_{MSY}, FF_{MSY} and BB_{MSY} are estimated from other areas. B and B_{MSY} are calculated in accordance with the current catch.

This table is supplemented for the 2076 directly assessed stocks by: (1) the graphical outputs of the CMSY algorithm, (2) the log files, and (3) graphs and corresponding data showing the temporal variation of the relative biomass versus the relative fishing mortality over the catch time series (with and without error bars). Stocks are defined for the ASFIS (Aquatic Sciences and Fisheries Information System) species by FAO Major Fishing Area, except for tuna and tuna-like species assessed at ocean (or half-ocean) scale.

2. Data Description

2.1. Descriptors Table

The main table ("Fish stock assessment data.xlsx") contains the following columns which can be organized in three categories: (1) information from the FAO database, (2) assessment metadata and (3) assessment result. Table 1 describes the column contains.

Table 1. Description of the result table.

Column Header	Description
Information from the FAO Database	
FAO species name	Common name of the species used by the FAO.
Scientific name	Corresponding scientific name. For most of the stocks, it is composed of the genus and the species name (e.g., *Engraulis ringens*) but can refer to the genus only (e.g., *Sebaste spp*) or to an upper taxonomic level (e.g., *Clupeoidei*) for multi-species stocks.
ISSCAAP group	The species are sorted according to the International Standard Statistical Classification for Aquatic Animals and Plants (ISSCAAP) group.
Main group	The species belong to one of the following seven main groups: amphibia or reptilia, crustacea, invertebrata aquatica, mammalia, mollusca, pisces, and plantae aquaticae.
FAO area name	Oceans and inland waters are divided into 19 marine and 6 continental FAO major fishing areas.
FAO area number	Associated area identification number.
Unit	Catch is commonly reported in tonnes (*t*), but some datasets are expressed in a number of individuals (*no*).
Assessment Metadata	
Assessment class	The assessments are sorted according to the available data defined in Hélias et al. [2]. Class I, II and III corresponds to stocks fully assessed by CMSY. Class I encompasses single marine fish species stocks. Stocks listed in class II are assessed with questionable hypotheses: (a) multi-stock dataset, but with five or fewer species, (b) non-fish species stocks, (c) stocks from an inland FAO area. Class III corresponds to (a) multi-stock dataset with more than five species, (b) non-fish species multi-stocks or (c) multi-stocks from an inland area. Stocks not directly assessed but aggregated values are used are listed in class IV. The aggregated value comes from the global level values of the corresponding (a) ASFIS species, (b) ISSCAAP group level (when values for ASFIS species are not available).

Comment	Additional information, reason why the stock is not assessed by the CMSY algorithm or reference to the determination of the number of species of non-fish species.
Interpolated data	Fraction (%) of the catch time-series interpolated (CMSY algorithm requires continuous times series without blank years).
Resilience	Resilience of the species coming from Fishbase.
C	Average catch (*t/yr* or *no/yr*) over the last three years of the time series
Year	Last year in the time series.
Stock ID	Internal stock identification code composed by [scientific name]_[FAO area number]_[internal ID]. This code is used in the name of the additional files provided (see below).
Assessment Result	
B	Average biomass in the area over the last three years (*t* or *no*). For class IV, $B = C/F$.
B_{min}	Lower bound of the 95% confidence interval of B. For class IV, $B_{min} = C/F_{max}$.
B_{max}	Upper bound of the 95% confidence interval of B. For class IV, $B_{max} = C/F_{min}$.
BB_{MSY}	Relative average biomass in the area over the last three years (i.e., B/B_{MSY}, unitless). For class IV, the weighted median of corresponding stocks is used.
$BB_{MSY,min}$	Lower bound of the 95% confidence interval of BB_{MSY}. For class IV, the weighted median of corresponding stocks is used.
$BB_{MSY,max}$	Upper bound of the 95% confidence interval of BB_{MSY}. For class IV, the weighted median of corresponding stocks is used.
F	Average fishing mortality in the area over the last three years (yr^{-1}). For class IV, the weighted median of corresponding stocks is used.
F_{min}	Lower bound of the 95% confidence interval of F. For class IV, the weighted median of corresponding stocks is used.
F_{max}	Upper bound of the 95% confidence interval of F. For class IV, the weighted median of corresponding stocks is used.
FF_{MSY}	Relative average fishing mortality in the area over the last three years (i.e., F/F_{MSY}, unitless). For class IV, the weighted median of corresponding stocks is used.
$FF_{MSY,min}$	Lower bound of the 95% confidence interval of FF_{MSY}. For class IV, the weighted median of corresponding stocks is used.
$FF_{MSY,max}$	Upper bound of the 95% confidence interval of FF_{MSY}. For class IV, the weighted median of corresponding stocks is used.
B_{MSY}	Biomass compatible with the maximum sustainability yield (*t* or *no*). For class IV, $B_{MSY} = (C/F_{max})/(BB_{MSY})$.
$B_{MSY,min}$	Lower bound of the 95% confidence interval of B_{MSY}. For class IV, $B_{MSY,min} = (C/F_{max})/(BB_{MSY,max})$.
$B_{MSY,max}$	Upper bound of the 95% confidence interval of B_{MSY}. For class IV, $B_{MSY,max} = (C/F_{min})/(BB_{MSY,min})$.
F_{MSY}	Fishing mortality compatible with the maximum sustainability yield (yr^{-1}). For class IV, the weighted median of corresponding stocks is used.
$F_{MSY,min}$	Lower bound of the 95% confidence interval of F_{MSY}. For class IV, the weighted median of corresponding stocks is used.
$F_{MSY,max}$	Upper bound of the 95% confidence interval of F_{MSY}. For class IV, the weighted median of corresponding stocks is used.

2.2. Traceability of Algorithm Runs

The two input files of the CMSY algorithm are provided. "Catchseries.csv" contains all catch data from the FAO database and "Metadata.csv" additional information needed (mainly the

resilience). The log files of CMSY algorithm ("[Stock ID] CMSY log file.txt") and the graphical output ("[Stock ID].jpeg") are available for each assessed stock.

2.3. Stock Status

Temporal variations of the stock status over the time series are illustrated by figures showing FF_{MSY} versus and BB_{MSY} (for all assessed stock with the CMSY algorithm: class I, II, and III). The scatterplots are provided without uncertainty ("[Stock ID] stock status.pdf") and with error bars ("[Stock ID] stock status (with uncertainty).pdf"). The corresponding tables are also available ("[Stock ID] stock status.csv"). Figure 1 illustrates the stock status of the Atlantic bluefin tuna (*Scombridae, Thunnus thynnus)* for the eastern Atlantic as an example. Target relative biomass ($BB_{MSY} = 1$) and target relative fishing mortality ($FF_{MSY} = 1$) are drawn with dashed lines. When $BB_{MSY} < 1$, the stock is overexploited and when $FF_{MSY} > 1$, the fishing effort is too high. The temporal evolution is given by the greyscale of the dot, from white for the oldest value to black for the most recent one (here from 1950 to 2015).
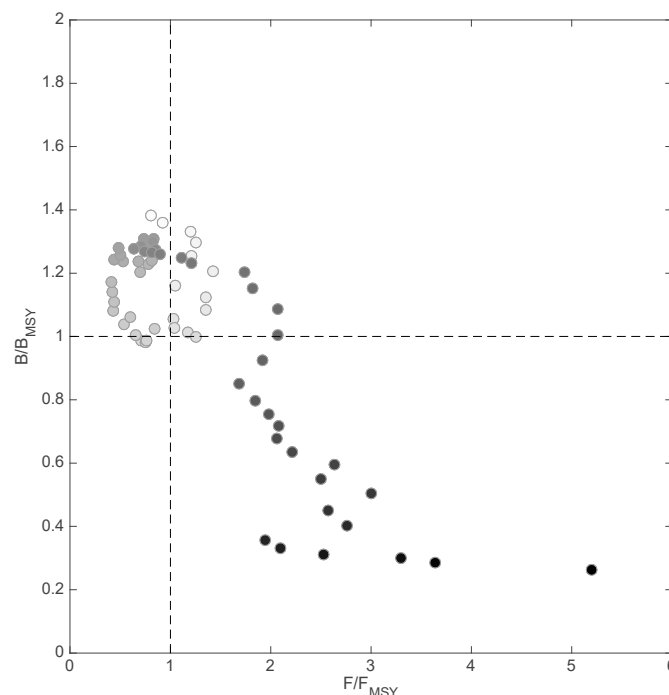

Figure 1. Temporal variation of the stock status for bluefin tuna in eastern Atlantic.

3. Methods

Data pretreatment and data processing are detailed in Hélias et al. [2] (in the article and in the associated supplementary materials). The stocks descriptors are used in [2] for the computation of characterization factors for biotic resource depletion, but not provided.

The recently proposed CMSY algorithm [1] (November 2016 version) allows the computation of fish population descriptors and parameters from only the resilience and catch time series. Resilience to fishing pressure values were obtained from FishBase [3] with the rfishbase v2.1.1 Library [4]. Catch time series were used for species of FAO Global Fishery and Aquaculture Statistics, v2017.1.0, with time series spanning between 1950 and 2015 [5], through the FishStatJ® interface.

The FAO Fisheries and Aquaculture Department provides global fish catch data from landings and by-catches reported by countries. Reported catch has to follow the Coordinating Working Party on Fishery Statistics handbook [6] to ensure data consistency. If unintentional catch (by-catch and

discards) should be reported, FAO data do not inventory illegal and undeclared fishing activities. Actual catch may be significantly higher than FAO values, but they cannot be assessed with the available data. Illegal fishing is therefore not addressed by stock parameters provided in this work and might introduce non-quantifiable errors in values.

A fish stock (i.e., a population in ecology) is defined by a given species in a specific habitat. With the FAO dataset, the stock is defined by an ASFIS-species in a FAO area. This could lead to additional inconsistencies between FAO-based stock parameters and real (but not available) values. The stock parameters have to be used accordingly and with caution, but a special attention in the qualitative classification has been devoted to multi-stock datasets, when several caught species or several associated habitats are merged into a unique available FAO dataset. See Hélias et al. [2] for more details.

Conflicts of Interest: The author declares no conflict of interest.

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