**Methods**

*Estimating FAO stock status*

We constructed time series of stock status (B/BMSY) for 1,536 FAO fish stocks using a recently developed superensemble model (Anderson et al. 2017) that estimates B/BMSY from the B/BMSY predictions of four individual catch-only models (**Table 1**) and two spectral properties of the catch time series. This superensemble model has been shown to generate better predictions of status than other catch-only models (Anderson et al. 2017; Jensen & Free 2017) and has been used to estimate the terminal year status of 785 FAO fish stocks (Rosenberg et al. 2017). We extended the analysis of Rosenberg et al. (2017) to estimate status from 1950-2015 for the 1,536 FAO fish stocks (FAO area-country-species triples) meeting the following criteria: marine wild capture fisheries for finfish and invertebrates with taxonomic identification resolved to the species-level and with catch time series ≥20 yrs and ≥1000 mt of median annual catch (**Table 2**).

For each stock, we used the superensemble model to estimate B/BMSY every year (year *i*) from the 15th year to the terminal year of the catch time series using: (1) the 0.20 and 0.05 spectral densities of the scaled catch time series (catch divided by maximum catch) from year *0* to year *i* and (2) B/BMSY predictions for year *i* from the four individual catch-only models applied to the full catch time series. We calculated the 0.20 and 0.05 spectral densities, which correspond to 5- and 20-year cycles respectively, using the *spec.ar* function in base R. We implemented the four individual catch-only models -- cMSY, SSCOM, COMSIR, and mPRM (**Table 1**) -- using the *datalimited* package in R (Anderson et al. 2016). In addition to catch time series, mPRM requires the classification of species into 17 life history categories (**Supp. Table 1**) and the other three models require estimates of resilience (i.e., the capacity to withstand exploitation; **Supp. Table 2**). We classified life history based on taxonomy and derived resilience estimates from FishBase (Froese & Pauly 2017) and SeaLifeBase (Palomares & Pauly 2017) life history information (see **Supplemental Methods** for more detail).

All analyses were conducted in R v.3.4.2 (R Core Team 2017) and the code is available here: <https://github.com/cfree14/trade_and_collapse>

**Supplemental methods**

*Assigning life history traits to the FAO species*

We used the *rfishbase* package in R (Boettiger et al. 2012) to correct the taxonomy of species in the FAO landings data and download their habitat types, Von Bertalanffy growth parameters, maximum size, and vulnerability and resilience from FishBase (FB, for finfish; Froese & Pauly 2017) and SeaLifeBase (SLB, for invertebrates; Palomares & Pauly 2017 ). We classified species into the 17 life history categories used by the mPRM catch-only model based on taxonomy using **Supp. Table 1**. We classified species into resilience categories (**Supp. Table 2**) using, in order of preference, the following: (1) resilience reported on FB/SLB; (2) resilience derived from the median Von Bertalanffy K parameter reported on FB/SLB (**Supp. Figure 1**); (3) resilience derived from the vulnerability reported on FB/SLB (**Supp. Figure 2**); or (4) the mode resilience for taxa in the same genus reported on FB/SLB.

Fitting the individual catch-only models

cMSY-13: 500,000 iterations

COMSIR: 1,000,000 iterations

https://rstudio.sesync.org/

**References**

Anderson, S.C., J. Afflerbach, A.B. Cooper, M. Dickey-Collas, O.P. Jensen, K.M. Kleisner, C. Longo, G.C. Osio, D. Ovando, C. Minte-Vera, C. Minto, I. Mosqueira, A.A. Rosenberg, E.R. Selig, J.T. Thorson, and J.C. Walsh. 2016. datalimited: Stock assessment methods for data-limited fisheries. R package version 0.0.2. Available at:<https://github.com/datalimited/datalimited>

Anderson, S.C, A.B. Cooper, O.P. Jensen, C. Minto, J.T. Thorson, J.C. Walsh, J. Afflerbach, M. Dickey-Collas, K.M. Kleisner, C. Longo, G.C. Osio, D. Ovando, I. Mosqueira, A.A. Rosenberg, and E.R. Selig. 2017. Improving estimates of population status and trend with superensemble models. Fish & Fisheries 18(4):732-741.

Costello, C., D. Ovando, R. Hilborn, S.D. Gaines, O. Deschenes, and S.E. Lester. 2012. Status and solutions for the world’s unassessed fisheries. Science338:517-520.

Jensen, O.P., Free, C.M. (2017) Testing and comparison of data-limited assessment models for estimating global and regional stock status. UN Food & Agriculture Organization.

Martell, S., and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. Fish & Fisheries 14:504-514.

Rosenberg, A.A., M.J. Fogarty, A.B. Cooper, M. Dickey-Collas, E.A. Fulton, N.L. Gutiérrez, K.J.W. Hyde, K.M. Kleisner, C. Longo, C.V. Minte-Vera, C. Minto, I. Mosqueira, G.C. Osio, D. Ovando, E.R. Selig, J.T. Thorson, and Y. Ye. 2014. Developing new approaches to global stock status assessment and fishery production potential of the seas. FAO Fisheries and Aquaculture Circular, Rome, Italy.

Rosenberg, A.A., Kleisner, K.M., Afflerbach, J., Anderson, S.C., Dickey‐Collas, M., Cooper, A.B., Fogarty, M.J., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Jardim, E., Jensen, O.P., Kristiansen, T., Longo, C., Minte-Vera, C.V., Minto, C., Mosqueira, I., Chato Osio, G., Ovando, D., Selig, E.R., Thorson, J.T., Walsh, J.C., Ye, Y. (2017) Applying a new ensemble approach to estimating stock status of marine fisheries around the world. *Conservation Letters*: doi: 10.1111/conl.12363

Thorson, J.T., C. Minto, C.V. Minte-Vera, K.M. Kleisner, and C. Longo. 2013. A new role for effort dynamics in the theory of harvested populations and data-poor stock assessment. Canadian Journal of Fisheries & Aquatic Sciences 70(12):1829-1844.

Vasconcellos, M., and K. Cochrane. 2005. Overview of world status of data-limited fisheries: inferences from landings statistics. In: Kruse, G.H., V.F. Gallucci, D.E. Hay, R.I. Perry, R.M. Peterman, T.C. Shirley, P.D. Spencer, B. Wilson, and R. Woodby (Eds.): Fisheries Assessment and Management in Data-Limited Situations. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, AK, pp. 1–20.

**Tables & Figures**

**Table 1.** Individual catch-only models used by the superensemble model.

|  |  |  |  |
| --- | --- | --- | --- |
| **Method** | **References** | **Data input/output** | **Brief description** |
| **cMSY-2013**  Catch-MSY | Martell & Froese 2013  Rosenberg et al. 2014 | In: Catch, resilience  Out: B/BMSY, MSY, B, BMSY | Uses a stock reduction analysis with priors for r, k, and initial/final year depletion derived from resilience to estimate status |
| **COM-SIR**  Catch-only-model with sampling importance resampling | Vasconcellos & Cochrane 2005  Rosenberg et al. 2014 | In: Catch, resilience  Out: B/BMSY | Uses a coupled harvest-dynamics model fit using a sampling importance resampling algorithm to estimate status |
| **SSCOM**  State-space catch-only model | Thorson et al. 2013 | In: Catch, resilience  Out: B/BMSY | Uses a coupled harvest-dynamics model fit using a Bayesian hierarchical state-space framework to estimate status |
| **mPRM**  Modified panel regression model | Costello et al. 2012  Anderson et al. 2017 | In: Catch, taxonomic group  Out: B/BMSY | Uses a panel regression model trained on the RAMLDB to predict status from characteristics of the catch time series and taxonomic group |

**Supp. Table 1.** Classification of FAO stocks into life history categories consistent with the mPRM catch-only model based on taxonomy.

|  |  |  |
| --- | --- | --- |
| **Type** | **Category** | **Taxonomic groups** |
| Finfish | Cods, hakes, haddocks | Order: Gadiformes |
| Finfish | Flounders, halibuts, soles | Order: Pleuronectiformes |
| Finfish | Herrings, sardines, anchovies | Order: Clupeiformes (except the shads) |
| Finfish | Shads | Subfamily: Alosinae; Genera: Alosa, Brevoortia, Ethmalosa, Ethmidium, Gudusia, Hilsa, Tenualosa |
| Finfish | Tunas, bonitos, billfishes | Scombridae (tunas, bonitos, mackerel), Istiophoridae (marlin), Xiphiidae (swordfish) |
| Finfish | Sharks, rays, chimaeras | Classes: Elasmobranchii (sharks, rays, skates, sawfish), Holocephali (chimaeras) |
| Finfish | Miscellaneous coastal fishes | Unclassified finfish/cephalopods with w/ a reef-associated, benthopelagic, pelagic-neritic, or pelagic habitat type |
| Finfish | Miscellaneous demersal fishes | Unclassified finfish/cephalopods with w/ a demersal, bathydemersal, or bathypelagic habitat type |
| Finfish | Miscellaneous diadromous fishes | Families: Salmonidae (salmon), Moronidae (temperate basses) |
| Finfish | Miscellaneous pelagic fishes | Unclassified finfish/cephalopods with w/ a pelagic-oceanic habitat type |
| Molluscs | Abalones, winkles, conchs | Class: Gastropoda |
| Molluscs | Clams, cockles, arkshells | Orders: Veneroida (clams/cockles), Arcoida (ark shells) plus Myoida (other clams), Mytiloida (mussels) |
| Molluscs | Scallops, pectens | Order: Ostreoida |
| Crustaceans | Crabs, sea-spiders | All crab/sea spider families plus geryon families |
| Crustaceans | King crabs, squat-lobsters | Families: Lithodidae (king crabs), Galatheidae (squat lobsters) |
| Crustaceans | Lobsters, spiny-rock lobsters | Families: Nephropidae (true lobsters), Palinuridae (spiny lobsters), Scyllaridae (slipper lobsters) |
| Crustaceans | Shrimps, prawns | All shrimp/prawn families plus krill/seabobs/mantis shrimp families |

**Supp. Table 2.** AFS and FishBase guidelines for using life history traits to classify the resilience of fish stocks to exploitation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Resilience** | **r prior** | **Von B**  **K (1/yr)** | **Age at**  **maturity (yr)** | **Maximum**  **age (yr)** | **Fecundity**  **(1/yr)** |
| High | [0.6, 1.5] | >0.3 | <1 | 1-3 | >10,000 |
| Medium | [0.2, 1.0] | 0.16-0.30 | 2-4 | 4-10 | 100-1000 |
| Low | [0.05, 0.5] | 0.05-0.15 | 5-10 | 11-30 | 10-100 |
| Very low | [0.015, 0.1] | <0.05 | >10 | > 30 | <10 |
| Unknown | [0.2, 1.0] | ------ | ------ | ------ | ------ |