Package ‘datalimited2’

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Type Package

Title More Stock Assessment Methods for Data-limited Fisheries

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Description Methods for estimating B/BMSY from fisheries catch time series.

URL https://github.com/cfree14/datalimited2

Depends R (>= 3.4.2)

License GPL-3

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LazyData true

Imports plyr, segmented, gbm, dismo, fGarch, R2jags, coda, parallel, foreach, doParallel, gplots, caret

RoxygenNote 6.0.1

R topics documented:

bbmsy2s — *Convert B/BMSY to saturation*

Description

Converts B/BMSY to saturation (S). Note: S = 1 - depletion = B / K = 0.5 * B/BMSY.

Usage

```
bbmsy2s(bbmsy)
```

Arguments

`bbmsy`	A vector of B/BMSY values

Value

A vector of saturation values

Examples

```
# Convert B/BMSY of 0.5 to saturation
bbmsy2s(0.5)
```

bsm — *Bayesian state-space surplus production model*

Description

Estimates biomass, fishing mortality, and stock status (B/BMSY and F/FMSY) time series and biological/management quantities (e.g., r, K, MSY, BMSY, FMSY) from a time series of catch and a resilience estimate using the Bayesian surplus production model from Froese et al. 2017.

Usage

```
bsm(year, catch, biomass, btype, resilience = NA, r.low = NA, r.hi = NA,
  stb.low = NA, stb.hi = NA, int.yr = NA, intb.low = NA, intb.hi = NA,
  endb.low = NA, endb.hi = NA, q.start = NA, q.end = NA, verbose = T)
```

Arguments

`year`	A time series of years
`catch`	A time series of catch
`biomass`	A time series of biomass or CPUE (specifiy type in `btype`)
`btype`	Biomass time series type: "CPUE" or "biomass"
`resilience`	Resilience of the stock: "High", "Medium", "Low", or "Very low" (optional if `r.low, r.hi` is specified)
`r.low, r.hi`	A user-specified prior on the species intrinsic growth rate, r (optional if `resilience` is specified)

`stb.low, stb.hi`
: A user-specified prior on biomass relative to unfished biomass at the beginning of the catch time series (optional)

`int.yr`
: A user-specified year of intermediate biomass (optional)

`intb.low, intb.hi`
: A user-specified prior on biomass relative to unfished biomass in the year of intermediate biomass (optional)

`endb.low, endb.hi`
: A user-specified prior on biomass relative to unfished biomass at the end of the catch time series (optional)

`q.start, q.end`
: A user-specified start and end year for estimating the catchability coefficient (optional; default is last 5 years)

`verbose`
: Set to FALSE to suppress printed updates on model progress (default=TRUE)

Details

The Bayesian state-space surplus production model (BSM) developed by Froese et al. 2017 is fitted using a catch time series and any available (i.e., doesn't have to be complete) biomass or catch-per-unit-effort (CPUE) data. It extends the algorithms used to set bounds for r, K, and start, intermediate, and final year saturation in CMSY by deriving density distributions from these originally uniform bounds and by adding a prior for catchability, q. BSM estimates biomass, fishing mortality, and stock status (B/BMSY and F/FMSY) time series and biological/management quantities (e.g., r, K, MSY, BMSY, FMSY).

Value

A list with the following elements:

`ref_pts`
: A dataframe with biological quantity and reference point estimates with 95% confidence intervals

`ref_ts`
: A dataframe with B/BMSY, F/FMSY, biomass, and fishing mortality time series with 95% confidence intervals

`priors`
: A dataframe with the priors used in the analysis

`r_out`
: A vector with the viable r values

`k_out`
: A vector with the viable K values

`method`
: Name of the method

References

Froese R, Demirel N, Coro G, Kleisner KM, Winker H (2017) Estimating fisheries reference points from catch and resilience. *Fish and Fisheries* 18(3): 506-526. http://onlinelibrary.wiley.com/doi/10.1111/faf.12190/abstract

Examples

```
# Fit BSM to catch time series and plot output
output <- bsm(year=SOLIRIS$yr, catch=SOLIRIS$ct, biomass=SOLIRIS$bt,
              btype="CPUE", r.low=0.18, r.hi=1.02)
plot_dlm(output)

# Extract reference points and time series from output
ref_pts <- output[["ref_pts"]]
ref_ts <- output[["ref_ts"]]
```

cmsy2 *CMSY catch-only stock assessment model*

Description

Estimates biomass, fishing mortality, and stock status (B/BMSY and F/FMSY) time series and biological/management quantities (e.g., r, K, MSY, BMSY, FMSY) from a time series of catch and a resilience estimate using CMSY from Froese et al. 2017.

Usage

```
cmsy2(year, catch, resilience = NA, r.low = NA, r.hi = NA, stb.low = NA,
  stb.hi = NA, int.yr = NA, intb.low = NA, intb.hi = NA,
  endb.low = NA, endb.hi = NA, verbose = T)
```

Arguments

`year`	A time series of years
`catch`	A time series of catch
`resilience`	Resilience of the stock: "High", "Medium", "Low", or "Very low" (optional if `r.low, r.hi` is specified)
`r.low, r.hi`	A user-specified prior on the species intrinsic growth rate, r (optional if `resilience` is specified)
`stb.low, stb.hi`	A user-specified prior on biomass relative to unfished biomass at the beginning of the catch time series (optional)
`int.yr`	A user-specified year of intermediate biomass (optional)
`intb.low, intb.hi`	A user-specified prior on biomass relative to unfished biomass in the year of intermediate biomass (optional)
`endb.low, endb.hi`	A user-specified prior on biomass relative to unfished biomass at the end of the catch time series (optional)
`verbose`	Set to FALSE to suppress printed updates on model progress (default=TRUE)

Details

The CMSY model developed by Froese et al. 2017 employs a stock reduction analysis using priors for r based on resilience, K based on maximum catch and the r priors, and start, intermediate, and final year saturation based on a set of simple rules. It also allows users to revise the default priors based on expert knowledge. The SRA employs a Schaefer biomass dynamics model and an algorithm for identifying feasible parameter combinations to estimate biomass, fishing mortality, and stock status (B/BMSY and F/FMSY) time series and biological/management quantities (e.g., r, K, MSY, BMSY, FMSY).

Value

A list with the following elements:

ref_pts	A dataframe with biological quantity and reference point estimates with 95% confidence intervals
ref_ts	A dataframe with B/BMSY, F/FMSY, biomass, and fishing mortality time series with 95% confidence intervals
priors	A dataframe with the priors used in the analysis
rv.all	A vector with the viable r values
kv.all	A vector with the viable K values
btv.all	A dataframe with the biomass trajectories produced by the viable r/K pairs
method	Name of the method

References

Froese R, Demirel N, Coro G, Kleisner KM, Winker H (2017) Estimating fisheries reference points from catch and resilience. *Fish and Fisheries* 18(3): 506-526. http://onlinelibrary.wiley.com/doi/10.1111/faf.12190/abstract

Examples

```
# Fit cMSY to catch time series and plot output
output <- cmsy2(year=SOLIRIS$yr, catch=SOLIRIS$ct, r.low=0.18, r.hi=1.02)
plot_dlm(output)

# Extract reference points and time series from output
ref_pts <- output[["ref_pts"]]
ref_ts <- output[["ref_ts"]]
```

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ocom *Optimized catch-only model*

Description

Estimates biomass, saturation (B/K), and stock status (B/BMSY) time series and biological/management quantities (i.e., r, k, MSY, BMSY, FMSY) from a time series of catch and a natural mortality (M) estimate using the optimized catch-only model (OCOM) from Zhou et al. 2017.

Usage

```
ocom(year, catch, m)
```

Arguments

year	A time series of years
catch	A time series of catch
m	Natural mortality (1/yr)

Details

The "optimized catch-only model" (OCOM) developed by Zhou et al. 2017 employs a stock reduction analysis (SRA) using priors for r and stock depletion derived from natural mortality and saturation estimated using the Zhou-BRT method, respectively. The SRA employs a Schaefer biomass dynamics model and an algorithm for identifying feasible parameter combinations to estimate biomass, saturation, and status time series and biological/management quantities such as r, K, MSY, BMSY, and FMSY.

Value

A list with the following elements:

`b_ts`	A data frame with time series of biomass estimates and confidence intervals
`s_ts`	A data frame with time series of saturation estimates and confidence intervals
`bbmsy_ts`	A data frame with time series of B/BMSY estimates and confidence intervals
`b_trajs`	A data frame with 1000 randomly selected biomass trajectories
`s_trajs`	A data frame with 1000 corresponding saturation trajectories
`bbmsy_trajs`	A data frame with 1000 corresponding B/BMSY trajectories
`krms`	A data frame with estimates of biological quantities r, k, MSY, and S and confidence intervals
`krms_draws`	A data frame with 10,000 draws underpinning the above values
`method`	Name of the method

References

Zhou S, Punt AE, Smith ADM, Ye Y, Haddon M, Dichmont CM, Smith DC (2017) An optimised catch-only assessment method for data poor fisheries. *ICES Journal of Marine Science*: doi:10.1093/icesjms/fsx226. https://doi.org/10.1093/icesjms/fsx226

Examples

```
# Fit OCOM to catch time series and plot output
set.seed(1) # stochastic fitting
output <- ocom(year=TIGERFLAT$yr, catch=TIGERFLAT$catch, m=0.27)
plot_dlm(output)

# Extract reference points and time series from output
b_ts <- output[["b_ts"]]
bbmsy_ts <- output[["bbmsy_ts"]]
krms <- output[["krms"]]
```

`plot_dlm` *Plot data-limited stock assessment model output*

Description

Plots the results of data-limited stock assessment models implemented in the **datalimited2** package.

Usage

```
plot_dlm(output)
```

Arguments

`output`	Output from a **datalimited2** model

Details

Produces different plots for each model:

1. **zBRT** - Plots show: (A) catch time series; (B) saturation time series; and (C) B/BMSY time series.

2. **OCOM** - Plots show: (A) catch time series; (B) viable r/K pairs; (C) saturation time series; and (D) B/BMSY time series.

3. **cMSY / BSM** - Plots show: (A) catch time series; (B) viable r/K pairs; (C) B/BMSY time series; (D) F/FMSY time series; and (E) Kobe plot.

In all plots, dashed lines show the reference point target (i.e., B/BMSY = 1, F/FMSY = 1, or saturation = 0.5) and dotted lines show the overfishing limit (i.e., B/BMSY = 0.5 or saturation = 0.25). If MSY is estimated, the median value and 95% confidence intervals are shown in the catch time series plot as a horizontal dashed line and grey rectangle, respectively.

Examples

```
# Fit OCOM to catch time series and plot output
output <- ocom(year=YELLSNEMATL$year, catch=YELLSNEMATL$tc, m=0.2)
plot_dlm(output)
```

`rorcs` *Refined ORCS approach*

Description

Estimates stock status (i.e., under, fully, or overexploited) from 12 stock- and fishery-related predictors using the refined ORCS approach from Free et al. 2017. Stock status categories are defined as follows: (1) B/BMSY>1.5 = underexploited; (2) 0.5<B/BMSY<1.5 = fully exploited; and (3) B/BMSY<0.5 = overexploited.

Usage

```
rorcs(scores)
```

Arguments

`scores` A numeric vector of length twelve containing scores for the following "Table of Attributes" questions (see Free et al. 2017 for more detail):

- TOA 1 - Status of assessed stocks in fishery
- TOA 3 - Behavior affecting capture (2 or 3 only)
- TOA 5 - Discard rate
- TOA 6 - Targeting intensity

- TOA 7 - M compared to dominant species
- TOA 8 - Occurence in catch
- TOA 9 - Value (US$/lb) - continuous value
- TOA 10 - Recent trends in catch
- TOA 11 - Habitat loss
- TOA 12 - Recent trend in effort
- TOA 13 - Recent trend in abundance index
- TOA 14 - Proportion of population protected

Details

The refined ORCS approach (rORCS) uses a boosted classification tree model trained on the RAM Legacy Database to estimate stock status (i.e., under, fully, or overexploited) from twelve stock- and fishery-related predictors, the most important of which are the value of the taxa, status of the assessed stocks in the fishery, targeting intensity, discard rate, and occurrence in the catch (Free et al. 2017). The approach also includes a step for estimating the overfishing limit (OFL) as the product of a historical catch statistic and scalar based on stock status and risk policy.

Value

A dataframe containing the probability that a stock is under, fully, or overexploited where stock status is identified by the most probable category.

References

Free CM, Jensen OP, Wiedenmann J, Deroba JJ (2017) The refined ORCS approach: a catch-based method for estimating stock status and catch limits for data-poor fish stocks. *Fisheries Research* 193: 60-70. https://doi.org/10.1016/j.fishres.2017.03.017

Examples

```
# Create vector of TOA scores and estimate status
scores <- c(1, 2, NA, 2, 2, 3, 1.93, 2, 1, 2, 1, 3)
rorcs(scores)
```

`s2bbmsy` *Convert saturation to B/BMSY*

Description

Converts saturation to B/BMSY. Note: S = 1 - depletion = B / K = 0.5 * B/BMSY.

Usage

```
s2bbmsy(s)
```

Arguments

`s`	A vector of saturation values

Value

A vector of B/BMSY values

Examples

```
# Convert saturation of 0.75 to B/BMSY
s2bbmsy(0.75)
```

SOLIRIS *Irish Sea Common sole time series*

Description

A dataset containing the catch and biomass time series for Irish Sea Common sole (*Solea solea*) from 1970-2014. This stock was used as an example in the CMSY/BSM user manual and is used to validate the **datalimited2** package's implementation of both CMSY and BSM.

Usage

```
SOLIRIS
```

Format

A data frame with 45 rows (years) and 4 variables:

Stock Stock id

yr Year

ct Catch, in metric tons

bt Biomass, in metric tons

Source

Froese R, Demirel N, Coro G, Kleisner KM, Winker H (2017) Estimating fisheries reference points from catch and resilience. *Fish and Fisheries* 18(3): 506-526. http://onlinelibrary.wiley.com/doi/10.1111/faf.12190/abstract

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TIGERFLAT *SE Australia Tiger flathead time series*

Description

A dataset containing the catch time series for SE Australia Tiger flathead (*Neoplatycephalus richardsoni*) from 1915-2012. This stock was used as an example in the OCOM paper and is used to validate the **datalimited2** package's implementation of zBRT and OCOM.

Usage

```
TIGERFLAT
```

Format

A data frame with 98 rows (years) and 3 variables:

stock Stock id

yr Year

catch Catch, in metric tons

Source

Zhou S, Punt AE, Smith ADM, Ye Y, Haddon M, Dichmont CM, Smith DC (2017) An optimised catch-only assessment method for data poor fisheries. *ICES Journal of Marine Science*: doi:10.1093/icesjms/fsx226. https://doi.org/10.1093/icesjms/fsx226

`YELLSNEMATL` *USA SNE/MA Yellowtail flounder time series*

Description

A dataset containing the catch and biomass time series for USA Southern New England/Mid-Atlantic (SNE/MA) Yellowtail flounder (*Pleuronectes ferruginea*) from 1973-2014.

Usage

```
YELLSNEMATL
```

Format

A data frame with 42 rows (years) and 7 variables:

stockid Stock id

year Year

catch Catch, in metric tons

biomass Spawning stock biomass (SSB), in metric tons

f Fishing mortality rate

bbmsy B/BMSY

ffmsy F/FMSY

zbrt *Zhou-BRT catch-only stock assessment model*

Description

Estimates saturation (B/K) and stock status (B/BMSY) time series from a time series of catch using the boosted regression tree (BRT) model from Zhou et al. 2017. Note: B/BMSY is equal to saturation times two.

Usage

```
zbrt(year, catch)
```

Arguments

`year`	A time series of years
`catch`	A time series of catch

Details

Zhou et al. 2017 use boosted regression tree models (Zhou-BRT) trained on the RAM Legacy Database to estimate saturation (i.e., 1 - depletion = 0.5*B/BMSY) from 56 catch history statistics, the most important of which are linear regression coefficients for the whole catch time series, the subseries before and after the maximum catch, and in recent years. Ultimately, saturation is estimated as the average of the saturation values predicted by two reduced and bias-corrected BRT models (8 and 38 predictors each). B/BMSY is estimated as saturation doubled.

Value

A list with the following elements:

`ts`	A data frame with a time series of saturation and B/BMSY estimates. S8 and S38 correspond to the saturation estimates from the 8- and 38-predictor models, respectively. S, the best estimate of saturation, is the mean of these two predictions. B/BMSY is this estimate doubled (B/BMSY = S * 2). High and low values correspond to the upper and lower 95% confidence intervals, respectively.
`method`	Name of the method

References

Zhou S, Punt AE, Yimin Y, Ellis N, Dichmont CM, Haddon M, Smith DC, Smith ADM (2017) Estimating stock depletion level from patterns of catch history. *Fish and Fisheries*. http://onlinelibrary.wiley.com/doi/10.1111/faf.12201/abstract

Examples

```
# Fit zBRT model to catch time series and plot output
output <- zbrt(year=TIGERFLAT$yr, catch=TIGERFLAT$catch)
plot_dlm(output)

# Extract time series from output
ts <- output[["ts"]]
```

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