

Package ‘DLMtool’

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Type Package

Title Data-Limited Methods Toolkit

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Description Development, simulation testing, and implementation of management procedures for data-limited fisheries
(see Carruthers et al (2014) <doi:10.1016/j.fishres.2013.12.014>).

License GPL-2

Depends R (>= 2.10.0), snowfall

Imports abind, coda, devtools, methods, LBSPR, grDevices, MASS, mvtnorm, parallel, r4ss, readxl, stats, utils

LazyData yes

LazyLoad yes

Suggests knitr, rmarkdown, testthat

LinkingTo Rcpp, RcppArmadillo

RoxygenNote 6.0.1

BugReports <https://github.com/DLMtool/DLMtool/issues>

NeedsCompilation yes

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DLMtool-package	<i>Data-Limited Methods Toolkit</i>
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Description

Simulation testing and implementation of data-limited fishery stock assessment methods

Additional Information

See the [DLMtool User Guide](#) for a detailed description of how to use the DLMtool package.

The help documentation for the DLMtool package can also be accessed [here](#).

See the [Data-Limited Toolkit Website](#) for more information on the DLMtool, including an interactive demo of the main features of the toolkit, information on case studies where the toolkit has been applied, and more about the history and development of the DLMtool.

Author(s)

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References

Carruthers, T.R., Punt, A.E., Walters, C.J., MacCall, A., McAllister, M.K., Dick, E.J., Cope, J. 2014. Evaluating methods for setting catch limits in data-limited fisheries. *Fisheries Research*. 153: 48-68.

Carruthers, T.R., Kell, L.T., Butterworth, D.S., Maunder, M.N., Geromont, H.F., Walters, C., McAllister, M.K., Hillary, R., Levontin, P., Kitakado, T., Davies, C.R. Performance review of simple management procedures. *ICES Journal of Marine Science*.

Albacore	<i>Albacore Stock</i>
----------	-----------------------

Description

An object of class Stock

Usage

Albacore

Format

An object of class Stock of length 1.

alphaconv	<i>Calculate alpha parameter for beta distribution from mean and standard deviation</i>
-----------	---

Description

Calculate alpha parameter for beta distribution from mean and standard deviation

Usage

alphaconv(m, sd)

Arguments

m	mean
sd	standard deviation

Value

numeric

Author(s)

T. Carruthers

Atlantic_mackerel	<i>Atlantic_mackerel Data</i>
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Description

An object of class Data

Usage

Atlantic_mackerel

Format

An object of class Data of length 1.

avail	<i>What objects of this class are available</i>
-------	---

Description

Generic class finder

Usage

avail(classy)

Arguments

classy A class of object (character string, e.g. 'Fleet')

Details

Finds objects of the specified class in the global environment or the package:DLMtool

Author(s)

T. Carruthers

AvC	<i>Average Catch</i>
-----	----------------------

Description

A simple average catch MP that is included to demonstrate a 'status quo' management option

Usage

```
AvC(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Author(s)

T. Carruthers

barplot.MSE	<i>Plot a barplot of MSE results</i>
-------------	--------------------------------------

Description

Plot a barplot of MSE results

Usage

```
## S3 method for class 'MSE'
barplot(height, MSEobj = NULL, PMs = list(B_BMSY = 0.5,
  SSB_SSB0 = 0.2), PLim = 0.8, lastYrs = 10, maxMP = 14, MPs = NA,
  Title = NULL, sims = NULL, msg = TRUE, cex.names = 1.3,
  incRef = FALSE, ...)
```

Arguments

height	An object of class MSE. Generic function must have argument height. But note that this must be an MSE object.
MSEobj	Optional. An object of class MSE. Overrides height
PMs	List of performance metrics. Options are c('SSB_SSB0', 'B_BMSY', 'F_FMSY', 'AAVE', 'AAVY')
PLim	Probability threshold
lastYrs	Last number of years in projection to calculate statistics

maxMP	Maximum number of MPs to include in each plot
MPs	Optional subset MSE object by MP
Title	Optional title for plot
sims	Optional subset MSE object by simulation
msg	Logical. Print out messages?
cex.names	Size of names
incRef	Logical. Include the reference methods?
...	Optional additional arguments passed to barplot

Author(s)

A. Hordyk

betaconv	<i>Calculate beta parameter for beta distribution from mean and standard deviation</i>
----------	--

Description

Calculate beta parameter for beta distribution from mean and standard deviation

Usage

```
betaconv(m, sd)
```

Arguments

m	mean
sd	standard deviation

Value

numeric

Author(s)

T. Carruthers

BK *Beddington and Kirkwood life-history MP (simple version)*

Description

Sets an OFL according to current abundance and an approximation of Fmax based on length at first capture.

Usage

BK(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object.
Data	A data-limited methods data object.
reps	The number of stochastic samples of the TAC recommendation

Note

This is the simple version of the BK MP. The paper has a more complex approach that might work better.

Author(s)

T. Carruthers.

References

Beddington, J.R., Kirkwood, G.P., 2005. The estimation of potential yield and stock status using life history parameters. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 360, 163-170.

BK_CC *Beddington and Kirkwood life-history method combined with catch curve analysis*

Description

Calculates an OFL using a catch curve estimate of current F and an approximation of FMSY based on length at first capture.

Usage

BK_CC(x, Data, reps = 100, Fmin=0.005)

Arguments

x	Position in a data-limited methods data object
Data	A data-limited methods data object (class Data)
reps	The number of samples of the TAC recommendation
Fmin	The minimum fishing mortality rate that is derived from the catch-curve (interval censor)

Author(s)

T. Carruthers

References

Beddington, J.R., Kirkwood, G.P., 2005. The estimation of potential yield and stock status using life history parameters. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 360, 163-170.

BK_ML	<i>Beddington and Kirkwood life-history analysis with mean-length estimator of current abundance</i>
-------	--

Description

Uses an approximation to FMSY based on length at first capture and an estimate of current abundance based on a mean-length estimator.

Usage

```
BK_ML(x, Data, reps = 100)
```

Arguments

x	Position in a data-limited methods data object
Data	A data-limited methods data object (class Data)
reps	The number of samples of the TAC recommendation

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

Beddington, J.R., Kirkwood, G.P., 2005. The estimation of potential yield and stock status using life history parameters. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 360, 163-170.

Blow_opt

*Blow internal parallel optimization function***Description**

Find the current biomass at which it would take HZN mean generation times to reach Bfrac x SSBMSY biomass level given zero catches

Usage

```
Blow_opt(lnq, SSBMSYc, MGThorizon, Fc, Perrc, Mc, hc, Mac, Wac, R0c, Vc, nyears,
maxage, movc, Spat_targc, SRrelc, aRc, bRc, Bfrac, mode = 1)
```

Arguments

lnq	number: estimate of log catchability
SSBMSYc	number: spawning biomass at MSY
MGThorizon	number: MGT x HZN
Fc	vector nyears long of fishing mortality rate
Perrc	vector nyears+maxage-1 long of recruitment deviations
Mc	matrix maxage by nyears+proyears of natural mortality rate
hc	number: steepness values
Mac	vector nages long of maturity at age
Wac	vector nages long of weight at age
R0c	number: unfisher recruitment
Vc	matrix of vulnerability maxage x nyears
nyears	integer: number of historical years
maxage	integer: maximum age
movc	matrix of movement 2 x 2
Spat_targc	number: spatial targetting parameters
SRrelc	integer representing recruitment dynamics type 1: Beverton Holt 2: Ricker
aRc	number: recruitment parameter
bRc	number: recruitment parameter
Bfrac	fraction of SSBMSY that is the target
mode	1: find Blow 2:report blow 3:plot results

Author(s)

T. Carruthers

Bluefin_tuna	<i>Bluefin_tuna Stock</i>
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Description

An object of class Stock

Usage

Bluefin_tuna

Format

An object of class Stock of length 1.

Bluefin_tuna_WAt1	<i>Bluefin_tuna_WAt1 Stock</i>
-------------------	--------------------------------

Description

An object of class Stock

Usage

Bluefin_tuna_WAt1

Format

An object of class Stock of length 1.

Blue_shark	<i>Blue_shark Stock</i>
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Description

An object of class Stock

Usage

Blue_shark

Format

An object of class Stock of length 1.

boxplot.Data	<i>Boxplot of TAC recommendations</i>
--------------	---------------------------------------

Description

Boxplot of TAC recommendations

Usage

```
## S3 method for class 'Data'
boxplot(x, upq = 0.9, lwq = 0.1, outline = FALSE, ...)
```

Arguments

x	An object of class MSE
upq	Upper quantile of TACs for max ylim
lwq	Lower quantile of TACs for min ylim
outline	Logical. Include outliers in plot?
...	Optional additional arguments passed to boxplot

Value

Returns a data frame containing the information shown in the plot

Author(s)

A. Hordyk

boxplot.MSE	<i>Boxplot of MP performance from MSE object</i>
-------------	--

Description

Boxplot of MP performance from MSE object

Usage

```
## S3 method for class 'MSE'
boxplot(x, MPs = NA, maxMP = 8, PMRefs = list(B_BMSY = 1,
  SSB_SSB0 = 0.2, F_FMSY = 1, AAVY = 30, AAVE = 30), lastYrs = 10,
  cex.lab = 1.2, cex.PM = 0.75, canMPs = NULL, cols = TRUE,
  outline = FALSE, CexName = 1.25, incLine = TRUE, incref = FALSE,
  Names = TRUE, ...)
```

Arguments

x	An object of class MSE
MPs	Optional subset MSE object by MP
maxMP	Maximum number of MPs to plot
PMRefs	List containing the Performance Metrics reference points. Options are 'SSB_SSB0', 'B_BMSY', 'F_FMSY'
lastYrs	Last number of years in projection to calculate statistics
cex.lab	Size of axis label text
cex.PM	Size of performance metric text
canMPs	Optional character vector of MPs that can be applied (plotted in different colour)
cols	Optional vector of colours
outline	Logical. Include outliers in boxplot?
CexName	Size of the names
inclLine	Logical. Include vertical line?
incref	Logical. Include reference methods?
Names	Logical. Include MP names in plot?
...	Additional arguments to be passed to plotting functions

Author(s)

A. Hordyk

Butterfish

Butterfish Stock

Description

An object of class Stock

Usage

Butterfish

Format

An object of class Stock of length 1.

CalcOutput	<i>Apply output control recommendations and calculate population dynamics</i>
------------	---

Description

Apply output control recommendations and calculate population dynamics

Usage

```
CalcOutput(y, TACused, TAC_f, lastCatch, availB, maxF, Biomass_P, VBiomass_P,
           CB_P, CB_Pret, FM_P, Z_P, Spat_targ, V_P, retA_P, M_ageArray, qs, nyears,
           nsim, maxage, nareas)
```

Arguments

y	Projection year
TACused	TAC recommendation
TAC_f	Implementation error on TAC
lastCatch	Catch from last year
availB	Total available biomass
maxF	Maximum fishing mortality
Biomass_P	Numeric array (nsim, maxage, proyears, nareas) with Biomass at age
VBiomass_P	Numeric array (nsim, maxage, proyears, nareas) with Vulnerable Biomass at age
CB_P	Numeric array (nsim, maxage, proyears, nareas) with Catch Biomass at age
CB_Pret	Numeric array (nsim, maxage, proyears, nareas) with Retained catch biomass at age
FM_P	Numeric array (nsim, maxage, proyears, nareas) with fishing mortality at age
Z_P	Numeric array (nsim, maxage, proyears, nareas) with total mortality at age
Spat_targ	Spatial targetting
V_P	Numeric array (nsim, maxage, nyears+proyears) with vulnerability at age
retA_P	Numeric array (nsim, maxage, nyears+proyears) with retention at age
M_ageArray	Numeric array (nsim, maxage, nyears+proyears) Natural mortality at age
qs	Catchability coefficient
nyears	Number of historical years
nsim	Number of simulations
maxage	Maximum age
nareas	Number of areas

Author(s)

A. Hordyk

 Can

What data-limited methods can be applied to this Data object?

Description

An diagnostic tool that looks up the slot requirements of each method and compares this to the data available to limit the analysis to methods that have the correct data, do not produce errors and run within a time limit. Time limit is the maximum time taken to carry out five reps (stochastic samples) of a given method and is in units of seconds.

Usage

```
Can(Data, timelimit = 1)
```

Arguments

Data	A data-limited methods data object (class Data)
timelimit	The maximum time (seconds) taken for a method to undertake 10 reps (this filters out methods that are too slow)

 Cant

What methods can't be applied to this DLM data object

Description

The methods that don't have sufficient data, lead to errors or don't run in time along with a list of their data requirements.

Usage

```
Cant(Data, timelimit = 1)
```

Arguments

Data	A data-limited methods data object (class Data)
timelimit	The maximum time (seconds) taken for a method to undertake 10 reps (this filters out methods that are too slow)

CC1	<i>Constant catch management procedure of Geromont and Butterworth (2014)</i>
-----	---

Description

The TAC is the average catch over last yrsmth years.

Usage

```
CC1(x, Data, reps = 100, yrsmth = 5, xx=0)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to calculate mean catches
xx	Parameter controlling the TAC. Mean catches are multiplied by (1-xx)

Details

This is one of four constant catch rules of Geromont and Butterworth 2014.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

CC4 *Constant catch management procedure of Geromont and Butterworth (2014)*

Description

The TAC is the average catch over last yrsmth years reduced by 30

Usage

CC4(x, Data, reps = 100, yrsmth = 5, xx=0.3)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to average catches
xx	Parameter controlling the TAC. Mean catches are multiplied by (1-xx)

Details

This is one of four constant catch MPs of Geromont and Butterworth 2014.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

CheckConverg	<i>MSE convergence diagnostic</i>
--------------	-----------------------------------

Description

Have I undertaken enough simulations (nsim)? Has my MSE converged on stable (reliable) performance metrics?

Usage

```
CheckConverg(MSEobj, thresh=2, Plot=TRUE)
```

Arguments

MSEobj	An object of class 'MSE'
thresh	The convergence threshold (percentage). If mean performance metrics are within thresh percent of the second to last iteration, the MSE can be considered to have converged.
Plot	Should figures be plotted?

Author(s)

A. Hordyk

checkMSE	<i>Check that MSE object includes all slots</i>
----------	---

Description

Check that an MSE object includes all slots in the latest version of DLMtool Use 'updateMSE' to update the MSE object

Usage

```
checkMSE(MSEobj)
```

Arguments

MSEobj	A MSE object.
--------	---------------

Author(s)

A. Hordyk

China_rockfish	<i>China_rockfish Data</i>
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Description

An object of class Data

Usage

China_rockfish

Format

An object of class Data of length 1.

ChkDatNA	<i>Check Data object is valid for a MP</i>
----------	--

Description

Checks that all slots in Data object required by the MP contain finite values

Usage

ChkDatNA(Data, dependencies)

Arguments

Data	An object of class Data
dependencies	A string of slots in the Data object required for the MP

Author(s)

A. Hordyk

ChkObj	<i>Check that a DLM object is valid</i>
--------	---

Description

Check that all slots in Object are valid and contain values

Usage

ChkObj(OM)

Arguments

OM	An object of class OM, Stock, Fleet, Obs, or Imp
----	--

ChooseEffort	<i>Manually map the historical relative fishing effort trajectory.</i>
--------------	--

Description

Interactive plot which allows users to specify the relative trajectory and variability in the historical fishing effort and populates Fleet object.

Usage

ChooseEffort(FleetObj, Years=NULL)

Arguments

FleetObj	A fleet object.
Years	An optional vector of years. Should be nyears long.

Author(s)

A. Hordyk

ChooseM *Manually map natural mortality at age or size.*

Description

Interactive plot which allows users to specify M by age or size class

Usage

```
ChooseM(OM, type = c("age", "length"), x = NULL, y = NULL)
```

Arguments

OM	An object of class 'OM'
type	A character string - is M to be mapped by 'age' or 'length'?
x	Optional vector for x-axis
y	Optional vector for y-axis

Author(s)

A. Hordyk

ChooseSelect *Manually choose the historical selectivity pattern*

Description

Input the first historical year, and all years where selectivity pattern changed (separated by comma). Interactive plot which allows users to specify a range for the length at 5% and full selection (LFS), as well as selectivity at maximum length for each year. Produces a simple plot which shows the range in selectivity pattern for each break-point year. Selectivity-at-length is fixed in between break-point years. Note that this function replaces 'years' in the Fleet object with the value defined here (FstYr:current year).

Usage

```
ChooseSelect(Fleet, Stock, FstYr = NULL, SelYears = NULL)
```

Arguments

Fleet	A fleet object.
Stock	Optional Stock object. If provided, average length-at-maturity is included on plot for reference.
FstYr	Optional value for first historical year. If empty, user must specify the year in console.
SelYears	Optional vector of values for each year where selectivity pattern changed. If empty, user must specify the years in console (comma separated).

Author(s)

A. Hordyk

Cobia

*Cobia Data***Description**

An object of class Data

Usage

Cobia

Format

An object of class Data of length 1.

complot

*Generic comparison plot for simulation testing of Stochastic SRA method***Description**

Plots simulation variables versus estimation variables for Stochastic SRA methods of conditioning operating models.

Usage`complot(simy, samy, xlab = "", ylab = "", maxplot = 10, type = "l")`**Arguments**

<code>simy</code>	The simulated time series
<code>samy</code>	The matrix of estimated time series from of StochasticSRA() function.
<code>xlab</code>	The x axis label for the plot
<code>ylab</code>	The y axis label for the plot
<code>maxplot</code>	The total number of individual simulations to be plotted in the first plot
<code>type</code>	Should a line 'l' or points 'p' be plotted?

Value

A plot

Author(s)

T. Carruthers (Canadian DFO grant)

Examples

```
nyears<-100
nsims<-200
simy<-sin(seq(0,2,length.out=nyears))
samy<-array(rep(simy,each=nsims)*rnorm(nsims,1,0.2)*rnorm(nsims*nyears,1,0.1),c(nsims,nyears))
par(mfrow=c(1,2))
compplot(simy,samy,xlab="Year",ylab="Some time varying parameter")
```

CompSRA

Age-composition-based estimate of current stock depletion given constant Z linked to an FMSY estimate to provide OFL

Description

Estimates an OFL based on a Stock Reduction analysis fitted to current age-composition data. Knife-edge vulnerability at age at maturity allows for an FMSY estimate. $OFL = FMSY * F/C$

Usage

```
CompSRA(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC.

Note

Given a fixed historical F, What level of depletion gives you this length composition?

Author(s)

T. Carruthers

CompSRA4010	<i>Age-composition-based estimate of current stock depletion given constant Z linked to an FMSY estimate to provide OFL (with a 40-10 rule)</i>
-------------	---

Description

Estimates an OFL based on a Stock Reduction analysis fitted to current age-composition data. Knife-edge vulnerability at age at maturity allows for an FMSY estimate. $OFL = FMSY * F/C$

Usage

CompSRA4010(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC.

Note

Given a fixed historical F, What level of depletion gives you this length composition?

Author(s)

T. Carruthers

condmet	<i>Condition met?</i>
---------	-----------------------

Description

Condition met?

Usage

condmet(vec)

Arguments

vec	vector of logical values
-----	--------------------------

Converge	<i>Check Convergence</i>
----------	--------------------------

Description

Have I undertaken enough simulations (nsim)? Has my MSE converged on stable (reliable) performance metrics?

Usage

```
Converge(MSEobj, thresh = 2, Plot = TRUE)
```

Arguments

MSEobj	An MSE object of class 'MSE'
thresh	The convergence threshold (percentage). If mean performance metrics are within thresh percent of the second to last iteration, the MSE can be considered to have converged.
Plot	Should figures be plotted?

Author(s)

A. Hordyk

COSEWIC_plot	<i>COSEWIC forward projection plot</i>
--------------	--

Description

Projection of biomass under three scenarios: no catch, FMSY fishing and status quo fishing This plot is for an MSE object created from runMSE with the argument MPs=c("NFref", "FMSYref", "curE")

Usage

```
COSEWIC_plot(MSEobj, syear = 2015)
```

Arguments

MSEobj	An object of class MSE created from runMSE() with the argument MPs=c("NFref", "FMSYref", "curE")
syear	Starting year of the projection for graphing purposes

Value

A plot

Author(s)

T. Carruthers

cparscheck	<i>Internal function of runMSE for checking that the OM slot cpars slot is formatted correctly</i>
------------	--

Description

Internal function of runMSE for checking that the OM slot cpars slot is formatted correctly

Usage

```
cparscheck(cpars)
```

Arguments

cpars	a list of model parameters to be sampled (single parameters are a vector nsim long, time series are matrices nsim x nyears)
-------	---

Value

either an error and the length of the first dimension of the various cpars list items or passes and returns the number of simulations

Author(s)

T. Carruthers

Cplot	<i>Plot the median biomass and yield relative to last historical year</i>
-------	---

Description

Compare median biomass and yield in first year and last 5 years of projection

Usage

```
Cplot(MSEobj, MPs = NA, lastYrs = 5, XMin = NULL, YMin = NULL,
      ShowLabs = FALSE)
```

Arguments

MSEobj	An object of class MSE
MPs	Optional subset by MP
lastYrs	Last number of years of projection to calculate median
XMin	Optional minimum for the x-axis
YMin	Optional minimum for the y-axis
ShowLabs	Logical. Show the MP labels? Otherwise only plot points

Value

Invisibly returns a data frame containing information shown in the plot

Author(s)

A. Hordyk

CSRA

Catch at size reduction analysis

Description

What depletion level and corresponding equilibrium F arise from data regarding mean length of current catches, natural mortality rate, steepness of the stock recruitment curve, maximum length, maximum growth rate, age at maturity, age based vulnerability, maturity at age, maximum age and number of historical years of fishing.

Usage

`CSRA(M,h,Linf,K,t0,AM,a,b,vuln,mat,ML,CAL,CAA,maxage,nyears)`

Arguments

<code>M</code>	A vector of natural mortality rate estimates
<code>h</code>	A vector of sampled steepness (Beverton-Holt stock recruitment)
<code>Linf</code>	A vector of maximum length (von Bertalanffy growth)
<code>K</code>	A vector of maximum growth rate (von Bertalanffy growth)
<code>t0</code>	A vector of theoretical age at length zero (von Bertalanffy growth)
<code>AM</code>	A vector of age at maturity
<code>a</code>	Length-weight conversion parameter a ($W=aL^b$)
<code>b</code>	Length-weight conversion parameter b ($W=aL^b$)
<code>vuln</code>	A matrix $n_{sim} \times n_{age}$ of the vulnerability at age (max 1) to fishing.
<code>mat</code>	A matrix $n_{sim} \times n_{age}$ of the maturity at age (max 1)
<code>ML</code>	A vector of current mean length estimates
<code>CAL</code>	A catch-at-length matrix $n_{years} \times (1 \text{ Linf unit})$ length bins
<code>CAA</code>	A catch-at-age matrix $n_{years} \times \text{maximum age}$
<code>maxage</code>	Maximum age
<code>nyears</code>	Number of historical years of fishing

Author(s)

T. Carruthers

CSRAfunc *Optimization function for CSRA*

Description

What depletion level and corresponding equilibrium F arise from data regarding mean length of current catches, natural mortality rate, steepness of the stock recruitment curve, maximum length, maximum growth rate, age at maturity, age based vulnerability, maturity at age, maximum age and number of historical years of fishing.

Usage

```
CSRAfunc(lnF,Mc,hc,maxage,nyears,AFSc,AFCc,Linfc,
Kc,t0c,AMc,ac,bc,vulnc,matc,MLc,CAL,CAA, opt=T, meth='ML')
```

Arguments

lnF	A proposed value of current instantaneous fishing mortality rate
Mc	Natural mortality rate estimates
hc	Steepness (Beverton-Holt stock recruitment)
maxage	Maximum age
nyears	Number of historical years of fishing
AFSc	Age at full selection
AFCc	Age at first capture
Linfc	Maximum length (von Bertalanffy growth)
Kc	Maximum growth rate (von Bertalanffy growth)
t0c	Theoretical age at length zero (von Bertalanffy growth)
AMc	Age at maturity
ac	Length-weight conversion parameter a ($W=aL^b$)
bc	Length-weight conversion parameter b ($W=aL^b$)
vulnc	A vector (nage long) of the vulnerability at age (max 1) to fishing.
matc	A vector (nage long) of the maturity at age (max 1)
MLc	A current mean length estimates
CAL	A catch-at-length matrix nyears x (1 Linf unit) length bins
CAA	A catch-at-age matrix nyears x maximum age
opt	Should the measure of fit be returned?
meth	Are we fitting to mean length or catch composition?

Author(s)

T. Carruthers

curE *Fishing at current effort levels*

Description

Constant fishing effort set at final year of historical simulations subject to changes in catchability determined by OM@qinc and interannual variability in catchability determined by OM@qcv. This MP is intended to represent a 'status quo' management approach.

Usage

curE(x, Data, ...)

Arguments

x	A position in a data-limited methods data object.
Data	A data-limited methods data object.
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Note

Made up for this package.

Author(s)

T. Carruthers.

curE75 *Fishing at 75 per cent of current effort levels*

Description

Constant fishing effort set at 75 per cent of final year of historical simulations subject to changes in catchability determined by OM@qinc and interannual variability in catchability determined by OM@qcv. This MP is intended to represent a 'status quo' management approach.

Usage

curE75(x, Data, ...)

Arguments

x	A position in a data-limited methods data object.
Data	A data-limited methods data object.
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Note

Made up for this package.

Author(s)

T. Carruthers.

cv

Calculate CV from vector of values

Description

Calculate CV from vector of values

Usage

cv(x)

Arguments

x	vector of numeric values
---	--------------------------

Value

numeric

Author(s)

T. Carruthers

 DAAC

Depletion Adjusted Average Catch

Description

Essentially DCAC multiplied by $2 \times$ depletion and divided by $BMSY/B_0$ (Bpeak)

Usage

DAAC(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Author(s)

W. Harford and T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES J. Mar. Sci. 66, 2267-2271. Harford W. and Carruthers, T. 2016. Simulation testing novel catch-based fisheries management. In draft, intended for Fish. Bull.

 Data-class

Class 'Data'

Description

An object for storing data for analysis using data-limited methods

Slots

Name	The name of the case-study
Year	A vector of years that correspond to catch and relative abundance data
Cat	Total annual catches
Ind	Relative abundance index
t	The number of years corresponding to AvC and Dt
AvC	Average catch over time t
Dt	Depletion over time t e.g. Bnow/Bthen

ML Mean length time series
Mort Natural mortality rate
FMSY_M An assumed ratio of FMSY to M
BMSY_B0 The most productive stock size relative to unfished
L50 Length at 50 percent maturity
L95 Length at 95 percent maturity
Lbar Mean length of catches over Lc (modal length)
Lc Modal length
LFC Length at first capture
LFS smallest Length at full selection
CAA Catch at Age data
Dep Stock depletion Bnow/Bunfished (total stock)
Abun An estimate of absolute current vulnerable abundance
SpAbun An estimate of absolute current spawning stock abundance
vbK The von Bertalanffy growth coefficient
vbLinf Maximum length
vbt0 Theoretical age at length zero
LenCV Coefficient of variation of length-at-age (assumed constant for all age classes)
w1a Weight-Length parameter alpha
w1b Weight-Length parameter beta
steep Steepness of the Beverton Holt stock-recruitment relationship
CV_Cat Coefficient of variation in annual catches
CV_Dt Coefficient of variation in depletion over time t
CV_AvC Coefficient of variation in average catches over time t
CV_Ind Coefficient of variation in the relative abundance index
CV_Mort Coefficient of variation in natural mortality rate
CV_FMSY_M Coefficient of variation in the ratio in FMSY/M
CV_BMSY_B0 Coefficient of variation in the position of the most productive stock size relative to unfished
CV_Dep Coefficient of variation in current stock depletion
CV_Abun Coefficient of variation in estimate of absolute current stock size
CV_vbK Coefficient of variation in the von Bert. k parameter
CV_vbLinf Coefficient of variation in maximum length
CV_vbt0 Coefficient of variation in age at length zero
CV_L50 Coefficient of variation in length at 50 per cent maturity
CV_LFC Coefficient of variation in length at first capture
CV_LFS Coefficient of variation in length at full selection

CV_wla Coefficient of variation in weight-length parameter a
 CV_wlb Coefficient of variation in weight-length parameter b
 CV_steep Coefficient of variation in steepness
 sigmaL Assumed observation error of the length composition data
 MaxAge Maximum age
 Units Units of the catch/absolute abundance estimates
 Ref A reference quota level
 Ref_type Its type
 Log A log of events
 params A place to store estimated parameters
 PosMPs The methods that can be applied to these data
 MPs The methods that were applied to these data
 OM A table of operating model conditions
 Obs A table of observation model conditions
 TAC The calculated TAC
 TACbias The known bias in the calculated TAC
 Sense The results of the sensitivity analysis
 CAL_bins The length bins for the catch-at-length data
 CAL Catch-at-length data
 Cref Reference or target catch level
 Iref Reference or target relative abundance index level
 Bref Reference or target biomass level
 CV_Cref CV for reference or target catch level
 CV_Iref CV for reference or target relative abundance index level
 CV_Bref CV for reference or target biomass level
 CV_Rec CV for recent recruitment strength
 Rec Recent recruitment strength
 MPrec The previous recommendation of a management procedure
 MPeff The current level of effort
 LHYear The last historical year of the simulation (before projection)
 nareas Number of fishing areas
 Misc Optional list which is passed to MPs

Objects from the Class

Objects can be created by calls of the form `new('Data', stock)`

Author(s)

T. Carruthers

Examples

```
newdata<-new('Data')
```

Data_xl*Read in Data object from Excel spreadsheet*

Description

A function to read in Data object from an Excel spreadsheet with tabs named following specific convention.

Usage

```
Data_xl(fname, stkname, fpath = "", saveCSV = FALSE)
```

Arguments

fname	Name of the Excel spreadsheet file. Must include file extension.
stkname	Name of the Stock.
fpath	Full file path, if file is not in current working directory
saveCSV	Do you also want to the Data parameters to a CSV file?

Details

The Excel spreadsheet must have tabs named with the following convention. For example if stkname is 'myFish', the Data parameters are in a tab named 'myFishData'.

Value

A object of class Data

Author(s)

A. Hordyk

Examples

```
## Not run:  
OM <- OM_xl(fname='OMTables.xlsx', stkname='myFish')  
  
## End(Not run)
```

Description

User prescribed BMSY/B0, M, FMSY/M are used to find B0 and therefore the OFL by back-constructing the stock to match a user specified level of stock depletion ($OFL = M * FMSY/M * \text{depletion} * B0$).

Usage

```
DBSRA(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods object.
Data	A data-limited methods object.
reps	The number of samples of the TAC (OFL) recommendation.

Details

You specify a range of stock depletion and, given historical catches DB-SRA calculates what unfished biomass must have been to get you here given samples for M, FMSY relative to M and also BMSY relative to B0.

Value

A vector of TAC (OFL) values.

Note

This is set up to return the OFL ($FMSY * \text{current biomass}$).

You may have noticed that you -the user- specify three of the factors that make the quota recommendation. So this can be quite a subjective method.

Also the DB-SRA method of this package isn't exactly the same as the original method of Dick and MacCall (2011) because it has to work for simulated depletions above BMSY/B0 and even on occasion over B0. Also it doesn't have the modification for flatfish life histories that has previously been applied by Dick and MacCall.

Author(s)

T. Carruthers

References

Dick, E.J., MacCall, A.D., 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. *Fish. Res.* 110, 331-341.

DBSRA4010	<i>Depletion-Based Stock Reduction Analysis paired with 40-10 harvest control rule</i>
-----------	--

Description

User prescribed BMSY/B0, M, FMSY/M are used to find B0 and therefore the OFL by back-constructing the stock to match a user specified level of stock depletion ($OFL = M * FMSY/M * depletion * B0$). In this method DBSRA is paired with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished biomass.

Usage

DBSRA4010(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Author(s)

T. Carruthers

References

Dick, E.J., MacCall, A.D., 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. *Fish. Res.* 110, 331-341.

DBSRA_40	<i>Depletion-Based Stock Reduction Analysis assuming 40 per cent stock depletion</i>
----------	--

Description

DBSRA assuming that current stock depletion is exactly 40 per cent of unfished stock levels.

Usage

DBSRA_40(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

A 40 percent assumption for current depletion is more or less the most optimistic state for a stock (ie very close to BMSY/B0 for many stocks).

Author(s)

T. Carruthers.

References

Dick, E.J., MacCall, A.D., 2010. Estimates of sustainable yield for 50 data-poor stocks in the Pacific Coast groundfish fishery management plan. Technical memorandum. Southwest fisheries Science Centre, Santa Cruz, CA. National Marine Fisheries Service, National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-460.

DBSRA_ML	<i>Depletion-Based Stock Reduction Analysis using mean length estimator of stock depletion</i>
----------	--

Description

DBSRA using the mean length estimator to calculate current stock depletion.

Usage

```
DBSRA_ML(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

Dick, E.J., MacCall, A.D., 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. *Fish. Res.* 110, 331-341.

DCAC

Depletion Corrected Average Catch

Description

A method of calculating an MSY proxy (FMSY * BMSY and therefore the OFL at most productive stock size) based on average catches accounting for the windfall catch that got the stock down to BMSY levels.

Usage

DCAC(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

It's probably worth noting that DCAC TAC recommendations do not tend to zero as depletion tends to zero. It adjusts for depletion only in calculating historical average catch. It follows that at stock levels much below BMSY, DCAC tends to chronically overfish.

Author(s)

T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. *ICES J. Mar. Sci.* 66, 2267-2271.

DCAC4010

*Depletion Corrected Average Catch paired with the 40-10 rule***Description**

A method of calculating an MSY proxy ($FMSY * BMSY$ and therefore the OFL at most productive stock size) based on average catches accounting for the windfall catch that got the stock down to BMSY levels. In this method DCAC is paired with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished stock size (the OFL is not subject to downward adjustment above 40 percent unfished)

Usage

```
DCAC4010(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

DCAC can overfish below BMSY levels. The 40-10 harvest control rule largely resolves this problem providing an MP with surprisingly good performance even at low stock levels.

Author(s)

T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES J. Mar. Sci. 66, 2267-2271.

DCAC_40

*Depletion Corrected Average Catch assuming 40 per cent stock depletion***Description**

DCAC assuming that current stock biomass is exactly 40 per cent of unfished levels.

Usage

```
DCAC_40(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

The 40 percent depletion assumption doesn't really affect DCAC that much as it already makes TAC recommendations that are quite MSY-like.

Author(s)

T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES J. Mar. Sci. 66, 2267-2271.

DCAC_ML	<i>Depletion-Based Stock Reduction Analysis using mean-length estimator of current depletion</i>
---------	--

Description

DCAC that uses the mean length estimator to calculate current stock depletion.

Usage

```
DCAC_ML(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. *ICES J. Mar. Sci.* 66, 2267-2271.

 DD

Delay - Difference Stock Assessment with UMSY and MSY leading

Description

A simple delay-difference assessment that estimates the TAC using a time-series of catches and a relative abundance index.

Usage

DD(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Value

A numeric vector of TAC recommendations

Note

This DD model is observation error only and has does not estimate process error (recruitment deviations). Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

Author(s)

T. Carruthers

References

Method based on equations of Carl Walters (bug him with questions and expect colourful responses)

DD4010	<i>Delay - Difference Stock Assessment with UMSY and MSY leading coupled with a 40-10 harvest control rule</i>
--------	--

Description

A simple delay-difference assessment that estimates the OFL using a time-series of catches and a relative abundance index. In this version of the DD MP a 40-10 rule is imposed over the OFL recommendation.

Usage

DD4010(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Method based on equations of Carl Walters

DDe	<i>Effort control version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading</i>
-----	---

Description

A simple delay-difference assessment that estimates and recommends FMSY using a time-series of catches and a relative abundance index.

Usage

DDe(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

This DD model is observation error only and has does not estimate process error (recruitment deviations). Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

Author(s)

T. Carruthers

References

Method based on equations of Carl Walters (bug him with questions and expect colourful responses)

DDe75	<i>Effort control version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading that fishes at 75 per cent of FMSY</i>
-------	--

Description

A simple delay-difference assessment that estimates and recommends 75 per cent FMSY using a time-series of catches and a relative abundance index.

Usage

DDe75(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Note

This DD model is observation error only and has does not estimate process error (recruitment deviations). Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

Author(s)

T. Carruthers

References

Method based on equations of Carl Walters (bug him with questions and expect colourful responses)

DDes	<i>Effort searching version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading that fishes at 75 per cent of FMSY</i>
------	--

Description

A simple delay-difference assessment that estimates FMSY using a time-series of catches and a relative abundance index. The MP provides a change in effort in the direction of FMSY up to a maximum change of 10 percent.

Usage

DDes(x, Data, reps = 100, LB=0.9, UB=1.1)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation
LB	The lowest permitted factor of previous fishing effort
UB	The highest permitted factor of previous fishing effort

Note

This DD model is observation error only and has does not estimate process error (recruitment deviations). Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

Author(s)

T. Carruthers

References

Method based on equations of Carl Walters (bug him with questions and expect colourful responses)

DecE_Dom	<i>DecE_Dom Fleet</i>
----------	-----------------------

Description

An object of class Fleet

Usage

DecE_Dom

Format

An object of class Fleet of length 1.

DecE_HDom	<i>DecE_HDom Fleet</i>
-----------	------------------------

Description

An object of class Fleet

Usage

DecE_HDom

Format

An object of class Fleet of length 1.

DecE_NDom	<i>DecE_NDom Fleet</i>
-----------	------------------------

Description

An object of class Fleet

Usage

DecE_NDom

Format

An object of class Fleet of length 1.

DepF	<i>Depletion Corrected Fratio</i>
------	-----------------------------------

Description

The Fratio MP with a harvest control rule that reduces F according to the production curve given an estimate of current stock depletion.

Usage

```
DepF(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object DLM
Data	A data-limited methods data object
reps	The number of TAC samples

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Made-up for this package.

derive_beta_par	<i>This function reduces the CV by 5 per cent until steepness values can be sampled without error</i>
-----------------	---

Description

This function reduces the CV by 5 per cent until steepness values can be sampled without error

Usage

```
derive_beta_par(mu, sigma)
```

Arguments

mu	mean h
sigma	sd of h

Author(s)

Q. Huynh

DFO_hist*Department of Fisheries and Oceans historical plot*

Description

A plot of current and historical stock status by simulation according to the stock status zones and reference points of DFO. <http://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm>

Usage

```
DFO_hist(OM, panel = T, nsim = 48)
```

Arguments

OM	An operating model object of class OM
panel	should the plots be separate or in two panels?
nsim	how many simulations should be plotted (over-ridden by OM@nsim where cparams is specified)

Author(s)

T. Carruthers

DFO_plot*Department of Fisheries and Oceans trade-off plot*

Description

A plot of mean biomass relative to BMSY and fishing mortality rate relative to FMSY over the final 5 years of the projection <http://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm>

Usage

```
DFO_plot(MSEobj)
```

Arguments

MSEobj	An MSE object of class MSE produced by DLMtool function runMSE
--------	--

Author(s)

T. Carruthers

DFO_plot2

Department of Fisheries and Oceans default plot 2

Description

A preliminary plot for returning trade-offs plots and performance table for probability of obtaining half reference (FMSY) yield and probability of biomass dropping below 50 per cent BMSY

Usage

```
DFO_plot2(MSEobj, nam = NA, panel = T, Bcut = 50, Ycut = 50)
```

Arguments

MSEobj	An object of class MSE
nam	Title of plot
panel	Should the plots be organized in many panels in a single figure
Bcut	The cutoff biomass for satisficing (relative to BMSY)
Ycut	the cutoff yield for satisficing (relative to reference yield)

Value

A table of performance metrics.

Author(s)

T. Carruthers

DFO_proj

Department of Fisheries and Oceans projection plot

Description

A projection plot of MP performance by simulation according to the stock status zones and reference points of DFO. <http://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm>

Usage

```
DFO_proj(MSEobj, maxplot = 3)
```

Arguments

MSEobj	An operating model object of class MSE
maxplot	The maximum number of MPs to be plotted per figure

Author(s)

T. Carruthers

DLMDataDir

*Directory of the installed package on your computer***Description**

A way of locating where the package was installed so you can find example data files and code etc.

Usage

```
DLMDataDir(stock=NA)
```

Arguments

stock Character string representing the name of a .csv file e.g. 'Snapper', 'Rockfish'

Author(s)

T. Carruthers

DOM

*How dominant is an MP?***Description**

The DOM function examines how consistently an MP outperforms another. For example DCAC might provide higher yield than AvC on average but outperforms AvC in less than half of simulations.

Usage

```
DOM(MSEobj, MPtg=NA)
```

Arguments

MSEobj An object of class 'MSE'
MPtg A character vector of management procedures for cross examination

Value

A matrix of performance comparisons length(MPtg) rows by MSE@nMPs columns

Author(s)

A. Hordyk

DTe40 *Effort searching MP aiming for 40 per cent stock depletion*

Description

A very simple MP that modifies effort to reach 40 percent stock depletion

Usage

DTe40(x, Data, reps = 100, alpha=0.4, LB=0.9, UB=1.1)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation
alpha	The target level of depletion
LB	The lowest permitted factor of previous fishing effort
UB	The highest permitted factor of previous fishing effort

Author(s)

T. Carruthers

DTe50 *Effort searching MP aiming for 50 per cent stock depletion*

Description

A very simple MP that modifies effort to reach 50 percent stock depletion

Usage

DTe50(x, Data, reps = 100, alpha=0.5, LB=0.9, UB=1.1)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation
alpha	The target level of depletion
LB	The lowest permitted factor of previous fishing effort
UB	The highest permitted factor of previous fishing effort

Author(s)

T. Carruthers

DynF

*Dynamic Fratio MP***Description**

The Fratio MP with a controller that changes the level of F according to the relationship between Surplus production and biomass. Ie lower F when dSP/dB is positive and higher F when dSP/dB is negative.

Usage

```
DynF(x, Data, yrsmth=10, gg=2, reps = 100)
```

Arguments

x	A position in a data-limited methods object
Data	A data-limited methods object
yrsmth	The number of historical recent years used for smoothing catch and biomass data
gg	A gain parameter that modifies F according to the gradient in surplus production with biomass
reps	The number samples of the TAC

Details

The method smoothes historical catches and biomass and then infers the relationship between surplus production and biomass (as suggested by Mark Maunder and Carl Walters). The approach then regulates a F based policy according to this gradient in which F may range between two different fractions of natural mortality rate.

The core advantage is the TAC(t) is not strongly determined by TAC(t-1) and therefore errors are not as readily propagated. The result is method that tends to perform alarmingly well and therefore requires debunking ASAP.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Made-up for this package.

EtargetLopt	<i>Effort MP: adjust effort up/down if mean length above/below Ltarget</i>
-------------	--

Description

Effort MP: adjust effort up/down if mean length above/below Ltarget

Usage

EtargetLopt(x, Data, reps = 100, yrsnth=3, buffer=0.1)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsnth	Number of years to calculate average length
buffer	Parameter controlling the fraction of mean catch to set the reference (or target) TAC level - acts as a precautionary buffer

Value

An adjustment for fishing effort

Author(s)

HF Geromont

Example_datafile	<i>Example_datafile Data</i>
------------------	------------------------------

Description

An object of class Data

Usage

Example_datafile

Format

An object of class Data of length 1.

Fadapt	<i>An adaptive MP that uses trajectory in inferred surplus production and fishing mortality rate to update a TAC</i>
--------	--

Description

Fishing rate is modified each year according to the gradient of surplus production with biomass (aims for zero). F is bounded by $FMSY/2$ and $2FMSY$ and walks in the logit space according to dSP/dB . This is derived from the theory of Maunder 2014.

Usage

```
Fadapt(x, Data, reps = 100, yrsmth = 7, gg=1)
```

Arguments

<code>x</code>	A position in data-limited methods data object
<code>Data</code>	A data-limited methods data object
<code>reps</code>	The number of TAC samples
<code>yrsmth</code>	Years over which to smooth recent estimates of surplus production
<code>gg</code>	A gain parameter controlling the speed in update in TAC.

Details

Tested in Carruthers et al. 2015.

Value

A numeric vector of quota recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press. Maunder. 2014. <http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf>

Fdem	<i>Demographic FMSY method</i>
------	--------------------------------

Description

FMSY is calculated as $r/2$ where r is calculated from a demographic approach (inc steepness). Coupled with an estimate of current abundance that gives you the OFL.

Usage

```
Fdem(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Details

Made up for this package. This uses Murdoch McAllister's demographic r method to derive FMSY ($r/2$) and then makes the quota $r \times \text{current biomass} / 2$. Easy.

Author(s)

T. Carruthers

References

McAllister, M.K., Pikitch, E.K., and Babcock, E.A. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. *Can. J. Fish. Aquat. Sci.* 58: 1871-1890.

Fdem_CC	<i>Demographic FMSY method using catch-curve analysis to estimate recent Z</i>
---------	--

Description

FMSY is calculated as $r/2$ from a demographic r prior method, current abundance is estimated from naive catch curve analysis.

Usage

```
Fdem_CC(x, Data, reps = 100, Fmin=0.005)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
Fmin	The minimum fishing mortality rate derived from the catch-curve analysis

Author(s)

T. Carruthers

References

McAllister, M.K., Pikitch, E.K., and Babcock, E.A. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. *Can. J. Fish. Aquat. Sci.* 58: 1871-1890.

Fdem_ML	<i>Demographic FMSY method that uses mean length data to estimate recent Z</i>
---------	--

Description

Demographic F ($r/2$) method using the mean length estimator to calculate current abundance.

Usage

```
Fdem_ML(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

McAllister, M.K., Pikitch, E.K., and Babcock, E.A. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. *Can. J. Fish. Aquat. Sci.* 58: 1871-1890.

Fease	<i>MP feasibility diagnostic</i>
-------	----------------------------------

Description

What MPs may be run (best case scenario) for various data-availability scenarios?

Usage

```
Fease(feaseobj, outy='table')
```

Arguments

feaseobj	An object of class 'Fease'
outy	Determines whether you would like a full table or some column of the table for a specific case of the feasibility object. When set equal to table, the full table is produced. When set equal to an integer number the names of MPs that are feasible for that case are returned.

Author(s)

T. Carruthers

Fease-class	<i>Class 'Fease'</i>
-------------	----------------------

Description

An object for storing information about what data are available or might be available

Slots

Name	The name of the data feasibility object
Case	The names of the data feasibility cases
Catch	Total annual catches
Index	An index of relative abundance, catch per unit effort data or of fishing mortality rate (effort)
Natural_mortality_rate	From Maximum age, Tagging data, early fishery catch composition data
Maturity_at_length	From gonadal analysis, growth and natural mortality rate estimates
Growth	Paired length and age observations, maximum length and an estimate of natural mortality rate
Length_weight_conversion	Paired weight and length observations, equivalent data from a similar species

Fleet_selectivity Length composition of catches with growth curve and natural mortality rate, estimates from a similar fleet type targetting a similar species

Catch_at_length Length composition of catches (length samples)

Catch_at_age Age composition of catches (age samples)

Recruitment_index Spawn survey, estimates from a stock assessment, VPA analysis of catch composition data

Stock_recruitment_relationship Stock assessment, a stock assessment of a similar species

Target_catch An agreed annual catch target, MSY proxy

Target_biomass An agreed absolute biomass target, mean historical biomass estimate

Target_index An agreed catch rate target

Abundance Fishery independent survey, current fishing mortality rate from recent length composition, natural mortality rate, maturity at age, growth and stock recruitment relationship, habitat and relative density extrapolation

Objects from the Class

Objects can be created by calls of the form `new('Fease', stock)`

Author(s)

T. Carruthers

Examples

```
newdata<-new('Fease')
```

Fease_xl

Read in feasibility parameters from Excel spreadsheet

Description

A function to read in feasibility parameters from an Excel spreadsheet with tabs named following specific convention

Usage

```
Fease_xl(fname, stkname, fpath = '', saveCSV = FALSE)
```

Arguments

fname	Name of the Excel spreadsheet file. Must include file extension.
stkname	Name of the Stock.
fpath	Full file path, if file is not in current working directory
saveCSV	Do you also want to save the Stock, Fleet and Observation parameters to CSV files?

Details

The Excel spreadsheet must have tabs named with the following convention. For example if stkname is 'myFish', the tab must be named 'myFishFease',

Value

A object of class Fease

Author(s)

A. Hordyk

Examples

```
## Not run:  
myFease <- Fease_xl(fname='FeaseTables.xlsx', stkname='myFish')  
  
## End(Not run)
```

Feasibility

Feasibility Fease

Description

An object of class Fease

Usage

Feasibility

Format

An object of class Fease of length 1.

Feasibility2 *Feasibility2 Fease*

Description

An object of class Fease

Usage

Feasibility2

Format

An object of class Fease of length 1.

fetch.file.names *Reads iSCAM Data, Control and Projection files*

Description

A function for returning the three types of iSCAM input and output files

Usage

fetch.file.names(path, filename)

Arguments

path File path
filename The filename

Author(s)

Chris Grandin (DFO PBS)

FlatE_Dom	<i>FlatE_Dom Fleet</i>
-----------	------------------------

Description

An object of class Fleet

Usage

FlatE_Dom

Format

An object of class Fleet of length 1.

FlatE_HDom	<i>FlatE_HDom Fleet</i>
------------	-------------------------

Description

An object of class Fleet

Usage

FlatE_HDom

Format

An object of class Fleet of length 1.

FlatE_NDom	<i>FlatE_NDom Fleet</i>
------------	-------------------------

Description

An object of class Fleet

Usage

FlatE_NDom

Format

An object of class Fleet of length 1.

 Fleet-class

 Class 'Fleet'

Description

The component of the operating model that controls fishing dynamics

Slots

Name Name of the Fleet object

nyears The number of years for the historical simulation

Spat_targ Distribution of fishing in relation to spatial biomass: F is proportional to $B^{\text{Spat_targ}}$ (uniform distribution)

Esd Inter-annual variability in fishing mortality rate

EffYears Vector of verticies, years at which to simulate varying relative effort

EffLower Lower bound on relative effort corresponding to EffYears (uniform distribution)

EffUpper Uppper bound on relative effort corresponding to EffYears (uniform distribution)

LFS Shortest length that is fully vulnerable to fishing (uniform distribution)

L5 Shortest length corresponding to 5 percent vulnerability (uniform distribution)

Vmaxlen The vulnerability of the longest (oldest) fish (uniform distribution)

LR5 Shortest length corresponding ot 5 percent retention (uniform distribution)

LFR Shortest length that is fully retained (uniform distribution)

Rmaxlen The retention of the longest (oldest) fish (uniform distribution)

DR Discard rate - fraction of caught fish that are discarded (must be ≤ 1) (uniform distribution)

SelYears Vector of verticies, index for years at which historical selectivity pattern changed. If left empty, historical selectivity is constant

AbsSelYears Optional values for SelYears, used for plotting only. Must be of same length as SelYears

L5Lower Optional vector of values of length SelYears, specifying lower limits of L5 (use ChooseSelect function to set these)

L5Upper Optional vector of values of length SelYears, specifying upper limits of L5 (use ChooseSelect function to set these)

LFSLower Optional vector of values of length SelYears, specifying lower limits of LFS (use ChooseSelect function to set these)

LFSUpper Optional vector of values of length SelYears, specifying upper limits of LFS (use ChooseSelect function to set these)

VmaxLower Optional vector of values of length SelYears, specifying lower limits of Vmaxlen (use ChooseSelect function to set these)

VmaxUpper Optional vector of values of length SelYears, specifying upper limits of Vmaxlen (use ChooseSelect function to set these)

qinc Average percentage change in fishing efficiency (uniform distribution)(applicable only to forward projection and input controls)

qcv Inter-annual variability in fishing efficiency (uniform distribution)(applicable only to forward projection and input controls)

isRel Are the selectivity parameters relative to size-of-maturity? TRUE or FALSE

CurrentYr The current calendar year (final year) of the historical simulations (e.g. 2011)

Objects from the Class

Objects can be created by calls of the form `new('Fleet')`

Author(s)

T. Carruthers

Examples

```
showClass('Fleet')
```

FMSYref

A reference FMSY method (uses perfect information about FMSY)

Description

FMSY is taken from the operating model stored at `DLM@OM$FMSY`

Usage

```
FMSYref(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Details

Note that you can out-perform this MP even though it has perfect information of FMSY and current abundance. The requirement for fixed F is actually quite strict and is by no means the upper limit in terms of yield. Don't panic if your method beats this one for yield, especially for short-lived species of high temporal variability in productivity!

Author(s)

T. Carruthers

FMSYref50	<i>A reference FMSY method that fishes at half of FMSY (uses perfect information about FMSY)</i>
-----------	--

Description

FMSY is taken from the operating model stored at DLM@OM\$FMSY

Usage

FMSYref50(x, Data, reps = 100)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC (OFL) samples

Details

Note that you can out-perform this method easily. The requirement for fixed F is actually quite strict and is by no means the upper limit in terms of yield. Don't panic if your method beats this one for yield!

Interesting that the reduction in yield is no way near commensurate with the reduction in F - as predicted by a yield curve and expressed in the pretty good yield theory.

Author(s)

T. Carruthers

FMSYref75	<i>A reference FMSY method that fishes at three quarters of FMSY (uses perfect information about FMSY)</i>
-----------	--

Description

FMSY is taken from the operating model stored at DLM@OM\$FMSY

Usage

FMSYref75(x, Data, reps = 100)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Details

Note that you can out-perform this method easily. The requirement for fixed F is actually quite strict and is by no means the upper limit in terms of yield. Don't panic if your method beats this one for yield!

Interesting that the reduction in yield is no way near commensurate with the reduction in F as predicted by a yield curve and expressed in the pretty good yield theory.

Author(s)

T. Carruthers

ForceCor	<i>Forces correlation among operating model parameters for M, K, Linf and L50</i>
----------	---

Description

Uses typical correlations among estimated parameters to generate realistic samples for natural mortality rate (M), growth rate (K), maximum length (Linf) and length at 50

Usage

```
ForceCor(OM, nsim = 48, plot = T)
```

Arguments

OM	An operating model object with M, growth, stock-recruitment and maturity parameters specified.
nsim	The number of simulated values to create (note that OM@nsim will be used preferentially).
plot	Should the sampled parameters and distributions be plotted?

Value

An object of class OM with a populated (or appended) cpars slot

Author(s)

T. Carruthers (Canadian DFO grant)

Examples

```
testOM<-ForceCor(testOM)
```

Fratio

An FMSY/M ratio method

Description

Calculates the OFL based on a fixed ratio of FMSY to M multiplied by a current estimate of abundance.

Usage

```
Fratio(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples of the TAC recommendation

Details

A simple method that tends to outperform many other approaches alarmingly often even when current biomass is relatively poorly known. The low stock crash potential is largely due to the quite large difference between Fmax and FMSY for most stocks.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Gulland, J.A., 1971. The fish resources of the ocean. Fishing News Books, West Byfleet, UK.
Martell, S., Froese, R., 2012. A simple method for estimating MSY from catch and resilience. Fish Fish. doi: 10.1111/j.1467-2979.2012.00485.x.

Fratio4010	<i>An FMSY/M ratio method paired with the 40-10 rule</i>
------------	--

Description

Calculates the OFL based on a fixed ratio of FMSY to M multiplied by a current estimate of abundance. In this method DBSRA is paired with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished biomass.

Usage

```
Fratio4010(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Author(s)

T. Carruthers

References

Gulland, J.A., 1971. The fish resources of the ocean. Fishing News Books, West Byfleet, UK.

Martell, S., Froese, R., 2012. A simple method for estimating MSY from catch and resilience. Fish Fish. doi: 10.1111/j.1467-2979.2012.00485.x.

Fratio_CC	<i>A data-limited method that uses FMSY/M ratio and a naive catch-curve estimate of recent Z</i>
-----------	--

Description

Calculates the OFL based on a fixed ratio of FMSY to M and a catch curve estimate of current stock size.

Usage

```
Fratio_CC(x, Data, reps = 100, Fmin = 0.005)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
Fmin	Minimum current fishing mortality rate for the catch-curve analysis

Author(s)

T. Carruthers

References

- Gulland, J.A., 1971. The fish resources of the ocean. Fishing News Books, West Byfleet, UK.
- Martell, S., Froese, R., 2012. A simple method for estimating MSY from catch and resilience. Fish Fish. doi: 10.1111/j.1467-2979.2012.00485.x.

Fratio_ML

An FMSY/M ratio MP that uses a mean length estimator of recent Z

Description

Calculates the OFL based on a fixed ratio of FMSY/M and an estimate of current stock size from a mean-length estimator.

Usage

```
Fratio_ML(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

- Gulland, J.A., 1971. The fish resources of the ocean. Fishing News Books, West Byfleet, UK.
- Martell, S., Froese, R., 2012. A simple method for estimating MSY from catch and resilience. Fish Fish. doi: 10.1111/j.1467-2979.2012.00485.x.

 GB_CC

Geromont and Butterworth Constant Catch Harvest Control Rule

Description

A simple MP that aims for average historical catches (as a proxy for MSY) subject to imperfect information.

Usage

```
GB_CC(x, Data, reps = 100)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Details

Note that this is my interpretation of their MP and is now stochastic. Currently it is generalized and is not 'tuned' to more detailed assessment data which might explain why in some cases it leads to stock declines.

Author(s)

T. Carruthers

References

- Geromont, H.F. and Butterworth, D.S. 2014. Complex assessment or simple management procedures for efficient fisheries management: a comparative study. ICES J. Mar. Sci. doi:10.1093/icesjms/fsu017

GB_slope	<i>Geromont and Butterworth index slope Harvest Control Rule</i>
----------	--

Description

An MP similar to SBT1 that modifies a time-series of catch recommendations and aims for a stable catch rates.

Usage

```
GB_slope(x, Data, reps = 100, yrsmth = 5, lambda = 1)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Number of years for evaluating slope in relative abundance index
lambda	A gain parameter

Details

Note that this is my interpretation of their approach and is now stochastic. Currently it is generalized and is not 'tuned' to more detailed assessment data which might explain why in some cases it leads to stock declines.

Author(s)

T. Carruthers

References

Geromont, H.F. and Butterworth, D.S. 2014. Complex assessment or simple management procedures for efficient fisheries management: a comparative study. ICES J. Mar. Sci. doi:10.1093/icesjms/fsu017

GB_target	<i>Geromont and Butterworth target CPUE and catch MP</i>
-----------	--

Description

An MP similar to SBT2 that modifies a time-series of catch recommendations and aims for target catch rate and catch level based on BMSY/B0 and MSY, respectively.

Usage

```
GB_target(x, Data, reps = 100, w = 0.5)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of quota samples
w	A gain parameter

Details

Note that this is my interpretation of their MP and is now stochastic. Currently it is generalized and is not 'tuned' to more detailed assessment data which might explain why in some cases it leads to stock declines.

Author(s)

T. Carruthers

References

Geromont, H.F. and Butterworth, D.S. 2014. Complex assessment or simple management procedures for efficient fisheries management: a comparative study. ICES J. Mar. Sci. doi:10.1093/icesjms/fsu017

Gcontrol	<i>G-control MP</i>
----------	---------------------

Description

A harvest control rule proposed by Carl Walters that uses trajectory in inferred surplus production to make upward/downward adjustments to TAC recommendations

Usage

```
Gcontrol(x, Data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of quota samples
yrsnth	The number of years over which to smooth catch and biomass data
gg	A gain parameter
glim	A constraint limiting the maximum level of change in quota recommendations

Author(s)

C. Walters and T. Carruthers

References

Made-up for this package. Carruthers et al. 2015. Performance of Simple Management Procedures.

Generic_DecE	<i>Generic_DecE Fleet</i>
--------------	---------------------------

Description

An object of class Fleet

Usage

Generic_DecE

Format

An object of class Fleet of length 1.

Generic_FlatE	<i>Generic_FlatE Fleet</i>
---------------	----------------------------

Description

An object of class Fleet

Usage

Generic_FlatE

Format

An object of class Fleet of length 1.

Generic_fleet	<i>Generic_fleet Fleet</i>
---------------	----------------------------

Description

An object of class Fleet

Usage

Generic_fleet

Format

An object of class Fleet of length 1.

Generic_IncE	<i>Generic_IncE Fleet</i>
--------------	---------------------------

Description

An object of class Fleet

Usage

Generic_IncE

Format

An object of class Fleet of length 1.

Generic_obs	<i>Generic_obs Obs</i>
-------------	------------------------

Description

An object of class Obs

Usage

Generic_obs

Format

An object of class Obs of length 1.

genLenComp *Generate length composition of catch*

Description

Generate size composition of catch given sample of catch-at-age, expected length-at-age, and standard deviation of length-at-age. Model assumes length-at-age is normally distributed, and that selectivity is size-dependant

Usage

```
genLenComp(CAL_bins, CAL_binsmid, SL, CAL_ESS, CAL_nsamp, CN, LaA, LaASD,
           truncSD)
```

Arguments

CAL_bins	vector of catch-at-length size bins
CAL_binsmid	vector (nbins = length(CAL_bins) - 1) of mid-points for catch-at-length size bins
SL	matrix (nbins, nyears) of selectivity-at-length class for each year
CAL_ESS	effective sample size of catch-at-length data
CAL_nsamp	sample size of catch-at-length data
CN	matrix (nyears, maxage) of catch-at-age for each year
LaA	matrix (maxage, nyears) of expected length-at-age for each year
LaASD	matrix (maxage, nyears) of standard deviation of length-at-age for each year
truncSD	optional argument to truncate the length-at-age distribution at 'truncSD' standard deviations e.g., a value of 2 truncates the length-at-age distribution at two standard deviations (set to 0 to ignore (default))

getAFC *Calculate age at first capture from length at first capture and growth*

Description

As title.

Usage

```
getAFC(t0c, Linfc, Kc, LFC, maxage)
```

Arguments

t0c	A vector of theoretical age at length zero (von Bertalanffy growth)
Linf	A vector of maximum length (von Bertalanffy growth)
Kc	A vector of maximum growth rate (von Bertalanffy growth)
LFC	A vector of length at first capture
maxage	Maximum age

Author(s)

T. Carruthers

getBH	<i>Predict Beverton-Holt recruitment and return fit to S-R observations</i>
-------	---

Description

Internal function to optBH

Usage

```
getBH(pars, SSB, rec, SSBpR, mode = 1, plot = F)
```

Arguments

pars	an initial guess at model parameters steepness and R0
SSB	'observations' of spawning biomass
rec	'observations' (model predictions) of recruitment
SSBpR	spawning stock biomass per recruit at unfished conditions
mode	should fit or recruitment deviations be returned
plot	should a plot of the model fit be produced?

Author(s)

T. Carruthers

getBlow

*Blow parallel optimization function***Description**

Find the current biomass at which it would take HZN mean generation times to reach Bfrac x SSBMSY biomass level given zero catches

Usage

```
getBlow(x, SSBMSY, MGThorizon, Find, Perr, M_ageArray, hs, Mat_age, Wt_age, R0,
        V, nyears, maxage, mov, Spat_targ, SRrel, aR, bR, Bfrac = 0.5, ploty = F)
```

Arguments

x	position in a vector
SSBMSY	vector nsim long of spawning biomass at MSY
MGThorizon	vector nsim long of MGT x HZN
Find	matrix of fishing mortality rate nsim x nyears
Perr	matrix of recruitment deviations nsim x nyears + maxage -1
M_ageArray	array of natural mortality rate nsim x maxage x nyears + proyears
hs	vector nsim long of steepness values
Mat_age	matrix nsim x nages of maturity at age
Wt_age	matrix nsim x nages of weight at age
R0	vector nsim long of unfished recruitment
V	array of vulnerability nsim x maxage x nyears
nyears	integer: number of historical years
maxage	integer: maximum age
mov	array of movement nsim x 2 x 2
Spat_targ	vector of spatial targetting parameters
SRrel	integer representing recruitmetn dynamics type 1: Bev Holt 2: Ricker
aR	vector of recruitment parameters
bR	vector of recruitment parameters
Bfrac	fraction of SSBMSY that is the target
ploty	logical: should a plot be produced

Author(s)

T. Carruthers

getclass	<i>get object class</i>
----------	-------------------------

Description

Internal function for determining if object is of classy

Usage

```
getclass(x, classy)
```

Arguments

x	Character string object name
classy	A class of object (character string, e.g. 'Fleet')

Value

TRUE or FALSE

Author(s)

T. Carruthers

getFMSY3	<i>Calculate FMSY and related metrics using Rcpp code</i>
----------	---

Description

Calculate FMSY and related metrics using Rcpp code

Usage

```
getFMSY3(x, nareas, maxage, N, pyears, M_ageArray, Mat_age, Wt_age, V, retA,
  Perr, mov, SRrel, Find, Spat_targ, hs, R0a, SSBpR, aR, bR, SSB0, B0, maxF,
  useCPP = TRUE)
```

Arguments

x	Integer, the simulation number
nareas	The number of spatial areas
maxage	The maximum age
N	Array of the numbers-at-age in population. Dimensions are nsim, maxage, nyears, nareas. Only values from the first year (i.e N[:,1,]) are used, which is the current N-at-age.

pyears	The number of years to project forward. Equal to 'nyears' for optimizing for q.
M_ageArray	An array (dimensions nsim, maxage, nyears+proyears) with the natural mortality-at-age and year
Mat_age	A matrix (dimensions nsim, maxage) with the proportion mature for each age-class
Wt_age	An array (dimensions nsim, maxage, nyears+proyears) with the weight-at-age and year
V	An array (dimensions nsim, maxage, nyears+proyears) with the vulnerability-at-age and year
retA	An array (dimensions nsim, maxage, nyears+proyears) with the probability retained-at-age and year
Perr	A matrix (dimensions nsim, nyears+proyears) with the recruitment deviations
mov	An array (dimensions nsim, nareas, nareas) with the movement matrix
SRrel	A numeric vector nsim long specifying the recruitment curve to use
Find	A matrix (dimensions nsim, nyears) with the historical fishing effort
Spat_targ	A numeric vector nsim long with the spatial targeting
hs	A numeric vector nsim long with the steepness values for each simulation
R0a	A matrix (dimensions nsim, nareas) with the unfished recruitment by area
SSBpR	A matrix (dimensions nsim, nareas) with the unfished spawning-per-recruit by area
aR	A numeric vector nsim long with the Ricker SRR a values
bR	A numeric vector nsim long with the Ricker SRR b values
SSB0	Unfished spawning biomass
B0	Unfished total biomass
maxF	A numeric value specifying the maximum fishing mortality for any single age class
useCPP	logical - use the CPP code? For testing purposes only

Author(s)

A. Hordyk

 getFref3

Calculate Reference Yield

Description

Calculate Reference Yield

Usage

```
getFref3(x, nareas, maxage, N, pyears, M_ageArray, Mat_age, Wt_age, V, retA,
        Perr, mov, SRrel, Find, Spat_targ, hs, R0a, SSBpR, aR, bR, maxF,
        useCPP = TRUE)
```

Arguments

x	Integer, the simulation number
nareas	The number of spatial areas
maxage	The maximum age
N	Array of the numbers-at-age in population. Dimensions are nsim, maxage, nyears, nareas. Only values from the first year (i.e N[:,1,]) are used, which is the current N-at-age.
pyears	The number of years to project forward. Equal to 'nyears' for optimizing for q.
M_ageArray	An array (dimensions nsim, maxage, nyears+proyears) with the natural mortality-at-age and year
Mat_age	A matrix (dimensions nsim, maxage) with the proportion mature for each age-class
Wt_age	An array (dimensions nsim, maxage, nyears+proyears) with the weight-at-age and year
V	An array (dimensions nsim, maxage, nyears+proyears) with the vulnerability-at-age and year
retA	An array (dimensions nsim, maxage, nyears+proyears) with the probability retained-at-age and year
Perr	A matrix (dimensions nsim, nyears+proyears) with the recruitment deviations
mov	An array (dimensions nsim, nareas, nareas) with the movement matrix
SRrel	A numeric vector nsim long specifying the recruitment curve to use
Find	A matrix (dimensions nsim, nyears) with the historical fishing effort
Spat_targ	A numeric vector nsim long with the spatial targeting
hs	A numeric vector nsim long with the steepness values for each simulation
R0a	A matrix (dimensions nsim, nareas) with the unfished recruitment by area
SSBpR	A matrix (dimensions nsim, nareas) with the unfished spawning-per-recruit by area
aR	A numeric vector nareas long with the Ricker SRR a values
bR	A numeric vector nareas long with the Ricker SRR b values
maxF	A numeric value specifying the maximum fishing mortality for any single age class
useCPP	logical - use the CPP code? For testing purposes only

Author(s)

A. Hordyk
A. Hordyk

getGpars	<i>Extracts growth parameters from a SS3 r4ss replist</i>
----------	---

Description

Extracts growth parameters from a SS3 r4ss replist

Usage

```
getGpars(repllist, seas = 1)
```

Arguments

repllist	the list output of the r4ss SS_output function (a list of assessment inputs / outputs)
seas	The reference season for the growth (not actually sure what this does yet)

Author(s)

T. Carruthers

GetMoreData	<i>Load more data from DLMdata package</i>
-------------	--

Description

Downloads the DLMdata package from GitHub

Usage

```
GetMoreData(silent = FALSE)
```

Arguments

silent	Logical. Should messages to printed?
--------	--------------------------------------

getmov	<i>Optimization function to find a movement model that matches user specified movement characteristics.</i>
--------	---

Description

The user specifies the probability of staying in the same area and spatial heterogeneity (both in the unfished state).

Usage

```
getmov(x, Prob_staying, Frac_area_1)
```

Arguments

x	A position in vectors Prob_staying and Frac_area_1
Prob_staying	User specified probability that individuals in area 1 remain in that area (unfished conditions)
Frac_area_1	User specified fraction of individuals found in area 1 (unfished conditions)

Details

This is paired with movfit to find the correct movement model.

Value

A markov movement matrix

Author(s)

T. Carruthers

Examples

```
Prob_staying<-0.8 # probability that individuals remain in area 1 between time-steps
Frac_area_1<-0.35 # the fraction of the stock found in area 1 under equilibrium conditions
markovmat<-getmov(1,Prob_staying, Frac_area_1)
vec<-c(0.5,0.5) # initial guess at equilibrium distribution (2 areas)
for(i in 1:300)vec<-apply(vec*markovmat,2,sum) # numerical approximation to stable distribution
c(markovmat[1,1],vec[1]) # pretty close right?
```

getmov2	<i>Optimization function to find a movement model that matches user specified movement characteristics modified for Rcpp.</i>
---------	---

Description

The user specifies the probability of staying in the same area and spatial heterogeneity (both in the unfished state).

Usage

```
getmov2(x, Prob_staying, Frac_area_1)
```

Arguments

x	A position in vectors Prob_staying and Frac_area_1
Prob_staying	User specified probability that individuals in area 1 remain in that area (unfished conditions)
Frac_area_1	User specified fraction of individuals found in area 1 (unfished conditions)

Details

This is paired with movfit to find the correct movement model.

Value

A markov movement matrix

Author(s)

T. Carruthers

Examples

```
Prob_staying<-0.8 # probability that individuals remain in area 1 between time-steps
Frac_area_1<-0.35 # the fraction of the stock found in area 1 under equilibrium conditions
markovmat<-getmov(1,Prob_staying, Frac_area_1)
vec<-c(0.5,0.5) # initial guess at equilibrium distribution (2 areas)
for(i in 1:300)vec<-apply(vec*markovmat,2,sum) # numerical approximation to stable distribution
c(markovmat[1,1],vec[1]) # pretty close right?
```

getq3 *optimize for catchability (q)*

Description

Function optimizes catchability (q , where $F=qE$) required to get to user-specified stock depletion

Usage

```
getq3(x, dep, SSB0, nareas, maxage, N, pyears, M_ageArray, Mat_age, Wt_age, V,
      retA, Perr, mov, SRrel, Find, Spat_targ, hs, R0a, SSBpR, aR, bR,
      bounds = c(1e-05, 15), maxF, useCPP = TRUE)
```

Arguments

x	Integer, the simulation number
dep	A numeric vector nsim long of sampled depletion
SSB0	A numeric vector nsim long of total unfished spawning biomass
nareas	The number of spatial areas
maxage	The maximum age
N	Array of the numbers-at-age in population. Dimensions are nsim, maxage, nyears, nareas. Only values from the first year (i.e N[:,1,]) are used, which is the current N-at-age.
pyears	The number of years to project forward. Equal to 'nyears' for optimizing for q .
M_ageArray	An array (dimensions nsim, maxage, nyears+proyears) with the natural mortality-at-age and year
Mat_age	A matrix (dimensions nsim, maxage) with the proportion mature for each age-class
Wt_age	An array (dimensions nsim, maxage, nyears+proyears) with the weight-at-age and year
V	An array (dimensions nsim, maxage, nyears+proyears) with the vulnerability-at-age and year
retA	An array (dimensions nsim, maxage, nyears+proyears) with the probability retained-at-age and year
Perr	A matrix (dimensions nsim, nyears+proyears) with the recruitment deviations
mov	An array (dimensions nsim, nareas, nareas) with the movement matrix
SRrel	A numeric vector nsim long specifying the recruitment curve to use
Find	A matrix (dimensions nsim, nyears) with the historical fishing effort
Spat_targ	A numeric vector nsim long with the spatial targeting
hs	A numeric vector nsim long with the steepness values for each simulation
R0a	A matrix (dimensions nsim, nareas) with the unfished recruitment by area

SSBpR	A matrix (dimensions nsim, nareas) with the unfished spawning-per-recruit by area
aR	A numeric vector nareas long with the Ricker SRR a values
bR	A numeric vector nareas long with the Ricker SRR b values
bounds	A numeric vector of length 2 with bounds for the optimizer
maxF	A numeric value specifying the maximum fishing mortality for any single age class
useCPP	logical - use the CPP code? For testing purposes only

Author(s)

A. Hordyk

Gulf_blue_tilefish	<i>Gulf_blue_tilefish Data</i>
--------------------	--------------------------------

Description

An object of class Data

Usage

Gulf_blue_tilefish

Format

An object of class Data of length 1.

HDAAC	<i>Hybrid Depletion Adjusted Average Catch</i>
-------	--

DescriptionEssentially DCAC multiplied by $2 \cdot \text{depletion}$ and divided by BMSY/B_0 (B_{peak}) when below BMSY, and DCAC above BMSY**Usage**

HDAAC(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the TAC recommendation

Author(s)

W. Harford and T. Carruthers

References

MacCall, A.D., 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES J. Mar. Sci. 66, 2267-2271. Harford W. and Carruthers, T. 2016. Testing novel catch-based fisheries management procedures.

Herring	<i>Herring Stock</i>
---------	----------------------

Description

An object of class Stock

Usage

Herring

Format

An object of class Stock of length 1.

hist2	<i>Wrapper for histogram function</i>
-------	---------------------------------------

Description

Produces a blank plot if all values in x are equal

Usage

```
hist2(x, col, axes = FALSE, main = "", breaks = 10, cex.main = 1)
```

Arguments

x	A vector of values
col	Colour of the histogram
axes	Logical - should axes be included?
main	Character - main title
breaks	Number of breaks. See ?hist for more details
cex.main	Text size of the main title

ICI

*Index Confidence Interval (ICI) MP by Jardim et al. (2015)***Description**

The MP adjusts catch based on the value of the index in the current year relative to the time series mean and standard error.

The mean and standard error of the index time series is calculated. There are two thresholds which delineates whether catch is reduced, held constant, or increased. The catch is reduced by 0.75 if the Z-score of the current year's index is less than -0.44. The catch is increased by 1.05 if the Z-score of the current year's index is greater than 1.96. Otherwise, the catch is held constant.

Usage

ICI(x, Data, reps)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Author(s)

Coded by Q. Huynh. Developed by Jardim et al. (2015)

References

Ernesto Jardim, Manuela Azevedo, Nuno M. Brites, Harvest control rules for data limited stocks using length-based reference points and survey biomass indices, *Fisheries Research*, Volume 171, November 2015, Pages 12-19, ISSN 0165-7836, <https://doi.org/10.1016/j.fishres.2014.11.013>

ICI2

*Less Precautionary Index Confidence Interval (ICI) MP by Jardim et al. (2015)***Description**

The MP adjusts catch based on the value of the index in the current year relative to the time series mean and standard error. This method is less precautionary of the two ICI MPs by allowing for a larger increase in TAC and a lower threshold of the index to decrease the TAC (see Jardim et al. 2015).

Usage

```
ICI2(x, Data, reps)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples

Details

The mean and standard error of the index time series is calculated. There are two thresholds which delineates whether catch is reduced, held constant, or increased. The catch is reduced by 0.75 if the Z-score of the current year's index is less than -1.96. The catch is increased by 1.25 if the Z-score of the current year's index is greater than 1.96. Otherwise, the catch is held constant.

Author(s)

Coded by Q. Huynh. Developed by Jardim et al. (2015)

References

Ernesto Jardim, Manuela Azevedo, Nuno M. Brites, Harvest control rules for data limited stocks using length-based reference points and survey biomass indices, Fisheries Research, Volume 171, November 2015, Pages 12-19, ISSN 0165-7836, <https://doi.org/10.1016/j.fishres.2014.11.013>

Imp-class	Class 'Imp'
-----------	-------------

Description

An operating model component that specifies the degree of adherence to management recommendations (Implementation error)

Slots

Name	The name of the Implementation error object
TACSD	lognormal standard deviation in fraction of TAC taken (uniform distribution)
TACFrac	Mean fraction of TAC taken (uniform distribution) (can be an improper fraction greater than 1)
ESD	lognormal standard deviation in fraction of TAE taken(uniform distribution)
EFrac	Mean fraction of recommended effort taken (uniform distribution)
SizeLimSD	lognormal error in size limit implementation (uniform distribution)
SizeLimFrac	Mean fraction of the size limit (uniform distribution) (can be an improper fraction greater than 1)
Source	A reference to a website or article form which parameters were taken to define the operating model

Objects from the Class

Objects can be created by calls of the form `new('Imp')`

Author(s)

T. Carruthers

Examples

```
showClass('Imp')
```

Imprecise_Biased *Imprecise_Biased Obs*

Description

An object of class Obs

Usage

```
Imprecise_Biased
```

Format

An object of class Obs of length 1.

Imprecise_Unbiased *Imprecise_Unbiased Obs*

Description

An object of class Obs

Usage

```
Imprecise_Unbiased
```

Format

An object of class Obs of length 1.

IncE_HDom	<i>IncE_HDom Fleet</i>
-----------	------------------------

Description

An object of class Fleet

Usage

IncE_HDom

Format

An object of class Fleet of length 1.

IncE_NDom	<i>IncE_NDom Fleet</i>
-----------	------------------------

Description

An object of class Fleet

Usage

IncE_NDom

Format

An object of class Fleet of length 1.

initialize-methods	<i>~~ Methods for Function initialize ~~</i>
--------------------	--

Description

~~ Methods for function initialize ~~

Methods

```
list('signature(.Object = \'DLM\')') here~~
list('signature(.Object = \'Fleet\')') here~~
list('signature(.Object = \'MSE\')') here~~
list('signature(.Object = \'Obs\')') method here~~
list('signature(.Object = \'OM\')')
list('signature(.Object = \'Stock\')') here~~
list('signature(.Object = \'Fease\')') here~~
list('signature(.Object = \'DLM_general\')') this method here~~
```

Input

Function to run a set of input control methods

Description

Runs a set of input control methods and returns the output in a single table

Usage

```
Input(Data, MPs = NA, reps = 100, timelimit = 10, CheckMPs = TRUE,
      msg = TRUE)
```

Arguments

Data	A Data object
MPs	A list of input MPs, if NA all available input MPs are run
reps	Number of repetitions (for those methods that use them)
timelimit	Maximum timelimit to run MP (in seconds)
CheckMPs	Logical, the Can function is run if this is TRUE
msg	Logical. Should messages be printed?

Author(s)

A. Hordyk

InputRec-class	Class 'InputRec'
----------------	------------------

Description

An object for storing the recommendation for an input control MP

Slots

Effort A numeric value with the effort recommendation as a fraction of current (nyear) fishing effort

Spatial A boolean vector of length 'nareas' specifying if area is open (1) or closed (0) to fishing

Allocate A boolean value describing if effort should be re-allocated from close to open areas

LR5 smallest length at 5 per cent retention

LFR smallest length at full retention

HS upper harvest slot (no retention above this)

Rmaxlen retention of the largest size class

Misc An empty list that can be used to store information and pass on to MPs in future

Objects from the Class

Objects can be created by calls of the form `new('InputRec')`

Author(s)

A. Hordyk

IOTC_plot	<i>Indian Ocean Tuna Commission trade-off plot</i>
-----------	--

Description

A one-panel trade-off plot showing the probability of exceeding a biomass reference level and a yield reference level

Usage

```
IOTC_plot(MSEobj, Bref = 0.75, Yref = 0.75, Bsat = 0.8, Ysat = 0.8,
  xlim = c(0, 1.1), ylim = c(0, 1.1))
```

Arguments

MSEobj	An object of class MSE created by the function runMSE()
Bref	A biomass reference level (an improper fraction of BMSY)
Yref	A yield reference level (an improper fraction of yield given FMSY management)
Bsat	The satisficing level for biomass (required fraction of simulations exceeding Bref)
Ysat	The satisficing level for yield (required fraction of simulations exceeding Yref)
xlim	The limits of the x axis plotting
ylim	The limits of the y axis plotting

Author(s)

T. Carruthers

Iratio

Mean index ratio MP from Jardim et al. 2015

Description

The TAC is adjusted by the ratio alpha, where the numerator being the mean index in the most recent two years of the time series and the denominator being the mean index in the three years prior to those in the numerator.

Usage

```
Iratio(x, Data, reps, yrs = c(2, 5))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrs	Vector of length 2 specifying the reference years

Details

This MP is the stochastic version of Method 3.2 used by ICES for Data-Limited Stocks (ICES 2012).

Author(s)

Coded by Q. Huynh. Developed by Jardim et al. (2015)

References

Ernesto Jardim, Manuela Azevedo, Nuno M. Brites, Harvest control rules for data limited stocks using length-based reference points and survey biomass indices, Fisheries Research, Volume 171, November 2015, Pages 12-19, ISSN 0165-7836, <https://doi.org/10.1016/j.fishres.2014.11.013>

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

iSCAM2Data

Reads data from iSCAM file structure into a DLMtool Data object

Description

A function that uses the file location of a fitted iSCAM model including input files to population the various slots of an data object. iSCAM2DLM relies on several functions written by Chris Grandin (DFO PBS).

Usage

```
iSCAM2Data(iSCAMdir, Name = NULL, Source = "No source provided",
  length_timestep = 1, Author = "No author provided")
```

Arguments

iSCAMdir	A folder with iSCAM input and output files in it
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
length_timestep	How long is a model time step in years (e.g. a quarterly model is 0.25, a monthly model 1/12)
Author	Who did the assessment

Author(s)

T. Carruthers

iSCAM2DLM	<i>Reads MLE estimates from iSCAM file structure into an operating model</i>
-----------	--

Description

A function that uses the file location of a fitted iSCAM model including input files to population the various slots of an operating model parameter estimates. iSCAM2DLM relies on several functions written by Chris Grandin (DFO PBS).

Usage

```
iSCAM2DLM(iSCAMdir, nsim = 48, proyears = 50, Name = NULL,
  Source = "No source provided", length_timestep = 1,
  Author = "No author provided")
```

Arguments

iSCAMdir	A folder with iSCAM input and output files in it
nsim	The number of simulations to take for parameters with uncertainty (for OM@cpar custom parameters)
proyears	The number of MSE projection years
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
length_timestep	How long is a model time step in years (e.g. a quarterly model is 0.25, a monthly model 1/12)
Author	Who did the assessment

Author(s)

T. Carruthers

iSCAMcomps	<i>Combines all iSCAM age composition data across fleets</i>
------------	--

Description

iSCAM assessments are often fitted to numerous fleets that have differing age selectivities. iSCAMcomps is a simple way of providing the aggregate catch at age data. It should be noted that this process is important and in a real application would require due diligence (ie peer reviewed data workshop).

Usage

```
iSCAMcomps(replist, Year)
```

Arguments

replist	S3 class object: the output from a read from an iSCAM data folder
Year	Integer vector: the years of the DLMtool data object ie Data@Year

Author(s)

T. Carruthers

iSCAMinds

Combines indices into a single index using linear modelling

Description

iSCAM assessments often make use of multiple indices of abundance. The DLMtool data object and MPs currently only make use of a single index. `combiSCAMinds` is a function that creates a single index from many using linear modelling. It is a simple way of providing initial calculations of management recommendations and it should be noted that this process is important and in a real application would require due diligence (ie peer reviewed data workshop).

Usage

```
iSCAMinds(idata, Year, fleeteffect = T)
```

Arguments

idata	List: the indices recorded in a read from an iSCAM data folder, e.g. <code>replist\$data\$indices</code>
Year	Integer vector: the years of the DLMtool data object ie Data@Year
fleeteffect	Logical: should a fleet effect be added to the linear model?

Author(s)

T. Carruthers

Islope1	<i>A management procedure that incrementally adjusts the TAC to maintain a constant CPUE or relative abundance index</i>
---------	--

Description

The least biologically precautionary of two constant index / CPUE methods proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Islope1(x, Data, reps = 100, yrsmth = 5, lambda=0.4,xx=0.2)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to smooth recent estimates of surplus production
lambda	A gain parameter controlling the speed in update in TAC.
xx	Parameter controlling the fraction of mean catch to start using in first year

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of quota recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance review of simple management procedures. Fish and Fisheries. In press.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

Islope4	<i>A management procedure that incrementally adjusts the TAC to maintain a constant CPUE or relative abundance index</i>
---------	--

Description

The most biologically precautionary of two constant index / CPUE methods proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Islope4(x, Data, reps = 100, yrsmth = 5, lambda=0.2,xx=0.4)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to smooth recent estimates of surplus production
lambda	A gain parameter controlling the speed in update in TAC.
xx	Parameter controlling the fraction of mean catch to start using in first year

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of quota recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

IT10

*Index Target 10***Description**

An index target MP where the TAC is modified according to current index levels (mean index over last 5 years) relative to a target level. Maximum annual changes are 10 per cent.

Usage

```
IT10(x, Data, reps = 100, yrsmth=5, mc=0.1)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation
yrsmth	The number of historical years over which to average the index
mc	The maximum fractional change in the TAC among years.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

IT5

*Index Target 5***Description**

An index target MP where the TAC is modified according to current index levels (mean index over last 5 years) relative to a target level. Maximum annual changes are 5 per cent.

Usage

```
IT5(x, Data, reps = 100, yrsmth=5, mc=0.05)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation
yrsnth	The number of historical years over which to average the index
mc	The maximum fractional change in the TAC among years.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

Itarget1	<i>A management procedure that incrementally adjusts the TAC (starting from reference level that is a fraction of mean recent catches) to reach a target CPUE / relative abundance index</i>
----------	--

Description

The least biologically precautionary of two index/CPUE target MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Itarget1(x, Data, reps = 100, yrsnth = 5, xx=0, Imulti=1.5)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsnth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

Itarget4	<i>A management procedure that incrementally adjusts the TAC (starting from reference level that is a fraction of mean recent catches) to reach a target CPUE / relative abundance index</i>
----------	--

Description

The most biologically precautionary of two index/CPUE target MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Itarget4(x, Data, reps = 100, yrsmith = 5, xx=0.3, Imulti=2.5)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmith	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

- Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.
- Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

ItargetE1	<i>A management procedure that incrementally adjusts the effort to reach a target CPUE / relative abundance index</i>
-----------	---

Description

An effort-based version of the least biologically precautionary of two index/CPUE target MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
ItargetE1(x, Data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

References

- Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.
- Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

ItargetE4	<i>A management procedure that incrementally adjusts the Effort to reach a target CPUE / relative abundance index</i>
-----------	---

Description

An effort-based version of the most biologically precautionary of two index/CPUE target MPs proposed by Geromont and Butterworth 2014.

Usage

```
ItargetE4(x, Data, reps = 100, yrsmth = 5, xx = 0, Imulti = 2.5)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

References

- Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.
- Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

ITe10 *Index Target Effort-Based 10*

Description

An index target MP where the Effort is modified according to current index levels (mean index over last 5 years) relative to a target level. Maximum annual changes are 10 per cent.

Usage

```
ITe10(x, Data, reps = 100, yrsnth = 5, mc = 0.1)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation
yrsnth	The number of historical years over which to average the index
mc	The maximum fractional change in the Effort among years.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

ITe5 *Index Target Effort-Based 5*

Description

An index target MP where the Effort is modified according to current index levels (mean index over last 5 years) relative to a target level. Maximum annual changes are 5 per cent.

Usage

```
ITe5(x, Data, reps = 100, yrsnth = 5, mc = 0.05)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation
yrsmth	The number of historical years over which to average the index
mc	The maximum fractional change in the effort among years.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

 ITM

Index Target based on natural mortality rate

Description

An index target MP where the TAC is modified according to current index levels (mean index over last yrsmth years) relative to a target level. Maximum fractional annual changes are mc. $mc = (5 + M^{*25}) / 100$ $yrsmth = 4 * (1/M)^{0.25}$

Usage

ITM(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

joinMSE	<i>Join multiple MSE objects together</i>
---------	---

Description

Joins two or more MSE objects together. MSE objects must have identical number of historical years, and projection years.

Usage

```
joinMSE(MSEobjs = NULL)
```

Arguments

MSEobjs	A list of MSE objects. Must all have identical operating model and MPs. MPs which don't appear in all MSE objects will be dropped.
---------	--

Value

An object of class MSE

Author(s)

A. Hordyk

Jplot	<i>Joint probability plot</i>
-------	-------------------------------

Description

Calculates and plots the joint probability of meeting all performance metrics simultaneously

Usage

```
Jplot(MSEobj, PLim = 0.8, YVar = c('LTY', 'STY', 'avgSSB_SSB0',  
'avgB_BMSY'), PMRefs = list(B_BMSY = 0.5, SSB_SSB0 = 0.2), UseMean = TRUE,  
lastYrs = 10, AvailMPs = NULL, XLim = NULL, ShowCols = TRUE, ShowLabs =  
FALSE, All = TRUE)
```

Arguments

MSEobj	An object of class MSE
PLim	Probability limit (acceptable risk threshold; e.g., 0.8 for 80 percent)
YVar	What to plot of the y-axis: choose from <code>c('LTY', 'STY', 'avgSSB_SSB0', 'avgB_BMSY')</code>
PMRefs	List containing the reference limits for each metric
UseMean	Logical. Calculate mean (TRUE) or median (FALSE)
lastYrs	Last number of years in projection period to calculate summary statistics
AvailMPs	Optional character vector of available MPs (plotted in a different colour)
XLim	Optional limits for the x-axis
ShowCols	Logical. Show the background colours?
ShowLabs	Logical. Show the MP labels?
All	Logical. Plot all MPs (TRUE) or only those above the probability limit (PLim)?

Value

Invisibly returns data frame containing statistics shown in the plot

Author(s)

A. Hordyk

Kplot

KOBE plot: a projection by projection plot of F/FMSY and B/BMSY

Description

A standard KOBE plot by each method that also shows the percentage of methods that ended up in each quadrant.

Usage

```
Kplot(MSEobj,maxsim=60, MPs=NA, sims=NULL, maxMP=9, nam=NA,
      cex.leg=1.5)
```

Arguments

MSEobj	An object of class MSE
maxsim	Maximum number of simulations (lines) to plot on each panel.
MPs	Optional subset MSE object by MP
sims	Optional subset MSE object by simulation
maxMP	Maximum number of MPs to include in plot
nam	The name of the plot
cex.leg	Size of legend

Note

Apologies for the nauseating shading.

Author(s)

T. Carruthers with some additions from A. Hordyk

 L2A

Length to age conversion

Description

Simple deterministic length to age conversion given inverse von Bertalanffy growth.

Usage

`L2A(t0c, Linfc, Kc, Len, maxage)`

Arguments

<code>t0c</code>	Theoretical age at length zero
<code>Linfc</code>	Maximum length
<code>Kc</code>	Maximum growth rate
<code>Len</code>	Length
<code>maxage</code>	Maximum age

Value

An age (vector of ages, matrix of ages) corresponding with Len

Author(s)

T. Carruthers

L95target	<i>A management procedure that adjusts the TAC up/down from reference (target) level (that is a fraction of mean recent premanagement catches) to reach a target mean length of fish caught.</i>
-----------	--

Description

This MP is based on Ltarget1 proposed by Geromont and Butterworth 2014, but here the target and limit mean lengths are based on the length at maturity distribution rather than an arbitrary multiplicative of the mean length.

Usage

```
L95target(x, Data, reps = 100, yrsmth = 5, buffer=0)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to calculate the mean historical catch
buffer	Parameter controlling the fraction of mean catch to set the reference (or target) TAC level - acts as a precautionary buffer

Value

A numeric vector of TAC recommendations

Author(s)

HF Geromont

References

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

LBSPR_ItSel *Length-based SPR model with HCR that iteratively adjusts Selectivity*

Description

Management Procedure which adjusts size-at-selection based on estimated SPR. Entirely untested, and included at to demonstrate MPs of this type.

Usage

LBSPR_ItSel(x, Data, yrsmth=1, reps=5, ...)

Arguments

x	Simulation number
Data	Data object
yrsmth	Number of years to smooth length data - not currently used
reps	Number of repetitions. Not currently used
...	ignored

Author(s)

A. Hordyk

LBSPR_ItTAC *Length-based SPR model with HCR that iteratively adjusts TAC*

Description

Iteratively adjusts TAC based on distance between estimated and target SPR (40%), and slope of recent SPR estimates.

Usage

LBSPR_ItTAC(x, Data, yrsmth=1, reps=5, ...)

Arguments

x	Simulation number
Data	Data object
yrsmth	Number of years to smooth length data - not currently used
reps	Number of repetitions
...	ignored

Author(s)

A. Hordyk

LinInterp	<i>Linear interpolation of a y value at level xlev based on a vector x and y</i>
-----------	--

Description

Linear interpolation of a y value at level xlev based on a vector x and y

Usage

```
LinInterp(x, y, xlev, ascending = F, zeroint = F)
```

Arguments

x	A vector of x values
y	A vector of y values (identical length to x)
xlev	A the target level of x from which to guess y
ascending	Are the the x values supposed to be ordered before interpolation
zeroint	is there a zero-zero x-y intercept?

Author(s)

T. Carruthers

load.iscam.files	<i>Reads iSCAM files into a hierarchical R list object</i>
------------------	--

Description

A function for reading iSCAM input and output files into R

Usage

```
load.iscam.files(model.dir, burnin = 1000, thin = 1, verbose = FALSE)
```

Arguments

model.dir	An iSCAM directory
burnin	The initial mcmc samples to be discarded
thin	The degree of chain thinning 1 in every thin iterations is kept
verbose	Should detailed outputs be provided.

Author(s)

Chris Grandin (DFO PBS)

 Low_Effort_Non_Target *Low_Effort_Non_Target Fleet*

Description

An object of class Fleet

Usage

Low_Effort_Non_Target

Format

An object of class Fleet of length 1.

 Lratio_BHI *Mean length-based indicator MP of Jardim et al. 2015 using
Beverton-Holt invariant M/K ratio = 1.5 and assumes FMSY = M.*

Description

The TAC is adjusted by the ratio alpha, where the numerator is the mean length of the catch (of lengths larger than L_c) and the denominator is the mean length expected when $FMSY = M$ and $M/K = 1.5$. Natural mortality M and von Bertalanffy K are not used in this MP (see Appendix A of Jardim et al. 2015). Here, L_c is the length at full selection (LFS).

Usage

Lratio_BHI(x, Data, reps, yrsnth = 3)

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsnth	The most recent years of data to smooth the calculation of the mean length

Details

Argument yrsnth currently takes the mean length of the most recent 3 years of data as a smoother.

Author(s)

Coded by Q. Huynh. Developed by Jardim et al. (2015)

References

Ernesto Jardim, Manuela Azevedo, Nuno M. Brites, Harvest control rules for data limited stocks using length-based reference points and survey biomass indices, Fisheries Research, Volume 171, November 2015, Pages 12-19, ISSN 0165-7836, <https://doi.org/10.1016/j.fishres.2014.11.013>

Lratio_BHI2

The more general version of the mean length-based indicator MP of Jardim et al. 2015.

Description

The TAC is adjusted by the ratio alpha, where the numerator is the mean length of the catch (of lengths larger than L_c) and the denominator is the mean length as a function of L_{inf} , $FMSY/M$, and M/K (see Appendix A of Jardim et al. 2015). Here, L_c is the length at full selection (LFS).

Usage

`Lratio_BHI2(x, Data, reps, yrsnth = 3)`

Arguments

<code>x</code>	A position in data-limited methods data object
<code>Data</code>	A data-limited methods data object
<code>reps</code>	The number of TAC samples
<code>yrsnth</code>	The most recent years of data to smooth the calculation of the mean length

Details

Argument `yrsnth` currently takes the mean length of the most recent 3 years of data as a smoother.

Author(s)

Coded by Q. Huynh. Developed by Jardim et al. (2015)

References

Ernesto Jardim, Manuela Azevedo, Nuno M. Brites, Harvest control rules for data limited stocks using length-based reference points and survey biomass indices, Fisheries Research, Volume 171, November 2015, Pages 12-19, ISSN 0165-7836, <https://doi.org/10.1016/j.fishres.2014.11.013>

LSRA	<i>Estimates R0 using SRA to match current F estimates and avoid penalties for low stock sizes</i>
------	--

Description

Estimates R0 using SRA to match current F estimates and avoid penalties for low stock sizes

Usage

LSRA(x, FF, Chist_arr, M, Mat_age, Wt_age, sel, Recdevs, h)

Arguments

x	a position in the various arrays and vectors that corresponds with a simulation (for use with sapply)
FF	a vector of recent fishign mortality rates (apical Fs)
Chist_arr	a vector of historical catch observations [nyears]
M	a vector of natural mortality rates [nsim]
Mat_age	a matrix of maturity at age [nsim x nage]
Wt_age	a matrix of weight at age [nsim x nage]
sel	a matrix of selectivity at age [nsim x nage]
Recdevs	a matrix of recruitment deviations [nsim x nyears]
h	a vector of steepness values of the Bev-Holt Stock-Recruitment relationship

Value

all package data objects are placed in the global namespace dir

Author(s)

T. Carruthers

LSRA2	<i>Alternative version of LSRA that's a wrapper for LSRA_opt to return the right type of output (mode) using sapply</i>
-------	---

Description

Alternative version of LSRA that's a wrapper for LSRA_opt to return the right type of output (mode) using sapply

Usage

```
LSRA2(x, lnR0s, FF, Chist, M, Mat_age, Wt_age, sel, Recdevs, h, mode = 2)
```

Arguments

x	a position in the various arrays and vectors that corresponds with a simulation (for use with sapply)
lnR0s	a vector nsim long that are estimated R0 values
FF	a vector of recent fishign mortality rates (apical Fs)
Chist	a vector of historical catch observations [nyears]
M	a vector of natural mortality rates [nsim]
Mat_age	a matrix of maturity at age [nsim x nage]
Wt_age	a matrix of weight at age [nsim x nage]
sel	a matrix of selectivity at age [nsim x nage]
Recdevs	a matrix of recruitment deviations [nsim x nyears]
h	a vector of steepness values of the Bev-Holt Stock-Recruitment relationship
mode	optimization or plotting

Value

all package data objects are placed in the global namespace dir

Author(s)

T. Carruthers

LSRA_MCMC_sim	<i>Internal SRA MCMC CPP code</i>
---------------	-----------------------------------

Description

Rcpp version of R code

Usage

```
LSRA_MCMC_sim(nits, pars, JumpCV, adapt, parLB, parUB, R0ind, inflind, slpind,
  RDind, nyears, maxage, M, Mat_age, Wt_age, Chist_a, Umax, h, CAA, CAAadj,
  sigmaR)
```

Arguments

nits	number of iterations
pars	vector of parameters
JumpCV	jump cv vector
adapt	adapt vector
parLB	lower bounds
parUB	upper bounds
R0ind	index for R0
inflind	index for inflection
slpind	index for slope
RDind	index for recruitment deviations
nyears	number of projection years
maxage	maximum age
M	Natural mortality
Mat_age	A vector of maturity at age
Wt_age	A vector of weight at age
Chist_a	A vector of historical catch observations (nyears long) going back to unfished conditions
Umax	A numeric value representing the maximum harvest rate for any age class (rejection of sims where this occurs)
h	steepness of SRR
CAA	A matrix nyears (rows) by nages (columns) of catch at age (age 1 to maxage in length)
CAAadj	internal parameter
sigmaR	A numeric value representing the prior standard deviation of log space recruitment deviations

Author(s)

A. Hordyk

LSRA_opt

Internal estimation function for LSRA and LSRA2 functions

Description

Internal estimation function for LSRA and LSRA2 functions

Usage

```
LSRA_opt(param, FF_a, Chist, M_a, Mat_age_a, Wt_age_a, sel_a, Recdevs_a, h_a,
         Umax = 0.5, mode = 1)
```


Arguments

param	a numeric value representing $\log(R0)$
FF_a	numeric value, recent fishign mortality rate (apical F)
Chist	a vector of historical catch observations [nyears]
M_a	numeric value, natural mortality rate
Mat_age_a	a vector of maturity at age [nage]
Wt_age_a	a vector of weight at age [nage]
sel_a	a vector of selectivity at age [nage]
Recdevs_a	a vector of recruitment deviations [nyears]
h_a	a numeric value of steepness values of the Bev-Holt Stock-Recruitment relationship
Umax	maximum harvest rate per year
mode	1-5 see below

Value

depends on mode but could be 1:objective function 2:trajectory of Fs 3: SSB depletion 4: $\log(R0)$ 5:diagnostic plots

Author(s)

T. Carruthers

LstepCC1 *A management procedure that incrementally adjusts the TAC according to the mean length of recent catches.*

Description

The least biologically precautionary of four adaptive length-based MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
LstepCC1(x, Data, reps = 100, yrsmth = 5, xx=0, stepsz=0.05,
l1im=c(0.96,0.98,1.05))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
stepsz	Parameter controlling the size of the TAC update increment.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the TAC.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

- Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.
- Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

LstepCC4

A management procedure that incrementally adjusts the TAC according to the mean length of recent catches.

Description

The most biologically precautionary of four adaptive length-based MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
LstepCC4(x, Data, reps = 100, yrsmth = 5, xx=0.3, stepsz=0.05,
llim=c(0.96,0.98,1.05))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
stepsz	Parameter controlling the size of the TAC update increment.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the TAC.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

- Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.
- Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

LstepCE1	<i>A management procedure that incrementally adjusts the TAC according to the mean length of recent catches.</i>
----------	--

Description

A effort-based version of least biologically precautionary of four adaptive length-based MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
LstepCE1(x, Data, reps = 100, yrsmth = 5, xx = 0, stepsz = 0.05,
llim = c(0.96, 0.98, 1.05))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of effort samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
stepsz	Parameter controlling the size of the effort update increment.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the effort.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

LstepCE2	<i>A management procedure that incrementally adjusts the Effort according to the mean length of recent catches.</i>
----------	---

Description

A effort-based version of one of the four adaptive length-based MPs proposed by Geromont and Butterworth 2014.

Usage

```
LstepCE2(x, Data, reps = 100, yrsmth = 5, xx = 0, stepsz = 0.1,
llim = c(0.96, 0.98, 1.05))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
stepsz	Parameter controlling the size of the effort update increment.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the effort.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

Ltarget1	<i>A management procedure that incrementally adjusts the TAC to reach a target mean length in catches.</i>
----------	--

Description

The least biologically precautionary of four target length MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Ltarget1(x, Data, reps = 100, yrsmth = 5, xx=0, xL=1.05)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

Ltarget4	<i>A management procedure that incrementally adjusts the TAC to reach a target mean length in catches.</i>
----------	--

Description

The most biologically precautionary of four target length MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015

Usage

```
Ltarget4(x, Data, reps = 100, yrsnth = 5, xx=0.2, xL=1.15)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsnth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Details

Tested by Carruthers et al. 2015.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. Fish and Fisheries. In press.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. doi:10.1093/icesjms/fst232

LtargetE1	<i>A management procedure that incrementally adjusts the Effort to reach a target mean length in catches.</i>
-----------	---

Description

A effort based version of the least biologically precautionary of four target length MPs proposed by Geromont and Butterworth 2014.

Usage

```
LtargetE1(x, Data, reps = 100, yrsmth = 5, xx = 0, xL = 1.05)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

LtargetE4	<i>A management procedure that incrementally adjusts the Effort to reach a target mean length in catches.</i>
-----------	---

Description

A effort based version of the most biologically precautionary of four target length MPs proposed by Geromont and Butterworth 2014.

Usage

```
LtargetE4(x, Data, reps = 100, yrsmth = 5, xx = 0, xL = 1.15)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples
yrsnth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Value

A numeric vector of input controls

Author(s)

T. Carruthers

Mackere1	<i>Mackerel Stock</i>
----------	-----------------------

Description

An object of class Stock

Usage

Mackere1

Format

An object of class Stock of length 1.

makePerf	<i>Convert a OM object to one without observation or process error</i>
----------	--

Description

Takes an existing OM object and converts it to one without any observation error, and very little process error. Used for debugging and testing that MPs perform as expected under perfect conditions.

Usage

makePerf(OMin, except = NULL)

Arguments

OMin	An object of class OM
except	An optional vector of slot names in the OM that will not be changed (not tested perfectly so watch out!)

Value

A new OM object

Author(s)

A. Hordyk

makeTransparent	<i>Make colors transparent</i>
-----------------	--------------------------------

Description

Make colors transparent

Usage

```
makeTransparent(someColor, alpha = 100)
```

Arguments

someColor	Character string describing color
alpha	transparency

Author(s)

T. Carruthers

matlenlim	<i>A data-limited method in which fishing retention is set according to the maturity curve</i>
-----------	--

Description

An example of the implementation of input controls in the DLM toolkit, where retention-at-length is set equivalent to maturity-at-length

Usage

```
matlenlim(x, Data, ...)
```

Arguments

x	A position in a data-limited methods object
Data	A data-limited methods object
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Value

A input control recommendation object

Author(s)

T. Carruthers

References

Made-up for this package

matlenlim2	<i>A data-limited method in which fishing vulnerability is set slightly higher than the maturity curve</i>
------------	--

Description

An example of the implementation of input controls in the DLM toolkit, where selectivity-at-length is set slightly higher than the maturity-at-length

Usage

```
matlenlim2(x, Data, ...)
```

Arguments

x	A position in a data-limited methods object
Data	A data-limited methods object
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Value

A vector of input control recommendations, with values for length at first capture and full selection

Author(s)

A. Hordyk

References

Made-up for this package

MCD	<i>Mean Catch Depletion</i>
-----	-----------------------------

Description

A simple average catch-depletion MP that was included to demonstrate just how informative an estimate of current stock depletion can be. $TAC=2*D*AvC$

Usage

`MCD(x, Data, reps = 100)`

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

MCD4010	<i>Mean Catch Depletion</i>
---------	-----------------------------

Description

A simple average catch-depletion MP linked to a 40-10 harvest control rule that was included to demonstrate just how informative an estimate of current stock depletion can be. $TAC=d(1-d)AvC$

Usage

`MCD4010(x, Data, reps = 100)`

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

mconv	<i>Get log normal mean from transformed space mean and standard deviation</i>
-------	---

Description

Get log normal mean from transformed space mean and standard deviation

Usage

```
mconv(m, sd)
```

Arguments

m	mean
sd	standard deviation

Value

numeric

Author(s)

T. Carruthers

minlenLopt1	<i>This input control sets the minimum length of fish caught to a fraction of the length that maximises the biomass, Lopt.</i>
-------------	--

Description

This aim of this simple MP is restrict the catch of small fish to rebuild the stock biomass towards the optimal length, L_{opt} , expressed in terms of the growth parameters $L_{opt}=b/(M/k+b)$ (Hordyk et al. (2014)

Usage

```
minlenLopt1(x, Data, reps = 100, buffer = 0.1)
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
buffer	Parameter controlling the fraction of L_{opt} to set the minimum length of fish caught: $minlen=L_{opt}*(0.7+buffer)$.

Value

The length at first capture, LFC, and length at full selectivity

Author(s)

HF Geromont

References

Hordyk, A., Ono, K., Sainsbury, K., Loneragan, N., and J. Prince. 2014. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio ICES Journal of Marine Science, doi:10.1093/icesjms/fst235.

ML2D

Depletion and F estimation from mean length of catches

Description

A highly dubious means of getting very uncertain estimates of current stock biomass and (equilibrium) fishing mortality rate from growth, natural mortality rate, recruitment and fishing selectivity.

Usage

```
ML2D(OM,ML,nsim=100,ploty=T,Dlim=c(0.05,0.6))
```

Arguments

OM	An object of class 'OM'
ML	A estimate of current mean length of catches
nsim	Number of simulations
ploty	Produce a plot of depletion and F
Dlim	Limits on the depletion that is returned as a fraction of unfished biomass.

Value

An object of class 'OM' with 'D' slot populated

Author(s)

T. Carruthers

movdistil	<i>Simplified a multi-area transition matrix into the best 2 x 2 representation</i>
-----------	---

Description

A Function that takes a larger movement matrix, identifies the most parsimonious representation of 2 non-mixed areas and returns the final unfished movement matrix

Usage

```
movdistil(movtab)
```

Arguments

movtab	a table of estimated movements
--------	--------------------------------

Author(s)

T. Carruthers

movfit	<i>Optimization function that returns the squared difference between user specified and calculated movement parameters. (deprecated: now in Rcpp)</i>
--------	---

Description

The user specifies the probability of staying in the same area and spatial heterogeneity (both in the unfished state). This function returns the squared difference between these values and those produced by the three logit movement model.

Usage

```
movfit(par, prb, frac)
```

Arguments

par	Three parameters in the logit space that control the four probabilities of moving between 2 areas
prb	User specified probability that individuals in area 1 remain in that area (unfished conditions)
frac	User specified fraction of individuals found in area 1 (unfished conditions)

Details

This is paired with getmov to find the correct movement model.

Author(s)

T. Carruthers

movfit_Rcpp	<i>Rcpp version of the Optimization function that returns the squared difference between user specified and calculated movement parameters.</i>
-------------	---

Description

The user specifies the probability of staying in the same area and spatial heterogeneity (both in the unfished state). This function returns the squared difference between these values and those produced by the three logit movement model.

Usage

```
movfit_Rcpp(par, prb, frac)
```

Arguments

par	Three parameters in the logit space that control the four probabilities of moving between 2 areas
prb	User specified probability that individuals in area 1 remain in that area (unfished conditions)
frac	User specified fraction of individuals found in area 1 (unfished conditions)

Details

This is paired with getmov to find the correct movement model.

Author(s)

T. Carruthers with an amateur attempt at converting to Rcpp by A. Hordyk (but it works!)

MPStats *Calculate Statistics for MP Performance*

Description

Function calculates probabilities and other statistics for a range of performance metrics

Usage

```
MPStats(MSEobj, PMRefs = list(B_BMSY = 0.5, SSB_SSB0 = 0.2, F_FMSY = 1,
AAVY = 30, AAVE = 30), lastYrs = 10, UseMean = TRUE, msg = TRUE)
```

Arguments

MSEobj	An object of class MSE
PMRefs	A list of reference points for the performance metrics (must be named)
lastYrs	The last number of years in the projection to calculate the statistics
UseMean	Logical. Calculate mean (TRUE) or median (FALSE)?
msg	Logical. Print out messages?

Author(s)

A. Hordyk

MRnoreal *An marine reserve in area 1 with no spatial reallocation of fishing effort*

Description

A spatial control that prevents fishing in area 1 and does not reallocate this fishing effort to area 2.

Usage

```
MRnoreal(x, Data, ...)
```

Arguments

x	A position in data / simulation object DLM
Data	A data limited methods data object
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Author(s)

T. Carruthers

MRreal	<i>An marine reserve in area 1 with full reallocation of fishing effort</i>
--------	---

Description

A spatial control that prevents fishing in area 1 and reallocates this fishing effort to area 2.

Usage

MRreal(x, Data, ...)

Arguments

x	A position in data / simulation object DLM
Data	A data limited methods data object
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Author(s)

T. Carruthers

MSE-class	<i>Class 'MSE'</i>
-----------	--------------------

Description

A Management Strategy Evaluation object that contains information about simulation conditions and performance of data-limited methods

Slots

Name	Name of the MSE object
nyears	The number of years for the historical simulation
proyears	The number of years for the projections - closed loop simulations
nMPs	Number of management procedures simulation tested
MPs	The names of the MPs that were tested
nsim	Number of simulations
OM	A table of nsim rows with a column for each sampled parameter of the operating model

- RefY: reference yield, the highest long-term yield (mean over last five years of projection) obtained from a fixed F strategy. This is a useful reference point for framing performance of MPs because it standardizes for starting point and future productivity.

- M: instantaneous natural mortality rate
- Depletion: stock depletion (biomass / unfished biomass) in the final historical year (prior to projection)
- A: abundance (biomass) updated in each management update of projection
- BMSY_B0: most productive stock size relative to unfished
- FMSY_M: fishing mortality rate divided by natural mortality rate
- Mgrad: mean average percentage gradient in natural mortality rate (percentage per time step)
- Msd: interannual variability in natural mortality rate (lognormal CV)
- procsd: process error - CV in log-normal recruitment deviations
- Esd: interannual variability in historical effort (fishing mortality rate)
- dFfinal: gradient in fishing mortality rate over final five years of the historical simulation
- MSY: Maximum Sustainable Yield
- qinc: mean percentage increase in fishing efficiency (catchability) in projected years (input controls only)
- qcv: interannual variability in future fishing efficiency (catchability) in projected years (input controls only)
- CALcv: variability in lengths at age around the growth curve (normal CV)
- FMSY: Fishing mortality rate at Maximum Sustainable Yield
- Linf: maximum length (von Bertalanffy Linf parameter)
- K: maximum growth rate (von Bertalanffy K parameter)
- t0: theoretical length at age zero (von Bertalanffy t0 parameter)
- hs: steepness of the stock recruitment relationship (the fraction of unfished recruitment at a fifth of unfished stock levels)
- Linfgrad: mean gradient in maximum length (per cent per time step)
- Kgrad: mean gradient in maximum growth rate (per cent per time step)
- Linfsd: interannual variability in maximum length (log normal CV)
- recgrad: gradient in recruitment strength (age 1 population numbers) over last 10 years of historical simulations
- Ksd: interannual variability in maximum growth rate (log normal CV)
- ageM: age at 50 per cent maturity
- LFS: length at full selection (the shortest length class where fishery selectivity is 100 per cent)
- age05: the age at 5 percent selectivity (ascending limb of selectivity curve)
- Vmaxage: the selectivity of the oldest age class (controls dome shape of selectivity curve)
- LFC: length at first capture, the smallest length that can be caught by the gear
- OFLreal: the true simulated Over Fishing Limit (FMSY x biomass) updated in each management update of the projection
- Spat_targ: spatial targetting parameter, fishing mortality rate across areas is proportional to vulnerable biomass raised to the power of this number.
- Frac_area_1: the fraction of unfished biomass inhabiting area 1 (can be seen as fraction of habitat in area 1 or relative size of area 1)
- Prob_staying: the probability that individuals in area 1 remain there between time-steps
- AC: autocorrelation in recruitment

Obs A table of nsim rows with a column for each sampled parameter of the observation model

- Cbias: bias in observed catches
- Csd: observation error in observed catches (lognormal CV)
- CAA_nsamp: the number of catch-at-age observations per time step
- CAA_ESS: the effective sample size of multinomial catch-at-age observation model (number of independent draws)
- CAL_nsamp: the number of catch-at-length observations per time step
- CAL_ESS: the effective sample size of multinomial catch-at-length observation model (number of independent draws)
- Isd: observation error in relative abundance index (lognormal CV)
- Dbias: bias in observed stock depletion (also applies to depletion Dt for DCAC)
- Mbias: bias in observed natural mortality rate
- FMSY_Mbias: bias in ratio of FMSY to natural mortality rate
- BMSY_B0bias: bias in ratio of most productive stock size relative to unfished
- AMbias: bias in age at 50 per cent maturity
- LFCbias: bias in length at first capture
- LFSbias: bias in length at full selection
- Abias: bias in observed current absolute stock biomass
- Kbias: bias in maximum growth rate (von Bertalanffy K parameter)
- t0bias: bias in theoretical length at age zero (von Bertalanffy t0 parameter)
- Linfbias: bias in maximum length (von Bertalanffy Linf parameter)
- hbias: bias in observed steepness of the stock recruitment relationship
- Irefbias: bias in abundance index corresponding to BMSY stock levels
- Crefbias: bias in MSY prediction (target or reference catch)
- Brefbias: bias in BMSY stock levels (target or reference biomass levels)

B_BMSY Stored biomass relative to BMSY over the projection (an array with dimensions nsim, nMPs, proyears)

F_FMSY Stored fishing mortality rate relative to FMSY over the projection (an array with dimensions nsim, nMPs, proyears)

B Stored stock biomass over the projection (an array with dimensions nsim, nMPs, proyears)

SSB Stored spawning stock biomass over the projection (an array with dimensions nsim, nMPs, proyears)

VB Stored vulnerable biomass over the projection (an array with dimensions nsim, nMPs, proyears)

FM Stored fishing mortality rate over the projection (an array with dimensions nsim, nMPs, proyears)

C Stored catches (taken) over the projection (an array with dimensions nsim, nMPs, proyears)

TAC Stored Total Allowable Catch (prescribed) over the projection (an array with dimensions nsim, nMPs, proyears)(note that this is NA for input controls)

SSB_hist Stored historical spawning stock biomass (historical simulations - an array with dimensions nsim, nages, nyears, nareas)

CB_hist Stored historical catches in weight (historical simulations - an array with dimensions nsim, nages, nyears, nareas)

FM_hist Stored historical fishing mortality rate (historical simulations - an array with dimensions nsim, nages, nyears, nareas)

Effort Stored relative fishing effort in the projection years

PAA Population at age in last projection year (an array with dimensions nsim, nMPs, nages)

CAA Catch at age in last projection year (an array with dimensions nsim, nMPs, nages)

CAL Catch at length in last projection year (an array with dimensions nsim, nMPs, nCALbins)

CALbins Mid-points of the catch-at-length bins

Objects from the Class

Objects can be created by calls of the form `new('MSE', Name, nyears, proyears, nMPs, MPs, nsim, OMtable, Obs, B_`

Author(s)

T. Carruthers

NAor0

Is a value NA or zero.

Description

As title

Usage

NAor0(x)

Arguments

x A numeric value.

Value

TRUE or FALSE

Author(s)

T. Carruthers

Needed	<i>Data needed to get MPs running</i>
--------	---------------------------------------

Description

Wrapper function for DLMdiag that lists what data are needed to run data-limited methods that are current not able to run given a DLM_cdata object

Usage

```
Needed(Data, timelimit=1)
```

Arguments

Data	A data-limited methods data object
timelimit	The maximum time (seconds) taken to complete 10 reps

Author(s)

T. Carruthers

negcorlogspace	<i>A function that samples multivariate normal (logspace) variables</i>
----------------	---

Description

A function that samples multivariate normal (logspace) variables

Usage

```
negcorlogspace(xmu, ymu, xcv = 0.1, nsim, cor = -0.9, ploty = F)
```

Arguments

xmu	The mean (normal space) of the first (x) variable
ymu	The mean (normal space) of the second (y) variable
xcv	The coefficient of variation (normal space, log normal sd) of the x variable
nsim	The number of random draws
cor	The off-diagonal (symmetrical) correlation among x and y
ploty	Whether a plot of the sampled variables should be produced

Author(s)

T. Carruthers

NFref	<i>No Fishing Reference MP</i>
-------	--------------------------------

Description

A reference MP that sets annual catch to zero (or very close to it). Used for looking at variability in stock with no fishing.

Usage

```
NFref(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of stochastic samples of the quota recommendation

Value

A TAC of 0.01

Author(s)

A. Hordyk

NOAA_plot	<i>National Oceanographic and Atmospheric Administration default plot 1</i>
-----------	---

Description

A preliminary plot for returning trade-offs plots and performance table for total yield, variability in yield, probability of overfishing and likelihood of biomass dropping below 50 per cent BMSY

Usage

```
NOAA_plot(MSEobj, nam=NA, type=NA, panel=T)
```

Arguments

MSEobj	An object of class MSE
nam	Title of plot
type	Plots full range of data if NA. Plots a subset that meet thresholds if not NA.
panel	Should a two panel plot be made or should plots be made in sequence.

Value

A table of performance metrics.

Author(s)

T. Carruthers

Obs-class	Class 'Obs'
-----------	-------------

Description

An operating model component that controls the observation model

Slots

- Name The name of the observation model object
- Cobs Log-normal catch observation error expressed as a coefficient of variation (uniform distribution)
- Cbiascv A coefficient of variation controlling the sampling of bias in catch observations for each simulation (uniform distribution)
- CAA_nsamp Number of catch-at-age observation per time step (uniform distribution)
- CAA_ESS Effective sample size (independent age draws) of the multinomial catch-at-age observation error model (uniform distribution)
- CAL_nsamp Number of catch-at-length observation per time step (uniform distribution)
- CAL_ESS Effective sample size (independent length draws) of the multinomial catch-at-length observation error model (uniform distribution)
- CALcv Lognormal, variability in the Cv of length-at-age (uniform distribution)
- Iobs Observation error in the relative abundance indices expressed as a coefficient of variation (uniform distribution)
- Mcv Persistent bias in the prescription of natural mortality rate sampled from a log-normal distribution with coefficient of variation (Mcv)(uniform distribution)
- Kcv Persistent bias in the prescription of growth parameter k sampled from a log-normal distribution with coefficient of variation (Kcv)(uniform distribution)
- t0cv Persistent bias in the prescription of t0 sampled from a log-normal distribution with coefficient of variation (t0cv)(uniform distribution)
- Linfcv Persistent bias in the prescription of maximum length sampled from a log-normal distribution with coefficient of variation (Linfcv)(uniform distribution)
- LFCcv Persistent bias in the prescription of length at first capture sampled from a log-normal distribution with coefficient of variation (LFCcv)(uniform distribution)
- LFScv Persistent bias in the prescription of length-at-fully selection sampled from a log-normal distribution with coefficient of variation (LFScv)(uniform distribution)

- B0cv Persistent bias in the prescription of maximum length unfished biomass sampled from a log-normal distribution with coefficient of variation (B0cv)(uniform distribution)
- FMSYcv Persistent bias in the prescription of FMSY sampled from a log-normal distribution with coefficient of variation (FMSYcv)(uniform distribution)
- FMSY_Mcv Persistent bias in the prescription of FMSY/M sampled from a log-normal distribution with coefficient of variation (FMSY_cv)(uniform distribution)
- BMSY_B0cv Persistent bias in the prescription of BMSY relative to unfished sampled from a log-normal distribution with coefficient of variation (BMSY_B0cv)(uniform distribution)
- rcv Persistent bias in the prescription of intrinsic rate of increase sampled from a log-normal distribution with coefficient of variation (rcv)(uniform distribution)
- LenMcv Persistent bias in the prescription of length at 50 percent maturity sampled from a log-normal distribution with coefficient of variation (A50cv)(uniform distribution)
- Dbiascv Persistent bias in the prescription of stock depletion sampled from a log-normal distribution with coefficient of variation (Lincv)(uniform distribution)
- Dcv Imprecision in the prescription of stock depletion among years, expressed as a coefficient of variation (uniform distribution)
- Btbias Persistent bias in the prescription of current stock biomass sampled from a uniform-log distribution with range (Btbias)(uniform distribution)
- Btcv Imprecision in the prescription of current stock biomass among years expressed as a coefficient of variation (uniform distribution)
- Fcurbiascv Persistent bias in the prescription of current fishing mortality rate sampled from a log-normal distribution with coefficient of variation (Fcurcv)(uniform distribution)
- Fcurcv Imprecision in the prescription of current fishing mortality rate among years expressed as a coefficient of variation (uniform distribution)
- hcv Persistent bias in steepness (uniform distribution)
- Icv Observation error in relative abundance index expressed as a coefficient of variation (uniform distribution)
- maxagecv Bias in the prescription of maximum age (uniform distribution)
- beta A parameter controlling hyperstability/hyperdepletion. I^{β} therefore values below 1 lead to hyperstability (an index that decreases slower than true abundance) and values above 1 lead to hyperdepletion (an index that decreases more rapidly than true abundance)(uniform distribution)
- Reccv Bias in the knowledge of recent recruitment strength (uniform distribution)
- Irefcv Bias in the knowledge of the relative abundance index at BMSY (uniform distribution)
- Brefcv Bias in the knowledge of BMSY (uniform distribution)
- Crefcv Bias in the knowledge of MSY(uniform distribution)

Objects from the Class

Objects can be created by calls of the form `new('Obs')`

Note

Its questionable whether the hyperstability/hyperdepletion should be categorised as an observation model characteristic as it is most often driven by fleet dynamics (and therefore should be in the fleet object). Oh well its here and you might want to make it hyperstable $\beta < 1$ or hyperdeplete $\beta > 1$, only.

Author(s)

T. Carruthers

Examples

```
showClass('Obs')
```

OM-class

Class 'OM'

Description

An object containing all the parameters needed to control the MSE which can be build from component Stock, Fleet and Obs objects. Almost all of these inputs are a vector of length 2 which describes the upper and lower bounds of a uniform distribution from which to sample the parameter.

Slots

Name Name of the operating model

nsim The number of simulations

proyears The number of projected years

nyears The number of years for the historical simulation

maxage The maximum age of individuals that is simulated (there is no 'plus group': individuals die off beyond the maximum age so there isn't a huge cost to simulating more older age classes)

R0 The magnitude of unfished recruitment. This is normally fixed to some arbitrary value since it simply scales the simulated numbers)

M Natural mortality rate (uniform distribution)

M2 Optional vector of M-at-age (must be length maxage)

Msd Inter-annual variability in natural mortality rate expressed as a coefficient of variation (uniform distribution)

Mgrad Mean temporal trend in natural mortality rate, expressed as a percentage change in M per year (uniform distribution)

Mexp Exponent of the Lorenzen function assuming an inverse relationship between M and weight (uniform distribution)

Fdisc Fraction of discarded fish that die

h Steepness of the stock recruit relationship (uniform distribution)
 SRrel Type of stock-recruit relationship (1)Beverton-Holt (2) Ricker
 Linf Maximum length (uniform distribution)
 K von B. growth parameter k (uniform distribution)
 t0 von B. theoretical age at length zero (uniform distribution)
 LenCV Coefficient of variation of length-at-age (assumed constant for all age classes (uniform distribution))
 Ksd Inter-annual variability in growth parameter k (uniform distribution)
 Kgrad Mean temporal trend in growth parameter k, expressed as a percentage change in k per year (uniform distribution)
 Linfsd Inter-annual variability in maximum length - uniform distribution
 Linfgrad Mean temporal trend in maximum length, expressed as a percentage change in Linf per year (uniform distribution)
 recgrad Mean temporal trend in log-normal recruitment deviations (uniform distribution)
 AC Autocorrelation in recruitment deviations $\text{rec}(t)=AC*\text{rec}(t-1)+(1-AC)*\text{sigma}(t)$ (uniform distribution)
 a Length-weight parameter alpha (uniform distribution)
 b Length-weight parameter beta (uniform distribution)
 D Current level of stock depletion ($B_{\text{current}}/B_{\text{unfished}}$) (uniform distribution)
 Size_area_1 The size of area 1 relative to area 2 (uniform distribution)
 Frac_area_1 The fraction of the unfished biomass in stock 1 (uniform distribution)
 Prob_staying The probability of individuals in area 1 remaining in area 1 over the course of one year
 beta A parameter controlling hyperstability/hyperdepletion. I^{beta} therefore values below 1 lead to hyperstability (an index that decreases slower than true abundance) and values above 1 lead to hyperdepletion (an index that decreases more rapidly than true abundance)(uniform distribution)
 Spat_targ Distribution of fishing in relation to spatial biomass: F is proportional to $B^{\text{Spat_targ}}$ (uniform distribution)
 LFS Shortest length that is fully vulnerable to fishing (uniform distribution)
 L5 Shortest length at 5 percent vulnerability (uniform distribution)
 Vmaxlen The vulnerability of the longest (oldest) fish (uniform distribution)
 LR5 Shortest length corresponding to 5 percent retention (uniform distribution)
 LFR Shortest length that is fully retained (uniform distribution)
 Rmaxlen The retention of the longest (oldest) fish (uniform distribution)
 DR Discard rate - fraction of caught fish that are discarded (must be ≤ 1) (uniform distribution)
 SelYears Vector of vertices that index years where historical selectivity pattern changed. Leave empty to ignore
 AbsSelYears vector of absolute year values that correspond to year indices in SelYears. Used only for plotting

- L5Lower Optional vector of values of length SelYears, specifying lower limits of L5 (use ChooseSelect function to set these. Overrides L5 above)
- L5Upper Optional vector of values of length SelYears, specifying upper limits of L5 (use ChooseSelect function to set these. Overrides L5 above)
- LFSLower Optional vector of values of length SelYears, specifying lower limits of LFS (use ChooseSelect function to set these. Overrides LFS above)
- LFSUpper Optional vector of values of length SelYears, specifying upper limits of LFS (use ChooseSelect function to set these. Overrides LFS above)
- VmaxLower Optional vector of values of length SelYears, specifying lower limits of Vmaxlen (use ChooseSelect function to set these. Overrides Vmaxlen above)
- VmaxUpper Optional vector of values of length SelYears, specifying upper limits of Vmaxlen (use ChooseSelect function to set these. Overrides Vmaxlen above)
- isRel Are the selectivity parameters relative to size-of-maturity? TRUE or FALSE
- L50 Length at 50 percent maturity (uniform distribution)
- L50_95 Length increment from 50 to 95 percent maturity (uniform distribution)
- Esd Inter-annual variability in fishing mortality rate
- EffYears Vector of verticies, years at which to simulate varying relative effort
- EffLower Lower bound on relative effort corresponding to EffYears (uniform distribution)
- EffUpper Upper bound on relative effort corresponding to EffYears (uniform distribution)
- qinc Average percentage change in fishing efficiency (uniform distribution)(applicable only to forward projection and input controls)
- qcv Inter-annual variability in fishing efficiency (uniform distribution)(applicable only to forward projection and input controls)
- CurrentYr The current calendar year (final year) of the historical simulations (e.g. 2011)
- Cobs Log-normal catch observation error expressed as a coefficient of variation (uniform distribution)
- Cbiascv A coefficient of variation controlling the sampling of bias in catch observations for each simulation (uniform distribution)
- CAA_nsamp Number of catch-at-age observation per time step (uniform distribution)
- CAA_ESS Effective sample size (independent age draws) of the multinomial catch-at-age observation error model (uniform distribution)
- CAL_nsamp Number of catch-at-length observation per time step (uniform distribution)
- CAL_ESS Effective sample size (independent length draws) of the multinomial catch-at-length observation error model (uniform distribution)
- CALcv Lognormal, variability in the length at age (uniform distribution)
- Iobs Observation error in the relative abundance indices expressed as a coefficient of variation (uniform distribution)
- Perr The extent of inter-annual log-normal recruitment variability (σ_R)(uniform distribution)
- Period Period for cyclical recruitment pattern in years (uniform distribution). Leave empty to ignore

- Amplitude Amplitude in deviation from long-term average recruitment during recruitment cycle, both positive and negative (uniform distribution). E.g., a range from 0 to 0.5 means recruitment decreases or increases by up to 50% each cycle. Leave empty to ignore
- Mcv Persistent bias in the prescription of natural mortality rate sampled from a log-normal distribution with coefficient of variation (Mcv)(uniform distribution)
- Kcv Persistent bias in the prescription of growth parameter k sampled from a log-normal distribution with coefficient of variation (Kcv)(uniform distribution)
- t0cv Persistent bias in the prescription of t_0 sampled from a log-normal distribution with coefficient of variation (t0cv)(uniform distribution)
- Linfcv Persistent bias in the prescription of maximum length sampled from a log-normal distribution with coefficient of variation (Linfcv)(uniform distribution)
- LFCcv Persistent bias in the prescription of length at first capture sampled from a log-normal distribution with coefficient of variation (LFCcv)(uniform distribution)
- LFScv Persistent bias in the prescription of length-at-fully selection sampled from a log-normal distribution with coefficient of variation (LFScv)(uniform distribution)
- B0cv Persistent bias in the prescription of maximum length unfish biomass sampled from a log-normal distribution with coefficient of variation (B0cv)(uniform distribution)
- FMSYcv Persistent bias in the prescription of FMSY sampled from a log-normal distribution with coefficient of variation (FMSYcv)(uniform distribution)
- FMSY_Mcv Persistent bias in the prescription of FMSY/M sampled from a log-normal distribution with coefficient of variation (FMSY_cv)(uniform distribution)
- BMSY_B0cv Persistent bias in the prescription of BMSY relative to unfish biomass sampled from a log-normal distribution with coefficient of variation (BMSY_B0cv)(uniform distribution)
- rcv Persistent bias in the prescription of intrinsic rate of increase sampled from a log-normal distribution with coefficient of variation (rcv)(uniform distribution)
- LenMcv Persistent bias in the prescription of length at 50 percent maturity sampled from a log-normal distribution with coefficient of variation (A50cv)(uniform distribution)
- Dbiascv Persistent bias in the prescription of stock depletion sampled from a log-normal distribution with coefficient of variation (Linfcv)(uniform distribution)
- Dcv Imprecision in the prescription of stock depletion among years, expressed as a coefficient of variation (uniform distribution)
- Btbias Persistent bias in the prescription of current stock biomass sampled from a uniform-log distribution with range (Btbias)(uniform distribution)
- Btcv Imprecision in the prescription of current stock biomass among years expressed as a coefficient of variation (uniform distribution)
- Fcurbiascv Persistent bias in the prescription of current fishing mortality rate sampled from a log-normal distribution with coefficient of variation (Fcurcv)(uniform distribution)
- Fcurcv Imprecision in the prescription of current fishing mortality rate among years expressed as a coefficient of variation (uniform distribution)
- hcv Persistent bias in steepness (uniform distribution)
- Icv Observation error in relative abundance index expressed as a coefficient of variation (uniform distribution)

maxagecv Bias in the prescription of maximum age (uniform distribution)
 Reccv Bias in the knowledge of recent recruitment strength (uniform distribution)
 Irefcv Bias in the knowledge of the relative abundance index at BMSY (uniform distribution)
 Brefcv Bias in the knowledge of BMSY (uniform distribution)
 Crefcv Bias in the knowledge of MSY(uniform distribution)
 cpars A list of custom parameters (single parameters are a vector nsim long, time series are a matrix nsim rows by nyears columns)
 seed A random seed to ensure users can reproduce results exactly
 Source A reference to a website or article from which parameters were taken to define the operating model
 TACSD lognormal standard deviation in fraction of TAC taken (uniform distribution)
 TACFrac Mean fraction of TAC taken (uniform distribution) (can be an improper fraction greater than 1)
 ESD lognormal standard deviation in fraction of TAE taken(uniform distribution)
 EFrac Mean fraction of recommended effort taken (uniform distribution)
 SizeLimSD lognormal error in size limit implementation (uniform distribution)
 SizeLimFrac Mean fraction of the size limit (uniform distribution) (can be an improper fraction greater than 1)

Objects from the Class

Objects can be created by calls of the form `new('OM', Stock, Fleet, Obs, Imp)`.

Author(s)

T. Carruthers

OM_xl

Read in operating model parameters from Excel spreadsheet

Description

A function to read in operating model parameters from an Excel spreadsheet with tabs named following specific convention.

Usage

```
OM_xl(fname, stkname, fpath = '', saveCSV = FALSE)
```

Arguments

fname	Name of the Excel spreadsheet file. Must include file extension.
stkname	Name of the Stock.
fpath	Full file path, if file is not in current working directory
saveCSV	Do you also want to save the Stock, Fleet and Observation parameters to CSV files?

Details

The Excel spreadsheet must have tabs named with the following convention. For example if stkname is 'myFish', the Stock parameters are in a tab named 'myFishStock', Fleet parameters in a tab named 'myFishFleet', Observation parameters in a tab named 'myFishObs', and Implementation in 'myFishImp'. All tabs (Stock, Fleet, Obs, and Imp) must be present for a single stock. You can have multiple stocks in a single spreadsheet, provided that the stock names are different.

Value

A object of class OM

Author(s)

A. Hordyk

Examples

```
## Not run:
OM <- OM_xl(fname='OMTables.xlsx', stkname='myFish')

## End(Not run)
```

optBH	<i>Wrapper for estimating stock recruitment parameters from resampled stock-recruitment data</i>
-------	--

Description

Wrapper for estimating stock recruitment parameters from resampled stock-recruitment data

Usage

```
optBH(x, SSB, rec, SSBpR, R0temp, pars, frac = 0.5, plot = F)
```

Arguments

x	position (currently redundant)
SSB	'observations' of spawning biomass
rec	'observations' (model predictions) of recruitment
SSBpR	spawning stock biomass per recruit at unfished conditions
R0temp	an initial guess at the level of unfished recruitment
pars	an initial guess at model parameters steepness and R0
frac	the fraction of observations for resampling
plot	should a plot of model fit be produced?

Author(s)

T. Carruthers

`optF`*Internal function to optimize for F*

Description

Internal function to optimize for F

Usage`optF(fapic, vuln, catch, bio, mort, fdist, maxage, nareas)`**Arguments**

<code>fapic</code>	Apical fishing mortality
<code>vuln</code>	Vulnerability
<code>catch</code>	Catch
<code>bio</code>	Biomass
<code>mort</code>	Natural mortality
<code>fdist</code>	Fishing distribution
<code>maxage</code>	Maximum age
<code>nareas</code>	Number of areas

Author(s)

A. Hordyk

`optMSY`*Optimize yield for a single simulation*

Description

Optimize yield for a single simulation

Usage`optMSY(logFa, nareas, maxage, Ncurr, pyears, M_age, MatAge, WtAge, Vuln, Retc, Prec, movc, SRrelc, Effind, Spat_targc, hc, R0c, SSBpRc, aRc, bRc, Qc, maxF, useCPP = TRUE)`

Arguments

logFa	log apical fishing mortality
nareas	Number of area
maxage	Maximum age
Ncurr	Current N-at-age
pyears	Number of projection years
M_age	M-at-age
MatAge	Maturity-at-age
WtAge	Weight-at-age
VuIn	Vulnerability-at-age
Retc	Retention-at-age
Prec	Recruitment error
movc	Movement matrix
SRrelc	SR Relationship
Effind	Historical effort
Spat_targc	Spatial targeting
hc	Steepness
R0c	Unfished recruitment by area
SSBpRc	Unfished spawning stock per recruit by area
aRc	Ricker aR
bRc	Ricker bR
Qc	Catchability
maxF	A numeric value specifying the maximum fishing mortality for any single age class
useCPP	logical - use the CPP code? For testing purposes only

Author(s)

A. Hordyk

optQ

Optimize q for a single simulation

Description

Optimize q for a single simulation

Usage

```
optQ(logQ, depc, SSB0c, nareas, maxage, Ncurr, pyears, M_age, MatAge, WtAge,
     Vuln, Retc, Prec, movc, SRrelc, Effind, Spat_targc, hc, R0c, SSBpRc, aRc, bRc,
     maxF, useCPP)
```

Arguments

logQ	log q
depc	Depletion value
SSB0c	Unfished spawning biomass
nareas	Number of areas
maxage	Maximum age
Ncurr	Current N-at-age
pyears	Number of years to project population dynamics
M_age	M-at-age
MatAge	Maturity-at-age
WtAge	Weight-at-age
Vuln	Vulnerability-at-age
Retc	Retention-at-age
Prec	Recruitment error by year
movc	movement matrix
SRrelc	SR parameter
Effind	Historical fishing effort
Spat_targc	Spatial targetting
hc	Steepness
R0c	Unfished recruitment by area
SSBpRc	Unfished spawning biomass per recruit by area
aRc	Ricker aR
bRc	Ricker bR
maxF	maximum F
useCPP	Logical. Use the CPP code?

Author(s)

A. Hordyk

`ourReefFish`*Example data object*

Description

Example data object with a number of output control MPs run on it, and includes resulting distributions of TACs

An object of class Data

Usage

```
data('ourReefFish')
```

```
ourReefFish
```

Format

An object of class Data of length 1.

Examples

```
## Not run:  
data(ourReefFish)  
str(ourReefFish)  
plot(ourReefFish)  
  
## End(Not run)
```

`Overages`*Overages Imp*

Description

An object of class Imp

Usage

```
Overages
```

Format

An object of class Imp of length 1.

Perfect_Imp	<i>Perfect_Imp Imp</i>
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Description

An object of class Imp

Usage

Perfect_Imp

Format

An object of class Imp of length 1.

Perfect_Info	<i>Perfect_Info Obs</i>
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Description

An object of class Obs

Usage

Perfect_Info

Format

An object of class Obs of length 1.

plot,Data,ANY-method	<i>Plot Data object</i>
----------------------	-------------------------

Description

Plot Data object

Usage

```
## S4 method for signature 'Data,ANY'  
plot(x, funcs = NA, maxlines = 6, perc = 0.5,  
      xlims = NA)
```

Arguments

x	object of class Data
funcs	MPs
maxlines	maximum number of lines
perc	percentile of TAC recommendation
xlims	limits of x-axis

plot,MSE,ANY-method *Plot MSE object*

Description

Plot MSE object

Usage

```
## S4 method for signature 'MSE,ANY'
plot(x)
```

Arguments

x	object of class MSE
---	---------------------

plot.OM *Plot the operating model (OM) object parameters*

Description

A function that plots the parameters and resulting time series of an operating model.

Usage

```
## S3 method for class 'OM'
plot(x, ...)
```

Arguments

x	An object of class OM or a list with historical simulation information (ie run-MSE(OM, Hist=TRUE))
...	Optional additional arguments passed to plot

Author(s)

T. Carruthers

plotFleet *Plot the Fleet object parameters*

Description

Plot the Fleet object parameters

Usage

```
plotFleet(x, Stock = NULL, nsamp = 3, nsim = 500, proyears = 28,
          col = "darkgray", breaks = 10, lwd = 2, ...)
```

Arguments

x	An object of class Fleet (or of class OM)
Stock	An object of class Stock
nsamp	Number of random samples for time-series plots
nsim	Number of iterations for histograms
proyears	Number of projection years
col	Color of histograms
breaks	Number of breaks for histograms
lwd	line width
...	Optional additional arguments passed to plot

Author(s)

A. Hordyk

plotFun *Print out plotting functions*

Description

This function prints out the available plotting functions for objects of class MSE or Data

Usage

```
plotFun(class = c('MSE', 'Data'), msg=TRUE)
```

Arguments

class	Character string. Prints out the plotting functions for objects of this class.
msg	Logical. Should the functions be printed to screen?

Note

Basically the function looks for any functions in the DLMtool that have the word ‘plot’ in them. There is a chance that some plotting functions are missed. Let us know if you find any and we will add them.

Author(s)

A. Hordyk

plotImp	<i>Plot the Implementation object parameters</i>
---------	--

Description

A function that plots histograms of samples from the implementation object parameters, and time-series plots of ‘nsamp’ samples of time-series examples. Used to visually examine the parameter values and ranges entered into the Obs object.

Usage

```
plotImp(x, nsim = 500, nyears = 50, col = "darkgray", breaks = 10, ...)
```

Arguments

x	An object of class Imp (or of class OM)
nsim	Number of iterations for histograms
nyears	Number of historical years
col	Color of histograms
breaks	Number of breaks for histograms
...	Optional additional arguments passed to plot

Author(s)

T. Carruthers and A. Hordyk

plotM	<i>Plot M-at-Age and Size</i>
-------	-------------------------------

Description

Plot M-at-Age and Size

Usage

```
plotM(Stock, nsim = 5)
```

Arguments

Stock	An object of class 'Stock' or 'OM'
nsim	The number of simulations to plot

Author(s)

A. Hordyk

Examples

```
plotM(Albacore)
```

plotObs	<i>Plot the Observation object parameters</i>
---------	---

Description

A function that plots histograms of samples from the observation object parameters, and time-series plots of 'nsamp' samples of time-series examples. Used to visually examine the parameter values and ranges entered into the Obs object.

Usage

```
plotObs(x, nsim = 500, nyears = 50, col = "darkgray", breaks = 10, ...)
```

Arguments

x	An object of class Obs (or of class OM)
nsim	Number of iterations for histograms
nyears	Number of historical years
col	Color of histograms
breaks	Number of breaks for histograms
...	Optional additional arguments passed to plot

Author(s)

T. Carruthers and A. Hordyk

plotOFL *A generic OFL plot for NOAA use*

Description

As title.

Usage

```
plotOFL(Data,xlims=NA,perc=0.5)
```

Arguments

Data	An object of class Data that has been run through TAC()
xlims	x axis limits
perc	The percentile of the OFL distribution to be plotted

Value

A table of performance metrics.

Author(s)

T. Carruthers

plotSelect *Plot the vulnerability and retention curves*

Description

Plot the vulnerability and retention curves

Usage

```
plotSelect(OM, pyears = 4, sim = NA, type = "l")
```

Arguments

OM	An object of class 'OM'
pyears	number of years to plot
sim	the simulation to plot. default is NA to plot a random simulation. Set to 1 for reproducible plot
type	plot type - line "l", point "p", or both "b"

Author(s)

A. Hordyk

plotStock

*Plot the Stock object parameters***Description**

A function that plots histograms of samples from the Stock object parameters, and time-series plots of 'nsamp' samples of time-varying parameters. Used to visually examine the parameter values and ranges entered into the Stock object.

Usage

```
plotStock(x, nsamp = 3, nsim = 500, nyears = 50, proyears = 28,
  col = "darkgray", breaks = 10, lwd = 2, ask = FALSE, incVB = TRUE,
  ...)
```

Arguments

x	An object of class Stock (or of class OM)
nsamp	Number of random samples for time-series plots
nsim	Number of iterations for histograms. Ignored if x is class 'OM'
nyears	Number of historical years. Ignored if x is class 'OM'
proyears	Number of projection years. Ignored if x is class 'OM'
col	Color of histograms
breaks	Number of breaks for histograms
lwd	line width
ask	Ask before displaying next page?
incVB	Show the sampled von Bertalanffy growth curves on second page?
...	Optional additional arguments passed to plot

Author(s)

A. Hordyk

popdyn

*Population dynamics model***Description**

Population dynamics model

Usage

```
popdyn(nareas, maxage, Ncurr, pyears, M_age, MatAge, WtAge, Vuln, Retc, Prec,
      movc, SRrelc, Effind, Spat_targc, hc, R0c, SSBpRc, aRc, bRc, Qc,
      Fapic = NULL, maxF, control = 1)
```

Arguments

nareas	Integer. The number of spatial areas
maxage	Integer. The maximum age
Ncurr	Numeric matrix (dimensions maxage, nareas) with the current N-at-age
pyears	Integer. Number of years to project the model forward
M_age	Numeric matrix (dimensions maxage, pyears) with natural mortality at age
MatAge	Numeric vector (length maxage) with proportion mature for each age-class
WtAge	Numeric matrix (dimensions maxage, pyears) with weight-at-age
Vuln	Numeric matrix (dimensions maxage, pyears) with proportion vulnerable-at-age
Retc	Numeric matrix (dimensions maxage, pyears) with proportion retained-at-age
Prec	Numeric vector (length pyears) with recruitment error
movc	Numeric matrix (dimensions nareas, nareas) with movement matrix
SRrelc	Integer. Stock-recruitment curve
Effind	Numeric vector (length pyears) with the fishing effort by year
Spat_targc	Integer. Value of spatial targetting
hc	Numeric. Steepness of stock-recruit relationship
R0c	Numeric vector of length nareas with unfished recruitment by area
SSBpRc	Numeric vector of length nareas with unfished spawning per recruit by area
aRc	Numeric. Ricker SRR a value
bRc	Numeric. Ricker SRR b value
Qc	Numeric. Catchability coefficient
Fapic	Numeric. Apical F value
maxF	A numeric value specifying the maximum fishing mortality for any single age class
control	Integer. 1 to use q and effort to calculate F, 2 to use Fapic (apical F) and vulnerability to calculate F.

Value

A named list of length 8 containing with arrays (dimensions: maxage, pyears, nareas) containing numbers-at-age, biomass-at-age, spawning stock numbers, spawning biomass, vulnerable biomass, fishing mortality, retained fishing mortality, and total mortality

Author(s)

A. Hordyk

Porgy

Porgy Stock

Description

An object of class Stock

Usage

Porgy

Format

An object of class Stock of length 1.

Pplot

A projection by projection plot of F/FMSY and B/BMSY

Description

A shorter version of the plot method for MSEs that just shows the projected trends in stock status and over exploitation

Usage

Pplot(MSEobj, nam=NA)

Arguments

MSEobj	An object of class MSE
nam	Title of plot

Author(s)

T. Carruthers

Pplot2

*A projection by projection plot of F/FMSY, B/BMSY, B/B0, and yield***Description**

A projection by projection plot of F/FMSY, B/BMSY, B/B0, and yield

Usage

```
Pplot2(MSEobj, YVar = c("SSB_SSBMSY", "F_FMSY"), MPs = NA, sims = NULL,
      traj = c("all", "quant"), quants = c(0.1, 0.9), incquant = TRUE,
      quantcol = "lightgray", RefYield = c("lto", "curr"), LastYr = TRUE,
      maxMP = 6, alpha = 60, cex.axis = 1.35, cex.lab = 1.4, YLab = NULL,
      incMP = TRUE, MPcex = 1.4, incLeg = TRUE, cex.leg = 1.5,
      legPos = "topleft", yline = NULL, parOR = FALSE, xaxis = TRUE,
      yaxis = TRUE, oneIt = TRUE, ...)
```

Arguments

MSEobj	An object of class MSE
YVar	What to plot on the y-axis? Options are: c('SSB_SSB0', 'SSB_SSBMSY', 'F_FMSY', 'Yield')
MPs	Optional subset by MP
sims	Optional subset by simulation
traj	Plot all projections (all) or only quantiles (quant)
quants	Numeric vector of length 2 specifying the quantiles (e.g., 10th and 90th. Median is always included)
incquant	Logical. Include the quantiles or only plot median?
quantcol	Colour of the quantile polygon
RefYield	Should yield be relative to long-term optimum (lto) or last historical year (curr)
LastYr	Logical. Include the last historical year in the yield projections?
maxMP	Maximum number of MPs to plot
alpha	Alpha for transparency of lines
cex.axis	Size of axis text
cex.lab	Size of axis label
YLab	Optional label for y-axis
incMP	Logical. Include name of MP?
MPcex	Size of MP label
incLeg	Logical. Include a legend?
cex.leg	Size of legend text
legPos	Legend position
yline	Optional horizontal line

parOR	Logical to over-ride the par parameters
xaxis	Logical. Should x-axis labels be displayed?
yaxis	Logical. Should y-axis labels be displayed?
oneIt	Logical. Should one iteration be plotted on the quantile plot?
...	Additional arguments to be passed to plotting functions

Author(s)

T. Carruthers & A.Hordyk

Precise_Biased	<i>Precise_Biased Obs</i>
----------------	---------------------------

Description

An object of class Obs

Usage

Precise_Biased

Format

An object of class Obs of length 1.

Precise_Unbiased	<i>Precise_Unbiased Obs</i>
------------------	-----------------------------

Description

An object of class Obs

Usage

Precise_Unbiased

Format

An object of class Obs of length 1.

Range	<i>Standardize values</i>
-------	---------------------------

Description

Function to standardize to value relative to minimum and maximum values

Usage

```
Range(x, Max, Min)
```

```
range01(x)
```

Arguments

x	vector of values
Max	Maximum value
Min	Minimum value

Rcontrol	<i>Harvest Control Rule using prior for intrinsic rate of increase</i>
----------	--

Description

An MP proposed by Carl Walters that modifies TACs according to trends in apparent surplus production that includes information from a demographically derived prior for intrinsic rate of increase

Usage

```
Rcontrol(x, Data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of quota samples
yrsmth	The number of years for smoothing catch and biomass data
gg	A gain parameters
glim	Limits for the change in TAC among years

Author(s)

C. Walters and T. Carruthers

References

Made-up for this package.

Rcontrol2	<i>MP using prior for intrinsic rate of increase with a quadratic approximation to surplus production</i>
-----------	---

Description

An MP proposed by Carl Walters that modifies quotas according to trends in apparent surplus production that includes information from a demographically derived prior for intrinsic rate of increase. This is different from Rcontrol because it includes a quadratic approximation of recent trend in surplus production given biomass

Usage

```
Rcontrol2(x, Data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of TAC samples
yrsmth	The number of years for smoothing catch and biomass data
gg	A gain parameters
glim	Limits for the change in TAC among years

Author(s)

C. Walters and T. Carruthers

References

Made-up for this package.

read.control.file *Reads iSCAM control file*

Description

A function for returning the results of the iscam control file

Usage

```
read.control.file(file = NULL, num.gears = NULL, num.age.gears = NULL,  
                  verbose = FALSE)
```

Arguments

file	File location
num.gears	The number of gears
num.age.gears	The number age-gears
verbose	should detailed results be printed to console

Author(s)

Chris Grandin (DFO PBS)

read.data.file *Reads iSCAM dat file*

Description

A function for returning the results of the .dat iscam file

Usage

```
read.data.file(file = NULL, verbose = FALSE)
```

Arguments

file	File location
verbose	should detailed results be printed to console

Author(s)

Chris Grandin (DFO PBS)

read.mcmc	<i>Reads iSCAM mcmc output files</i>
-----------	--------------------------------------

Description

A function for returning the results of the iscam mcmc files

Usage

```
read.mcmc(model.dir = NULL, verbose = TRUE)
```

Arguments

model.dir	Folder name
verbose	should detailed results be printed to console

Author(s)

Chris Grandin (DFO PBS)

read.par.file	<i>Reads iSCAM parameter file</i>
---------------	-----------------------------------

Description

A function for returning the results of the iscam .par file

Usage

```
read.par.file(file = NULL, verbose = FALSE)
```

Arguments

file	File location
verbose	should detailed results be printed to console

Author(s)

Chris Grandin (DFO PBS)

read.projection.file *Reads iSCAM projection file*

Description

A function for returning the results of the iscam projection file

Usage

```
read.projection.file(file = NULL, verbose = FALSE)
```

Arguments

file	File location
verbose	should detailed results be printed to console

Author(s)

Chris Grandin (DFO PBS)

read.report.file *Reads iSCAM Rep file*

Description

A function for returning the results of the .rep iscam file

Usage

```
read.report.file(fn)
```

Arguments

fn	File location
----	---------------

Author(s)

Chris Grandin (DFO PBS)

Red_snapper	<i>Red_snapper Data</i>
-------------	-------------------------

Description

An object of class Data

Usage

Red_snapper

Format

An object of class Data of length 1.

Replace	<i>Replace an existing Stock, Fleet, Obs, or Imp object</i>
---------	---

Description

A function that replaces a Stock, Fleet, Obs, or Imp object from an OM with one from another OM. Mainly used for internal functions.

Usage

```
Replace(OM, from, Sub = c("Stock", "Fleet", "Obs", "Imp"))
```

Arguments

OM	An operating model object (class OM) which will be updated with a sub-model from another OM
from	The OM object from which the sub-model is being taken
Sub	A character string specifying what object type to replace "Stock", "Fleet", "Obs" or "Imp" (default is all four which is probably not what you want to do)

Value

An object of class OM

Author(s)

A. Hordyk

replic8	<i>Enlarge (replicate) a DLM data object to create an additional dimension for simulation / sensitivity testing</i>
---------	---

Description

Replicates position 1 data to multiple positions for sensitivity testing etc

Usage

```
replic8(Data, nrep)
```

Arguments

Data	A data-limited methods data object
nrep	The number of positions to expand the DLM object to

Author(s)

T. Carruthers

Required	<i>What methods need what data</i>
----------	------------------------------------

Description

A function that finds all methods in the environment and searches the function text for slots in the DLM data object

Usage

```
Required(funcs = NA)
```

Arguments

funcs	A character vector of possible methods of class DLM quota, DLM space or DLM size
-------	--

Author(s)

T. Carruthers

Rockfish

Rockfish Stock

Description

An object of class Stock

Usage

Rockfish

Format

An object of class Stock of length 1.

runInMP

Runs input control MPs on a Data object.

Description

Function runs a MP (or MPs) of class 'Input' and returns a list: input control recommendation(s) in element 1 and Data object in element 2.

Usage

```
runInMP(Data, MPs = NA, reps = 100)
```

Arguments

Data	A object of class Data
MPs	A vector of MPs of class 'Input'
reps	Number of stochastic repetitions - often not used in input control MPs.

Author(s)

A. Hordyk

runMSE

*Run a Management Strategy Evaluation***Description**

A function that runs a Management Strategy Evaluation (closed-loop simulation) for a specified operating model

Usage

```
runMSE(OM = DLMtool::testOM, MPs = c("AvC", "DCAC", "FMSYref", "curE",
  "matlenlim"), nsim = 48, proyears = 50, interval = 4, pstar = 0.5,
  maxF = 0.8, timelimit = 1, reps = 1, CheckMPs = FALSE, Hist = FALSE,
  ntrials = 50, fracD = 0.05, CalcBlow = FALSE, HZN = 2, Bfrac = 0.5)
```

Arguments

OM	An operating model object (class 'OM')
MPs	A vector of methods (character string) of class Output or Input.
nsim	Number of simulations. Note that in DLMtool V4.1+ 'nsim' is ignored if OM object contains the slot 'nsim'.
proyears	Number of projected years. Note that in DLMtool V4.1+ 'proyears' is ignored if OM object contains the slot 'proyears'.
interval	The assessment interval - how often would you like to update the management system?
pstar	The percentile of the sample of the management recommendation for each method
maxF	Maximum instantaneous fishing mortality rate that may be simulated for any given age class
timelimit	Maximum time taken for a method to carry out 10 reps (methods are ignored that take longer)
reps	Number of samples of the management recommendation for each method. Note that when this is set to 1, the mean value of the data inputs is used.
CheckMPs	Logical to indicate if Can function should be used to check if MPs can be run.
Hist	Should model stop after historical simulations? Returns a list containing all historical data
ntrials	Maximum of times depletion and recruitment deviations are resampled to optimize for depletion. After this the model stops if more than percent of simulations are not close to the required depletion
fracD	maximum allowed proportion of simulations where depletion is not close to sampled depletion from OM before model stops with error
CalcBlow	Should low biomass be calculated where this is the spawning biomass at which it takes HZN mean generation times of zero fishing to reach Bfrac fraction of SSBMSY

HZN	The number of mean generation times required to reach Bfrac SSBMSY in the Blow calculation
Bfrac	The target fraction of SSBMSY for calculating Blow

Value

An object of class MSE

Author(s)

T. Carruthers and A. Hordyk

runMSErobust *Run a Management Strategy Evaluation*

Description

Run a Management Strategy Evaluation and save out the results to a Rdata file. To increase speed and efficiency, particularly for runs with a large number simulations (nsim), the simulations are split into a number of packets. The functions loops over the packets and combines the output into a single MSE object. If the MSE model crashes during a run, the MSE is run again until it is successfully completed. The MSE is stopped if the number of consecutive crashes exceeds maxCrash. There is an option to save the packets as Rdata files to the current working directory (default is FALSE). By default, the functions saves the completed MSE object as a Rdata file (to the current working directory).

Usage

```
runMSErobust(OM = DLMtool::testOM, MPs = c("AvC", "DCAC", "FMSYref", "curE",
      "matlenlim"), nsim = 256, proyears = 50, interval = 4, pstar = 0.5,
      maxF = 0.8, timelimit = 1, reps = 1, CheckMPs = FALSE, Hist = FALSE,
      ntrials = 50, fracD = 0.05, CalcBlow = FALSE, HZN = 2, Bfrac = 0.5,
      maxsims = 64, name = NULL, unique = FALSE, maxCrash = 10,
      saveMSE = TRUE, savePack = FALSE)
```

Arguments

OM	An operating model object (class OM)
MPs	A vector of methods (character string) of class Output or Input.
nsim	Number of simulations
proyears	Number of projected years
interval	The assessment interval - how often would you like to update the management system?
pstar	The percentile of the sample of the management recommendation for each method
maxF	Maximum instantaneous fishing mortality rate that may be simulated for any given age class

timelimit	Maximum time taken for a method to carry out 10 reps (methods are ignored that take longer)
reps	Number of samples of the management recommendation for each method. Note that when this is set to 1, the mean value of the data inputs is used.
CheckMPs	Logical to indicate if Can function should be used to check if MPs can be run.
Hist	Should model stop after historical simulations? Returns a list containing all historical data
ntrials	Maximum of times depletion and recruitment deviations are resampled to optimize for depletion. After this the model stops if more than percent of simulations are not close to the required depletion
fracD	maximum allowed proportion of simulations where depletion is not close to sampled depletion from OM before model stops with error
CalcBlow	Should low biomass be calculated where this is the spawning biomass at which it takes HZN mean generation times of zero fishing to reach
HZN	The number of mean generation times required to reach Bfrac SSBMSY in the Blow calculation
Bfrac	fraction of SSBMSY
maxsims	Maximum number of simulations per packet
name	Character string for name of saved MSE packets (if savePack=TRUE) and final MSE object. If none provided, it uses the first five letters from the OM name
unique	Logical. Should the name be unique? Current date and time appended to name.
maxCrash	Maximum number of consecutive crashes before the MSE stops
saveMSE	Logical to indicate if final MSE object should be saved to current working directory (this is probably a good idea)
savePack	Logical to indicate if packets should be save to current working directory

Value

An object of class MSE

Author(s)

A. Hordyk and T. Carruthers

Sam

Conduct stock assessment

Description

A wrapper function that gets the OFL recommendation in cases where a method of DLM quota has been specified

Usage

```
Sam(Data, MPs = NA, reps = 100, perc = 0.5)
```

Arguments

Data	A data-limited methods data object
MPs	A character vector of methods of DLM quota, DLM space or DLM size
reps	The number of samples of quota recommendations by method
perc	quantile of the recommendation to use

Author(s)

T. Carruthers

SampleCpars

Sample custom pars

Description

Sample custom pars

Usage

```
SampleCpars(cpars, nsim = 48, msg = TRUE)
```

Arguments

cpars	A named list containing custom parameters for the OM
nsim	number of simulations
msg	logical - print the names of the cpars? Turn off when using the function in a loop

Value

A named list of sampled custom parameters

SampleFleetPars *Sample Fleet Parameters*

Description

Sample Fleet Parameters

Usage

```
SampleFleetPars(Fleet, Stock = NULL, nsim = NULL, nyears = NULL,
  proyears = NULL, cpars = NULL)
```

Arguments

Fleet	An object of class 'Fleet' or class 'OM'
Stock	An object of class 'Stock' or a list of sampled Stock parameters. Ignored if 'Fleet' is class 'OM'
nsim	Number of simulations. Ignored if 'Fleet' is class 'OM'
nyears	Number of historical years. Ignored if 'Fleet' is class 'OM'
proyears	Number of projection years. Ignored if 'Fleet' is class 'OM'
cpars	Optional named list of custom parameters. Ignored if 'Fleet' is class 'OM'

Value

A named list of sampled Fleet parameters

SampleImpPars *Sample Implementation Error Parameters*

Description

Sample Implementation Error Parameters

Usage

```
SampleImpPars(Imp, nsim = NULL)
```

Arguments

Imp	An object of class 'Imp' or class 'OM'
nsim	Number of simulations. Ignored if 'Stock' is class 'OM'

Value

A named list of sampled Implementation Error parameters

SampleObsPars	<i>Sample Observation Parameters</i>
---------------	--------------------------------------

Description

Sample Observation Parameters

Usage

```
SampleObsPars(Obs, nsim = NULL)
```

Arguments

Obs	An object of class 'Obs' or class 'OM'
nsim	Number of simulations. Ignored if 'Obs' is class 'OM'

Value

A named list of sampled Observation parameters

SampleStockPars	<i>Sample Stock parameters</i>
-----------------	--------------------------------

Description

Sample Stock parameters

Usage

```
SampleStockPars(Stock, nsim = 48, nyears = 80, proyears = 50,
  cpars = NULL)
```

Arguments

Stock	An object of class 'Stock' or class 'OM'
nsim	Number of simulations. Ignored if 'Stock' is class 'OM'
nyears	Number of historical years. Ignored if 'Stock' is class 'OM'
proyears	Number of projection years. Ignored if 'Stock' is class 'OM'
cpars	Optional named list of custom parameters. Ignored if 'Stock' is class 'OM'

Value

A named list of sampled Stock parameters

sample_steepness2 *Sample steepness given mean and cv*

Description

Sample steepness given mean and cv

Usage

```
sample_steepness2(n, mu, cv)
```

Arguments

n	number of samples
mu	mean h
cv	cv of h

Author(s)

Q. Huynh

sampy *Sample vector*

Description

Sample vector

Usage

```
sampy(x)
```

Arguments

x	vector of values
---	------------------

SBT1

SBT simple MP

Description

An MP that makes incremental adjustments to TAC recommendations based on the apparent trend in CPUE

Usage

```
SBT1(x, Data, reps = 100, yrsmth=10, k1=1.5, k2=3, gamma=1)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples of the TAC
yrsmth	The number of years for evaluating trend in relative abundance indices
k1	Control parameter
k2	Control parameter
gamma	Control parameter

Details

This isn't exactly the same as the proposed methods and is stochastic in this implementation. The method doesn't tend to work too well under many circumstances possibly due to the lack of 'tuning' that occurs in the real SBT assessment environment. You could try asking Rich Hillary at CSIRO about this approach.

Author(s)

T. Carruthers

References

http://www.ccsbt.org/site/recent_assessment.php

 SBT2

SBT complex MP

Description

An MP that makes incremental adjustments to TAC recommendations based on index levels relative to target levels (BMSY/B0) and catch levels relative to target levels (MSY)

Usage

```
SBT2(x, Data, reps = 100,
     epsB=0.25, epsR=0.75, tauR=5, tauB=7, gamma=1)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples of the TAC
epsB	Control parameter
epsR	Control parameter
tauR	Control parameter
tauB	Control parameter
gamma	Control parameter

Details

This isn't exactly the same as the proposed methods and is stochastic in this implementation. The method doesn't tend to work too well under many circumstances possibly due to the lack of 'tuning' that occurs in the real SBT assessment environment. You could try asking Rich Hillary at CSIRO about this approach.

Author(s)

T. Carruthers

References

http://www.ccsbt.org/site/recent_assessment.php

sdconv	<i>Get log normal standard deviation from transformed space mean and standard deviation</i>
--------	---

Description

Get log normal standard deviation from transformed space mean and standard deviation

Usage

```
sdconv(m, sd)
```

Arguments

m	mean
sd	standard deviation

Value

numeric

Author(s)

T. Carruthers

Sense	<i>Sensitivity analysis</i>
-------	-----------------------------

Description

A function that determines the inputs for a given data-limited method of class Output and then analyses the sensitivity of TAC estimates to marginal differences in each input. The range used for sensitivity is based on the user-specified CV for that input (e.g. CV_Mort, Mort)

Usage

```
Sense(Data, MP, nsense = 6, reps = 100, perc = c(0.05, 0.5, 0.95), ploty = T)
```

Arguments

Data	A data-limited methods data object
MP	A character string representing an MP applied in calculating the TAC recommendations in the DLM object
nsense	The number of points over which to calculate the TAC (resolution)
reps	The number of samples of the quota taken for the calculation of the TAC
perc	The percentile of the sample TAC
ploty	A logical switch, (T/F, should a plot be drawn?)

Author(s)

T. Carruthers

SetRecruitCycle	<i>Function to calculate cyclic recruitment pattern given user-specified values of period and amplitude.</i>
-----------------	--

Description

Calculates cyclic pattern in recruitment deviations for a simulation. Ranges for Period and Amplitude are specified by user, and function produces cyclic pattern from within these ranges. Default is a sine wave.

Usage

```
SetRecruitCycle(x=1, Period, Amplitude, TotYears, Shape=c('sin',
'shift'))
```

Arguments

x	Simulation number.
Period	A vector of length 2 specifying the minimum and maximum values for the period of the recruitment cycles. e.g., if Period = c(10,10), then recruitment cycle occurs every 10 years exactly.
Amplitude	A vector of length 2 specifying the minimum and maximum values for the amplitude of the recruitment cycles. e.g., if Amplitude = c(0,0.5), the average recruitment will increase (or decrease) by a factor between 0 and 0.5 each cycle.
TotYears	A numeric value specifying the total number of years (should be nyears + proyears).
Shape	Specifies whether cyclic recruitment pattern is sine wave (default) or a step-change (shift).

Author(s)

A. Hordyk

setup	<i>Setup parallel processing</i>
-------	----------------------------------

Description

Sets up parallel processing using the snowfall package

Usage

```
setup(cpus = parallel::detectCores())
```

Arguments

cpus	number of CPUs
------	----------------

Simulation_1	<i>Simulation_1 Data</i>
--------------	--------------------------

Description

An object of class Data

Usage

```
Simulation_1
```

Format

An object of class Data of length 1.

simYears	<i>Simulate population dynamics for historical years</i>
----------	--

Description

Simulate population dynamics for historical years

Usage

```
simYears(x, nareas, maxage, N, pyears, M_ageArray, Mat_age, Wt_age, V, retA,
  Perr, mov, SRrel, Find, Spat_targ, hs, R0a, SSBpR, aR, bR, qs, maxF,
  useCPP = TRUE)
```

Arguments

x	Integer, the simulation number
nareas	The number of spatial areas
maxage	The maximum age
N	Array of the numbers-at-age in population. Dimensions are nsim, maxage, nyears, nareas. Only values from the first year (i.e N[:,1,]) are used, which is the current N-at-age.
pyears	The number of years to project forward. Equal to 'nyears' for optimizing for q.
M_ageArray	An array (dimensions nsim, maxage, nyears+proyears) with the natural mortality-at-age and year
Mat_age	A matrix (dimensions nsim, maxage) with the proportion mature for each age-class
Wt_age	An array (dimensions nsim, maxage, nyears+proyears) with the weight-at-age and year
V	An array (dimensions nsim, maxage, nyears+proyears) with the vulnerability-at-age and year
retA	An array (dimensions nsim, maxage, nyears+proyears) with the probability retained-at-age and year
Perr	A matrix (dimensions nsim, nyears+proyears) with the recruitment deviations
mov	An array (dimensions nsim, nareas, nareas) with the movement matrix
SRrel	A numeric vector nsim long specifying the recruitment curve to use
Find	A matrix (dimensions nsim, nyears) with the historical fishing effort
Spat_targ	A numeric vector nsim long with the spatial targeting
hs	A numeric vector nsim long with the steepness values for each simulation
R0a	A matrix (dimensions nsim, nareas) with the unfished recruitment by area
SSBpR	A matrix (dimensions nsim, nareas) with the unfished spawning-per-recruit by area
aR	A numeric vector nsim long with the Ricker SRR a values
bR	A numeric vector nsim long with the Ricker SRR b values
qs	A numeric vector nsim long with catchability coefficients
maxF	A numeric value specifying the maximum fishing mortality for any single age class
useCPP	logical - use the CPP code? For testing purposes only

Author(s)

A. Hordyk

SketchFun	<i>Manually map the historical relative fishing effort trajectory.</i>
-----------	--

Description

Internal function for ininteractive plot which allows users to specify the relative trajectory and variability in the historical fishing effort.

Usage

```
SketchFun(nyears, Years=NULL)
```

Arguments

nyears	Number of years
Years	An optional vector of years. Should be nyears long.

Author(s)

A. Hordyk

slotlim	<i>An data-limited method which sets a slot limit</i>
---------	---

Description

An example of the implementation of input controls in the DLM toolkit, where selectivity-at-length is set using a slot limit; that is, a minimum and maximum legal length. The maximum limit is set here, quite arbitrarily, as the 75th percentile between the new minimum legal length and the estimated asymptotic length.

Usage

```
slotlim(x, Data, ...)
```

Arguments

x	A position in a data-limited methods object
Data	A data-limited methods object
...	Optional additional arguments that are ignored. Note arguments reps or ... are required for all input controls

Value

An object of class 'InputRec'

Author(s)

A. Hordyk

References

Made-up for this package

Snapper

Snapper Stock

Description

An object of class Stock

Usage

Snapper

Format

An object of class Stock of length 1.

Sole

Sole Stock

Description

An object of class Stock

Usage

Sole

Format

An object of class Stock of length 1.

Splot

*Scatter plot of B/BMSY or B/B0 and F/FMSY for lastYrs***Description**

Scatter plot of B/BMSY or B/B0 and F/FMSY for lastYrs

Usage

```
Splot(MSEobj = NULL, MPs = NA, All = TRUE, Var = c('B_BMSY', 'SSB_SSB0'),
      lastYrs = 10, Fref = 1, BMSYref = 1, B0ref = 0.4, cex.MP = 1, Fbg = FALSE,
      Bbg = FALSE, Props = FALSE, TP = FALSE)
```

Arguments

MSEobj	An object of class MSE
MPs	Optional subset by MP
All	Logical. Plot all points or just the mean?
Var	What to plot on the y-axis: B_BMSY or SSB_SSB0
lastYrs	Last number of years in projection to calculate statistics
Fref	Location of F statistic reference line
BMSYref	Location of B_MS Y statistic reference line
B0ref	Location of B_0 statistic reference line
cex.MP	size of MP label
Fbg	Logical. Include background colours for F-statistic?
Bbg	Logical. Include background colours for B-statistic?
Props	Logical. Display the proportion of points in each quadrant?
TP	Logical. Use transparent colours?

Author(s)

A. Hordyk

SPmod

Surplus production based catch-limit modifier

Description

An MP that makes incremental adjustments to TAC recommendations based on the apparent trend in surplus production. Based on the theory of Mark Maunder (IATTC)

Usage

```
SPmod(x, Data, reps = 100, alp = c(0.8, 1.2), bet = c(0.8, 1.2))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of quota samples
alp	Condition for modifying the TAC (bounds on change in abundance)
bet	Limits for how much the TAC can change among years

Details

Note that this isn't exactly what Mark has previously suggested and is stochastic in this implementation.

Value

A numeric vector of TAC recommendations

Author(s)

T. Carruthers

References

<http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf>

 SPMSY

Catch trend Surplus Production MSY MP

Description

An MP that uses Martell and Froese (2012) method for estimating MSY to determine the OFL. Since their approach estimates stock trajectories based on catches and a rule for intrinsic rate of increase it also returns depletion. Given their surplus production model predicts K , r and depletion it is straightforward to calculate the OFL based on the Schaefer productivity curve. $OFL = dep \times (1 - dep) \times r \times K \times 2$

Usage

SPMSY(x, Data, reps = 100)

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples of the TAC

Details

Requires the assumption that catch is proportional to abundance. Occasionally the rule that limits r and K ranges does not allow r - K pairs to be found that lead to the depletion inferred by the catch trajectories. In this case this method widens the search.

Author(s)

T. Carruthers

References

Martell, S. and Froese, R. 2012. A simple method for estimating MSY from catch and resilience. Fish and Fisheries. DOI: 10.1111/j.1467-2979.2012.00485.x

 SPslope

Slope in surplus production MP

Description

A management procedure that makes incremental adjustments to TAC recommendations based on the apparent trend in recent surplus production. Based on the theory of Mark Maunder (IATTC)

Usage

```
SPslope(x, Data, reps = 100, yrsmth = 4, alp = c(0.9, 1.1), bet =
c(1.5, 0.9))
```

Arguments

x	A position in data-limited methods data object
Data	A data-limited methods data object
reps	The number of quota samples
yrsmth	Years over which to smooth recent estimates of surplus production
alp	Condition for modifying the Data (bounds on change in abundance)
bet	Limits for how much the Data can change among years

Details

Note that this isn't exactly what Mark has previously suggested and is stochastic in this implementation.

Value

A numeric vector of Data recommendations

Author(s)

T. Carruthers

References

<http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf>

SPSRA *Surplus Production Stock Reduction Analysis*

Description

A surplus production equivalent of DB-SRA that uses a demographically derived prior for intrinsic rate of increase (McAllister method, below)

Usage

```
SPSRA(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object (class DLM)
reps	The number of samples of the TAC taken for the calculation of the quota

Author(s)

T. Carruthers

References

McAllister, M.K., Pikitch, E.K., and Babcock, E.A. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. *Can. J. Fish. Aquat. Sci.* 58: 1871-1890.

SPSRA_ML *Surplus Production Stock Reduction Analysis using a mean-length estimate of current stock depletion*

Description

A surplus production equivalent of DB-SRA that uses a demographically derived prior for intrinsic rate of increase. A prior for depletion is calculated from a mean-length estimator

Usage

```
SPSRA_ML(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object (class DLM)
reps	The number of samples of the TAC taken

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

T. Carruthers

References

McAllister, M.K., Pikitch, E.K., and Babcock, E.A. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. *Can. J. Fish. Aquat. Sci.* 58: 1871-1890.

SRComp

Plot simulation test of Stochastic SRA method

Description

Plots simulation variables versus estimation variables for Stochastic SRA methods of conditioning operating models.

Usage

```
SRComp(sim, OM, outfile = NA, maxplot = 10)
```

Arguments

sim	The output list object of SRAsim() function.
OM	The output object of StochasticSRA() function.
outfile	The name of the figure (something.jpg) you wish to make using SRComp
maxplot	The maximum number of simulations to plot

Author(s)

T. Carruthers (Canadian DFO grant)

Examples

```
## Not run:
sim<-SRAsim(testOM,qmult=1,patchy=0.8)
CAA<-sim$CAA
Chist<-sim$Chist
testOM<-StochasticSRA(testOM,CAA,Chist,nsim=30,nits=500)
SRComp(sim,testOM)

## End(Not run)
```

SRAsim	<i>Simulates catch at age and catch history data for testing SRA methods</i>
--------	--

Description

Catch at age and catch simulator.

Usage

```
SRAsim(OM, qmult = 0.5, patchy = 0.2, nCAA = 100, sigmaE = 0.25)
```

Arguments

OM	An operating model object with M, growth, stock-recruitment and maturity parameters specified.
qmult	Fraction of natural mortality rate that is mean fishing mortality (Fishing catchability multiplier)
patchy	The fraction of years that have catch at age data
nCAA	The number of independent annual catch at age observations (same among all years)
sigmaE	Level of simulated interannual variability in effort (F) expressed as a lognorma SD

Value

A list: Chist = historical catch series, Recdevs = historical recruitment deviations (mean = 1), CAA = catch at age matrix, N = numbers at age matrix, SSB = annual spawning biomass, FM = Fishing mortality rate at age matrix, M = natural mortality rate classy

Author(s)

T. Carruthers (Canadian DFO grant)

Examples

```
out<-SRAsim(testOM)
```

SRopt	<i>Function that returns a stochastic estimate of steepness given observed stock recruitment data</i>
-------	---

Description

Function that returns a stochastic estimate of steepness given observed stock recruitment data

Usage

```
SRopt(nsim, SSB, rec, SSBpR, plot = F, type = "BH")
```

Arguments

nsim	number of samples of steepness to generate
SSB	'observations' of spawning biomass
rec	'observations' (model predictions) of recruitment
SSBpR	spawning stock biomass per recruit at unfished conditions
plot	should plots of model fit be produced?
type	what type of stock recruitment curve is being fitted BH = Beverton-Holt

Author(s)

T. Carruthers

SS2Data	<i>Reads data Stock Synthesis file structure into an data object using package r4ss</i>
---------	---

Description

A function that uses the file location of a fitted SS3 model including input files to population the various slots of an data object

Usage

```
SS2Data(SSdir, Source = "No source provided", length_timestep = NA,  
Name = "", Author = "No author provided", printstats = F, verbose = T)
```

Arguments

SSdir	A folder with Stock Synthesis input and output files in it
Source	Reference to assessment documentation e.g. a url
length_timestep	The duration (in years) of each timestep in the model (if an quarterly model is used this is 0.25)
Name	The name of the operating model
Author	Who did the assessment
printstats	Should the r4ss function SS_output return info on data that was read in?
verbose	Should the r4ss function SS_ouput return detailed messages?

Author(s)

T. Carruthers

SS2DLM	<i>Reads MLE estimates from Stock Synthesis file structure into an operating model using package r4ss</i>
--------	---

Description

A function that uses the file location of a fitted SS3 model including input files to population the various slots of an operating model with MLE parameter estimates

Usage

```
SS2DLM(SSdir, nsim = 48, proyears = 50, length_timestep = NA,
       Name = NULL, Source = "No source provided",
       Author = "No author provided", printstats = F, verbose = T)
```

Arguments

SSdir	A folder with Stock Synthesis input and output files in it
nsim	The number of simulations to take for parameters with uncertainty (for OM@cpar custom parameters)
proyears	The number of projection years for MSE
length_timestep	The duration (in years) of each timestep in the model (if an quarterly model is used this is 0.25)
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
Author	Who did the assessment
printstats	Should the r4ss function SS_output return info on data that was read in?
verbose	Should the r4ss function SS_ouput return detailed messages?

Author(s)

T. Carruthers

StochasticSRA

*Stochastic SRA construction of operating models***Description**

Specify an operating model, using catch composition data and a historical catch series. Returns and operating model with depletion (D), selectivity parameters (L5, LFS) and effort trajectory (Effyears, EffLower, EffUpper) filled. Modified version using cpp code.

Usage

```
StochasticSRA(OM, CAA, Chist, Cobs = 0.1, sigmaR = 0.5, Umax = 0.9,
  nsim = 48, proyears = 50, Jump_fac = 1, nits = 20000, burnin = 1000,
  thin = 50, ESS = 300, ploty = T, nplot = 6, SRAdir = NA)
```

Arguments

OM	An operating model object with M, growth, stock-recruitment and maturity parameters specified.
CAA	A matrix nyears (rows) by nages (columns) of catch at age (age 1 to maxage in length)
Chist	A vector of historical catch observations (nyears long) going back to unfished conditions
Cobs	A numeric value representing catch observation error as a log normal sd
sigmaR	A numeric value representing the prior standard deviation of log space recruitment deviations
Umax	A numeric value representing the maximum harvest rate for any age class (rejection of sims where this occurs)
nsim	The number desired draws of parameters / effort trajectories
proyears	The number of projected MSE years
Jump_fac	A multiplier of the jumping distribution variance to increase acceptance (lower Jump_fac) or decrease acceptance rate (higher Jump_fac)
nits	The number of MCMC iterations
burnin	The number of initial MCMC iterations to discard
thin	The interval over which MCMC samples are extracted for use in graphing / statistics
ESS	Effective sample size - the weighting of the catch at age data
ploty	Do you want to see diagnostics plotted?
nplot	how many MCMC samples should be plotted in convergence plots?
SRAdir	A directory where the SRA diagnostics / fit are stored

Value

A list with three positions. Position 1 is the filled OM object, position 2 is the custompars data.frame that may be submitted as an argument to runMSE() and position 3 is the matrix of effort histories [nyears x nsim] vector of objects of classclassy

Author(s)

T. Carruthers (Canadian DFO grant)

References

Walters, C.J., Martell, S.J.D., Korman, J. 2006. A stochastic approach to stock reduction analysis. Can. J. Fish. Aqua. Sci. 63:212-213.

Examples

```
## Not run:
setup()
sim<-SRAsim(testOM,patchy=0.8)
CAA<-sim$CAA
Chist<-sim$Chist
testOM<-StochasticSRA(testOM,CAA,Chist,nsim=30,nits=1000)
runMSE(testOM)

## End(Not run)
```

StochasticSRA2

Stochastic SRA construction of operating models

Description

Specify an operating model, using catch composition data and a historical catch series. Returns and operating model with depletion (D), selectivity parameters (L5, LFS) and effort trajectory (Effyears, EffLower, EffUpper) filled.

Usage

```
StochasticSRA2(OM, CAA, Chist, Cobs = 0.1, sigmaR = 0.5, Umax = 0.9,
  nsim = 48, proyears = 50, Jump_fac = 1, nits = 4000, burnin = 500,
  thin = 10, ESS = 300, ploty = T, nplot = 6, SRAdir = NA)
```

Arguments

OM	An operating model object with M, growth, stock-recruitment and maturity parameters specified.
CAA	A matrix nyears (rows) by nages (columns) of catch at age (age 1 to maxage in length)

Chist	A vector of historical catch observations (nyears long) going back to unfished conditions
Cobs	A numeric value representing catch observation error as a log normal sd
sigmaR	A numeric value representing the prior standard deviation of log space recruitment deviations
Umax	A numeric value representing the maximum harvest rate for any age class (rejection of sims where this occurs)
nsim	The number desired draws of parameters / effort trajectories
proyears	The number of projected MSE years
Jump_fac	A multiplier of the jumping distribution variance to increase acceptance (lower Jump_fac) or decrease acceptance rate (higher Jump_fac)
nits	The number of MCMC iterations
burnin	The number of initial MCMC iterations to discard
thin	The interval over which MCMC samples are extracted for use in graphing / statistics
ESS	Effective sample size - the weighting of the catch at age data
ploty	Do you want to see diagnostics plotted?
npplot	how many MCMC samples should be plotted in convergence plots?
SRAdir	A directory where the SRA diagnostics / fit are stored

Value

A list with three positions. Position 1 is the filled OM object, position 2 is the custompars data.frame that may be submitted as an argument to runMSE() and position 3 is the matrix of effort histories [nyears x nsim] vector of objects of classclassy

Author(s)

T. Carruthers (Canadian DFO grant)

References

Walters, C.J., Martell, S.J.D., Korman, J. 2006. A stochastic approach to stock reduction analysis. Can. J. Fish. Aqua. Sci. 63:212-213.

Examples

```
## Not run:
setup()
sim<-SRAsim(testOM,patchy=0.8)
CAA<-sim$CAA
Chist<-sim$Chist
testOM<-StochasticSRA(testOM,CAA,Chist,nsim=30,nits=1000)
runMSE(testOM)

## End(Not run)
```

 Stock-class

 Class 'Stock'

Description

An operating model component that specifies the parameters of the population dynamics model

Slots

Name The name of the Stock object

maxage The maximum age of individuals that is simulated (there is no 'plus group': individuals die off beyond the maximum age so there isn't a huge cost to simulating more older age classes)

R0 The magnitude of unfished recruitment. This is normally fixed to some arbitrary value since it simply scales the simulated numbers)

M Natural mortality rate (uniform distribution)

M2 Optional vector of M-at-age (must be length maxage)

Msd Inter-annual variability in natural mortality rate expressed as a coefficient of variation (uniform distribution)

Mgrad Mean temporal trend in natural mortality rate, expressed as a percentage change in M per year (uniform distribution)

Mexp Exponent of the Lorenzen function assuming an inverse relationship between M and weight (uniform distribution)

Fdisc Fraction of discarded fish that die

h Steepness of the stock recruit relationship (uniform distribution)

SRrel Type of stock-recruit relationship (1)Beverton-Holt (2) Ricker

Linf Maximum length (uniform distribution)

K von B. growth parameter k (uniform distribution)

t0 von B. theoretical age at length zero (uniform distribution)

LenCV Coefficient of variation of length-at-age (assumed constant for all age classes (uniform distribution)

Ksd Inter-annual variability in growth parameter k (uniform distribution)

Kgrad Mean temporal trend in growth parameter k, expressed as a percentage change in k per year (uniform distribution)

Linfsd Inter-annual variability in maximum length - uniform distribution

Linfgrad Mean temporal trend in maximum length, expressed as a percentage change in Linf per year (uniform distribution)

recgrad Mean temporal trend in log-normal recruitment deviations (uniform distribution)

AC Autocorrelation in recruitment deviations $\text{rec}(t)=AC*\text{rec}(t-1)+(1-AC)*\text{sigma}(t)$ (uniform distribution)

a Length-weight parameter alpha (uniform distribution)

- b Length-weight parameter beta (uniform distribution)
- L50 Length-at- 50 percent maturity (uniform distribution)
- L50_95 Length increment from 50 percent to 95 percent maturity
- D Current level of stock depletion (Bcurrent/Bunfished) (uniform distribution)
- Perr Process error, the CV of lognormal recruitment deviations (uniform distribution)
- Period Period for cyclical recruitment pattern in years (uniform distribution). Leave empty to ignore
- Amplitude Amplitude in deviation from long-term average recruitment during recruitment cycle, both positive and negative (uniform distribution). E.g., a range from 0 to 0.5 means recruitment decreases or increases by up to 50% each cycle. Leave empty to ignore
- Size_area_1 The size of area 1 relative to area 2 (uniform distribution)
- Frac_area_1 The fraction of the unfished biomass in stock 1 (uniform distribution)
- Prob_staying The probability of individuals in area 1 remaining in area 1 over the course of one year
- Source A reference to a website or article from which parameters were taken to define the operating model

Objects from the Class

Objects can be created by calls of the form `new('Stock')`

Author(s)

T. Carruthers

Examples

```
showClass('Stock')
```

Sub

Subset MSE object by management procedure (MP) or simulation.

Description

Subset the MSE object by particular MPs (either MP number or name), or particular simulations, or a subset of the projection years (e.g., 1: < projection years).

Usage

```
Sub(MSEobj, MPs=NULL, sims=NULL, years=NULL)
```

Arguments

MSEobj	A MSE object.
MPs	A vector MPs names or MP numbers to subset the MSE object. Defaults to all MPs.
sims	A vector of simulation numbers to subset the MSE object. Can also be a logical vector. Defaults to all simulations.
years	A numeric vector of projection years. Should start at 1 and increase by one to some value equal or less than the total number of projection years.

Author(s)

A. Hordyk

SubCpars	<i>Subset an OM cpars slot</i>
----------	--------------------------------

Description

Subset the custom parameters of an operating model

Usage

```
SubCpars(OM, sims)
```

Arguments

OM	An object of class OM
sims	A logical vector OM@nsim long of simulations to either retain (TRUE) or remove (FALSE)

Value

An object of class OM

Author(s)

T. Carruthers

 SubOM

Subset a Stock, Fleet, Obs, or Imp object from an OM object

Description

A function that strips out a Stock, Fleet, Obs, or Imp object from a complete OM object. Mainly used for internal functions.

Usage

```
SubOM(OM, Sub = c("Stock", "Fleet", "Obs", "Imp"))
```

Arguments

OM	An operating model object (class OM)
Sub	A character string specifying what object type to strip out "Stock", "Fleet", "Obs", or "Imp"

Value

An object of class Stock, Fleet, Obs, or Imp

Author(s)

A. Hordyk

 summary,Data-method

Summary of Data object

Description

Summary of Data object

Usage

```
## S4 method for signature 'Data'
summary(object)
```

Arguments

object	object of class Data
--------	----------------------

summary,MSE-method	<i>Summary of MSE object</i>
--------------------	------------------------------

Description

Summary of MSE object

Usage

```
## S4 method for signature 'MSE'
summary(object)
```

Arguments

object	object of class MSE
--------	---------------------

TAC	<i>Calculate TAC recommendations for more than one MP</i>
-----	---

Description

A function that returns the stochastic TAC recommendations from a vector of data-limited MPs (Output) given a data-limited data object Data

Usage

```
TAC(Data, MPs = NA, reps = 100, timelimit = 1)
```

Arguments

Data	A data-limited methods data object
MPs	optional vector of MP names
reps	Number of repetitions
timelimit	The maximum time (seconds) taken to complete 10 reps

Author(s)

T. Carruthers

TACfilter

TAC Filter

Description

Filters vector of TAC recommendations by replacing negatives with NA and values beyond five standard deviations from the mean as NA

Usage

```
TACfilter(TAC)
```

Arguments

TAC A numeric vector of TAC recommendations

Author(s)

T. Carruthers

Targeting_Small_Fish

Targeting_Small_Fish Fleet

Description

An object of class Fleet

Usage

```
Targeting_Small_Fish
```

Format

An object of class Fleet of length 1.

Target_All_Fish	<i>Target_All_Fish Fleet</i>
-----------------	------------------------------

Description

An object of class Fleet

Usage

Target_All_Fish

Format

An object of class Fleet of length 1.

tdlnorm	<i>Calculate density of log-normally distributed random numbers</i>
---------	---

Description

Calculate density of log-normally distributed random numbers

Usage

tdlnorm(x, mu, cv)

Arguments

x	vector
mu	mean
cv	coefficient of variation

Value

numeric

Author(s)

T. Carruthers

testOM	<i>testOM OM</i>
--------	------------------

Description

An object of class OM

Usage

testOM

Format

An object of class OM of length 1.

Toothfish	<i>Toothfish Stock</i>
-----------	------------------------

Description

An object of class Stock

Usage

Toothfish

Format

An object of class Stock of length 1.

Tplot	<i>A trade-off plot for an MSE object</i>
-------	---

Description

A shorter version of the plot method for MSEs that just shows the overall trade-offs

Usage

Tplot(MSEobj, nam=NA)

Arguments

MSEobj	An object of class 'MSE'
nam	Name of the plot

Author(s)

T. Carruthers

Tplot2

*A shorter version of the plot method for MSEs that just shows the overall trade-offs***Description**

A trade-off plot for an MSE object that compares long-term yield (LTY: fraction of simulations getting over half FMSY yield in the last ten years of the projection), short-term yield (STY: fraction of simulations getting over half FMSY yield in the first ten years of the projection), variability in yield (VY: fraction of simulations where average annual variability in yield is less than 10 per cent) and biomass level (B10: the fraction of simulations in which biomass stays above 10 percent of BMSY).

Usage

```
Tplot2(MSEobj, nam=NA)
```

Arguments

MSEobj	An object of class 'MSE'
nam	Name of the plot

Author(s)

T. Carruthers

TradePlot

*Generic Trade-off Plot***Description**

Creates a trade-off plot (up to four panels) of built-in performance metrics.

Usage

```
TradePlot(MSEobj, XAxis=c('Overfishing', 'Biomass:BMSY'),
YAxis=c('Long-term Yield', 'AnnualVar'), XThresh=c(30, 80), YThresh=c(0,50),
maxVar=15, BmsyRef=0.5, B0Ref=0.2, AvailMPs=NULL, ShowLabs=FALSE,
ShowCols=TRUE)
```

Arguments

MSEobj	Object of class MSE, output of the runMSE function
XAxis	Character string describing the performance metrics for the x-axis (or x-axes if vector; max 4). Must be chosen for list of existing PMs and same length as YAxis. See PMs
YAxis	Character string describing the performance metrics for the y-axis (or y-axes if vector; max 4). Must be chosen for list of existing PMs and same length as XAxis. See PMs
XThresh	Minimum threshold values in percent (i.e., 50 = 50%) for the x-axes (must be same length as XAxis)
YThresh	Minimum threshold values in percent (i.e., 50 = 50%) for the y-axes (must be same length as YAxis)
maxVar	Reference for average annual variability in yield in percent
BmsyRef	Reference level of BMSY, in proportion, i.e., 0.5 = 0.5BMSY
B0Ref	Reference level of B0, in proportion, i.e., 0.2 = 0.2B0
AvailMPs	vector of MPs that *could* be applied to the fishery, i.e., sufficient data exists. These a plotted with different symbol
ShowLabs	Logical to specify if MP labels are shown
ShowCols	Logical to specify if background colors are shown

Details

Returns a list containing the names of performance metrics that meet the minimum performance metrics for each trade-off, and ranks the MPs by increasing distance from the top-right corner.

Author(s)

A. Hordyk

trlnorm

Generate log-normally distributed random numbers

Description

Generate log-normally distributed random numbers

Usage

```
trlnorm(reps, mu, cv)
```

Arguments

reps	number of random numbers
mu	mean
cv	coefficient of variation

Value

numeric

Author(s)

T. Carruthers

`updateMSE`*Update an MSE object with new slots*

Description

Updates an existing MSE object (class MSE) from a previous version of the DLMtool to include the new slots. The slots will be empty, but avoids the 'slot doesn't exist' error that sometimes occurs. Also works with Stock, Fleet, Obs, Imp, and Data objects.

Usage`updateMSE(MSEobj)`**Arguments**

MSEobj A MSE object from a previous version of the DLMtool. Also works with Stock, Fleet, Obs, Imp, and Data objects.

Value

An object of class matching class(MSEobj)

Author(s)

A. Hordyk

`userguide`*Open the DLMtool User Guide*

Description

Opens the DLMtool User Guide website (requires internet connection)

Usage`userguide()`

Examples

```
## Not run:
userguide()

## End(Not run)
```

validcpars	<i>Valid custom parameters (cpars)</i>
------------	--

Description

Valid custom parameters (cpars)

Usage

```
validcpars(print = TRUE)
```

Arguments

print Print the valid names for cpars?

Value

invisibly returns vector of valid cpars names

VOI	<i>Calculate Value Of Information</i>
-----	---------------------------------------

Description

A function that relates operating model parameters and parameters of the observation model to yield (by default). A user can also specific their own utility values (Ut) which is arranged in a matrix of nsim rows and nMP columns.

Usage

```
VOI(MSEobj, ncomp = 6, nbins = 8, maxrow = 8, Ut = NA, Utnam =
'Utility')
```

Arguments

MSEobj	An object of class MSE
ncomp	Maximum number of variables to examine per MP
nbins	Number of percentile bins for sampled parameters of the operating model or observation model, which is used for calculating variability in utility across the sampled range of each parameter
maxrow	maximum number of MPs per plot
Ut	A matrix of user-specified utility values of nsim rows and nMPs columns
Utnam	The name of the utility measure for plotting

Author(s)

T. Carruthers

VOI2

Calculate Value Of Information 2

Description

A function that relates operating model parameters and parameters of the observation model to relative yield (yield over last 5 years of projection relative to a 'best F' scenario that maximizes yield).

Usage

```
VOI2(MSEobj, ncomp = 6, nbins = 4, Ut = NA, Utnam = 'yield', lay = F)
```

Arguments

MSEobj	An object of class MSE
ncomp	Maximum number of observation variables to examine per MP
nbins	Number of bins for sampled observation variables used for calculating variability in utility across the sampled range of each parameter
Ut	A matrix of user-specified utility values of nsim rows and nMPs columns
Utnam	The name of the utility measure for plotting
lay	Controls whether labels are in lay terms or not

Note

VOI2 assumes that relative cost for each type of improvement in data is linearly related to the number of samples (e.g. nCAAobs) or square function of improved precision and bias e.g.: relative cost= 1/(newCV/oldCV)^2

Author(s)

T. Carruthers

 VOIplot

Yet another Value of Information Plot

Description

A function that relates parameters of the observation model and the operating model parameters to yield.

Usage

```
VOIplot(MSEobj, MPs=NA, nvars=5, nMP=4, Par=c('Obs', 'OM'),
YVar=c('Y', 'B'), doPlot=TRUE, incStat=FALSE, availMP=NULL, acceptMP=NULL,
incNames=TRUE, labcex=0.8, quants=c(0.05, 0.95))
```

Arguments

MSEobj	An object of class MSE
MPs	The MPs to plot. If NA it will plot the first nMP from MSEobj
nvars	The number of observation or operating model parameters to plot (number of columns)
nMP	The maximum number of MPs to plot (number of rows)
Par	Plot Operating Model (OM) or Observation (Obs) parameters?
YVar	Variable for Y-Axis: Yield (Y) or Biomass (B) (relative to BMSY)
doPlot	Output the plot?
incStat	Include a print out of statistic describing the curviness of the line?
availMP	Optional character string of MPs that are available. These names are colored black
acceptMP	Optional character string of MPs that are acceptable. These names are colored green if they are also in availMP
incNames	Include the names?
labcex	Character size of the label
quants	Quantiles to calculate

Value

A list of all the information included in the plot

Author(s)

A. Hordyk

wormplot	<i>Biomass wormplot</i>
----------	-------------------------

Description

A worm plot for plotting the likelihood of meeting biomass targets in future years.

Usage

```
wormplot(MSEobj, Bref=0.5, LB=0.25, UB=0.75)
```

Arguments

MSEobj	Object of class MSE, output of the runMSE function
Bref	The reference fraction of BMSY (to evaluate the probability of exceeding this level)
LB	The lower bound probability that separates red (bad) and yellow (O.K.) colored segments
UB	The upper bound probability that separates yellow (O.K.) and green (good) colored segments

Details

Returns a matrix of nMPs rows and proyears columns which is the fraction of simulations for which biomass was above Bref.

Author(s)

T. Carruthers

writeCSV	<i>Internal function to write CSVs for objects</i>
----------	--

Description

Used internally in the DLMtool package to write CSV files from an existing DLMtool object

Usage

```
writeCSV(inobj, tmpfile = NULL, objtype = c("Stock", "Fleet", "Obs", "Imp",
      "Data", "OM", "Fease"))
```

Arguments

<code>inobj</code>	A object of class Stock, Fleet, Obs, Imp, Data, OM, or Fease
<code>tmpfile</code>	The full file path and name for the saved CSV file
<code>objtype</code>	The class corresponding to the <code>inobj</code>

Author(s)

A. Hordyk

YPR

Yield Per Recruit analysis to get FMSY proxy F01

Description

A simple yield per recruit approximation to FMSY (F01) which is the position of the ascending YPR curve for which $dYPR/dF = 0.1(dYPR/d0)$

Usage

`YPR(x, Data, reps = 100)`

Arguments

<code>x</code>	A position in a data-limited methods data object
<code>Data</code>	A data-limited methods data object
<code>reps</code>	The number of samples of the TAC

Value

A numeric vector of TAC samples

Note

Based on the code of Meaghan Bryan

Author(s)

Meaghan Bryan and Tom Carruthers

References

Beverton and Holt. 1954.

YPR_CC	<i>Yield Per Recruit analysis to get FMSY proxy F01 paired to a naive catch curve estimate of recent Z</i>
--------	--

Description

A simple yield per recruit approximation to FMSY (F01) which is the position of the ascending YPR curve for which $dYPR/dF = 0.1(dYPR/d0)$ A naive catch-curve analysis is used to determine recent Z which given M (Mort) gives F and thus abundance = $Ct/(1-\exp(-F))$

Usage

```
YPR_CC(x, Data, reps = 100, Fmin=0.005)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object (class DLM)
reps	The number of samples of the TAC
Fmin	The minimum fishing mortality rate inferred from the catch-curve analysis

Author(s)

Meaghan Bryan and T. Carruthers

YPR_ML	<i>Yield Per Recruit analysis to get FMSY proxy F01 paired with a mean-length estimate of current stock size</i>
--------	--

Description

A simple yield per recruit approximation to FMSY (F01) which is the position of the ascending YPR curve for which $dYPR/dF = 0.1(dYPR/d0)$ A mean-length estimate of recent Z is used to infer current abundance

Usage

```
YPR_ML(x, Data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
Data	A data-limited methods data object
reps	The number of samples of the TAC

Note

The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'

Author(s)

Meaghan Bryan and T. Carruthers

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