DLMtool: Data-Limited Methods Toolkit (v3.2)

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SEDAR49-RD-03

June 2016

Package ‘DLMtool’

June 9, 2016

Type Package

Title Data-Limited Methods Toolkit

Version 3.2

Date 2016-06-08

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

License GPL-2

Depends R (>= 2.10.0), methods, snowfall, boot, MASS, parallel

LazyData yes

LazyLoad yes

VignetteBuilder knitr

Suggests knitr, rmarkdown

NeedsCompilation no

Imports Rcpp, abind, readxl

LinkingTo Rcpp

Repository CRAN

Date/Publication 2016-06-09 05:49:14

R topics documented:

`DLMtool-package` *Data-Limited Methods Toolkit*

Description

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

Details

Package:	DLMtool
Type:	Package
Version:	3.2
Date:	2016-06-08
License:	GPL-2
Depends:	methods

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.

Examples

```
# --- Application to real fishery data ---
library(DLMtool)
library(snowfall)             # load package for parallel computing
sfInit(parallel=TRUE,cpus=2)  # initiate the cluster with two cpus
```

```
mydata<-new('DLM_data')        # create a new DLM data object and define:
mydata@Year<-2001:2010         # years
mydata@Cat<-matrix((11:20)*10*runif(10,0.5,1.5),nrow=1) # make up some annual catches
mydata@Ind<-matrix(seq(1.1,0.9,length.out=10)*runif(10,0.5,1.5),nrow=1)
mydata@Mort<-0.2               # instantaneous natural mortality rate
mydata@Abun<-1000              # current abundance estimate (biomass)
mydata@FMSY_M<-0.5             # guess of the ratio of FMSY to natural mortality rate
mydata@vbLinf<-200             # maximum length
mydata@vbK<-0.2                # von B growth coefficient k
mydata@LFC<-50                 # length at first capture
mydata<-TAC(mydata)            # calculate quotas
plot(mydata)                   # plot them
mydata<-Sense(mydata,"Fratio") # conduct a sensitivity analysis for one of the methods

sfStop()
```

avail   *What objects of this class are available*

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 — *An MP where the TAC is average historical catch*

Description

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

Usage

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

Arguments

`x`	A position in a data-limited methods data object
`DLM_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

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

Description

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

Usage

```
BK(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object.
`DLM_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, DLM_data, reps = 100, Fmin=0.005)
```

Arguments

`x`	Position in a data-limited methods data object
`DLM_data`	A data-limited methods data object (class DLM_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 *Beddington and Kirkwood life-history analysis with mean-length estimator of current abundance*

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, DLM_data, reps = 100)
```

Arguments

x	Position in a data-limited methods data object
DLM_data	A data-limited methods data object (class DLM_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.

Can *What data-limited methods can be applied to this DLM_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(DLM_data, timelimit = 1)
```

Arguments

`DLM_data`	A data-limited methods data object (class DLM_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 requirments.

Usage

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

Arguments

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

`CC1` *Constant catch management procedure of Geromont and Butterworth (2014)*

Description

The TAC is the average catch over last yrsmth years.

Usage

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

Arguments

`x`	A position in data-limited methods data object
`DLM_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, DLM_data, reps = 100, yrsmth = 5, xx=0.3)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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 *MSE convergence diagnostic*

Description

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

Usage

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

Arguments

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

Author(s)

A. Hordyk

ChooseEffort *Manually choose the historical relative fishing effort trajectory.*

Description

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

Usage

```
ChooseEffort(FleetObj, Years=NULL)
```

Arguments

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

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 'nyears' in the Fleet object with the value defined here (FstYr:current year).

Usage

```
ChooseSelect(Fleet, Stock=NULL, 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

`comp` *Comparison plots for individual simulations*

Description

A simulation by simulation approach to plotting results

Usage

```
comp(MSEobj,MPs=NA)
```

Arguments

`MSEobj`	An object of class MSE
`MPs`	A character vector of two methods that were applied in making the MSE object

Author(s)

T. Carruthers

`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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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` *Age-composition-based estimate of current stock depletion given constant Z linked to an FMSY estimate to provide OFL (with a 40-10 rule)*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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

`CSRA` *Catch at size reduction analysis*

Description

What depletion level and corresponding equlibrium 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

`M`	A vector of natural mortality rate estimates
`h`	A vector of sampled steepness (Beverton-Holt stock recruitment)
`Linf`	A vector of maximum length (von Bertalanffy growth)
`K`	A vector of maximum growth rate (von Bertalanffy growth)
`t0`	A vector of theoretical age at length zero (von Bertalanffy growth)
`AM`	A vector of age at maturity
`a`	Length-weight conversion parameter a (W=aL^b)
`b`	Length-weight conversion parameter b (W=aL^b)
`vuln`	A matrix nsim x nage of the vulnerabilty at age (max 1) to fishing.
`mat`	A matrix nsim x nage of the maturity at age (max 1)
`ML`	A vector of 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
`maxage`	Maximum age
`nyears`	Number of historical years of fishing

Author(s)

T. Carruthers

CSRAfunc *Optimization function for CSRA*

Description

What depletion level and corresponding equlibrium 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 vulnerabilty 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, DLM_data, ...)
```

Arguments

`x`	A position in a data-limited methods data 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

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, DLM_data, ...)
```

Arguments

`x`	A position in a data-limited methods data 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

Note

Made up for this package.

Author(s)

T. Carruthers.

`DAAC` *Depletion Adjusted Average Catch*

Description

Essentially DCAC multiplied by 2*depletion and divided by BMSY/B0 (Bpeak)

Usage

```
DAAC(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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.

DBSRA *Depletion-Based Stock Reduction Analysis*

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).

Usage

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

Arguments

`x`	A position in a data-limited methods object.
`DLM_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 Bunfished.

Value

A vector of TAC (OFL) values.

Note

This is set up to return the OFL (FMSY * 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 — *Depletion-Based Stock Reduction Analysis paired with 40-10 harvest control rule*

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 paried with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished biomass.

Usage

```
DBSRA4010(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 — *Depletion-Based Stock Reduction Analysis assuming 40 per cent stock depletion*

Description

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

Usage

```
DBSRA_40(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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` *Depletion-Based Stock Reduction Analysis using mean length estimator of stock depletion*

Description

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

Usage

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

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 recomemndations 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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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` *Depletion-Based Stock Reduction Analysis using mean-length estimator of current depletion*

Description

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

Usage

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

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 *Delay - Difference Stock Assessment with UMSY and MSY leading coupled with a 40-10 harvest control rule*

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, DLM_data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
DLM_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 *Effort control version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 — *Effort control version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading that fishes at 75 per cent of FMSY*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 — *Effort searching version of DD - Delay - Difference Stock Assessment with UMSY and MSY leading that fishes at 75 per cent of FMSY*

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, DLM_data, reps = 100, LB=0.9, UB=1.1)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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)

DepF — *Depletion Corrected Fratio*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in data-limited methods data object DLM
`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.

DLMdat — *Data and Operating model objects*

Description

A dataset including objects for operating models and real data examples

Usage

```
DLMdat
```

Format

A list of 61 objects

`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

`DLM_data-class` *Class* `"DLM_data"`

Description

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

Objects from the Class

Objects can be created by calls of the form `new("DLM_data", stock)`.

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

`vbK`: The von Bertalanffy growth coefficient

`vbLinf`: Maximum length

`vbt0`: Theoretical age at length zero

`wla`: Weight-Length parameter alpha

`wlb`: 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 observaton 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 proceedure

`MPeff`: The current level of effort

`LHYear`: The last historical year of the simulation (before projection)

`Misc`: Optional list which is passed to MPs

Methods

initialize `signature(.Object = "DLM_data")`: ...

plot `signature(x = "DLM_data")`: ...

summary `signature(object = "DLM_data")`: ...

Author(s)

T. Carruthers

Examples

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

DLM_fease-class *Class* "DLM_fease"

Description

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

Objects from the Class

Objects can be created by calls of the form `new("DLM_fease", stock)`.

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

Methods

initialize `signature(.Object = "DLM_fease")`: ...

plot `signature(x = "DLM_fease")`: ...

summary `signature(object = "DLM_fease")`: ...

Author(s)

T. Carruthers

Examples

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

DLM_general-class *Class* "DLM_general"

Description

An object for storing general toolkit data. The data are stored in the right format in the slot data.

Objects from the Class

Objects can be created by calls of the form `new("DLM_general", stock)`.

Slots

`Name`**:** The name of the data

`data`**:** The data correctly formated

Methods

initialize `signature(.Object = "DLM_general")`: ...

plot `signature(x = "DLM_general")`: ...

summary `signature(object = "DLM_general")`: ...

Author(s)

T. Carruthers

Examples

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

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

DoOpt — *Optimization routine for LBSPR methods*

Description

Internal optimization routine.

Usage

```
DoOpt(StockPars, LenDat, SizeBins = NULL, mod = c("GTG", "LBSPR"))
```

Arguments

`StockPars`	Life history parameters of stock.
`LenDat`	Binned length data
`SizeBins`	Information on the length bins.
`mod`	Optional for alternative models - only "LBSPR" currently used.

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, DLM_data, reps = 100, alpha=0.4, LB=0.9, UB=1.1)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100, alpha=0.5, LB=0.9, UB=1.1)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, yrsmth=10, gg=2, reps = 100)
```

Arguments

`x`	A position in a data-limited methods object
`DLM_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.

`Fadapt` *An adaptive MP that uses trajectory in inferred suplus production and fishing mortality rate to update a TAC*

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, DLM_data, reps = 100, yrsmth = 7, gg=1)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_data`	A data-limited methods data object
`reps`	The number of TAC samples
`yrsmth`	Years over which to smooth recent estimates of surplus production
`gg`	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 — *Demographic FMSY method*

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, DLM_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

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*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 — *Demographic FMSY method using catch-curve analysis to estimate recent Z*

Description

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

Usage

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

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *Demographic FMSY method that uses mean length data to estimate recent Z*

Description

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

Usage

```
Fdem_ML(x, DLM_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

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` *MP feasibility diagnostic*

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 'DLM_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_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 <- Feasе_xl(fname="FeaseTables.xlsx", stkname="myFish")

## End(Not run)
```

`Fleet-class` *Class* `"Fleet"`

Description

The component of the operating model that controls fishing dynamics

Objects from the Class

Objects can be created by calls of the form `new("Fleet", OM)`.

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^Spat_targ (uniform distribution)

`Fsd`: 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 ot 5 percent vulnerability (uniform distribution)

`Vmaxlen`: The vulnerability of the longest (oldest) fish (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, specifiying lower limits of L5 (use `ChooseSelect` function to set these)

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

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

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

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

`VmaxUpper`: Optional vector of values of length SelYears, specifiying 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

Methods

initialize `signature(.Object = "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, DLM_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

Details

Note that you can out-performm this MP even though it has perfect information of FMSY and current abundance. The requirment 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` *A reference FMSY method that fishes at half of FMSY (uses perfect information about FMSY)*

Description

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

Usage

```
FMSYref50(x, DLM_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 (OFL) samples

Details

Note that you can out-performm 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` *A reference FMSY method that fishes at three quarters of FMSY (uses perfect information about FMSY)*

Description

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

Usage

```
FMSYref75(x, DLM_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

Details

Note that you can out-performm this method easily. The requirment 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

`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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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` *An FMSY/M ratio method paired with the 40-10 rule*

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, DLM_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

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` *A data-limited method that uses FMSY/M ratio and a naive catch-curve estimate of recent Z*

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, DLM_data, reps = 100, Fmin = 0.005)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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, DLM_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

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, DLM_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

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` *Geromont and Butterworth index slope Harvest Control Rule*

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, DLM_data, reps = 100, yrsmth = 5, lambda = 1)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *Geromont and Butterworth target CPUE and catch MP*

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, DLM_data, reps = 100, w = 0.5)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *G-control MP*

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, DLM_data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

`x`	A position in data-limited methods data object
`DLM_data`	A data-limited methods data object
`reps`	The number of quota samples
`yrsmth`	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.

`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)
`Linfc`	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

`getmov` *Optimization function to find a movement model that matches user specified movement characteristics.*

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?
```

---

getq   *Optimization function that find the catchability (q where F=qE) value required to get to user-specified stock depletion (current biomass / unfished biomass)*

Description

The user specifies the level of stock depleiton. This funciton takes the derived effort trajectories and finds the catchabiltiy to get the stock there.

Usage

```
getq(x,dep,Find,Perr,Marray,hs,
     Mat_age,Wt_age,R0,V,nyears,
     maxage,mov,Spat_targ,SRrel,
     aR,bR)
```

Arguments

x
dep
Find
Perr
Marray
hs
Mat_age
Wt_age
R0
V
nyears
maxage
mov
Spat_targ
SRrel
aR
bR

Details

Paired with qopt.

Author(s)

T. Carruthers

HDAAC *Hybrid Depletion Adjusted Average Catch*

Description

Essentially DCAC multiplied by 2*depletion and divided by BMSY/B0 (Bpeak) when below BMSY, and DCAC above BMSY

Usage

```
HDAAC(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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.

initialize-methods *~~ Methods for Function* `initialize` *~~*

Description

~~ Methods for function `initialize` ~~

Methods

`signature(.Object = "DLM")`

`signature(.Object = "Fleet")`

`signature(.Object = "MSE")`

`signature(.Object = "Observation")`

`signature(.Object = "OM")`

`signature(.Object = "Stock")`

`signature(.Object = "lmmodel")`

`signature(.Object = "DLM_fease")`

`signature(.Object = "DLM_general")`

Input *Function to run a set of input control methods*

Description

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

Usage

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

Arguments

`DLM_data`	A DLM_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

Author(s)

A. Hordyk

`Islope1` *A management procedure that incrementally adjusts the TAC to maintain a constant CPUE or relative abundance index.*

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, DLM_data, reps = 100, yrsmth = 5, lambda=0.4,xx=0.2)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *A management procedure that incrementally adjusts the TAC to maintain a constant CPUE or relative abundance index.*

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, DLM_data, reps = 100, yrsmth = 5, lambda=0.2,xx=0.4)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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, DLM_data, reps = 100,yrsmth=5,mc=0.1)
```

Arguments

x	A position in a data-limited methods data object
DLM_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, DLM_data, reps = 100,yrsmth=5,mc=0.05)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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

`Itarget1` *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.*

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, DLM_data, reps = 100, yrsmth = 5, xx=0, Imulti=1.5)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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
`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 — *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.*

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, DLM_data, reps = 100, yrsmth = 5, xx=0.3, Imulti=2.5)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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
`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` *A management procedure that incrementally adjusts the effort to reach a target CPUE / relative abundance index.*

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, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 1.5)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *A management procedure that incrementally adjusts the Effort to reach a target CPUE / relative abundance index.*

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, DLM_data, reps = 100, yrsmth = 5, xx = 0, Imulti = 2.5)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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, DLM_data, reps = 100, yrsmth = 5, mc = 0.1)
```

Arguments

x	A position in a data-limited methods data object
DLM_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

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, DLM_data, reps = 100, yrsmth = 5, mc = 0.05)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 — *Join multiple MSE objects together*

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

KalmanFilter — *Kalman filter and Rauch-Tung-Striebel smoother*

Description

Kalman filter to predict new points and smoother for time-series.

Usage

```
KalmanFilter(RawEsts, R = 1, Q = 0.1, Int = 100)
```

Arguments

`RawEsts`	Vector of numeric values to be filtered and smoothed.
`R`	Variance of sampling noise
`Q`	Variance of random walk increments
`Int`	Covariance of initial uncertainty

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,nam=NA)
```

Arguments

`MSEobj`	An object of class MSE
`maxsim`	Maximum number of simulations (lines) to plot on each panel.
`nam`	The name of the plot

Note

Apologies for the nauseating shading.

Author(s)

T. Carruthers

`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

`t0c`	Theoretical age at length zero
`Linfc`	Maximum length
`Kc`	Maximum growth rate
`Len`	Length
`maxage`	Maximum age

Value

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

Author(s)

T. Carruthers

`LBSPR` *Apply LBSPR model to time-series of catch-at-length*

Description

Apply LBSPR model to time-series of catch-at-length data, and return smoothed estimates of SPR, and relative fishing mortality (F/M).

Usage

```
LBSPR(x, DLM_data, yrsmth = 1, reps = reps)
```

Arguments

`x`	Simulation number
`DLM_data`	DLM_data object
`yrsmth`	Number of years to smooth length data - currently not used
`reps`	Currently not used

Author(s)

A. Hordyk

References

Hordyk, A.R., Ono, K., Sainsbury, K.J., Loneragan, N., and Prince, J.D. 2015. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio. ICES J. Mar. Sci. 72: 204-216.

Hordyk, A.R., Ono, K., Valencia, S.R., Loneragan, N.R., and Prince, J.D. 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES J. Mar. Sci. 72: 217-231.

LBSPRSim *Per-Recruit Length-Based Spawning Potential Ratio Simulation Model*

Description

Function that takes stock (biology) and fleet (selectivity and fishing mortality) parameters and returns expected equilibrum size strucure of the catch and spawning potential ratio.

Usage

```
LBSPRSim(StockPars, FleetPars, SizeBins = NULL, P = 0.001, Nage = 101)
```

Arguments

`StockPars`	The life-history parameters of the stock.
`FleetPars`	The relative fishing mortality (F/M) and the selectivity-at-length parameters.
`SizeBins`	Optional - specifies the maximum length bin (ToSize) and the length increment of the binned length data (Linc). If empty, Linc = 5 and ToSize = Linf + MaxSD * SDLinf
`P`	Percentage of initial cohort still alive at maximum age.
`Nage`	Maximum age of generic age-strucured model. Not sensitive, unless set too low (e.g., < 50).

Author(s)

A. Hordyk

References

Hordyk, A.R., Ono, K., Sainsbury, K.J., Loneragan, N., and Prince, J.D. 2015. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio. ICES J. Mar. Sci. 72: 204-216.

Hordyk, A.R., Ono, K., Valencia, S.R., Loneragan, N.R., and Prince, J.D. 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES J. Mar. Sci. 72: 217-231.

LBSPR_ItEff — *Length-based SPR model with HCR that iteratively adjusts Effort*

Description

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

Usage

```
LBSPR_ItEff(x, DLM_data, yrsmth = 1, reps = reps)
```

Arguments

`x`	Simulation number
`DLM_data`	DLM_data object
`yrsmth`	Number of years to smooth length data - not currently used
`reps`	Not currently used

Author(s)

A. Hordyk

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, DLM_data, yrsmth = 1, reps = reps)
```

Arguments

`x`	Simulation number
`DLM_data`	DLM_data object
`yrsmth`	Number of years to smooth length data - not currently used
`reps`	Not currently used

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, DLM_data, yrsmth = 1, reps = reps)
```

Arguments

`x`	Simulation number
`DLM_data`	DLM_data object
`yrsmth`	Number of years to smooth length data - not currently used
`reps`	Not currently used

Author(s)

A. Hordyk

---

lmmodel-class *Class* `"lmmodel"`

Description

An object for storing fitted linear model objects in this case the relationship between M, age-at-maturity and the von B. K parameter.

Objects from the Class

Objects can be created by calls of the form `new("lmmodel", stock)`.

Slots

`Name`**:** The Name of the list of linear models

`models`**:** A list of fitted linear models

Methods

initialize `signature(.Object = "lmmodel")`: ...

Author(s)

T. Carruthers

Examples

```
newdata<-new('lmmodel',"Name",new('list'))
```

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

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, DLM_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
`DLM_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` *A management procedure that incrementally adjusts the Effort according to the mean length of recent catches.*

Description

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

Usage

```
LstepCE2(x, DLM_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
`DLM_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` *A management procedure that incrementally adjusts the TAC to reach a target mean length in catches.*

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, DLM_data, reps = 100, yrsmth = 5, xx=0, xL=1.05)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *A management procedure that incrementally adjusts the TAC to reach a target mean length in catches.*

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, DLM_data, reps = 100, yrsmth = 5, xx=0.2, xL=1.15)
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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

`LtargetE1` *A management procedure that incrementally adjusts the Effort to reach a target mean length in catches.*

Description

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

Usage

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

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *A management procedure that incrementally adjusts the Effort to reach a target mean length in catches.*

Description

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

Usage

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

Arguments

`x`	A position in data-limited methods data object
`DLM_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

makePerf — *Convert a OM object to one without observation or process error*

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

matlenlim — *A data-limited method in which fishing vulnerability is set according to the maturity curve*

Description

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

Usage

```
matlenlim(x, DLM_data, ...)
```

Arguments

`x`	A position in a data-limited methods object
`DLM_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)

T. Carruthers

References

Made-up for this package

`matlenlim2` *A data-limited method in which fishing vulnerability is set slightly higher than the maturity curve*

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, DLM_data, ...)
```

Arguments

`x`	A position in a data-limited methods object
`DLM_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 *Mean Catch Depletion*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 *Mean Catch Depletion*

Description

A simple average catch-depletion MP linked to a 40-10 harvest controle 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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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

`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

A table of nsim rows and 2 columns (depletion, fishing mortality rate)

Author(s)

T. Carruthers

`movfit` *Optimization function that returns the squared difference between user specified and calculated movement parameters.*

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

`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, DLM_data, ...)
```

Arguments

x	A position in data / simulation object DLM
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 — *An marine reserve in area 1 with full reallocation of fishing effort*

Description

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

Usage

```
MRreal(x, DLM_data, ...)
```

Arguments

x	A position in data / simulation object DLM
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 — *Class* "MSE"

Description

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

Objects from the Class

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

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)

`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)

Methods

initialize `signature(.Object = "MSE")`: ...

plot `signature(x = "MSE")`: ...

Author(s)

T. Carruthers

`NAor0` *Is a value NA or zero.*

Description

As title

Usage

```
NAor0(x)
```

Arguments

`x`	A numeric value.

Value

A table of nsim rows and 2 columns (depletion, fishing mortality rate)

Author(s)

T. Carruthers

`Needed` *Data needed to get MPs running*

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(DLM_data, timelimit=1)
```

Arguments

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

Author(s)

T. Carruthers

`NFref` *No Fishing Reference MP*

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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` *National Oceanographic and Atmospheric Administration default plot 1*

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

`Observation-class` *Class* `"Observation"`

Description

An operating model component that controls the observation model

Objects from the Class

Objects can be created by calls of the form `new("Observation", OM)`.

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 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 lenght 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 lengthunfished 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 (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 realtive abundance index expressed as a coefficient of variation (uniform distirbution)

`maxagecv`: Bias in the prescription of maximum age (uniform distribution)

`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)

`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)

Methods

initialize `signature(.Object = "Observation")`: ...

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("Observation")
```

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 Observation 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.

Objects from the Class

Objects can be created by calls of the form `new("OM", Stock, Fleet, Observation)`.

Slots

`Name`: Name of the operating model

`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 beyone 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)

`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)

`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)

`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 rec(t)=AC*rec(t-1)+(1-AC)*sigma(t) (uniform distribution) `a`: Length-weight parameter alpha (uniform distribution)

`b`: Length-weight parameter beta (uniform distribution)

`D`: Current level of stock depletion (Bcurrent/Bunfished) (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 inviduals in area 1 remaining in area 1 over the course of one year

`Source`: A reference to a website or article form which parameters were taken to define the operating model

`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^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)

`SelYears`: Vector of verticies 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, specifiying lower limits of L5 (use `ChooseSelect` function to set these. Overrides L5 above)

`L5Upper`: Optional vector of values of length SelYears, specifiying upper limits of L5 (use `ChooseSelect` function to set these. Overrides L5 above)

`LFSLower`: Optional vector of values of length SelYears, specifiying lower limits of LFS (use `ChooseSelect` function to set these. Overrides LFS above)

`LFSUpper`: Optional vector of values of length SelYears, specifiying upper limits of LFS (use `ChooseSelect` function to set these. Overrides LFS above)

`VmaxLower`: Optional vector of values of length SelYears, specifiying lower limits of Vmaxlen (use `ChooseSelect` function to set these. Overrides Vmaxlen above)

`VmaxUpper`: Optional vector of values of length SelYears, specifiying 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)

`Fsd`: 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)

`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)

`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 (sigma R)(uniform distribution)

`Period`: Period for cylical 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 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 lenght 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 lengthunfished 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 (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 realtive abundance index expressed as a coefficient of variation (uniform distirbution)

`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)

Methods

initialize `signature(.Object = "OM")`: ...

Author(s)

T. Carruthers

Examples

```
showClass("OM")
```

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", and Observation parameters in a tab named "myFishObs". All three tabs (Stock, Fleet and Obs) 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)
```

`OptFun` *Objective function for LBSPR methods*

Description

Used internally to define objective function for LBSPR methods.

Usage

```
OptFun(tryFleetPars, LenDat, StockPars, SizeBins = NULL, mod = c("GTG", "LBSPR"))
```

Arguments

`tryFleetPars`	Vector of relative fishing mortality (F/M) and selectivity-at-length parameters.
`LenDat`	Binned length data
`StockPars`	Life history parameters of stock.
`SizeBins`	Information on the length bins.
`mod`	Optional for alternative models - only "LBSPR" currently used.

Author(s)

A. Hordyk

`ourMSE` *Example MSE object used in the vignette*

Description

A dummy example MSE object, with customized stock and fleet, all MPs, and 16 simulations.

Usage

```
data("ourMSE")
```

Format

The format is: Formal class 'MSE' [package "DLMtool"] with 17 slots ..@ Name : chr "Stock:Snapper Fleet:Generic_FlatE Observation model:Imprecise_Biased" ..@ nyears : num 50 ..@ proyears: num 20 ..@ nMPs : int 63 ..@ MPs : chr [1:63] "AvC" "BK" "BK_CC" "BK_ML" ... ..@ nsim : num 16 ..@ OM :'data.frame': 16 obs. of 34 variables: .. ..$ RefY : num [1:16] 50.2 120.1 50.8 67.8 78.4 ... .$ M : num [1:16] 0.213 0.239 0.217 0.243 0.241 ... .$ Depletion : num [1:16] 0.311 0.257 0.257 0.199 0.13 ... .$ A : num [1:16] 144.4 656.6 191.9 72.2 146.1 ... .$ BMSY_B0 : num [1:16] 0.325 0.325 0.325 0.296 0.306 ... .$ FMSY_M : num [1:16] 0.579 0.564 0.556 0.664 0.62 ... .$ Mgrad : num [1:16] -0.1677 -0.0985 -0.1874 0.1456 0.0794 ... .$ Msd : num [1:16] 0.0313 0.0253 0.015 0.0364 0.011 ... .$ procsd : num [1:16] 0.475 0.415 0.331 0.343 0.436

... .$ Esd : num [1:16] 0.293 0.13 0.372 0.106 0.312 ... .$ dFfinal : num [1:16] -0.009183 -0.007048 -0.006787 -0.003407 -0.000569 ... .$ MSY : num [1:16] 55.2 51.1 39.2 48.7 51.8 ... .$ qinc : num [1:16] -0.686 -0.127 1.558 0.78 0.692 ... .$ qcv : num [1:16] 0.159 0.298 0.187 0.241 0.102 ... .$ FMSY : num [1:16] 0.123 0.135 0.121 0.161 0.149 ... .$ Linf : num [1:16] 91.1 89.7 88.9 91.2 89.9 ... .$ K : num [1:16] 0.198 0.205 0.179 0.199 0.21 ... .$ t0 : num [1:16] -0.0367 -0.0296 -0.0333 -0.0322 -0.0319 ... .$ hs : num [1:16] 0.856 0.875 0.856 0.937 0.94 ... .$ Linfgrad : num [1:16] -0.185 0.0209 -0.1721 -0.185 -0.1004 ... .$ Kgrad : num [1:16] -0.0662 0.0667 0.1438 0.0726 0.1547 ... .$ Linfsd : num [1:16] 0.01334 0.01203 0.02384 0.01377 0.00404 ... .$ recgrad : num [1:16] -0.731 2.751 -4.075 -0.234 -1.097 ... .$ Ksd : num [1:16] 0.00443 0.01185 0.01474 0.00921 0.02128 ... .$ ageM : num [1:16] 2.26 1.97 2.25 2.51 2.25 ... .$ V26 : num [1:16] 12.5 10.3 10.8 13.7 11.1 ... .$ V27 : num [1:16] 32 27 31.8 34.8 30.8 ... .$ V28 : num [1:16] 0.798 0.681 0.896 0.687 0.902 ... .$ LFC : num [1:16] 13.4 13.3 10.9 12.1 12.6 ... .$ OFLreal : num [1:16] 51.4 28.4 31.1 40 22.3 ... .$ Spat_targ : num [1:16] 1 1 1 1 1 1 1 1 1 1 ... .$ Frac_area_1 : num [1:16] 0.136 0.138 0.145 0.07 0.133 ... .$ Prob_staying: num [1:16] 0.884 0.911 0.651 0.427 0.658 ... .$ AC : num [1:16] 0.569 0.717 0.763 0.572 0.8 ... ..@ Obs :'data.frame': 16 obs. of 25 variables: .. ..$ Cbias : num [1:16] 0.659 1.007 0.745 1.866 1.27 ... .$ Csd : num [1:16] 0.202 0.311 0.554 0.575 0.589 ... .$ CAA_nsamp : num [1:16] 88 59 86 71 97 81 87 80 97 99 ... .$ CAA_ESS : num [1:16] 13 19 18 19 13 12 19 15 15 18 ... .$ CAL_nsamp : num [1:16] 77.1 71.2 72.3 77.8 74 ... .$ CAL_ESS : num [1:16] 19 19 16 17 15 19 15 14 14 19 ... .$ Isd : num [1:16] 0.512 0.289 0.439 0.543 0.352 ... .$ Dbias : num [1:16] 0.621 2.023 0.765 1.325 0.648 ... .$ Derr : num [1:16] 0.0663 0.0647 0.0921 0.1788 0.1261 ... .$ Mbias : num [1:16] 1.108 1.769 1.271 0.901 0.397 ... .$ FMSY_Mbias : num [1:16] 1.208 0.98 1.189 2.058 0.583 ... .$ BMSY_B0bias: num [1:16] 0.897 0.947 0.998 0.942 0.953 ... .$ lenMbias : num [1:16] 1.087 0.898 1.067 0.821 0.842 ... .$ LFCbias : num [1:16] 0.939 0.96 0.896 1.042 0.903 ... .$ LFSbias : num [1:16] 0.977 1.006 0.926 1.252 0.76 ... .$ Abias : num [1:16] 0.331 2.987 0.272 0.231 1.854 ... .$ Aerr : num [1:16] 0.449 0.271 0.262 0.302 0.39 ... .$ Kbias : num [1:16] 0.899 1.166 1.03 1.157 0.841 ... .$ t0bias : num [1:16] 1.019 1 0.982 0.954 1.096 ... .$ Linfbias : num [1:16] 0.925 0.927 0.929 1.038 0.971 ... .$ hbias : num [1:16] 1.021 0.977 1.029 0.983 0.969 ... .$ Irefbias : num [1:16] 1.264 0.718 1.281 0.902 0.952 ... .$ Crefbias : num [1:16] 0.839 0.576 0.921 0.908 1.1 ... .$ Brefbias : num [1:16] 0.655 1.141 1.095 0.725 1.58 ... .$ betas : num [1:16] 0.389 0.521 0.366 1.689 0.357 ... ..@ B_BMSY : num [1:16, 1:63, 1:20] 1.096 0.472 0.956 0.828 0.371 ... ..@ F_FMSY : num [1:16, 1:63, 1:20] 0.447 1.344 0.802 2.214 2.207 ... ..@ B : num [1:16, 1:63, 1:20] 579 223 346 305 144 ... ..@ FM : num [1:16, 1:63, 1:20] 0.0552 0.1816 0.0969 0.3566 0.3297 ... ..@ C : num [1:16, 1:63, 1:20] 29.5 38 33.5 116.3 54 ... ..@ TAC : num [1:16, 1:63, 1:20] 29.5 38 33.5 116.3 54 ... ..@ SSB_hist: num [1:16, 1:34, 1:50, 1:2] 0.0125 0.0513 0.0463 0.0164 0.0113 ... ..@ CB_hist : num [1:16, 1:34, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ... ..@ FM_hist : num [1:16, 1:34, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ...

Examples

```
data(ourMSE)
```

`ourReefFish` *Example data object*

Description

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

Usage

```
data("ourReefFish")
```

Format

The format is: Formal class 'DLM_data' [package "DLMtool"] with 71 slots ..@ Name : chr "ourReefFish" ..@ Year : num [1:55] 1954 1955 1956 1957 1958 ... ..@ Cat : num [1, 1:55] 1.33 1.46 1.66 1.56 2.23 ... ..@ Ind : num [1, 1:55] 0.163 0.138 0.148 0.157 0.146 ... ..@ Rec : num [1, 1:55] NA NA NA NA NA NA NA NA NA NA ... ..@ t : num 54 ..@ AvC : num 1.84 ..@ Dt : num 0.545 ..@ Mort : num 0.094 ..@ FMSY_M : num 0.7 ..@ BMSY_B0 : num 0.3 ..@ Cref : num NA ..@ Bref : num NA ..@ Iref : num NA ..@ L50 : num 31.6 ..@ L95 : num 52.5 ..@ LFC : num 20 ..@ LFS : num 36 ..@ CAA : num [1, 1:21, 1:48] 0 0 0 0 0 0 0 0 0 0 ... ..@ Dep : num 0.2 ..@ Abun : num NA ..@ vbK : num 0.192 ..@ vbLinf : num 85.6 ..@ vbt0 : num -0.395 ..@ wla : num 0.0000167 ..@ wlb : num 2.95 ..@ steep : num 0.99 ..@ CV_Cat : num 0.2 ..@ CV_Dt : num 0.25 ..@ CV_AvC : num 0.2 ..@ CV_Ind : num 0.2 ..@ CV_Mort : num 0.2 ..@ CV_FMSY_M : num 0.2 ..@ CV_BMSY_B0: num 0.045 ..@ CV_Cref : num 0.2 ..@ CV_Bref : num 0.2 ..@ CV_Iref : num 0.2 ..@ CV_Rec : num 0.2 ..@ CV_Dep : num 0.25 ..@ CV_Abun : num 0.25 ..@ CV_vbK : num 0.00803 ..@ CV_vbLinf : num 0.00325 ..@ CV_vbt0 : num 0.00777 ..@ CV_L50 : num 0.1 ..@ CV_LFC : num 0.2 ..@ CV_LFS : num 0.2 ..@ CV_wla : num 0.1 ..@ CV_wlb : num 0.1 ..@ CV_steep : num 0.1 ..@ sigmaL : num 0.2 ..@ MaxAge : num 48 ..@ Units : chr "thousand tonnes" ..@ Ref : num NA ..@ Ref_type : chr NA ..@ Log :List of 1 .. ..$: chr "Created: 2016-02-18 14:28:11" ..@ params : list() ..@ PosMPs : chr [1:31] "AvC" "BK_CC" "BK_ML" "CC1" ... ..@ MPs : chr [1:31] "AvC" "BK_CC" "BK_ML" "CC1" ... ..@ OM :'data.frame': 1 obs. of 1 variable: .. ..$ NA.: logi NA ..@ Obs :'data.frame': 1 obs. of 1 variable: .. ..$ NA.: logi NA ..@ TAC : num [1:31, 1:100, 1] 1.36 15.91 1.14 3.08 1.77 ... ..@ TACbias : logi [1, 1, 1] NA ..@ Sense : logi [1, 1, 1] NA ..@ CAL_bins : num [1:44] 0 20 22 24 26 28 30 32 34 36 ... ..@ CAL : num [1, 1:28, 1:43] 0 0 2 1 0 1 0 0 0 0 ... ..@ MPrec : num NA ..@ MPeff : num NA ..@ ML : num [1, 1:55] NA NA NA NA NA NA NA NA NA NA ... ..@ Lbar : num [1, 1:55] NA NA NA NA NA NA NA NA NA NA ... ..@ Lc : num [1, 1:55] NA NA NA NA NA NA NA NA NA NA ... ..@ LHYear : num 2008 ..@ Misc : list()

Examples

```
data(ourReefFish)
str(ourReefFish) ;
plot(ourReefFish)
```

`plot-methods` ~~ *Methods for Function* `plot` ~~

Description

~~ Methods for function `plot` ~~

Methods

`signature(x = "DLM_data")`

`signature(x = "MSE")`

---

plotOFL — *A generic OFL plot for NOAA use*

Description

As title.

Usage

```
plotOFL(DLM_data,xlims=NA,perc=0.5)
```

Arguments

DLM_data	An object of class DLM_data that has been run though 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

PorgMSE — *Example MSE object used in the vignette*

Description

A dummy example MSE object, based on porgy, generic fleet and imprecise and unbiased observation model, four new MPs, and 20 simulations.

Usage

```
data("PorgMSE")
```

Format

The format is: Formal class 'MSE' [package "DLMtool"] with 17 slots ..@ Name : chr "Stock:Porgy Fleet:Generic_IncE Observation model:Imprecise_Unbiased" ..@ nyears : num 50 ..@ proyears: num 20 ..@ nMPs : int 4 ..@ MPs : chr [1:4] "AvC" "THC" "matlenlim" "area1_50" ..@ nsim : num 20 ..@ OM :'data.frame': 20 obs. of 34 variables: .. ..$ RefY : num [1:20] 44.8 101.2 119.9 84.3 126 ... .$ M : num [1:20] 0.242 0.242 0.24 0.22 0.211 ... .$ Depletion : num [1:20] 0.0791 0.37 0.5231 0.087 0.3618 ... .$ A : num [1:20] 53.7 659.3 1074.2 240.2 281.7 ... .$ BMSY_B0 : num [1:20] 0.429 0.419 0.421 0.394 0.414 ... .$ FMSY_M : num [1:20] 0.217 0.243 0.194 0.404 0.22 ... .$ Mgrad : num [1:20] 0.0556 0.0192 0.0365 0.08 -0.1671 ... .$ Msd : num [1:20] 0.08302 0.02084 0.03384 0.03472 0.00318 ... .$ procsd : num [1:20] 0.492 0.31 0.401 0.3 0.432 ... .$ Esd : num [1:20] 0.391 0.194 0.194 0.366 0.38 ... .$ dFfinal : num [1:20] 0.0276 0.0166 0.0156 0.0249 0.0181 ... .$ MSY : num [1:20] 58.1 55.8 56.5 54.6 51.9 ... .$ qinc : num [1:20] 0.501 -0.656 1.35 -1.478 1.554 ... .$ qcv : num [1:20] 0.128 0.288 0.163 0.163 0.263 ... .$ FMSY : num [1:20] 0.0526 0.059 0.0465 0.0889 0.0465 ... .$ Linf : num [1:20] 53.5 51 50.2 51.2 51.7 ... .$ K : num [1:20] 0.189 0.209 0.2 0.186 0.19 ... .$ t0 : num [1:20] -1.02 -1.01 -1.04 -1.02 -1.01 ... .$ hs : num [1:20] 0.397 0.408 0.383 0.459 0.366 ... .$ Linfgrad : num [1:20] 0.0781 0.1421 0.1478 0.1272 0.0708 ... .$ Kgrad : num [1:20] 0.0737 -0.1356 0.2391 -0.0225 -0.1415 ... .$ Linfsd : num [1:20] 0.00464 0.01446 0.0104 0.00358 0.01344 ... .$ recgrad : num [1:20] -6.94 -6.77 3.21 -8.52 1.53 ... .$ Ksd : num [1:20] 0.00384 0.02322 0.00456 0.01538 0.01945 ... .$ ageM : num [1:20] 1.47 2.59 3.16 2.75 3.15 ... .$ V26 : num [1:20] 4.42 7.94 6.13 6 10.87 ... .$ V27 : num [1:20] 21 20.3 24 23.1 24.7 ... .$ V28 : num [1:20] 0.855 0.536 0.927 0.107 0.626 ... .$ LFC : num [1:20] 12.4 12.1 12.3 12.3 13.6 ... .$ OFLreal : num [1:20] 9.24 40.85 44.74 11.03 37.62 ... .$ Spat_targ : num [1:20] 1 1 1 1 1 1 1 1 1 1 ... .$ Frac_area_1 : num [1:20] 0.1034 0.1014 0.1038 0.0979 0.1012 ... .$ Prob_staying: num [1:20] 0.976 0.976 0.937 0.986 0.926 ... .$ AC : num [1:20] 0.322 0.614 0.761 0.478 0.31 ... ..@ Obs :'data.frame': 20 obs. of 25 variables: .. ..$ Cbias : num [1:20] 1.06 1.01 1 1.04 1.01 ... .$ Csd : num [1:20] 0.55 0.399 0.288 0.406 0.373 ... .$ CAA_nsamp : num [1:20] 92 53 83 70 76 68 71 95 79 76 ... .$ CAA_ESS : num [1:20] 14 19 11 19 14 19 20 13 18 16 ... .$ CAL_nsamp : num [1:20] 90 66.6 86.8 58.2 65.1 ... .$ CAL_ESS : num [1:20] 15 17 16 13 12 15 13 18 13 17 ... .$ Isd : num [1:20] 0.439 0.563 0.571 0.21 0.512 ... .$ Dbias : num [1:20] 1.038 0.936 0.77 0.873 0.846 ... .$ Derr : num [1:20] 0.1293 0.1501 0.0756 0.1422 0.0647 ... .$ Mbias : num [1:20] 0.935 1.048 0.986 1.009 1.028 ... .$ FMSY_Mbias : num [1:20] 1.121 0.768 0.881 1.063 0.862 ... .$ BMSY_B0bias: num [1:20] 1.056 0.978 0.781 1.111 0.819 ... .$ lenMbias : num [1:20] 1.041 0.939 1.029 1.019 1.02 ... .$ LFCbias : num [1:20] 0.898 1.007 0.903 0.989 0.973 ... .$ LFSbias : num [1:20] 0.971 1.013 1.059 1.027 1.034 ... .$ Abias : num [1:20] 1.045 1.079 0.525 0.826 2.767 ... .$ Aerr : num [1:20] 0.423 0.211 0.499 0.493 0.299 ... .$ Kbias : num [1:20] 1.056 0.979 0.939 1.01 1.019 ... .$ t0bias : num [1:20] 0.994 0.943 0.985 0.993 0.995 ... .$ Linfbias : num [1:20] 0.93 1.04 1.076 0.944 0.994 ... .$ hbias : num [1:20] 0.961 0.925 1.028 1.054 1.002 ... .$ Irefbias : num [1:20] 1.117 0.979 0.869 1.027 1.146 ... .$ Crefbias : num [1:20] 0.969 1.137 0.873 1.035 0.941 ... .$ Brefbias : num [1:20] 1.015 1.015 0.871 1.023 1.004 ... .$ betas : num [1:20] 0.967 0.815 0.813 1.357 0.74 ... ..@ B_BMSY : num [1:20, 1:4, 1:20] 0.113 0.644 0.516 0.171 0.581 ... ..@ F_FMSY : num [1:20, 1:4, 1:20] 8.68 1.68 1.62 5.01 1.99 ... ..@ B : num [1:20, 1:4, 1:20] 135 783 665 190 804 ... ..@ FM : num [1:20, 1:4, 1:20] 0.4565 0.0988 0.0752 0.4454 0.0923 ... ..@ C : num [1:20, 1:4, 1:20] 73.9 65.2 50.1 61.6 64.1 ... ..@ TAC : num [1:20, 1:4, 1:20] 73.9 65.2 50.1 61.6 64.1 ... ..@ SSB_hist: num [1:20, 1:34, 1:50, 1:2] 2.37 2.28 1.18 1.48 1.64 ... ..@ CB_hist : num [1:20, 1:34, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ... ..@ FM_hist : num [1:20, 1:34, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ...

Examples

```
data(PorgMSE)
```

`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`	Name of the plot

Author(s)

T. Carruthers

`qopt` *Internal optimization function that find the catchability (q where F=qE) value required to get to user-specified stock depletion (current biomass / unfished biomass)*

Description

The user specifies the level of stock depleiton. This funciton takes the derived effort trajectories and finds the catchabiltiy to get the stock there.

Usage

```
qopt(lnq,depc,Fc,Perrc,Mc,hc,Mac,
     Wac,R0c,Vc,nyears,maxage,movc,
     Spat_targc,SRrelc,aRc,bRc,opt=T)
```

Arguments

lnq

depc

Fc

Perrc

Mc

hc

Mac

Wac

R0c

Vc

nyears

maxage

movc

Spat_targc

SRrelc

aRc

bRc

opt

Details

Paired with qopt.

Author(s)

T. Carruthers

Rcontrol *Harvest Control Rule using prior for intrinsic rate of increase*

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, DLM_data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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` *MP using prior for intrinsic rate of increase with a quadratic approximation to surplus production*

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, DLM_data, reps = 100, yrsmth = 10, gg = 2, glim = c(0.5, 2))
```

Arguments

`x`	A position in data-limited methods data object
`DLM_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.

`replic8` *Enlarge (replicate) a DLM data object to create an additional dimension for simulation / sensitivity testing*

Description

Replicates position 1 data to multiple positions for sensitivity testing etc

Usage

```
replic8(DLM_data, nrep)
```

Arguments

`DLM_data`	A data-limited methods data object
`nrep`	The number of positions to expand the DLM object to

Author(s)

T. Carruthers

`Required` *What methods need what data*

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

runInMP — *Runs input control MPs on a DLM_data object.*

Description

Function runs a MP (or MPs) of class 'DLM_input' and returns a list: input control recommendation(s) in element 1 and DLM_data object in element 2.

Usage

```
runInMP(DLM_data, MPs = NA, reps = 100)
```

Arguments

`DLM_data`	A object of class DLM_data
`MPs`	A vector of MPs of class 'DLM_input'
`reps`	Number of stochastic repititions - 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, MPs = NA, nsim = 48, proyears = 28,
       interval = 4, pstar = 0.5, maxF = 0.8,
       timelimit = 1, reps=1, custompars = 0, CheckMPs=TRUE)
```

Arguments

`OM`	An operating model object (class OM)
`MPs`	A vector of methods (character string) of class DLM_output or DLM_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.
`custompars`	A data.table with nsim rows and nparameter columns. The column names must respond to variables of the operating model or observation model see the OM and Obs slots of the MSE class for correct names and interpretation. This allows users to prescribe correlated parameters or estimates from stock assessments.
`CheckMPs`	Logical to indicate if Can function should be used to check if MPs can be run.

Value

An object of class MSE

Author(s)

T. Carruthers

`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, particulary 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 ption 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 = "1", MPs = NA, nsim = 200, proyears = 28, interval = 4, pstar = 0.5,
  maxF = 0.8, timelimit = 1, reps = 1, custompars = 0, CheckMPs = TRUE, maxsims = 64,
  name = NULL, maxCrash = 10, saveMSE = TRUE, savePack = FALSE)
```

Arguments

`OM`	An operating model object (class OM)
`MPs`	A vector of methods (character string) of class DLM_output or DLM_input. If NA all available MPs are run.
`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.
`custompars`	A data.table with nsim rows and nparameter columns. The column names must respond to variables of the operating model or observation model see the OM and Obs slots of the MSE class for correct names and interpretation. This allows users to prescribe correlated parameters or estimates from stock assessments.
`CheckMPs`	Logical to indicate if Can function should be used to check if MPs can be run
`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 four letters from the `OM` name
`maxCrash`	Maximum number of consecutive crashes before the MSE stops
`saveMSE`	Logical to indiciate if final MSEobject 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(DLM_data, MPs = NA, reps = 100, maxlines = 10, perc = 0.5)
```

Arguments

`DLM_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
`maxlines`	
`perc`	

Author(s)

T. Carruthers

SBT1 — *SBT simple MP*

Description

An MP that makes incremental adjustments to TAC recommendations based on the apparent trend in CPUE

Usage

```
SBT1(x, DLM_data, reps = 100, yrsmth=10, k1=1.5, k2=3, gamma=1)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_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
`DLM_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

`Sense` *Sensitivity analysis*

Description

A function that determines the inputs for a given data-limited method of class DLM_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(DLM_data, MP, nsense = 6, reps = 100, perc = c(0.05, 0.5, 0.95), ploty = T)
```

Arguments

`DLM_data`	A data-limited methods data object (class DLM_data)
`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` *Function to calculate cyclic recruitment pattern given user-specified values of period and amplitude.*

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

`slotlim` *An data-limited method which sets a slot limit*

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, DLM_data, ...)
```

Arguments

x	A position in a data-limited methods object
DLM_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, full selection, and maximum size limit in the 5th, 6th, and 7th elements of the vector

Author(s)

A. Hordyk

References

Made-up for this package

SnapMSE — *Example MSE object used in the vignette*

Description

A dummy example MSE object, with blue shark, generic fleet and imprecise and biased observation model, four MPs, and 16 simulations.

Usage

```
data("SnapMSE")
```

Format

The format is: Formal class 'MSE' [package "DLMtool"] with 17 slots ..@ Name : chr "Stock:Blue_shark Fleet:Generic_fleet Observation model:Imprecise_Biased" ..@ nyears : num 50 ..@ proyears: num 30 ..@ nMPs : int 4 ..@ MPs : chr [1:4] "Fratio" "DCAC" "Fdem" "DD" ..@ nsim : num 16 ..@ OM :'data.frame': 16 obs. of 34 variables: .. ..$ RefY : num [1:16] 15916 7401 10480 2887 8534 ... .$ M : num [1:16] 0.172 0.175 0.167 0.242 0.185 ... .$ Depletion : num [1:16] 0.397 0.555 0.361 0.338 0.57 ... .$ A : num [1:16] 63144 1191 34716 118 4138 ... .$ BMSY_B0 : num [1:16] 0.38 0.346 0.304 0.337 0.349 ... .$ FMSY_M : num [1:16] 0.497 0.577 0.83 0.423 0.478 ... .$ Mgrad : num [1:16] -0.1167 -0.2097 -0.0849 0.197 -0.0967 ... .$ Msd : num [1:16] 0.06411 0.08061 0.09191 0.00586 0.04776 ... .$ procsd : num [1:16] 0.248 0.213 0.152 0.233 0.25 ... .$ Esd : num [1:16] 0.315 0.398 0.214 0.333 0.38 ... .$ dFfinal : num [1:16] 0.00832 -0.00412 0.00492 0.01095 -0.00757 ... .$ MSY : num [1:16] 2573 3845 4674 2884 4262 ... .$ qinc : num [1:16] -0.331 0.525 -1.985 0.71 0.915 ... .$ qcv : num [1:16] 0.181 0.218 0.151 0.251 0.133 ... .$ FMSY : num [1:16] 0.0855 0.1011 0.1387 0.1025 0.0882 ... .$ Linf : num [1:16] 197 196 201 197 201 ... .$ K : num [1:16] 0.226 0.232 0.239 0.238 0.218 ... .$ t0 :

num [1:16] -1.032 -1.027 -0.971 -1.011 -0.959 ... .$ hs : num [1:16] 0.487 0.647 0.769 0.656 0.638 ... .$ Linfgrad : num [1:16] 0.1212 -0.0666 -0.1746 -0.1365 0.1226 ... .$ Kgrad : num [1:16] 0.0116 0.1432 -0.2061 -0.1219 -0.0717 ... .$ Linfsd : num [1:16] 0.0044 0.01507 0.02219 0.01226 0.00046 ... .$ recgrad : num [1:16] -8.58 1.41 1.21 -1.32 9.24 ... .$ Ksd : num [1:16] 0.0206 0.0245 0.0159 0.0173 0.0198 ... .$ ageM : num [1:16] 4.37 3.81 3.8 4.33 4.12 ... .$ V26 : num [1:16] 35.7 46 31.1 33.4 44 ... .$ V27 : num [1:16] 147 103 117 108 117 ... .$ V28 : num [1:16] 0.164 0.456 0.297 0.797 0.695 ... .$ LFC : num [1:16] 55.9 48.9 60 52.2 58 ... .$ OFLreal : num [1:16] 2035 4356 5837 3427 4114 ... .$ Spat_targ : num [1:16] 1 1 1 1 1 1 1 1 1 1 ... .$ Frac_area_1 : num [1:16] 0.0952 0.1028 0.0983 0.0997 0.1023 ... .$ Prob_staying: num [1:16] 0.85 0.833 0.879 0.878 0.829 ... .$ AC : num [1:16] 0.12 0.705 0.611 0.146 0.639 ... ..@ Obs :'data.frame': 16 obs. of 25 variables: .. ..$ Cbias : num [1:16] 0.604 1.099 0.787 1.049 0.999 ... .$ Csd : num [1:16] 0.375 0.289 0.429 0.512 0.262 ... .$ CAA_nsamp : num [1:16] 89 80 86 65 73 88 97 54 70 57 ... .$ CAA_ESS : num [1:16] 14 13 17 13 15 20 15 12 15 19 ... .$ CAL_nsamp : num [1:16] 77.3 70.6 78.5 96.8 73.9 ... .$ CAL_ESS : num [1:16] 20 11 17 19 16 16 20 14 15 19 ... .$ Isd : num [1:16] 0.274 0.341 0.47 0.528 0.342 ... .$ Dbias : num [1:16] 0.762 1.424 1.64 0.697 0.599 ... .$ Derr : num [1:16] 0.0747 0.0884 0.0918 0.0827 0.0928 ... .$ Mbias : num [1:16] 0.749 0.727 2.711 0.437 0.981 ... .$ FMSY_Mbias : num [1:16] 0.862 1.336 0.273 1.268 0.683 ... .$ BMSY_B0bias: num [1:16] 0.685 0.941 1.192 1.006 1.446 ... .$ lenMbias : num [1:16] 0.828 0.734 1.033 0.672 0.816 ... .$ LFCbias : num [1:16] 0.922 0.881 1.1 0.993 1.093 ... .$ LFSbias : num [1:16] 0.884 0.958 0.86 1 1.041 ... .$ Abias : num [1:16] 0.538 3.303 3.903 0.969 0.975 ... .$ Aerr : num [1:16] 0.311 0.288 0.393 0.317 0.21 ... .$ Kbias : num [1:16] 1.265 0.905 1.052 0.974 0.899 ... .$ t0bias : num [1:16] 1.043 0.956 1.091 0.994 1.103 ... .$ Linfbias : num [1:16] 0.805 0.975 0.964 0.895 1.037 ... .$ hbias : num [1:16] 0.89 0.945 0.921 1.19 1.007 ... .$ Irefbias : num [1:16] 1.928 0.836 0.845 0.581 0.706 ... .$ Crefbias : num [1:16] 0.876 1.052 0.792 0.553 0.672 ... .$ Brefbias : num [1:16] 0.334 0.458 1.194 1.003 1.656 ... .$ betas : num [1:16] 2.988 2.751 0.453 2.727 2.308 ... ..@ B_BMSY : num [1:16, 1:4, 1:30] 0.638 1.17 1.758 1.359 0.861 ... ..@ F_FMSY : num [1:16, 1:4, 1:30] 0.373 2.854 1.198 0.668 0.83 ... ..@ B : num [1:16, 1:4, 1:30] 34017 67403 97638 44286 49632 ... ..@ FM : num [1:16, 1:4, 1:30] 0.0319 0.2886 0.1661 0.0685 0.0732 ... ..@ C : num [1:16, 1:4, 1:30] 649 15647 11473 2852 3300 ... ..@ TAC : num [1:16, 1:4, 1:30] 649 15647 11473 2852 3300 ... ..@ SSB_hist: num [1:16, 1:46, 1:50, 1:2] 3.144 2.76 12.83 19.055 0.222 ... ..@ CB_hist : num [1:16, 1:46, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ... ..@ FM_hist : num [1:16, 1:46, 1:50, 1:2] 0 0 0 0 0 0 0 0 0 0 ...

Examples

```
data(SnapMSE)
```

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, DLM_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
DLM_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 straighforward to calculate the OFL based on the Schaefer productivity curve. OFL = dep x (1-dep) x r x K x 2

Usage

```
SPMSY(x, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_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
`DLM_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 DLM_data (bounds on change in abundance)
`bet`	Limits for how much the DLM_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 DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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.

`Stock-class` *Class* `"Stock"`

Description

An operating model component that specifies the parameters of the population dynamics model

Objects from the Class

Objects can be created by calls of the form `new("Stock", OM)`.

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 beyone 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)

`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)

`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)

`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 rec(t)=AC*rec(t-1)+(1-AC)*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 cylical 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 inviduals in area 1 remaining in area 1 over the course of one year

`Source`: A reference to a website or article form which parameters were taken to define the operating model

Methods

initialize `signature(.Object = "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

`summary-methods` *~~ Methods for Function* `summary` *~~*

Description

~~ Methods for function `summary` ~~

Methods

`signature(object = "DLM")`

`signature(object = "MSE")`

`TAC` *Calculate TAC recommendations for more than one MP*

Description

A function that returns the stochastic TAC recommendations from a vector of data-limited MPs (DLM_output) given a data-limited data object DLM_data

Usage

```
TAC(DLM_data, MPs = NA, reps = 100, maxlines = 6, perc = NA, xlims = NA, timelimit = 1)
```

Arguments

`DLM_data`

`MPs`

`reps`

`maxlines`

`perc`

`xlims`

`timelimit`

Author(s)

T. Carruthers

`Tplot` *A trade-off plot for an MSE object*

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 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).*

Description

A shorter version of the plot method for MSEs that just shows the overall trade-offs

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

VOI *Calculate Value Of Information*

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)
```

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

Value

A list of all the information included in the plot

Author(s)

A. Hordyk

VPA *Robust Virtual Population Analysis*

Description

A simple 2 parameter (q, terminal F) VPA. Note that this is an early version that needs more testing.

Usage

```
VPA(x, DLM_data, reps = reps)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_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 is an early version of the VPA and seems not to be working correctly at present. More testing and development is needed.

Author(s)

C. Walters (Model), R. Licandeo (R code), T. Carruthers (DLMtool implementation)

References

Method based on VPA of Carl Walters and Roberto Licandeo.

wormplot *Biomass wormplot.*

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 seperates red (bad) and yellow (O.K.) colored segments
UB	The upper bound probability that seperates 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 *Internal function to write CSVs for objects*

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", "Observation", "DLM_data",
  "OM", "DLM_fease"))
```

Arguments

`inobj`	A object of class Stock, Fleet, Observation, DLM_data, OM, or DLM_fease
`tmpfile`	The full file path and name for the saved CSV file
`objtype`	The class corresonding to the `inobj`

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, DLM_data, reps = 100)
```

Arguments

`x`	A position in a data-limited methods data object
`DLM_data`	A data-limited methods data object
`reps`	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 *Yield Per Recruit analysis to get FMSY proxy F01 paired to a naive catch curve estimate of recent Z*

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, DLM_data, reps = 100, Fmin=0.005)
```

Arguments

x	A position in a data-limited methods data object
DLM_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 *Yield Per Recruit analysis to get FMSY proxy F01 paired with a mean-length estimate of current stock size*

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, DLM_data, reps = 100)
```

Arguments

x	A position in a data-limited methods data object
DLM_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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