

Package ‘MSEtool’

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Title Management Strategy Evaluation Toolkit

Version 3.4.0

Description

Development, simulation testing, and implementation of management procedures for fisheries
(see Carruthers & Hordyk (2018) <[doi:10.1111/2041-210X.13081](https://doi.org/10.1111/2041-210X.13081)>).

License GPL-3

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stats, utils

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LinkingTo Rcpp, RcppArmadillo

BugReports <https://github.com/Blue-Matter/MSEtool/issues>

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Albacore

*Stock class objects***Description**

Example objects of class Stock

Usage

Albacore

Blue_shark

Bluefin_tuna

Bluefin_tuna_WAt1

Butterfish

Herring

Mackerel

Porgy

Rockfish

Snapper

Sole

Toothfish

Format

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

An object of class Stock of length 1.

Examples

```
avail("Stock")
```

Albacore_TwoFleet *MOM class objects*

Description

Example objects of class MOM

Usage

```
Albacore_TwoFleet
```

Format

An object of class MOM of length 1.

Examples

```
avail("MOM")
```

applyMMP	<i>Apply multi Management Procedures (class MMP) to a hierarchical list of Data class objects</i>
----------	---

Description

Apply multi Management Procedures (class MMP) to a hierarchical list of Data class objects

Usage

```
applyMMP(DataList, MP = NA, reps = 1, nsims = NA, silent = FALSE)
```

Arguments

DataList	A hierarchical list of Data objects (Fleets nested in Stocks)
MP	Name(s) of the MPs to run
reps	Number of samples
nsims	Optional. Number of simulations.
silent	Logical. Should messages be suppressed?

Value

A hierarchical list of management recommendations (object class Rec), Fleets nested in Stocks

applyMP	<i>Apply Management Procedures to an object of class Data</i>
---------	---

Description

Apply Management Procedures to an object of class Data

Usage

```
applyMP(
  Data,
  MPs = NA,
  reps = 100,
  nsims = NA,
  silent = FALSE,
  parallel = snowfall::sfIsRunning()
)
```

Arguments

Data	An object of class Data
MPs	Name(s) of the MPs to run
reps	Number of samples
nsims	Optional. Number of simulations.
silent	Logical. Should messages be suppressed?
parallel	Logical. Whether to run MPs in parallel. Can be a vector of length(MPs)

Value

A list with the first element a list of management recommendations, and the second the updated Data object

Assess2OM	<i>Reads bootstrap estimates from a stock assessment model (including VPA) into an operating model. Assess2OM is identical to VPA2OM.</i>
-----------	---

Description

A function that uses a set of bootstrap estimates of numbers-at-age, fishing mortality rate-at-age, M-at-age, weight-at-age, length-at-age and Maturity-at-age to define a fully described MSEtool operating model. The user still needs to parameterize most of the observation and implementation portions of the operating model.

Usage

```
Assess2OM(
  Name = "A fishery made by VPA2OM",
  proyears = 50,
  interval = 2,
  CurrentYr = as.numeric(format(Sys.Date(), "%Y")),
  h = 0.999,
  Obs = MSEtool::Imprecise_Unbiased,
  Imp = MSEtool::Perfect_Imp,
  naa,
  faa,
  waa,
  Mataa,
  Maa,
  laa,
  nyr_par_mu = 3,
  LowerTri = 1,
  recind = 0,
  plusgroup = TRUE,
  altinit = 0,
```



```

    fixq1 = TRUE,
    report = FALSE,
    silent = FALSE,
    ...
)

VPA20M(
  Name = "A fishery made by VPA20M",
  proyears = 50,
  interval = 2,
  CurrentYr = as.numeric(format(Sys.Date(), "%Y")),
  h = 0.999,
  Obs = MSEtool::Imprecise_Unbiased,
  Imp = MSEtool::Perfect_Imp,
  naa,
  faa,
  waa,
  Mataa,
  Maa,
  laa,
  nyr_par_mu = 3,
  LowerTri = 1,
  recind = 0,
  plusgroup = TRUE,
  altinit = 0,
  fixq1 = TRUE,
  report = FALSE,
  silent = FALSE,
  ...
)

```

Arguments

Name	Character string. The name of the operating model.
proyears	Positive integer. The number of projection years for MSE.
interval	Positive integer. The interval at which management procedures will update the management advice in runMSE , e.g., 1 = annual updates.
CurrentYr	Positive integer. The current year (final year of fitting to data)
h	The steepness of the stock-recruitment curve (greater than 0.2 and less than 1, assumed to be close to 1 to match VPA assumption). Either a single numeric or a length <code>nsim</code> vector.
Obs	The observation model (class <code>Obs</code>). This function only updates the catch and index observation error.
Imp	The implementation model (class <code>Imp</code>). This function does not update implementation parameters.
naa	Numeric array [sim, ages, year]. Numbers-at-age [first age is age zero].

faa	Numeric array [sim, ages, year]. Fishing mortality rate-at-age [first age is age zero].
waa	Numeric array [sim, ages, year]. Weight-at-age [first age is age zero].
Mataa	Numeric array [sim, ages, year]. Maturity (spawning fraction)-at-age [first age is age zero].
Maa	Numeric array [sim, ages, year]. Natural mortality rate-at-age [first age is age zero].
laa	Numeric array [sim, ages, year]. Length-at-age [first age is age zero].
nyr_par_mu	Positive integer. The number of recent years that natural mortality, age vulnerability, weight, length and maturity parameters are averaged over for defining future projection conditions.
LowerTri	Integer. The number of recent years for which model estimates of recruitment are ignored (not reliably estimated by the assessment)
recind	Positive integer. The first age class that fish 'recruit to the fishery'. The default is 0 - ie the first position in the age dimension of naa is age zero
plusgroup	Logical. Does the assessment assume that the oldest age class is a plusgroup?
altinit	Integer. Various assumptions for how to set up the initial numbers. 0: standard, 1: no plus group, 2: temporary fix for MSEtool plus group initialization
fixq1	Logical. Should q be fixed (ie assume the F-at-age array faa is accurate?)
report	Logical, if TRUE, a diagnostic will be reported showing the matching of the OM reconstructed numbers at age vs the assessment.
silent	Whether to silence messages to the console.
...	Additional arguments, including R0 (unfished recruitment), phi0 (unfished spawners per recruit associated with R0 and h for calculating stock recruit parameters), Perr (recruitment standard deviation for sampling future recruitment), and AC (autocorrelation in future recruitment deviates). For all, either a numeric or a length nsim vector.

Details

Use a seed for the random number generator to sample future recruitment.

Value

An object of class [OM](#).

Author(s)

T. Carruthers

See Also

[SS2OM](#)

Atlantic_mackerel *Data class objects*

Description

Example objects of class Data

Usage

Atlantic_mackerel

China_rockfish

Cobia

Example_datafile

Gulf_blue_tilefish

ourReefFish

Red_snapper

Simulation_1

Format

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

An object of class Data of length 1.

Examples

```
avail("Data")
```

`avail`*What objects of this class are available*

Description

Generic class finder

Usage

```
avail(classy, package = NULL, msg = TRUE)
```

Arguments

<code>classy</code>	A class of object (character string, e.g. 'Fleet')
<code>package</code>	Optional. Names(s) of the package to search for object of class <code>classy</code> . String Default is all openMSE packages. Always searches the global environment as well.
<code>msg</code>	Print messages?

Details

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

Author(s)

T. Carruthers

See Also

[Can Cant avail](#)

Examples

```
avail("OM", msg=FALSE)
Stocks <- avail("Stock")
Fleets <- avail("Fleet")
MPs <- avail("MP")
```

Awatea2OM	<i>Reads MCMC estimates from Awatea (Paul Starr) processed r file structure into an operating model</i>
-----------	---

Description

A function that generates an operating model from the MCMC samples of an Awatea model. Code optimized for the BC Pacific ocean perch assessment (Haigh et al. 2018).

Usage

```
Awatea2OM(
  AwateaDir,
  nsim = 48,
  proyears = 50,
  Name = "OM made by Awatea2OM",
  Source = "No source provided",
  Author = "No author provided",
  verbose = TRUE
)
```

Arguments

AwateaDir	A folder with Awatea files
nsim	The number of simulations
proyears	The number of projection years for the MSE
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
Author	Who did the assessment
verbose	Return detailed messages?

Details

This function averages biological parameters across sex and then sends arrays to [VPA2OM](#), assumes unfish status ($B/B0 = 1$) in the first year, and assumes a single fishing fleet.

Author(s)

Q. Huynh and T. Carruthers

References

Haigh, R., et al. 2018. Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2017. Canadian Science Advisory Secretariat (CSAS) Research Document 2018/038. 232 pp. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2018/2018_038-eng.html

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

Description

Boxplot of TAC recommendations

Usage

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

Arguments

x	An object of class MSE
upq	Upper quantile of TACs for max ylim
lwq	Lower quantile of TACs for min ylim
ylim	Optional numeric vector of length 2 to specify limits of y-axis.
outline	Logical. Include outliers in plot?
col	Optional colours to pass to boxplot
...	Optional additional arguments passed to boxplot

Value

Returns a data frame containing the information shown in the plot

Author(s)

A. Hordyk

calcRefYield	<i>Calculate Reference Yield</i>
--------------	----------------------------------

Description

Calculate Reference Yield

Usage

```
calcRefYield(x, StockPars, FleetPars, pyears, Ncurr, nyears, proyears)
```

Arguments

x	Integer, the simulation number
StockPars	List of Stock Parameters
FleetPars	List of Fleet Parameters
pyears	The number of years to project forward. Equal to 'nyears' for optimizing for q.
Ncurr	Array with current numbers-at-age (dim=c(nsim, maxage+1, nareas))
nyears	Number of historical years
proyears	Number of projection years

Author(s)

A. Hordyk

CALsimp

Simplifies the CAL slot of data object

Description

A function that condenses the number of catch-at-length bins in a data object

Usage

```
CALsimp(Data, nbins = 10, simno = 1)
```

Arguments

Data	An object of class 'Data'.
nbins	Integer. The target number of catch at length bins
simno	Integer. An optional argument to specify the simulation number if writing simulated data

Author(s)

T. Carruthers

Can *Identify management procedures (MPs) based on data availability*

Description

Diagnostic tools that look up the slot requirements of each MP and compares to the data available in the Data object.

Usage

```
Can(Data, timelimit = 1, MPs = NA, dev = FALSE, silent = FALSE)
```

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

```
DLMdiag(
  Data,
  command = c("available", "not available", "needed"),
  reps = 5,
  timelimit = 1,
  funcs1 = NA,
  dev = FALSE,
  silent = FALSE
)
```

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

Arguments

Data	A data-limited methods data object (class Data)
timelimit	The maximum time (seconds) taken for an MP to undertake 5 reps (this filters out methods that are too slow)
MPs	Optional list of MP names
dev	Logical. Run in development mode?
silent	Logical Display messages?
command	What to calculate? Character. Options = c("available", "not available", "needed")
reps	The number of replicates for the MP
funcs1	A character vector of the MP names (optional)

Functions

- Can: Identifies MPs that have the correct data, do not produce errors, and run within the time limit.
- Cant: Identifies MPs that don't have sufficient data, lead to errors, or don't run in time along with a list of their data requirements.

- `DLMDiag`: Internal function called by `Can` and `Cant`
- `Needed`: Identifies what data are needed to run the MPs that are currently not able to run given a `Data` object

See Also

[avail Data](#)

Examples

```
CanMPs <- Can(MSEtool::Cobia)
CantMPs <- Cant(MSEtool::Cobia)
Needs <- Needed(MSEtool::Cobia)
```

CheckDuplicate	<i>Check for duplicated MPs names</i>
----------------	---------------------------------------

Description

Custom MPs cannot have the same names of MPs in `MSEtool` and related packages

Usage

```
CheckDuplicate(MPs)
```

Arguments

`MPs` Character vector of MP names

Value

An error if duplicated MP names, otherwise nothing

CheckMPs	<i>Check that specified MPs are valid and will run on MSE-tool::SimulatedData</i>
----------	---

Description

Check that specified MPs are valid and will run on `MSEtool::SimulatedData`

Usage

```
CheckMPs(MPs = NA, silent = FALSE)
```

Arguments

MPs	Character vector of MP names
silent	Logical. Report messages?

Value

MP names

checkMSE *Utility functions for MSE objects*

Description

Utility functions for MSE objects

Usage

```
checkMSE(MSEobj)

joinMSE(MSEobjs = NULL)

joinHist(Hist_List)

updateMSE(MSEobj, save.name = NULL)
```

Arguments

MSEobj	A MSE object
MSEobjs	A list of MSE objects
Hist_List	A list of objects of class Hist
save.name	Character string. Optional file name to save the updated MSE object to disk.

Value

An object of class MSE
 A new object of class Hist

Functions

- `checkMSE`: Check that an MSE object includes all slots in the latest version of DLMtool
- `joinMSE`: Joins two or more MSE objects together. MSE objects must have identical number of historical years, and projection years. Also works for Hist objects returned by `runMSE(Hist=TRUE)`
- `joinHist`: Join objects of class Hist
- `updateMSE`: Updates an existing MSE object (class MSE) from a previous version of the DLMtool to include slots new to the latest version. Also works with Stock, Fleet, Obs, Imp, and Data objects. The new slots will be empty, but avoids the 'slot doesn't exist' error that sometimes occurs. Returns an object of class matching `class(MSEobj)`

Author(s)

A. Hordyk

Choose

*Manually map parameters for the historical period of operating model***Description**

Interactive plots to specify trends and variability in fishing effort, fleet selectivity, and natural mortality for the operating model.

Usage

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

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

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

Arguments

Fleet	A fleet object.
Years	An optional vector of years. Should be nyears long.
OM	An object of class 'OM'
type	A character string - is M to be mapped by 'age' or 'length'?
x	Optional vector for x-axis
y	Optional vector for y-axis
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).

Details

ChooseEffort	Interactive plot which allows users to specify the relative trajectory and variability in the historical fishing effort
ChooseM	Interactive plot which allows users to specify M by age or size class
ChooseSelect	Input the first historical year, and all years where selectivity pattern changed (separated by comma). Interact

Value

ChooseEffort and ChooseSelect return a Fleet object while ChooseM returns an OM object.

Author(s)

A. Hordyk

CombineMMP	<i>Create a blank MP recommendations object (class Rec) of the right dimensions</i>
------------	---

Description

Create a blank MP recommendations object (class Rec) of the right dimensions

Usage

CombineMMP(temp, nareas)

Arguments

temp	A list of nsim simulations.
nareas	The number of areas.

Author(s)

T. Carruthers

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

Description

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

Usage

```

Converge(
  MSEobj,
  PMs = c("Yield", "P10", "AAVY"),
  maxMP = 15,
  thresh = 0.5,
  ref.it = 20,
  inc.leg = FALSE,
  all.its = FALSE,
  nrow = NULL,
  ncol = NULL,
  silent = FALSE
)

```

Arguments

MSEobj	An MSE object of class 'MSE'
PMs	A character vector of names of the PM methods or a list of the PM methods
maxMP	Maximum number of MPs to include in a single plot
thresh	The convergence threshold. Maximum root mean square deviation over the last <code>ref.it</code> iterations
ref.it	The number of iterations to calculate the convergence statistics. For example, a value of 20 means convergence diagnostics are calculated over last 20 simulations
inc.leg	Logical. Should the legend be displayed?
all.its	Logical. Plot all iterations? Otherwise only $(\text{nsim} - \text{ref.it}) : \text{nsim}$
nrow	Numeric. Optional. Number of rows
ncol	Numeric. Optional. Number of columns
silent	Hide the messages printed in console?

Details

Performance metrics are plotted against the number of simulations. Convergence diagnostics are calculated over the last `ref.it` (default = 20) iterations. The convergence diagnostics are:

1. Is the order of the MPs stable over the last `ref.it` iterations?
2. Is the average difference in performance statistic over the last `ref.it` iterations $<$ `thresh`?

By default three commonly used performance metrics are used:

1. Average Yield Relative to Reference Yield
2. Probability Spawning Biomass is above 0.1BMSY
3. Probability Average Annual Variability in Yield is $<$ 20 per cent

Additional or alternative performance metrics objects can be supplied. Advanced users can develop their own performance metrics.

Value

A table of convergence results for each MP

Author(s)

A. Hordyk

Examples

```
## Not run:
MSE <- runMSE()
Converge(MSE)

## End(Not run)
```

Cos_thresh_tab	<i>Current default thresholds for COSEWIC satisficing</i>
----------------	---

Description

Current default thresholds for COSEWIC satisficing

Usage

```
Cos_thresh_tab(Ptab1)
```

Arguments

Ptab1 A COSEWIC performance table made by COSEWIC_tab()

Author(s)

T. Carruthers

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

Description

Internal function for checking that the OM@cpars is formatted correctly

Usage

```
cparscheck(cpars)
```

Arguments

`cpars` a list of model parameters to be sampled (single parameters are a vector `nsim` long, first dimension of matrices and arrays must be `nsim`)

Value

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

Author(s)

T. Carruthers

Cplot

Plot the median biomass and yield relative to last historical year

Description

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

Usage

```
Cplot(
  MSEobj,
  MPs = NA,
  lastYrs = 5,
  point.size = 2,
  lab.size = 4,
  axis.title.size = 12,
  axis.text.size = 10,
  legend.title.size = 12
)
```

Arguments

`MSEobj` An object of class MSE

`MPs` Optional vector of MPs to plot

`lastYrs` Numeric. Last number of years to summarize results.

`point.size` Size of the points

`lab.size` Size of labels

`axis.title.size` Axis title size

`axis.text.size` Axis text size

`legend.title.size` Legend title size

Examples

```
## Not run:
MSE <- runMSE()
Cplot(MSE)

## End(Not run)
```

Data-class

Class 'Data'

Description

An object for storing fishery data for analysis

Slots

Name The name of the Data object. Single value. Character string

Common_Name Common name of the species. Character string

Species Scientific name of the species. Genus and species name. Character string

Region Name of the general geographic region of the fishery. Character string

LHYear The last historical year of the simulation (before projection). Single value. Positive integer

MPrec The previous recommendation of a management procedure. Vector of length nsim. Positive real numbers

Units Units of the catch/absolute abundance estimates. Single value. Character string

MPeff The current level of effort. Vector of length nsim. Positive real numbers

nareas Number of fishing areas. Vector of length nsim. Non-negative integer

MaxAge Maximum age. Vector nsim long. Positive integer

Mort Natural mortality rate. Vector nsim long. Positive real numbers

CV_Mort Coefficient of variation in natural mortality rate. Vector nsim long. Positive real numbers

vbLinf Maximum length. Vector nsim long. Positive real numbers

CV_vbLinf Coefficient of variation in maximum length. Vector nsim long. Positive real numbers

vbK The von Bertalanffy growth coefficient K. Vector nsim long. Positive real numbers

CV_vbK Coefficient of variation in the von Bertalanffy K parameter. Vector nsim long. Positive real numbers

vbt0 Theoretical age at length zero. Vector nsim long. Non-positive real numbers

CV_vbt0 Coefficient of variation in age at length zero. Vector nsim long. Positive real numbers

w1a Weight-Length parameter alpha. Vector nsim long. Positive real numbers

CV_w1a Coefficient of variation in weight-length parameter a. Vector nsim long. Positive real numbers

w1b Weight-Length parameter beta. Vector nsim long. Positive real numbers

- CV_wlb Coefficient of variation in weight-length parameter b . Vector n_{sim} long. Positive real numbers
- steep Steepness of stock-recruitment relationship. Vector n_{sim} long. Value in the range of one-fifth to 1
- CV_steep Coefficient of variation in steepness. Vector n_{sim} long. Positive real numbers
- sigmaR Recruitment variability. Vector n_{sim} long. Positive real numbers
- CV_sigmaR Coefficient of variation in recruitment variability. Vector n_{sim} long. Positive real numbers
- L50 Length at 50 percent maturity. Vector n_{sim} long. Positive real numbers
- CV_L50 Coefficient of variation in length at 50 per cent maturity. Vector n_{sim} long. Positive real numbers
- L95 Length at 95 percent maturity. Vector n_{sim} long. Positive real numbers
- LenCV Coefficient of variation of length-at-age (assumed constant for all age classes). Vector n_{sim} long. Positive real numbers
- LFC Length at first capture. Vector n_{sim} long. Positive real numbers
- CV_LFC Coefficient of variation in length at first capture. Vector n_{sim} long. Positive real numbers
- LFS Shortest length at full selection. Vector n_{sim} long. Positive real numbers
- CV_LFS Coefficient of variation in length at full selection. Vector n_{sim} long. Positive real numbers
- Vmaxlen Vulnerability of individuals at asymptotic length. Vector n_{sim} long. Real number between 0 and 1.
- Year Years that corresponding to catch and relative abundance data. Vector n_{years} long. Positive integer
- Cat Total annual catches. Matrix of n_{sim} rows and n_{years} columns. Non-negative real numbers
- CV_Cat Coefficient of variation in annual catches. Matrix n_{sim} rows and either 1 or n_{year} columns. Positive real numbers. Note: built-in MPs use only the first value of CV_Cat for all years.
- Effort Annual fishing effort. Matrix of n_{sim} rows and n_{years} columns. Non-negative real numbers
- CV_Effort Coefficient of variation in annual effort. Matrix n_{sim} rows and either 1 or n_{year} columns. Positive real numbers. Note: built-in MPs use only the first value of CV_Effort for all years.
- Ind Relative total abundance index. Matrix of n_{sim} rows and n_{years} columns. Non-negative real numbers
- CV_Ind Coefficient of variation in the relative total abundance index. Matrix n_{sim} rows and either 1 or n_{year} columns. Positive real numbers. Note: built-in MPs use only the first value of CV_Ind for all years
- SpInd Relative spawning abundance index. Matrix of n_{sim} rows and n_{years} columns. Non-negative real numbers
- CV_SpInd Coefficient of variation in the relative spawning abundance index. Matrix n_{sim} rows and either 1 or n_{year} columns. Positive real numbers.
- VInd Relative vulnerable abundance index. Matrix of n_{sim} rows and n_{years} columns. Non-negative real numbers
- CV_VInd Coefficient of variation in the relative vulnerable abundance index. Matrix n_{sim} rows and either 1 or n_{year} columns. Positive real numbers.

- AddInd** Optional additional indices. Array of dimensions *nsim*, *n* additional indices, and *nyears* (length Year).
- CV_AddInd** Coefficient of variation for additional indices. Array of same dimensions as **AddInd**
- AddIndV** Vulnerability-at-age schedules for the additional indices. Array with dimensions: *nsim*, *n* additional indices, *MaxAge*+1.
- AddUnits** Units for the additional indices - biomass (1; default) or numbers (0). Numeric vector length *n.ind*.
- AddIndType** Index calculated from total stock (1, default), spawning stock (2), or vulnerable stock (3). Numeric vector of length *n.ind*
- Rec** Recent recruitment strength. Matrix of *nsim* rows and *nyears* columns. Non-negative real numbers
- CV_Rec** Log-normal CV for recent recruitment strength. Matrix *nsim* rows and either 1 or *nyear* columns. Positive real numbers. Note: built-in MPs use only the first value of **CV_Rec** for all years.
- ML** Mean length time series. Matrix of *nsim* rows and *nyears* columns. Non-negative real numbers
- Lc** Modal length of catches. Matrix of *nsim* rows and *nyears* columns. Positive real numbers
- Lbar** Mean length of catches over **Lc**. Matrix of *nsim* rows and *nyears* columns. Positive real numbers
- VuIn_CAA** Optional vulnerability-at-age schedule for catch-at-age samples. Used to condition OM for closed-loop simulation testing. Replaces the fleet selectivity schedule in the OM used to generate CAA samples. Matrix with dimensions *nsim* x *MaxAge*+1.
- CAA** Catch at Age data (numbers). Array of dimensions *nsim* x *nyears* x *MaxAge*+1. Non-negative integers
- VuIn_CAL** Optional vulnerability-at-length schedule for catch-at-length samples. Used to condition OM for closed-loop simulation testing. Replaces the fleet selectivity schedule in the OM used to generate CAL samples. Matrix with dimensions *nsim* x length(CAL_mids).
- CAL_bins** The values delimiting the length bins for the catch-at-length data. Vector. Non-negative real numbers
- CAL_mids** The values of the mid-points of the length bins. Optional, calculated from **CAL_bins** if not entered. Vector. Non-negative real numbers.
- CAL** Catch-at-length data. An array with dimensions *nsim* x *nyears* x length(CAL_mids). Non-negative integers. By default the CAL data will be the retained lengths (i.e, not including discards). If `OM@control$CAL=="removals"` then the CAL data will include all removals (retained + discards).
- Dep** Stock depletion $SSB(\text{current})/SSB(\text{unfished})$. Vector *nsim* long. Fraction.
- CV_Dep** Coefficient of variation in current stock depletion. Vector *nsim* long. Positive real numbers
- Abun** An estimate of absolute current vulnerable abundance. Vector *nsim* long. Positive real numbers
- CV_Abun** Coefficient of variation in estimate of absolute current stock size. Vector *nsim* long. Positive real numbers
- SpAbun** An estimate of absolute current spawning stock abundance. Vector *nsim* long. Positive real numbers

CV_SpAbun Coefficient of variation in estimate of absolute spawning current stock size. Vector nsim long. Positive real numbers
 FMSY_M An assumed ratio of FMSY to M. Vector nsim long. Positive real numbers
 CV_FMSY_M Coefficient of variation in the ratio in FMSY/M. Vector nsim long. Positive real numbers
 BMSY_B0 The most productive stock size relative to unfished. Vector nsim long. Fraction
 CV_BMSY_B0 Coefficient of variation in the position of the most productive stock size relative to unfished. Vector nsim long. Positive real numbers
 Cref Reference or target catch level (eg MSY). Vector of length nsim. Positive real numbers
 CV_Cref Log-normal CV for reference or target catch level. Vector of length nsim. Positive real numbers
 Bref Reference or target biomass level (eg BMSY). Vector of length nsim. Positive real numbers
 CV_Bref Log-normal CV for reference or target biomass level. Vector of length nsim. Positive real numbers
 Iref Reference or target relative abundance index level (eg BMSY / B0). Vector of length nsim. Positive real numbers
 CV_Iref Log-normal CV for reference or target relative abundance index level. Vector of length nsim. Positive real numbers
 t The number of years corresponding to AvC and Dt. Single value. Positive integer
 AvC Average catch over time t. Vector nsim long. Positive real numbers
 CV_AvC Coefficient of variation in average catches over time t. Vector nsim long. Positive real numbers
 Dt Depletion over time t $SSB(now)/SSB(now-t+1)$. Vector nsim long. Fraction
 CV_Dt Coefficient of variation in depletion over time t. Vector nsim long. Positive real numbers
 Ref A reference management level (eg a catch limit). Single value. Positive real number
 Ref_type Type of reference management level (eg 2009 catch limit). Single value. Character string
 Log A record of events. Single value. Character string
 params A place to store estimated parameters. An object. R list
 PosMPs The methods that can be applied to these data. Vector. Character strings
 TAC The calculated catch limits (function TAC). An array with dimensions PosMPs x replicate TAC samples x nsim. Positive real numbers
 Sense The results of the sensitivity analysis (function Sense). An array with dimensions PosMPs x sensitivity increments. Positive real numbers
 MPs The methods that were applied to these data. Vector. Character strings
 OM A table of operating model conditions. R table object of nsim rows. Real numbers
 Obs A table of observation model conditions. R table object of nsim rows. Real numbers
 Misc Other information for MPs. An object. R list

Objects from the Class

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

Author(s)

T. Carruthers and A. Hordyk

Examples

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

Data2csv	<i>Converts a Data object into a .csv data file</i>
----------	---

Description

A function that writes a correctly formatted .csv file from a DLMtool / MSEtool Data object

Usage

```
Data2csv(Data, file = NULL, simno = 1, overwrite = F, keepNAs = T)
```

Arguments

Data	An object of class 'Data'.
file	Character string. The name of the location and file you wish to create (e.g. "C:/temp/mydata.csv")
simno	Integer. An optional argument to specify the simulation number if writing simulated data
overwrite	Boolean. Should existing data files be automatically overwritten.
keepNAs	Boolean. Should slots with NAs still be written to the data file.

Author(s)

T. Carruthers

DataDescription	<i>DataDescription</i>
-----------------	------------------------

Description

A data.frame with description of slots for class Data

Usage

```
DataDescription
```

Format

An object of class data.frame with 94 rows and 2 columns.

DataDir	<i>Directory of the data in the installed package on your computer</i>
---------	--

Description

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

Usage

```
DataDir(stock = NA)
```

Arguments

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

Value

The file path to the object

Author(s)

T. Carruthers

Examples

```
## Not run:
tilefish_location <- DataDir("Gulf_blue_tilefish")
tilefish_Data <- new("Data", tilefish_location)

## End(Not run)
```

DataInit	<i>Initialize Data Input Files</i>
----------	------------------------------------

Description

Creates template for the Data input file (Excel or CSV) and Data documentation file (Markdown) in the working directory or the directory specified by the `dir` argument

Usage

```
DataInit(name = "Data", ext = c("xlsx", "csv"), overwrite = FALSE, dir = NULL)
```

Arguments

name	Name of the data input files. Default is 'Data'. Use 'Example' to create populated example Data Input and Data Documentation files.
ext	Optional file extension for input file. 'xlsx' (default) or 'csv'
overwrite	Logical. Overwrite existing files?
dir	Optional directory path to create the Data files. Default is 'getwd()'

Value

Nothing. Creates template data files in the working directory.

Author(s)

A. Hordyk

Examples

```
## Not run:
DataInit("Example") # populated example
DataInit("myData") # empty template

## End(Not run)
```

DataSlots

DataSlots

Description

Dataframe with details of slots in Dat object

Usage

```
DataSlots
```

Format

An object of class `tbl_df` (inherits from `tbl`, `data.frame`) with 101 rows and 4 columns.

`Data_xl`*Read in Data object from Excel spreadsheet*

Description

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

Usage

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

Arguments

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

Details

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

Value

A object of class Data

Author(s)

A. Hordyk

Examples

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

DecE_Dom

Fleet class objects

Description

Example objects of class Fleet

Usage

DecE_Dom

DecE_HDom

DecE_NDom

FlatE_Dom

FlatE_HDom

FlatE_NDom

Generic_DecE

Generic_FlatE

Generic_Fleet

Generic_IncE

IncE_HDom

IncE_NDom

Low_Effort_Non_Target

Target_All_Fish

Targeting_Small_Fish

Format

An object of class Fleet of length 1.

An object of class Fleet of length 1.

An object of class Fleet of length 1.

An object of class Fleet of length 1.

An object of class Fleet of length 1.

An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.
An object of class Fleet of length 1.

Examples

```
avail("Fleet")
```

DFO_bar

Department of Fisheries and Oceans stock status bar plot

Description

A plot of biomass relative to BMSY over projected years

Usage

```
DFO_bar(MSEobj, yres = 10)
```

Arguments

MSEobj	An MSE object of class MSE produced by DLMtool function runMSE
yres	Integer: the year interval over which to calculate B/BMSY in future years

Author(s)

T. Carruthers

DFO_hist

Department of Fisheries and Oceans historical plot

Description

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

Usage

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

Arguments

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

Author(s)

T. Carruthers

DFO_plot

Department of Fisheries and Oceans trade-off plot

Description

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

Usage

```
DFO_plot(MSEobj, zero_origin = T)
```

Arguments

MSEobj	An MSE object of class MSE produced by DLMtool function runMSE
zero_origin	Logical: should plots have a zero-zero origin?

Author(s)

T. Carruthers

DFO_plot2

Department of Fisheries and Oceans default plot 2

Description

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

Usage

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

Arguments

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

Value

A table of performance metrics.

Author(s)

T. Carruthers

DFO_proj

Department of Fisheries and Oceans projection plot

Description

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

Usage

```
DFO_proj(MSEobj, maxplot = 6)
```

Arguments

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

Author(s)

T. Carruthers

DFO_quant

*Department of Fisheries and Oceans biomass quantile plot***Description**

A plot of biomass relative to BMSY quantiles over projected years

Usage

```

DFO_quant(
  MSEobj,
  maxcol = 6,
  qcol = rgb(0.4, 0.8, 0.95),
  lcol = "dodgerblue4",
  curyr = 2018,
  quants = c(0.05, 0.25, 0.75, 0.95),
  addline = T,
  forreport = T
)

```

Arguments

MSEobj	An MSE object of class MSE produced by DLMtool function runMSE
maxcol	Integer how many columns for panel plots?
qcol	A color, the quantile coloration
lcol	A color, the mean B/BMSY line
curyr	The current calendar year
quants	A vector 2 long for the quantiles e.g. 0.1 and 0.9 for the 10th and 90th quantiles
addline	Should two individual example simulations be added to the plot?
forreport	Logical. Is it for a report? If true, one plot of six MPs in a row will be provided one after another.

Author(s)

T. Carruthers

DFO_report	<i>Create a standard DFO MSE report</i>
------------	---

Description

Provides performance plots typical in the assessment of Canadian fish stocks.

Usage

```
DFO_report(
  MSEobj,
  output_file = NA,
  author = "Author not specified",
  title = NA,
  maxMPs = 15
)
```

Arguments

MSEobj	An object of class MSE
output_file	The directory and filename you wish to use for the report e.g. "C:/temp/myMSEreport.html"
author	The person who made this report
title	The title of the report
maxMPs	Maximum number of MPs to plot

Author(s)

T. Carruthers

DFO_spider	<i>DFO performance spider plot (top three MPs)</i>
------------	--

Description

DFO performance spider plot (top three MPs)

Usage

```
DFO_spider(MSEobj)
```

Arguments

MSEobj	An object of class MSE produced by DLMtool::runMSE()
--------	--

Author(s)

T. Carruthers

DFO_tab	<i>Create a standard DFO performance table</i>
---------	--

Description

P_Cr_S is the probability of being in the critical zone in the first 10 projected years P_Ct_S is the probability of being in the cautious zone in the first 10 projected years P_H_S is the probability of being in the healthy zone in the first 10 projected years POF_S is the probability of overfishing in the first 10 projected years STY is the mean yield relative to FMSY management over the first 10 projected years P_Cr_L is the probability of being in the critical zone in the last 10 projected years P_Ct_L is the probability of being in the cautious zone in the last 10 projected years P_H_L is the probability of being in the healthy zone in the last 10 projected years POF_L is the probability of overfishing in the last 10 projected years LTY is the mean yield relative to FMSY management over the last 10 projected years AAVY is the average annual variability in yield over the whole projection phrased as a CV percentage P_Reb is the probability the stock has rebuilt to over BMSY in 2 mean generation times

Usage

```
DFO_tab(MSEobj, maxMPs = 15, rnd = 0)
```

Arguments

MSEobj	An object of class MSE
maxMPs	Integer: the maximum number of top ranking MPs to include in the table (ranked by long term yield)
rnd	The number of significant figures for rounding.

Author(s)

T. Carruthers

DFO_tab_formatted	<i>A formatted version of the standard DFO performance plot, color coded by thresholds</i>
-------------------	--

Description

Crit_S is the probability of being in the critical zone in the first 10 projected years Caut_S is the probability of being in the cautious zone in the first 10 projected years Health_S is the probability of being in the healthy zone in the first 10 projected years OvFish_S is the probability of overfishing in the first 10 projected years Yield_S is the mean yield relative to FMSY management over the first 10 projected years Crit is the probability of being in the critical zone in the last 10 projected years Caut is the probability of being in the cautious zone in the last 10 projected years Health is the probability of being in the healthy zone in the last 10 projected years OvFish is the probability

of overfishing in the last 10 projected years Yield is the mean yield relative to FMSY management over the last 10 projected years AAVY is the average annual variability in yield over the whole projection phrased as a CV percentage Reb is the probability the stock has rebuilt to over BMSY in 2 mean generation times

Usage

```
DFO_tab_formatted(
  Ptab1,
  thresh = c(30, 50, 40, 60, 50, 20, 40, 50, 60, 50, 30, 50),
  ret_thresh = F
)
```

Arguments

Ptab1	A DFO performance table made by DFO_tab()
thresh	A vector of thresholds for each column Health, Yield and Reb are 'greater than threshold' conditions
ret_thresh	Logical: if true just the threshold levels are returned

Author(s)

T. Carruthers

DLMDataDir

Directory of the installed package on your computer

Description

Directory of the installed package on your computer

Usage

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

Arguments

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

Value

The file path to the object

dnormal	<i>Double-normal selectivity curve</i>
---------	--

Description

Double-normal selectivity curve

Usage

```
dnormal(lens, lfs, sl, sr)
```

Arguments

lens	Vector of lengths
lfs	Length at full selection
sl	Sigma of ascending limb
sr	Sigma of descending limb

Dom	<i>Determine dominate MPs</i>
-----	-------------------------------

Description

MPs that perform worse than comparable MPs across all performance metrics are considered 'dominated' as other options are always preferable.

Usage

```
Dom(MSEobj, ..., PMList = NULL, Refs = NULL, Yrs = NULL)
```

Arguments

MSEobj	An object of class MSE
...	Names of Performance Metrics (PMs), or other arguments to TradePlot. First PM is recycled if number of PMs is not even
PMList	Optional list of PM names. Overrides any supplied in ... above
Refs	An optional named list (matching the PM names) with numeric values to override the default Ref values.
Yrs	An optional named list (matching the PM names) with numeric values to override the default Yrs values.

Details

The Dom function compares the probabilities calculated in the performance metric (PM) functions and determines the MPs that have a lower probability across all PMs compared to other MPs of the same management type (e.g., size limit, TAC, etc). Consequently, it is important that all PM functions are constructed so that higher probabilities = better performance (e.g, PNOF is the probability of NOT overfishing)

Value

A named list of length 2 with a character vector of non-dominated MPs in `MPs` and a data.frame of dominated MPs and the names of the relevant dominated MPs in `DomMPs`

Author(s)

A. Hordyk

Examples

```
## Not run:
MSE <- runMSE(MPs=NA) # run all MPs
Nondom <- Dom(MSE, "P10", "LTY", "PNOF")
# Non-dominated MPs
Nondom$MPs

# Dominated MPs
Nondom$DomMPs

## End(Not run)
```

expandHerm

Expand the Herm list in SexPars to a matrix of fractions at age

Description

Expand the Herm list in SexPars to a matrix of fractions at age

Usage

```
expandHerm(Herm, maxage, np, nsim)
```

Arguments

Herm	A list of Hermaphroditic fractions at age (starting age class 1)
maxage	The maximum age of stocks being simulated
np	The total number of stocks being simulated
nsim	The number of simulations

Author(s)

T. Carruthers

Fease

*MP feasibility diagnostic***Description**

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

Usage

```
Fease(
  Data = NULL,
  TAC = TRUE,
  TAE = TRUE,
  SL = TRUE,
  Spatial = TRUE,
  names.only = TRUE,
  msg = TRUE,
  include.ref = FALSE
)
```

Arguments

Data	An object of class 'Data'. Optional. If Data object is included, the returned MPs are both feasible (in terms of management) and possible (sufficient data to run MP)
TAC	Logical. Are catch limits feasible for this fishery?
TAE	Logical. Are effort controls feasible for this fishery?
SL	Logical. Are size-selectivity regulations (either gear changes or size-retention regulations) feasible for this fishery?
Spatial	Logical. Are spatial closures feasible for this fishery?
names.only	Logical. Should only the names of the feasible MPs be returned (default)? If FALSE, a data frame with MP name, and two columns of logical values: Can (possible given data) and Fease (feasible given management constraints) is returned
msg	Logical. Should messages be printed to the console?
include.ref	Logical. Should reference MPs (e.g. FMSYref) be included as feasible methods? Default is FALSE

Value

Either a vector of MP names that are feasible for the fishery (default) or a 3 column data frame (names.only=FALSE).

Author(s)

T. Carruthers & A. Hordyk

Examples

```
## Not run:
Fease(TAC=FALSE)
Fease(SL=FALSE, Spatial=FALSE)
Fease(Atlantic_mackerel, TAE=FALSE, names.only=FALSE)

## End(Not run)
```

Fleet-class

Class 'Fleet'

Description

The component of the operating model that controls fishing dynamics

Slots

Name Identifying name for the fleet. Usually includes location and gear type.

nyears The number of years for the historical simulation. Single value. For example, if the simulated population is assumed to be unfished in 1975 and this is the year you want to start your historical simulations, and the most recent year for which there is data available is 2019, then nyears equals 45.

CurrentYr The last historical year simulated before projections begin. Single value. Note that this should match the last historical year specified in the Data object, which is usually the last historical year for which data is available.

EffYears Vector indicating the historical years where there is information available to infer the relative fishing effort expended. This vector is specified in terms of the position of the year in the vector rather than the calendar year. For example, say our simulation starts with an unfished stock in 1975, and the current year (the last year for which there is data available) is 2019. Then there are 45 historical years simulated, and EffYears should include numbers between 1 and 45. Note that there may not be information available for every historical year, especially for data poor fisheries. In these situations, the EffYears vector should include only the positions of the years for which there is information, and the vector may be shorter than the total number of simulated historical years (nyears).

EffLower Lower bound on relative fishing effort corresponding to EffYears. EffLower must be a vector that is the same length as EffYears describing how fishing effort has changed over time. Information on relative fishing effort can be entered in any units provided they are consistent across the entire vector because the data provided will be scaled to 1 (divided by the maximum number provided).

- EffUpper** Upper bound on relative fishing effort corresponding to **EffYears**. **EffUpper** must be a vector that is the same length as **EffYears** describing how fishing effort has changed over time. Information on relative fishing effort can be entered in any units provided they are consistent across the entire vector because the data provided will be scaled to 1 (divided by the maximum number provided).
- Esd** Additional inter-annual variability in fishing mortality rate. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive (non-zero) value, the yearly fishing mortality rate is drawn from a log-normal distribution with a standard deviation (in log space) specified by the value of **Esd** drawn for that simulation. This parameter applies only to historical projections.
- qinc** Mean temporal trend in catchability (also thought of as the efficiency of fishing gear) parameter, expressed as a percentage change in catchability (*q*) per year. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive numbers indicate an increase and negative numbers indicate a decrease. *q* then changes by this amount for in each year of the simulation This parameter applies only to forward projections.
- qcv** Inter-annual variability in catchability expressed as a coefficient of variation. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter applies only to forward projections.
- L5** Shortest length at which 5% of the population is vulnerable to selection by the gear used in this fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter **isRel** for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless **cpars** is used to provide time-varying selection.
- LFS** Shortest length at which 100% of the population is vulnerable to selection by the gear used by this fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter **isRel** for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless **cpars** is used to provide time-varying selection.
- VmaxLen** Proportion of fish selected by the gear at the asymptotic length (**Stock@Linf**). Upper and Lower bounds between 0 and 1. A value of 1 indicates that 100% of fish are selected at the asymptotic length, and the selection curve is logistic. If **VmaxLen** is less than 1 the selection curve is dome shaped. For example, if **VmaxLen** is 0.4, then only 40% of fish are vulnerable to the fishing gear at the asymptotic length.
- isRel** Specify whether selection and retention parameters use absolute lengths or relative to the size of maturity. Single logical value (TRUE or FALSE).
- LR5** Shortest length at which 5% of the population is vulnerable to retention by the fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter **isRel** for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless **cpars** is used to provide time-varying selection.
- LFR** Shortest length where 100% of the population is vulnerable to retention by the fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters

in the stock object) or as a percentage of the size of maturity (see the parameter `isRel` for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless `cpars` is used to provide time-varying selection.

RmaxLen Proportion of fish retained at the asymptotic length (`Stock@Linf`). Upper and Lower bounds between 0 and 1. A value of 1 indicates that 100% of fish are retained at the asymptotic length, and the selection curve is logistic. If `RmaxLen` is less than 1 the retention curve is dome shaped. For example, if `RmaxLen` is 0.4, then only 40% of fish at the asymptotic length are retained.

DR Discard rate, defined as the proportion of fully selected fish that are discarded by the fleet. Upper and Lower bounds between 0 and 1, with a value of 1 indicates that 100% of selected fish are discarded. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided.

Spat_targ Distribution of fishing in relation to vulnerable biomass (VB) across areas. The distribution of fishing effort is proportional to VB^{Spat_targ} . Upper and lower bounds of a uniform distribution. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter allows the user to model either avoidance or spatial targeting behavior by the fleet. If the parameter value is 1, fishing effort is allocated across areas in proportion to the population density of that area. Values below 1 simulate an avoidance behavior and values above 1 simulate a targeting behavior.

MPA Logical argument (TRUE or FALSE). Creates an MPA in Area 1 for all years if true is selected. Defaults to FALSE.

Misc Miscellaneous list for bio-economic parameters

Creating Object

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

Author(s)

T. Carruthers and A. Hordyk

Examples

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

FleetDescription	<i>FleetDescription</i>
------------------	-------------------------

Description

A data.frame with description of slots for class Fleet

Usage

```
FleetDescription
```

Format

An object of class `data.frame` with 20 rows and 2 columns.

FMSYref

Reference management procedures

Description

Several reference MPs for your operating model to use in the management strategy evaluation. FMSYref (and related) assume perfect information about FMSY (FMSY is taken from the operating model stored at `Data@Misc$ReferencePoints$ByYear$FMSY`), and set an effort limit (TAE) so that $F=FMSY$ (or some fraction of FMSY) in each year the MP is applied. NFref sets annual catch to zero and is used for looking at variability in stock with no fishing.

Usage

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

```
FMSYref50(x, Data, reps = 100, plot = FALSE)
```

```
FMSYref75(x, Data, reps = 100, plot = FALSE)
```

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

```
curEref(x, Data, reps = 100, plot = FALSE)
```

Arguments

<code>x</code>	A position in the data object
<code>Data</code>	A data object
<code>reps</code>	The number of stochastic samples of the MP recommendation(s)
<code>plot</code>	Logical. Show the plot?

Details

Note that you can out-perform FMSYref 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, especially for short-lived species of high temporal variability in productivity!

Value

An object of class `Rec` with the TAC slot populated with a numeric vector of length `reps`

Functions

- FMSYref: A reference FMSY method that fishes at FMSY
- FMSYref50: A reference FMSY method that fishes at 50% of FMSY
- FMSYref75: A reference FMSY method that fishes at 75% of FMSY
- NFref: A reference MP that sets annual catch to almost zero (1e-15)
- curEref: A reference MP that keeps fishing effort at the level of the last historical year

Required Data

See [Data](#) for information on the Data object

Author(s)

T. Carruthers, A. Hordyk

Examples

```
FMSYref(1, MSEtool::SimulatedData, plot=TRUE)
FMSYref50(1, MSEtool::SimulatedData, plot=TRUE)
FMSYref75(1, MSEtool::SimulatedData, plot=TRUE)
NFref(1, MSEtool::SimulatedData, plot=TRUE)
curEref(1, MSEtool::SimulatedData)
```

Generic_Obs

Obs class objects

Description

Example objects of class Obs

Usage

Generic_Obs

Imprecise_Biased

Imprecise_Unbiased

Perfect_Info

Precise_Biased

Precise_Unbiased

Format

An object of class Obs of length 1.

An object of class Obs of length 1.

An object of class Obs of length 1.

An object of class Obs of length 1.

An object of class Obs of length 1.

An object of class Obs of length 1.

Examples

```
avail("Obs")
```

getclass

get object class

Description

Internal function for determining if object is of classy

Usage

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

Arguments

x Character string object name

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

Value

TRUE or FALSE

Author(s)

T. Carruthers with nasty hacks from A. Hordyk

getDataList	<i>Get part of an MP specific data-list</i>
-------------	---

Description

Get part of an MP specific data-list

Usage

```
getDataList(MSElist, mm)
```

Arguments

MSElist	A hierarchical list [Stock][Fleet][MP]
mm	integer the MP number

Value

a sublist of MSElist for a specific MP

getfirstlev	<i>Extract the first dimension of a hierarchical list of recommendation objects</i>
-------------	---

Description

Extract the first dimension of a hierarchical list of recommendation objects

Usage

```
getfirstlev(x, name, pp, ff)
```

Arguments

x	Simulation number
name	Character. The slot name to extract.
pp	Integer. The stock number (second level list)
ff	Integer. The fleet number (third level list)

Author(s)

T. Carruthers

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

Description

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

Usage

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

Arguments

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

Details

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

Value

A markov movement matrix

Author(s)

T. Carruthers

Examples

```
Prob_staying<-0.8 # probability that individuals remain in area 1 between time-steps
Frac_area_1<-0.35 # the fraction of the stock found in area 1 under equilibrium conditions
markovmat<-getmov2(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?
```

getsel *Calculate selectivity curve*

Description

Calculate selectivity curve

Usage

getsel(x, lens, lfs, sls, srs)

Arguments

x	Simulation number
lens	Matrix of lengths (nsim by nlengths)
lfs	Vector of length at full selection (nsim long)
sls	Vector of sigmas of ascending limb (nsim long)
srs	Vector of sigmas of descending limb (nsim long)

Hist-class *Class 'Hist'*

Description

An object for storing information generated by the end of the historical simulations

Slots

Data The Data object at the end of the historical period

OMPars A numeric data.frame with nsim rows with sampled Stock, Fleet, Obs, and Imp parameters.

AtAge A named list with arrays of dimensions: c(nsim,maxage+1,nyears+proyears) or c(nsim,maxage+1,nyears,nare

- Length: Length-at-age for each simulation, age, and year
- Weight: Weight-at-age for each simulation, age, and year
- Select: Selectivity-at-age for each simulation, age, and year
- Retention: Retention-at-age for each simulation, age, and year
- Maturity: Maturity-at-age for each simulation, age, and year
- N.Mortality: Natural mortality-at-age for each simulation, age, and year
- Z.Mortality: Total mortality-at-age for each simulation, age, year and area
- F.Mortality: Fishing mortality-at-age for each simulation, age, year and area
- Fret.Mortality: Fishing mortality-at-age for retained fish for each simulation, age, year and area
- Number: Total numbers by simulation, age, year and area

- Biomass: Total biomass by simulation, age, year and area
- VBiomass: Vulnerable biomass by simulation, age, year and area
- SBiomass: Spawning biomass by simulation, age, year and area
- Removals: Removals (biomass) by simulation, age, year and area
- Landings: Landings (biomass) by simulation, age, year and area
- Discards: Discards (biomass) by simulation, age, year and area

TSdata A named list with population and fleet dynamics:

- Number: Total numbers; array dimensions $c(nsim, nyears, nareas)$
- Biomass: Total biomass; array dimensions $c(nsim, nyears, nareas)$
- VBiomass: Vulnerable biomass; array dimensions $c(nsim, nyears, nareas)$
- SBiomass: Spawning Biomass; array dimensions $c(nsim, nyears, nareas)$
- Removals: Removals (biomass); array dimensions $c(nsim, nyears, nareas)$
- Landings: Landings (biomass); array dimensions $c(nsim, nyears, nareas)$
- Discards: Discards (biomass); array dimensions $c(nsim, nyears, nareas)$
- Find: Historical fishing mortality (scale-free); matrix dimensions $c(nsim, nyears)$
- RecDev: Recruitment deviations (historical and projection); matrix dimensions $c(nsim, nyears+proyears+maxage)$
- SPR: Named list with Equilibrium and Dynamic SPR (both matrices iwth dimensions $c(nsim, nyears)$)
- Unfished_Equilibrium: A named list with unfished equilibrium numbers and biomass-at-age

Ref A named list with biological reference points:

- ByYear: A named list with asymptotic reference points (i.e., calculated annually without recruitment deviations) all matrices with dimensions $nsim$ by $nyears+proyears$:
 - N0: Asymptotic unfished total number
 - SN0: Asymptotic unfished spawning number
 - B0: Asymptotic unfished total biomass
 - SSB0: Asymptotic unfished spawning biomass
 - VB0: Asymptotic unfished vulnerable biomass
 - MSY: Asymptotic MSY
 - FMSY: Fishing mortality corresponding with asymptotic MSY
 - SSBMSY: Spawning stock biomass corresponding with asymptotic MSY
 - BMSY: total biomass corresponding with asymptotic MSY
 - VBMSY: Vulnerable biomass corresponding with asymptotic MSY
 - F01: Fishing mortality where the change in yield per recruit is 10% of that at $F = 0$
 - Fmax: Fishing mortality that maximizes yield per recruit
 - F_SPR: Fishing mortality corresponding to spawning potential ratio of 20 - 60% in increments of 5%; array dimensions $c(nsim, 9, nyears+proyears)$
 - Fcrash: Fishing mortality corresponding to the recruits-per-spawner at the origin of the stock-recruit relationship
 - Fmed: Fishing mortality corresponding to the median recruits-per-spawner in the historical period
 - SPRcrash: SPR corresponding to the recruits-per-spawner at the origin of the stock-recruit relationship

- **Dynamic_Unfished:** A named list with dynamic unfished reference points for each simulation and year:
 - N0: Unfished total numbers
 - B0: Unfished total biomass
 - SN0: Unfished spawning numbers
 - SSB0: Unfished spawning biomass
 - VB0: Unfished vulnerable biomass
 - Rec: Unfished recruitment
- **ReferencePoints:** A data.frame with nsim rows with with biological reference points calculated as an average over age-of-maturity ageM years around the current year (i.e. nyears):
 - N0: Average unfished numbers
 - B0: Average unfished biomass
 - SSB0: Average unfished spawning biomass (used to calculate depletion)
 - SSN0: Average unfished spawning numbers
 - VB0: Average unfished vulnerable biomass (used to calculate depletion if cpar\$control\$D='VB')
 - MSY: Average maximum sustainable yield (equilibrium)
 - FMSY: Average fishing mortality corresponding with MSY
 - SSBMSY: Average spawning stock biomass corresponding with MSY
 - BMSY: Average total biomass corresponding with MSY
 - VBMSY: Average vulnerable biomass corresponding with MSY
 - UMSY: Average exploitation rate corresponding with MSY
 - FMSY_M: Average FMSY/M ratio
 - SSBMSY_SSB0: Average ratio of SSBMSY to SSB0
 - BMSY_B0: Average ratio of BMSY to B0
 - VBMSY_VB0: Average ratio of VBMSY to VB0
 - RefY: Maximum yield obtained in forward projections with a fixed F

SampPars A named list with all sampled Stock, Fleet, Obs, and Imp parameters

OM The OM object (without cpars)

Misc A list for additional information

Author(s)

A. Hordyk

hist2

Wrapper for histogram function

Description

Produces a blank plot if all values in x are equal

Usage

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

Arguments

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

HistDescription	<i>HistDescription</i>
-----------------	------------------------

Description

A data.frame with description of slots for class Hist

Usage

```
HistDescription
```

Format

An object of class data.frame with 75 rows and 2 columns.

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

Description

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

Slots

Name The name of the Implementation error object. Single value. Character string.

Name The name of the Implementation error object. Single value. Character string.

TACFrac Mean fraction of recommended TAC that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean TAC fraction obtained across all years of that simulation, and a yearly TAC frac is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of TACSD drawn for that simulation. If the value drawn is greater than 1 the amount of catch taken is greater than that recommended by the TAC, and if it is less than 1 the amount of catch taken is less than that recommended by the TAC. Positive real numbers.

TACSD Log-normal coefficient of variation in the fraction of recommended TAC that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the TACFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual amount of catch taken are drawn from. Positive real numbers.

TAEFrac Mean fraction of recommended TAE that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean TAE fraction obtained across all years of that simulation, and a yearly TAE frac is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of TAESD drawn for that simulation. If the value drawn is greater than 1 the amount of effort employed is greater than that recommended by the TAE, and if it is less than 1 the amount of effort employed is less than that recommended by the TAE. Positive real numbers.

TAESD Log-normal coefficient of variation in the fraction of recommended TAE that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the TAEFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual amount of effort employed are drawn from. Positive real numbers.

SizeLimFrac Mean fraction of recommended size limit that is actually retained. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean size limit fraction obtained across all years of that simulation, and a yearly size limit fraction is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of SizeLimSD drawn for that simulation. If the value drawn is greater than 1 the size of fish retained is greater than that recommended by the size limit, and if it is less than 1 the amount of size of fish retained is less than that recommended by the size limit. Positive real numbers.

SizeLimSD Log-normal coefficient of variation in the fraction of recommended size limit that is actually retained. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the SizeLimFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual fraction of the size limit retained are drawn from. Positive real numbers.

Objects from the Class

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

Author(s)

T. Carruthers and A. Hordyk

Examples

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

ImpDescription	<i>ImpDescription</i>
----------------	-----------------------

Description

A data.frame with description of slots for class Imp

Usage

```
ImpDescription
```

Format

An object of class data.frame with 7 rows and 2 columns.

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

Description

```
~~ Methods for Function initialize ~~
```

Methods

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

Input	<i>Function to run a set of input control methods</i>
-------	---

Description

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

Usage

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

Arguments

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

Author(s)

A. Hordyk

Examples

```
## Not run:
library(DLMtool)
Input(MSEtool::Cobia)

## End(Not run)
```

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

Description

Internal functions for reading iSCAM input and output files into R

Usage

```

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

fetch.file.names(path, filename)

read.report.file(fn)

read.data.file(file = NULL, verbose = FALSE)

read.control.file(
  file = NULL,
  num.gears = NULL,
  num.age.gears = NULL,
  verbose = FALSE
)

read.projection.file(file = NULL, verbose = FALSE)

read.par.file(file = NULL, verbose = FALSE)

read.mcmc(model.dir = NULL, verbose = TRUE)

```

Arguments

model.dir	Folder name
burnin	The initial mcmc samples to be discarded
thin	The degree of chain thinning 1 in every thin iterations is kept
verbose	should detailed results be printed to console
path	File path
filename	The filename
fn	File location
file	File location
num.gears	The number of gears
num.age.gears	The number age-gears

Functions

- `load.iscam.files`: Wrapper function to generate R list
- `fetch.file.names`: A function for returning the three types of iSCAM input and output files
- `read.report.file`: A function for returning the results of the .rep iscam file
- `read.data.file`: A function for returning the results of the .dat iscam file
- `read.control.file`: A function for returning the results of the iscam control file
- `read.projection.file`: A function for returning the results of the iscam projection file
- `read.par.file`: A function for returning the results of the iscam .par file
- `read.mcmc`: A function for returning the results of the iscam mcmc files

Author(s)

Chris Grandin (DFO PBS)

See Also[iSCAM2OM](#)

iSCAM2OM	<i>Reads MPD or MCMC estimates and data from iSCAM file structure into an operating model</i>
----------	---

Description

Functions for importing an iSCAM assessment. From a fitted model, iSCAM2OM populates the various slots of an operating model and iSCAM2Data generates a Data object. These functions rely on several functions written by Chris Grandin (DFO PBS).

Usage

```
iSCAM2OM(
  iSCAMdir,
  nsim = 48,
  proyears = 50,
  mcmc = FALSE,
  Name = "iSCAM model",
  Source = "No source provided",
  length_timestep = 1,
  nyr_par_mu = 2,
  Author = "No author provided",
  report = FALSE,
  silent = FALSE
)

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

Arguments

iSCAMdir	A folder with iSCAM input and output files in it. Alternatively, a list returned by load.iscam.files .
nsim	The number of simulations to take for parameters with uncertainty (for OM@cpar custom parameters)

proyears	The number of MSE projection years
mcmc	Logical, whether to use mcmc samples to create custom parameters cpars. Alternatively, a list returned by read.mcmc . Set the seed for the function to sub-sample the mcmc samples.
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
length_timestep	How long is a model time step in years (e.g. a quarterly model is 0.25, a monthly model 1/12) (currently only uses annual time step)
nyr_par_mu	integer, the number of recent years to estimate vulnerability over for future projections
Author	Who did the assessment
report	logical should a numbers at age reconstruction plot be produced?
silent	logical should progress reporting be printed to the console?

Biological parameters

The function calls `model <- load.iscam.files(iSCAMdir)` and grabs the following matrices:

- `modelmpdd3_weight_mat` - fecundity (product of weight and maturity at age)
- `modelmpdma` - maturity at age

MPD historical reconstruction

The function calls `model <- load.iscam.files(iSCAMdir)` and then grabs the following matrices:

- `modelmpdN` - abundance at age
- `modelmpdF` - fishing mortality at age
- `modelmpdM` - natural mortality at age

If a delay-difference model is recognized, then the following is used instead:

- `modelmpdF_dd` - fishing mortality at age
- `modelmpdM_dd` - natural mortality at age

Abundance at age is reconstructed using `modelmpdrt` (recruitment) and projected with `F_dd` and `M_dd` to match `modelmpdnumbers`.

MCMC historical reconstruction

If `mcmc = TRUE` the function calls `mcmc_model <- read.mcmc(iSCAMdir)`, and grabs `nsim` sub-samples of the MCMC output through the following arrays:

- `mcmc_model$params` and `mcmc_model$ft` - fishing mortality at age from the fleet selectivity parameters and apical F 's
- `mcmc_model$m` - year-specific natural mortality at age
- `mcmc_model$params$rinit` and `mcmc_model$rt` - recruitment and abundance

Start age

While the iSCAM start age can be greater than zero, abundance at age is back-calculated to age zero using the M at the start age.

These arrays are then passed to VPA20M to generate the operating model.

Reference points

iSCAM calculates the stock-recruit relationship and subsequently a single set of MSY and unfished reference points using R_0 , steepness, and unfished spawners per recruit from the mean M , fecundity, and growth (mean with respect to time).

R_0 and h are recalculated for the operating model by obtaining the stock-recruit alpha and beta from the iSCAM parameters and the mean unfished spawners per recruit in the first age M (age of 50% maturity) years. R_0 is also back calculated to age zero.

Author(s)

T. Carruthers, Q. Huynh

iSCAMcomps

Combines all iSCAM age composition data across fleets

Description

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

Usage

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

Arguments

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

Author(s)

T. Carruthers

iSCAMinds	<i>Combines indices into a single index using linear modelling (** Deprecated **)</i>
-----------	---

Description

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

Usage

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

Arguments

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

Author(s)

T. Carruthers

joinData	<i>Join Data objects present in a list</i>
----------	--

Description

A function that combined a list of data objects into a single data object (same dimensions but can have different numbers of simulations)

Usage

```
joinData(DataList)
```

Arguments

DataList	A list of data objects of identical dimension (except for simulation)
----------	---

Author(s)

T. Carruthers

join_plots	<i>Plot several plots with a shared legend</i>
------------	--

Description

Plot several plots with a shared legend

Usage

```
join_plots(
  plots,
  ncol = length(plots),
  nrow = 1,
  position = c("right", "bottom"),
  legend = TRUE
)
```

Arguments

plots	list of plot objects of class gg or ggplot
ncol	Optional number of columns
nrow	Optional number of rows
position	position of the legend ("bottom" or "right")
legend	Logical. Use a legend?

Note

modified from <https://github.com/tidyverse/ggplot2/wiki/share-a-legend-between-two-ggplot2-graphs>

Kplot	<i>KOBE plot: a projection by projection plot of F/FMSY and B/BMSY</i>
-------	--

Description

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

Usage

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

Arguments

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

Note

Apologies for the nauseating shading.

Author(s)

T. Carruthers with some additions from A. Hordyk

ldim	<i>Dimensions of a hierarchical list object</i>
------	---

Description

Dimensions of a hierarchical list object

Usage

```
ldim(x)
```

Arguments

x	A list
---	--------

Author(s)

T. Carruthers

LH2OM

*Predict missing life-history parameters***Description**

Predict missing life-history based on taxonomic information and hierarchical model fitted to Fish-Base life-history parameters

Usage

```
LH2OM(
  OM,
  dist = c("unif", "norm"),
  filterMK = FALSE,
  plot = TRUE,
  Class = "predictive",
  Order = "predictive",
  Family = "predictive",
  msg = TRUE,
  db = MSEtool::LHdatabase
)
```

```
predictLH(
  inpars = list(),
  Genus = "predictive",
  Species = "predictive",
  nsamp = 100,
  db = MSEtool::LHdatabase,
  dist = c("unif", "norm"),
  filterMK = TRUE,
  plot = TRUE,
  Class = "predictive",
  Order = "predictive",
  Family = "predictive",
  msg = TRUE
)
```

Arguments

OM	An object of class 'OM'
dist	Character. Should parameters be sampled from a uniform (unif) or normal (norm) distribution?
filterMK	Logical. Should the predicted M and K parameters be filtered within the range specified in inpars or OM? e.g. OM@M and OM@K. Empty slots or slots with all values of 0 are considered unknown.
plot	Logical. Should the plot be produced?

Class	Optional higher order taxonomic information
Order	Optional higher order taxonomic information
Family	Optional higher order taxonomic information
msg	Logical. Should messages be printed?
db	Database from FishLife model with fitted model results
inpars	A named list with lower and upper bounds of provided parameters: <i>Linf</i> , <i>L50</i> , <i>K</i> and <i>M</i> (must be length 2). Unknown or missing parameters should not be included. For example, an empty list assumes that all four life history parameters are unknown and need to be estimated. See Details below for more information.
Genus	Character string specifying the Genus name. Optional. Default is 'predictive'
Species	Character string specifying the Species name. Optional. Default is 'predictive'. If full species name (Genus + Species) is not found in FishLife database (based on FishBase) higher order taxonomy will be used (e.g., Family) for the predictions.
nsamp	The number of samples to return

Details

The model predicts missing life-history parameters based on provided parameters and taxonomic information. If both *M* and *K* are provided in `inpars` or `OM`, *K* values are predicted and predictions filtered so that resulting *K* values are within bounds specified in `inpars$K` or `OM@K` (see `filterMK`). If both *Linf* and *L50* are provided in `inpars` or `OM`, *L50* values are predicted and values in `inpars$L50` or `OM@L50` are ignored.

Value

LH2OM: An `OM` with `OM@cpars` populated with `OM@nsim` samples of *M*, *K*, *Linf* and *L50*
 predictLH: A `data.frame` with `nsamp` rows with *Linf*, *L50*, *K*, and *M* values.

Functions

- LH2OM: Predict missing life-history and populate `OM@cpars`
- predictLH: Predict missing life-history based on taxonomic information and hierarchical model fitted to FishBase life-history parameters

Author(s)

A. Hordyk

Source

<https://github.com/James-Thorson-NOAA/FishLife>

References

Thorson, J. T., S. B. Munch, J. M. Cope, and J. Gao. 2017. Predicting life history parameters for all fishes worldwide. *Ecological Applications*. 27(8): 2262–2276

LHdatabase

LHdatabase

Description

Database from the FishLife package with predicted life-history parameters for all species on Fish-Base

Usage

LHdatabase

Format

An object of class `list` of length 3.

Source

<https://github.com/James-Thorson-NOAA/FishLife/>

References

Thorson, J. T., S. B. Munch, J. M. Cope, and J. Gao. 2017. Predicting life history parameters for all fishes worldwide. *Ecological Applications*. 27(8): 2262–2276

makeMOM

Utility for making multi-OMs

Description

Converts an OM to a single stock, single fleet MOM.

Usage

```
makeMOM(..., silent = FALSE)
```

Arguments

... An OM.
silent Should messages be printed out to the console?

Value

A class `MOM` object.

Author(s)

Q. Huynh

Examples

```
MOM <- makeMOM(testOM)
```

makemov

Calculates movement matrices from user inputs for fraction in each area (fracs) and probability of staying in areas (prob)

Description

A function for calculating a movement matrix from user specified unfished stock biomass fraction in each area. Used by [simmov](#) to generate movement matrices for an operating model.

Usage

```
makemov(frac = c(0.1, 0.2, 0.3, 0.4), prob = c(0.5, 0.8, 0.9, 0.95))
```

Arguments

frac	A vector nareas long of fractions of unfished stock biomass in each area
prob	A vector of the probability of individuals staying in each area or a single value for the mean probability of staying among all areas

Author(s)

T. Carruthers

See Also[simmov](#)

makeRel	<i>MICE relationships for multi-OM</i>
---------	--

Description

Generate a MICE Rel object, with `predict` and `simulate` methods, for [multiMSE](#). Currently implements intra-stock dynamics via density-dependent processes.

Usage

```
makeRel(type = "DDM", stock = 1, CV = 0, ...)
```

```
## S3 method for class 'Rel'
print(x, ...)
```

```
## S3 method for class 'Rel'
predict(object, newdata, ...)
```

```
## S3 method for class 'Rel'
simulate(object, nsim = 1, seed = 1, ...)
```

Arguments

<code>type</code>	String to indicate the type of stock interaction. "DDM" for density-dependent natural mortality.
<code>stock</code>	The index position of the stock in the MOM.
<code>CV</code>	Coefficient of variation of the predicted value for <code>simulate</code> . Used to pass values to the operating model.
<code>...</code>	Additional arguments depending on <code>type</code> . See details below.
<code>x</code>	For <code>print.Rel</code> , a <code>Rel</code> class object from <code>make_Rel</code> .
<code>object</code>	A <code>Rel</code> class object from <code>make_Rel</code> .
<code>newdata</code>	A data frame to provide values of predictor variables with which to calculate the response variable.
<code>nsim</code>	The number of simulations.
<code>seed</code>	Integer to specify the seed for the random number generator.

Value

A class "Rel" object to pass to `MOM@Rel`.

Density-dependent M ("DDM")

Natural mortality (M) is a linear function of stock depletion in terms to total biomass (B) in year y (Forrest et al. 2018):

$$M_y = M_0 + (M_1 + M_0)(1 - B_y/B_0)$$

with a constraint that $M_y = M_0$ if $B_y > B_0$

Provide the following arguments:

- M0: Natural mortality as B approaches B0. Vector [nsim]
- M1: Natural mortality as B approaches zero. Vector [nsim]
- Optional B0: Unfished biomass. Calculated from stock-recruit alpha and beta and unfished biomass per recruit at M = M0. Vector [nsim]

Author(s)

Q. Huynh

References

Forrest, R., Holt, K., and Kronlund, A. 2018. Performance of alternative harvest control rules for two Pacific groundfish stocks with uncertain natural mortality: Bias, robustness and trade-offs. *Fisheries Research* 206: 259–286. doi: [10.1016/j.fishres.2018.04.007](https://doi.org/10.1016/j.fishres.2018.04.007)

Examples

```
# Depensatory natural mortality
Rel <- makeRel(type = "DDM", M0 = 0.8, M1 = 0.2, CV = 0.1)

# Predict M when B/B0 = 0.1
pred <- predict(Rel, newdata = data.frame(B_1 = 0.1, B0_1 = 1))

# Simulate values of M with CV = 0.1
Rel$fitted.values <- pred
simulate(Rel, nsim = 10, seed = 1)

# Add Rel to MOM
MOM <- makeMOM(testOM)
MOM@Rel <- list(Rel)
```

makeTransparent *Make colors transparent*

Description

Make colors transparent

Usage

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

Arguments

someColor	Character string describing color
alpha	transparency

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

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

Author(s)

T. Carruthers

MMSE-class

Class 'MMSE'

Description

A Multi Management Strategy Evaluation object that contains information about simulation conditions and performance of MPs for a multi-stock, multi-fleet operating model.

Slots

Name Name of the MMSE object. Single value. Character string

nyears The number of years for the historical simulation. Single value. Positive integer

proyears The number of years for the projections - closed loop simulations. Single value. Positive integer

nMPs Number of management procedures simulation tested. Single value. Positive integer.

MPs The names of the MPs that were tested. Vector of length nMPs. Character strings.

MPcond The MP condition. Character ('bystock': an MP per stock, 'byfleet' and MP per stock and fleet, 'MMP' an MP for all stocks and fleets)

MPrefs The names of the MPs applied for each stock (row) and fleet (column). An array.

nsim Number of simulations. Single value. Positive integer

nstocks Number of stocks. Single value. Positive integer

nfleets Number of fleets. Single value. Positive integer

Snames Names of the stocks

Fnames Names of the fleets (matrix nstocks x nfleets)

Stocks The stock operating model objects. List of Stocks

Fleets The fleet operating model objects. Hierarchical list, fleets nested in stocks.

Obs The fleet specific observation error operating model objects. Hierarchical list, fleets nested in stocks.

Imps The fleet specific implementation error operating model objects. Hierarchical list, fleets nested in stocks.

OM A table of sampled parameters of the operating model. Data frame of nsim rows.

Obs A table of sampled parameters of the observation model. Data frame of nsim rows.

SB_SBMSY Simulated spawning biomass relative to SBMSY over the projection. An array with dimensions: nsim, nStocks, nMPs, proyears. Non-negative real numbers

F_FMSY Simulated fishing mortality rate relative to FMSY over the projection. An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers

N Simulated stock numbers over the projection. An array with dimensions: nsim, nStocks, nMPs, proyears. Non-negative real numbers

B Simulated stock biomass over the projection. An array with dimensions: nsim, nStocks, nMPs, proyears. Non-negative real numbers

- SSB Simulated spawning stock biomass over the projection. An array with dimensions: nsim, nStocks, nMPs, proyears. Non-negative real numbers
- VB Simulated vulnerable biomass over the projection. An array with dimensions: nsim, nStocks, nMPs, proyears. Non-negative real numbers
- FM Simulated fishing mortality rate over the projection. An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- SPR A list of SPR values. Currently not used.
- Catch Simulated catches (landings) over the projection. An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- Removals Simulated removals (landings+discards) over the projection. An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- Effort Simulated relative fishing effort in the projection years. An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- TAC Simulated Total Allowable Catch (prescribed) over the projection (this is NA for input controls). An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- TAE Simulated Total Allowable Effort (prescribed) over the projection (this is NA for output controls). An array with dimensions: nsim, nStocks, nFleets, nMPs, proyears. Non-negative real numbers
- BioEco A named list of bio-economic output. Not currently used.
- RefPoint Named list of annual MSY reference points MSY, FMSY, and SBMSY. Array with dimensions: nsim, nstocks, nMPs, nyears+proyears. Will be the same as multiHist@Ref\$ByYear unless selectivity is changed by MP
- multiHist The object of class multiHist containing information from the spool-up period.
- PPD Posterior predictive data. List of Data objects at the end of the projection period (length nMPs)
- Misc Miscellaneous output such as posterior predictive data

Objects from the Class

Objects can be created by calls of the form `new('MMSE', Name, nyears, proyears, nMPs, MP, nsim, OMtable, Obs, B_BMSYa,`

Author(s)

T. Carruthers

MOM-class

Class 'MOM'

Description

An object containing all the parameters needed to control a multi-stock, multi-fleet MSE which can be build from component Stock, Fleet, Obs, and Imp objects.

Details

Almost all of these inputs are a vector of length 2 which describes the upper and lower bounds of a uniform distribution from which to sample the parameter.

Slots

Name Name of the operating model

Agency Name of the agency responsible for the management of the fishery. Character string

Region Name of the general geographic region of the fishery. Character string

Sponsor Name of the organization who sponsored the OM. Character string

Latitude Latitude (decimal degrees). Negative values represent the South of the Equator. Numeric. Single value

Longitude Longitude (decimal degrees). Negative values represent the West of the Prime Meridian. Numeric. Single value

nsim The number of simulations

proyears The 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

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.

cpars A hierarchical list nstock then nfleet long of custom parameters. Time series are a matrix nsim rows by nyears columns. Single parameters are a vector nsim long

seed A random seed to ensure users can reproduce results exactly

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

Stocks List of stock objects

Fleets List of Fleet objects

Obs Hierarchical List of Observation model objects Level 1 is stock, level 2 is fleet

Imps Hierarchical List of Implementation model objects Level 1 is stock, level 2 is fleet

CatchFrac A list nstock long, of matrices nsim x nfleet representing the fraction of current catches of the various fleets to each stock (each matrix is nsim by nfleet long and rows sum to 1 for each stock)

Allocation A list nstock long, of matrices nsim x nfleet representing the fraction of future TACs of the various fleets to each stock (each matrix is nsim by nfleet long and rows sum to 1 for each stock).

Efactor A list nstock long, of current effort factors by fleet (default is 1 - same as current effort)

Complexes A list of stock complexes. Each position is a vector of stock numbers (as they appear in StockPars) for which data should be aggregated and TAC recommendations split among stocks according to vulnerable biomass

SexPars A list of slots that control sex-specific dynamics

Rel A list of biological / ecological relationships among stocks over-ridden if an MP of class 'MP_F' is supplied that is a multi-fleet MP.

Objects from the Class

Objects can be created by calls of the form `new('MOM', Stock_list, Fleet_list, Obs_list, Imp_list)`.

Author(s)

T. Carruthers and A. Hordyk

movestockCPP

Apply the movement model to the stock for one time-step

Description

Apply the movement model to the stock for one time-step

Usage

`movestockCPP(nareas, maxage, mov, Number)`

Arguments

nareas	The number of spatial areas
maxage	The maximum age
mov	Numeric matrix (nareas by nareas) with the movement matrix
Number	A numeric matrix (maxage+1, nareas) with current numbers-at-age in each area

Author(s)

A. Hordyk

movfit_Rcpp

Rcpp version of the 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_Rcpp(par, prb, frac)`

Arguments

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

Details

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

Author(s)

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

MPCalcsNAs

Fill any NAs arising from MPCalcs (hermaphroditism mode)

Description

Fill any NAs arising from MPCalcs (hermaphroditism mode)

Usage

```
MPCalcsNAs(MPCalcs)
```

Arguments

MPCalcs	A list of arrays arising from the DLMtool function CalcMPDynamics()
---------	---

Author(s)

T. Carruthers

MPtype	<i>Management Procedure Type</i>
--------	----------------------------------

Description

Management Procedure Type

Usage

MPtype(MPs = NA)

Arguments

MPs A vector of MP names. If none are provided function is run on all available MPs

Value

A data.frame with MP names, management type (e.g "Input", "Output") and management recommendations returned by the MP (e.g, TAC (total allowable catch), TAE (total allowable effort), SL (size-selectivity), and/or or Spatial)

See Also

[Required](#)

Examples

```
MPtype(c("AvC", "curE", "matlenlim", "MRreal", "FMSYref"))
```

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

Description

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

Slots

Name Name of the MSE object. Single value. Character string
 nyears The number of years for the historical simulation. Single value. Positive integer
 proyears The number of years for the projections - closed loop simulations. Single value. Positive integer
 nMPs Number of management procedures simulation tested. Single value. Positive integer.

- MPs The names of the MPs that were tested. Vector of length nMPs. Character strings.
- nsim Number of simulations. Single value. Positive integer
- OM Operating model parameters (last historical year used for time-varying parameters). Data.frame with nsim rows
- Obs Observation parameters (last historical year used for time-varying parameters). Data.frame with nsim rows
- SB_SBMSY Simulated spawning biomass relative to spawning BMSY over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- F_FMSY Simulated fishing mortality rate relative to FMSY over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- N Simulated total numbers over the projection. An array with dimensions: nsim, maxage+1, nMPs, proyears, nareas. Non-negative real numbers.
- B Simulated stock biomass over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- SSB Simulated spawning stock biomass over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- VB Simulated vulnerable biomass over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- FM Simulated fishing mortality rate over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- SPR Named list with equilibrium and dynamic SPR. Each element is an array with dimensions: nsim, nMPs, proyears. Non-negative real numbers.
- Catch Simulated catches (landings) over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- Removals Simulated removals (catch + discards) over the projection. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- Effort Simulated relative fishing effort in the projection years. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- TAC Simulated Total Allowable Catch prescribed by MPs. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- TAE Simulated Total Allowable Effort prescribed by MPs. An array with dimensions: nsim, nMPs, proyears. Non-negative real numbers
- BioEco Named list with bio-economic output Only used if bio-economic parameters are included in OM
- RefPoint Named list of annual MSY reference points MSY, FMSY, and SBMSY. Array with dimensions: nsim, nMPs, nyears+proyears. Will be the same as Hist@Ref\$ByYear unless selectivity is changed by MP
- CB_hist Simulated catches (landings) from the spool-up period. An array with dimensions: nsim, nyears. Non-negative real numbers
- FM_hist Simulated fishing mortality rate from the spool-up period. An array with dimensions: nsim, nyears Non-negative real numbers
- SSB_hist Simulated spawning stock biomass from the spool-up period. An array with dimensions: nsim, nyears. Non-negative real numbers

Hist Information from the historical spool-up period. Object of class Hist. Only returned if `extended=TRUE` in `runMSE`

PPD Posterior predictive data. List of Data objects at the end of the projection period (length nMPs)

Misc Miscellaneous output

Author(s)

T. Carruthers and A. Hordyk

MSEDescription	<i>MSEDescription</i>
----------------	-----------------------

Description

A data.frame with description of slots for class MSE

Usage

```
MSEDescription
```

Format

An object of class data.frame with 29 rows and 2 columns.

MSEextra	<i>Load more data from MSEextra package</i>
----------	---

Description

Downloads the MSEextra package from GitHub

Usage

```
MSEextra(silent = FALSE, force = FALSE)
```

Arguments

<code>silent</code>	Logical. Should messages to printed?
<code>force</code>	Logical. For install from github if package is up-to-date?

MSYCalcs

Internal function to calculate MSY Reference Points

Description

Internal function to calculate MSY Reference Points

Usage

```
MSYCalcs(
  logF,
  M_at_Age,
  Wt_at_Age,
  Mat_at_Age,
  Fec_at_Age,
  V_at_Age,
  maxage,
  R0x = 1,
  SRrelx = 3L,
  hx = 1,
  SSBpR = 0,
  opt = 1L,
  plusgroup = 1L
)
```

Arguments

logF	log fishing mortality
M_at_Age	Vector of M-at-age
Wt_at_Age	Vector of weight-at-age
Mat_at_Age	Vector of maturity-at-age
Fec_at_Age	Vector of mature weight-at-age
V_at_Age	Vector of selectivity-at-age
maxage	Maximum age
R0x	R0 for this simulation. Set = 1 if SRrelx = 3 for per-recruit calculations
SRrelx	SRR type for this simulation. Use 3 for per-recruit calculations, i.e. constant recruitment.
hx	numeric. Steepness value for this simulation. Not used if SRrelx = 3.
SSBpR	numeric. Unfished spawners per recruit for this simulation. Not used if SRrelx = 3.
opt	Option. 1 = return -Yield, 2= return all MSY calcs
plusgroup	Integer. Default = 0 = no plus-group. Use 1 to include a plus-group

Value

See opt

multiData	<i>Combine data among fleets</i>
-----------	----------------------------------

Description

Catches, CAA, CAL are summed. LFC and LFS are weighted averages. ML, Lc and Lbar are recalculated from summed CAL. All other observations are for fleet 1 (indicative)

Usage

```
multiData(MSElist, StockPars, p, mm, nf)
```

Arguments

MSElist	A hierarchical list of data objects stock then fleet then MP
StockPars	A list of stock parameters
p	Integer the Stock number
mm	Integer the MP number
nf	The number of fleets

Author(s)

T. Carruthers

multiDataS	<i>Combine data among stocks</i>
------------	----------------------------------

Description

Catches, CAA, CAL are summed. Indices, LFC and LFS are weighted averages. ML, Lc and Lbar are recalculated from summed CAL. All other observations are for fleet 1 and weighted average across stocks

Usage

```
multiDataS(MSElist, StockPars, np, mm, nf, realVB)
```

Arguments

MSElist	A hierarchical list of data objects stock then fleet then MP
StockPars	A list of stock parameters
np	The number of stocks
mm	Integer the MP number
nf	The number of fleets
realVB	A matrix of real vulnerable biomass [nsim,np, year]

Author(s)

T. Carruthers

multidebug	<i>A basic comparison of runMSE output (MSE) and multiMSE (MMSE)</i>
------------	--

Description

A basic comparison of runMSE output (MSE) and multiMSE (MMSE)

Usage

```
multidebug(MSEsingle, MSEmulti, p = 1, f = 1, MPno = 1, maxsims = 4)
```

Arguments

MSEsingle	An object of class MSE arising from a run of runMSE(OM, ...)
MSEmulti	An object of class MMSE arising from a run of multiMSE(MOM, ...)
p	Integer. The stock number from the MSEmulti object (to be plotted)
f	Integer. The fleet number from the MSEmulti object (to be plotted)
MPno	Integer. The MP number from the MSEmulti and MSEsingle object (to be plotted)
maxsims	Integer. The maximum number of simulations to plot.

Author(s)

T.Carruthers

NIL *Item in list: get the list values from a list of lists*

Description

Create of vector of values that correspond with a slot in a list of objects

Usage

```
NIL(listy, namey, lev1 = T)
```

Arguments

listy	A list of objects
namey	A character vector representing the list item's name
lev1	Logical, should NIL default to the first level of the list?

Author(s)

T. Carruthers

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

Obs-class

Class 'Obs'

Description

An operating model component that controls the observation model

Slots

Name The name of the observation model object. Single value. Character string.

Name The name of the Observation error object. Single value. Character string.

Cobs Observation error around the total catch. Observation error in the total catch is expressed as a coefficient of variation (CV). Cobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the catch data are then drawn from this distribution. For each time step the simulation model records the true catch, but the observed catch is generated by applying this yearly error term (plus any bias, if specified) to the true catch.

Cbiascv Log-normally distributed coefficient of variation controlling the sampling bias in observed catch for each simulation. Bias occurs when catches are systematically skewed away from the true catch level (for example, due to underreporting of catch or undetected illegal catches). Cbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years.

CAA_nsamp Number of catch-at-age observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive integers.

CAA_ESS Effective sample size of catch-at-age observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. CAA_ESS should not exceed CAA_nsamp. If greater than 1, then this is the multinomial distribution sample size. If less than 1, this is the coefficient of variation for the logistic normal distribution (see help documentation for simCAA for details).

CAL_nsamp Number of catch-at-length observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive integers.

CAL_ESS Effective sample size. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. CAL_ESS should not exceed CAL_nsamp. Positive integers.

- Iobs** Observation error in the relative abundance index expressed as a coefficient of variation (CV). Iobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the index of abundance data are then drawn from this distribution. For each time step the simulation model records the true change in abundance, but the observed index is generated by applying this yearly error term (plus any bias, if specified) to the true relative change in abundance. Positive real numbers.
- Btobs** Observation error in the absolute abundance expressed as a coefficient of variation (CV). Btobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the absolute abundance data are then drawn from this distribution. For each time step the simulation model records the true abundance, but the observed abundance is generated by applying this yearly error term (plus any bias, if specified) to the true abundance. Positive real numbers.
- Btbiasecv** Log-normally distributed coefficient (CV) controlling error in observations of the current stock biomass. Bias occurs when the observed index of abundance is systematically higher or lower than the true relative abundance. Btbiasecv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- beta** A parameter controlling hyperstability/hyperdepletion in the measurement of abundance. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Values below 1 lead to hyperstability (the observed index decreases more slowly than the true abundance) and values above 1 lead to hyperdepletion (the observed index decreases more rapidly than true abundance). Positive real numbers.
- LenMbiasecv** Log-normal coefficient of variation for sampling bias in observed length at 50 percent maturity. LenMbiasecv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Mbiasecv** Log-normal coefficient of variation for sampling bias in observed natural mortality rate. Uniform distribution lower and upper bounds. Mbiasecv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Kbiasecv** Log-normal coefficient of variation for sampling bias in observed growth parameter K. Kbiasecv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- t0biasecv** Log-normal coefficient of variation for sampling bias in observed t0. t0biasecv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Linfbiasecv** Log-normal coefficient of variation for sampling bias in observed maximum length. Linfbiasecv is a single value specifying the standard deviation of a log-normal distribution with

- a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- LFCbiascv** Log-normal coefficient of variation for sampling bias in observed length at first capture. LFCbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- LFSbiascv** Log-normal coefficient of variation for sampling bias in length-at-full selection. LFSbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- FMSY_Mbiascv** Log-normal coefficient of variation for sampling bias in estimates of the ratio of the fishing mortality rate that gives the maximum sustainable yield relative to the assumed instantaneous natural mortality rate. FMSY/M. FMSY_Mbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- BMSY_B0biascv** Log-normal coefficient of variation for sampling bias in estimates of the BMSY relative to unfished biomass (BMSY/B0). BMSY_B0biascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Irefbiascv** Log-normal coefficient of variation for sampling bias in the observed relative index of abundance (Iref). Irefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Brefbiascv** Log-normal coefficient of variation for sampling bias in the observed reference biomass (Bref). Brefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Crefbiascv** Log-normal coefficient of variation for sampling bias in the observed reference catch (Cref). Crefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Dbiascv** Log-normal coefficient of variation for sampling bias in the observed depletion level. Dbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.
- Dobs** Log-normal coefficient of variation controlling error in observations of stock depletion among years. Observation error in the depletion expressed as a coefficient of variation (CV). Dobs requires the upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the depletion data are then drawn from this distribution. For each time step

the simulation model records the true depletion, but the observed depletion is generated by applying this yearly error term (plus any bias, if specified) to the true depletion.

hbiasecv Log-normal coefficient of variation for sampling persistent bias in steepness. **hbiasecv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Recbiasecv Log-normal coefficient of variation for sampling persistent bias in recent recruitment strength. **Recbiasecv** requires the upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly bias values for the depletion data are then drawn from this distribution. Positive real numbers.

sigmaRbiasecv Log-normal coefficient of variation for sampling persistent bias in recruitment variability. **sigmaRbiasecv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Eobs Observation error around the total effort. Observation error in the total effort is expressed as a coefficient of variation (CV). **Eobs** requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the effort data are then drawn from this distribution. For each time step the simulation model records the true effort, but the observed effort is generated by applying this yearly error term (plus any bias, if specified) to the true effort.

Ebiasecv Log-normally distributed coefficient of variation controlling the sampling bias in observed effort for each simulation. Bias occurs when effort is systematically skewed away from the true effort level. **Ebiasecv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years.

Objects from the Class

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

Note

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

Author(s)

T. Carruthers and A. Hordyk

Examples

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

ObsDescription	<i>ObsDescription</i>
----------------	-----------------------

Description

A data.frame with description of slots for class Obs

Usage

```
ObsDescription
```

Format

An object of class data.frame with 30 rows and 2 columns.

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

Description

An object containing all the parameters needed to control the MSE which can be build from component Stock, Fleet, Obs, and Imp objects.

Details

Almost all of these inputs are a vector of length 2 which describes the upper and lower bounds of a uniform distribution from which to sample the parameter.

Slots

Name Name of the operating model

Agency Name of the agency responsible for the management of the fishery. Character string

Region Name of the general geographic region of the fishery. Character string

Sponsor Name of the organization who sponsored the OM. Character string

Latitude Latitude (decimal degrees). Negative values represent the South of the Equator. Numeric. Single value

Longitude Longitude (decimal degrees). Negative values represent the West of the Prime Meridian. Numeric. Single value

nsim The number of simulations

proyears The 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
 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.
 cparms A list of custom parameters. Time series are a matrix nsim rows by nyears columns. Single parameters are a vector nsim long
 seed A random seed to ensure users can reproduce results exactly
 Source A reference to a website or article from which parameters were taken to define the operating model

Objects from the Class

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

Author(s)

T. Carruthers and A. Hordyk

OMDescription

OMDescription

Description

A `data.frame` with description of slots for class OM

Usage

OMDescription

Format

An object of class `data.frame` with 15 rows and 2 columns.

 OMdoc

Generate OM Documentation Report

Description

Generate OM Documentation Report

Usage

```
OMdoc(
  OM = NULL,
  rmd.source = NULL,
  overwrite = FALSE,
  out.file = NULL,
  inc.plot = TRUE,
  render = TRUE,
  output = "html_document",
  openFile = TRUE,
  quiet = FALSE,
  dir = NULL,
  ...
)
```

Arguments

OM	An object of class 'OM' or the name of an OM xlsx file
rmd.source	Optional. Name of the source.rmd file corresponding to the 'OM'. Default assumption is that the file is 'OM@Name.Rmd'
overwrite	Logical. Should existing files be overwritten?
out.file	Optional. Character. Name of the output file. Default is the same as the text file.
inc.plot	Logical. Should the plots be included?
render	Logical. Should the document be compiled? May be useful to turn off if there are problems with compiling the Rmd file.
output	Character. Output file type. Default is 'html_document'. 'pdf_document' is available but may require additional software and have some formatting issues.
openFile	Logical. Should the compiled file be opened in web browser?
quiet	TRUE to suppress printing of the pandoc command line.
dir	Optional file path to read the xlsx and rmd files. Default is getwd()
...	Optional additional named arguments provided to runMSE

Value

Creates a Rmarkdown file and compiles a HTML report file in the working directory.

Author(s)

A. Hordyk

Examples

```
## Not run:
OMinit('myOM', Stock='Herring', Fleet='Generic_Fleet', Obs='Generic_Obs',
Imp='Perfect_Imp', overwrite=TRUE)
myOM <- XL2OM('myOM.xlsx')
OMdoc(myOM)

## End(Not run)
```

OMexample

Copy example OM XL and OM Documentation

Description

Copy example OM XL and OM Documentation

Usage

```
OMexample(dir = getwd())
```

Arguments

dir the file path to copy the files to.

Examples

```
## Not run:
OMexample()

## End(Not run)
```

OMinit

Initialize Operating Model

Description

Generates an Excel spreadsheet and a source.rmd file in the current working directory for specifying and documenting a MSETool Operating Model.

Usage

```

OMinit(
  name = NULL,
  ...,
  files = c("xlsx", "rmd"),
  dir = NULL,
  overwrite = FALSE
)

```

Arguments

name	The name of the Excel and source.rmd file to be created in the working directory (character). Use 'example' for a populated example OM XL and documentation file.
...	Optional MSEtool objects to use as templates: OM, Stock, Fleet, Obs, or Imp objects
files	What files should be created: 'xlsx', 'rmd', or c('xlsx', 'rmd') (default: both) to use as templates for the Operating Model.
dir	Optional file path to create the xlsx and rmd files. Default is getwd()
overwrite	Logical. Should files be overwritten if they already exist?

Value

name.xlsx and name.rmd files are created in the working directory.

Author(s)

A. Hordyk

Examples

```

## Not run:
# Create an Excel OM template and rmd file called 'myOM.xlsx' and 'myOM.rmd':
OMinit('myOM')

# Create an Excel OM template and text file called 'myOM.rmd' and 'myOM.rmd', using
another OM as a template:
OMinit('myOM', myOM)

# Create an Excel OM template and text file called 'myOM.rmd' and 'myOM.rmd', using
the Stock object 'Herring' as a template:
OMinit('myOM', Herring)

# Create an Excel OM template and text file called 'myOM.rmd' and 'myOM.rmd', using
the Stock object 'Herring', and Obs object 'Generic_obs' as templates:
OMinit('myOM', Herring, Generic_obs)

## End(Not run)

```

optCPU	<i>Determine optimal number of cpus</i>
--------	---

Description

Determine optimal number of cpus

Usage

```
optCPU(nsim = 96, thresh = 5, plot = TRUE, msg = TRUE, maxn = NULL)
```

Arguments

nsim	Numeric. Number of simulations.
thresh	Recommended n cpus is what percent of the fastest time?
plot	Logical. Show the plot?
msg	Logical. Should messages be printed to console?
maxn	Optional. Maximum number of cpus. Used for demo purposes

Author(s)

A. Hordyk

See Also

[setup](#)

Examples

```
## Not run:  
optCPU()  
  
## End(Not run)
```

Overages	<i>Imp class objects</i>
----------	--------------------------

Description

Example objects of class Imp

Usage

Overages

Perfect_Imp

Format

An object of class Imp of length 1.

An object of class Imp of length 1.

Examples

```
avail("Imp")
```

PerformanceMetric	<i>Performance Metrics Methods</i>
-------------------	------------------------------------

Description

Performance metric (PMs) methods for your management strategy evaluation.

Usage

```
P10(MSEobj = NULL, Ref = 0.1, Yrs = NULL)
```

```
P50(MSEobj = NULL, Ref = 0.5, Yrs = NULL)
```

```
P100(MSEobj = NULL, Ref = 1, Yrs = NULL)
```

```
PNOF(MSEobj = NULL, Ref = 1, Yrs = NULL)
```

```
LTY(MSEobj = NULL, Ref = 0.5, Yrs = -10)
```

```
STY(MSEobj = NULL, Ref = 0.5, Yrs = 10)
```

```
Yield(MSEobj = NULL, Ref = 1, Yrs = NULL)
```

```
AAVY(MSEobj = NULL, Ref = 0.2, Yrs = NULL)
```

```
AAVE(MSEobj = NULL, Ref = 0.2, Yrs = NULL)
```

Arguments

MSEobj An object of class MSE

Ref Reference point for calculating the performance metric. See details.

Yrs Numeric vector of length 2 with year indices to summarize performance. If NULL, the performance is summarized over all projection years.

Details

Performance Metric definitions:

P10	Probability $B > 0.1$ BMSY
P50	Probability $B > 0.5$ BMSY
P100	Probability $B > \text{BMSY}$
PNOF	Probability $F < \text{FMSY}$
LTY	Probability Long-Term Yield > 0.5 Relative Yield
STY	Probability Short-Term Yield > 0.5 Relative Yield
AAVY	Probability $\text{AAVY} < 0.2$ (Average Annual Variability in Yield)
AAVE	Probability $\text{AAVE} < 0.2$ (Average Annual Variability in Effort)
Yield	Average Yield (relative to Reference Yield)

Argument `Ref` provides the ratio relative to the reference point for calculating the performance metric. For biomass-based PMs (P10, P50, P100), this is the fraction of BMSY. For PNOF, the fraction of FMSY. For Yield (and LTJ/STY), the fraction of the Reference Yield. For AAVY is it the maximum acceptable variability in yield (i.e, default for AAVY is $\text{Ref}=0.2$)

The `Yrs` argument defines the number of years to calculate the performance statistic over. A value of NULL, the default for AAVY, AAVE, P10, P50, P100, and PNOF, means that the performance metric is calculated over all projection years. A numeric vector of length two is used to specify the first and last year, e.g, if `Yrs=c(1, 10)` the performance statistic is calculated over the first 10 projection years. A numeric vector of length one with positive or negative value respectively can be used to specify the first x or last x years, e.g, `Yrs=10` is first 10 years, and `Yrs=-10` is the last 10 years. See [ChkYrs](#) for more details.

By default Long-Term Yield (LTY) is the Yield in the last ten years of the projection period in the MSE, and Short-Term Yield (STY) is that in the first 10 years of the projection period.

Value

An object of class `PMobj`

Examples

```
## Not run:
myMSE <- runMSE()
P10(myMSE)
P50(myMSE)
P100(myMSE)
PNOF(myMSE)
LTY(myMSE)
STY(myMSE)
AAVY(myMSE)
AAVE(myMSE)
Yield(myMSE)

## End(Not run)
```

 plot.Data

Plot Data object

Description

Creates plots of the Data object in the R console. Wrapper for `summary(Data)`

Usage

```
## S3 method for class 'Data'
plot(
  x,
  wait = TRUE,
  i = 1,
  plots = "all",
  rmd = FALSE,
  head = "##",
  tplot = 25,
  ...
)
```

Arguments

x	An object of class Data
wait	Logical. Wait for key press before next plot?
i	iteration number for the Data object.
plots	Character. What plots to show? all, TS, CAA, CAL, PD for all plots, time-series, catch-at-age, catch-at-length, and probability distributions respectively
rmd	Logical. Used in a rmd file?
head	Character. Heading for rmd file. Default is '##' (second level heading)
tplot	Integer. Number of plots per page. Default 25
...	Not used

 plot.MMSE

Standard plot for an object of class MMSE (multi MSE)

Description

Plot the projected biomass, fishing, mortality rate and yield for all stocks and MPs

Usage

```
## S3 method for class 'MMSE'
plot(
  x = NULL,
  maxcol = 6,
  qcol = rgb(0.4, 0.8, 0.95),
  lcol = "dodgerblue4",
  quants = c(0.05, 0.25, 0.75, 0.95),
  curyr = 2018,
  addline = FALSE,
  ...
)
```

Arguments

x	Object of class MMSE . A Multi-OM object created by <code>multiMSE(MOM, ...)</code>
maxcol	Integer. The maximum number of columns (MPs) to be plotted in each plot
qcol	Character, color. The color of the inner percentile range
lcol	Character, color. The color of the outer percentile range.
quants	Numeric vector. The percentiles that are plotted (LB2, LB1, UB1, UB2). LB2 and UB2 are the outer percentiles, LB1 and UB1 are the inner percentiles.
curyr	Integer. The current year from which projections start.
addline	Logical. Should two individual simulations be added to the percentile plots?
...	Not used

Author(s)

T.Carruthers

plot.MSE

Plot MSE object

Description

Plot MSE object

Usage

```
## S3 method for class 'MSE'
plot(x, ...)
```

Arguments

x	object of class MSE
...	other parameters passed to plot (currently ignored)

`plot.pars`*Plot Operating Model Object*

Description

Generate HTML reports with plots of operating model components ("Stock", "Fleet", "Obs", and "Imp"), the historical simulations ("Hist"), or the complete OM ("OM").

The individual component plots of objects of class `Stock` and `Fleet` can also be generated by using the generic `plot.pars` function. See Examples below.

Usage

```
## S3 method for class 'pars'
plot(
  x,
  Object,
  Stock = NULL,
  nsamp = 3,
  nsim = 200,
  nyears = 50,
  proyears = 28,
  output_file = NULL,
  output_dir = getwd(),
  quiet = TRUE,
  tabs = TRUE,
  title = NULL,
  date = NULL,
  plotPars = NULL,
  html = FALSE,
  open = TRUE,
  dev = FALSE,
  ...
)

## S3 method for class 'Stock'
plot(
  x,
  nsamp = 3,
  nsim = 200,
  nyears = 50,
  proyears = 28,
  output_file = NULL,
  output_dir = getwd(),
  quiet = TRUE,
  tabs = TRUE,
  title = NULL,
```

```
    date = NULL,  
    plotPars = NULL,  
    open = TRUE,  
    dev = FALSE,  
    ...  
  )  
  
## S3 method for class 'Fleet'  
plot(  
  x,  
  Stock = NULL,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,  
  date = NULL,  
  plotPars = NULL,  
  open = TRUE,  
  dev = FALSE,  
  ...  
)  
  
## S3 method for class 'Obs'  
plot(  
  x,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,  
  date = NULL,  
  plotPars = NULL,  
  open = TRUE,  
  dev = FALSE,  
  ...  
)  
  
## S3 method for class 'Imp'  
plot(  
  x,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,  
  date = NULL,  
  plotPars = NULL,  
  open = TRUE,  
  dev = FALSE,  
  ...  
)
```

```
x,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,  
  date = NULL,  
  plotPars = NULL,  
  open = TRUE,  
  dev = FALSE,  
  ...  
)  
  
## S3 method for class 'Hist'  
plot(  
  x,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,  
  date = NULL,  
  plotPars = NULL,  
  open = TRUE,  
  dev = FALSE,  
  ...  
)  
  
## S3 method for class 'OM'  
plot(  
  x,  
  nsamp = 3,  
  nsim = 200,  
  nyears = 50,  
  proyears = 28,  
  output_file = NULL,  
  output_dir = getwd(),  
  quiet = TRUE,  
  tabs = TRUE,  
  title = NULL,
```

```

    date = NULL,
    plotPars = NULL,
    open = TRUE,
    dev = FALSE,
    ...
)

```

Arguments

x	An object of class Stock, Fleet, Obs, Imp, Hist, or OM, OR one of the following character strings for Object of class Stock: "M", "Growth", "Maturity", "Recruitment", "Spatial", or "Depletion" and for Object of class Fleet: "Effort", "Catchability", "MPA", and "Selectivity".
Object	An object of class Stock or Fleet
Stock	An object of class Stock required for Fleet parameters
nsamp	The number of random samples to show in the plot
nsim	The number of simulations (only used for objects not of class OM)
nyears	The number of historical years (only used for objects not of class OM)
proyears	The number of projection years (only used for objects not of class OM)
output_file	Name of the output html file (without file extension)
output_dir	Output directory. Defaults to getwd()
quiet	An option to suppress printing of the pandoc command line
tabs	Include tabs in the HTML file?
title	Optional title for the markdown report
date	Optional date for the markdown report
plotPars	A named list with options for plots: <ul style="list-style-type: none"> • breaks - numeric. Number of breaks in histograms. • col - character. Color of histograms. • axes - logical. Include axes in histogram? • cex.main - numeric. Size of main title in plots. • lwd - numeric. Line width for time-series plots.
html	Logical. Compile to a HTML report (TRUE) or print plots in R console (FALSE)
open	Logical. Open the html file?
dev	Logical. For development use only.
...	Not used

Examples

```

## Not run:
# Plot Stock Object:
Stock <- MSEtool::Albacore
plot(Stock)

```

```
# Individual plots:
plot("M", Stock)
plot("Growth", Stock)
plot("Maturity", Stock)
plot("Recruitment", Stock)
plot("Spatial", Stock)
plot("Depletion", Stock)

# Plot Fleet Object
Fleet <- MSEtool::Generic_DecE
plot(Fleet, Stock)

# Individual plots:
plot("Effort", Fleet, Stock)
plot("Catchability", Fleet, Stock)
plot("MPA", Fleet, Stock)
plot("Selectivity", Fleet, Stock)

# Plot Obs Object
Obs <- MSEtool::Imprecise_Unbiased
plot(Obs)

# Plot Imp Object
Imp <- MSEtool::Overages
plot(Imp)

# Plot Hist Object
OM <- MSEtool::testOM
Hist <- Simulate(OM)
plot(Hist)

# Plot OM Object
plot(OM)

## End(Not run)
```

plotFun

Print out plotting functions

Description

This function prints out the available plotting functions for objects of class MSE or Data

Usage

```
plotFun(class = c("MSE", "Data"), msg = TRUE)
```

Arguments

class	Character string. Prints out the plotting functions for objects of this class.
msg	Logical. Should the functions be printed to screen?

Note

Basically the function looks for any functions in the MSEtool that have the word `plot` in them. There is a chance that some plotting functions are missed. Let us know if you find any and we will add them.

Author(s)

A. Hordyk

plotmulti	<i>A basic SSB plot for debugging runMSE output</i>
-----------	---

Description

A basic SSB plot for debugging runMSE output

Usage

```
plotmulti(MSEmulti, maxsim = 8)
```

Arguments

MSEmulti	An object of class MMSE arising from a run of multiMSE(MOM, ...)
maxsim	Integer. The number of simulations to plot

Author(s)

T.Carruthers

plotOFL	<i>A generic OFL plot for NOAA use</i>
---------	--

Description

As title.

Usage

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

Arguments

Data	An object of class 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

plotquant	<i>A fairly tidy time-series quantile plot</i>
-----------	--

Description

A fairly tidy time-series quantile plot

Usage

```
plotquant(  
  x,  
  p = c(0.05, 0.25, 0.75, 0.95),  
  yrs,  
  qcol,  
  lcol,  
  addline = T,  
  ablines = NA  
)
```


Arguments

x	Matrix. A time series quantity [simulation, year]
p	Numeric vector. The percentiles that are plotted (LB2, LB1, UB1, UB2). LB2 and UB2 are the outer percentiles, LB1 and UB1 are the inner percentiles.
yrs	Numeric vector. The years corresponding to the indexing of x
qcol	Character, color. The color of the inner percentile range
lcol	Character, color. The color of the outer percentile range.
addline	Logical. Should two individual simulations be added to the percentile plots?
ablines	Numeric vector. Horizontal lines to be added to the plot.

Author(s)

T.Carruthers

PMLimit

*Create a table of Performance Limits and Performance Objectives***Description**

Create a table of Performance Limits and Performance Objectives

Usage

```

PMLimit(
  MSE,
  ...,
  Prob = NULL,
  Labels = NULL,
  FeaseMPs = NULL,
  out.file = NULL,
  output_format = "html_document",
  openFile = TRUE,
  quiet = TRUE,
  dir = NULL,
  RMDfile = NULL,
  font_size = 14,
  auto_width = FALSE,
  enableSearch = TRUE,
  PMList = NULL,
  build = TRUE
)

PMObj(
  MSE,
  ...,

```

```

Labels = NULL,
out.file = NULL,
output_format = "html_document",
openFile = TRUE,
quiet = TRUE,
dir = NULL,
RMDfile = NULL,
font_size = 14,
use.colors = TRUE,
cols = NULL,
show.legend = TRUE,
auto_width = FALSE,
enableSearch = TRUE,
PMList = NULL,
build = TRUE,
cex.tex = 0.75,
inc.title = TRUE,
title = "Legend"
)

```

Arguments

MSE	An object of class 'MSE'
...	PM objects to be used as performance limits. Characters (i.e names of PM objects)
Prob	Minimum probability threshold
Labels	Optional named list specifying new labels for MPs. For example: <code>Labels = list(AvC="Average Catch", CC1="Constant Catch")</code>
FeaseMPs	Optional. Character vector of MP names that are considered feasible. e.g. the output from <code>Fease()</code>
out.file	Name of the output file. If none provided, output file will be named 'PerfLimTable'
output_format	Output file format. Currently only 'html_document' is supported
openFile	Logical. Should the file be opened in browser?
quiet	Logical. An option to suppress printing of the pandoc command line.
dir	Optional. Directory for output file. Default is working directory.
RMDfile	Optional. RMD template file
font_size	Numeric. Font size for text in the table
auto_width	Logical. Should table be width be automatic?
enableSearch	Currently disabled. Logical. Should search be enabled in the html table?
PMList	Optional. List of PM names.
build	Logical. Build the html table?
use.colors	Logical. Color scale the probability text?
cols	Optional character vector of colors for probability text

show.legend	Logical. Show the legend??
cex.tex	Size of legend text
inc.title	Logical. Include title for legend?
title	Title for the legend

Value

PMLimit invisibly returns names of MPs that pass all performance limits

Functions

- PMLimit: Create a table of Performance Limits
- PMObj: Create a table of Performance Objectives.

Author(s)

A. Hordyk

Examples

```
## Not run:
MSE <- runMSE()
PMLimit(MSE, "P50", "PNOF", Prob=0.9)
PMObj(MSE, "P100", "LTY")

## End(Not run)
```

PMobj-class

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

Description

Used internally

Slots

Name Name of the Performance Metric. Character

Caption A caption to be used in plots. Character, call, or function.

Stat Statistic of interest for the PM. Dimensions: nsim, nMP, yrs. Array

Ref Reference value to calculate probability for statistic. Numeric.

Prob Probability (mean over years) Dimensions: nsim by MP. Matrix, numeric or data.frame

Mean Mean probability (mean over years and simulations). Numeric. Length nMPs

MPs Name of MPs. Single value. Character string

Objects from the Class

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

Author(s)

A. Hordyk

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, maxMP = 10, MPs = NA, maxsims = 20)
```

Arguments

MSEobj	An object of class MSE
nam	Title of plot
maxMP	The maximum number of MPs to plot (defaults to the first 10)
MPs	A character vector of MPs to plot
maxsims	Integer, the maximum number of simulations to plot

Author(s)

T. Carruthers

Pplot2

A projection by projection plot of F/FMSY, B/BMSY, B/B0, and yield

Description

A projection by projection plot of F/FMSY, B/BMSY, B/B0, and yield

Usage

```

Pplot2(
  MSEobj,
  YVar = c("F_FMSY", "SSB_SSBMSY"),
  MPs = NA,
  sims = NULL,
  traj = c("all", "quant", "both"),
  quants = c(0.1, 0.9),
  incquant = TRUE,
  quantcol = "lightgray",
  RefYield = c("lto", "curr"),
  LastYr = TRUE,
  ref.lines = c(0.5, 1, 1.5),
  maxMP = 6,
  alpha = 60,
  cex.axis = 1,
  cex.lab = 1,
  YLab = NULL,
  incMP = TRUE,
  MPcex = 1,
  MPcol = "black",
  incLeg = TRUE,
  cex.leg = 1.5,
  legPos = "topleft",
  yline = NULL,
  xline = NULL,
  parOR = FALSE,
  xaxis = TRUE,
  yaxis = TRUE,
  oneIt = TRUE,
  ...
)

```

Arguments

MSEobj	An object of class MSE
YVar	What to plot on the y-axis? Options are: c('SSB_SSB0', 'SSB_SSBMSY', 'F_FMSY', 'Yield')
MPs	Optional subset by MP
sims	Optional subset by simulation
traj	Plot all projections (all), only quantiles (quant), or both projections and median (both)
quants	Numeric vector of length 2 specifying the quantiles (e.g., 10th and 90th. Median is always included)
incquant	Logical. Include the quantiles or only plot median?
quantcol	Colour of the quantile polygon
RefYield	Should yield be relative to long-term optimum (lto) or last historical year (curr)

LastYr	Logical. Include the last historical year in the yield projections?
ref.lines	Numeric vector of y-values for horizontal reference lines. Set to NULL to remove lines.
maxMP	Maximum number of MPs to plot
alpha	Alpha for transparency of lines
cex.axis	Size of axis text
cex.lab	Size of axis label
YLab	Optional label for y-axis
incMP	Logical. Include name of MP?
MPcex	Size of MP label
MPcol	Optional character vector of colors for MP labels
incLeg	Logical. Include a legend?
cex.leg	Size of legend text
legPos	Legend position
yline	Optional horizontal lines
xline	Optional vertical lines
parOR	Logical to over-ride the par parameters
xaxis	Logical. Should x-axis labels be displayed?
yaxis	Logical. Should y-axis labels be displayed?
oneIt	Logical. Should one iteration be plotted on the quantile plot?
...	Additional arguments to be passed to plotting functions

Author(s)

T. Carruthers & A.Hordyk

PWhisker

Performance Whisker Plot

Description

A NAFO / ICCAT / SSB style MSE performance whisker plot

Usage

PWhisker(MSEobj)

Arguments

MSEobj An object of class MSE

Value

A box plot of performance

Author(s)

T. Carruthers

RealFease

MP feasibility diagnostic using real data

Description

What MPs do not return NAs from the real data

Usage

RealFease(Data = NULL)

Arguments

Data	An object of class 'Data'. Optional. If Data object is included, the returned MPs are both feasible (in terms of management) and possible (sufficient data to run MP)
------	---

Value

a vector of MP names that calculate without errors for the specific data.

Author(s)

T. Carruthers

Rec-class

Class 'Rec'

Description

An object for storing the MP recommendations

Slots

TAC A numeric value with the TAC recommendation

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

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

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

LR5 smallest length at 5 per cent retention - in absolute units - i.e same units as Linf and L50

LFR smallest length at full retention - in absolute units - i.e same units as Linf and L50

HS upper harvest slot (no retention above this) - in absolute units - i.e same units as Linf and L50

Rmaxlen retention of the largest size class - fraction between 0 and 1

L5 smallest length at 5 per cent selection - in absolute units - i.e same units as Linf and L50

LFS smallest length at full selection - in absolute units - i.e same units as Linf and L50

Vmaxlen selection of the largest size class - fraction between 0 and 1

Fdisc fraction of discarded fish that die - fraction between 0 and 1

DR Discard rate - the fraction of caught fish that are discarded

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

Objects from the Class

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

Author(s)

A. Hordyk

Replace

Replace an existing Stock, Fleet, Obs, or Imp object

Description

A function that replaces a Stock, Fleet, Obs, or Imp object from an OM with one from another object.

Usage

```
Replace(
  OM,
  from,
  Sub = c("Stock", "Fleet", "Obs", "Imp"),
  Name = NULL,
  silent = FALSE
)
```


Arguments

OM	An operating model object (class OM) which will be updated with a sub-model from another OM
from	An object of class OM, Stock, Fleet, Obs, or Imp to be replace the values in OM
Sub	A character string specifying what object type to replace (only used if from is class OM) "Stock", "Fleet", "Obs", or "Imp" (default is all four which is probably not what you want to do)
Name	Character. Name for the new OM object (OM@Name)
silent	Should messages be printed?

Value

An object of class OM

Author(s)

A. Hordyk

Examples

```
# Replace Stock
OM <- MSEtool::testOM
OM2 <- Replace(OM, Blue_shark)

# Replace Fleet
OM <- MSEtool::testOM
OM2 <- Replace(OM, Generic_DecE)

# Replace Fleet from another OM
OM1 <- new("OM", Albacore, Generic_DecE, Perfect_Info, Overages)
OM2 <- new("OM", Blue_shark, Generic_IncE, Generic_Obs, Perfect_Imp)
OM1a <- Replace(OM1, OM2, "Fleet")
```

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(Data, nrep)
```

Arguments

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

Author(s)

T. Carruthers

Report	<i>Generate a Data Report</i>
--------	-------------------------------

Description

A HTML Data Report is generated and opened in a web browser

Usage

```
Report(
  Data = NULL,
  md = NULL,
  name = "Data-Report",
  title = "Data Documentation",
  author = "Author Name",
  date = Sys.Date(),
  output_format = c("html_document", "pdf_document"),
  open = TRUE,
  quiet = TRUE,
  dir = NULL,
  overwrite = FALSE
)
```

Arguments

Data	Either an object of class Data or the file path to a valid file to be imported with XL2Data
md	Full file path to a valid text file documenting the Data
name	Optional. Name of the output file
title	Title for the Report. Title in the markdown file will override this value
author	Author of the Report. Author in the markdown file will override this value
date	Date of the Report. Date in the markdown file will override this value
output_format	Output file format: html_document or pdf_document
open	Logical. Open the compiled report?
quiet	Logical. An option to suppress printing of the pandoc command line.
dir	Optional. Directory to save the file. Defaults to getwd()
overwrite	Logical. Overwrite an existing file with the same name?

Value

Nothing. A Data Report is generated and saved in dir

Author(s)

A. Hordyk

Examples

```
## Not run:
DataInit('Example') # generate example Data Input and Documentation files
Report('Example', 'Example.md')

## End(Not run)
```

ReqData

ReqData

Description

Dataframe with required data slots for built-in MPs

Usage

```
ReqData
```

Format

An object of class `data.frame` with 123 rows and 2 columns.

Required

What management procedures need what data

Description

A function that finds all the MPs and searches the function text for slots in the Data object

Usage

```
Required(funcs = NA, noCV = FALSE)
```

Arguments

funcs	A character vector of management procedures
noCV	Logical. Should the CV slots be left out?

Value

A matrix of MPs and their required data in terms of slotnames('Data'), and broad Data classes for each MP

Author(s)

T. Carruthers

See Also

[Can Cant Needed MPtype Data](#)

Examples

```
## Not run:
library(DLMtool) # load Data-Limited MPs
Required(c("DCAC", "AvC"))
Required() # For all MPs

## End(Not run)
```

runCOSEWIC

COSEWIC MSE run using the correct MPs and projected time horizon

Description

Dedicated functions for MSE run and reporting for COSEWIC (Committee on the Status of Endangered Wildlife in Canada). MSE projects for 6x maximum age using NFref, FMSYref and curE management procedures.

Usage

```
runCOSEWIC(OM, ...)
```

```
COSEWIC_Pplot(
  MSEobj,
  syear = 2017,
  qcol = "#FFCB62",
  quants = c(0.05, 0.25, 0.5, 0.75, 0.95)
)
```

```
COSEWIC_Dplot(
  MSEobj,
  syear = 2017,
  qcol = "#79F48D",
  quants = c(0.05, 0.25, 0.5, 0.75, 0.95),
  nGT = 3
)
```

```

)

COSEWIC_Blow(
  MSEobj,
  syear = 2017,
  qcol = rgb(0.4, 0.8, 0.95),
  quants = c(0.05, 0.25, 0.5, 0.75, 0.95),
  nGT = 3
)

COSEWIC_Hplot(
  MSEobj,
  syear = 2017,
  qcol = rgb(0.4, 0.8, 0.95),
  quants = c(0.05, 0.25, 0.5, 0.75, 0.95)
)

COSEWIC_report(
  MSEobj,
  output_file = NA,
  author = "Author not specified",
  title = NA
)

COSEWIC_tab(MSEobj, rnd = 0, GTs = c(3, 6), syear = 2017, nGT = 3)

COSEWIC_tab_formatted(
  Ptab1,
  thresh = c(20, 40, 40, 20, 40, 40, 40, 30, 5),
  ret_thresh = F
)

```

Arguments

OM	An operating model object of class OM
...	Other named arguments to pass to runMSE
MSEobj	An object of class MSE with MPs = c("NFref", "FMSYref", "curE")
syear	Current year, starting year for projections (e.g. 2017)
qcol	Color of shaded regions (bars, quantiles)
quants	Quantiles of the shaded regions (vector 5 long e.g. 0.1, 0.2, 0.5, 0.8, 0.9)
nGT	Number of generation times. For COSEWIC_tab, for moving window of SSB chance (metrics A1 and A2). For COSEWIC_Blow and COSEWIC_Dplot, used for projections (the number of projection years should be greater than MaxAge * nGT).
output_file	The directory and filename you wish to use for the report e.g. "C:/temp/myMSEreport.html"
author	The person who made this report

title	The title of the report
rnd	The number of significant figures for rounding.
GTs	A vector of mean generation times to evaluate performance metrics over
Ptab1	A COSEWIC performance table made by COSEWIC_tab
thresh	A vector of thresholds for each column Health, Yield and Reb are 'greater than threshold' conditions
ret_thresh	Logical: if true just the threshold levels are returned

Functions

- runCOSEWIC: Calls runMSE with number of projection years for 6x maximum age and uses NFref, FMSYref, and curE MPs.
- COSEWIC_Pplot: Projection plots of spawning stock biomass under three scenarios: no catch, FMSY fishing and status quo fishing effort.
- COSEWIC_Dplot: Depletion plots evaluate whether significant declines have occurred over three generation times in both historical and projection years.
- COSEWIC_Blow: Plots that evaluate the likelihood of declining below Blow, by default, biomass that takes 3 generation times to reach half BMSY with zero fishing
- COSEWIC_Hplot: Plots of historical spawning stock relative to unfished and MSY levels.
- COSEWIC_report: Create a standard DFO COSEWIC report (provides performance plots to inform COSEWIC processes in Canadian fish stocks).
- COSEWIC_tab: Creates a standard COSEWIC performance table:
 - P_Cr is the probability of being in the critical zone (less than 20% depletion)
 - P_Ct is the probability of being in the cautious zone (between 20% and 40% depletion)
 - P_H is the probability of being in the healthy zone (above 40% depletion)
 - P_Cr_MSY is the probability of being in the critical zone (less than 40% BMSY)
 - P_Ct_MSY is the probability of being in the cautious zone (between 40% and 80% BMSY)
 - P_H_MSY is the probability of being in the healthy zone (above 80% BMSY)
 - Caut is the probability of being in the cautious zone in the last 10 projected years
 - P_A1 is the probability of being designated threatened according to COSEWIC Indicator A1 (Spawning biomass less than 70% that three generation times previously)
 - P_A2 is the probability of being designated threatened according to COSEWIC Indicator A2 (Spawning biomass less than 50% that three generation times previously)
 - Blow is the probability that the stock is below the biomass for which it takes 3 generation times to reach 50% BMSY with zero fishing
- COSEWIC_tab_formatted: A formatted version of the standard COSEWIC performance plot, color coded by thresholds.

Author(s)

T. Carruthers

References

<https://cosewic.ca/index.php/en-ca/>

runInMP	<i>Runs input control MPs on a Data object.</i>
---------	---

Description

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

Usage

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

Arguments

Data	A object of class Data
MPs	A vector of MPs of class 'Input'
reps	Number of stochastic repetitions - often not used in input control MPs.

Author(s)

A. Hordyk

runMP	<i>Run a Management Procedure</i>
-------	-----------------------------------

Description

Run a Management Procedure

Usage

```
runMP(Data, MPs = NA, reps = 100, perc = 0.5, chkMPs = FALSE, silent = FALSE)
```

Arguments

Data	A MSEtool Data object
MPs	The name of the MP to run (or a vector or names)
reps	Number of repetitions
perc	Percentile to summarize reps (default is median)
chkMPs	Logical. Should the MPs be checked before attempting to run them?
silent	Logical. Should messages be suppressed?

Value

invisibly returns the Data object

Examples

```
Data_TAc <- runMP(MSEtool::Cobia)
```

Sense

Sensitivity analysis

Description

A function that determines the inputs for a given data-limited method of class Output and then analyses the sensitivity of TAC estimates to marginal differences in each input. The range used for sensitivity is based on the user-specified CV for that input (e.g. CV_Mort, Mort)

Usage

```
Sense(Data, MP, nsense = 6, reps = 100, perc = c(0.05, 0.5, 0.95), ploty = T)
```

Arguments

Data	A data-limited methods data object
MP	A character string representing an MP applied in calculating the TAC recommendations in the DLM object
nsense	The number of points over which to calculate the TAC (resolution)
reps	The number of samples of the quota taken for the calculation of the TAC
perc	The percentile of the sample TAC
ploty	A logical switch, (T/F, should a plot be drawn?)

Author(s)

T. Carruthers

Examples

```
## Not run:
Data <- Sense(MSEtool::Cobia, "AvC")

## End(Not run)
```

setup	<i>Setup parallel processing</i>
-------	----------------------------------

Description

Sets up parallel processing using the snowfall package

Usage

```
setup(cpus = NULL, logical = FALSE, ...)
```

Arguments

cpus	the number of CPUs to use for parallel processing. If left empty all physical cores will be used, unless <code>logical=TRUE</code> , in which case both physical and logical (virtual) cores will be used.
logical	Use the logical cores as well? Using the virtual cores may not lead to any significant decrease in run time. You can test the optimal number of cores using <code>optCPU()</code>
...	other arguments passed to <code>'snowfall::sfInit'</code>

Examples

```
## Not run:
setup() # set-up the physical processors
setup(6) # set-up 6 processors
setup(logical=TRUE) # set-up physical and logical cores

## End(Not run)
```

show, PMobj-method	<i>Show the output of a PM</i>
--------------------	--------------------------------

Description

Show the output of a PM

Usage

```
## S4 method for signature 'PMobj'
show(object)
```

Arguments

object	object of class MSE
--------	---------------------

show, Rec-method *Show the output of a single MP recommendation*

Description

Show the output of a single MP recommendation

Usage

```
## S4 method for signature 'Rec'  
show(object)
```

Arguments

object object of class Rec

SIL *Slot in list: get the slot values from a list of objects*

Description

Create of vector of values that correspond with a slot in a list of objects

Usage

```
SIL(listy, sloty)
```

Arguments

listy A list of objects
sloty A character vector representing the slot name

Author(s)

T. Carruthers

simCAA	<i>Simulate Catch-at-Age Data</i>
--------	-----------------------------------

Description

CAA generated with either a multinomial or logistic normal observation model from retained catch-at-age array

Usage

```
simCAA(nsim, yrs, n_age, Cret, CAA_ESS, CAA_nsamp)
```

Arguments

nsim	Number of simulations
yrs	Number of years
n_age	Number of age classes
Cret	Retained Catch at age in numbers - array(sim, years, maxage+1)
CAA_ESS	CAA effective sample size. If greater than 1, then this is the multinomial distribution sample size. If less than 1, this is the coefficient of variation for the logistic normal distribution (see details).
CAA_nsamp	CAA sample size

Details

The logistic normal generates the catch-at-age sample by first sampling once from a multivariate normal distribution with the mean vector equal to the logarithm of the proportions-at-age and the diagonal of the covariance matrix is the square of the product of the CV and the log proportions (all off-diagonals are zero). The sampled vector is then converted to proportions with the softmax function and expanded to numbers (CAA_nsamp). This method allows for simulating fractional values in the catch-at-age matrix.

Value

CAA array

simCAL

*Simulate Catch-at-Length Data***Description**

Simulate CAL and calculate length-at-first capture (LFC), mean length (ML), modal length (Lc), and mean length over modal length (Lbar)

Usage

```
simCAL(
  nsim,
  nyears,
  maxage,
  CAL_ESS,
  CAL_nsamp,
  nCALbins,
  CAL_binsmid,
  CAL_bins,
  vn,
  retL,
  Linfarray,
  Karray,
  t0array,
  LenCV
)
```

Arguments

nsim	Number of simulations
nyears	Number of years
maxage	Maximum age
CAL_ESS	CAA effective sample size
CAL_nsamp	CAA sample size
nCALbins	number of CAL bins
CAL_binsmid	mid-points of CAL bins
CAL_bins	Boundary of CAL bins
vn	Vulnerable numbers-at-age
retL	Retention at length curve
Linfarray	Array of Linf values by simulation and year
Karray	Array of K values by simulation and year
t0array	Array of t0 values by simulation and year
LenCV	CV of length-at-age#'

Value

named list with CAL array and LFC, ML, & Lc vectors

```
CALdat <- simCAL(nsim, nyears, StockPars$maxage, ObsPars$CAL_ESS,
```

simmov

Calculates movement matrices from user inputs

Description

A wrapper function for [makemov](#) used to generate movement matrices for the operating model. Calculates a movement matrix from user-specified unfished stock biomass fraction in each area and probability of staying in the area in each time step.

Usage

```
simmov(
  OM,
  dist = c(0.1, 0.2, 0.3, 0.4),
  prob = 0.5,
  distE = 0.1,
  probE = 0.1,
  prob2 = NA,
  figure = TRUE
)
```

```
plot_mov(mov, age = 1, type = c("matrix", "all"), year = 1, qual = 0.9)
```

Arguments

OM	Operating model, an object of class OM .
dist	A vector of fractions of unfished stock in each area. The length of this vector will determine the number of areas (nareas) in the OM.
prob	Mean probability of staying across all areas (single value) or a vector of the probability of individuals staying in each area (same length as dist).
distE	Logit (normal) St.Dev error for sampling stock fractions from the frags vector
probE	Logit (normal) St.Dev error for sampling desired probability of staying either by area (prob is same length as dist) or the mean probability of staying (prob is a single number).
prob2	Optional vector as long as prob and dist. Upper bounds on uniform sampling of probability of staying, lower bound is prob.
figure	Logical to indicate if the movement matrix will be plotted (mean values and range across OM@nsim simulations.)

mov	A four-dimensional array of dimension $c(\text{nsim}, \text{maxage}, \text{nareas}, \text{nareas})$ or a five-dimensional array of dimension $c(\text{nsim}, \text{maxage}, \text{nareas}, \text{nareas}, \text{nyears} + \text{proyears})$ specifying movement in the operating model.
age	An age from 0 to maxage for the movement-at-age matrix figure when <code>type = "matrix"</code> .
type	Whether to plot a movement matrix for a single age (<code>"matrix"</code>) or the full movement versus age figure (<code>"all"</code>)
year	If mov is a 5-dimensional array, the year (from 1 to <code>nyears + proyears</code>) for which to plot movement.
qval	The quantile to plot or report the range of values among simulations.

Value

The operating model OM with movement parameters in slot `cpars`. The `mov` array is of dimension `nsim, maxage, nareas, nareas`.

Functions

- `simmov`: Estimation function for creating movement matrix.
- `plot_mov`: Plotting function.

Note

Array `mov` is age-specific, but currently the movement generated by `simmov` is independent of age.

Author(s)

T. Carruthers and Q. Huynh

Examples

```
## Not run:
movOM_5areas <- simmov(testOM, dist = c(0.01,0.1,0.2,0.3,0.39), prob = c(0.1,0.6,0.6,0.7,0.9))
movOM_5areas@cpars$mov[1, 1, , ] # sim 1, age 1, movement from areas in column i to areas in row j
plot_mov(movOM_5areas@cpars$mov)
plot_mov(movOM_5areas@cpars$mov, type = "all")

## End(Not run)
```

 Simulate

Run a Management Strategy Evaluation

Description

Functions to run the Management Strategy Evaluation (closed-loop simulation) for a specified operating model

Usage

```
Simulate(OM = MSEtool::testOM, parallel = FALSE, silent = FALSE)
```

```
Project(
  Hist = NULL,
  MPs = NA,
  parallel = FALSE,
  silent = FALSE,
  extended = FALSE,
  checkMPs = TRUE
)
```

```
runMSE(
  OM = MSEtool::testOM,
  MPs = NA,
  Hist = FALSE,
  silent = FALSE,
  parallel = FALSE,
  extended = FALSE,
  checkMPs = TRUE
)
```

Arguments

OM	An operating model object (class OM or class Hist)
parallel	Logical. Should the MSE be run using parallel processing? Can be a vector of length(MPs)
silent	Should messages be printed out to the console?
Hist	Should model stop after historical simulations? Returns an object of class 'Hist' containing all historical data
MPs	A vector of methods (character string) of class MP
extended	Logical. Return extended projection results? if TRUE, MSE@Misc\$extended is a named list with extended data (including historical and projection by area), and extended version of MSE@Hist is returned.
checkMPs	Logical. Check if the specified MPs exist and can be run on SimulatedData?

Value

Functions return objects of class [Hist](#) or [MSE](#)

- Simulate - An object of class [Hist](#)
- Project - An object of class [MSE](#)
- runMSE - An object of class [MSE](#)

Functions

- Simulate: Run the Historical Simulations from an object of class OM
- Project: Run the Forward Projections
- runMSE: Run the Historical Simulations and Forward Projections from an object of class 'OM

SimulatedData	<i>SimulatedData Data</i>
---------------	---------------------------

Description

An object of class Data

Usage

SimulatedData

Format

An object of class Data of length 1.

SimulateMOM	<i>Run a multi-fleet multi-stock Management Strategy Evaluation</i>
-------------	---

Description

Functions for running a multi-stock and/or multi-fleet Management Strategy Evaluation (closed-loop simulation) for a specified operating model

Usage

```

SimulateMOM(MOM = MSEtool::Albacore_TwoFleet, parallel = TRUE, silent = FALSE)

ProjectMOM(
  multiHist = NULL,
  MPs = NA,
  parallel = FALSE,
  silent = FALSE,
  checkMPs = TRUE,
  dropHist = TRUE
)

multiMSE(
  MOM = MSEtool::Albacore_TwoFleet,
  MPs = list(list(c("AvC", "DCAC"), c("FMSYref", "curE"))),
  Hist = FALSE,
  silent = FALSE,
  parallel = TRUE,
  checkMPs = TRUE,
  dropHist = TRUE
)

```

Arguments

MOM	A multi-fleet multi-stock operating model (class 'MOM')
parallel	Logical. Should the MSE be run using parallel processing?
silent	Should messages be printed out to the console?
multiHist	An Historical Simulation object (class multiHist)
MPs	A matrix of methods (nstock x nfleet) (character string) of class MP
checkMPs	Logical. Check if the specified MPs exist and can be run on SimulatedData?
dropHist	Logical. Drop the (very large) multiHist object from the returned MMSE object? The multiHist object can be (re-)created using SimulateMOM or kept in MMSE@multiHist if dropHist=FALSE
Hist	Should model stop after historical simulations? Returns a list containing all historical data

Value

Functions return objects of class MMSE and multiHist #'

- SimulateMOM - An object of class multiHist
- ProjectMOM - An object of class MMSE
- multiMSE - An object of class MMSE

Functions

- `SimulateMOM`: Simulate historical dynamics for multi-OM
- `ProjectMOM`: Run Forward Projections for a MOM object
- `multiMSE`: Run a multi-stock, multi-fleet MSE

Author(s)

T. Carruthers and A. Hordyk

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

Description

Internal function for interactive plot which allows users to specify the relative trajectory and variability in the historical fishing effort.

Usage

```
SketchFun(nyears, Years=NULL)
```

Arguments

nyears	Number of years
Years	An optional vector of years. Should be nyears long.

Author(s)

A. Hordyk

SS2Data	<i>Reads data Stock Synthesis file structure into a Data object using package r4ss</i>
---------	--

Description

A function that uses the file location of a fitted SS3 model including input files to population the various slots of an Data object.

Usage

```

SS2Data(
  SSdir,
  Name = "Imported by SS2Data",
  Common_Name = "",
  Species = "",
  Region = "",
  min_age_M = 1,
  gender = 1,
  comp_fleet = "all",
  comp_season = "sum",
  comp_partition = "all",
  comp_gender = "all",
  index_season = "mean",
  silent = FALSE,
  ...
)

```

Arguments

SSdir	A folder with Stock Synthesis input and output files in it
Name	The name for the Data object
Common_Name	Character string for the common name of the stock.
Species	Scientific name of the species
Region	Geographic region of the stock or fishery.
min_age_M	Currently, the Data object supports a single value of M for all ages. The argument selects the minimum age for calculating the mean of age-dependent M from the SS assessment.
gender	An integer index for the sex for importing biological parameters (1 = female, 2 = male).
comp_fleet	A vector of indices corresponding to fleets in the assessment over which to aggregate the composition (catch-at-length and catch-at-age) data. By default, character string "all" will aggregate across all fleets.
comp_season	Integer, for seasonal models, the season for which the value of the index will be used. By default, "mean" will take the average across seasons.
comp_partition	Integer vector for selecting length/age observations that are retained (2), discarded (1), or both (0). By default, "all" sums over all available partitions.
comp_gender	Integer vector for selecting length/age observations that are female (1), male (2), or both (0), or both scaled to sum to one (3). By default, "all" sums over all gender codes.
index_season	Integer, for seasonal models, the season for which the value of the index will be used. By default, "mean" will take the average across seasons.
silent	Logical. Suppress all messages?
...	Arguments to pass to SS_output

Value

An object of class Data.

Note

Currently supports the version of r4ss on CRAN (v.1.24) and Github (v.1.34-40). Function may be incompatible with other versions of r4ss.

Author(s)

T. Carruthers and Q. Huynh

See Also

[SS2OM](#)

SS2DataMOM	<i>Reads data Stock Synthesis file structure into a nested Data object analogous with multiMSE</i>
------------	--

Description

A function that uses the file location of a fitted SS3 model including input files to population the various slots of an Data object.

Usage

```
SS2DataMOM(SSdir, age_M = NULL, comp_partition = 2, silent = FALSE, ...)
```

Arguments

SSdir	A folder with Stock Synthesis input and output files in it. Alternatively,
age_M	A vector of ages to average across to calculate a single value of natural mortality. Currently, the Data object supports a single value of M for all ages. By default, NULL averages over all ages.
comp_partition	Integer vector for selecting length/age observations that are retained (2), discarded (1), or both (0). By default, only retained comps are used. If multiple codes are used, then comp matrix is the sum over all codes.
silent	Logical. Suppress messages?
...	Arguments to pass to SS_output

Value

A nested list of Data objects, with the first index by stock/sex and the second index by fleet.

Note

Currently tested on r4ss version 1.38.1-41 and SS 3.30.14.

Catches in Data@Cat are the predicted sex-specific catch calculated from the SS output.

Author(s)

Q. Huynh

See Also

[SS2MOM](#)

SS2MOM	<i>Import Stock Synthesis to MOM (2-sex multi-fleet) or OM (single-sex, single-fleet)</i>
--------	---

Description

Functions that uses the file location or the r4ss output list of a fitted SS3 model including input files to populate the various slots of an [MOM](#) or [OM](#) object. SS2MOM and SS2OM mainly populates the Stock and Fleet components components of the operating model. SS2MOM creates a 2-sex model and multiple fleets with discarding behavior. SS2OM returns a single sex (either male, female, or averaged biological parameters) and single fleet (aggregate selectivity and mortality, no explicit discarding modeled). For either, the user still needs to parameterize most of the observation and implementation portions. SSMOM2OM is the internal function that simplifies the MOM object to an OM object. plot_SS2OM generates a markdown report to compare the OM and SS output.

Usage

```
SS2MOM(
  SSdir,
  nsim = 48,
  proyears = 50,
  reps = 1,
  maxF = 3,
  seed = 1,
  interval = 1,
  pstar = 0.5,
  Obs = MSEtool::Generic_Obs,
  Imp = MSEtool::Perfect_Imp,
  silent = FALSE,
  Name = "MOM generated by SS2MOM",
  Source = "No Source provided",
  ...
)
```

```
plot_SS2MOM(  
  x,  
  SSdir,  
  gender = 1:2,  
  filename = "SS2MOM",  
  dir = tempdir(),  
  open_file = TRUE,  
  silent = FALSE,  
  ...  
)  
  
SS2OM(  
  SSdir,  
  nsim = 48,  
  proyears = 50,  
  reps = 1,  
  maxF = 3,  
  seed = 1,  
  interval = 1,  
  pstar = 0.5,  
  Obs = MSEtool::Generic_Obs,  
  Imp = MSEtool::Perfect_Imp,  
  import_mov = TRUE,  
  gender = 1:2,  
  seasons_to_years = TRUE,  
  model_discards = TRUE,  
  silent = FALSE,  
  Name = "OM generated by SS2OM function",  
  Source = "No source provided",  
  Author = "No author provided",  
  report = FALSE,  
  filename = "SS2OM",  
  dir = tempdir(),  
  open_file = TRUE,  
  ...  
)  
  
SSMOM2OM(  
  MOM,  
  SSdir,  
  gender = 1:2,  
  import_mov = TRUE,  
  seed = 1,  
  silent = FALSE,  
  model_discards = TRUE  
)  
  
plot_SS2OM(  
  x,  
  SSdir,  
  gender = 1:2,  
  filename = "SS2OM",  
  dir = tempdir(),  
  open_file = TRUE,  
  silent = FALSE,  
  ...  
)
```

```

    x,
    SSdir,
    gender = 1:2,
    filename = "SS2OM",
    dir = tempdir(),
    open_file = TRUE,
    silent = FALSE,
    ...
)

```

Arguments

SSdir	A folder with Stock Synthesis input and output files in it.
nsim	The number of simulations to take for parameters with uncertainty (for OM@cparams custom parameters).
proyears	The number of projection years for MSE
reps	The number of stochastic replicates within each simulation in the operating model.
maxF	The maximum allowable F in the operating model.
seed	The random seed for the operating model.
interval	The interval at which management procedures will update the management advice in multiMSE , e.g., 1 = annual updates.
pstar	The percentile of the sample of the management recommendation for the MP/MMP.
Obs	The observation model (class Obs). These functions do not update implementation parameters.
Imp	The implementation model (class Imp). These functions do not update implementation parameters.
silent	Whether to silence messages to the console.
Name	The name of the operating model
Source	Reference to assessment documentation e.g. a url
...	Arguments to pass to SS_output .
x	For <code>plot_SS2OM</code> , an object of either class OM or Hist . For <code>plot_SS2MOM</code> , an object of either class MOM or <code>multiHist</code> .
gender	An integer that indexes the sex for importing life history parameters (1 = usually female, 2 = usually male, 1:2 = mean across both sexes). Only used for SS2OM only in a 2-sex model.
filename	If <code>report = TRUE</code> , character string for the name of the markdown and HTML files.
dir	If <code>report = TRUE</code> , the directory in which the markdown and HTML files will be saved.
open_file	If <code>report = TRUE</code> , whether the HTML document is opened after it is rendered.
import_mov	Logical. Import movement matrix?

seasons_to_years	Logical, when season is the time step, whether to convert OM from a seasonal model to annual model.
model_discards	Logical, how to simplify a multi-fleet SS model to an OM object. If TRUE, OM will still model discards using the mean retention across fleets (weighted by fleet F). Otherwise, no discards are modeled and all fishing removals are calculated in the OM from the SS F-at-age matrix.
Author	Who did the assessment
report	Logical, if TRUE, the function will run runMSE to generate the Hist object from the operating model to compare against SS output. A markdown report will be generated.
MOM	MOM object

Value

SS2MOM returns an object of class [MOM](#). SS2OM returns an object of class [OM](#).

Note

Currently tested on r4ss version 1.38.1-40.0 and SS 3.30.14.

Author(s)

Q. Huynh

See Also

[SS2Data](#) [SS2DataMOM](#)

SSBrefplot	<i>Plot Spawning stock biomass and reference points for both historical and projected period</i>
------------	--

Description

Plot Spawning stock biomass and reference points for both historical and projected period

Usage

```
SSBrefplot(MSE, simno = 1, ystart = 1, log = F, leg = T)
```

Arguments

MSE	An object of class 'MSE' produced by from runMSE()
simno	Positive integer, the simulation number you wish to plot
ystart	Positive integer, the calendar year corresponding with the first historical year
log	Boolean, whether log SSB and reference points should be plotted
leg	Boolean, should a legend be included in the plot?

Author(s)

T. Carruthers

Stock-class

Class 'Stock'

Description

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

Slots

Name An identifying name for the Stock object. Single value. Character string.

Common_Name Common name of the species. Character string.

Species Scientific name of the species. Genus and species name. Character string.

maxage The maximum age of individuals that is simulated. There are maxage+1 (recruitment to age-0) age classes in the storage matrices. maxage is the 'plus group' where all age-classes > maxage are grouped, unless option switched off with OM@cpars\$plusgroup=0. Single value. Positive integer.

R0 Initial number of unfished recruits to age-0. This number is used to scale the size of the population to match catch or data, but does not affect any of the population dynamics unless the OM has been conditioned with data. As a result, for a data-limited fishery any number can be used for R0. In data-rich stocks R0 may be estimated as part of a stock assessment, but for data limited stocks users can choose either an arbitrary number (say, 1000) or choose a number that produces simulated catches in recent historical years that are similar to real world catch data. Single value. Positive real number.

M The instantaneous rate of natural mortality. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.

Msd Inter-annual variation in M expressed as a coefficient of variation of a log-normal distribution. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter is positive, yearly M is drawn from a log-normal distribution with a mean specified by $\log(M)$ drawn for that simulation and a standard deviation in log space specified by the value of Msd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers

h Steepness of the stock recruit relationship. Steepness governs the proportion of unfished recruits produced when the stock is at 20% of the unfished population size. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years of a given simulation. Uniform distribution lower and upper bounds. Values from 1/5 to 1.

SRrel Type of stock-recruit relationship. Use 1 to select a Beverton Holt relationship, 2 to select a Ricker relationship. Single value. Integer

- Perr Recruitment process error, which is defined as the standard deviation of the recruitment deviations in log space. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.
- AC Autocorrelation in the recruitment deviations in log space. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided, and used to add lag-1 auto-correlation to the log recruitment deviations. Uniform distribution lower and upper bounds. Non-negative real numbers.
- Linf The von Bertalanffy growth parameter Linf, which specifies the average maximum size that would be reached by adult fish if they lived indefinitely. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless Linfsd is a positive number. Uniform distribution lower and upper bounds. Positive real numbers.
- Linfsd Inter-annual variation in Linf. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive value, yearly Linf is drawn from a log-normal distribution with a mean specified by the value of Linf drawn for that simulation and a standard deviation (in log space) specified by the value of Linfsd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers.
- K The von Bertalanffy growth parameter k, which specifies the average rate of growth. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless Ksd is a positive number. Uniform distribution lower and upper bounds. Positive real numbers.
- Ksd Inter-annual variation in K. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive value, yearly K is drawn from a log-normal distribution with a mean specified by the value of K drawn for that simulation and a standard deviation (in log space) specified by the value of Ksd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers.
- t0 The von Bertalanffy growth parameter t0, which specifies the theoretical age at a size 0. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-positive real numbers.
- LenCV The coefficient of variation (defined as the standard deviation divided by mean) of the length-at-age. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided to specify the distribution of observed length-at-age, and the CV of this distribution is constant for all age classes (i.e., standard deviation increases proportionally with the mean). Uniform distribution lower and upper bounds. Positive real numbers.
- L50 Length at 50% maturity. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. The L50 and L50_95 parameters are converted to ages using the growth parameters provided and used to construct a logistic curve to determine the proportion of the population that is mature in each age class. Uniform distribution lower and upper bounds. Positive real numbers.
- L50_95 Difference in lengths between 50% and 95% maturity. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. The

value drawn is then added to the length at 50% maturity to determine the length at 95% maturity. This parameterization is used instead of specifying the size at 95 percent maturity to avoid situations where the value drawn for the size at 95% maturity is smaller than that at 50% maturity. The L50 and L50_95 parameters are converted to ages using the growth parameters provided and used to construct a logistic curve to determine the proportion of the population that is mature in each age class. Uniform distribution lower and upper bounds. Positive real numbers.

- D Estimated current level of stock depletion, which is defined as the current spawning stock biomass divided by the unfished spawning stock biomass. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter is used during model initialization to select a series of yearly historical recruitment values and fishing mortality rates that, based on the information provided, could have resulted in the specified depletion level in the simulated last historical year. Uniform distribution lower and upper bounds. Positive real numbers (typically < 1)
 - a The alpha parameter in allometric length-weight relationship. Single value. Weight parameters are used to determine catch-at-age and population-at-age from the number of individuals in each age class and the length of each individual, which is drawn from a normal distribution determined by the Linf, K, t0, and LenCV parameters. As a result, they function as a way to scale between numbers at age and biomass, and are not stochastic parameters. Single value. Positive real number.
 - b The beta parameter in allometric length-weight relationship. Single value. Weight parameters are used to determine catch-at-age and population-at-age from the number of individuals in each age class and the length of each individual, which is drawn from a normal distribution determine by the Linf, K, t0, and LenCV parameters. As a result, they function as a way to scale between numbers at age and biomass, and are not stochastic parameters. Single value. Positive real number.

Size_area_1 The size of area 1 relative to area 2. The fraction of the unfished biomass in area 1. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, if Size_area_1 is 0.2, then 20% of the total area is allocated to area 1. Fishing can occur in both areas, or can be turned off in one area to simulate the effects of a no take marine reserve. Uniform distribution lower and upper bounds. Positive real numbers.

Frac_area_1 The fraction of the unfished biomass in area 1. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, if Frac_area_1 is 0.5, then 50% of the unfished biomass is allocated to area 1, regardless of the size of area 1 (i.e, size and fraction in each area determine the density of fish, which may impact fishing spatial targeting). In each time step recruits are allocated to each area based on the proportion specified in Frac_area_1. Uniform distribution lower and upper bounds. Positive real numbers.

Prob_staying The probability of individuals in area 1 remaining in area 1 over the course of one year. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, in an area with a Prob_staying value of 0.95 each fish has a 95% probability of staying in that area in each time step, and a 5% probability of moving to the other area. Uniform distribution lower and upper bounds. Positive fraction.

Fdisc The instantaneous discard mortality rate the stock experiences when fished using the gear type specified in the corresponding fleet object and discarded. For each simulation a single

value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.

Source A reference to a website or article from which parameters were taken to define the stock object. Single value. Character string.

Objects from the Class

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

Author(s)

T. Carruthers and A. Hordyk

Examples

```
showClass('Stock')
```

StockDescription	<i>StockDescription</i>
------------------	-------------------------

Description

A `data.frame` with description of slots for class `Stock`

Usage

```
StockDescription
```

Format

An object of class `data.frame` with 27 rows and 2 columns.

Sub	<i>Subset MSE object by management procedure (MP) or simulation.</i>
-----	--

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

See Also

[SubOM](#) for OM components and [SubCpars](#) for subsetting by simulation and projection years.

Examples

```
## Not run:
MSE <- runMSE()
MSE_1 <- Sub(MSE, MPs=1:2)
MSE_1@MPs
MSE_2 <- Sub(MSE, sims=1:10)
MSE_2@nsim

## End(Not run)
```

SubCpars

Subset an OM cpars slot

Description

Subset the custom parameters of an operating model by simulation and projection years

Usage

```
SubCpars(OM, sims = 1:OM@nsim, proyears = OM@proyears)
```

Arguments

OM	An object of class OM
sims	A logical vector of length OM@nsim to either retain (TRUE) or remove (FALSE). Alternatively, a numeric vector indicating which simulations (from 1 to nsim) to keep.
proyears	If provided, a numeric to reduce the number of projection years (must be less than OM@proyears).

Value

An object of class OM

Author(s)

T. Carruthers, Q. Huynh

See Also

[Sub](#) for MSE objects, [SubOM](#) for OM components.

SubOM

Subset a Stock, Fleet, Obs, or Imp object from an OM object

Description

A function that strips out a Stock, Fleet, Obs, or Imp object from a complete OM object. Mainly used for internal functions.

Usage

```
SubOM(OM, Sub = c("Stock", "Fleet", "Obs", "Imp"))
```

Arguments

OM	An operating model object (class OM)
Sub	A character string specifying what object type to strip out "Stock", "Fleet", "Obs", or "Imp"

Value

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

Author(s)

A. Hordyk

See Also

[Sub](#) for subsetting MSE output and [SubCpars](#) for subsetting by simulation and projection years.

Examples

```
Stock <- SubOM(testOM, "Stock")
class(Stock)
```

summary,Data-method *Summary of Data object*

Description

Summary of Data object

Usage

```
## S4 method for signature 'Data'
summary(
  object,
  wait = TRUE,
  x = 1,
  plots = "all",
  rmd = FALSE,
  head = "##",
  tplot = 25
)
```

Arguments

object	An object of class Data
wait	Logical. Wait for key press before next plot?
x	iteration number for the Data object.
plots	Character. What plots to show? all, TS, CAA, CAL, PD for all plots, time-series, catch-at-age, catch-at-length, and probability distributions respectively
rmd	Logical. Used in a rmd file?
head	Character. Heading for rmd file. Default is '##' (second level heading)
tplot	Integer. Number of plots per page. Default 25

summary,MSE-method *Summary of MSE object*

Description

Summary of MSE object

Usage

```
## S4 method for signature 'MSE'
summary(object, ..., silent = FALSE, Refs = NULL)
```

Arguments

object	object of class MSE
...	a list of names of PM methods
silent	Should summary be printed to console? Logical.
Refs	An optional named list (matching the PM names) with numeric values to override the default Ref values. See examples.

TAC

Calculate TAC recommendations for more than one MP

Description

A function that returns the stochastic TAC recommendations from a vector of output control MPs given a data object Data

Usage

```
TAC(Data, MPs = NA, reps = 100, timelimit = 1, checkMP = TRUE, silent = FALSE)
```

Arguments

Data	A data-limited methods data object
MPs	optional vector of MP names
reps	Number of repetitions
timelimit	The maximum time (seconds) taken to complete 10 reps
checkMP	Logical. Check if the MP can be run first?
silent	Logical. Suppress messages?

Author(s)

T. Carruthers

Examples

```
## Not run:
library(DLMtool)
Data <- TAC(MSEtool::Cobia)
plot(Data)

## End(Not run)
```

`TACfilter`*TAC Filter*

Description

Filters vector of TAC recommendations by replacing negatives with NA and values beyond five standard deviations from the mean as NA

Usage

```
TACfilter(TAC)
```

Arguments

TAC A numeric vector of TAC recommendations

Author(s)

T. Carruthers

`TEG`*Tom's expand grid*

Description

Create an indexing grid from just a vector of maximum dimension sizes

Usage

```
TEG(vec)
```

Arguments

vec A vector of maximum array sizes

Author(s)

T. Carruthers

testOM	<i>OM class objects</i>
--------	-------------------------

Description

Example objects of class OM

Usage

testOM

Format

An object of class OM of length 1.

Examples

```
avail("OM")
```

Thresh_tab	<i>Current default thresholds for DFO satiscing</i>
------------	---

Description

Crit_S is the probability of being in the critical zone in the first 10 projected years Caut_S is the probability of being in the cautious zone in the first 10 projected years Health_S is the probability of being in the healthy zone in the first 10 projected years OvFish_S is the probability of overfishing in the first 10 projected years Yield_S is the mean yield relative to FMSY management over the first 10 projected years Crit is the probability of being in the critical zone in the last 10 projected years Caut is the probability of being in the cautious zone in the last 10 projected years Health is the probability of being in the healthy zone in the last 10 projected years OvFish is the probability of overfishing in the last 10 projected years Yield is the mean yield relative to FMSY management over the last 10 projected years AAVY is the average annual variability in yield over the whole projection phrased as a CV percentage Reb is the probability the stock has rebuilt to over BMSY in 2 mean generation times

Usage

```
Thresh_tab(Ptab1)
```

Arguments

Ptab1 A DFO performance table made by DFO_tab()

Author(s)

T. Carruthers

tinyErr	<i>Remove observation, implementation, and process error</i>
---------	--

Description

Takes an existing OM object and converts it to one without any observation error, implementation error, very little process error, and/or gradients in life history parameters and catchability.

Usage

```
tinyErr(x, ...)
```

```
## S4 method for signature 'OM'  
tinyErr(x, obs = TRUE, imp = TRUE, proc = TRUE, grad = TRUE, silent = FALSE)
```

Arguments

x	An object of class OM
...	Arguments to generic function
obs	Logical. Remove observation error? Obs is replaced with Perfect_Info
imp	Logical. Remove implementation error? Imp is replaced with Perfect_Imp
proc	Logical. Remove process error? All sd and cv slots in Stock and Fleet object are set to 0.
grad	Logical. Remove gradients? All grad slots in Stock and qinc in Fleet are set to 0.
silent	Logical. Display messages?

Details

Useful for debugging and testing that MPs perform as expected under perfect conditions.

Value

An updated object of class OM

Examples

```
OM_noErr <- tinyErr(MSEtool::testOM)
```

TradePlot

*Generic Trade-Plot Function***Description**

Generic Trade-Plot Function

Usage

```
TradePlot(
  MSEobj,
  ...,
  Lims = c(0.2, 0.2, 0.8, 0.8),
  Title = NULL,
  Labels = NULL,
  Satisficed = FALSE,
  Show = "both",
  point.size = 2,
  lab.size = 4,
  axis.title.size = 12,
  axis.text.size = 10,
  legend = TRUE,
  legend.title.size = 12,
  position = c("right", "bottom"),
  cols = NULL,
  fill = "gray80",
  alpha = 0.4,
  PMList = NULL,
  Refs = NULL,
  Yrs = NULL
)
```

```
Tplot(MSEobj, Lims = c(0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5), ...)
```

```
Tplot2(MSEobj, Lims = c(0.2, 0.2, 0.8, 0.8), ...)
```

```
Tplot3(MSEobj, Lims = c(0.5, 0.5, 0.8, 0.5), ...)
```

```
NOAA_plot2(MSEobj)
```

Arguments

MSEobj	An object of class MSE
...	Names of Performance Metrics (PMs), or other arguments to TradePlot. First PM is recycled if number of PMs is not even
Lims	A numeric vector of acceptable risk/minimum probability thresholds. Recycled if not equal to number of PMs.

Title	Optional title for each plot. Character vector of length(PMs)/2. Recycled.
Labels	Optional named list specifying new labels for MPs. For example: Labels = list(AvC="Average Catch", CC1="Constant Catch")
Satisficed	Logical. Show only the MPs that meet minimum acceptable thresholds (specified in Lims)
Show	Character. Show the plots ('plots'), results table ('table'), 'both' (default), or invisibly return objects only ('none')
point.size	Numeric. Size of the MP points
lab.size	Numeric. Size of MP label. Set to NULL to remove MP labels.
axis.title.size	Numeric. Size of axis titles
axis.text.size	Numeric. Size of axis text
legend	Logical. Include legend?
legend.title.size	Numeric. Size of legend title text
position	Character. Position of legend - 'right' or 'bottom'
cols	Optional character vector of colors for the legend (MP Types) or if cols is a character vector of length MSEobj@nMPs, then the MP labels are colored (no color legend).
fill	Character. Color of the fill
alpha	Numeric. Transparency of fill
PMlist	Optional list of PM names. Overrides any supplied in ... above
Refs	An optional named list (matching the PM names) with numeric values to override the default Ref values. See examples.
Yrs	An optional named list (matching the PM names) with numeric values to override the default Yrs values. See examples.

Value

Invisibly returns a list with summary table of MP performance and the ggplot objects for the plots

Functions

- Tplot: A trade-off plot showing probabilities that:
 - not overfishing (PNOF) against long-term yield is > 50\
 - spawning biomass is below BMSY (P100) against LTY
 - spawning biomass is below 0.5BMSY (P50) against LTY
 - spawning biomass is below 0.1BMSY (P10) against LTY
- Tplot2: A trade-off plot showing probabilities that:
 - short-term yield is > 50\
 - spawning biomass is below 0.1BMSY (P10) against average annual variability in yield is < 20\

- Tplot3: A trade-off plot showing probabilities that:
 - not overfishing (PNOF) against long-term yield is $> 50\%$
 - spawning biomass is below $0.1BMSY$ (P10) against average annual variability in yield is $< 20\%$
- NOAA_plot2: A trade-off plot developed for NOAA showing probabilities that:
 - not overfishing (PNOF) against long-term yield is $> 50\%$
 - spawning biomass is below $0.5BMSY$ (P50) against average annual variability in yield is $< 15\%$

Author(s)

A. Hordyk

 Turing

Turing Test

Description

Plots the available data in the Data object together with 5 samples of historical data from the Operating Model (OM) in a random order. The test is used to determine if the data generated by the OM is similar to the fishery data in the Data object. In a well specified OM the user should not be able to visually identify which of the 6 plots is the real fishery data and which are generated by the OM.'

Usage

```
Turing(OM, Data, wait = TRUE)
```

```
TuringMOM(multiHist, Data, wait = TRUE)
```

Arguments

OM	An object of class OM or class multiHist
Data	An object of class Data or a nested list of Data objects for each stock and fleet
wait	Logical. Wait for key press before next plot?
multiHist	An object of class multiHist. The output of SimulateMOM

Details

In its current form the Turing function does not interpolate missing data in the Data object. Therefore if there are years with missing data, say in the catch time-series, it will be obvious which are the real data and which have been generated by the model. Future versions of the function may include methods to impute missing data for plotting purposes.

The question to ask when examining the plots produced by Turing: do the plots of the 6 data samples look like they are all samples from the same underlying distribution?

Functions

- TuringMOM: Turing function for multi-stock, multi-fleet MOMs

Note

The Turing function was suggested by Andre Punt in his review of one of our recent projects. It is named after the Turing test, developed by Alan Turing in 1950, which is designed to see if a human can detect the difference between human and machine generated information.

Examples

```
## Not run:  
Turing(MSEtool::testOM, MSEtool::SimulatedData, wait=FALSE)  
  
## End(Not run)
```

Uses

Find the Management Procedures that use a particular data slot

Description

Find the Management Procedures that use a particular data slot

Usage

```
Uses(slot, silent = FALSE)
```

Arguments

slot	A slot from an object of class Data. Character string.
silent	Logical. Should messages be printed?

Value

A character string of MPs that use the slot.

Author(s)

A. Hordyk

Examples

```
Uses("Mort")
```

validcpars	<i>Valid custom parameters (cpars)</i>
------------	--

Description

Valid custom parameters (cpars)

Usage

```
validcpars(
  type = c("all", "Stock", "Fleet", "Obs", "Imp", "internal"),
  valid = TRUE,
  show = TRUE
)
```

Arguments

type	What cpars to show? 'all', 'Stock', 'Fleet', 'Obs', 'Imp', or 'internal'
valid	Logical. Show valid cpars?
show	Logical. Display the table in the Viewer?

Value

a HTML datatable with variable name, description and type of valid cpars

Examples

```
## Not run:
validcpars() # all valid cpars

validcpars("Obs", FALSE) # invalid Obs cpars

## End(Not run)
```

VOI	<i>Calculate Value Of Information</i>
-----	---------------------------------------

Description

A function that relates operating model parameters and parameters of the observation model to yield (by default). A user can also specify 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",
  plot = TRUE
)

```

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
plot	Logical. Show the plot?

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= $1/(\text{newCV}/\text{oldCV})^2$

Author(s)

T. Carruthers

VOIplot

Yet another Value of Information Plot

Description

A function that relates parameters of the observation model and the operating model parameters to yield.

Usage

```
VOIplot(
  MSEobj,
  MPs = NA,
  nvars = 5,
  nMP = 4,
  Par = c("Obs", "OM"),
  YVar = c("Y", "B"),
  doPlot = TRUE,
  incStat = FALSE,
  availMP = NULL,
  acceptMP = NULL,
  incNames = TRUE,
  labcex = 0.8,
  quants = c(0.05, 0.95)
)
```

Arguments

MSEobj	An object of class MSE
MPs	The MPs to plot. If NA it will plot the first nMP from MSEobj
nvars	The number of observation or operating model parameters to plot (number of columns)
nMP	The maximum number of MPs to plot (number of rows)
Par	Plot Operating Model (OM) or Observation (Obs) parameters?
YVar	Variable for Y-Axis: Yield (Y) or Biomass (B) (relative to BMSY)
doPlot	Output the plot?
incStat	Include a print out of statistic describing the curviness of the line?
availMP	Optional character string of MPs that are available. These names are colored black
acceptMP	Optional character string of MPs that are acceptable. These names are colored green if they are also in availMP
incNames	Include the names?
labcex	Character size of the label
quants	Quantiles to calculate

Value

A list of all the information included in the plot

Author(s)

A. Hordyk

wormplot

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 separates red (bad) and yellow (O.K.) colored segments
UB	The upper bound probability that separates yellow (O.K.) and green (good) colored segments

Details

Returns a matrix of nMPs rows and proyears columns which is the fraction of simulations for which biomass was above Bref.

Author(s)

T. Carruthers

writeCSV	<i>Internal function to write CSVs for objects</i>
----------	--

Description

Used internally in the DLMtool package to write CSV files from an existing DLMtool object

Usage

```
writeCSV(
  inobj,
  tmpfile = NULL,
  objtype = c("Stock", "Fleet", "Obs", "Imp", "Data", "OM")
)
```

Arguments

inobj	A object of class Stock, Fleet, Obs, Imp, Data, or OM
tmpfile	The full file path and name for the saved CSV file
objtype	The class corresponding to the inobj

Author(s)

A. Hordyk

XL2Data	<i>Import a Data object from Excel file</i>
---------	---

Description

Import a Data object from Excel file

Usage

```
XL2Data(name, dec = c(".", ","), sheet = 1, silent = FALSE)
```

Arguments

name	Name of the data file, with or without file extension. Include full file path if not in working directory
dec	the character used in the file for decimal points.
sheet	Sheet number if importing Data from XL file
silent	Logical. Hide messages?

Value

An object of class 'Data'

Author(s)

A. Hordyk

Examples

```
## Not run:
MyData <- XL2Data("MyData.xlsx")

## End(Not run)
```

XL2Fleet

Import Fleet Object from Excel file

Description

Imports a Fleet Object from a correctly formatted Excel file.

Usage

```
XL2Fleet(name = NULL, cpars = NULL, msg = TRUE)
```

Arguments

name	Name of the OM Excel file. Provide full file path if not in current directory.
cpars	An optional list of custom parameters (single parameters are a vector nsim long, time series are a matrix nsim rows by nyears columns)
msg	Should messages be printed?

Details

An error message will alert if any slots are missing values, or if the Excel file is missing the required tabs.

Value

An object of class Fleet

Author(s)

A. Hordyk

 XL2OM

Load OM from Excel file

Description

Imports an OM from a correctly formatted Excel file. Create the Excel spreadsheet template using `OMinit` and document each slot in the corresponding text file.

Imports an OM from a correctly formatted Excel file. Create the Excel spreadsheet template using `OMinit` and document each slot in the corresponding text file.

Usage

`XL2OM(name = NULL, cpars = NULL, msg = TRUE)`

`XL2OM(name = NULL, cpars = NULL, msg = TRUE)`

Arguments

<code>name</code>	Name of the OM Excel file. Provide full file path if not in current directory.
<code>cpars</code>	An optional list of custom parameters (single parameters are a vector <code>nsim</code> long, time series are a matrix <code>nsim</code> rows by <code>nyears</code> columns)
<code>msg</code>	Should messages be printed?

Details

An error message will alert if any slots are missing values, or if the Excel file is missing the required tabs.

An error message will alert if any slots are missing values, or if the Excel file is missing the required tabs.

Value

An object of class OM

An object of class OM

Author(s)

A. Hordyk

A. Hordyk

Examples

```
## Not run:
OMinit('myOM', templates=list(Stock='Herring', Fleet='Generic_Fleet', Obs='Generic_Obs',
Imp='Perfect_Imp'), overwrite=TRUE)
myOM <- XL2OM('myOM.xlsx')

## End(Not run)
## Not run:
OMinit('myOM', templates=list(Stock='Herring', Fleet='Generic_Fleet', Obs='Generic_Obs',
Imp='Perfect_Imp'), overwrite=TRUE)
myOM <- XL2OM('myOM.xlsx')

## End(Not run)
```

XL2Stock

Import Stock Object from Excel file

Description

Imports a Stock Object from a correctly formatted Excel file.

Usage

```
XL2Stock(name = NULL, cpars = NULL, msg = TRUE)
```

Arguments

name	Name of the OM Excel file. Provide full file path if not in current directory.
cpars	An optional list of custom parameters (single parameters are a vector nsim long, time series are a matrix nsim rows by nyears columns)
msg	Should messages be printed?

Details

An error message will alert if any slots are missing values, or if the Excel file is missing the required tabs.

Value

An object of class Stock

Author(s)

A. Hordyk

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