Package 'MSEtool'

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Title Management Strategy Evaluation Toolkit

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

License GPL-3

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Contents

Albacore . . . 6
Albacore_TwoFleet . . . 7
applyMMP . . . 7
applyMP . . . 8
ASAP2OM . . . 9
Assess2MOM . . . 10
Assess2OM . . . 12
Atlantic_mackerel . . . 15
avail . . . 16
Awatea2OM . . . 17
BAM2MOM . . . 18
boxplot.Data . . . 19
calcRefYield . . . 20
CALsimp . . . 20
Can . . . 21
CheckDuplicate . . . 22
CheckMPs . . . 22
checkMSE . . . 23
CheckOM . . . 24
Choose . . . 25
CombineMMP . . . 26
Converge . . . 26
Cos_thresh_tab . . . 28
cparscheck . . . 28
Cplot . . . 29
Data-class . . . 30
Data2csv . . . 34
DataDescription . . . 34
DataDir . . . 35
DataInit . . . 35
DataSlots . . . 36
Data_xl . . . 37
DecE_Dom . . . 38
DFO_bar . . . 39
DFO_hist . . . 40
DFO_plot . . . 40
DFO_plot2 . . . 41
DFO_proj . . . 41
DFO_quant . . . 42
DFO_report . . . 43
DFO_spider . . . 43
DFO_tab . . . 44
DFO_tab_formatted . . . 44
DLMDataDir . . . 45
dnormal . . . 46
doHCR . . . 46

doIfreq . . . 47
Dom . . . 48
doRec . . . 49
Emp . . . 50
Fease . . . 52
Fleet-class . . . 53
FleetDescription . . . 55
FMSYref . . . 56
Generic_Obs . . . 57
getclass . . . 58
getDataList . . . 59
getfirstlev . . . 59
getmov2 . . . 60
getMP . . . 61
getnIVs . . . 61
getsel . . . 62
hconv . . . 62
Herm-int . . . 63
Hist-class . . . 64
hist2 . . . 66
HistDescription . . . 67
Imp-class . . . 67
ImpDescription . . . 69
initialize-methods . . . 69
Input . . . 70
iSCAM . . . 70
iSCAM2OM . . . 72
iSCAMcomps . . . 74
iSCAMinds . . . 75
joinData . . . 75
join_plots . . . 76
Kplot . . . 77
Lag_Data . . . 78
ldim . . . 79
LH2OM . . . 79
LHdatabase . . . 81
makeMOM . . . 82
makemov . . . 83
makemov2 . . . 83
makeRel . . . 84
makeTransparent . . . 86
ML2D . . . 86
MMSE-class . . . 87
MOM-class . . . 89
movestockCPP . . . 91
movfit_Rcpp . . . 91
MPCalcsNAs . . . 92
MPtype . . . 92

MSE-class . . . 93
MSEDescription . . . 94
MSEextra . . . 95
MSYCalcs . . . 95
multiData . . . 96
multiDataS . . . 97
multidebug . . . 97
NIL . . . 98
NOAA_plot . . . 99
Obs-class . . . 99
ObsDescription . . . 103
OM-class . . . 104
OMDescription . . . 105
OMdoc . . . 105
OMexample . . . 106
OMinit . . . 107
optCPU . . . 108
Overages . . . 109
PerformanceMetric . . . 109
plot.Data . . . 111
plot.MMSE . . . 112
plot.MOM . . . 113
plot.MSE . . . 113
plot.pars . . . 114
plotFun . . . 118
plotmulti . . . 119
plotOFL . . . 120
plotquant . . . 120
plotRel . . . 121
PMLimit . . . 122
PMobj-class . . . 124
Pplot . . . 125
Pplot2 . . . 125
PWhisker . . . 127
quantile_plot . . . 128
RealFease . . . 129
Rec-class . . . 129
Replace . . . 130
replic8 . . . 131
Report . . . 132
ReqData . . . 133
Required . . . 133
runCOSEWIC . . . 134
runInMP . . . 136
runMP . . . 137
select_MP . . . 138
Sense . . . 138
setup . . . 139

show,PMobj-method . . . 140
show,Rec-method . . . 140
show-MSEtool . . . 141
SIL . . . 141
simCAA . . . 142
simCAL . . . 143
simmov . . . 144
simmov2 . . . 145
Simulate . . . 147
SimulatedData . . . 149
SimulateMOM . . . 149
SketchFun . . . 151
smoothy . . . 151
Splot . . . 152
SS2Data . . . 153
SS2DataMOM . . . 154
SS2MOM . . . 155
SSBrefplot . . . 159
Stock-class . . . 159
StockDescription . . . 163
Sub . . . 163
SubCpars . . . 164
SubOM . . . 165
summary,Data-method . . . 166
summary,MMSE-method . . . 166
summary,MSE-method . . . 167
TAC . . . 167
TACfilter . . . 168
Taxa_Table . . . 169
TEG . . . 169
testOM . . . 170
Thresh_tab . . . 170
tinyErr . . . 171
TradePlot . . . 172
tune_MP . . . 174
Turing . . . 175
Uses . . . 177
validcpars . . . 177
VOI . . . 179
VOI2 . . . 180
VOIplot . . . 181
WHAM2OM . . . 182
wormplot . . . 184
writeCSV . . . 184
XL2Data . . . 185
XL2Fleet . . . 186
XL2OM . . . 186
XL2Stock . . . 187

Index 189

`Albacore` *Stock class objects*

Description

Example objects of class Stock

Usage

```
Albacore

Blue_shark

Bluefin_tuna

Bluefin_tuna_WAtl

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

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,
  parallel = snowfall::sfIsRunning()
)
```

Arguments

DataList	A hierarchical list of Data objects (Fleets nested in Stocks)
MP	Name of the MMP 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

Value

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

---

applyMP *Apply Management Procedures to an object of class Data*

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

ASAP2OM *Convert ASAP 3 assessments into an operating model*

Description

Reads a fitted ASAP model and uses the MLE estimates with identical reconstruction among simulations. Future recruitment is sampled from a lognormal distribution with autocorrelation. `ASAP2Data` imports a Data object.

Usage

```
ASAP2OM(
  asap,
  nsim = 48,
  proyears = 50,
  mcmc = FALSE,
  Name = "ASAP Model",
  Source = "No source provided",
  nyr_par_mu = 3,
  Author = "No author provided",
  report = FALSE,
  silent = FALSE
)

ASAP2Data(asap, Name = "ASAP assessment")
```

Arguments

`asap`	A list returned by ASAP, e.g., `asap <- dget("asap3.rdat")`.
`nsim`	The number of simulations in the operating model
`proyears`	The number of MSE projection years
`mcmc`	Logical, whether to use mcmc samples. Currently unsupported.
`Name`	The name of the operating model
`Source`	Reference to assessment documentation e.g. a url
`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 comparison of biomass reconstruction be produced?
`silent`	Logical, should progress reporting be printed to the console?

Details

Length at age is not used in ASAP so arbitrary placeholder values are used for length-based parameters. Update these parameters to model length in the operating model.

Value

An operating model OM class.

Author(s)

Q. Huynh

See Also

Assess2OM

`Assess2MOM` *Reads bootstrap estimates from a stock assessment model into a multi-fleet operating model.*

Description

A function that develops a multiple fleet operating model (MOM) and either models a unisex or 2-sex stock from arrays of abundance, fishing mortality, and biological parameters. The user still needs to parameterize most of the observation and implementation portions of the operating model.

Usage

```
Assess2MOM(
  Name = "MOM created by Assess2MOM",
  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,
  fecaa,
  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 multi-OM.
`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 multiMSE, e.g., 1 = annual updates.
`CurrentYr`	Positive integer. The current year (e.g., final year of fitting to data)
`h`	The steepness of the stock-recruitment curve. Either a single numeric or a length nsim vector.
`Obs`	Either a single observation model to be used for all sexes and populations (class Obs), or a list where `Obs[[f]]` is the Obs object for fleet `f` (identical between sexes).
`Imp`	Either a single implementation model to be used for all sexes and populations (class Imp), or a list where `Imp[[f]]` is the Obs object for fleet `f` (identical between sexes).
`naa`	Numbers-at-age by sex `[first age is age zero]`. Four-dimensional numeric array `[sim, ages, year, p]`. `[p]` indexes the population, where `[p = 1]` for females and `[p = 2]` for males.
`faa`	Fishing mortality rate-at-age by sex and fleet `[first age is age zero]`. Five-dimensional numeric array `[sim, ages, year, p, f]` where `[f]` indexes fishery fleet.
`waa`	Weight-at-age `[first age is age zero]`. Four-dimensional numeric array `[sim, ages, year, p]`.
`Mataa`	Maturity (spawning fraction)-at-age `[first age is age zero]`. Four-dimensional numeric array `[sim, ages, year, p]`.
`Maa`	Natural mortality rate-at-age `[first age is age zero]`. Four-dimensional numeric array `[sim, ages, year, p]`.
`laa`	Length-at-age `[first age is age zero]`. Four-dimensional numeric array `[sim, ages, year, p]`.
`fecaa`	Fecundity at age `[first age is age zero]`. If missing, default fecundity is the product of maturity and weight at age.
`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 (for all, either a numeric or a length nsim vector):

- `SRrel` Stock-recruit relationship. (`1` for Beverton-Holt (default), `2` for Ricker)
- `R0` unfished recruitment
- `phi0` unfished spawners per recruit associated with R0 and h. With time-varying parameters, openMSE uses the mean phi0 in the first `ageM` (age of 50 percent maturity) years for the stock-recruit relationship. `Assess2OM` will re-calculate R0 and h in the operating model such that the stock-recruit `alpha` and `beta` parameters match values implied in the input.
- `Perr` recruitment standard deviation (lognormal distribution) for sampling future recruitment
- `AC` autocorrelation in future recruitment deviates.

Details

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

Value

An object of class MOM.

Author(s)

Q. Huynh

See Also

SS2MOM multiMSE Assess2OM

`Assess2OM` *Reads bootstrap estimates from a stock assessment model (including VPA) into an operating model.* `Assess2OM` *is identical to* `VPA2OM`.

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,
  ...
)

VPA2OM(
  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,
```

```
  ...
)
```

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 nsim vector.
Obs	The observation model (class Obs). This function only updates the catch and index observation error.
Imp	The implementation model (class Imp). 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 (for all, either a numeric or a length nsim vector): • fecaa Fecundity at age. Default fecundity is the product of maturity and weight at age. • SRrel Stock-recruit relationship. (1 for Beverton-Holt (default), 2 for Ricker) • R0 unfished recruitment

- `phi0` unfished spawners per recruit associated with R0 and h. With time-varying parameters, openMSE uses the mean phi0 in the first `ageM` (age of 50 percent maturity) years for the stock-recruit relationship. `Assess2OM` will re-calculate R0 and h in the operating model such that the stock-recruit `alpha` and `beta` parameters match values implied in the input.
- `Perr` recruitment standard deviation (lognormal distribution) for sampling future recruitment
- `AC` autocorrelation in future recruitment deviates.
- `spawn_time_frac` The fraction of a year when spawning takes place (e.g., 0.5 is the midpoint of the year)

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 iSCAM2OM WHAM2OM ASAP2OM

`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

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

Details

Finds objects of the specified class in the global environment or the openMSE packages.

Author(s)

T. Carruthers

See Also

Can Cant avail

Examples

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

`Awatea2OM` *Reads MCMC estimates from Awatea (Paul Starr) processed r file structure into an operating model*

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 unfished 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

---

`BAM2MOM` *Import a multi-stock, multi-fleet OM from a BAM object*

Description

Import a multi-stock, multi-fleet OM from a BAM object

Usage

```
BAM2MOM(
  rdat,
  nsim = 48,
  proyears = 50,
  interval = 1,
  stock_name = NULL,
  fleet_name = NULL,
  LowerTri = 0,
  report = FALSE,
  ...
)

BAM2OM(rdat, nsim = 48, proyears = 50, interval = 2, report = FALSE, ...)
```

Arguments

`rdat`	A list object from the `BAMextras` package. Use `bamExtras::standardize_rdat(rdat)`
`nsim`	the number of simulations
`proyears`	the number of projection years
`interval`	the management interval
`stock_name`	Name of the stock(s)
`fleet_name`	Name of the fleet(s)
`LowerTri`	Integer. The number of recent years for which model estimates of recruitment are ignored (not reliably estimated by the assessment)
`report`	Logical, if TRUE, a diagnostic will be reported showing the matching of the OM reconstructed numbers at age vs the assessment.
`...`	Additional arguments passed to `MSEtool::Assess2MOM`

Value

An object of class MOM

Functions

- BAM2OM(): Create a single stock/fleet OM from a BAM object

---

boxplot.Data *Boxplot of TAC recommendations*

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 *Calculate Reference Yield*

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` *Check for duplicated MPs names*

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

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)

addMPs(MSEobjs)

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
- `addMPs()`: Adds additional MPs to an MSE object by combining multiple MSE objects that have identical historical OM values but different MPs.
- `joinMSE()`: Joins two or more MSE objects together across simulations. MSE objects must have identical number of historical years, and projection years.
- `joinHist()`: Join objects of class `Hist`. Does not join slot `OM`
- `updateMSE()`: Updates an existing MSE object (class MSE) from a previous version of the MSEtool 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

See Also

joinData

CheckOM *Check OM object is complete*

Description

Check OM object is complete

Usage

```
CheckOM(OM, msg = TRUE, stop_if_missing = TRUE)
```

Arguments

`OM`	An object of class `OM`
`msg`	Logical. Display messages?
`stop_if_missing`	Logical. Stop with error is values are missing and there is no default?

Value

The OM object with default values (if needed)

Examples

```
testOM <- CheckOM(testOM)
```

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

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` *Check Convergence*

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 ref.it 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 (nsim-ref.it):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 *Current default thresholds for COSEWIC satisficing*

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

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

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

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

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

`CV_wlb` Coefficient of variation in weight-length parameter b. Vector nsim long. Positive real numbers

`steep` Steepness of stock-recruitment relationship. Vector nsim long. Value in the range of one-fifth to 1

`CV_steep` Coefficient of variation in steepness. Vector nsim long. Positive real numbers

`sigmaR` Recruitment variability. Vector nsim long. Positive real numbers

CV_sigmaR Coefficient of variation in recruitment variability. Vector nsim long. Positive real numbers

L50 Length at 50 percent maturity. Vector nsim long. Positive real numbers

CV_L50 Coefficient of variation in length at 50 per cent maturity. Vector nsim long. Positive real numbers

L95 Length at 95 percent maturity. Vector nsim long. Positive real numbers

LenCV Coefficient of variation of length-at-age (assumed constant for all age classes). Vector nsim long. Positive real numbers

LFC Length at first capture. Vector nsim long. Positive real numbers

CV_LFC Coefficient of variation in length at first capture. Vector nsim long. Positive real numbers

LFS Shortest length at full selection. Vector nsim long. Positive real numbers

CV_LFS Coefficient of variation in length at full selection. Vector nsim long. Positive real numbers

Vmaxlen Vulnerability of individuals at asymptotic length. Vector nsim long. Real number between 0 and 1.

Year Years that corresponding to catch and relative abundance data. Vector nyears long. Positive integer

Cat Total annual catches. Matrix of nsim rows and nyears columns. Non-negative real numbers

CV_Cat Coefficient of variation in annual catches. Matrix nsim rows and either 1 or nyear 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 nsim rows and nyears columns. Non-negative real numbers

CV_Effort Coefficient of variation in annual effort. Matrix nsim rows and either 1 or nyear 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 nsim rows and nyears columns. Non-negative real numbers

CV_Ind Coefficient of variation in the relative total abundance index. Matrix nsim rows and either 1 or nyear 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 nsim rows and nyears columns. Non-negative real numbers

CV_SpInd Coefficient of variation in the relative spawning abundance index. Matrix nsim rows and either 1 or nyear columns. Positive real numbers.

VInd Relative vulnerable abundance index. Matrix of nsim rows and nyears columns. Non-negative real numbers

CV_VInd Coefficient of variation in the relative vulnerable abundance index. Matrix nsim rows and either 1 or nyear 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.

`AddIunits` 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

`Vuln_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

`Vuln_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(current)/SSB(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-normalCV 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 *Converts a Data object into a .csv data file*

Description

A function that writes a correctly formatted .csv file from a 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 *DataDescription*

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 *Directory of the data in the installed package on your computer*

Description

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

Usage

```
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 *Initialize Data Input Files*

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

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

Details

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

Value

A object of class Data

Author(s)

A. Hordyk

Examples

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

## End(Not run)
```

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 MSEtool 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 *Create a standard DFO MSE report*

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 *DFO performance spider plot (top three MPs)*

Description

DFO performance spider plot (top three MPs)

Usage

```
DFO_spider(MSEobj)
```

Arguments

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

Author(s)

T. Carruthers

DFO_tab — *Create a standard DFO performance table*

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 — *A formatted version of the standard DFO performance plot, color coded by thresholds*

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 *Double-normal selectivity curve*

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

doHCR *Hockey Stick Harvest control rule that modifies TAC.*

Description

A hockey stick (2 inflection points) HCR that accepts estimated level relative to reference level and modifies a proposed TAC based on control points for the x axis (est/ref) and y axis (fraction of TAC)

Usage

```
doHCR(trial_TAC, est, ref, CP = c(0, 1), CPy = c(0, 1))
```

Arguments

trial_TAC	Postitive real number, the proposed total allowable catch before HCR modification.
est	Positive real number on same scale as ref, the estimated stock level (e.g. mean current index level)
ref	Positive real number on same scale as est, a reference level of stock level (e.g. index level at BMSY)
CP	Vector of real numbers, 2 positions long (c(Lx, Ux)), the lower and upper control points of a hockey stick HCR on the xaxis (est/ref). Below Lx (est/ref < Lx) the TAC is trial_TAC x Ly. Above Ux (est/ref > Ux) the TAC is trial_TAC x Uy. Between the TAC is linearly ramped between these levels.
CPy	Vector of real numbers, 2 positions long (c(Ly, Uy)), the lower and upper control points of a hockey stick HCR on the yaxis (fraction of trial_TAC).

Value

A real number (TAC advice but theoretically could be used for effort, size limits etc).

Author(s)

T. Carruthers

`doIfreq` *Create indices that are sampled at various frequencies*

Description

Given an index (historical period and projected period) this function creates sparsity in the projected index to simulate varying frequency (intensity) of data collection.

Usage

```
doIfreq(I_hist, I_freq, LHYr, CurYr, Year)
```

Arguments

`I_hist`	Vector of real numbers, concatinated observed (historical) and simulated (projected) indices.
`I_freq`	Positive integer. The frequency of index sampling (e.g. 1 is every year, 2 is every 2 years - a gap every 2 years in the projected, simulated data).
`LHYr`	Positive integer, a year (e.g. 2023), the last historical year, demarks the historical period where observations have been collected from the projected period where sparsity is to be simulated.
`CurYr`	Positive integer, a year (e.g. 2043), the most recent year of the simulation.
`Year`	Vector of positive integers (as long as I_hist), the years corresponding with I_hist.

Value

A thinned ector I_hist long of index observations.

Author(s)

T. Carruthers

Dom *Determine dominate MPs*

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)
```

---

doRec *Calculate a management recommendation given constraints*

Description

Creates a TAC management recommendation given constraints on how much that can change from previous TAC and contraints on minimum and maximum TAC

Usage

```
doRec(MPrec, mod, delta_down, delta_up, TACrng)
```

Arguments

MPrec	Positive real number, the previous management recommendation (e.g. 100 tonnes).
mod	Imperfect fraction, the proposed modification (change to MPrec) (e.g. 1.2 is a 20% increase)
delta_down	A vector 2 positions long, the minimum and maximum levels of downward change (e.g. when mod < 1) in the recommendation.
delta_up	A vector 2 positions long, the minimum and maximum levels of upward change (e.g. when mod > 1) in the recommendation.
TACrng	A vector 2 positions long, the minimum and maximum TAC (same units as MPrec).

Value

n object of class Rec.

Author(s)

T. Carruthers

Emp *A flexible empirical management procedure.*

Description

An all-purpose empirical MP that runs of Indices of relative abundance

Usage

```
Emp(
  x,
  Data,
  reps = 1,
  Inds = NA,
  I_freq = NA,
  I_wt = NA,
  calib_yrs = 2,
  enp_mult = 0.3,
  Ind_fac = NA,
  TACrng = NA,
  delta_down = c(0.01, 0.5),
  delta_up = c(0.01, 0.5),
  resp = 1,
  curI_2_target = NA,
  HCR_CP_B = c(0, 0),
  HCR_CP_TAC = c(0, 1),
  Mode = 1
)
```

Arguments

x	Positive integer, the simulation number (a position in data object Data)
Data	An object of class 'Data' containing all fishery data (simulated or real - real has only one 'simulation')
reps	Positive integer, the number of stochastic samples of management advice (not applicable here)
Inds	Vector of positive integers. The indices (dimension 2) of the Additional Indices Data@AddInd to be used in calculation. When this is NA, the single index Data@Ind is used
I_freq	Vector of positive integers. Same length as Inds - how frequently will each index be available. 1 is every year, 2 is every 2 years, etc.
I_wt	Vector of positive real numbers. Same lengtt as Inds - the weighting of each index in the calculation of mean index level.
calib_yrs	Positive integer. The number of recent historical years used to calculate the 'current' Catch per Index value (more or less a nuisance parameter)

enp_mult — Fraction. The degree of smoothing for the polynomial function of indices. Larger numbers mean more smoothing. This is effective number of parameters. 0.3 means that the number of parameters in the polynomial smoother is 30% the length of the index.

Ind_fac — Positive real number. The factor (multiplier) of current catch(calib_yrs) / index(calib_yrs) to fish at in the future. A value of 2 means that per index the catches will be twice as high as today. If NA, the fraction of defaults to perfectly known mean((0.75 * FMSY)/last_historical_F) - mean over simulations.

TACrng — Vector 2 positions long, the minimum and maximum allowable catches. If NA this defaults to c(0, max_historical_catch*100) - essentially no TAC limit.

delta_down — Vector 2 positions long, the minimum and maximum allowable fractional downward change in TAC among management cycles.

delta_up — Vector 2 positions long, the minimum and maximum allowable fractional upward change in TAC among management cycles.

resp — Positive real number, the responsiveness of the TAC change algorithm. TAC_change = exp(log(new_TAC/old_TAC)*resp). Lower values linearly reduce the logspace TAC response and make smaller adjustements as proposed TAC changes are larger).

curI_2_target — Positive real number, the current (most recent historical year) index relative that at the target biomass level. If NA this defaults to perfectly known mean(last_historical_biomass / (1.25 * BMSY)), mean over all simulations.

HCR_CP_B — Vector of positive real numbers. Biomass control points of an HCR. These are the x-axis locations of the hockey stick inflection points. c(0,1) means a linear ramp from I/I_target. c(0.5,1) means no fishing til half I_target then a linear ramp in fishing to I_target. c(0,0) means no HCR.

HCR_CP_TAC — Vector of positive real numbers. Response control points of an HCR. These are the y-levels corresponding with the hockey stick. These are the minimum and maximum modifiers applied to the TAC recommendation.

Mode — Integer. What type of index-based MP is used? 1 = Index rate, aims to fish at a rate of index (ie TAC = f(I, current_C / current_I, Ind_fac, HCR_CP_B, HCR_CP_TAC)), 2 = Index target, makes incremental TAC adjustments based on I/I_target (i.e. TAC = f(I, curI_2_target,))

Value

An object of class MP.

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 though 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` *FleetDescription*

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

`x`	A position in the data object
`Data`	A data object
`reps`	The number of stochastic samples of the MP recommendation(s)
`plot`	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 *Get part of an MP specific data-list*

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 *Extract the first dimension of a hierarchical list of recommendation objects*

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 *Optimization function to find a movement model that matches user specified movement characteristics modified for Rcpp.*

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?
```

`getMP` *Search R session for MP*

Description

Calls `dynGet()`, then `get()` in order to find the MP definition in the R session.

Usage

```
getMP(MP)
```

Arguments

`MP`	Character of MP name

Value

The function definition or an error message from `try()` if unsuccessful

Author(s)

Q. Huynh

`getnIVs` *Count independent variables for a MICE relationship at position x in a Rel list*

Description

Count independent variables for a MICE relationship at position x in a Rel list

Usage

```
getnIVs(x, Rel)
```

Arguments

`x`	Position of a MICE relationship in the list Rel (MOM@Rel)
`Rel`	The list of MICE relationships (MOM@Rel)

Author(s)

T.Carruthers

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)

hconv *Stock recruit parameterization*

Description

Convert stock recruit parameters from steepness parameterization to alpha/beta (and vice versa)

Usage

```
hconv(alpha, phi0, SR = 1, type = 1)

R0conv(alpha, beta, phi0, SR = 1, type = 1)

SRalphaconv(h, phi0, SR = 1, type = 1)

SRbetaconv(h, R0, phi0, SR = 1, type = 1)
```

Arguments

alpha	Alpha parameter
phi0	Unfished spawners per recruit
SR	Stock-recruit function: (1) Beverton-Holt, or (2) Ricker
type	The parameterization of the Beverton-Holt function with respect to alpha and beta. See details.
beta	Beta parameter
h	Steepness parameter
R0	Unfished recruitment parameter

Details

The Type 1 Beverton-Holt equation is

$$R = \alpha S/(1 + \beta S)$$

The Type 2 Beverton-Holt equation is

$$R = S/(\alpha + \beta S)$$

The Ricker equation is

$$R = \alpha S \exp(-\beta S)$$

Value

A numeric.

Functions

- `hconv()`: Returns steepness (h) from `alpha` and `phi0`
- `R0conv()`: Returns unfished recruitment (R0) from `alpha`, `beta`, and `phi0`
- `SRalphaconv()`: Returns `alpha` from `h` and `phi0`
- `SRbetaconv()`: Returns `beta` from `h`, `R0`, and `phi0`

Author(s)

Q. Huynh

`Herm-int` *Internal Herm functions*

Description

- `expandHerm` expands the Herm list in SexPars to a matrix of fractions at age
- `checkHerm` checks that each array in the list has dimension nsim x maxage+1 x nyears + proyears. For backwards compatibility, also converts matrices to arrays by adding the year dimension.
- `subsetHerm` returns year-specific Herm values.

Usage

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

checkHerm(Herm, maxage, nsim, nyears, proyears)

subsetHerm(Herm, y)
```

Arguments

Herm	A list of Hermaphroditic fractions at age
maxage	The maximum age of stocks being simulated
np	The total number of stocks being simulated
nsim	The number of simulations
nyears	The number of historical years
proyears	The number of projection years
y	The year to subset

Author(s)

T. Carruthers

Q. Huynh

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, nareas)`

- 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 *HistDescription*

Description

A data.frame with description of slots for class Hist

Usage

```
HistDescription
```

Format

An object of class `data.frame` with 76 rows and 2 columns.

Imp-class *Class* 'Imp'

Description

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

Slots

`Name` The name of the Implementation error object. 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 speciying the actual amount of efort 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 speciying 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 *ImpDescription*

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 *Function to run a set of input control methods*

Description

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

Usage

```
Input(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(MSEtool)
Input(MSEtool::Cobia)

## End(Not run)
```

iSCAM *Reads iSCAM files into a hierarchical R list object*

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` *Reads MPD or MCMC estimates and data from iSCAM file structure into an operating model*

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,
  spawn_time_frac = 0,
  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@cpars 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 subsample the mcmc samples.
spawn_time_frac	Numeric between 0-1 indicating when spawning occurs within the time step
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:

- `model$mpd$d3_weight_mat` - fecundity (product of weight and maturity at age)
- `model$mpd$ma` - maturity at age

MPD historical reconstruction

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

- `model$mpd$N` - abundance at age
- `model$mpd$F` - fishing mortality at age
- `model$mpd$M` - natural mortality at age

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

- `model$mpd$F_dd` - fishing mortality at age
- `model$mpd$M_dd` - natural mortality at age

Abundance at age is reconstructed using `model$mpd$rt` (recruitment) and projected with `F_dd` and `M_dd` to match `model$mpd$numbers`.

MCMC historical reconstruction

If `mcmc = TRUE` the function calls `mcmc_model <- read.mcmc(iSCAMdir)`, and grabs `nsim` subsamples 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 with M, maturity, growth = 0. In this way, the stock-recruit dynamics from iSCAM are preserved.

These arrays are then passed to Assess2OM 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 R0, steepness, and unfished spawners per recruit from the mean M, fecundity, and growth (mean with respect to time).

R0 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 `ageM` (age of 50% maturity) years.

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` *Combines indices into a single index using linear modelling (** Deprecated **)*

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` *Join Data objects present in a list*

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

See Also

joinMSE joinHist

`join_plots` *Plot several plots with a shared legend*

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

Description

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

Usage

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

Arguments

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

Note

Apologies for the nauseating shading.

Author(s)

T. Carruthers with some additions from A. Hordyk

Lag_Data *Lag the time-series slots in a* Data *object by a specified number of time-steps*

Description

Lag the time-series slots in a Data object by a specified number of time-steps

Usage

```
Lag_Data(Data, Data_Lag = 0, msg = FALSE)
```

Arguments

Data	An object of class Data
Data_Lag	Either a numeric vector of length 1 with a positive number specifying the number of time-steps to lag all time-series data, or a named list with numeric values (length 1). See details for more information.
msg	Logical. Display the messages?

Details

By default, all simulated data in the forward projections are provided up to the previous time-step. That is, in projection year t, the simulated data are up to and including t-1. This function will lag the time-series values by the specified value. For example, Data_Lag=5 will mean in projection time-step t the data will be up to and including t-6.

Note: The Data@Year slot is *not* lagged by this function. Many built-in MPs use the length of Data@Year to determine the number of years of data for smoothing over recent years etc. This may not be appropriate so check the MP is behaving as you expect if you use Lag_Data.

Value

An object of class Data with time-series slots lagged.

Examples

```
# Lag all time-series slots by 2 time-steps (usually years)
Data <- Example_datafile
Lagged_1 <- Lag_Data(Data, 2)
length(Data@Year)
length(Lagged_1@Year)
length(Data@Cat[1,])
length(Lagged_1@Cat[1,])
length(Data@Ind[1,])
length(Lagged_1@Ind[1,])

# Lag CAA by 5 and Ind by 3 time-steps
Lagged_2 <- Lag_Data(Data, Data_Lag=list(CAA=5, Ind=3))
```

```
length(Lagged_2@Year)
length(Lagged_2@Cat[1,])
dim(Data@CAA[1,,])
dim(Lagged_2@CAA[1,,])

length(Data@Ind[1,])
length(Lagged_2@Ind[1,])
```

`ldim` *Dimensions of a hierarchical list object*

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 FishBase 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 or numeric specifying percentiles. See Details. 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: *Linf*, *L50*, *K* and *M* (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 if 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

filterMK:

If filterMK is logical: Should the predicted M and K parameters be filtered within the range specified in `inpars`or `OM`?

Otherwise, filterMK must be numeric vector of length(2) specifying lower and upper percentiles that will be applied to the predicted M or K values

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 FishBase

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

Arguments

fracs	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

makemov2 *Calculates movement matrices from user inputs for fraction in each area (fracs) the relative fraction moving to other areas, plus a mean probability of staying in any given area.*

Description

A function for calculating a movement matrix from user specified distribution among areas (v) and relative movement to other areas (solves for positive diagonal - vector of prob staying). Used by simmov2 to generate movement matrices for an operating model. There must be a prior on the positive diagonal of the movement matrix or these will tend to 1 and hence perfectly satisfy the requirement V = MV.

Usage

```
makemov2(
  dist = c(0.05, 0.6, 0.35),
  prob = 0.5,
  probE = 1,
  frac_other = matrix(c(NA, 2, 1, 2, NA, 1, 1, 2, NA), nrow = 3, byrow = T),
  plot = F
)
```

Arguments

dist	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
probE	The logit CV associated with prob (used as a penalty when optimizing for diagonal)
frac_other	A matrix nareas x nareas that specifies the relative fraction moving from one area to the others. The positive diagonal is unspecified.
plot	Should the convergence to a stable distribution be plotted?

Author(s)

T. Carruthers

See Also

simmov2

---

makeRel *MICE relationships for multi-OM*

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

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

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.

`Obss` 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, `maxage+1`, nMPs, proyears, nareas. 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, MPs, nsim, OMtable, Obs,B_BMSYa, F_FMSYa, Ba, FMa, Ca, OFLa, Effort, PAA, CAA, CAL, CALbins)`

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. See `validcpars()`

`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, i.e., sex-specific spawning and hermaphroditism. More generally, controls spawning and moving abundance between stocks. See details.

`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)`.

SexPars

- `SSBfrom` A nstock x nstock matrix that specifies the proportion of the spawning output of the row p stock for the column p' stock. A diagonal matrix means each stock is responsible for its own recruitment.
- `Herm` A list with each entry containing a matrix (nsim x maxage + 1) that specifies the proportion at age that moves from stock p to p' (sequential hermaphroditism). The names of the list should be of the form "H_p'_p" where p and p' are integers that identify the stock. Arrays can also be used (nsim x maxage + 1 x nyears + proyears) for time-varying values.
- `share_par` Optional. Logical to indicate whether stock-recruit, depletion, and observation/implementation parameters are mirrored between stocks. By default, TRUE.

Author(s)

T. Carruthers and A. Hordyk

See Also

Article on `MOM` and `multiMSE`: https://openmse.com/features-multimse/

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 fromt the DLMtool function CalcMPDynamics()

Author(s)

T. Carruthers

MPtype *Management Procedure Type*

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` *Class* `'MSE'`

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 contains slots AtAge and TSdata unless 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 *MSEDescription*

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 *Load more data from MSEextra package*

Description

Downloads the MSEextra package from GitHub

Usage

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

Arguments

silent	Logical. Should messages to printed?
force	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,
  relRfun,
  SRRpars,
  R0x = 1,
  SRrelx = 3L,
  hx = 1,
  SSBpR = 0,
  opt = 1L,
  plusgroup = 1L,
  spawn_time_frac = 0
)
```

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
relRfun	Optional. A function used to calculate reference points if SRrelc =3
SRRpars	Optional. A named list of arguments for SRRfun
R0x	R0 for this simulation. Set = 1 if SRrelx = 4 for per-recruit calculations
SRrelx	SRR type for this simulation. Use 4 for per-recruit calculations, i.e. constant recruitment.
hx	numeric. Steepness value for this simulation. Not used if SRrelx = 4.
SSBpR	numeric. Unfished spawners per recruit for this simulation. Not used if SRrelx = 4.
opt	Option. 1 = return -Yield, 2= return all MSY calcs
plusgroup	Integer. Default = 0 = no plus-group. Use 1 to include a plus-group
spawn_time_frac	Numeric. Fraction of the year when spawning occurs. Default = 0.

Value

See opt

---

multiData *Combine data among fleets*

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` *Combine data among stocks*

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, Real.Data.Map, np, mm, nf, realVB)
```

Arguments

`MSElist`	A hierarchical list of data objects stock then fleet then MP
`Real.Data.Map`	Matrix describing which data are mapped across stocks
`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` *A basic comparison of runMSE output (MSE) and multiMSE (MMSE)*

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 doucmentation 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.

`Btbiascv` Log-normally distributed coefficient (CV) controlling error in observations of the current stock biomass. Bias occurs when the observed index of abundance is is systematically higher or lower than the true relative abundance. Btbiascv 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.

`LenMbiascv` Log-normal coefficient of variation for sampling bias in observed length at 50 percent maturity. LenMbiascv 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.

`Mbiascv` Log-normal coefficient of variation for sampling bias in observed natural mortality rate. 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.

`Kbiascv` Log-normal coefficient of variation for sampling bias in observed growth parameter K. Kbiascv 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.

`t0biascv` Log-normal coefficient of variation for sampling bias in observed t0. t0biascv 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.

`Linfbiascv` Log-normal coefficient of variation for sampling bias in observed maximum length. Linfbiascv 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.

`hbiascv` Log-normal coefficient of variation for sampling persistent bias in steepness. hbiascv 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.

`Recbiascv` Log-normal coefficient of variation for sampling persistent bias in recent recruitment strength. Recbiascv 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.

`sigmaRbiascv` Log-normal coefficient of variation for sampling persistent bias in recruitment variability. sigmaRbiascv 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.

`Ebiascv` 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. Ebiascv 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` *ObsDescription*

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 *Class* 'OM'

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.

`cpars` A list of custom parameters. Time series are a matrix nsim rows by nyears columns. Single parameters are a vector nsim long. See `validcpars()`

`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 *Determine optimal number of cpus*

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 *Imp class objects*

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 *Performance Metrics Methods*

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)
```

```
PGK(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 > BMSY
PNOF	Probability F < FMSY
LTY	Probability Long-Term Yield > 0.5 Relative Yield
STY	Probability Short-Term Yield > 0.5 Relative Yield
AAVY	Probability AAVY < 0.2 (Average Annual Variability in Yield)
AAVE	Probability 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 LTY/STY), the fraction of the Reference Yield. For AAVY is it the maximum acceptable variability in yield (i.e, default for AAVY is 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 multiMSE(MOM, ...)
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.MOM *Standard plot for an object of class MOM*

Description

Plot the stocks, fleets, catch fractions and relationships in multi operating model object

Usage

```
## S4 method for signature 'MOM,missing'
plot(x, silent = TRUE, maxsims = 6)
```

Arguments

x	Object of class MOM. A Multi-OM object created by new('MOM', ...)
silent	Logical. Do you wish to see print outs / warnings?
maxsims	Integer. What are the maximum number of individual simulations you wish to plot?

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,
  ...
)

## 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: • 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 *A basic SSB plot for debugging runMSE output*

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 *A generic OFL plot for NOAA use*

Description

As title.

Usage

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

Arguments

Data	An object of class Data that has been run 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 *A fairly tidy time-series quantile plot*

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

---

plotRel *Plot a relationship between stocks*

Description

Plot a relationship between stocks

Usage

```
plotRel(Stocks, Rel, Relno, Snams, leg = F, extras = 0)
```

Arguments

Stocks	A list of stock objects (MOM@Stocks)
Rel	A list of inter-stock MICE relationships (MOM@Rel)
Relno	Integer. The relationship you wish to plot
Snams	A vector of stock names
leg	Logical. Do you want to plot a legend?
extras	Integer. The number of blank plots to create at the end.

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: `Labels = list(AvC="Average Catch", CC1="Constant Catch")`
FeaseMPs	Optional. Character vector of MP names that are considered feasible. e.g. the output from `Fease()`
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

quantile_plot *A quantile plot*

Description

Plots quantiles and simulations for a stochastic time-series variable

Usage

```
quantile_plot(
  datmat,
  xvals,
  p = c(0.05, 0.25, 0.5, 0.75, 0.95),
  tcol,
  ylim,
  sims = 1:3,
  refline = NA,
  dox = F,
  doy = F
)
```

Arguments

datmat	Matrix of real values with dimensions (simulation, year) (e.g. SB/SBMSY)
xvals	Vector of numerical values of length ncol(datmat). The xaxis labels for datmat.
p	Vector of quantiles five positions long. Defaults to c(0.05,0.25,0.5,0.75,0.95) so the 90% and 50% intervals with the median plotted in white.
tcol	Color of shaded regions (transparent)
ylim	Numerical vector of length 2, lower and upper limits for the yaxis
sims	Vector of positive integers, the individual simulations to plot
refline	Positive real number, a reference line to plot (on scale of y axis)
dox	Logical, should the x axis labels be plotted.
doy	Logical, should the y axis labels be plotted.

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` *Generate a Data Report*

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

---

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/

---

runInMP *Runs input control MPs on a Data object.*

Description

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

Usage

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

Arguments

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

Author(s)

A. Hordyk

---

runMP *Run a Management Procedure*

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 by suppressed?

Value

invisibly returns the Data object

select_MP *Select DataList for an MP from* MMSE@PPD

Description

Select DataList for an MP from MMSE@PPD

Usage

```
select_MP(PPD, MP = 1)
```

Arguments

PPD	PPD slot from an MMSE object
MP	Numeric value indicating the MP to return DataList

Value

A nested list Data objects (nstock by nfleet)

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` *Setup parallel processing*

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 `logical=TRUE`, 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 `optCPU()`
`...`	other arguments passed to 'snowfall::sfInit'

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 *Show the output of a PM*

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

show-MSEtool *Show MSEtool S4 objects*

Description

Briefly prints a couple of lines from str to avoid swamping the console with the contents of very large objects.

Usage

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

## S4 method for signature 'OM'
show(object)

## S4 method for signature 'Hist'
show(object)

## S4 method for signature 'MSE'
show(object)

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

Arguments

object	S4 object from MSEtool

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` *Simulate Catch-at-Age Data*

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

---

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, qval = 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 fracs 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(nsim, maxage, nareas, nareas) or a five-dimensional array of dimension c(nsim, maxage, nareas, nareas, nyears + proyears) specifying movement in the operating model.

age	An age from 0 to maxage for the movement-at-age matrix figure when type = "matrix".
type	Whether to plot a movement matrix for a single age ("matrix") or the full movement versus age figure ("all")
year	If mov is a 5-dimensional array, the year (from 1 to nyears + proyears) 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)
```

---

simmov2 *Calculates movement matrices from user specified distribution among other areas*

Description

A wrapper function for makemov2 used to generate movement matrices for the operating model. Calculates a movement matrix from user-specified relative movement to other areas and probability of staying in the area in each time step.

Usage

```
simmov2(
  OM,
  dist = c(0.05, 0.6, 0.35),
  distE = 0.01,
  frac_other = matrix(c(NA, 2, 1, 3, NA, 1, 1, 4, NA), nrow = 3, byrow = T),
  frac_otherE = 0.01,
  prob = 0.8,
  probE = 1,
  figure = TRUE
)
```

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.
distE	Logit (normal) St.Dev error for sampling desired fraction in each area
frac_other	A matrix (nareas rows from, nareas columns to) of relative fractions moving to other areas (the positive diagonal (staying) is unspecified).
frac_otherE	Logit (normal) St.Dev error for sampling desired fraction moving to other areas.
prob	the mean probability of staying in the same area among all areas
probE	Logit (normal) St.Dev error for sampling desired probability of staying in each area
figure	Logical to indicate if the movement matrix will be plotted (mean values and range across OM@nsim simulations.)

Value

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

Functions

- simmov2(): Estimation function for creating movement matrix.

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_3areas <- simmov2(testOM, frac_other = matrix(c(NA,2,1, 2,NA,1, 1,2,NA),
nrow=3, byrow=T), frac_otherE = 0.01, prob = 0.8, probE = 0.3)
# sim 1, age 1, movement from areas in column i to areas in row j
movOM_3areas@cpars$mov[1, 1, , ]
plot_mov(movOM_3areas@cpars$mov)
plot_mov(movOM_3areas@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, nsim = NULL)

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

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

Arguments

`OM`	An operating model object (class OM or class `Hist`). Also works for `MOM` objects, as a wrapper for `ProjectMOM`

parallel	Logical or a named list. Should MPs be run using parallel processing? For runMSE, can also be "sac" to run the entire MSE in parallel using the split-apply-combine technique. See Details for more information.
silent	Should messages be printed out to the console?
nsim	Optional. numeric value to override OM@nsim.
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?

Details

Running MPs in parallel:

For most MPs, running in parallel can actually lead to an increase in computation time, due to the overhead in sending the information over to the cores. Consequently, by default the MPs will not be run in parallel if parallel=TRUE (although other internal code will be run in parallel mode).

To run MPs in parallel, specify a named list with the name of the MP(s) assigned as TRUE. For example,parallel=list(AvC=TRUE) will run the AvC MP in parallel mode.

Split-apply-combine MSE in parallel:

Additional savings in computation time can be achieved by running the entire simulation in batches. Individual simulations of the operating model are divided into separate cores using SubCpars, Simulate and Project are applied independently for each core via snowfall::sfClusterApplyLB, and the output (a list of MSE objects) is stitched back together into a single MSE object using joinMSE.

The ideal number of cores will be determined based on the number of simulations and available cores.

There are several issues to look out for when using this split-apply-combine technique:

- Numerical optimization for depletion may fail in individual cores when OM@cpars$qs is not specified.
- Length bins should be specified in the operating model in OM@cpars$CAL_bins. Otherwise, length bins can vary by core and create problems when combining into a single object.
- Compared to non-parallel runs, sampled parameters in the operating model will vary despite the same value in OM@seed.
- If there is an error in individual cores or while combining the parallel output into a single Hist or MSE object, the list of output (from the cores) will be returned.

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 if Hist = TRUE otherwise a class Hist object

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` *SimulatedData Data*

Description

An object of class Data

Usage

```
SimulatedData
```

Format

An object of class `Data` of length 1.

`SimulateMOM` *Run a multi-fleet multi-stock Management Strategy Evaluation*

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 = FALSE,
  dropHist = FALSE,
  extended = FALSE
)

multiMSE(
  MOM = MSEtool::Albacore_TwoFleet,
```

```
  MPs = list(list(c("AvC", "DCAC"), c("FMSYref", "curE"))),
  Hist = FALSE,
  silent = FALSE,
  parallel = TRUE,
  checkMPs = FALSE,
  dropHist = TRUE,
  extended = FALSE
)
```

Arguments

MOM	A multi-fleet multi-stock operating model (class MOM)
parallel	Logical or a named list. Should MPs be run using parallel processing? See Details for more information.
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
extended	Logical. Return extended projection results? if TRUE, MMSE@Misc$extended is a named list with extended data (including historical and projected abundance by area).
Hist	Should model stop after historical simulations? Returns a list containing all historical data

Details

Running MPs in parallel:

For most MPs, running in parallel can actually lead to an increase in computation time, due to the overhead in sending the information over to the cores. Consequently, by default the MPs will not be run in parallel if parallel=TRUE (although other internal code will be run in parallel mode).

To run MPs in parallel, specify a named list with the name of the MP(s) assigned as TRUE. For example,parallel=list(AvC=TRUE) will run the AvC MP in parallel mode.

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 *Manually map the historical relative fishing effort trajectory.*

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

---

smoothy *General purpose polynomial smoother*

Description

Polynomial smoother (no gradient prediction) applied to a vector that can include NA values. Intended to be rapid for use in management procedures

Usage

```
smoothy(xx, plot = F, enp_mult, plotname = "", xlab = "x", ylab = "y", x = NA)
```

Arguments

xx	Vector of real numbers, data to be smoothed.
plot	Logical, should the 'fit' of the smoother be plotted?
enp_mult	Fraction, effective number of parameters multiplier. The smoother parameter number is length(xx) x enp_mult. So higher values of enp_mult means less smoothing (more parameters).
plotname	Character, in case you want to put a label on the plot (plot = T).
xlab	Character, in case you want an xaxis label on the plot (plot = T)
ylab	Character, in case you want a yaxis label on the plot (plot = T)
x	Numeric vector same length as xx, in case you want to have a custom xaxis (e.g. years)

Author(s)

T. Carruthers

Splot *Standard MSE projection plot*

Description

Plots projections of F/FMSY, SB/SBMSY and Yield

Usage

```
Splot(MSEobj, MPs = 5, p = c(0.05, 0.25, 0.5, 0.75, 0.95))
```

Arguments

MSEobj	Object of class 'MSE' from runMSE() or Project()
MPs	Either a positive integer (the first MPs number of MPs to plot), a character vector (the names of the MPs to plot), or an integer vector (the index of the MPs to plot)
p	Vector of quantiles five positions long. Defaults to c(0.05,0.25,0.5,0.75,0.95) so the 90% and 50% intervals with the median plotted in white.

Author(s)

T. Carruthers

SS2Data *Reads data Stock Synthesis file structure into a Data object using package r4ss*

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 *Reads data Stock Synthesis file structure into a nested Data object analogous with multiMSE*

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 *Import Stock Synthesis to MOM (2-sex multi-fleet) or OM (single-sex, single-fleet)*

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,
  ...
)

MOM_agg_fleets(MOM)
```

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@cpars 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 plot_SS2OM, an object of either class OM or Hist. For plot_SS2MOM, an object of either class MOM or multiHist.
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 report = TRUE, character string for the name of the markdown and HTML files.
dir	If report = TRUE, the directory in which the markdown and HTML files will be saved.
open_file	If report = TRUE, 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.

Functions

- MOM_agg_fleets(): Aggregate all fleets in an MOM object.

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

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 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 *StockDescription*

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 *Subset MSE object by management procedure (MP) or simulation.*

Description

Subset the MSE object by particular MPs (either MP number or name), or particular simulations, or a subset of the projection years (e.g., 1: < projection years).

Usage

```
Sub(MSEobj, MPs = NULL, sims = NULL, years = NULL)
```

Arguments

`MSEobj`	A MSE object.
`MPs`	A vector MPs names or MP numbers to subset the MSE object. Defaults to all MPs.
`sims`	A vector of simulation numbers to subset the MSE object. Can also be a logical vector. Defaults to all simulations.
`years`	A numeric vector of projection years. Should start at 1 and increase by one to some value equal or less than the total number of projection years.

Author(s)

A. Hordyk

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 the cpars slot in an operating model*

Description

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

Usage

```
SubCpars(x, ...)

## S4 method for signature 'OM'
SubCpars(x, sims = 1:x@nsim, proyears = x@proyears, silent = FALSE)

## S4 method for signature 'MOM'
SubCpars(x, sims = 1:x@nsim, proyears = x@proyears, silent = FALSE)
```

Arguments

x	An object of class OM or MOM
...	Arguments for method.
sims	A logical vector of length x@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 x@proyears).
silent	Logical to indicate if messages will be reported to console.

Details

Useful function for running multiMSE in batches if running into memory constraints.

Value

An object of class OM or MOM (same class as x).

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,MMSE-method *Summary of MMSE object*

Description

Summary of MMSE object

Usage

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

Arguments

object	object of class MMSE
...	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.

---

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(MSEtool)
Data <- TAC(MSEtool::Cobia)
plot(Data)

## End(Not run)
```

TACfilter *TAC Filter*

Description

Filters vector of TAC recommendations by replacing negatives with NA and 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

`Taxa_Table` *Taxa_Table*

Description

Database from rfishbase

Usage

```
Taxa_Table
```

Format

An object of class `tbl_df` (inherits from `tbl`, `data.frame`) with 34721 rows and 8 columns.

Source

doi:10.1111/j.10958649.2012.03464.x

References

Carl Boettiger and Duncan Temple Lang and Peter Wainwright 2012. Journal of Fish Biology

---

`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 *OM class objects*

Description

Example objects of class OM

Usage

```
testOM
```

Format

An object of class `OM` of length 1.

Examples

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

Thresh_tab *Current default thresholds for DFO satisficing*

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 *Remove observation, implementation, and process error*

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

`tune_MP` *Tune MP*

Description

A generic function that uses optimize to tune a single MP parameter to minimize a user-specified function (e.g. squared distance from a mean yield, PGK = 60%, etc.)

Usage

```
tune_MP(Hist_list, MP, MP_parname, interval, minfunc, tol = 0.01, parallel = F)
```

Arguments

`Hist_list`	A list of objects of class Hist - created by runMSE(..., Hist=T)
`MP`	A character string that is the name of the MP to be tuned
`MP_parname`	A character string that is the argument (parameter) of the MP to be tuned
`interval`	A numeric vector two positions long that is the c(lower.bound, upper.bound) for the parameter to be tuned (MP_parname)
`minfunc`	A function to be minimized (e.g. the squared difference between mean yield obtained by the MP and a desired yield) that takes a list of MSE objects as its first argument.
`tol`	A positive numerical value that is the tolerance for the optimize procedure (default is 1E-2)
`parallel`	Logical: should the MSE projections (over the Hist objects in Hist_list) be calculated in parallel?

Value

A function of class MP with argument MP_parname tuned by optim to minimize minfunc

Author(s)

T. Carruthers

Examples

```
## Not run:
testOM@cpars$Data = new('Data')
testOM@cpars$Data@MPrec=2000
Hist_1 = runMSE(testOM,Hist=T)
testOM2 = testOM
testOM2@D = testOM@D / 2
Hist_2 = runMSE(testOM2,Hist=T)

myMP = function(x, Data, reps=1, rate = 1){
  CpI = mean(Data@Cat[x,46:50]) / mean(Data@Ind[x,46:50],na.rm=T)
  I = Data@Ind[x,]
  recI = mean(I[length(I)-((5-1):0)])
  Rec=new('Rec')
  Rec@TAC = recI * CpI * rate
  Rec
}
class(myMP) = "MP"

C1000 = function(MSE_list){
  mucat = mean(sapply(MSE_list,function(X){mean(X@Catch)}))
  cat(paste0("mean catch = ",round(mucat,3),"\n"))
  (mucat - 1000)^2 # try to match 1,250t mean yield
}

myMP_t = tune_MP(list(Hist_1,Hist_2), MP = "myMP", MP_parname = "rate",
                 interval = c(1,1.5), minfunc = C1000, tol=1E-3, parallel =F)

formals(myMP_t)$rate

## End(Not run)
```

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 *Valid custom parameters (cpars)*

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

Control list

A named list for `control`, for example, `OM@cpars$control <- list(TAC = "removals", CAL = "removals")`, can be specified to override default settings in the MSE simulation. Possible names in the `control` list are:

- `TAC` Character, set to `"removals"` so that the TAC is applied to the sum of retained + discarded catch. Default only applies the TAC to the retained catch.
- `CAL` Character, set to `"removals"` to sample the catch-at-length from retained + discarded catch. Default only samples from retained catch.
- `D` Character, set to `"VB"` so that historical depletion `OM@D` corresponds to vulnerable biomass depletion (only used when `OM@cpars$qs = NULL`).
- `optVB` Logical, set to `TRUE` so that historical depletion `OM@D` corresponds to vulnerable biomass depletion. Default sets depletion according to spawning biomasss when `OM@cpars$qs = NULL`.
- `optSBMSY` Logical, set to `TRUE` such that `OM@D` corresponds to the ratio of spawning biomass to MSY. Default uses according to spawning biomass depletion (biomass relative to unfished levels).
- `Depletion` Character, set to `"end"` such that historical depletion `OM@D` corresponds to the biomass at the end of the last projection year. Default corresponds to the value at the beginning of the last projection year.
- `ntrials` Integer, set the number of iterations to sample the operating model to match the depletion to `OM@D`. Default is 50.
- `fracD` Numeric, the maximum allowable proportion of simulations allowed to hit the bounds of the depletion parameter (simulation returns an error if exceeded). Default is 0.05.
- `checks` Logical. If `TRUE`, plots depletion and SB/SBMSY figures and prints values to the R console to diagnose issues with operating model configuration with regards to depletion.
- `unfished` Logical. If `TRUE`, returns historical simulations with F = 0.
- `progress` Logical. If `TRUE`, updates progress bar through `shiny::incProgress`. Used in conjunction with Shiny apps.
- `maxiterF` Integer, the number of iterations to solve for F in the projections from the specified TAC. Default is 300.
- `tolF` Numeric, the tolerance for the catch relative to the TAC when solving for F in the projections. Default is 1e-4.
- `HZN` Integer, the number of generations to solve for B_low. Default is 2. See `getBlow()`.
- `Bfrac` Numeric, proportion of SBMSY to solve for B_low. Default is 0.5. See `getBlow()`.

- skipdata Logical. If TRUE, skips conditioning on data in MOM@cpars[[p]][[f]]$Data. Only used in multiMSE().
- HermEq Logical, whether the equilibrium population age structures in the multi-OM is generated from the hermaphroditism vector (intended for use in salmonMSE). Default is TRUE. Only used in multiMSE().
- HistRel Logical, whether to perform the historical reconstruction with inter-stock relationships in MOM@Rel. Default is TRUE. Only used in multiMSE().

Examples

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

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

## End(Not run)
```

VOI *Calculate Value Of Information*

Description

A function that relates operating model parameters and parameters of the observation model to yield (by default). A user can also specific their own utility values (Ut) which is arranged in a matrix of nsim rows and nMP columns.

Usage

```
VOI(
  MSEobj,
  ncomp = 6,
  nbins = 8,
  maxrow = 8,
  Ut = NA,
  Utnam = "Utility",
  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/(newCV/oldCV)^2

Author(s)

T. Carruthers

VOIplot *Yet another Value of Information Plot*

Description

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

Usage

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

Arguments

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

Value

A list of all the information included in the plot

Author(s)

A. Hordyk

`WHAM2OM` *Takes a fitted SAM model and samples historical population and fishing dynamics from the MLE fit and variance-covariance matrix.*

Description

Takes a fitted SAM model and samples historical population and fishing dynamics from the MLE fit and variance-covariance matrix. Maturity-at-age-year, Mortality-at-age-year and weight-at-age-year are identical among simulations and are a direct copy of the matrices in the WHAM fitting object.

Usage

```
WHAM2OM(
  obj,
  nsim = 3,
  proyears = 30,
  interval = 2,
  Name = NULL,
  WLa = 1,
  WLb = 3,
  WAAind = 1,
  Obs = MSEtool::Imprecise_Unbiased,
  Imp = MSEtool::Perfect_Imp,
  nyr_par_mu = 3,
  LowerTri = 2,
  plusgroup = T,
  altinit = 0,
  fixq1 = T,
  report = FALSE,
  silent = FALSE,
  ...
)
```

Arguments

`obj`	a SAM output object
`nsim`	Positive integer. The number of simulations.
`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.
Name	Character string. The name of the operating model.
WLa	positive real number or array [sim, ages, year]. The default weight-length parameter a (W=aL^b)
WLb	positive real number or array [sim, ages, year]. The default weight-length parameter b (W=aL^b)
WAAind	positive integer. The index of the WHAM weight-at-age array input$data$waa to be assumed as the weight-at-age for the operating model
Obs	The observation model (class Obs). This function only updates the catch and index observation error.
Imp	The implementation model (class Imp). This function does not update implementation parameters.
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)
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),

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

Assess2OM

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 *Internal function to write CSVs for objects*

Description

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

Usage

```
writeCSV(
  inobj,
  tmpfile = NULL,
  objtype = c("Stock", "Fleet", "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 corresonding to the inobj

Author(s)

A. Hordyk

XL2Data *Import a Data object from Excel file*

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.

Usage

```
XL2OM(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 OM

Author(s)

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)
```

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

Index

∗ **~~**
    initialize-methods, 69
∗ **classes**
    Data-class, 30
    Fleet-class, 53
    Hist-class, 64
    Imp-class, 67
    MMSE-class, 87
    MOM-class, 89
    MSE-class, 93
    Obs-class, 99
    OM-class, 104
    PMobj-class, 124
    Rec-class, 129
    Stock-class, 159
∗ **datasets**
    Albacore, 6
    Albacore_TwoFleet, 7
    Atlantic_mackerel, 15
    DataDescription, 34
    DataSlots, 36
    DecE_Dom, 38
    FleetDescription, 55
    Generic_Obs, 57
    HistDescription, 67
    ImpDescription, 69
    LHdatabase, 81
    MSEDescription, 94
    ObsDescription, 103
    OMDescription, 105
    Overages, 109
    ReqData, 133
    SimulatedData, 149
    StockDescription, 163
    Taxa_Table, 169
    testOM, 170
∗ **keyword(s)**
    initialize-methods, 69
∗ **methods**
    initialize-methods, 69
∗ **other**
    initialize-methods, 69
∗ **possible**
    initialize-methods, 69

AAVE *(*PerformanceMetric*)*, 109
AAVY *(*PerformanceMetric*)*, 109
addMPs *(*checkMSE*)*, 23
Albacore, 6
Albacore_TwoFleet, 7
applyMMP, 7
applyMP, 8
ASAP2Data *(*ASAP2OM*)*, 9
ASAP2OM, 9, *15*
Assess2MOM, 10
Assess2OM, *10*, *12*, 12, *74*, *183*
Atlantic_mackerel, 15
avail, 16, *17*, *22*
Awatea2OM, 17

BAM2MOM, 18
BAM2OM *(*BAM2MOM*)*, 18
Blue_shark *(*Albacore*)*, 6
Bluefin_tuna *(*Albacore*)*, 6
Bluefin_tuna_WAtl *(*Albacore*)*, 6
boxplot.Data, 19
Butterfish *(*Albacore*)*, 6

calcRefYield, 20
CALsimp, 20
Can, *17*, 21, *134*
Cant, *17*, *134*
Cant *(*Can*)*, 21
CheckDuplicate, 22
checkHerm *(*Herm-int*)*, 63
CheckMPs, 22
checkMSE, 23
CheckOM, 24
China_rockfish *(*Atlantic_mackerel*)*, 15

ChkYrs, *110*
Choose, 25
ChooseEffort *(*Choose*)*, 25
ChooseM *(*Choose*)*, 25
ChooseSelect *(*Choose*)*, 25
Cobia *(*Atlantic_mackerel*)*, 15
CombineMMP, 26
Converge, 26
Cos_thresh_tab, 28
COSEWIC_Blow *(*runCOSEWIC*)*, 134
COSEWIC_Dplot *(*runCOSEWIC*)*, 134
COSEWIC_Hplot *(*runCOSEWIC*)*, 134
COSEWIC_Pplot *(*runCOSEWIC*)*, 134
COSEWIC_report *(*runCOSEWIC*)*, 134
COSEWIC_tab *(*runCOSEWIC*)*, 134
COSEWIC_tab_formatted *(*runCOSEWIC*)*, 134
cparscheck, 28
Cplot, 29
curEref *(*FMSYref*)*, 56

Data, *8*, *22*, *57*, *134*
Data-class, 30
Data-class-objects *(*Atlantic_mackerel*)*, 15
Data2csv, 34
Data_xl, 37
DataDescription, 34
DataDir, 35
DataInit, 35
DataSlots, 36
DecE_Dom, 38
DecE_HDom *(*DecE_Dom*)*, 38
DecE_NDom *(*DecE_Dom*)*, 38
DFO_bar, 39
DFO_hist, 40
DFO_plot, 40
DFO_plot2, 41
DFO_proj, 41
DFO_quant, 42
DFO_report, 43
DFO_spider, 43
DFO_tab, 44
DFO_tab_formatted, 44
DLMDataDir, 45
DLMdiag *(*Can*)*, 21
dnormal, 46
doHCR, 46
doIfreq, 47
Dom, 48
doRec, 49
dynGet(), *61*

Emp, 50
Example_datafile *(*Atlantic_mackerel*)*, 15
expandHerm *(*Herm-int*)*, 63

Fease, 52
fetch.file.names *(*iSCAM*)*, 70
FlatE_Dom *(*DecE_Dom*)*, 38
FlatE_HDom *(*DecE_Dom*)*, 38
FlatE_NDom *(*DecE_Dom*)*, 38
Fleet-class, 53
Fleet-class-objects *(*DecE_Dom*)*, 38
FleetDescription, 55
FMSYref, 56
FMSYref50 *(*FMSYref*)*, 56
FMSYref75 *(*FMSYref*)*, 56

Generic_DecE *(*DecE_Dom*)*, 38
Generic_FlatE *(*DecE_Dom*)*, 38
Generic_Fleet *(*DecE_Dom*)*, 38
Generic_IncE *(*DecE_Dom*)*, 38
Generic_Obs, 57
get(), *61*
getBlow(), *178*
getclass, 58
getDataList, 59
getfirstlev, 59
getmov2, 60
getMP, 61
getnIVs, 61
getsel, 62
Gulf_blue_tilefish *(*Atlantic_mackerel*)*, 15

hconv, 62
Herm-int, 63
Herring *(*Albacore*)*, 6
Hist, *148*, *158*
Hist-class, 64
hist2, 66
HistDescription, 67

Imp, *11*
Imp-class, 67
Imp-class-objects *(*Overages*)*, 109
ImpDescription, 69
Imprecise_Biased *(*Generic_Obs*)*, 57

Imprecise_Unbiased (Generic_Obs), 57
IncE_HDom (DecE_Dom), 38
IncE_NDom (DecE_Dom), 38
initialize (initialize-methods), 69
initialize,Data-method (initialize-methods), 69
initialize,DLM_general-method (initialize-methods), 69
initialize,Fease-method (initialize-methods), 69
initialize,Fleet-method (initialize-methods), 69
initialize,MSE-method (initialize-methods), 69
initialize,Obs-method (initialize-methods), 69
initialize,OM-method (initialize-methods), 69
initialize,Stock-method (initialize-methods), 69
initialize-methods, 69
Input, 70
iSCAM, 70
iSCAM2Data (iSCAM2OM), 72
iSCAM2OM, *15*, *72*, 72
iSCAMcomps, 74
iSCAMinds, 75

join_plots, 76
joinData, *24*, 75
joinHist, *76*
joinHist (checkMSE), 23
joinMSE, *76*, *148*
joinMSE (checkMSE), 23

Kplot, 77

Lag_Data, 78
ldim, 79
LH2OM, 79
LHdatabase, 81
load.iscam.files, *72*
load.iscam.files (iSCAM), 70
Low_Effort_Non_Target (DecE_Dom), 38
LTY (PerformanceMetric), 109

Mackerel (Albacore), 6
makeMOM, 82
makemov, 83, *144*
makemov2, 83, *145*
makeRel, 84
makeTransparent, 86
ML2D, 86
MMSE, *112*
MMSE-class, 87
MOM, *10*, *12*, *82*, *113*, *150*, *155*, *158*, *164*
MOM-class, 89
MOM-class-objects (Albacore_TwoFleet), 7
MOM_agg_fleets (SS2MOM), 155
movestockCPP, 91
movfit_Rcpp, 91
MPCalcsNAs, 92
MPtype, 92, *134*
MSE, *148*
MSE-class, 93
MSEDescription, 94
MSEextra, 95
MSYCalcs, 95
multiData, 96
multiDataS, 97
multidebug, 97
multiMSE, *11*, *12*, *84*, *157*, *164*
multiMSE (SimulateMOM), 149
multiMSE(), *179*

Needed, *134*
Needed (Can), 21
NFref (FMSYref), 56
NIL, 98
NOAA_plot, 99
NOAA_plot2 (TradePlot), 172

Obs, *11*
Obs-class, 99
Obs-class-objects (Generic_Obs), 57
ObsDescription, 103
OM, *10*, *15*, *82*, *144*, *146*, *147*, *155*, *158*, *164*, *183*
OM-class, 104
OM-class-objects (testOM), 170
OMDescription, 105
OMdoc, 105
OMexample, 106
OMinit, 107
optCPU, 108
ourReefFish (Atlantic_mackerel), 15
Overages, 109

P10 (PerformanceMetric), 109
P100 (PerformanceMetric), 109
P50 (PerformanceMetric), 109
Perfect_Imp (Overages), 109
Perfect_Info (Generic_Obs), 57
PerformanceMetric, 109
PGK (PerformanceMetric), 109
plot,MOM,missing-method (plot.MOM), 113
plot.Data, 111
plot.Fleet (plot.pars), 114
plot.Hist (plot.pars), 114
plot.Imp (plot.pars), 114
plot.MMSE, 112
plot.MOM, 113
plot.MSE, 113
plot.Obs (plot.pars), 114
plot.OM (plot.pars), 114
plot.pars, 114
plot.Stock (plot.pars), 114
plot_mov (simmov), 144
plot_SS2MOM (SS2MOM), 155
plot_SS2OM (SS2MOM), 155
plotFun, 118
plotmulti, 119
plotOFL, 120
plotquant, 120
plotRel, 121
PMLimit, 122
PMObj (PMLimit), 122
PMobj-class, 124
PNOF (PerformanceMetric), 109
Porgy (Albacore), 6
Pplot, 125
Pplot2, 125
Precise_Biased (Generic_Obs), 57
Precise_Unbiased (Generic_Obs), 57
predict.Rel (makeRel), 84
predictLH (LH2OM), 79
print.Rel (makeRel), 84
Project (Simulate), 147
ProjectMOM (SimulateMOM), 149
PWhisker, 127

quantile_plot, 128

R0conv (hconv), 62
read.control.file (iSCAM), 70
read.data.file (iSCAM), 70
read.mcmc, *73*
read.mcmc (iSCAM), 70
read.par.file (iSCAM), 70
read.projection.file (iSCAM), 70
read.report.file (iSCAM), 70
RealFease, 129
Rec, *49*, *56*
Rec-class, 129
Red_snapper (Atlantic_mackerel), 15
Replace, 130
replic8, 131
Report, 132
ReqData, 133
Required, *93*, 133
Rockfish (Albacore), 6
runCOSEWIC, 134
runInMP, 136
runMP, 137
runMSE, *14*, *158*, *183*
runMSE (Simulate), 147

select_MP, 138
Sense, 138
setup, *108*, 139
show (show-MSEtool), 141
show,Data-method (show-MSEtool), 141
show,Hist-method (show-MSEtool), 141
show,MMSE-method (show-MSEtool), 141
show,MSE-method (show-MSEtool), 141
show,OM-method (show-MSEtool), 141
show,PMobj-method, 140
show,Rec-method, 140
show-MSEtool, 141
SIL, 141
simCAA, 142
simCAL, 143
simmov, *83*, 144
simmov2, *83*, *84*, 145
Simulate, 147
simulate.Rel (makeRel), 84
SimulatedData, 149
SimulateMOM, 149
Simulation_1 (Atlantic_mackerel), 15
SketchFun, 151
smoothy, 151
Snapper (Albacore), 6
Sole (Albacore), 6
Splot, 152
SRalphaconv (hconv), 62
SRbetaconv (hconv), 62

SS2Data, 153, *158*
SS2DataMOM, 154, *158*
SS2MOM, *12*, *155*, 155
SS2OM, *15*, *154*
SS2OM *(*SS2MOM*)*, 155
SS_output, *154, 155*, *158*
SSBrefplot, 159
SSMOM2OM *(*SS2MOM*)*, 155
Stock-class, 159
Stock-class-objects *(*Albacore*)*, 6
StockDescription, 163
str, *141*
STY *(*PerformanceMetric*)*, 109
Sub, 163, *165*
SubCpars, *148*, *163*, 164, *165*
SubCpars,MOM-method *(*SubCpars*)*, 164
SubCpars,OM-method *(*SubCpars*)*, 164
SubOM, *163*, *165*, 165
subsetHerm *(*Herm-int*)*, 63
summary,Data-method, 166
summary,MMSE-method, 166
summary,MSE-method, 167

TAC, 167
TACfilter, 168
Target_All_Fish *(*DecE_Dom*)*, 38
Targeting_Small_Fish *(*DecE_Dom*)*, 38
Taxa_Table, 169
TEG, 169
testOM, 170
Thresh_tab, 170
tinyErr, 171
tinyErr,OM-method *(*tinyErr*)*, 171
Toothfish *(*Albacore*)*, 6
Tplot *(*TradePlot*)*, 172
Tplot2 *(*TradePlot*)*, 172
Tplot3 *(*TradePlot*)*, 172
TradePlot, 172
try(), *61*
tune_MP, 174
Turing, 175
TuringMOM *(*Turing*)*, 175

updateMSE *(*checkMSE*)*, 23
Uses, 177

validcpars, 177
validcpars(), *89*, *104*
VOI, 179
VOI2, 180
VOIplot, 181
VPA2OM, *17*
VPA2OM *(*Assess2OM*)*, 12

WHAM2OM, *15*, 182
wormplot, 184
writeCSV, 184

XL2Data, 185
XL2Fleet, 186
XL2OM, 186
XL2Stock, 187

Yield *(*PerformanceMetric*)*, 109