Package 'LBSPR'

Title Length-Based Spawning Potential Ratio

Version 0.1.6

Description Simulate expected equilibrium length composition, yield-per-recruit, and
the spawning potential ratio (SPR) using the length-based SPR (LBSPR) model. Fit the LBSPR
model to length data to estimate selectivity, relative apical fishing mortality, and
the spawning potential ratio for data-limited fisheries.
See Hordyk et al (2016) <doi:10.1139/cjfas-2015-0422> for more information about the
LBSPR assessment method.

URL https://github.com/AdrianHordyk/LBSPR

BugReports https://github.com/AdrianHordyk/LBSPR/issues

Depends R (>= 3.2.4)

License GPL-3

Imports dplyr, ggplot2, graphics, gridExtra, methods, plotrix, Rcpp,
RColorBrewer, shiny, tidyr

RoxygenNote 7.1.1

Encoding UTF-8

LinkingTo Rcpp

Suggests colorspace, knitr, scales, shinyBS, rmarkdown

VignetteBuilder knitr

NeedsCompilation yes

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Repository CRAN

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Contents

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calcCurves	*Calculate Relative Yield, YPR, SPR, SSB, and Recruitment curves for F/M*

Description

A function that takes a LB_pars or LB_obj object and returns a data frame of values for relative Yield, YPR, SPR, SSB, and Recruitment at different values of F/M

Usage

```
calcCurves(LB_obj)
```

Arguments

LB_obj   An object of class `'LB_obj'` or class `'LB_pars'` that contains the life history and fishing information

Value

a dataframe with YPR, Yield, SSB, Rec, and FM

Author(s)

A. Hordyk

DataDir	*Report the location of the Data Files*

Description

A function that returns the location of the example CSV files

Usage

```
DataDir()
```

Author(s)

A. Hordyk modified (i.e., stolen) from T. Carruthers' code (DLMtool package)

FilterSmooth	*Kalman filter and Rauch-Tung-Striebel smoother*

Description

A function that applies a filter and smoother to estimates

Usage

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

Arguments

RawEsts	a vector of estimated values
R	variance of sampling noise
Q	variance of random walk increments
Int	covariance of initial uncertainty

Value

a vector of smoothed values

---

getFMfun   *Calculate F/M given SPR and other parameters*

Description

A internal function that optimizes for F/M when SPR is provided in the simulation parameters.

Usage

```
getFMfun(FM, LB_pars, Control = list())
```

Arguments

FM	a F/M value
LB_pars	an object of class 'LB_pars' that contains the life history information
Control	a list of control options for the LBSPR model.

Details

The Control options are:

modtype Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

maxsd Maximum number of standard deviations for length-at-age distribution (default is 2)

ngtg Number of groups for the GTG model. Default is 13

P Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is 0.01

Nage Number of pseudo-age classes in the Age Structured model. Default is 101

maxFM Maximum value for F/M. Estimated values higher than this are trunctated to maxFM. Default is 4

Value

sum of squares value

Author(s)

A. Hordyk

```
initialize,LB_lengths-method
```
                    Create a new LB_lengths object

Description

Function

Usage

```
## S4 method for signature 'LB_lengths'
initialize(
  .Object,
  file = "none",
  LB_pars = NULL,
  dataType = c("raw", "freq"),
  header = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

.Object	class of object to be created
file	file path and name to CSV containing parameters. Alternatively it can be a matrix or vector of length data
LB_pars	a object of class LB_pars
dataType	is the length data individual measurements (raw) or a length frequency (freq)?
header	is there a header?
verbose	display a message?
...	optional additional arguments passed to read.csv

Value

a object of class `'LB_lengths'`

Author(s)

A. Hordyk

```
initialize,LB_obj-method
```
Create a new LB_obj object

Description

Function

Usage

```
## S4 method for signature 'LB_obj'
initialize(.Object, defaults = FALSE, verbose = FALSE)
```

Arguments

.Object	class of object to be created
defaults	use defaults?
verbose	display a message?

Value

a object of class `'LB_obj'`

Author(s)

A. Hordyk

```
initialize,LB_pars-method
```
Create a new LB_pars object

Description

Function

Usage

```
## S4 method for signature 'LB_pars'
initialize(.Object, file = "none", defaults = TRUE, verbose = TRUE)
```

Arguments

.Object	class of object to be created
file	use 'example' to create example LB_pars object. File path and name to CSV containing parameters. Import CSV currently not working
defaults	use defaults for some parameters?
verbose	display a message?

Value

a object of class `'LB_pars'`

Author(s)

A. Hordyk

LBSPRfit   *Fit LBSPR model to length data*

Description

A function that fits the LBSPR model to length data

Usage

```
LBSPRfit(
  LB_pars = NULL,
  LB_lengths = NULL,
  yrs = NA,
  Control = list(),
  pen = TRUE,
  verbose = TRUE,
  useCPP = TRUE,
  ...
)
```

Arguments

LB_pars	an object of class `'LB_pars'` that contains the life history information
LB_lengths	an object of class `'LB_lengths'` that contains the length data
yrs	index of years to include. If NA the model is run on all years
Control	a list of control options for the LBSPR model.
pen	apply a penalty if estimate of selectivity is very high?
verbose	display messages?
useCPP	use cpp optimization code?
...	additional parameters to pass to `FilterSmooth`

Details

The Control options are:

modtype Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

maxsd Maximum number of standard deviations for length-at-age distribution (default is 2)

ngtg Number of groups for the GTG model. Default is 13

P Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is
     0.01

Nage Number of pseudo-age classes in the Age Structured model. Default is 101

maxFM Maximum value for F/M. Estimated values higher than this are trunctated to maxFM. Default
       is 4

Value

a object of class 'LB_obj'

Author(s)

A. Hordyk

Examples

```
## Not run:
MyFit <- LBSPRfit(LBparameters, LBlengths)
MyFit@Ests

## End(Not run)
```

LBSPRfit_   *Internal function to fit LBSPR model to length data*

Description

An internal function that fits the LBSPR model to a single year of length data

Usage

```
LBSPRfit_(
  yr = 1,
  LB_pars = NULL,
  LB_lengths = NULL,
  Control = list(),
  pen = TRUE,
  useCPP = TRUE,
  verbose = TRUE
)
```

Arguments

`yr`	index of the year column to fit model to
`LB_pars`	an object of class `'LB_pars'` that contains the life history information
`LB_lengths`	an object of class `'LB_lengths'` that contains the length data
`Control`	a list of control options for the LBSPR model.
`pen`	apply a penalty if estimate of selectivity is very high?
`useCPP`	use cpp optimization code?
`verbose`	display messages?

Details

The Control options are:

modtype Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

maxsd Maximum number of standard deviations for length-at-age distribution (default is 2)

ngtg Number of groups for the GTG model. Default is 13

P Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is 0.01

Nage Number of pseudo-age classes in the Age Structured model. Default is 101

maxFM Maximum value for F/M. Estimated values higher than this are trunctated to `maxFM`. Default is 4

Value

a object of class `'LB_obj'`

Author(s)

A. Hordyk

LBSPRopt *Optimisation Routine for fitting LBSPR*

Description

A function that calculate the negative log-likelihood of the LBSPR model

Usage

```
LBSPRopt(
  trypars,
  yr = 1,
  LB_pars = NULL,
  LB_lengths = NULL,
  Control = list(),
  pen = TRUE
)
```

Arguments

`trypars`	a vector of exploitation parameters in log space
`yr`	index of the year column to fit the model to
`LB_pars`	an object of class `'LB_pars'` that contains the life history information
`LB_lengths`	an object of class `'LB_lengths'` that contains the length data
`Control`	a list of control options for the LBSPR model.
`pen`	apply a penalty if estimate of selectivity is very high?

Details

The Control options are:

`modtype` Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

`maxsd` Maximum number of standard deviations for length-at-age distribution (default is 2)

`ngtg` Number of groups for the GTG model. Default is 13

`P` Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is 0.01

`Nage` Number of pseudo-age classes in the Age Structured model. Default is 101

`maxFM` Maximum value for F/M. Estimated values higher than this are trunctated to `maxFM`. Default is 4

Value

a NLL value

Author(s)

A. Hordyk

LBSPRsim   *LBSPR Simulation Model*

Description

Function that generates the expected equilbrium size composition given biological parameters, and fishing mortality and selectivity pattern.

Usage

```
LBSPRsim(LB_pars = NULL, Control = list(), verbose = TRUE)
```

Arguments

LB_pars	an object of class 'LB_pars' that contains the life history information
Control	a list of control options for the LBSPR model.
verbose	display messages?

Details

The Control options are:

modtype Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

maxsd Maximum number of standard deviations for length-at-age distribution (default is 2)

ngtg Number of groups for the GTG model. Default is 13

P Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is 0.01

Nage Number of pseudo-age classes in the Age Structured model. Default is 101

maxFM Maximum value for F/M. Estimated values higher than this are trunctated to maxFM. Default is 4

Value

a object of class 'LB_obj'

Author(s)

A. Hordyk

Examples

```
LB_pars <- new("LB_pars")
LB_pars@MK <- 1.5
LB_pars@Linf <- 100
LB_pars@L50 <- 50
LB_pars@L95 <- 55
LB_pars@SL50 <- 60
LB_pars@SL95 <- 65
LB_pars@FM <- 1
Sim <- LBSPRsim(LB_pars)
Sim@SPR
```

LBSPRsim_   *Internal LBSPR Simulation Model*

Description

A internal function that generates the expected equilbrium size composition given biological parameters, and fishing mortality and selectivity pattern. Typically only used by other functions in the package.

Usage

```
LBSPRsim_(LB_pars = NULL, Control = list(), verbose = TRUE, doCheck = TRUE)
```

Arguments

LB_pars	an object of class 'LB_pars' that contains the life history information
Control	a list of control options for the LBSPR model.
verbose	display messages?
doCheck	check if the LB_pars object is valid? Switch off when calling function from a optimization routine.

Details

The Control options are:

modtype Model Type: either Growth-Type-Group Model (default: "GTG") or Age-Structured ("absel")

maxsd Maximum number of standard deviations for length-at-age distribution (default is 2)

ngtg Number of groups for the GTG model. Default is 13

P Proportion of survival of initial cohort for maximum age for Age-Structured model. Default is 0.01

Nage Number of pseudo-age classes in the Age Structured model. Default is 101

maxFM Maximum value for F/M. Estimated values higher than this are trunctated to maxFM. Default is 4

Value

a object of class `'LB_obj'`

Author(s)

A. Hordyk

LBSPR_NLLabsel | *LBSPR Optimization function for age-based selectivity model*

Description

Internal optimization function

Usage

```
LBSPR_NLLabsel(
  starts,
  x,
  P,
  LMids,
  LBins,
  LDat,
  MK,
  Linf,
  FecB,
  L50,
  L95,
  maxsd,
  CVLinf,
  Nage,
  usePen
)
```

Arguments

starts	a vector of starting parameters, relative SL50 (SL50/Linf), deltaSL (SL95-SL50)/Linf, and F/M (in log space)
x	vector of relative ages
P	numeric value indicating proportion of cohort remaining at maximum age
LMids	a vector of the midpoints of the length classes
LBins	a vector of length classes
LDat	a vector of lenght frequencies. Must be same length as LMids
MK	the M/K value
Linf	the Linf value for the population as a hole

FecB	exponent of the length-fecundity relationship
L50	length at 50 per cent maturity
L95	length at 95 per cent maturity
maxsd	numeric value - maximum number of standard deviations of length-at-age dist
CVLinf	CV of length-at-age
Nage	number of pseudo age-classes
usePen	logical to use penalty for extreme estimates of selectivity

Value

negative log-likelihood value

Author(s)

A. Hordyk

LBSPR_NLLgtg   *LBSPR Optimization function for GTG model*

Description

Internal optimization function

Usage

```
LBSPR_NLLgtg(
  starts,
  LMids,
  LBins,
  LDat,
  gtgLinfs,
  MKMat,
  MK,
  Linf,
  ngtg,
  recP,
  usePen
)
```

Arguments

starts	a vector of starting parameters, relative SL50 (SL50/Linf), deltaSL (SL95-SL50)/Linf, and F/M (in log space)
LMids	a vector of the midpoints of the length classes
LBins	a vector of length classes

LDat	a vector of lenght frequencies. Must be same length as LMids
gtgLinfs	a vector of Linfs for the growth-type-groups
MKMat	a matrix of M/K for each GTG and length-class
MK	the M/K value
Linf	the Linf value for the population as a hole
ngtg	the number of growth-type-groups
recP	a vector of recruitment by GTG
usePen	logical to use penalty for extreme estimates of selectivity

Value

negative log-likelihood value

Author(s)

A. Hordyk

LB_lengths-class   *An S4 class containing length data*

Description

An S4 class containing length data

Slots

LMids A numeric vector containing the mid-points of the length bins

LData A numeric matrix containing length data

L_units Character descrbing units of the length measurements

Years A numeric vector containing the year indices

NYears A length-one numeric vector for number of years

Elog A error log

`LB_obj-class` *An S4 class containing all parameters for the LBSPR model*

Description

An S4 class containing all parameters for the LBSPR model

Slots

SPR The Spawning Potential Ratio

Yield Relative yield

YPR Yield per recruit

SSB Spawning stock biomass (relative only)

SSB0 Unfished spawning stock biomass

B0 Unfished biomass

LMids A numeric vector containing the mid-points of the length bins

pLCatch A numeric vector containing expected proportion for each length class in the catch

pLPop A numeric vector containing expected proportion for each length class in the population

RelRec Relative recruitment

Ests A matrix of estimated values

Vars A vector of estimated variance for SL50, SL95, F/M and SPR

NLL A numeric NLL values

maxFM A numeric of maximum estimated F/M value (note this is apical F)

SPRatsize A vector of cumulative SPR at length (currently only works for GTG model)

fitLog A vector of error logs for each fit. 0 means everything is okay.

`LB_pars-class` *An S4 class containing life history and other parameters*

Description

An S4 class containing life history and other parameters

Slots

Species Character vector of species name

MK A length-one numeric vector for M/K ratio

M An optional value for natural mortality (M)

Linf A length-one numeric vector for Linf

L_units Character describing units of length parameters

CVLinf A length-one numeric vector for CV of length-at-age

L50 A length-one numeric vector for length at 50% maturity

L95 A length-one numeric vector for length at 95% maturity

Walpha A length-one numeric vector for alpha parameter of length-weight relationship

Walpha_units Character describing units for weight scaling parameter

Wbeta A length-one numeric vector for beta parameter of length-weight relationship

FecB A length-one numeric vector for beta parameter of length-fecundity relationship

Steepness A length-one numeric vector for steepness of SRR

Mpow A length-one numeric vector for M at length

R0 A length-one numeric vector for initial number of recruits (1 for per-recruit)

SL50 A length-one numeric vector for length at 50% selectivity

SL95 A length-one numeric vector for length at 95% selectivity

MLL Minimum legal length (inflection point)

sdLegal Standard deviation of MLL curve

fDisc Fraction discarded that die

FM A length-one numeric vector for F/M ratio (note this is apical F)

SPR A length-one numeric vector for SPR

BinMin A length-one numeric vector for minimum length bin

BinMax A length-one numeric vector for maximum length bin

BinWidth A length-one numeric vector for width of length bins

---

plotCurves *Plot the Relative Yield, YPR, SPR, SSB, and Recruitment curves*

Description

A function that plots the Relative Yield, YPR, SPR, SSB, and Recruitment curves

Usage

```
plotCurves(
  LB_obj,
  X = c("FM", "SSB", "SPR"),
  Y = c("SPR", "SSB", "Yield"),
  size.axtex = 12,
  size.title = 14,
  size.leg = 12,
  size.pt = 4,
  inc.pts = TRUE
)
```

Arguments

LB_obj	An object of class 'LB_obj' that contains the life history and fishing information
X	a character value indicating what to plot on the x-axis: F/M ("FM") or SSB ("SSB")
Y	a character value indicating what to plot on the y-axis: SPR, SSB, Yield, YPR or Rec(multiple okay)
size.axtex	size of the axis text
size.title	size of axis title
size.leg	size of legend text
size.pt	size of the points on the plots
inc.pts	Include points on the plots?

Value

a ggplot object

Author(s)

A. Hordyk

---

plotEsts *Plot LBSPR model estimates*

Description

A function that plots the estimates of the LBSPR with a smoother line

Usage

```
plotEsts(
  LB_obj = NULL,
  pars = c("Sel", "FM", "SPR"),
  Lwd = 2.5,
  ptCex = 1.25,
  axCex = 1.45,
  labCex = 1.55,
  doSmooth = TRUE,
  incL50 = FALSE,
  CIcol = "darkgray",
  L50col = "gray"
)
```

Arguments

LB_obj	an object of class `'LB_obj'` that contains the life history and fishing information
pars	a character vectors specifying which plots to create
Lwd	line width
ptCex	size of plotted points
axCex	size of the axis
labCex	size of axis label
doSmooth	apply the smoother?
incL50	include L50 line?
CIcol	colour of the confidence interval bars
L50col	colour of L50 line (if included)

Author(s)

A. Hordyk

---

plotMat	*Plot the maturity-at-length and selectivity-at-length curves*

Description

A function that plots the maturity-at-length and selectivity-at-length curves

Usage

```
plotMat(
  LB_obj = NULL,
  size.axtex = 12,
  size.title = 14,
  size.leg = 12,
  useSmooth = TRUE,
  Title = NULL
)
```

Arguments

`LB_obj`	an object of class `'LB_obj'` that contains the life history and fishing information
`size.axtex`	size of the axis text
`size.title`	size of axis title
`size.leg`	size of legend text
`useSmooth`	use the smoothed estimates?
`Title`	optional character string for plot title

Value

a ggplot object

Author(s)

A. Hordyk

---

plotSim   *General plotting function for simulated data*

Description

A general function that plots the simulation object. Includes four different plots: equilbrium size structure, maturity and selectivity curves, growth curves, and relative Yield, YPR, SPR, SSB, and Recruitment curves.

Usage

```
plotSim(
  LB_obj = NULL,
  type = c("all", "len.freq", "growth", "maturity.select", "yield.curve"),
  lf.type = c("catch", "pop"),
  growth.type = c("LAA", "WAA"),
  y.type = c("SPR", "SSB", "Yield", "YPR"),
  x.type = c("FM", "SSB", "SPR"),
```

```
  perRec = FALSE,
  inc.SPR = TRUE,
  Cols = NULL,
  size.axtex = 12,
  size.title = 14,
  size.SPR = 4,
  size.leg = 12,
  inc.pts = TRUE,
  size.pt = 4
)
```

Arguments

LB_obj	an object of class 'LB_obj' that contains the life history and fishing information
type	a character value indicating which plots to include: "all", "len.freq", "growth", "maturity.select", "yield.curve"
lf.type	a character value indicating if the catch or pop (population) should be plotted for the length frequency
growth.type	should growth be plotted as length-at-age ("LAA") or weight-at-age ("WAA")
y.type	what curves should be plotted on y-axis? "SPR", "SSB", "Yield", "YPR"
x.type	what curves should be plotted on x-axis? "FM", "SSB", "SPR"
perRec	a logical to indicate if plot should be per-recruit (ignore steepness) or not (zero recruitment if SPR below replacement level)
inc.SPR	a logical to indicate if SPR value should be printed in top right corner of plot
Cols	optional character vector of colours for the plot
size.axtex	size of the axis text
size.title	size of axis title
size.SPR	size of SPR text
size.leg	size of legend text
inc.pts	Include points on the plots?
size.pt	size of the points on the plots

Value

a ggplot object

Author(s)

A. Hordyk

Examples

```
LB_pars <- new("LB_pars")
LB_pars@MK <- 1.5
LB_pars@Linf <- 100
LB_pars@L50 <- 50
LB_pars@L95 <- 55
LB_pars@SL50 <- 60
LB_pars@SL95 <- 65
LB_pars@FM <- 1
Sim <- LBSPRsim(LB_pars)
plotSim(Sim)
```

---

plotSize   *Plot the size data and model fits*

Description

A function that plots size data and the fitted LBSPR model

Usage

```
plotSize(
  LB_obj = NULL,
  size.axtex = 12,
  size.title = 14,
  Title = NULL,
  scales = c("fixed", "free_x", "free_y", "free"),
  inc.text = FALSE,
  warn.size = 0.8
)
```

Arguments

LB_obj   an object of class 'LB_obj' that contains the life history and fishing information

size.axtex   size of the axis text

size.title   size of axis title

Title   optional character string for plot title

scales   argument to ggplot2 function. Are scales shared across all facets (the default, "fixed"), or do they vary across rows ("free_x"), columns ("free_y"), or both rows and columns ("free")

inc.text   Include text on plotting warning of high F or selectivity estimates?

warn.size   numeric. Size of font for the warnings

Value

a ggplot object

Author(s)

A. Hordyk

---

plotSPRCirc   *Circle of estimated SPR and target and limit points*

Description

A function that creates a circle plot showing the estimated SPR relative to the target and limit reference points

Usage

```
plotSPRCirc(
  LB_obj = NULL,
  SPRTarg = 0.4,
  SPRLim = 0.2,
  useSmooth = TRUE,
  Title = FALSE,
  Leg = TRUE,
  limcol = "#ff1919",
  targcol = "#f2ff02",
  abtgcol = "#32ff36",
  labcol = NULL,
  bgcol = "#FAFAFA",
  labcex = 2,
  texcex = 1.3
)
```

Arguments

LB_obj	an object of class 'LB_obj' that contains the life history and fishing information
SPRTarg	a numeric value specifying the SPR target
SPRLim	a numeric value specifying the SPR limit
useSmooth	use the smoothed estimates? Usually would want to do this
Title	include the title?
Leg	include the legend?
limcol	colour for SPR Limit (hex; default is red)
targcol	colour for SPR target (hex; default is yellow)
abtgcol	colour for above SPR target (hex; default is green)
labcol	optional fixed colour for estimated SPR label
bgcol	colour for the background
labcex	size for the estimated SPR label
texcex	size for estimated other labels

Author(s)

A. Hordyk

---

plotTarg   *Plot sampled length structure against target simulated size composi-*
                          tion

Description

A function that plots the observed size structure against the expected size composition at the target
SPR

Usage

```
plotTarg(
  LB_pars = NULL,
  LB_lengths = NULL,
  yr = 1,
  Cols = NULL,
  title = NULL,
  targtext = TRUE,
  size.axtex = 12,
  size.title = 14,
  scales = c("fixed", "free_x", "free_y", "free")
)
```

Arguments

LB_pars	an object of class 'LB_pars' that contains the life history and fishing information
LB_lengths	an object of class 'LB_lengths' that contains the observed size data
yr	index for sampled length data (defaults to 1)
Cols	optional character vector of colours for the plot
title	character - optional title for plot
targtext	logical - should the SPR target text be displayed as a subtitle?
size.axtex	size of the axis text
size.title	size of axis title
scales	argument to ggplot2 function. Are scales shared across all facets (the default, "fixed"), or do they vary across rows ("free_x"), columns ("free_y"), or both rows and columns ("free")

Value

a ggplot object

Author(s)

A. Hordyk

Shiny   *Run a Shiny Application*

Description

Shiny runs one of the Shiny Applications that are included in the package

Usage

```
Shiny(app)
```

Arguments

app   The name of the Shiny application to run. Currently the available Shiny apps
                are "LBSPR" and "Sim"

References

Modified from Deal Attali's code: https://deanattali.com/2015/04/21/r-package-shiny-app/

Index