Package 'DLMtool'

January 20, 2025

Type Package

Title Data-Limited Methods Toolkit

Version 6.0.6

Maintainer Adrian Hordyk <adrian@bluematterscience.com>

Description A collection of data-limited management procedures that can be evaluated
with management strategy evaluation with the 'MSEtool' package, or applied to
fishery data to provide management recommendations.

License GPL-3

Depends R (>= 3.5.0), MSEtool

Imports dplyr, ggplot2, graphics, methods, Rcpp, stats, TMB (>=
1.7.22)

LinkingTo TMB, RcppEigen, Rcpp

Suggests gridExtra, mvtnorm, testthat

LazyLoad yes

Encoding UTF-8

RoxygenNote 7.2.0

NeedsCompilation yes

Author Tom Carruthers [aut],
Quang Huynh [aut],
Adrian Hordyk [aut, cre],
M. Bryan [ctb],
HF. Geremont [ctb],
C. Grandin [ctb],
W. Harford [ctb],
Q. Huynh [ctb],
C. Walters [ctb]

Repository CRAN

Date/Publication 2022-06-20 16:20:09 UTC

Contents

AvC *Average Catch*

Description

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

Usage

```
AvC(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

The average catch method is very simple. The mean historical catch is calculated and used to set a constant catch limit (TAC). If reps > 1 then the reps samples are drawn from a log-normal distribution with mean TAC and standard deviation (in log-space) of 0.2.

For completeness, the TAC is calculated by:

$$\text{TAC} = \frac{\sum_{y=1}^{n} C_y}{n}$$

where TAC is the the mean catch recommendation, n is the number of historical years, and C_y is the catch in historical year y

Value

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

Required Data

See Data-class for information on the Data object

AvC: Cat, LHYear, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

See Also

Other Average Catch MPs: AvC_MLL(), DCACs()

Examples

```
Rec <- AvC(1, MSEtool::Cobia, reps=1000, plot=TRUE) # 1,000 log-normal samples with CV = 0.2
```

AvC_MLL   *Average Catch with a size limit*

Description

A example mixed control MP that uses the average catch output control MP together with a minimul size limit set at the size of maturity.

Usage

```
AvC_MLL(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

The average catch method is very simple. The mean historical catch is calculated and used to set a constant catch limit (TAC). If reps > 1 then the reps samples are drawn from a log-normal distribution with mean TAC and standard deviation (in log-space) of 0.2.

For completeness, the TAC is calculated by:

$$\text{TAC} = \frac{\sum_{y=1}^{n} C_y}{n}$$

where TAC is the the mean catch recommendation, n is the number of historical years, and C_y is the catch in historical year y.

The size of retention is set to the length of maturity.

This MP has been included for demonstration purposes of a mixed control MP.

Value

An object of class [Rec-class](#) with the TAC, Retention slot(s) populated

Required Data

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

`AvC_MLL`: Cat, LHYear, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

See Also

Other Average Catch MPs: [AvC](#)(), [DCACs](#)()

Examples

```
Rec <- AvC_MLL(1, MSEtool::Cobia, reps=1000, plot=TRUE) # 1,000 log-normal samples with CV = 0.2
```

BK   *Beddington and Kirkwood life-history MP*

Description

Family of management procedures that sets the TAC by approximation of Fmax based on the length at first capture relative to asymptotic length and the von Bertalanffy growth parameter *K*.

Usage

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

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

BK_ML(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?
Fmin	The minimum fishing mortality rate that is derived from the catch-curve (interval censor).

Details

The TAC is calculated as:

$$\text{TAC} = A F_{\max}$$

where A is (vulnerable) stock abundance, and $F_{\max}$ is calculated as:

$$F_{\max} = \frac{0.6K}{0.67 - L_c/L_\infty}$$

where K is the von Bertalanffy growth coefficient, L_c is the length at first capture, and L_∞ is the von Bertalanffy asymptotic length

Abundance (A) is either assumed known (BK) or estimated (BK_CC and BK_ML):

$$A = \frac{\bar{C}}{(1 - e^{-F})}$$

where $\bar{C}$ is the mean catch, and F is estimated. See Functions section below for the estimation of F.

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Functions

- BK: Assumes that abundance is known, i.e. Data@Abun and Data@CV_abun contain values
- BK_CC: Abundance is estimated using an age-based catch curve to estimate Z and F, and abundance estimated from recent catches and F.
- BK_ML: Abundance is estimated using mean length to estimate Z and F, and abundance estimated from recent catches and F.

Required Data

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

BK: Abun, LFC, vbK, vbLinf

BK_CC: CAA, Cat, LFC, vbK, vbLinf

BK_ML: CAL, Cat, LFC, Lbar, Lc, Mort, vbK, vbLinf

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Note

Note that the Beddington-Kirkwood method is designed to estimate $F_{\max}$, that is, the fishing mortality that produces the maximum yield *assuming constant recruitment independent of spawning biomass*.

Beddington and Kirkwood (2005) recommend estimating F using other methods (e.g., a catch curve) and comparing the estimated F to the estimated $F_{\max}$ and adjusting exploitation accordingly. These MPs have not been implemented that way.

Author(s)

T. Carruthers.

References

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

Examples

```
## Not run:
BK(1, MSEtool::SimulatedData, reps=1000, plot=TRUE)

## End(Not run)

## Not run:
BK_CC(1, MSEtool::SimulatedData, reps=1000, plot=TRUE)

## End(Not run)

## Not run:
BK_ML(1, MSEtool::SimulatedData, reps=100, plot=TRUE)

## End(Not run)
```

CC1 *Geromont and Butterworth (2015) Constant Catch*

Description

The TAC is the average historical catch over the last yrsmth (default 5) years, multiplied by (1-xx)

Usage

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

CC2(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0.1)

CC3(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0.2)

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

CC5(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0.4)

CurC(x, Data, reps = 100, plot = FALSE, yrsmth = 1, xx = 0)
```

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?
yrsmth	Years over which to calculate mean catches
xx	Parameter controlling the TAC. Mean catches are multiplied by (1-xx)

Details

The TAC is calculated as:

$$\text{TAC} = (1 - x)C_{\text{ave}}$$

where x lies between 0 and 1, and C_{ave} is average historical catch over the previous `yrsmth` years. The TAC is constant for all future projections.

Value

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

Functions

- CC1: TAC is average historical catch from recent yrsmth years
- CC2: TAC is average historical catch from recent yrsmth years reduced by 10\
- CC3: TAC is average historical catch from recent yrsmth years reduced by 20\
- CC4: TAC is average historical catch from recent yrsmth years reduced by 30\
- CC5: TAC is average historical catch from recent yrsmth years reduced by 40\
- CurC: TAC is fixed at last historical catch

Required Data

See Data-class for information on the Data object

CC1: Cat, LHYear, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Geromont, H. F., and D. S. Butterworth. 2015. Generic Management Procedures for Data-Poor Fisheries: Forecasting with Few Data. ICES Journal of Marine Science: Journal Du Conseil 72 (1). 251-61.

See Also

Other Constant Catch MPs: GB_CC()

Examples

```
CC1(1, MSEtool::Cobia, plot=TRUE)

CC2(1, MSEtool::Cobia, plot=TRUE)

CC3(1, MSEtool::Cobia, plot=TRUE)

CC4(1, MSEtool::Cobia, plot=TRUE)

CC5(1, MSEtool::Cobia, plot=TRUE)

CurC(1, MSEtool::Cobia, plot=TRUE)
```

CompSRA   *Age-Composition Stock-Reduction Analysis*

Description

A stock reduction analysis (SRA) model is fitted to the age-composition from the last 3 years (or less if fewer data are available)

Usage

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

CompSRA4010(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

A stock reduction analysis (SRA) model is fitted to the age-composition from the last 3 years (or less if fewer data are available) assuming a constant total mortality rate (Z) and used to estimate current stock depletion (D), F_{MSY}, and stock abundance (A).

Abundance is estimated in the SRA. F_{MSY} is calculated assuming knife-edge vulnerability at the age of full selection.

The TAC is calculated as $F_{MSY}A$. CompSRA4010 uses a 40-10 harvest control rule to reduce TAC at low biomass.

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Functions

- CompSRA: TAC is FMSY x Abundance
- CompSRA4010: With a 40-10 control rule based on estimated depletion

Required Data

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

CompSRA: CAA, Cat, L50, LFC, LFS, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

CompSRA4010: CAA, Cat, L50, LFC, LFS, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
## Not run:
CompSRA(1, MSEtool::SimulatedData, plot=TRUE)

## End(Not run)

CompSRA4010(1, MSEtool::SimulatedData, plot=TRUE)
```

---

curE   *Fishing at current effort levels*

Description

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

Usage

```
curE(x, Data, reps, plot = FALSE)

curE75(x, Data, reps, 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?

Value

An object of class [Rec-class](#) with the TAE slot(s) populated

Functions

- curE: Set effort to 100\
- curE75: Set effort to 75\

Required Data

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

curE:

curE75:

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers.

Examples

```
curE(1, MSEtool::Atlantic_mackerel, plot=TRUE)
curE75(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

DBSRA   *Depletion-Based Stock Reduction Analysis*

Description

Depletion-Based Stock Reduction Analysis (DB-SRA) is a method designed for determining a catch limit and management reference points for data-limited fisheries where catches are known from the beginning of exploitation. User prescribed BMSY/B0, M, FMSY/M are used to find B0 and therefore the a catch limit by back-constructing the stock to match a user specified level of stock depletion.

Usage

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

DBSRA_40(x, Data, reps = 100, plot = FALSE)

DBSRA4010(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

DB-SRA assumes that a complete time-series of catch from the beginning of exploitation is available. Users prescribe estimates of current depletion (D), biomass at MSY relative to unfished $\left(\frac{B_{\text{MSY}}}{B_0}\right)$, the natural mortality rate (M), and the ratio fishing mortality at MSY to M $\left(\frac{F_{\text{MSY}}}{M}\right)$.

You may have noticed that you -the user- specify three of the factors that make the quota recommendation. So this can be quite a subjective method. In the MSE the MSY reference points (e.g., $\left(\frac{F_{\text{MSY}}}{M}\right)$) are taken as the true value calculate in the MSE with added uncertainty specified in the Obs object (e.g `Obs@FMSY_Mbiascv`).

The catch limit, for the Base Version, is calculated as:

$$\text{TAC} = M \frac{F_{\text{MSY}}}{M} D B_0$$

Value

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

Functions

- `DBSRA`: Base Version. TAC is calculated assumed MSY harvest rate multiplied by the estimated current abundance (estimated B0 x Depletion)
- `DBSRA_40`: Same as the Base Version but assumes 40 percent current depletion (Bcurrent/B0 = 0.4), which is more or less the most optimistic state for a stock (ie very close to BMSY/B0 for many stocks).
- `DBSRA4010`: Base version paired with the 40-10 rule that linearly throttles back the TAC when depletion is below 0.4 down to zero at 10 percent of unfished biomass.

Required Data

See `Data-class` for information on the `Data` object

DBSRA: BMSY_B0, Cat, Dep, FMSY_M, L50, vbK, vbLinf, vbt0

DBSRA_40: BMSY_B0, Cat, FMSY_M, L50, vbK, vbLinf, vbt0

DBSRA4010: BMSY_B0, Cat, Dep, FMSY_M, L50, vbK, vbLinf, vbt0

Rendered Equations

See Online Documentation for correctly rendered equations

Note

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

Author(s)

T. Carruthers

References

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

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

Examples

```
DBSRA(1, MSEtool::ourReefFish, plot=TRUE)

DBSRA_40(1, MSEtool::ourReefFish, plot=TRUE)
DBSRA4010(1, MSEtool::ourReefFish, plot=TRUE)
```

DCACs *Depletion Corrected Average Catch*

Description

This group of MPs calculates a catch limit (*dcac*; intended as an MSY proxy) based on average historical catch while accounting for the windfall catch that got the stock down to its current depletion level (*D*).

Usage

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

DCAC(x, Data, reps = 100, plot = FALSE)

DCAC_40(x, Data, reps = 100, plot = FALSE)

DCAC4010(x, Data, reps = 100, plot = FALSE)

DCAC_ML(x, Data, reps = 100, plot = FALSE)

DAAC(x, Data, reps = 100, plot = FALSE)

HDAAC(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

The method calculates the depletion-corrected average catch (*dcac*) as:

$$\text{dcac} = \frac{\sum_{y=1}^{n} C_y}{n + (1 - D)/Y_{\text{pot}}}$$

where

$$Y_{\text{pot}} = \frac{B_{\text{MSY}}}{B_0} \frac{F_{\text{MSY}}}{M} M$$

and C is the historical catches; i.e C does not change in the future projections in the MSE

The methods differ in the assumptions of current depletion (*D*). See the **Functions** section below for details.

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Functions

- DCACs: Depletion is not updated in the future projections. The TAC is static and not updated in the future years. This represents an application of the DCAC method where a catch limit is calculated based on current estimate of depletion and time-series of catch from the beginning of the fishery, and the TAC is fixed at this level for all future projections.

- `DCAC`: Depletion is estimated each management interval and used to update the catch limit recommendation based on the historical catch (which is not updated in the future projections).

- `DCAC_40`: Current stock biomass is assumed to be exactly at 40 per cent of unfished levels. The 40 percent depletion assumption may not really affect DCAC that much as it already makes TAC recommendations that are quite MSY-like.

- `DCAC4010`: The dynamic DCAC (depletion is updated) is paired with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished stock size (the OFL is not subject to downward adjustment above 40 percent unfished). DCAC can overfish below BMSY levels. The 40-10 harvest control rule largely resolves this problem providing an MP with surprisingly good performance even at low stock levels.

- `DCAC_ML`: This variant uses the mean length estimator to calculate current stock depletion. The mean length extension was programmed by Gary Nelson as part of his excellent R package 'fishmethods'.

- `DAAC`: Depletion Adjusted Average Catch: essentially DCAC (with updated Depletion) divided by BMSY/B0 (Bpeak) (Harford and Carruthers, 2017).

- `HDAAC`: Hybrid Depletion Adjusted Average Catch: essentially DCAC (with updated Depletion) divided by BMSY/B0 (Bpeak) when below BMSY, and DCAC above BMSY (Harford and Carruthers 2017).

Required Data

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

DCACs: AvC, BMSY_B0, Dt, FMSY_M, LHYear, Mort, Year, t

DCAC: AvC, BMSY_B0, Dt, FMSY_M, LHYear, Mort, Year, t

DCAC_40: AvC, BMSY_B0, FMSY_M, LHYear, Mort, Year, t

DCAC4010: AvC, BMSY_B0, Dt, FMSY_M, LHYear, Mort, Year, t

DCAC_ML: AvC, CAL, Cat, LHYear, Lbar, Lc, Mort, Year, t, vbK, vbLinf

DAAC: AvC, BMSY_B0, Dt, FMSY_M, LHYear, Mort, Year, t

HDAAC: AvC, BMSY_B0, Dt, FMSY_M, LHYear, Mort, Year, t

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Note

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

Author(s)

T. Carruthers

References

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

Harford W. and Carruthers, T. 2017. Interim and long-term performance of static and adaptive management procedures. Fish. Res. 190, 84-94.

See Also

Other Average Catch MPs: AvC_MLL(), AvC()

Examples

```
DCACs(1, MSEtool::Atlantic_mackerel, plot=TRUE)

DCAC(1, MSEtool::Atlantic_mackerel, plot=TRUE)

DCAC_40(1, MSEtool::Atlantic_mackerel, plot=TRUE)

Data <- MSEtool::Atlantic_mackerel
Data@LHYear <- 2005
DCAC4010(1, Data, plot=TRUE)

DCAC_ML(1, MSEtool::SimulatedData, plot=TRUE)

Data <- MSEtool::Atlantic_mackerel
Data@LHYear <- 2005
DAAC(1, Data, plot=TRUE)

Data <- MSEtool::Atlantic_mackerel
Data@LHYear <- 2005
HDAAC(1, Data, plot=TRUE)
```

DD | *Delay - Difference Stock Assessment*

Description

A simple delay-difference assessment with UMSY and MSY as leading parameters that estimates the TAC using a time-series of catches and a relative

Usage

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

DD4010(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

This DD model is observation error only and has does not estimate process error (recruitment deviations). Assumption is that knife-edge selectivity occurs at the age of 50% maturity. Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

The method is conditioned on effort and estimates catch. The effort is calculated as the ratio of catch and index. Thus, to get a complete effort time series, a full time series of catch and index is also needed. Missing values are linearly interpolated.

A detailed description of the delay-difference model can be found in Chapter 9 of Hilborn and Walters (1992).

Value

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

Functions

- DD: Base version where the TAC = UMSY * Current Biomass.
- DD4010: A 40-10 rule is imposed over the TAC recommendation.

Required Data

See Data-class for information on the Data object

DD: Cat, Ind, L50, MaxAge, Mort, vbK, vbLinf, vbt0, wla, wlb
DD4010: Cat, Ind, L50, MaxAge, Mort, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers, T, Walters, C.J,, and McAllister, M.K. 2012. Evaluating methods that classify fisheries stock status using only fisheries catch data. Fisheries Research 119-120:66-79.

Hilborn, R., and Walters, C. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York.

See Also

Other Delay-Difference MPs: DDe()

Examples

```
DD(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
DD4010(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

DDe   *Effort-based Delay - Difference Stock Assessment*

Description

A simple delay-difference assessment with UMSY and MSY as leading parameters that estimates E_{MSY} using a time-series of catches and a relative abundance index.

Usage

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

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

DDe75(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?
LB	The lowest permitted factor of previous fishing effort
UB	The highest permitted factor of previous fishing effort

Details

This DD model is observation error only and has does not estimate process error (recruitment deviations). Assumption is that knife-edge selectivity occurs at the age of 50% maturity. Similar to many other assessment models it depends on a whole host of dubious assumptions such as temporally stationary productivity and proportionality between the abundance index and real abundance. Unsurprisingly the extent to which these assumptions are violated tends to be the biggest driver of performance for this method.

The method is conditioned on effort and estimates catch. The effort is calculated as the ratio of catch and index. Thus, to get a complete effort time series, a full time series of catch and index is also needed. Missing values are linearly interpolated.

A detailed description of the delay-difference model can be found in Chapter 9 of Hilborn and Walters (1992).

Value

An object of class [Rec-class](#) with the TAE slot(s) populated

Functions

- `DDe`: Effort-control version. The recommended effort is EMSY.
- `DDes`: Variant of `DDe` that limits the maximum change in effort to 10 percent.
- `DDe75`: Variant of `DDe` where the recommended effort is 75\

Required Data

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

DDe: Cat, Ind, L50, MPeff, MaxAge, Mort, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

See Also

Other Delay-Difference MPs: [DD](#)()

Examples

```
DDe(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
DDes(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
DDe75(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

DTe40   *Effort searching MP aiming for a fixed stock depletion*

Description

Effort is adjusted using a simple rule that aims for a specified level of depletion.

Usage

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

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

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?
alpha	The target level of depletion
LB	The lowest permitted factor of previous fishing effort
UB	The highest permitted factor of previous fishing effort

Details

The TAE is calculated as:

$$\text{TAE}_y = \frac{D}{\alpha}\text{TAE}_{y-1}$$

where D is estimated current level of depletion and α is argument alpha specifying the target level of depletion.

The maximum fractional change in TAE is specified with arguments LB and UB

Value

An object of class Rec-class with the TAE slot(s) populated

Functions

- DTe40: Effort is adjusted to reach 40 percent stock depletion
- DTe50: Effort is adjusted to reach 50 percent stock depletion

Required Data

See Data-class for information on the Data object

DTe40: Dep, MPeff

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
DTe40(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

DynF   *Dynamic Fratio MP*

Description

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

Usage

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

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?
yrsmth	The number of historical recent years used for smoothing catch and biomass data
gg	A gain parameter that modifies F according to the gradient in surplus production with biomass

Details

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

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

The catch limit (TAC) is calculated as:

$$\text{TAC} = FB$$

where F is fishing mortality and B is the estimated current biomass.

F is calculated as:

$$F = F_{\text{MSY}} \exp -gG$$

where F_{MSY} is calculated from assumed values of $\frac{F_{\text{MSY}}}{M}$ and M, g is a gain parameter and G is the estimated gradient in surplus production (*SP*) as a function of biomass (*B*). Surplus production for year *y* is calculated as:

$$SP_y = B_{y+1} - B_y + C_y$$

Trends in historical catch (*C*) and biomass (*B*) are both estimated using a loess smoother, over the last yrsmth years, of available catch and a time-series of abundance, calculated from an index of abundance (Data@Ind) and an estimate of abundance (Data@Abun) for the current year.

Value

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

Required Data

See Data-class for information on the Data object

DynF: Abun, Cat, FMSY_M, Ind, Mort, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Made-up for this package.

See Also

Other Fmsy/M methods: Fadapt(), Fratio()

Examples

```
DynF(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

EtargetLopt   *Effort Target Optimum Length*

Description

This MP adjusts effort limit based on the ratio of recent mean length (over last yrsmth years) and a target length defined as L_{opt}. Effort MP: adjust effort up/down if mean length above/below Ltarget

Usage

```
EtargetLopt(x, Data, reps = 100, plot = FALSE, yrsmth = 3, buffer = 0.1)
```

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?
yrsmth	Number of years to calculate average length
buffer	Parameter controlling the fraction of calculated effor - acts as a precautionary buffer

Details

The TAE is calculated as:

$$\mathrm{TAE}_y = \mathrm{TAE}_{y-1}\left((1 - \mathrm{buffer})(w + (1 - w)r)\right)$$

where buffer is specified in argument buffer, w is fixed at 0.5, and:

$$r = \frac{L_{\mathrm{recent}}}{L_{\mathrm{opt}}}$$

where L_{recent} is mean length over last yrmsth years, and:

$$L_{\mathrm{opt}} = \frac{L_\infty W_b}{\frac{M}{K} + W_b}$$

where L_∞ is von Bertalanffy asymptotic length, W_b is exponent of the length-weight relationship, M is natural mortality, and K is von Bertalanffy growth coefficient.#'

Value

An object of class Rec-class with the TAE slot(s) populated

Required Data

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

EtargetLopt: ML, MPeff, Mort, Year, vbK, vbLinf, wlb

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

HF Geromont

Examples

```
EtargetLopt(1, MSEtool::SimulatedData, plot=TRUE)
```

Fadapt	*Adaptive Fratio*

Description

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

Usage

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

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?
yrsmth	Years over which to smooth recent estimates of surplus production
gg	A gain parameter controlling the speed in update in TAC.

Details

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

The TAC is calculated as:

$$\text{TAC}_y = F_y B_{y-1}$$

where B_{y-1} is the most recent biomass, estimated with a loess smoother of the most recent `yrsmth` years from the index of abundance (`Data@Ind`) and estimate of current abundance (`Data@Abun`), and

$$F_y = F_{\lim_1} + \left(\frac{\exp^{F_{\text{mod}_2}}}{1 + \exp^{F_{\text{mod}_2}}} F_{\lim_3} \right)$$

where $F_{\lim_1} = 0.5 \frac{F_{\text{MSY}}}{M} M$, $F_{\lim_2} = 2 \frac{F_{\text{MSY}}}{M} M$, $F_{\lim_3}$ is $F_{\lim_2} - F_{\lim_1}$, F_{mod_2} is

$$F_{\text{mod}_1} + g - G$$

where g is gain parameter `gg`, `G` is the predicted surplus production given current abundance, and:

$$F_{\text{mod}_1} = \begin{cases} -2 & \text{if } F_{\text{old}} < F_{\lim_1} \\ 2 & \text{if } F_{\text{old}} > F_{\lim_2} \\ \log \frac{F_{\text{frac}}}{1 - F_{\text{frac}}} & \text{if } F_{\lim_1} \leq F_{\text{old}} \leq F_{\lim_2} \end{cases}$$

where $-F_{\text{frac}} = \frac{F_{\text{old}} - F_{\lim_1}}{F_{\lim_3}}$, $F_{\text{old}} = \sum \frac{C_{\text{hist}}}{B_{\text{hist}}} / n$ where C_{hist} and B_{hist} are smooth catch and biomass over last `yrsmth`, and n is `yrsmth`.

Tested in Carruthers et al. 2015.

Value

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

A numeric vector of quota recommendations

Required Data

See `Data-class` for information on the `Data` object

Fadapt: Abun, Cat, FMSY_M, Ind, Mort, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

Maunder, M. 2014. http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf

See Also

Other Fmsy/M methods: DynF(), Fratio()

Other Surplus production MPs: Rcontrol(), SPMSY(), SPSRA(), SPmod(), SPslope()

Examples

```
Fadapt(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

Fdem   *Demographic FMSY method*

Description

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

Usage

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

Fdem_CC(x, Data, reps = 100, plot = FALSE, Fmin = 0.005)

Fdem_ML(x, Data, reps = 100, plot = FALSE, Fmin = 0.005)
```

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?
Fmin	The minimum fishing mortality rate derived from the catch-curve analysis

Details

The TAC is calculated as:

$$\text{TAC} = F_{\text{MSY}} A$$

where A is an estimate of current abundance, and F_{MSY} is estimated as $r/2$, where r is the intrinsic rate of population growth, estimated from the life-history parameters using the methods of McAllister et al. (2001).

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Functions

- Fdem: Current abundance is assumed to be known (i.e Data@Abun)

- Fdem_CC: Current abundance is estimated from catch curve analysis

- Fdem_ML: Current abundance is estimated from mean length

Required Data

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

Fdem: Abun, FMSY_M, L50, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

Fdem_CC: CAA, Cat, FMSY_M, L50, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

Fdem_ML: CAL, Cat, FMSY_M, L50, Lbar, Lc, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

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

Examples

```
Fdem(1, MSEtool::SimulatedData, plot=TRUE)
Fdem_CC(1, MSEtool::SimulatedData, plot=TRUE)
Fdem_ML(1, MSEtool::SimulatedData, plot=TRUE)
```

Fratio   *FMSY/M ratio methods*

Description

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

Usage

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

Fratio4010(x, Data, reps = 100, plot = FALSE)

DepF(x, Data, reps = 100, plot = FALSE)

Fratio_CC(x, Data, reps = 100, plot = FALSE, Fmin = 0.005)

Fratio_ML(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?
Fmin	Minimum current fishing mortality rate for the catch-curve analysis

Details

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

The TAC is calculated as:

$$\text{TAC} = F_{\text{MSY}}A$$

where F_{MSY} is calculated as $\frac{F_{\text{MSY}}}{M}M$ and A is estimate of current abundance.

The MP variants differ in the assumption of current abundance (see Functions section below)

Value

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

Functions

- `Fratio`: Requires an estimate of current abundance (i.e `Data@Abun`)
- `Fratio4010`: Paired with the 40-10 rule that throttles back the OFL to zero at 10 percent of unfished biomass. Requires an estimate of current depletion.
- `DepF`: Depletion Corrected Fratio: the Fratio MP with a harvest control rule that reduces F according to the production curve given an estimate of current stock depletion (made-up for this package).
- `Fratio_CC`: Current abundance is estimated using average catch and estimate of F from an age-based catch curve
- `Fratio_ML`: Current abundance is estimated using average catch and estimate of F from mean lengths

Required Data

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

`Fratio`: Abun, FMSY_M, Mort

`Fratio4010`: Abun, Dep, FMSY_M, Mort

`DepF`: Abun, Dep, FMSY_M, Mort

`Fratio_CC`: CAA, Cat, FMSY_M, Mort

`Fratio_ML`: CAL, Cat, FMSY_M, Lbar, Lc, Mort, vbK, vbLinf

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

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

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

See Also

Other Fmsy/M methods: [DynF](#)(), [Fadapt](#)()

Examples

```
Fratio(1, MSEtool::Atlantic_mackerel, plot=TRUE)
Fratio4010(1, MSEtool::Atlantic_mackerel, plot=TRUE)
Fratio_CC(1, MSEtool::SimulatedData, plot=TRUE)
Fratio_ML(1, MSEtool::SimulatedData, plot=TRUE)
```

GB_CC   *Geromont and Butterworth Constant Catch Harvest Control Rule*

Description

A simple MP that aims for a reference catch (as a proxy for MSY) subject to imperfect information.

Usage

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

The TAC is calculated as:

$$\text{TAC} = C_{\text{ref}}$$

where C_{ref} is a reference catch assumed to be a proxy for MSY. In the MSE C_{ref} is the calculated MSY subject to observation error defined in Obs@CV_Cref.

The TAC is subject to the following conditions:

1. if next TAC > 1.2 last catch, then TAC = 1.2 last catch
2. if next TAC < 0.8 last catch, then TAC = 0.8 last catch

Value

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

Required Data

See Data-class for information on the Data object

GB_CC: Cref

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

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

See Also

Other Constant Catch MPs: `CC1`()

Examples

```
GB_CC(1, MSEtool::SimulatedData, plot=TRUE)
```

GB_slope   *Geromont and Butterworth index slope Harvest Control Rule*

Description

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

Usage

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

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?
yrsmth	Number of years for evaluating slope in relative abundance index
lambda	A gain parameter

Details

The TAC is calculated as:

$$\text{TAC}_y = C_{y-1}\left(1 + \lambda I\right)$$

where C_{y-1} is catch from the previous year, λ is a gain parameter, and I is the slope of the linear regression of log Index (`Data@Ind`) over the last `yrsmth` years.

The TAC is subject to the following conditions:

1. if next TAC > 1.2 last catch, then TAC = 1.2 last catch

2. if next TAC < 0.8 last catch, then TAC = 0.8 last catch

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

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Required Data

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

GB_slope: Cat, Ind, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

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

See Also

Other Index methods: [GB_target](#)(), [Gcontrol](#)(), [ICI](#)(), [Iratio](#)(), [Islope1](#)(), [Itarget1_MPA](#)(), [Itarget1](#)(), [ItargetE1](#)()

Examples

```
GB_slope(1, MSEtool::SimulatedData, plot=TRUE)
```

GB_target   *Geromont and Butterworth target CPUE and catch MP*

Description

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

Usage

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

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?
w	A gain parameter

Details

The TAC is calculated as: If $I_{\text{recent}} \geq I_0$:

$$\text{TAC} = C_{\text{ref}} \left(w + (1 - w) \frac{I_{\text{rec}} - I_0}{I_{\text{target}} - I_0} \right)$$

else:

$$\text{TAC} = w C_{\text{ref}} \frac{I_{\text{rec}}^2}{I_0}$$

where C_{ref} is a reference catch assumed to be a proxy for MSY (Data@Cref), w is a gain parameter, I_{rec} is the average index over the last 4 years, I_{target} is the target Index (Data@Iref), and I_0 is 0.2 x the average index over the past 5 years.

In the MSE C_{ref} is the calculated MSY subject to observation error defined in Obs@CV_Cref, and I_{target} is assumed to be the index at MSY subject to observation error (Obs@CV_Iref). Consequently, the performance of this method in the MSE is strongly determined by the specified uncertainty for these parameters.

The TAC is subject to the following conditions:

1. if next TAC > 1.2 last catch, then TAC = 1.2 last catch
2. if next TAC < 0.8 last catch, then TAC = 0.8 last catch

Value

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

Required Data

See Data-class for information on the Data object

GB_target: Cref, Ind, Iref

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

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

See Also

Other Index methods: GB_slope(), Gcontrol(), ICI(), Iratio(), Islope1(), Itarget1_MPA(), Itarget1(), ItargetE1()

Examples

```
GB_target(1, MSEtool::SimulatedData, plot=TRUE)
```

Gcontrol   *G-control MP*

Description

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

Usage

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

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?
yrsmth	The number of years over which to smooth catch and biomass data
gg	A gain parameter
glim	A constraint limiting the maximum level of change in quota recommendations

Details

The TAC is calculated as:

$$\text{TAC} = \text{SP}\,(1 - gG)$$

where SP is the predicted surplus production for the next year, *g* is a gain parameter, and *G* is the slope of surplus production as a function of biomass over the last `yrsmth` years.

The change in TAC is bounded by the `glim` argument, which by default does not allow the TAC to decrease by more than half or increase more than twice the last annual catch.

Value

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

Required Data

See `Data-class` for information on the `Data` object

Gcontrol: Abun, Cat, Ind, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

C. Walters and T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

See Also

Other Index methods: `GB_slope()`, `GB_target()`, `ICI()`, `Iratio()`, `Islope1()`, `Itarget1_MPA()`, `Itarget1()`, `ItargetE1()`

Examples

```
Gcontrol(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

ICI   *Index Confidence Interval*

Description

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

Usage

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

ICI2(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

The TAC is calculated as:
$$\text{TAC}_y = C_{y-1}\alpha$$
where C_{y-1} is the catch from the previous year, and α is defined as:
$$\alpha = \left\{ \begin{array}{ll} d & \text{if } I < \text{CI}_L \\ u & \text{if } I > \text{CI}_H \\ 1 & \text{if } \text{CI}_L \leq I \leq \text{CI}_H \end{array} \right.$$

where I is the index in the most recent year, d is 0.75 for ICI and ICI2, u is 1.05 and 1.25 for ICI and ICI2 respectively, and CI_L and CI_L are the lower and upper bound of the confidence interval of mean historical index. The confidence interval is calculated using Z-scores described in the Functions section below.

Value

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

Functions

- ICI: The catch is reduced by 0.75 if the Z-score of the current year's index is less than -0.44. The catch is increased by 1.05 if the Z-score of the current year's index is greater than 1.96. Otherwise, the catch is held constant.

- ICI2: This method is less precautionary of the two ICI MPs by allowing for a larger increase in TAC and a lower threshold of the index to decrease the TAC. The catch is reduced by 0.75 if the Z-score of the current year's index is less than -1.96. The catch is increased by 1.25 if the Z-score of the current year's index is greater than 1.96. Otherwise, the catch is held constant.

Required Data

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

ICI: Cat, Ind

ICI2: Cat, Ind

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

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

References

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

See Also

Other Index methods: [GB_slope](#)(), [GB_target](#)(), [Gcontrol](#)(), [Iratio](#)(), [Islope1](#)(), [Itarget1_MPA](#)(), [Itarget1](#)(), [ItargetE1](#)()

Examples

```
ICI(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)

ICI2(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

Iratio	*Mean Index Ratio*

Description

The TAC is adjusted by the ratio alpha, where the numerator being the mean index in the most recent two years of the time series and the denominator being the mean index in the three years prior to those in the numerator. This MP is the stochastic version of Method 3.2 used by ICES for Data-Limited Stocks (ICES 2012).

Usage

```
Iratio(x, Data, reps = 100, plot = FALSE, yrs = c(2, 5))
```

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?
yrs	Vector of length 2 specifying the reference years

Details

The TAC is calculated as:

$$\text{TAC}_y = \alpha C_{y-1}$$

where C_{y-1} is the catch from the previous year, and α is the ratio of the mean index in the most recent two years of the time series and the mean index in 3-5 years before current time (reference years are specified as yrs argument.

Value

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

Required Data

See Data-class for information on the Data object

Iratio: Cat, Ind

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

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

References

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

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

See Also

Other Index methods: GB_slope(), GB_target(), Gcontrol(), ICI(), Islope1(), Itarget1_MPA(), Itarget1(), ItargetE1()

Examples

```
Iratio(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

Islope1   *Index Slope Tracking MP*

Description

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

Usage

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

Islope2(x, Data, reps = 100, plot = FALSE, yrsmth = 5, lambda = 0.4, xx = 0.3)

Islope3(x, Data, reps = 100, plot = FALSE, yrsmth = 5, lambda = 0.4, xx = 0.4)

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

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?
yrsmth	Years over which to calculate index
lambda	A gain parameter controlling the speed in update in TAC.
xx	Parameter controlling the fraction of mean catch to start using in first year

Details

The TAC is calculated as:

$$\text{TAC} = \text{TAC}^* \left(1 + \lambda I\right)$$

where TAC^* is $1 - xx$ multiplied by the mean catch from the past `yrsmth` years for the first year and catch from the previous year in projection years, λ is a gain parameter, and I is the slope of log index over the past `yrsmth` years.

Value

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

Functions

- `Islope1`: The least biologically precautionary of the Islope methods

- `Islope2`: More biologically precautionary. Reference TAC is 0.7 average catch

- `Islope3`: More biologically precautionary. Reference TAC is 0.6 average catch

- `Islope4`: The most biologically precautionary of the Islope methods. Reference TAC is 0.6 average catch and gain parameter is 0.2

Required Data

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

`Islope1`: Cat, Ind, LHYear, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

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

See Also

Other Index methods: [GB_slope](#)(), [GB_target](#)(), [Gcontrol](#)(), [ICI](#)(), [Iratio](#)(), [Itarget1_MPA](#)(), [Itarget1](#)(), [ItargetE1](#)()

Examples

```
Islope1(1, MSEtool::SimulatedData, plot=TRUE)
Islope2(1, MSEtool::SimulatedData, plot=TRUE)
Islope3(1, MSEtool::SimulatedData, plot=TRUE)
Islope4(1, MSEtool::SimulatedData, plot=TRUE)
```

IT5							*Iterative Index Target MP*

Description

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

Usage

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

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

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?
yrsmth	The number of historical years over which to average the index
mc	The maximum fractional change in the TAC among years.

Details

The TAC is calculated as:

$$\text{TAC}_y = C_{y-1} I_\delta$$

where C_{y-1} is the catch from the previous year and I_δ is the ratio of the mean index over the past yrsmth years to a reference index level. The maximum allowable change in TAC is determined by mc: e.g mc=0.05 means that the maximum change in TAC from the previous catch is 5%.

The reference index level (Data@Iref) is assumed to be a proxy for MSY. In the MSE Iref is the index at MSY subject to observation error (Obs@Irefbiascv). Consequently the performance of these methods in MSE is strongly determined by the uncertainty the in reference index.

Value

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

Functions

- IT5: Maximum annual changes in TAC are 5 per cent.
- IT10: Maximum annual changes are 10 per cent.

Required Data

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

IT5: Ind, Iref, MPrec
IT10: Ind, Iref, MPrec

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
IT5(1, MSEtool::SimulatedData, plot=TRUE)
IT10(1, MSEtool::SimulatedData, plot=TRUE)
```

Itarget1   *Incremental Index Target MP*

Description

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

Usage

```
Itarget1(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, Imulti = 1.5)

Itarget2(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, Imulti = 2)

Itarget3(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, Imulti = 2.5)

Itarget4(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0.3, Imulti = 2.5)
```

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?
yrsmth	Years over which the average index is calculated.
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Four index/CPUE target MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015.

The TAC is calculated as: If $I_{\text{recent}} \geq I_0$:

$$\text{TAC} = 0.5\text{TAC}^* \left[1 + \left(\frac{I_{\text{recent}} - I_0}{I_{\text{target}} - I_0} \right) \right]$$

else:

$$\text{TAC} = 0.5\text{TAC}^* \left[\frac{I_{\text{recent}}}{I_0}^2 \right]$$

where I_0 is $0.8I_{\text{ave}}$ (the average index over the 2 x yrsmth years prior to the projection period), I_{recent} is the average index over the past yrsmth years, and I_{target} is Imulti times I_{ave}, and TAC^* is:

$$(1 - x)C$$

where x is argument xx and C is the average catch over the last 5 years of the historical period.

Value

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

Functions

- Itarget1: The less precautionary TAC-based MP
- Itarget2: Increasing biologically precautionary TAC-based MP
- Itarget3: Increasing biologically precautionary TAC-based MP
- Itarget4: The most biologically precautionary TAC-based MP

Required Data

See Data-class for information on the Data object

Itarget1: Cat, Ind, LHYear, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. 72, 251-261. doi:10.1093/icesjms/fst232

See Also

Other Index methods: `GB_slope()`, `GB_target()`, `Gcontrol()`, `ICI()`, `Iratio()`, `Islope1()`, `Itarget1_MPA()`, `ItargetE1()`

Examples

```
Itarget1(1, MSEtool::Atlantic_mackerel, plot=TRUE)
Itarget2(1, MSEtool::Atlantic_mackerel, plot=TRUE)
Itarget3(1, MSEtool::Atlantic_mackerel, plot=TRUE)
Itarget4(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

Itarget1_MPA   *Itarget1 with an MPA*

Description

A example mixed control MP that uses the Itarget1 output control MP together with a spatial closure.

Usage

```
Itarget1_MPA(
  x,
  Data,
  reps = 100,
  plot = FALSE,
  yrsmth = 5,
  xx = 0,
  Imulti = 1.5
)
```

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?
yrsmth	Years over which to smooth recent estimates of surplus production
xx	Parameter controlling the fraction of mean catch to start using in first year
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

The TAC is calculated as: If $I_{\text{recent}} \geq I_0$:

$$\text{TAC} = 0.5\text{TAC}^* \left[1 + \left(\frac{I_{\text{recent}} - I_0}{I_{\text{target}} - I_0} \right) \right]$$

else:

$$\text{TAC} = 0.5\text{TAC}^* \left[\frac{I_{\text{recent}}}{I_0}^2 \right]$$

where I_0 is $0.8 I_{\text{ave}}$ (the average index over the 2 x `yrsmth` years prior to the projection period), I_{recent} is the average index over the past `yrsmth` years, and I_{target} is `Imulti` times I_{ave}, and TAC* is:

$$(1 - x)C$$

where x is argument `xx` and C is the average catch over the last 5 years of the historical period.

This mixed control MP also closes Area 1 to fishing.

This MP has been included for demonstration purposes of a mixed control MP.

Value

An object of class [Rec-class](#) with the TAC, Spatial slot(s) populated

Required Data

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

`Itarget1_MPA`: Cat, Ind, LHYear, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

See Also

Other Index methods: [GB_slope](#)(), [GB_target](#)(), [Gcontrol](#)(), [ICI](#)(), [Iratio](#)(), [Islope1](#)(), [Itarget1](#)(), [ItargetE1](#)()

Examples

```
Itarget1_MPA(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

ItargetE1   *Incremental Index Target MP - Effort-Based*

Description

A management procedure that incrementally adjusts the fishing effort to reach a target CPUE / relative abundance index

Usage

```
ItargetE1(x, Data, reps = 100, plot = FALSE, yrsmth = 5, Imulti = 1.5)

ItargetE2(x, Data, reps = 100, plot = FALSE, yrsmth = 5, Imulti = 2)

ItargetE3(x, Data, reps = 100, plot = FALSE, yrsmth = 5, Imulti = 2.5)

ItargetE4(x, Data, reps = 100, plot = FALSE, yrsmth = 5, Imulti = 2.5)
```

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?
yrsmth	Years over which the average index is calculated.
Imulti	Parameter controlling how much larger target CPUE / index is compared with recent levels.

Details

Four index/CPUE target MPs proposed by Geromont and Butterworth 2014.

The TAE is calculated as: If $I_{\text{recent}} \geq I_0$:

$$\text{TAE}_y = 0.5\text{TAE}_{y-1} \left[1 + \left(\frac{I_{\text{recent}} - I_0}{I_{\text{target}} - I_0} \right) \right]$$

else:

$$\text{TAE}_y = 0.5\text{TAE}_{y-1} \left(\frac{I_{\text{recent}}}{I_0}^2 \right)$$

where I_0 is $0.8I_{\text{ave}}$ (the average index over the 2 x yrsmth years prior to the projection period), I_{recent} is the average index over the past yrsmth years, and I_{target} is Imulti times I_{ave}.

Value

An object of class `Rec-class` with the TAE slot(s) populated

Functions

- `ItargetE1`: The less precautionary TAE-based MP

- `ItargetE2`: Increasing biologically precautionary TAE-based MP

- `ItargetE3`: Increasing biologically precautionary TAE-based MP

- `ItargetE4`: The most biologically precautionary TAE-based MP

Required Data

See `Data-class` for information on the `Data` object

`ItargetE1`: Ind, LHYear, MPeff, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

Geromont, H.F., Butterworth, D.S. 2014. Generic management procedures for data-poor fisheries; forecasting with few data. ICES J. Mar. Sci. 72, 251-261. doi:10.1093/icesjms/fst232

See Also

Other Index methods: `GB_slope`(), `GB_target`(), `Gcontrol`(), `ICI`(), `Iratio`(), `Islope1`(), `Itarget1_MPA`(), `Itarget1`()

Examples

```
ItargetE1(1, MSEtool::Atlantic_mackerel, plot=TRUE)
ItargetE2(1, MSEtool::Atlantic_mackerel, plot=TRUE)
ItargetE3(1, MSEtool::Atlantic_mackerel, plot=TRUE)
ItargetE4(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

ITe5 *Index Target Effort-Based*

Description

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

Usage

```
ITe5(x, Data, reps = 100, plot = FALSE, yrsmth = 5, mc = 0.05)

ITe10(x, Data, reps = 100, plot = FALSE, yrsmth = 5, mc = 0.1)
```

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?
yrsmth	The number of historical years over which to average the index
mc	The maximum fractional change in the effort among years.

Details

The TAE is calculated as:

$$\text{TAE}_y = \text{TAE}_{y-1}\delta$$

where δ is $\frac{I}{I_{\text{ref}}}$ averaged over last `yrsmth` years. I_{ref} is the index target (Data@Iref). The maximum fractional change in TAE is specified in `mc`.

Value

An object of class `Rec-class` with the TAE slot(s) populated

Functions

- `ITe5`: Maximum annual changes are 5 per cent.
- `ITe10`: Maximum annual changes are 10 per cent.

Required Data

See `Data-class` for information on the Data object

ITe5: Ind, Iref, MPeff
ITe10: Ind, Iref, MPeff

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
ITe5(1, MSEtool::SimulatedData, plot=TRUE)
ITe10(1, MSEtool::SimulatedData, plot=TRUE)
```

ITM   *Index Target based on natural mortality rate*

Description

An index target MP where the TAC is modified according to current index levels (mean index over last number of years determined by natural mortality (M)) relative to a target level.

Usage

```
ITM(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

The TAC is caluclated as:

$$\text{TAC}_y = \text{TAC}_{y-1}\delta I$$

where δI is the ratio of the mean index over $4\frac{1}{M}^{1/4}$ years to the reference index (Data@Iref).

The maximum fractional change in TAC is determined by mc, defined as $mc = \max\left(\frac{5+25M}{100}, 0.2\right)$

Value

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

Required Data

See Data-class for information on the Data object

ITM: Ind, Iref, MPrec, Mort

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
ITM(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

LBSPR   *Length-Based SPR MPs*

Description

The spawning potential ratio (SPR) is estimated using the LBSPR method and compared to a target of 0.4.

Usage

```
LBSPR(
  x,
  Data,
  reps = 1,
  plot = FALSE,
  SPRtarg = 0.4,
  theta1 = 0.3,
  theta2 = 0.05,
  maxchange = 0.3,
  n = 5,
  smoother = TRUE,
  R = 0.2
)

LBSPR_MLL(
  x,
  Data,
  reps = 1,
  plot = FALSE,
  SPRtarg = 0.4,
  n = 5,
  smoother = TRUE,
  R = 0.2
)
```

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?
SPRtarg	The target SPR
theta1	Control parameter for the harvest control rule
theta2	Control parameter for the harvest control rule
maxchange	Maximum change in effort
n	Last number of years to run the model on.
smoother	Logical. Should the SPR estimates be smoothed?
R	variance of sampling noise for smoother

Details

Effort is modified according to the harvest control rules described in Hordyk et al. (2015b):

Value

An object of class `Rec-class` with the TAE slot populated

Functions

- LBSPR_MLL: Fishing retention-at-length is set equivalent to slightly higher than the maturity curve if SPR < 0.4

Required Data

See `Data-class` for information on the `Data` object

LBSPR: CAL, CAL_bins, L50, L95, LHYear, MPeff, Mort, Year, vbK, vbLinf, wlb

Rendered Equations

See Online Documentation for correctly rendered equations

References

Hordyk, A., Ono, K., Valencia, S., Loneragan, N., and Prince J (2015a). A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries, ICES Journal of Marine Science, 72 (1), 217-231

Hordyk, A. R., Loneragan, N. R., & Prince, J. D. (2015b). An evaluation of an iterative harvest strategy for data-poor fisheries using the length-based spawning potential ratio assessment methodology. Fisheries Research, 171, 20-32. https://doi.org/10.1016/j.fishres.2014.12.018

Examples

```
LBSPR(1, Data=MSEtool::SimulatedData, plot=TRUE)
LBSPR_MLL(1, Data=MSEtool::SimulatedData, plot=FALSE)
```

Lratio_BHI   *Mean length-based indicator MP of Jardim et al. 2015*

Description

The TAC is calculated as the most recent catch, modified by the ratio alpha, where the numerator is the mean length of the catch (of lengths larger than Lc) and the denominator is the mean length expected at MSY. Here, Lc is the length at full selection (LFS).

Usage

```
Lratio_BHI(x, Data, reps = 100, plot = FALSE, yrsmth = 3)

Lratio_BHI2(x, Data, reps = 100, plot = FALSE, yrsmth = 3)

Lratio_BHI3(x, Data, reps = 100, plot = FALSE, yrsmth = 3)
```

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?
yrsmth	The most recent years of data to smooth the calculation of the mean length

Details

The TAC is calculated as:

$$\text{TAC}_y = C_{y-1} \frac{L}{L_{\text{ref}}}$$

where C_{y-1} is the catch from the previous year, L is the mean length of the catch over the last yrsmth years (of lengths larger than Lc) and L_{ref} is the mean length expected at MSY. Here, Lc is the length at full selection (LFS).

Value

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

Functions

- `Lratio_BHI`: Assumes M/K = 1.5 and FMSY/M = 1. Natural mortality M and von Bertalanffy K are not used in this MP (see Appendix A of Jardim et al. 2015).

- `Lratio_BHI2`: More general version that calculates the reference mean length as a function of M, K, and presumed FMSY/M.

- `Lratio_BHI3`: A modified version of Lratio_BHI2 where mean length is calculated for lengths > modal length (Lc)

Required Data

See `Data-class` for information on the `Data` object

`Lratio_BHI`: CAL, CAL_bins, Cat, LFS, vbLinf

`Lratio_BHI2`: CAL, CAL_bins, Cat, FMSY_M, LFS, Mort, vbK, vbLinf

`Lratio_BHI3`: CAL, CAL_bins, Cat, FMSY_M, LFS, Mort, vbK, vbLinf

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

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

References

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

See Also

Other Length target MPs: `Ltarget1()`, `LtargetE1()`

Examples

```
Lratio_BHI(1, Data=MSEtool::SimulatedData, plot=TRUE)

Lratio_BHI2(1, Data=MSEtool::SimulatedData, plot=TRUE)

Lratio_BHI3(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

LstepCC1   *Step-wise Constant Catch*

Description

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

Usage

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

LstepCC2(
  x,
  Data,
  reps = 100,
  plot = FALSE,
  yrsmth = 5,
  xx = 0.1,
  stepsz = 0.05,
  llim = c(0.96, 0.98, 1.05)
)

LstepCC3(
  x,
  Data,
  reps = 100,
  plot = FALSE,
  yrsmth = 5,
  xx = 0.2,
  stepsz = 0.05,
  llim = c(0.96, 0.98, 1.05)
)

LstepCC4(
  x,
  Data,
  reps = 100,
```

```
    plot = FALSE,
    yrsmth = 5,
    xx = 0.3,
    stepsz = 0.05,
    llim = c(0.96, 0.98, 1.05)
)
```

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?
yrsmth	Years over which to calculate mean length.
xx	Parameter controlling the fraction of mean catch to start using in first year
stepsz	Parameter controlling the size of update increment in TAC or effort.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the TAC or effort.

Details

The TAC is calculated as:

$$\text{TAC} = \begin{cases} \text{TAC}^* - 2S\text{TAC}^* & \text{if } r < 0.96 \\ \text{TAC}^* - S\text{TAC}^* & \text{if } r < 0.98 \\ \text{TAC}^* & \text{if } > 1.058 \end{cases}$$

where TAC^* is (1-xx) times average catch in the first year, and previous catch in all projection years, S is step-size determined by stepsz, and r is the ratio of L_{recent} and L_{ave} which are mean length over the most recent yrsmth years and 2 x yrsmth historical years respectively.

The conditions are specified in the llim argument to the function.

Value

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

Functions

- LstepCC1: The least biologically precautionary TAC-based MP.

- LstepCC2: More biologically precautionary than LstepCC1 (xx = 0.1)

- LstepCC3: More biologically precautionary than LstepCC2 (xx = 0.2)

- LstepCC4: The most precautionary TAC-based MP.

Required Data

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

LstepCC1: Cat, LHYear, ML, Year

LstepCC2: Cat, LHYear, ML, Year

LstepCC3: Cat, LHYear, ML, Year

LstepCC4: Cat, LHYear, ML, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

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

Examples

```
LstepCC1(1, Data=MSEtool::SimulatedData, plot=TRUE)

LstepCC2(1, Data=MSEtool::SimulatedData, plot=TRUE)
LstepCC3(1, Data=MSEtool::SimulatedData, plot=TRUE)
LstepCC4(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

LstepCE1 *Step-wise Constant Effort*

Description

A management procedure that incrementally adjusts the total allowable effort (TAE) according to the mean length of recent catches.

Usage

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

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

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?
yrsmth	Years over which to calculate trend in mean length.
stepsz	Parameter controlling the size of update increment in effort.
llim	A vector of length reference points that determine the conditions for increasing, maintaining or reducing the effort.

Details

The TAE is calculated as:

$$\text{TAE} = \begin{cases} \text{TAE}^* - 2S\text{TAE}^* & \text{if } r < 0.96 \\ \text{TAE}^* - S\text{TAE}^* & \text{if } r < 0.98 \\ \text{TAE}^* & \text{if } > 1.058 \end{cases}$$

where TAE^* is effort in the previous year, S is step-size determined by `stepsz`, and r is the ratio of L_{recent} and L_{ave} which are mean length over the most recent `yrsmth` years and 2 x `yrsmth` historical years respectively.

The conditions are specified in the `llim` argument to the function.

Value

An object of class Rec-class with the TAE slot(s) populated

Functions

- `LstepCE1`: The least biologically precautionary effort-based MP.

- `LstepCE2`: Step size is increased to 0.1

Required Data

See `Data-class` for information on the `Data` object

`LstepCE1`: LHYear, ML, MPeff, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

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

See Also

LstepCC1

Examples

```
LstepCE1(1, Data=MSEtool::SimulatedData, plot=TRUE)
LstepCE2(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

Ltarget1   *Length Target TAC MP*

Description

A management procedure that incrementally adjusts the TAC to reach a target mean length in catches.

Usage

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

Ltarget2(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, xL = 1.1)

Ltarget3(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, xL = 1.15)

Ltarget4(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0.2, xL = 1.15)

L95target(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xx = 0, xL = 1.05)
```

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?
yrsmth	Years over which to calculate mean length.
xx	Parameter controlling the fraction of mean catch to start using in first year
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Details

Four target length MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015.

The TAC is calculated as:

If $L_{\text{recent}} \geq L_0$:

$$\text{TAC} = 0.5\text{TAC}^* \left[1 + \left(\frac{L_{\text{recent}} - L_0}{L_{\text{target}} - L_0} \right) \right]$$

else:

$$\text{TAC} = 0.5\text{TAC}^* \left[\frac{L_{\text{recent}}}{L_0}^2 \right]$$

where TAC* is (1 - xx) mean catches from the last yrsmth historical years (pre-projection), L_{recent} is mean length in last yrmsth years, L_0 is (except for L95target) 0.9 average catch in the last 2 x yrsmth historical (pre-projection years) (L_{ave}), and L_{target} is (except for L95target) xL L_{ave}.

Value

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

Functions

- `Ltarget1`: The least biologically precautionary TAC-based MP.
- `Ltarget2`: Increasingly biologically precautionary (xL = 1.1).
- `Ltarget3`: Increasingly biologically precautionary (xL = 1.1).
- `Ltarget4`: The most biologically precautionary TAC-based MP (xL = 1.1, xx=0.2).
- `L95target`: Same as Ltarget1 but here the target and limit mean lengths are based on the length at maturity distribution rather than an arbitrary multiplicative of the mean length

Required Data

See `Data-class` for information on the `Data` object

`Ltarget1`: Cat, LHYear, ML, Year

`Ltarget2`: Cat, LHYear, ML, Year

`Ltarget3`: Cat, LHYear, ML, Year

`Ltarget4`: Cat, LHYear, ML, Year

`L95target`: Cat, L50, LHYear, ML, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

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

See Also

Other Length target MPs: `Lratio_BHI()`, `LtargetE1()`

Examples

```
Ltarget1(1, Data=MSEtool::SimulatedData, plot=TRUE)
Ltarget2(1, Data=MSEtool::SimulatedData, plot=TRUE)
Ltarget3(1, Data=MSEtool::SimulatedData, plot=TRUE)
Ltarget4(1, Data=MSEtool::SimulatedData, plot=TRUE)
L95target(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

LtargetE1 *Length Target TAE MP*

Description

A management procedure that incrementally adjusts the TAE to reach a target mean length in catches.

Usage

```
LtargetE1(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xL = 1.05)

LtargetE4(x, Data, reps = 100, plot = FALSE, yrsmth = 5, xL = 1.15)
```

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?
yrsmth	Years over which to calculate mean length
xL	Parameter controlling the magnitude of the target mean length of catches relative to average length in catches.

Details

Four target length MPs proposed by Geromont and Butterworth 2014. Tested by Carruthers et al. 2015.

The TAE is calculated as:

If $L_{\text{recent}} \geq L_0$:

$$\text{TAE} = 0.5\text{TAE}^* \left[1 + \left(\frac{L_{\text{recent}} - L_0}{L_{\text{target}} - L_0}\right)\right]$$

else:

$$\text{TAE} = 0.5\text{TAE}^* \left[\frac{L_{\text{recent}}}{L_0}^2\right]$$

where TAE^* is the effort in the previous year, L_{recent} is mean length in last `yrmsth` years, L_0 is (except for `L95target`) 0.9 average catch in the last 2 x `yrsmth` historical (pre-projection years) (L_{ave}), and L_{target} is (except for `L95target`) `xL` L_{ave}.

Value

An object of class `Rec-class` with the TAE slot(s) populated

Functions

- `LtargetE1`: The least biologically precautionary TAE-based MP.

- `LtargetE4`: The xL argument is increased to 1.15.

Required Data

See `Data-class` for information on the `Data` object

`LtargetE1`: LHYear, ML, MPeff, Year

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

Carruthers et al. 2015. Performance evaluation of simple management procedures. ICES J. Mar Sci. 73, 464-482.

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

See Also

Other Length target MPs: `Lratio_BHI()`, `Ltarget1()`

Examples

```
LtargetE1(1, Data=MSEtool::SimulatedData, plot=TRUE)
LtargetE4(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

---

matlenlim   *Size limit management procedures*

Description

A set of size-selectivity MPs that adjust the retention curve of the fishery.

Usage

```
matlenlim(x, Data, reps, plot = FALSE)

matlenlim2(x, Data, reps, plot = FALSE)

minlenLopt1(x, Data, reps, plot = FALSE, buffer = 0.1)

slotlim(x, Data, reps, 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?
buffer	Parameter controlling the fraction of Lopt to set the minimum length of fish caught: minlen=Lopt*(0.7+buffer).

Details

The the LF5 and LFR slots in the Rec object are modified to change the retention curve (length at 5 per cent and smallest length at full retention respectively). A upper harvest slot limit can be set using the Rec@HS slot. The underlying selectivity pattern of the fishing gear does not change, and therefore the performance of these methods depends on the degree of discard mortality on fish that are selected by the gear but not retained by the fishery (Stock@Fdisc).

The level of discard mortality can be modified using the Rec@Fdisc slot which over-rides the discard mortality set in the operating model.

The selectivity pattern can be adjusted by creating MPs that modify the selection parameters (Rec@L5, Rec@LFS and Rec@Vmaxlen).

Value

An object of class Rec-class with the Retention slot(s) populated

Functions

- matlenlim: Fishing retention-at-length is set equivalent to the maturity curve.

- matlenlim2: Fishing retention-at-length is set slightly higher (110\ than the length-at-maturity

- minlenLopt1: The minimum length of retention is set to a fraction of the length that maximises the biomass, Lopt. The aim of this simple MP is restrict the catch of small fish to rebuild the stock biomass towards the optimal length, Lopt, expressed in terms of the growth parameters Lopt=b/(M/k+b) (Hordyk et al. 2015)

- slotlim: Retention-at-length is set using a upper harvest slot limit; that is, a minimum and maximum legal length. The maximum limit is set here, completely arbitrarily, as the 75th percentile between the new minimum legal length and the estimated asymptotic length Linf. This MP has been included to demonstrate an upper harvest slot limit.

Required Data

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

`matlenlim`: L50

`matlenlim2`: L50

`minlenLopt1`: Mort, vbK, vbLinf, wlb

`slotlim`: L50, vbLinf

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers & A. Hordyk

HF Geromont

References

Hordyk, A., Ono, K., Sainsbury, K., Loneragan, N., and J. Prince. 2015. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio ICES Journal of Marine Science, doi:10.1093/icesjms/fst235.

Examples

```
matlenlim(1, MSEtool::Atlantic_mackerel, plot=TRUE)
matlenlim2(1, MSEtool::Atlantic_mackerel, plot=TRUE)
minlenLopt1(1, MSEtool::Atlantic_mackerel, plot=TRUE)
slotlim(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

MCD   *Mean Catch Depletion*

Description

A simple average catch-depletion MP that was included to demonstrate just how informative an estimate of current stock depletion can be.

Usage

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

MCD4010(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

The TAC is calculated as:

$$\text{TAC} = 2\bar{C}D$$

where $\bar{C}$ is mean historical catch, and D is estimate of current depletion.

The TAC is modified by a harvest control rule in `MCD4010`.

Value

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

Functions

- `MCD`: The calculated TAC = 2 * depletion * AvC
- `MCD4010`: Linked to a 40-10 harvest control rule

Required Data

See `Data-class` for information on the Data object

MCD: Cat, Dep

MCD4010: Cat, Dep

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
MCD(1, MSEtool::Atlantic_mackerel, plot=TRUE)
MCD4010(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

MRreal

Spatial closure and allocation management procedures

Description

Management procedures that close Area 1 to fishing and reallocate fishing effort spatially.

Usage

```
MRreal(x, Data, reps, plot = FALSE)

MRnoreal(x, Data, reps, 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?

Value

An object of class `Rec-class` with the Spatial slot(s) populated

Functions

- `MRreal`: A spatial control that prevents fishing in area 1 and reallocates this fishing effort to area 2 (or over other areas).
- `MRnoreal`: A spatial control that prevents fishing in area 1 and does not reallocate this fishing effort to area 2.

Required Data

See `Data-class` for information on the Data object

```
MRreal:

MRnoreal:
```

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

Examples

```
MRreal(1, MSEtool::Atlantic_mackerel, plot=TRUE)
MRnoreal(1, MSEtool::Atlantic_mackerel, plot=TRUE)
```

Rcontrol   *Intrinsic rate of Increase MP*

Description

An MP proposed by Carl Walters that modifies the TAC according to trends in apparent surplus production that includes information from a demographically derived prior for intrinsic rate of increase

Usage

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

Rcontrol2(
  x,
  Data,
  reps = 100,
  plot = FALSE,
  yrsmth = 10,
  gg = 2,
  glim = c(0.5, 2)
)
```

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?
yrsmth	The number of years for smoothing catch and biomass data
gg	A gain parameters
glim	Limits for the change in TAC among years

Details

The TAC is calculated as:

$$\text{TAC} = \text{SP}(1 - gG)$$

where g is a gain parameter, SP is estimated surplus production, and G is: For `Rcontrol`: $G = r(1 - 2D)$ where r is the estimated intrinsic rate of increase, and D is assumed depletion.

For `Rcontrol2`: $G = r - 2bB_{\text{hist}}$ where B_{hist} is the smoothed biomass overlast `yrsmth` years and:

$$b = \sum \frac{\text{SP}}{B_{\text{hist}}} - r \frac{\sum B_{\text{hist}}}{\sum B_{\text{hist}}^2}$$

.

The TAC is subject to conditions limit the maximum change from the smoothed catch over the last `yrsmth` years by the `glim` argument, e.g, default values of `glim = c(0.5, 2)` means that maximum decrease in TAC is 50% of average catch and maximum increase is 2 x average catch.

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length `reps`

Functions

- `Rcontrol`: Base version `Rcontrol`
- `Rcontrol2`: This is different from `Rcontrol` because it includes a quadratic approximation of recent trend in surplus production given biomass

Required Data

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

`Rcontrol`: Abun, Cat, Dep, FMSY_M, Ind, L50, MaxAge, Mort, Year, steep, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

C. Walters and T. Carruthers

References

Made-up for this package.

See Also

Other Surplus production MPs: [Fadapt()](#), [SPMSY()](#), [SPSRA()](#), [SPmod()](#), [SPslope()](#)

Examples

```
Rcontrol(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
Rcontrol2(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

SBT1 *SBT simple MP*

Description

An MP that makes incremental adjustments to TAC recommendations based on the apparent trend in CPUE, a an MP that makes incremental adjustments to TAC recommendations based on index levels relative to target levels (BMSY/B0) and catch levels relative to target levels (MSY).

Usage

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

SBT2(x, Data, reps = 100, plot = FALSE, epsR = 0.75, tauR = 5, gamma = 1)
```

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?
yrsmth	The number of years for evaluating trend in relative abundance indices
k1	Control parameter
k2	Control parameter
gamma	Control parameter
epsR	Control parameter
tauR	Control parameter

Details

For SBT1 the TAC is calculated as:

$$\text{TAC}_y = \begin{cases} C_{y-1}(1 + K_2\,|\lambda|) & \text{if } \lambda \geq 0 \\ C_{y-1}(1 - K_1\,|\lambda|^{\gamma}) & \text{if } \lambda < 0 \end{cases}$$

where λ is the slope of index over the last `yrmsth` years, and K_1, K_2, and γ are arguments to the MP.

For SBT2 the TAC is calculated as:

$$\text{TAC}_y = 0.5(C_{y-1} + C_{\text{targ}}\delta)$$

where C_{y-1} is catch in the previous year, C_{targ} is a target catch (`Data@Cref`), and :

$$\delta = \begin{cases} R^{1-\text{epsR}} & \text{if } R \geq 1 \\ R^{1+\text{epsR}} & \text{if } R < 1 \end{cases}$$

where epsR is a control parameter and: $R = \frac{\bar{r}}{\phi}$ where $\bar{r}$ is mean recruitment over last `tauR` years and ϕ is mean recruitment over last 10 years.

This isn't exactly the same as the proposed methods and is stochastic in this implementation. The method doesn't tend to work too well under many circumstances possibly due to the lack of 'tuning' that occurs in the real SBT assessment environment. You could try asking Rich Hillary at CSIRO about this approach.

Value

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

Functions

- SBT1: Simple SBT MP
- SBT2: Complex SBT MP

Required Data

See Data-class for information on the Data object

SBT1: Cat, Ind, Year

SBT2: Cat, Cref, Rec

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

http://www.ccsbt.org/site/recent_assessment.php

Examples

```
SBT1(1, Data=MSEtool::SimulatedData, plot=TRUE)
SBT2(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

SPmod	*Surplus production based catch-limit modifier*

Description

An MP that makes incremental adjustments to TAC recommendations based on the apparent trend in surplus production. Based on the theory of Mark Maunder (IATTC)

Usage

```
SPmod(x, Data, reps = 100, plot = FALSE, alp = c(0.8, 1.2), bet = c(0.8, 1.2))
```

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?
alp	Condition for modifying the TAC (bounds on change in abundance)
bet	Limits for how much the TAC can change among years

Details

Note that this isn't exactly what Mark has previously suggested and is stochastic in this implementation.

The TAC is calculated as:

$$\text{TAC}_y = \begin{cases} C_{y-1}\text{bet}_1 & \text{if } r < \alpha_1 \\ C_{y-1} & \text{if } \alpha_1 < r < \alpha_2 \\ \text{bet}_2(b_2 - b_1 + C_{y-2}) & \text{if } r > \alpha_2 \end{cases}$$

where bet_1 and bet_2 are elements in bet, r is the ratio of the index in the most recent two years, C_{y-1} is catch in the previous year, b_1 and b_2 are ratio of index in $y-2$ and $y-1$ over the estimate of catchability $\left(\frac{I}{A}\right)$, and α_1, α_2, and α_3 are specified in argument alp.

Value

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

A numeric vector of TAC recommendations

Required Data

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

SPmod: Cat, Ind

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf

See Also

Other Surplus production MPs: [Fadapt](#)(), [Rcontrol](#)(), [SPMSY](#)(), [SPSRA](#)(), [SPslope](#)()

Examples

```
SPmod(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

SPMSY   *Catch trend Surplus Production MSY MP*

Description

An MP that uses Martell and Froese (2012) method for estimating MSY to determine the OFL. Since their approach estimates stock trajectories based on catches and a rule for intrinsic rate of increase it also returns depletion. Given their surplus production model predicts K, r and depletion it is straight forward to calculate the OFL based on the Schaefer productivity curve.

Usage

```
SPMSY(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

The TAC is calculated as:

$$\text{TAC} = DK\frac{r}{2}$$

where D is depletion, K is unfished biomass, and r is intrinsic rate of increasase, all estimated internally by the method based on trends in the catch data and life-history information.

Requires the assumption that catch is proportional to abundance, and a catch time-series from the beginning of exploitation.

Occasionally the rule that limits r and K ranges does not allow r-K pairs to be found that lead to the depletion inferred by the catch trajectories. In this case this method widens the search.

Value

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

Required Data

See `Data-class` for information on the `Data` object

SPMSY: Cat, L50, MaxAge, vbK, vbLinf, vbt0

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

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

See Also

Other Surplus production MPs: `Fadapt()`, `Rcontrol()`, `SPSRA()`, `SPmod()`, `SPslope()`

Examples

```
SPMSY(1, Data=MSEtool::SimulatedData, plot=TRUE)
```

SPslope   *Slope in surplus production MP*

Description

A management procedure that makes incremental adjustments to TAC recommendations based on the apparent trend in recent surplus production. Based on the theory of Mark Maunder (IATTC)

Usage

```
SPslope(
  x,
  Data,
  reps = 100,
  plot = FALSE,
  yrsmth = 4,
  alp = c(0.9, 1.1),
  bet = c(1.5, 0.9)
)
```

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?
yrsmth	Years over which to smooth recent estimates of surplus production
alp	Condition for modifying the Data (bounds on change in abundance)
bet	Limits for how much the Data can change among years

Details

Note that this isn't exactly what Mark has previously suggested and is stochastic in this implementation.

The TAC is calculated as:

$$\text{TAC}_y = \begin{cases} M\bar{C} & \text{if } r < \alpha_1 \\ \bar{C} & \text{if } \alpha_1 < r < \alpha_2 \\ \text{bet}_2\text{SP} & \text{if } r > \alpha_2 \end{cases}$$

where r is the ratio of predicted biomass in next year to biomass in current year $\bar{C}$ is the mean catch over the last yrmsth years, α_1 and α_2 are specified in alp, bet_1 and bet_2 are specified in bet, SP is estimated surplus production in most recent year, and:

$$M = 1 - \text{bet}_1 \frac{B_y - \tilde{B}_y}{B_y}$$

where B_y is the most recent estimate of biomass and $\tilde{B}$ is the predicted biomass in the next year.

Value

An object of class [Rec-class](#) with the TAC slot populated with a numeric vector of length reps

Required Data

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

SPslope: Abun, Cat, Ind, Year

Rendered Equations

See [Online Documentation](#) for correctly rendered equations

Author(s)

T. Carruthers

References

http://www.iattc.org/Meetings/Meetings2014/MAYSAC/PDFs/SAC-05-10b-Management-Strategy-Evaluation.pdf

See Also

Other Surplus production MPs: [Fadapt()](#), [Rcontrol()](#), [SPMSY()](#), [SPSRA()](#), [SPmod()](#)

Examples

```
SPslope(1, Data=MSEtool::Atlantic_mackerel, plot=TRUE)
```

SPSRA   *Surplus Production Stock Reduction Analysis*

Description

A surplus production equivalent of DB-SRA that uses a demographically derived prior for intrinsic rate of increase (McAllister method, below)

Usage

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

SPSRA_ML(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

The TAC is calculated as:

$$\text{TAC} = KD\frac{r}{2}$$

where K is estimated unfished biomass, D is depletion, and r is the estimated intrinsic rate of increase.

Like all SRA methods, this MP requires a time-series of catch extending from the beginning of exploitation.

Value

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

Functions

- SPSRA: Base version. Requires an estimate of current depletion
- SPSRA_ML: Variant that uses a mean-length mortality estimator to obtain a prior for current stock depletion.

Required Data

See Data-class for information on the Data object

SPSRA: Cat, Dep, FMSY_M, L50, MaxAge, Mort, steep, vbK, vbLinf, vbt0, wla, wlb

SPSRA_ML: CAL, Cat, Dep, FMSY_M, L50, Lbar, Lc, MaxAge, Mort, Year, steep, vbK, vbLinf, vbt0, wla, wlb

Rendered Equations

See Online Documentation for correctly rendered equations

Author(s)

T. Carruthers

References

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

See Also

Other Surplus production MPs: `Fadapt()`, `Rcontrol()`, `SPMSY()`, `SPmod()`, `SPslope()`

Examples

```
SPSRA(1, MSEtool::SimulatedData, plot=TRUE)
SPSRA_ML(1, MSEtool::SimulatedData, plot=TRUE)
```

YPR   *Yield Per Recruit analysis to get FMSY proxy F01*

Description

A simple yield per recruit approximation to FMSY (F01) which is the position of the ascending YPR curve for which dYPR/dF = 0.1(dYPR/d0)

Usage

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

YPR_CC(x, Data, reps = 100, plot = FALSE, Fmin = 0.005)

YPR_ML(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?
Fmin	The minimum fishing mortality rate inferred from the catch-curve analysis

Details

The TAC is calculated as:

$$\text{TAC} = F_{0.1}A$$

where $F_{0.1}$ is the fishing mortality (F) where the slope of the yield-per-recruit (YPR) curve is 10\

The YPR curve is calculated using an equilibrium age-structured model with life-history and selectivity parameters sampled from the `Data` object.

The variants of the YPR MP differ in the method to estimate current abundance (see Functions section below). #'

Value

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

Functions

- YPR: Requires an external estimate of abundance.
- YPR_CC: A catch-curve analysis is used to determine recent Z which given M (Mort) gives F and thus abundance = Ct/(1-exp(-F))
- YPR_ML: A mean-length estimate of recent Z is used to infer current abundance.

Required Data

See Data-class for information on the Data object

YPR: Abun, LFS, MaxAge, vbK, vbLinf, vbt0

YPR_CC: CAA, Cat, LFS, MaxAge, vbK, vbLinf, vbt0

YPR_ML: CAL, Cat, LFS, Lbar, Lc, MaxAge, Mort, vbK, vbLinf, vbt0

Rendered Equations

See Online Documentation for correctly rendered equations

Note

Based on the code of Meaghan Bryan

Author(s)

Meaghan Bryan and Tom Carruthers

References

Beverton and Holt. 1954.

Examples

```
YPR(1, MSEtool::SimulatedData, plot=TRUE)
YPR_CC(1, MSEtool::SimulatedData, plot=TRUE)
YPR_ML(1, MSEtool::SimulatedData, plot=TRUE)
```

Index