Package 'ALKr'

August 29, 2016

Type Package

Title Generate Age-Length Keys for fish populations

Description A collection of functions that implement several algorithms for generating age-length keys for fish populations from incomplete data.

URL http://www.github.com/ALKr

Version 0.5.3.1

Date 2014-02-20

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Depends R (>= 2.15.2)

LinkingTo Rcpp

Imports MASS, methods, Rcpp (>= 0.10.2)

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NeedsCompilation yes

Repository CRAN

Date/Publication 2014-02-26 14:24:59

R topics documented:

`age_slicing` *Age slicing*

Description

Estimation of a population's age distribution from its length distribution based on von Bertalanffy's growth curve, as described by Kell and Kell (2011)

Usage

```
age_slicing(fi, li = as.numeric(names(fi)), vb_params, age_limits,
  timing = 0.5)
```

Arguments

`fi`	A vector with the number of individuals per length class.
`li`	A vector containing the length value for each length class. If blank, will use `as.numeric(names(fi))`.
`vb_params`	A named vector with the parameters of the von Bertalanffy growth equation, `Linf`, `K` and `t0`.
`age_limits`	A vector with two elements, containing the lowest and highest age classes.
`timing`	Correction for the offset between the data collection and recruitment. Defaults to `0.5`, i.e. half a year

Details

Age distribution is calculated by using the inverse of the von Bertalanffy growth curve, whose parameters must be known. Limits for the minimum and maximum ages must also be given.

Value

A vector containing the number of individuals in each age class.

References

Kell, L., Kell, A. (2011). A comparison of age slicing and statistical age estimation for mediterranean swordfish (Xiphias gladius). *Collect. Vol. Sci. Pap. ICCAT*. **66**/4, 1522-1534

Examples

```
data(hom)
age_slicing(fi = hom$F1992,
  vb_params = c(Linf = 54.98, K = 0.064, t0 = -4.68),
  age_limits = c(0,5))
```

`ALKr` *Calculating Age-Length Keys from incomplete data*

Description

Generate Age-Length Keys for fish populations from complete or incomplete data.

Details

A collection of functions that implement several algorithms for generating age-length keys for fish populations from incomplete data.

References

Alberto Murta, Jose Francisco Loff, Laura Wise, Manuela Neves, Laurence Kell.

`ALKr-class` *ALKr*

Description

Every function used to calculate Age-Length Keys returns an `ALKr` object.

Details

alk A $i \times j$ matrix with the probability of an individual of length i having age j, i.e. $P(j|i)$

N A $i \times j$ matrix with the estimated number of individuals of length i and age j

method A string with the name of the algorithm used to calculate the ALK

params A named list with any parameters needed by the algorithm

name A string with a user-defined name for the ALKr object

description A string with a user-defined description for the ALKr object

calc_ALK *Classic ALK*

Description

Returns an Age-Length Key calculated from a matrix with the count of individuals per age- and length-class, as described by Fridriksson (1934).

Usage

```
calc_ALK(x)
```

Arguments

`x`	A matrix with `i` lines and `j` columns, where `x[i, j]` is the count of individuals of length `i` and age `j`.

Value

A matrix with the probability of an individual of length `i` having age `j`, i.e. $P(j|i)$.

References

Fridriksson, A (1934). On the calculation of age-distribution within a stock of cod by means of relatively few age determinations as a key to measurements on a large scale. *Rapp. P.-V. CIEM*, **86**, 1-5.

Examples

```
data(hom)
calc_ALK(hom$otoliths[[1]])
```

calc_invALK *Classic ALK*

Description

Returns an inverse Age-Length Key calculated from a matrix with the count of individuals per age- and length-class, as described by Clark (1981), Bartoo and Parker (1983) and Hilborn and Walters (1992)

Usage

```
calc_invALK(x, fi)
```

Arguments

x	A matrix with `i` lines and `j` columns, where `x[i, j]` is the count of individuals of length `i` and age `j`.
fi	A vector of length `i` where `fi[i]` is the number of fish in the length-class `j` on the population from which `x` was sampled.

Value

A matrix with the probability of an individual of age `j` having length `i`, i.e. $P(i|j)$.

References

Bartoo, N.W., Parker, K.R. (1983). Stochastic age-frequency estimation using the von Bertalanffy growth equation. *Fishery Bulletin*, **81**/1, 91-96

Clark, W.G. (1981). Restricted Least-Squares Estimates of Age Composition from Length Composition. *Canadian Journal of Fisheries and Aquatic Sciences*, **38**/3, 297-307. DOI: `10.1139/f81-041`

Hilborn, R., Walters, C.J. (1992). Quantitative fisheries stock assessment: Choice, dynamics and uncertainty. *Reviews in Fish Biology and Fisheries*, **2**/2, 177-178. DOI: `10.1007/BF00042883`

Examples

```
data(hom)
calc_invALK(hom$otoliths[[1]], hom$F1992)
```

`classic_ALK` *Classic Age-Length Key*

Description

`classicALK` returns an Age-Length Key calculated from a matrix with the count of individuals per age- and length-class, as described by Fridriksson (1934).

Usage

```
classic_ALK(x, fi = rowSums(x), age_classes = colnames(x),
  length_classes = rownames(x), name = "", description = "")
```

Arguments

x	A $i \times j$ matrix with the count of individuals of length i and age j.
fi	A vector of length `i` where `fi[i]` is the number of fish in the length-class `i` on the population from which `x` was sampled. Defaults to the number of samples per length class, which will
age_classes	A vector with the name of each age class. Defaults to the column names of `x`.
length_classes	A vector with the name of each length class. Defaults to the row names of `x`.
name	A string with the name of the ALK.
description	A string describing the ALK.

Value

An ALKr object, containing a $i \times j$ matrix with the probability of an individual of length i having age j, i.e. $P(j|i)$, a $i \times j$ matrix with the estimated number of individuals of length i and age j, and information about the method used to generate the key.

References

Fridriksson, A. (1934). On the calculation of age-distribution within a stock of cod by means of relatively few age determinations as a key to measurements on a large scale. *Rapp. P.-V. CIEM*, **86**, 1-5.

Examples

```
data(hom)
classic_ALK(hom$otoliths[[1]], fi = hom$F1992)
```

---

gascuel *Age-Length Key by the methods based on inverse ALKs*

Description

Generation of Age-Length Keys (ALK) using incomplete data, by methods based on inverse ALKs.

Usage

```
gascuel(x, fi1, fi2, initial_values, threshold = 1e-04, maxiter = 2000,
  age_classes = colnames(x), length_classes = rownames(x), name = "",
  description = "")

hoenig_heisey(x, fi1, fi2, threshold = 1e-04, maxiter = 2000,
  age_classes = colnames(x), length_classes = rownames(x), name = "",
  description = "")

inverse_ALK(x, fi1, fi2, age_classes = colnames(x),
  length_classes = rownames(x), name = "", description = "")

kimura_chikuni(x, fi1, fi2, threshold = 1e-04, maxiter = 2000,
  age_classes = colnames(x), length_classes = rownames(x), name = "",
  description = "")
```

Arguments

x	A $i \times j$ matrix with i lines and j columns, where x[i, j] is the count of individuals of length i and age j.
fi1	A vector of length i where fi[i] is the number of fish in the length-class i on the population from which x was sampled.

`fi2`	A vector of length `i` where `fi[i]` is the number of fish in the length-class `i` on a population with unknown age information.
`age_classes`	A vector with the name of each age class.
`length_classes`	A vector with the name of each age class.
`threshold`	The value at which convergence is considered to be achieved: see 'details'.
`maxiter`	The maximum number of iterations of the EM algorithm: see 'details'.
`initial_values`	A vector with the initial values for α, β and γ: see 'details'.
`name`	A string with the name of the ALK.
`description`	A string describing the ALK.

Details

`inverseALK` calculates an ALK from a sample of aged-fish, the length distribution of the sampled population and the length distribution of a population with unknown age-length data, as described by Clark (1981), Bartoo and Parker (1983) and Hilborn and Walters (1992).

`kimura_chikuni`, `hoenig_heisey` and `gascuel` use the same inputs as `inverseALK` to calculate an ALK as described respectively by Kimura and Chikuni (1987), Hoenig and Heisey (1987) and Gascuel (1994).

`hoenig` employs the generalized method proposed by Hoenig *et al.* (1993, 1994), which takes an undefined number of data sets with known and unknown age information and combines them to calculate the ALK.

The returned `ALKr` object contains information on the convergence threshold that was used, the number of iterations ran, and if convergence was reached.

Initial values:

The method proposed by Gascuel (1994) is based on the assumption that the length distribution *within* each age class follows a Normal distribution, where the standard deviation of length at age σ_j is given by a linear model as a function of three parameters α, β and γ:

$$\sigma_j = \alpha + \beta \cdot l_j + \gamma \cdot \Delta l_j$$

where Δl_j is the difference between the mean lengths at age-class `j` and age-class `j-1`.

Convergence:

The methods proposed by Kimura and Chikuni (1987), Hoenig and Heisey (1987) and Gascuel (1994) are all based on the EM algorithm as defined by Dempster *et al.* (1997), and build the ALK by a series of iterations which are repeated until convergence is acheived.

The convergence is tested by evaluating the sum of the absolute differences between the ages distributions calculated on the previous and current iterations: `sum(abs(pj_prev - pj_curr))`. The algorithm exits when either this value is smaller than the specified `threshold` or when the number of iterations reaches `maxiter`.

Value

An `ALKr` object, containing a $i \times j$ matrix with the probability of an individual of length `i` having age `j`, i.e. $P(j|i)$, a $i \times j$ matrix with the estimated number of individuals of length `i` and age `j`, and information about the method used to generate the key.

References

Bartoo, N.W., Parker, K.R. (1983). Stochastic age-frequency estimation using the von Bertalanffy growth equation. *Fishery Bulletin*, **81**/1, 91-96

Clark, W.G. (1981). Restricted Least-Squares Estimates of Age Composition from Length Composition. *Canadian Journal of Fisheries and Aquatic Sciences*, **38**/3, 297-307. DOI: `10.1139/f81-041`

Dempster, A.P., Laird, N.M., Rubin, D.B. (1977). Maximum Likelihood from Incomplete Data via the EM Algorithm. *Journal of the Royal Statistical Society. Series B (Methodological)*, **39**/1, 1-38. DOI: `10.2307/2984875`

Gascuel, D. (1994). Une methode simple d'ajustement des cles taille/age: application aux captures d'albacores (Thunnus albacares) de l'Atlantique Est. *Canadian Journal of Fisheries and Aquatic Sciences*, **51**/3, 723-733. DOI: `10.1139/f94-072`

Hilborn, R., Walters, C.J. (1992). Quantitative fisheries stock assessment: Choice, dynamics and uncertainty. *Reviews in Fish Biology and Fisheries*, **2**/2, 177-178. DOI: `10.1007/BF00042883`

Hoenig, J.M., Heisey, D.M. (1987), Use of a Log-Linear Model with the EM Algorithm to Correct Estimates of Stock Composition and to Convert Length to Age. *Transactions of the American Fisheries Society*, **116**/2, 232-243. DOI: `10.1577/1548-8659(1987)116<232:UOALMW>2.0.CO;2`

See Also

hoenig

Examples

```
data(hom)

inverse_ALK(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993)

kimura_chikuni(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993) # converges
kimura_chikuni(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993, maxiter = 10) # won't converge

hoenig_heisey(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993)

gascuel(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993,
  initial_values = c(0.1, 0.07, 0.06))
```

`hoenig` *Age-Length Key by the Hoening* et al. *(1993, 1994) method*

Description

Generation of Age-Length Keys (ALK) using incomplete data, by the method proposed by Hoenig *et al.* (1993, 1994).

Usage

```
hoenig(Ak, fik, fiz, threshold = 1, maxiter = 2000,
  age_classes = colnames(Ak[[1]]), length_classes = rownames(Ak[[1]]),
  name = "", description = "")
```

Arguments

`Ak`	A list of `k` equally dimensioned matrices, so that `A[[k]][i, j]` is the count of individuals of length `i` and age `j` on sample `k`.
`fik`	A list of `k` vectors of equal length (`i`), so that `fik[[k]][i]` is the total number of fish in the length-class `i` on the population from which `Ak[[k]]` was sampled.
`fiz`	A list of vectors of equal length (`i`) where `fiz[[z]][i]` is the number of fish in the length-class `i` on population `z`, for which no age data is available.
`age_classes`	A vector with the name of each age class.
`length_classes`	A vector with the name of each age class.
`threshold`	The value at which convergence is considered to be achieved: see 'details'.
`maxiter`	The maximum number of iterations of the EM algorithm: see 'details'.
`name`	A string with the name of the ALK.
`description`	A string describing the ALK.

Details

Calculates an ALK using the generalized method proposed by Hoenig *et al.* (1993, 1994), which uses an undefined number of data sets with known and unknown age information.

The returned `ALKr` object contains information on the convergence threshold that was used, the number of iterations ran, and if convergence was reached.

Convergence:

The method proposed by Hoenig *et al.* (1993, 1994) is based on the EM algorithm as defined by Dempster *et al.* (1997), and it generates the ALK by a series of iterations which are repeated until convergence is acheived.

Let `Nz` be a list of matrices containing the number of fish in each length and age class for each of the `z` populations with unknown age information and with length distribution specified by `fiz`. Convergence is tested by evaluating the greatest of the absolute differences between all pairs of `Nz` matrices generated on the current and previous iterations: `max(mapply("-", Nz, Nz.old))`.

Value

A list of `ALKr` objects, one for each item in the `fiz` list, each containing a matrix with the probability of an individual of age `j` having length `i`, i.e. $P(i|j)$, the vectors of age and length classes, and information about the method used to generate the key.

References

Dempster, A.P., Laird, N.M., Rubin, D.B. (1977). Maximum Likelihood from Incomplete Data via the EM Algorithm. *Journal of the Royal Statistical Society. Series B (Methodological)*, **39**/1, 1-38. DOI: `10.2307/2984875`

Hoenig, J.M., Heisey, D.M., Hanumara, R.C. (1993). Using Prior and Current Information to Estimate Age Composition: a new kind of age-length key. *ICES CM Documents 1993*, 10.

Hoenig, J.M., Heisey, D.M., Hanumara, R.C. (1994). A computationally simple approach to using current and past data in age-length key. *ICES CM Documents 1994*, 5.

See Also

inverse_ALK kimura_chikuni hoenig_heisey gascuel

Examples

```
data(hom)

hoenig(Ak = hom$otoliths[1:10],
       fik = replicate(10, hom$F1992, simplify = FALSE),
       fiz = list(hom$F1993))
```

---

hom — *Horse mackerel (Trachurus trachurus) off the portuguese coast*

Description

A dataset containing data collected in two bottom-trawl surveys carried out in the Portuguese coast in 1992 and 1993, and data generated and sampled from it.

Format

A list of 9 elements

Details

Proportions of each age class in the catch (`pj`) were calculated using classic Age-Length Keys built from the surveys' data. Mean length at age (`lmed`) was given values close to the ones observed in the real data, and its standard deviation (`stdv`) was calculated as suggested by Schnute and Fournier (1980).

The two catch matrices `N1992` and `N1993` were generated from this data, and the `F1992` and `F1993` were calculated from them.

The `otoliths` list contains a total of 1000 length-stratified random samples, extracted from the `N1992` matrix. Each of these samples simulate process of the sampling of a small subset of fish from the total catch to analyze its otoliths for age determination. The age data then obtained can then be used either alone or in combination with length data to calculate Age-Length Keys for the population.

The data is presented as a list containing the following items:

- lmed. Mean length at age.
- stdv. Standard deviation of length at age.
- pj_1992. Proportions of each age-class in the catch (1992 survey).
- pj_1993. Proportions of each age-class in the catch (1993 survey).
- N1992. Number of individuals per length and age class (1992 survey).
- N1993. Number of individuals per length and age class (1993 survey).
- F1992. Number of individuals per length (1992 survey).
- F1993. Number of individuals per length (1993 survey).
- otoliths. A list of 1000 length-stratified samples taken from N1992.

References

Schnute, J., Fournier, D. (1980). A New Approach to Length-Frequency Analysis: Growth Structure. Canadian Journal of Fisheries and Aquatic Sciences, 37(9), 1337-1351. DOI: 10.1139/f80-172

`summary.ALKr` *Summarizing ALK Estimations*

Description

`summary` method for class `"ALKr"`. Returns the mean length-at-age, the variance of the length-at-age, and the proportion of the age class in the population, for each age class.

Usage

```
## S3 method for class 'ALKr'
summary(object, length_classes = NULL, ...)
```

Arguments

`object`	An `ALKr` object.
`length_classes`	A vector with the length value to be used for each length class. Defaults to the row names of `x`, which must be coercible as numerics.
`...`	other arguments (currently ignored)

Value

A `summary_ALKr` object, containing the mean length-at-age, the variance of the length-at-age, and the proportion of the age class in the population, for each age class. The name of the method used to calculate the ALK and its parameters are also included.

Examples

```
data(hom)
cALK <- classic_ALK(hom$otoliths[[1]], fi = hom$F1992)
summary(cALK)
hhALK <- hoenig_heisey(hom$otoliths[[1]], fi1 = hom$F1992, fi2 = hom$F1993)
summary(hhALK)
```

summary_ALKr-class *Summary of an ALKr object*

Description

Summarizes an `ALKr` object, calculating the proportion of each age on the population, the mean length-at-age and the variance of the length-at-age. The summary object also contains the name of the algorithm used to calculate the ALK, the parameters used, as well as the user-defined name and description of the `ALKr` object.

Details

pj A vector of length j with the proportion of each age on the population

mean_lj A vector of length j with the mean length-at-age for each age class

var_lj A vector of length j with the variance of the length-at-age for each age class

method A string with the name of the algorithm used to calculate the ALK

params A named list with any parameters needed by the algorithm

name A string with a user-defined name for the ALKr object

description A string with a user-defined description for the ALKr object

[*Extract elements of ALKr class*

Description

Extract elements of ALKr class

Usage

```
## S4 method for signature 'ALKr'
x[i]
```

Arguments

x	object from which to extract element(s) or in which to replace element(s).
i	indices specifying elements to extract or replace. Indices are `numeric` or `character` vectors or empty (missing) or `NULL`. Numeric values are coerced to integer as by `as.integer` (and hence truncated towards zero). Character vectors will be matched to the `names` of the object (or for matrices/arrays, the `dimnames`): see 'Character indices' below for further details. For `[`-indexing only: `i`, `j`, `...` can be logical vectors, indicating elements/slices to select. Such vectors are recycled if necessary to match the corresponding

extent. i, j, ... can also be negative integers, indicating elements/slices to leave out of the selection.

When indexing arrays by [a single argument i can be a matrix with as many columns as there are dimensions of x; the result is then a vector with elements corresponding to the sets of indices in each row of i.

An index value of NULL is treated as if it were integer(0).

Index