Package 'cuttlefish.model'

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Title An R package to perform LPUE standardization and stock assessment of the English Channel cuttlefish stock using a two-stage biomass model

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Depends R (>= 3.0.0)

Type Package

Description This package can be used to standardize abundance indices using the delta-GLM method and to model the English Channel cuttlefish stock using a two-stage biomass model

License GPL-3

LazyLoad yes

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Cuttlefish modelling

Description

The cuttlefish.model package was developed to provide a software application of the two-stage biomass model to assess the English Channel cuttlefish stock. Functions enable, first, the standardization of the Landings Per Unit Effort (LPUE) using the delta-GLM method. Then, 4 abundance indices, 2 derived from surveys and 2 derived from standardized LPUE, and total landings (by all gears) are used as input data to fit a two-stage biomass model and estimate the recruited biomass and the catchability of each abundance index time series.

Details

Package:	cuttlefish.model
Type:	Package
Version:	1.0
Date:	2013-12-13
License:	GPL
LazyLoad:	yes

Three functions and two datasets are provided in the cuttlefish.model package. First, the delta.glm function enables the LPUE standardization using the Delta-GLM method. An exemple using generated data stored in fr.data.lpue illustrates how to use this function. Then, the two.stage.model.fit function enables the fitting of the two-stage biomass model and provides an estimation of the recruited biomass on the one hand and of the 4 catchability coefficients on the other hand. An exemple using generated data stored in input.data illustrates how to fit the model. Finally, the two.stage.model.outputs function enables the estimation of the two-stage biomass model outputs using the recruited biomass and catchability estimations.

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References

Gras, M., Roel, B. A., Coppin, F., Foucher, E. and Robin, J.-P. (2014). A two-stage biomass model to assess the English Channel cuttlefish (Sepia officinalis L.) stock. Submitted to ICES Journal of Marine Science.

`delta.glm` *LPUE standardisation using Delta-GLM method*

Description

The delta.glm function enables the standardization of observed Landings Per Unit Effort (LPUE) collected by commercial fishing vessels using the Delta-GLM methodology. It consists in a combination of a binomial error GLM which explains the presence/absence of the stock and a Gaussian error GLM which explains the abundance of the resource. The standardization is performed using 4 explaining variables, the fishing season, the month, the ICES rectangle and the engine power of the vessel.

Usage

```
delta.glm(input.data)
```

Arguments

`input.data`	Must be filled with an object of class data frame with 4 explaining variables named "fishing.season", "month", "rectangle", "power.class" and one explained variable named "lpue".

Details

The 4 explaining variables ("fishing.season", "month", "rectangle", "power.class") can be either of class integer, character or factor. The explained variable "lpue" must be of class numeric and positive or null. The data frame can include more variables than the 5 mentioned above but they will not be used in the function.

Value

`binomial.glm`	Stores the result of the binomial error GLM
`binomial.summary`	Stores the summary of the binomial error GLM
`binomial.residuals`	Stores the residuals of the binomial error GLM
`binomial.fit`	Stores the fitted values of the binomial error GLM
`gaussian.glm`	Stores the result of the gaussian error GLM
`gaussian.summary`	Stores the summary of the gaussian error GLM
`gaussian.residuals`	Stores the residuals of the gaussian error GLM
`gaussian.fit`	Stores the fitted values of the gaussian error GLM
`predicted.lpue`	Stores the standardized LPUE for each quadruplet year, month, rectangle, power.class

Note

The development of the two-stage biomass model to assess the English Channel cuttlefish stock was carried out in the framework of the EU funded project CRESH (under the Interreg IV A France-Manche-England programme). The development of the R package to perform the routine assessment of the cuttlefish stock was co-funded by France Filiere Peche and by the Departement des Peches Maritimes et de l'Aquaculture.

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See Also

glm

Examples

```
data(fr.data.lpue)

fr.delta.glm<-delta.glm(input.data=fr.data.lpue)


par(mfrow = c(2,2))
#Histogram of the binomial error GLM residuals
hist(fr.delta.glm$binomial.residuals)

#Plot with the fitted data on the x axis and and the re
plot(fr.delta.glm$binomial.fit, fr.delta.glm$binomial.residuals)

#QQplot of the residuals from the binomial error GLM
qqnorm(fr.delta.glm$binomial.residuals)
qqline(fr.delta.glm$binomial.residuals)


par(mfrow = c(2,2))
#Histogram of the residuals from the Gaussian error GLM
hist(fr.delta.glm$gaussian.residuals)

#Plot of fitted values vs residuals from the Gaussian error GLM
plot(fr.delta.glm$gaussian.fit,fr.delta.glm$gaussian.residuals)
qqnorm(fr.delta.glm$gaussian.residuals)
qqline(fr.delta.glm$gaussian.residuals)

#Aggregation of the standardised LPUE per year. Aggregation
```

```
#can be done on the 3 other factors in the same way.
fr.yearly.lpue<-aggregate(fr.delta.glm$predicted.lpue$st.lpue,
list(fr.delta.glm$predicted.lpue$fishing.season), FUN="mean")
fr.yearly.lpue<-data.frame(c(1900:1905), fr.yearly.lpue)
colnames(fr.yearly.lpue)<-c("year","fishing.season","fr.st.lpue")
```

`fr.data.lpue` *Observed French Landings Per Unit Effort*

Description

The object fr.data.lpue stores generated Observed Landings Per Unit Effort which could be derived from commercial bottom trawl fleets. As real data are confidential, data presented in the example are generated data.

Usage

```
data(fr.data.lpue)
```

Format

The object fr.data.lpue is a data.frame made of 6 columns named year (calendar year), fishing.season (the fishing season during which the cuttlefish is exploited; a fishing season starts in July of a calendar year Y and ends in June of a calendar year Y+1), month (calendar month from January (1) to December (12)), rectangle (ICES rectangle code), power.class (power class of the trawler concerned).

Each of the 9110 rows of the data frame refer to the fishing effort carried out during one cruise in one ICES rectangle.

Note

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See Also

delta.glm and optim

Examples

```
data(fr.data.lpue)

fr.delta.glm<-delta.glm(input.data=fr.data.lpue)


par(mfrow = c(2,2))
#Histogram of the binomial error GLM residuals
hist(fr.delta.glm$binomial.residuals)

#Plot with the fitted data on the x axis and and the re
plot(fr.delta.glm$binomial.fit, fr.delta.glm$binomial.residuals)

#QQplot of the residuals from the binomial error GLM
qqnorm(fr.delta.glm$binomial.residuals)
qqline(fr.delta.glm$binomial.residuals)


par(mfrow = c(2,2))
#Histogram of the residuals from the Gaussian error GLM
hist(fr.delta.glm$gaussian.residuals)

#Plot of fitted values vs residuals from the Gaussian error GLM
plot(fr.delta.glm$gaussian.fit,fr.delta.glm$gaussian.residuals)
qqnorm(fr.delta.glm$gaussian.residuals)
qqline(fr.delta.glm$gaussian.residuals)

#Aggregation of the standardised LPUE per year. Aggregation
#can be done on the 3 other factors in the same way.
fr.yearly.lpue<-aggregate(fr.delta.glm$predicted.lpue$st.lpue,
list(fr.delta.glm$predicted.lpue$fishing.season), FUN="mean")
fr.yearly.lpue<-data.frame(c(1900:1905), fr.yearly.lpue)
colnames(fr.yearly.lpue)<-c("year","fishing.season","fr.st.lpue")
```

---

input.data *Input data (4 abundance indices and total landings per quarter).*

Description

The object input.data is filled with observed survey abundance indices (derived from BTS and CGFS surveys), standardized Landings Per Unit Effort (LPUE) derived from French and UK bottom trawl fleets and total landings (French and UK landings by all gears) per quarter.

As real data are confidential, all data presented in the example are generated data.

Usage

```
data(fr.data.lpue)
```

Format

The object input.data is a data frame made of 10 columns called year (calendar year) fishing.season (the fishing season during which the cuttlefish is exploited; a fishing season starts in July of the year Y and ends in June of the year Y+1), bts (abundance index derived from BTS survey carried out by Cefas each July in ICES division VIId), cgfs (abundance index derived from CGFS survey carried out by Ifremer each October in ICES division VIId), lpue.fr (abundance index derived from French bottom trawl LPUE estimated in the ICES divisions VIId and VIIe), lpue.uk (abundance index derived from UK beam trawl LPUE estimated in the ICES divisions VIId and VIIe), landings.q3, are the summer landings of the calendar year Y, landings.q4, are the autumn landings of the calendar year Y, landings.q1, are the winter landings of the calendar year Y+1, landings.q2 are the spring landings of the calendar year Y+1.

Each of the 5 rows of the data frame refers to the data for one fishing season (a fishing season starts in July of the year Y and ends in June of the year Y+1). The calendar year refers to the recruitment year.

Note

The development of the two-stage biomass model to assess the English Channel cuttlefish stock was carried out in the framework of the EU funded project CRESH (under the Interreg IV A France-Manche-England programme). The development of the R package to perform the routine assessment of the cuttlefish stock was co-funded by France Filiere Peche and by the Departement des Peches Maritimes et de l'Aquaculture.

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See Also

delta.glm and optim

Examples

```
data(input.data)

#Abundance indices are re-scaled by dividing the time series by its mean
```

```
input.data$bts<-input.data$bts/mean(input.data$bts)
input.data$cgfs<-input.data$cgfs/mean(input.data$cgfs)
input.data$lpue.fr<-input.data$lpue.fr/mean(input.data$lpue.fr)
input.data$lpue.uk<-input.data$lpue.uk/mean(input.data$lpue.uk)

#Creation of a data frame filled with the year, the fishing season,
#the abundance indices, the landings of the 3 first quarters of the
#fishing season (used in the modelling of the UK LPUE) and the landings
#of all the fishing season (used in the modelling of the french LPUE)
lpue.obs<-data.frame(c(1900:1904),
c(1:5),
input.data$bts,
input.data$cgfs,
input.data$lpue.uk,
input.data$lpue.fr,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1
+ input.data$landings.q2)
colnames(lpue.obs)<-c("year", "fishing.year", "bts","cgfs","lpue.uk",
"lpue.fr","L.Q341","L.Q3412")

#Growth parameter
growth<--1.01

#Initial values for the fitting with 17 starting values for B1
#(for the 17 years) and the 4 log values of the catchabilities
biom.init<-c(rep(15000,5),-9, -9, -9, -9)

#Fitting of the two-stage biomass model

result.optim<-optim(par=biom.init,fn=two.stage.model.fit,
obs.fit=lpue.obs[1:5,], g.fit=-1.01, method = "BFGS",
control=list(maxit=99990,reltol=1e-9,trace=TRUE))

#Plot of the B1 time series
plot(x=input.data$year, y=result.optim$par[1:5], type='b',
ylim=c(0, max(result.optim$par[1:5])), xlab="Years",
ylab= "B1 estimation in tons of cuttlefish")
```

`two.stage.model.fit` *Two-stage biomass model fitting function*

Description

The two.stage.model.fit function enables, using a vector of starting parameters, the observed abundance indices, the total landings and the optim function, the fitting of the two-stage biomass model to estimate the recruited biomass time series and the catchability of the 4 abundance index time series. The two-stage biomass model is fitted by minimimizing the sum of square residuals.

Usage

```
two.stage.model.fit(to.fit, obs.fit, g.fit)
```

Arguments

to.fit	An object of class vector to give starting values of recruited biomass (B1) for each year and the 4 starting catchability values (one for each abundance index) in order to estimate the sum or square residuals. The two-stage biomass model to assess the English Channel cuttlefish stock was fitted using starting biomasses of 15000 tons for each year and log catchabilities of -9. The length of the vector equals the number of years plus 4 for the catchability of each survey and LPUE time series.
obs.fit	An object of class data frame filled with the 4 observed abundance indices as columns. Columns must be called bts, cgfs, lpue.uk, lpue.fr for BTS and CGFS surveys, UK and French bottom trawl fleet LPUE respectively. Moreover, total landings of the 3 first quarters of the fishing season must be mentioned in a column called "L.Q341" and the total landings of the 4 quarters of each fishing season must be mentioned in a column named "L.Q3412".
g.fit	The growth parameter. The common value currently used is -1.01.

Value

sum.residuals	The Sum of Square Residuals which is minimized by the optim function in order to fit the two-stage biomass model

Note

The development of the two-stage biomass model to assess the English Channel cuttlefish stock was carried out in the framework of the EU funded project CRESH (under the Interreg IV A France-Manche-England programme). The development of the R package to perform the routine assessment of the cuttlefish stock was co-funded by France Filiere Peche and by the Departement des Peches Maritimes et de l'Aquaculture.

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See Also

optim

Examples

```
data(input.data)

#Abundance indices are re-scaled by dividing the time series by its mean
input.data$bts<-input.data$bts/mean(input.data$bts)
input.data$cgfs<-input.data$cgfs/mean(input.data$cgfs)
input.data$lpue.fr<-input.data$lpue.fr/mean(input.data$lpue.fr)
input.data$lpue.uk<-input.data$lpue.uk/mean(input.data$lpue.uk)

#Creation of a data frame filled with the year, the fishing season,
#the abundance indices, the landings of the 3 first quarters of the
#fishing season (used in the modelling of the UK LPUE) and the landings
#of all the fishing season (used in the modelling of the french LPUE)
lpue.obs<-data.frame(c(1900:1904),
c(1:5),
input.data$bts,
input.data$cgfs,
input.data$lpue.uk,
input.data$lpue.fr,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1
+ input.data$landings.q2)
colnames(lpue.obs)<-c("year", "fishing.year", "bts","cgfs","lpue.uk",
"lpue.fr","L.Q341","L.Q3412")

#Growth parameter
growth<--1.01

#Initial values for the fitting with 17 starting values for B1
#(for the 17 years) and the 4 log values of the catchabilities
biom.init<-c(rep(15000,5),-9, -9, -9, -9)

#Fitting of the two-stage biomass model

result.optim<-optim(par=biom.init,fn=two.stage.model.fit,
obs.fit=lpue.obs[1:5,], g.fit=-1.01, method = "BFGS",
control=list(maxit=99990,reltol=1e-9,trace=TRUE))

#Plot of the B1 time series
plot(x=input.data$year, y=result.optim$par[1:5], type='b',
ylim=c(0, max(result.optim$par[1:5])), xlab="Years",
ylab= "B1 estimation in tons of cuttlefish")
```

`two.stage.model.outputs` *Two-stage biomass model output estimation*

Description

This function enables the estimation of the two-stage biomass model outputs using the time series of recruited biomass (B1), the catchability of BTS and CGFS surveys and the French and UK trawl fleets, the 4 abundance index time series collected by the BTS and CGFS surveys and the French and UK trawling fleets and the total landings (French and UK landings by all gear).

Usage

```
two.stage.model.outputs(B1, catchability, obs, g)
```

Arguments

B1	An object of class vector filled with the estimated recruited biomass (B1 in tons). The B1 time series can be estimated, using the observed abundance indices and the total landings, by running optim and two.stage.model.fit functions.
catchability	An object of class vector and length 4 filled with the log of the estimated catchabilities (negative values). Catchabilities must be filled in the following order: BTS, CGFS, UK and French fleets.
obs	An object of class data frame filled with the 4 observed abundance indices as columns. Columns must be called bts, cgfs, lpue.uk, lpue.fr for BTS and CGFS surveys, UK and French bottom trawl fleet LPUE respectively. Moreover, total landings of the 3 first quarters of the fishing season must be mentioned in a column called "L.Q341" and the total landings of the 4 quarters of each fishing season must be mentioned in a column named "L.Q3412".
g	A value of the growth parameter. The common value currently used is -1.01.

Details

Reminder : the fishing season starts on July of a year Y and ends in June of a year Y+1. For practical reasons, fishing seasons are numbered from 1 and the corresponding year mentioned is always the year of the beginning of the fishing season (starting from 1900).

Value

The two.stage.model.outputs function returns a list with the following data frames

observed	A dataframe with the observed data. Calendar year and fishing seasons are mentioned in the two first columns. The 4 following columns are filled with the observed survey abundance indices and the LPUE. Finally the two last columns are filled with the landings of the 3 first quarters of the fishing season (L.Q341) and the 4 quarters of each fishing season (L.Q3412).
sum.residuals	The sum of square residuals.
residuals.ssr	A dataframe filled with the residuals of each abundance index time series computed as log([observed abundance indices]/[predicted abundance indices])^2
residuals.mlh	A dataframe filled with the raw residuals computed using the likelyhood method.
residuals.raw	A dataframe filled with the raw residuals computed as [observed abundance indices] - [predicted abundance indices]

`residuals.st`	A dataframe filled with the standardized residuals computed as ([raw residuals] - [mean(raw residuals)]) / SD([raw residuals])
`predicted.ai`	A data frame filled with the predicted abundance index time series.
`biomass`	A data frame filled with the estimated recruited biomass (B1), the estimated biomass in January (B.jan), the total landings per year (landings), the estimated exploitation rate (exp.rate) and the estimated Spawning Stock Biomass (B2).

Note

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See Also

`two.stage.model.fit` and `optim`

Examples

```
data(input.data)

lpue.obs<-data.frame(c(1900:1904),
c(1:5),
input.data$bts,
input.data$cgfs,
input.data$lpue.uk,
input.data$lpue.fr,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1,
input.data$landings.q3 + input.data$landings.q4 + input.data$landings.q1
+ input.data$landings.q2)
colnames(lpue.obs)<-c("year", "fishing.year", "bts","cgfs","lpue.uk",
"lpue.fr","L.Q341","L.Q3412")


#B1 time series estimated by the two.stage.model.fit and optim functions
B1.time.series<-c(13321.68, 15162.38, 10461.95, 23642.48, 15213.79)

#Catchabilities estimated by the two.stage.model.fit and optim functions
```

```
kq<-c(-9.699609, -9.955116, -9.974922, -9.578453)

#g parameter
growth<--1.01


two.stage.model.results<-two.stage.model.outputs(B1=B1.time.series,
catchability=kq, obs=lpue.obs, g=growth)

two.stage.model.results
```

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