Package 'RchivalTag'

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Type Package

Title Analyzing Archival Tagging Data

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Description A set of functions to generate, access and analyze standard data products from archival tagging data.

Depends R (>= 3.0.1)

Imports plyr, maptools, graphics, stats, raster, rgeos, ncdf4, maps, mapdata, grDevices, oceanmap, sp, methods, PBSmapping

License GPL (>= 3)

LazyLoad yes

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R topics documented:

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bin_TempTS   *bin depth-temperature time series data*

Description

bins depth-temperature time series data to a user-defined resolution, returning the minimum, maxmium and average temperature recorded at each depth interval (bin) per sampling day. The output is comparable to that of read_PDT.

Why binning temperature data?

In case of archival tagging data, depth-temperature time series data at a given day may consist of multiple tempertaure profiles of different signatures, depending on the animal's behaviour. Slight differences in temperature profiles could impede further analyses (e.g. the estimation of the thermocline depth), if just the average profile is applied. To avoid such problmes, it is useful to calculate the average temperature at given depth intervals (bins) and thus smooth temperature profiles of a given period.

In addition, temperature at depth profiles can be interpolated and then visualized using functions interpolate_TempDepthProfiles and image_TempDepthProfiles, respectively. This faciliates the analysis of temporal changes of temperature profiles, for instance, in relation to animal behaviour (e.g. diving behaviour).

Usage

```
bin_TempTS(ts, res=8)
```

Arguments

ts   a data.frame with columns date, Depth and Temperature
res   the depth interval at which temperatures should be binned.

Value

A data.frame with the columns date, MeanTemp, MinTemp, MaxTemp, bin and MeanPDT (the latter being the average of the min and maximum water temperatures). Additional columns, used to distinguish tags, may include Serial, DeployID and Ptt, depending on their availability in the original ts-data.fralme.

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanography, 24(6): 533-539, doi: 10.1111/fog.12127

See Also

read_PDT, interpolate_TempDepthProfiles, image_TempDepthProfiles

Examples

```
# #### example 1) run on time series data:
## step I) read sample time series data file:
DepthTempTS <- read.table(system.file("example_files/104659-Series.csv",
                                      package="RchivalTag"),header = TRUE,sep=',')
DepthTempTS$date <- as.Date(DepthTempTS$Day,"%d-%b-%Y")
head(DepthTempTS)
#
#
# ## step Ib) bin temperature data on 10m depth bins
# ##          to increase later estimate accuracy (see Bauer et al. 2015):
# # DepthTempTS_binned <- bin_TempTS(DepthTempTS,res=10)
#
# ## step II) interpolate average temperature fields (MeanTemp) from binned data:
# m <- interpolate_TempDepthProfiles(DepthTempTS)
# # m <- interpolate_PDTs(DepthTempTS_binned)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
# ## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
```

---

classify_DayTime	*Classifying the time period of the day*

Description

Classifying the time period of the day based on the timing of sunrise, sunset (and twilight events) or alternatively, geolocation estimates, as specified in get_DayTimeLimits, that allow their internal estimation during the function call.

Usage

```
classify_DayTime(pos, twilight.set="ast")
```

Arguments

pos   A [data.frame](#) pos with the columns sunrise, sunset, dawn.ast,/dawn.naut
                and dawn.ast/dawn.naut in POSIXct-format. Note that the expected twilight
                vector (suffix ″ast″ for astronomical dawn and dusks; vs suffix ″naut″ for nau-
                tical twilight events) is defined by the function's second argument twilight.set
                (see description below).

twilight.set   character string, indicating the type of twilight used for the long daytime classif-
                cation: ″ast″ (default) for astronomical and ″naut″ for nautical twilight events
                with sun angles of 18 vs 12 below the horizon, respectvely. Corresponding (ex-
                pected) dawn and dusk vector names are dawn.ast & dusk.ast vs dawn.naut
                & dusk.naut).

Value

The input [data.frame](#) pos extended by the time vectors daytime and daytime.long. In the former
case, "Day" and "Night" periods are distinguished. In the latter case, "Day", "Night", "Dawn" and
"Dusk".

Author(s)

Robert K. Bauer

References

Meeus, J. (1991) Astronomical Algorithms. Willmann-Bell, Inc.

See Also

[sunriset](#), [crepuscule](#), [get_DayTimeLimits](#)

Examples

```
#### example 1) estimate current times of dawn, sunrise, dusk and sunset in Mainz, Germany:
pos <- data.frame(Lat=8.2667, Lon=50)
pos$date.long <- strptime(Sys.Date(),"%Y-%m-%d")
get_DayTimeLimits(pos)

#### example 1b) classify current ime of the day in Mainz, Germany:
classify_DayTime(get_DayTimeLimits(pos))

## convert 1c) back-to-back histogram showing day vs night TAD frequencies:
### load sample depth and temperature time series data from miniPAT:
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
tad_breaks <- c(0, 2, 5, 10, 20, 50, 100, 200, 300, 400, 600, 2000)

ts_df$Lat <- 4; ts_df$Lon=42.5 ## required geolocations to estimate daytime
ts_df$date.long <- strptime(paste(ts_df$Day,ts_df$Time),"%d-%B-%Y %H:%M:%S")
head(ts_df)
```

```
ts_df2 <- classify_DayTime(get_DayTimeLimits(ts_df)) # estimate daytime
head(ts_df2)

ts2histos(ts_df2, tad_breaks = tad_breaks,split_by = "daytime")
hist_tad(ts_df2, bin_breaks = tad_breaks,split_by = "daytime", do_mid.ticks = FALSE)
```

---

combine_histos   *combine lists of TAD/TAT frequency data*

Description

This function allows to combine seperate lists of TAD/TAT frequency data from archival tags
(i.e. by Wildlife Computers). The function requires ungrouped/unmerged TAD/TAT lists to avoid
merging duplicate records (e.g. multiple TAD/TAT lists from the same individual). However,
grouped/merged lists with TAD/TAT from multiple individuals and even duplicate records can be
provided, as the function includes an internal call of unmerge_histos to meet this requirement.

Usage

```
combine_histos(hist_list1, hist_list2)
```

Arguments

hist_list1, hist_list2

> Two list-of-lists to be combined, each containing TAD and TAT frequency data
> and the corresponding bin_breaks from one or several archival tags.

Value

A list-of-lists of ungrouped/unmerged TAD and TAT frequency data.

$ TAD:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
$ TAT:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
..$ ID2 : List of 2
...

Author(s)

Robert K. Bauer

See Also

unmerge_histos, merge_histos, hist_tad, hist_tat

Examples

```
## example 1) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks

## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)
```

---

get_DayTimeLimits   *Estimating the timing of sunrise, sunset, astronomical and nautical*
                     twilight events

Description

Estimating the timing of sunrise, sunset, astronomical and nautical twilight events in POSIXct-
format based on geolocations and a similar time vector. The function is a simplified call of the
sunriset and crepuscule functions of the maptools-package that are based on algorithms provided
by the National Oceanic & Atmospheric Administration (NOAA).

Usage

```
get_DayTimeLimits(pos)
```

Arguments

pos   a data.frame with the columns date.long (a time vector in POSIXct-format),
                Lon and Lat.

Value

The input [data.frame](#) pos extended by the time vectors `sunrise`, `sunset`, `dawn.naut`, `dawn.ast`, `dusk.naut` and `dusk.ast`.

Author(s)

Robert K. Bauer

References

Meeus, J. (1991) Astronomical Algorithms. Willmann-Bell, Inc.

See Also

[sunriset](#), [crepuscule](#), [classify_DayTime](#)

Examples

```
#### example 1) estimate current times of dawn, sunrise, dusk and sunset in Mainz, Germany:
pos <- data.frame(Lat=8.2667, Lon=50)
pos$date.long <- strptime(Sys.Date(),"%Y-%m-%d")
get_DayTimeLimits(pos)

#### example 1b) classify current ime of the day in Mainz, Germany:
classify_DayTime(get_DayTimeLimits(pos))
```

---

get_thermalstrat *estimate thermal stratification indices*

Description

estimates thermal stratification indices, including thermocline depth, gradient, mixed later depth and stratifcation index from daily temperature at depth profiles, as illustrated by Bauer et al. (2015) for archival tagging data.

Usage

```
get_thermalstrat(x, dz=20, strat_lim=100, na.rm=FALSE,
                 show_info=TRUE, Depth_res, all_info=FALSE)
```

Arguments

x	A list generated by [interpolate_TempDepthProfiles](), containing interpolated temperature at depth profiles and their corresponding date and depth vectors:

                                  $ Data_Source.ID_key:List of 3
                                  ..$ Temperature_matrix: num
                                  ..$ Depth : num
                                  ..$ Date :Date
                                  ..$ sm :data.frame
                                  .. ..$ Date :chr
                                  .. ..$ nrecs :int
                                  .. ..$ Depths :chr

dz	size of the moving window in meters between which temperature values should be compared for the estimation of the thermocline gradient and depth (by default 20).
na.rm	whether interpolated temperature at depth profiles with missing values should be treated (default is FALSE).
strat_lim	up to which depth (in meters) temperature values should be considered for the estimation of the stratication index (by default 100).
Depth_res	numeric value, defining the depth resolution at which the temperature data should be interpolated.
show_info	whether the process of the function run should be indicated (by default TRUE).
all_info	whether the summary information of the input file should be generated in the output (by default FALSE).

Value

a [data.frame]() composed of

Date a date vector (see input argument x)

maxDepth_interp the maxmium depth (in meters) of a daily temperature at depth profile to which its interpolation is limitied)

tgrad the maximum temperature gradient of all possible moving windows of size dz)

tcline the thermocline depth, defined as the average depth (of the depth range) of the moving window(s) with the maximum temperature gradient tgrad)

dz size of the moving window in meters between which temperature values were compared

mld mixed layer depth, defined as the average depth of the first moving window that meets maximum temperature gradient criterium)

mld_0.5 mixed layer depth, defined as as the depth at which T = SST-0.5 degrees, the temperature criterion of Monterey and Levitus (1997).

mld_0.8 mixed layer depth, defined as the depth at which T = SST-0.8 degrees, the temperature criterion of Kara et al. (2000, 2003).

strat_index stratification index, defined as the standard deviation of all interpolated temperature values up to the depth defined by the argument strat_lim

... optional columns to be taken from the `sm` data.frame of the input list (in case that `all_info=TRUE`)

nrecs number of records of the non-interpolated daily temperature at depth profiles

Depths unique depth records of the non-interpolated daily temperature at depth profiles, seperated by '; '

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanography, 24(6): 533-539, doi: 10.1111/fog.12127

Kara, A. B., P. A. Rochford, and H. E. Hurlburt (2000). An optimal definition for ocean mixed layer depth. Journal of Geophysical Research, 105:16803-16821, doi: 10.1029/2000JC900072

Kara, A. B., P. A. Rochford, and H. E. Hurlburt (2003) Mixed layer depth variability over the global ocean. Journal of Geophysical Research, 108:3079, doi: 10.1029/2000JC000736

Monterey, G., and S. Levitus (1997) Seasonal variability of mixed layer depth for the world ocean. NOAA Atlas NESDIS 14, U. S. Govt. Printing Office.

See Also

interpolate_TempDepthProfiles

Examples

```
#### example 1) run on PDT file:
## step I) read sample PDT data file:
path <- system.file("example_files",package="RchivalTag")
PDT <- read_PDT("104659-PDTs.csv",folder=path)
head(PDT)
#
# ## step II) interpolate average temperature fields (MeanPDT) from PDT file:
# m <- interpolate_PDTs(PDT)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
#
# #### example 2) run on time series data:
# ## step I) read sample time series data file:
# DepthTempTS <- read.table(system.file("example_files/104659-Series.csv",
#                                     package="RchivalTag"),header = TRUE,sep=',')
# DepthTempTS$date <- as.Date(DepthTempTS$Day,"%d-%b-%Y")
# head(DepthTempTS)
#
```

```
#
# ## step Ib) bin temperature data on 10m depth bins
# ##             to increase later estimate accuracy (see Bauer et al. 2015):
# # DepthTempTS_binned <- bin_TempTS(DepthTempTS,res=10)
#
# ## step II) interpolate average temperature fields (MeanTemp) from binned data:
# m <- interpolate_TempDepthProfiles(DepthTempTS)
# # m <- interpolate_PDTs(DepthTempTS_binned)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
```

---

hist_tad   *Time-at-Depth histogram*

Description

generates daily or back-to-back (e.g. Day-vs-Night-) Time-at-Depth histograms from binned depth
or depth time series data

Usage

```
hist_tad(df,
              bin_breaks=NULL, bin_prefix="Bin",
              select_id, select_from='Ptt', aggregate_by='Ptt',
              date,
              main, xlab='Time at Depth (%)', ylab="Depth (m)", labeling=TRUE,
              xlim=c(0, 100), adaptive.xlim=FALSE,
              split_by=NULL, split_levels, xlab2=split_levels,
              ylab.side=2, ylab.line, ylab.font=1,
              xlab.side=3, xlab.line=2.5, xlab.font=1,
              xlab2.side=1, xlab2.line=1, xlab2.font=2,
              main.side=2, main.line=3.8, main.font=1,
              col=c("darkgrey", "white"),
              do_mid.ticks=TRUE, yaxis.pos=0,
              mars,
              plot_sd=TRUE, plot_nrec=TRUE, plot_ntags=TRUE,
              cex=1.2, cex.main=cex, cex.lab=cex, cex.inf=cex,
              return.sm=FALSE,
              subplot=FALSE, inside=FALSE,Type="TAD")
```

Arguments

df	dataframe that either contains depth time series data (as a vector "Depth") or several vectors of Time-at-Depth frequencies. In the latter case, column names composed of a common bin_prefix (default is "Bin.") hold the pre-binned Time-at-Depth frequencies whose depth limits are defined in bin_breaks.
bin_breaks, bin_prefix	
	bin_breaks is a numeric vector of depth bin breaks for the histogram data. In case of binned data (e.g. from standard wildlife computer histogram files), column names with a bin_prefix are expected to contain the preprossesed data (by default: Bin1, Bin2, Bin3, etc.). Alternatively, depth time series data will be directly converted using function ts2histos.
select_id, select_from	
	these arguments allow to take a direct subset of the input dataframe. select_from defines the vector whereas select_id defines the identification key(s) that should be selected.
aggregate_by	character vector defining the columns by which the tagging data should be aggregated. Should contain columns that identify tags (e.g. Serial, Ptt, DeployID) the date and/or day time period (to seperate records from night, day, dawn and dusk see classify_DayTime). Default values are: date, Day and Ptt.
date	An optional vector to select depth data of a specified date/-range.
main, xlab, ylab, labeling	
	The titles for the plot, x- and y-axes to be plotted if labeling is set TRUE (default).
xlim, adaptive.xlim	
	a vector defining the limits (x1,x2) of the x-axis, by default c(0,100). However, if adaptive.xlim is set TRUE, these limits will be overwritten, and the maximum value (xlim[2]) will be chosen from the histogram data.
split_by	Name of the logical vector by which TaD data should be splitted (e.g. daytime; see classify_DayTime).
split_levels, xlab2	
	Character vector defining the name and order of the levels of the split_by vector (e.g. c("Night", "Day") for split_by vector 'day.time'. The same groups are plotted as a second x-axis label if not defined otherwise (xlab2=split_levels).
ylab.side, ylab.line, ylab.font	
	side, line and font of second y-axis label.
xlab.side, xlab.line, xlab.font	
	side, line and font of first x-axis label.
xlab2.side, xlab2.line, xlab2.font	
	side, line and font of second x-axis labels.
main.side, main.line, main.font	
	side, line and font of plot title.
col	colours to be used for the TaD-histogram, by default 'grey' and 'white' (corresponding to the values of split_by/split_levels).
do_mid.ticks	whether centered tick-labels, indicating the depth range of histogram cells, shall be plotted (by default FALSE). Alternatively, tick labels will be indicated at the breakpoints of the histrogram cells.

yaxis.pos   x-axis coordinate at which the y-axis should be plotted (by default xlim[1], and
                thus 0).

mars   a numerical vector of the form c(bottom, left, top, right), decribing the
                number of margin lines to be specified on the each side of the plot. The default
                is c(2.1, 4.1, 6.1, 2.1). In case that do_mid.ticks is TRUE margins are:
                c(2.1, 8, 6.1, 2.1).

plot_sd, plot_nrec , plot_ntags
                whether standard deviation bars, the number of records and tags shall be plotted
                (default is TRUE) inside the TaD/TaT histogram.

cex, cex.main, cex.lab, cex.inf
                font size of the title (cex.main), x- and y-axes labels (cex.lab), and other la-
                bels, like the number of records (cex.inf).

return.sm   whether summary information of the TaD histograms, including the number of
                records per summary period, the relative frequencies per bin and corresponding
                standard deviation, should be plotted (default is TRUE).

subplot, inside
                whether the TaD histogram is a subplot or an inner plot of a figure (default is
                FALSE). If subplot or inside are set TRUE, graphic margins will not be set by
                hist_tad. In case that inside is TRUE, no axis-labels and titels wil be plotted.

Type   The Type of data to be plotted (TAD: Time-at-Depth histograms; TAT: Time-at-
                Temperature histograms)

Details

Time-at-Temperature (Tat) and Time-at-Depth (TaD) fequencies are a standard data product of
archival tags (incl. tag models TDR-Mk9, PAT-Mk10 and miniPAT by Wildlife Computers) that
allow to assess habitat preferences of tagged animals (see function read_histos). It can be likewise
generated from transmitted or recovered time series data sets using function ts2histos.

However, different depth and temperature bin breaks are often used during different deployment
programs, which makes a later comparitive analysis of TaT and TaT data difficult. For such cases,
the function combine_histos and merge_histos can be applied to merge TaT and TaD frequencies
based on common bin breaks of different tags.

The purpose of this function is the visualization of Time-at-Depth (TaD) histograms, whereas
hist_tad is the related function for Time-at-Temperature (TaT) data.

Author(s)

Robert K. Bauer

See Also

ts2histos, combine_histos, merge_histos, hist_tat

Examples

```
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
```

```
head(ts_df)

tad_breaks <- c(0, 2, 5, 10, 20, 50, 100, 200, 300, 400, 600, 2000)
tat_breaks <- c(10,12,15,17,18,19,20,21,22,23,24,27)

## example 1a) convert only DepthTS data to daily TAD frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks, do_mid.ticks = FALSE)

## convert 1b) only TemperatureTS data to daily TAT frequencies:
tat <- ts2histos(ts_df, tat_breaks = tat_breaks)
hist_tat(ts_df, bin_breaks = tat_breaks, do_mid.ticks = FALSE)
hist_tat(tat$TAT$merged, do_mid.ticks = FALSE)

## convert 1c) DepthTS & TemperatureTS data to daily TAD & TAT frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks, tat_breaks = tat_breaks)

## convert 1d) back-to-back histogram showing day vs night TAD frequencies:
ts_df$Lat <- 4; ts_df$Lon=42.5 ## required geolocations to estimate daytime
ts_df$date.long <- strptime(paste(ts_df$Day,ts_df$Time),"%d-%B-%Y %H:%M:%S")
head(ts_df)
ts_df2 <- classify_DayTime(get_DayTimeLimits(ts_df)) # estimate daytime
head(ts_df2)

ts2histos(ts_df2, tad_breaks = tad_breaks,split_by = "daytime")
hist_tad(ts_df2, bin_breaks = tad_breaks,split_by = "daytime", do_mid.ticks = FALSE)


## example 2) rebin daily TAD frequencies:
tad <- ts2histos(ts_df, tad_breaks = tad_breaks)
tad2 <- rebin_histos(hist_list = tad, tad_breaks = tad_breaks[c(1:3,6:12)])
par(mfrow=c(2,2))
hist_tad(tad, do_mid.ticks = FALSE) ## example for multiple individuals
hist_tad(tad$TAD$merged, do_mid.ticks = FALSE)
hist_tad(tad$TAD$merged, bin_breaks = tad_breaks[c(1:3,6:12)]) ## from inside hist_tad


## example 3) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks

## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
```

```
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)
```

---

hist_tat   *Time-at-Temperature histogram*

Description

generates daily or back-to-back (e.g. Day-vs-Night-) Time-at-Temperature histograms from binned
Temperature or Temperature time series data

Usage

```
hist_tat(df,
            bin_breaks=NULL, bin_prefix="Bin",
            main, xlab="Time at Temperature (%)",
            ylab=expression(paste("Temperature (",degree,"C)")), labeling=TRUE,
            Type="TAT", ...)
```

Arguments

df   dataframe that either contains Temperature time series data (as a vector "Tem-
                          perature") or several vectors of Time-at-Temperature frequencies. In the latter
                          case, vector names are composed of a common bin_prefix (default is "tad."),
                          followed by the upper Temperature limit (bin break).

bin_breaks, bin_prefix
                          bin_breaks is a numeric vector of depth bin breaks for the histogram data.
                          In case of binned data (e.g. from standard wildlife computer histogram files),
                          column names with a bin_prefix are expected to contain the preprossesed data
                          (by default: Bin1, Bin2, Bin3, etc.). Alternatively, depth time series data will be
                          directly converted using function [ts2histos](#).

main, xlab, ylab, labeling
                          The titles for the plot, x- and y-axes to be plotted if labeling is set TRUE (de-
                          fault).

Type   The Type of data to be plotted (TAD: Time-at-Depth histograms; TAT: Time-at-
                          Temperature histograms)

...   additional arguments to be passed:

select_id, select_from these arguments allow to take a direct subset of the input dataframe. select_from defines the vector whereas select_id defines the identification key(s) that should be selected.

aggregate_by character vector defining the columns by which the tagging data should be aggregated. Should contain columns that identify tags (e.g. Serial, Ptt, DeployID) the date and/or day time period (to seperate records from night, day, dawn and dusk see classify_DayTime). Default values are: date, Day and Ptt.

date An optional vector to select depth data of a specified date/-range.

xlim, adaptive.xlim a vector defining the limits (x1,x2) of the x-axis, by default c(0,100). However, if adaptive.xlim is set TRUE, these limits will be overwritten, and the maximum value (xlim[2]) will be chosen from the histogram data.

split_by Name of the logical vector by which TaD data should be splitted (e.g. daytime; see classify_DayTime).

split_levels, xlab2 Character vector defining the name and order of the levels of the split_by vector (e.g. c("Night", "Day") for split_by vector 'day.time'. The same groups are plotted as a second x-axis label if not defined otherwise (xlab2=split_levels).

ylab.side, ylab.line, ylab.font side, line and font of second y-axis label.

xlab.side, xlab.line, xlab.font side, line and font of first x-axis label.

xlab2.side, xlab2.line, xlab2.font side, line and font of second x-axis labels.

main.side, main.line, main.font side, line and font of plot title.

col colours to be used for the TaD-histogram, by default 'grey' and 'white' (corresponding to the values of split_by/split_levels).

do_mid.ticks whether centered tick-labels, indicating the depth range of histogram cells, shall be plotted (by default FALSE). Alternatively, tick labels will be indicated at the breakpoints of the histrogram cells.

yaxis.pos x-axis coordinate at which the y-axis should be plotted (by default xlim[1], and thus 0).

mars a numerical vector of the form c(bottom, left, top, right), decribing the number of margin lines to be specified on the each side of the plot. The default is c(2.1, 4.1, 6.1, 2.1). In case that do_mid.ticks is TRUE margins are: c(2.1, 8, 6.1, 2.1).

plot_sd, plot_nrec , plot_ntags whether standard deviation bars, the number of records and tags shall be plotted (default is TRUE) inside the TaD/TaT histogram.

cex, cex.main, cex.lab, cex.inf font size of the title (cex.main), x- and y-axes labels (cex.lab), and other labels, like the number of records (cex.inf).

return.sm whether summary information of the TaD histograms, including the number of records per summary period, the relative frequencies per bin and corresponding standard deviation, should be plotted (default is TRUE).

subplot, inside whether the TaD histogram is a subplot or an inner plot of a figure (default is FALSE). If subplot or inside are set TRUE, graphic margins will not be set by hist_tat. In case that inside is TRUE, no axis-labels and titels wil be plotted.

Details

Time-at-Temperature (Tat) and Time-at-Depth (TaD) fequencies are a standard data product of archival tags (incl. tag models TDR-Mk9, PAT-Mk10 and miniPAT by Wildlife Computers) that allow to assess habitat preferences of tagged animals (see function read_histos). It can be likewise generated from transmitted or recovered time series data sets using function ts2histos.

However, different depth and temperature bin breaks are often used during different deployment programs, which makes a later comparitive analysis of TaT and TaT data difficult. For such cases, the function combine_histos and merge_histos can be applied to merge TaT and TaD frequencies based on common bin breaks of different tags.

The purpose of this function is the visualization of Time-at-Temperature (TaT) histograms, whereas hist_tad is the related function for Time-at-Depth (TaD) data.

Author(s)

Robert K. Bauer

See Also

ts2histos, combine_histos, merge_histos, hist_tad

Examples

```
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
head(ts_df)

tad_breaks <- c(0, 2, 5, 10, 20, 50, 100, 200, 300, 400, 600, 2000)
tat_breaks <- c(10,12,15,17,18,19,20,21,22,23,24,27)

## example 1a) convert only DepthTS data to daily TAD frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks, do_mid.ticks = FALSE)

## convert 1b) only TemperatureTS data to daily TAT frequencies:
tat <- ts2histos(ts_df, tat_breaks = tat_breaks)
hist_tat(ts_df, bin_breaks = tat_breaks, do_mid.ticks = FALSE)
hist_tat(tat$TAT$merged, do_mid.ticks = FALSE)

## convert 1c) DepthTS & TemperatureTS data to daily TAD & TAT frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks, tat_breaks = tat_breaks)

## convert 1d) back-to-back histogram showing day vs night TAD frequencies:
ts_df$Lat <- 4; ts_df$Lon=42.5 ## required geolocations to estimate daytime
ts_df$date.long <- strptime(paste(ts_df$Day,ts_df$Time),"%d-%B-%Y %H:%M:%S")
head(ts_df)
ts_df2 <- classify_DayTime(get_DayTimeLimits(ts_df)) # estimate daytime
head(ts_df2)

ts2histos(ts_df2, tad_breaks = tad_breaks,split_by = "daytime")
```

```
hist_tad(ts_df2, bin_breaks = tad_breaks,split_by = "daytime", do_mid.ticks = FALSE)


## example 2) rebin daily TAD frequencies:
tad <- ts2histos(ts_df, tad_breaks = tad_breaks)
tad2 <- rebin_histos(hist_list = tad, tad_breaks = tad_breaks[c(1:3,6:12)])
par(mfrow=c(2,2))
hist_tad(tad, do_mid.ticks = FALSE) ## example for multiple individuals
hist_tad(tad$TAD$merged, do_mid.ticks = FALSE)
hist_tad(tad$TAD$merged, bin_breaks = tad_breaks[c(1:3,6:12)]) ## from inside hist_tad


## example 3) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks

## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)
```

---

image_TempDepthProfiles

plots interpolated daily temperature at depth profiles

Description

plots interpolated daily temperature at depth profiles, thus faciliating the analysis of temporal changes of temperature profiles, for instance, in relation to animal behaviour (e.g. diving behaviour). See Bauer et al. (2015) for further examples.

Usage

```
image_TempDepthProfiles(x, main=NULL, xlab='Date', ylab="Depth (m)",
                  cb.xlab=expression(paste("Temperature (",degree,"C)")),
                  cex.cb.xlab=1, cex.cb.ticks=1,
              xlim, ylim, zlim, pal="jet", only.months, month.line, mars, ...)
```

Arguments

x   A list , generated by interpolate_TempDepthProfiles or interpolate_PDTs, con-
                     taining interpolated temperature at depth profiles and their corresponding date
                     and interpolated depth values as well as a summary table with the original depth
                     values and their number per day:

                     $ Temperature_matrix: num
                     $ Depth : num
                     $ Date :Date
                     $ sm :data.frame

main, xlab, ylab
                     the title, x- and y-axis labels to be plotted.

cb.xlab   character string indicating the x-axis label of the colorbar.

cex.cb.xlab, cex.cb.ticks
                     cex.cb.xlab: font size of the x-axis label of the colorbar (by default 1). *cex.cb.ticks*:
                     font size of the x-axis tick labels of the colorbar (by default 1).

xlim, ylim, zlim
                     the x, y and z limits of the plot.

pal   color map to be plotted (default is 'jet'). See cmap for available color maps.

only.months, month.line
                     whether only mid-months shall be plotted as tick labels of the x-axis (by de-
                     fault FALSE for time ranges of less than 3 months (93 days)). In case, that
                     only.months is set TRUE, month.line defines the line where the month labels
                     shall be plotted.

mars   a numerical vector defining the plot margins c(bottom, left, top, right)
                     (by default c(5,4,4,9)).

...   additional arguments to be passed to set.colorbarp

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the
accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanogra-
phy, 24(6): 533-539, doi: 10.1111/fog.12127

See Also

read_PDT, bin_TempTS, get_thermalstrat, image_TempDepthProfiles

Examples

```
#### example 1) run on PDT file:
## step I) read sample PDT data file:
path <- system.file("example_files",package="RchivalTag")
PDT <- read_PDT("104659-PDTs.csv",folder=path)
head(PDT)
#
# ## step II) interpolate average temperature fields (MeanPDT) from PDT file:
# m <- interpolate_PDTs(PDT)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
# ## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
#
#
# #### example 2) run on time series data:
# ## step I) read sample time series data file:
# DepthTempTS <- read.table(system.file("example_files/104659-Series.csv",
#                                        package="RchivalTag"),header = TRUE,sep=',')
# DepthTempTS$date <- as.Date(DepthTempTS$Day,"%d-%b-%Y")
# head(DepthTempTS)
#
#
# ## step Ib) bin temperature data on 10m depth bins
# ##          to increase later estimate accuracy (see Bauer et al. 2015):
# # DepthTempTS_binned <- bin_TempTS(DepthTempTS,res=10)
#
# ## step II) interpolate average temperature fields (MeanTemp) from binned data:
# m <- interpolate_TempDepthProfiles(DepthTempTS)
# # m <- interpolate_PDTs(DepthTempTS_binned)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
# ## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
```

---

interpolate_TempDepthProfiles

interpolate daily temperature at depth profiles

Description

interpolates depth-temperature data and returns daily average temperature at depth profiles on a user-specified resolution (`Depth_res`).

Results are returned as a list containing the interpolated Temperature-matrix, and the corresponding date and depth values. Thus interpolated temperature at depth profiles can be visualized using function image_TempDepthProfiles and faciliates the analysis of temporal changes of temperature profiles, for instance, in relation to animal behaviour (e.g. diving behaviour).

Usage

```
interpolate_TempDepthProfiles(ts, Temp_field="Temperature", ID_key="Serial",
                              Depth_res=.5, show_info=TRUE, Data_Source='station')

interpolate_PDTs(ts, Temp_field="MeanPDT", ID_key="Serial", #return_as_matrix=FALSE,
                 Depth_res=.5, show_info=TRUE, Data_Source='station')
```

Arguments

ts, Temp_field, ID_key

> `ts` is a data.frame with temperature at depth data. Required columns are `Depth` for the depth data and a column containing temperature data, whose name is defined by `Temp_field`. `ID_key` specifies the name of an optional column on which sampling stations or tags can be distinguished (by default `Serial`).

Depth_res   numeric value, defining the depth resolution at which the temperature data should be interpolated.

show_info   whether the sampling dates and ids of stations or tags, as defined by the columns date and `ID_key`, should be indicated during the interpolation process.

Data_Source   a character string, defining the data source (by default `station`).

Value

A list containing the interpolated temperature at depth profiles and their corresponding date and interpolated depth values as well as a summary table with the original depth values and their number per day:

$ Data_Source.ID_key:List of 4
..$ Temperature_matrix: num
..$ Depth : num
..$ Date :Date
..$ sm :data.frame

Please see the examples for further understaning.

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanography, 24(6): 533-539, doi: 10.1111/fog.12127

See Also

read_PDT, bin_TempTS, get_thermalstrat, image_TempDepthProfiles

Examples

```
#### example 1) run on PDT file:
## step I) read sample PDT data file:
path <- system.file("example_files",package="RchivalTag")
PDT <- read_PDT("104659-PDTs.csv",folder=path)
head(PDT)
#
# ## step II) interpolate average temperature fields (MeanPDT) from PDT file:
# m <- interpolate_PDTs(PDT)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
# ## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
#
#
# #### example 2) run on time series data:
# ## step I) read sample time series data file:
# DepthTempTS <- read.table(system.file("example_files/104659-Series.csv",
#                                        package="RchivalTag"),header = TRUE,sep=',')
# DepthTempTS$date <- as.Date(DepthTempTS$Day,"%d-%b-%Y")
# head(DepthTempTS)
#
#
# ## step Ib) bin temperature data on 10m depth bins
# ##          to increase later estimate accuracy (see Bauer et al. 2015):
# # DepthTempTS_binned <- bin_TempTS(DepthTempTS,res=10)
#
# ## step II) interpolate average temperature fields (MeanTemp) from binned data:
# m <- interpolate_TempDepthProfiles(DepthTempTS)
# # m <- interpolate_PDTs(DepthTempTS_binned)
# str(m)
# m$sm
#
# ## step III) calculate thermal stratifcation indicators per day (and tag):
# get_thermalstrat(m, all_info = TRUE)
# get_thermalstrat(m, all_info = FALSE)
#
```

```
# ## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
```

---

merge_histos   *merge and/or rebin TAD/TAT-frequency data*

Description

The joint analysis of archival tagging data from different tagging programs is often hampered by differences in the tags' setups, e.g. by the user-specified temporal resolution of time series data or the definition of summary data products. The latter particuarly concerns different selected bin breaks of Time-at-Depth (TAD) and Time-at-Temperature (TAT) frequency data from archival tags by Wildlife Computers.

The purpose of this function is to allow:

1) a grouping of TAD and TAT data from multiple tags based on similiar bin breaks (For this, run the function with default statements, i.e. force_merge is FALSE),

2) merging (rebinning) of TAD and TAT data from multiple tags based on the bin breaks that all tags have in common (To do so, run the function with force_merge set TRUE).

3) merging (rebinning) of TAD and TAT data from multiple tags based on new user-specified tad_breaks and/or tat_breaks. In this case, the force_merge-statements TRUE and FALSE will omit or seperately group tags that do not share all user-specified bin breaks, respectively.

To combine of TAD/TAT data of several hist_lists, see combine_histos.

To visualize Time-at-Temperature (TaT) and Time-at-Depth (TaD) data, please see hist_tat and hist_tad, respectively.

Usage

```
merge_histos(hist_list, tad_breaks=NULL, tat_breaks=NULL, force_merge=FALSE)
rebin_histos(hist_list, tad_breaks=NULL, tat_breaks=NULL, force_merge=FALSE)
```

Arguments

hist_list   A list-of-lists containing the TAD and TAT frequency data and the corresponding
                bin_breaks from one or several tags.

tad_breaks   a numeric vector defining the bin_breaks for the merging (rebinning) of the
                TAD frequency data.
                In case that the additional argument force_merge is set TRUE, only tags whose
                original TAD bin breaks included all of the user-specified tad_breaks will be
                merged in a single group ('merged') based on the new bin breaks, while other

tags will be omitted in the output. By contrast, if `force_merge` is set `FALSE`, tags that do not contain all specified `tad_breaks` will be merged in seperate groups (group2, group3, etc.), based on similar `bin_breaks`.

`tat_breaks`   a numeric vector defining the `bin_breaks` for the merging (rebinning) of the TAT frequency data.

In case that the additional argument `force_merge` is set `TRUE`, only tags whose original TAT bin breaks included all of the user-specified `tat_breaks` will be merged in a single group ('merged') based on the new bin breaks, while other tags will be omitted in the output. By contrast, if `force_merge` is set `FALSE`, tags that do not contain all specified `tat_breaks` will be merged in seperate groups (group2, group3, etc.), based on similar `bin_breaks`.

`force_merge`   If `FALSE` (default), groups of tags with similar TAD and TAT-`bin_breaks` will be combined (no merging on new bin breaks) and identifier labels renamed as group1, group2, etc.

If set `TRUE`, TAD and TAT frequency data will be merged on user-specified `tad/tat_breaks` or, if those arguments are missing, on the `bin_breaks` that all tags have in common. In both latter cases, identifier labels will be renamed "merged".

Value

A list-of-lists of grouped or merged TAD and TAT frequency data.

$ TAD:List
..$ group1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
$ TAT:List
..$ group1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
..$ group2 : List of 2
...

Author(s)

Robert K. Bauer

See Also

unmerge_histos, combine_histos, hist_tad

Examples

```
## example 1) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks
```

```
## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)
```

plot_geopos   *plot geolocation estimates derived from archival tagging data*

Description

In case that geolocations are provided by csv-files or data frames, line and scatter plots are imple-
mented. In case of ncdf-files, generated by the Wildlife Computers-data portal, are selected, surface
probability maps are illustrated. The latter procedure is based on the R-code given in the location
processing user guide by Wildlife Computers.

Usage

```
plot_geopos(file, pos, xlim, ylim,
            prob_lim=.75, pal="jet", alpha=70, type="p", pch=19, add=FALSE, ...)
```

Arguments

file	path and file name of .csv or .nc-file.
pos	alternative data.frame containing horziontal position records (allowed column names are 'Most.Likely.Longitude', 'Longitude' or 'Lon' and 'Most.Likely.Latitude', 'Latitude' or 'Lat', respectively.
xlim, ylim	Numeric vector, defining the limts of the x and y-axes.
prob_lim	in case that a netcdf-file (.nc) is selected, the value defines the limit of the prob-ability surfaces in % (By default 75%). Otherwise ignored.
pal	color map to be plotted in case of polygon (.nc-files) or scatter plots (default is the 'jet'-colormap). See cmap for pre-installed color maps. Note that tracking data with constant time steps is being assumed in the color assignment. To verify this, a data.frame containing the colors at each time steps will be returned for polygon and scatter plots.

alpha	transparency of polygons and dots to be plotted in percent (By default 70%).
type	character string giving the type of plot desired. The following values are possible, for details (By default "p" for points, but "l" for lines is also implemented).
pch	dot-type to be plotted if 'points' have been selected (By default '19' for solid dots).
add	whether the a the plot should be added to an existent figure (default is FALSE)
...	additional arguments to be passed to plot.

Author(s)

Robert K. Bauer

See Also

plotmap, plot_DepthTS, hist_tat, hist_tad

Examples

```
## example 1a) line plot from csv-file:
csv_file <- system.file("example_files/15P1019-104659-1-GPE3.csv",package="RchivalTag")
plot_geopos(csv_file, type='l', add=FALSE) ## show tracks as line plot

## example 1b) scatter plot from csv-file on existing landmask:
require('oceanmap')
plotmap('lion') ## use keyword to derive area limits
plot_geopos(csv_file, add=TRUE) ## show tracks as scatter plot

## example 1c) scatter plot from csv-file on existing landmask:
require('oceanmap')
plotmap('lion') ## use keyword to derive area limits
pos <- read.csv(csv_file, header = TRUE, sep = ",", skip = 5)
plot_geopos(file="",pos=pos, add=TRUE) ## show tracks as scatter plot


## example 2) probability surfaces of horizontal tracks from nc-file:
## this can take some time as it inlcudes time consuming data processing
nc_file <- system.file("example_files/15P1019-104659-1-GPE3.nc",package="RchivalTag")
# plot_geopos(nc_file)
```

---

plot_TS	*plot time series data*

Description

plotting functions for time series data (e.g. depth or temperature time series data from archival tags) with user specified xtick intervals.

Usage

```
plot_DepthTS(df, y="Depth", xlim, ylim, xticks_interval,
              ylab=y, xlab="Time (UTC)", main, main.line=1, plot_info=TRUE,
              ID, ID_label="Serial",
              plot_DayTimePeriods=TRUE, twilight.set="ast",
              type="l", las=1, xaxs="i", yaxs="i", cex=1,
              plot_box=TRUE, bty="l", Return=FALSE, ...)

plot_TS(df, y="Depth", xlim, ylim, xticks_interval,
        ylab=y, xlab="Time (UTC)", main, main.line=1, plot_info=TRUE,
        ID, ID_label="Serial",
        plot_DayTimePeriods=TRUE, twilight.set="ast",
        type="l", las=1, xaxs="i", yaxs="i", cex=1,
        plot_box=TRUE, bty="l", Return=FALSE, ...)

empty.plot_TS(xlim, ylim, xticks_interval, ylab="", xlab="Time (UTC)",
              las=1, xaxs="i", yaxs="i", cex=1,
              plot_box=TRUE, bty="l", ...)
```

Arguments

df	[data.frame](#) holding the time series data to be plotted, including the x-vector 'date.long' (in POSIXct-format and UTC), and the numeric y-vector whose label is defined by y.
y	character label of time series vector to be plotted (by default 'Depth').
xlim	the x limits (x1, x2) of the plot (by default range(df$date.long), but needs to be specified in empty.plot_TS).
ylim	the y limits of the plot (by default range(df[[y]]), but needs to be specified in empty.plot_TS).
xticks_interval	
	time step of the x-axis ticklabels in (full) hours. By default 3 hours for xlim differences <= 1 day, and 6 hours for differences > 1 day.
ylab, xlab	the y- and x-axis labels.
main, main.line	
	main title (by default "Tag ID") for the plot and its line (see [mtext](#) for reference).
plot_info	wheather the plot title and axes labels should be shown (by default TRUE).
ID, ID_label	Tag ID and its label (column name; by default "Serial") to be selected (e.g. if input data frame holds tagging data from several tags).
type	what type of plot should be drawn. Possible types are:

- "p" for points,
- "l" for lines (default),
- "b" for both,
- "c" for the lines part alone of "b",
- "o" for both 'overlapped',

           • "n" for nothing (similar to empty.plot_TS-function call)

las   numeric in 0,1,2,3; the style of axis labels.

                     0: always parallel
                     1: always horizontal (default)
                     3: always perpendicular
                     4: always vertical

xaxs, yaxs   The style of axis interval calculation to be used for the x-and y-axes. Possible values are "r" and "i" (default). The styles are generally controlled by the range of data or xlim, if given.

                  Style "r" (regular) first extends the data range by 4 percent at each end and then finds an axis with pretty labels that fits within the extended range.

                  Style "i" (internal) just finds an axis with pretty labels that fits within the original data range.

cex   The standard font size (by default 1). Attention, the (internal) standard font size of axis labels cex.axis is 0.9*cex and the plot title cex.main= 1.2*cex.

plot_DayTimePeriods, twilight.set

                  whether day-time periods ('Night', 'Dawn', 'Day', 'Dusk') should be plotted as shaded areas. In case that plot_DayTimePeriods is set TRUE), the limits of each time period are required (columns sunrise, sunset, dawn.ast,/dawn.naut and dawn.ast/dawn.naut in POSIXct-format. In case of the twilight events, the additional argument twilight.set defines the suffix of the twlight-set to be selected ("ast" for astronomical dawn and dusks vs "naut" for nautical twilight events). If any of the day-time columns, described above, is missing, it/they will be calculated based on geolocation estimates (required columns Lon and Lat) through an internal call of function get_DayTimeLimits.

plot_box, bty   whether a box of box-type bty should be plotted (by default TRUE. bty is one of "o" (the default), "l", "7", "c", "u", or "]" the resulting box resembles the corresponding upper case letter.

Return   whether edited time series data set should be returned (by default FALSE).

...   additional arguments to be passed to [plot](#).

Author(s)

Robert K. Bauer

See Also

[hist_tad](#), [hist_tat](#)

Examples

```
### load sample depth and temperature time series data from miniPAT:
```

```
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
head(ts_df)
ts_df$date.long <- as.POSIXct(strptime(paste(ts_df$Day, ts_df$Time),
                                       "%d-%b-%Y %H:%M:%S",tz = "UTC"))
ts_df$date <- as.Date(ts_df$date.long)

### select subsets (dates to plot)
# plot_DepthTS(ts_df, plot_DayTimePeriods = FALSE, xlim = unique(ts_df$date)[2:3])
# xlim <- c("2016-08-10 6:10:00", "2016-08-11 17:40:00")
# plot_DepthTS(ts_df, plot_DayTimePeriods = FALSE, xlim = xlim)

### check xtick time step:
# plot_DepthTS(ts_df, plot_DayTimePeriods = FALSE, xlim = "2016-08-10")
# plot_DepthTS(ts_df, plot_DayTimePeriods = FALSE, xlim = "2016-08-10", xticks_interval = 2)


### add daytime periods during plot-function call and return extended data set
# ts_df$Lon <- 5; ts_df$Lat <- 43
# plot_DepthTS(ts_df, plot_DayTimePeriods = TRUE, xlim = unique(ts_df$date)[2:3])
# ts_df2 <- plot_DepthTS(ts_df, plot_DayTimePeriods = TRUE, Return = TRUE)
# names(ts_df)
# names(ts_df2)

### add daytime periods before function call
# ts_df_extended <- get_DayTimeLimits(ts_df)
# plot_DepthTS(ts_df_extended, plot_DayTimePeriods = TRUE)
# plot_DepthTS(ts_df_extended, plot_DayTimePeriods = TRUE, twilight.set = "naut")

### introduce data transmission gaps that are then filled internally
### as well as daytime periods based on interpolated Lon & Lat positions
# ts_df_cutted <- ts_df[-c(200:400, 1800:2200), ]
# plot_DepthTS(ts_df_cutted, plot_DayTimePeriods = FALSE)
# plot_DepthTS(ts_df_cutted, plot_DayTimePeriods = TRUE)

### example for empty.plotTS and adding time series data as line:
# empty.plot_TS(xlim="2016-08-10",ylim=c(100,0))
# lines(ts_df$date.long, ts_df$Depth)

### alternative:
# plot_DepthTS(ts_df, xlim=c("2016-08-10","2016-08-12"), plot_DayTimePeriods = TRUE, type='n')
# lines(ts_df$date.long, ts_df$Depth)
```

RchivalTag   *RchivalTag - Analyzing Archival Tagging Data*

Description

RchivalTag provides a set of functions to analyze and visualize (aquatic) archival tagging data,
including:

- "(Depth) time series data" (See empty.plot_TS, plot_TS & plot_DepthTS)

- "Time-at-Depth (TaD) and Time-at-Temperature (TaT) fequencies" (See ts2histos, merge_histos, hist_tad & hist_tat)

- "Depth Temperature profiles (time series data)" (See interpolate_TempDepthProfiles, get_thermalstrat & image_TempDepthProfiles)

- "PDT (PAT-style Depth Temperature profiles) data" (See read_PDT, interpolate_TempDepthProfiles, get_thermalstrat & image_TempDepthProfiles)

- "visualization of geolocation estimates" (See: plot_geopos)

Details

TaD-/TaT-histogram data
- The package allows to read and calculate standard summary data products (TaD-/TaT-profiles, see above) from recovered or transmitted time series data sets as well as to merge and visualize such summary data products from different tag setups/tagging programs. For more information on these data products, please see: Wildlife Computers (2016).

Depth time series data
- data visualization, optionally highlighting daytime differences (dawn, day, dusk, night).

Depth-temperature time series data
- data visualization and examination of the thermal stratification of the water column (i.e. thermocline depth, gradient and stratification index), based on previously interpolated. The paper by Bauer et al. (2015) is highly recommended in this context.

Compatibility
So far, the package is mainly adapted for archival tagging data from Wildlife Computers, but can also be applied to data from other tag manufacturers (e.g. see ts2histos in order to calculate TaD & TaT-frequencies from time series data). Function examples are based on the transmitted data sets of a miniPAT-tag from the BLUEMED-project `http://bluemed-project.com/`, funded by the French National Research Agency (ANR; `http://www.agence-nationale-recherche.fr`).

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanography, 24(6): 533-539, doi: 10.1111/fog.12127

Wildlife Computers (2016) MiniPAT-User-Guide, 4 April 2016, 26 pp. `http://wildlifecomputers.com/wp-content/uploads/manuals/MiniPAT-User-Guide.pdf`

---

read_histos   *reads a TAD/TAT-histogram file from archival tags*

Description

reads or posttreats a manually loaded standard histogram data file, containing Time-at-Depth (TAD) and Time-at-Temperature (TAT) frequency data, from archival tags by Wildlife Computers.

Usage

```
read_histos(hist_file)
```

Arguments

hist_file   character string indicating the name of a standard Wildlife Computers file to read or the data.frame of a manually loaded histogram data file. The Date-vector of the file is expected to be or the format "%H:%M:%S %d-%b-%Y, tz='UTC'". The combination of the columns DeployID, Ptt and Serial is assumed to provide an unique key to distinguish data from indiviudal tags.

Details

This function reads or posttreats a manually loaded standard Wildlife Computers histogram file including Time-at-Depth (TAD) and Time-at-Temperature (TAT) frequency data. In the post-treatment, the histogram data is split in lists of TAD and TAT per individual (see below). Thus processed data from several histogram files (or similarly processed time series data) can be combined using the function combine_histos. Merging of histogram data from several tags, based on similar or user-specified TAD and TAT-bin_breaks, can be done by applying function merge_histos. To generate TAD/TAT histogram data from depth and temperature time series data, see ts2histos.

Value

A list-of-lists containing the loaded histogram data. Lists of TAD and TAT data are distinguished at the first nesting level. Further sublists include the bin_breaks and data.frames of the histogram data per tag (ID). Tag IDs are constructed based on the columns DeployID, Ptt and Serial keys (e.g. DeployID.101_Ptt.102525). **The data.frames of the histogram data also contain average (avg) and standard deviation (SD) of depth and temperature values that are estimated internally from the TAD and TAT data sets (not measured!). The accuracy of these estimates thus depends on the number and selection of bin breaks**, unlike ts2histos-generated values that are directly estimated from time series data. See statistics-example below.

$ TAD:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
.. .. ..$ DeployID
.. .. ..$ Ptt
.. .. ..$ date.long

.. .. ..$ date
.. .. ..$ Bin1
.. ..$ Bin? (up to number of bin breaks)
.. .. ..$ avg (average depth estimated!! from histogram data)
.. .. ..$ SD (average depth estimated!! from histogram data)

$ TAT:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame (with columns as above)
..$ ID2 : List of 2
...

Author(s)

Robert K. Bauer

See Also

ts2histos, combine_histos, merge_histos, hist_tad, hist_tat

Examples

```
## example 1) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks

## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)

## part VI - statistics:
# get histogram data with histogram-derived average depth and temperature values
```

```
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
avg1 <- hist_dat_1$TAD$DeployID.15P1019_Ptt.104659$df$avg # infered from the histogram data

# generate histogram data and average/sd-estimates from depth time series data of the same tag.
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")

tad_breaks <- c(0, 2, 5, 10, 20, 50, 100, 200, 300, 400, 600, 2000)
hist_dat_2 <- ts2histos(ts_df, tad_breaks = tad_breaks)
avg2 <- hist_dat_2$TAD$merged$df$avg # directly estimated from the depth time series data

# check accuracy of average depth values:
plot(avg1, avg2)
avg1-avg2
```

---

read_PDT   *read PDT data from archival one or multiple tags*

Description

reads PDT data (PAT-style Depth Temperature profiles) from archival tags by Wildlife Computers).
The PDT file can contain data from one or multiple tags.

What are PDTs?
PDT data provides minimum and maximum water temperatures during a user-programmed interval
(usually 24h) at 8 to 16 depths. The sampled depths are thereby rounded (binned) to multiples of 8
and include the minimum and maximum depth bins as well as the 6 to 14 most frequent depth bins
at which the tagged animal was located. The total number of depth bins (8 or 16) also depends on
the tagged animals' behaviour. If the animal was in waters deeper than 400 m during the summary
data period, the range of temperature at 16 depth bins will be reported, otherwise 8.

Why using PDT data?
Despite its low resolution, PDT data can give accurate information on the in-situ thermal stratifi-
cation of the water column (e.g. thermocline depth, stratification index, ocean heat content) ex-
perienced by the tagged animal, as illustrated by Bauer et al. (2015). Accordingly, PDT data can
provide precious insights into the relations between animal behaviour and environmental condi-
tions. See the example section below on how to obtain thermal stratification indicators of the water
column from PDT data.

For instance, daily PDT data can be interpolated and then visualized using functions interpo-
late_PDTs and image_TempDepthProfiles, respectively. This faciliates the analysis of temporal
changes of temperature profiles, for instance, in relation to animal behaviour (e.g. diving be-
haviour).

Usage

```
read_PDT(pdt_file, folder, sep=",")
```

Arguments

pdt_file	character string indicating the name of a standard PDT-file. The Date-vector of the file is expected to be or the format "%H:%M:%S %d-%b-%Y, tz='UTC'".
folder	path to pdt-file.
sep	the field separator character. Values on each line of the file are separated by this character (default is ',').

Value

A [data.frame](#) with the columns:
"pdt_file", "DeployID", "Ptt", "NumBins", "Depth", "MinTemp", "MaxTemp", "date.long", "date", "MeanPDT"
Attention: Column "MeanPDT" is not measured but calculated as the average of "MinTemp" and "MaxTemp" values.

Author(s)

Robert K. Bauer

References

Bauer, R., F. Forget and JM. Fromentin (2015) Optimizing PAT data transmission: assessing the accuracy of temperature summary data to estimate environmental conditions. Fisheries Oceanography, 24(6): 533-539, doi: 10.1111/fog.12127

See Also

bin_TempTS, interpolate_PDTs, image_TempDepthProfiles

Examples

```
## step I) read sample PDT data file:
path <- system.file("example_files",package="RchivalTag")
PDT <- read_PDT("104659-PDTs.csv",folder=path)
head(PDT)

## step II) interpolate average temperature fields (MeanPDT) from PDT file:
# m <- interpolate_PDTs(PDT)
# str(m)
# m$sm

## step III) calculate thermal stratifcation indicators per day (and tag):
# strat <- get_thermalstrat(m, all_info = TRUE)
# strat <- get_thermalstrat(m, all_info = FALSE)

## step IV) plot interpolated profiles:
# image_TempDepthProfiles(m$station.1)
```

---

resample_TS   *resample time series data at a lower resolution*

Description

resample time series data at a lower resolution

Usage

```
resample_TS(df, tstep)
```

Arguments

df   [data.frame](#) holding the time series data to be resampled, including a 'date.long'-
              vector (in POSIXct-format and UTC).

tstep   numeric vector indicating the resampling resolution in seconds).

Author(s)

Robert K. Bauer

See Also

[plot_TS](#)

Examples

```
### load sample depth and temperature time series data from miniPAT:
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
head(ts_df)
ts_df$date.long <- as.POSIXct(strptime(paste(ts_df$Day, ts_df$Time),
                              "%d-%b-%Y %H:%M:%S",tz = "UTC"))

tsims <- resample_TS(ts_df,600)
length(tsims)
```

---

ts2histos	*convert depth and temperature time series data to discrete Time-at-Depth and Time-at-Temperature data (histogram data)*

Description

convert depth and temperature time series data to discrete Time-at-Depth (TaD) and Time-at-Temperature (TaT) data (histogram data) at user-defined breakpoints

Usage

```
ts2histos(ts_df, tad_breaks=NULL, tat_breaks=NULL, split_by=NULL, aggregate_by="Ptt")
```

Arguments

ts_df
: dataframe of depth time series data. Obligatory columns are the numeric vector "Depth", "date" (of class Date) and "Serial". split.by defines an optional vector to consider (e.g. day.period).

tad_breaks, tat_breaks
: a numeric vector, defining the depth and/or temperature breakpoints of the histogram cells.

split_by
: Name of the logical vector by which TaD/TaT data shall be splitted (e.g. daytime; see classify_DayTime).

aggregate_by
: character vector defining the columns by which the tagging data should be aggregated. Should contain columns that identify tags (e.g. Serial, Ptt, DeployID) the date and/or day time period (to seperate records from night, day, dawn and dusk see classify_DayTime). Default values are: date, Day and Ptt.

Details

Time-at-Depth and Time-at-Temperature fequencies (histograms) are a standard data product of archival tags (incl. tag models TDR-Mk9, PAT-Mk10 and miniPAT by Wildlife Computers) that allow to assess habitat preferences of tagged animals. It can be likewise generated from transmitted or recovered time series data sets, which is the purpose of this function.

However, different depth and temperature bin breaks are often used during different deployment programs, which makes a later comparitive analysis of TaT and TaD data difficult. For such cases, the functions combine_histos and merge_histos can be applied to merge TaT and TaD frequencies based on common bin breaks of different tags.

To visualize Time-at-Temperature (TaT) and Time-at-Depth (TaD) data, please see hist_tat and hist_tad, respectively.

Value

A list-of-lists containing the loaded histogram data. Lists of TAD and TAT data are distinguished at the first nesting level. Further sublists include the bin_breaks and data.frames of the generated histogram data. **The data.frames of the histogram data thereby also contain average (avg) and**

standard deviation (SD) of depth and temperature values that are likewise directly estimated from time series data, unlike read_histos-generated values that are estimated from the histogram data. The accuracy of latter estimates thus depends on the number and selection of bin breaks (see statistics-example in read_histos).

$ TAD:List
..$ merged : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
.. .. ..$ DeployID
.. .. ..$ Ptt
.. .. ..$ date.long
.. .. ..$ date
.. .. ..$ Bin1
.. ..$ Bin? (up to number of bin breaks)
.. .. ..$ avg (average depth estimated!! from histogram data)
.. .. ..$ SD (average depth estimated!! from histogram data)

$ TAT:List
..$ merged : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame (with columns as above)

Author(s)

Robert K. Bauer

See Also

read_histos, hist_tad, merge_histos

Examples

```
### load sample depth and temperature time series data from miniPAT:
ts_file <- system.file("example_files/104659-Series.csv",package="RchivalTag")
ts_df <- read.table(ts_file, header = TRUE, sep = ",")
head(ts_df)

tad_breaks <- c(0, 2, 5, 10, 20, 50, 100, 200, 300, 400, 600, 2000)
tat_breaks <- c(10,12,15,17,18,19,20,21,22,23,24,27)


## example 1a) convert only DepthTS data to daily TAD frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks)
hist_tad(ts_df, bin_breaks = tad_breaks, do_mid.ticks = FALSE)

## convert 1b) only TemperatureTS data to daily TAT frequencies:
tat <- ts2histos(ts_df, tat_breaks = tat_breaks)
hist_tat(ts_df, bin_breaks = tat_breaks, do_mid.ticks = FALSE)
```

```
hist_tat(tat$TAT$merged, do_mid.ticks = FALSE)

## convert 1c) DepthTS & TemperatureTS data to daily TAD & TAT frequencies:
ts2histos(ts_df, tad_breaks = tad_breaks, tat_breaks = tat_breaks)

## convert 1d) back-to-back histogram showing day vs night TAD frequencies:
ts_df$Lat <- 4; ts_df$Lon=42.5 ## required geolocations to estimate daytime
ts_df$date.long <- strptime(paste(ts_df$Day,ts_df$Time),"%d-%B-%Y %H:%M:%S")
head(ts_df)
ts_df2 <- classify_DayTime(get_DayTimeLimits(ts_df)) # estimate daytime
head(ts_df2)

ts2histos(ts_df2, tad_breaks = tad_breaks,split_by = "daytime")
hist_tad(ts_df2, bin_breaks = tad_breaks,split_by = "daytime", do_mid.ticks = FALSE)


## example 2) rebin daily TAD frequencies:
tad <- ts2histos(ts_df, tad_breaks = tad_breaks)
tad2 <- rebin_histos(hist_list = tad, tad_breaks = tad_breaks[c(1:3,6:12)])
par(mfrow=c(2,2))
hist_tad(tad, do_mid.ticks = FALSE) ## example for multiple individuals
hist_tad(tad$TAD$merged, do_mid.ticks = FALSE)
hist_tad(tad$TAD$merged, bin_breaks = tad_breaks[c(1:3,6:12)]) ## from inside hist_tad
```

---

unmerge_histos	*unmerge previously grouped or merged lists of TAD/TAT frequency data*

Description

This function unmerges previously grouped or merged lists of TAD/TAT frequency data, and thus allows to add TAD/TAT lists from new tags (see combine_histos).

Usage

```
unmerge_histos(hist_list)
```

Arguments

hist_list   A previously grouped or merged list-of-lists to be unmerged (seperated by tags).

Value

A list-of-lists of ungrouped/unmerged TAD and TAT frequency data.

$ TAD:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num

.. ..$ df : data.frame
$ TAT:List
..$ ID1 : List of 2
.. ..$ bin_breaks: num
.. ..$ df : data.frame
..$ ID2 : List of 2
...

Author(s)

Robert K. Bauer

See Also

combine_histos, merge_histos, hist_tad

Examples

```
## example 1) read, merge and plot TAD frequency data from several files:
## part I - read histogram data from two files:
hist_dat_1 <- read_histos(system.file("example_files/104659-Histos.csv",package="RchivalTag"))
hist_dat_2 <- read_histos(system.file("example_files/104659b-Histos.csv",package="RchivalTag"))
## note the second list is based on the same data (tag), but on different bin_breaks

## part II - combine TAD/TAT frecuency data from seperate files in one list:
hist_dat_combined <- combine_histos(hist_dat_1, hist_dat_2)
par(mfrow=c(2,1))
hist_tad(hist_dat_combined)
hist_tat(hist_dat_combined)

## part III - force merge TAD/TAT frecuency data from seperate files
# in one list, by applying common bin_breaks:
hist_dat_merged <- merge_histos(hist_dat_combined,force_merge = TRUE)
hist_tad(hist_dat_merged)
hist_tat(hist_dat_merged)

## part IV - plot merged data:
hist_tad(hist_dat_merged) # of all tags
unique(hist_dat_merged$TAD$merged$df$DeployID) ## list unique tags in merged list
hist_tad(hist_dat_merged, select_id = "15P1019b", select_from = 'DeployID') # of one tag

## part V - unmerge data:
unmerge_histos(hist_dat_merged)
```

Index