Package ‘RchivalTag’

March 24, 2017

Type Package

Title Analyzing Archival Tagging Data

Version 0.0.2

Date 2017-03-22

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

LazyLoad yes

Repository CRAN

Date/Publication 2017-03-22 10:03:00

NeedsCompilation no

R topics documented:

`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 nautical 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 classifcation: "ast" (default) for astronomical and "naut" for nautical twilight events with sun angles of 18 vs 12 below the horizon, respectvely. Corresponding (expected) 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:
setwd(system.file("example_files",package="RchivalTag"))
PDT <- read_PDT("104659-PDTs.csv")
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 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_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 "Temperature") 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` (default).

`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, containing 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 default 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 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:
setwd(system.file("example_files",package="RchivalTag"))
PDT <- read_PDT("104659-PDTs.csv")
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:
setwd(system.file("example_files",package="RchivalTag"))
PDT <- read_PDT("104659-PDTs.csv")
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 implemented. 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 probability 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 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 contain 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).

$ 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

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)
```

---

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 stratification of the water column (e.g. thermocline depth, stratification index, ocean heat content) experienced 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 conditions. 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 interpolate_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 behaviour).

Usage

```
read_PDT(pdt_file, 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'".
`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:
setwd(system.file("example_files",package="RchivalTag"))
PDT <- read_PDT("104659-PDTs.csv")
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)
```

`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.

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)
```

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